



AT&T

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System Programmer's Guide

AT&T Personal
Computer 6300

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System Programming Concepts

- **Purpose of this Manual**
 - **Notation**
 - **Programming Steps**
-

Purpose of this Manual

This guide provides you with in-depth information on the AT&T Personal Computer program development tools. The guide focuses on what you need to know to make use of the existing AT&T Personal Computer 6300 hardware and hardware interfaces.

The final chapter on programming devices assumes that you have a working knowledge of the principles of designing device drivers and need the technical details on how to program the AT&T Personal Computer.

Notation

The following syntax is used throughout this manual in descriptions of command and statement syntax:

- [] Square brackets indicate that the enclosed entry is optional.
- { } Braces indicate a choice between two or more entries. At least one of the entries enclosed in braces must be chosen.
- ... Ellipses indicate that an entry may be repeated as many times as needed.

This guide contains examples of prompts and messages displayed on the screen. These system-displayed items are indented from the main body of the text so that you can easily distinguish them. For example, MS-LINK prompts:

OBJECT MODULES[.OBJ]

Descriptions or examples that show a required response are indented and presented in boldface type:

LINK OBJ1+OBJ2+OBJ3,MAP

Programming Steps

This section shows where to go for information on the task you are performing.

Running High-Level Language

If you are running a program via the BASIC interpreter, the section on "System Calls" is applicable, since you can call these functions via a BASIC program.

If you are running a compiled program, read the section on MS-LINK as well as the section on System Calls.

Writing Assembler Programs

The first eight chapters are aimed at programmers writing assembler programs. If you have not used the 8088 or 8086 assembly language, the section "8086 Addressing Scheme" gives you a good start. The sections on the linker and debugger are fundamental to writing and debugging assembler programs. Also read the sections on "System Calls" and "ROM BIOS Service Calls."

Writing Utilities

If you are writing a supplementary utility program, read the sections on assembly programs, the sections on "Memory Maps, Control Blocks, and Diskette Allocation," and "Program File Structure and Loading."

Programming Devices Directly

Every section applies to writing device drivers, especially the chapter on "MS-DOS Device Drivers."

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- **Overview**
- **MS-LINK File Usage**
- **Segments, Groups, and Classes**
- **Invoking MS-LINK**
- **Sample MS-LINK Session**
- **MS-LINK Error Messages**

Overview

MS-LINK is an executable program on your DOS Supplemental Programs diskette. MS-LINK combines object modules that are the output of the MACRO-86 assembler or a compatible compiler. It produces a relocatable run file (load module) and a list file of external references and error messages.

To run MS-LINK, you provide object, run, list, and library file parameters. You may optionally enter switches that modify the operation of MS-LINK.

“Invoking the Linker” describes the three ways to run MS-LINK: interactive entry, command line entry, and automatic response file entry. Interactive entry is used most frequently, so its section contains information common to all three methods.

If you are linking a high-level language program, the compiler determines the arrangement of your object modules in memory. If you are using assembler, however, you have more control over your program’s organization. The section “Segments, Groups, and Classes” shows you how to specify the order of your object modules at run time.

MS-LINK File Usage

The link process involves the use of several files.

MS-LINK:

- Works with one or more input files
- Produces two output files
- Creates a temporary disk file if necessary
- Searches up to eight library files

The format for MS-LINK file specifications is the same as that of any disk file:

Syntax [d:][path]filename[.ext]

d: the drive designation. Permissible drive designations for MS-LINK are A: through O:.

path a path of directory names.

filename any legal filename of one to eight characters.

ext a one- to three-character extension to the filename.

If no filename extensions are given in the input (object) file specifications, MS-LINK recognizes the following extensions by default:

.OBJ Object
.LIB Library

MS-LINK appends the following default extensions to the output (Run and List) files:

.EXE Run (may not be overridden)
.MAP List (may be overridden)

VM.TMP File MS-LINK uses available memory for the link session. If an output file exceeds available memory, MS-LINK creates a temporary file, names it VM.TMP, and puts it on the disk in the default drive. If MS-LINK creates VM.TMP, it will display the message:

VM.TMP has been created.

Do not change diskette in drive, <d:>

Once this message is displayed, do not remove the diskette from the default drive until the link session ends. If the diskette is removed, the operation of MS-LINK is unpredictable and MS-LINK usually displays the error message:

Unexpected end of file on VM.TMP

MS-LINK writes the contents of VM.TMP to the file named following the Run File: prompt. VM.TMP is a working file only and is deleted at the end of the linking session.

Do not use VM.TMP as a filename for any file. If MS-LINK requires the VM.TMP file, MS-LINK deletes the VM.TMP already on disk and creates a new VM.TMP. Thus, the contents of the previous VM.TMP file are lost.

Changing diskettes

You may want to change diskettes during the link operation. If MS-LINK cannot find an object file on the specified diskette, it prompts you to change diskettes rather than aborting the session. If you enter the /PAUSE switch, MS-LINK pauses and prompts you to change diskettes before it creates the run file. You may change diskettes when prompted except in the following cases:

- the diskette you want to change has a VM.TMP file on it.
- you have requested a list file on the diskette you want to change.

Segments, Groups, and Classes

Below terms are explained to help you understand how MS-LINK works. Generally, if you are linking object modules from a high-level language compiler, you do not need to know these terms. If you are linking assembly language modules, read this section carefully.

Segment

The segment is one of the most basic units of program memory organization. A segment is a contiguous area of memory up to 64K bytes long, and may be located anywhere in RAM. The contents of a segment are addressed by a segment:offset address pair, where “segment” is the segment’s base or lowest address (see “The 20-Bit Address” in chapter 4).

Each segment has a class name in addition to its segment name. All segments with the same class name are loaded into memory contiguously by the linker from the first segment of that class to the last.

Class

A class is a collection of related segments. By naming the segments of your assembly language program to classes, you control the order in which they are loaded into memory (for high level languages, the compiler does this for you).

MS-LINK loads segments into memory on a class-by-class basis. Starting with the first class encountered in the first object file, all of the segments of each class are loaded. Within each class, the linker loads the segments in the order in which it finds them in the object files. Therefore, you can control the order in which classes are loaded by the order in which segments from different classes appear in the object files.

To ensure that classes are loaded in the order you desire, you can create a dummy module to feed to the linker as the first object file. This module declares empty-segment classes in the order you want the classes loaded. For example, one such file might look like this:

```
A SEGMENT 'CODE'  
A ENDS  
B SEGMENT 'CONST'  
B ENDS  
C SEGMENT 'DATA'  
C ENDS  
D SEGMENT STACK 'STACK'  
D ENDS
```

If this method is used, be sure to declare all the classes used in your program in the dummy module; otherwise, you lose absolute control over the ordering of classes. Also, this method should only be used when linking assembly language programs. Do not create a dummy module if linking object files for a compiler, or unpredictable results may occur. Classes may be any length.

Group

Just as classes allow you to combine segments in a way that is logical, groups combine segments in 64K byte chunks to make them easily addressable. The segments in a group need not be contiguous, but when loaded they must fit within 64K bytes. This way each segment in the group can be fully addressed by an offset to one segment address, which is the start address of the lowest segment in the group. Segments are named to groups by the assembler or compiler or, as is possible in assembly language programs, by the programmer. Note that a segment can be large enough to be an entire group by itself.

Invoking MS-LINK

Ways to Invoke MS-LINK

MS-LINK is invoked in one of three ways. The first method, interactive entry, requires you to respond to individual prompts.

For the second method, command line entry, type all commands on the same line used to start MS-LINK.

To use the third method, automatic response file entry, create a response file that contains all the necessary commands and tell MS-LINK where that file is when you run MS-LINK.

Interactive Entry	LINK
Command Line Entry	LINK filenames[/switches]
Automatic Response File Entry	LINK @filespec

Interactive Entry

To invoke MS-LINK interactively, type:

LINK

MS-LINK loads into memory, then displays four prompts, one at a time. At the end of each line, after typing your response to the prompt, you may type one or more switches preceded by a forward slash.

The command prompts are summarized below. Defaults appear in square brackets ([]) after the prompt. **Object Modules** is the only prompt that requires a response.

MS-LINK Prompts

Prompt	Responses
Object Modules[.OBJ]:	[d:][path]filename[.ext] +[d:][path]filename[.ext]]...
Run File[filename.EXT]:	[d:][path][filename[.ext]]
List File[NUL.MAP]:	[d:][path][filename[.ext]]
Libraries[.LIB]:	[d:][path][filename[.ext]] +[d:][path]filename[.ext]]...

Notes:

- If you enter a filename without specifying the drive, the default drive is assumed. If you enter a filename without specifying the path, the default path is assumed. The libraries prompt is an exception — if the linker looks for the libraries on the default drive and doesn't find them, it looks on the drive specified by the compiler.
- To select default responses to all remaining prompts, use a single semicolon (;) followed immediately by <return> at any time after the second prompt (Run File:).

Once you enter the semicolon, you can no longer respond to any of the prompts for that link session. Use the <RETURN> key to skip prompts.

- Use <CONTROL-C> to abort the link session at any time.

**Object
Modules
to be
Included**

Object Modules [.OBJ]:

List .OBJ files to be linked. They must be separated by blank spaces or plus signs (+). If the plus sign is the last character typed, this prompt will reappear so that you can enter more object modules.

MS-LINK assumes that object modules have the extension .OBJ unless you explicitly specify some other extension. Object filenames may not begin with the @ symbol (@ is used for specifying an automatic response file).

The order in which you key in the the object files is significant. See section on segments, groups, and classes for more information.

**Load
Module**

Run File [Obj-file.EXE]:

Give filename for executable object code. The default is: <first-object-filename>.EXE. (You cannot change the output extension.) You can specify just the drive designation or just a path for this prompt.

Listing

List File [NUL.MAP]:

Give filename for listing (also known as a linker map). The listing is not created if you select the default. You can request a listing by entering a drive designator, path, or filename[.ext]. If you do not specify an extension, the default .MAP is used.

You can have the listing printed by specifying a print device instead of a filename or have the listing displayed on the screen by specifying CON. If you display the linker map, you can also print it by pressing Ctrl-PrtSc.

**Libraries
to be
Searched**

Libraries [.LIB]:

List filenames to be searched separated by blank spaces or plus signs (+). If a plus sign is the last character typed, the prompt will reappear.

MS-LINK searches library files in the order listed to resolve external references. When it finds the module that defines the external symbol, MS-LINK processes that module as another object module.

There is no default library search for MACRO assembler object modules. For compiled modules, if you select the default for this prompt, MS-LINK looks for the compiler package's library on the default drive. If not found there, MS-LINK looks on the drive specified by the compiler.

If MS-LINK cannot find a library file, it displays:

Cannot find library <library-name>
Type new drive letter:

Press the letter for the drive designation (for example, B).

If two libraries have the same filename, only the first in the list is searched.

**MS-LINK
Switches**

The seven MS-LINK switches control various MS-LINK functions. Type switches at the end of a prompt response regardless of which method you use to start MS-LINK. Switches may be grouped at the end of any response, or may be scattered at the end of several. Even if you type more than one switch at the end of one response, each switch must be preceded by a forward slash (/).

All switches may be abbreviated. The only restriction is that an abbreviation must be sequential from the first letter through the last typed; no gaps or transpositions are allowed. For example:

Legal	Illegal
/D	/DSL
/DS	/DAL
/DSA	/DLC
/DSALLOCA	/DSALLOCT

/DSALLOCATE

/DSALLOCATE tells MS-LINK to load all data at the high end of the Data Segment. Otherwise, MS-LINK loads all data at the low end of the Data Segment. At runtime, the DS pointer is set to the lowest possible address to allow the entire DS segment to be used. Use of **/DSALLOCATE** in combination with the default load low (that is, the **/HIGH** switch is not used) permits the user application to dynamically allocate any available memory below the area specifically allocated within DGroup yet to remain addressable by the same DS pointer. This dynamic allocation is needed for Pascal and FORTRAN programs.

Your application program may dynamically allocate up to 64K bytes (or the actual amount of memory available) less the amount allocated within DGroup.

/HIGH

/HIGH causes MS-LINK to place the Run file as high as possible in memory. Otherwise, MS-LINK places the Run file as low as possible.

Note:

Do not use **/HIGH** with Pascal or FORTRAN programs.

/LINENUMBERS

/LINENUMBERS tells MS-LINK to include in the List file the line numbers and addresses of the source statements in the input modules. Otherwise, line numbers are not included in the List file.

Not all compilers produce object modules that contain line number information. In these cases, of course, MS-LINK cannot include line numbers.

/MAP

/MAP directs MS-LINK to list all public (global) symbols defined in the input modules. If **/MAP** is not given, MS-LINK will list only errors (including undefined globals).

The symbols are listed alphabetically. For each symbol, MS-LINK lists its value and its segment:offset location in the Run file. The symbols are listed at the end of the List file.

/PAUSE

/PAUSE causes MS-LINK to pause in the link session when the switch is encountered. Normally, MS-LINK performs the linking session from beginning to end without stopping. This switch enables you to swap the diskettes before MS-LINK outputs the Run (.EXE) file.

When MS-LINK encounters /PAUSE, it displays the message:

```
About to generate .EXE file
Change disks <hit any key>
```

MS-LINK resumes processing when you press any key.

Note

Do not remove the disk which will receive the List file, or the disk used for the VM.TMP file, if one has been created.

**/STACK:
<number>**

Stack number represents any positive numeric value (in hexadecimal radix) up to 65536 bytes. If a value from 1 to 511 is typed, MS-LINK will use 512. If /STACK is not used for a link session, MS-LINK calculates the necessary stack size automatically.

All compilers and assemblers should provide information in the object modules that allow the linker to compute the required stack size.

At least one object (input) module must contain a stack allocation statement. If not, MS-LINK will display the following error message:

```
WARNING: NO STACK STATEMENT
```

/NO

/NO is short for **NODEFAULTLIBRARY-SEARCH**. This switch applies only to higher level language modules. This switch tells **MS-LINK** not to search the default libraries in the object modules. For example, if you are linking object modules in Pascal, specifying **/NO** tells **MS-LINK** not to automatically search the library named **PASCAL.LIB** to resolve external references.

Command Line Entry

Purpose You may invoke MS-LINK by typing all commands on one line. The entries following LINK are responses to the command prompts. The entry fields for the different prompts must be separated by commas. Use the following syntax:

Syntax LINK <obj-list>,<runfile>,<listfile>,
<lib-list>[/switch...]

obj-list a list of object modules, separated by plus signs or spaces.

runfile name of the file to receive the executable output.

listfile name of the file to receive the listing.

lib-list list of library modules to be searched, separated by spaces or plus signs.

/switch refers to optional switches which may be placed following any of the response entries (just before any of the commas or after the <lib-list>, as shown).

To select the default for a field, simply type a second comma with no spaces between the two commas.

Example:

**LINK FUN+TEXT+TABLE+CARE,
FUNLIST, COBLIB.LIB**

This command causes MS-LINK to load. Then the object modules FUN.OBJ, TEXT.OBJ, TABLE.OBJ and CARE.OBJ are loaded. MS-LINK links the object modules and writes the output to FUN.EXE (by default), creates a List file named FUNLIST.MAP, and searches the library file COBLIB.LIB.

Automatic Response File Entry

It is often convenient to save responses to the linker for re-use at a later time. This is especially useful when a long list of object modules needs to be specified. The use of an automatic response file allows you to do this.

Before using this option, you must create the response file. Each line of text corresponds to one MS-LINK prompt. The responses must be typed in the same order as they are when entered interactively. To continue a line, type a plus sign (+) at the end of the line.

You can enter the name of more than one automatic response file on the command line and combine response file names with additional parameters. The combined series of resulting parameters must be a valid sequence of MS-LINK prompts.

Use switches and special characters (+ and ;) in the response file the same way they are used when entered interactively.

To invoke the linker using a response file, type

```
LINK @ <filespec>
```

Filespec is the name of a response file.

When the session begins, MS-LINK displays each prompt with the corresponding response from the response file. If the response file does not contain answers for all the prompts, MS-LINK displays the prompt which does not have a response and waits for a response. When you type a legal response, MS-LINK continues the link session.

Example:

```
FUN TEXT TABLE CARE  
/PAUSE /MAP  
FUNLIST  
COBLIB.LIB
```

This response file tells MS-LINK to load the four object modules named FUN.OBJ, TEXT.OBJ, TABLE.OBJ, and CARE.OBJ. MS-LINK pauses before producing a public symbol map to permit you to swap disks. When you press any key, the output files will be named FUN.EXE and FUNLIST.MAP. MS-LINK will search the library file COBLIB.LIB.

Sample MS-LINK Session

This sample shows you the type of information displayed during an MS-LINK session.

In response to the MS-DOS prompt, type:

LINK

The system displays the following messages and prompts:

```
Microsoft Object Linker V2.01 (Large)
(C) Copyright 1982,1983 by Microsoft Inc.
```

```
Object Modules [.OBJ]: IO SYSINIT
Run File [IO.EXE]:
List File [NUL.MAP]: PRN /MAP /LINE
Libraries [.LIB]: ;
```

Notes:

- By specifying /MAP, you get both an alphabetic listing and a chronological listing of public symbols.
- By responding PRN to the List File: prompt, you can redirect your output to the printer.
- By specifying the /LINE switch, MS-LINK gives you a listing of all line numbers for all modules. (Note that /LINE can generate a large volume of output.)

Once MS-LINK locates all libraries, the linker map displays a list of segments in the order of their appearance within the load module. The list might look like this:

Start	Stop	Length	Name
00000H	009ECH	09EDH	CODE
009F0H	01166H	0777H	SYSINITSEG

The information in the Start and Stop columns shows the 20-bit hex address of each segment relative to location zero. Location zero is the beginning of the load module.

The addresses displayed are not the absolute addresses where these segments are loaded. See the following section on the MS-LINK DEBUG program for information on how to determine the absolute address of a segment.

Because the /MAP switch was used, MS-LINK displays the public symbols by name and value. For example:

ADDRESS	PUBLICS BY NAME
009F:0012	BUFFERS
009F:0005	CURRENT DOS LOCATION
009F:0011	DEFAULT DRIVE
009F:000B	DEVICE LIST
009F:0013	FILES
009F:0009	FINAL DOS LOCATION
009F:000F	MEMORY SIZE
009F:0000	SYSINIT

ADDRESS	PUBLICS BY VALUE
009F:0000	SYSINIT
009F:0005	CURRENT DOS LOCATION
009F:0009	FINAL DOS LOCATION
009F:000B	DEVICE LIST
009F:000F	MEMORY SIZE
009F:0011	DEFAULT DRIVE
009F:0012	BUFFERS
009F:0013	FILES

The final line in the listing file describes the program's entry point:

Program entry point at 0009F:0000

MS-LINK Error Messages

All errors, except for the two warning messages, cause the link session to abort. After the cause has been found and corrected, MS-LINK must be rerun. The following error messages are displayed by MS-LINK:

Attempt to access data outside of segment bounds, possibly bad object module

There is probably a bad object file.

Bad numeric parameter

Numeric value is not in digits.

Cannot open temporary file

MS-LINK is unable to create the file VM.TMP because the disk directory is full. Insert a new disk. Do not remove the disk that will receive the List. MAP file.

Error: dup record too complex

DUP record in assembly language module is too complex. Simplify DUP record in assembly language program.

Error: fixup offset exceeds field width

An assembly language instruction references an address with a short or near instruction instead of a long or far instruction. Edit assembly language source and reassemble.

Input file read error

There is probably a bad object file.

Invalid object module

An object module(s) is incorrectly formed or incomplete (as when assembly is stopped in the middle).

Symbol defined more than once

MS-LINK found two or more modules that define a single symbol name.

Program size or number of segments exceeds capacity of linker

The total size may not exceed 384K bytes and the number of segments may not exceed 255.

Requested stack size exceeds 64K

Specify a size less than or equal to 64K bytes with the /STACK switch.

Segment size exceeds 64K

64K bytes is the addressing system limit.

Symbol table capacity exceeded

Very many and/or very long names were typed exceeding the limit of approximately 50K bytes.

Too many external symbols in one module

The limit is 256 external symbols per module.

Too many groups

The limit is ten groups.

Too many libraries specified

The limit is 8 libraries.

Too many public symbols

The limit is 1024 public symbols.

Too many segments or classes

The limit is 256 (segments and classes together must total 256 or less).

Unresolved externals: <list>

The external symbols listed have no defining module among the modules or library files specified.

VM read error

This is a disk error; it is not caused by MS-LINK.

Warning: no stack segment

None of the object modules specified contains a statement allocating stack space.

Warning: segment of absolute or unknown type

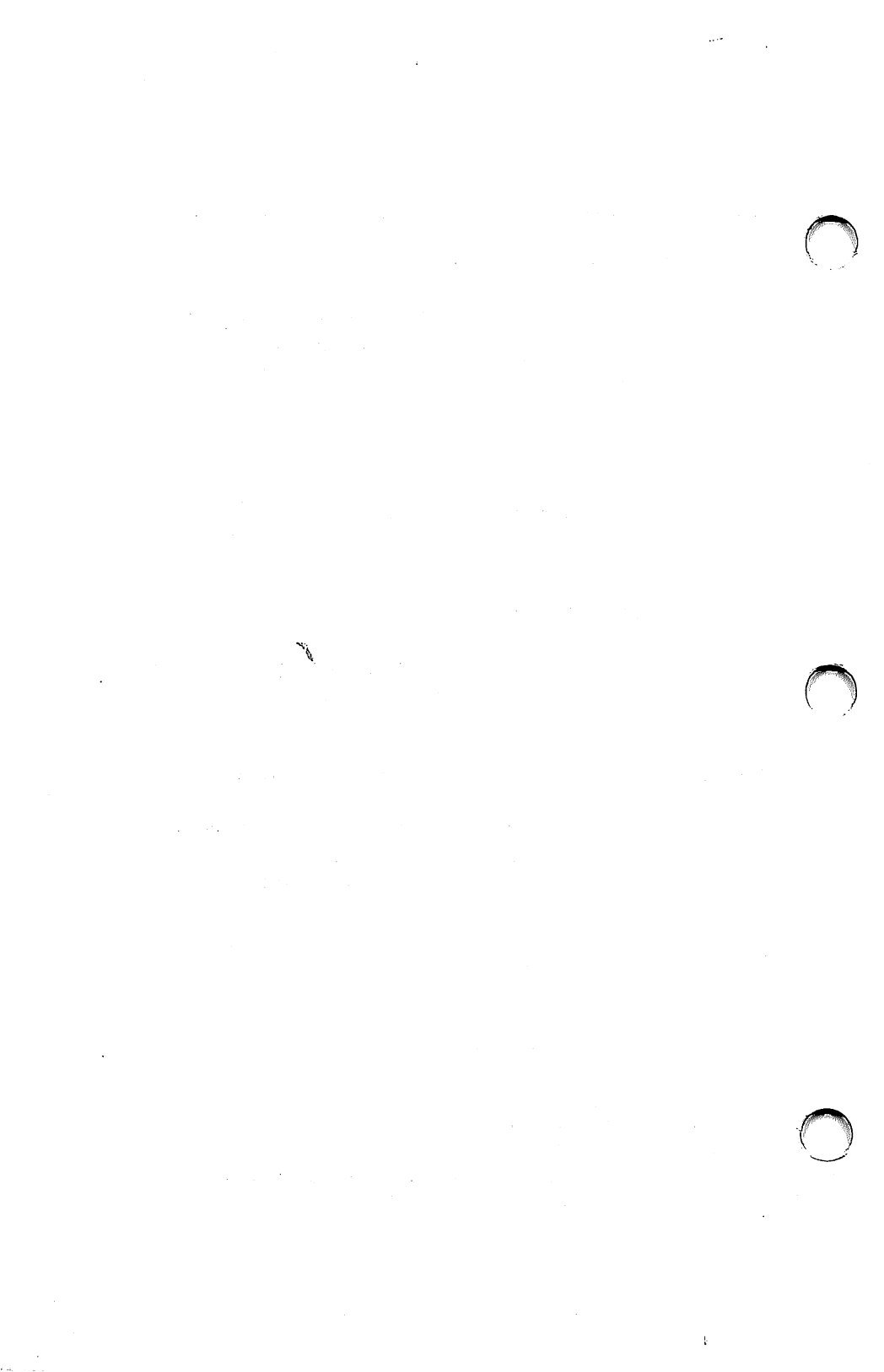
There is a bad object module or an attempt has been made to link modules that MS-LINK cannot handle (e.g., an absolute object module).

Write error in TMP file

No more disk space remains to expand the VM.TMP file.

Write error on run file

Usually, this means there is not enough disk space for the Run file.



3

- Overview
- How to Invoke DEBUG
- Debugging Commands
- Command Parameters

A Assemble
C Compare
D Display
E Enter
F Fill
G Go
H Hexarithmic
I Input
L Load
M Move
N Name
O Output
Q Quit
R Register
S Search
T Trace
U Unassemble
W Write

- **DEBUG Error Messages**

Overview

The DEBUG utility is an executable object program that resides on your MS-DOS diskette. DEBUG performs the following functions:

- Allows you to single step through a program, instruction by instruction, for testing purposes.
- Changes register and file contents during the DEBUG session so that you can test a code change without reassembling your program.
- Makes permanent changes to diskette files so you can use DEBUG to recover files that may otherwise be lost.
- Supports a disassemble command so you can translate machine code instructions into their assembly language equivalents for testing purposes.

How to Invoke DEBUG

The DEBUG program is invoked as follows:

```
DEBUG [filespec [,arglist]]
```

filespec the name of the program file to be debugged.

arglist An optional list of file name parameters and switches. These will be passed to the program specified by the filespec parameter. When the program is loaded into memory, it is loaded as if it had been invoked with the command

```
filespec arglist
```

That is, filespec indicates the file to be debugged, and arglist is the rest of the command line that is used when the file is invoked and loaded in memory via COMMAND.COM.

If you enter DEBUG without parameters, since no file name has been specified, current memory, disk blocks, or disk files can be manipulated.

Comments On entering the DEBUG environment DEBUG responds with the hyphen (-) prompt and underline (_) cursor. You now may enter any DEBUG command.

If you include the filespec in the command line, the specified file is loaded into memory starting at location 100 (hexadecimal). However, if you specify a file with a .EXE extension, the program is relocated to the address specified in the header of the file. See the chapter on “Program Structure and Loading” for information on the format of the file header.

If the file has the HEX extension, the file is loaded beginning at the address specified in the HEX file. HEX files are in INTEL hex format and are converted to memory image format by DEBUG.

All DEBUG commands may be aborted at any time by pressing <CTRL-C>. Pressing <CTRL-S> suspends the display, so that you can read it before the output scrolls away. After suspending the display, press any key (except <CTRL-S> or <CTRL-C>) to continue scrolling.

Examples **DEBUG <CR>.**

The DEBUG session begins, but without loading a file.

DEBUG b:myprog <CR>.

The DEBUG environment is entered and the file named “myprog” is loaded into memory from drive B.

When you invoke DEBUG, it sets up a program segment prefix at offset 0 in the program work area. You can overwrite this area if you enter DEBUG without parameters. Moreover, if you are debugging a file with a COM or EXE extension, do not tamper with the program header below location 5CH, or DEBUG will terminate.

Do not restart a program after a “Program terminated normally” message is displayed. You must reload the program with the N and L commands for it to run properly.

Debugging Commands

This section describes the DEBUG commands in alphabetical order for ease of reference.

- Commands can be entered in either upper or lower case.
- Command keywords and command parameters can be separated from each other by spaces or commas for readability but need not be, except where two hexadecimal numbers are entered as parameters, in which case they must be separated by a comma or space. For brevity, the syntax of this chapter will always indicate a comma where separation is obligatory, but note that a space can alternatively be used.
- Commands only become effective after entering <CR>.
- If you make a syntax error when entering a command, the message “Error” will be displayed. You must re-enter the command using the correct syntax.

Command Parameters

The following DEBUG command parameters require definition.

- address** a hex value in one of the following formats:
- a segment register designation and a hex offset separated from each other by a colon. For example:
`DS:0300`
 - a hexadecimal segment and offset separated from each other by a colon. For example:
`9D0:0100`
 - a hexadecimal offset value. The DEBUG command will use a default segment value from either the DS or CS registers, depending on the command. For example:
`200`
- byte** a one or two character hexadecimal value.
- drive** 0, 1, or 2 depending on whether you wish to select drive A, drive B or drive C, respectively.

range

a range of addresses. The range can be specified as

address L value

where address specifies the start of the range and value specifies the length of the range. For example:

DS:300L30

indicates a range of 48 locations starting at address 300 in the segment indicated by the DS register.

The specified range cannot be greater than 10000 (hexadecimal). To specify this value enter 0000 (or 0) as the value parameter.

A range can also be specified as:

address,address

where the two addresses indicate the limits of the range. A space may be used instead of a comma.

value

a 1 to 4 character hexadecimal value.

A (ASSEMBLE)

Assembles 8086 mnemonics directly into memory.

Syntax **A [address]**

Address is the start address into which the subsequently entered line of mnemonics is to be assembled. If this parameter is omitted, offset 100 from the segment in the CS register is assumed, if you did not enter an Assemble command previously. If you did enter Assemble previously, the code assembles into the address following the last instruction loaded by the previous Assemble command.

- Comments**
- After you enter the Assemble command, DEBUG displays the specified address followed by the cursor. You may then enter a line of 8086 assembler mnemonics. On terminating the line with <CR>, the line will be assembled into memory starting at the specified location. The address of the byte subsequent to the assembled code will be displayed on the next line along with the cursor to enable you to enter the next line of code. If, instead of a line of 8086 mnemonics, you simply enter <CR>, the Assemble command terminates and the DEBUG prompt reappears.
 - All numeric values are hexadecimal and must be entered as 1 to 4 characters without a trailing H. Prefix mnemonics must be specified in front of the opcode to which they refer. You may also enter them on a separate line.
 - The segment override mnemonics are CS:, DS:, ES: and SS:. The mnemonic for the far return is RETF. String manipulation mnemonics must explicitly state the string size. For example, use MOVSB to move byte strings.

- The Assemble command will automatically assemble short, near, or far jumps and calls, depending on byte displacement with respect to the destination address. These may be overridden with the NEAR or FAR prefix. For example:

```

0100:0500 JMP 502           ;a two-byte
                           ;short jump
0100:0502 JMP NEAR 505    ;a three-byte
                           ;near jump
0100:505 JMP FAR 50A      ;a five-byte far
                           ;jump
    
```

The NEAR prefix may be abbreviated to NE, but the FAR prefix cannot be abbreviated.

- DEBUG cannot tell whether some operands refer to a word memory location or to a byte memory location. In this case the data type must be explicitly stated with the prefix “WORD PTR” or “BYTE PTR”. Acceptable abbreviations are “WO” and “BY”. For example:

```

NEG    BYTE PTR [128]
DEC    WO [SI]
    
```

- DEBUG cannot distinguish whether an operand refers to a memory location or to an immediate operand. Enclose operands that refer to memory locations in square brackets. For example:

```

MOV AX,21           ;Load AX with 21H
MOV AX,[21]        ;Load AX with the contents of
                   ;location 21H
    
```


-
- Two pseudo-instructions are available with the Assemble command. The DB opcode will assemble byte values directly into memory. The DW opcode assembles word values into memory. For example:

```
DB 1,2,3,4,"THIS IS AN EXAMPLE"  
DB "THIS IS A QUOTE:" '  
DB "THIS IS A QUOTE" "  
DW 1000,2000,3000,"BACH"
```

- The Assemble command supports all forms of register indirect addressing. For example:

```
ADD BX,34[BP+2]. [SI-1]  
POP [BP+DI]  
PUSH [SI]
```

All opcode synonyms are supported. For example:

```
LOOPZ 100  
LOOPE 100  
JA 200  
JNBE 200
```

- Example**
- 1** Enter **A200 <CR>**.
 - 2** DEBUG displays **09AC:0200_.**
 - 3** Enter **MOV AX,[21] <CR>**.
 - 4** The 8086 mnemonics are assembled starting at location 200. The byte location subsequent to the assembled code is then displayed:

09AC:0203_
 - 5** Enter **<CR>**.
 - 6** The Assemble command terminates and the DEBUG prompt reappears.

C (COMPARE)

Compares the contents of two areas of memory.

Syntax **C** *range,address*

range the range of addresses defining the first area to be compared. If no segment is specified, then the segment specified in the DS register is assumed.

address the start of the area to be compared with the area specified by the range parameter.

Comments • The Compare command compares the area of memory specified by the range parameter with an area of the same size starting at the location specified by the address parameter.

- If the contents of the two areas are identical, nothing is displayed. If there are differences, then the differences are displayed in the form

<address1><contents1><contents2><address2>

<address1> indicates the address in the first area and <contents1> its contents. <address2> indicates the corresponding address in the second area and <contents2> its contents.

Example 1 Enter C100,1FF,300 <CR> or
C100L100, 300 <CR>.

2 The area of memory from 100 to 1FF is compared with the area of memory from 300 to 3FF.

D (DISPLAY)

Displays an area of memory.

Syntax **D [range] or**
 D [address]

range the range of addresses whose contents are to be displayed. If you enter only offsets, then the segment specified in the DS register is assumed.

address the address from which the display is to start. The contents of this address and the subsequent 127 locations are displayed. If only an offset is entered, then the segment specified in the DS register is assumed.

Comments • If D is specified without parameters, then the 128 bytes following the last address to be displayed are displayed. If no location has yet been accessed, the display will start from location DS:100.

- If D and the range parameter are specified, the contents of that range of addresses are displayed. If this takes more than 24 screen lines, the display is scrolled until the contents of the final address in the range are displayed on line 24.

- The display is displayed in two portions:

A hexadecimal display, where each byte is represented by its hexadecimal value, and an ASCII display, where the equivalent ASCII character for the byte is displayed. If there is no corresponding printable ASCII character, a period (.) is displayed.

- Each line of the display begins with an address followed by the hexadecimal contents of the 16 bytes starting from the addressed location. The eighth and ninth bytes are separated by a hyphen (-). The right-hand columns display the equivalent ASCII values. Each line of the display, except possibly the first, begins on a 16 byte boundary.

- Example**
- 1** Enter `D 100,110 <CR>`.
 - 2** Lines 100H to 110H (inclusive) are displayed.
 - 3** Enter `D <CR>`.
 - 4** The 128 bytes starting from location 111H are displayed.
 - 5** Enter `D200 <CR>`.
 - 6** The 128 bytes starting from location 200H are displayed.

E (ENTER)

Replaces the contents of memory locations at the byte address(es) specified.

Syntax **E** address[,bytevalue[,bytevalue...]]

address the address of the location whose value is to be replaced; or the address of the first of a succession of locations whose contents are to be replaced. If only an offset is specified, then the segment indicated by the DS register is assumed.

bytevalue the value that is to replace the contents of the specified address. The first bytevalue parameter will replace the contents of the location specified by the address parameter. A second bytevalue will replace the contents of the location following that specified by the address parameter, and so on.

Comments • If the command is entered without the byte value list, then DEBUG displays the specified address and its contents. The Enter command then waits for you to perform one of the following:

- 1** Replace the displayed bytevalue by entering another value. Enter the new value after the current value. If you enter an illegal value, or if you type more than two dig. 's, the illegal or extra character is not echoed.
- 2** Advance to the next byte by pressing <SPACE>. To change the value of this byte simply enter the value as described above. If you

advance beyond an eight-byte boundary, DEBUG starts a new display line with the address displayed at the start of the line. To advance to the next byte without changing the current byte, press <SPACE> again.

- 3** To return to the previous byte enter hyphen (-). DEBUG then starts a new display line with the address of the byte you have returned to and its contents. You can then change the contents of this location as described above. To move back one byte further without changing this value, enter hyphen again, and another new display line will be generated.
- 4** Terminate the Enter command by pressing <CR>. This key may be pressed in any byte position.
 - If you specify byte values in the command line, then the first of these byte values will replace the contents of the location specified by the address parameter. Subsequent entries in the list of byte values will replace subsequent bytes in memory.

- Example**
- 1** Enter E100 <CR>.
 - 2** DEBUG displays something like 058D:0100 CD._
 - 3** Enter 26.
 - 4** the value of location 100 is changed to 26 and DEBUG displays:
058D:0100 CD.26._

-
- 5** Enter **<SPACE>**.
- 6** The next byte (location 101) is displayed
058D:0100 CD.26 20._
- 7** Enter **<SPACE>**.
- 8** The next byte (location 102) is displayed
058D:100 CD.26 20. 00._
- 9** Enter **<->**.
- 10** The previous byte (location 101) is displayed on the next line
058D:0100 CD.26 20. 00.
058D:0101 20._
- 11** Enter **30 <CR>**.
- 12** The contents of location 101 are changed to 30 and the Enter command is terminated.
058D:0100 CD.26. 20. 00.
058D:0101 20.30
_
- 13** Enter **E 200,26,0A,19,23 <CR>**.
- 14** The contents of byte locations 200, 201, 202 and 203 are changed to 26, 0A, 19 and 23, respectively.
-

F (FILL)

Fills an area of memory with specified byte values.

Syntax **F** range,bytevalue[,bytevalue...]

range the range of addresses whose contents are to be overwritten with the specified bytevalues. If only the offset is specified, then the segment indicated by the DS register is assumed.

bytevalue a two digit hexadecimal value that is to overwrite the contents of the specified address(es).

Comments

- If the specified range contains more bytes than the list of byte values, then the list of byte values is repeated until the specified range is filled.
- If the list of byte values is longer than the specified range, the extra byte values are ignored.

Example 1 Enter **F04BA:100L100,42,45,48,37,20 <CR>**.

2 DEBUG fills memory locations **04BA:100** to **04BA:1FF** with the byte values specified. The five values are repeated until all 256 locations are filled.

G (GO)

Executes the program currently in memory, optionally halting at specified breakpoint(s) and displaying information about the system and program environment.

Syntax **G [=address][,address...]**

=address the address in memory at which program execution is to start. “=” must be entered to distinguish a start address from a breakpoint address.

address the breakpoint address. You can specify up to ten breakpoints, in any order.

Comments If you enter G without parameters, the program currently in memory is executed starting from the address specified by the CS and IP registers.

If you specify the =address parameter, the contents of the CS and IP registers are changed to those specified by the =address parameter and the program in memory is executed, starting from the address you specified.

If you specify one or more breakpoint addresses, program execution stops at the first such address encountered and displays the contents of the registers, the state of the flags and the next instruction to be executed (see the Register command for a description of the display).

- If only an offset is entered for an address, the GO command assumes the segment in the CS register.

- If you enter more than ten breakpoints, DEBUG will display

BP Error

- Before executing the program, the GO command replaces the contents of the breakpoint locations with an interrupt instruction (hexadecimal CC). Therefore, each breakpoint address that you specify must point to the first byte of an 8086 instruction, or unpredictable results occur.

When program execution halts at a breakpoint DEBUG restores the original values of all the specified breakpoint locations. However, if the program terminates normally (that is, not at a specified breakpoint), the original values are not restored.

Note: Once a program has reached completion (DEBUG has displayed "Program terminated normally") you must reload the program before you can re-execute it.

The stack segment must have six bytes available at the stack pointer for this command, otherwise unpredictable results occur. This is because the GO command jumps into the user program with the IRET instruction. The flag, CS, and IP registers have to be pushed onto the stack in preparation for the IRET, taking up six bytes.

-
- Example 1** Enter **G=200,1AF,141 <CR>**.
- 2** The program currently in memory is executed starting from location 200. Assuming location 141 is encountered before 1AF, then the program halts at location 141 and the register and flag values are displayed along with the next instruction to be executed. If neither breakpoint location is encountered, then the program terminates normally.
- 3** Enter **G <CR>**.
- 4** If, in step two, the program had halted at location 141, then program execution continues from that address.

H (HEXARITHMETIC)

Calculates and displays the sum and the difference of two hexadecimal values.

Syntax **H value_a,value_b**

value_a The first of two hexadecimal values.

value_b The hexadecimal value that is to be added to or subtracted from value_a.

Comments The hexadecimal values may be up to four digits long.

The Hex command displays two four-digit values:

- the first is the result of adding value_b to value_a
- the second is the result of subtracting value_b from value_a

Example **1** Enter **H19F,10A <CR>**.

2 DEBUG displays

02A9 0095

3 Enter **HFFFF,2 <CR>**.

4 DEBUG displays

0001 FFFD

I (INPUT)

Inputs and displays (in hexadecimal) one byte from the specified port.

Syntax I value

value the address of the port that the byte is to be input from.

Comments The port address can be up to 16 bits.

Example 1 Enter I2F8.

2 the byte at the addressed port is input and displayed.

L (LOAD)

Loads a file or absolute disk blocks into memory.

Syntax L [address[,drive,block,count]]

address the address in memory at which the file or range of blocks is to be loaded. If only an offset is entered, then the segment indicated by the CS register is assumed.

drive the drive from which disk blocks are to be loaded. For drive A you must enter 0, for drive B you must enter 1, etc.

block the first of a range of blocks to be loaded from the disk specified by the drive parameter.

count the number of blocks to be loaded.

- Comments**
- If all parameters are specified, then DEBUG loads blocks of information from disk into memory.
 - If you enter L without parameters, or with just the address parameter, the file whose file control block is correctly formatted at location CS:5C is loaded into memory. The file control block at CS:5C is set either to the filespec specified when the DEBUG command was invoked, or to the filespec specified by the most recent "Name" command.
 - The default location for programs to load is at CS:100. If you specify L and the address parameter, the file is loaded at the specified

address unless it is a .EXE or .HEX file. In any case DEBUG sets the BX:CX registers to the number of bytes loaded.

- If the file has an EXE extension, then it is relocated to the load address specified in the header of the .EXE file. That is, the address parameter to the Load command is ignored. The header itself is stripped off the .EXE file before the file is loaded into memory. Thus the size of the .EXE file on disk will differ from its size in memory.
- If the file is a .HEX file, entering the Load command with no parameters causes the file to be loaded starting at the address specified within the .HEX file. If the address parameter, however, is specified, then loading starts at the address which is the sum of the address specified and the address in the .HEX file.

Examples

The following examples assume the system to be initially in MS-DOS.

- 1 Enter `debug <CR>`
 `Nb:file.com <CR>`
 `L <CR>`.

Debug is entered and the subsequent Name command sets the file control block at CS:5C to identify file "file.com" on the diskette inserted in drive B. The Load command then loads this file into memory starting at CS:100 (the default address).

- 2 Enter `debug b:file.com <CR>`
 `L300 <CR>`.

file.com is loaded into memory at location CS:100 by the DEBUG command. It is then relocated to CS:300 by the Load command.

M (MOVE)

Moves the contents of a specified range of memory addresses to the locations starting at a specified address.

Syntax **M range,address**

range The area of memory whose contents are to be moved. If you only enter an offset, the segment indicated in the DS register is assumed.

address The start of the destination area. If you only enter an offset, then the segment indicated by the DS register is assumed.

Comments If the source and destination areas overlap, the move is performed without loss of data.

The contents of the source area are not changed by the move, unless the destination area overlaps it.

If you specify an address as the end of the range, you must only enter the offset. The segment specified, or defaulted to, in the start address of the range is assumed.

Example **1** Enter **MCS:100,110,CS:500 <CR>** or
 MCS:100L11,CS:500 <CR>.

2 The 17 bytes starting at location CS:100 are copied to the 17 bytes starting at location CS:500.

N (NAME)

Provides file names for the Load and Write commands or file name parameters for the program to be debugged.

Syntax N filespec[,filespec...]

filespec the file specifier of a file to be loaded into memory, written to diskette, or used as a file name parameter to the file currently in memory.

Comments The Name command can be used to provide:

the name of the disk file to be loaded into memory by a subsequent Load command

the name to be assigned to the file currently in memory when the file is subsequently written to disk

file name parameters to the file in memory to be debugged.

The first case enables you to specify the file you wish to debug after entering the DEBUG environment. That is, you can enter DEBUG without specifying parameters, then use the Name command to name the disk file you wish to debug, then load the file into memory using the Load command. This has the same effect as entering the file name as the first parameter to the DEBUG command upon invocation. In either case the file control block for the file to be debugged is set up at location CS:5C and the file is loaded.

In the second case, the file is already in memory and the Name command sets up the file control block for the specified file name at location CS:5C. When a Write command is subsequently entered the file in memory is written to disk with the file name whose file control block is set up at location CS:5C.

In the third case, the Name command provides file name parameters for the program currently in memory. Whatever file control block was set at CS:5C is replaced by that of the first such parameter. If a second file parameter is specified, its file control block is set up at location CS:6C. Only two file control blocks are set up, although additional file name parameters may be included if required. All the specified — including any delimiters and switches that may have been typed — are placed in a save area at CS:81, with CS:80 containing a character count. Parameters specified in this way are analogous to file names specified in the argument list to the DEBUG command.

Examples 1 Enter **DEBUG <CR>**
Nb:file.com <CR>
L <CR>.

The system enters the DEBUG environment and FILE.COM resident on drive B has its file control block set up at location CS:5C. The Load command subsequently loads this file into memory.

This sequence has the same effect as entering
"DEBUG b:file.com"

-
- 2** Enter `Nb:newfile.com <CR>`
`W <CR>`

The file control block is set up at location CS:5C for the file specifier “b:newfile.com”. The subsequent Write command writes the file currently in memory to drive B and names the file “newfile.com”.

- 3** Enter `DEBUG b:file1.com <CR>`
`Nfile2.dat,file3.dat <CR>`
`G <CR>`

The DEBUG command loads the file named “file1.com” from drive B to be debugged. The Name command sets up two file control blocks at locations CS:5C and CS:6C for the file specifiers b:file2.dat and b:file3.dat, respectively. These files then become parameters to file1.COM when the subsequent GO command executes file1.COM. Therefore, the file is executed as if the following command line had been typed:

`b:file1 file2.dat file3.dat`

O (OUTPUT)

Sends a specified byte to an output port.

Syntax O value,byte

value the address of the output port. It must be specified in hexadecimal and can be up to 16 bits.

byte a two-digit hexadecimal value to be sent to the specified port.

Example 1 01E, 27 <CR>

2 the byte value 27H is output to the port 1EH.

Q (QUIT)

Terminates the DEBUG program.

Syntax Q

Comments The Quit command terminates the debugger without saving the file you are working on. Control is returned to MS-DOS command mode.

R (REGISTER)

Displays the contents of the registers and flag settings, or displays the contents of a specified register with the option to change that value, or displays the flag settings with the option of reversing any number of those settings.

Syntax **R [register-name pipe: F]**

register-name any valid register name whose contents are to be examined and optionally changed. This may be one of:

```
AX  DX  SI  ES  IP
BX  SP  DI  SS  PC
CX  BP  DS  CS
```

Note: IP and PC both refer to the Instruction Pointer.

F the flag settings are to be displayed and optionally changed.

Comments If you enter R without parameters, then the contents of all registers are displayed along with the flag settings and the next instruction to be executed. For Example:

```
AX=058D BX=0000 CS=0000 DX=0000
SP=FFFO BP=0000 SI=0000 DI=0000 DS=058D
ES=058D CS=058D IP=013B
NV UP EI PL NZ NA PO NC
058D:013B 83D8     MOV DS,AX
```

If you enter R with a register name, then DEBUG displays the contents of that register. The command then waits for you to do one of the following:

-
- press <CR> to terminate the Register command without changing the value of the displayed register.
 - change the value of the register by entering the four-digit hexadecimal value, then terminate the Register command by entering <CR>.

The valid flag values are shown in the following table:

Flag Name	Set	Clear
Overflow	OV (yes)	NV (no)
Direction	DN (decrement)	UP (increment)
Interrupt	EI (enabled)	DI (disabled)
Sign	NG (negative)	PL (plus)
Zero	ZR (yes)	NZ (no)
Auxiliary	AC (yes)	NA (no)
Carry		
Parity	PE (even)	PO (odd)
Carry	CY (yes)	NC (no)

If you enter RF, then the current flag settings are displayed. You can then either

- press <CR> to terminate the Register command without changing the flag values, or
- change the setting of one or more flags by entering the alternate value of the appropriate flags. The new values may be entered in any order, with or without delimiters.

- Example 1** Enter **R** <CR>.
- 2** DEBUG displays the contents of all registers, flag settings and the next instruction to be executed.
- 3** Enter **RIP** <CR>.
- 4** DEBUG displays the contents of the Instruction Pointer. For example:
- IP 0139
:-
- 5** Enter **0138** <CR>.
- 6** the contents of the Instruction Pointer are changed to 0138.
- 7** Enter **RF** <CR>.
- 8** DEBUG displays the flag settings. For example:
- NV UP EI PL NZ NA PO NC -
- 9** Enter **PE ZR DI NG** <CR>.
- 10** The Parity flag is set to even (PE), the Zero flag is set (ZR), the Interrupt flag is cleared (DI), and the Sign flag is set (NG).
- 11** Enter **RF** <CR>.
- 12** DEBUG displays the new state of the flags
- NV UP DI NG ZR NA PE NC-

S (SEARCH)

Searches a specified range for a list of bytes.

Syntax **S** range,list

range the range of addresses within which the search is to be made. If you only enter the offset, the segment indicated by the DS register is assumed.

list the list of one or more bytes to be searched for. Bytes in the list must be separated by a space or a comma.

Comments For each occurrence of the list of bytes within the specified range, DEBUG returns the address of the first byte. If no address is returned, no match was found.

Example **1** Enter **S100L100,20 <CR>** or
 S100,1FF,20 <CR>.

2 DEBUG displays the address of every occurrence of byte value 20 in the address range 100 to 1FF, inclusive, for example:

```
058D: 010C
058D: 0110
058D: 0115
058D: 0118
058D: 0120
058D: 0128
058D: 01CE
```

T (TRACE)

Executes one or more instructions and displays the register contents, flag settings and the next instruction to be executed.

Syntax **T [=address][,value]**

= address DEBUG is to commence execution at this address.

value the number of instructions to be executed.

Comments If the =address parameter is not specified, execution begins at CS:IP.

If the value parameter is not specified, only one instruction is executed.

The display generated is of the same format as that of the Register command (without parameters).

Example 1 Enter **T = 200,5 <CR>**.

2 Five instructions, starting with the one at location CS:200, are executed, and the register and flag values following each instruction are displayed along with the next instruction to be executed.

3 Enter **T <CR>**.

4 The instruction pointed to by CS:IP is executed and the register and flag contents are displayed along with the next instruction to be executed.

U (UNASSEMBLE)

Disassembles strings of bytes in memory and displays them as assembler-like statements along with their corresponding addresses.

Syntax U [range]
 or
 U [address]

range the range of addresses whose byte values are to be disassembled. If you do not specify the segment, then the segment indicated by the CS register is assumed.

address the start of a 32 byte area of memory to be disassembled. If you only enter an offset, then the segment indicated by the CS register is assumed.

- Comments**
- If neither the range nor address parameter is specified, then 32 bytes are disassembled starting at location CS:IP. If the Unassemble command is given more than once, each subsequent invocation starts at the address following the last disassembled location.
 - The number of bytes disassembled may be slightly more than the number you specified. This is because instructions are not always the same length and the final address in a range will not always contain the last byte of an instruction.
 - The first address of a range, or the address parameter, must always refer to the first byte of an 8086 instruction, otherwise results are unpredictable.

Example 1 Enter U058D:204L8 <CR>.

2 Eight bytes starting at location 058D:204 are disassembled and the result displayed:

```
058D:0204 8D16DF0D LEA  DX,[ODDF]
058D:0208 42          INC  DX
058D:0209 03D0          ADD  DX,AX
058D:020B 8916E50B     MOV  [0BE5],DX
```

W (WRITE)

Writes the file being debugged to disk.

Syntax

W [address[,drive,block,count]]

address

the start address of the code in memory that is to be written to disk. If you enter only an offset, then the segment indicated in the CS register is assumed.

drive

the drive containing the specified blocks to which code in memory is to be written. For drive A you must enter 0, for drive B you must enter 1, etc.

block

the block number on disk that is the first of a contiguous range of blocks to be overwritten with code from memory.

count

the number of disk blocks to be overwritten with code from memory.

Comments

- If you enter the WRITE command without parameters, then the file is written to disk starting from memory address CS:100. If you specify the address parameter, then the file in memory, starting from the specified address, is written to disk.
- In either case, before executing the WRITE command, BX:CX must be set to the number of bytes to be written if the count parameter is not included. This value was set up correctly when the file was loaded (either by the Load command or the DEBUG command itself). However, if, since loading the file, you have executed a GO or

TRACE command, then the value of BX:CX will have been changed. Be sure this value is set up correctly.

- When the WRITE command writes a file to disk, it obtains the drive specifier and file name via the file control block set up at CS:5C. If no drive specifier is set up, then the default is assumed. This file control block is set up either by the DEBUG command (for the file you specify as a parameter to DEBUG) or by a subsequent NAME command. If it does not indicate the file specifier you require, you must set up this file control block using the NAME command. Refer to “Memory Maps, Control Blocks, and Diskette Allocation” for further details.
- When the file is written to disk it overwrites the version currently on disk unless the specified file name does not exist, in which case a new file is created.
- If all parameters are specified, then the code in memory is written to the drive specified by the parameter. The data to be written starts at the memory location specified by the address parameter, and is written to the blocks on the disk specified by the block and count parameters. Be extremely careful to correctly specify the blocks, since information stored there previously will be destroyed by this operation.

Examples 1 Enter W <CR>.

The file in memory, starting from location CS:100, is written to disk with the file specifier defined by the file control block set up at location CS:5C. The number of bytes written is given by BX:CX.

2 Enter `W200 <CR>`.

The file in memory, starting from location CS:200, is written to disk with the file specifier defined by the file control block set up at location CS:5C. The number of bytes written is given by BX:CX.

3 Enter `W200,1,1F,20 <CR>`.

Blocks 1F through 3F on drive B are overwritten with the data starting at memory location CS:200.

DEBUG ERROR MESSAGES

- BF** **Bad Flag**
You attempted to alter a flag, but entered some characters that are not acceptable pairs of flag values. See R (Register) command for the list of acceptable flag entries.
- BP** **Too many Breakpoints**
You specified more than ten breakpoints as parameters to the GO command. Reenter the command with ten or fewer breakpoints.
- BR** **Bad Register**
You entered the R command with an invalid register name.
- DF** **Double Flag**
You entered two values for one flag.

4

8086 Addressing Scheme

- Overview
- The 20-Bit Address
- Aligned and Non-Aligned Words
- Registers and Flags
- Code, Data, and Stack Segments
- Addressing Modes

Overview

The 8086 microprocessor has an extremely flexible addressing scheme. The 8086 uses a 16-bit word, but can address a megabyte of memory. The 8086 supports seven different addressing modes.

To take advantage of the flexibility of the 8086, so that you can write assembly language code and navigate through programs while debugging, study the addressing scheme by carefully reading this chapter.

The 20-Bit Address

The AT&T Personal Computer 6300 utilizes the full address space that is available due to the design of the 8086 microprocessor. The addresses are 20 bits long, so the address space is two to the twentieth power, 1024K, or one megabyte.

The 8086 has a 16-bit word. To convert 16-bit words to a 20-bit address, the 8086 uses “segmented addressing.” A 20-bit address is created by using values from two separate registers. Two 16-bit numbers are used.

The binary representation of the first number is considered to have four binary zeroes tacked on to its end. This effectively multiplies the number by 16. This value is known as the segment portion of the address. The segment portion can point to any 16-byte segment of memory in the megabyte address space. However, with four zeroes as its least significant bits, it cannot “zero in” on individual bytes. The segment register’s function is just to point to a 16-byte boundary (also known as a paragraph boundary).

Once a segment is located, the other register comes into play. This “offset register” points to the relative part of the address. The 16 bits that comprise the offset register point to an individual byte which is relative to the start of the segment.

The 8086 locates a particular address by:

- 1** Shifting the segment register to the left by four bits
- 2** Adding the contents of the offset register

The 20-bit address is conventionally expressed in special notation:

Syntax

<segment register><offset register>

Example

009F:0012

Segment address	009F0
+ Relative address	0012
<hr/>	
= Actual Address	00A02

Aligned and Non-Aligned Words

The instructions for the 8086 are made up of from one to six bytes. Instructions can start at either an even or odd address. The 8086 is capable of accessing two bytes of data in memory in a single memory cycle. When the CPU accesses a word (16 bits) located at an even address, it is accessing an “aligned” word. The word is aligned because both bytes are located at the same word address and can be accessed in a single memory cycle.

When the CPU accesses a word starting at an odd address, it is accessing a “non-aligned” word. Since the two bytes comprising the word do not occupy the same word address, two memory cycles are required to read the entire word.

The importance of aligned or non-aligned words is determined by the importance of execution speed in your application. It is good programming practice to store data starting at an even address. If your program accesses or manipulates many word quantities, this will help speed program execution. If you are writing a device driver and instruction cycle times affect the execution of your program, the impact of aligned and non-aligned words should be taken into consideration.

Registers and Flags

General Registers

There are two main groups of general registers used by the 8086: the data group and the pointer and index group. Each register is 16 bits wide.

- The data registers are AX, BX, CX, and DX. Each can be used as a single 16-bit register or as two 8-bit registers. When they are used as two 8-bit registers, they are divided into an upper(H) and lower(L) half and called AH, AL, BH, BL, CH, CL, DH, and DL.
- The pointer and index registers are 16-bit registers. They are named according to their functions: SP (stack pointer), BP (base pointer), SI (source index), and DI (destination index).

Segment Registers

There are four segment registers in the 8086. Each register is 16 bits and their names reflect their use:

- CS — Code Segment
Always defines the current code segment.
- DS — Data Segment
Usually defines the current data segment.
- SS — Stack Segment
Always defines the current stack segment.
- ES — Extra Segment
Can define an auxiliary data segment.

These registers are used in combination with other registers to form the 20-bit address. Each segment begins on a paragraph (16 byte) boundary. There are four “current” segments at any one time. The contents of each segment register is called the “segment base value”. The sections on “Code, Data, and Stack Segments” and “Addressing Modes” give details on how these registers are utilized.

Instruction Pointer

The instruction pointer (IP) is used in conjunction with the Code Segment register to point to the address of the next executable instruction. The IP is also a 16-bit register.

Flags

The 8086 has nine 1-bit status or condition flags that are used to indicate the condition of the result of an arithmetic or logical operation that has just occurred. Some of the assembly language instructions use these flags to conditionally change the execution path of a program.

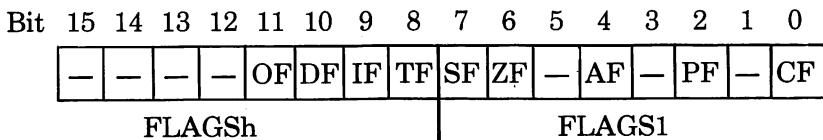
**Flag
Definitions**

- AF Auxiliary Carry Flag**
This flag is set (i.e., equal to 1) under two conditions:
- During addition there is a carry of the low nybble to the high nybble. (nybble = 4 bits)
- During subtraction there is a borrow from the low nybble to the high.
- CF Carry Flag**
This flag is set when there has been a carry or a borrow to the high-order bit of the (8- or 16-bit) result of an operation.
- OF Overflow Flag**
When this flag is set, an arithmetic overflow has occurred and a significant digit has been lost.
- SF Sign Flag**
This flag is set when the high-order bit of the result of an operation is a logical 1. Since negative binary numbers are represented using two's complement notation, SF reflects the sign of the result: 0 indicates a positive number and 1 indicates a negative number.
- PF Parity Flag**
If this flag is set, the result of the operation has an even number of ones in it. Use this flag to check for data transmission errors.
- ZF Zero Flag**
This flag is set when the result of an operation is zero.

**Flag
Definitions
(Cont'd)**

- TF** **Trap Flag**
When set, the trap flag puts the system into single-step mode for the purposes of debugging. An internal interrupt is generated after each instruction so that you can inspect your program one instruction at a time.
- IF** **Interrupt-enable Flag**
If this flag is set, external (maskable) interrupts are recognized by the 8086.
- DF** **Direction Flag**
This flag is set and cleared by the **STD** (Set Direction Flag) and **CLD** (Clear Direction Flag) instructions. If it has the value 1, **SI** and **DI** are decremented during string move operations. If it has the value of 0, **SI** and **DI** are incremented during string move operations. This flag is used for the following instructions: **MOVS**, **MOVSB**, **MOVSW**, **CMPS**, **CMPSB**, and **CMPSW**.

The flag register looks like this:



CPU
Registers

AX	AH	AL	accumulator
BX	BH	BL	base
CX	CH	CL	count
DX	DH	DL	data

SP	stack pointer
BP	base pointer
SI	source index
DI	destination index

IP	instruction pointer	
FLGSh	FLGS1	flags

CS	code segment
DS	data seg
ES	extra seg
SS	stack seg

Code, Data, and Stack Segments

When you invoke a program, MS-DOS loads all of its segments into memory on paragraph boundaries. The segment registers are set to point to these locations. The data, code, and stack segments aren't necessarily far apart in memory; they may, in fact, overlap. Each segment may be up to 64 KB in length.

Code Segment

Programs are limited to 64K of code, unless they change the value in the CS register. If a program changes the CS register, it may address up to 1024K of code.

The CS register is modified by the FAR CALL and FAR RETURN instructions. Use these instructions to execute code that is located outside the bounds of the current segment.

Data Segment

Most programs use a maximum of 64 KB of memory for data. This includes Pascal and compiled BASIC. Assembly language programs, however, can use additional memory for data by employing the Extra Segment.

Extra Segment

The extra segment may be used in any manner you wish but is often used for transferring large blocks of data quickly in memory or as a storage area for a second stack.

Stack Segment

Stacks are used for temporarily storing register contents and other important values under these conditions:

- Interrupts
- Inter-segment calls
- One program calls another

Addressing Modes

General Comments

The flexible architecture of the 8086 supports many different memory-addressing modes. These can be broken down into six main types of addressing: immediate, register, direct, register indirect, and two kinds of calculated addressing. The following section discusses these modes and concerns the nature of the operand.

Immediate Addressing

In the immediate addressing mode, the operand appears in the instruction. For example,

```
MOV AX,333
```

moves the constant value 333 into the AX register.

Register Addressing

The register addressing mode uses the contents of one of the registers as the operand for the instruction. The instruction can specify that either 8 bits or 16 bits are to be manipulated. For example:

```
MOV AX,BX ;moves 16 bits from BX to AX
```

```
MOV AL,BL ;moves 8 bits from BL to AL
```

**Direct
Addressing**

The direct addressing mode specifies a location in memory whose contents are used as the operand for the instruction. Example:

```
MOV CX,COUNT
```

This instruction uses the value found in the memory location designated by the symbol COUNT. Unless otherwise specified, COUNT is expected to be somewhere in the Data Segment. To specify that the operand is located in a segment other than the data segment, use the "segment override prefix:"

```
MOV CX,ES:COUNT
```

This syntax specifies that COUNT is located in the Extra Segment.

**Register
Indirect
Addressing**

With the register indirect addressing mode, the 16-bit offset address is contained in a base or index register. That is, the offset address resides in the BX, BP, SI, or DI register. Example:

```
MOV AX,[SI]
```

The 16-bit offset contained in the SI register is combined with the data segment register to compute the 20-bit address of the operand to move into register AX. Which segment register is used to compute the address depends on which instruction you are using (i.e., data segment or segment override for MOV, code segment for JMP or CALL, etc.).

Calculated Addressing Modes

The calculated addressing modes are like a combination of register indirect mode and direct addressing mode. There are two calculated addressing modes: single index and double index. In single index addressing, a 16-bit offset from the BX, BP, SI or DI register is added to an offset location in memory specified in the instruction. The combined value of these two items provides the offset into memory from which the operand is fetched. If the BP register is used the offset is from within the stack segment; otherwise the offset is from within the data segment. As always, use of a segment override prefix can change this. Examples:

```
MOV AX, COUNT[DI]
MOV AX, RECORD[BP]
```

In double index calculated addressing mode, values from two 16-bit registers are added to an optionally specified location in memory to produce the final offset. Either the BX or BP register is used for one of the register values, and the SI or DI register is used for the other one. If only two registers are given with no memory location, the memory location defaults to 0000 (start of segment). Once again, the default calculation is from the stack segment if the BP register is used; if BX is used the default is from the data segment. Examples:

```
MOV AX, COUNT[BX+SI]
MOV AX, RECORD[BP] [DI]
MOV AX, [BX] [DI]
```


5 Memory Maps Control Blocks Diskette Allocation

- **Overview**
- **The Address Space**
- **Low Memory Map**
- **ROM BIOS Data Area**
- **File Control Blocks**
- **ASCIIZ Strings**
- **Handles**
- **Diskette Layout**
- **Diskette Directory**
- **File Allocation Table**
- **Diskette Formats**

Overview

The purpose of this chapter is to enable you to locate items in memory or on diskette for the purposes of programming and debugging.

The first portion of the chapter contains detailed memory maps of the RAM and ROM memory areas. The sections on control blocks deal with program file formats and I/O data structures. The last part of this chapter describes how data is organized on the diskette.

The Address Space

Hex	Decimal	Contents
00000	0K	Interrupt vectors (see detail in low memory map)
04000	16K	DOS software
08000	32K	Language, applications programs and data
<p>Note: There is at least 98,000 hex or 608K of address space reserved for user programs and data. To take advantage of the full amount, you must have purchased and installed the physical memory.</p>		
<p>• • •</p>		
A0000	640K	Reserved for extended graphics
B0000	704K	Monochrome display buffer — Not used
B8000	736K	Color/graphics display buffer(s)
C8000	800K	Fixed disk adapter's ROM (Optional)
F0000	960K	Reserved for ROM expansion
FC000	1008K	ROM BIOS

Low Memory Map

Hexadecimal addresses are in segment:offset format.

Hex	Decimal	Contents
0:0000	0	Interrupt vectors 0 - 7 8259 interrupt controller vectors (8-F)
0:0040	64	BIOS interrupt vectors 10-1F
0:0080	128	
0:0100	256	
		MS-DOS interrupt vectors 20-3F
		Assignable interrupt vectors (40-FF)
		Note: These vectors may be assigned to non-Intel hardware and software products.
0:0400	1024	ROM BIOS data area (also called BIOS communications area) See map on next page.
0:0500	1280	DOS data area (also called DOS communications area)
0:0600	1536	

ROM BIOS Data Area

Hex addresses are in segment:offset format.

Hex	Decimal	Contents
0:0400	1024	Hardware environment parameters (printer and RS232C device addresses, memory size, etc.)
0:0417	1047	Keyboard buffer and status bytes
0:043E	1086	Floppy and hard disk status bytes
0:0449	1097	Video display area (current mode, color palette, cursor position, active page numbers, etc.)
0:0467	1127	Data area for option ROM and 8253 timer chip
0:0471	1137	Fixed disk, I/O timeouts, and more key- board status information
0:0488	1160	RESERVED
0:0500	1280	Inter-applications communications area

File Control Blocks

FCB
Format

The standard File Control Block (FCB) contains 37 bytes of file control information. The extended File Control Block is used to create or search for files in the disk directory that have special attributes. If the extended FCB is used, it adds a 7-byte prefix to the standard FCB.

Any of the DOS functions which employ FCBs may use either an FCB or an extended FCB. (See chapter 7 for a description of each DOS function call.)

If you are using an extended FCB, set the appropriate register to the first byte of the prefix, not to the first byte of the standard FCB, before executing the function call.

-7	FFH	Zeros		attri- bute	(1)
0	Drive	Filename (first 7 bytes) or Reserved Device Name			(2)
8	File- name (1 byte)	Filename extension	Current block	Record size	
10	(*) File size (low part)	(*) File size (high part)	(*) Date of last write	(*) Time of last write	
18	(*) Reserved for system use				
20	Current record	Random record no. (low part)	Random record no. (high part)		

- (1) FCB extension
- (2) Standard FCB

(*) Areas with an asterisk are filled by DOS and must not be modified. Other areas must be filled by the using program.

Offsets are in decimal.

Byte	Function
0	Drive number Before open: 0 — default drive 1 — drive A 2 — drive B etc. After open: 1 — drive A 2 — drive B etc. A 0 is replaced by the actual drive number when the file is opened.
1-8	Filename, left-justified, padded with trailing blanks. If a reserved device name is placed here (e.g., LPT1,) do not include the optional colon.
9-0B	Filename extension, left-justified, with trailing blanks (may be all blanks).
0C-0D	Current block number relative to the beginning of the file (starting at zero). A block is defined as a group of 128 records. This field is set to 0 when the file is opened. This field and the Current Record field (offset 20H) make up the record pointer that is used for sequential reads and writes.
0E-0F	Logical record size in bytes. Automatically set to 80H during open. If this is not correct, set it to the correct value.
10-13	File size in bytes. The first word of the field is the low-order part of the size.

Byte	Function
14-15	<p>Date the file was created or last updated. The bits correspond to the date as follows:</p> <pre> < 15 > < 14 > 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 y y y y y y y y m m m m d d d d d </pre> <p>yy = 0 - 119 (1980 to 2099) mm = 1 - 12 dd = 1 - 31</p>
16-17	<p>Time the file was created or last updated. The bits correspond to the time as follows:</p> <pre> < 17 > < 16 > 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 h h h h h m m m m m s s s s s </pre> <p>hh = 0 - 23 mm = 0 - 59 ss = 0 - 30 (number of 2-second increments)</p>
18-1F	Reserved for use by DOS.
20	Current relative record number (0-127) within the current block. Set this field before doing sequential read/write operations; it is not initialized by the Open File function call.
21-24	Relative record number; relative to the beginning of the file, starting with zero.

Byte	Function
	<p>This field is not initialized by the Open File function call and must be set before doing a random read or write. If the record size is less than 64 bytes, both words of the field are used; otherwise, only the first three bytes are used.</p> <p>Note: If you use the FCB at offset 5CH of the Program Segment Prefix, the last byte of the Relative Record field is the first byte of the unformatted parameter area that starts at offset 80H. This is the default Disk Transfer Address.</p>

**Extended
Control
Block**

Byte	Function
FCB-7	Contains hex FF to indicate this is extended FCB.
FCB-6 to FCB-2	Reserved
FCB-1	Attribute byte. 02 = Hidden file 04 = System file

ASCIIZ Strings

MS-DOS version 2.11 provides a set of new function calls for file I/O that are easier to use than the “traditional” calls that were used in past versions. These new calls do not utilize file control blocks. To open a diskette file, you simply provide information to identify the file in the form of an ASCIIZ string. DOS returns a numeric value, a “handle”, that you use to refer to the file once you have opened it.

The older function calls that require the use of file control blocks and do not utilize ASCIIZ strings and handles are supported in MS-DOS 2.11 to provide upward compatibility. Use the newer function calls whenever possible. See Chapter 7 for details of function calls.

ASCIIZ String Format

An ASCIIZ string, also known as a pathname string, has the following format: an optional drive specifier, followed by a directory path, and where applicable, a filename. The last byte must be binary zeroes. For example:

A:\LEVELA\LEVELB\FILEA

(followed by a byte of zeroes)

Either back slash (\) or forward slash (/) are valid path-separator characters.

Handles

Several of the new function calls that support files or devices use an identifier known as a “handle” (also known as a “token”). When you create or open a file or device with these function calls, a 16-bit value is returned in register AX. Use this handle to refer to the file after it has been opened.

The following handles are pre-defined by DOS for your use. You need not open them before using them:

0000	Standard input device
0001	Standard output device
0002	Standard error output device
0003	Standard auxiliary device
0004	Standard printer device

Note:

See your MS-DOS User's Guide for information on redirecting I/O for the first two handles.

Diskette Layout

The DOS area of the diskette is formatted as follows:

Reserved Area — variable size

First copy of file allocation table — variable size

Second copy of file allocation table — variable size

Root directory — variable size

File data area

Clusters

Space for a file in the data area is not preallocated. The space is allocated one “cluster” at a time. A cluster consists of one or more consecutive sectors; all of the clusters for a file are “chained” together in the File Allocation Table (FAT). On diskettes formatted by MS-DOS 2.11, there are two copies of the FAT kept, for consistency. Should the disk develop a bad sector in the middle of the first FAT, the second is used as a backup.

Diskette Directory

The **FORMAT** command builds the root directory for all disks. Its location on disk and the maximum number of entries are dependent on the media.

Since directories other than the root directory are regarded as files by MS-DOS, there is no limit to the number of files they may contain.

All directory entries are 32 bytes in length, and are in the following format (byte offsets are in hexadecimal):

Directory Format

- 0-7 Filename. Eight characters, left aligned and padded, if necessary, with blanks. If this is not currently a file directory entry, the first byte of this field indicates the status as follows:
- 00H The directory entry has never been used. This is used to mark the end of the allocated directory and limit the length of directory searches, for performance reasons.
 - 2EH The entry is for a directory (2EH is the ASCII code for the dot '.' character used to represent a directory). If the second byte is also 2EH (i.e., the entry is '..'), then the cluster field contains the cluster number of this directory's parent directory (0000H if the parent directory is the root directory). Otherwise, bytes 01H through 0AH are all spaces (i.e., the entry is '.') and the cluster field contains the cluster number of this directory.
 - E5H The file was used, but it has been erased.
- Any other character is the first character of a filename.

**Directory
Format
(cont'd)**

- 8-0A Filename extension.
- 0B File attribute. The attribute byte is mapped as follows (values are in hex):
- 01 File is marked read-only. An attempt to open the file for writing using the Open a File system call (Function Request 3DH) results in an error code being returned. This value can be used along with other values below. Attempts to delete the file with the Delete File system call (13H) or Delete a Directory Entry (41H) will also fail.
 - 02 Hidden file. The file is excluded from normal directory searches.
 - 04 System file. The file is excluded from normal directory searches.
 - 08 The entry contains the volume label in the first 11 bytes. The entry contains no other usable information (except date and time of creation), and may exist only in the root directory.
 - 10 The entry defines a sub-directory, and is excluded from normal directory searches.
 - 20 Archive bit. The bit is set to "on" whenever the file has been written to and closed. It is used by BACKUP and RESTORE commands for determining whether or not a file has changed since its last backup. The BACKUP command clears this attribute on all files backed up.

**Directory
Format
(cont'd)**

The system files (IO.SYS and MSDOS.SYS) are marked as read-only, hidden, and system files. Files can be marked hidden when they are created. Also, the read-only, hidden, system, and archive attributes may be changed through the Change Attributes system call (Function Request 43H).

0C-15 Reserved.

16-17 Time the file was created or last updated. The hour, minutes, and seconds are mapped into two bytes as follows:

Offset 17H

H	H	H	H	H	M	M	M
7	6	5	4	3	2	1	0

Offset 16H

M	M	M	S	S	S	S	S
7	6	5	4	3	2	1	0

H is the number of hours (0-23)

M is the number of minutes (0-59)

S is the number of two-second increments

The time is stored with the least significant bit first.

**Directory
Format
(cont'd)**

18-19 Date the file was created or last updated. The year, month, and day are mapped into two bytes as follows:

Offset 19H

Y	Y	Y	Y	Y	Y	Y	M
7	6	5	4	3	2	1	0

Offset 18H

M	M	M	D	D	D	D	D
7	6	5	4	3	2	1	0

Y is the number of years since 1980, 0-119 (1980-2099)

M is the month number 1-12

D is the day of the month 1-31

The date is stored with its least significant byte first.

1A-1B The cluster number of the first cluster in the file. The first cluster for data space on all disks is cluster 002.

The cluster number is stored with the least significant byte first.

Note:

Refer to "How to Use the File Allocation Table" for details on converting cluster numbers to logical sector numbers.

1C-1F File size in bytes. The first word of this four-byte field is the low-order part of the size.

File Allocation Table (FAT)

The following information is included primarily for system programmers who are writing installable device drivers. This section explains how MS-DOS uses the File Allocation Table to convert the clusters of a file to logical sector numbers. The driver program is then responsible for locating the logical sector on disk. If you are writing a system utility, use the MS-DOS file management function calls for accessing files; programs that access the FAT directly are not guaranteed to be upwardly-compatible with future releases of MS-DOS.

FAT Entries

The File Allocation Table is an array of 12-bit entries (1.5 bytes) for each cluster on the disk.

- The first two FAT entries map a portion of the directory; these FAT entries indicate the size and format of the disk.
- The second and third bytes currently always contain FFH.
- The third FAT entry, which starts at byte offset 4, begins the mapping of the data area (cluster 002). Files in the data area are not always written sequentially on the disk. The data area is allocated one cluster at a time, skipping over clusters already allocated. The first free cluster found will be the next cluster allocated, regardless of its physical location on the disk. This permits the most efficient utilization of disk space because clusters made available by erasing files can be allocated for new files.

Each FAT entry contains three hexadecimal characters:

- 000 If the cluster is unused and available.
- FF7 The cluster has a bad sector in it. MS-DOS will not allocate such a cluster. CHKDSK counts the number of bad clusters for its report. These bad clusters are not part of any allocation chain.
- FF8-FFF Indicates the last cluster of a file.
- XXX The cluster number of the next cluster in the file. The cluster number of the first cluster in the file is kept in the file's directory entry.

The File Allocation Table always begins on the first sector after the reserved sectors. If the FAT is larger than one sector, the sectors are contiguous. Two copies of the FAT are usually written for data integrity. The FAT is read into one of the MS-DOS buffers as needed (open, read, write, etc.). For performance reasons, this buffer is given a high priority so that it stays in memory as long as possible.

**How to Use
the File
Allocation
Table**

Use the directory entry to find the starting cluster of the file. Next, to locate each subsequent cluster of the file:

- 1** Multiply the cluster number just used by 1.5 (each FAT entry is 1.5 bytes long).
- 2** The whole part of the product is an offset into the FAT, pointing to the entry that maps the cluster just used. That entry contains the cluster number of the next cluster of the file.
- 3** Use a MOV instruction to move the word at the calculated FAT offset into a register.
- 4** If the last cluster used was an even number, keep the low-order 12 bits of the register by ANDing it with FFF; otherwise, keep the high-order 12 bits by shifting the register right 4 bits with a SHR instruction.
- 5** If the resultant 12 bits are FF8H-FFFH, the file contains no more clusters. Otherwise, the 12 bits contain the cluster number of the next cluster in the file.

To convert the cluster to a logical sector number (relative sector, such as that used by Interrupts 25H and 26H and by DEBUG):

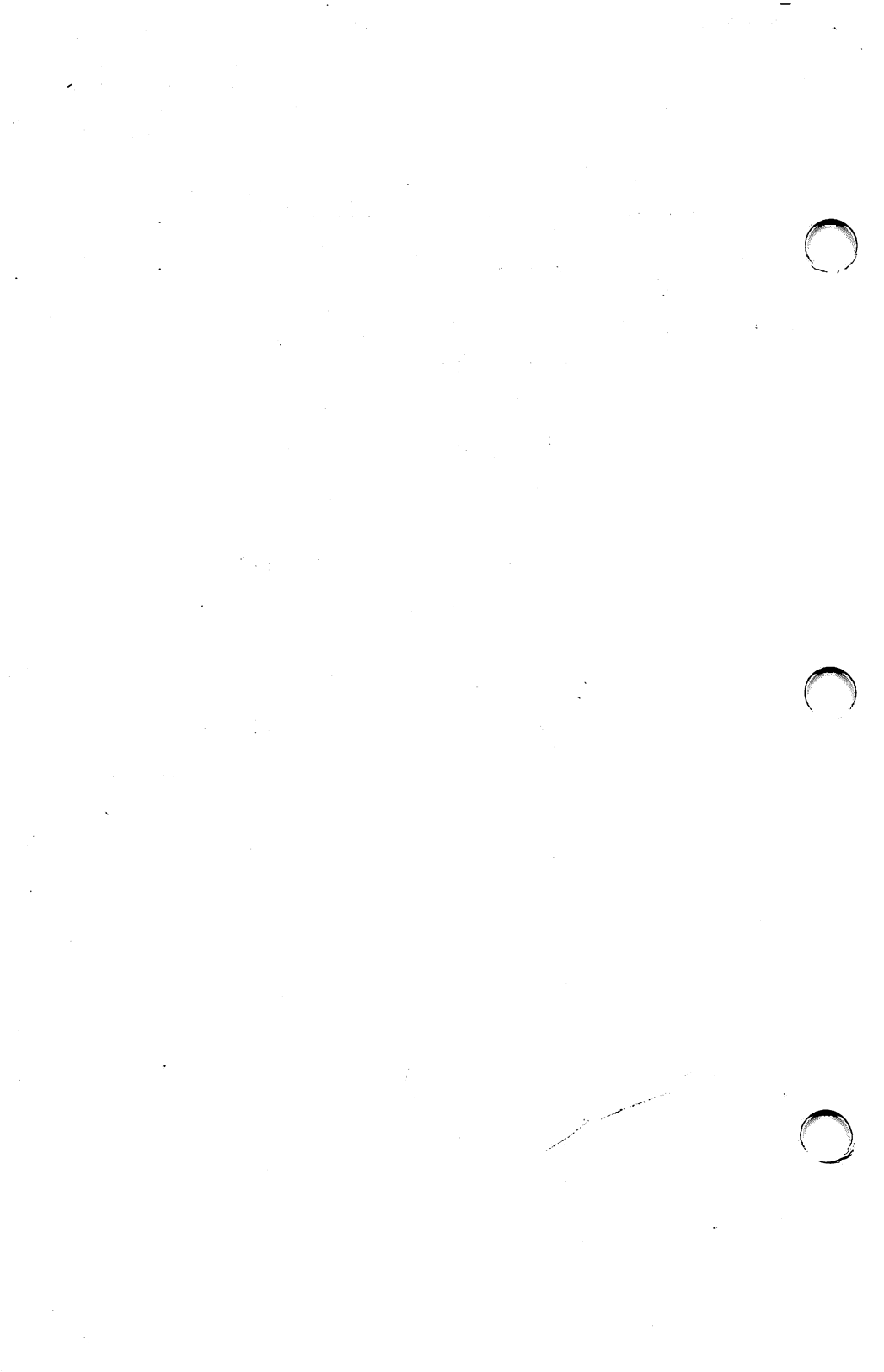
- 1** Subtract 2 from the cluster number.
- 2** Multiply the result by the number of sectors per cluster.
- 3** Add to this result the logical sector number of the beginning of the data area.

Diskette Formats

On an MS-DOS disk, the clusters are arranged on diskette to minimize head movement for multi-sided media. All of the space on a track (or cylinder) is allocated before moving on to the next track. This is accomplished by using the sequential sectors on the lowest-numbered head, then all the sectors on the next head, and so on until all sectors on all heads of the track are used. The next sector to be used will be sector 1 on head 0 of the next track.

The first byte of the FAT, called the Media Descriptor Byte, can sometimes be used to determine the format of the disk. The following formats have been defined for the AT&T Personal Computer 6300, based on values of the first byte of the FAT.

MS-DOS Standard Diskette Formats	No. sides	1	1	2	2
	Tracks/side	40	40	40	40
	Bytes/sector	512	512	512	512
	Sectors/track	8	9	8	9
	Sectors/cluster	1	1	2	2
	Reserved sectors	1	1	1	1
	No. FATs	2	2	2	2
	Root directory entries	64	64	112	112
	No. sectors	320	360	640	720
	Media Descriptor Byte	FE	FC	FF	FD
	Sectors for 1 FAT	1	2	1	2



6

Program Structure and Loading

- **Overview**
- **Pros and Cons for Selecting a Program File Format**
- **EXE2BIN**
- **File Header Format**
- **Relocation Process for .EXE Files**
- **Program Segment Prefix**
- **Program Loading Process**

Overview

This chapter describes the MS-DOS program file formats and procedures for loading them into memory. MS-DOS supports two main program file formats: .EXE and .COM.

The .EXE format is the more flexible program type. An .EXE file is limited in size only by the amount of user memory installed in your system.

Programs linked by MS-LINK are output in .EXE format. .EXE files can be executed either by COMMAND.COM or by an EXEC system call (Function Request 4BH) in your program.

A .COM program file cannot exceed 64K bytes in length. However, because it does not have the same lengthy header that an .EXE file does, a .COM file takes up less diskette storage space and loads into memory more quickly than an .EXE file.

After assembling and linking your program, it must be converted to .COM format. The easiest way to do this is with the EXE2BIN utility provided on your MS-DOS Supplemental Programs diskette.

Pros and Cons for Selecting a Program File Format

This section is concerned with the pros and cons of selecting between a .EXE program format and the .COM program type.

PROS for .EXE

- Can be larger than 64 K
- Can cross segment boundaries
- Can run .EXE immediately after linking, i.e., you need not take the extra step of running EXE2BIN
- Can declare a stack segment in the assembly program

CONS for .EXE

- Disk file has large “header” containing relocation information. .EXE therefore takes more space on disk and takes longer to load into memory at execution time.

PRO for .COM

- .COM files are smaller and faster loading because .COM does not have a file header containing relocation information.

CONS for .COM

- .COM files can be no larger than one 64K segment.
- .COM is segment-relocatable; the segment can be relocated at run time. However, all of the addresses in the program must be relative to the same segment address.

EXE2BIN

EXE2BIN

EXE2BIN is an executable program available on your MS-DOS system diskette. It converts programs that are in .EXE format (as they are after having been linked) into the .COM format.

EXE2BIN can generate two types of .COM files: relocatable and non-relocatable.

Syntax EXE2BIN <input filename> <output file
 name>

Both file names are in the form:

[d:][path][filename[.ext]]

Example EXE2BIN B:PROG.EXE B:PROG.COM

Discussion In specifying the input file, everything except
the file name is optional. If you do not specify a
drive, the default is used. If you do not specify a
path, the default path is used. If you do not spec-
ify an extension, the default is .EXE. The input
file is converted to .COM file format (memory
image of the program) and placed in the output
file.

You are not required to enter any part of the
output file specification. If you do not specify a
drive, the drive of the input file will be used. If
you do not specify an output path or filename,
the input path or filename will be used. If you do
not specify a filename extension in the output
filename, the new file will be given an extension
of .BIN.

The input file must be in valid .EXE format pro-
duced by the linker. The resident, or actual code
and data part of the file must be less than 64K.
There must be no STACK segment.

Two kinds of conversions are possible, depending on the initial CS:IP (Code Segment: Instruction Pointer) specified in the .EXE file:

- 1** If CS:IP is specified as 0000:100H, it is assumed that the file is to be run as a .COM file with the location pointer set at 100H by the assembler statement ORG; the first 100H bytes of the file are deleted. No segment address fixups (that is, instructions that contain a reference to an absolute segment address) are allowed, as .COM files must be segment relocatable. Once the conversion is complete, rename the resulting file with a .COM extension. The command processor can load and execute the program in the same way as the .COM programs supplied on your MS-DOS diskettes.
- 2** If CS:IP is not specified in the .EXE file, a pure binary conversion is assumed. If segment fixups are necessary (i.e., the program contains instructions requiring a segment address), you are prompted for the fixup value. This value is the absolute segment at which the program is to be loaded. The resulting program is usable only when loaded at the absolute memory address specified by your application. The command processor is not capable of properly loading the program. This is the case when writing a .BIN program to use in an application such as a device driver that is always loaded at the same absolute address.

EXE2BIN Messages

Amount read less than size in header

The program portion of the file was smaller than indicated in the file's header. You should reassemble and relink your program.

File cannot be converted

CS:IP does not meet either of the criteria specified above, or it meets the .COM file criterion but has segment fixups. This message is also displayed if the file is not a valid executable file.

File creation error

EXE2BIN cannot create the output file. Run CHKDSK to determine if the directory is full or if some other condition caused the error.

File not found

The file is not on the diskette specified.

Fixups needed - base segment (hex):

The source (.EXE) file contained information indicating that a load segment is required for the file. Specify the absolute segment address at which the finished module is to be located.

Insufficient disk space

There is not enough disk space to create a new file.

Insufficient memory

There is not enough memory to run EXE2BIN.

WARNING - Read error in EXE file

Amount read less than size in header. This is a warning message only. However, it is usually a good idea to reassemble and relink your source program when this message appears.

File Header Format

The .EXE files produced by MS-LINK consist of two parts:

- Control and relocation information
- The load module

The control and relocation information is at the beginning of the file in an area called the header. The load module immediately follows the header.

Note:

.COM files do not have file headers.

The header is formatted as follows (offsets are in hexadecimal):

Offset	Contents
00-01	Must contain 4DH, 5AH.
02-03	Number of bytes contained in last page; used for reading overlays.
04-05	Size of the file in 512-byte pages, including the header.
06-07	Number of relocation entries in table.
08-09	Size of the header in 16-byte paragraphs. This is used to locate the beginning of the load module in the file.
0A-0B	Minimum number of 16-byte paragraphs required above the end of the loaded program (minalloc).
0C-0D	Maximum number of 16-byte paragraphs required above the end of the loaded program (maxalloc). If both minalloc and maxalloc are 0, then the program will be loaded as high as possible.

- 0E-0F Initial value to be loaded into stack segment before starting program execution. This must be adjusted by relocation.
- 10-11 Value to be loaded into the SP register before starting program execution.
- 12-13 Negative sum of all the words in the file.
- 14-15 Initial value to be loaded into the IP register before starting program execution.
- 16-17 Initial value to be loaded into the CS register before starting program execution. This must be adjusted by relocation.
- 18-19 Relative byte offset from beginning of run file to relocation table.
- 1A-1B The number of the overlays generated by MS-LINK.

This is followed by the relocation table. The table consists of a variable number of relocation items. Each relocation item contains two fields: a two-byte offset value, followed by a two-byte segment value. These two fields contain the offset into the load module of a word which requires modification before the module is given control.

Relocation Process for .EXE Files

The following steps describe the relocation process:

- 1** The formatted part of the header is read into memory. Its size is 1BH.
- 2** A portion of memory is allocated depending on the size of the load module and the allocation numbers (0A-0B and 0C-0D). MS-DOS attempts to allocate FFFFH paragraphs. This will always fail, returning the size of the largest free block. If this block is smaller than minalloc and loadsize, then there will be a no memory error. If this block is larger than maxalloc and loadsize, MS-DOS will allocate (maxalloc + loadsize). Otherwise, MS-DOS will allocate the largest free block of memory.
- 3** A Program Segment Prefix is built in the lowest part of the allocated memory.
- 4** The load module size is calculated by subtracting the header size from the file size. Offsets 04-05 and 08-09 can be used for this calculation. The actual size is downward-adjusted based on the contents of offsets 02-03. Based on the setting of the high/low loader switch, an appropriate segment is determined at which to load the load module. This segment is called the start segment.

- 5** The load module is read into memory beginning with the start segment.
- 6** The relocation table items are read into a work area.
- 7** Each relocation table item segment value is added to the start segment value. This calculated segment, plus the relocation item offset value, points to a word in the load module to which is added the start segment value. The result is placed back into the word in the load module.
- 8** Once all relocation items have been processed, the SS and SP registers are set from the values in the header. Then, the start segment value is added to SS. The ES and DS registers are set to the segment address of the Program Segment Prefix. The start segment value is added to the header CS register value. The result, along with the header IP value, is the initial CS:IP to transfer to before starting execution of the program.

Program Segment Prefix

Unless you specify otherwise when linking your program, DOS loads your program in the lowest memory address available, immediately following the DOS code. This occurs whether the program loads as a result of your entering its name at the DOS prompt or through your use of the EXEC (4BH) function call. The area into which your program is loaded is called the Program Segment.

DOS requires control information for each running program: it builds a Program Segment Prefix and places it at offset 0 within the program segment. The Program Segment Prefix is hex 100 bytes long, so your program is loaded at relative address 100H.

PSP Format

HEX 0

8	INT 20H	End of alloc. block	Reserved	Length of program segment, in bytes
10		Terminate address (IP,CS)		CTRL-C exit address(IP)
10	CTRL-C exit address(CS)	Hard error exit address (IP,CS)		
	Used by DOS			
	2CH			
	5CH			
50	Function dispatch call			
	Formatted Parameter Area 1 formatted as standard unopened FCB			
	6CH			
	Formatted Parameter Area 2 formatted as standard unopened FCB (overlaid if FCB at 5CH is opened)			
80	Unformatted Parameter Area (default Disk Transfer Area)			
100				

HEX OFFSET	CONTENTS	
0	Return address used by interrupt hex 20	
2	Segment address of allocatable memory following this program (If this program calls a memory management function to get more memory, this is its starting address.)	
4	Reserved	
6	Number of bytes in this program segment (2 byte value)	
8	Not used	
A	Terminate address : IP	
C	Terminate address : CS	
E	Ctrl break exit : IP	
10	Ctrl break exit : CS	
12	Critical error exit : IP	
14	Critical error exit : CS	
2C	Segment address of the environment	USED by DOS
50	Code to call function dispatcher for DOS (INT 21H) interrupts	
5C	Formatted parameter area 1: formatted as standard, unopened FCB	
6C	Formatted parameter area 2: formatted as standard, unopened FCB	
80	Count of argument characters that follow the command name.	These comprise the default DTA: Disk Transfer Area(80H - FFH)
81	The argument characters themselves.	

Program Loading Process

PSP Conditions upon Program Initiation

When a program receives control, the following conditions are in effect:

- The segment address of the passed environment is contained at offset 2CH in the Program Segment Prefix. The environment is a series of ASCII strings (totaling less than 32K) in the form:

NAME = parameter

Each string is terminated by a byte of zeros, and the set of strings is terminated by another byte of zeros. The environment built by the command processor contains at least a COMSPEC= string (the parameters on COMSPEC define the path used by MS-DOS to locate COMMAND.COM on disk). The last PATH and PROMPT commands issued will also be in the environment, along with any environment strings defined with the MS-DOS SET command.

The environment that is passed is a copy of the invoking process environment. If your application uses a “keep process” concept, be aware that the copy of the environment passed to you is static. That is, it will not change even if subsequent SET, PATH, or PROMPT commands are issued.

- Offset 50H in the Program Segment Prefix contains code to call the MS-DOS function dispatcher. After correctly loading the registers, a program can issue a far call to offset 50H to invoke an MS-DOS function, rather than issuing an Interrupt 21H. Since this is a call and not an interrupt, MS-DOS may place any code appropriate to making a system call at this position. This makes the process of calling the system portable.
- The Disk Transfer Address (DTA) is set to 80H (default DTA in the Program Segment Prefix).
- File control blocks at 5CH and 6CH are formatted from the first two parameters typed when the command was entered. If either parameter contains a pathname, then the corresponding FCB contains only the valid drive number. The filename field will not be valid.
- An unformatted parameter area at 81H contains all the characters typed after the command (including leading and imbedded delimiters), with the byte at 80H set to the number of characters. If the < or > parameters were typed on the command line, they (and the filenames associated with them) do not appear in this area or in the character count; redirection of standard input and output is transparent to applications.
- Offset 6 (one word) contains the number of bytes available in the segment.

- Register AX indicates whether or not the drive specifiers (entered with the first two parameters) are valid, as follows:

AL=FF if the first parameter contained an invalid drive specifier (otherwise **AL=00**)

AH=FF if the second parameter contained an invalid drive specifier (otherwise **AH=00**)

- Offset 2 (one word) contains the segment address of the first byte of unavailable memory. Programs must not modify addresses beyond this point unless they were obtained by allocating memory via the Allocate Memory system call (Function Request 48H).

**Initial
Conditions
for .EXE
Programs**

- DS and ES registers are set to point to the Program Segment Prefix.
- CS, IP, SS, and SP registers are set to the values passed by MS-LINK.

**Initial
Conditions
for .COM
Programs**

- All four segment registers contain the segment address of the initial allocation block that starts with the Program Segment Prefix control block.
- The Instruction Pointer (IP) is set to 100H.
- The Stack Pointer register is set to the end of the program's segment. The segment size at offset 6 is reduced by 100H to allow for a stack of that size.
- A word of zeros is placed on top of the stack. This allows your program to exit to COM-MAND.COM by doing a RET instruction last. Make sure, however, to maintain your stack and code segments.

Other Uses of the Program Segment Prefix In MS-DOS versions prior to 2.0, the PSP contained the mechanism for program termination. One of these four techniques had to be used to terminate your programs:

- 1** A long jump to offset 0 in the Program Segment Prefix.
- 2** By issuing an INT 20H with CS:0 pointing at the PSP.
- 3** By issuing an INT 21H with register AH = 0 and CS:0 pointing at the PSP.
- 4** By a long call to location 50H in the Program Segment Prefix with AH = 0 and CS:0 pointing at the PSP.

It is the responsibility of all programs to ensure that the CS register contains the segment address of the Program Segment Prefix when terminating via any of these methods.

However, with the 2.0 Terminate a Process system call (Function Request 4CH), the CS register need not point to the Program Segment Prefix. For this reason, Function Request 4CH is the preferred method. It may be invoked by loading the AH register with 4CH and issuing an INT 21H (or a long call to offset 50H in the Program Segment Prefix).

7

System Calls

- **Quick Reference: Functions and Interrupts**
- **Overview**
- **Programming Considerations**
- **Interrupts**
- **Functions**
- **System Call Descriptions**

Functions

Number	Function Name	Number	Function Name
00H	Terminate Program	30H	Get DOS Version Number
01H	Read Keyboard and Echo	31H	Keep Process
02H	Display Character	33H	<CTRL C> Check
03H	Auxiliary Input	35H	Get Interrupt Vector
04H	Auxiliary Output	36H	Get Disk Free Space
05H	Print Character	38H	Return Country-Dependent Info.
06H	Direct Console I/O	39H	Create Sub-Directory
07H	Direct Console Input	3AH	Remove a Directory
08H	Read Keyboard	3BH	Change the Current Directory
09H	Display String	3CH	Create a File
0AH	Buffered Keyboard Input	3DH	Open a File Handle
0BH	Check Keyboard Status	3EH	Close a File Handle
0CH	Flush Buffer, Read Keyboard	3FH	Read From File/Device
0DH	Disk Reset	40H	Write to a File/Device
0EH	Select Disk	41H	Delete a Directory Entry
0FH	Open File	42H	Move a File Pointer
10H	Close File	43H	Change Attributes
11H	Search for First Entry	44H	I/O Control for Devices
12H	Search for Next Entry	45H	Duplicate a File Handle
13H	Delete File	46H	Force a Duplicate of a Handle
14H	Sequential Read	47H	Return Name of Current Directory
15H	Sequential Write	48H	Allocate Memory
16H	Create File	49H	Free Allocated Memory
17H	Rename File	4AH	Modify Allocated Memory Blocks
19H	Current Disk	4BH	Load and Execute a Program (EXEC)
1AH	Set Disk Transfer Address	4CH	Terminate a Process
21H	Random Read	4DH	Retrieve the Return Code of a Child
22H	Random Write	4EH	Find Match File
23H	File Size	4FH	Step Through a Directory Matching Files
24H	Set Relative Record	54H	Return Current Setting of Verify
25H	Set Vector	56H	Move a Directory Entry
27H	Random Block Read	57H	Get/Set Date/Time of File
28H	Random Block Write		
29H	Parse File Name		
2AH	Get Date		
2BH	Set Date		
2CH	Get Time		
2DH	Set Time		
2EH	Set/Reset Verify Flag		
2FH	Get Disk Transfer Address		

Function Name	Number	Function Name	Number
Allocate Memory	48H	Modify Allocated	
Auxiliary Input	03H	Memory Blocks	4AH
Auxiliary Output	04H	Move a Directory Entry	56H
Buffered Keyboard		Move a File Pointer	42H
Input	0AH	Open a File Handle	3DH
Change Attributes	43H	Open File	0FH
Change the Current		Parse File Name	29H
Directory	3BH	Print Character	05H
Check Keyboard Status	0BH	Random Block Read	27H
Close a File Handle	3EH	Random Block Write	28H
Close File	10H	Random Read	21H
CTRL C Check	33H	Random Write	22H
Create a File	3CH	Read From File/Device	3FH
Create File	16H	Read Keyboard	08H
Create Sub-Directory	39H	Read Keyboard and	
Current Disk	19H	Echo	01H
Delete a Directory Entry	41H	Remove a Directory	3AH
Delete File	13H	Rename File	17H
Direct Console Input	07H	Retrieve the Return	
Direct Console I/O	06H	Code of a Child	4DH
Disk Reset	0DH	Return Current Setting	
Display Character	02H	of Verify	54H
Display String	09H	Return Country-	
Duplicate a File Handle	45H	Dependent Info.	38H
File Size	23H	Return Name of Current	
Find Match File	4EH	Directory	47H
Flush Buffer, Read		Search for First Entry	11H
Keyboard	0CH	Search for Next Entry	12H
Force a Duplicate of a		Select Disk	0EH
Handle	46H	Sequential Read	14H
Free Allocated Memory	49H	Sequential Write	15H
Get Date	2AH	Set Date	2BH
Get Disk Free Space	36H	Set Disk Transfer	
Get Disk Transfer		Address	1AH
Address	2FH	Set Relative Record	24H
Get DOS Version		Set Time	2DH
Number	30H	Set Vector	25H
Get Interrupt Vector	35H	Set/Reset Verify Flag	2EH
Get Time	2CH	Step Through a Di-	
Get/Set Date/Time of		rectory Matching	4FH
File	57H	Terminate a Process	4CH
I/O Control for Devices	44H	Terminate Program	00H
Keep Process	31H	Write to a File/Device	40H
Load and Execute a			
Program (EXEC)	4BH		

Interrupts

Interrupts (in Numerical Order)	Interrupt (Hex)	Interrupt (Decimal)	Description
	20H	32	Program Terminate
	21H	33	Function Request
	22H	34	Terminate Address
	23H	35	<CTRL C> Exit Address
	24H	36	Fatal Error Abort Address
	25H	37	Absolute Disk Read
	26H	38	Absolute Disk Write
	27H	39	Terminate But Stay Resident
	28-40H	40-64	RESERVED — DO NOT USE

Interrupts in Alphabetical Order	Description	Interrupt in Hex	Interrupt in Dec
	Absolute Disk Read	25H	37
	Absolute Disk Write	26H	38
	<CTRL C> Exit Address	23H	35
	Fatal Error Abort Address	24H	36
	Function Request	21H	33
	Program Terminate	20H	32
	RESERVED — DO NOT USE	28-40H	40-64
	Terminate Address	22H	34
	Terminate But Stay Resident	27H	39

Overview

System Calls are procedures used to interface with I/O or to manage memory. They can be accessed from utility programs written in assembly language, and from some high level languages. Their use frees the programmer from having to perform primitive functions, and makes it easier to write machine-independent programs.

MS-DOS provides two types of system calls: interrupts and function requests. This chapter describes the environments from which these routines can be called, how to call them, and the processing performed by each.

Programming Considerations

System calls can be invoked from Assembly Language, from GW BASIC, or from high-level languages like PASCAL and FORTRAN. This section describes the techniques for invoking calls and for returning control to MS-DOS.

**Calling from
Assembly
Language**

The system calls can be invoked from Assembly Language simply by moving any required data into registers and issuing an interrupt. Some of the calls destroy registers, so you may have to save registers before using a system call.

**Calling from
GW BASIC**

The BLOAD and BSAVE commands are used for loading and saving machine language programs. These are then called, using the CALL statement.

The USR function calls an indicated machine language subroutine. The starting address of the subroutine must first be specified in a DEF USR statement.

Interrupts

MS-DOS reserves interrupts 20H through 3FH for its own use. The table of interrupt routine addresses (vectors) is maintained in locations 80H-FCH. User programs should only issue Interrupts 20H, 21H, 25H, 26H, and 27H. (Functions Requests 4CH and 31H are the preferred method for Interrupts 20H and 27H for versions of MS-DOS that are 2.0 and higher.

Interrupts 22H, 23H, and 24H are not interrupts that can be issued by user programs; they are simply locations where a segment and offset address are stored. For a discussion, see the section on Address Interrupts in this chapter.

Functions

Requirements Most of the MS-DOS function calls require input to be passed to them in registers. After setting the proper register values, the function may be invoked in one of the following ways:

- Place the function number in AH and execute a long call to offset 50H in your Program Segment Prefix. Note that programs using this method will not operate correctly on versions of MS-DOS that are lower than 2.0.
- Place the function number in AH and issue Interrupt 21H. All of the examples in this chapter use this method.
- An additional method exists for programs that were written with different calling conventions. This method should be avoided for all new programs. The function number is placed in the CL register and other registers are set according to the function specification. Then, an intrasegment call is made to location 5 in the current code segment. That location contains a long call to the MS-DOS function dispatcher. Register AX is always destroyed if this method is used; otherwise, it is the same as normal function calls. Note that this method is valid only for Function Requests 00H through 024H.

This chapter provides the following type of information for each DOS interrupt and function call:

- a description of the register contents required before the system call
- a description of the register contents after the system call
- a description of the processing performed
- an example of its use.

Registers

When MS-DOS takes control after a function call, it switches to an internal stack. Registers not used to return information (except AX) are preserved. The calling program's stack must be large enough to accommodate the interrupt system — at least 128 bytes in addition to other needs.

Note

The macro definitions and extended example for MS-DOS system calls 00H through 2EH can be found at the end of this chapter.

System Call Descriptions

Interrupts The following are not true interrupts but rather storage locations for a segment and offset address:

- Terminate Address (Interrupt 22H)
- **CTRL C** Exit Address (Interrupt 23H)
- Fatal Error Abort Address (Interrupt 24H)

The interrupts are issued by MS-DOS under the specified circumstance. You can change any of these addresses with Function Request 25H (Set Vector) if you prefer to write your own interrupt handlers.

Programming Examples A macro is defined for most system calls, then used in some examples. In addition, a few other macros are defined for use in the examples. The use of macros allows the examples to be more complete programs, rather than isolated uses of the system calls. All macro definitions are listed at the end of the chapter.

The examples are not intended to represent good programming practice. In particular, error checking and good human interface design have been sacrificed to conserve space. You may, however, find the macros a convenient way to include system calls in your assembly language programs.

A detailed description of each system call follows. They are listed in numeric order; the interrupts are described first, then the function requests.

Note Unless otherwise stated, all numbers in the system call descriptions, both text and code, are in hex.

20H Program Terminate

Call CS
Segment address of Program Segment Prefix

Return None

Remarks All open file handles are closed and the disk cache is cleaned. The current process is terminated and control returns to the parent process. This interrupt is almost always used in old .COM files for termination.

The CS register must contain the segment address of the Program Segment Prefix before you call this interrupt.

The following exit addresses are restored from the Program Segment Prefix:

Exit Address	Offset
Program Terminate	0AH
<CTRL C>	0EH
Critical Error	12H

All file buffers are flushed to disk.

20H Program Terminate

Note Close all files that have changed in length before issuing this interrupt. If a changed file is not closed, its length is not recorded correctly in the directory. See Functions 10H and 3EH for a description of the Close File system calls.

Interrupt 20H is provided for compatibility with versions of MS-DOS prior to 2.0. New programs should use Function Request 4CH, Terminate a Process.

Macro terminate macro
int 20H
endm

Example ;CS must be equal to PSP values given at program
;start
;(ES and DS values)
INT 20H
;There is no return from this interrupt

21H Function Request

Call	AH Function number Other registers as specified in individual function
Return	As specified in individual function
Remarks	The AH register must contain the number of the system function. See the following section on Function Requests, in this chapter, for a description of the MS-DOS system functions.
Note	No macro is defined for this interrupt, because all function request descriptions in this chapter that define a macro include Interrupt 21H.
Example	To call the Get Time function: <pre>mov ah,2CH ;Get Time is Function 2CH int 21H ;THIS INTERRUPT</pre>

22H

Terminate Address

When a program terminates, control transfers to the address at offset 0AH of the Program Segment Prefix. This address is copied into the Program Segment Prefix, from the Interrupt 22H vector, when the segment is created. Interrupt 22H, then, is just a storage location for an address rather than a true interrupt.

23H <CTRL C> Exit Address

If the user types **CTRL C** during keyboard input or display output, control transfers to the INT 23H vector in the interrupt table. This address is copied into the Program Segment Prefix, from the Interrupt 23H vector, when the segment is created.

If the **CTRL C** routine preserves all registers, it can end with an IRET instruction (return from interrupt) to continue program execution. When the interrupt occurs, all registers are set to the value they had when the original call to MS-DOS was made. There are no restrictions on what a **CTRL C** handler can do — including MS-DOS function calls — so long as the registers are unchanged if IRET is used.

If Function 09H or 0AH (Display String or Buffered Keyboard Input) is interrupted by **CTRL C**, the three-byte sequence 03H-0DH-0AH (ETX-CR-LF) is sent to the display and the function resumes at the beginning of the next line.

If the program creates a new segment and loads a second program that changes the **CTRL C** address, termination of the second program restores the **CTRL C** address to its value before execution of the second program.

Like INT 22H, this is really not a true interrupt, but a storage location.

24H

Fatal Error Abort Address

- Call** If a fatal disk error occurs during execution of one of the disk I/O function calls, control transfers to the INT 24H vector in the vector table. This address is copied into the Program Segment Prefix, from the Interrupt 24H vector, when the segment is created.
- Return** BP:SI contains the address of a Device Header Control Block from which additional information can be retrieved.
- Note** Interrupt 24H is not issued if the failure occurs during execution of Interrupt 25H (Absolute Disk Read) or Interrupt 26H (Absolute Disk Write). These errors are usually handled by the MS-DOS error routine in COMMAND.COM that retries the disk operation, then gives the user the choice of aborting, retrying the operation, or ignoring the error. The following topics give you the information you need about interpreting the error codes, managing the registers and stack, and controlling the system's response to the error in order to write your own error-handling routines.
- Error Codes** When an error-handling program gains control from Interrupt 24H, the AX and DI registers can contain codes that describe the error. If Bit 7 of AH is 1, the error is either a bad image of the File Allocation Table or an error which has occurred on a character device. The device header passed in BP:SI can be examined to determine which case exists. If the attribute byte high order bit indicates a block device, then the error was a bad FAT. Otherwise, the error is on a character device.

24H Fatal Error Abort Address

The following are error codes for Interrupt 24H:

Error Code	Description
0	Attempt to write on write-protected disk
1	Unknown unit
2	Drive not ready
3	Unknown command
4	Data error
5	Bad request structure length
6	Seek error
7	Unknown media type
8	Sector not found
9	Printer out of paper
A	Write fault
B	Read fault
C	General failure

The user stack will be in effect (the first item described below is at the top of the stack), and will contain the following from top to bottom:

IP	MS-DOS registers from
CS	issuing INT 24H
FLAGS	
AX	User registers at time of original
BX	INT 21H request
CX	
DX	
SI	
DI	
BP	
DS	
ES	
IP	From the original INT 21H
CS	from the user to MS-DOS
FLAGS	

The registers are set such that if an IRET is executed, MS-DOS will respond according to (AL) as follows:

24H

Fatal Error Abort Address

(AL) = 0 ignore the error
= 1 retry the operation
= 2 terminate the program via INT 23H

Note

- Before giving this routine control for disk errors, MS-DOS performs five retries.
- For disk errors, this exit is taken only for errors occurring during an Interrupt 21H. It is not used for errors during Interrupts 25H or 26H.
- This routine is entered in a disabled state.
- The SS,SP,DS,ES,BX,CX, and DX registers must be preserved.
- The interrupt handler should refrain from using MS-DOS function calls. If necessary, it may use calls 01H through 0CH. Use of any other call will destroy the MS-DOS stack and will leave MS-DOS in an unpredictable state.
- The interrupt handler must not change the contents of the device header.
- If the interrupt handler will handle errors rather than returning to MS-DOS, it should restore the application program's registers from the stack, remove all but the last three words on the stack, then issue an IRET. This will return to the program immediately after the INT 21H that experienced the error. Note that if this is done, MS-DOS will be in an unstable state until a function call higher than 0CH is issued.

25H Absolute Disk Read

Call

- AL
Drive number (0 = A, 1 = B, etc.)
- DS:BX
Disk Transfer Address
- CX
Number of sectors
- DX
Beginning relative sector

Return

- Flags
 - CF = 0 if successful
 - = 1 if not successful
- AL
Error code if CF = 1

Remarks

This interrupt transfers control to the MS-DOS BIOS. The number of sectors specified in CX is read from the disk to the Disk Transfer Address. Its requirements and processing are identical to Interrupt 26H, except data is read rather than written.

25H Absolute Disk Read

Note All registers except the segment registers are destroyed by this call. Be sure to save any registers your program uses before issuing the interrupt.

The system pushes the flags at the time of the call; they are still there upon return. (This is necessary because data is passed back in the flags). Be sure to pop the stack upon return to restore your stack pointer at the point of invocation.

If the disk operation was successful, the Carry Flag (CF) is 0. If the disk operation was not successful, CF is 1 and AL contains the MS-DOS error code (see Interrupt 24H earlier in this section for the codes and their meaning).

Macro

```
abs_disk_read macro disk,buffer,num_sectors, start
    mov  al,disk
    mov  bx,offset buffer
    mov  cx,num_sectors
    mov  dx,start
    int  25H
endm
```

Example

The following program copies the contents of a single-sided disk in drive A: to the disk in drive B:. It uses a buffer of 32K bytes:

```
prompt    db  "Source in A, target in B",13,10
          db  "Any key to start. $"
start     dw  0
buffer    db  64 dup (512 dup (?)) ;64 sectors
          .

int_25H:  display prompt ;see Function 09H
          read_kbd      ;see Function 08H

          mov cx,5      ;copy 5 groups of
                       ;64 sectors
copy:     push cx      ;save the loop
          ;counter
          abs_disk_read 0,buffer, 64,start ;THIS
          ;INTERRUPT
          abs_disk_write 1,buffer, 64,start ;see INT
          ;26H
          add start,64  ;do the next 64
          ;sectors
          pop cx       ;restore the loop
          ;counter
          loop copy
```

26H

Absolute Disk Write

Call

- AL
Drive number (0 = A, 1 = B, etc.)
- DS:BX
Disk Transfer Address
- CX
Number of sectors
- DX
Beginning relative sector

Return

- FLAGS
CF = 0 if successful
= 1 if not successful
- AL
Error code if CF = 1

Remarks

This interrupt transfers control to the MS-DOS BIOS. The number of sectors specified in CX is written from the Disk Transfer Address to the disk. Its requirements and processing are identical to Interrupt 25H, except data is written to the disk rather than read from it.

26H Absolute Disk Write

Note

All registers except the segment registers are destroyed by this call. Be sure to save any registers your program uses before issuing the interrupt.

The system pushes the flags at the time of the call; they are still there upon return. (This is necessary because data is passed back in the flags). Be sure to pop the stack upon return to restore your stack pointer at the point of invocation.

If the disk operation was successful, the Carry Flag (CF) is 0. If the disk operation was not successful, CF is 1 and AL contains the MS-DOS error code (see Interrupt 24H earlier in this section for the codes and their meaning).

Macro

```
abs_disk_write macro disk,buffer,num_sectors, start
    mov  al,disk
    mov  bx,offset buffer
    mov  cx,num_sectors
    mov  dx,start
    int  26H
endm
```

26H

Absolute Disk Write

Example

The following program copies the contents of a single-sided disk in drive A: to the disk in drive B:, verifying each write. It uses a buffer of 32K bytes:

```
off      equ 0
on       equ 1
        .
        .
prompt  db "Source in A, target in B", 13,10
        db "Any key to start. $"
start   dw 0

buffer  db 64 dup (512 dup (?)) ; 64 sectors
        .
        .
int_26H: display prompt          ;see Function 09H
        read_kbd                ;see Function 08H
        verify on                ;see Function 2EH
        mov cx,5                 ;copy 5 groups of
                                ;64 sectors
copy:   push cx                  ;save the loop
                                ;counter
        abs_disk_read 0,buffer, 64,start ;see INT
                                ;25H
        abs_disk_write 1,buffer, 64,start ;THIS
                                ;INTERRUPT
        add start,64            ;do the next 64
                                ;sectors
        pop cx                  ;restore the loop
                                ;counter
        loop copy
        verify off              ;see Function 2EH
```

27H Terminate But Stay Resident

Call CCS:DX
First byte following
last byte of code

Return None

Remarks The Terminate But Stay Resident call is used to make a piece of code remain resident in the system after its termination. Typically, this call is used in .COM files to allow some device-specific interrupt handler to remain resident to process asynchronous interrupts.

DX must contain the number of bytes in the CS segment to be reserved. When Interrupt 27H is executed, the program terminates but is treated as an extension of MS-DOS; it remains resident and is not overlaid by other programs when it terminates.

If an executable file whose extension is .COM or .EXE ends with this interrupt, it becomes a resident operating system command.

This interrupt is provided for compatibility with versions of MS-DOS prior to 2.0. New programs should use Function 31H, Keep Process.

Macro

```
stay_resident macro last_instruc
    mov dx,offset last_instruc
    inc dx
    int 27H
endm
```

27H

Terminate But Stay Resident

Example

```
;CS must be equal to PSP values given at program  
;start  
;(ES and DS values)  
;the variable Last Address must be equal  
;to the offset of the last byte in the  
;program.  
    mov  DX,LastAddress  
    inc  dx  
    int  27H  
;There is no return from this interrupt
```


00H Terminate Program

Call AH = 00H
CS
Segment address of
Program Segment Prefix

Return None

Remarks Function 00H is called by Interrupt 20H; it performs the same processing.

The CS register must contain the segment address of the Program Segment Prefix before you call this interrupt.

The following exit addresses are restored from the specified offsets in the Program Segment Prefix:

Program terminate	0AH
<CTRL C>	0EH
Critical error	12H

All file buffers are flushed to disk.

Warning Close all files that have changed in length before calling this function. If a changed file is not closed, its length is not recorded correctly in the directory. See Function 10H for a description of the Close File system call.

00H Terminate Program

Macro terminate_program macro
 xor ah,ah
 int 21H
 endm

Example ;CS must be equal to PSP values given at program start
 ;(ES and DS values)
 mov ah,0
 int 21H
 ;There are no returns from this interrupt

01H Read Keyboard and Echo

Call AH = 01H

Return AL
Character typed

Remarks Function 01H waits for a character to be typed at the keyboard, then echoes the character to the display and returns it in AL. If the character is **CTRL C**, Interrupt 23H is executed.

Macro

```
read_kdb_and_echo macro
    mov     ah,01H
    int    21H
endm
```

Example The following program both displays and prints characters as they are typed. If **CR** is pressed, the program sends Line Feed-Carriage Return to both the display and the printer:

```
func_01H: read_kdb_and_echo      ;THIS FUNCTION
          print_char             al      ;see Function 05H
          cmp                     al,0DH ;is it a CR?
          jne                      func_01H ;no, print it
          print_char              10     ;see Function 05H
          display_char            10     ;see Function 02H
          jmp                      func_01H ;get another character
```

02H

Display Character

Call AH = 02H
 DL
 Character to be displayed

Return None

Remarks If **CTRL C** is typed, Interrupt 23H is issued.

Macro display_char macro character
 mov dl,character
 mov ah,02H
 int 21H
 endm

Example The following program converts lowercase characters to uppercase before displaying them:

```
func_02H:  read_kbd           ;see FUNCTION 08H
           cmp  al,"a"
           jl  uppercase     ;don't convert
           cmp al,"z"
           jg  uppercase     ;don't convert
           sub al,20H        ;convert to ASCII code
                               ;for uppercase
uppercase: display_char al   ;THIS FUNCTION
           jmp func_02H     ;get another character
```

03H Auxiliary Input

Call AH = 03H

Return AL
Character from auxiliary device

Remarks Function 03H waits for a character from the auxiliary input device, then returns the character in AL.

This system call does not return a status or error code.

If a **CTRL C** has been typed at console input, Interrupt 23H is issued.

Macro

```
aux_input macro
    mov ah,03H
    int 21H
endm
```

Example The following program prints characters as they are received from the auxiliary device. It stops printing when an end-of-file character (ASCII 26, or **CTRL Z**) is received:

```
func_03H:  aux_input      ;THIS FUNCTION
            cmp         al,1AH    ;end of file?
            je          continue  ;yes, all done
            print_char al        ;see Function 05H
            jmp         func_03H  ;get another character
continue:  .
            .
```

04H

Auxiliary Output

Call AH = 04H
DL
Character for auxiliary device

Return None

Remarks This system call does not return a status or error code.

If a **CTRL C** has been typed at console input, Interrupt 23H is issued.

Macro aux_output macro character
mov dl,character
mov ah,04H
int 21H
endm

Example The following program gets a series of strings of up to 80 bytes from the keyboard, sending each to the auxiliary device. It stops when a null string (CR only) is typed:

```
string db 82 dup(?) ;see Function 0AH
.
.
func_04H: get_string 80,string ;see Function 0AH
          cmp string[1],0 ;null string?
          je continue ;yes, all done
          xor ch,ch ;zero high byte
          mov cl, byte ptr string[1] ;get string length
          mov bx,0 ;set index to 0
send_it:  aux_output string[bx+2] ;THIS FUNCTION
          inc bx ;bump index
          loop send_it ;send another character
          jmp func_04H ;get another string
continue: .
.
```

05H Print Character

Call AH = 05H
 DL
 Character for printer

Return None

Remarks If **CTRL C** has been typed at console input,
Interrupt 23H is issued.

Macro `print_char macro character`
 `mov dl,character`
 `mov ah,05H`
 `int 21H`
 `endm`

05H Print Character

Example The following program prints a walking test pattern on the printer. It stops if **CTRL C** is pressed.

```
line_num db 0
        .
        .
func_05H: mov    bl,33      ;first printable ASCII
        .                ;character (!)
        add     bl,line_num ;to offset next character
        mov     cx,80      ;loop counter for line
print_it: print_char bl   ;THIS FUNCTION
        inc     bl        ;move to next ASCII character
        cmp     bl,126    ;last printable ASCII
        .                ;character (~)
        jle     no_reset  ;not there yet
        mov     bl,33     ;start over with (!)

no_reset: loop    print_it ;print another character
        print_char 13    ;carriage return
        print_char 10   ;line feed
        inc     line_num ;to offset 1st char. of line
        cmp     line_num,93 ;end of cycle?
        jle     func_05H ;nope, not yet
        mov     line_num,0 ;reset char offset
        jmp     func_05H ;continue
```


06H Direct Console I/O

Call	AH = 06H DL See Text
Return	AL If DL = FFH before call If Zero flag not set: Character from keyboard If Zero flag set: No character input
Remarks	Processing depends on the value in DL when the function is called: DL is FFH. If a character has been typed at the keyboard, it is returned in AL and the Zero flag is 0; if a character has not been typed, the Zero flag is 1. DL is not FFH. The character in DL is displayed. This function does not check for CTRL C.
Macro	<pre>dir_console_io macro switch mov dl,switch mov ah,06H int 21H endm</pre>

06H Direct Console I/O

Example The following program acts as a stopwatch. When a character is typed, it sets the system clock to zero and begins to continuously display the time. When a second character is typed the system stops updating the time display.

```
time      db"00:00:00.00",13,"$"
ten       db 10
.
.
func_06H: dir_console_io OFFH   ;THIS FUNCTION
          jz      func_06H     ;wait for keystroke
          set_time      0,0,0,0 ;see Function 2DH
read_clock: get_time          ;see Function 2CH
            convert ch,ten,time ;see end of chapter
            convert cl,ten,time[3] ;see end of chapter
            convert dh,ten,time[6] ;see end of chapter
            convert dl,ten,time[9] ;see end of chapter
            display time        ;see Function 09H
            dir_console_io OFFH ;THIS FUNCTION
            jz      read_clock  ;no char, keep updating
continue: .
.
.
```

07H Direct Console Input

Call AH = 07H

Return AL
Character from keyboard

Remarks This function does not echo the character or check for **CTRL C**. (For a keyboard input function that echoes or checks for **CTRL C**, see Functions 01H or 08H.)

Macro dir_console_input macro
mov ah,07H
int 21H
endm

Example The following program fragment prompts for a password (8 characters maximum) and places the characters into a string without echoing them:

```
password db 8 dup(?)
prompt db "Password: $" ;see Function 09H for
;explanation of $
.
.
func_07H: display prompt ;see Function 09H
mov cx,8 ;maximum length of password
xor bx,bx ;so BL can be used as index
get_pass: dir_console_input ;THIS FUNCTION
cmp al,0DH ;was it a CR?
je continue ;yes, all done
mov password[bx],al ;no, put character in string
inc bx ;bump index
loop get_pass ;get another character
continue: . ;BX has length of password
.
```

08H

Read Keyboard

Call AH = 08H

Return AL
Character from keyboard

Remarks If **CTRL C** is pressed, Interrupt 23H is executed. This function does not echo the character. (For a keyboard input function that echoes the character or does not check for **CTRL C**, see Functions 01H or 07H.)

Macro read_kbd macro
mov ah,08H
int 21H
endm

Example The following program fragment prompts for a password (8 characters maximum) and places the characters into a string without echoing them:

```
password db 8 dup(?)
prompt db "Password: $" ;see Function 09H
;for explanation of $
.
.
func_08H: display prompt ;see Function 09H
mov cx,8 ;maximum length of password
xor bx,bx ;BL can be an index
get_pass: read_kbd; ;THIS FUNCTION
cmp al,0DH ;was it a CR?
je continue ;yes, all done
mov password[bx],al ;no, put char. in string
inc bx ;bump index
loop get_pass ;get another character
continue: . ;BX has length of password
.
```

09H Display String

Call AH = 09H
DS:DX
String to be displayed

Return None

Remarks DX must contain the offset (from the segment address in DS) of a string that ends with "\$". The string is displayed (the \$ is not displayed).

Macro display macro string
mov dx,offset string
mov ah,09H
int 21H
endm

Example The following program displays the hexadecimal code of the key that is typed:

```
table      db "0123456789ABCDEF"  
sixteen   db 16  
result    db "-00H",13,10,"$"      ;see text for  
                                                ;explanation of $  
  
func_09H: read_kbd_and_echo      ;see Function 01H  
          convert al,sixteen,result[1] ;see end of chapter  
          display result          ;THIS FUNCTION  
          jmp func_09H            ;do it again
```

0AH

Buffered Keyboard Input

Call AH = 0AH
 DS:DX
 Input buffer

Return None

Remarks DX must contain the offset (from the segment address in DS) of an input buffer of the following form:

Byte	Contents
1	Maximum number of characters in buffer, including the CR (you must set this value).
2	Actual number of characters typed, not counting the CR (the function sets this value).
3-n	Buffer; must be at least as long as the number in byte 1.

This function waits for characters to be typed. Characters are read from the keyboard and placed in the buffer beginning at the third byte until **CR** is pressed. If the buffer fills to one less than the maximum, additional characters typed are ignored and ASCII 7 (BEL) is sent to the display until **CR** is pressed. The string can be edited as it is being entered. If **CTRL C** is typed, Interrupt 23H is issued.

The second byte of the buffer is set to the number of characters entered (not counting the **CR**).

Macro `get_string macro limit,string`
 `mov dx,offset string`
 `mov string,limit`
 `mov ah,0AH`
 `int 21H`
 `endm`

Example The following program gets a 16-byte (maximum) string from the keyboard and fills a 24-line by 80-character screen with it:

```

buffer          label    byte
max_length     db       ?                  ;maximum length
chars_entered   db       ?                 ;number of chars.
string          db       17 dup (?)       ;16 chars + CR
strings_per_line dw       0                ;how many strings
                                          ;fit on line

crlf           db       13,10,"$"

               .
               .

func_OAH:      get_string 17,buffer       ;THIS FUNCTION
               xor       bx,bx            ;so byte can be
                                          ;used as index
               mov       bl,chars_entered ;get string length
               mov       buffer[bx+2],"$" ;see Function 09H
               mov       al,50H           ;columns per line
               cbw
               div       chars_entered    ;times string fits
                                          ;on line
               xor       ah,ah            ;clear remainder
               mov       strings_per_line,ax ;save col. counter
               mov       cx,24           ;row counter

display_screen: push cx                  ;save it
               mov       cx,strings_per_line ;get col. counter
display_line:  display  string            ;see Function 09H
               loop      display_line
               display  crlf              ;see Function 09H
               pop      cx                ;get line counter
               loop      display_screen   ;display 1 more line

```

0BH

Check Keyboard Status

Call AH = 0BH

Return AL
 FFH = characters in type-ahead buffer
 0 = no characters in type-ahead buffer

Remarks Checks whether there are characters in the type-ahead buffer. If so, AL returns FFH; if not, AL returns 0. If CTRL C is in the buffer, Interrupt 23H is executed.

Macro check_kbd_status macro
 mov ah,0BH
 int 21H
 endm

Example The following program fragment continuously displays the time until any key is pressed.

```
time            db "00:00:00.00",13,10,"$"  
ten             db 10  
.  
.  
func_OBH:      get_time                    ;see Function 2CH  
                 convert ch,ten,time        ;see end of chapter  
                 convert cl,ten,time[3]     ;see end of chapter  
                 convert dh,ten,time[6]     ;see end of chapter  
                 convert dl,ten,time[9]     ;see end of chapter  
                 display time               ;see Function 09H  
                 check_kbd_status          ;THIS FUNCTION  
                 cmp al,OFFH               ;has a key been typed  
                 je all_done               ;yes, go home  
                 jmp func_OBH              ;no, keep displaying  
                 ;time  
  
all_done:      .  
                 .
```


0CH Flush Buffer, Read Keyboard

Call	AH = 0CH AL 1, 6, 7, 8, or 0AH = The corresponding function is called. Any other value = return from function.
Return	AL 0 = Type-ahead buffer was flushed; no other processing performed.
Remarks	The keyboard type-ahead buffer is emptied. Further processing depends on the value in AL when the function is called: 1, 6, 7, 8, or A: The corresponding MS-DOS function is executed. Any other value: No further processing; AL returns 0.
Macro	<pre>flush_and_read_kbd macro switch mov al,switch mov ah,0CH int 21H endm</pre>

0CH Flush Buffer, Read Keyboard

Example The following program both displays and prints characters as they are typed. If **CR** is pressed, the program sends Carriage Return-Line Feed to both the display and the printer.

```
func_0CH: flush_and_read_kbd 1      ;THIS FUNCTION
          print_char      al      ;see Function 05H
          cmp              al,0DH      ;is it a CR?
          jne              func_0CH      ;no, print it
          print_char      10      ;see Function 05H
          display_char      10      ;see Function 02H
          print_char      13      ;see Function 05H
          display_char      13      ;see Function 02H
          jmp              func_0CH      ;get another character
```

0DH Disk Reset

Call AH = 0DH

Return None

Remarks Function 0DH is used to ensure that the internal buffer cache matches the disks in the drives. If buffers have been modified, but not yet written to disk, this function writes them out and marks all buffers in the internal cache as free.

Function 0DH flushes (frees) all file buffers. It does not update directory entries; you must close files that have changed to update their directory entries (see Function 10H, Close File). This function need not be called before a disk change if all files that changed were closed. It is generally used to force a known state of the system; **CTRL C** interrupt handlers should call this function.

Macro

```
disk_reset macro disk
    mov ah,0DH
    int 21H
endm
```

Example

```
mov ah,0DH
int 21H
;There are no errors returned by this call.
```

0EH

Select Disk

Call AH = 0EH
 DL
 Drive number
 (0 = A:, 1 = B:, etc.)

Return AL
 Number of logical drives

Remarks The drive specified in DL (0 = A:, 1 = B:, etc.) is selected as the default disk. The number of drives is returned in AL.

Macro select_disk macro disk
 mov dl,disk[-65] ;ASCII offset
 mov ah,0EH
 int 21H
 endm

Example The following program fragment selects the drive not currently selected in a 2-drive system:

```
func_0EH:  current_disk    ;see Function 19H
           cmp al,00H      ;drive A: selected?
           je  select_b    ;yes, select B
           select_disk "A" ;THIS FUNCTION
           jmp continue
select_b:  select_disk "B" ;THIS FUNCTION
continue:  .
```

0FH Open File

Call AH = 0FH
DS:DX
Unopened FCB

Return AL
0 = Directory entry found
FFH = No directory entry found

Remarks DX must contain the offset (from the segment address in DS) of an unopened File Control Block (FCB). The disk directory is searched for the named file.

If a directory entry for the file is found, AL returns 0 and the FCB is filled as follows:

- If the drive code was 0 (default disk), it is changed to the actual disk used (1 = A:, 2 = B:, etc.). This lets you change the default disk without interfering with subsequent operations on this file.
- The Current Block field (offset 0CH) is set to zero.
- The Record Size (offset 0EH) is set to the system default of 128.
- The File Size (offset 10H), Date of Last Write (offset 14H), and Time of Last Write (offset 16H) are set from the directory entry.

Before performing a sequential disk operation on the file, you must set the Current Record field (offset 20H). Before performing a random disk operation on the file, you must set the Relative Record field (offset 21H). If the default record size (128 bytes) is not correct, set it to the correct length.

OFH Open File

If a directory entry for the file is not found, AL returns FFH.

Macro

```
open macro fcb
    mov dx,offset fcb
    mov ah,OFH
    int 21H
endm
```

Example The following program prints the file named TEXTFILE.ASC that is on the disk in drive B:. If a partial record is in the buffer at end-of-file, the routine that prints the partial record prints characters until it encounters an end-of-file mark (ASCII 26, or **CTRL Z**):

```
fcb          db 2,"TEXTFILEASC"
            db 25 dup (?)
buffer      db 128 dup (?)

func_OFH:   set_dta buffer          ;see Function 1AH
            open fcb              ;THIS FUNCTION
read_line:  read_seq fcb          ;see Function 14H
            cmp al,01H            ;end of file?
            je all_done          ;yes, go home
            cmp al,00H          ;more to come?
            jg check_more        ;no, check for partial
            ;record
            mov cx,128          ;yes, print the buffer
            xor si,si           ;set index to 0
print_it:   print_char buffer[si] ;see Function 05H
            inc si              ;bump index
            loop print_it       ;print next character
            jmp read_line       ;read another record
check_more: cmp al,03H          ;part. record to print?
            jne all_done        ;no
```

0FH Open File

```

                                mov  cx,128      ;yes, print it
                                xor   si,si      ;set index to 0
find_eof:  cmp   buffer[si],26    ;end-of-file mark?
                                je    all_done   ;yes
                                print_char buffer[si] ;see Function 05H
                                inc   si        ;bump index to next
                                                ;character
                                loop  find_eof
all_done:  close  fcb              ;see Function 10H
```

10H Close File

Call AH = 10H
 DS:DX
 Opened FCB

Return AL
 0 = Directory entry found
 FFH = No directory entry found

Remarks DX must contain the offset (to the segment address in DS) of an opened FCB. The disk directory is searched for the file named in the FCB. This function must be called after a file is changed to update the directory entry.

If a directory entry for the file is found, the entry is compared with the corresponding entries in the FCB. The directory entry is updated, if necessary, to match the FCB, and AL returns 0.

If a directory entry for the file is not found, AL returns FFH.

Macro close macro fcb
 mov dx,offset fcb
 mov ah,10H
 int 21H
 endm

Example The following program checks the first byte of the file named MOD1.BAS in drive B: to see if it is FFH, and prints a message if it is:

```

message db "Not saved in ASCII format",13,10,"$"
fcb     db 2,"MOD1  BAS"
       db 25 dup (?)
buffer  db 128 dup (?)
       .
       .
func_10H: set_dta buffer      ;see Function 1AH
         open fcb           ;see Function 0FH
         read_seq fcb       ;see Function 14H
         cmp  buffer,OFFH   ;is first byte FFH?
         jne  all_done      ;no
         display message    ;see Function 09H
all_done close fcb         ;THIS FUNCTION

```

11H

Search for First Entry

Call AH = 11H
DS:DX
Unopened FCB

Return AL
0 = Directory entry found
FFH = No directory entry found

Remarks DX must contain the offset (from the segment address in DS) of an unopened FCB. The disk directory is searched for the first matching name. The name can have the ? wild card character to match any character. To search for hidden or system files, DX must point to the first byte of the extended FCB prefix.

If a directory entry for the filename in the FCB is found, AL returns 0 and an unopened FCB of the same type (normal or extended) is created at the Disk Transfer Address.

If a directory entry for the filename in the FCB is not found, AL returns FFH.

Note If an extended FCB is used, the following search pattern is used:

- If the FCB attribute is zero, only normal file entries are found. Entries for volume label, sub-directories, hidden, and system files will not be returned.

- If the attribute field is set for hidden or system files, or directory entries, it is to be considered as an inclusive search. All normal file entries plus all entries matching the specified attributes are returned. To look at all directory entries except the volume label, the attribute byte may be set to hidden + system + directory (all 3 bits on).
- If the attribute field is set for the volume label, it is considered an exclusive search, and only the volume label entry is returned.

Macro

```
search_first macro fcb
    mov dx,offset fcb
    mov ah,11H
    int 21H
endm
```

Example

The following program verifies the existence of a file named REPORT. ASM on the disk in drive B::

```
yes          db "FILE EXISTS.$"
no           db "FILE DOES NOT EXIST.$"
fcb          db 2,"REPORT ASM"
             db 25 dup (?)
buffer       db 128 dup (?)
crlf         db 13,10 "$"

func_11H:    set_dta buffer ;see Function 1AH
             search_first fcb ;THIS FUNCTION
             cmp al,OFFH ;directory entry found?
             je not_there ;no
             display yes ;see Function 09H
             jmp continue
not_there:   display no ;see Function 09H
continue:    display crlf ;see Function 09H
             .
             .
```

12H

Search for Next Entry

Call AH = 12H
 DS:DX
 Unopened FCB

Return AL
 0 = Directory entry found
 FFH = No directory entry found

Remarks DX must contain the offset (from the segment address in DS) of an FCB previously specified in a call to Function 11H (Search for First Entry). Function 12H is used after Function 11H to find additional directory entries that match a filename that contains wild card characters. The disk directory is searched for the next matching name.

If a directory entry for the filename in the FCB is found, AL returns 0 and an unopened FCB of the same type (normal or extended) is created at the Disk Transfer Address.

If a directory entry for the filename in the FCB is not found, AL returns FFH.

Macro search_next macro fcb
 mov dx,offset fcb
 mov ah,12H
 int 21H
 endm

Example The following program displays the number of files on the disk in drive B:

```
message db "No files",10,13,"$"
files   db 0
ten     db 10
fcb     db 2,"????????????"
        db 25dup(?)
buffer  db 128 dup(?)
        .
        .
func_12H: set_dta buffer           ;see Function 1AH
          search_first fcb        ;see Function 11H
          cmp al,OFFH             ;directory entry found?
          je all_done            ;no, no files on disk
          inc files               ;yes, increment file
                                   ;counter
search_dir: search_next fcb      ;THIS FUNCTION
          cmp al,OFFH             ;directory entry found?
          je done                ;no
          inc files               ;yes, increment file
                                   ;counter
          jmp search_dir         ;check again
done:    convert files,ten,message ;see end of chapter
all_done: display message       ;see Function 09H
```

13H

Delete File

Call AH = 13H
 DS:DX
 Unopened FCB

Return AL
 0 = Directory entry found
 FFH = No directory entry found

Remarks DX must contain the offset (from the segment address in DS) of an unopened FCB. The directory is searched for a matching filename. The filename in the FCB can contain the ? wild card character to match any character.

If a matching directory entry is found, it is deleted from the directory. If the ? wild card character is used in the filename, all matching directory entries are deleted. AL returns 0.

If no matching directory entry is found, AL returns FFH.

Macro delete macro fcb
 mov dx,offset fcb
 mov ah,13H
 int 21H
 endm

Example The following deletes each file on the disk in drive B: that was last written before June 30, 1984:

```

year          dw  1984
month         db  6
day           db  30
files         db  0
ten           db  10
message       db  "NO FILES DELETED.",13,10,"$"
                                   ;see Function 09H for
                                   ;explanation of $

fcb           db  2,"???????????"
              db  25 dup(?)

buffer        db  128 dup (?)
              .
              .

func_13H:     set_dta buffer          ;see Function 1AH
              search_first fcb       ;see Function 11H
              cmp  al,OFFH           ;directory entry found?
              je   all_done          ;no, no files on disk

compare:      convert_date buffer    ;see end of chapter
              cmp  cx,year           ;next several lines
              jg   next              ;check date in directory
              cmp  dl,month          ;entry against date
              jg   next              ;above & check next file
              cmp  dh,day            ;if date in directory
              jge  next              ;entry isn't earlier.
              delete buffer          ;THIS FUNCTION
              inc  files              ;bump deleted-files
                                   ;counter

next:         search_next fcb        ;see Function 12H
              cmp  al,00H            ;directory entry found?
              je   compare           ;yes, check date
              cmp  files,0           ;any files deleted?
              je   all_done          ;no, display NO FILES

```

13H

Delete File

all_done: convert files,ten,message ;message.
 display message ;see end of chapter
 ;see Function 09H

14H Sequential Read

Call AH = 14H
DS:DX
Opened FCB

Return AL
0 = Read completed successfully
1 = EOF
2 = DTA too small
3 = EOF, partial record

Remarks DX must contain the offset (from the segment address in DS) of an opened FCB. The record pointed to by the current block (offset 0CH) and Current Record (offset 20H) fields is loaded at the Disk Transfer Address, then the Current Record and, if necessary, the Current Block fields are incremented.

The record size is set to the value at offset 0EH in the FCB.

AL returns a code that describes the processing:

Code	Meaning
0	Read completed successfully.
1	End-of-file, no data in the record.
2	Not enough room at the Disk Transfer Address to read one record; read canceled.
3	End-of-file; a partial record was read and padded to the record length with zeros.

14H

Sequential Read

Macro

```
read_seq macro fcb
    mov dx,offset fcb
    mov ah,14H
    int 21H
endm
```

Example The following program displays the file named TEXTFILE.ASC that is on the disk in drive B; its function is similar to the MS-DOS TYPE command. If a partial record is in the buffer at end of file, the routine that displays the partial record displays characters until it encounters an end-of-file mark (ASCII 26, or CTRL Z):

```
fcbl      db 2,"TEXTFILEASC"
          db 25 dup (?)
buffer    db 128 dup (?),"$"
          .
          .
func_14H: set_dta buffer          ;see Function 1AH
          open fcb              ;see Function 0FH
read_line: read_seq fcb         ;THIS FUNCTION
          cmp al,01H           ;end-of-file?
          je all_done          ;yes
          cmp al,00H           ;more to come?
          jg check_more        ;no, check for partial record
          display buffer        ;see Function 09H
          jmp read_line        ;get another record
check_more: cmp al,03H         ;partial record in buffer?
          jne all_done         ;no, go home
          xor si,si            ;set index to 0
find_eof:  cmp buffer[si],26   ;is character EOF?
          je all_done          ;yes, no more to display
          display_char buffer[si] ;see Function 02H
          inc si                ;bump index to next
```

14H Sequential Read

```
all_done:      jmp   find_eof      ;character  
               close  fcb      ;check next character  
               ;see Function 10H
```

15H

Sequential Write

Call AH = 15H
DS:DX
Opened FCB

Return AL
00H = Write completed successfully
01H = Disk full
02H = DTA too small

Remarks DX must contain the offset (from the segment address in DS) of an opened FCB. The record pointed to by Current Block (offset 0CH) and Current Record (offset 20H) fields is written from the Disk Transfer Address, then the fields are incremented as necessary.

The record size is set to the value at offset 0EH in the FCB. If the Record Size is less than a sector, the data at the Disk Transfer Address is written to a buffer; the buffer is written to disk when it contains a full sector of data, or the file is closed, or a Reset Disk system call (Function 0DH) is issued.

AL returns a code that describes the processing:

Code	Meaning
0	transfer completed successfully
1	disk full; write canceled
2	write canceled; the area beginning at the Disk Transfer Address is too small to hold a record of data without overflowing or wrapping around a segment boundary.

Macro

```

write_seq macro fcb
    mov dx,offset fcb
    mov ah,15H
    int 21H
endm

```

Example The following program creates a file named DIR.TMP on the disk in drive B: that contains the disk number (0 = A:, 1 = B:, etc.) and file-name from each directory entry on the disk:

```

record_size equ 14 ;offset of Record Size
                ;field in FCB
.
.
fcb1 db 2,"DIR TMP"
      db 25 dup (?)
fcb2 db 2,"?????????????"
      db 25 dup (?)
buffer db 128 dup (?)
.
.
func_15H: set_dta buffer ;see Function 1AH
          search_first fcb2 ;see Function 11H
          cmp al,OFFH ;directory entry found?
          je all_done ;no, no files on disk
          create fcb1 ;see Function 16H
          mov fcb1[record_size],12
.
.
write_it: write_seq fcb1 ;THIS FUNCTION
          search_next fcb2 ;see Function 12H
          cmp al,OFFH ;directory entry found?
          je all_done ;no, go home
          jmp write_it ;yes, write the record
all_done: close fcb1 ;see Function 10H

```

16H

Create File

Call AH = 16H
DS:DX
Unopened FCB

Return AL
00H = Empty directory entry found
FFH = No empty entry directory available

Remarks DX must contain the offset (from the segment address in DS) of an unopened FCB. The directory is searched for an empty entry or an existing entry for the specified filename.

If an empty directory entry is found, it is initialized to a zero-length file, the Open File system call (Function 0FH) is called, and AL returns 0. You can create a hidden file by using an extended FCB with the attribute byte (offset FCB-1) set to 2.

If an entry is found for the specified filename, all data in the file is released, making a zero-length file, and the Open File system call (Function 0FH) is issued for the filename (in other words, if you try to create a file that already exists, the existing file is erased, and a new, empty file is created).

If an empty directory entry is not found and there is no entry for the specified filename, AL returns FFH.

Macro

```

create macro fcb
    mov dx,offset fcb
    mov ah,16H
    int 21H
endm

```

Example The following program creates a file named DIR.TMP on the disk in drive B: that contains the disk number (0 = A:, 1 = B:, etc.) and file-name from each directory entry on the disk:

```

record_size equ 14 ;offset of Record Size
                ;field of FCB
.
.
fcb1 db 2,"DIR TMP"
      db 25 dup (?)
fcb2 db 2,"???????????"
      db 25 dup (?)
buffer db 128 dup (?)
.
.
func_16H: set_dta buffer ;see Function 1AH
          search_first fcb2 ;see Function 11H
          cmp al,OFFH ;directory entry found?
          je all_done ;no, no files on disk
          create fcb1 ;THIS FUNCTION
          mov fcb1[record_size],12
                ;set record size to 12
write_it: write_seq fcb1 ;see Function 15H
          search_next fcb2 ;see Function 12H
          cmp al,OFFH ;directory entry found?
          je all_done ;no, go home
          jmp write_it ;yes, write the record
all_done: close fcb1 ;see Function 10H

```

17H

Rename File

Call AH = 17H
DS:DX
Modified FCB

Return AL
00H = Directory entry found
FFH = No directory entry found or
destination already exists

Remarks DX must contain the offset (from the segment address in DS) of an FCB with the drive number and filename filled in, followed by a second filename at offset 11H. The disk directory is searched for an entry that matches the first filename, which can contain the ? wild card character.

If a matching directory entry is found, the filename in the directory entry is changed to match the second filename in the modified FCB (the two filenames cannot be the same name). If the ? wild card character is used in the second filename, the corresponding characters in the filename of the directory entry are not changed. AL returns 0.

If a matching directory entry is not found or an entry is found for the second filename, AL returns FFH.

Macro

```

rename macro special_fcb
    mov  dx,offset special_fcb
    mov  ah,17H
    int  21H
endm

```

Example The following program prompts for the name of a file and a new name, then renames the file:

```

fcb          db  37 dup (?)
prompt1     db  "Filename: $"
prompt2     db  "New name: $"
reply       db  17 dup(?)
crlf        db  13,10,"$"

.
.
func_17H:   display prompt1      ;see Function 09H
            get_string 15,reply   ;see Function 0AH
            display  crlf         ;see Function 09H
            parse  reply[2],fcb  ;see Function 29H
            display  prompt2     ;see Function 09H
            get_string 15,reply  ;see Function 0AH
            display  crlf         ;see Function 09H
            parse  reply[2],fcb[16]
            ;see Function 29H
            rename  fcb          ;THIS FUNCTION

```

19H Current Disk

Call AH = 19H

Return AL
 Currently selected drive
 (0 = A:, 1 = B:, etc.)

Macro current_disk macro
 mov ah,19H
 int 21H
 endm

Example The following program displays the currently
 selected (default) drive:

```
message db "Current disk is $" ;see Function 09H
;for explanation of $
crlf db 13,10,"$"
.
func_19H: display message ;see Function 09H
current_disk ;THIS FUNCTION
add al,41H ;ASCII offset
display_char al ;see function 02H
display crlf ;see function 09H
```

1AH Set Disk Transfer Address

Call AH = 1AH
DS:DX
Disk Transfer Address

Return None

Remarks DX must contain the offset (from the segment address in DS) of the Disk Transfer Address. Disk transfers cannot wrap around from the end of the segment to the beginning, nor can they overflow into another segment.

Note: If you do not set the Disk Transfer Address, MS-DOS defaults to offset 80H in the Program Segment Prefix.

The size of the buffer that the DTA points to must be greater than or equal to the record size at open file time.

Macro

```
set_dta macro buffer
    mov  dx,offset buffer
    mov  ah,1AH
    int  21H
endm
```

1AH

Set Disk Transfer Address

Example

The following program prompts for a letter, converts the letter to its alphabetic sequence (A = 1, B = 2, etc.), then reads and displays the corresponding record from a file named ALPHABET.DAT on the disk in drive B:. The file contains 26 records; each record is 28 bytes long:

```
record_size    equ 14      ;offset of Record Size
                ;field of FCB
relative_record equ 33     ;offset of Relative Record
                ;field of FCB

.
fcb            db 2,"ALPHABETDAT"
                db 25 dup (?)
buffer        db 34 dup(?),"$"
prompt       db "Enter letter: $"
crLf         db 13,10,"$"

.
func_1AH:     set_dta buffer          ;THIS FUNCTION
open         fcb                    ;see Function 0FH
mov         fcb[record_size],28 ;set record size
get_char:    display prompt          ;see Function 09H
read_kbd_and_echo ;see Function 01H
cmp         al,0DH                  ;just a CR?
je         all_done                 ;yes, go home
sub         al,41H                   ;convert ASCII
                ;code to record #
mov         fcb[relative_record],al
                ;set relative record
display crLf                        ;see Function 09H
read_ran fcb                        ;see Function 21H
display buffer                        ;see Function 09H
display crLf                        ;see Function 09H
jmp         get_char                 ;get another character
all_done:    close fcb               ;see Function 10H
```

21H Random Read

Call AH = 21H
DS:DX
Opened FCB

Return AL
00H = Read completed successfully
01H = EOF
02H = DTA too small
03H = EOF, partial record

Remarks DX must contain the offset (from the segment address in DS) of an opened FCB. The Current Block (offset 0CH) and Current Record (offset 20H) fields are set to agree with the Relative Record field (offset 21H), then the record addressed by these fields is loaded at the Disk Transfer Address.

AL returns a code that describes the processing:

Code	Meaning
0	read completed successfully
1	End-of-file; no data in the record
2	not enough room at the Disk Transfer Address to read one record; read canceled
3	End-of-file; a partial record was read and padded to the record length with zeros.

Macro

```
read_ran macro fcb
    mov dx,offset fcb
    mov ah,21H
    int 21H
endm
```

21H Random Read

Example The following program prompts for a letter, converts the letter to its alphabetic sequence (A = 1, B = 2, etc.), then reads and displays the corresponding record from a file named ALPHABET.DAT on the disk in drive B:. The file contains 26 records; each record is 28 bytes long:

```
record_size    equ    14        ;offset of Record Size
                                   ;field of FCB
relative_record equ    33        ;offset of Relative Record
                                   ;field of FCB

.
.
fcb            db    2,"ALPHABETDAT"
               db    25 dup (?)
buffer         db    34 dup(?, "$")
prompt         db    "Enter letter: $"
crlf           db    13,10,"$"

.
.
func_21H:     set_dta buffer          ;see Function 1AH
               open  fcb              ;see Function OFH
               mov   fcb[record_size],28;set record size
get_char:     display prompt          ;see Function 09H
               read_kbd_and_echo     ;see Function 01H
               cmp   al,0DH           ;just a CR?
               je    all_done        ;yes, go home
               sub   al,41H           ;convert ASCII
                                   ;code to record #
               mov   fcb[relative_record],al
                                   ;set relative record
               display crlf          ;see Function 09H
               read_ran fcb          ;THIS FUNCTION
               display buffer        ;see Function 09H
               display crlf         ;see Function 09H
               jmp   get_char        ;get another character
all_done:     close  fcb              ;see Function 10H
```

22H Random Write

Call AH = 22H
DS:DX
Opened FCB

Return AL
00H = Write completed successfully
01H = Disk full
02H = DTA too small

Remarks DX must contain the offset from the segment address in DS of an opened FCB. The Current Block (offset 0CH) and Current Record (offset 20H) fields are set to agree with the Relative Record field (offset 21H), then the record addressed by these fields is written from the Disk Transfer Address. If the record size is smaller than a sector (512 bytes), the records are buffered until a sector is ready to write.

AL returns a code that describes the processing:

Code	Meaning
0	Write completed successfully
1	disk is full
2	write canceled; the area beginning at the Disk Transfer Area is too small to hold a record of data without overflowing or wrapping around a segment boundary.

Macro write_ran macro fcb
mov dx,offset fcb
mov ah,22H
int 21H
endm

22H Random Write

Example The following program prompts for a letter, converts the letter to its alphabetic sequence (A = 1, B = 2, etc.), then reads and displays the corresponding record from a file named ALPHABET.DAT on the disk in drive B:. After displaying the record, it prompts the user to enter a changed record. If the user types a new record, it is written to the file; if the user just presses CR, the record is not replaced. The file contains 26 records; each record is 28 bytes long:

```

record_size    equ    14        ;offset of Record Size
                                   ;field of FCB
relative_record equ    33      ;offset of Relative Record
                                   ;field of FCB

.
.
fcb            db    2,"ALPHABETDAT"
              db    25 dup (?)
buffer        db    28 dup(?),13,10,"$"
prompt1       db    "Enter letter: $"
prompt2       db    "New record(CR for no change): $"
crlf          db    13,10,"$"
reply         db    30 dup (32)
blanks        db    28 dup (32)
.
.
func_22H:     set_dta buffer          ;see Function 1AH
              open  fcb              ;see Function OFH
              mov   fcb[record_size],28 ;set record size
get_char:     display prompt1         ;see Function 09H
              read_kbd_and_echo      ;see Function 01H
              cmp   al,0DH            ;just a CR?
              je    all_done          ;yes, go home
              sub   al,41H            ;convert ASCII
                                   ;code to record #
              mov   fcb[relative_record],al
                                   ;set relative record

```



```
display crlf           ;see Function 09H
read_ran fcb          ;THIS FUNCTION
display buffer        ;see Function 09H
display crlf         ;see Function 09H
display prompt2      ;see Function 09H
get_string 29, reply ;see Function 09H
display crlf         ;see Function 09H
cmp    reply[1],0    ;was anything typed
                        ;besides cr?
je     get_char      ;no
                        ;get another character
xor    bx,bx         ;to load a byte
mov    bl,reply[1]   ;use reply length as
                        ;counter
move_string blanks, buffer, 28
                        ;see chapter end
move_string reply[2], buffer, bx
                        ;see chapter end
write_ran fcb        ;THIS FUNCTION
jmp    get_char      ;get another character
all_done: close fcb  ;see Function 10H
```

23H File Size

Call	AH = 23H DS:DX Unopened FCB
Return	AL 00H = Directory entry found FFH = No directory entry found
Remarks	<p>DX must contain the offset (from the segment address in DS) of an unopened FCB. You must set the Record Size field (offset 0EH) to the proper value before calling this function. The disk directory is searched for the first matching entry.</p> <p>If a matching directory entry is found, the Relative Record field (offset 21H) is set to the number of records in the file, calculated from the total file size in the directory entry (offset 10H) and the Record Size field of the FCB (offset 0EH). AL returns 00.</p> <p>If no matching directory entry is found, AL returns FFH.</p>
Note	<p>If the value of the Record Size field of the FCB (offset 0EH) doesn't match the actual number of characters in a record, this function may not return the correct file size. If the default record size (128) is not correct, you must set the Record Size field to the correct value before using this function.</p>

Macro file_size macro fcb
 mov dx,offset fcb
 mov ah,23H
 int 21H
 endm

Example The following program prompts for the name of a file, opens the file to set the Record Size field of the FCB to 80H, issues a File Size system call, and displays the file size and number of records in hexadecimal:

```

fcb          db          37 dup(?)
prompt      db          "File name: $"
msg1        db          "Record length: ",13,10,"$"
msg2        db          "Records: ",13,10,"$"
crlf        db          13,10,"$"
reply       db          17 dup(?)
sixteen     db          16
.
.
func_23H:   display prompt          ;see Function 09H
            get_string 17,reply      ;see Function 0AH
            cmp         reply[1],0   ;just a CR?
            jne         get_length   ;no, keep going
            jmp         all_done     ;yes, go home
get_length: display crlf            ;see Function 09H
            parse      reply[2],fcb ;see Function 29H
            open       fcb          ;see Function 0FH
            file_size fcb          ;THIS FUNCTION
            mov        si,33         ;offset to Relative
                                   ;Record field
            mov        di,9          ;reply in msg2
convert_it: cmp         fcb[si],0    ;digit to convert?
            je         show_it       ;no, prepare message

```

23H File Size

```
convert fcb[si],sixteen,msg2[di]
inc      si          ;bump n-o-r index
inc      di          ;bump message index
jmp      convert_it ;check for a digit
show_it: convert fcb[14],sixteen,msg1[15]
display msg1        ;see Function 09H
display msg2        ;see Function 09H
jmp      func23H    ;get a filename
all_done: close     fcb      ;see Function 10H
```

24H Set Relative Record

Call AH = 24H
DS:DX
Opened FCB

Return None

Remarks DX must contain the offset (from the segment address in DS) of an opened FCB. The Relative Record field (offset 21H) is set to the same file address as the Current Block (offset 0CH) and Current Record (offset 20H) fields.

Macro

```
set_relative_record macro fcb
    mov dx,offset fcb
    mov ah,24H
    int 21H
endm
```

Example The following program copies a file using the Random Block Read and Random Block Write system calls. It speeds the copy by setting the record length equal to the file size and the record count to 1, and using a buffer of 32K bytes. It positions the file pointer by setting the Current Record field (offset 20H) to 0 and using Set Relative Record to make the Relative Record field (offset 21H) point to the same record as the combination of the Current Block (offset 0CH) and Current Record (offset 20H) fields:

24H Set Relative Record

```
current_record equ 32 ;offset of Current Record
;field of FCB
fsize equ 16 ;offset of File Size
;field of FCB
.
fcb db 37 dup (?)
filename db 17 dup(?)
prompt1 db "File to copy: $" ;see Function 09H for
prompt2 db "Name of copy: $" ;explanation of $
crlf db 13,10,"$"
file_length dw ?
buffer db 32767 dup(?)
.
func_24H: set_dta buffer ;see Function 1AH
display prompt1 ;see Function 09H
get_string 15,filename ;see Function 0AH
display crlf ;see Function 09H
parse filename[2],fcb ;see Function 29H
open fcb ;see Function 0FH
mov fcb[current_record],0 ;set Current Record
;field
set_relative_record fcb ;THIS FUNCTION
mov ax,word ptr fcb[fsize] ;get file size
mov file_length,ax ;save it for
;ran_block_write
ran_block_read fcb,1,ax ;see Function 27H
display prompt2 ;see Function 09H
get_string 15,filename ;see Function 0AH
display crlf ;see Function 09H
parse filename[2],fcb ;see Function 29H
set_relative_record fcb ;THIS FUNCTION
```

24H Set Relative Record

```
mov      ax,file_length      ;get original file
                                ;length
ran_block_write fcb,1,ax     ;see Function 28H
close    fcb                 ;see Function 10H
```

25H

Set Vector

Call AH = 25H
 AL
 Interrupt number
 DS:DX
 Interrupt-handling routine

Return None

Remarks Function 25H should be used to set a particular interrupt vector. The operating system can then manage the interrupts on a per-process basis. Note that programs should never set interrupt vectors by writing them directly in the low memory vector table.

DX must contain the offset (to the segment address in DS) of an interrupt-handling routine. AL must contain the number of the interrupt handled by the routine. The address in the vector table for the specified interrupt is set to DS:DX.

Macro set_vector macro interrupt, seg_addr, off_addr
 push ds
 mov ax, seg_addr
 mov ds, ax
 mov dx, off_addr
 mov al, interrupt
 mov ah, 25H
 int 21H
 pop ds
 endm

Example lds dx, intvector
 mov ah, 25H
 mov al, intnumber
 int 21H
 ;There are no errors returned

27H Random Block Read

Call AH = 27H
 DS:DX
 Opened FCB
CX
 Number of blocks to read

Return **AL**
 00H = Read completed successfully
 01H = EOF
 02H = End of segment
 03H = EOF, partial record
CX
 Number of blocks read

Remarks DX must contain the offset (to the segment address in DS) of an opened FCB. CX must contain the number of records to read; if it contains 0, the function returns without reading any records (no operation). The specified number of records, calculated from the Record Size field (offset 0EH), is read starting at the record specified by the Relative Record field (offset 21H). The records are placed at the Disk Transfer Address.

AL returns a code that describes the processing:

Code	Meaning
0	Read completed successfully
1	End-of-file; no data in the record
2	not enough room at the Disk Transfer Address to read one record without overflowing a segment boundary; read cancelled
3	End-of-file; a partial record was read and padded to the record length with zeros

27H Random Block Read

CX returns the number of records read; the Current Block (offset 0CH), Current Record (offset 20H), and Relative Record (offset 21H) fields are set to address the next record.

Macro

```
ran_block_read macro fcb,count,rec_size
    mov  dx,offset fcb
    mov  cx,count
    mov  word ptr fcb[14],rec_size
    mov  ah,27H
    int  21H
endm
```

Example

The following program copies a file using the Random Block Read system call. It speeds the copy by specifying a record count of 1 and a record length equal to the file size, and using a buffer of 32K bytes; the file is read as a single record (compare to the sample program for Function 28H that specifies a record length of 1 and a record count equal to the file size):

```
current_record equ 32                ;offset of Current Record
                                        ;field
fsize          equ 16                ;offset of File Size
                                        ;field
.
fcb            db 37 dup (?)
filename       db 17 dup(?)
prompt1        db "File to copy: $"   ;see Function 09H for
prompt2        db "Name of copy: $"   ;explanation of $
crlf           db 13,10,"$"
.
file_length    dw ?
buffer         db 32767 dup(?)
.
func_27H:      set_dta buffer         ;see Function 1AH
```

```
display prompt1           ;see Function 09H
get_string 15,filename    ;see Function 0AH
display crlf             ;see Function 09H
parse filename[2],fcb    ;see Function 29H
open fcb                 ;see Function 0FH
mov fcb[current_record],0 ;set Current Record
                          ;field
set_relative_record fcb   ;see Function 24H
mov ax,word ptr fcb[fsize] ;get file size
mov file_length,ax       ;save it for
                          ;ran_block_write
ran_block_read fcb,1,ax   ;THIS FUNCTION
display prompt2         ;see Function 09H
get_string 15,filename    ;see Function 0AH
display crlf             ;see Function 09H
parse filename[2],fcb    ;see Function 29H
create fcb               ;see Function 16H
mov fcb[current_record],0 ;set Current Record
                          ;field
set_relative_record fcb   ;see Function 24H
mov ax,file_length       ;get original file
                          ;size
ran_block_write fcb,1,ax  ;see Function 28H
close fcb
```

28H

Random Block Write

Call AH = 28H
 DS:DX
 Opened FCB
 CX
 Number of blocks to write
 (0 = set File Size field)

Return AL
 00H = Write completed successfully
 01H = Disk full
 02H = End of segment
 CX
 Number of blocks written

Remarks DX must contain the offset (to the segment address in DS) of an opened FCB; CX must contain either the number of records to write or 0. The specified number of records (calculated from the Record Size field, offset 0EH) is written from the Disk Transfer Address. The records are written to the file starting at the record specified in the Relative Record field (offset 21H) of the FCB. If CX is 0, no records are written, but the File Size field of the directory entry (offset 10H) is set to the number of records specified by the Relative Record field of the FCB (offset 21H); allocation units are allocated or released, as required.

AL returns a code that describes the processing:

Code	Meaning
0	Write completed successfully
1	Disk full. No records written.
2	Not enough room at the Disk Transfer Address to write one record without overflowing a segment boundary; write canceled.

CX returns the number of records written; the current block (offset 0CH), Current Record (offset 20H), and Relative Record (offset 21H) fields are set to address the next record.

Macro

```
ran_block_write macro fcb,count,rec_size
    mov  dx,offset fcb
    mov  cx,count
    mov  word ptr fcb[14],rec_size
    mov  ah,28H
    int  21H
endm
```

Example

The following program copies a file using the Random Block Read and Random Block Write system calls. It copies by specifying a record count equal to the file size and a record length of 1, and using a buffer of 32K bytes; the file is copied with one disk access each to read and write (compare to the sample program of Function 27H, that specifies a record count of 1 and a record length equal to file size):

```
current_record equ 32                ;offset of Current Record
                                        ;field
fsize          equ 16                ;offset of File Size
                                        ;field
.
fcb            db 37 dup (?)
filename       db 17 dup(?)
prompt1       db "File to copy: $"   ;see Function 09H for
prompt2       db "Name of copy: $"  ;explanation of $
crlf          db 13,10,"$"

num_recs      dw ?
buffer        db 32767 dup(?)
```

28H Random Block Write

```
func_28H: set_dta    buffer                ;see Function 1AH
          display   prompt1              ;see Function 09H
          get_string 15,filename          ;see Function 0AH
          display   crlf                 ;see Function 09H
          parse     filename[2],fcb      ;see Function 29H
          open      fcb                  ;see Function 0FH
          mov       fcb[current_record],0;set Current Record
                                     ;field
          set_relative_record fcb        ;see Function 24H
          mov       ax,word ptr fcb[fsize];get file size
          mov       num_recs, ax         ;save it for
                                     ;ran_block_write
          ran_block_read fcb,num_recs,1 ;see Function 27H
          display   prompt2              ;see Function 09H
          get_string 15,filename          ;see Function 0AH
          display   crlf                 ;see Function 09H
          parse     filename[2],fcb      ;see Function 29H
          create    fcb                  ;see Function 16H
          mov       fcb[current_record],0;set Current Record
                                     ;field
          set_relative_record fcb        ;see Function 24H
          ran_block_write fcb,num_recs,1;THIS FUNCTION
          close     fcb                  ;see Function 10H
```

29H Parse File Name

Call	AH = 29H AL Controls parsing (see text) DS:SI String to parse ES:DI Unopened FCB
Return	AL 00H = No wild card characters 01H = Wild-card characters used FFH = Drive letter invalid DS:SI First byte past string that was parsed ES:DI Unopened FCB
Remarks	SI must contain the offset (to the segment address in DS) of a string (command line) to parse; DI must contain the offset (to the segment address in ES) of an unopened FCB. The string is parsed for a filename of the form d:filename.ext; if one is found, a corresponding unopened FCB is created at ES:DI. Bits 0-3 of AL control the parsing and processing. Bits 4-7 are ignored:

29H

Parse File Name

Bit	Value	Meaning
0	0	All parsing stops if a file separator is encountered.
	1	Leading separators are ignored.
1	0	The drive number in the FCB is set to 0 (default drive) if the string does not contain a drive number.
	1	The drive number in the FCB is not changed if the string does not contain a drive number.
2	0	The filename in the FCB is set to 8 blanks if the string does not contain a filename.
	1	The filename in the FCB is not changed if the string does not contain a filename.
3	0	The extension in the FCB is set to 3 blanks if the string does not contain an extension.
	1	The extension in the FCB is not changed if the string does not contain an extension.

If the filename or extension includes an asterisk (*), all remaining characters in the name or extension are set to question mark (?).

Filename separators:

: . ; , = + / " [] \ < > | space tab

Filename terminators include all the filename separators plus any control character. A filename cannot contain a filename terminator; if one is encountered, parsing stops.

If the string contains a valid filename:

AL returns 1 if the filename or extension contains a wild card character (* or ?); AL returns 0 if neither the filename nor extension contains a wild card character.

DS:SI point to the first character following the string that was parsed.

ES:DI point to the first byte of the unopened FCB.

If the drive letter is invalid, AL returns FFH. If the string does not contain a valid filename, ES:DI+1 points to a blank (ASCII 20H).

29H

Parse File Name

Macro

```
parse macro string, fcb
    mov si, offset string
    mov di, offset fcb
    push es
    push ds
    pop es
    mov al,0FFH ;bits 0, 1, 2, 3 on
    mov ah,29H
    int 21H
    pop es
endm
```

Example

The following program verifies the existence of the file named in reply to the prompt:

```
fcb          db 37 dup (?)
prompt      db "Filename: $"
reply       db 17 dup (?)
yes         db "FILE EXISTS", 13,10,"$"
no          db "FILE DOES NOT EXIST", 13,10,"$"
crlf        db 13,14,"$"
.
.
func_29H:   display    prompt          ;see Function 09H
            get_string 15,reply        ;see Function 0AH
            display    crlf            ;see Function 09H
            parse      reply[2],fcb    ;THIS FUNCTION
            search_first fcb          ;see Function 11H
            cmp        al,0FFH         ;dir. entry found?
            je         not_there       ;no
            display    yes             ;see Function 09H
            jmp        continue
not_there:  display    no
continue:   .
```

2AH Get Date

Call AH = 2AH

Return CX
Year (1980-2099)
DH
Month (1-12)
DL
Day (1-31)
AL
Day of week (0 = Sunday, 6 = Saturday)

Remarks This function returns the current date set in the operating system as binary numbers in CX and DX:

CX Year (1980-2099)
DH Month (1 = January, 2 = February, etc.)
DL Day (1-31)
AL Day of week (0 = Sunday, 1 = Monday, etc.)

Macro

```
get_date macro
    mov ah,2AH
    int 21H
endm
```

Example The following program gets the date, increments the day, increments the month or year, if necessary, and sets the new date:

2AH Get Date

```
month      db      31,28,31,30,31,30,31,31,30,31,30,31
           .
           .
func_2AH:  get_date      ;see above
           inc          dl          ;increment day
           xor          bx,bx      ;so BL can be used as index
           mov          bl,dh      ;move month to index register
           dec          bx          ;month table starts with 0
           cmp          dl,month[bx] ;past end of month?
           jle          month_ok   ;no, set the new date
           mov          dl,1        ;yes, set day to 1
           inc          dh          ;and increment month
           cmp          dh,12       ;past end of year?
           jle          month_ok   ;no, set the new date
           mov          dh,1        ;yes, set the month to 1
           inc          cx          ;increment year
month_ok:  set_date cx,dh,dl      ;THIS FUNCTION
```

2BH Set Date

Call AH = 2BH
 CX
 Year (1980-2099)
 DH
 Month (1-12)
 DL
 Day (1-31)

Return AL
 00H = Date was valid
 FFH = Date was invalid

Remarks Registers CX and DX must contain a valid date
 in binary:

 CX Year (1980-2099)
 DH Month (1 = January, 2 = February, etc.)
 DL Day (1-31)

If the date is valid, the date is set and AL
returns 0. If the date is not valid, the function is
canceled and AL returns FFH.

Macro set_date macro year,month,day
 mov cx,year
 mov dh,month
 mov dl,day
 mov ah,2BH
 int 21H
 endm

2BH Set Date

Example The following program gets the date, increments the day, increments the month or year, if necessary, and sets the new date:

```
month        db            31,28,31,30,31,30,31,31,30,31,30,31
.
.
func_2BH:    get_date                ;see Function 2AH
            inc            dl            ;increment day
            xor            bx,bx        ;so BL can be used as index
            mov            bl,dh        ;move month to index register
            dec            bx            ;month table starts with 0
            cmp            dl,month[bx] ;past end of month?
            jle            month_ok     ;no, set the new date
            mov            dl,1        ;yes, set day to 1
            inc            dh            ;and increment month
            cmp            dh,12        ;past end of year?
            jle            month_ok     ;no, set the new date
            mov            dh,1        ;yes, set the month to 1
            inc            cx            ;increment year
month_ok:    set date cx,dh,dl        ;THIS FUNCTION
```

2CH Get Time

Call AH = 2CH

Return CH
Hour (0-23)
CL
Minutes (0-59)
DH
Seconds (0-59)
DL
Hundredths (0-99)

Remarks This function returns the current time set in the operating system as binary numbers in CX and DX:

CH Hour (0-23)
CL Minutes (0-59)
DH Seconds (0-59)
DL Hundredths of a second (0-99)

Macro

```
get_time macro
    mov    ah,2CH
    int   21H
endm
```

Example The following program continuously displays the time until any key is pressed:

2CH Get Time

```
time      db      "00:00:00.00",13,"$"
ten       db      10
.
.
func_2CH: get_time      ;THIS FUNCTION
           convert ch,ten,time ;see end of chapter
           convert c1,ten,time[3] ;see end of chapter
           convert dh,ten,time[6] ;see end of chapter
           convert d1,ten,time[9] ;see end of chapter
           display time ;see Function 09H
           check_kbd_status ;see Function 0BH
           cmp      a1,0FFH ;has a key been pressed?
           je      all_done ;yes, terminate
           jmp     func_2CH ;no, display time
all_done: .
.
.
```


2DH Set Time

Call AH = 2DH
 CH
 Hour (0-23)
 CL
 Minutes (0-59)
 DH
 Seconds (0-59)
 DL
 Hundredths (0-99)

Return AL
 00H = Time was valid
 FFH (255) = Time was invalid

Remarks Registers CX and DX must contain a valid time
 in binary:

 CH Hour (0-23)
 CL Minutes (0-59)
 DH Seconds (0-59)
 DL Hundredths of a second (0-99)

If the time is valid, the time is set and AL returns 0. If the time is not valid, the function is canceled and AL returns FFH (255).

Macro set_time macro hour,minutes,seconds,hundredths
 mov ch,hour
 mov cl,minutes
 mov dh,seconds
 mov dl,hundredths
 mov ah,2DH
 int 21H
 endm

2DH Set Time

Example The following program acts as a stopwatch. When a character is typed, it sets the system clock to zero and begins to continuously display the time. When a second character is typed the system stops updating the time display.

```
time            db            "00:00:00.00",13,"$"
ten            db            10
.
.
func_2DH:      dir_console_io  OFFH            ;see Function 06H
              jz            func_2DH        ;wait for keystroke
              set_time      0,0,0,0        ;THIS FUNCTION
read_clock:    get_time            ;see Function 2CH
              convert ch,ten,time        ;see end of chapter
              convert cl,ten,time[3]     ;see end of chapter
              convert dh,ten,time[6]     ;see end of chapter
              convert dl,ten,time[9]     ;see end of chapter
              display time                ;see Function 09H
              dir_console_io  OFFH        ;THIS FUNCTION
              jz            read_clock     ;no char, keep updating
continue:      .
              .
```

2EH Set/Reset Verify Flag

Call AH = 2EH
AL
00H = Do not verify
01H = Verify

Return None

Remarks AL must be either 1 (verify after each disk write) or 0 (write without verifying). MS-DOS checks this flag each time it writes to a disk.

The flag is normally off; you may wish to turn it on when writing critical data to disk. Because disk errors are rare and verification slows writing, you will probably want to leave it off at other times.

Macro verify macro switch
mov al,switch
mov ah,2EH
int 21H
endm

Example The following program copies the contents of a single-sided disk in drive A: to the disk in drive B:, verifying each write. It uses a buffer of 32K bytes:

```
on          equ    1
off         equ    0
.
.
prompt     db      "Source in A, target in B",13,10
           db      "Any key to start. $"
start      dw      0
buffer     db      64 dup (512 dup(?)) ;64 sectors
```

2EH Set/Reset Verify Flag

```
func_2EH:  display prompt           ;see Function 09H
           read_kbd                 ;see Function 08H
           verify on                 ;THIS FUNCTION
           mov     cx,5              ;copy 64 sectors
                                           ;5 times
copy:      push     cx               ;save counter
           abs_disk_read 0,buffer,64,start ;see Interrupt 25H
           abs_disk_write 1,buffer,64,start ;see Interrupt 26H
           add     start,64          ;do next 64 sectors
           pop     cx               ;restore counter
           loop   copy              ;do it again
           verify off                ;THIS FUNCTION
```

2FH Get Disk Transfer Address

Call AH = 2FH

Return ES:BX
 Points to Disk Transfer Address

Macro ;
 get_dta macro
 mov 2h,2fh
 int 21h
 endm

30H

Get DOS Version Number

Call AH = 30H

Return AL
Major version number
AH
Minor version number
BH
OEM number
BL:CX
User number (24 bits)

Remarks On return, AL:AH will be the two-part version designation; i.e., for MS-DOS 1.28, AL would be 1 and AH would be 28. For pre-1.28 DOS AL = 0. Note that version 1.1 is the same as 1.10, not the same as 1.01.

Macro

```
;  
get_version_num macro  
    mov ah,30h  
    int 21h  
endm
```

31H Keep Process

Call AH = 31H
 AL
 Exit code
 DX
 Memory size, in paragraphs

Return None

Remarks This call terminates the current process and attempts to set the initial allocation block to a specific size in paragraphs. It will not free up any other allocation blocks belonging to that process. The exit code passed in AX is retrievable by the parent via Function 4DH.

This method is preferred over Interrupt 27H and has the advantage of allowing more than 64K to be kept.

Macro ;
 keep_process macro exitcode,parasize
 mov al,exitcode
 mov dx,parasize
 mov ah,31h
 int 21h
 endm

33H <CTRL C> Check

Call	AH = 33H AL Function 00H = Request current state 01H = Set state DL (if setting state) 00H = Off 01H = On
Return	DL 00H = Off 01H = On
Remarks	MS-DOS ordinarily checks for a CTRL C on the controlling device only when doing function call operations 01H-0CH to that device. Function 33H allows the user to expand this checking to include any system call. For example, with the CTRL C trapping off, all disk I/O will proceed without interruption; with CTRL C trapping on, the CTRL C interrupt is given at the system call that initiates the disk operation.
Note	Programs that wish to use calls 06H or 07H to read CTRL C 's as data must ensure that the CTRL C check is off.
Error Returns	AL = FF The function passed in AL was not in the range 0:1.

Macro

```
;  
ctrl_c_check macro switch,val  
    mov  dl,val  
    mov  al,switch  
    mov  ah,33h  
    int  21h  
endm
```

35H

Get Interrupt Vector

Call AH = 35H
 AL
 Interrupt number

Return ES:BX
 Pointer to interrupt routine

Remarks This function returns the interrupt vector associated with an interrupt. Note that programs should never get an interrupt vector by reading the low memory vector table directly.

Macro ;
 get_vector macro interrupt
 mov al,interrupt
 mov ah,35h
 int 21h
 endm

36H Get Disk Free Space

Call	AH = 36H DL Drive (0 = Default, 1 = A, etc.)
Return	AX FFFF if drive number is invalid; otherwise sectors per cluster BX Available clusters CX Bytes per sector DX Clusters per drive
Remarks	This function returns free space on a disk along with additional information about the disk.
Error Returns	AX = FFFF The drive number given in DL was invalid.
Macro	; get_disk_space macro drive mov d1,drive mov ah,36h int 21h endm

38H

Return Country-Dependent Information

Call AH = 38H
DS:DX
Pointer to 32-byte memory area
AL
Function code.

Return Carry set:
AX
2 = file not found
Carry not set:
DX:DS filled in with country data

Remarks The value passed in AL is either 0 (for current country) or a country code. Country codes are typically the international telephone prefix code for the country.

If DX = -1, then the call sets the current country (as returned by the AL = 0 call) to the country code in AL. If the country code is not found, the current country is not changed.

Note Applications must assume 32 bytes of information. This means the buffer pointed to by DS:DX must be able to accommodate 32 bytes.

This function is fully supported only in versions of MS-DOS 2.01 and higher. It exists in MS-DOS 2.0, but is not fully implemented.

This function returns, in the block of memory pointed to by DS:DX, information pertinent to international applications. The contents of the block are shown in the following table.

Return Country-Dependent Information

WORD Date/time format
5 BYTE ASCII string currency symbol
2 BYTE ASCII string thousands separator
2 BYTE ASCII string decimal separator
2 BYTE ASCII string date separator
2 BYTE ASCII string time separator
1 BYTE Bit field
1 BYTE Currency places
1 BYTE time format
DWORD Case Mapping call
2 BYTE ASCII string data list separator

38H

Return Country-Dependent Information

The format of most of the entries is ASCIIZ (a NUL terminated ASCII string), but a fixed size is allocated for each field for easy indexing into the table.

The date/time format (see table) has the following values:

- 0 — USA standard h:m:s m/d/y
- 1 — Europe standard h:m:s d/m/y
- 2 — Japan standard y/m/d h:m:s

The bit field contains 8 bit values. Any bit not currently defined must be assumed to have a random value.

Bit 0 = 0 If currency symbol precedes the currency amount.

= 1 If currency symbol comes after the currency amount.

Bit 1 = 0 If the currency symbol is directly adjacent to the currency amount.

= 1 If there is a space between the currency symbol and the amount.

The time format has the following values:

- 0 - 12 hour time
- 1 - 24 hour time

The currency places field indicates the number of places which appear after the decimal point on currency amounts.

The Case Mapping call is a FAR procedure which will perform country specific lower-to-upper case mapping on character values from 80H to FFH. It is called with the character to be mapped in AL. It returns the correct upper case code for that character, if any, in AL. AL and the FLAGS are the only registers altered. It is allowable to pass this routine codes below 80H; however nothing is done to characters in this range. In the case where there is no mapping, AL is not altered.

**Error
Returns**

AX
2 = file not found

The country passed in AL was not found (no table for specified country).

38H

Return Country-Dependent Information

Macro

```
;  
get_country_info macro buffer, country  
    mov dx,offset buffer  
    mov al,country          ;country = 0  
    mov ah,38h  
    int 21h  
endm
```


39H Create Sub-Directory

Call AH = 39H
 DS:DX
 Pointer to path name

Return Carry set:
 AX
 3 = path not found
 5 = access denied
 Carry not set:
 No error

Remarks Given a pointer to an ASCIIIZ name, this function creates a new directory entry at the end.

Error Returns AX
 3 = path not found

 The path specified was invalid or not found.

 5 = access denied

 The directory could not be created (no room in parent directory), the directory/file already existed or a device name was specified.

Macro ;
 mkdir macro name
 mov dx,offset name
 mov ah,39h
 int 21h
 endm

3AH

Remove a Directory

Call	AH = 3AH DS:DX Pointer to path name
Return	Carry set: AX 3 = path not found 5 = access denied 16 = current directory Carry not set: No error
Remarks	Function 3AH is given an ASCIIZ name of a directory. That directory is removed from its parent directory.
Error Returns	AX 3 = path not found The path specified was invalid or not found. 5 = access denied The path specified was not empty, not a directory, the root directory, or contained invalid information. 16 = current directory The path specified was the current directory on a drive.
Macro	; rmdir macro name mov dx,offset name mov ah,3ah int 21h endm

3BH Change the Current Directory

Call AH = 3BH
DS:DX
Pointer to path name

Return Carry set:
AX
3 = path not found
Carry not set:
No error

Remarks Function 3BH is given the ASCIIZ name of the directory which is to become the current directory. If any member of the specified pathname does not exist, then the current directory is unchanged. Otherwise, the current directory is set to the string.

Error Returns AX
3 = path not found

The path specified in DS:DX either indicated a file or the path was invalid.

Macro

```
;  
chdir macro name  
    mov dx,offset name  
    mov ah,3bh  
    int 21h  
endm
```

3CH

Create a File

Call AH = 3CH
 DS:DX
 Pointer to path name
CX
 File attribute

Return Carry set:
 AX
 3 = path not found
 4 = too many open files
 5 = access denied
 Carry not set:
 AX is handle number

Remarks Function 3CH creates a new file or truncates an old file to zero length in preparation for writing. DS:DX must point to an ASCIIZ path to the file. If the file did not exist, then the file is created in the appropriate directory and the file is given the attribute found in CX. The given attribute byte is placed at offset 0BH in the file's directory entry. See the section on "Diskette Directory" in chapter 5 for details about the attribute byte. The file handle returned has been opened for read/write access.

**Error
Returns**

AX

3 = path not found

The path specified was invalid.

4 = too many open files

5 = access denied

The attributes specified in CX contained one that could not be created (directory, volume ID), a file already existed with a more inclusive set of attributes, or a directory existed with the same name.

The file was created with the specified attributes, but there were no free handles available for the process, or the internal system tables were full.

Macro

```
;  
create_file macro name,attrib  
    mov    dx,offset name  
    mov    cx,attrib  
    mov    ah,3ch  
    int    21h  
endm
```

3DH

Open a File Handle

Call AH = 3DH
 AL
 Access
 0 = file opened for reading
 1 = file opened for writing
 2 = file opened for both
 reading and writing
 DS:DX
 pointer to pathname

Return Carry set:
 AX
 2 = file not found
 4 = too many open files
 5 = access denied
 12 = invalid access
 Carry not set
 AX is handle number

Remarks Function 3DH associates a 16-bit handle with a file.

The following values are allowed:

ACCESS	Function
0	opened for reading
1	opened for writing
2	opened for both reading and writing.

DS:DX point to an ASCII name of the file to be opened.

The read/write pointer is set at the first byte of the file and the record size of the file is 1 byte. The returned file handle must be used for subsequent I/O to the file.

**Error
Returns**

AX

2 = file not found

The path specified was invalid or not found.

4 = too many open files

There were no free handles available in the current process or the internal system tables were full.

5 = access denied

The user attempted to open a directory or volume-id, or open a read-only file for writing.

12 = invalid access

The access specified in AL was not in the range 0:2.

Macro

```
;  
open_handle macro name, access  
    mov dx,offset name  
    mov al,access  
    mov ah,3dh  
    int 21h  
endm
```

3EH

Close a File Handle

Call AH = 3EH
 BX
 File handle

Return Carry set:
 AX
 6 = invalid handle
 Carry not set:
 No error

Remarks If BX is passed a file handle (like that returned by Functions 3CH, 3DH, or 45H), Function 3EH closes the associated file. Internal buffers are flushed to disk.

Error Returns AX
 6 = invalid handle

The handle passed in BX was not currently open.

Macro ;
 close_handle macro handle
 mov bx,handle
 mov ah,3eh
 int 21h
 endm

3FH

Read From File/Device

Call

AH = 3FH
DS:DX
 Pointer to buffer
CX
 Bytes to read
BX
 File handle

Return

Carry set:
AX
 5 = error set:
 6 = invalid handle
Carry not set:
 AX = number of bytes read

Remarks

Function 3FH transfers a specified number of bytes from a file into a buffer location. It is not guaranteed that the number of bytes requested will be read; for example, reading from the keyboard will read at most one line of text. If the returned value is zero, then the program has tried to read from the end of file.

All I/O is done using normalized pointers; no segment wraparound will occur.

Error Returns

AX
 5 = access denied

The handle passed in BX was opened in a mode that did not allow reading.

6 = invalid handle

The handle passed in BX was not currently open.

3FH

Read From File/Device

Macro

```
;  
read_from_handle macro buffer,bytes,handle  
    mov dx,offset buffer  
    mov cx,bytes  
    mov bx,handle  
    mov ah,3fh  
    int 21h  
endm
```

40H Write to a File or Device

Call AH = 40H
 DS:DX
 Pointer to buffer
 CX
 Bytes to write
 BX
 File handle

Return Carry set:
 AX
 5 = access denied
 6 = invalid handle
 Carry not set:
 AX = number of bytes written

Remarks Function 40H transfers a specified number of bytes from a buffer into a file. It should be regarded as an error if the number of bytes written is not the same as the number requested.

The write system call with a count of zero (CX = 0) will set the file size to the current position. Allocation units are allocated or released as required.

All I/O is done using normalized pointers; no segment wraparound will occur.

40H

Write to a File or Device

Error Returns

AX

5 = access denied

The handle was not opened in a mode that allowed writing.

6 = invalid handle

The handle passed in BX was not currently open.

Macro

```
;  
write_to_handle macro buffer,bytes,handle  
    mov dx,offset buffer  
    mov cx, bytes  
    mov bx,handle  
    mov ah,40h  
    int 21h  
endm
```

41H Delete a Directory Entry

Call AH = 41H
DS:DX
Pointer to path name

Return Carry set:
AX
2 = file not found
5 = access denied
Carry not set:
No error

Remarks Function 41H deletes the file named in the ASCII string pointed to by DS:DX.

Error Returns AX
2 = file not found
The path specified was invalid or not found.
5 = access denied
The path specified was a directory or read-only.

Macro ;
erase macro name
mov dx,offset name
mov ah,41h
int 21h
endm

42H

Move File Pointer

Call AH = 42H
 CX:DX
 Distance to move, in bytes
 AL
 Method of moving:
 (see text)
 BX
 File handle

Return Carry set:
 AX
 1 = invalid function
 6 = invalid handle
 Carry not set:
 DX:AX = new pointer location

Remarks Function 42H moves the read/write pointer according to one of the following methods:

Method	Function
0	the pointer is moved to offset bytes from the beginning of the file
1	the pointer is moved to the current location plus offset
2	the pointer is moved to the end of file plus offset

Offset should be regarded as a 32-bit integer with CX occupying the most significant 16 bits.

**Error
Returns**

AX

1 = invalid function

The function passed in AL was not in the range 0:2.

6 = invalid handle

The handle passed in BX was not currently open.

Macro

```
;  
move_pointer macro highword,lowword,switch,  
                handle  
    mov    dx,lowword  
    mov    cx,highword  
    mov    al,switch  
    mov    bx,handle  
    mov    ah,42h  
    int   21h  
    endm
```

43H

Change Attributes

Call AH = 43H
 DS:DX
 Pointer to path name
 AL
 Function
 00 Return in CX
 01 Set to CX
 CX (if AL = 01)
 Attribute to be set

Return Carry set:
 AX
 1 = invalid function
 3 = path not found
 5 = access denied
 Carry not set:
 CX attributes (if AL = 00)

Remarks Given an ASCIIZ name pointed to by DS:DX, Function 42H will set/get the attributes of the file to those given in CX. See the section on “Diskette Directory” in chapter 5 for a description of the attribute byte.

A function code is passed in AL:

AL	Function
0	return the attributes of the file in CX
1	set the attributes of the file to those in CX

**Error
Returns**

AX

1 = invalid function

The function passed in AL was not in the range 0:1.

3 = path not found

The path specified was invalid.

5 = access denied

The attributes specified in CX contained one that could not be changed (directory, volume ID).

Macro

```
;  
change_attr macro name,attrib,switch  
    mov dx,offset name  
    mov cx,attrib  
    mov al,switch  
    mov ah,43h  
    int 21h  
endm
```

44H

I/O Control for Devices

Call

- AH = 44H
- BX
Handle
- BL
Drive (for function codes 4 and 5;
0 = default, 1 = A., etc.)
- DS:DX
Data or buffer
- CX
Bytes to read or write
- AL
Function code; see text

Return

Carry set:

- AX
 - 1 = invalid function
 - 5 = access denied
 - 6 = invalid handle
 - 13 = invalid data

Carry not set:

- Function Code = 2,3,4,5
- AX = Count transferred
- Function Code = 6,7
- AL
 - 00 = Not ready
 - FF = Ready

Remarks

Function 44H sets or gets device information associated with an open handle, or sends/receives a control string to a device handle or device.

The inputs to AL are function numbers, for which there are returns. The function number values and functions are discussed below.

The following values are allowed in AL as function codes:

Call	Function
0	get device information (returned in DX)
1	set device information (as determined by DX)
2	read CX number of bytes into DS:DX from device control channel
3	write CX number of bytes from DS:DX to device control channel
4	read CX number of bytes into DS:DX from disk (drive number in BL)
5	write CX number of bytes from DS:DX to disk (drive number in BL)
6	get input status
7	get output status

This function can be used to get information about device channels. Calls can be made on regular files, but only calls 0,6 and 7 are defined in that case (AL = 0,6,7). All other calls return an invalid function error.

Calls 0,1: The bits of DX are defined as follows for calls AL = 0 and AL = 1. Note that the upper byte **MUST** be zero on a set call.

44H
I/O Control for Devices

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	C							I	E	R	S	I	I	I	I
e	T							S	O	A	P	S	S	S	S
s	R		Reserved					D	F	W	E	C	N	C	C
	L							E		C	L	U	O	I	
								V		L	K	L	T	N	

ISDEV = 1 if this channel is a device
 = 0 if this channel is a disk file
 (Bits 8-15 = 0 in this case)

If ISDEV = 1

- EOF = 0 if End Of File on input
- RAW = 1 if this device is in Raw mode
 = 0 if this device is cooked
- SPECL = 1 if this device is special
- ISCLK = 1 if this device is the clock device
- ISNUL = 1 if this device is the null device
- ISCOT = 1 if this device is the console output
- ISCIN = 1 if this device is the console input

CTRL = 0 if this device cannot do control strings
 via calls AL = 2 and AL = 3

CTRL = 1 if this device can process control
 strings via calls AL = 2 and AL = 3.

NOTE that this bit cannot be set.

If ISDEV = 0

EOF = 0 if channel has been written
 Bits 0-5 are the block device number for the
 channel (0 = A:, 1 = B:, ...)

NOTE: Bits 15,8-13,4 are reserved and should not be altered.

Calls 2..5: These four calls allow arbitrary control strings to be sent or received from a device. The call syntax is the same as the read and write system calls, except for 4 and 5, which take a drive number in BL instead of a handle in BX.

An invalid function error is returned if the CTRL bit (see above) is 0.

An access denied error is returned by calls AL = 4,5 if the drive number is invalid.

Calls 6,7: These two calls allow the user to check if a file handle is ready for input or output. Status of handles open to a device is the intended use of these calls, but status of a handle open to a disk file is allowed, and is defined as follows:

For input:

- Always ready (AL = FF) until EOF reached, then always not ready (AL = 0) unless current position changed via Function Request 42H (LSEEK).

For output:

- Always ready (even if disk full).

The status is defined at the time the system is CALLED. On future versions, by the time control is returned to the user from the system, the status returned may NOT correctly reflect the true current state of the device or file.

44H I/O Control for Devices

Error Returns

AX

1 = invalid function

The function passed in AL was not in the range 0:7.

5 = access denied (calls AL = 4,5)

6 = invalid handle

The handle passed in BX was not currently open.

13 = invalid data

Macro

```
;  
io_ctrl_dev macro handle,buffer,bytes,switch  
    mov  bx,handle           ;or 8-bit drive number  
    mov  dx,offset buffer  
    mov  cx,bytes  
    mov  al,switch  
    mov  2h,44h  
    int  21h  
endm
```

45H Duplicate a File Handle

Call	AH = 45H BX File handle
Return	Carry set: AX 4 = too many open files 6 = invalid handle Carry not set: AX = new file handle
Remarks	Function 45H takes an already opened file handle and returns a new handle that refers to the same file at the same position.
Error Returns	AX 4 = too many open files There were no free handles available in the current process or the internal system tables were full. 6 = invalid handle The handle passed in BX was not currently open.
Example	<pre>mov bx,fh mov ah,45H int 21H ;ax has the returned handle</pre>

46H

Force a Duplicate of a Handle

Call	AH = 46H BX Existing file handle CX New file handle
Return	Carry set: AX 4 = too many open files 6 = invalid handle Carry not set: No error
Remarks	Function 46H takes an already opened file handle and returns a new handle that refers to the same file at the same position. If there was already a file open on handle CX, it is closed first.
Error Returns	AX 4 = too many open files The internal system tables were full. 6 = invalid handle The handle passed in BX was not currently open.
Example	<pre>mov bx,fh mov cx,newfh mov ah,46H int 21H</pre>

47H

Return Name of Current Directory

Call AH = 47H
DS:SI
 Pointer to 64-byte memory area
DL
 Drive number

Return Carry set:
AX
 15 = invalid drive
Carry not set:
 No error

Remarks Function 47H returns an ASCII string giving the name of the current directory for a particular drive. The directory is root-relative and does not contain the drive specifier or leading path separator. The drive code passed in DL is 0 = default, 1 = A:, 2 = B:, etc.

Error Returns AX
15 = invalid drive

 The drive specified in DL was invalid.

Macro ;
duplicate_handle macro handle
 mov bx,handle
 mov ah,45h
 int 21h
endm

48H

Allocate Memory

Call AH = 48H
 BX
 Size of memory to be allocated in paragraphs

Return Carry set:
 AX
 7 = arena trashed
 8 = not enough memory
 BX
 Maximum size that could be allocated
 Carry not set:
 AX:0
 Pointer to the allocated memory

Remarks Function 48H returns a pointer to a free block of memory that has the requested size in paragraphs.

Error Returns AX
 7 = arena trashed

The internal consistency of the memory arena has been destroyed. This is due to a user program changing memory that does not belong to it, thus destroying the memory manager allocation marks.

8 = not enough memory

The largest available free block is smaller than that requested or there is no free block.

Macro

```
;  
force_handle macro old,new  
    mov  bx,old  
    mov  cx,new  
    mov  ah,46h  
    int  21h  
endm
```

49H

Free Allocated Memory

Call AH = 49H
 ES
 Segment address of memory
 area to be freed

Return Carry set:
 AX
 7 = arena trashed
 9 = invalid block
 Carry not set:
 No error

Remarks Function 49H returns a piece of previously allo-
 cated memory to the system pool.

Error AX
Returns 7 = arena trashed

 The internal consistency of the memory
 arena has been destroyed. This is due to a
 user program changing memory that does
 not belong to it, thus destroying the
 memory manager allocation marks.

 9 = invalid block

 The block passed in ES is not one allo-
 cated via Function Request 48H.

Macro ;
 cur_dir_name macro buffer,drive
 mov si,offset buffer
 mov d1,drive
 mov ah,47h
 int 21h
 endm

4AH Modify Allocated Memory Blocks

Call	AH = 4AH ES Segment address of memory area BX Requested memory area size
Return	Carry set: AX 7 = arena trashed 8 = not enough memory 9 = invalid block BX Maximum size possible Carry not set: No error
Remarks	Function 4AH will attempt to grow/shrink an allocated block of memory.
Error Returns	AX 7 = arena trashed The internal consistency of the memory arena has been destroyed. This is due to a user program changing memory that does not belong to it, thus destroying the memory manager allocation marks. 8 = not enough memory There was not enough free memory after the specified block to satisfy the grow request. 9 = invalid block The block passed in ES is not one allocated via this function.

4AH Modify Allocated Memory Blocks

Macro ;
 alloc_mem macro size
 mov bx,size
 mov ah,48h
 int 21h
 endm

4BH Load and Execute a Program (EXEC)

Call AH = 4BH
DS:DX
 Pointer to pathname
ES:BX
 Pointer to parameter block
AL
 00 = Load and execute program
 03 = Load program

Return Carry set:
AX
 1 = invalid function
 2 = file not found
 8 = not enough memory
 10 = bad environment
 11 = bad format
Carry not set:
 No error

Remarks This function allows a program to load another program into memory and optionally begin execution of it. DS:DX points to the ASCII name of the file to be loaded. ES:BX points to a parameter block for the load.

A function code is passed in AL:

AL	Function
0	load and execute the program. A program header is established for the program and the terminate and CTRL C addresses are set to the instruction after the EXEC system call.
3	load (do not create) the program header, and do not begin execution. This is useful in loading program overlays.

4BH Load and Execute a Program (EXEC)

For each value of AL, the block has the format shown in the following table.

AL = 0 - load/execute program

WORD segment address of environment.
DWORD pointer to command line at 80H of Program Segment Prefix
DWORD pointer to default FCB to be passed at 5CH of PSP
DWORD pointer to default FCB to be passed at 6CH of PSP

AL = 3 - load overlay

WORD segment address where file will be loaded.
WORD relocation factor to be applied to the image.

Note that all open files of a process are duplicated in the child process after an EXEC. This is extremely powerful; the parent process has control over the meanings of stdin, stdout, stderr, stderr and stdprn. The parent could, for example, write a series of records to a file, open the file as standard input, open a listing file as standard output and then EXEC a sort program that takes its input from stdin and writes to stdout.

Also inherited (or passed from the parent) is an “environment.” This is a block of text strings (less than 32K bytes total) that convey various configurations parameters. The format of the environment is as follows:

(paragraph boundary)

BYTE ASCIIZ string 1
BYTE ASCIIZ string 2
...
BYTE ASCIIZ string n
BYTE of zero

Typically the environment strings have the form:

parameter = value

For example, COMMAND.COM might pass its execution search path as:

PATH=A:\BIN;B:\BASIC\LIB

A zero value of the environment address causes the child process to inherit the parent’s environment unchanged.

4BH

Load and Execute a Program (EXEC)

Error Returns

AX

1 = invalid function

The function passed in AL was not 0 or 3.

2 = file not found

The path specified was invalid or not found.

8 = not enough memory

There was not enough memory for the process to be created.

10 = bad environment

The environment was larger than 32Kb.

11 = bad format

The file pointed to by DS:DX was in .EXE format and contained information that was internally inconsistent.

Macro

```
;  
free_memory macro address  
    mov ax,address  
    mov es,ax  
    mov ah,49h  
    int 21h  
endm
```

4CH Terminate a Process

Call AH = 4CH
AL = Return code

Return None

Remarks Function 4CH terminates the current process and transfers control to the invoking process. In addition, a return code may be sent. All files open at the time are closed.

This method is preferred over all others (Interrupt 20H, JMP 0) and has the advantage that CS:0 does not have to point to the Program Header Prefix.

Macro

```
;  
modify_memory macro address,size  
    mov ax,address  
    mov es,ax  
    mov bx,size  
    mov ah,4ah  
    int 21h  
endm
```

4DH

Retrieve the Return Code of a Child

Call AH = 4DH

Return AX
Exit code

Remarks Function 4DH returns the Exit code specified by a child process. It returns this Exit code only once. The low byte of this code is that sent by the Exit routine. The high byte is one of the following:

- 0 - Terminate/abort
- 1 - CTRL C
- 2 - Hard error
- 3 - Terminate and stay resident

Macro ;
exec macro path,param,switch
mov dx,offset path
mov bx,offset param
mov al,switch
mov ah,4bh
int 21h
endm

4EH Find Match File

Call AH = 4EH
DS:DX
 Pointer to pathname
CX
 Search attributes

Return Carry set:
AX
 2 = file not found
 18 = no more files
Carry not set:
 No error

Remarks Function 4EH takes a pathname with wild card characters in the last component (passed in an ASCIIZ string pointed to by DS:DX) along with a set of attributes (passed in CX) and attempts to find all files that match the pathname and have a subset of the required attributes. A datablock at the current DTA is written that contains information in the following form:

```
find_buf_reserved DB 21 DUP (?); Reserved*
find_buf_attr     DB ? ;attribute found
find_buf_time     DW ? ;time
find_buf_date     DW ? ;date
find_buf_size_l   DW ? ;low(size)
find_buf_size_h   DW ? ;high(size)
find_buf_pname    DB 13 DUP (?);packed name
find_buf ENDS
```

*Reserved for MS-DOS internal use on subsequent find_nexts

To obtain the subsequent matches of the path-name, see the description of Function 4FH.

4EH Find Match File

Error Returns

AX

2 = file not found

The path specified in DS:DX was an
invalid path.

18 = no more files

There were no files matching this speci-
fication.

Macro

```
;  
terminate_process macro code  
    mov  al,code  
    mov  ah,4ch  
    int  21h  
endm
```

4FH Step Through a Directory Matching Files

Call AH = 4FH

Return Carry set:
AX
18 = no more files
Carry not set:
No error

Remarks The current DTA address must point at a block returned by Function 4EH (see Function 4EH).

Error Returns AX
18 = no more files

There are no more files matching this pattern.

Macro ;
retrieve_code macro
mov ah,4dh
int 21h
endm

54H

Return Current Setting of Verify After Write Flag

Call AH = 54H

Return AL
Current verify flag value

Remarks The current value of the verify flag is returned in AL.

Macro

```
;  
find_match macro name,attrib  
    mov dx,offset name  
    mov cx,attrib  
    mov ah,4eh  
    int 21h  
endm
```


56H

Move a Directory Entry

Call	AH = 56H DS:DX Pointer to pathname of existing file ES:DI Pointer to new pathname
Return	Carry set: AX 2 = file not found 5 = access denied 17 = not same device Carry not set: No error
Remarks	Function 56H attempts to rename a file into another path. The paths must be on the same device.
Error Returns	AX 2 = file not found The file name specified by DS:DX was not found. 5 = access denied The path specified in DS:DX was a directory or the file specified by ES:DI already exists or the destination directory entry could not be created. 17 = not same device The source and destination are on different drives.

56H

Move a Directory Entry

Macro

```
;  
step_match macro  
  mov ah,4fh  
  int 21h  
endm
```

57H Get/Set Date/Time of File

Call AH = 57H
 AL
 00 = get date and time
 01 = set date and time
 BX
 File handle
 CX (if AL = 01)
 Time to be set
 DX (if AL = 01)
 Date to be set

Return Carry set:
 AX
 1 = invalid function
 6 = invalid handle
 Carry not set:
 No error
 CX/DX set if function 0

Remarks Function 57H returns or sets the last-write time for a handle. These times are not recorded until the file is closed.

A function code is passed in AL:

AL	Function
0	return the time/date of the handle in CX/DX
1	set the time/date of the handle to CX/DX

The format for the date and time is the same as the date and time fields for a directory entry, except that the individual bytes in each word are reversed. The high order portion of the time is in CL, and the high order portion of the date is in DL.

57H

Get/Set Date/Time of File

Error Returns

AX

1 = invalid function

The function passed in AL was not in the range 0:1.

6 = invalid handle

The handle passed in BX was not currently open.

Macro

```
;  
check_verify_flag macro  
    mov ah,54h  
    int 21h  
endm
```

Macro

Note These macro definitions apply to system call examples 00H through 57H.

```
;  
;*****  
; Interrupts  
;*****  
;  
;ABS_DISK_READ  
abs_disk_read macro disk, buffer, num_sectors, first_sector  
    mov     al,disk  
    mov     bx,offset buffer  
    mov     cx,num_sectors  
    mov     dx,first_sector  
    int     25H                ;interrupt 25H  
    popf  
    endm  
;  
;ABS_DISK_WRITE  
abs_disk_write macro disk, buffer, num_sectors, first_sector  
    mov     al,disk  
    mov     bx,offset buffer  
    mov     cx,num_sectors  
    mov     dx,first_sector  
    int     26H                ;interrupt 26H  
    popf  
    endm  
;  
stay_resident macro last_instruc ;STAY_RESIDENT  
    mov     dx,offset last_instruc  
    inc     dx  
    int     27H                ;interrupt 27H  
    endm  
;  
;*****  
; Functions  
;*****  
;
```

```

;
read_kbd_and_echo macro          ;READ_KBD_AND_ECHO
    mov    ah,1                  ;function 1
    int    21H
endm

;
display_char macro character     ;DISPLAY_CHAR
    mov    dl,character
    mov    ah,2                  ;function 2
    int    21H
endm

;
aux_input macro                 ;AUX_INPUT
    mov    ah,3                  ;function 3
    int    21H
endm

;
aux_output macro               ;AUX_OUTPUT
    mov    ah,4                  ;function 4
    int    21H
endm

;
print_char macro character      ;PRINT_CHAR
    mov    dl,character
    mov    ah,5                  ;function 5
    int    21H
endm

dir_console_io macro switch     ;DIR_CONSOLE_IO
    mov    dl,switch
    mov    ah,6                  ;function 6
    int    21H
endm

;
dir_console_input macro         ;DIR_CONSOLE_INPUT
    mov    ah,7                  ;function 7
    int    21H
endm

;
read_kbd macro                 ;READ_KBD
    mov    ah,8                  ;function 8
    int    21H
endm

```

```

;
display macro string                ;DISPLAY
    mov    dx,offset string
    mov    ah,9                    ;function 9
    int    21H
    endm

;
get_string macro limit,string      ;GET_STRING
    mov    string,limit
    mov    dx,offset string
    mov    ah,0AH                 ;function 0AH
    int    21H
    endm

;
check_kbd_status macro            ;CHECK_KBD_STATUS
    mov    ah,0BH                 ;function 0BH
    int    21H
    endm

;
flush_and_read_kbd macro switch  ;FLUSH_AND_READ_KBD
    mov    al,switch
    mov    ah,0CH                 ;function 0CH
    int    21H
    endm

;
reset_disk macro                  ;RESET DISK
    mov    ah,0DH                 ;function 0DH
    int    21H
    endm

;
select_disk macro disk            ;SELECT_DISK
    mov    dl,disk[-65]
    mov    ah,0EH                 ;function 0EH
    int    21H
    endm

;
open macro fcb                    ;OPEN
    mov    dx,offset fcb
    mov    ah,0FH                 ;function 0FH
    int    21H
    endm

```

```

;
close macro fcb                                ;CLOSE
    mov    dx,offset fcb
    mov    ah,10H                               ;function 10H
    int    21H
    endm

;
search_first macro fcb                        ;SEARCH_FIRST
    mov    dx,offset fcb
    mov    ah,11H                               ;function 11H
    int    21H
    endm

;
search_next macro fcb                        ;SEARCH_NEXT
    mov    dx,offset fcb
    mov    ah,12H                               ;function 12H
    int    21H
    endm

;
delete macro fcb                             ;DELETE
    mov    dx,offset fcb
    mov    ah,13H                               ;function 13H
    int    21H
    endm

;
read_seq macro fcb                          ;READ_SEQ
    mov    dx,offset fcb
    mov    ah,14H                               ;function 14H
    int    21H
    endm

;
write_seq macro fcb                         ;WRITE_SEQ
    mov    dx,offset fcb
    mov    ah,15H                               ;function 15H
    int    21H
    endm

;
create macro fcb                             ;CREATE
    mov    dx,offset fcb
    mov    ah,16H                               ;function 16H
    int    21H
    endm

```



```

;
rename macro special_fcb                ;RENAME
    mov    dx,offset special_fcb
    mov    ah,17H                        ;function 17H
    int    21H
    endm
;
current_disk macro                      ;CURRENT_DISK
    mov    ah,19H                        ;function 19H
    int    21H
    endm
;
set_dta macro buffer                   ;SET_DTA
    mov    dx,offset buffer
    mov    ah,1AH                        ;function 1AH
    int    21H
    endm
;
read_ran macro fcb                     ;READ_RAN
    mov    dx,offset fcb
    mov    ah,21H                        ;function 21H
    int    21H
    endm
;
write_ran macro fcb                   ;WRITE_RAN
    mov    dx,offset fcb
    mov    ah,22H                        ;function 22H
    int    21H
    endm
;
file_size macro fcb                   ;FILE_SIZE
    mov    dx,offset fcb
    mov    ah,23H                        ;function 23H
    int    21H
    endm

```

```

;
set_relative_record macro fcb          ;SET_RELATIVE_RECORD
    mov    dx,offset fcb
    mov    ah,24H                      ;function 24H
    int    21H
    endm
;
set_vector macro interrupt,seg_addr,off_addr ;SET_VECTOR
    push   ds
    mov    ax,seg_addr
    mov    ds,ax
    mov    dx,off_addr
    mov    al,interrupt
    mov    ah,25H                      ;function 25H
    int    21H
    endm
;
ran_block_read macro fcb,count,rec_size;RAN_BLOCK_READ
    mov    dx,offset fcb
    mov    cx,count
    mov    word ptr fcb[14], rec_size
    mov    ah,27H                      ;function 27H
    int    21H
    endm
;
ran_block_write macro fcb,count,rec_size;RAN_BLOCK_WRITE
    mov    dx,offset fcb
    mov    cx,count
    mov    word ptr fcb[14], rec_size
    mov    ah,28H                      ;function 28H
    int    21H
    endm

```

```

;
parse_macro macro filename, fcb          ;PARSE
    mov     si,offset filename
    mov     di,offset fcb
    push    es
    push    ds
    pop     es
    mov     al,0FH
    mov     ah,29H                        ;function 29H
    int     21H
    pop     es
endm

;
get_date macro                          ;GET_DATE
    mov     ah,2AH                        ;function 2AH
    int     21H
endm

;
set_date macro year,month,day           ;SET_DATE
    mov     cx,year
    mov     dh,month
    mov     dl,day
    mov     ah,2BH                        ;function 2BH
    int     21H
endm

;
get_time macro                          ;GET_TIME
    mov     ah,2CH                        ;function 2CH
    int     21H
endm

;
set_time macro hour, minutes, seconds, hundredths
                                           ;SET_TIME
    mov     ch,hour
    mov     cl,minutes
    mov     dh,seconds
    mov     dl,hundredths
    mov     ah,2DH                        ;function 2DH
    int     21H
endm

```

```

;
verify macro switch ;VERIFY
    mov     al,switch
    mov     ah,2EH ;function 2EH
    int     21H
endm

;
get_dta macro ;GET_DTA
    mov     ah,2FH
    int     21H
endm

;
get_version_num macro ;GET_VERSION_NUM
    mov     ah,30H
    int     21H
endm

;
keep_process macro exitcode,parasize ;KEEP_PROCESS
    mov     al,exitcode
    mov     dx,parasize
    mov     ah,31H
    int     21H
endm

;
ctrl_c_check macro switch,val ;CTRL_C_CHECK
    mov     dl,val
    mov     al,switch
    mov     ah,33H
    int     21H
endm

;
get_vector macro interrupt ;GET_VECTOR
    mov     al,interrupt
    mov     ah,35H
    int     21H
endm

;
get_disk_space macro drive ;GET_DISK_SPACE
    mov     dl,drive
    mov     2h,36H
    int     21H
endm

```

```

;
get_country_info macro buffer, country ;GET_COUNTRY_INFO
    mov     dx, offset buffer
    mov     al, country ;country = 0
    mov     ah, 38H
    int     21H
endm

;
mkdir macro name ;MKDIR
    mov     dx, offset name
    mov     ah, 39H
    int     21H
endm

;
rmdir macro name ;RMDIR
    mov     dx, offset name
    mov     ah, 3AH
    int     21H
endm

;
chdir macro name ;CHDIR
    mov     dx, offset name
    mov     ah, 3BH
    int     21H
endm

;
create_file macro name, attrib ;CREATE_FILE
    mov     dx, offset name
    mov     cx, attrib
    mov     ah, 3CH
    int     21H
endm

;
open_handle macro name, access ;OPEN_HANDLE
    mov     dx, offset name
    mov     al, access
    mov     2h, 3DH
    int     21H
endm

```

```

;
close_handle macro handle                ;CLOSE_HANDLE
    mov     bx,handle
    mov     2h,3EH
    int     21H
    endm

;
read_from_handle macro buffer,bytes,handle ;READ_FROM_HANDLE

    mov     dx,offset buffer
    mov     cx,bytes
    mov     bx,handle
    mov     ah,3FH
    int     21H
    endm

;
write_to_handle macro buffer,bytes,handle ;WRITE_TO_HANDLE

    mov     dx,offset buffer
    mov     cx,bytes
    mov     bx,handle
    mov     ah,40H
    int     21H
    endm

;
erase macro name                        ;ERASE
    mov     dx,offset name
    mov     ah,41H
    int     21H
    endm

;
move_pointer macro highword,lowword,switch,handle ;MOVE_POINTER

    mov     dx,lowword
    mov     cx,highword
    mov     al,switch
    mov     bx,handle
    mov     ah,42H
    int     21H
    endm

```

```

;
change_attrib macro name,attrib,switch ;CHANGE_ATTRIB
    mov     dx,offset name
    mov     cx,attrib
    mov     al,switch
    mov     2h,43H
    int     21H
endm

;
io_ctrl_dev macro handle,buffer,bytes,switch
;IO_CTRL_DEV
;or 8-bit drive number
    mov     bx,handle
    mov     dx,offset buffer
    mov     cx,bytes
    mov     al,switch
    mov     ah,44H
    int     21H
endm

;
duplicate_handle macro handle ;DUPLICATE_HANDLE
    mov     bx,handle
    mov     ah,45H
    int     21H
endm

;
force_handle macro old,new ;FORCE_HANDLE
    mov     bx,old
    mov     cx,new
    mov     ah,46H
    int     21H
endm

;
cur_dir_name macro buffer,drive ;CUR_DIR_NAME
    mov     si,offset buffer
    mov     dl,drive
    mov     ah,47H
    int     21H
endm

```

```

;
alloc_mem macro size                ;ALLOC_MEM
    mov     bx,size
    mov     ah,48H
    int     21H
    endm
;
free_memory macro address           ;FREE_MEMORY
    mov     ax,address
    mov     es,ax
    mov     ah,49H
    int     21H
    endm
;
modify_memory macro address,size    ;MODIFY_MEMORY
    mov     ax,address
    mov     es,ax
    mov     bx,size
    mov     ah,4AH
    int     21H
    endm
;
exec macro path,param,switch        ;EXEC
    mov     dx,offset path
    mov     bx,offset param
    mov     al,switch
    mov     ah,4BH
    int     21H
    endm
;
terminate_process macro code        ;TERMINATE_PROCESS
    mov     al,code
    mov     ah,4CH
    int     21H
    endm
;
retrieve_code macro                 ;RETRIEVE_CODE
    mov     ah,4DH
    int     21H
    endm

```



```

;
find_match macro name,attrib           ;FIND_MATCH
    mov     dx,offset name
    mov     cx,attrib
    mov     ah,4EH
    int     21H
    endm
;
step_match macro                       ;STEP_MATCH
    mov     ah,4FH
    int     21H
    endm
;
check_verify_flag macro                ;CHECK_VERIFY_FLAG
    mov     ah,54H
    int     21H
    endm
;
rename macro old,new                   ;RENAME
    mov     dx,offset old
    mov     di,offset new
    mov     ah,56H
    int     21H
    endm
;
date_time_of_file macro switch,handle,date,time
                                           ;DATE_TIME_OF_FILE
    mov     al,switch
    mov     bx,handle
    mov     cx,time
    mov     dx,date
    mov     ah,57H
    int     21H
    endm

```

```

;*****
; General
;*****
move_string macro source, destination, num_bytes
;MOVE_STRING
    push    es
    mov     ax,ds
    mov     es,ax
    mov     si,offset source
    mov     di,offset destination
    mov     cx,num_bytes
rep movsb es:destination,source
    pop     es
endm
;
;
convert macro value, base, destination ;CONVERT
    local  table,start
    jmp    start
table db "0123456789ABCDEF"
start: mov  al,value
      xor  ah,ah
      xor  bx,bx
      div  base
      mov  bl,al
      mov  al,cs:table[bx]
      mov  destination,al
      mov  bl,ah
      mov  al,cs:table[bx]
      mov  destination[1],al
      endm

```

```

;
convert_to_binary macro string, number, value
                                ;CONVERT_TO_BINARY
                                local    ten,start,calc,mult,no_mult
                                jmp      start
ten      db      10
start:   mov      value,0
        xor      cx,cx
        mov      cl,number
        xor      si,si
calc:    xor      ax,ax
        mov      al,string[si]
        sub      al,48
        cmp      cx,2
        jl      no_mult
        push     cx
        dec      cx
mult:    mul      cs:ten
        loop     mult
        pop      cx
no_mult: add      value,ax
        inc      si
        loop     calc
        endm
;
convert_date macro dir_entry
        mov      dx,word ptr dir_entry[25]
        mov      cl,5
        shr      dl,cl
        mov      dh,dir_entry[25]
        and      dh,1fh
        xor      cx,cx
        mov      cl,dir_entry[26]
shr      cl,1
add      cx,1980
endm
;

```



8

ROM BIOS Service Routines

- **Overview**
- **Conventions**
- **Interrupt Vector Listing**
- **Video Control**
- **Diskette Services**
- **Communications Services**
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- **Miscellaneous ROM BIOS Services**
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- **Notes on Enhancements in ROM BIOS 1.21**
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Overview

This chapter describes the ROM BIOS service routines that are provided to perform the more low-level functions that you may need in your assembly language programs. Because these are low-level routines, they provide more direct access to the hardware than the DOS routines. However, they do not provide some of the protection and conveniences that the DOS routines give. Be sure to check the chapter on “System Calls” to make your choice between similar DOS and BIOS calls.

Conventions

Access to the BIOS service routines is through the 8086 software interrupts. The routines are called with conventions that are very similar to the conventions for calling DOS routines.

To issue a BIOS interrupt, use the `Interrupt` statement to select the desired interrupt:

`INT 11H`

Some interrupts, like `Interrupt 11H` (Equipment List), perform only one function. Others, like `Interrupt 13H` (Diskette Services), have several sub-functions that you can call. To select a sub-function, move the number of the sub-function into the `AH` register.

This chapter describes the register usage for each of the BIOS service routines. It is usually wise to save all important registers before calling a BIOS service routine.

Interrupt Vector List

Interrupt Number (Hex)	Name
5	Print Screen
10	Video
11	Equipment Check
12	Determine Memory Size
13	Diskette
14	Communications
16	Keyboard
17	Printer
19	Bootstrap

Video Control

Introduction The video controller on the standard AT&T Personal Computer 6300 supports both monochrome and color monitors and produces text or graphics for both color and monochrome. Interrupt 10H has the BIOS services to support all of these modes. This section describes the details that pertain to each major type of video access.

Monochrome Text Mode The monochrome text modes are mode 0 — 40x25 characters and mode 2 — 80x25 characters. The monochrome text mode uses 32K starting at B8000H. For each screen position, there are two bytes in memory. The first byte is the ASCII code for the character to be displayed. The second byte is the “attribute” that specifies how the character is to be displayed. This attribute byte controls brightness, underlining, and blinking.

The low order nybble of the attribute byte governs the character being displayed according to the following table:

Value	Meaning
0	Character is black
1	Character is normal (white) intensity, underlined
7	Character is normal (white) intensity
F	Character is high intensity white

Any other value for the low nybble selects a particular gray character intensity.

The high order nybble of the attribute byte governs the character background and blinking. A displayed character will blink if the high order bit of its attribute byte is set. The remaining

three bits select the gray scale of the background — again, 000 is black and 111 is white. Note that inverse video can be obtained by forcing a black character on a white background, i.e. an attribute byte of 70H.

The first two bytes in the display memory control the character in the top left corner of the screen. The next two bytes control the character in the top row, in the second column position, and so on.

At the end of each line, the display memory returns to the first column of the next line. There are no gaps in the display storage, and no boundaries between one line and the next.

Eight pages of memory are used to build up to eight separate screens. Only one page is active at any time, but you can switch the active page number and thereby display screens very rapidly.

The display pages are numbered 0 - 7 for 40x25 mode and 0 - 3 for 80x25 mode. Page 0 starts at memory location B8000H. For 40 column mode, the pages occur at 2K intervals; for 80 column, at 4K intervals. A total of 32K of memory is used.

Color Text Modes

The color text modes are mode 1 — 40x25 color mode and mode 3 — 80x25 color.

Memory usage for the color text modes is similar to the method used for monochrome text. Two bytes of memory are used for each character position: the first is the ASCII code for the character and the second is the attribute byte. The attribute byte specifies blinking, brightness, and color.

The attribute bytes in color text mode operate much the same way as they do in monochrome text modes with two major differences:

- Instead of bits 0-3 and 4-7 selecting the gray scale of the foreground and background, they select foreground and background colors according to the following chart:

Bit				Color
d	c	b	a	
0	0	0	0	Black
0	0	0	1	Blue
0	0	1	0	Green
0	0	1	1	Cyan
0	1	0	0	Red
0	1	0	1	Magenta
0	1	1	0	Brown
0	1	1	1	White
1	0	0	0	Grey
1	0	0	1	Lt. blue
1	0	1	0	Lt. green
1	0	1	1	Lt. cyan
1	1	0	0	Lt. red
1	1	0	1	Lt. magenta
1	1	1	0	Yellow
1	1	1	1	High intensity white

Note that since background color is determined by a three-bit value, only the first eight colors apply to that field.

- There is no underline attribute possible in color mode. As can be seen by the chart above, attribute settings that produce an underline in monochrome mode produce a blue character in color mode.

The display memory maps to the character positions exactly as it does in monochrome text mode.

Color Graphics Mode

There is one color graphics mode: mode 4 — medium resolution (320x200) color graphics. For any color display, you can use up to four colors. You select from one of two “palettes,” each of which provides three colors. You select a “background” color to be used as the fourth color.

Palette 0 contains green, yellow, and red. Palette 1 contains cyan (light blue), magenta, and white.

320 pixels can be displayed on each of 200 lines. Each line takes 80 bytes or 640 bits of display memory. Each color pixel use two bits of memory. Since two bits give you four possible combinations, for each pixel you specify either the background color or one of the three colors in the current palette. The leftmost pixels are represented by the high order bits in the byte.

Display memory for color graphics mode starts at location B8000H and is divided into four 8K blocks. Starting at B8000, the first 8000D bytes contain the pixel data for the even scan lines on page zero. That is, the first 80 bytes describe line 0, the next 80H describe line 2, and so on through line 198. The odd lines are described in the 8K block starting at BA000. The same pattern is repeated for page one in the next 16K block, with the even lines starting at BC000 and the odd lines starting at BE000.

High Resolution Monochrome Graphics

Memory for high resolution 640x200 monochrome graphics is handled similarly to 320x200 color graphics. The only difference is that instead of memory containing two bits of color information per pixel, each pixel can only be on or off and is thus represented by one bit. In this way eight pixels can be represented in a byte instead of four, so that a scan line takes as many bytes as in color graphics mode even though it contains twice as many pixels. As in color graphics mode, the leftmost pixels are represented in the high order bits of each byte. Line mapping is exactly as described above for color graphics mode. In high resolution monochrome graphics the background color is always black and the foreground color is chosen by bits 0-3 of the color select register.

**Super High
Resolution
Monochrome
Graphics**

Super high resolution 640x400 monochrome graphics mode maps one bit per pixel with the leftmost pixel represented at the high end of the byte, just like high resolution 640x200 mode. Also like high resolution mode, super high mode maps onto a black background with a foreground color chosen by the color select register. The memory mapping, however, takes up all 32K of display memory for a single page. Memory is broken up into four 8K segments, with each segment containing the data for every fourth scan line. Thus display memory looks like this:

Memory location	Contains pixels for line numbers
B8000	0, 4, 8, ... 396
B9F3F	Not used.
BA000	1, 5, 9, ... 397
BBF3F	Not used.
BC000	2, 6, 10, ... 398
BDF3F	Not used.
BE000	3, 7, 11, ... 399
BFF3F	Not used.

**Set Mode
and Clear
Screen**

Input:
(AH) = 0
(AL) contains the CRT mode value

Text Modes:
(AL) = 0 40x25 monochrome
(AL) = 1 40x25 color
(AL) = 2 80x25 monochrome
(AL) = 3 80x25 color

Graphics modes:
(AL) = 4 320x200(medium resolution), color
(AL) = 5 320x200(medium resolution),
monochrome
(AL) = 6 640x200 black/white (high resolution)
(AL) = 40H graphics 640x400 monochrome
super high resolution
(AL) = 48H graphics 640x400 monochrome
tiny text (80x50 text)

**Set Cursor
Type**

Input:
(AH) = 1
Low order 5 bits of (CH) = start line for cursor.

Note
Do not set the high bits of CH: unpredictable
results will occur.

Low order 5 bits of (CL) = end line for cursor.

**Set Cursor
Position**

Input:
(AH) = 2
(DH,DL) = Row,Column (Position 0,0 is upper
left.)
(BH) = page number (must be 0 for super-res
graphics mode.)

**Read
Cursor
Position**

Input:
(AH) = 3
(BH) = page number (must be 0 for super-res
graphics mode.)

Output:
(DH,DL) = row, column of current cursor
(CH,CL) = current cursor start and end lines

**Read
Light Pen
Position**

Input:
(AH) = 4

Output:
(AH) = 0 light pen switch not triggered
(AH) = 1 valid light pen value obtained:
 (DH,DL) = row, column of character
 light pen position
(CH) = raster line (0-199)
(BX) = pixel column (0-319 for medium
resolution, 0-639 for high
resolution.)

**Select
Active
Page
Number**

Valid only for modes (0 - 6)

Input:
(AH) = 5
(AL) = 0-15 for modes 0, 1
 = 0-7 for modes 2, 3
 = 0-1 for modes 4, 6

**Scroll Active
Page up**

Input:

(AH) = 6

(AL) = number of lines blanked at bottom of window by scrolling up. AL = 0 means blank entire window.

(CH,CL) = row, column of upper left corner of scroll

(DH,DL) = row, column of lower right corner of scroll

(BH) = attribute to be used on blank line(s).

**Scroll Active
Page Down**

Input:

(AH) = 7

(AL) = number of lines blanked at top of window by scrolling down. AL = 0 means blank entire window.

(CH,CL) = row, column of upper left corner of scroll

(DH,DL) = row, column of lower right corner of scroll

(BH) = attribute to be used on blank line(s).

**Character
Handling**

The next three video services perform character input/output for the CRT. If your program displays characters to the screen while in graphics modes, the characters are formed from a character generator image that is maintained in the ROM. However, only the first 128 characters are encoded there. If you want to create your own characters, either for the purposes of doing character graphics or implementing a foreign language alphabet, you must set up a table of code points for 128 new characters and initialize the pointer at interrupt 1F (address 0007CH) to point to the 1K table. These codes can then be accessed by referring to characters 128-255.

When you write characters to the screen in text mode, if you send more characters to be written than will fit on one line, the extra characters automatically wrap around to the beginning to the next line. In graphics mode, the character handling routines only produce correct results for characters contained on the same row (continuation to succeeding lines does not work.)

**Read
Attribute or
Character at
Current
Cursor
Position** **Input:**
(AH) = 8
(BH) = current display page

Output:
(AL) = character read
(AH) = attribute of character read

**Write
Attribute and
Character at
Current
Cursor
Position** **Input:**
(AH) = 9
(BH) = current display page
(CX) = count of characters to write
(AL) = character to write
(BL) = attribute of character (if text mode)
 = color of character (if graphics mode)

Note
If bit 7 of BL = 1, the color value is exclusive OR'd with the current contents of the dot.

**Write
Character
Only at
Current
Cursor
Position** **Input:**
(AH) = 0AH
(BH) = current display page
(CX) = count of characters to write
(AL) = character to write

**Set Color
Palette**

Input:

(AH) = OBH

(BH) = color palette ID (0-127)

(BL) = color value to be used with that color ID

Color ID = 0 selects the background color (0-15)

Color ID = 1 selects the palette to be used:

0 = green/red/yellow

1 = cyan/magenta/white

Write Dot

Input:

(AH) = OCH

(DX) = row number

(CX) = column number

(AL) = color value. If bit 7 of AL = 1, the color value is exclusive OR'd with the current contents of the dot.

Read Dot

Input:

(AH) = ODH

(DX) = row number

(CX) = column number

Output:

(AL) = the dot read

**Write
Teletype**

This routine is used by the "TYPE" command and other DOS commands to display data on the screen.

Input:

(AH) = 0EH

(AL) = character to write

(BL) = foreground color in graphics mode

Note

Screen width is controlled by previous mode set.

**Current
Video State**

Input:

(AH) = 0FH

Output:

(AL) = current mode

(AH) = number of character columns on screen

(BH) = current active display page

Diskette Services

Introduction Interrupt 13H is the BIOS routine for diskette services. There are six services provided by INT 13H.

Input

- (AH) = 0 Reset Diskette System
- (AH) = 1 Read status of diskette system into AL
- (AH) = 2 Read sectors into memory
- (AH) = 3 Write sectors from memory to diskette
- (AH) = 4 Verify the specified sectors
- (AH) = 5 Format a track

Additional settings for read, write, verify, and format:

(DL) = drive number (0 - 3 allowed, value checked)

(DH) = head number (0 - 1 allowed, value not checked)

(CH) = track number (0-39 allowed, value not checked)

Additional settings for read, write, and verify:

(CL) = sector number (1-9, value not checked)

(AL) = number of sectors (max = 9, value not checked)

ES:BX = address of buffer (not required for verify) For the format operation, ES:BX points to the collection of address fields for the track. There must be one of these fields for every sector on the track. Each field has four bytes:

Offset 0 = track number

1 = head number

2 = sector number

3 = number of bytes/ sector

(00 = 128, 01 = 256, 02 = 512, 03 = 1024)

Output

(AH) = Status of operation:

- 01 bad command
- 02 address mark not found
- 03 write was requested on write-protected disk
- 04 requested sector not found
- 08 DMA overrun
- 09 DMA transfer crossed a 64K boundary
- 10 read data error detected by CRC
- 20 diskette controller chip failed
- 40 seek to desired track failed
- 80 device timeout

(CY) = 0 successful operation

(CY) = 1 unsuccessful operation (AH has details)

For read, write, and verify these registers are preserved: DS, BX, DX, CH, and CL.

(AL) = number of sectors read; this value may be incorrect if a timeout occurred.

NOTE

If an error is reported by the diskette, reset the diskette, then retry the operation. On read operations, no motor start delay is taken, so your code should retry three times to make sure that a read error is not caused by motor start-up.

Communications Services

Introduction This set of routines performs serial, RS232C communications through the communications port. You should use a polling technique in your communications; this is not interrupt-driven I/O. All functions are accessed through BIOS interrupt 14H.

Initialize the Communications Port Input:
(AH) = 0
(DX) = selection of RS-232 channel (0 or 1)
(AL) = parameters for initialization in the following form:

7 6 5	4 3	2	1 0
—Baud Rate—	—Parity—	Stopbit	—Word length—
000 - 110 baud	00 - None	0 - 1	10 - 7 bits
001 - 150	01 - Odd	1 - 2	11 - 8 bits
010 - 300	11 - Even		
011 - 600			
100 - 1200			
101 - 2400			
110 - 4800			
111 - 9600			

Output:
Condition is set according to the same conventions as in “Get Comm Port Status” (see below).

**Send
Character**

Input:

(AH) = 1
(DX) = RS232 channel to be used (0 or 1)
(AL) = the character to be sent.

Output:

(AL) is preserved.
(AH) — if the operation was unsuccessful, bit 7 is set. The other bits in (AH) are set as they are in “Get Comm Port Status” if the operation was successful.

**Receive
Character**

Input:

(AH) = 2
(DX) = RS232 channel to be used (0 or 1)

Output:

(AL) = the received character.
(AH) = status of operation, if (AH) = 0, the operation was successful. If the high order bit of (AH) is set, a timeout error aborted the operation and the rest of (AH) can be ignored. Any other setting of (AH) indicates errors in the receive character operation.

**Get Comm
Port Status**

Input:

(AH) = 3

(DX) = RS232 channel to be used (0 or 1)

Output

(AX) = status:

(AH) = line control status

bit 7 = timeout

bit 6 = transmission shift reg. empty

bit 5 = transmission holding reg. empty

bit 4 = break detect

bit 3 = framing error

bit 2 = parity error

bit 1 = overrun error

bit 0 = data ready

(AL) = modem status

bit 7 = received line signal detect

bit 6 = ringing detect

bit 5 = data set ready

bit 4 = clear to send

bit 3 = delta receive line signal detect

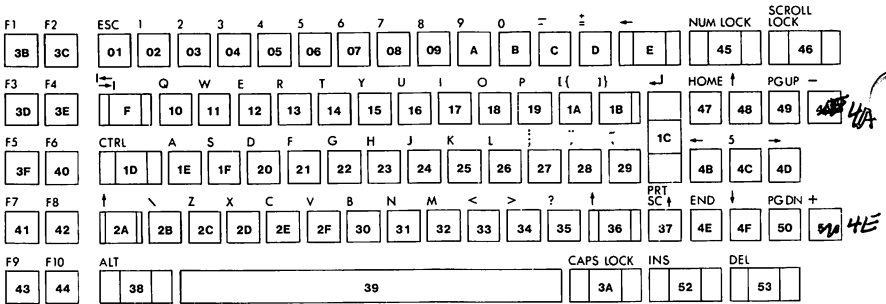
bit 2 = trailing edge ring detected

bit 1 = delta data set ready

bit 0 = delta clear to send

Keyboard Handling

Introduction Interrupt 16H provides the keyboard handling functions through three sub-functions. Most keys return two values: a scan code and a character code. The scan code is the same as the key number (see diagram below), and the character code is the ASCII superset interpretation of the key (including coincident SHIFTs or CTRLs). Check the section on “DOS Interrupts and Function Calls” to select either the BIOS keyboard routines or the DOS routines.



CHARACTER CODES

ASCII Decimal	Value Hex	Character	Control Character	ASCII Decimal	Value Hex	Character
000	00	(null)	NUL	032	20	(space)
001	01	☺	SOH	033	21	!
002	02	☹	STX	034	22	"
003	03	♥	ETX	035	23	#
004	04	♦	EOT	036	24	\$
005	05	♣	ENQ	037	25	%
006	06	♠	ACK	038	26	&
007	07	(beep)	BEL	039	27	'
008	08	▣	BS	040	28	(
009	09	(tab)	HT	041	29)
010	0A	(line feed)	LF	042	2A	*
011	0B	(home)	VT	043	2B	+
012	0C	(form feed)	FF	044	2C	,
013	0D	(carriage return)	CR	045	2D	-
014	0E	🎵	SO	046	2E	.
015	0F	☼	SI	047	2F	/
016	10	▶	DLE	048	30	0
017	11	◀	DC1	049	31	1
018	12	↕	DC2	050	32	2
019	13	!!	DC3	051	33	3
020	14	π	DC4	052	34	4
021	15	§	NAK	053	35	5
022	16	▬	SYN	054	36	6
023	17	↕	ETB	055	37	7
024	18	↑	CAN	056	38	8
025	19	↓	EM	057	39	9
026	1A	→	SUB	058	3A	:
027	1B	←	ESC	059	3B	;
028	1C	(cursor right)	FS	060	3C	<
029	1D	(cursor left)	GS	061	3D	=
030	1E	(cursor up)	RS	062	3E	>
031	1F	(cursor down)	US	063	3F	?

CHARACTER CODES (Cont'd)

ASCII Decimal	Value Hex	Character	Control Character	ASCII Decimal	Value Hex	Character
064	40	@		096	60	©
065	41	A		097	61	a
066	42	B		098	62	b
067	43	C		099	63	c
068	44	D		100	64	d
069	45	E		101	65	e
070	46	F		102	66	f
071	47	G		103	67	g
072	48	H		104	68	h
073	49	I		105	69	i
074	4A	J		106	6A	j
075	4B	K		107	6B	k
076	4C	L		108	6C	l
077	4D	M		109	6D	m
078	4E	N		110	6E	n
079	4F	O		111	6F	o
080	50	P		112	70	p
081	51	Q		113	71	q
082	52	R		114	72	r
083	53	S		115	73	s
084	54	T		116	74	t
085	55	U		117	75	u
086	56	V		118	76	v
087	57	W		119	77	w
088	58	X		120	78	x
089	59	Y		121	79	y
090	5A	Z		122	7A	z
091	5B	[		123	7B	{
092	5C	\		124	7C	|
093	5D	]		125	7D	}
094	5E	^		126	7E	~
095	5F	_		127	7F	␣

CHARACTER CODES (Cont'd)

ASCII Decimal	Value Hex	Character	ASCII Decimal	Value Hex	Character
128	80	Ç	160	A0	á
129	81	ü	161	A1	í
130	82	é	162	A2	ó
131	83	à	163	A3	ú
132	84	ä	164	A4	ñ
133	85	à	165	A5	N
134	86	á	166	A6	a
135	87	ç	167	A7	o
136	88	ê	168	A8	<
137	89	ë	169	A9	┌
138	8A	è	170	AA	└
139	8B	ÿ	171	AB	½
140	8C	î	172	AC	¼
141	8D	ï	173	AD	i
142	8E	À	174	AE	«
143	8F	Á	175	AF	»
144	90	É	176	B0	░
145	91	æ	177	B1	▒
146	92	Æ	178	B2	▓
147	93	ô	179	B3	|
148	94	ö	180	B4	└
149	95	ò	181	B5	├
150	96	û	182	B6	├
151	97	ù	183	B7	└
152	98	ÿ	184	B8	└
153	99	Û	185	B9	├
154	9A	Ü	186	BA	||
155	9B	¢	187	BB	└
156	9C	£	188	BC	└
157	9D	¥	189	BD	└
158	9E	Pt	190	BE	└
159	9F	ƒ	191	BF	└

CHARACTER CODES (Cont'd)

ASCII Decimal	Value Hex	Character	ASCII Decimal	Value Hex	Character
192	C0		224	E0	
193	C1		225	E1	
194	C2		226	E2	
195	C3		227	E3	
196	C4		228	E4	
197	C5		229	E5	
198	C6		230	E6	
199	C7		231	E7	
200	C8		232	E8	
201	C9		233	E9	
202	CA		234	EA	
203	CB		235	EB	
204	CC		236	EC	
205	CD		237	ED	
206	CE		238	EE	
207	CF		239	EF	
208	D0		240	F0	¡
209	D1	¡	241	F1	¢
210	D2	¢	242	F2	£
211	D3	£	243	F3	¤
212	D4	¤	244	F4	¥
213	D5	¥	245	F5	¦
214	D6	¦	246	F6	§
215	D7	§	247	F7	¨
216	D8	¨	248	F8	©
217	D9	©	249	F9	ª
218	DA	ª	250	FA	«
219	DB	«	251	FB	¬
220	DC	¬	252	FC	­
221	DD	­	253	FD	®
222	DE	®	254	FE	¯
223	DF	¯	255	FF	(blank)

**Read Next
ASCII
Character**

Input:
(AH) = 0

Output:
(AL) = character code
(AH) = scan code

Note

This routine will not return execution to the calling program until it has a keystroke to report.

**Check if
Keystroke
Available**

This routine is used to check to see if a keystroke has been entered. Use this function if you want to continue processing whether or not a key has been pressed.

Input:
(AH) = 1

Output:
Z flag = 1 — no code available
Z flag = 0 — code is available

If a character is available, it is stored in AX in the same format as for the “Read Next ASCII Character” call. However, the code also remains in the keyboard buffer, so that a “Read Next ASCII Character” call returns this character’s code value again.

Get Current Shift Status Input:
 (AH) = 2

 Output:
 (AL) = current shift status

Shift States

Bit	Subject matter	Meaning, when bit is 1
7	Insert	state active
6	Caps-Lock	state active
5	Num-Lock	state active
4	Scroll-Lock	state active
3	Alt shift	key depressed
2	Ctrl shift	key depressed
1	left-hand shift	key depressed
0	right-hand shift	key depressed

Printer Routines

This set of BIOS routines communicates with the printer through interrupt 17H.

Print a Character

Input:
(AH) = 0
(AL) = the character to be printed
(DX) = printer port number (0-3)

Output:
(AH) = 1 if character not printed due to timeout.
Otherwise, bits are set as they are in
“Get Printer Status” call.

Initialize Printer Port

Input:
(AH) = 1
(DX) = printer port number (0-3)

Output:
(AH) = printer status (see below)

Get Printer Status

Input:
(AH) = 2
(DX) = printer port number (0-3)

Output:

Bit	Meaning if Set (equal to 1)
7	not busy
6	acknowledge
5	out of paper
4	selected
3	I/O error
2	not used
1	not used
0	timeout (set by software)

If a printer is connected, 10H and 90H are healthy statuses. Otherwise 30H is healthy.

Miscellaneous ROM BIOS Services

System Reset

If you issue interrupt 19H, the system bootstraps itself in much the same way as it does with the Ctrl-Alt-Delete key sequence. The only difference is that Ctrl-Alt-Delete causes diagnostics to be run, whereas Interrupt 19H causes an immediate system load.

Print Screen

To obtain a printed copy of what is on the screen, issue a request for interrupt 5H. This produces exactly the same result as pressing the shift and PrtSc keys. This routine works in either text or graphics modes. Unrecognizable characters are printed as blanks.

Equipment List

You can use this routine to obtain a list of the optional equipment attached to your system. Simply issue an interrupt 11H; no register set-up is necessary. Output (starting with the most significant bit of (AX)) is as follows:

	Bit	Meaning	
AH	7-6	number of printer adapters (0-3)	
	5	not used	
	4	game adapter attached, or not	
	3-1	number of communications adapters (0-7)	
	0	not used	
AL	7-6	number of diskette drives minus 1, if bit 0 is set.	
	5-4	starting video mode:	
		01	— graphics card display, 40 columns, b/w
		10	— graphics card display, 80 columns, b/w
	11	— monochrome card display	
	3-2	amount of memory on system board:	
		00	— 16KB Base
		01	— 32KB Base
		10	— 48KB Base
		11	— 64KB Base
1	not used		
0	diskettes are attached; refer to bits 7 and 6.		

Determine Memory Size

Interrupt 12H gives the total amount of memory in the address space, up to a megabyte. No register set-up is required. The BIOS reads the switches on the system board and adds the amount of memory on a memory expansion board and returns the total in (AX). The amount of memory is expressed as the number of 1K blocks.

Bypassing the BIOS

This section explains how you can either replace one of the BIOS service routines with a program of your own or add a “front-end” so that you perform some preprocessing immediately prior to using a particular BIOS routine.

When the system is powered on, low memory is initialized with the addresses of all of the BIOS interrupt routines. To replace a BIOS routine, change the address in the interrupt table to the address of the code which you want to execute in place of the BIOS code. To perform preprocessing before handing execution on to the BIOS code:

- 1** replace the address of the BIOS routine with the address of your program
- 2** transfer execution to the BIOS routine at the end of your program.

Be sure to use the “Set Vector” system call (Function Request 25H) to replace the BIOS routine addresses instead of writing directly to low memory.

CONFIG.SYS

The special file CONFIG.SYS is processed automatically when DOS starts. As with the batch file AUTOEXEC.BAT, this processing is automatic. DOS will simply look at the root directory to see if the file is there.

CONFIG.SYS is a text file that can be edited by EDLIN or any other text editor that produces ASCII files. Five commands can be used in the CONFIG.SYS file. Each command changes a system parameter.

- **BREAK ON/OFF**
Changes the way DOS checks for a CTRL/BREAK
- **BUFFERS=xx**
Sets the number of data buffers that DOS uses.
- **DEVICE=[d:] [path] filename [.ext]**
Adds a nonstandard device driver to DOS.
- **FILES=xx**
Sets the number of files that can use ASCII strings.
- **SHELL=[d:] [path] filename [.ext] [d:] [path] /P**
Specifies an alternate command processor.

Break

Normally, DOS checks for a CTRL/BREAK only when it is doing input or output. Some programs do very little (if any) input or output for long periods of time. The BREAK ON command sets DOS to check for a CTRL/BREAK when any DOS function is called.

BREAK OFF resets the default so that DOS only checks for a CTRL/BREAK during input and output. This command can be used to override a **BREAK ON** that was set by **CONFIG-SYS**.

Buffers

The number of buffers has an effect on both the speed of disk I/O and available memory. A larger number of buffers allocates more memory to the system for operations. This is highly desirable for systems with large amounts of RAM that will be used for database applications. It is highly undesirable for systems with minimal RAM that do little work with disk files.

The system default is **BUFFERS=2**, which is adequate for most purposes and requires only 1K of RAM. If your system will be doing a significant amount of data handling, especially on a hard disk, **BUFFERS=4** would improve access times at a cost of only 1K of internal memory.

Device

When DOS is first started, it loads all of the standard device drivers for the keyboard, screen and so on. If your system requires a special device driver, this command tells DOS where to find it. The device driver will then be loaded as an extension to DOS.

Device drivers are .COM files with a specific structure described in Chapter 9. The command **DEVICE=ANSI.SYS** causes DOS to replace the standard display and keyboard device drivers with the extended screen and keyboard support that the extended functions require.

If you wish to load several special device drivers, you must use a DEVICE command for each one.

Files

Opening a file with an ASCIIZ string eliminates the traditional direct handling of a File Control Block (FCB). DOS will handle all these things for you by creating and maintaining FCBs internally. To do this, it needs memory. Each file requires 39 bytes of memory.

The FILES command sets aside memory for this operation. The default is FILES=8. The maximum is FILES=99. This is the limit for the entire system. A particular process (or program) can still have only 20 files open at once.

Shell

The COMMAND.COM file that DOS uses as its “front end” processor can be replaced by another command processor. The SHELL command specifies the file to be used and the default path for processing commands. The command processor must be able to read and execute commands, and handle interrupts 22H, 23H, and 24H.

Since COMMAND.COM handles internal commands, .BAT file execution, and .EXE file loading, these functions will be unavailable unless the new command processor duplicates them.

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ROM BIOS Listing

```

;BOOT ROM - AT&T PERSONAL COMPUTER 6300
;Rev. 1.0 - MAY 1984

page 60,132
;-----
; Filespec:      flags.src
;
; This file contains the temporary conditional assembly flag
; definitions and includes of the other assembly modules.
;-----
; Macro Definitions
;-----
; MASM does not let you code a 'jump intersegment direct' instruction, so
; this macro simulates that instruction.

jmpf macro arg1,arg2          ;; USAGE:      jmpf  seg,off
      db 0EAh
      dw arg2
      dw arg1
      endm
;-----
; Code Declaration
;-----
0000      code segment public 'ROM'      ; link code segments first
          assume cs:code, ds:nothing, es:nothing, ss:nothing

0000      ORG      0C000h

0000      flags_data proc
0000 00      chk_lo      db 0          ; space for checksum of F000:C000 to F000:DFFF
0001 00      rom_id     db 0          ; ROM identifier.
0002 E2CE R  rom_ut     dw mastab     ; offset of mastab in ROM.

0004      flags_data endp

0004      far_calls  proc far        ; far call table: the user does a far call to
          ; F000:C0XX, a near call is done to the proper
          ; routine, and a far return back to the user.

0004 EB E602 R      call DString      ; F000:C004      (3 bytes per near call)
0007 CB            ret                ;                (1 byte per far return)
0008 EB E619 R      call DCrLf
0009 CB            ret
000C EB E626 R      call DColon
000F CB            ret
0010 EB E632 R      call DHexLong
0013 CB            ret
0014 EB E63C R      call DHexWord
0017 CB            ret
0018 EB E643 R      call DHexByte
0019 CB            ret
001C EB E650 R      call DHexNib
001F CB            ret
0020 EB E665 R      call DNum
0023 CB            ret
0024 EB E66D R      call DNugW
0027 CB            ret
0028 EB E6E5 R      call rom_checksum ; F000:C028
0029 CB            ret
002C EB E1F6 R      call rtc_chk      ; F000:C02C
002F CB            ret
0030 EB E266 R      call memst      ; F000:C030
0033 CB            ret
0034 EB CF9F R      call h_init      ; F000:C034
0037 CB            ret
0038 EB D640 R      call h_fmt       ; F000:C038
003B CB            ret

003C DB8C R        dw offset banner_m ; pointer to banner
003E 0000          dw 0                ; For aligning the copyright message.
0040 43 4F 50 59 52 49
          47 48 54 20 28 43
          29 20 20 20
0050 4F 4C 49 56 45 54
          54 49 20 31 39 38
          34 20 20 20

0060      far_calls  endp

0060      code ends
;-----
; Includes of Assembly Modules
;-----
;include flags.asm      (this module)
;include sysdata.asm
C
C
C
C ; Filespec:      sysdata.src
C
C
C ; This is the port equate and system data definition module.

```

ROM BIOS Listing

```

C ; (See flags.src for conditional assembly flags...)
C ;
C ;-----
C ; Global Constants
C ;-----
= 0000 C abs0_seg equ 00000h
= 0030 C stack_seg equ 00030h
= 0040 C data_seg equ 00040h
= 8000 C para_mono equ 08000h
= B800 C para_graph equ 0B800h
= F000 C code_seg equ 0F000h

= 0007 C BEL equ 007h
= 0008 C BS equ 008h
= 000D C CR equ 00Dh
= 000A C LF equ 00Ah
= 0000 C NUL equ 0

;-----
; AT&T PERSONAL COMPUTER Addresses
;-----
;-----
; 18237A p_dma Controller Port Addresses
;-----
= 0000 C dma_addr_0 equ 00h ; 16-bit address register - channel 0 - refresh
= 0001 C dma_count_0 equ 01h ; 16-bit count register
= 0002 C dma_addr_1 equ 02h ; 16-bit address register - channel 1 - not used
= 0003 C dma_count_1 equ 03h ; 16-bit count register
= 0004 C dma_addr_2 equ 04h ; 16-bit address register - channel 2 - FDU
= 0005 C dma_count_2 equ 05h ; 16-bit count register
= 0006 C dma_addr_3 equ 06h ; 16-bit address register - channel 3 - display
= 0007 C dma_count_3 equ 07h ; 16-bit count register

= 0008 C dma_status equ 08h ; 8-bit read status register
= 0008 C dma_command equ 08h ; 8-bit write command register
= 0009 C dma_request equ 09h ; 4-bit write request register
= 000A C dma_mask_bit equ 0Ah ; 4-bit (write) set/clear one mask register bit
= 000B C dma_mode equ 0Bh ; 6-bit write mode register
= 000C C dma_ff_clr equ 0Ch ; (write) clear byte pointer flip/flop
= 000D C dma_temp equ 0Dh ; 8-bit read temporary register
= 000D C dma_master_clr equ 0Dh ; (write) master clear command
= 000E C dma_mask_clr equ 0Eh ; 4-bit (write) clear all mask register bits
= 000F C dma_mask_write equ 0Fh ; 4-bit write all mask register bits at once

= 0080 C dma_seg_0 equ 080h ; RAM refresh - 4x4-bit high nibble segment port
= 0082 C dma_seg_1 equ 082h ; not used
= 0081 C dma_seg_2 equ 081h ; FDU
= 0083 C dma_seg_3 equ 083h ; display TEMP

;-----
; 18237A p_dma controller constants
;-----
; dma_command port: ; bit #0: memory-to-memory/I/O enable
; ; bit #2: controller disable
; ; bit #3: compressed/normal timing
; ; bit #8: rotating/fixd priority
; ; bit #5: extended/late write selection
; ; bit #6: DREQ active low/high
; ; bit #7: DACK active high/low

= 0004 C dma_cmd_disable equ 004h ; controller disable (bit #2) command
= 0000 C dma_cmd_enable equ 000h ; memory-to-I/O, controller enable, normal
; fixed priority, late write, DREQ/DACK

= 0058 C dma_mode_0 equ 058h ; channel 0, read, autoinitialize, inc-
; rement, single mode for RAM refresh.
= 0041 C dma_mode_1 equ 041h ; channel 1, verify, autoinit disabled,
; increment, single mode for not used.
= 0056 C dma_mode_2 equ 056h ; channel 2, write, autoinitialize, inc-
; rement, single mode for FDU.
= 0043 C dma_mode_3 equ 043h ; channel 3, verify, autoinit disabled,
; increment, single mode for display.

; dma_mask_bit port: ; bits #0-1: channel select
; ; bit # 2: set/-clr mask bit (off/on)

= 0000 C dma_unmask_0 equ 000h ; turn on channel 0 for RAM refresh.

;-----
; 18259A Programmable Interrupt Controller Port Addresses
;-----
= CC2C C pic_0 equ 020h ; 8259A 'control' port (A0 = 0)
= 0021 C pic_1 equ 021h ; 8259A 'data' port (A0 = 1)

;-----
; 18259A Programmable Interrupt Controller Commands
;-----
= 0013 C pic_icw1 equ 013h ; ICW1 for both master & slave pic's
; bit #0 = 1: ICW4 to follow (wvector base)
; bit #1 = 1: single mode (no slaves or icw3)

```

ROM BIOS Listing

```

C                                     ; bit #2 = 0: call address interval of 8 bytes
C                                     ; (don't care if 8086 mode -- always vectors &
C                                     ; byte interval)
= 0008 C pic_low2      equ    008h    ; bit #3 = 0: edge triggered
= 0008 C pic_low3      equ    008h    ; interrupt vector base address (INTs 08h - 0Fh)
C                                     ; if cascade mode , and IR3 is a
C                                     ; slave, 8259A is reprogrammed including low3
= 000D C pic_low4      equ    00Dh    ; bit #0 = 1: 8086 mode
C                                     ; bit #1 = 0: normal_end_of_int
C                                     ; bit #2 = 1: specify master for buffered mode
C                                     ; ( specifies slave for buffered mode )
C                                     ; bit #3 = 1: buffered mode
C                                     ; bit #4 = 0: not special fully nested
= 00FF C pic_off_msk   equ    0FFh    ; pic interrupt mask bits (all interrupts off)
C
= 0020 C pic_nesi      equ    020h    ; non-specific end-of-interrupt
C
= 0060 C pic_nesi_0    equ    060h    ; specific end-of-interrupt for IRO: 18253 p_timer
= 0061 C pic_nesi_1    equ    061h    ; specific end-of-interrupt for IRO: 18041A kb
= 0066 C pic_nesi_6    equ    066h    ; specific end-of-interrupt for IR6: Fdu
C
C -----
C ; 18253 p_timer Port Addresses
C -----
= 0040 C p_8253_0      equ    040h    ; 8253 p_timer 0 - rtc interrupt - IRO = INT 08h
= 0041 C p_8253_1      equ    041h    ; 8253 p_timer 1 - memory refresh p_daa
= 0042 C p_8253_2      equ    042h    ; 8253 p_timer 2 - tone generator for speaker
= 0043 C p_8253_ctrl   equ    043h    ; 8253 p_timer control port
C
C -----
C ; 18253 p_timer Control Bytes
C -----
C ; bit #0 -> Binary Code Decimal (BCD) Enable
C ; bits #1-3 -> Mode (0-5) 000 Mode 0: Interrupt on Terminal Count
C ; 001 Mode 1: Programmable One-Shot
C ; x10 Mode 2: Rate Generator
C ; x11 Mode 3: Square Wave Rate Generator
C ; 100 Mode 4: Software Triggered Strobe
C ; 101 Mode 5: Hardware Triggered Strobe
C ; bits #4-5 -> Read/Load Instruction (0-3)
C ; bits #6-7 -> Select Counter (0-2)
C
= 0036 C t0cmd        equ    036h    ; 00 11 011 0 -> p_8253_0, lab 1st, mode 3, no BCD
= 0074 C t1cmd        equ    074h    ; 01 11 010 0 -> p_8253_1, lab 1st, mode 2, no BCD
= 0086 C t2cmd        equ    086h    ; 10 11 011 0 -> p_8253_2, lab 1st, mode 3, no BCD
C
C -----
C ; 18253 p_timer Counts
C -----
C ; 8253 input is 1.2288 MHz (3.6864/3) or a period of 813.8 nsec = 0.814 usec
C ; Note: PC input is 1.19318 MHz or a period of 838.1 nsec = 0.838 usec
= 0000 C t0count     equ    0      ; 65,536 -> (1,228,800 Hz)/(65,536) = 18.75 intsa/sec
C                                     ; -> (1,193,180 Hz)/(65,536) = 18.21 intsa/sec
C
C ; t1count equ 9 ; OLD refresh cycle = 9*(813.8 nsec) = 7.32 usec
= 0013 C t1count     equ    19    ; REAL refresh cycle = 19*(813.8 nsec) = 15.5 usec
C                                     ; < 15.625 usec minimum required. ( is 18 - safety???)
= 0266 C t2count     equ    614    ; (1.2288 MHz)/(2*614) = 1.00 kHz tone
C
C -----
C ; 28530 Serial Communication Controller
C -----
C ; (scc_data_x port addresses are indexed from the scc_ctl_x
C ; port addresses. See com.src.)
C
= 0050 C scc_ctl_a     equ    050h    ; write to SCC pointer register (0-Fh),
= 0052 C scc_ctl_b     equ    052h    ; then read or write from selected register.
C
C -----
C ; 8041 Keyboard Controller
C -----
= 0060 C p_kscan      equ    060h
= 0061 C p_kctrl      equ    061h    ; bit #7: reset interrupt pending
C                                     ; bit #6: kb clock reset
C                                     ; bit #5: I/O channel (NMI) enable
C                                     ; bit #4: RAM parity (NMI) enable
C                                     ; bits #3 & #2: not used
C                                     ; bit #1: speaker data
C                                     ; bit #0: speaker gate to p_8253_2
= 0064 C kb_status    equ    064h    ; bit #1: input buffer (ok to write byte)
C                                     ; bit #0: output buffer (byte to be read)
C
C -----
C ; General Control Ports
C -----
= 0062 C ControlB     equ    062h    ; 8087, etc.
= 0065 C ComaControl  equ    065h
= 0066 C sys_conf_a   equ    066h    ; bit #7: 2764/~2732 ROM's
C                                     ; bit #6: not used
C                                     ; bit #5: SCC 8530 chip installed
C                                     ; bit #4: 8087 installed

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ROM BIOS Listing

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C
C ; bit #3: 256k x 1 RAM used
= 0067 C sys_conf_b equ 067h ; bits #2 - #0: RAM configuration
C ; bits #7 - #6: (number of FDUs)-1
C ; bits #5 - #4: reserved for monitor type
C ; bits #3 - #2: reserved for HDU type
C ; bit #1: "Fast" FDU start up
C ; bits #0: 95 tpi FDU
C
C ;-----
C ; 58174A Clock Calendar
C ;
C ; (See calendar.src)
C ;-----
C ; FDU & HDU Disk Driver Error Codes
C ;-----
= 0080 C time_out equ 80h
= 0040 C seek_error equ 40h
= 0020 C fdc_error equ 20h
= 0010 C crc_error equ 10h
= 0009 C dma_seg_error equ 09h
= 0008 C dma_error equ 08h
= 0004 C sect_not_found equ 04h
= 0003 C write_protect equ 03h
= 0002 C addr_mark_error equ 02h
= 0001 C cmd_error equ 01h
C
C ;-----
C ; Game Card
C ;-----
= 0201 C game_card equ 201h
C
C ;-----
C ; Parallel Printer Interface
C ;
C ; (prt_stat_x & prt_cmd_x port addresses are indexed from the
C ; prt_data_x port addresses. See prt.src.)
C ;-----
= 038C C prt_data_a equ 038Ch
C ; prt_stat_a equ 038Dh
C ; prt_cmd_a equ 038Eh
= 0378 C prt_data_b equ 0378h ; on mother board
C ; prt_stat_b equ 0379h
C ; prt_cmd_b equ 037Ah
= 0278 C prt_data_c equ 0278h
C ; prt_stat_c equ 0279h
C ; prt_cmd_c equ 027Ah
C
C ;-----
C ; Color and Monochrome Video Controller
C ;
C ; (xxxxx_data, xxxxx_mode, xxxxx_status, xxxxx_LPelear, and
C ; xxxxx_LFPreset port addresses are indexed from the xxxxx_Pointer
C ; port addresses for color & display. See vid.src and graph.src.)
C ;-----
C ; Color Controller.
= 03D4 C color_pointer equ 03D4h ; 6845 pointer to internal regs
C ; Monochrome Controller.
= 03B4 C v_pointer equ 03B4h ; 6845 pointer to internal regs
C
C ;-----
C ; INS8250 Asynchronous Communication Chip
C ;
C ; (com_int_x, com_lctl_x, com_mctl_x, com_lstat_x, and
C ; com_mstat_x port addresses are indexed from the com_data_x
C ; port addresses. See com.src.)
C ;-----
= 03F8 C com_data_a equ 03F8h ; channel A 8250 data register/low byte baud
C ; com_int_a equ 03F9h ; channel A 8250 high byte baud count register
= 03FA C com_id_s equ 03FAh ; channel A 8250 check for presence register
C ; com_lctl_a equ 03FBh ; channel A 8250 line control register
C ; com_mctl_a equ 03FCh ; channel A 8250 modem control register
C ; com_lstat_a equ 03FDh ; channel A 8250 line status register
C ; com_mstat_a equ 03FEh ; channel A 8250 modem status register
= 02F8 C com_data_b equ 02F8h ; channel B 8250 data register/low byte baud
C ; com_int_b equ 02F9h ; channel B 8250 high byte baud count register
= 02FA C com_id_b equ 02FAh ; channel B 8250 check for presence register
C ; com_lctl_b equ 02FBh ; channel B 8250 line control register
C ; com_mctl_b equ 02FCh ; channel B 8250 modem control register
C ; com_lstat_b equ 02FDh ; channel B 8250 line status register
C ; com_mstat_b equ 02FEh ; channel B 8250 modem status register
C
C ;-----
C ; Keyboard Constants
C ;-----
C ; --- shift flag equates within kb_flg
C

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ROM BIOS Listing

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C
= 0080      C insert_mode      equ      80h      ; insert state in action
= 0040      C caps_lock_mode   equ      40h      ; caps lock state toggled
= 0020      C num_lock_mode   equ      20h      ; num lock state toggled
= 0010      C scrll_lock_mode equ      10h      ; scroll lock state toggled
= 0008      C pause_mode      equ      08h      ; pause toggled
= 0001      C dix_kb          equ      01h      ; deluxe keyboard
C
C
C ;--- shift flag equates within kb_flag_1
C
= 0080      C insert_shift    equ      80h      ; insert key depressed
= 0040      C caps_lock_shift equ      40h      ; caps lock key depressed
= 0020      C num_lock_shift  equ      20h      ; num lock key depressed
= 0010      C scrll_lock_shift equ      10h      ; scroll lock key depressed
= 0008      C alt_shift       equ      08h      ; alternate shift key depressed
= 0004      C cntrl_shift     equ      04h      ; control shift key depressed
= 0002      C left_shift      equ      02h      ; left shift key depressed
= 0001      C right_shift     equ      01h      ; right shift key depressed
C
C
C ;--- Scan codes for special function keys
C
= 001D      C cntrl_key       equ      29h      ; control key scan code
= 0024      C left_shift_key equ      42h      ; left shift scan code
= 0036      C right_shift_key equ      54h      ; right shift scan code
= 0038      C alt_key       equ      56h      ; alt shift key scan code
= 003A      C caps_lock_key   equ      58h      ; shift lock scan code
= 0045      C num_lock_key   equ      59h      ; number lock scan code
= 0046      C scrll_lock_key equ      70h      ; scroll lock key scan code
= 0052      C insert_key     equ      82h      ; insert key scan code
= 0053      C delete_key     equ      83h      ; delete key scan code
C
C
C ;-----
C ; Data Declarations
C ;-----
C
C ;-----
C ; Interrupt Locations (dummy data segment to define constant offsets)
C ;-----
C
0000      C abs0          segment public 'RAM'          ; at abs0_seg
C                assume cs:nothing, ds:nothing, es:nothing, as:nothing
C
C ;-----
C ; CPU Interrupt Routines
C ;-----
C
0000  ???????? C int00loen      dd      ?          ; divide by zero
0004  ???????? C int01loen      dd      ?          ; single step trap
0008  ???????? C int02loen      dd      ?          ; nmi parity trap
000C  ???????? C int03loen      dd      ?          ; break interrupt
0010  ???????? C int04loen      dd      ?          ; divide overflow
0014  ???????? C int05loen      dd      ?          ; print screen
C
0C18  ???????? C int06loen      dd      ?
001C  ???????? C int07loen      dd      ?
C
C ;-----
C ; 1825A Hardware Interrupt Routines
C ;-----
C
0020  ???????? C int08loen      dd      ?          ; 1825J rtc interrupt
0024  ???????? C int09loen      dd      ?          ; 18041 kb interrupt
C
0028  ???????? C int0Aloen      dd      ?
002C  ???????? C int0Bloen      dd      ?
0030  ???????? C int0Cloen      dd      ?
C
003A  ???????? C int0Dloen      dd      ?          ; hard disk interrupt
0038  ???????? C int0Eloen      dd      ?          ; floppy disk interrupt
C
003C  ???????? C int0Floen      dd      ?
C
C ;-----
C ; Software Interrupt Routines
C ;-----
C
0040  ???????? C int10loen      dd      ?          ; display request
0044  ???????? C int11loen      dd      ?          ; equipment request
0048  ???????? C int12loen      dd      ?          ; memory size request
004C  ???????? C int13loen      dd      ?          ; disk I/O request
0050  ???????? C int14loen      dd      ?          ; serial communication request
0054  ???????? C int15loen      dd      ?          ; cassette request
0058  ???????? C int16loen      dd      ?          ; kb request
005C  ???????? C int17loen      dd      ?          ; printer request
0060  ???????? C int18loen      dd      ?          ; cassette BASIC pointer
0064  ???????? C int19loen      dd      ?          ; boot-strap request
0068  ???????? C int1Aloen      dd      ?          ; time of day request
006C  ???????? C int1Bloen      dd      ?          ; kb break pointer
0070  ???????? C int1Cloen      dd      ?          ; p_timer break pointer
0074  ???????? C int1Dloen      dd      ?          ; display parameter pointer
0078  ???????? C int1Eloen      dd      ?          ; disk parameter pointer
007C  ???????? C int1Floen      dd      ?          ; graphics character extensions pointer
C
0080      C abs0          ends
C
C ;-----
C ; RAM stack
C ;-----
C

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ROM BIOS Listing

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0000      C stack_ram      segment public 'RAM'      ; at stack_seg
          C
          C stack_ram      ends
          C
          C -----
          C ; System Data Area
          C -----
0000      C data          segment public 'RAM'      ; at data_seg
          C          assume cs:nothing, ds:nothing, es:nothing, ss:nothing
          C
          C -----
          C ; Data Area
          C -----
          C
          C ; ROM Bios Data Area
          C
0000      04 [      C rs232_addr      dw      4 dup (?) ; 0040:0000 addresses of rs232 adapters
          C          ]
          C
0008      04 [      C printer_addr     dw      4 dup (?) ; 0040:0008 addresses of printers
          C          ]
          C
0010      C switch_bits   dw      ? ; 0040:0010 state of DIP switches
0012      C mfg_tst         db      ? ; 0040:0012 initialization flag
0013      C memory_size   dw      ? ; 0040:0013 memory size in kbytes
0015      02 [      C mfg_err_flag    db      2 dup (?) ; 0040:0015 error codes for manufacturing
          C          ]
          C
          C ; Keyboard Data Area
          C
0017      C kb_flag       db      ? ; 0040:0017 keyboard shift flag status byte
0018      C kb_flag_1    db      ? ; 0040:0018 second byte of keyboard status
0019      C all_input    db      ? ; 0040:0019 alternate keypad entry
001A      C buffer_head   dw      ? ; 0040:001A keyboard output pointer offset
001C      C buffer_tail   dw      ? ; 0040:001C keyboard input pointer offset
          C
001E      10 [      C kb_buffer       dw      16 dup (?) ; 0040:001E room for 15 entries: head =
          C          ]
          C          ; tail implies buffer is empty
          C
          C ; Floppy Diskette Data Area
          C
003E      C seek_status   db      ? ; 0040:003E floppy disk restore status bits
003F      C motor_status  db      ? ; 0040:003F floppy disk motor status bits
0040      C motor_count   db      ? ; 0040:0040 floppy disk turn off counter
0041      C diskette_status db      ? ; 0040:0041 floppy disk driver status byte
          C
0042      C cmd_block     label byte ; 0040:0042 HDU command block buffer
0042      C hcd_error     label byte ; 0040:0042 HDU sense byte buffer
0042      07 [      C nec_status     db      7 dup (?) ; 0040:0042 status bytes from NEC controller
          C          ]
          C
          C ; Video Display Data Area
          C
0049      C v_mode        db      ? ; 0040:0049 CRT mode
004A      C v_width       dw      ? ; 0040:004A CRT number of columns (often db)
004C      C v_height     dw      ? ; 0040:004C CRT length of video ram in bytes
004E      C v_top        dw      ? ; 0040:004E CRT video ram buffer address
0050      08 [      C v_curpos      dw      8 dup (?) ; 0040:0050 cursor for each of up to 8 pages
          C          ]
          C
          C
0060      C v_cursorize  dw      ? ; 0040:0060 v_curs_type sets cursor value
0062      C v_page_seg   db      ? ; 0040:0062
0063      C v_base6845   dw      ? ; 0040:0063
0065      C v_3x8       db      ? ; 0040:0065
0066      C v_colorpal   db      ? ; 0040:0066
          C
          C ; Optional Post Data Area
          C
0067      C io_rom_init   dw      ? ; 0040:0067 option ROM init routine offset
0069      C io_rom_seg   dw      ? ; 0040:0069 option ROM init routine segment
006B      C intr_flag    db      ? ; 0040:006B occurrence of interrupt flag
          C
          C ; 18253 p_timer Data Area
          C
006C      C t_low_order  dw      ? ; 0040:006C low word of 18253 p_timer count
006E      C t_hi_order   dw      ? ; 0040:006E high word of 18253 p_timer count
0070      C t_overflow   db      ? ; 0040:0070 time rolled over flag
          C
          C ; System Data Area
          C
0071      C bios_break   db      ? ; 0040:0071 bit #7 set if break key hit
0072      C reset_flag   dw      ? ; 0040:0072 = 1234h if keyboard reset hit
          C
          C ; Fixed Disk Data Area
          C
0074      C disk_status  db      ? ; 0040:0074 fixed disk driver status byte
0075      C hf_num       db      ? ; 0040:0075 fixed disk drive count

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ROM BIOS Listing

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0076 ??      C control_byte db ? ; 0040:0076 fixed disk control byte options
0077 ??      C port_off db ? ; 0040:0077 fixed disk port offset
C
C ; Printer & RS-232 Time-Out Data Areas
C
0078 04 [ ?? ] C printer_t_out db 4 dup (?) ; 0040:0078 printer time-out variables
C
C
007C 04 [ ?? ] C serial_t_out db 4 dup (?) ; 0040:007C RS-232 time-out variables
C
C
C ; Additional Keyboard Data Area
C
0080 ?????   C buffer_start dw ? ; 0040:0080 offset of kb_buffer = 001E
0082 ?????   C buffer_end dw ? ; 0040:0082 offset of kb_buffer_end = 003E
C
C -----
C ; Data Area
C -----
C
C ; Master Table Pointer.
C
0084 ???????? C master_tbl_ptr dd ? ; 0040:0084 pointer to master table
C
0088         C data ends
C
C -----
C ; Video RAM
C -----
C
0000         C v_ram segment public 'RAM' ; at para_mono
C
0000         C v_ram ends
C060         C oode segment public 'ROM'
C
C font_lo_8x16 label byte ; 2048 bytes
C060         C include fontlo16.asm
C
C fontlo16 proc near ; System Font Table for M24
C
C060 00 00 00 00 00 00 00 DB 00h,00h,00h,00h,00h,00h,00h,00h
C
C068 00 00 00 00 00 00 00 DB 00h,00h,00h,00h,00h,00h,00h,00h ; 0
C
C070 00 00 7E 81 A5 81 DB 00h,00h,07eh,081h,0a5h,081h,081h,0bdh
C078 81 8D 00 00 00 00 00 DB 099h,081h,07eh,00h,00h,00h,00h,00h ; 1
C080 00 00 7E FF DB FF DB 00h,00h,07eh,0ffh,0dbb,0ffh,0ffh,0c3h
C088 FF C3 00 00 00 00 00 DB 0e7h,0e7h,0ffh,07eh,00h,00h,00h,00h ; 2
C090 00 00 00 36 7F 7F DB 00h,00h,00h,036h,07fh,07fh,07fh,07fh
C098 7F 7F 3E 1C 08 00 00 00 DB 03eh,01eh,08h,00h,00h,00h,00h,00h ; 3
C0A0 00 00 00 08 1C 3E DB 00h,00h,00h,08h,01eh,03eh,07fh,03eh
C0A8 7F 3E 1C 0E 00 00 00 DB 01eh,08h,00h,00h,00h,00h,00h,00h ; 4
C0B0 00 00 18 3C 3C E7 DB 00h,00h,018h,03ch,03ch,0e7h,0e7h,0e7h
C0B8 E7 E7 18 18 3C 00 00 00 DB 018h,018h,03ch,00h,00h,00h,00h,00h ; 5
C0C0 00 00 18 3C 7E FF DB 00h,00h,018h,03ch,07ch,07ch,0ffh,07eh
C0C8 FF 7E 18 18 3C 00 00 00 DB 018h,018h,03ch,00h,00h,00h,00h,00h ; 6
C0D0 00 00 00 00 00 18 DB 00h,00h,00h,00h,00h,018h,03ch,03ch
C0D8 3C 3C 18 00 00 00 00 00 DB 018h,00h,00h,00h,00h,00h,00h,00h ; 7
C0E0 00 00 00 00 00 00 00 DB 0ffh,0ffh,0ffh,0ffh,0ffh,0ffh,0ffh,0c3h
C0E8 FF FF FF FF FF E7 C3 C3 DB 0c3h,0e7h,0ffh,0ffh,0ffh,0ffh,0ffh,0ffh ; 8
C0F0 FF FF FF FF FF FF FF DB 00h,00h,00h,00h,03ch,024h,042h,042h
C0F8 42 42 24 3C 00 00 00 00 DB 024h,03ch,00h,00h,00h,00h,00h,00h ; 9
C100 FF FF FF FF C3 99 BD BD DB 0ffh,0ffh,0ffh,0ffh,0c3h,099h,099h,0dbd,0dbd
C108 BD 99 C3 FF FF FF FF DB 0bdh,099h,0c3h,0ffh,0ffh,0ffh,0ffh,0ffh ; a
C110 00 00 1F 07 0D 19 78 CC DB 00h,00h,01fh,07h,0dh,019h,078h,0cch
C118 CC CC 78 00 00 00 00 DB 0cch,0cch,078h,00h,00h,00h,00h,00h ; b
C120 00 00 3C 66 66 66 3C 18 DB 00h,00h,03ch,066h,066h,066h,03ch,018h
C128 78 18 18 00 00 00 00 DB 07eh,018h,018h,00h,00h,00h,00h,00h ; c
C130 00 00 18 14 12 12 12 14 DB 00h,00h,018h,014h,012h,012h,012h,014h
C138 10 70 F0 F0 60 00 00 00 DB 010h,070h,0f0h,0f0h,060h,00h,00h,00h ; d

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ROM BIOS
Listing

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C140 00 00 1F 11 1F 11      C      DB 00h,00h,01fh,011h,01fh,011h,011h,011h
      11 11                  C      DB 013h,037h,077h,072h,020h,00h,00h,00h ; e
      00 00                  C      DB 00h,00h,018h,018h,04bh,03ch,0efh,03ch
C150 00 00 18 18 DB 3C      C      DB 04bh,018h,018h,00h,00h,00h,00h,00h ; f
      87 3C                  C      DB 00h,00h,040h,060h,070h,07eh,07fh,07eh
C158 DB 18 18 00 00 00 00      C      DB 070h,060h,040h,00h,00h,00h,00h,00h ; 10
      00 00                  C      DB 00h,00h,01h,03h,07h,01fh,07fh,01fh
C168 70 60 40 00 00 00 00      C      DB 07h,03h,01h,00h,00h,00h,00h,00h ; 11
      00 00                  C      DB 00h,00h,018h,03ch,07eh,018h,018h,018h
C170 00 00 01 03 07 1F      C      DB 07eh,03ch,018h,00h,00h,00h,00h,00h ; 12
      7F 1F                  C      DB 00h,00h,033h,033h,033h,033h,033h,033h
C178 07 03 01 00 00 00 00      C      DB 00h,00h,033h,00h,00h,00h,00h,00h ; 13
      00 00                  C      DB 00h,00h,07fh,04bh,0dbb,0dbb,07bh,01bh
C180 00 00 16 3C 7E 18      C      DB 01bh,01bh,01bh,00h,00h,00h,00h,00h ; 14
      18 18                  C      DB 00h,03ch,063h,030h,01eh,036h,063h,063h
C188 7E 3C 18 00 00 00 00      C      DB 036h,01eh,06h,063h,03eh,00h,00h,00h ; 15
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C190 00 00 33 33 33 33      C      DB 07eh,07eh,07eh,00h,00h,00h,00h,00h ; 16
      33 33                  C      DB 00h,00h,018h,03ch,07eh,018h,018h,018h
C198 00 00 33 00 00 00 00      C      DB 18 18
      00 00                  C      DB 7E 3C 18 FF 00 00
C1A0 00 00 7F DB DB DB      C      DB 00h,00h,018h,03ch,07eh,018h,018h,018h
      7B 1B                  C      DB 018h,018h,018h,00h,00h,00h,00h,00h ; 18
C1A8 1B 1B 18 00 00 00 00      C      DB 00h,00h,018h,018h,018h,018h,018h,018h
      00 00                  C      DB 07eh,03ch,018h,00h,00h,00h,00h,00h ; 19
C1B0 00 3E 63 30 1C 36      C      DB 00h,00h,00h,00h,06h,07fh,06h
      63 63                  C      DB 0ch,00h,00h,00h,00h,00h,00h,00h ; 1a
C1B8 36 1C 06 63 3E 00      C      DB 00h,00h,00h,00h,018h,030h,07fh,030h
      00 00                  C      DB 018h,00h,00h,00h,00h,00h,00h,00h ; 1b
C1C0 00 00 00 00 00 00 00      C      DB 00h,00h,00h,00h,060h,060h,060h,060h
      00 00                  C      DB 07fh,07fh,00h,00h,00h,00h,00h,00h ; 1c
C1C8 7E 7E 7E 00 00 00 00      C      DB 00h,00h,00h,00h,024h,042h,07fh,042h
      00 00                  C      DB 024h,00h,00h,00h,00h,00h,00h,00h ; 1d
C1D0 00 00 18 3C 7E 18      C      DB 00h,00h,00h,00h,00h,00h,00h,018h
      18 18                  C      DB 03ch,07eh,07fh,00h,00h,00h,00h,00h ; 1e
C1D8 7E 3C 18 FF 00 00 00      C      DB 00h,00h,00h,00h,00h,07fh,03eh
      00 00                  C      DB 00h,00h,00h,00h,00h,07fh,07eh,03eh
C1E0 00 00 1B 3C 7E 18      C      DB 018h,00h,00h,00h,00h,00h,00h,00h ; 1f
      18 18                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C1E8 18 18 18 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C1F0 00 00 18 18 18 18      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      18 18                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C1F8 7E 3C 18 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C200 00 00 00 0C 0E      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      7F 0E                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C208 0C 00 00 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C210 00 00 00 00 18 30      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      7F 30                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C218 18 00 00 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C220 00 00 00 60 60 60      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      60 60                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C228 7F 7F 00 00 00 00      C      DB 07fh,07fh,00h,00h,00h,00h,00h,00h ; 1e
      00 00                  C      DB 00h,00h,00h,00h,024h,042h,07fh,042h
C230 00 00 00 00 24 42      C      DB 024h,00h,00h,00h,00h,00h,00h,00h ; 1d
      FF 42                  C      DB 00h,00h,00h,00h,00h,00h,00h,018h
C238 24 00 00 00 00 00      C      DB 03ch,07eh,07fh,00h,00h,00h,00h,00h ; 1e
      00 00                  C      DB 00h,00h,00h,00h,00h,07fh,03eh
C240 00 00 00 00 00 00      C      DB 018h,00h,00h,00h,00h,00h,00h,00h ; 1f
      00 18                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C248 3C 7E FF 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C250 00 00 00 00 00 FF      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      7E 3C                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C258 18 00 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C260 00 00 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C268 00 00 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C270 00 00 18 3C 3C 3C      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      18 18                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C278 00 18 18 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h ; 11' 21
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h
C280 00 00 66 66 24 00 00      C      DB 00h,00h,066h,066h,024h,00h,00h,00h
      00 00                  C      DB 00h,00h,00h,00h,00h,00h,00h,00h ; 11'' 22
C288 00 00 00 00 00 00      C      DB 00h,00h,00h,00h,00h,00h,00h,00h
      00 00                  C      DB 00h,00h,036h,036h,07fh,036h,036h,036h
C290 00 00 36 36 7F 36      C      DB 07fh,036h,036h,00h,00h,00h,00h,00h ; 11''' 23
      36 36                  C      DB 08h,08h,03eh,063h,060h,060h,03eh,03h
C298 7F 36 36 00 00 00 00      C      DB 03h,063h,03eh,08h,08h,00h,00h,00h ; 11'''' 24
      00 00                  C      DB 00h,00h,00h,061h,063h,06h,0eh,018h
C2A0 08 08 3E 63 60 60      C      DB 030h,063h,043h,00h,00h,00h,00h,00h ; 11'''' 25
      3E 03                  C      DB 00h,00h,01eh,036h,036h,01eh,03bh,06eh
C2A8 03 63 3E 08 08 00 00      C      DB 066h,066h,03bh,00h,00h,00h,00h,00h ; 11'''' 26
      00 00                  C
C2B0 00 00 00 61 63 06      C
      0C 18                  C
C2B8 30 63 43 00 00 00 00      C
      00 00                  C
C2C0 00 00 1C 36 36 1C      C
      3B 6E                  C
C2C8 66 66 3B 00 00 00 00      C
      00 00                  C

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ROM BIOS
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C2D0	00 00 30 30 30 60	C	DB 00h,00h,030h,030h,030h,060h,00h,00h
00 00		C	
C2D6	00 00 00 00 00 00	C	DB 00h,00h,00h,00h,00h,00h,00h,00h ;'1' 27
00 00		C	
C2E0	00 00 0C 18 30 30	C	DB 00h,00h,00h,018h,030h,030h,030h,030h
30 30		C	
C2E6	30 18 0C 00 00 00	C	DB 030h,018h,00h,00h,00h,00h,00h,00h ;'1' 28
00 00		C	
C2F0	00 00 30 18 0C 0C	C	DB 00h,00h,030h,018h,00h,00h,00h,00h
0C 0C		C	
C2F6	0C 18 30 00 00 00	C	DB 00h,018h,030h,00h,00h,00h,00h,00h ;'1' 29
00 00		C	
C300	00 00 00 00 66 3C	C	DB 00h,00h,00h,00h,066h,030h,0FFh,030h
FF 3C		C	
C306	66 00 00 00 00 00	C	DB 066h,00h,00h,00h,00h,00h,00h,00h ;'18' 2a
00 00		C	
C310	00 00 00 00 18 18	C	DB 00h,00h,00h,00h,018h,018h,070h,018h
7E 18		C	
C316	18 00 00 00 00 00	C	DB 018h,00h,00h,00h,00h,00h,00h,00h ;'1a' 2b
00 00		C	
C320	00 00 00 00 00 00	C	DB 00h,00h,00h,00h,00h,00h,00h,00h
00 00		C	
C326	18 18 18 30 00 00	C	DB 018h,018h,018h,030h,00h,00h,00h,00h ;'1' 2c
00 00		C	
C330	00 00 00 00 00 00	C	DB 00h,00h,00h,00h,00h,00h,00h,00h
7E 00		C	
C336	00 00 00 00 00 00	C	DB 00h,00h,00h,00h,00h,00h,00h,00h ;'1-' 2d
00 00		C	
C340	00 00 00 00 00 00	C	DB 00h,00h,00h,00h,00h,00h,00h,00h
00 00		C	
C346	00 18 18 00 00 00	C	DB 00h,018h,018h,00h,00h,00h,00h,00h ;'1.' 2e
00 00		C	
C350	00 00 01 03 06 0C	C	DB 00h,00h,01h,03h,06h,00h,018h,030h
18 30		C	
C356	60 80 00 00 00 00	C	DB 060h,040h,00h,00h,00h,00h,00h,00h ;'1/' 2f
00 00		C	
C360	00 00 3E 63 67 6F	C	DB 00h,00h,030h,063h,067h,067h,070h,073h
7E 73		C	
C366	63 63 3E 00 00 00	C	DB 063h,063h,030h,00h,00h,00h,00h,00h ;'10' 30
00 00		C	
C370	00 00 0C 1C 3C 0C	C	DB 00h,00h,00h,010h,030h,00h,00h,00h
0C 0C		C	
C376	0C 0C 3F 00 00 00	C	DB 00h,00h,03Fh,00h,00h,00h,00h,00h ;'11' 31
00 00		C	
C380	00 00 3E 63 03 06	C	DB 00h,00h,030h,063h,03h,06h,00h,018h
0C 18		C	
C386	30 63 7F 00 00 00	C	DB 030h,063h,07Fh,00h,00h,00h,00h,00h ;'12' 32
00 00		C	
C390	00 00 3E 63 03 03	C	DB 00h,00h,030h,063h,03h,03h,030h,03h
3E 03		C	
C396	03 63 3E 00 00 00	C	DB 03h,063h,030h,00h,00h,00h,00h,00h ;'13' 33
00 00		C	
C3A0	00 00 06 0E 1E 3E	C	DB 00h,00h,06h,00h,010h,036h,066h,07Fh
66 7F		C	
C3A6	06 06 0F 00 00 00	C	DB 06h,06h,0Fh,00h,00h,00h,00h,00h ;'14' 34
00 00		C	
C3B0	00 00 7F 60 60 60	C	DB 00h,00h,07Fh,060h,060h,060h,070h,03h
7E 03		C	
C3B6	63 63 3E 00 00 00	C	DB 03h,063h,030h,00h,00h,00h,00h,00h ;'15' 35
00 00		C	
C3C0	00 00 1C 30 60 60	C	DB 00h,00h,010h,030h,060h,060h,070h,063h
7E 63		C	
C3C6	63 63 3E 00 00 00	C	DB 063h,063h,030h,00h,00h,00h,00h,00h ;'16' 36
00 00		C	
C3D0	00 00 7F 63 03 06	C	DB 00h,00h,07Fh,063h,03h,06h,00h,018h
0C 18		C	
C3D6	18 18 18 00 00 00	C	DB 018h,018h,018h,00h,00h,00h,00h,00h ;'17' 37
00 00		C	
C3E0	00 00 3E 63 63 63	C	DB 00h,00h,030h,063h,063h,063h,030h,063h
3E 63		C	
C3E6	63 63 3E 00 00 00	C	DB 063h,063h,030h,00h,00h,00h,00h,00h ;'18' 38
00 00		C	
C3F0	00 00 3E 63 63 63	C	DB 00h,00h,030h,063h,063h,063h,03Fh,03h
3F 03		C	
C3F6	03 06 1C 00 00 00	C	DB 03h,06h,010h,00h,00h,00h,00h,00h ;'19' 39
00 00		C	
C400	00 00 00 18 18 00	C	DB 00h,00h,00h,018h,018h,00h,00h,00h
00 00		C	
C406	18 18 00 00 00 00	C	DB 018h,018h,00h,00h,00h,00h,00h,00h ;'2' 3a
00 00		C	
C410	00 00 00 18 18 00	C	DB 00h,00h,00h,018h,018h,00h,00h,00h
00 00		C	
C416	18 18 30 00 00 00	C	DB 018h,018h,030h,00h,00h,00h,00h,00h ;'2' 3b
00 00		C	
C420	00 00 06 0C 18 30	C	DB 00h,00h,06h,00h,018h,030h,060h,030h
60 30		C	
C426	18 0C 06 00 00 00	C	DB 018h,00h,06h,00h,00h,00h,00h,00h ;'1<' 3c
00 00		C	
C430	00 00 00 00 7E 00	C	DB 00h,00h,00h,00h,070h,00h,00h,00h
00 00		C	
C436	7E 00 00 00 00 00	C	DB 070h,00h,00h,00h,00h,00h,00h,00h ;'1=' 3d
00 00		C	
C440	00 00 60 30 18 0C	C	DB 00h,00h,060h,030h,018h,00h,06h,00h
06 0C		C	
C446	18 30 60 00 00 00	C	DB 018h,030h,060h,00h,00h,00h,00h,00h ;'1>' 3e
00 00		C	
C450	00 00 3E 63 63 06	C	DB 00h,00h,030h,063h,063h,06h,00h,00h
0C 0C		C	
C456	00 0C 0C 00 00 00	C	DB 00h,00h,00h,00h,00h,00h,00h,00h ;'1?' 3f
00 00		C	

ROM BIOS Listing

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C460 00 00 3E 63 63 6F      C      DB 00h,00h,03eh,063h,063h,06fh,06fh,06fh
      6F 6F                  C      DB 06eh,060h,03eh,00h,00h,00h,00h,00h ;'E' 40
C468 6E 60 3E 00 00 00      C      DB 00h,00h,08h,01eh,036h,063h,063h,07fh
      00 00                  C      DB 063h,063h,063h,00h,00h,00h,00h,00h ;'A' 41
C470 00 00 08 1C 36 63      C      DB 00h,00h,07eh,033h,033h,032h,03eh,033h
      63 7F                  C      DB 033h,033h,07eh,00h,00h,00h,00h,00h ;'B' 42
C478 63 63 63 00 00 00      C      DB 00h,00h,01eh,033h,060h,060h,060h,060h
      00 00                  C      DB 060h,033h,01eh,00h,00h,00h,00h,00h ;'C' 43
C480 00 00 7E 33 33 32      C      DB 00h,00h,07eh,036h,033h,033h,033h,033h
      3E 33                  C      DB 033h,036h,07eh,00h,00h,00h,00h,00h ;'D' 44
C488 33 33 7E 00 00 00      C      DB 00h,00h,07fh,033h,030h,034h,03eh,034h
      00 00                  C      DB 030h,033h,07fh,00h,00h,00h,00h,00h ;'E' 45
C490 00 00 1E 33 60 60      C      DB 00h,00h,07fh,031h,034h,03eh,03eh,034h
      60 60                  C      DB 030h,030h,078h,00h,00h,00h,00h,00h ;'F' 46
C498 60 33 1E 00 00 00      C      DB 00h,00h,01eh,033h,060h,060h,060h,06fh
      00 00                  C      DB 063h,033h,01eh,00h,00h,00h,00h,00h ;'G' 47
C4A0 00 00 63 63 63 63      C      DB 00h,00h,063h,063h,063h,063h,07fh,063h
      00 00                  C      DB 063h,063h,063h,00h,00h,00h,00h,00h ;'H' 48
C4A8 63 63 63 00 00 00      C      DB 00h,00h,03eh,018h,018h,018h,018h,018h
      00 00                  C      DB 018h,018h,03eh,00h,00h,00h,00h,00h ;'I' 49
C4B0 00 00 3C 18 18 18      C      DB 00h,00h,07h,06h,06h,06h,06h,06h
      00 00                  C      DB 066h,066h,03eh,00h,00h,00h,00h,00h ;'J' 4a
C4B8 18 18 3C 00 00 00      C      DB 00h,00h,073h,033h,036h,036h,03eh,036h
      00 00                  C      DB 036h,033h,073h,00h,00h,00h,00h,00h ;'K' 4b
C4C0 00 00 0F 06 06 06      C      DB 00h,00h,078h,030h,030h,030h,030h,030h
      06 06                  C      DB 030h,033h,07fh,00h,00h,00h,00h,00h ;'L' 4c
C4C8 66 66 3C 00 00 00      C      DB 00h,00h,063h,077h,07fh,06bh,063h,063h
      00 00                  C      DB 063h,063h,063h,00h,00h,00h,00h,00h ;'M' 4d
C4D0 00 00 73 33 36 36      C      DB 00h,00h,063h,073h,07bh,07fh,06fh,06fh
      3C 36                  C      DB 063h,063h,063h,00h,00h,00h,00h,00h ;'N' 4e
C4D8 36 33 73 00 00 00      C      DB 00h,00h,03eh,01eh,00h,00h,00h,00h,00h ;'O' 4f
      00 00                  C      DB 00h,00h,07eh,033h,033h,033h,03eh,036h
C4E0 00 00 78 30 30 30      C      DB 00h,00h,07eh,033h,033h,033h,03eh,030h
      30 30                  C      DB 030h,030h,078h,00h,00h,00h,00h,00h ;'P' 50
C4E8 30 33 7F 00 00 00      C      DB 00h,00h,01eh,036h,063h,063h,063h,063h
      00 00                  C      DB 06bh,03eh,01eh,06h,03h,00h,00h,00h ;'Q' 51
C4F0 00 00 63 77 7F 6B      C      DB 00h,00h,07eh,033h,033h,033h,03eh,036h
      63 63                  C      DB 033h,033h,033h,00h,00h,00h,00h,00h ;'R' 52
C4F8 63 63 63 00 00 00      C      DB 00h,00h,03eh,063h,063h,030h,01eh,06h
      00 00                  C      DB 063h,063h,03eh,00h,00h,00h,00h,00h ;'S' 53
C500 00 00 63 78 7F 6F      C      DB 00h,00h,07eh,05ah,018h,018h,018h,018h
      6F 6F                  C      DB 018h,018h,03eh,00h,00h,00h,00h,00h ;'T' 54
C508 63 63 63 00 00 00      C      DB 00h,00h,063h,063h,063h,063h,063h,063h
      00 00                  C      DB 063h,063h,03eh,00h,00h,00h,00h,00h ;'U' 55
C510 00 00 1C 36 63 63      C      DB 00h,00h,063h,063h,063h,063h,063h,063h
      63 63                  C      DB 036h,01eh,08h,00h,00h,00h,00h,00h ;'V' 56
C518 6B 3E 1C 06 03 00      C      DB 00h,00h,063h,063h,063h,063h,063h,06bh
      00 00                  C      DB 06bh,07fh,036h,00h,00h,00h,00h,00h ;'W' 57
C520 00 00 7E 33 33 33      C      DB 00h,00h,063h,063h,063h,036h,01eh,036h
      3E 36                  C      DB 063h,063h,063h,00h,00h,00h,00h,00h ;'X' 58
      00 00                  C
C528 00 00 63 63 63 63      C
      63 63                  C
C530 36 1C 08 00 00 00      C
      00 00                  C
C538 00 00 63 63 63 63      C
      63 6B                  C
C540 6B 7F 36 00 00 00      C
      00 00                  C
C548 00 00 63 63 63 36      C
      1C 36                  C
C550 63 63 63 00 00 00      C
      00 00                  C
      00 00                  C

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ROM BIOS Listing

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C5F0 00 00 66 66 66 66   C   DB 00h,00h,066h,066h,066h,066h,066h,03eh
      66 3C               C   DB 018h,018h,03eh,00h,00h,00h,00h,00h ;'Y' 59
C5F8 18 18 3C 00 00 00   C   DB 00h,00h,07fh,063h,06h,0eh,018h,030h
      00 00               C   DB 060h,063h,07fh,00h,00h,00h,00h,00h ;'Z' 5a
C600 00 00 7F 63 06 0C   C   DB 00h,00h,03eh,030h,030h,030h,030h,030h
      18 30               C   DB 030h,030h,03eh,00h,00h,00h,00h,00h ;'[' 5b
C608 60 63 7F 00 00 00   C   DB 00h,00h,040h,060h,030h,018h,0eh,06h
      00 00               C   DB 03h,01h,00h,00h,00h,00h,00h,00h ;'\ ' 5e
C610 00 00 3C 30 30 30   C   DB 00h,00h,03eh,0eh,0eh,0eh,0eh,0eh
      30 30               C   DB 0eh,0eh,03eh,00h,00h,00h,00h,00h ;']' 5d
C618 30 30 3C 00 00 00   C   DB 08h,01eh,036h,063h,00h,00h,00h,00h
      00 00               C   DB 00h,00h,00h,00h,00h,00h,00h,00h ;'^' 5e
C620 00 00 40 60 30 18   C   DB 00h,00h,00h,00h,00h,00h,00h,00h
      0C 06               C   DB 00h,00h,00h,00h,00h,00h,00h,00h
C628 03 01 00 00 00 00   C   DB 06h,066h,03bh,00h,00h,00h,00h,00h ;'a' 61
      00 00               C   DB 00h,00h,070h,030h,030h,030h,033h,033h
C630 00 00 3C 0C 0C 0C   C   DB 033h,033h,06eh,00h,00h,00h,00h,00h ;'b' 62
      0C 0C               C   DB 00h,00h,00h,00h,00h,03eh,063h,060h
C638 0C 0C 3C 00 00 00   C   DB 060h,063h,03eh,00h,00h,00h,00h,00h ;'o' 63
      00 00               C   DB 00h,00h,0eh,06h,06h,03eh,066h,066h
C640 08 1C 36 63 00 00   C   DB 066h,066h,03bh,00h,00h,00h,00h,00h ;'d' 6a
      00 00               C   DB 00h,00h,00h,00h,00h,03eh,063h,07fh
C648 00 00 00 00 00 00   C   DB 060h,063h,03eh,00h,00h,00h,00h,00h ;'e' 65
      00 00               C   DB 00h,00h,01eh,033h,030h,030h,07eh,030h
C650 00 00 00 00 00 00   C   DB 030h,030h,078h,00h,00h,00h,00h,00h ;'f' 66
      00 00               C   DB 00h,00h,00h,00h,00h,03bh,066h,066h
C658 00 00 00 00 00 00   C   DB 066h,066h,03eh,06h,066h,03eh,00h,00h ;'g' 67
      00 00               C   DB 00h,00h,070h,030h,036h,03bh,033h,033h
C660 00 00 70 30 30 3E   C   DB 033h,033h,073h,00h,00h,00h,00h,00h ;'h' 68
      33 33               C   DB 00h,00h,0eh,0eh,0eh,01eh,0eh,0eh
C668 33 33 6E 00 00 00   C   DB 0eh,0eh,01eh,00h,00h,00h,00h,00h ;'i' 69
      00 00               C   DB 00h,00h,0eh,0eh,0eh,01eh,0eh,0eh
C690 00 00 00 00 00 3E   C   DB 0eh,0eh,0eh,0eh,0eh,078h,00h,00h ;'j' 6a
      63 60               C   DB 00h,00h,070h,030h,030h,033h,036h,03eh
C698 60 63 3E 00 00 00   C   DB 036h,033h,073h,00h,00h,00h,00h,00h ;'k' 6b
      00 00               C   DB 00h,00h,01eh,0eh,0eh,0eh,0eh,0eh
C6A0 00 00 0E 06 06 3E   C   DB 0eh,0eh,01eh,00h,00h,00h,00h,00h ;'l' 6c
      66 66               C   DB 00h,00h,00h,00h,00h,06eh,033h,033h
C6A8 66 66 3E 00 00 00   C   DB 033h,033h,033h,00h,00h,00h,00h,00h ;'n' 6e
      00 00               C   DB 00h,00h,00h,00h,00h,03eh,063h,063h
C6B0 00 00 00 00 00 3E   C   DB 063h,063h,03eh,00h,00h,00h,00h,00h ;'o' 6f
      63 7F               C   DB 00h,00h,00h,00h,00h,06eh,033h,033h
C6B8 60 63 3E 00 00 00   C   DB 033h,033h,03eh,030h,030h,078h,00h,00h ;'p' 70
      00 00               C   DB 00h,00h,00h,00h,00h,03bh,066h,066h
C6C0 00 00 1E 33 30 30   C   DB 066h,066h,03eh,06h,06h,0fh,00h,00h ;'q' 71
      7C 30               C
C6C8 30 30 78 00 00 00   C
      00 00               C
C6D0 00 00 00 00 00 3B   C
      66 66               C
C6D8 66 66 3E 06 66 3C   C
      00 00               C
C6E0 00 00 70 30 36 3B   C
      33 33               C
C6E8 33 33 73 00 00 00   C
      00 00               C
C6F0 00 00 0C 0C 00 1C   C
      0C 0C               C
C6F8 0C 0C 1E 00 00 1C   C
      00 00               C
C700 00 00 0C 0C 00 1C   C
      0C 0C               C
C708 0C 0C 0C 0C 78     C
      00 00               C
C710 00 00 70 30 30 33   C
      36 3C               C
C718 36 33 73 00 00 00   C
      00 00               C
C720 00 00 1C 0C 0C 0C   C
      0C 0C               C
C728 0C 0C 1E 00 00 00   C
      00 00               C
C730 00 00 00 00 00 66   C
      7F 68               C
C738 68 68 68 00 00 00   C
      00 00               C
C740 00 00 00 00 00 6E   C
      33 33               C
C748 33 33 33 00 00 00   C
      00 00               C
C750 00 00 00 00 00 3E   C
      63 63               C
C758 63 63 3E 00 00 00   C
      00 00               C
C760 00 00 00 00 00 6E   C
      33 33               C
C768 33 33 3E 30 30 78   C
      00 00               C
C770 00 00 00 00 00 3B   C
      66 66               C
C778 66 66 3E 06 06 0F   C
      00 00               C

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ROM BIOS Listing

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C780 00 00 00 00 00 6E C DB 00h,00h,00h,00h,00h,06eh,03bh,030h
      38 30 C
C788 30 30 78 00 00 00 C DB 030h,030h,078h,00h,00h,00h,00h,00h ; 'r' 72
      00 00 C
C790 00 00 00 00 00 3E C DB 00h,00h,00h,00h,00h,03eh,063h,038h
      63 38 C
C798 0E 63 3E 00 00 00 C DB 0eh,063h,03eh,00h,00h,00h,00h,00h ; 'a' 73
      00 00 C
C7A0 00 00 00 08 18 7E C DB 00h,00h,00h,08h,018h,07eh,018h,018h
      18 18 C
C7A8 18 18 0E 00 00 00 C DB 018h,01bh,0eh,00h,00h,00h,00h,00h ; 't' 74
      00 00 C
C7B0 00 00 00 00 00 66 C DB 00h,00h,00h,00h,00h,066h,066h,066h
      66 66 C
C7B8 66 66 3B 00 00 00 C DB 066h,066h,03bh,00h,00h,00h,00h,00h ; 'u' 75
      00 00 C
C7C0 00 00 00 00 00 63 C DB 00h,00h,00h,00h,00h,063h,063h,063h
      63 63 C
C7C8 36 1C 08 00 00 00 C DB 036h,01eh,08h,00h,00h,00h,00h,00h ; 'v' 76
      00 00 C
C7D0 00 00 00 00 00 63 C DB 00h,00h,00h,00h,00h,063h,06bh,06bh
      6B 6B C
C7D8 6B 7F 36 00 00 00 C DB 06bh,07fh,036h;00h,00h,00h,00h,00h ; 'w' 77
      00 00 C
C7E0 00 00 00 00 00 63 C DB 00h,00h,00h,00h,00h,063h,036h,01eh
      36 1C C
C7E8 1C 36 63 00 00 00 C DB 01eh,036h,063h,00h,00h,00h,00h,00h ; 'x' 78
      00 00 C
C7F0 00 00 00 00 00 63 C DB 00h,00h,00h,00h,00h,063h,066h,066h
      66 66 C
C7F8 66 66 3E 0E 66 3C C DB 066h,066h,03eh,06h,066h,03eh,00h,00h ; 'y' 79
      00 00 C
C800 00 00 00 00 00 7F C DB 00h,00h,00h,00h,00h,07fh,066h,0eh
      66 06 C
C808 18 3F 7F 00 00 00 C DB 018h,033h,07fh,00h,00h,00h,00h,00h ; 'z' 7a
      00 00 C
C810 00 00 0E 18 18 18 C DB 00h,00h,0eh,018h,018h,018h,070h,018h
      70 18 C
C818 18 18 0E 00 00 00 C DB 018h,018h,0eh,00h,00h,00h,00h,00h ; '[' 7b
      00 00 C
C820 00 00 18 18 18 18 C DB 00h,00h,018h,018h,018h,018h,00h,018h
      00 18 C
C828 18 18 18 00 00 00 C DB 018h,018h,018h,00h,00h,00h,00h,00h ; '|' 7c
      00 00 C
C830 00 00 70 18 18 18 C DB 00h,00h,070h,018h,018h,018h,0eh,018h
      0E 18 C
C838 18 18 70 00 00 00 C DB 018h,018h,070h,00h,00h,00h,00h,00h ; ']' 7d
      00 00 C
C840 00 00 3B 6E 00 00 C DB 00h,00h,03bh,06eh,00h,00h,00h,00h
      00 00 C
C848 00 00 00 00 00 00 C DB 00h,00h,00h,00h,00h,00h,00h,00h ; '^' 7e
      00 00 C
C850 00 00 00 08 1C C DB 00h,00h,00h,00h,00h,01eh,036h,063h
      36 63 C
C858 63 7F 00 00 00 00 C DB 063h,07fh,00h,00h,00h,00h,00h,00h ; '~' 7f
      00 00 C
      C ;End of font matrix
C860 C fontlo16 endp
      C
C860 C font_hi_8x8 label byte ; 1024 bytes
      C include fonthi8.asm
      C
C860 C fonthi8 proc near
      C ; SystemFont ; <hi_mediumres> (M24) 8 x 8 font table for M24
      C ;
      C
C860 1E 33 60 33 C DB 01eh,033h,060h,033h
C864 1E 08 04 08 C DB 01eh,08h,04h,08h ; 0
C868 66 00 66 66 C DB 066h,00h,066h,066h ; 1
C86C 66 66 66 3B C DB 066h,066h,066h,03bh ; 1
C870 06 0C 00 1E C DB 06h,0eh,00h,01eh
C874 33 3F 70 1E C DB 033h,03fh,030h,01eh ; 2
C878 08 14 00 3C C DB 08h,014h,00h,03eh
C87C 06 3E 66 3B C DB 06h,03eh,066h,03bh ; 3
C880 00 36 00 3C C DB 00h,036h,00h,03ch
C884 06 3E 66 3B C DB 06h,03eh,066h,03bh ; 4
C888 30 18 00 3C C DB 030h,018h,00h,03ch
C88C 06 3E 66 3B C DB 06h,03eh,066h,03bh ; 5
C890 08 14 08 3C C DB 08h,014h,08h,03ch
C894 06 3E 66 3B C DB 06h,03eh,066h,03bh ; 6
C898 30 66 80 66 C DB 03ch,066h,060h,066h
C89C 3C 08 04 08 C DB 03ch,08h,04h,08h ; 7
C8A0 18 34 00 3E C DB 018h,034h,00h,03eh
C8A4 63 7F 60 3E C DB 063h,07fh,060h,03eh ; 8
C8A8 00 36 00 3C C DB 00h,036h,00h,03eh
C8AC 63 7F 60 3E C DB 063h,07fh,060h,03eh ; 9
C8B0 30 18 00 3C C DB 030h,018h,00h,03ch
C8B4 66 7E 60 3C C DB 066h,07eh,060h,03ch ; a
C8B8 00 36 00 3C C DB 00h,036h,00h,01eh
C8BC 0C 0C 0C 1E C DB 0eh,0eh,0eh,01eh ; b
C8C0 08 14 00 1C C DB 08h,014h,00h,01eh
C8C4 0C 0C 0C 1E C DB 0eh,0eh,0eh,01eh ; c
C8C8 30 18 00 1C C DB 030h,018h,00h,01eh
C8CC 0C 0C 0C 1E C DB 0eh,0eh,0eh,01eh ; d
C8D0 66 00 18 3C C DB 066h,00h,018h,03ch
C8D4 66 7E 66 66 C DB 066h,07eh,066h,066h ; e
C8D8 18 24 18 3C C DB 018h,024h,018h,03ch
C8DC 66 7E 66 66 C DB 066h,07eh,066h,066h ; f
C8E0 0C 18 7F 31 C DB 0eh,018h,07fh,031h
C8E4 3C 30 31 7F C DB 03ch,030h,031h,07fh ; 10

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C8E8 00 36 4B 0F C DB 00h,036h,04bh,0fh ;
C8EC 38 58 5D 36 C DB 038h,058h,05db,036h ; 11
C8F0 00 1F 28 49 C DB 00h,01fh,028h,059h ;
C8F4 4F 79 48 4F C DB 04fh,079h,048h,04fh ; 12
C8F8 08 14 00 1C C DB 08h,014h,00h,01ch ;
C8FC 36 63 36 1C C DB 036h,063h,036h,01ch ; 13
C900 00 36 00 1C C DB 00h,036h,00h,01ch ;
C904 36 63 36 1C C DB 036h,063h,036h,01ch ; 14
C908 30 18 00 1C C DB 030h,018h,00h,01ch ;
C90C 36 63 36 1C C DB 036h,063h,036h,01ch ; 15
C910 08 18 00 66 C DB 08h,018h,00h,066h ;
C914 66 66 66 3B C DB 066h,066h,066h,03bh ; 16
C918 30 18 00 66 C DB 030h,018h,00h,066h ;
C91C 66 66 66 3B C DB 066h,066h,066h,03bh ; 17
C920 66 00 66 66 C DB 066h,00h,066h,066h ;
C924 66 3E 06 78 C DB 066h,03eh,06h,078h ; 18
C928 00 36 00 1C C DB 00h,036h,00h,01ch ;
C92C 36 63 36 1C C DB 036h,063h,036h,01ch ; 19
C930 00 63 00 63 C DB 00h,063h,00h,063h ;
C934 63 63 63 3E C DB 063h,063h,063h,03eh ; 1a
C938 08 08 3E 40 C DB 08h,08h,03eh,040h ;
C93C 40 3E 08 08 C DB 040h,03eh,08h,08h ; 1b
C940 0E 18 18 3C C DB 0eh,018h,018h,03ch ;
C944 18 18 39 7E C DB 018h,018h,039h,07eh ; 1c
C948 22 14 08 3E C DB 022h,014h,08h,03eh ; 1d
C94C 08 3E 08 08 C DB 08h,03eh,08h,08h ; 1e
C950 70 48 72 42 C DB 070h,048h,072h,042h ;
C954 47 42 42 01 C DB 047h,042h,042h,01h ; 1e
C958 0C 12 10 38 C DB 0ch,012h,010h,038h ;
C95C 10 10 50 20 C DB 010h,010h,050h,020h ; 1f
C960 06 0C 00 3C C DB 06h,0ch,00h,03ch ;
C964 06 3E 66 3B C DB 06h,03eh,066h,03bh ; ' 20
C968 06 0C 00 1C C DB 06h,0ch,00h,01ch ;
C96C 0C 0C 0C 1E C DB 0ch,0ch,0ch,01eh ; '!' 21
C970 06 0C 00 1C C DB 06h,0ch,00h,01ch ;
C974 36 63 36 1C C DB 036h,063h,036h,01ch ;'' 22
C978 0C 0C 00 66 C DB 0ch,0ch,00h,066h ;
C97C 66 66 66 3B C DB 066h,066h,066h,03bh ; '0' 23
C980 33 CC 00 7C C DB 033h,0cch,00h,07ch ;
C984 66 66 66 66 C DB 066h,066h,066h,066h ; '8' 24
C988 33 CC 63 73 C DB 033h,0cch,063h,073h ;
C98C 7B 6F 67 63 C DB 07bh,06fh,067h,063h ; '5' 25
C990 00 3C 06 3E C DB 00h,03ch,06h,03eh ;
C994 66 3B 00 7F C DB 066h,03bh,00h,07fh ; '8' 26
C998 00 1C 36 63 C DB 00h,01ch,036h,063h ;
C99C 36 1C 00 7F C DB 036h,01ch,00h,07fh ;'' 27
C9A0 18 00 18 18 C DB 018h,00h,018h,018h ;
C9A4 30 46 3C 00 C DB 030h,046h,03ch,00h ; ' (' 28
C9A8 00 00 7F 60 C DB 00h,00h,07fh,060h ;
C9AC 60 00 00 00 C DB 060h,00h,00h,00h ; '!' 29
C9B0 00 00 7F 03 C DB 00h,00h,07fh,03h ;
C9B4 03 00 00 00 C DB 03h,00h,00h,00h ; '!' 2a
C9B8 20 62 24 28 C DB 020h,062h,024h,028h ;
C9BC 18 21 42 07 C DB 018h,021h,042h,07h ; '!' 2b
C9C0 20 62 24 2A C DB 020h,062h,024h,02ah ;
C9C4 16 2A 4F 02 C DB 016h,02ah,04fh,02h ; '!' 2c
C9C8 18 18 00 18 C DB 018h,018h,00h,018h ;
C9CC 18 3C 3C 18 C DB 018h,03ch,03ch,018h ;'- 2d
C9D0 00 1B 36 6C C DB 00h,01bh,036h,06ch ;
C9D4 36 1B 00 00 C DB 036h,01bh,00h,00h ; '!' 2e
C9D8 00 6C 36 1B C DB 00h,06ch,036h,01bh ;
C9DC 36 6C 00 00 C DB 036h,06ch,00h,00h ; '!' 2f
C9E0 22 88 22 88 C DB 022h,088h,022h,088h ;
C9E4 22 88 22 88 C DB 022h,088h,022h,088h ; '0' 30
C9E8 55 AA 55 AA C DB 055h,0aah,055h,0aah ;
C9EC 55 AA 55 AA C DB 055h,0aah,055h,0aah ; '!' 31
C9F0 CE 77 CE 77 C DB 0ceh,077h,0ceh,077h ;
C9F4 CE 77 CE 77 C DB 0ceh,077h,0ceh,077h ; '2' 32
C9F8 18 18 18 18 C DB 018h,018h,018h,018h ;
C9FC 18 18 18 18 C DB 018h,018h,018h,018h ; '3' 33
CA00 18 18 18 F8 C DB 018h,018h,018h,0f8h ;
CA04 18 18 18 18 C DB 018h,018h,018h,018h ; '4' 34
CA08 18 18 F8 18 C DB 018h,018h,0f8h,018h ;
CA0C F8 18 18 18 C DB 0f8h,018h,018h,018h ; '5' 35
CA10 36 36 36 F6 C DB 036h,036h,036h,0f6h ;
CA14 36 36 36 36 C DB 036h,036h,036h,036h ; '6' 36
CA18 00 00 00 FE C DB 00h,00h,00h,0feh ;
CA1C 36 36 36 36 C DB 036h,036h,036h,036h ; '7' 37
CA20 00 00 FE 18 C DB 00h,00h,0feh,018h ;
CA24 F8 18 18 18 C DB 0f8h,018h,018h,018h ; '8' 38
CA28 36 36 F6 36 C DB 036h,036h,0f6h,036h ;
CA2C F6 36 36 36 C DB 0f6h,036h,036h,036h ; '9' 39
CA30 18 36 36 18 C DB 018h,036h,036h,018h ;
CA34 36 36 36 36 C DB 036h,036h,036h,036h ; '!' 3a
CA38 00 00 FE 06 C DB 00h,00h,0feh,06h ;
CA3C F6 36 36 36 C DB 0f6h,036h,036h,036h ; '!' 3b
CA40 36 36 FE 18 C DB 036h,036h,0feh,018h ;
CA44 FE 00 00 00 C DB 0feh,00h,00h,00h ; '!' 3c
CA48 36 36 36 FE C DB 036h,036h,036h,0feh ;
CA4C 00 00 00 00 C DB 00h,00h,00h,00h ; '!' 3d
CA50 18 18 F8 18 C DB 018h,018h,0f8h,018h ;
CA54 F8 00 00 00 C DB 0f8h,00h,00h,00h ; '!' 3e
CA58 00 00 00 F8 C DB 00h,00h,00h,0f8h ;
CA5C 18 18 18 18 C DB 018h,018h,018h,018h ; '2' 3f
CA60 18 18 18 18 C DB 018h,018h,018h,018h ;
CA64 00 00 00 00 C DB 00h,00h,00h,00h ; '0' 40
CA68 18 18 18 FF C DB 018h,018h,018h,0ffh ;
CA6C 00 00 00 00 C DB 00h,00h,00h,00h ; 'A' 41
CA70 00 00 00 FF C DB 00h,00h,00h,0ffh ;
CA74 18 18 18 18 C DB 018h,018h,018h,018h ; 'B' 42

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CA78 18 18 18 1F C DB 018h,018h,018b,01fh
CA7C 18 18 18 18 C DB 018h,018h,018b,018h ;'C' 43
CA80 00 00 00 FF C DB 00h,00h,00h,00fh ;'C' 43
CA84 00 00 00 00 C DB 00h,00h,00h,00h ;'D' 44
CA88 18 18 18 FF C DB 018h,018h,018b,00fh ;'E' 45
CA8C 18 18 18 18 C DB 018h,018h,018b,018h ;'E' 45
CA90 18 18 1F 18 C DB 018h,018h,01fh,018h
CA94 1F 18 18 18 C DB 01fh,018h,018b,018h ;'F' 46
CA98 36 36 36 37 C DB 036h,036h,036b,037h
CA9C 36 36 36 36 C DB 036h,036b,036h,036h ;'G' 47
CAA0 36 36 37 30 C DB 036h,036h,037h,030h
CAA4 3F 00 00 00 C DB 03fh,00b,00b,00h ;'H' 48
CAA8 00 00 3F 30 C DB 00h,00h,03fh,030h
CAAC 37 36 36 36 C DB 037h,036b,036h,036h ;'I' 49
CAB0 36 36 FF 00 C DB 036h,036h,07fh,00h ;'J' 4a
CAB4 3F 00 00 00 C DB 00fh,00b,00b,00h ;'J' 4a
CAB8 00 00 FF 00 C DB 00b,00b,00fh,00h
CABC FF 36 36 36 C DB 07fh,036b,036b,036h ;'K' 4b
CAC0 36 36 37 30 C DB 036h,036h,037h,030h
CAC4 37 3A 2A 3A C DB 037h,034b,034b,034h ;'L' 4c
CAC8 00 00 FF 00 C DB 00b,00b,00fh,00h
CACC FF 00 00 00 C DB 00fh,00b,00b,00h ;'M' 4d
CAD0 36 36 FF 00 C DB 036h,036b,07fh,00h
CAD4 FF 36 36 36 C DB 07fh,036b,036b,036h ;'N' 4e
CAB8 18 18 FF 00 C DB 018h,018h,00fh,00h
CADC FF 00 00 00 C DB 00fh,00b,00b,00h ;'O' 4f
CAE0 36 36 36 FF C DB 036h,036b,036b,00fh
CAE4 00 00 3F 30 C DB 00b,00b,00b,00h ;'P' 50
CAE8 00 00 FF 00 C DB 00b,00b,00fh,00h
CAEC FF 18 18 18 C DB 00fh,018b,018b,018h ;'Q' 51
CAF0 00 00 FF C DB 00b,00b,00b,00fh
CAF4 36 36 36 C DB 036h,036b,036b,036h ;'R' 52
CAF8 36 36 36 3P C DB 036h,036h,036b,03fh
CAFC 00 00 00 00 C DB 00b,00b,00b,00h ;'S' 53
CB00 18 18 1F 18 C DB 018h,018b,01fh,018h
CB04 1F 00 00 00 C DB 01fh,00b,00b,00h ;'T' 54
CB08 00 00 1F 18 C DB 00b,00b,01fh,018h
CB0C 1F 18 18 18 C DB 01fh,018b,018b,018h ;'U' 55
CB10 00 00 00 3F C DB 00b,00b,00b,03fh
CB14 36 36 36 36 C DB 036h,036b,036b,036h ;'V' 56
CB18 36 36 36 FF C DB 036h,036h,036b,00fh
CB1C 36 36 36 36 C DB 036h,036b,036b,036h ;'W' 57
CB20 18 18 FF 18 C DB 018h,018b,00fh,018h
CB24 FF 18 18 18 C DB 07fh,018b,018b,018h ;'X' 58
CB28 18 18 1F 18 C DB 018h,018b,018b,00fh
CB2C 00 00 00 00 C DB 00b,00b,00b,00h ;'Y' 59
CB30 00 00 00 1F C DB 00b,00b,00b,01fh
CB34 18 18 18 18 C DB 018h,018b,018b,018h ;'Z' 5a
CB38 FF FF FF FF C DB 07fh,07fh,07fh,07fh
CB3C FF FF FF FF C DB 00fh,00fh,00fh,00fh ;'[' 5b
CB40 00 00 00 00 C DB 00b,00b,00b,00h
CB44 FF FF FF FF C DB 07fh,07fh,07fh,07fh ;'\' ' 5c
CB48 F0 F0 F0 F0 C DB 070b,070b,070b,070b ;']' 5d
CB4C F0 F0 F0 F0 C DB 07b,07b,07b,07b
CB50 0F 0F 0F 0F C DB 07b,07b,07b,07b ;'" ' 5e
CB54 0F 0F 0F 0F C DB 07fh,07fh,07fh,07fh
CB58 00 00 00 00 C DB 00b,00b,00b,00h ;'_' 5f
CB60 00 00 3B 6E C DB 00b,00b,03bh,06eh ;'` ' 60
CB64 6C 6C 6E 3B C DB 06ch,06ch,06eh,03bh ;'~ ' 61
CB68 3B 63 7E 63 C DB 03eh,063h,07eh,063h
CB6C 63 7E 60 60 C DB 063b,07eh,060h,060h ;'a' 61
CB70 00 7E 32 30 C DB 00b,07eh,032h,030h
CB74 30 30 30 78 C DB 030h,030b,030b,078h ;'b' 62
CB78 00 01 7F 54 C DB 00h,01h,07fh,054h
CB7C 14 14 14 14 C DB 014h,014b,014b,014h ;'c' 63
CB80 00 7F 30 30 C DB 00b,07fh,061h,030h
CB84 18 30 61 7F C DB 018h,030b,061b,07fh ;'d' 64
CB88 00 00 1F 34 C DB 00h,00b,01fh,034h
CB8C 62 62 3A 70 C DB 062h,062b,034h,018h ;'e' 65
CB90 00 36 36 36 C DB 00b,036h,036b,036h
CB94 3C 30 30 60 C DB 03ch,030b,030b,060h ;'f' 66
CB98 00 3B 6E 0C C DB 00b,03bh,06eh,00ch ;'g' 67
CB9C 0C 0C 00 00 C DB 00b,00b,00b,00h ;'h' 68
CBA0 66 3C 1E 30 C DB 066h,03ch,018b,03ch ;'i' 69
CBA4 00 1C 36 63 C DB 00b,01ch,036b,063h
CBA8 7F 63 36 1C C DB 07fh,063h,036b,01ch ;'j' 69
CBB0 00 1C 36 63 C DB 00b,01ch,036b,063h
CBB4 63 36 63 77 C DB 063b,063b,036h,07fh ;'k' 6a
CBB8 1E 30 18 0C C DB 01eh,030b,018b,00ch ;'l' 6a
CBBC 3E 66 66 3C C DB 03eh,066h,066h,03ch ;'k' 6b
CBC0 00 00 76 DB C DB 00h,00b,076b,0dbh
CBC4 DB 6E 30 00 C DB 0dbh,06eh,00b,00h ;'l' 6c
CBC8 03 06 7E DB C DB 03h,06h,07eh,0dbh
CBCC DB 7E 60 C0 C DB 0dbh,07eh,060b,000h ;'m' 6d
CBD0 00 1C 30 60 C DB 00b,01ch,030b,060h
CBD4 70 60 1C 0C C DB 07ch,060b,030b,01ch ;'n' 6e
CBD8 00 00 3E 63 C DB 00b,00b,03eh,063h ;'o' 6f
CBDC 63 63 63 63 C DB 063b,063h,063b,063h ;'o' 6f
CBE0 00 00 3E 00 C DB 00b,00b,03eh,00h
CBE4 3E 00 3E 00 C DB 03eh,00b,03eh,00h ;'p' 70
CBE8 18 18 7E 18 C DB 018h,018b,07eh,018h ;'q' 71
CBEC 18 00 7E 00 C DB 018h,00b,06eh,00h
CBF0 18 00 0E 00 C DB 018h,00b,03eh,00h ;'r' 72
CBF4 18 00 3E 00 C DB 00h,018b,030b,018h ;'s' 73
CBF8 0C 18 30 18 C DB 00b,00b,03eh,00h ;'a' 73
CBFC 0C 00 3E 00 C DB 00b,01bh,01bh,018h
CC00 18 18 18 18 C DB 018h,018b,018b,018h ;'t' 74
CC04 18 18 18 18 C DB 018h,018b,018b,018h

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CC0C 18 D8 D8 70      C      DB 018h,0d8h,0d8h,070h ;'u' 75
CC10 00 18 18 00      C      DB 00h,018h,018h,00h
CC14 3E 00 18 18      C      DB 03eh,00h,018h,018h ;'v' 76
CC18 00 00 3B 6E      C      DB 00h,00h,03bh,06eh
CC1C 00 3B 6E 00      C      DB 00h,03bh,06eh,00h ;'w' 77
CC20 00 38 6C 6C      C      DB 00h,038h,06eh,06eh
CC24 38 00 00 00      C      DB 038h,00h,00h,00h
CC28 00 18 3C 3C      C      DB 00h,018h,03eh,03eh ;'x' 78
CC2C 18 00 00 00      C      DB 018h,00h,00h,00h ;'y' 79
CC30 00 00 00 18      C      DB 00h,00h,00h,018h
CC34 15 00 00 00      C      DB 018h,00h,00h,00h ;'z' 7a
CC38 0F 0C 0C 0C      C      DB 0Fh,00h,00h,00h
CC3C 0C 6C 3C 1C      C      DB 00h,06eh,03eh,01eh ;'{' 7b
CC40 6C 36 36 36      C      DB 06eh,036h,036h,036h
CC44 36 00 00 00      C      DB 036h,00h,00h,00h ;'|' 7c
CC48 08 14 04 08      C      DB 08h,014h,04h,08h
CC4C 10 1C 00 00      C      DB 010h,01eh,00h,00h ;'}' 7d
CC50 00 1C 1C 1C      C      DB 00h,01eh,01eh,01eh
CC54 1C 1C 00 00      C      DB 01eh,01eh,00h,00h ;'~' 7e
CC58 00 00 00 00      C      DB 00h,00h,00h,00h
CC5C 00 00 00 00      C      DB 00h,00h,00h,00h ; 7f
                                C ;End of font matrix
                                C
                                C fontb18 endp
CC60
                                C oode ends
                                C
                                C include kbdata.asm
                                C ;=====
                                C ;      Filename:      kb.data:      USA-ASCII
                                C ;
                                C ;      This module includes the keyboard scan code translation data
                                C ;      for different keyboards.
                                C ;
                                C ;=====
CC60
                                C oode segment public 'ROM'
                                C assume os:code, ds:nothing, es:nothing, as:nothing
                                C
                                C kb_data1 proc
                                C ;-----
                                C ;      special_cases
                                C ;-----
                                C
                                C kbins equ 0C0h ; kb_insert_lock (min_case)
                                C kboap equ 0C1h ; kb_caps_lock
                                C kbnum equ 0C2h ; kb_num_lock
                                C kbscr equ 0C3h ; kb_scroll_lock
                                C kbalt equ 0C4h ; kb_alt_lock
                                C kbctl equ 0C5h ; kb_control_lock
                                C kblsh equ 0C6h ; kb_l_shift_lock
                                C kbrsh equ 0C7h ; kb_r_shift_lock
                                C
                                C kbrea equ 0C8h ; kb_reset (mid_case)
                                C kbbrk equ 0C9h ; kb_break
                                C pause equ 0CAh ; kb_pause
                                C kbprt equ 0CBh ; kb_print_screen
                                C kbnul equ 0CCh ; kb_null
                                C kNONE equ 0CDh ; kb_none
                                C
                                C kdce9 equ 0CEh ; kb_alt_dec_9
                                C kdce8 equ 0CFh ; kb_alt_dec_8
                                C kdce7 equ 0D0h ; kb_alt_dec_7
                                C kdce6 equ 0D1h ; kb_alt_dec_6
                                C kdce5 equ 0D2h ; kb_alt_dec_5
                                C kdce4 equ 0D3h ; kb_alt_dec_4
                                C kdce3 equ 0D4h ; kb_alt_dec_3
                                C kdce2 equ 0D5h ; kb_alt_dec_2
                                C kdce1 equ 0D6h ; kb_alt_dec_1
                                C kdce0 equ 0D7h ; kb_alt_dec_0
                                C
                                C kdbl0 equ 0D8h ; kb_double_zero (max_case)
                                C
                                C ;-----
                                C ;      7 Caplk Bytes
                                C ;-----
                                C
                                C kb_osp_flags label byte
                                C
                                C db 00000000h ; scancode 00 (00h) - 07 (07h) ESC to '6'
                                C db 00000000h ; scancode 08 (08h) - 15 (0Fh) '7' to HT
                                C db 11111111h ; scancode 16 (10h) - 23 (17h) 'q' to '1'
                                C db 11000011b ; scancode 24 (18h) - 31 (1Fh) 'o' & 'p' to 'a' & 's'
                                C db 11111110b ; scancode 32 (20h) - 39 (27h) 'd' to '1' & '!'
                                C db 00001111b ; scancode 40 (28h) - 47 (2Fh) ':' to ':' & ';' to '1' & '!'
                                C db 11100000b ; scancode 48 (30h) - 55 (37h) 'b' to 'm' to '1' to '8'
                                C
                                C ;-----
                                C ;      Alphabetic (Migratory) | Olivetti | Other |
                                C ;      | KB | KB |
                                C ;-----
CC67
                                C kb_data_table label byte
                                C
                                C dw (1Bh) * 100h + (1Bh) ; 01 01h ESC ESC (BASE)
                                C dw (1Bh) * 100h + (1Bh) ; ESC ESC (SHIFT)
                                C dw (1Bh) * 100h + (1Bh) ; ESC ESC (CTL)
                                C dw kNONE * 100h + kNONE ; None None (ALT)

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CC6F	3131	C	dw	(31b) * 100b + (31b)	:	02 02h	1	1
CC71	2121	C	dw	(21b) * 100b + (21b)	:		1	1
CC73	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CC75	7800	C	dw	7800h	:		X120	
CC77	3232	C	dw	(32b) * 100b + (32b)	:	03 03h	2	2
CC79	2240	C	dw	(22b) * 100b + (20b)	:		#	#
CC7B	CDCD	C	dw	kNONE * 100b + kbnul	:		None	NUL=X03('^E)
CC7D	7900	C	dw	7900h	:		X121	
CC7F	3333	C	dw	(33b) * 100b + (33b)	:	04 04h	3	3
CC81	2323	C	dw	(23b) * 100b + (23b)	:		#	#
CC83	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CC85	7A00	C	dw	7A00h	:		X122	
CC87	3434	C	dw	(34b) * 100b + (34b)	:	05 05h	4	4
CC89	2424	C	dw	(24b) * 100b + (24b)	:		#	#
CC8B	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CC8D	7B00	C	dw	7B00h	:		X123	
CC8F	3535	C	dw	(35b) * 100b + (35b)	:	06 06h	5	5
CC91	2525	C	dw	(25b) * 100b + (25b)	:		#	#
CC93	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CC95	7C00	C	dw	7C00h	:		X124	
CC97	3636	C	dw	(36b) * 100b + (36b)	:	07 07h	6	6
CC99	2626	C	dw	(26b) * 100b + (52b)	:		#	#
CC9B	CDCD	C	dw	kNONE * 100b + (15b)	:		None	RS (^*)
CC9D	7D00	C	dw	7D00h	:		X125	
CC9F	3737	C	dw	(37b) * 100b + (37b)	:	08 08h	7	7
CCA1	2727	C	dw	(27b) * 100b + (26b)	:		None	None
CCA3	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CCA5	7E00	C	dw	7E00h	:		X126	
CCA7	3838	C	dw	(38b) * 100b + (38b)	:	09 09h	8	8
CCA9	282A	C	dw	(28b) * 100b + (2Ab)	:		(#
CCAB	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CCAD	7F00	C	dw	7F00h	:		X127	
CCAF	3939	C	dw	(39b) * 100b + (39b)	:	10 0Ah	9	9
CCB1	2928	C	dw	(29b) * 100b + (28b)	:		(#
CCB3	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CCB5	8000	C	dw	8000h	:		X128	
CCB7	3030	C	dw	(30b) * 100b + (30b)	:	11 0Bh	0	0
CCB9	5F29	C	dw	(5Fb) * 100b + (29b)	:		US (^_)	None
CCBB	1FCD	C	dw	(1Fb) * 100b + kNONE	:		X129	
CCBD	8100	C	dw	8100h	:		-	-
CCBF	2D2D	C	dw	(2Db) * 100b + (2Db)	:	12 0Ch	=	US (^_)
CCC1	3D5F	C	dw	(3Db) * 100b + (5Fb)	:		None	US (^_)
CCC3	C91F	C	dw	kNONE * 100b + (1Fb)	:		X130	
CCC5	8200	C	dw	8200h	:		=	=
CCC7	583D	C	dw	(58b) * 100b + (3Db)	:	13 0Dh	=	+
CCC9	7E2B	C	dw	(7Eb) * 100b + (2Bb)	:		-	None
CCCB	18CD	C	dw	(18b) * 100b + kNONE	:		RS (^*)	None
CCCD	8300	C	dw	8300h	:		X131	
CCCF	0808	C	dw	(08b) * 100b + (08b)	:	14 0Eh	BS	BS
CCD1	0808	C	dw	(08b) * 100b + (08b)	:		BS	BS
CCD3	7F7F	C	dw	(7Fb) * 100b + (7Fb)	:		DEL	DEL
CCD5	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CCD7	0959	C	dw	(09b) * 100b + (09b)	:	15 0Fh	HT	BT
CCD9	0F00	C	dw	0F00h	:		RHT=X15	
CCDB	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CCDD	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None
CCDF	7171	C	dw	(71b) * 100b + (71b)	:	16 10h	Q	Q
CCE1	5151	C	dw	(51b) * 100b + (51b)	:		Q	Q
CCE3	1111	C	dw	(11b) * 100b + (11b)	:		DC1(^Q) DC1(^Q)	
CCE5	1000	C	dw	1000h	:		X16	
CCE7	7777	C	dw	(77b) * 100b + (77b)	:	17 11h	W	W
CCE9	5757	C	dw	(57b) * 100b + (57b)	:		W	W
CCEB	1717	C	dw	(17b) * 100b + (17b)	:		ETB(^W) ETB(^W)	
CCED	1100	C	dw	1100h	:		X17	
CCEF	6565	C	dw	(65b) * 100b + (65b)	:	18 12h	e	E
CCF1	4545	C	dw	(45b) * 100b + (45b)	:		E	E
CCF3	0505	C	dw	(05b) * 100b + (05b)	:		ENQ(^E) ENQ(^E)	
CCF5	1200	C	dw	1200h	:		X18	
CCF7	7272	C	dw	(72b) * 100b + (72b)	:	19 13h	r	r
CCF9	5252	C	dw	(52b) * 100b + (52b)	:		R	R
CCFB	1212	C	dw	(12b) * 100b + (12b)	:		DC2(^R) DC2(^R)	
CCFD	1300	C	dw	1300h	:		X19	
CCFF	7474	C	dw	(74b) * 100b + (74b)	:	20 14h	t	t
CD01	5454	C	dw	(54b) * 100b + (54b)	:		T	T
CD03	1414	C	dw	(14b) * 100b + (14b)	:		DC4(^T) DC4(^T)	
CD05	1400	C	dw	1400h	:		X20	
CD07	7979	C	dw	(79b) * 100b + (79b)	:	21 15h	y	y
CD09	5959	C	dw	(59b) * 100b + (59b)	:		Y	Y
CD0B	1919	C	dw	(19b) * 100b + (19b)	:		EM (^Y) EM (^Y)	
CD0D	1500	C	dw	1500h	:		X21	
CD0F	7575	C	dw	(75b) * 100b + (75b)	:	22 16h	u	u
CD11	5555	C	dw	(55b) * 100b + (55b)	:		U	U
CD13	1515	C	dw	(15b) * 100b + (15b)	:		NAK(^U) NAK(^U)	
CD15	1600	C	dw	1600h	:		X22	
CD17	6969	C	dw	(69b) * 100b + (69b)	:	23 17h	i	i
CD19	4949	C	dw	(49b) * 100b + (49b)	:		I	I
CD1B	0909	C	dw	(09b) * 100b + (09b)	:		HT (^I) HT (^I)	
CD1D	1700	C	dw	1700h	:		X23	
CD1F	6F6F	C	dw	(6Fb) * 100b + (6Fb)	:	24 18h	o	o
CD21	4F4F	C	dw	(4Fb) * 100b + (4Fb)	:		0	0
CD23	0F0F	C	dw	(0Fb) * 100b + (0Fb)	:		SI (^O) SI (^O)	
CD25	1800	C	dw	1800h	:		X24	
CD27	7070	C	dw	(70b) * 100b + (70b)	:	25 19h	p	p
CD29	5050	C	dw	(50b) * 100b + (50b)	:		P	P
CD2B	1010	C	dw	(10b) * 100b + (10b)	:		DL E(^P) DL E(^P)	
CD2D	1900	C	dw	1900h	:		X25	
CD2F	405B	C	dw	(40b) * 100b + (5Bb)	:	26 1Ah	#	[
CD31	607B	C	dw	(60b) * 100b + (7Bb)	:		[[
CD33	CC1B	C	dw	kbnul * 100b + (1Bb)	:		NUL=X03('^E) ESC(^I)	
CD35	CDCD	C	dw	kNONE * 100b + kNONE	:		None	None

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CD37	5B5D	C	dw	(5Bh) * 100h + (5Dh)	;	27	1Bh	[]
CD39	7B7D	C	dw	(7Bh) * 100h + (7Dh)	;			[]
CD3B	1B1D	C	dw	(1Bh) * 100h + (1Dh)	;			ESC(") GS (")	
CD3D	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None
CD3F	0D0D	C	dw	(0Dh) * 100h + (0Dh)	;	28	1Ch	CR	CR
CD41	0D0D	C	dw	(0Dh) * 100h + (0Dh)	;			CR	CR
CD43	0A0A	C	dw	(0Ah) * 100h + (0Ah)	;			LF	LF
CD45	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None
CD47	C505	C	dw	kb0t1 * 100h + kb0t1	;	29	1Dh	Ctrl	Ctrl
CD49	C505	C	dw	kb0t1 * 100h + kb0t1	;			Ctrl	Ctrl
CD4B	C505	C	dw	kb0t1 * 100h + kb0t1	;			Ctrl	Ctrl
CD4D	C505	C	dw	kb0t1 * 100h + kb0t1	;			Ctrl	Ctrl
CD4F	6161	C	dw	(61h) * 100h + (61h)	;	30	1Eh	a	a
CD51	4141	C	dw	(41h) * 100h + (41h)	;			A	A
CD53	0101	C	dw	(01h) * 100h + (01h)	;			SOH(") SOH(")	
CD55	1800	C	dw	1800h	;			X30	
CD57	7373	C	dw	(73h) * 100h + (73h)	;	31	1Fh	s	s
CD59	5353	C	dw	(53h) * 100h + (53h)	;			S	S
CD5B	1313	C	dw	(13h) * 100h + (13h)	;			DC3(")S DC3(")S	
CD5D	1F00	C	dw	1F00h	;			d	d
CD5F	6464	C	dw	(64h) * 100h + (64h)	;	32	20h	D	D
CD61	4444	C	dw	(44h) * 100h + (44h)	;			D	D
CD63	0404	C	dw	(04h) * 100h + (04h)	;			EOT(")D EOT(")D	
CD65	2000	C	dw	2000h	;			X32	
CD67	6666	C	dw	(66h) * 100h + (66h)	;	33	21h	f	f
CD69	4646	C	dw	(46h) * 100h + (46h)	;			F	F
CD6B	0606	C	dw	(06h) * 100h + (06h)	;			ACK(")F ACK(")F	
CD6D	2100	C	dw	2100h	;			X33	
CD6F	6767	C	dw	(67h) * 100h + (67h)	;	34	22h	G	G
CD71	4747	C	dw	(47h) * 100h + (47h)	;			GT	GT
CD73	0707	C	dw	(07h) * 100h + (07h)	;			BEL(")G BEL(")G	
CD75	2200	C	dw	2200h	;			X34	
CD77	6868	C	dw	(68h) * 100h + (68h)	;	35	23h	h	h
CD79	4848	C	dw	(48h) * 100h + (48h)	;			H	H
CD7B	0808	C	dw	(08h) * 100h + (08h)	;			BS(")H BS(")H	
CD7D	2300	C	dw	2300h	;			X35	
CD7F	6A6A	C	dw	(6Ah) * 100h + (6Ah)	;	36	24h	J	J
CD81	4A4A	C	dw	(4Ah) * 100h + (4Ah)	;			J	J
CD83	0A0A	C	dw	(0Ah) * 100h + (0Ah)	;			LF(")J LF(")J	
CD85	2400	C	dw	2400h	;			X36	
CD87	6B6B	C	dw	(6Bh) * 100h + (6Bh)	;	37	25h	k	k
CD89	4B4B	C	dw	(4Bh) * 100h + (4Bh)	;			K	K
CD8B	0B0B	C	dw	(0Bh) * 100h + (0Bh)	;			VT(")X VT(")X	
CD8D	2500	C	dw	2500h	;			X37	
CD8F	6C6C	C	dw	(6Ch) * 100h + (6Ch)	;	38	26h	L	L
CD91	4C4C	C	dw	(4Ch) * 100h + (4Ch)	;			L	L
CD93	0C0C	C	dw	(0Ch) * 100h + (0Ch)	;			PF(")L PF(")L	
CD95	2600	C	dw	2600h	;			X38	
CD97	3B3B	C	dw	(3Bh) * 100h + (3Bh)	;	39	27h	:	:
CD99	2B2A	C	dw	(2Bh) * 100h + (3Ah)	;			:	:
CD9B	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None
CD9D	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None
CD9F	3A27	C	dw	(3Ah) * 100h + (27h)	;	40	28h	:	:
CDA1	2A22	C	dw	(2Ah) * 100h + (22h)	;			:	:
CDA3	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None
CD45	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None
CD47	5D60	C	dw	(5Dh) * 100h + (60h)	;	41	29h]]	-
CD49	7D7E	C	dw	(7Dh) * 100h + (7Eh)	;]]	-
CD4B	1D0D	C	dw	(1Dh) * 100h + kNONE	;			GS (")] None	
CD4D	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None
CD4F	C6C6	C	dw	kb1ab * 100h + kb1ab	;	42	2Ah	LShft	LShft
CDB1	C6C6	C	dw	kb1ab * 100h + kb1ab	;			LShft	LShft
CDB3	C6C6	C	dw	kb1ab * 100h + kb1ab	;			LShft	LShft
CDB5	C6C6	C	dw	kb1ab * 100h + kb1ab	;			LShft	LShft
CD87	5C5C	C	dw	(5Ch) * 100h + (5Ch)	;	43	2Bh	\	\
CD89	7C7C	C	dw	(7Ch) * 100h + (7Ch)	;			|	|
CD8B	1C1C	C	dw	(1Ch) * 100h + (1Ch)	;			FS (")\ FS (")\	
CD8D	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None
CD8F	7A7A	C	dw	(7Ah) * 100h + (7Ah)	;	44	2Ch	z	z
CD91	5A5A	C	dw	(5Ah) * 100h + (5Ah)	;			Z	Z
CD93	1A1A	C	dw	(1Ah) * 100h + (1Ah)	;			SUB(")Z SUB(")Z	
CD95	2C00	C	dw	2C00h	;			X44	
CD97	7878	C	dw	(78h) * 100h + (78h)	;	45	2Dh	x	x
CD99	5858	C	dw	(58h) * 100h + (58h)	;			X	X
CD9B	1818	C	dw	(18h) * 100h + (18h)	;			CAN(")X CAN(")X	
CD9D	2D00	C	dw	2D00h	;			X45	
CD9F	6363	C	dw	(63h) * 100h + (63h)	;	46	2Eh	c	c
CD01	4343	C	dw	(43h) * 100h + (43h)	;			C	C
CD03	0303	C	dw	(03h) * 100h + (03h)	;			ETI(")C ETI(")C	
CD05	2800	C	dw	2800h	;			X46	
CD07	7676	C	dw	(76h) * 100h + (76h)	;	47	2Fh	v	v
CD09	5656	C	dw	(56h) * 100h + (56h)	;			V	V
CD0B	1616	C	dw	(16h) * 100h + (16h)	;			SYN(")V SYN(")V	
CD0D	2F00	C	dw	2F00h	;			X47	
CD0F	6262	C	dw	(62h) * 100h + (62h)	;	48	30h	b	b
CD11	4242	C	dw	(42h) * 100h + (42h)	;			B	B
CD13	0202	C	dw	(02h) * 100h + (02h)	;			STI(")B STI(")B	
CD15	3000	C	dw	3000h	;			X48	
CD17	6E6E	C	dw	(6Eh) * 100h + (6Eh)	;	49	31h	n	n
CD19	4E4E	C	dw	(4Eh) * 100h + (4Eh)	;			N	N
CD1B	0E0E	C	dw	(0Eh) * 100h + (0Eh)	;			SO (")N SO (")N	
CD1D	3100	C	dw	3100h	;			X49	
CD1F	6D6D	C	dw	(6Dh) * 100h + (6Dh)	;	50	32h	m	m
CD21	4D4D	C	dw	(4Dh) * 100h + (4Dh)	;			M	M
CD23	0D0D	C	dw	(0Dh) * 100h + (0Dh)	;			CR (")M CR (")M	
CD25	3200	C	dw	3200h	;			X50	
CD27	2C2C	C	dw	(2Ch) * 100h + (2Ch)	;	51	33h	<	<
CD29	3C3C	C	dw	(3Ch) * 100h + (3Ch)	;			<	<
CD2B	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None
CD2D	CD0D	C	dw	kNONE * 100h + kNONE	;			None	None

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CDFE	2E2E	C	dw	(2Eh) * 100h + (2Eh)	52 34h	-	-	-
CE01	3E3E	C	dw	(3Eh) * 100h + (3Eh)		>	>	
CE03	CDCE	C	dw	kNONE * 100h + kNONE		None	None	None
CE05	CDCE	C	dw	kNONE * 100h + kNONE		None	None	None
CE07	2F2F	C	dw	(2Fh) * 100h + (2Fh)	53 35h	/	/	
CE09	3F3F	C	dw	(3Fh) * 100h + (3Fh)		?	?	
CE0C	CDCE	C	dw	kNONE * 100h + kNONE		None	None	None
CE0D	CDCE	C	dw	kNONE * 100h + kNONE		None	None	None

Alphabetic (Non-Migratory)						Olivetti	Other	
						KB	KBs	

CE0F	C7C7	C	dw	kbrsh * 100h + kbrsh	54 36h	RSbft	RSbft	
CE11	C7C7	C	dw	kbrsh * 100h + kbrsh		RSbft	RSbft	
CE13	C7C7	C	dw	kbrsh * 100h + kbrsh		RSbft	RSbft	
CE15	C7C7	C	dw	kbrsh * 100h + kbrsh		RSbft	RSbft	
CE17	2A2A	C	dw	(2Ah) * 100h + (2Ah)	55 37h	*	*	
CE19	CBCE	C	dw	kbprt * 100h + kbprt		PrtSc	PrtSc	
CE1B	7200	C	dw	kNONE * 100h + kNONE		X114	None	
CE1D	CDCE	C	dw	kNONE * 100h + kNONE		ALT	ALT	
CE1F	C4C4	C	dw	kbal * 100h + kbal	56 38h	ALT	ALT	
CE21	C4C4	C	dw	kbal * 100h + kbal		ALT	ALT	
CE23	C4C4	C	dw	kbal * 100h + kbal		ALT	ALT	
CE25	C4C4	C	dw	kbal * 100h + kbal		ALT	ALT	
CE27	2020	C	dw	(20h) * 100h + (20h)	57 39h	SP	SP	
CE29	2020	C	dw	(20h) * 100h + (20h)		SP	SP	
CE2B	2020	C	dw	(20h) * 100h + (20h)		SP	SP	
CE2D	2020	C	dw	(20h) * 100h + (20h)		SP	SP	
CE2F	C1C1	C	dw	kbcap * 100h + kbcap	58 3Ah	CapLk	CapLk	
CE31	C1C1	C	dw	kbcap * 100h + kbcap		CapLk	CapLk	
CE33	C1C1	C	dw	kbcap * 100h + kbcap		CapLk	CapLk	
CE35	C1C1	C	dw	kbcap * 100h + kbcap		CapLk	CapLk	
CE37	3800	C	dw	3800h	59 3Bh	F01=X95		
CE39	5800	C	dw	5800h		F11=X84		
CE3B	5800	C	dw	5800h		F21=X94		
CE3D	6800	C	dw	6800h		F31=X104		
CE3F	3C00	C	dw	3C00h	60 3Ch	F02=X60		
CE41	5500	C	dw	5500h		F22=X85		
CE43	5F00	C	dw	5F00h		F22=X95		
CE45	6900	C	dw	6900h		F32=X105		
CE47	3D00	C	dw	3D00h	61 3Dh	F03=X61		
CE49	5600	C	dw	5600h		F13=X86		
CE4B	6000	C	dw	6000h		F23=X96		
CE4D	6400	C	dw	6400h		F33=X106		
CE4F	3E00	C	dw	3E00h	62 3Eh	F04=X62		
CE51	5700	C	dw	5700h		F14=X87		
CE53	6100	C	dw	6100h		F24=X97		
CE55	6800	C	dw	6800h		F34=X107		
CE57	3F00	C	dw	3F00h	63 3Fh	F05=X63		
CE59	5800	C	dw	5800h		F15=X88		
CE5B	6200	C	dw	6200h		F25=X98		
CE5D	6C00	C	dw	6C00h		F35=X108		
CE5F	4000	C	dw	4000h	64 40h	F06=X64		
CE61	5900	C	dw	5900h		F16=X89		
CE63	6300	C	dw	6300h		F26=X99		
CE65	6D00	C	dw	6D00h		F36=X109		
CE67	4100	C	dw	4100h	65 41h	F07=X65		
CE69	5100	C	dw	5100h		F17=X90		
CE6B	6400	C	dw	6400h		F27=X100		
CE6D	6800	C	dw	6800h		F37=X110		
CE6F	4200	C	dw	4200h	66 42h	F08=X66		
CE71	5B00	C	dw	5B00h		F18=X91		
CE73	6500	C	dw	6500h		F28=X101		
CE75	6F00	C	dw	6F00h		F38=X111		
CE77	4300	C	dw	4300h	67 43h	F09=X67		
CE79	5C00	C	dw	5C00h		F19=X92		
CE7B	6600	C	dw	6600h		F29=X102		
CE7D	7000	C	dw	7000h		F39=X112		
CE7F	4400	C	dw	4400h	68 44h	F10=X68		
CE81	5D00	C	dw	5D00h		F20=X93		
CE83	6700	C	dw	6700h		F30=X103		
CE85	7100	C	dw	7100h		F40=X113		
CE87	C2C2	C	dw	kbnun * 100h + kbnun	69 45h	NumLk	NumLk	
CE89	C2C2	C	dw	kbnun * 100h + kbnun		NumLk	NumLk	
CE8B	C4C4	C	dw	pause * 100h + pause		Pause	Pause	
CE8D	C2C2	C	dw	kbnun * 100h + kbnun		NumLk	NumLk	
CE8F	C3C3	C	dw	kbscr * 100h + kbscr	70 46h	SerLk	SerLk	
CE91	C3C3	C	dw	kbscr * 100h + kbscr		SerLk	SerLk	
CE93	C9C9	C	dw	kbrbk * 100h + kbrbk		Break	Break	
CE95	C3C3	C	dw	kbscr * 100h + kbscr		SerLk	SerLk	

Numeric keypad						Olivetti	Other	
						KB	KBs	

CE97	4700	C	dw	4700h	71 47h	Home=X71		
CE99	3737	C	dw	(37h) * 100h + (37h)		7	7	
CE9B	7700	C	dw	7700h		X119		
CE9D	D0D0	C	dw	kdec7 * 100h + kdec7		XDec7	XDec7	
CE9F	8000	C	dw	8000h	72 48h	Up =X72		
CEA1	3838	C	dw	(38h) * 100h + (38h)		8	8	
CEA3	CDCE	C	dw	kNONE * 100h + kNONE		None	None	None
CEA5	CFCE	C	dw	kdec8 * 100h + kdec8		XDec8	XDec8	
CEA7	8900	C	dw	8900h	73 49h	PgUp=X73		
CEA9	3939	C	dw	(39h) * 100h + (39h)		9	9	
CEAB	8400	C	dw	8400h		X132		
CEAD	CECE	C	dw	kdec9 * 100h + kdec9		XDec9	XDec9	

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CEAF	2D2D	C	dw	(2Dh) * 100h + (2Dh)	74 4Ah	-	-
CEB1	2D2D	C	dw	(2Dh) * 100h + (2Dh)	;		
CEB3	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CEB5	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CEB7	4B00	C	dw	4B00h	75 4Bh	Left=X75	
CEB9	3434	C	dw	(34h) * 100h + (34h)	;	4	a
CEBB	7300	C	dw	7300h	;	X115	
CEBD	D3D3	C	dw	kdec4 * 100h + kdec4	;	XDec4	XDec4
CEBF	CDCD	C	dw	kNONE * 100h + kNONE	76 4Ch	None	None
CEC1	3535	C	dw	(35h) * 100h + (35h)	;	5	5
CEC3	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CEC5	D2D2	C	dw	kdec5 * 100h + kdec5	;	XDec5	XDec5
CEC7	4D00	C	dw	4D00h	77 4Dh	Rght=X77	
CEC9	3636	C	dw	(36h) * 100h + (36h)	;	6	6
CECB	7400	C	dw	7400h	;	X116	
CECD	D1D1	C	dw	kdec6 * 100h + kdec6	;	XDec6	XDec6
CECF	2B2B	C	dw	(2Bh) * 100h + (2Bh)	78 4Eh	+	+
CED1	2B2B	C	dw	(2Bh) * 100h + (2Bh)	;	None	None
CED3	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CED5	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CED7	4F00	C	dw	4F00h	79 4Fh	End=X79	
CED9	3131	C	dw	(31h) * 100h + (31h)	;	1	1
CEDB	7500	C	dw	7500h	;	X117	
CEDD	D6D6	C	dw	kdec1 * 100h + kdec1	;	XDec1	XDec1
CEDF	5000	C	dw	5000h	80 50h	Down=X80	
CEE1	3232	C	dw	(32h) * 100h + (32h)	;	2	2
CEE3	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CEE5	D5D5	C	dw	kdec2 * 100h + kdec2	;	XDec2	XDec2
CEE7	5100	C	dw	5100h	81 51h	PgDn=X81	
CEEB	3333	C	dw	(33h) * 100h + (33h)	;	3	3
CEED	7600	C	dw	7600h	;	X118	
CEEF	CDCD	C	dw	kdec3 * 100h + kdec3	;	XDec3	XDec3
CEF1	3030	C	dw	kbin3 * 100h + kbin3	82 52h	INS=X82	INS=X82
CEF3	CDCD	C	dw	(30h) * 100h + (30h)	;	0	0
CEF5	D7D7	C	dw	kNONE * 100h + kNONE	;	None	None
CEF7	5300	C	dw	kdec0 * 100h + kdec0	;	XDec0	XDec0
CEF9	2E2E	C	dw	(2Eh) * 100h + (2Eh)	83 53h	DEL=X83	
CEFB	C8C8	C	dw	kbres * 100h + kbres	;	Reset	Reset
CEFD	C8C8	C	dw	kbres * 100h + kbres	;	Reset	Reset

				Function Keypad		| Olivetti | Other |	
						| KB |	| Kbs |

CEFF	D8D8	C	dw	kdb10 * 100h + kdb10	84 54h	00	00
CF01	D8D8	C	dw	kdb10 * 100h + kdb10	;	00	00
CF03	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CF05	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CF07	C8C8	C	dw	kbprrt * 100h + kbprrt	85 55h	PrtSc	PrtSc
CF09	C8C8	C	dw	kbprrt * 100h + kbprrt	;	PrtSc	PrtSc
CF0B	7200	C	dw	7200h	;	X119	
CF0D	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CF0F	CACA	C	dw	pause * 100h + pause	86 56h	Pause	Pause
CF11	CACA	C	dw	pause * 100h + pause	;	Pause	Pause
CF13	CACA	C	dw	pause * 100h + pause	;	Pause	Pause
CF15	CACA	C	dw	pause * 100h + pause	;	Pause	Pause
CF17	0DD0	C	dw	(0Dh) * 100h + (0Dh)	87 57h	CR	CR
CF19	0DD0	C	dw	(0Dh) * 100h + (0Dh)	;	CR	CR
CF1B	0A0A	C	dw	(0Ah) * 100h + (0Ah)	;	LF	LF
CF1D	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CF1F	4B00	C	dw	4B00h	88 58h	Left=X75	
CF21	7300	C	dw	7300h	;	Rev Word = X115	
CF23	7300	C	dw	7300h	;	Rev Word = X115	
CF25	7300	C	dw	7300h	;	Rev Word = X115	
CF27	5000	C	dw	5000h	89 59h	Down=X80	
CF29	5000	C	dw	5000h	;	Down=X80	
CF2B	5000	C	dw	5000h	;	Down=X80	
CF2D	5000	C	dw	5000h	;	Down=X80	
CF2F	4D00	C	dw	4D00h	90 5Ah	Rght=X77	
CF31	7400	C	dw	7400h	;	Adv Word = X116	
CF33	7400	C	dw	7400h	;	Adv Word = X116	
CF35	7400	C	dw	7400h	;	Adv Word = X116	
CF37	4800	C	dw	4800h	91 5Bh	Up=X72	
CF39	4700	C	dw	4700h	;	Home=X71	
CF3B	4700	C	dw	4700h	;	Home=X71	
CF3D	4700	C	dw	4700h	;	Home=X71	
CF3F	C9C9	C	dw	kbbrrk * 100h + kbbrrk	92 5Ch	Break	Break
CF41	C9C9	C	dw	kbbrrk * 100h + kbbrrk	;	Break	Break
CF43	C9C9	C	dw	kbbrrk * 100h + kbbrrk	;	Break	Break
CF45	C9C9	C	dw	kbbrrk * 100h + kbbrrk	;	Break	Break
CF47	C9C9	C	dw	kbbrrk * 100h + kbbrrk	93 5Dh	Break	Break
CF49	C9C9	C	dw	kbbrrk * 100h + kbbrrk	;	Break	Break
CF4B	C9C9	C	dw	kbbrrk * 100h + kbbrrk	;	Break	Break
CF4D	C9C9	C	dw	kbbrrk * 100h + kbbrrk	;	Break	Break
CF4F	C2C2	C	dw	kbnun * 100h + kbnun	94 5Eh	NumLk	NumLk
CF51	C2C2	C	dw	kbnun * 100h + kbnun	;	NumLk	NumLk
CF53	CACA	C	dw	pause * 100h + pause	;	Pause	Pause
CF55	C2C2	C	dw	kbnun * 100h + kbnun	;	NumLk	NumLk
CF57	2F2F	C	dw	(2Fh) * 100h + (2Fh)	95 5Fh	/	/
CF59	2F2F	C	dw	(2Fh) * 100h + (2Fh)	;	/	/
CF5B	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CF5D	CDCD	C	dw	kNONE * 100h + kNONE	;	None	None
CF5F	5400	C	dw	5400h	96 60h	F11=X84	
CF61	5400	C	dw	5400h	;	F11=X84	
CF63	5400	C	dw	5400h	;	F11=X84	
CF65	5400	C	dw	5400h	;	F11=X84	
CF67	5500	C	dw	5500h	97 61h	F12=X85	
CF69	5500	C	dw	5500h	;	F12=X85	

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CF68 5500      C   dw      5500h      ;          F12=X85
CF6D 5500      C   dw      5500h      ;          F12=X85
CF6F 5600      C   dw      5600h      ;          F13=X86
CF71 5600      C   dw      5600h      ;          98 62h  F13=X86
CF73 5600      C   dw      5600h      ;          F13=X86
CF75 5600      C   dw      5600h      ;          F13=X86
CF77 5700      C   dw      5700h      ;          99 63h  F14=X87
CF79 5700      C   dw      5700h      ;          F14=X87
CF7B 5700      C   dw      5700h      ;          F14=X87
CF7D 5700      C   dw      5700h      ;          F14=X87
CF7F 5800      C   dw      5800h      ;          100 64h F15=X88
CF81 5800      C   dw      5800h      ;          F15=X88
CF83 5800      C   dw      5800h      ;          F15=X88
CF85 5800      C   dw      5800h      ;          F15=X88
CF87 5900      C   dw      5900h      ;          101 65h F16=X89
CF89 5900      C   dw      5900h      ;          F16=X89
CF8B 5900      C   dw      5900h      ;          F16=X89
CF8D 5900      C   dw      5900h      ;          F16=X89
CF8F 5A00      C   dw      5A00h      ;          102 66h F17=X90
CF91 5A00      C   dw      5A00h      ;          F17=X90
CF93 5A00      C   dw      5A00h      ;          F17=X90
CF95 5A00      C   dw      5A00h      ;          F17=X90
CF97 5B00      C   dw      5B00h      ;          103 67h F18=X91
CF99 5B00      C   dw      5B00h      ;          F18=X91
CF9B 5B00      C   dw      5B00h      ;          F18=X91
CF9D 5B00      C   dw      5B00h      ;          F18=X91
CF9F          C
C   kb_data1      endp
CF9F          C
C   code      ends
C   include hdu.asm
C
C
C   ;-----
C   ;          Filename:      hdu.asm
C   ;
C   ;          This module includes HDU support.
C   ;
C   ;-----
CF9F          C
C   code      segment public 'ROM'
C   assume es:code, ds:nothing, es:nothing
C
C   ; ##### COMMANDS AVAILABLE FROM INTERRUPT 13 #####
= 0000      C   reset_int      equ      00h      ;reset disks (according to drive#) and
C   ; assign_param
C   status_int      equ      01h      ;return status of last operation
C   ; (disk_status) in al
C   read_int         equ      02h      ;read sectors from disk
C   write_int        equ      03h      ;write sectors to disk
C   checktrk_int     equ      04h      ;check track
C   formatr_int      equ      05h      ;format track
C   formatd_int      equ      06h      ;format drive starting at the
C   ; indicated track
= 0007      C   ;
C   ;
C   read_param_int   equ      08h      ;read the current drive parameters
= 0009      C   assign_param_int equ      09h      ;assign parameters to drives
C   rlong_int        equ      0Ah      ;read long (512 data + 4 ecc)
C   wlong_int        equ      0Bh      ;write long
C   seek_int         equ      0Ch      ;seek cylinder
C   reset2_int       equ      0Dh      ;same as 00h
C   rbuff_int        equ      0Eh      ;read sector buffer
= 000F      C   wbuff_int        equ      0Fh      ;write sector buffer
C
C   tst_drv_rdy_int  equ      10h      ;test drive ready
= 0010      C   recal_int        equ      11h      ;reallocate drive (seek track 00)
= 0012      C   randia_int       equ      12h      ;controller ram diagnostic
= 0014      C   drvdia_int       equ      13h      ;drive diagnostic
C   bxdiag_int       equ      14h      ;controller internal diagnostic
= 0014      C   max_int         equ      14h      ;maximum interrupt command number
C
C   ; ##### INT13 STATUS CODES #####
C
C   ; These are put into the disk_status byte in data_seg when there is an error.
= 0007      C   rreset_err      equ      05h      ;disk reset (int13-00) failed
= 000B      C   int_err         equ      07h      ;assign parameter (int13-09) failed
= 0011      C   badtrack_err   equ      0Bh      ;bad track
= 00FF      C   ecc_used_err    equ      11h      ;ecc used to correct data
C   sense_err        equ      0Fh      ;request sense failed
C
C   ; ##### CONTROLLER INFORMATION #####
C
C   ; drives_per_bx   equ      2      ;max number of drives on a controller
C   ; drives_per_pc   equ      8      ;max number of drives on a pc
C   ; bxs_per_pc       equ      4      ;max number of bxs on a pc
C   ; ports_per_bx    equ      4      ;number of i/o ports for a controller
= 0011      C   sectors_per_track equ      17      ;compatible fixed format
C
C   ; ##### CONTROLLER PORTS #####
= 0320      C   read_port      equ      320h      ;read data port
= 0320      C   write_port     equ      320h      ;write data port
= 0321      C   status_port    equ      321h      ;read controller hardware status
= 0321      C   reset_port     equ      321h      ;write to reset controller hardware
= 0322      C   switch_port   equ      322h      ;read the drivetype switches
= 0322      C   select_port   equ      322h      ;write to select controller

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ROM BIOS Listing

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= 0323      C mask_port      equ    323h          ;write to mask_p_dma and interrupts
C           C ; ##### CONTROLLER REGISTER BITS #####
C           C ; This is the completion status byte received in the read_port after
C           C ; command completion.
C           C ;completion_status:
= 0002      C           h_du_drive      equ    0E0h      ; bits #7 to 5
C           C           h_du_err       equ    002h      ; bit #1
C           C ; This is the controller hardware status read from status_port.
C           C ;hdu_status:
= 0020      C           hdu_irq5       equ    020h      ; bit #5
C           C           hdu_drvq3      equ    010h      ; bit #4
= 0008      C           hdu_bay       equ    008h      ; bit #3
= 0004      C           hdu_ed       equ    008h      ; bit #2
= 0002      C           hdu_io       equ    002h      ; bit #1
= 0001      C           hdu_req       equ    001h      ; bit #0
C           C ; This is the controller p_dma and interrupt mask written to mask_port.
C           C ;mask_port_cmd: mask_port_bank equ    008h      ; bit #3
= 0002      C           mask_port_inte equ    002h      ; bit #1
= 0001      C           mask_port_dmae equ    001h      ; bit #0
C           C ; These are the bits for a drive in the switch.
C           C ; switch_mask      equ    00110011b
C           C ; ##### CONTROLLER COMMANDS #####
C           C ; The first byte of the cmd_block (CDB) is the controller command.
C           C ; The upper 3 bits are the class (either 0 or 7, all reset or all set).
C           C ; The lower 5 bits are the opcode (0 to 31).
C           C ; odb_0      record class:3, opcode:5
C           C ; Class 0 Controller Commands: 0007?????.
C           C ;
= 0000      C           tst_drv_rdy_bx   equ    00h
= 0001      C           recal_bx     equ    01h
C           C ; reserved
= 0003      C           sense_bx     equ    03h
= 0004      C           fatdrv_bx   equ    04h
= 0005      C           chktrk_bx   equ    05h
= 0006      C           fattrk_bx   equ    06h
= 0007      C           fatbad_bx   equ    07h
= 0008      C           read_bx     equ    08h
C           C ; reserved
= 000A      C           write_bx     equ    0Ah
= 000B      C           seek_bx     equ    0Bh
= 000C      C           assign_param_bx equ    0Ch
= 000D      C           read_sec_bx  equ    0Dh
= 000E      C           rbuff_bx    equ    0Eh
= 000F      C           wbuff_bx    equ    0Fh
C           C ; Class 7 Controller Commands: 111??????.
C           C ;
= 0080      C           randing_bx   equ    0E0h
C           C ; reserved
C           C ; reserved
= 00E3      C           drvdiag_bx   equ    0E3h
= 00E4      C           bxdia_g_bx  equ    0E4h
= 00E5      C           rlong_bx    equ    0E5h
= 00E6      C           wlong_bx    equ    0E6h
C           C ; ##### CONTROLLER CDB BYTES #####
C           C ; The remainder of the cmd_block bytes (CDB) are defined as follows:
C           C ; odb_1      record zsp:2, drivenum:1, headnum:5
C           C ; odb_2      record cylhi:2, secnum:6
C           C ; odb_3      record cyllo:8
C           C ; odb_4      record zsf:3, interleave:5
C           C ; odb_5      record retry:1, use_sec:1, zsg:3, stepcode:3
C           C ; ##### SENSE BYTES FOR REQUEST SENSE COMMAND #####
C           C ; Bytes returned when a request sense command is issued in response to an error.
C           C ; sense0:      sense0_val_addr equ    080h      ; bit #7
C           C ;                 sense0_type   equ    030h      ; bits #5 & 4
C           C ;                 sense0_code   equ    00Fh      ; bits #3 to 0
C           C ;                 sense0_mask  equ    03Fh      ; sense0_type+sense0_code
= 003F      C ; sense1:      sense1_drive   equ    020h      ; bit #5
C           C ;                 sense1_head   equ    01Fh      ; bits #4 to 0
C           C ; sense2:      sense2_cylhi   equ    0C0h      ; bits #7 & 6
C           C ;                 sense2_sector equ    03Fh      ; bit #5 to 0
C           C ; sense3:      sense2_cyllo   equ    0FFh      ; bits #7 to 0
C           C ; ##### HARD DISK PARAMETER TABLE #####

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ROM BIOS Listing

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C
C ; This is a table which is indexed by the switch settings to determine
C ; the parameters for each drive.
C
C parameter_table struc
0000 0132      p_cyls      dw      306d      ;number of cylinders
0002 04       p_heads     db      4d      ;number of heads
0003 0132      p_write_cur  dw      306d      ;reduced write current
0005 0000      p_precomp   dw      0d      ;write precompensation
0007 08       p_ect_len   db      11d      ;maximum eec burst length
0008 05       p_control_byte db      5d      ;enable retry, enable eec, 70usec steps
0009 0C       p_timeout   db      0ch      ;standard timeout
000A B4       p_fmt_timeout db      0bh4h   ;timeout for format drive
000B 28       p_drvdiag_timeout db      028h   ;timeout for test drive ready
000C 00 00 00 00      p_wzj     db      0,0,0,0
0010
C parameter_table ends
C
C ; ##### p_dma SYSTEM (8237) #####
= 0047
C read_mode     equ      01000111b      ;write to dma_mode
C              ;7:6      single mode
C              ;5:5      address increment
C              ;4:4      autoint disable
C              ;3:2      read
C              ;1:0      channel 3
= 004B
C write_mode    equ      01001011b      ;write to dma_mode
C              ;7:6      single mode
C              ;5:5      address increment
C              ;4:4      autoint disable
C              ;3:2      write
C              ;1:0      channel 3
= 0003
= 0007
C allow_dma3    equ      00000011b      ;write to dma_mask_bit to allow
C disallow_dma3 equ      00000111b      ;or disallow_dma3 interrupt
= 0082
C hdu_dma_segm  equ      082h          ;port sets top 4 bits of 20-bit p_dma address
C
C ; ##### MACROS #####
C ; Input to a register from a port.
C ; Won't work when the index has to cause a carry to high byte.
C inport macro  inrg,inpt
C               mov dx,inpt             ;get the port number for the base controller
C               add dl,byte ptr ds:[port_off] ;add port_off for the correct bx
C               in inrg,dx
C               endm
C ; Output from a register to a port.
C ; Ditto.
C outport macro outpt,outrg
C               mov dx,outpt           ;get the port number for the base controller
C               add dl,byte ptr ds:[port_off] ;add port_off for the correct bx
C               out out,dx,outrg
C               endm
C ;===== hd2.asm =====
C ; Power on self test
C ;=====
C               assume es:code, ds:abs0, es:abs0, ss:nothing
CF9F
C h_init proc  near
C ; Install vectors.
C               assume es:code, ds:abs0, es:abs0, ss:nothing
CF9F 33 C0      xor ax,ax ; satisfy assumptions
CFA1 8E D8      mov da,ax ; ds = es = ax = abs0_seg
CFA3 8E C0      mov es,ax
CFA5 FA        cli ; disable during critical code.
C ; Install HDU hardware interrupt service routine.
CFA6 C7 06 003h R D62F R      mov word ptr ds:[int0D10cm+0000h],es:(offset h_int)
CFA8 8C 0E 0036 R      mov word ptr ds:[int0D10cm+0002h],es
C ; Transfer old FDU int 13 vector to the new int 40 FDU location.
CFB0 A1 004C R      mov ax,word ptr ds:[int1310cm+0000h]
CFB3 A3 0100      mov word ptr ds:[(4*40h)+0000h],ax
CFB6 A1 004E R      mov ax,word ptr ds:[int1310cm+0002h]
CFB9 A3 0102      mov word ptr ds:[(4*40h)+0002h],ax
C ; Install new HDU request int 13 vector.
CFC0 C7 06 004C R D1AB R      mov word ptr ds:[int1310cm+0000h],es:(offset h_1o)
CFC2 8C 0E 004E R      mov word ptr ds:[int1310cm+0002h],es
C ; Install new HDU boot-strap int 19 vector
CFC6 C7 06 0064 R D0E9 R      mov word ptr ds:[int1910cm+0000h],es:(offset h_boot)

```

ROM BIOS Listing

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CFCC 8C 0E 0066 R      C      mov     word ptr ds:[int19locn+0002h],cs
C      ; Install new int 41 HDU parameter table pointer
C      ;
CFDB C7 06 0104 D14B R  C      mov     word ptr ds:[(4*41h)+0000h],cs:(offset hdu_parm_tbl)
CFDE 8C 0E 0106         C      mov     word ptr ds:[(4*41h)+0002h],cs
C      ;
CFDA FB                C      sti                     ; exit critical code.
C      ;
C      ; Initialize stuff in low memory.
C      ;
C      assume cs:code, ds:data, es:abs0, ss:nothing
C      ;
CFDB B8 0040           C      mov     ax,data_seg           ; satisfy assumptions.
CFDE 8E D8             C      mov     ds,ax
C      ;
CFE0 C6 06 0074 R 00   C      mov     byte ptr ds:[disk_status],0           ; clear errors.
CFE5 C6 06 0075 R 01   C      mov     byte ptr ds:[bf_num],1             ; assume 1 hard disk.
C      ;
C      ; Reset the controller.
C      ;
CFEA B9 000A         C      mov     cx,10                     ;try to reset controller up to 10 times
CFED                                C      init_controller_lp:
C      ;
CFED 8A 16 0075 R      C      mov     dl,byte ptr ds:[bf_num]           ;get the current hd number
CFE1 D0 E2             C      shl     dl,1                           ;make it look like
CFE2 80 E2 FC          C      and     dl,11111100b                   ;an index
CFE3 88 16 0077 R      C      mov     byte ptr ds:[port_off],dl        ;fake for reset_bx
CFE4 EB D5B1 R         C      call    reset_bx                       ;reset that controller
C      ;
C      ; Set up dl to call int13.
C      ;
CFFD B6 00             C      mov     dh,0                           ;clear dh
CFE0 8A 16 0075 R      C      mov     dl,byte ptr ds:[bf_num]           ;number of HDUs (incremented in this
C      ; loop)
D003 FE CA            C      dec     dl                               ;compensate for zero-origin
D005 80 CA 80          C      or      dl,80h                          ;flag as a hard disk number
C      ;
C      ; Test the controller.
C      ;
D008 B4 12             C      mov     ah,ramdiag_int                 ;set up for int13 - controller ram test
D00A CD 13             C      int     13h                             ;
D00C 72 5C             C      jc      post_no_more_drives            ;if error returned
C      ;
D00E B4 14             C      mov     ah,bxdiaq_int                 ;set up for int13 - controller internal test
D010 CD 13             C      int     13h                             ; test
D012 72 56             C      jc      post_no_more_drives            ;if error returned
C      ;
C      ; Set up p_timer for timeout of tst_rdy.
D014 C7 06 006C R 0000 C      mov     word ptr ds:[t_low_order],0*18 ; start counting at zero seconds
C      ; t_low_order counts
C      ; 18times/sec.
C      ;
C      ; Test system reset_flag.
D01A 81 3E 0072 R 1234 C      cmp     word ptr ds:[reset_flag],01234h ; test flag for reset function.
D020 75 06             C      jne     init_start_timer              ; skip if not CTL ALI DEL reboot
D022                                C      init_drive_lp:
D022 C7 06 006C R 0132 C      mov     word ptr ds:[t_low_order],17*18 ; only give 3 seconds if
C      ; warm boot or not first disk
C      ; t_low_order counts
C      ; 18times/sec.
D028                                C      init_start_timer:
D028 FA                C      cli
D029 EA 21             C      in      al,pic_1                       ; get interrupt mask
D02B 24 FE             C      and     al,0Fh                          ; un-mask p_timer interrupt IRO
D02D B6 21             C      out     pic_1,al                       ; set the controller
D02F FB                C      sti
C      ;
D030 B4 09             C      mov     ah,assign_param_int            ;assign drive parameters according to
D032 CD 13             C      int     13h                             ;
D034 72 3B             C      jc      post_lose                       ;switch settings on bx board
C      ;
D036                                C      init_try_drive:
D036 B4 10             C      mov     ah,tst_drv_rdy_int            ;test drive ready
D038 CD 13             C      int     13h                             ;
D03A 73 0B             C      jno     init_drive_win                 ;
D03C 81 3E 006C R 0168 C      cmp     word ptr ds:[t_low_order],20*18 ; t_low_order counts
C      ; 18times/sec.
D042 72 F2             C      jb      init_try_drive                 ;if not given enough time yet, go back
D044 EB 24 90          C      jmp     post_no_more_drives            ;if given enough time and still losing
C      ;
D047                                C      init_drive_win:
D047 B4 11             C      mov     ah,recal_int                   ;recalibrate drive
D049 CD 13             C      int     13h                             ;
D04B 72 24             C      jc      post_lose                       ;
C      ;
C      assume es:code
C      ;
D04D 8C C8             C      mov     ax,cs                           ;satisfy assumption
D04F 8E C0             C      mov     es,ax
D051 33 DB             C      xor     bx,bx                           ;initialize offset (es:bx)

```

ROM BIOS Listing

```
D053 B4 0F           C      mov  ah,buffer_int          ;write sector buffer as a test
D055 B0 01           C      mov  al,01                    ;one block length
D057 CD 13           C      int  13h
D059 72 16           C      jc   post_lose
C
C
C
C
C
C
C
C
D05B FE 06 0075 R    C      inc  byte ptr ds:[hf_num]      ;point to the next one
D05F FE C2           C      inc  dl                        ;register for calling int13
D061 F6 06 0075 R 01 C      test byte ptr ds:[hf_num],0fh ;have we proceeded to a new controller?
D066 74 BA           C      js   init_drive_lp            ;no, go init second drive on this one
D068 EB 83           C      jmp  init_controller_lp       ;and go back .
C
C
C
C
C
C
C
C
D06A FE 0E 0075 R    C      post_no_more_drives:
D06C             C      dec  byte ptr ds:[hf_num]      ;restore hf_num
D06E EB 13 90           C      jmp  post_win                  ; could be FDU system only
C
C
C
C
C
C
C
C
D071 FE 0E 0075 R    C      post_lose:
D073             C      dec  byte ptr ds:[hf_num]      ;anticipation disproved
C
C
C
C
C
C
C
C
D075 BD 000F           C      ;post_message:
D077             C      mov  bp,0fh                    ;error flag
D079 BE D0A2 R        C      mov  si,cs:(offset h_bad_m)     ;string for error '1701' (HDU)
D07B EB E5FA R        C      call DROMString                 ;display message on screen
D07E E8 D0BB R        C      call show_sense                 ;display the sense bits
D081 EB 18           C      jmp  short p_disp
C
C
C
C
C
C
C
C
D083             C      post_win:
D085             C      mov  al,byte ptr ds:[hf_num]    ; number of hard disks.
D086 0A C0           C      or   al,al                      ; are there any fixed disks.
D088 75 08           C      jnz  p_som                    ;
C
C
C
C
C
C
C
C
D08A BE D0AE R        C      mov  si,cs:(offset h_abs_m)     ; message for no HDU
D08D E8 E5FA R        C      call DROMString                 ;
D090 EB 09           C      jmp  short p_disp
C
C
C
C
C
C
C
C
D092             C      p_som:
D094 EB E650 R        C      call DHexNib                    ; display the number
C
C
C
C
C
C
C
C
D095 BE D0A6 R        C      mov  si,cs:(offset h_good_m)    ; message for 'H DU'
D098 E8 E5FA R        C      call DROMString                 ;
C
C
C
C
C
C
C
C
D09B E8 E619 R        C      p_disp: call DCrLf
C
C
C
C
C
C
C
C
D09E E8 D5FA R        C      call disable_disk_interrupts
D0A1 C3              C      ret
C
C
C
C
C
C
C
C
D0A2 20 4E 6F 74     C      h_bad_m db ' Not'                ; purposely no NUL!!!!
D0A6 20 52 65 61 64 79 C      h_good_m db ' Ready ',NUL
D0A8 20 00           C
D0AE 20 4E 6F 74 20 50 C      h_abs_m db ' Not Present',NUL
D0B0 72 65 73 65 6E 74 C
D0B2 00           C
C
C
C
C
C
C
C
C
D0BB             C      h_init endp
D0BB             C
C
C
C
C
C
C
C
C
D0BB             C      show_sense proc near
C
C
C
C
C
C
C
C
D0BB B8 0E28           C      mov  ax,(0Eh*100h)+'('         ;display a '('
D0BE CD 10           C      INT  10h
C
C
C
C
C
C
C
C
D0C0 A0 0042 R        C      mov  al,byte ptr ds:[hd_error] ;get the error code
D0C3 24 3F           C      and  al,sense0_mask            ;isolate the type and code bits
D0C5 E8 E643 R        C      call DHexByte                 ;display error type and code
C
C
C
C
C
C
C
C
D0C8 B8 0E29           C      mov  ax,(0Eh*100h)+'('         ;display a ')'
D0CB CD 10           C      INT  10h
C
C
C
C
C
C
C
C
D0CD C3              C      ret
C
C
C
C
C
C
C
C
D0CE             C      show_sense endp
D0CE             C
C
C
C
C
C
C
C
C
D0CE             C      maybe_show_sense proc near
C
C
C
C
C
C
C
C
D0CE             C      ; Show sense information if switch 8 is zero (closed) and 6 is one (open).
D0CE             C      ; To be used for field maintenance.
C
C
C
C
C
C
C
C
D0CE 50           C      push  ax
D0CF 80 3E 0074 R 00 C      cmp  byte ptr ds:[disk_status],0
D0D4 74 11           C      je   s_exit                     ;if no error, do not display
C
C
C
C
C
C
C
C
D0D6 BA 0322           C      inport al,switch_port          ;read the switches
D0D9 02 16 0077 R    C+   mov  dx,switch_port            ;get the port number for the base controller
D0DB EC           C      add  dl,byte ptr ds:[port_off]  ;add port_off for the correct bx
D0DD EC           C      in  al,dx
D0DE 24 A0           C      and  al,0A0h
D0E0 3C 80           C      cmp  al,080h                    ;mask switches 8 and 6
C
C
```


ROM BIOS Listing

```

DOE2 75 03          C          jne     m_exit
DOE4 E8 DOBB R     C          call    show_sense          ;if so, display sense
DOE7              C          m_exit:
DOE7 58            C          pop     ax                  ;back to caller
DOE8 C3            C          ret
DOE9              C          maybe_show_sense      endp
C
C          ;===== hd3.asm
C          ; This is called from the ROM Bios after the hard disk has been initialized.
C          ; It attempts to read and initiate a master boot block from logical sector 0 of
C          ; the floppy disk, and then from the hard disk.
C          ;=====
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
DOE9              C          h_boot proc far
C          ; Install vectors.
C          assume cs:code, ds:abs0, es:abs0, ss:nothing
C
DOE9 33 C0         C          xor     ax,ax                ; satisfy assumptions
DOE8 8E D8        C          mov     ds,ax                ; ds = es = ax = abs0_seg
DOED 8E C0        C          mov     es,ax
DOEF FA          C          cli                      ; disable during critical code.
C          ; Install new int 01 HDU parameter table pointer.
DOFO CT 06 0104 D14B R C          mov     word ptr ds:[(4*01h)+0000h],es:(offset hdu_parm_tbl)
DOF6 8C 0E 0106   C          mov     word ptr ds:[(4*01h)+0002h],cs
C          ; Install new FDU parameter table pointer.
C          ;
C          ; mov     word ptr ds:[int:0100n+0000h],es:(offset fd_parms)
C          ; mov     word ptr ds:[int:0100n+0002h],cs
DOFA .FB         C          sti                      ; exit critical code.
C          ; Attempt to reset the diskette. Motor startup time requires 3 tries.
C          assume cs:code, ds:data, es:abs0, ss:nothing
DOFB E8 0040     C          mov     ax,data_seg          ; satisfy assumptions.
DOFE 8E D8        C          mov     ds,ax
C
D100 B9 0003     C          mov     cx,3                 ;3 retries
D103 B2 00        C          mov     dl,0                ;drive number zero (soft disk A:)
D105 B8 D12A R   C          call    boot_a_disk          ;try to boot from floppy
D108 72 02        C          je     b_try_hdu             ;failed - try the hard disk
D10A EB 13        C          jmp     short b_ok            ;jump to the boot code if we succeeded
C          ; else boot from the hard disk.
D10C              C          b_try_hdu:
D10C B9 0003     C          mov     cx,3                 ;3 retries
D10F B2 80        C          mov     dl,80h              ;drive number 80h (hard disk C:)
D111 B8 D12A R   C          call    boot_a_disk          ;try to boot from hard disk
D114 72 0E        C          je     b_failed              ;if this failed too, then exit.
C
D116 26: 81 3E 7DPE AA55 C          cmp     word ptr es:[07C00h+510d],0AA55h ;is it the code?
D11D 75 05        C          jne     b_failed              ;code tester
C
D11F              C          b_ok:
D11F 2E: FF 2E D126 R C          jmp     dword ptr es:[boot_indirect] ;jump to boot code if correct
C
D124              C          b_failed:
D124 CD 18        C          int     18h                 ; initiate reboot through ROM BASIC INT.
C
D126 7C00        C          boot_indirect dw 07C00h      ; jump indirect to boot code at 0:7C00
D128 0000        C          dw     abs0_seg
C
D12A              C          h_boot endp
C
D12A              C          boot_a_disk proc
C          ; Set dl:disk number and call this proc.
C          ; It will reat and try to read ox times (in case there is a read error).
C          ; If it succeeds, it will return with CY=0. If it fails, it will leave CY=1.
D12A              C          b_lp:
D12A B4 00        C          mov     ah,reset_int         ;reset the disk
D12C CD 13        C          int     13h
C
D12E 72 14        C          jc     b_lost                ;if the operation lost
C
D130 B4 02        C          mov     ah,read_int          ;if it worked, read from the disk
D132 B0 01        C          mov     al,1                 ;one sector
C
D134 B8 7C00     C          mov     bx,07C00h           ;offset for the boot_area.
C
D137 51          C          push    cx                   ;save the retry count
C
D138 B5 00        C          mov     ch,0                 ;cylinder 0
D13A B1 01        C          mov     cl,1                 ;sector 1 (lowest sector)
D13C B6 00        C          mov     dh,0                 ;head 0
C

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ROM BIOS Listing

```

D13E CD 13          C          int    13h          ;attempt read
D140 59            C          pop     cx          ;restore retry count
D141 72 01        C          jc     b_lost      ;if it worked, return to caller
D143 C3           C          ret             ;return with no carry
D144             C          b_lost:
D144 80 FC 80      C          cmp     ah,time_out  ;if it was a timeout,
D147 E0 E1        C          loopne b_lp        ;otherwise, another chance
D149 F9           C          stc             ;dropped through loop
D14A C3           C          ret             ;return with carry
D14B             C          boot_a_disk  endp
D14B             C          hdu_param_tbl:
D14B             C          ; The next six are the supported drives:
D14B 0132         C          parameter_table <2d,,,00h>          ;type 0: 5mb drive
D14D 02           C
D14E 0132         C
D150 0000         C
D152 0B           C
D153 00           C
D154 0C           C
D155 B4           C
D156 28           C
D157 00 00 00 00 C
D15B 0177         C          parameter_table <375d,8d,375d>      ;type 1: 24mb drive
D15D 08           C
D15E 0177         C
D160 0000         C
D162 0B           C
D163 05           C
D164 0C           C
D165 B4           C
D166 28           C
D167 00 00 00 00 C
D16B 0132         C          parameter_table <6d,128d,256d>      ;type 2: 15mb drive
D16D 06           C
D16E 0080         C
D170 0100         C
D172 0B           C
D173 05           C
D174 0C           C
D175 B4           C
D176 28           C
D177 00 00 00 00 C
D17B 0132         C          parameter_table <>                  ;type 3: 10mb drive
D17D 04           C
D17E 0132         C
D180 0000         C
D182 0B           C
D183 05           C
D184 0C           C
D185 B4           C
D186 28           C
D187 00 00 00 00 C
D18B 0132         C          parameter_table <,2d,128d,306d>      ; (default)
D18D 02           C          ;type 4: Syquest SQ306
D18E 0080         C
D190 0132         C
D192 0B           C
D193 05           C
D194 0C           C
D195 B4           C
D196 28           C
D197 00 00 00 00 C
D19B 0284         C          parameter_table <644d,5d,128d,128d>  ;type 5: CDC Wren
D19D 05           C
D19E 0080         C
D1A0 0080         C
D1A2 0B           C
D1A3 05           C
D1A4 0C           C
D1A5 B4           C
D1A6 28           C
D1A7 00 00 00 00 C
D1A8             C          ; ...End of hard disk parameters.
D1A8             C          ;===== hd4.asm =====
D1A8             C          ; Interrupt 13h - HDU I/O request
D1A8             C          ;=====
D1A8             C          h_io  proc  far
D1A8             C          assume cs:code, ds:nothing, es:nothing, as:nothing
D1A8             C          ; Debugging code to display all calls to this procedure.

```

ROM BIOS Listing

```

C
C ;      push   ax
C ;      mov    al,ah
C ;      call  DHexByte
C ;      mov    al,dl
C ;      call  DHexNib
C ;      call  DColon
C ;      pop    ax
C
C
D1A8 F6 C2 80          test    dl,080h                ; test HDU flag bit #7.
D1AE 75 05            jnz    hard_disk_int13        ; is this an HDU command?
D1B0 CD 40            int    40h                    ; if not, pass to the FDU driver
C
C
D1B2 CA 0002          ret_from_40:
D1B2          ret    2                    ; and then return, saving flags
C
C
hard_disk_int13:
C
D1B5 FB              sti    ah,reset_int          ; enable interrupts
D1B6 80 FC 00        cmp    ah,reset_int          ; is this a reset command?
D1B9 75 09          jne    h_save_regs          ; if no, must reset FDU also
D1BB CD 40          int    40h
C
C
D1BD 80 FA 87        cmp    dl,87h                ; is the number absurd?
D1CD 77 F0          js     ret_from_40          ; if so, return without HDU
C
C
D1C2 B4 00          mov    ah,reset_int          ; perform a hard disk reset
C
C
h_save_regs:
C
D1CA          push  di
D1CA 57            push  si
D1C5 56            push  es
D1C6 06            push  ds
D1C7 1E            push  bx
D1C8 53            push  ex
D1C9 51            push  dx
D1CA 52            push  dx
C
C
; Set up ds: segment.
C
C
assume  es:code, ds:data, es:nothing, ss:nothing
C
C
D1CB 50            push  ax
D1CC B8 0040        mov    ax,data_seg          ; satisfy assumptions.
D1CF 8E D8          mov    ds,ax
D1D1 58            pop   ax
C
C
D1D2 88 16 0076 R    mov    byte ptr ds:[control_byte],dl ;retain drive specifier
C
C
D1D6 80 FC 01        cmp    ah,status_int        ;is it a status request?
D1D9 75 03          jne    h_make_odb          ;no
D1DB 89 D263 R      jmp    status                ;treat as a special case
C
C
; Set up some of the CDB.
C
C
h_make_odb:
C
D1DE          dec    cl                    ;bx sectors are 0-16, not 1-17
D1DE FE C9          mov    byte ptr ds:[cmd_block+2],cl ;cylinder-hi and sector
D1E0 88 0E 0044 R    mov    byte ptr ds:[cmd_block+3],ch ;cylinder-low
D1E2 88 2E 0045 R    mov    byte ptr ds:[cmd_block+4],al ;interleave or block count
C
C
D1E8          push  es
D1E8 06            push  bx
D1EC 53            call  get_drivetype_vector    ;point to parms for this drive
D1ED 88 D5C1 R      mov    al,es:[bx+p_control_byte] ;get the control byte
D1F0 26: 8A 47 08    pop   bx
D1F4 5B            pop   es
D1F5 07            pop   es
D1F6 42 0047 R      mov    byte ptr ds:[cmd_block+5],al ;put it in the odb
C
C
; Set up the port_off with the port offset for the drive.
C
C
D1F9 8A C2          mov    al,dl                ; HDU drive number
D1FB 24 7F          and    al,07Fh              ; mask off HDU flag bit #7
D1FD 3A 06 0075 R    cmp    al,byte ptr ds:[hf_num] ; count of HDU's
D201 73 57          jae    h_bad_command        ; error if too high
C
C
D203 50            push  ax
D204 D0 E0          shl   al,1                  ;multiply by 2
D206 24 FC          and    al,11111100b         ;provide port offset
D208 42 0077 R      mov    byte ptr ds:[port_off],al ;store for use by port routine
D20B 58            pop   ax
C
C
D20C B1 05          mov    cl,drivenum          ;shift for odb drive#
D20E 02 20          shl   dl,cl
D210 80 E6 1F      and    db,(mask_headnum)    ;get the bits for head number
D213 0A C6          or    al,db                  ;share drives with head number
D215 42 0043 R      mov    byte ptr ds:[cmd_block+1],al ;store into the drive/head byte
C
C
; Set up an index to use the h_cmd_table.
C
C
D218 80 FC 14        cmp    ah,max_int           ;highest-numbered valid int13 command
D21B 77 3D          ja     h_bad_command        ;error if out of range
C
C
D21D 8A C3          mov    al,ah                ;get the command code
D21F D0 E0          shl   al,1                  ;multiply command by 4...
D221 D0 E0          shl   al,1                  ;For indexing of table
D223 B4 00          mov    ah,0                 ;zero top 8 bits
D225 05 D26D R      add    ax,offset h_cmd_table ;now we point to the command in the table
D228 8B F0          mov    si,ax                ;we'll use es:[si] to index the table

```

ROM BIOS Listing

```

C
C
C ; Now we can finish setup of the command.
C ; If it's a p_dma operation, the command subroutine will be
C ; called with al=p_dma mode byte for 8237.
D22A 2E: 8A A4 0000      C      mov     ah,cs:[si].bx_opcode      ;get the opcode for the cdb
D22F 88 26 0042 R      C      mov     byte ptr ds:[cmd_block+0],ah ;and put it in place
D233 2E: 8A 84 0003      C      mov     al,cs:[si].h_cmd_mode_dma ;p_dma mode byte (read/write)
D238 C6 06 0074 R 00    C      mov     byte ptr ds:[disk_status],0 ; clear errors.
D23D 2E: FF 94 0001      C      ccall  cs:[si].h_cmd_subr        ;call subroutine to execute command
D242
D242 E8 D5FA R          C      h_finish: call    disable_disk_interrupts
D245 E8 DOCE R          C      call    maybe_show_sense
D248 8A 26 0074 R      C      mov     ah,byte ptr ds:[disk_status] ; get the status code from oper.
D24C 80 FC 01          C      cmp     ah,1                      ; if nonzero, clear CF
D24F F5                C      ome                                ; now CF reflects error status.
D250 5A                C      pop     dx
D251 59                C      pop     cx
D252 5B                C      pop     bx
D253 1F                C      pop     ds
D254 07                C      pop     es
D255 5E                C      pop     si
D256 5F                C      pop     di
D257 CA 0002          C      ret     2                          ;return, preserving flags
D25A
D25A C6 06 0074 R 01    C      h_bad_command: byte ptr ds:[disk_status],cmd_error ;bad command to int13
D25F B0 00             C      mov     al,0                      ;clear burst length
D261 EB DF             C      jmp     h_finish                    ;and exit
C
C ; Special code for return_status.
D263
D263 A0 0074 R          C      status:  mov     al,byte ptr ds:[disk_status] ;return status from last command
D264 C6 06 0074 R 00    C      mov     byte ptr ds:[disk_status],0 ;this command was successful
D26B EB D5             C      jmp     h_finish                    ;and exit
C
C ; This is the structure for the table which allows command dispatch.
C
C h_cmd_struct      struct
C bx_opcode         db     0h        ;opcode for the bx (cdb byte 0)
C h_cmd_subr        ds     0h        ;address of command routine
C h_cmd_mode_dma    db     0h        ;code for 8237 read/write
C h_cmd_struct      ends
C
C ; This is the table itself. Each entry corresponds to a command.
D26D
C h_cmd_table:
C h_cmd_struct      <assign_param_bx,assign_param> ;00 reset
C
C h_cmd_struct      <0h, 0h> ;01 status
C
C h_cmd_struct      <read_bx, h_dma, read_mode> ;02 read
C
C h_cmd_struct      <write_bx, h_dma, write_mode> ;03 write
C
C h_cmd_struct      <chktrk_bx, h_ndma> ;04 chktrk
C
C h_cmd_struct      <fmttrk_bx, h_ndma> ;05 fmttrk
C
C h_cmd_struct      <fmtbad_bx, h_ndma> ;06 fmtbad
C
C h_cmd_struct      <fmtdrv_bx, h_ndma> ;07 fmtdrv
C
C h_cmd_struct      <0h, read_param> ;08 read_param
C
C h_cmd_struct      <assign_param_bx,assign_param> ;09 assign_param
C
C

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ROM BIOS Listing

```

D295 E5          C h_cmd_struct <rlong_bx, h_dma, read_mode> ;0a rlong
D296 D2C1 R      C
D298 47          C
C
C
C
D299 E6          C h_cmd_struct <wlong_bx, h_dma, write_mode> ;0b wlong
D29A D2C1 R      C
D29C 4B          C
C
C
C
D29D 08          C h_cmd_struct <seek_bx, h_ndma> ;0c seek
D29E D33E R      C
D2A0 00          C
C
C
C
D2A1 0C          C h_cmd_struct <assign_param_bx,assign_param> ;0d reset
D2A2 D504 R      C
D2A4 00          C
C
C
C
D2A5 0E          C h_cmd_struct <rbuf_bx, h_dma, read_mode> ;0e rbuf
D2A6 D2C1 R      C
D2A8 47          C
C
C
C
D2A9 0F          C h_cmd_struct <wbuf_bx, h_dma, write_mode> ;0f wbuf
D2AA D2C1 R      C
D2AC 4B          C
C
C
C
D2AD 00          C h_cmd_struct <tst_drv_rdy_bx,h_ndma> ;10 tst_drv_rdy
D2AE D33E R      C
D2B0 00          C
C
C
C
D2B1 01          C h_cmd_struct <recl_bx, h_ndma> ;11 recl
D2B2 D33E R      C
D2B4 00          C
C
C
C
D2B5 E0          C h_cmd_struct <randia_bx, h_ndma> ;12 randia
D2B6 D33E R      C
D2B8 00          C
C
C
C
D2B9 E3          C h_cmd_struct <drvdiag_bx, h_ndma> ;13 drvdiag
D2BA D33E R      C
D2BC 00          C
C
C
C
D2BD E4          C h_cmd_struct <bxdiag_bx, h_ndma> ;14 bxdiag
D2BE D33E R      C
D2C0 00          C
C
C
C
C
D2C1             C h_io endp
C
C ; This procedure is called by int13 when a command requires a p_dma operation.
C ; The al register should contain the h_cmd_mode_dma.
C
C
C
D2C1             C h_dma proc
C
C
C
D2C1 FA          C cli ; disable interrupts
D2C2 E6 0B       C out dma_mode,al ; set the p_dma mode
C
C ; Convert es:bx to an absolute 20-bit address for data.
C
C
C
D2C4 8C C0       C mov ax,es ; get es
D2C6 B1 04       C mov ol,4 ; rotate 4 bits (*16)
D2C8 03 C0       C rol ax,ol ; now it's aligned with bx
D2CA 8A E8       C mov ch,al ; save the top nibble of address
D2CC 24 F0       C and al,0F0h ; clear low nibble
C
C
C
D2CE 03 D8       C add bx,ax ; add the offset of the address
D2D0 80 D5 00    C adc oh,0 ; propagate CF (20-bit addition)
C ; oh = 20-bit address hi nibble
C ; bx = 20-bit offset of address
C
C
C
D2D3 E6 0C       C out dma_ff_olr,al ; clear the first/last ff
C
C
C
D2D5 8A C3       C mov al,bl
D2D7 E6 06       C out dma_addr_3,al ; output low byte of address
C
C
C
D2D9 8A C7       C mov al,bh
D2DB E6 06       C out dma_addr_3,al ; output high byte of address
C
C
C
D2DD 8A C5       C mov al,oh
D2DF 24 0F       C and al,0Fh ; restore top nibble of address
D2E1 E6 82       C out hdu_dma_sigm,al ; to bank select register
C
C
C
D2E3 A0 0042 R    C mov al,byte ptr ds:[cmd_block*0] ; get command from cmd_block
C
C ; If it is a rlong or wlong, it's limited to one block (516 chars)
C ; Note that if rlong or wlong is requested, the length is not checked.
C
C
C
D2E6 3C E5       C cmp al,rlong_bx ; is command rlong_bx?
D2E8 74 38       C je h_dma_long
D2EA 3C E6       C cmp al,wlong_bx ; is command wlong_bx?
D2EC 74 34       C je h_dma_long
C
C ; If it is a rbuf or wbuf, it's forced to one block (512 chars)
C ; Note that if rbuf or wbuf is requested, the length is not checked.
C
C
C
D2EE 3C E8       C cmp al,rbuf_bx ; is command rbuf_bx?
D2F0 74 3A       C je h_dma_buff
D2F2 3C 0F       C cmp al,wbuf_bx ; is command wbuf_bx?
D2F4 74 36       C je h_dma_buff
C
C ; Set up the number of bytes for a normal command.

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D2F6 80 3E 0046 R 80      C
D2F7 7F 39                C
C
C      cmp      byte ptr ds:[cmd_block+4],080h ; too many blocks requested?
C      ja       h_dma_err ; (64k RAM/512 bytes per sector)
C
C      ; Determine number of bytes to transfer.
C
D2FD B1 09                C
D2FE A0 0046 R            C
D302 D3 E0                C
C      mov      cx,09h ; multiply 512 times
C      mov      al,byte ptr ds:[cmd_block+4] ; ...block count
C      shl      ax,cl ; to make byte count
C
D304                C
D304 48                C
C      h_dma_len:
C      dec     ax ; ax = byte count - 1
C
D305 E6 07                C
D307 86 C4                C
D309 E6 07                C
D30B 86 C4                C
C      out     dma_count_3,al ; output low byte of count
C      xchg    al,ah ; ...
C      out     dma_count_3,al ; output high byte of count
C      xchg    al,ah ; ax = byte count - 1
C
D30D FB                C
C      sti     ; critical code is over
C
D30E 03 C3                C
D310 72 24                C
C      add     ax,bx ; compute last byte to transfer
C      jc     h_dma_err ; if carry flag set, overflow!!
C
C      ; Enable and allow interrupts from p_dma, and issue command.
C
D312 B0 03                C
D314 E8 D3DD R            C
D317 72 31                C
C      mov     al,(mask_port_inte+mask_port_dmae)
C      call    command ; send the cmd out to the bx
C      jc     h_err_chk ; return error
C
D319 B0 03                C
D31B E6 0A                C
C      mov     al,allow_dma3 ; allow interrupts
C      out     dma_mask_bit,al ; from the p_dma channel
C
D31D E8 D43B R            C
D320 EB 28                C
C      call    h_cmd_wait ; wait for command completion
C      jmp     short h_err_chk ; check for possible error
C
C
C      ; For rlong and wlong commands:
C
D322                C
D322 C6 06 0046 R 01      C
D327 B8 0204              C
D32A EB D8                C
C      h_dma_long:
C      mov     byte ptr ds:[cmd_block+4],01h ; one block maximum
C      mov     ax,512d + 4d ; length of data + ecc
C      jmp     h_dma_len
C
C      ; For rbuff and wbuff commands:
C
D32C                C
D32C C6 06 0046 R 01      C
D331 B8 0200              C
D334 EB CE                C
C      h_dma_buff:
C      mov     byte ptr ds:[cmd_block+4],01h ; one block maximum
C      mov     ax,512d ; length of data
C      jmp     h_dma_len
C
D336                C
D336 FB                C
D337 F9                C
D338 C6 06 0074 R 09      C
D33D C3                C
C      h_dma_err:
C      sti     ; enable interrupts
C      stc     ; set carry flag.
C      mov     byte ptr ds:[disk_status],dma_seg_error
C      ret
C
D33E                C
D33E                C
C      h_dma     endp
C
C
C      ; This procedure is called by int13 when a non-p_dma command is requested.
C
D33E                C
D33E                C
C      h_ndma   proc
C
D33E B0 02                C
D340 E8 D3DD R            C
D343 72 05                C
C      mov     al,mask_port_inte ; allow bx interrupt at cmd completion
C      call    command ; send the cmd out to the bx
C      jc     h_err_chk ; return error
C
D345 E8 D43B R            C
D348 EB 00                C
C      call    h_cmd_wait ; wait for the command to complete
C      jmp     short h_err_chk ; check for possible error
C
D34A                C
D34A                C
C      h_ndma   endp
C
D34A                C
D34A                C
C      h_err_chk proc
C
D34A 80 3E 0074 R 00      C
D34F 75 01                C
D351 C3                C
C      cmp     byte ptr ds:[disk_statv~],0 ; check status flag from command
C      jne    h_bad_err
C      ret ; no error - looking good
C
C      ; Perform request sense command same drive number.
C
D352                C
D352 C6 06 0042 R 03      C
D357 B0 00                C
D359 E8 D3DD R            C
D35C 72 75                C
C      mov     byte ptr ds:[cmd_block+0],sense_bx
C      mov     al,0 ; interrupt and p_dma for bx
C      call    command ; wait for status byte ready
C      jc     e_loss ; sense command lost
C
D35E B9 0004              C
D361 B8 0000              C
D364 8B F8                C
C      mov     cx,4 ; accept 4 data + 1 status byte
C      mov     ax,0
C      mov     di,ax ; used as index of array
C
D366                C
D366                C
C      e_read_sense:
C      mov     ah,(hdu_bay+hdu_io+hdu_req) ; bay-od-io-req
C      D368 EB D418 R            C
C      D36B 72 66                C
C      call    wait_for_status ; wait for status byte ready
C      jc     e_loss ; jump if error
C      inport al,read_port ; read data
C      D36D BA 0320              C+
C      D370 02 16 0077 R      C+
C      mov     dx,read_port ; get the port number for the base controller
C      add     di,byte ptr ds:[port_off] ; add port_off for the correct bx

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D374 EC          C+   in      al,dx
D375 88 85 0042 R  C+   mov     byte ptr ds:[hd_error+dl],al ; store in array
D379 47          C     inc     di
D37A E2 EA        C     loop   a_read_sense
C
D37C B4 0F        C     mov     ah,(hdu_bsy+hdu_cd+hdu_io+hdu_req) ;bsy+cd+io+req
D37E EB D418 R   C     call   wait_for_status ; wait for status byte ready
D381 72 50        C     je      a_lose ; jump if error
C
D383 BA 0320     C+   inport  al,read_port ; read the status byte
D386 02 16 0077 R C+   mov     dx,read_port ;get the port number for the base controller
D38A EC          C+   add     dl,byte ptr ds:[port_off] ; add port_off for the correct bx
C
D38B A8 02        C     test    al,h_c_err ; check status byte
D38D 75 44        C     jnz     a_lose ; leave if we had sense error
C
D38F A0 0042 R   C     mov     al,byte ptr ds:[hd_error+0] ; get first sense byte
D392 24 3F        C     and     al,sense0_mask ; isolate the type and code bits
D394 BB D49F R   C     mov     bx,offset bx_error_table ; get the dos error code
D397 2B D7        C     r16    ds:bx_error_table ; store the status
D399 42 0074 R   C     mov     byte ptr ds:[disk_status],al
D39C 3C 11        C     cmp     al,ecoc_used_err ; was it a correctable eoc err?
D39E 75 32        C     jne     h_err_ret ; if not, return
C
; Read eoc burst length.
C
D3A0 C6 06 0042 R OD C     mov     byte ptr ds:[cmd_block+0],read_eoc_bx
D3A5 B0 00        C     mov     al,0 ; interrupt mask = no interrupts
D3A7 EB D3DD R   C     call   ocommand
D3AA 72 27        C     jo      a_lose
C
D3AC B4 0B        C     mov     ah,(hdu_bsy+hdu_io+hdu_req) ; bsy+od+io+req
D3AE EB D418 R   C     call   wait_for_status ; read the status byte
D3B1 72 20        C     je      a_lose
C
D3B3 BA 0320     C+   inport  al,read_port ; read the burst length
D3B6 02 16 0077 R C+   mov     dx,read_port ;get the port number for the base controller
D3BA EC          C+   add     dl,byte ptr ds:[port_off] ; add port_off for the correct bx
D3BB 8A C8        C     inc     si
C     mov     cl,al ; save it for a moment
C
D3BD B4 0F        C     mov     ah,(hdu_bsy+hdu_cd+hdu_io+hdu_req) ;bsy+cd+io+req
D3BF EB D418 R   C     call   wait_for_status ; read the status byte
D3C2 72 0F        C     je      a_lose
C
D3C4 BA 0320     C+   inport  al,read_port ;get the port number for the base controller
D3C7 02 16 0077 R C+   mov     dx,read_port ; add port_off for the correct bx
D3CB EC          C+   inc     di
D3CC A8 02        C     test    al,h_c_err ; check completion status
D3CE 75 03        C     jnz     a_lose
C
D3D0 8A C1        C     mov     al,cl ; get burst length back
D3D2          C     h_err_ret:
D3D2 C3          C     ret
C
; Sense failed. Try to recover.
C
D3D3          C     a_lose:
C
D3D3 E8 D504 R   C     call   assign_params ;reset controller and assign parameters
D3D6 C6 06 0074 R FF C     mov     byte ptr ds:[disk_status],sense_err ;sense failed
D3DB F9          C     stc
D3DC C3          C     ret
C
D3DD          C     h_err_chk endp
C
; Send a CDB to the bx.
C
; The al register should be set to a mask_port_omd.
C
D3DD          C     command proc
C
D3DD          C
C
D3DD BA 0322     C+   outport select_port,al ;select controller
D3E0 02 16 0077 R C+   mov     dx,select_port ;get the port number for the base controller
D3E4 EE          C+   add     dl,byte ptr ds:[port_off] ; add port_off for the correct bx
C
D3E5 BA 0323     C+   outport mask_port,al ;allow interrupts and maybe p_dma
D3E8 02 16 0077 R C+   mov     dx,mask_port ;get the port number for the base controller
D3EC EE          C+   add     dl,byte ptr ds:[port_off] ; add port_off for the correct bx
C
D3ED B4 0D        C     mov     ah,(hdu_bsy+hdu_cd+hdu_req) ;bsy+od+io+req
D3EF EB D418 R   C     call   wait_for_status ;wait for controller to setup for cmd
D3F2 72 23        C     je      o_finish ;leave if timed out
D3F4 FC 0042 R   C     old
D3F5 BE 0042 R   C     mov     si,ds:(offset cmd_block) ;clear direction: count up with [si]
;use si as index
C
D3F8 AC          C     send_odb_byte:
C     lodsb
D3F9 BA 0320     C+   outport write_port,al ;get a byte of odb
D3FC 02 16 0077 R C+   mov     dx,write_port ;get the port number for the base controller
D400 EE          C+   add     dl,byte ptr ds:[port_off] ; add port_off for the correct bx
D401 B9 0000     C     out     dx,al
C     mov     cx,0 ;prepare for loop
C
D404          C     c_wait:
C     inport  al,status_port ;check status
D404 BA 0321     C+   mov     dx,status_port ;get the port number for the base controller
D407 02 16 0077 R C+   add     dl,byte ptr ds:[port_off] ; add port_off for the correct bx
D40B EC          C+   inc     in
D40C A8 01        C     test    al,hdu_req ;is status valid?
D40E E1 F4        C     loopz  c_wait ;wait for valid or timeout

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D410 24 07      C      and    al,07h                ;mask low 3 bits
D412 3C 05      C      cmp     al,(hdu_0d+hdu_req)    ;is it still looking for 0d+0?
D414 74 E2      C      je      send_cdb_byte         ;yes - go send another byte
D416 F8         C      cld
D417 C3         C      q_finiah: ret                ;done sending all bytes, so return
D418            C      command endp
C
C      ; Wait for status from bx (specified in ah), or else time out.
C
D418            C      wait_for_status proc
C
D418 50         C      push  ax
D419 51         C      push  ox
D41A B9 0000    C      mov   ox,0
D41D            C      r_waiting:
C      inport  al,status_port        ;read bx status
C      mov     dx,status_port        ;get the port number for the base controller
C+      add     di,byte ptr ds:[port_off] ;add port_off for the correct bx
D424 EC         C+      in     al,dx
C      test   al,hdu_req            ;look for validity of status
D425 A8 01      C      and     al,0fh                ;loop if not valid yet
D427 E1 F4      C      loopz  r_waiting           ;get low 4 bits
D429 24 0F      C      cmp     al,ah                ;test for the specified status
D42B 34 C4      C      je      bx_ready            ;took too long to select
D42D 74 09      C      mov   byte ptr ds:[disk_status],time_out ;flag error
D42F C6 06 0074 R 80 C      stc
D434 F9         C      r_finish:
D435 59         C      pop   ox
D436 58         C      pop   ax
D437 C3         C      ret
C
C      bx_ready:
D438            C      cld                        ;got the req
D439 EB FA      C      jmp   r_finish
D43B            C      wait_for_status endp
C
C      ; Wait for a command to complete.
C
D43B            C      h_cmd_wait  proc
C
D43B FA         C      cli
D43C 84 21      C      in     al,pic_1            ; get interrupt mask
D43E 24 DF      C      and   al,0DFh            ; un-mask HDU interrupt IR5
D440 B6 21      C      out   pic_1,al           ; set the controller
D442 F8         C      sti
C
C      assume es:abs0
C
D443 33 C0      C      xor   ax,ax                ; es = ax = abs0_seg
D445 8E C0      C      mov   es,ax                ; es points to abs0_seg segment
D447 26: C4 36 0104 C      les   si,dword ptr es:[0*4h] ; es:si points to hdu_parm_tbl
C
C      assume es:nothing
C
C      ; Determine timeout count.
C
D44C B7 00      C      mov   bh,0                ;zero top byte of count
D44E 26: 8A 5C 09 C      mov   bl,es:byte ptr [si].p_timeout ;standard timeout
D452 80 3E 0042 R 04 C      cmp   byte ptr ds:[cmd_block*0],fmtdrv_bx ;but is it a format
C      ;drive command?
D457 75 07      C      jae   w1
D459 26: 8A 5C 0A C      mov   bl,es:byte ptr [si].p_fmt_timeout ;fmtdrv timeout
D45D EB 0C 90      C      jmp   w2
D460            C      w1:
D460 80 3E 0042 R E3 C      cmp   byte ptr ds:[cmd_block*0],drvdiag_bx ;but is it a drive
C      ;diagnostic?
D465 75 04      C      jne   w2
D467 26: 8A 5C 0B C      mov   bl,es:byte ptr [si].p_drvdiag_timeout ;drvdiag timeout
C
C      ; Now we can wait for the interrupt.
C
D46B            C      w2:
D46B D1 E3      C      shl   bx,1                ;double the timeout for the
C      ;8086.
D46D            C
D46D            C      wait_for_irq5:
C      inport  al,status_port        ;get the port number for the base controller
D46D BA 0321    C+      mov     dx,status_port        ;get the port number for the base controller
D470 02 16 0077 R C+      add     di,byte ptr ds:[port_off] ;add port_off for the correct bx
D474 EC         C+      in     al,dx
D475 A6 20      C      test   al,hdu_irq5          ;was there an interrupt yet?
D477 75 0D      C      jnz   wait_for_irq5
D479 E2 F2      C      loop  wait_for_irq5
C
D47B 4B         C      dec   bx                    ;outer timing loop
D47C 75 EF      C      jnz   wait_for_irq5
C
D47E C6 06 0074 R 80 C      mov   byte ptr ds:[disk_status],time_out ;we fell through
D483 EB 0F 90      C      jmp   w_finish
C
D486            C      w_ita_done:
C      inport  al,read_port          ;read status byte
D486 BA 0320    C+      mov     dx,read_port         ;get the port number for the base controller
D489 02 16 0077 R C+      add     di,byte ptr ds:[port_off] ;add port_off for the correct bx
D48D EC         C+      in     al,dx
D48E 24 02      C      and   al,h_err              ;get completion error bit
D490 08 06 0074 R C      or     byte ptr ds:[disk_status],al ;h_err_chk will look at it
C

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D494          C      W_finish:
D494          C      mov     al,0                ;turn off controller interrupts
D494          C      outport mask_port,al
D496          C+     mov     dx,mask_port    ;get the port number for the base controller
D499          C+     add     dl,byte ptr ds:[port_off] ;add port_off for the correct bx
D49D          C+     out     dx,al
D49E          C      ret
D49F          C      h_cmd_wait   endp
D49F          C      h_data1 proc
D49F          C      bx_error_table:
D49F          C      ; Type 0 errors
D49F          C      db     0, fdc_error, seek_error, fdc_error
D4A3          C      db     time_out, 0, fdc_error, 0
D4A7          C      db     seek_error, 0, 0, 0
D4AB          C      db     0, 0, 0, 0
D4AF          C      ;Type 1 errors
D4AF          C      db     crc_error, crc_error, addr_mark_error, 0
D4B3          C      db     sect_not_found, seek_error, 0, 0
D4B7          C      db     ecc_used_err, badtrack_err, 0, 0
D4BB          C      db     0, 0, 0, 0
D4BF          C      ;Type 2 errors
D4BF          C      db     cmd_error, addr_mark_error, 0, 0
D4C3          C      db     12 dup(0)
D4C3          C      ]
D4C3          C      ;Type 3 errors
D4CF          C      db     fdc_error, fdc_error, crc_error, 0
D4D3          C      db     12 dup(0)
D4D3          C      ]
D4DF          C      h_data1 endp
D4DF          C      ;===== hd5.asm =====
D4DF          C      read_param   proc
D4DF          C      push    es                ;save caller's es: register
D4E0          C      call   get_drivetype_vector ;loads es with pointer & bx with offset
D4E3          C      mov     cx,es:[bx].p_cyls  ;get number of cylinders
D4E6          C      sub     cx,2d                ;subtract 2: zero origin and diag track
D4E9          C      xchg   cx,cl                ;put low-order in ch
D4EB          C      ror     cl,1                ;put high-order 2 bits
D4ED          C      or     cl,1                ;in top of cl
D4EF          C      or     cl,sectors_per_track ;fixed, not variable
D4F2          C      mov     dh,es:[bx].p_heads ;number of heads
D4F6          C      dec     dh                ;zero origin
D4F8          C      mov     dl,byte ptr ds:[bf_num] ;count of hard disks
D4FC          C      pop     es
D4FD          C      pop     ax                ;save the return address
D4FE          C      pop     bx                ;trash the dx
D4FF          C      pop     bx                ;and cx from the caller
D500          C      push    cx                ;push new parameters
D501          C      push    dx                ;for caller to receive
D502          C      push    ax                ;replace return address
D503          C      read_param   ret
D504          C      read_param   endp
D504          C      ; Perform a reset and assign parameters for the drives.
D504          C      ; Note: parameters must be assigned for BOTH drives on the chosen controller.
D504          C      assign_param  proc
D504          C      call   reset_bx
D507          C      push    es
D508          C      mov     byte ptr ds:[cmd_block+0],assign_param_bx ;set odb
D50D          C      mov     byte ptr ds:[cmd_block+1],0 ;assume drive 0
D512          C      byte ptr ds:[control_byte],0feh
D517          C      call   assign_param_1 ;assign params
D51A          C      jc     ap_finish ;jump if OK
D51C          C      pop     es
D51D          C      push    es
D51E          C      mov     byte ptr ds:[cmd_block+0],assign_param_bx ;set odb
D523          C      mov     byte ptr ds:[cmd_block+1],(mask_drivenum) ;assume drive 1
D528          C      byte ptr ds:[control_byte],01h
D52D          C      call   assign_param_1 ;assign params
D530          C      ap_finish:
D530          C      pop     es
D531          C      ret
D532          C      assign_param  endp

```

ROM BIOS Listing

```

D532          C      assign_param_1  proc
D532  B0 00      C          mov     al,0           ;no interrupts desired
D534  E8 D3DD R  C          call    command        ;send the odb
D537  72 63      C          jc     a_finish
C
C      ; Send the 8 bytes of drive parameters as PIO.
D539  E8 D5C1 R  C          call    get_drivetype_vector ;anare pointer to the table
C
C      ; send asb before lab
D53C  26: 8A 47 01 C          mov     al,es:byte ptr [bx].p_cyls+1
D540  E8 D59D R  C          call    data_out
D543  72 57      C          jc     a_finish
C
D545  26: 8A 07   C          mov     al,es:byte ptr [bx].p_cyls
D548  E8 D59D R  C          call    data_out
D54B  72 4F      C          jc     a_finish
C
D54D  26: 8A 47 02 C          mov     al,es:[bx].p_heads
D551  E8 D59D R  C          call    data_out
D554  72 46      C          jc     a_finish
C
D556  26: 8A 47 04 C          mov     al,es:byte ptr [bx].p_write_cour+1
D55A  E8 D59D R  C          call    data_out
D55D  72 3D      C          jc     a_finish
C
D55F  26: 8A 47 03 C          mov     al,es:byte ptr [bx].p_write_cour
D563  E8 D59D R  C          call    data_out
D566  72 34      C          jc     a_finish
C
D568  26: 8A 47 06 C          mov     al,es:byte ptr [bx].p_precomp+1
D56C  E8 D59D R  C          call    data_out
D56F  72 2B      C          jc     a_finish
C
D571  26: 8A 47 05 C          mov     al,es:byte ptr [bx].p_precomp
D575  E8 D59D R  C          call    data_out
D578  72 22      C          jc     a_finish
C
D57A  26: 8A 47 07 C          mov     al,es:[bx].p_ecc_len
D57E  E8 D59D R  C          call    data_out
D581  72 19      C          jc     a_finish
C
C      ; Note that control byte is handled differently... See near h_make_odb.
D583  B4 0F      C          mov     ah,(hdu_bsy+hdu_od+hdu_io+hdu_req) ;bsy+od+io+req
D585  E8 D418 R  C          call    wait_for_status
D588  72 12      C          jc     a_finish
C
C          inport  al,read_port      ;read the status byte
D58A  BA 0320    C+         mov     dx,read_port ;get the port number for the base controller
D58D  02 16 0077 R C+         add     di,byte ptr ds:[port_off] ;add port_off for the correct bx
D591  EC         C+         in     ax,dx
D592  A8 02     C+         test  al,h_0_err ;did we do ok?
D594  74 06     C+         jz     a_finish
D596  C6 06 0074 R 07 C          mov     byte ptr ds:[disk_status],init_err ;no
D59B  F9         C          stc
C
C      a_finish:
D59C          C          ret
D59C  C3         C
D59D          C      assign_param_1  endp
C
C      ; Send a byte of data out the write_port.
D59D          C      data_out      proc
C
C          push  ax
D59D  50         C          mov     ah,(hdu_bsy+hdu_req) ;bsy+od+io+req
D59E  B4 09     C          mov     ah,(hdu_bsy+hdu_req) ;bsy+od+io+req
D5A0  E8 D418 R  C          call    wait_for_status
D5A3  58         C          pop     ax
D5A4  73 01     C          jnc    do_ready ;if it didn't time out, output the data
D5A6  C3         C          ret
C
C      do_ready:
D5A7          C          outputport write_port,al ;write it out
D5A7  50         C+         mov     dx,write_port ;get the port number for the base controller
D5AA  02 16 0077 R C+         add     di,byte ptr ds:[port_off] ;add port_off for the correct bx
D5AE  EE         C+         out    dx,al
D5AF  F8         C          cld
D5B0  C3         C          ret ;no problem
C
C      data_out      endp
D5B1          C
D5B1          C      reset_bx      proc
C
C          outputport reset_port,al ;reset controller
D5B1  50         C+         mov     dx,reset_port ;get the port number for the base controller
D5B4  02 16 0077 R C+         add     di,byte ptr ds:[port_off] ;add port_off for the correct bx
D5B8  EE         C+         out    dx,al
D5B9  51         C          push  cx
D5BA  B9 0100    C          mov     cx,100h ;wait in a loop
D5BD  E2 FE     C          loop  $
D5BF  59         C          pop     cx
D5C0  C3         C          ret
C      reset_bx      endp
D5C1          C
C      ; Returns with es:[bx] pointing to the drivetype vector for the selected drive.
C      ;

```

ROM BIOS Listing

```

C ;           The bits are selected from the switch as follows:
C ;
C ;           switch      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
C ;           bit        | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
C ;           drive 0    | 0 | 1 |   |   | 2 | 3 |   |   |
C ;           drive 1    |   |   | 0 | 1 |   |   | 2 | 3 |
C ;
D5C1          get_drivetype_vector   proc
D5C1 50          push    ax
C              assume es:abs0
C              xor     ax,ax          ; es = ax = abs0_seg
D5C2 33 C0      mov     es,ax          ; es points to abs0_seg segment
D5C4 8E C0      les     bx,dword ptr es:[4*41h] ; es:bx points to hdu_parm_tbl
D5C6 26 C4 1E 0104
C              assume es:nothing
C
D5CB 52          push    dx
C              inport  al,switch_port ;read switches on controller board
D5CC BA 0322     mov     dx,switch_port ;get the port number for the base controller
D5CP 02 16 0077 R add     di,byte ptr ds:[port_off] ;add port_off for the correct bx
D5D3 EC          in     al,dx
D5D4 5A          pop     dx
D5D5 24 7F      and     al,07fh ;ignore top switch!
C
D5D7 P6 06 0076 R 01 test   byte ptr ds:[control_byte],01h ;was this controller drive one?
D5DC 75 04      jnz    g_mask
D5DE D0 B8      shr    al,1 ;to get drive zero,
D5E0 D0 B8      shr    al,1 ;shift twice right
C
C g_mask:
D5E2          and     al,00110011b ;get switch_mask bits for this drivetype
D5E4 8A E0      mov     ah,al ;get top two bits from bits #45
D5E6 D0 EC      shr    ah,1 ;..into bits 2&3
D5E8 D0 EC      shr    ah,1
D5EA 0A C4     or     al,ah ;combine with low 2 bits
C
D5EC D0 E0      shl    al,1 ;multiply by 16 for offset in table
D5EE D0 E0      shl    al,1
D5F0 D0 E0      shl    al,1
D5F2 D0 E0      shl    al,1
D5F4 B4 00      mov     ah,0
D5F6 03 D8     add     bx,ax ;add offset to base of param_table
C
D5F8 58          pop     ax
D5F9 C3          ret
D5FA          get_drivetype_vector   endp
C
D5FA          disable_disk_interrupts proc
C ; Disables interrupts from all bx controllers on the system.
C
D5FA 52          push    dx
D5FB 51          push    cx
D5FC 50          push    ax
D5FD 1E          push    ds
C ; Set up ds: segment.
C
C          assume ds:data
C
D5FE B8 0080     mov     ax,data_seg ; satisfy assumptions.
D601 8E D8      mov     ds,ax
C
D603 FA          cli
D604 E4 21     in     al,pio_1 ; get interrupt mask
D606 0C 20     or     al,020h ; turn off IR5
D608 E5 21     out    pio_1,al ; and set the new mask
D60A FB          sti
C
D60B B5 00      mov     ch,0
D60D 9A 0E 0075 R mov     ci,byte ptr ds:[hf_num] ;number of drives
D611 41          inc     cx ;make it into
D612 D1 E9      shr    cx,1 ;...number of controllers
D614 74 10      jz     v_disallow ;if zero, disallow
C
D616          v_reset_bx:
C ; Reset controller cx by sending mask byte.
C
D616 B0 00      mov     al,0
D618 8B D1      mov     dx,cx ;mask to impose on bx
D61A 4A          dec     dx ;get controller number
D61B D1 E2      shl    dx,1 ;we go from 0-3, not 1-4
D61D D1 E2      shl    dx,1 ;make it an offset (4 ports/bx)
D61F 81 C2 0323 add     dx,mask_port ;now bx-> controller
D623 EE          out    dx,al
C
D624 E2 F0      loop   v_reset_bx
C
D626          v_disallow:
D626 B0 07      mov     al,disallow_dma3 ;command to turn off dma3 interrupts
D628 E6 0A      mov     dma_mask_bit,al ;send it
C
C          assume ds:nothing
D62A 1F          pop     ds

```

ROM BIOS Listing

```

D62B 58          C          pop     ax
D62C 59          C          pop     cx
D62D 5A          C          pop     dx
D62E C3          C          ret
D62F             C          disable_disk_interrupts endp
C
C          ;=====
C          ; Interrupt 00h - handle interrupt from controller
C          ;=====
C          ; This is run when the hard disk causes an interrupt due to command completion.
C
D62F             C          h_int  proc
C
D62F 50          C          push    ax
C
D630 B0 20       C          mov     al,pic_neoi          ;command for 8259
D632 B6 20       C          out    pic_0,al
C
D634 B0 07       C          mov     al,dissalow_dma3    ;command for 8237
D636 B6 0A       C          out    dma_mask_bit,al
C
D638 B4 21       C          in     al,pic_1          ; get interrupt mask
D63A 0C 20       C          or     al,020h          ; turn off IR5
D63C B6 21       C          out    pic_1,al          ; and set the new mask
C
D63E 58          C          pop     ax
D63F CF          C          iret
C
D640             C          h_int  endp
C
C          ;===== dtofmt.asm =====
C          ; HDU Physical Formatting Utility
C          ;
C          ; Formatting utility to perform physical format of hard disk drive
C          ; using DTC-5150BI controller. Calls int 13h to provide disk services.
C          ;
C          ; Use this program when you first use a new disk. Then use FDISK and
C          ; FORMAT programs to finish the job.
C          ;
C          ; The user can supply an argument number for any hard disk on the system.
C          ; ex: 1=drive 0, 2=drive d.
C          ;=====
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
C
D640             C          h_fmt  proc  near
C
C          ; Write greeting and prompt for drive number.
C          ; Drives are numbered the same way as in the industry standard "FDISK" utility.
C
D640 BE D6AC R   C          mov     si,cs:(offset h_intro_m) ;greeting string
D643 B8 B5FA R   C          call   DRomString
C
D646 32 B4       C          xor     ah,ah              ; ah = 0.
D648 CD 16       C          INT    16h              ; get a keystroke.
C
D64A 3C 71       C          cmp     al,'q'            ;check for quit code
D64C 74 45       C          je     finished          ;eject if user typed a q
D64E 3C 51       C          cmp     al,'Q'
D650 74 41       C          je     finished
C
D652 B8 B619 R   C          call   DCrlf
C
D655 2C 31       C          sub     al,'1'            ; range should be '1' to '8'
D657 72 3E       C          je     no_hard_disk      ; if negative, incorrect number
D659 0C 80       C          or     al,080h          ; set HDU flag bit #7.
D65B 8A D0       C          mov     di,al            ; prepare drive code for int13
C
C          ; Create a 512 byte sector buffer of 6Ch (on the stack!).
C
D65D FC          C          cld                      ; clear direction flag.
D65E 06          C          push   es                ; save registers.
D65F 16          C          push   ss
D660 07          C          pop    es                ; es gets ss.
D661 81 EC 0200 C          sub    sp,512            ; make room on stack!
C
D665 8B FC       C          mov    di,sp             ; es:di points to stack buffer.
D667 B8 6C6C     C          mov    ax,06C6Ch        ; word fill pattern.
D66A B9 0100     C          mov    cx,(512/2)       ; number of words to fill.
D66D F3 AB       C          rep   stosw             ; fill stack buffer.
C          ; di saves original stack pointer
C
C          ; Write the stack sector buffer with the 06Ch code to fill data fields on drive.
C
D66F B8 0F01     C          mov    ax,(wbuff_int*100h)+1 ; prepare for write sector of 1 buffer.
D672 B8 DC       C          mov    bx,sp            ; es:bx points to stack buffer (of 06Ch)
C
D674 B6 00       C          mov    dh,0             ; clear head number.
C
D676 CD 13       C          INT    13h            ; call for write sector buffer
C
D678 B8 E7       C          mov    sp,di            ; restore original stack pointer.
D67A 07          C          pop    es                ; restore registers.
C
D67B 72 1A       C          je     no_hard_disk      ; error writing sector buffer
C
C          ; Print message that we are formatting the drive.
C

```

ROM BIOS Listing

```

D67D BE D733 R      C      mov     si,os:(offset h_fmt_m) ;text for informational message
D680 E8 E5FA R      C      call    DRomString
C
C      ; Format the drive.
C
D683 B8 0706        C      mov     ax,(fmtdrv_int*100h)+6 ; format drive with interleave of 6
D686 B9 0001        C      mov     cx,01h ; start with sector zero
C
C      ; Note that dx is retained from above.
C
D689 CD 13          C      INT     13h ; format the drive
D68B 72 12          C      jc     format_error ; problem during format
C
D68D BE D750 R      C      mov     si,os:(offset h_pass_m)
D690 E8 E5FA R      C      call    DRomString
C
C      finished:
D693 E8 E619 R      C      call    DCrLf
D695 C3              C      ret     ; return to caller
C
C      no_hard_disk:
D697 BE D78A R      C      mov     si,os:(offset h_none_m) ;give error message
D69A E8 E5FA R      C      call    DRomString
D69D EB F4          C      jmp     short finished ;exit
C
C      format_error:
D69F BE D7B7 R      C      mov     si,os:(offset h_err_m) ;give error message
D6A2 E8 E5FA R      C      call    DRomString
C
D6A5 8A C9          C      mov     al,ah ; print error code in ah
D6A7 EB E843 R      C      call    DHexByte
C
D6AA EB E7          C      jmp     short finished
C
D6AC              C      h_fmt  endp
C
D6AC              C      h_data2 proc
C
D6AC 46 69 78 65 6A 20 C      h_intro_m db 'Fixed Disk Formatting Utility',CR,LF
      4A 69 73 69 20 36
      6F 72 6D 61 74 74
      69 6E 67 20 55 74
      69 6C 69 74 79 0D
      0A
C
D6CB 81 6C 6C 20 6A 61 C      db 'All data on the specified fixed disk will be erased.'
      74 61 20 6F 6E 20
      74 68 65 20 73 70
      65 63 69 6E 69 65
      64 20 66 69 78 65
      64 20 64 69 73 6B
      20 77 69 6C 6C 20
      62 65 20 65 72 61
      73 65 64 2E
C
D6FF 0D 0A          C      db CR,LF
D701 35 E6 74 65 72 20 C      db 'Enter fixed disk number (1 to 8) or "Q" to quit: ',NUL
      66 69 78 65 64 20
      64 69 73 6B 20 6E
      75 6D 62 65 72 20
      28 31 20 74 6F 20
      38 29 20 6F 72 20
      22 51 22 20 74 6F
      20 71 75 69 74 3A
      20 00
C
D733 0D 0A 46 6F 72 6D C      h_fmt_m db CR,LF,'Formatting Fixed Disk...',CR,LF,NUL
      61 74 74 69 67
      20 46 69 78 65 64
      20 4A 69 73 6B 2E
      2E 2E 0D 0A 00
C
D750 46 6F 72 6D 61 74 C      h_pass_m db 'Format is complete.',CR,LF
      20 69 73 20 63 6F
      6D 70 6C 65 74 65
      2E 0D 0A
C
D765 50 72 6F 63 65 65 C      db 'Proceed with FDISK and FORMAT.',NUL
      64 20 77 69 74 68
      20 46 4A 89 53 4B
      20 61 6E 64 20 46
      4F 52 4D 41 54 2E
      00
C
D784 45 72 72 6F 72 3A C      h_none_m db 'Error: No fixed disk drive exists for this number.',NUL
      20 4E 6F 20 66 69
      78 65 64 20 64 69
      73 6B 20 64 72 69
      76 65 20 65 78 69
      73 74 73 20 66 6F
      72 20 74 68 69 73
      20 6E 75 6D 62 65
      72 2E 00
C
D787 46 6F 72 6D 61 74 C      h_err_m db 'Format Error. Code: ',NUL
      20 45 72 72 6F 72
      2E 20 24 6F 64
      65 3A 20 00
C
D7CD              C      h_data2 endp
C

```

ROM BIOS Listing

```

D7CD          C   oode   ends
              C   include graph.asm
              C   ;=====
              C   ;      Filename:      graph.src
              C   ;
              C   ;      This module includes the four graphics functions for INT 10h.
              C   ;
              C   ;=====
              C   page
              C   ;-----
              C   ;      INT 10h Graphics Support
              C   ;
              C   ;      Must preserve bx, cx, dx and return values in ax
              C   ;
              C   ;      All other registers are saved and restored by video dispatcher.
              C   ;
              C   ;      Entered with the following in registers:
              C   ;      al, bx, cx, dx intact (set by INT 10 invoker)
              C   ;      ah = v_mode
              C   ;-----

D7CD          C   oode   segment public 'ROM'
              C   assume  es:ocode, ds:data, es:v_ram, es:nothing
              C   ;=====
              C   ;      Read Light Pen          function code = 0Ah
              C   ;
              C   ;      Input:  None.
              C   ;      Output: ah      = 0 light pen switch not down/not triggered
              C   ;           ah      = 1 implies:
              C   ;           (dh,dl) = (row,col) of character light pen
              C   ;           position from (0,0)
              C   ;           ch      = raster line (0-199)
              C   ;           bx      = pixel column (0-319,0-639)
              C   ;
              C   ;      Trash:  None.  ???
              C   ;-----

D7CD          C   grf_light_pen  proc  near
D7CD 32 B4      C   xor      ah,ah          ; return ah = 0 for now (al intact)...
D7CF C3        C   ret
D7D0          C   grf_light_pen  endp
              C   ;=====
              C   page
              C   ;-----
              C   ;      Read Dot          function code = 0Dh
              C   ;
              C   ;      reads a pixel from the indicated location returning its value.
              C   ;      valid in graphics modes only.
              C   ;
              C   ;      Input:
              C   ;      AH = CRT Mode
              C   ;      DX = row (0..199 in Med. & Hi-Res., 0..399 in Ultra Res Mode)
              C   ;      CX = column (0..319 in Med, 0..639 in Hi & Ultra Res. Modes)
              C   ;
              C   ;      Output:
              C   ;      AL = dot value read
              C   ;      AH = mask of pixel in byte (from g_addr)
              C   ;
              C   ;      Saved:  BX, CX, DX (Video dispatcher saves the rest)
              C   ;-----

D7D0          C   grf_read_dot  proc  near
D7D0 52        C   push   dx          ; save registers
D7D1 51        C   push   cx
D7D2 50        C   push   ax          ; save crt mode (high byte)
D7D3 88 DB15 R C   call  g_addr      ; compute address & mask
D7D6 8A C9     C   mov    al,ah      ; copy mask
D7D8 26: 22 05 C   and  al,byte ptr es:[di] ; AND with byte containing pixel
D7DB 5A       C   pop    dx          ; dh = crt mode
D7DC FE C1    C   inc  cl          ; prep for wraparound left (B & W)
D7DE 80 FE 05 C   cmp  dh,5        ; color?
D7E1 7F 02    C   jg   &_jsfy_dot ; jump if not
D7E3 FE C1    C   inc  cl          ; prep for wraparound left (color)
D7E5         C   &_jsfy_dot:
D7E5 D2 C0    C   rcl  al,cl      ; right justify pixel
D7E7 59       C   pop    cx          ; restore registers
D7E8 5A       C   pop    dx
D7E9 63       C   ret
D7EA          C   grf_read_dot  endp
              C   ;=====
              C   page
              C   ;-----
              C   ;      Write Dot          function code = 0Ch
              C   ;
              C   ;      writes a pixel, with the indicated value, at the indicated location.

```

```

C ; valid in graphics modes only.
C ;
C ;
C ; Input:
C ; AL = dot value to write (1 or 2 bits depending on mode,
C ; right justified). Bit 7 = 1 specifies XOR the value
C ; with the pixel at DX, CX
C ; AH = CRT Mode
C ; DX = row (0-399) (the actual value depends on the mode)
C ; CX = column (0-639) (the values are not range checked)
C ;
C ; Saved: AX, BX, CX, DX (Video dispatcher saves the rest)
C ;
C ;-----
D7EA grf_write_dot proc near
C ;
C ; push dx ; preserve working registers
D7EB push cx
C ;
D7EC push ax
C ;
C ; call g_addr ; compute address & mask
D7ED mov al,byte ptr es:[di] ; fetch byte from video memory
D7EE pop dx ; get v_mode & dot value to write
D7EF push dx ; resave
D7F0 or di,di ; is the XOR bit set?
D7F1 js g_xorbit ; jump if yes
D7F2 not ah ; invert mask
D7F3 and al,ah ; clear bits for new pixel
D7F4 not ah ; restore mask for later
C ;
D7F5 g_xorbit:
C ; inc ol ; prep for wraparound right (b&w)
D7F6 cnp dh,5 ; color ?
D7F7 jg g_align_dot ; jump if no
D7F8 inc ol ; prep for wraparound right (color)
C ;
D7F9 g_align_dot:
C ; ror dl,ol ; align new pixel
D7FA and dl,ah ; strip off non-pixel bits (xor bit, etc)
D7FB xor al,dl ; OR or XOR in new pixel depending on xor bit
D7FC mov byte ptr es:[di],al ; update video memory
C ;
C ; pop ax ; restore registers
D811 pop cx
D812 pop dx
D813 ret
C ;
D815 grf_write_dot endp
C ;
C ; page
C ;=====
C ; This subroutine determines the video RAM byte location
C ; of the indicated row column value. The current graphics mode
C ; is taken into account.
C ;
C ; INPUT:
C ; AH = current graphics mode
C ; DX = row value (0-399)
C ; CX = column value (0-639)
C ;
C ; OUTPUT:
C ; DI = byte address of pixel location in video ram
C ; AH = mask of pixel in byte
C ; CL = # of bits from left end of byte to leftmost bit in mask
C ;
C ; DESTROYED:
C ; AL, CX, DX, BP
C ;-----
D815 g_addr proc near
C ; convert row-count to a "Mod #" value;
C ; multiply it by 2000H for offset to start of v_ram subarea
C ;
D816 push cx ; save column count
D817 mov bp,1 ; shift count; assume not 640x400
D818 mov cx,bp ; multiplier; assume not 640x400
D819 cmp ah,64 ; video mode 64 or 72?
D81A jb g_skp_1 ; -no: jmp
D81B mov bp,2 ; -yes; change shift count
D81C mov cx,3 ; -yes: change multiplier
C ;
D81D g_skp_1:
C ; xor di,di ; init offset amount
D81E and dx,dx ; get least sig. bit(s) from row count
D81F jz g_skp_3 ; jmp if nothing to add
C ;
D820 g_skp_2:
C ; add di,2000H ; add v_ram sub-area size
D821 loop g_skp_2 ; do it again (maybe)
C ;
C ; add bytes for the row coordinate to the offset into the v_ram subarea
C ;
D822 g_skp_3:
C ; push di ; temp. store offset
D823 mov di,dx ; DX--row count
D824 mov cx,bp ; CX--mode-related shift val
D825 shr di,cl ; get #rows into a v_ram subarea
C ;
D826 mov dx,di ; save a copy for a moment
D827 mov dx,0406H ; mult. di by 80 [rows-->byte offset]

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ROM BIOS Listing

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D83E D3 E7      C      sal    di,cl      ; [fast multiply-
D840 8A CD      C      mov    cl,oh        ; by-80]
D842 D3 E2      C      sal    dx,cl
D844 03 FA      C      add    di,dx        ; #subarea byte offset for this row
C
D846 59          C      pop    cx           ; retrieve subarea beginning's offset
D847 03 F9      C      add    di,cx       ; offset from start of v_ram
D849 5A          C      pop    dx           ; restore column count
C
C ; find column offset
C
D84A B9 0703     C      mov    cx,703H     ; initialize for black & white
D84D 80 FC 05     C      cmp    ah,5        ; color ?
D850 7F 03       C      jg    g_skip_4     ; CX = 703H (black & white)
D852 B9 0302     C      mov    cx,302H     ; CX = 302H (color)
D855             C      g_skip_4:
C
C ; CL = shift count to divide column by pixels per byte ...
C ; 3 for b&w (divide by 8), 2 for color (divide by 4)
C ; CH = remainder's mask during division (7 for b&w , 3 for color)
C ; DX = column
C ; DI = address to column 0 of requested row
C
D855 22 EA       C      and    oh,di       ; get division's remainder in CH
D857 D3 EA       C      shr    dx,cl       ; perform division
C
C ; DI = quotient = column's byte offset from start of row
C ; CH = remainder (= pixel's offset into byte)
C
D859 03 FA      C      add    di,dx        ; DI = pixel's byte address
C
C ; NOW:
C ; DI = address of byte containing the pixel
C ; CH = pixel offset into byte (remainder)
C ; CL = 3 (black & white) or 2 (color)
C
D85B 80 F9 03    C      cmp    cl,3        ; black & white?
D85E 74 02       C      je    g_bitmask   ; jump if yes
D860 D0 E5       C      shl    ch,1        ; color: convert to bit offset
C
C g_bitmask:
D862             C      xorb   cl,oh       ; load CL, preserve "mode"
D864 B4 80       C      mov    ah,80H     ; set high bit in byte
D866 D2 EC       C      shr    ah,cl       ; mask pixel's leftmost bit
D868 80 FD 03    C      cmp    oh,3        ; black & white?
D86B 74 06       C      je    g_skip_5     ; jump if yes
D86D 8A C4      C      mov    al,ah       ; color: create 2-bit mask
D86F D0 E8       C      shr    al,1
D871 0A E0       C      or     ah,al
C
C g_skip_5:
D873 C3           C      ret              ; DI = byte address, AH = pixel mask,
C ; CL = bit offset: pixel's leftmost bit
C
D874             C      g_addr  endp
C
C page
C ;-----
C ;
C ; Scroll Up In Graphics Mode
C ;
C ; Scroll up the number of lines specified within the specified screen
C ; area (window).
C ;
C ; Input:
C ; AL = number of lines to be scrolled up ( zero
C ; means clear the window)
C ; BH = fill pattern to be used
C ; CH,CL = upper left corner of window in which to scroll
C ; DH,DL = lower right corner of window in which to scroll
C ; DS = data segment
C ; ES = graphics refresh ram segment
C ;
C ; Saved: BX, CX, DX (Video dispatcher saves the rest)
C ;
C ;-----
C
D874             C      grf_graphics_up proc near
C
D874 53          C      push   bx          ; save
D875 51          C      push   cx          ; the
D876 52          C      push   dx          ; registers
C
C ;
C ; old
C ; mov    bp,80        ;dir. flag = increment (from v_scroll_up)
C ; ;offset to next scanline (CLD => +80)
C
D87A 50          C      push   ax          ;save mode, # rows to scroll
D87B 8B C1      C      mov    ax,cx       ;compute address of window's
D87D E8 DB5F H  C      call   g_sura_off   ; upper left corner
D880 8B F8       C      mov    di,ax       ;save in DI for string instructions
C
D882 06          C      push   es          ;set DS to video ram for string inst.
D883 1F          C      pop    ds
C
D884 2B D1       C      sub    dx,cx       ;compute window's dimensions
D886 81 C2 0101 C      add    dx,101H     ; DH = height, DL = width
C
D88A 58          C      pop    ax          ;AH = mode, AL = # rows to scroll
C
D88B B3 02       C      mov    bl,2        ;# interlace areas = 2 for modes 4,5,6
D88D 8A CB       C      mov    cl,bl       ;# scanlines per i.a. = 4 for modes 7,2

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ROM BIOS Listing

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D88F 80 FC 40      C      cmp     ah,64
D892 72 06        C      jb      g_tst_mod      ;jump if mode = 4,5,6
D894 E3 04        C      mov     bl,4          ;# interlace areas = 4 for modes 64 & 72
D896 74 02        C      jbe    g_tst_mod      ;jump if mode = 64
D898 D0 F9        C      sar     cl,1          ;# scanlines per i.a. = 2 for mode 72
D89A              C
D89A D2 E0        C      sal     al,cl        ;convert number of rows to number of
D89C D2 E6        C      sal     dh,cl        ; scanlines per interlace area
D89E 8B C8        C      mov     cx,ax        ;CH = mode, CL = # scanlines to scroll
D8A0 80 FD 06     C      cmp     ch,6          ;are we in a medium resolution mode?
D8A3 7D 04        C      jge    g_set_up      ;jump if no
D8A5 D1 E7        C      sal     di,1         ;double number of bytes per character
D8A7 D0 E2        C      sal     di,1
D8A9              C
D8A9 81 E1 00FF    C      &set_up:  ;get address of lines to scroll in refresh ram memory
D8AD 74 3C        C      and     cx,00FFH     ;CH = # of scanlines to scroll per i.a.
D8AF              C      jz      g_filler     ;if zero, go fill all of window
D8B1 8B C1        C      mov     bx,cx        ;make BH = # scanlines to fill per i.a.
D8B3 86 F5        C      rcbg   dh,ch        ; CH = # scanlines in window = *
D8B5 8B F7        C
D8B7 31 04        C      mov     si,di        ;compute address of scanline to be
D8B9 D3 E0        C      sal     ax,cl        ; scrolled to top of window:
D8BB 03 F0        C      add     si,ax        ; <window's address> *
D8BD D1 E0        C      sal     ax,1         ; (<# scanlines to scroll per i.a.> *
D8BF D1 E0        C      sal     ax,1         ; <# bytes per scanline = 80>)
D8C1 03 F0        C      add     si,ax
D8C3 8A E5        C      mov     ah,ch        ;compute # of scanlines per i.a.
D8C5 2A E6        C      sub     ah,dh        ; to be moved
D8C7 33 C9        C      xor     cx,cx        ;CH = 0 for REP counter
D8C9              C      ; jmp short g_scroller ;go scroll up and fill
D8C9              C      grf_graphics_up endp
D8C9              C
D8C9              C      page
D8C9              C      ;=====
D8C9              C      ; Scroll rows in graphics refresh memory
D8C9              C      ;
D8C9              C      ; Input:
D8C9              C      ; AH = Number of scanlines per interlace area to be moved
D8C9              C      ; BL = Number of interlace areas
D8C9              C      ; CH = 0
D8C9              C      ; DI = Destination scanline address of first byte to fill
D8C9              C      ; SI = Source scanline address of first byte to fill
D8C9              C      ; DL = Number of bytes to fill in each scanline
D8C9              C      ; BP = offset to next scanline (+/- 80)
D8C9              C      ;
D8C9              C      ; Output:
D8C9              C      ; DI = address of first byte to be filled
D8C9              C      ; AH = 0
D8C9              C      ;
D8C9              C      ; BL,BH,CH,DL,DH,SP preserved
D8C9              C      ;-----
D8C9              C
D8C9              C      g_scroller proc near
D8C9 56          C      push  si             ;save original source
D8CA 57          C      push  di             ; and destination addresses
D8CB 53          C      push  bx             ;save interlace areas count (BL)
D8CC              C      g_areas: ;Move Interlace Areas Loop
D8CC 57          C      push  di             ;save interlace area
D8CD 56          C      push  si             ; addresses
D8CE 8A CA      C      mov     cl,di         ;count of bytes to be moved
D8D0 F3 A4      C      rep   movsb         ;move the scanline
D8D2 5E          C      pop   si             ;restore interlace area
D8D3 5F          C      pop   di             ; addresses
D8D4 81 C7 2000 C      add     di,2000H     ;next interlace area
D8D6 81 C6 2000 C      add     si,2000H     ; addresses
D8DC FE CB      C      dec    bl             ;loop to move one scanline in
D8DE 75 EC      C      jnz   g_a_area      ; each interlace area
D8E0 5B          C      pop   bx             ;restore interlace areas count (BL)
D8E1 5F          C      pop   di             ;restore original source
D8E2 5E          C      pop   si             ; and destination addresses
D8E3 03 FD      C      add     di,bp         ;address next scanline in
D8E5 03 F5      C      add     si,bp         ; each interlace area
D8E7 FE CC      C      dec    ah             ;loop to move "all" scanlines in
D8E9 75 DE      C      jnz   g_scroller    ; each interlace area
D8E9              C      ; jmp short g_filler ;now fill in the gap
D8EB              C      g_scroller endp
D8EB              C
D8EB              C      page
D8EB              C      ;=====
D8EB              C      ; Fill rows in graphics refresh memory with the fill pattern
D8EB              C      ;
D8EB              C      ;
D8EB              C      ; Input:
D8EB              C      ; BL = Number of interlace areas

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ROM BIOS Listing

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C ;           BH =   Fill pattern to be used
C ;           CH =   0
C ;           DL =   Number of bytes to fill in each scanline
C ;           DH =   Number of scanlines to fill in each interlace area
C ;           DI =   Destination scanline address of first byte to fill
C ;           BP =   offset to next scanline (+/- 80)
C ;
C ;           Output: AL =   fill pattern
C ;                   AH =   0
C ;
C ;-----
D8EB          C      g_filler      proc near
D8EB 8A C7    C      mov     al,bh          ;AL = fill pattern for STOSB instruction
D8ED          C      g_f_1_lp:    ;Fill Interlace Areas Loop
D8ED 57      C      push    di          ;save interlace area address
D8EE 52      C      push    dx          ;save scanlines count (DH)
D8EF          C      g_f_a_lp:    ;Fill Scanlines Loop
D8EF 57      C      push    di          ;save scanline address
D8F0 8A CA    C      mov     cl,di         ;count of bytes to fill in scanline
D8F2 F3 AA    C      rep     scsb        ;fill scanline
D8F4 5F      C      pop     di          ;restore scanline address
D8F5 03 FD    C      add     di,bp         ;next scanline in interlace area
D8F7 FE CE    C      dec     dh          ;fill an interlace area
D8F9 75 F4    C      jnz     g_f_a_lp
D8FB 5A      C      pop     dx          ;restore scanlines count (DH)
D8FC 5F      C      pop     di          ;restore interlace area address
D8FD 81 C7 2000 C      add     di,2000H     ;next interlace area address
D901 FE CB    C      dec     bl          ;fill next interlace area
D903 75 B8    C      jnz     g_f_1_lp
D905 5A      C      pop     dx          ;restore
D906 59      C      pop     cx          ;       the
D907 5B      C      pop     bx          ;       registers
D908 C3      C      ret                ;exit scroll routine
D909          C      g_filler      endp
C ;
C ; page
C ;-----
C ; Scroll Down In Graphics Mode
C ;
C ;       Scroll down the number of lines specified within the specified screen
C ;       area (window).
C ;
C ;       Input:
C ;       AL = number of lines to be scrolled up ( zero
C ;           means clear the window)
C ;       BH = fill pattern to be used
C ;       CH,CL = upper left corner of window in which to scroll
C ;       DH,DL = lower right corner of window in which to scroll
C ;       DS = data segment
C ;       ES = graphics refresh ram segment
C ;
C ;       Saved: BX, CX, DX (Video dispatcher saves the rest)
C ;
C ;-----
D909          C      grf_graphics_down  proc near
D909 53      C      push    bx          ; save
D90A 51      C      push    ox          ;       the
D90B 52      C      push    dx          ;       registers
D90C BD FFBD  C      std     bp,-80       ;dir. flag = decrement (from v_scroll_dn)
D90F 50      C      push    ax          ;save mode, # rows to scroll
D910 8B C2    C      mov     ax,dx         ;compute address of window's
D912 EB D8F5 F R C      call    g_cursor_off ; lower right corner
D915 8B F8    C      mov     di,ax         ;save in DI for string instructions
D917 06      C      push    es          ;set DS to video ram for string inst.
D918 1F      C      pop     ds
D919 2B D1    C      sub     dx,cx         ;compute window's dimensions
D91B 81 C2 0101 C      add     dx,1C1H      ; DH = height, DL = width
D91F 58      C      pop     ax          ;AH = mode, AL = # rows to scroll
D920 B3 02    C      mov     bl,2         ; # interlace areas = 2 for modes 4,5,6
D922 8A CB    C      mov     cl,bl         ; # scanlines per i.a. = 4 for modes 72
D924 80 FC 40 C      cmp     ah,64
D927 72 06    C      jb     g_cmp_mod     ;jump if mode = 4,5,6
D929 B3 04    C      mov     bl,4         ; # interlace areas = 4 for modes 64 & 72
D92B 74 02    C      je     g_cmp_mod     ;jump if mode = 64
D92D D0 F9    C      sar     cl,1         ; # scanlines per i.a. = 2 for mode 72
D92F          C      g_cmp_mod:
D92F D2 E0    C      sal     al,cl        ;convert number of rows to number of
D931 D2 E6    C      sal     dh,cl        ; scanlines per interlace area
D933 80 FC 06 C      cmp     ah,6         ;are we in a medium resolution mode ?
D936 7D 05    C      jge    g_setdown    ;jump if no
D938 D1 E7    C      sal     di,1         ;double number of bytes per character

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ROM BIOS Listing

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D93A D0 E2      C      sal    dl,1
D93C 47         C      inc    di                ;address last byte in bottom row
C
D93D          C      g_setdown: ;get address of lines to scroll in refresh RAM memory
D93D BE 0050    C      mov    si,80          ;address bottom scanline in i.a.
D940 D3 E6    C      sal    si,01
D942 03 E2 50  C      sub    si,80
D945 03 FE    C      add    di,si
D947 8B C8    C      mov    cx,ax
D949 81 E1 00FF C      and    cx,00FFH        ;CH = mode, CL = # scanlines to scroll
D94B 74 9C    C      jz     g_filler        ;CL = # of scanlines to scroll per i.a.
C                                     ;if zero, go fill all of window
C
D94F 8B C1    C      mov    ax,cx
D951 8A E9    C      mov    oh,01          ;make DH = # scanlines to fill per i.a.
D953 86 F5    C      xchg  dh,oh          ; AX = # scanlines to scroll " "
C                                     ; CH = # scanlines in window " "
C
D955 8B F7    C      mov    si,di
D957 B1 04    C      mov    ol,4           ;compute address of scanline to be
D959 D3 80    C      sal    ax,01          ; scrolled to top of window:
D95B 2B F0    C      sub    si,ax          ; <window's address> -
D95D D1 E0    C      sal    ax,1           ; (<# scanlines to scroll per i.a.> *
D95F D1 80    C      sal    ax,1           ; <# bytes per scanline = 80>)
D961 2B F0    C      sub    si,ax
C
D963 8A E5    C      mov    ah,ah
D965 2A E6    C      sub    ah,dh          ;compute # of scanlines per i.a.
C                                     ; to be read
C
D967 33 C9    C      xor    cx,cx          ;CH = 0 for REP counter
C
D969 E9 D8C9 R C      jmp    g_scroller     ;go scroll down and fill
C
D96C          C      grf_graphics_down  endp
C
C      page
C      ;-----
C      ; graphics_read - read the character at the current cursor
C      ; Input: none
C      ; Output: AL = character at the current cursor position or zero
C      ; Saved: BX, CX, DX (video dispatcher saves the rest)
C      ;-----
D96C          C      grf_graphics_read  proc  near
C
D96C 53         C      push   bx            ; save
D96D 51         C      push   cx            ; the
D96E 52         C      push   dx            ; registers
C
D96F 8A DC      C      mov    bl,ah          ;BL saves v_mode
D971 41 0050 R C      mov    ax,word ptr ds:[v_cursor] ;get address of cursor position
D974 E8 D85F R C      call  g_aura_off      ;save as a pointer for later
D977 8B F0      C      mov    si,ax
C
D979 8A C3      C      mov    al,bl          ;AL saves v_mode
D97B 89 0004   C      mov    cx,4           ;# scanlines per i.a. = 4 for modes *72
D97E 33 DB      C      xor    bx,bx          ;make BX=4 for mode 4,5,6
D980 3C 40      C      cmp    al,64
D982 72 08      C      jb     g_lda_r        ;jump if mode = 4,5,6
D984 B3 04      C      mov    bl,4           ;make BX=4 for mode 64
D986 74 04      C      je     g_lda_r
D988 D1 F9      C      sar    cx,1           ;# scanlines per i.a. = 2 for mode 72
D98A 33 DB      C      xor    bx,bx          ;make BX=0 for mode 72
C
D98C          C      g_lda_r: ;(BX= font pointer offset in master table)
D98C C5 3E 008A R C      lds   di,dword ptr ds:[master_tbl_ptr] ;get pointer to master table
D990 C5 79 06   C      lds   di,dword ptr ds:[di+6][bx] ;get pointer to font's 1st 128 chars
D993 1E         C      ds   push  es          ;XCHG DS,ES
D994 06         C      push  es
D995 1F         C      pop   ds             ;DS:SI -> grafix ram read location ???
D996 07         C      pop   es             ;ES:DI -> font's 1st 128 characters
C
D997 D1 E3      C      sal    bx,1          ;make BX=8 for modes 4,5,6,72
D999 83 C3 08   C      add    bx,8           ; BX=16 for mode 64
C                                     ;(BX= number of font bytes per character)
C
D99C 2B E3      C      sub    sp,bx          ;get stack space for font bytes
D99E 8B EC      C      mov    bp,sp         ;save pointer to stack space
D9A0 BA 0002   C      mov    dx,2           ;number of interlace areas (modes 4,5,6)
D9A3 3C 06      C      cmp    al,6           ;check graphics mode
D9A5 7C 33      C      jll   g_rd_mmd        ;jump if in medium resolution mode (4,5)
D9A7 74 03      C      jle   g_rd_loop       ;jump if in 640x200 resolution mode (6)
C
D9A9 BA 0004   C      ; we're in super resolution (640x400) mode (64 & 72)
C      mov    dx,4           ;number of interlace areas
C
D9AC          C      g_rdloop: ;Read Scanlines Loop for both 640x200 and 640x400
D9AC 51         C      push   cx            ;save # of scanlines per interlace area
D9AD 56         C      push   si            ;save current addr. in interlace area #1
D9AE 8B CA      C      mov    cx,dx          ;init. counter: # of interlace areas
C
D9B0          C      g_rd_ia: ;Read Interlace Area Loop
D9B0 8A 04      C      mov    al,[si]       ;get byte from grafix ram
D9B2 8B 46 00   C      mov    [bp],al       ;save on reserved stack
D9B5 45         C      inc    bp            ;bump reserved stack address
D9B6 81 C6 2000 C      add    si,2000H       ;address next interlace area
D9BA E2 F4      C      loop  g_rd_ia

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ROM BIOS Listing

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C
D9BC 5E                C      pop     si                ;restore interlace area #1 address
D9BD 83 C6 50         C      add     si,80              ;address next scanline in each i.a.
D9C0 59                C      pop     cx                ;restore # of scanlines counter
D9C1 E2 E9           C      loop   g_rdlloop
C
D9C3 83 FA D4         C      cmp     dx,4               ;are we in mode 64 or 72 (64x400)?
D9C5 75 47           C      jne    g_matchb          ;jump if no (reverse video not allowed)
D9C8 8B F5           C      mov     si,bp             ;point to first byte in stack save area
D9CA 2B F3           C      sub     si,bx
D9CC F6 04 80         C      test   byte ptr [si],80H  ;is upper left bit of char = 0 or 1 ?
D9CF 74 3E           C      jz     g_matchb          ;jump if 0 (not reversed video)
D9D1 8B CB           C      mov     cx,bx             ;number of char bytes counter
D9D3                C      g_unreverse_video_loop:
D9D3 F6 14           C      not    byte ptr [si]     ;reverse the reversed byte for matching
D9D5 46           C      inc    si                ;address next char byte
D9D6 E2 FB           C      loop   g_unreverse_video_loop
D9D8 EB 35           C      jmp    short g_matchb    ;now find the char in the font table
C
D9DA                C      g_rd_med:                ;Read Medium Resolution
D9DA D1 E6           C      sal    si,1              ;double graf ram pointer (2 bytes/char)
C
D9DC                C      g_medget:                ;Get font bytes in medium resolution (320 X 200) mode
D9DC 51           C      push   cx                ;save # scanlines per i.a. counter
D9DD 56           C      push   si                ;save current scanline address
D9DE B9 0002         C      mov     cx,2              ;init. # interlace areas counter
C
D9E1                C      g_med_ia:
D9E1 51           C      push   cx                ;save i.a. counter
D9E2 8B 04         C      mov     ax,[si]          ;get 2 bytes of 1 char from video memory
D9E4 86 20           C      xchg   ax,al             ;order them logically
C
D9E6 F7 D0           C      not    ax                ;map background pixels to 0,
D9E8 8B D0           C      mov     dx,ax            ; foreground pixels to 1
D9EA D1 E2           C      shl    dx,1
D9EC 23 D0           C      and    dx,ax
D9EE F7 D2           C      not    dx
C
D9F0 32 C0           C      xor    al,al             ;clear result accumulator
D9F2 B9 0008         C      mov     cx,8              ;prepare to process 8 bits
C
D9F5                C      g_med_bit:
D9F5 D1 E4           C      shr    dx,1              ;ignore unused bit
D9F7 D1 E4           C      shr    dx,1              ;load carry with mapped pixel value
D9F9 D0 D8           C      ror    al,1              ;rotate it into result accumulator
D9FB E2 F8           C      loop   g_med_bit        ;process next bit of character
C
D9FD 8B 46 00         C      mov     [bp],al          ;save font byte on reserved stack
DA00 45           C      inc    bp                ;bump reserved stack pointer
DA01 81 C6 2000      C      add    si,2000H          ;address next interlace area
DA05 59           C      pop     cx                ;restore i.a. counter
DA06 E2 D9           C      loop   g_med_ia        ;process next i.a. of character
C
DA08 5E           C      pop     si                ;restore scanline address
DA09 83 C6 50         C      add    si,80              ;address next scanline
DA0C 59           C      pop     cx                ;restore scanlines counter
DA0D E2 CD           C      loop   g_medget        ;process next scanline of character
C
DA0F                C      g_matchb:                ;Match Font Byte: find character
C
DA0F 2B EB           C      sub     bp,eb            ;point to first byte in stack save area
DA11 8B F5           C      mov     si,bp            ;pointer to font bytes from graf ram
DA13 32 C0           C      xor    al,al            ;index to font bytes (start with 0)
C
DA15                C      g_f_cont:                ; Get Font Byte Match Control
DA15 16           C      push   aa                ;setup string compare registers
DA16 1F           C      pop    ds                ;DS:SI -> stack area w/grafix ram bytes
DA17 B9 0080         C      mov     cx,128           ;loop control = 1st 128 ascii chars.
C
DA1A                C      g_f_mach:                ;Get Font Byte Match Loop
DA1A 51           C      push   cx                ;save loop counter
DA1B 8B CB           C      mov     cx,bx            ;counter for string compare
DA1D 57           C      push   di                ;save font pointer
DA1E 56           C      push   si                ;save pointer to stack save area
DA1F F3 A6           C      cmpb   byte ptr [si],cx  ;screen bytes match font bytes ?
DA21 5E           C      pop    si                ;retrieve pointer to stack save area
DA22 5F           C      pop    di                ;retrieve pointer to font byte table
DA23 59           C      pop    cx                ;restore loop counter
DA24 74 2D           C      jz     g_f_exit          ;if match go to exit code
DA26 03 FB           C      add    di,bx            ;address next font in table
DA28 FE C0           C      inc    al                ;bump ascii index
DA2A E2 EE           C      loop   g_f_mach         ;go back if more chars to search for
C
C      ; no match in first 128 ascii character set - look for user's second set
C
DA2C 0A C0           C      or     al,al            ;have we scanned both 128 char 1/2s ?
DA2E 74 23           C      jz     g_f_exit          ;jump if yes
DA30 83 F8 10         C      cmp    bx,16            ;are we in mode 64 ?
DA33 74 08           C      je     g_8x16_2         ;jump if yes
C
DA35 8E D9           C      mov     ds,cx            ;move zero to segment register
C
DA37 C4 3E 007C R     C      assume ds:abs0
C      les    di,dword ptr ds:[int1flo0] ;get pointer to 2nd half of 8x8 font
C      assume ds:data
C      jmp    short g_test_addr ;see if font is really there
C
DA3D                C      g_8x16_2:
DA3D                C      ;get 2nd half of 8x16 font
DA3D 2E: 8E 1E E5F2 R  C      mov     ds,word ptr cs:[set_da_word] ;set DS to data segment
DA42 C5 3E 0084 R     C      lds    di,dword ptr ds:[master_tbl_ptr] ;get pointer to master table
DA46 C4 7D 0E         C      les    di,dword ptr ds:[di+4] ;get pointer to 2nd half of 8x16 font
C
DA49                C      g_test_addr:
DA49 8C C0           C      mov     ax,es            ;check if font table is set up

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ROM BIOS Listing

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D48B 0B C7      C      or      ax,di      ;if zeros, then no user font table
D48D 74 04      C      js      g_f_exit      ;no table, just go to exit
D48F 00 80      C      mov      al,128        ;offset to 2nd 1/2 of ascii set
D491 EB C2      C      jmp short g_f_cont      ;go back to try rest of ascii set

D493           C      g_f_exit:           ;either the character is found, or al = 0
D495 03 E3      C      add      sp,bx         ;restore stack pointer
D496 5A         C      pop      dx           ;restore
D497 59         C      pop      cx           ;   the
D498 5B         C      pop      bx           ;   registers
D499 C3         C      ret

D499           C      grf_graphics_read      endp

C      page
C      ;=====
C      ;
C      ; Graphics_write - write a character to the screen
C      ;
C      ; Input: AL = character to write
C      ;        BL = foreground color attribute
C      ;        bit 7 = 1: xor character with graphics ram
C      ;        CX = number of characters to write
C      ;        DS = data segment
C      ;        ES = graphics ram segment
C      ;
C      ; Saved: BX, CX, DX (video dispatcher saves the rest)
C      ;
C      ;-----

D499           C      grf_graphics_write      proc      near
D499 53         C      push     bx          ;save
D4A5 51         C      push     cx          ;   the
D4A5 52         C      push     dx          ;   registers
D4A5 C2         C      mov      dx,ax        ;DH= ort mode, DL= char to write
D4A5 C2         C      ; locate beginning of character in graphics ram
D4A5 C2         C      mov      ax,word ptr ds:[v_cursor]
D4A5 C2         C      call     g_cursor_off ;get address of cursor position
D4A5 C2         C      mov      di,ax        ; pointer to graphics location
D4A5 C2         C      ; determine if character is from 1st or 2nd half of table
D4A5 C2         C      cmp     di,128        ;is it in first 1/2 of ASCII set ?
D4A5 C2         C      jb     g_selfont      ;jump if in 1st 1/2 (0 -> 127)
D4A5 C2         C      ; character (128 -> 255) is in 2nd 1/2 of font table
D4A5 C2         C      sub     di,128        ;make zero origin for font table lookup
D4A5 C2         C      cmp     di,64         ;are we in mode 64 ?
D4A5 C2         C      jno    g_8x8_2        ;jump if no
D4A5 C2         C      lds     si,dword ptr ds:[master_tbl_ptr] ;get pointer to master table
D4A5 C2         C      lds     si,dword ptr ds:[si+16] ;get pointer to 2nd half of 8x16 font
D4A5 C2         C      jmp short g_addr_test ;see if font table is really there
D4A5 C2         C      g_8x8_2:           ;get 2nd half of 8x8 font table
D4A5 C2         C      xor     si,si         ;save zero to segment register
D4A5 C2         C      mov     di,si
D4A5 C2         C      assume ds:abs0
D4A5 C2         C      lds     si,dword ptr ds:[int1Floor] ;get pointer to 2nd half of 8x8 font
D4A5 C2         C      assume ds:data
D4A5 C2         C      g_addr_test:
D4A5 C2         C      mov     ax,ds         ;check if font table is set up
D4A5 C2         C      or     ax,si         ;if zero, then no 2nd half of table
D4A5 C2         C      jnz     g_detmode     ;continue if font table is present
D4A5 C2         C      xor     di,di        ;substitute null character
D4A5 C2         C      mov     ds,word ptr cs:[set_ds_word] ;restore data segment register
D4A5 C2         C      jmp short g_selfont   ;and continue in 1st half of font table
D4A5 C2         C      ; character (0 -> 127) is in 1st 1/2 of font table
D4A5 C2         C      g_selfont:
D4A5 C2         C      push     bx          ;preserve register
D4A5 C2         C      xor     bx,bx        ;make BX=0 for modes 4,5,6
D4A5 C2         C      cmp     dx,64        ;
D4A5 C2         C      jb     g_lds_w        ;jump if mode = 4,5,6
D4A5 C2         C      mov     bl,4         ;make BX=4 for mode 64
D4A5 C2         C      je     g_lds_w        ;jump if mode = 64
D4A5 C2         C      xor     bx,bx        ;make BX=0 for mode 72
D4A5 C2         C      g_lds_w:           ;(BX= font pointer offset in master table)
D4A5 C2         C      lds     si,dword ptr ds:[master_tbl_ptr] ;get pointer to master table
D4A5 C2         C      lds     si,dword ptr ds:[si+6][bx] ;get pointer to font's 1st 128 chars
D4A5 C2         C      pop     bx          ;restore register
D4A5 C2         C      g_detmode:
D4A5 C2         C      push     cx          ;determine graphics mode
D4A5 C2         C      xor     ax,ax        ;get ascii code in AX
D4A5 C2         C      mov     al,dx        ;
D4A5 C2         C      mov     cl,3         ;
D4A5 C2         C      sal     ax,cl        ; to multiply by
D4A5 C2         C      pop     cx          ; 8 (font bytes per character)
D4A5 C2         C      add     si,ax        ;and add to address of font table
D4A5 C2         C      mov     di,h         ;# scanlines per l.a. (modes 4,5,6,64)

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ROM BIOS Listing

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DAB5 80 FE 06      C      cmp      dh,6           ;which resolution are we using?
DAB8 7C 49         C      j!       &_med_wr      ;jump if medium resolution (modes 4 & 5)
DABA 74 0F         C      je      &_hi_wr      ;jump if 640x200 resolution (mode 6)
C
C
C                                     ;we're in 640x400 resolution
DABC 80 FE 48      C      cmp      dh,72
DABF B6 04         C      mov     dh,4
DAC1 75 04         C      jne     &_super_wr    ;# interlace areas = 4 for modes 64 & 72
C
C
DAC3               C      &_tinytext:           ;640x400 resolution (mode 72)
DAC3 B2 02         C      mov     di,2           ;# scanlines per i.a. = 2 for mode 72
DAC5 EB 09         C      jmp     short &_repehar
C
C
DAC7               C      &_super_wr:           ;640x400 resolution (mode 64)
DAC7 03 F0         C      add     si,ax          ;multiply ascii code by 16 bytes/char
DAC9 EB 05         C      jmp     short &_repehar
C
C
DACB               C      &_hi_wr:             ;Hi-resolution Character Write
DACB B6 02         C      mov     dh,2           ;interlace areas count (even/odd)
DACD 80 CB 01      C      or      bl,1           ;mode 6 doesn't allow reverse video
C
C
DAD0               C      &_repehar:           ;Repeat Character Loop
DAD0 51            C      push    cx             ;save character repeat count
DAD1 56            C      push    si             ;save source address (font table)
DAD2 57            C      push    di             ;save destination addr. (grafix ram)
DAD3 33 C9         C      xor     ox,ox          ;prepare loop counter
DAD5 8A CA         C      mov     ol,dl          ;scanlines per interlace area counter
C
C
DAD7               C      &_linelp:           ;Scanline Loop
DAD7 51            C      push    ox             ;save scanlines per i.a. counter
DAD8 57            C      push    di             ;save interlace area #1 address
DAD9 8A CE         C      mov     ol,dh          ;init. interlace areas counter (2 or 4)
C
C
DADB               C      &_i_a_lp:           ;Interlace Area Loop
DADB AC           C      lodsb                ;iget byte from font table
DAC2 F6 C3 01      C      test    bl,1           ;reverse video?
DADF 75 02         C      jnz     &_t_xor        ;jump if no
DAE1 F6 D0         C      not     al             ;reverse video
C
C
DAE3               C      &_t_xor:            ;Test For XOR
DAE3 04 DB         C      or      bl,bl          ;XOR the char. with grafix ram?
DAE5 79 03         C      jns     &_w_byte       ;jump if no
DAE7 26: 32 05     C      xor     al,es:[di]     ;XOR with grafix ram
DAEA               C      &_w_byte:           ;Write Byte
DAEA 26: 88 05     C      mov     es:[di],al    ;write byte in grafix ram
DAE9 D1 C7 2000    C      add     di,2000H       ;address next interlace area
DAF1 E2 E8         C      loop    &_i_a_lp
C
C
DAF3 5F            C      pop     di             ;restore interlace area #1 address
DAF4 83 C7 50      C      add     di,80          ;address next scanline in each i.a.
DAF7 59            C      pop     cx             ;restore scanlines per i.a. counter
DAF8 E2 DD         C      loop    &_linelp
C
C
DAFA 5F            C      pop     di             ;restore char's grafix ram address
DAFB 47            C      inc     di             ;address next character in grafix ram
DAFC 5E            C      pop     si             ;restore char's font table address
DAFD 59            C      pop     cx             ;restore character repeat count
DAFE E2 D0         C      loop    &_repehar     ;repeat the character
DB00 EB 55 90      C      jmp     &_return
C
C
DB03               C      &_med_wr:           ;Medium Resolution Character Write
DB03 D1 E7         C      sal     di,1           ;double graf ram pointer (2 bytes/char)
DB05 8A D3         C      mov     dl,bl          ;DL saves XOR bit input param (bit 7)
DB07 81 E3 0003    C      and     bx,0003H       ;BX= foreground color (& table offset)
DB08 2E: 8A 9F DB5B R C      mov     bl,es:&_color_table[bx] ;propagate color through byte
DB10 8A FB         C      mov     bh,bl          ;propagate color through word
DB12 8B B8         C      mov     bp,bx          ;BP saves word of color masks
C
C
DB14               C      &_char_lp:           ;Repeat Character Loop
DB14 51            C      push    cx             ;save character repeat counter
DB15 56            C      push    si             ;save source address (font table)
DB16 57            C      push    di             ;save destination addr. (grafix ram)
DB17 B9 0004       C      mov     cx,4           ;init. scanlines per i.a. counter
C
C
DB1A               C      &_scan_lp:           ;Scanline Loop
DB1A 51            C      push    cx             ;save scanlines per i.a. counter
DB1B 57            C      push    di             ;save interlace area #1 address
DB1C B9 0002       C      mov     cx,2           ;init. interlace areas counter
C
C
DB1F               C      &_i_a_lp:           ;Interlace Area Loop
DB1F 51            C      push    cx             ;save i.a. counter
DB20 AC           C      lodsb                ;iget
C
C
DB1F 51            C      push    cx             ;save i.a. counter
DB20 AC           C      lodsb                ;iget a byte from the font table
DB21 8A E0         C      mov     ah,al          ;copy it
DB23 B9 0008       C      mov     cx,8           ;init. loop counter (8 bits/byte)
C
C
DB26               C      &_exp_byt:           ;Expand Byte Loop
DB26 D0 EC         C      shr     ah,1           ;load carry with font byte bit
DB28 D1 DB         C      ror     bx,1           ;rotate it into expansion accumulator
DB2A D0 EB         C      shr     al,1           ;load carry with same bit as before
DB2C D1 DB         C      ror     bx,1           ;double the bit
DB2E E2 F6         C      loop    &_exp_byt     ;expand font byte bits
C
C
DB30 23 D0         C      and     bx,bp          ;color pixels with foreground color
DB32 86 FB         C      xchg    bh,bl          ;reorder the bytes for grafix ram
DB34 0A D2         C      or      di,di          ;is the XOR bit set ?
DB36 79 03         C      jns     &_med_store    ;jump if no
DB38 26: 33 1D     C      xor     bx,es:[di]     ;XOR with grafix ram

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DB3B          C  g_med_store:
DB3B 26: 89 1D      C      mov     es:[di],bx           ;update grafix ram
DB3E 81 C7 2000    C      add     di,2000H           ;address next interlace area
DB42 59            C      pop     cx                 ;restore i.a. loop counter
DB43 E2 DA        C      loop   g_ia_lp           ;next interlace area
C
DB45 5F          C      pop     di                 ;restore interlace area #1 address
DB46 83 C7 50     C      add     di,80             ;address next scanline in each i.a.
DB49 59          C      pop     cx                 ;restore scanline loop counter
DB4A E2 CE        C      loop   g_scan_lp        ;next scanline
C
DB4C 5F          C      pop     di                 ;restore char's grafix ram address
DB4D 47          C      inc     di                 ;address next character in grafix ram
DB4E 47          C      inc     di
DB4F 5E          C      pop     si                 ;restore char's font table address
DB50 59          C      pop     cx                 ;restore character repeat count
DB51 E2 C1        C      loop   g_char_lp        ;repeat the character
C
DB53 8A E3        C      mov     ah,bl             ;return AX with last word written
DB55 8A C7        C      mov     al,bh
C
DB57          C  g_return:
DB57 5A          C      pop     dx                 ;Return from Write Char
DB58 59          C      pop     cx                 ;restore
DB59 5B          C      pop     bx                 ; the
DB5A C3          C      ret                      ; registers
C
DB5B          C  g_color_table label byte ;Table of foreground colors extended to byte
C
DB5B 00          C      db     00000000B         ;color 0 (bit pattern: 00)
DB5C 55          C      db     01010101B         ;color 1 (bit pattern: 10)
DB5D AA          C      db     10101010B         ;color 2 (bit pattern: 01)
DB5E FF          C      db     11111111B         ;color 3 (bit pattern: 11)
C
DB5F          C  grf_graphics_write  endp
C
C  page
C ;-----
C ;
C ; Get offset into graphics ram refresh memory which corresponds to
C ; the current cursor position (or any arbitrary character position).
C ;
C ; Input: AX = current cursor position (AL = Column #, AH = Row #)
C ;
C ; Output: AX = offset into graphics ram
C ;-----
C
DB5F          C  g_cura_off  proc  near

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ROM BIOS Listing

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DB5F 51          C          push    ax          ;leave work register
DB60 8A EB      C          mov     ch,al       ;hold column number
DB62 8A C4      C          mov     al,ah       ;row number to al
C
DB64 B1 01      C          mov     cl,1        ;mode 72 shift count (multiply * 2)
DB66 80 3E 0049 R 48 C          cmp     byte ptr ds:[v_mode],72 ;jump if mode 72
DB6B 73 02      C          je     &_72        ;mode 72 shift count (multiply * 4)
DB6D FE C1      C          inc     cl
C
DB6F          C          &_72:
DB6F D2 E0      C          shl     al,cl       ;multiply row # by rows per byte
DB71 32 C9      C          xor     cl,cl       ;zero out the shift count
DB73 86 E9      C          xchg   ch,cl       ;move column number for add
DB75 F6 26 004A R C          mul     byte ptr ds:[v_width] ;multiply by bytes per column
DB79 03 C1      C          add     ax,ax       ;compute offset into refresh ram
DB7B 59          C          pop     ax          ;restore register
DB7C C3          C          ret              ;and return to caller
C
DB7D          C          g_ours_off      endp
C
DB7D          C          code ends
C          include pwrup1.asm
C
C          ;=====
C          ;          Filename:      pwrup1.src
C          ;
C          ;          This module includes CPU, ROM, 8253 p_dma p_timer, & 8237 p_dma
C          ;          Controller tests.
C          ;
C          ;=====
C
DB7D          C          code segment public 'ROM'
C          assume cs:code, ds:nothing, es:nothing, as:nothing
C
DB7D          C          pi_data1      proc      near
C
DB7D 90          C          even              ; word-align stack_rom
C
DB7E DB22 R      C          stack_rom      dw     i_rom          ; return from i_opu
DB80 DB80 R      C          dw     i_rom_ret      ; return from rom_checksum
DB82 DDC7 R      C          dw     i_dmat        ; return from i_rom
DB84 DDD3 R      C          dw     i_dmat_ret     ; return from rto_ohk
DB86 DDE2 R      C          dw     i_dmac         ; return from i_dmat
DB88 DE51 R      C          dw     i_dmac_ret     ; return from i_dmat
DB8A DE6B R      C          dw     i_pic          ; return from i_dmac
C
DB8C 52 65 73 69 64 65 C          banner_m      db     'Resident Diagnostics',CR,LF
C          6E 74 20 44 69 61 C
C          67 6E 6F 73 74 69 C
C          63 73 0D 0A      C
DBA2 52 65 76 20 31 2E C          db     'Rev 1.0 May 1984',CR,LF,LF,NUL
C          30 20 20 4D 61 79 C
C          20 31 39 38 34 0D C
C          0A 0A 00          C
C
DBB7 0D 0A 50 72 69 6D C          bt_m          db     CR,LF,'Primary Boot-Strap... ',CR,LF,NUL
C          61 72 79 20 42 6F C
C          6F 74 2D 53 74 72 C
C          61 70 2E 2E 2E 0D C
C          0A 00          C
DBD1 50 72 69 6D 61 72 C          bt_merr       db     'Primary Boot-Strap DISK READ ERROR.',CR,NUL
C          79 20 42 6F 6F 74 C
C          2D 53 74 72 61 70 C
C          20 44 49 53 4B 20 C
C          52 45 41 44 20 45 C
C          52 52 4F 52 2E 0D C
C          00          C
C
DBF6 20 20 20 20 20 20 C          ; This line must have same number of blanks as the preceding has characters:
C          bt_spaces  db     ' ',CR,NUL
C          20 20 20 20 20 20 C
C          20 20 20 20 20 20 C
C          20 20 20 20 20 20 C
C          20 20 20 20 20 20 C
C          20 20 20 20 20 0D C
C          00          C
C
DC1B 2A 20 49 6C 6C 65 C          ill_m1        db     '* Illegal Interrupt No. ',NUL
C          61 61 20 49 6E C
C          74 65 72 72 75 70 C
C          74 20 4E 6F 2E 20 C
C          00          C
DC34 68 20 61 74 20 00 C          ill_m2        db     'h at ',NUL
DC3A 20 2A 00          C          ill_m3        db     ' * ',NUL
C
DC3D 20 50 61 73 73 0D C          pass_m        db     ' Pass',CR,LF,NUL
C          0A 00          C
DC45 20 46 61 69 6C 00 C          fail_m         db     ' Fail',NUL
C
DC4B 43 50 55 20 28 69 C          i_opu_m        db     'CPU (18086) ',NUL ; Pass/Fail
C          38 30 38 36 29 20 C
C          00          C
DC58 52 4F 4D 20 4D 6F C          i_rom_m        db     'ROM Module ',NUL ; Pass/Fail
C          64 75 6C 65 20 20 C
C          00          C
DC65 44 4D 41 20 54 69 C          i_dmat_m       db     'DMA Timer ',NUL ; Pass/Fail
C          6D 65 72 20 20 20 C
C          00          C
DC72 44 4D 41 20 43 6F C          i_dmac_m       db     'DMA Control ',NUL ; Pass/Fail
C          6E 74 72 6F 6C 20 C
C          00          C

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ROM BIOS Listing

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DD6F 73 1C      C      jnb     i_opu_err      ; CF = AF set? if not, abort
DD71 0A E4      C      or      ah,ah        ; ah = 0? if not, abort
DD73 75 18      C      jnz     i_opu_err
C
C
DD75 80 80      C      mov     al,40h        ; ah = 0
DD77 02 C0      C      add     al,al         ; al = 40h + 40h = 80h = -128
DD79 71 12      C      jno     i_opu_err     ; OF set? if not, abort
C
C ; Flags Test (All Reset): SF, ZF, AF, PF, CF & OF.
C ; (Exercises flags and accumulator only.)
C
DD7B 33 C0      C      xor     ax,ax         ; ax = 0
DD7D 9E          C      aahf                    ; reset SF, ZF, AF, PF, & CF
DD7E 78 0D      C      js      i_opu_err     ; SF reset? if not, abort
DD80 76 0B      C      jbe     i_opu_err     ; ZF or CF reset? if not, abort
DD82 7A 09      C      jp      i_opu_err     ; PF reset? if not, abort
C
DD84 37          C      aaa                    ; to test if AF reset, al must be <= 9
C ; if AF reset, then: ah unchanged;
C ; al = (al & 0Fh) == 0; CF = AF == 0
DD85 72 06      C      jb      i_opu_err     ; CF = AF reset? if not, abort
DD87 03 C0      C      add     ax,ax         ; ax = 0? if not, abort
DD89 75 02      C      jnz     i_opu_err     ; ax = 0 + 0 = 0, so should be no OF.
C ; OF reset? if not, abort
C
DD8B 71 11      C      jno     i_opu_ok     ; OF reset? if not, abort
C
C      assume es:code, ds:code, es:abs0, ss:code
C
DD8D          C      i_opu_err:
DD8D 8C C8      C      mov     ax,os         ; satisfy assumptions
DD8F 8E D8      C      mov     ds,ax
DD91 8E D0      C      mov     ss,ax         ; use ROM 'stack'
DD93 8C DB7E R  C      mov     sp,os:(offset stack_rom)
C
DD96 8E DCAB R  C      mov     si,os:(offset i_opu_m)
DD99 32 E4      C      xor     ah,ah        ; clear ah (no error number to report)
DD9B E9 E0E9 R  C      jmp     i_fatal       ; i_fatal will 'ret' to i_rom
C
DD9E          C      i_opu_ok:
DD9E 8C C8      C      mov     ax,os         ; satisfy assumptions
DDA0 8E D8      C      mov     ds,ax
DDA2 8E D0      C      mov     ss,ax         ; use ROM 'stack'
DDA4 8C DB7E R  C      mov     sp,os:(offset stack_rom)
C
DDA7 80 41      C      mov     al,41h        ; Check Point #1
DDA9 BA 0378    C      mov     dx,378h       ; parallel port data port address
DDAC EE        C      out     dx,al         ; output "Running- Checkpoint 1"
C ; Reset the keyboard
C
DDAD 80 00      C      mov     al,0
DDAF 86 61      C      out     p_kotrl,al
C      ret                    ; will 'ret' to i_rom
C
C -----
C ; ROM Module Test
C -----
C
C      assume es:code, ds:code, es:abs0, ss:code
C
DDB2          C      i_rom:
C ; Calculate Checksum of ROM.
C
DDB2 BE E000    C      mov     si,0E000h     ; ROM starts at ds:si = F000:E000
DDB5 E9 E5E5 R  C      jmp     rom_checksum   ; 'call' rom_checksum
C ; will 'ret' here
C
DDB8 74 06      C      jz      i_rom_ok
C
C
DDBA          C      i_rom_err:
DDBA BE DC58 R  C      mov     si,cs:(offset i_rom_m)
C      jmp     i_fatal       ; ah has illegal checksum
C ; i_fatal will 'ret' to i_dmat
C
DDC0          C      i_rom_ok:
DDC0 80 42      C      mov     al,42h        ; Check Point #2
DDC2 BA 0378    C      mov     dx,378h       ; parallel port data port address
DDC5 EE        C      out     dx,al         ; output "Running- Checkpoint 2"
DDC6 C3        C      ret                    ; will 'ret' to i_dmat
C
C -----
C ; 8253 p_dma p_timer Test
C -----
C
C      assume es:code, ds:code, es:abs0, ss:code
C
DDC7          C      i_dmat:
C ; Disable 8237A p_dma Controller before the testing of the 8253 p_dma p_timer channel.
C
DDC7 80 04      C      mov     al,dma_cmd_disable ; disable p_dma controller command
DDC9 E6 08      C      out     dma_command,al
C
C ; Proceed with the testing of the 8253 p_dma p_timer channel ()p_8253_1.
C
DDCB 80 74      C      mov     al,074h       ; 01 11 010 0 -> p_8253_1, 1st 1st, mode 2, no BCD
DDCD BA 0041    C      mov     dx,p_8253_1
DDDD E9 E1F6 R  C      jmp     rtc_chk        ; select p_dma refresh counter
C ; 'call' rtc_chk
C
DDDD          C      i_dmat_ret:
DDDD 74 06      C      jz      i_dmat_ok

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C
C
DD55          C      i_dmat_err:
DD55 BE DC65 R      mov     si,cs:(offset i_dmat_m)
DD58 E9 E0E9 R      jmp     i_fatal          ; sh has error code to report.
C                                     ; i_fatal will 'ret' to i_dmae
C
C
DD5B          C      i_dmat_ok:
DD5B B0 43          C      mov     al,43h          ; Check Point #3
DD5D BA 0378       C      mov     dx,378h       ; parallel port data port address
DD5D E2           C      out     dx,al        ; output "Running- Checkpoint 3"
DD5E           C      ret                ; will 'ret' to i_dmae
C
C-----C-----
C      ;
C      ; 8237 p_dma Controller Test -- Test Chip's Operation & Channel Registers
C      ;
C      ; The 8237A p_dma Controller was disabled before the testing of the
C      ; 8253 p_dma p_timer channel.
C-----C-----
C
C      assume cs:code, ds:code, es:base0, ss:code
C
DD5E          C      i_dmae:
C      ; Send a 'master clear' to 8237 p_dma Controller.
C
DD5E E6 0D       C      out     dma_master_clr,al      ; send master clear to port
C
C      ; The dma_command, dma_status, dma_request, dma_temp, and dma_ff registers
C      ; are cleared, and the dma_mask register is set (all off).
C      ; Test readable control registers: dma_status & dma_temp)
C
DD5E B8 01       C      mov     ah,1          ; TEMP Error #1
C
DD5E B8 0D       C      in     al,dma_temp
DD5E 0A C0       C      or     al,al
DD5A 75 72       C      jnz    i_dmae_err       ; if not, abort
C
C      ; Test all 8 16-bit readable/writable channel registers (address and count
C      ; registers for all 4 channels, i.e., ports 0 through 7) with register bit test:
C      ; (dma_addr_x & dma_count_x are tested with 0FFFFh and then 0h for x = 0 to 3.)
C
DD5C BB FFFF     C      mov     bx,0FFFFh       ; bx = 0 all bits reset
C
DD5F           C      i_dmae_pass2:
C      ; outer loop
C      ; if 1st pass, bx = 0FFFFh
C      ; if 2nd pass, bx = 0h
C      ; loop counter and port address!!!
C
DD5F BA 0007     C      mov     dx,7
C
C      ; inner loop
C      ; get bit test pattern
C      ; write low byte of address/count
C      ; write high byte of address/count
C      ; read low byte of address/count
C      ; save low byte in ah
C      ; read high byte of address/count
C
DD5F DF2        C      mov     ax,bx
DD5F 8B C3      C      out     dx,al
DD5F 8E        C      out     dx,al
DD5F EE        C      in     al,dx
DD5F EC        C      mov     sh,al
DD5F 8A E0      C      in     al,dx
DD5F EC        C      ; read high byte of address/count
C
DD5F DFA 3B C3  C      cmp     ax,bx
DD5F DF8        C      mov     ah,2          ; TEMP Error #2
DD5F DFC        C      jnz    i_dmae_err       ; if not, abort
DD5F DF8 75 5E  C      ;
C
DD5F DE0 84     C      dec     dx
DD5F DE01 79 EF C      jns    i_dmae_lp        ; did we decrement past port address 0?
C      ; if not, continue same pass for all 8.
C
DD5F DE03 83     C      ino    bx
DD5F DE04 74 E9 C      jz     i_dmae_pass2     ; 1st pass? if so, bx = 0FFFFh & loop
C      ; 2nd pass? if so, bx = 0 & continue
C
C      ; We are done testing all 8 16-bit readable/writable channel registers (address
C      ; and count registers for all 4 channels) with the following results: All the
C      ; address registers (dma_addr_x) and count registers (dma_count_x) have been
C      ; initialized to zero.
C
C      ; Load 64k (0FFFFh-1) count for RAM refresh p_dma controller channel.
C
DD5F DE06 B0 FF  C      mov     al,0FFh
DD5F DE08 E6 01 C      out     dma_count_0,al      ; low byte of count for 64k RAM refresh
DD5F DE0A E6 01 C      out     dma_count_0,al      ; high byte of count for 64k RAM refresh
C
C      ; Load mode for RAM refresh p_dma controller channel: channel 0, read, auto-
C      ; initialize, increment, single mode.
C
DD5F DE0C B0 58  C      mov     al,dma_mode_0
DD5F DE0E E6 0B C      out     dma_mode,al
C
C      ; Enable p_dma controller: memory-to-I/O, controller enable, normal, fixed
C      ; priority, late write, and DRBQ/~DACK.
C
DD5F DE10 B0 00 C      mov     al,dma_cmd_enable
DD5F DE12 E6 08 C      out     dma_command,al
C
C      ; The master clear command above has masked off all channels. Now, we 'unmask'
C      ; the RAM refresh dma_mask bit. p_dma RAM refresh begins for the first time!
C
DD5F DE14 B0 00  C      mov     al,dma_unmask_0
DD5F DE16 E6 0A C      out     dma_mask_bit,al      ; turn on RAM refresh channel 0
C
C      ; Program p_8253_1 of 18253 p_timer to proper value for RAM refresh.
C
DD5F DE18 B0 74  C      mov     al,t1cmd
DD5F DE1A E6 43 C      out     p_8253_ctl1,al

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DE1C B8 0013      C          mov     ax,ticount          ; load p_dma refresh count
DE1F B6 41        C          out     p_8253_1,al
DE21 8A C4        C          mov     al,ah
DE23 B6 41        C          out     p_8253_1,al
C
C ; Check dma_status for 'hot' p_dma request from p_8253_1.
C
DE25 B4 03        C          mov     ah,3              ; TEMP Error #3
DE27 BA 06        C          in     al,dma_status      ; test for RAM refresh request in status
DE29 A8 10        C          test    al,010h          ; bit #4 -> channel 0 request
DE2B 75 31        C          jnz    i_dmae_err        ; if 'hot' p_dma request is there, abort
C
C ; Initialize other p_dma counters and modes.
C
DE2D BA 00B0      C          mov     dx,dma_mode
C
C ; Initialize p_dma channel 1 not used.
C
DE30 B0 41        C          mov     al,dma_mode_1    ; mode for not used
DE32 EB          C          out     dx,al
C
C ; Initialize p_dma channel 2 PDU.
C
DE33 B0 56        C          mov     al,dma_mode_2    ; mode for PDU
DE35 EB          C          out     dx,al
C
C ; Initialize p_dma channel 3 display.
C
DE36 B0 43        C          mov     al,dma_mode_3    ; mode for display
DE38 EB          C          out     dx,al
C
C ; Initialize p_dma Segment Nibble Latches to zero.
C ; (dma_seg_x For x = 0 to 3 is port addresses 80h to 83h).
C
DE39 32 C0        C          xor     al,al             ; al = 0
DE3B BA 0083      C          mov     dx,083h         ; loop counter and port address1
C                          ; dx = dma_seg_3 = 083h
C
DE3E EB          C          i_dmae_nib:
DE3F EB          C          out     dx,al
DE41 FE CA        C          dec     dl               ; when dl goes from 80h (-128) to
DE43 78 FB        C          js     i_dmae_nib        ; 07fh (+127) we will exit
C
C ;-----
C ; 8237 p_dma Controller Test -- Test Lowest 64k bank of RAM
C ;-----
C
C          assume cs:code, ds:data, es:ba0, ss:code
C
DE43 2E: 8E 1E E5F2 R  C          mov     ds,word ptr es:[set_ds_word] ; satisfy assumptions
DE45 B8 36 0072 R  C          mov     si,word ptr ds:[reset_flag] ; save reset_flag
C
C
DE4C 33 D2        C          xor     dx,dx
DE4E E9 E266 R  C          jmp     reset            ; dx = 0; test 0000:0 to 0000:FFFF
DE51 EB          C          i_dmae_ret:
C                          ; will 'ret' here
C
DE51 2E: 8E 1E E5F2 R  C          mov     ds,word ptr es:[set_ds_word] ; satisfy assumptions
DE53 B8 36 0072 R  C          mov     word ptr ds:[reset_flag],si ; restore reset_flag
C
DE5A B4 04        C          mov     ah,4
DE5C 74 06        C          jz     i_dmae_ok        ; TEMP Error #4
C
C
DE5E EB          C          i_dmae_err:
DE5F EB          C          mov     si,cs:(offset i_dmae_m)
DE61 E9 E0E9 R  C          jmp     i_fatal         ; ah has error code to report.
C                          ; i_fatal will 'ret' to i_pic
C
C
DE64 EB          C          i_dmae_ok:
DE65 B0 44        C          mov     al,44h          ; Check Point #4
DE66 BA 0378      C          mov     dx,378h         ; parallel port data port address
DE68 EB          C          out     dx,al           ; output "Running- Checkpoint 4"
DE6A C3          C          ret                    ; will 'ret' to pic
C
C ;-----
C ; 8259A Programmable Interrupt Controller Test.
C ;-----
C
C          assume cs:code, ds:data, es:ba0, ss:stack_ram
C
DE6B EB          C          i_pic:
DE6C B8 0030      C          mov     ax,stack_seg    ; Initialize RAM Stack
DE6E B8 D0        C          mov     ss,ax           ; on lower tested memory
DE70 BC 0100      C          mov     sp,100h
C
C ; Initialize & Disable 8259A Programmable Interrupt Controller.
C
DE73 E8 E1DC R  C          call    i_pic_init
C
C ; Install Interrupt Vectors for diagnostics.
C
C ; Install unexpected diagnostic interrupt vectors.
C
DE76 33 F6        C          xor     si,si
DE78 B8 FE        C          mov     di,si           ; es:si = abs0_seg:int0010cn
DE7A B9 01FE      C          mov     cx,(0400h-0004h)/2 ; words from 0:0004h to 0:0400h
C
C
DE7D B8 DEDC R  C          mov     ax,cs:(offset i_pic_err) ; store offset i_pic_err
DE80 AB          C          stow
DE81 8C C8        C          mov     ax,cs           ; store segment address

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DEB3 AB          ; es:di = ab00_seg:int00looc + 4
DEB4 F3/ 26: A5  C      stow      word ptr es:0004h,word ptr es:0000h ; replicate vector
C
C
C      ; Install software diagnostic interrupt vectors.
C
DEB7 B8 DEA9 R   C      mov     ax,es:(offset i_pic_0_ok) ; ax = offset i_pic_0_ok
DEB8 33 FF       C      xor     di,di ; es:di = ab00_seg:int00looc
DEB9 B1 05       C      mov     cl,5 ; load INT's 0h through 4h.
C
DEBE          i_pic_soft: C      ; ax = (4*x)-(i_pic_0_ok)
DEBF AB        C      stow     ; es:di gets offset i_pic_x_ok
DEBF 47        C      inc     di ; skip segment (already = es)
DE90 47        C      inc     di
DE91 05 0004    C      add     ax,4 ; i_pic_x_ok are 4 bytes apart
DE94 E2 F8     C      loop   i_pic_soft ; until cx = 0.
C
C      ; Install hardware diagnostic interrupt vectors.
C
DE96 B8 FF23 R  C      mov     ax,es:(offset ill_int) ; ax = offset ill_int
DE99 BF 0020 R  C      mov     di,es:(offset int08looc) ; es:di = ab00_seg:int08looc
DE9C B1 08     C      mov     cl,8 ; load INT's 8h through Fh.
C
DE9E          i_pic_hard: C      ; es:di gets offset ill_int
DE9E AB        C      stow     ; skip segment (already = es)
DE9F 47        C      inc     di
DEA0 47        C      inc     di
DEA1 E2 FB     C      loop   i_pic_hard ; until cx = 0.
C
C      ; Test software interrupts first (cl = 0 if error).
C
DEA3 B7 09     C      mov     bh,09h ; bx has its 8th and 11th bits set.
C
C      ; cx = 0 from loop above.
C
DEA5 F6 F5     C      div     oh ; generate a divide-by-zero INT 00h
DEA7 EB 33     C      jmp     short i_pic_err
DEA9          i_pic_0_ok: C      ; bh = 09h, set trap & OF flags in bx
C      ; (bits 8 and 11 of flags).
DEA9 53        C      push    bx ; put trap flags on stack
DEAA 9D 1C     C      popf   ; generate a single-step trap INT 01h
DEAB EB 2F     C      jmp     short i_pic_err ; must be 4 bytes long!
DEAD          i_pic_1_ok: C
DEAD CD 02     C      INT     02h ; generate a software interrupt INT 02h
DEAF EB 28     C      jmp     short i_pic_err ; must be 4 bytes long!
DEB1          i_pic_2_ok: C
DEB1 INT     03h ; generate a 1-byte break-point INT 03h
DEB2 90       C      nop     ; must be 4 bytes long!
DEB3 EB 27     C      jmp     short i_pic_err
DEB5          i_pic_3_ok: C
DEB5 INT0    C      ; OF overflow flag is still set.
DEB6 90       C      nop     ; generate an overflow interrupt INT 04h
DEB7 EB 23     C      jmp     short i_pic_err ; must be 4 bytes long!
DEB9          i_pic_4_ok: C
C
C      ; Test hardware interrupts second.
C
C      ; Test 8259A PIC interrupt mask with test patterns (cl = 0 if error).
C
DEB9 B0 01     C      mov     al,1 ; initialize mask value = 1
C
DEBB          i_pic_test: C
DEBB EB E1ED R C      call   i_out_mask ; output pattern, test input
DEBE 75 1C     C      jne   i_pic_err ; if not same pattern, abort
DECF D0 D0     C      rol   al,1 ; rotate test pattern
DECE 73 F7     C      jne   i_pic_test ; test again, if not finished
C
DECN B0 FF     C      mov     al,0FFh ; test pattern of all ones
DECS EB E1ED R C      call   i_out_mask ; output pattern, test input
DECD 75 11     C      jne   i_pic_err ; if not same pattern, abort
C
C      ; Look for 'hot' (active though masked off) PIC interrupts (cl = IR# if error).
C
C      ; Enable interrupts for the very first time!
C
DECD FB       C      sti    ; enable interrupts
DECC 33 C9     C      xor     cx,cx ; delay awhile, waiting for
DECE E2 FE     C      loop   $ ; a 'hot' interrupt.
C
DEDD A0 006B R C      mov     al,byte ptr ds:[intr_flag] ; get the flag from ill_int
DEDE 04 C0     C      or     al,al ; intr_flag = 0?
DEDE 74 34     C      jz     i_pic_ok ; if so, we're all done.
C
C      ; Convert 'hot' interrupt mask (bit pattern) to IR# (1 to 8 error code).
C
DEDD          i_pic_hot: C
DEDD 41        C      inc     cx ; cx = 0 from loop above.
DEDE D0 DB     C      ror     al,1 ; increment cx (IR#+1).
DEDD 75 FB     C      jnb   i_pic_hot ; mask's least significant bit.
C      ; if not set, continue.
C      ; (exit with cl = 1 to 8.)
C
DEDD          i_pic_err: C
DEDD BC 0100  C      mov     sp,100h ; cl = 0 or failing PIC 'hot' active IR#
DEDD          ; re-initialize stack
DEDD          ; save error code.
DEDD 51        C      push    ox
C
C      ; Install Vector Table. ; set int10looc = code_seg:v_10, and

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DEE0 EB E1A0 R      C      call    i_vector          ; set int1Dloon = code_seg:v_parms.
C
C      ; Initialize Video.
C
DEE3 EB E148 R      C      call    i_d_init
C
C      ; Display error message.
C
DEE6 BE DC7F R      C      mov     si,cs:(offset i_pic_m)
DEE9 EB E5FA R      C      call    DRomString        ; display failing test message.
C
DEEC BE DC45 R      C      mov     si,cs:(offset fail_m)
DEEF EB E5FA R      C      call    DRomString        ; display fail message.
C
DEF2 59             C      pop     cx                ; restore error code.
DEF3 0A C9          C      or     cl,cl              ; cl = 0?
DEF5 74 0E          C      jz     i_pic_no_hot      ; if so, we're done.
C
C      ; Display 'hot' interrupt number :Hx. (where x is the IR# from 0 to 7)
C
DEF7 EB E626 R      C      call    DColon           ; display a colon.
DEFA BB 0848          C      mov     ax,(0Eh*100h)+'H' ; display 'hot' interrupt symbol.
DEFD CD 10           C      int    10h
DEFF 8A C1          C      mov     al,al            ; transfer error code.
DF01 48             C      dec     ax                ; error code (1 to 8) to (0 to 7) IR#.
DF02 EB E650 R      C      call    DHexNib         ; display lowest nibble.
C
DF05             C      i_pic_no_hot:
DF05 EB E619 R      C      call    DCrLf           ;
DF08 EB 07          C      jmp     short i_pic_end
C
DF0A F4            C      hlt
C
DF0B             C      i_pic_ok:
DF0B B0 45          C      mov     al,45h           ; Check Point #5
DF0D BA 0378       C      mov     dx,378h         ; parallel port data port address
DF10 EB             C      out     dx,al            ; output "Running- Checkpoint 5"
C
DF11             C      i_pic_end:
C
C      ;-----
C      ; Install Vector Table.
C      ;-----
DF11 BC 0100       C      mov     sp,100h        ; re-initialize stack
DF14 EB E1A0 R      C      call    i_vector
C
C      ;-----
C      ; Determine System Configuration from Switches and Initialize Video.
C      ;-----
DF17 EB E148 R      C      call    i_d_init
C
C      ;-----
C      ; Display Passing Error Messages
C      ;-----
DF1A             C      disp_pass:
DF1A BE DB8C R      C      mov     si,cs:(offset banner_m)
DF1D EB E5FA R      C      call    DRomString
C
DF20 BE DC4B R      C      mov     si,cs:(offset i_opu_m)
DF23 EB E5FA R      C      call    DRomString
DF26 BE DC3D R      C      mov     si,cs:(offset pass_m)
DF29 EB E5FA R      C      call    DRomString
C
DF2C BE DC58 R      C      mov     si,cs:(offset i_rom_m)
DF2F EB E5FA R      C      call    DRomString
DF32 BE DC3D R      C      mov     si,cs:(offset pass_m)
DF35 EB E5FA R      C      call    DRomString
C
DF38 BE DC65 R      C      mov     si,cs:(offset i_dmat_m)
DF3B EB E5FA R      C      call    DRomString
DF3E BE DC3D R      C      mov     si,cs:(offset pass_m)
DF41 EB E5FA R      C      call    DRomString
C
DF44 BE DC72 R      C      mov     si,cs:(offset i_dmac_m)
DF47 EB E5FA R      C      call    DRomString
DF4A BE DC3D R      C      mov     si,cs:(offset pass_m)
DF4D EB E5FA R      C      call    DRomString
C
DF50 BE DC7F R      C      mov     si,cs:(offset i_pic_m)
DF53 EB E5FA R      C      call    DRomString
DF56 BE DC3D R      C      mov     si,cs:(offset pass_m)
DF59 EB E5FA R      C      call    DRomString
C
C      ;-----
C      ; Size & clear RAM at every 64k byte bank past the lowest 64k.
C      ;-----
DF5C             C      RAM_size_tst:
DF5C             C      assume cs:code, ds:data, es:abs0, ss:stack_ram
DF5C BD 0040        C      mov     bp,64           ; initialize memory count
C
DF5F 8B 36 0072 R   C      mov     si,word ptr ds:[reset_flag] ; get warm bootflag
DF63 81 EE 1234    C      sub     si,01234h        ; si=0 iff CTL ALT DEL sequence.
DF67 33 FF         C      xor     di,di            ; offset = 0000h
C

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DF69 BA 1000      C      mov     dx,1000h      ; start at 1000:0000 (dx keeps segment)
DF6C              C      RAM_size_lp:
DF6C 8E C2        C      mov     es,dx          ; get segment
C
DF6E 26: 8B 05    C      mov     ax,word ptr es:[di] ; read existing ram value
DF71 F7 D0        C      not     ax             ; complement it
DF73 26: 89 05    C      mov     word ptr es:[di],ax ; write complement back to RAM
C
DF76 26: 8B 1D    C      mov     bx,word ptr es:[di] ; read back from RAM
C
DF79 3B C3        C      cmp     ax,bx         ; verify to test for end of RAM
DF7B F7 D0        C      not     ax             ; recreate original value
DF7D 75 2C        C      jne     RAM_size_end   ; if verify fails, at end of RAM
C
DF77 26: 89 05    C      mov     word ptr es:[di],ax ; restore original value back to RAM
DF82 0B F6        C      or     si,si          ; test warm boot flag
DF84 74 1D        C      jz     RAM_size_next  ; if CTL ALT DEL sequence,
C                          ; don't clear memory
DF86 EB E266 R    C      call   testst         ; test and clear memory
DF89 75 3E        C      jnz     RAM_error     ; test flag from storage test
C
DF8B 83 C5 40     C      add     bp,64         ; increment size
DF8E 56           C      push   si             ; save Warm Boot Flag
DF8F B8 0E0D     C      mov     ax,0E0Dh     ; put out a CR
DF92 CD 10       C      INT    10H
C
DF94 8B C5        C      mov     ax,bp         ; display tested RAM
DF96 BB 0003     C      mov     bx,3
DF99 EB E66D R    C      call   DNnum
DF9C BE DCEA R    C      mov     si,cs:(offset i_RAM_m)
DF9F EB E5FA R    C      call   DRomString
C
DFA2 5E          C      pop     si             ; retrieve Warm Boot Flag
C
DFA3              C      RAM_size_next:
DFA3 80 C6 10     C      add     dh,10h       ; maximum RAM = 640k = 10 * 64k
DFA6 80 FE A0     C      cmp     dh,0A0h     ; next segment
DFA9 72 C1        C      jb     RAM_size_lp   ; top of RAM yet (A000:0000)?
C                          ; if not, continue.
C
DFAB              C      RAM_size_end:
DFAB 0B F6        C      assume es:code, ds:data, es:abs0, ss:stack_ram
DFAD 74 06        C      or     si,si         ; test warm boot flag
DFAF BE DC3D R    C      mov     si,cs:(offset pass_m) ; if CTL ALT DEL sequence,
DFB2 EB E5FA R    C      call   DRomString   ; Display OK
C
DFB5              C      RAM_size_end_1:
DFB5 33 C0        C      xor     ax,ax        ; bx = RAM size/16
DFB7 BE C0        C      mov     ax,ax        ; ax = 0
DFB9 8A C6        C      mov     al,dh        ; satisfy assumptions es = 0 = abs0_seg
DFBB D1 E0        C      and    al,dh        ; ax = (RAM size/16)/256 = RAM size/4k
DFBD D1 E0        C      shl    ax,1         ; ax = (RAM size/4k) * 2 = RAM size/2k
DFBF D1 E0        C      shl    ax,1         ; ax = (RAM size/2k) * 2 = RAM size/1k
C
DFC1 2E: 8E 1E E5F2 R C      mov     ds,word ptr es:[set_ds_word] ; restore data segment pointer
DFC4 A3 0013 R    C      mov     word ptr ds:[memory_size],ax
C
; GoTo Display Passing Messages
C
DFC7 EB 30        C      jmp     short i_oval ;Go check clock calendar
C
DFC9              C      RAM_error:
DFC9              C      ; Error message looks like: Fail:cc:y000:zzzz:www:rrrr
DFC9              C      ; where: cc = RAM oonfiguration number
DFC9              C      ;         y000 = Segment of failure = dx = es
DFC9              C      ;         zzzz = Offset of failure = di
DFC9              C      ;         www = Data that was written = ax
DFC9              C      ;         rrrr = Data that was read = bx
C
DFC9 52          C      push   dx             ;save failing segment
DFCA 1E          C      push   ds             ;save ds
DFCB 50          C      push   ax             ; save failing test pattern.
C
DFCC EB E619 R    C      call   DCrlf         ;Carriage Return, Line Feed
DFCF BE DC45 R    C      mov     si,cs:(offset fail_m)
DFD2 EB E5FA R    C      call   DRomString   ; display fail message.
C
DFD5 EB E626 R    C      call   DColon       ; display a colon
C
DFDB E4 66        C      in     al,sys_conf_a ; get RAM configuration.
DFDA 24 0F        C      and    al,0FH        ; mask valid bits.
DFDC EB E643 R    C      call   DHexByte     ; display RAM configuration.
C
DFDF EB E626 R    C      call   DColon       ; display a colon
C
DFE2 8E DA        C      mov     ds,dx         ; ds = failing segment = dx
DFE4 8B C7        C      mov     ax,di         ; ax = failing segment = di
DFE6 EB E632 R    C      call   DHexLong     ; display ds:ax
C
DFE9 EB E626 R    C      call   DColon       ; display a colon
C
DFEC 1F          C      pop     ds            ; ds = failing test pattern = on stack
DFED 8B C3        C      mov     ax,bx         ; ax = what was read = bx
DFEF EB E632 R    C      call   DHexLong     ; display ds:ax
C
DFE9 EB E619 R    C      call   DCrlf
C
DFE5 1F          C      pop     da            ;restore ds
DFE6 5A          C      pop     dx            ;restore failing segment
DFE7 EB BC        C      jmp     short RAM_size_end_1

```

ROM BIOS Listing

```

-----
;
; MMS8174 Clock Calendar Device Test
;
-----
C
C
C          assume cs:code, ds:data, es:abs0, ss:stack_ram
C
DFF9      i_cal:
C
C          ; Read Clock Calendar Device.           ; bx = day (from 1-1 of leap year)
C
DFF9 B4 FE          mov ah,-2                    ; ch = hour
DFFB CD 1A          int 1Ah                      ; cl = minutes
; Check time & date read.                        ; dh = seconds
; Hundredths of Seconds.                        ; dl = hundredths of seconds
C
DFFD B8 000A        mov ax,10                    ; ax = 10; dl = hundredths
E000 86 C2          xchg al,dl                    ; ax = hundredths; dl = 10
E002 F6 F2          div dl                    ; ah = remainder, al = quotient
; (can only read tenths of seconds.)
E004 3D 000A        cmp ax,10                    ; ah should = 0, and al should be < 10.
E007 73 15          jae i_cal_1_1_80          ; if not, test chip & write 1-1-80.
C
C          ; Seconds.
C
E009 80 FE 3C        cmp dh,60                    ; dh = seconds should be < 60.
E00C 73 10          jae i_cal_1_1_80          ; if not, test chip & write 1-1-80.
C
C          ; Minutes.
C
E00E 80 F9 3C        cmp cl,60                    ; cl = minutes should be < 60.
E011 73 0B          jae i_cal_1_1_80          ; if not, test chip & write 1-1-80.
C
C          ; Hours.
C
E013 80 FD 18        cmp ch,24                    ; ch = hour should be < 24.
E016 73 06          jae i_cal_1_1_80          ; if not, test chip & write 1-1-80.
C
C          ; Days.
C
E018 81 FB 0B6A      cmp bx,(2*366)+(6*365)      ; bx = day from leap year mod 8 should
E01C 72 5D          jb i_cal_end                ; be < (0-2921) = (0-0B69h)
; if so, valid time & day, skip test.
E01E                      i_cal_1_1_80:            ; else invalid time & day, write 1-1-80.
C
C          ; Initialize and Stop Clock.
C
E01E 33 C0          xor ax,ax                    ; ax = 0
E020 E6 70          out 70h,al                  ; test only port = out of test mode
E022 E6 7E          out 7Eh,al                  ; stop/start port = stop clock
C
C          ; Output test pattern of maximum value with all bits set to read/writable ports.
C
E024 BE DD51 R        mov si,cs:(offset i_cal_val) ; ch keeps 0; cx = 9
E027 B9 0009          mov cx,9                    ; dh keeps 0; dx = 74h
E02A BA 0074          mov dx,0074h
C
C          i_cal_max:
C
E02D      lods      byte ptr cs:[si]          ; al get cs:si (ds overridden).
E02F 8A E0          mov ah,al                    ; save maximum value.
E031 EE          out dx,al                    ; ports 74 through 7C (units of minutes
; to tens of months) get max value.
C
E032 EC          in ax,dx                    ; read it back.
E033 22 C4          and al,ah                    ; mask valid bits.
E035 3A C4          cmp al,ah                    ; is it equal to the value written?
E037 75 28          jnz i_cal_err                ; if not, abort.
C
E039 42          inc dx                        ; increment to next port
E03A E2 F1          loop i_cal_max
C
E03C B0 07          mov al,07h                  ;
E03E B2 7F          mov dl,7Fh                  ; dh kept 0; dx = 7Fh
E040 EE          out dx,al                    ; interrupt (year mod 8) gets 0Fh.
E041 EC          in ax,dx                    ; must do 'in' from this port 3 times.
E042 EC          in al,dx
E043 EC          in al,dx
E044 24 07          and al,07h                  ; mask valid bits.
E046 2C 07          sub al,07h                  ; is it equal to the value written?
E048 75 17          jnz i_cal_err                ; if not, abort.
C
C          ; Write out 0h (bits of lower nibble reset) test pattern to read/writable ports.
C
E04A B1 09          mov cl,9                    ; al kept 0h.
E04C B2 74          mov dl,74h                  ; ch kept 0; cx = 9
E04E EE          out dx,al                    ; dh kept 0; dx = 74h
C
C          i_cal_0:
C
E04F EC          in ax,dx                    ; ports 74 through 7C (units of minutes
E050 24 0F          and al,0Fh                  ; to tens of months) get 0h.
E052 75 0D          jnz i_cal_err                ; read it back.
; mask valid bits (lower nibble) = 0h?
; if not, abort.
C
E054 42          inc dx                        ; increment to next port
E055 E2 F7          loop i_cal_0
C
E057 B2 7F          mov dl,7Fh                  ; dh kept 0; dx = 7Fh
E059 EE          out dx,al                    ; interrupt (year mod 8) gets 0Fh.

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E05A EC          C      in      al,dx          ; must do 'in' from this port 3 times.
E05B EC          C      in      al,dx
E05C EC          C      in      al,dx
E05D 24 0F      C      and     al,0Fh          ; mask valid bits (lower nibble) = 0h?
E05F 74 12      C      jz      i_cal_ok          ; if so, we're all done.
                                     ; else, abort.
E061            C      i_cal_err:
E061 BE DCA6 R   C      mov     si,cs:(offset i_rtc_m)
E064 E8 E5FA R   C      call    DROMString
E067 BE DC45 R   C      mov     si,cs:(offset fail_m)
E06A E8 E5FA R   C      call    DROMString          ; display fail message.
E06D EB E619 R   C      call    DCrLf
E070 EB 01       C      jmp     short i_cal_ok          ; try to write 1-1-80, regardless...
E072 FA         C      hit
E073            C      i_cal_ok:
E073 33 DB         C      xor     bx,bx          ; 1-1-80 is day 0.
E075 33 C9         C      xor     cx,cx          ; hours & minutes = 0.
                                     ; Write & Start Clock Calendar Device.
E077 B4 FF         C      mov     ah,-1          ; bh = day (from 1-1 of leap year)
E079 CD 1A         C      int    1Ah          ; oh = hour
                                     ; ol = minutes
                                     ; Output: ah = -1 implies date/time err.
                                     ;         ah = 0 implies date/time OK.
E07B            C      i_cal_end:
-----
; 18253 Real-Time Time Clock Test (p_8253_1 tested in i_dmat)
-----
E07B            C      assume cs:code, ds:data, es:abs0, ss:stack_ram
                                     i_rtc:
; String to be displayed regardless of results.
E07B BE DCA6 R   C      mov     si,cs:(offset i_rtc_m)
E07E E8 E5FA R   C      call    DROMString
; Test 18253 real-time clock interrupt p_timer counter (p_8253_0).
E081 B0 34         C      mov     al,034h          ; 00 11 010 0 -> p_8253_0, lab 1st, mode 2, no BCD
E083 BA 0040      C      mov     dx,p_8253_0      ; select real-time clock counter
E086 EB E1F6 R   C      call    rtc_chk
E089 75 2E         C      jnz     i_rtc_err          ; if nz, ah has error code to report.
; Test 18253 tone generator p_timer counter (p_8253_2).
E08B B0 01         C      mov     al,1           ; clear kb interrupts, reset kb, disable parity
E08D E6 61         C      out    p_kotrl,al      ; turn off speaker data -- bit #1
                                     ; turn on speaker gate to p_8253_2 -- bit #0
E08F B0 B4         C      mov     al,0B4h          ; 10 11 010 0 -> p_8253_2, lab 1st, mode 2, no BCD
E091 BA 0042      C      mov     dx,p_8253_2      ; select tone generator counter
E094 E8 E1F6 R   C      call    rtc_chk
E097 B0 00         C      mov     al,0           ; clear kb interrupts, reset kb, disable parity
E099 E6 61         C      out    p_kotrl,al      ; turn off speaker data & gate -- bits #1 & #0
E09B 75 1C         C      jnz     i_rtc_err          ; if nz, ah has error code to report.
; Initialize 18253 real-time clock interrupt p_timer counter (p_8253_0).
E09D B0 36         C      mov     al,t0cmd
E09F E6 43         C      out    p_8253_ctrl,al   ; select real time clock counter
E0A1 B8 0000      C      mov     ax,t0count
E0A4 E5 40         C      out    p_8253_0,al      ; load real time clock count
E0A6 8A C4        C      mov     al,ah
E0A8 E6 40         C      out    p_8253_0,al
; Initialize 18253 tone generator p_timer counter (p_8253_2).
E0AA B0 B6         C      mov     al,t2cmd
E0AC E6 43         C      out    p_8253_ctrl,al   ; select tone generator counter
E0AE B8 0266      C      mov     ax,t2count
E0B1 E6 42         C      out    p_8253_2,al      ; load tone generator count
E0B3 8A C4        C      mov     al,ah
E0B5 E6 42         C      out    p_8253_2,al
E0B7 EB 1C         C      jmp     short i_rtc_ok
E0B9            C      i_rtc_err:
E0B9 BE DC45 R   C      mov     si,cs:(offset fail_m)
E0BC E8 E5FA R   C      call    DROMString          ; display fail message.
E0BF BE DCA6 R   C      mov     si,cs:(offset i_rtc_lo_m-(4*1))
E0C2 8A C4        C      mov     al,ah
E0C4 32 E4        C      xor     ah,ah
E0C6 D1 E0        C      shl     ax,1           ; ah = error code = (1, 2 or, 3)
E0C8 D1 E0        C      shl     ax,1           ; ax = error code = (1, 2 or, 3)
E0CA 03 F0        C      and     ax,ax          ; ax = 2*(error code) = (2, 4, or 6)
E0CC E8 E5FA R   C      call    DROMString          ; ax = 4*(error code) = (4, 8, or 12)
E0CF E8 E619 R   C      call    DCrLf          ; index to (L0, H1, or NR message.)
                                     ; display failing mode.

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ROM BIOS Listing

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E0D2 EB 0D          C          jmp     short i_rtc_end
E0D4 F4            C          bit
E0D5 BE DC3D R     C          i_rtc_ok:
E0D8 E8 E5FA R     C          mov     si,cs:(offset pass_m)
E0DB B0 48         C          oall   DRomString
E0DD BA 0378       C          mov     al,48h           ; Check Point #8
E0E0 EE           C          mov     dx,378h         ; parallel port data port address
E0E1              C          out     dx,al           ; output "Running- Checkpoint 8"
E0E1              C          i_rtc_end:
E0E1 B8 E0E7         C          mov     ax,(0Eh*100h)+BEH ; beep keyboard
E0E4 CD 10         C          int     10h
E0E6 E9 E2E4 R     C          jmp     point
E0E9              C          diagnostics_1 endp
E0E9              C          -----
E0E9              C          ; Fatal Error Routine.
E0E9              C          ; Input:  cs:si = points to offset of failing error message
E0E9              C          ;         if ah <> 0, do DHexByte of ah.
E0E9              C          ;         if ah = 0, do nothing (just print error).
E0E9              C          ; Output: None.
E0E9              C          ; Trash:  al, dx, & si destroyed.
E0E9              C          -----
E0E9              C          i_fatal proc    near
E0E9              C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
E0E9              C          ; Disable 8237A p_dma Controller.
E0E9 B0 04          C          mov     al,dma_cmd_disable ; disable p_dma controller command
E0EB E6 08          C          out     dma_command,al
E0ED E6 0D          C          ; Send a 'master clear' to 8237 p_dma Controller.
E0ED          C          dma_master_clr,al ; send master clear port any garbage
E0ED          C          ; Load 64k (0FFFFh+1) count for RAM refresh p_dma controller channel.
E0EF B0 FF          C          mov     al,0FFh
E0F1 E6 01          C          out     dma_count_0,al    ; low byte of count for 64k RAM refresh
E0F3 E6 01          C          out     dma_count_0,al    ; high byte of count for 64k RAM refresh
E0F5          C          ; Load mode for RAM refresh p_dma controller channel: channel 0, read, auto-
E0F5          C          ; initialize, increment, single mode.
E0F5 B0 58          C          mov     al,dma_mode_0     ; mode for RAM refresh
E0F7 E6 08          C          out     dma_mode,al
E0F9          C          ; Enable p_dma controller: memory-to-I/O, controller enable, normal, fixed
E0F9          C          ; priority, late write, and DREQ/~DACI.
E0F9 B0 00          C          mov     al,dma_cmd_enable ; enable p_dma controller
E0FB E6 08          C          out     dma_command,al
E0FD          C          ; The master clear command above has masked off all channels. Now, we 'unmask'
E0FD          C          ; the RAM refresh dma_mask bit. p_dma RAM refresh begins for the first time!
E0FD B0 00          C          mov     al,dma_unmask_0   ; turn on RAM refresh channel 0
E0FF E6 0A          C          out     dma_mask_bit,al
E101          C          ; Program p_8253_1 of i8253 p_timer to proper value for RAM refresh.
E101 B0 78          C          mov     al,t1cmd         ; select p_dma refresh counter
E103 E6 43          C          out     p_8253_ctrl,al
E105          C          ; load p_dma refresh count
E105 B0 13          C          mov     al,t1count
E107 E6 41          C          out     p_8253_1,al
E109          C          ;
E109 B2 C0          C          mov     al,al
E10B E6 41          C          out     p_8253_1,al
E10D          C          assume  cs:code, ds:nothing, es:nothing, ss:stack_ram
E10D B0 87          C          mov     di,es            ; save stack pointer
E10F B8 EC          C          mov     bp,sp
E111 BA 0030        C          mov     dx,stack_seg
E114 B2 D2          C          mov     ss,dx
E116 BC 0100        C          mov     sp,100h
E119 50            C          push    ax                ; save error code
E11A          C          ; Initialize & Disable 8259A Programmable Interrupt Controller.
E11A E8 E1DC R     C          call   i_pic_init
E11B          C          ; Install Vector Table.
E11B          C          ; set int10locn = code_seg:v_10, and
E11B          C          ; set int1Dlocn = code_seg:v_parms.
E11D E8 E1A0 R     C          call   i_vector
E11E          C          ; Initialize Video.
E11E          C          ;

```

ROM BIOS Listing

```

E120 E8 E1A8 R      C          call    i_d_init
C
C          ; Display error message.
C
E123 58             C          pop     ax          ; restore error code
C
E124 E8 E5FA R      C          call    DRomString    ; display string at cs:si.
C
E127 BE DCA5 R      C          mov     si,cs:(offset fail_m)
E12A E8 E5FA R      C          call    DRomString    ; display fail message.
C
E12D 0A E4          C          or      ah,ah        ; ah = 0?
E12F 74 08          C          jz     i_fatal_ret    ; if so, no arguments
C
E131 E8 E626 R      C          call    DColon        ; display a colon
C
E134 8A C4          C          mov     al,ah        ; display error code
E136 E8 E643 R      C          call    DHexByte
C
E139              C          i_fatal_ret:
E139 E8 E619 R      C          call    DCrLf
C
C          ;Output fatal error status for manufacturing tests
C
E13C BA 0378        C          mov     dx,378h      ; parallel port address
E13F EC            C          in     al,dx        ; read last checkpoint value
E140 34 3F          C          xor     al,03Fh     ; extract checkpoint number from status
E142 EE            C          out    dx,al        ; output "Hot OE - number"
C
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
C
E143 8E D7          C          mov     ss,di        ; restore stack pointer
E145 8B E5          C          mov     sp,bp
C          ;
C
E147 FA            C          hit
C
E148              C          i_fatal endp
C
C          -----
C          ; Determine System Configuration from Switches and Enable Video.
C          ;
C          ; Input: None.
C          ; Output: None.
C          ;
C          ; Trash: ax & cx destroyed.
C          -----
E148              C          i_d_init      proc  near
C          assume cs:code, ds:nothing, es:nothing, ss:stack_ram
E148 1E            C          push    ds          ; save registers
C
C          ; Initialize both boards.
C
C          assume cs:code, ds:data, es:nothing, ss:stack_ram
E149 B8 0040        C          mov     ax,data_seg  ; ds = ax = data_seg = 0040h.
E14C 8E D8          C          mov     ds,ax        ; (ah = 0.)
C
C          ; Initialize monochrome board.
C
E14E B0 30          C          mov     al,30h      ; switch_bits for monochrome.
E150 A3 0010 R      C          mov     word ptr ds:[switch_bits],ax ; set data for monochrome.
E153 CD 10          C          INT     10h         ; ah = 0 = v_set_mode.
C
C          ; Initialize color board.
C
E155 B8 0003        C          mov     ax,0003h    ; switch_bits for not monochrome.
E158 A3 0010 R      C          mov     word ptr ds:[switch_bits],ax ; set data for color.
E15B CD 10          C          INT     10h         ; ah = 0 = v_set_mode.
C
C          ; Determine system configuration from switches (low byte of switch_bits).
C
E15D E4 67          C          in     al,sys_conf_b ; read high nibble of
C          ; system configuration switches.
C          ; bits #7 - #6: (number of FDU's)-1
E15F 24 F0          C          and    al,0F0h     ; bits #5 - #4: monitor type
C          ; mask off low nibble (keep high nibble)
E161 0C 0D          C          or     al,00Dh     ; of low byte; clear high byte.
C          ; ALWAYS 64k planar RAM and >= 1 FDU!
C
E163 8A C8          C          mov     cl,al
E165 B5 03          C          mov     oh,03h     ; cl is ok, excepts bits #5 & #4.
C          ; initialize display to mode #3 (default).
C
E167 24 30          C          and    al,030h     ; isolate display switches (bits #5 & #4).
E169 74 1C          C          js     i_d_80x25   ; if zero, default to 80x25 color.
E16B 3C 30          C          cmp    al,030h     ; is it the monochrome board?
E16D 75 1E          C          jnz    i_d_ok      ; if not, 40x25 or 80x25 color ok.
C
C          assume cs:code, ds:v_ram, es:nothing, ss:stack_ram
E16F 1E            C          push    ds          ; save ds = data_seg = 0040h.
E170 B8 B000        C          mov     ax,para_mono ; satisfy assumptions
E173 8E D8          C          mov     ds,ax
E175 B0 A5          C          mov     al,0A5h    ; test pattern
E177 A2 0000        C          mov     byte ptr ds:[0000h],al ; if so, is monochrome there?
E17A 8A 26 0000    C          mov     ah,byte ptr ds:[0000h] ; read monochrome RAM
E17E 1F            C          pop     ds          ; restore ds = data_seg = 0040h.

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ROM BIOS Listing

```

C                                     assume es:code, ds:data, es:nothing, ss:stack_ram
C
E17F 3A C4      C      cmp     al,ah           ; if monochrome RAM is there,
E181 75 04      C      jnz     i_d_80x25     ; then the board must be there!
C                                     ; if not, default to 80x25 color
E183 B5 07      C      mov     ch,07h       ; if there, we believe switches,
E185 EB 06      C      jmp     short i_d_ok    ; initialize display to mode #7.
C
E187           C      i_d_80x25:
E187 80 E1 EF      C      and     ol,0EFh     ; reset bit #8 for 80x25 color.
E18A 80 C9 20      C      or      ol,020h     ; set bit #5 for 80x25 color.
C
E18D           C      i_d_ok:
C                                     ; Set system configuration (switch_bits) from switches.
C
E18D 32 E4      C      xor     ah,ah         ; ah = 0.
E18F 8A C1      C      mov     al,al        ; get data from switches.
E191 A3 0010 R   C      mov     word ptr ds:[switch_bits],ax ; save data from switches
C
C                                     ; Determine mode to initialize display monitor (from switches).
C
E19A A8 20      C      test    al,020h      ; does user want 40x25 color?
E196 75 02      C      jnz     i_d_mode     ; if so, initialize mode #1.
E198 B5 01      C      mov     ch,01h
E19A           C      i_d_mode:
C                                     ; Initialize desire board (from switches).
C
E19A 8A C5      C      mov     al,ah        ; transfer display mode to al.
E19C CD 10      C      INT    10h         ; ah = 0 = v_set_mode.
C
E19E 1F        C      pop     ds          ; restore registers
E19F C3        C      ret
C
E1A0           C      i_d_init      endp
C
C-----
C                                     Install Vector Table
C
C                                     Input: None.
C                                     Output: None.
C
C                                     Trash: ax = cx = 0 destroyed.
C-----
C
E1A0           C      i_vector      proc   near
C                                     assume es:code, ds:nothing, es:nothing, ss:stack_ram
C
E1A0 1E        C      push    ds          ; save registers
E1A1 06        C      push    es
E1A2 57        C      push    di
E1A3 56        C      push    si
C
C                                     ; Initialize Interrupt Vectors 00h through 07h to known routines.
C
E1A4 33 FF      C      assume es:code, ds:abs0, es:abs0, ss:stack_ram
E1A6 8E DF      C      xor     di,di        ; satisfy assumptions
E1A8 8E C7      C      mov     ds,di       ; ds = es = ax = abs0_seg = 0
E1AA B8 FF23 R  C      mov     ax,cs:(offset ill_int) ; es:di = abs0_seg:int00100h
E1AD B9 0008    C      mov     cx,(07h-00h)+1 ; ax = offset ill_int
C                                     ; load INT's 00h through 07h.
C
E1B0 AB        C      i_vec0: stoww      ; es:di++ gets offset ill_int
E1B1 8C 0D      C      mov     word ptr ds:[di],cs ; es:di gets cs
E1B3 47        C      inc     di          ; di++
E1B5 E2 F9      C      loop   i_vec0     ; until cx = 0.
C
C                                     ; load INT's 02h and 05h
E1B7 C7 06 001A R FF5A R  C      mov     word ptr ds:[int05100h],cs:(offset a_int)
E1BD C7 06 0008 R FF5F R  C      mov     word ptr ds:[int02100h],cs:(offset a_int)
C
C                                     ; Initialize Interrupt Vectors 08h through 1Eh to known routines.
C
E1C3 8C C8      C      assume es:code, ds:code, es:abs0, ss:stack_ram
E1C5 8E D8      C      mov     ax,es        ; satisfy assumptions
E1C7 BE FEF3 R   C      mov     si,cs:(offset i_vec_tbl) ; ds = ax = cs
C                                     ; ds:si = code_seg:i_vec_tbl
E1CA B1 18      C      mov     cl,((1Fh-08h)+1) ; es:di = abs0_seg:int08100h
C                                     ; load INT's 08h through 1Fh.
C
E1CC A5        C      i_vec8: movsw     ; es:di++ gets ds:si (offset)
E1CD AB        C      stoww   ; es:di++ gets ax = cs (segment)
E1CE E2 FC      C      loop   i_vec8     ; until cx = 0.
C
C                                     ; Initialize Interrupt Vectors 20h and above to zero.
C
E1D0 33 C0      C      xor     ax,ax        ; ax = 0
E1D2 B9 01B8    C      mov     cx,((03F0h-0080h)/2) ; es:di = abs0_seg:int20100h
C                                     ; clear 0:0080h to 0:03F0h
E1D5 F3/ AB     C      rep     stoww      ; don't blow away stack!
C                                     ; es:di++ gets 0
E1D7 5E        C      pop     si          ; restore registers
E1D8 5F        C      pop     di
E1D9 07        C      pop     es
E1DA 1F        C      pop     ds

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ROM BIOS Listing

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E1DB C3          C          ret
E1DC          C          i_vector      endp
C          C          ;-----
C          C          ; Initialize & Disable 8259A Programmable Interrupt Controller.
C          C          ;
C          C          ; Input: None.
C          C          ; Output: None.
C          C          ;
C          C          ; Trash: al & dx destroyed.
C          C          ;-----
E1DC          C          i_pic_init    proc   near
C          C          assume  cs:code, ds:nothing, es:nothing, ss:stack_ran
E1DC BA 0020    C          mov     dx,pic_0      ; dx = pic_0 (8259A 'control' port)
E1DF B0 13     C          mov     al,pic_0low1   ; edge triggered, single, iow4 to follow
E1E1 EE       C          out     dx,al
C          C          ;
E1E2 42       C          inc     dx              ; dx = pic_1 (8259A 'data' port)
E1E3 B0 08     C          mov     al,pic_0low2   ; interrupt vector base address
E1E5 EE       C          out     dx,al
C          C          ; since we are single mode (no slave), skip iow3
C          C          ;
E1E6 B0 0D     C          mov     al,pic_0low4   ; dx = pic_1 (8259A 'data' port)
E1E8 EE       C          out     dx,al      ; not special fully nested, buffered,
C          C          ; master, normal end_of_int, 8086 mode
E1E9 B0 FF     C          mov     al,pic_off_mask ; mask all interrupts off for now
E1EB EE       C          out     dx,al      ; dx = pic_1 (8259A 'data' port)
E1EC C3       C          ret
E1ED          C          i_pic_init    endp
C          C          ;-----
C          C          ; Output Mask to 8259A Programmable Interrupt Controller.
C          C          ;
C          C          ; Input: AL = mask pattern
C          C          ; Output: Flags
C          C          ;
C          C          ; Trash: ah destroyed.
C          C          ;-----
E1ED          C          i_out_mask   proc   near
C          C          assume  cs:code, ds:nothing, es:nothing, ss:stack_ran
E1ED E6 21     C          out     pic_1,al    ;output interrupt mask pattern
E1EF 8A E0     C          mov     ah,al          ;save pattern for compar
E1F1 E4 21     C          in     al,pic_1      ;get mask from 8259
E1F3 3A E0     C          cmp     ah,al          ;the same ?
E1F5 C3       C          ret              ;return flags = result of compare
E1F6          C          i_out_mask   endp
C          C          ;-----
C          C          ; 8253 p_timer test for one p_timer counter channel
C          C          ;
C          C          ; Input: al = 8253 p_timer control byte
C          C          ; dx = port address of 8253 p_timer data (counter)
C          C          ;
C          C          ; Output: zf = set (z status) if no error; reset (nz status) if error
C          C          ; ah = Error codes: 0 -> No Error!
C          C          ; 1 -> Low below time interval window.
C          C          ; 2 -> High above time interval window.
C          C          ; 3 -> No Response.
C          C          ;
C          C          ; Trash: al, bx & cx destroyed.
C          C          ;-----
E1F6          C          rtc_chk    proc   near
C          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
E1F6 8A E0     C          mov     ah,al          ; save control byte for later.
E1F8 B9 FFFF   C          mov     cx,0FFFFh    ; time out for both Register Bit Tests.
C          C          ; Register Bit Test (All Reset): Count down from 100h until all bits reset.
E1FB 8B D9     C          mov     bx,cx
E1FD E6 43     C          out     p_8253_ctr1,al ; send 18253 p_timer control byte.
E1FF 32 C0     C          xor     al,al          ; al = 00h
E201 EE       C          out     dx,al          ; load low byte of p_timer count.
E202 FE C0     C          inc     al             ; al = 01h
E204 EE       C          out     dx,al          ; load high byte of p_timer count.
E205          C          rtc_chk_reset_lp:
E205 8A C4     C          mov     al,ah          ; get control byte for read.
E207 22 C0     C          and     al,0C0h       ; mask off all but top 2 bits.
E209 E6 43     C          out     p_8253_ctr1,al ; send latching control byte for read.
E20B EC       C          in     al,dx          ; get low byte of p_timer count.
E20C 22 D8     C          and     bl,al          ; 'and' low byte.
E20E 5C       C          in     al,dx          ; get high byte of p_timer count.
E20F 22 F8     C          and     bh,al          ; 'and' high byte.
E211 0B D8     C          or     bx,bx          ; is bx = 0?

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E213 74 05      C          jz      rtc_chk_reset_ok      ; if so, we're done.
E215 E2 EE      C          loop     rtc_chk_reset_lp      ; if not, continue reading.
C              C              ; (Note: loops less than 16 times.)
C
E217            C      rtc_chk_reset_err:      ; time out.
E217 B4 03      C          mov      ah,3      ; Error #3. (No Response.)
E219 C3          C          ret              ; return nz status (loop leaves zf ok).
C
E21A            C      rtc_chk_reset_ok:
C              C      ; Register Bit Test (All Set): Count down from 0h (FFFFh+1) until all bits set.
C
E21A 33 DB      C          xor      bx,bx      ; bx gets all its bits reset.
C
E21C 8A C4      C          mov      al,ah      ; get control byte for load.
E21E E6 A3      C          out      p_8253_ctrl,al      ; send i8253 p_timer control byte.
C
E220 32 C0      C          xor      al,al      ; al = 00h
E222 EE          C          out      dx,al      ; load low byte of p_timer count.
E223 EE          C          out      dx,al      ; load high byte of p_timer count.
C
E224            C      rtc_chk_set_lp:
E224 8A C4      C          mov      al,ah      ; get control byte for read.
E226 24 C0      C          and      al,0C0h      ; mask off all but top 2 bits.
E228 E6 A3      C          out      p_8253_ctrl,al      ; send latching control byte for read.
C
E22A EC          C          in      al,dx      ; get low byte of p_timer count.
E22B 0A D8      C          or       bl,al      ; 'or' low byte.
E22D EC          C          in      al,dx      ; get high byte of p_timer count.
E22E 0A F8      C          or       bh,al      ; 'or' high byte.
C
E230 81 FB FFFF  C          cmp      bx,0FFFFh      ; is bx = 0FFFFh?
E234 74 05      C          jz      rtc_chk_set_ok      ; if so, we're done.
E236 E2 EC      C          loop     rtc_chk_set_lp      ; if not, continue reading.
C              C              ; (Note: loops less than 16 times.)
C
E238            C      rtc_chk_set_err:      ; time out.
E238 B4 03      C          mov      ah,3      ; Error #3. (No Response.)
E23A C3          C          ret              ; return nz status (loop leaves zf ok).
C
E23B            C      rtc_chk_set_ok:
C              C      ; p_timer Time Window Test: Test p_timer versus CPU & see if it falls within spec.
C
E23B 8A C4      C          mov      al,ah      ; get control byte for read.
E23D 24 C0      C          and      al,0C0h      ; mask off all but top 2 bits.
E23F E6 A3      C          out      p_8253_ctrl,al      ; send latching control byte for read.
C
E241 EC          C          in      al,dx      ; get low byte of p_timer count.
E242 0A D8      C          or       bl,al      ; save low byte.
E244 EC          C          in      al,dx      ; get high byte of p_timer count.
E245 0A F8      C          or       bh,al      ; save high byte.
C
E247 8A C4      C          mov      al,ah      ; get control byte for read.
E249 24 C0      C          and      al,0C0h      ; mask off all but top 2 bits.
E24B E6 A3      C          out      p_8253_ctrl,al      ; send latching control byte for read.
C
E24D EC          C          in      al,dx      ; get low byte of p_timer count.
E24E 0A C8      C          or       cl,al      ; save low byte.
E250 EC          C          in      al,dx      ; get high byte of p_timer count.
E251 0A E8      C          or       ch,al      ; save high byte.
C
E253 2B D9      C          sub      bx,cx      ; calculate time difference.
C
C              C      ; Do Time Range Checking (4 <= bx <= 14).
C
E255 B4 02      C          mov      ah,2      ; Error #2. (High above time window.)
E257 83 FB 0E      C          cmp      bx,14      ; Error #2. (High above time window.)
E25A 77 09      C          ja      rtc_chk_high      ; return nz status. (ja has zf reset.)
C
E25C FE CC      C          dec      ah      ; Error #1. (Low below time window.)
E25E 83 FB 04      C          cmp      bx,4      ; Error #1. (Low below time window.)
E261 72 02      C          jb      rtc_chk_low      ; return nz status. (jb has zf reset.)
C
E263 FE CC      C          dec      ah      ; Error #0. (No Error!) return z status.
C
E265            C      rtc_chk_high:
E265            C      rtc_chk_low:
E265            C          ret
C
E266            C      rtc_chk endp
C
C      ;-----
C      ; RAM (64k) Storage Test.
C      ;
C      ; Input: dx = segment of RAM to be tested
C      ;
C      ; Output: zf = set (z status) if no error; reset (nz status) if error
C      ;          es:di = dx:di = failing RAM location if error; else di = 0.
C      ;          ax = test pattern (what was written).
C      ;          bx = if error, what was read.
C      ;          cx = number left to test if error; else cx = 0.
C      ;
C      ; Trash: None.
C      ;-----
C
E266            C      mov     near proc      ; assume ds:nothing, es:nothing, ss:nothing
C
E266 B9 8000      C          mov     cx,08000h      ; get word count

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E269 8E C2      C      mov     es,dx          ; (64k = 32k * 2 bytes/word)
E26B 33 FF      C      xor     di,di          ; es:di = address
E26D          C      mentat_w1:
E26D 8B C7      C      mov     ax,di          ;data = offset
E26F AB        C      stoww
E270 E2 FB      C      loop   mentat_w1
E272 8E DA      C      mov     dx,dx
E274 33 DB      C      xor     bx,bx
E276 B9 8000    C      mov     cx,08000h     ;ds:bx = address
E279          C      mentat_r1:
E279 8B 07      C      mov     ax,[bx]       ;read data
E27B 3B C3      C      cmp     ax,bx         ;verify data
E27D 75 2C      C      jne    mentat_err
E27F 43          C      inc    bx
E280 43          C      inc    bx
E281 E2 F6      C      loop   mentat_r1     ;next address
E283 B9 8000    C      mov     cx,08000h     ; word count
E286          C      mentat_w2:
E286 8B C7      C      mov     ax,di          ; address is already ok
E288 F7 D0      C      not    ax              ; data = offset
E28A AB        C      stoww
E28B E2 F9      C      loop   mentat_w2     ; complement it
E28D B9 8000    C      mov     cx,08000h     ; word count
E290          C      mentat_r2:
E290 8B 07      C      mov     ax,[bx]       ; read data
E292 F7 D0      C      not    ax              ; complement
E294 3B C3      C      cmp     ax,bx         ; verify
E296 75 0F      C      jne    mentat_err_c
E298 43          C      inc    bx
E299 43          C      inc    bx
E29A E2 F4      C      loop   mentat_r2
E29C B8 0000    C      mov     ax,0           ; to clear memory
E29F B9 8000    C      mov     cx,08000h     ; word count
E2A2 F3 AB      C      rep   stoww
E2A4 0B C0      C      or     ax,ax
E2A6 C3          C      ret
E2A7          C      mentat_err_c:
E2A7 F7 D0      C      not    ax              ; error during complemented
E2A9 F7 D3      C      not    bx              ; address test
E2AB          C      mentat_err:
E2AB 93          C      xchg  ax,bx           ;return registers as specified
E2AC C3          C      ret
E2AD          C      mentst      endp
E2AD          C      code ends
E2AD          C      include pwrup0.asm
E2AD          C      ;=====
E2AD          C      ; Filename:      pwrup0.src
E2AD          C      ;
E2AD          C      ; This module includes temporary hardware initialization.
E2AD          C      ;
E2AD          C      ; includes      Diagnostics
E2AD          C      ;              Cold Boot
E2AD          C      ;              Device Drivers
E2AD          C      ;
E2AD          C      ;=====
E2AD          C      code segment public 'ROM'
E2AD          C      assume cs:code, ds:nothing, es:nothing, ss:nothing
E2AD          C
E2AD          C      p0_data1    proc near
E2AD          C
E2AD 4F 70 74 69 6F 6E  C      opt_ROM_m    db 'Optional ROM at ',NUL
E2AD 61 6C 20 52 4F 4D  C
E2AD 20 61 74 20 00    C
E2AD          C
E2AD          C      p_tbl      dw prt_data_a      ; printer in port address space
E2AD          C      dw prt_data_b      ; always on mother board.
E2AD          C      dw prt_data_c      ; printer in port address space
E2AD          C      dw 0                ; no printer
E2AD          C
E2AD          C      sec_tbl     dw sec_ctl_b      ; ra232 SCC channel B
E2AD          C      dw sec_ctl_a      ; ra232 SCC channel A
E2AD          C
E2AD          C      alt_ret     dw i_alt_restart  ; 00h 28000 restart sequence offset
E2AD          C      code_seg    dw 02C000      ; 00h 28000 restart sequence segment
E2AD          C
E2AD          C      mastab     dw ((mt_end)-(mastab)) ; 00h master table byte length
E2AD          C
E2AD          C      dw kb_data_table ; 02h kb llation table offset
E2AD          C      code_seg    dw 02C000      ; 00h kb llation table segment
E2AD          C
E2AD          C      dw font_lo_8x8  ; 05h 1st 128 char.s 8x8 font offset
E2AD          C      code_seg    dw 02C000      ; 00h 1st 128 char.s 8x8 font segment
E2AD          C
E2AD          C      dw font_lo_8x16 ; 0Ah 1st 128 char.s 8x16 font offset
E2AD          C      code_seg    dw 02C000      ; 0Ch 1st 128 char.s 8x16 font segment
E2AD          C
E2AD          C      dw 0          ; 0Eh 2nd 128 char.s 8x16 font offset
E2AD          C

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E2DE 0000      C          dw      0          ; 10h 2nd 128 char.s 8x16 font segment
E2E0 0000      C          dw      0          ; 12h soft font utility offset
E2E2 0000      C          dw      0          ; 14h soft font utility segment
E2E4          C          ; 16h etc...
E2E4          C          at_end label word
E2E4          C          p0_data1 endp
E2E4          C          ;-----
E2E4          C          ; Initialize the basic hardware,
E2E4          C          ; Set up the interrupt pointers,
E2E4          C          ; Initialize all RAM variables,
E2E4          C          ; Clear the screen,
E2E4          C          ; Initialize the disk drivers,
E2E4          C          ; and perform the cold boot.
E2E4          C          ;-----
E2E4          C          point proc near
E2E4          C          assume cs:code, ds:data, es:data, ss:stack_ram
E2E4          C          mov     ax,data_seg      ; satisfy assumptions
E2E7 8E D8      C          mov     ds,ax
E2E9 8E C0      C          mov     es,ax
E2E4          C          ; Initialize Keyboard Controller.
E2EB 9C          C          pushf      ; save flags and
E2EC FA          C          ori          ; disable interrupts
E2ED BA 0061    C          mov     dx,p_kctrl      ; dx = p_kctrl
E2F0 B0 40      C          mov     al,40h          ; remove keyboard reset
E2F2 EE          C          out     dx,al
E2F3 33 C9      C          xor     ox,ox          ; delay
E2F5 E2 FE      C          loop    $
E2F7 B8 01      C          mov     ah,1           ; enable self test
E2F9 EB 9581 R   C          call   kb_end_send
E2FC 89 0E 0072 R C          mov     word ptr ds:[reset_flag],ox
E300 33 C9      C          xor     ox,ox          ; delay
E302 E2 FE      C          loop    $
E300          C          ; Flush any keyboard scan code and store AAh if we get it.
E304          C          kb_flush:
E304 B8 64          C          in     al,kb_status    ; get 8041 status
E306 48 01      C          test   al,1           ; test output buffer bit
E308 74 09      C          jz     kb_flush_back   ; jump if no character pending
E30A E4 60      C          in     al,p_kscan      ; get scan code from data port
E30C 3C AA      C          cmp    al,0AAh        ; verify keyboard present
E30E 75 F8      C          jnc    kb_flush
E310 A3 0072 R   C          mov     word ptr ds:[reset_flag],ax ; keyboard present
E313          C          kb_flush_back:
E313 E2 EF          C          loop   kb_flush       ; loop if zero
E315 33 C9      C          xor     ox,ox          ; delay
E317 E2 FE      C          loop   $
E317          C          ; Initialize System Variables.
E319 C7 06 0084 R E2CE R C          mov     word ptr ds:[master_tbi_ptr+0000h],cs:(offset mastab)
E31F 8C 0E 0086 R C          mov     word ptr ds:[master_tbi_ptr+0002h],cs
E319          C          ; Initialize Keyboard Driver Variables.
E323 B8 001E R   C          mov     ax,ds:(offset kb_buffer) ; pointer to beginning of buffer
E326 A3 001A R   C          mov     word ptr ds:[buffer_head],ax ; keyboard output pointer offset
E329 A3 001C R   C          mov     word ptr ds:[buffer_tail],ax ; keyboard input pointer offset
E32C A3 0080 R   C          mov     word ptr ds:[buffer_start],ax ; keeps beginning of buffer
E32F C7 06 0082 R 003E R C          mov     word ptr ds:[buffer_end],ds:(offset kb_buffer)+(size kb_buffer)
E32F          C          ; Assume first not Deluxe Keyboard
E335 80 26 0017 R DF C          and     byte ptr ds:[kb_flag],(not num_lock_mode)
E33A 80 26 0018 R FE C          and     byte ptr ds:[kb_flag_1],(not dx_kb)
E335          C          ; Send command to request ID code from keyboard.
E33F B4 05          C          mov     ah,05H         ; Read keyboard type
E341 EB 9581 R   C          call   kb_end_send    ; -- send command.
E344 33 C9      C          xor     ox,ox          ; set up timeout count
E346          C          kb_type_wait:
E346 B8 64          C          in     al,kb_status    ; get port status
E348 A8 01      C          test   al,1           ; data byte available?
E34A 75 05      C          jnz    kb_type_read    ; if so, go read it ..
E34C E2 F8      C          loop   kb_type_wait    ; else wait awhile longer.
E34E EB 11 90      C          jmp    kb_not_dix      ; timeout, default to non-dlx
E351          C          kb_type_read:
E351 B8 60          C          in     al,p_kscan      ; read ID byte..
E353 48 01      C          test   al,01H         ; deluxe kb. bit set?
E355 74 0A      C          jz     kb_not_dix
E351          C          ; 01H bit set, so initialize to Deluxe Keyboard.

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E357 80 0E 0017 R 20      C      or      byte ptr ds:[kb_flag],num_look_mode
E35C 80 0E 0018 R 01      C      or      byte ptr ds:[kb_flag_1],dlx_kb
E361                      C      kb_not_dlx:
E361 9D                    C      popf                                ; restore interrupt-
                                           ; enable state.
                                           C
                                           C ; Initialize Printer & Communication (RS-232) Driver Variables.
                                           C
E362 B0 13                C      mov     al,13h                       ; printer default timeout = 20
E364 BF 0078 R            C      mov     di,ds:(offset printer_t_out)
E367 B9 0004              C      mov     cx,4
E36A F3/ AA               C      rep     stosb                        ; es:di gets al
                                           C
E36C B0 01                C      mov     al,01h                       ; printer default timeout = 01
E36E BF 007C R            C      mov     di,ds:(offset serial_t_out)
E371 B9 0004              C      mov     cx,4
E374 F3/ AA               C      rep     stosb                        ; es:di gets al
                                           C
                                           C ; Determine Parallel Port Configuration.
                                           C
                                           C      assume  os:code, ds:code, es:data, ss:stack_ram
E376 8C C8                C      mov     ax,os
E378 8E DB                C      mov     ds,ax                        ; satisfy assumptions
                                           C
E37A 32 DB                C      xor     bl,bl                         ; clear high byte of switch_bits
                                           C
E37C BF 0008 R            C      mov     di,es:(offset printer_addr)   ; es:di points at printer_base
E37F BE E2BE R            C      mov     si,ds:(offset p_tbl)         ; addresses of printer ports
                                           C
E382                      C      i_prt_loop:
E382 AD                    C      lodsb                                ; ax gets ds:si port address.
E383 0B C0                C      or      ax,ax                        ; valid port address?
E385 74 14                C      js      i_prt_exit                 ; exit if invalid port address
                                           C
E387 8B D0                C      mov     dx,ax
E389 B0 A5                C      mov     al,0A5h                      ; transfer to data register
E38B EE                    C      out     dx,al                        ; load test pattern
E38C 86 CA                C      scbh   al,ah                          ; output test pattern.
E38E EC                    C      in     al,dx                          ; mov ah,al; trash al; t delay.
E38F 3A C4                C      cmp     al,ah                          ; input test pattern back.
E391 75 EF                C      jnz    i_prt_loop                  ; what we read = test pattern ?
                                           ; if not, loop as port is absent
E393 8B C2                C      mov     ax,dx                          ; else, printer port is present
E395 AB                    C      stosw                                ; retrieve port address
                                           ; es:di gets ax.
                                           C
E398 80 C3 40              C      add     bl,040h                       ; add to high byte of switch_bits
E399 EB E7                C      jmp     i_prt_loop                  ; will go around loop 3 times
                                           C
E39B                      C      i_prt_exit:
                                           C
                                           C ; Determine Communication (RS-232) Configuration (SCC 28530 + INS8250's).
                                           C
E39B BF 0000 R            C      mov     di,es:(offset rs232_addr)    ; es:di points at rs232_base
                                           C
E39E BA 03FA              C      mov     dx,com_id_a                  ; read interrupt I.D. register
E3A1 EC                    C      in     al,dx                          ; for first 8250 port.
E3A2 A8 F8                C      test   al,0F8h                       ; bits #3-7 are always low if
E3A4 75 07                C      jnz    i_no_com_a                  ; installed.
                                           C
E3A6 B8 03F8              C      mov     ax,com_data_a                ; if present, load address of
E3A9 AB                    C      stosw                                ; first 8250 data port.
E3AA 80 C3 02              C      add     bl,002h                       ; es:di gets ax.
E3AD                      C      i_no_com_a:
                                           C      es:di points next empty word
E3AD BA 02FA              C      mov     dx,com_id_b                  ; read interrupt I.D. register
E3B0 EC                    C      in     al,dx                          ; for second 8250 port.
E3B1 A8 F8                C      test   al,0F8h                       ; bits #3-7 are always low if
E3B3 75 07                C      jnz    i_no_com_b                  ; installed.
                                           C
E3B5 B8 02F8              C      mov     ax,com_data_b                ; if present, load address of
E3B8 AB                    C      stosw                                ; second 8250 data port.
E3B9 80 C3 02              C      add     bl,002h                       ; es:di gets ax.
E3BC                      C      i_no_com_b:
E3BC E4 66                C      in     al,sys_conf_a                 ; read switch settings to test
E3BE A8 20                C      test   al,020h                       ; for SCC 28530 chip
E3C0 74 08                C      js      i_no_scc                     ; bit #5: SCC chip installed
                                           ; if not, don't load SCC table
E3C2 BE E2C6 R            C      mov     si,ds:(offset scc_tbl)       ; SCC 28530 control ports
E3C5 A5                    C      movsw                                ; always 2 ports
E3C6 A5                    C      movsw                                ; es:di gets ds:si (twice)
E3C7 80 C3 04              C      add     bl,2*(002h)                  ; add to high byte of switch_bits
E3CA                      C      i_no_sccs:
                                           C ; Determine Game Card Configuration.
                                           C
E3CA BA 0201              C      mov     dx,game_card                 ; get game card address.
E3CD EC                    C      in     al,dx                          ; bits #0-3 are low if installed
E3CE A8 0F                C      test   al,0Fh                         ;
E3D0 75 03                C      jnz    i_no_game_card                ; skip, if not present
                                           C
E3D2 80 C3 10              C      add     bl,010h                       ; add to high byte of switch_bits

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E3D5          C   _i_no_game_card:
C             C
C             ; Initialize High Byte of switch_bits.
E3D5 26: 88 1E 0011 R      C           mov     byte ptr es:[switch_bits+1],bl ; save high byte of switch_bits
C             C
C             ; Initialize i8259A PIC with appropriate interrupt mask and enable interrupts.
C             C
C             ;
C             ;   mov     al,10111100b           ; p_timer & kb & dsk at this point
C             ;   mov     al,11111100b           ; p_timer & kb only at this point.
E3DA 80 FC          C           mov     al,10111100b
E3DC BA 0021        C           mov     dx,pic_0
E3DF EE            C           out     dx,al
C             ; now set proper interrupt mask
C             C
C             ; Send specific end of interrupt (SEOI) to pic 'command' port for keyboard.
C             C
C             ;   mov     al,pic_seoi_1         ; specific end of interrupt
E3E0 80 61          C           mov     dx,pic_0
E3E2 BA 0020        C           out     dx,al
C             ; to pic 'command' port.
E3E5 EE            C           sti
E3E6 FB            C           ; enable interrupts
C             C
C             ; Initialize Parallel Printer Interface.
C             C
E3E7 BA 01          C           mov     ah,1
E3E9 33 D2          C           xor     dx,dx
E3EB CD 17          C           INT     17h
C             ; initialize printer...
C             ; ...port 0
C             C
C             ; Initialize all 4 (2) Z8530 Serial Communication Controller.
C             ; NOTE: Special function code (FF) for power up ONLY initialization of 8530
E3ED B9 0004        C           ; ra_init:
E3F0 B8 FF83        C           mov     ax,111111111100011b
C             ; initialize SCC RS-232
C             ; 9600 baud,none,1 stop & 8 data
C             ; port number = loop - 1
E3F3 8B D1          C           mov     dx,ax
E3F5 41            C           dec     dx
E3F6 CD 14          C           INT     14h
E3F8 E2 F6          C           loop   ra_init
C             C
C             -----
C             ;Test for and Initialize optional ROMs
C             ;-----
C             C
C             ; assume cs:code, ds:nothing, es:nothing, ss:nothing
E3FA BB C800        C           mov     bx,0C800h
C             ; load starting segment
C             C
E3FD          C           rom_scan_loop:
E3FD 82 DB          C           mov     ds,bx
E3FF 33 F6          C           xor     si,si
C             ; bx has pending segment
C             ; offset 0000h
C             C
E401 81 3C AA55      C           cmp     word ptr ds:[si],0AA55h
E405 75 43          C           jne    rom_scan_next
C             ;
E407 BE E2AD R      C           mov     si,es:(offset opt_ROM_b)
E40A E8 E5FA R      C           call   DROMString
C             ; indicate ROM detected
C             C
E40D 33 C0          C           xor     ax,ax
E40F E8 E632 R      C           call   DHexLong
C             ; ds:ax points at ROM
C             C
E412 B8 0E20        C           mov     ax,(0Eh*100h)+' '
E415 CD 10          C           INT     10h
C             ; put out SPACE
C             C
E417 B8 0040        C           mov     ax,data_seg
C             ; satisfy assumptions
E41A 8E C0          C           mov     es,ax
E41C 33 F6          C           xor     si,si
C             ; for es in rom_check
C             ; ds:si points to ROM to check
C             C
C             ; Now: ds:si = pointer to ROM to be tested
C             ; bx = ds = pending segment of ROM under test
C             ; es: = data segment
C             C
C             ; assume cs:code, ds:nothing, es:data, ss:nothing
C             C
E41E 33 C0          C           xor     ax,ax
E420 8A 64 D2        C           mov     ah,byte ptr ds:[si+2]
E423 D1 E0          C           shl     ax,1
C             ; clear al
C             ; ax = (ROM length/512) * 256
C             ; ax = (ROM length/512) * 512
C             ; ax = ROM length in bytes
C             ; save ROM length
E425 50            C           push   ax
E426 B1 04          C           mov     cl,4
E428 D3 E8          C           shr     ax,cl
C             ; advance segment for next ROM
E42A 03 D8          C           add     bx,ax
C             ; by the number of paragraphs
E42C 59            C           pop     cx
C             ; restore ROM length in cx
C             C
E42D E8 E5E8 R      C           call   rom_checksum_cnt
C             ; get the checksum of the ex-
C             ; byte ROM.
E430 74 03          C           jz     rom_chksum_ok
E432 E9 E5D5 R      C           jmp     rom_err
C             ; OK if the checksum was zero
C             ; error the checksum wasn't zero
C             C
E435          C           rom_chksum_ok:
E435 53            C           push   bx
C             ; save the segment for next ROM
C             C
E436 26: C7 06 0067 R 0003 C           mov     word ptr es:[io_rom_init],0003h
E43D 26: 8C 1E 0069 R      C           mov     word ptr es:[io_rom_seg],ds
E442 26: FF 1E 0067 R      C           call   dword ptr es:[io_rom_init]
C             ; initialize the ROM
C             C
E444 5B            C           pop     bx
C             ; restore segment for next ROM
C             C
E446 EB 04          C           jmp     short rom_scan_exit
C             C
E44A          C           rom_scan_next:
E44A 81 C3 0080        C           add     bx,(800h/10h)
C             ; add 2k to the pending segment
C             C

```

ROM BIOS Listing

```

E44E      rom_scan_exit:      C   rom_scan_exit:
E44E      cmp                 C       bx,0F600h           ; are we done?
E452      jnge               C       rom_scan_loop       ; if not, continue
C
C
C-----
C       HDU Test
C-----
C
C       assume cs:code, ds:abs0, es:nothing, ss:stack_ram
C
E454      xor                 C       ax,ax             ; satisfy assumptions
E456      mov                 C       ds,ax
C
C ; Check int 41h to see if any one installed a HDU parameter table pointer.
C
E458      mov                 C       ax,word ptr ds:[(4*41h)+0000h]
E458      or                  C       ax,word ptr ds:[(4*41h)+0002h]
E459      jnz                 C       i_hdu_ok           ; if so, let them be...
C
C ; If not, call HDU initialization routine.
C
E461      mov                 C       si,cs:(offset i_hdu_m)
E464      call                C       DROMString         ; print test message
E467      call                C       h_init
C
C       assume cs:code, ds:data, es:nothing, ss:stack_ram
C
E46A      mov                 C       ds,word ptr cs:[set_ds_word] ; satisfy assumptions
E46F      cmp                 C       byte ptr ds:[hfr_num],0    ; number of hard disks.
E474      jnz                 C       i_hdu_ok           ; if ok, leave everything alone.
C
E476      mov                 C       sp,100h          ; re-initialize stack
E479      cld                 C
E47A      call                C       i_vector         ; re-install old vectors
E47D      i_hdu_ok:
C
C ; Clean Up after Option ROM's
C
E47D      cld                 C
C
C       ; disable interrupts
C
E47E      mov                 C       dx,pio_1         ; get current interrupt mask
E481      in                  C       al,dx
C       ;
C       and al,10111100b    ; P_timer & kb & dsk at this point.
E482      and                 C       and al,11111100b    ; P_timer & kb must be on at this point.
E484      out                  C       dx,al
C
C       assume cs:code, ds:abs0, es:nothing, ss:stack_ram
C
E485      xor                 C       ax,ax
E487      mov                 C       ds,ax
E489      mov                 C       word ptr ds:[int18locn+0000h],cs:(offset bt_int)
E48F      mov                 C       word ptr ds:[int18locn+0002h],cs ; (ROM BASIC not available)
E493      sti                 C
C       ; enable interrupts
C
C-----
C       FDU Test
C-----
C
C ; Initialize Floppy Disk Controller and related Driver Variables
C
E49A      xor                 C       ax,ax             ; initialize the disk routines
E496      xor                 C       bx,bx
E498      xor                 C       cx,cx
E49A      xor                 C       dx,dx
E49C      int                 C       13h
C
C ; Dummy Disk Attachment Test to Spin Up Drive for INT 19h (boot-strap).
C
E49E      mov                 C       si,cs:(offset i_fdu_m)
E4A1      call                C       DROMString         ; print test message
C
E4A4      mov                 C       bp,3             ; loop counter
E4A7      i_fdu_lp:
E4A7      mov                 C       ax,0201h         ; read one sector
C
E4AA      xor                 C       bx,bx
E4AC      mov                 C       ds,bx
E4AE      mov                 C       es,bx           ; xfer_segment
E4B0      mov                 C       bx,7C00h        ; xfer_offset
C
E4B3      mov                 C       cx,0001h
E4B6      xor                 C       dx,dx
C
E4B8      push                C       bp             ; save retry count
E4B9      push                C       ax             ; save return registers
E4BA      push                C       es
E4BD      int                 C       13h           ; bx, cx, dx, & ds preserved
E4BE      pop                 C       es           ; restore return registers
E4BF      pop                 C       ax
E4C0      pop                 C       bp           ; restore retry count
C
E4C0      jnc                 C       i_fdu_ok        ; error during read?
E4C2      dec                 C       bp             ; if so, decrement retry count
E4C3      jnz                 C       i_fdu_lp        ; and try again
C
E4C5      mov                 C       si,cs:(offset i_fdu_not_m) ; drive not ready message.

```

ROM BIOS Listing

```

E4C8 EB 03          C          jmp      short i_fdu_end
E4CA BE DD1F R     C          i_fdu_ok:
E4CD              C          mov      si,es:(offset i_fdu_rdy_m) ; drive ready message.
E4CD              C          i_fdu_end:
E4CD E8 E5FA R     C          call   DRonString
E4D0              C          ; Initialize & enable NMI's (parity register).
E4D0 BA 0061       C          mov      dx,p_kctrl
E4D3 EC           C          in       al,dx
E4D4 0C 30        C          or       al,030h ; enable bits #5 & #4
E4D6 EE           C          out      dx,al
E4D7              C          ; If alternate processor is available, let user select which one to use.
E4D7              C          i_alt_cpu:
E4D7 9C           C          pushf   ax ; preserve state for int 19h
E4D8 50           C          push   ax
E4D9 53           C          push   bx
E4DA 51           C          push   cx
E4DB 52           C          push   dx
E4DC 55           C          push   bp
E4DD 57           C          push   di
E4DE 56           C          push   si
E4DF 1E           C          push   ds
E4E0 06           C          push   es
E4E1              C          assume cs:code, ds:data, es:nothing, ss:nothing
E4E1 2E: 8E 1E E5F2 R C          mov      ds,word ptr es:[set_ds_word] ; satisfy assumptions
E4E5 A1 0072 R     C          mov      ax,word ptr ds:[reset_flag] ; get result of keyboard test
E4E9 3C AA        C          cmp     al,0AAh ; is keyboard attached?
E4EB 74 03        C          je      i_alt_cont ; jump if yes (continue)
E4ED EB 7D 90     C          jmp     i_init_end ; jump if no (in mfg)
E4F0              C          i_alt_cont:
E4F0 FA           C          cli ; disable interrupts
E4F1              C          assume cs:code, ds:abs0, es:nothing, ss:nothing
E4F1 33 C0        C          xor     ax,ax ; set up absolute zero address
E4F3 8E D8        C          mov     ds,ax ; for alternate cpu semaphore
E4F5 8B 16 0000   C          mov     dx,word ptr ds:0 ; save word at 0:0
E4F9 52           C          push   dx
E4FA A2 0000       C          mov     byte ptr ds:0,al ; request alt cpu id (0:0 = 0)
E4FD BA 80C1      C          mov     dx,80C1h ; Z8000 liaison port
E500 B0 01        C          mov     al,1 ; AL=1 starts Z8000
E502 EE          C          out     dx,al ; try to boot Z8000
E503 B9 00FF     C          mov     cx,0FFh ; loop counter
E506              C          i_alt_test:
E506 80 3E 0000 01 C          cmp     byte ptr ds:0,01h ; has the semaphore changed?
E50B 74 04        C          je      i_alt_found ; jump if yes (Z8000 id = 1)
E50D E2 F7        C          loop   i_alt_test ; wait for Z8000 to gain control
E50F EB 56        C          jmp     short i_alt_end ; jump: no alternate cpu
E511              C          i_alt_found:
E511 58           C          pop     ax ; restore word at 0:0
E512 43 0000     C          mov     word ptr ds:0,ax ; reserve for future pop
E515 50           C          push   ax ; enable interrupts
E516 FB          C          sti ; enable interrupts
E517 E8 E619 R     C          call   DCrLr
E51A BE D035 R     C          mov     si,es:(offset i_alt_select_m) ; ask user if alt. cpu used
E51D E8 E5FA R     C          call   DRonString
E520 33 D2        C          xor     dx,dx ; for int 14h
E522              C          i_alt_inq:
E522 B4 01        C          mov     ah,1 ; has a key been struck?
E524 CD 16        C          INT    16h
E526 74 FA        C          jz     i_alt_inq ; if not, stay in loop
E528 32 E4        C          xor     ah,ah ; if so, get the keystroke
E52A CD 16        C          INT    16h
E52C 0C 20        C          or     al,00100000b ; force lower case
E52E 3C 79        C          cmp     al,'y' ; did user mean "yes"
E530 74 02        C          je      i_alt_echo ; jump if yes
E532 B0 6E        C          mov     al,'n' ; force "no"
E534              C          i_alt_echo:
E534 B4 0E        C          mov     ah,0Eh ; echo "y" or "n"
E536 CD 10        C          INT    10h
E538 3C 79        C          cmp     al,'y' ; was answer "yes"
E53A 75 2B        C          jne    i_alt_end ; jump if no
E53C E8 E619 R     C          call   DCrLr
E53F FA           C          cli ; disable interrupts
E540 C6 06 0000 0F C          mov     byte ptr ds:0,0Fh ; tell Z8000 to take over
E545              C          i_alt_restart: ; entry for re-entering Z8000 (assume 0:0 setup)
E545 BA 80C1      C          mov     dx,80C1h ; Z8000 liaison port
E548 B0 01        C          mov     al,1 ; AL=1 starts Z8000
E54A EE          C          out     dx,al ; pass control to Z8000
E54B B9 00FF     C          mov     cx,0FFh ; loop counter
E54E E2 FE        C          loop   $ ; wait for Z8000 to gain control

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ROM BIOS Listing

```

E550 33 C0          C          xor     ax,ax          ; we're here only if 28000 released control
E552 8E D8          C          mov     ds,ax          ; react segment register
E554 80 3E 0000 10 C          cmp     byte ptr ds:0,10h ; to absolute zero
E559 72 0C          C          jb     i_alt_end      ; is a jump requested?
E55B 8C C8          C          mov     ax,cs          ; no, try to boot (or crash)
E55D 8E C0          C          mov     es,ax          ; pass return registers so that:
E55F BD E2CA R      C          mov     bp,offset alt_ret ; restarts 28000 as desired
E562 EA            C          jmpf   0,0            ;
E563 0000          C+         db     0EAh          ; intersegment direct jmp to 0:0
E565 0000          C+         dw     0             ;

; End of Initialization.

E567              C          i_alt_end:
E567 58            C          pop     ax             ; restore word at 0:0
E568 A3 0000       C          mov     word ptr ds:0,ax
E56B FB            C          sti     ; enable interrupts

E56C              C          i_init_end:
E56C BA 0378       C          mov     dx,0378h      ; printer port
E56F 80 80        C          mov     al,80h        ; OK status
E571 EE            C          out     dx,al         ; tell mfg tester

E572 07            C          pop     es             ; restore state for boot
E573 1F            C          pop     ds
E574 5E            C          pop     si
E575 5F            C          pop     di
E576 5D            C          pop     bp
E577 5A            C          pop     dx
E578 59            C          pop     cx
E579 5B            C          pop     bx
E57A 58            C          pop     ax
E57B 9D            C          popf

E57C E8 E619 R     C          call   DCrLf
E57F CD 19         C          int    19h           ; go to boot-strap routine

E581              C          point endp

; Send command in AH to keyboard interface processor. AX is used.

E581              C          kb_cmd_send proc near
E581              C          kb_cmd_wlup:
E581 E4 64           C          in     al,kb_status   ; get 8041 port status
E582 A8 02           C          test   al,10b         ; ready to receive?
E585 75 FA           C          jnz   kb_cmd_wlup

E587 8A C4           C          mov     al,ah         ; ready, send command
E589 B6 60           C          out   p_ksoan,al
E58B C3             C          ret

E58C              C          kb_cmd_send endp

E58C              C          code ends
E58C              C          include pwrup2.asm

;=====
; Filename: pwrup2.asm
;
; This module includes 8259 Interrupt, Video Controller, 8087
; FPU, and 8253 & MM58174 Clock tests.
;=====

E58C              C          code segment public 'ROM'
E58C              C          assume cs:code, ds:nothing, es:nothing, ss:nothing

;=====
; Note: We are called from ill_int ONLY (see vector.asm), and
; stack looks like this:
;
; High Address
; (10) |-----| return fsw flags <-- sp before ill_int trap
; (0E) |-----| return cs segment
; (0C) |-----| return ip offset
; (0A) |-----| ax <-- sp after ill_int trap
; (08) |-----| ds
; (06) |-----| near call here <-- sp after ill_int pushes
; (04) |-----| ax <-- sp after ill_int calls ill_trap
; (02) |-----| dx
; (00) |-----| si <-- sp after ill_trap pushes
; Low Address
;=====

E58C              C          assume cs:code, ds:nothing, es:nothing, ss:nothing
E58C              C          ill_trap proc near

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ROM BIOS Listing

```

C ; Turn off floppy disk drives.
C
E58C 50          C          push    ax                ; save registers
E58D 52          C          push    dx
E58E 56          C          push    si
C
E58F E8 EF4F R   C          call    stop_disk         ; destroys ax & dx
C
E592 E8 E5C4 R   C          call    ill_ln           ;
E595 BE DC1B R   C          mov     si,cs:(offset ill_m1) ; part 1 of message
E598 E8 E5FA R   C          call    DRomString
C
E59B 8B F4          C          mov     si,sp
E59D 36: 8E 5C 0E C          ds,word ptr ss:[si+0Eh] ; cs past si,dx,ax,ret,ds,ax,ip
E5A1 36: 8B 74 0C C          ds,word ptr ss:[si+0Ch] ; ip past si,dx,ax,ret,ds,ax
C
E5A5 4E          C          dec     si                ; si points to interrupt number
E5A6 8A 04          C          mov     al,byte ptr ds:[si] ; print illegal interrupt number
E5A8 E8 E643 R   C          call    DHexByte
E5AB 4E          C          dec     si                ; si points to interrupt instr.
E5AC 8B C6          C          mov     ax,si            ; save pointer
C
E5AE BE DC34 R   C          mov     si,cs:(offset ill_m2) ; part 2 of message
E5B1 E8 E5FA R   C          call    DRomString
C
E5B4 E8 E632 R   C          call    DHexLong        ; print illegal cs:ip = ds:ax
C
E5B7 BE DC3A R   C          mov     si,cs:(offset ill_m3) ; part 3 of message
E5BA E8 E5FA R   C          call    DRomString
E5BD E8 E5C4 R   C          call    ill_ln
C
E5C0 5E          C          pop     si                ; restore registers
E5C1 5A          C          pop     dx
E5C2 5B          C          pop     ax
E5C3 C3          C          ret
C
E5CA E8 E619 R   C          ill_ln: call    DCrLf         ; prints a line of '*'s
E5C7 B2 2A          C          mov     dl,42
C
E5C9 BB 0E2A        C          ill_lp: mov     ax,(0Eh*100h)*('')
E5CC CD 10          C          INT     10h
E5CE FE CA          C          dec     dl
E5D0 75 F7          C          jnz    ill_lp
E5D2 EB 45 90          C          jmp     DCrLf
C
E5D5          C          ill_trap    endp
C
E5D5          C          code    ends
C          include pwrup3.asm
C
C ;=====
C ;      Filename:      pwrup3.asm
C ;
C ;      This module includes 8041 keyboard, communication LSI, RAM, and
C ;      optional ROM tests.
C ;=====
E5D5          C          code    segment public 'ROM'
C
C                  assume cs:code, ds:nothing, es:data, ss:nothing
C
C ;-----
C ;      Input:  ds  = segment of ROM under test
C ;             es  = firmware data segment
C ;
C ;      Trash: All other registers except bx destroyed (in general).
C ;-----
E5D5          C          rom_err    proc    near
C                  assume cs:code, ds:nothing, es:data, ss:nothing
C
E5D5 8C D8          C          mov     ax,ds
E5D7 26: 88 26 0015 R C          mov     byte ptr es:[wfg_err_flag],ah ; high byte of ROM address
C
E5DC BE DC45 R   C          mov     si,cs:(offset fail_m) ; indicate ROM failed
E5DF E8 E5FA R   C          call    DRomString
E5E2 EB 35 90          C          jmp     DCrLf
C
E5E5          C          rom_err    endp
C
C                  assume cs:code, ds:nothing, es:nothing, ss:nothing
C
C ;-----
C ;      Input:  ds:si = pointer to ROM to be tested
C ;
C ;      Output: ah = checksum for the ROM
C ;             cx = 0
C ;             si = pointer to byte past ROM
C ;             zf = state of checksum for the ROM
C ;
C ;      Trash:  al destroyed.
C ;-----
E5E5          C          rom_checksum proc    near
C                  assume cs:code, ds:nothing, es:nothing, ss:nothing

```

ROM BIOS Listing

```

E5E5 B9 2000      C      mov     cx,2000h
E5E8              C
E5E8 33 C0         C      rom_checksum_cnt:
E5E8              C      xor     ax,ax                ; clear ah
E5EA              C
E5EA AC          C      rom_checksum_loop:
E5EB 02 E0         C      lodsb                    ; 12 al gets ds:si
E5ED 02 FB         C      add     sh,al                ; 3
E5EF 0A EA         C      loop   rom_checksum_loop   ; 17
E5F1 C3           C      or     ah,ah
E5F2              C      ret
E5F2              C      rom_checksum   endp
E5F2              C
E5F2              C      ocode   ends
E5F2              C      include pwrup4.asm
E5F2              C
E5F2              C      ;=====
E5F2              C      ;      Filename:      pwrup4.src
E5F2              C      ;
E5F2              C      ;      This module includes disk drive tests, system initialization,
E5F2              C      ;      keyboard boot-strap options, and message routines.
E5F2              C      ;
E5F2              C      ;=====
E5F2              C
E5F2              C      ocode   segment public 'ROM'
E5F2              C      assume cs:code, ds:nothing, es:nothing, ss:nothing
E5F2              C
E5F2              C      ;=====
E5F2              C      ;      Utility Routines:
E5F2              C      ;
E5F2              C      ;      DRomString      DString      DCrLf      DColon
E5F2              C      ;      DHexLong       DHexWord    DHexByte    DHexNib
E5F2              C      ;      DNum           DNumW
E5F2              C      ;=====
E5F2              C
E5F2              C      p4_data1  proc   near
E5F2              C
E5F2              C      even
E5F2 0040         C      set_da_word dw    data_seg        ; 2 bytes      = 0 clocks
E5F4              C
E5F4              C      p4_data1  endp
E5F4              C
E5F4              C      set_da     proc   near                ; set ds to firmware data segment
E5F4              C      assume   cs:code, ds:nothing, es:nothing, ss:nothing
E5F4 2E: 8E 1E E5F2 R C      mov     ds,word ptr cs:[set_da_word] ; 5 bytes 2*9-6 = 17 clocks
E5F9 C3           C      ret                                     ; 1 byte      = 8 clocks
E5FA              C      ;-----
E5FA              C      set_da     endp
E5FA              C      ;=====
E5FA              C      ;      Display ASCII String Utilities
E5FA              C      ;=====
E5FA              C
E5FA              C      DRomString  proc   near                ; Displays NUL terminated string at es:si
E5FA              C      assume   cs:code, ds:nothing, es:nothing, ss:nothing
E5FA              C
E5FA 1E          C      push   ds                ; all registers saved
E5FB 0E          C      push   es                ; ds gets es
E5FC 1F          C      pop    da
E5FD E8 E602 R    C      call   DString
E600 1F          C      pop    da                ; restore ds
E601 C3           C      ret
E602              C      DRomString  endp
E602              C
E602              C      DString    proc   near                ; Displays NUL terminated string at ds:si
E602              C      assume   cs:code, ds:nothing, es:nothing, ss:nothing
E602              C
E602 50          C      push   ax                ; all registers & flags saved
E603 53          C      push   bx
E604 56          C      push   si
E605 5C          C      pushf
E606 FC          C      old
E607 B3 01       C      mov     bl,1                ; auto increment
E609 AC          C      DS_1p: lodsb              ; select foreground color for grafix modes
E60A 04 C0       C      or     al,al                ; al gets ds:si and si++
E60C 74 06       C      je     DS_ret              ; NUL ?
E60E B4 0E       C      mov     ah,0Eh             ; tty emulator
E610 CD 10       C      INT    10h
E612 EB F5       C      jmp     short DS_1p
E614              C
E614              C      DS_ret:
E614 9D          C      popf                    ; restore registers & flags
E615 5E          C      pop    si
E616 5B          C      pop    bx
E617 58          C      pop    ax
E618 C3           C      ret
E619              C      DString    endp
E619              C
E619              C      DCrLf     proc   near                ; Displays a CR & LF.
E619              C      assume   cs:code, ds:nothing, es:nothing, ss:nothing
E619 50          C      push   ax                ; all registers preserved
E61A B8 0E0D      C      mov     ax,(0Eh*100h)+CR
E61D CD 10       C      INT    10h                ; tty emulator
E61F B8 0E0A      C      mov     ax,(0Eh*100h)+LF
E622 CD 10       C      INT    10h                ; tty emulator
E624 58          C      pop    ax                ; restore ax

```

ROM BIOS Listing

```

E625 C3          C      DCrLf      ret      endp
E626          C
E626          C      DColon     proc      near      ; Displays a ':'
E626 50          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
E627 53          C          push     bx          ; all registers preserved
E628 B3 01       C          mov      bl,1        ; select foreground color for grafix modes
E62A B8 0E3A    C          mov      ax,(0Eh*100h)+';'
E62D CD 10      C          INT     10h         ; tty emulator
E62P 5B         C          pop      bx          ; restore registers
E630 58         C          pop      ax
E631 C3         C          ret
E632          C      DColon     endp
E632          C
E632          C      ;=====
E632          C      ; Display Hexadecimal Number in ASCII Utilities
E632          C      ;=====
E632          C      DHexLong   proc      near      ; Displays ds:ax in ASCII
E632 50          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
E633 8C D8      C          push     ax          ; all registers preserved
E635 B8 E63C R   C          mov      ax,ds      ; display segment first
E635          C          call    DHexWord
E638 B8 E626 R   C          call    DColon     ; display a colon
E63B 58         C          pop      ax          ; restore ax
E63B          C          jmp     short DHexWord ; fall through: display offset second
E63C          C
E63C          C      DHexLong   endp
E63C          C      DHexWord   proc      near      ; Displays ax in ASCII
E63C 50          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
E63D 8A C4      C          push     al,ah       ; all registers preserved
E63F B8 E643 R   C          call    DHexByte    ; display high byte first
E642 58         C          pop      ax          ; restore ax
E642          C          jmp     short DHexByte ; fall through: display low byte second
E643          C
E643          C      DHexWord   endp
E643          C      DHexByte   proc      near      ; Displays al in ASCII
E643 50          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
E644 DO C8      C          push     ax          ; all registers preserved
E644 DO C8      C          ror     al,1        ;
E644 DO C8      C          ror     al,1        ;
E644 DO C8      C          ror     al,1        ;
E644 DO C8      C          ror     al,1        ; move high nibble to low nibble
E64C B8 E650 R   C          call    DHexNib     ; display high nibble in ASCII
E64P 58         C          pop      ax          ; restore ax
E64P          C          jmp     short DHexNib ; fall through: display low nibble in ASCII
E650          C
E650          C      DHexByte   endp
E650          C      DHexNib   proc      near      ; Displays low nibble of al in ASCII
E650 50          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
E651 53          C          push     bx          ; all registers preserved
E652 B3 01       C          mov      bl,1        ; select foreground color for grafix modes
E654 24 0F      C          and     al,0Fh       ; clear high nibble
E656 04 30      C          add     al,'0'       ;
E658 3C 39      C          cmp     al,'9'       ; minimum width
E65A 76 02      C          jbe     NibOk       ; '0' <= al <= '9' ?
E65C 04 07      C          add     al,'A'-'0'-10
E65E B4 0E      C      NibOk:  mov     ah,0Eh     ; tty emulator
E660 CD 10      C          INT     10h         ;
E662 5B         C          pop      bx          ; restore registers
E663 58         C          pop      ax
E664 C3         C          ret
E665          C      DHexNib   endp
E665          C
E665          C      ;=====
E665          C      ; Display Decimal Number in ASCII Utilities
E665          C      ;=====
E665          C      DNum       proc      near      ; Displays decimal of ax in ASCII in min width
E665 53          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
E666 33 DB      C          push     bx          ; all registers preserved
E668 B8 E66D R   C          mov      dx,bx      ; minimum width
E66B 5B         C          call    DNumW       ; display ax
E66C 58         C          pop      bx          ; restore bx
E66D          C          ret
E66D          C      DNum       endp
E66D          C      DNumW     proc      near      ; Displays decimal of ax in ASCII of width bx
E66D 50          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
E66E 53          C          push     ax          ; all registers preserved
E66E 53          C          push     bx
E66F 51          C          push     cx
E670 52          C          push     dx
E671 56          C          push     si
E672 BE 000A    C          mov     si,10        ; decimal modulus
E675 33 C9     C          xor     cx,cx        ; clear digit counter
E677          C      DNumW_loop:
E677 33 D2     C          xor     dx,dx        ; dx:ax = decimal number
E679 F7 F6     C          div    si           ; dh = 0
E679          C          ; dl = remainder = (0-9)

```


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```

C
E67B 52          C          push   dx          ; ax = quotient = higher order digits
E67C 41          C          inc    cx          ; save the digit on stack
E67D 0B C0       C          or     ax,ax       ; increment count of what's on stack
E67F 75 F6       C          jnz   DNuM_loop    ; are we done?
C
E681 2B D9       C          sub   bx,cx       ; subtract digit count from width
E683 76 08       C          jbe   DNuM_skip    ; skip spaces if bx is not > cx
C
E685            C          DNuM_spaces:
E685 B8 0E20       C          mov   ax,(0Eh*100h)+' ' ; display a space
E688 CD 10       C          INT 10h          ;
E68A 4B          C          dec  bx          ; decrement count of spaces
E68B 75 F8       C          jnz   DNuM_spaces  ; keep going
C
E68D            C          DNuM_skip:
E68D B3 01       C          mov   bl,1        ; foreground color for grafix modes
E68F 58          C          pop  ax          ; remove digit from stack
E690 04 30       C          add  al,'0'       ; convert to ASCII
E692 B4 0E       C          mov  ah,0Eh      ; display the digit
E694 CD 10       C          INT 10h          ;
E696 E2 P5       C          loop  DNuM_skip
C
E698 5E          C          pop  si          ; restore registers
E699 5A          C          pop  dx
E69A 59          C          pop  cx
E69B 5B          C          pop  bx
E69C 58          C          pop  ax
E69D C3          C          ret
E69E            C          DNuM  endp
C
E69E            C          oode  ends
C
C          include boot1.asm
C
C          ;=====
C          ;          Filename:      boot1.src
C          ;
C          ;          This module includes the ORG'd jump to INT 19h (boot2.src)
C          ;=====
C
E69E            C          oode  segment public 'ROM'
C          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
C
E6F2            C          ORG   0E6F2h
E6F2            C          bt_jmp  proc  near
E6F2 E9 F860 R     C          jmp  bt_int          ; necessary jump for ORG
E6F5            C          bt_jmp  endp
C
E6F5            C          oode  ends
C          C          include com1.asm
C
C          ;=====
C          ;          Filename:      com1.src
C          ;
C          ;          This module, com2, and com3 supply INT 14h.
C          ;=====
C
E6F5            C          oode  segment public 'ROM'
C          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
C
C          ;-----
C          ;          INS8250 Compatible Line Status Bits (ah) for Z8530 SCC Re-Mapping
C          ;-----
C          C          com_te      equ   80h          ; time out error (bit #7)
C          C          com_txd     equ   20h          ; transmit ready (bit #5)
C          C          com_fe      equ   08h          ; framing error (bit #3)
C          C          com_pe      equ   04h          ; parity error (bit #2)
C          C          com_oe      equ   02h          ; overrun error (bit #1)
C          C          com_rxd     equ   01h          ; receive ready (bit #0)
C
C          ;-----
C          ;          INS8250 Compatible Modem Status Bits (al) for Z8530 SCC Re-Mapping
C          ;-----
C          C          com_dar     equ   20h          ; data set ready (bit #5)
C          C          com_ots     equ   10h          ; clear to send (bit #4)
C
C          ;-----
C          ;          INS8250 Compatible Modem Control Bits.
C          ;-----
C          C          com_rts     equ   02h          ; request to send (bit #1)
C          C          com_dtr     equ   01h          ; data terminal ready (bit #0)
C
C          ;-----
C          ;          Z8530 SCC Status Register (Read Register #0)
C          ;-----
C          C          scc_txd     equ   04h          ; transmit ready (bit #2)
C          C          scc_rxd     equ   01h          ; receive ready (bit #0)
C
C          ;-----
C          ;          Z8530 SCC Error Register (Read Register #1)

```

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```

C ;-----
C
= 0040
= 0020
= 0010
C sec_fe          equ    40h          ; framing error (bit #6)
C sec_oe          equ    20h          ; overrun error (bit #5)
C sec_pe          equ    10h          ; parity error (bit #4)
C
C ;-----
C ;          INS8250 Asynchronous Communication Chip Baud Rate Time Constants
C ;          (baud rate generator signal is 3.6864 MHz put through a
C ;          divide-by-2 circuit.
C ;
C ;          Time Constant = ((3,686,400 Hz)/2) = Input Freq.
C ;          (16)*(baud rate)
C ;-----
E729
C          ORG    0E729h
C
E729
C          com_data1  proc
C
E729 0417
C          com_baud   dw    1047      ; 110 baud (0)
E72B 0300
C          dw    768        ; 150 baud (1)
E72D 0180
C          dw    384        ; 300 baud (2)
E72F 00C0
C          dw    192        ; 600 baud (3)
E731 0060
C          dw    96         ; 1200 baud (4)
E733 0030
C          dw    48         ; 2400 baud (5)
E735 0018
C          dw    24         ; 4800 baud (6)
E737 000C
C          dw    12         ; 9600 baud (7)
C
C          .list
C
E739
C          com_data1  endp
C
C ;-----
C ;          Z8530 Serial Communication Controller Baud Rate Time Constants
C ;          (baud rate generator signal is 3.6864 MHz)
C ;          (NO divide-by-2 circuit!!!!)
C ;
C ;          Time Constant = (3,686,400 Hz) = Input Freq.
C ;          (16)*(2)*(baud rate) - 2
C ;
C ;          NOTE: These values are the SAME as the above EXCEPT for the - 2!!!!
C ;-----
C
C          iscc_baud  dw    1085      ; 110 baud (0)
C          dw    766        ; 150 baud (1)
C          dw    382        ; 300 baud (2)
C          dw    190        ; 600 baud (3)
C          dw    94         ; 1200 baud (4)
C          dw    46         ; 2400 baud (5)
C          dw    22         ; 4800 baud (6)
C          dw    10         ; 9600 baud (7)
C
C          .list
C
C ;-----
C ;          INT 14h -- RS-232 Software Interrupt Request Routine
C ;
C ;          Assumes:  INS8250 port addresses are > 256. That is, the
C ;                   high byte of the port address is nonzero, if and
C ;                   only if, the port is a INS8250. (e.g. com_a ports
C ;                   are 03F8h - 03FBh & com_b ports are 02F8h - 02FBh.)
C ;
C ;          Similarly: Z8530 port addresses are < 256. That is, the
C ;                   high byte of the port address is zero, if and
C ;                   only if, the port is a Z8530. (e.g. sec_a ports
C ;                   are 0050h - 0053h & sec_b ports are 0052h - 0053h.)
C ;
C ;          Z8530 Note: For the reset during power-up, DTR and RTS must be
C ;                   set low which is the only difference from a normal
C ;                   reset (AH=0). This is accomplished by a special
C ;                   function code (AH=0FFh).
C ;-----
E739
C          ORG    0E739h
E739
C          serial_io  proc  near
C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
C
E739 PB
C          sti                    ; enable interrupts
E73A 55
C          push  bp                ; save register
C
E73B 83 FA 04
C          cmp  dx,4               ; 4 RS-232 channels allowed max
E73E 73 3D
C          jae  rs_nop
C
E740 8B E8
C          mov  bp,ax              ; save original function code
E742 80 FC FF
C          cmp  ah,0FFh            ; power-up reset?
E745 75 02
C          jne  rs_norm            ; jump if no
E747 32 E4
C          xor  ah,ah              ; same as reset, BP remembers FF
C
C          rs_norm:
E749
C          cmp  ah,03h              ; input out of range?
E74C 77 2F
C          ja   rs_nop
C
C          assume  cs:code, ds:data, es:nothing, ss:nothing
C
E74E 52
C          push dx                  ; save registers
E74F 51
C          push ox
E750 53
C          push bx
E751 1E
C          push ds                  ; save ds

```

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```

E752 2E: 8E 1E E5F2 R    C    mov     ds,word ptr es:[set_ds_word]    ; satisfy assumptions
E757 8B DA              C    mov     bx,dx                           ; get port number (0-3)
E759 33 C9              C    xor     cx,cx                           ; clear ch
E75B 8A 8F 007C R      C    mov     cl,byte ptr ds:[bx+serial_t_out] ; get RS-232 time-out
E75F D1 E3              C    shl     bx,1                             ; make word index
E761 8B 97 0000 R      C    mov     dx,word ptr ds:[bx+rs232_addr]   ; get address of RS-232
E765 1F                  C    pop     ds                               ; data port
                                           C    ; restore ds
                                           C    assume cs:code, ds:nothing, es:nothing, ss:nothing
E766 0B D2              C    or     dx,dx                           ; RS-232 port present?
E768 74 10              C    jz     ra_ret                           ; if not, leave
E76A 0A F6              C    or     dh,dh                           ; are we a INS8250 chip?
E76C 75 03              C    jnz    ra_ok                            ; if so, take jump
E76E 80 C4 04          C    add     ah,4                             ; if SCC Z8530 add 4 to function
E771                  C    ra_ok:
E771 8A DC              C    mov     bl,ah                           ; bx = function number
E773 D1 E3              C    shl     bx,1                             ; bx = 2*(function number)
E775 2E: FF 97 E77F R    C    call    cs:[bx+(offset ra_tbl)]         ; perform rs232 function
E77A                  C    ra_ret:
E77A 5B                  C    pop     bx                               ; restore registers
E77B 59                  C    pop     cx
E77C 5A                  C    pop     dx
E77D                  C    ra_nop:
E77D 5D                  C    pop     bp
E77E CF                  C    iret

-----
;
; INT N# Jump Table
;
-----
E77F E78F R            C    ra_tbl dw    com_init    ; ah = 00h for INS8250
E781 E85C R            C    dw      com_pb        ; ah = 01h for INS8250
E783 E92A R            C    dw      com_gb        ; ah = 02h for INS8250
E785 E87F R            C    dw      com_stat     ; ah = 03h for INS8250
E787 F513 R           C    dw      sec_init     ; ah = 00h for SCC Z8530
E789 E91B R            C    dw      sec_pb       ; ah = 01h for SCC Z8530
E78B E94D R            C    dw      sec_gb       ; ah = 02h for SCC Z8530
E78D E88A R            C    dw      sec_stat     ; ah = 03h for SCC Z8530
E78F                  C    serial_io  endp

-----
;
; Initialize RS-232 Interface.
;
; Input:  al = input parameters
;         dx = address of RS-232 channel
; Output: ax = RS-232 channel status
;
; al initializes port with: bit # 7 6 5 4 3 2 1 0
;
;          +-----+
;          |B|B|B|P|P|S|D|D|
;          +-----+
;
; Baud (BBB):          Parity (PP):          Stop Bits (S):  Data Bits (DD):
; 0 = 110 4 = 1200    0 = None              0 = 1           10 = 7
; 1 = 150 5 = 2400    01 = Odd              1 = 2           11 = 8
; 2 = 300 6 = 4800    11 = Even              00 = 5?         (00 = 5?)
; 3 = 600 7 = 9600                                (01 = 6?)
;
; Assumes:      com_int_x = com_data_x + 1 = dx + 1
;              com_lctl_x = com_data_x + 3 = dx + 3
;
-----
E78F com_init proc near ; ah = 00h
E791 assume cs:code, ds:nothing, es:nothing, ss:nothing
E792 push dx ; save dx = com_data_x
E793 mov ch,al ; save input parameters.
E794 mov al,080h ; access divisor latch of
E796 add dx,3 ; baud count register.
E797 out dx,al ; dx = com_lctl_x
E798 call ra_dly ; write to line control register
E799 mov bl,ch ; get input parameters.
E79D and bx,11100000b ; get bits #5, 6, & 7 (clear bb)
E7A1 mov cl,4 ;
E7A3 shr bl,cl ; move to bits #1,2,& 3
E7A5 mov ax,word ptr es:[bx+com_baud] ; bx is word index
                                           ; get 8250 baud count
E7AA pop dx ; restore dx = com_data_x
E7AB out dx,al ; output low byte of baud rate
E7AC call ra_dly
E7AF mov al,ah ; transfer high byte to low byte
E7B1 inc dx ; dx = com_int_x
E7B2 out dx,al ; dx = com_int_x
E7B3 call ra_dly ; output high byte of baud rate
E7B6 mov al,ah ; get input parameters.

```

ROM BIOS Listing

```

E7B8 24 1F      C      and     al,0001111b      ; get bits #0 thru #4
E7BA 42        C      inc     dx                ; dx = com_lctl_x
E7BB 42        C      out    dx,al           ; write to line control register
E7BC 2E        C      oall   ra_dly         ; disable access divisor latch,
E7BD E8 E8E2 R  C      ; set data & stop bits, & parity
C      ;
C      ;
E7C0 32 C0      C      xor     al,al           ; disable all interrupts!!
E7C2 4A        C      dec     dx                ; dx = com_int_x
E7C3 4A        C      dec     dx                ; write to interrupt ID register
E7C4 E8        C      out    dx,al
C      ;
E7C5 4A        C      dec     dx                ; dx = com_data_x
E7C6 E9 E87F R  C      jmp     com_stat        ; return status
C      ;
E7C9           C      com_init      endp
C      ;
E7C9           C      oode     ends
C      include kb1.asm
C      ;
C      ;-----
C      ;      Filename:      kb1.src
C      ;
C      ;      This module includes INT 09h & 16h.
C      ;
C      ;-----
E7C9           C      oode     segment public 'ROM'
C      ;      assume cs:code, ds:nothing, es:nothing, ss:nothing
C      ;-----
C      ;      INT 16h -- 18041A Keyboard Software Interrupt Request Routine
C      ;-----
C      ;      Input:  ah      = function number (00h <= ah <= 03h)
C      ;      Output: ah      = (ah - 2) if ah >= 2
C      ;
C      ;      Trash: None. (bx & ds if ROM stack)
C      ;
C      ;      Note:  The stack never gets deeper than 6 words!!!
C      ;
C      ;      High Address
C      ;      |-----|
C      ;      | return fsw flags | <-- sp (at entry & exit)
C      ;      |-----|
C      ;      | return cs segment |
C      ;      |-----|
C      ;      | return ip offset |
C      ;      |-----|
C      ;      |      ds      | <-- sp after kb trap
C      ;      |-----|
C      ;      |      bx      |
C      ;      |-----|
C      ;      |      1 near call |
C      ;      |-----| <-- sp (at its deepest!!!)
C      ;      |      Low Address
C      ;-----
C      ;-----
E82E           C      ORG     0B82Eh
C      ;
E82E           C      k_io    proc     near
C      ;      assume cs:code, ds:nothing, es:nothing, ss:nothing
C      ;
E82E FB        C      sti     ds                ; enable interrupts!!
E82F 1E        C      push   ds                ; save ds
E830 2E: 8E 1E E5F2 R  C      mov     ds,word ptr cs:[set_ds_word] ; avoid potential stack problems
E835 53        C      push   bx                ; save bx
C      ;
C      ;      assume cs:code, ds:data, es:nothing, ss:nothing
C      ;
E836 80 FC 01   C      cmp     ah,1                ; ah <= 1 ?
E839 72 0A     C      jb     k_read            ; jump if ah = 0
E83B 74 23     C      je     k_look           ; jump if ah = 1
E83D 80 FC 02   C      cmp     ah,2                ; ah=2 ?
E840 74 27     C      jne    k_stat
C      ;
E842 5B        C      k_ret:  pop     bx                ; restore registers
E843 1F        C      pop     ds
E844 CF        C      iret
C      ;
E845           C      k_io    endp
C      ;-----
C      ;      Wait for key and extract if from the keyboard buffer.
C      ;
C      ;      Output: ah = raw scnn code
C      ;      ;      al = ASCII translated key
C      ;      ;      or
C      ;      ;      ah = translated key
C      ;      ;      al = 00h
C      ;
C      ;      Trash: Ncne.
C      ;-----
E845           C      k_read  proc     near
C      ;      assume cs:code, ds:data, es:nothing, ss:nothing
C      ;
E845 FB        C      sti     ds                ; enable interrupts (again)
E846 E8 E854 R  C      call   k_eee            ; is there a character present?

```

```

E849 74 FA          C                   ; interrupts come back disabled!
E84B EB E86E R     C         jz     k_read         ; loop until something in buffer
E84E 89 1E 001A R  C         call    k_adv_ptr      ; move pointer to next position
E852 EB EB        C         mov     word ptr ds:[buffer_head],bx ; store value in variable
                                          C         jmp     short k_ret

E854 FA          C         k_see: clli          ; disable interrupts!!
E855 8B 1E 001A R  C         mov     bx,word ptr ds:[buffer_head] ; get pointer to head of buffer
E859 3B 1E 001C R  C         cmp     bx,word ptr ds:[buffer_tail] ; if equal, then nothing there
E85D 8B 07        C         mov     ax,word ptr ds:[bx]         ; get scan code and ascii code
E85F C3          C         ret

E860             C         k_read endp

-----
; Checks for key in keyboard buffer, but does not extract it.
;
; Output: if key is in buffer, then:
;         zf = 0 (nz = reset)
;         ah = raw scan code
;         al = ASCII translated key
;         or
;         ah = translated key
;         al = 00h
;
; else:
;         zf = 1 (z = set)
;         ax = 16th previous key
;
; Trash: ax is trashed if keyboard buffer is empty.
-----

E860             C         k_look proc far ; must be far!!!!
                C         assume os:code, ds:data, es:nothing, ss:nothing

E860 EB E854 R     C         call    k_see          ; is there a character present?
                C                   ; interrupts come back disabled!
E863 FB          C         sti          ; must return interrupts enabled
E864 5B          C         pop     bx          ; restore registers
E865 1F          C         pop     ds          ; blow away flags returning:
E866 CA 0002     C         ret     2         ; zf & ax = k_see output, & sti

E869             C         k_look endp

-----
; Returns keyboard shift state kb_flag in al.
;
; Output: ah = 0.
;         al = kb_flag
; Trash: None.
-----

E869             C         k_stat proc near
                C         assume os:code, ds:data, es:nothing, ss:nothing

E869 AD 0017 R     C         mov     al,byte ptr ds:[kb_flag] ; get the shift status flags
E86C EB D4        C         jmp     short k_ret

E86E             C         k_stat endp

-----
; Advances kb_buffer ring buffer pointer.
;
; Input:  bx
; Output: bx
; Trash:  None.
-----

E86E             C         k_adv_ptr proc near
                C         assume os:code, ds:data, es:nothing, ss:nothing

E86E 43          C         inc     bx          ; move to next word in list
E86F 43          C         inc     bx          ;
E870 3B 1E 0082 R  C         cmp     bx,word ptr ds:[buffer_end] ; end of buffer ?
E874 75 04        C         jne     k_adv_end     ;
E876 8B 1E 0080 R  C         mov     word ptr ds:[buffer_start] ; yes, buffer to beginning
E87A C3          C         k_adv_end:
                C         ret

E87B             C         k_adv_ptr endp
E87B             C         code ends

C         include com2.asm
C         ;=====
C         ;      Filename:    com2.src
C         ;=====
E87B             C         code segment public 'ROM'
                C         assume cs:code, ds:nothing, es:nothing, ss:nothing

-----
; Read Status of RS-232 Interface. (rs_stat)
;
; Input:  dx =      if dh = 0, then address of 28530 channel (see_ctl_x).
;         if dh <> 0, then address of 8250 data port (com_data_x).
; Output: ax =      RS-232 (INSTR250-compatible) channel status.
; Trash:  None.
-----

```

ROM BIOS Listing

```

C ;
C ;           Assumes:      com_lstat_x = com_data_x + 5 = dx + 5 (line status)
C ;                        com_mstat_x = com_data_x + 6 = dx + 6 (modem status)
C ;-----
C
C
E87B          C      rs_stat proc      near          ; ah = 03h
C              assume     es:code, ds:nothing, es:nothing, ss:nothing
E87B 0A F6    C              or          dh,dh          ; are we a SCC 28530 chip?
E87D 74 0B    C              jz          sec_stat       ; if so, take jump
C
E87F          C      com_stat:          ; INSR250 read status routine.
C
C ; Get Line Status.
C
E87F 52      C      push     dx          ; save dx = com_data_x
E880 83 C2 05 C      add      dx,5          ; dx = com_lstat_x
E883 EC      C      in       al,dx         ; get line status
E884 8A E0    C      mov     ah,al        ; line status comes back in high byte
C
C ; Get Modem Status.
C
E886 42      C      inc     dx          ; dx = com_mstat_x
E887 EC      C      in       al,dx         ; get modem status in low byte
E888 5A      C      pop     dx          ; restore dx = com_data_x
E889 C3      C      ret
C
E88A          C      sec_stat:          ; SCC 28530 read status routine.
C
C ; Get Channel Status.
C
E88A 33 C0    C      xor     ax,ax         ; al = selects 0 ; ah = no errors
E88C EE      C      out     dx,al        ; dx = sec_ctl_x
E88D E8 E8E2 R C      call    rs_dly         ;
E890 EC      C      in       al,dx         ; get channel status
C
E891 A8 04    C      test    al,sec_txd      ; test for transmit ready
E893 74 03    C      jz          sec_no_txd
C
E895 80 CC 20 C      or      ah,com_txd     ; if so, set INSR250-compatible bit.
E898          C      sec_no_txd:
C
E898 A8 01    C      test    al,sec_rxd      ; test for receive ready
E89A 74 03    C      jz          sec_no_rxd
C
E89C 80 CC 01 C      or      ah,com_rxd     ; if so, set INSR250-compatible bit.
E89F          C      sec_no_rxd:
C
C ; Get Error Status.
C
E89F B0 01    C      mov     al,1          ; get errors
E8A1 EE      C      out     dx,al        ; dx = sec_ctl_x
E8A2 E8 E8E2 R C      call    rs_dly         ;
E8A5 EC      C      in       al,dx         ; get error status
C
E8A6 A8 80    C      test    al,sec_fe      ; test for framing error
E8A8 74 03    C      jz          sec_no_fe
C
E8AA 80 CC 08 C      or      ah,com_fe      ; if so, set INSR250-compatible bit.
E8AD          C      sec_no_fe:
C
E8AD A8 10    C      test    al,sec_pe      ; test for parity error
E8AF 74 03    C      jz          sec_no_pe
C
E8B1 80 CC 04 C      or      ah,com_pe      ; if so, set INSR250-compatible bit.
E8B4          C      sec_no_pe:
C
E8B4 A8 20    C      test    al,sec_oe      ; test for overrun error
E8B6 74 03    C      jz          sec_no_oe
C
E8B8 80 CC 02 C      or      ah,com_oe      ; if so, set INSR250-compatible bit.
E8BB          C      sec_no_oe:
C
C ; Set Modem Status.
C
E8BB B0 30    C      mov     al,(com_dsr+com_ets) ; al = DSR and CTS
E8BD C3      C      ret
E8BE          C      rs_stat endp
C
C ;-----
C ;           Wait for Status of RS-232 Interface. (rs_ws)
C ;
C ;           Input:  ah = RS-232 channel status for which to wait
C ;                   cx = RS-232 time-out
C ;                   dx = if dh = 0, then address of 28530 channel (sec_ctl_x).
C ;                       if dh <> 0, then address of 8250 data port to poll.
C ;
C ;           Output: AH = Status.
C ;                   ZF = set, if status matches.
C ;                   reset, if time-out.
C ;
C ;           Trash:  al & bx destroyed.
C ;
C ;           Assumes:  com_lstat_x = com_data_x + 5 = dx + 5 (line status)
C ;                   com_mstat_x = com_data_x + 6 = dx + 6 (modem status)
C ;-----
C

```

ROM BIOS Listing

```

E8BE          C   rs_ws   proc   near
C             assume  cs:code, ds:nothing, es:nothing, as:nothing
C
C             push  cx           ; save time-out
E8BF 51       C             xor    bx,bx           ; clear bx
E8C1 87 CB    C             xchg  cx,bx           ; BL now has rs232_time_out.
C
C             rs_ws_lp:
E8C3 0A F6    C             or    dh,dh           ; are we an INSR250 chip?
E8C5 75 06    C             jnz  rs_ws_com       ; if so, take jump
C
C             xor    al,al       ; al = selects 0 on SCC 28530
E8C7 32 C0    C             out  dx,al           ; dx = scc_ctl_x
E8C9 8E       C             call  rs_dly
E8CA 88 E8 E2 R C             ;
C
C             rs_ws_com:
E8CD 8C       C             in  al,dx           ; get channel status
E8CE 8A F8    C             mov  bh,al           ; save status in BH.
E8D0 22 C4    C             and  al,ah           ; mask bits we're waiting for
E8D2 3A C4    C             cmp  al,ah           ; are they all on?
C
C             jz    rs_ws_exit   ; if so, exit with zf set
E8D4 74 08    C
C             loop  rs_ws_lp     ; inner loop
E8D6 E2 EB    C             dec  bl
E8D8 FE CB    C             jnz  rs_ws_lp     ; outer loop
E8DA 75 E7    C
C             or    ah,ah       ; time-out, exit with zf reset
E8DC 0A E4    C
E8DE 8E DE    C             rs_ws_exit:
E8DE 8E DE    C             mov  ah,bh           ; move status to AH.
E8E0 59       C             pop  cx             ; restore time-out
E8E1 C3       C
C             rs_ws   endp
E8E2          C
C
C             rs_dly  proc   near
C             assume  cs:code, ds:nothing, es:nothing, ss:nothing
C
C             pushf
E8E2 9C       C             push  cx
E8E3 51       C             mov  cx,8
E8E4 B9 0008   C             rs_lp: loop  rs_lp
E8E7 E2 FE    C             pop  cx
E8E9 59       C             popf
E8EA 9D       C             ret
E8ED C3       C
C             rs_dly  endp
E8EC          C
C             assume  cs:code, ds:nothing, es:nothing, ss:nothing
C
C             ;-----
C             ; INSR250 Put Byte (com_pb) & SCC 28530 Put Byte (scc_pb)
C             ;
C             ; Transmit Character to RS-232 Interface.
C             ;
C             ; Input:  al = character to transmit
C             ;          cx = RS-232 time-out
C             ;          dx = if dh = 0, then address of 28530 channel (scc_ctl_x).
C             ;          ; if dh <> 0, then address of 8250 data port (com_data_x).
C             ; Output: ah = line status
C             ;          bx destroyed.
C             ;
C             ; Assumes:  com_ctl_x = com_data_x + 4 = dx + 4
C             ;          com_lstat_x = com_data_x + 5 = dx + 5
C             ;          com_rstat_x = com_data_x + 6 = dx + 6
C             ;          scc_data_x = scc_ctl_x + 1 = dx + 1
C             ;-----
C
E8EC          C             com_pb  proc   near
C             assume  cs:code, ds:nothing, es:nothing, ss:nothing
C             ; ah = 01h
C
C             push  dx           ; save dx = com_data_x
E8ED 50       C             push  ax           ; save character to output in al
C
C             mov  al,(com_rts+com_dtr) ; signal RTS & DTR
E8EE B0 03    C             add  dx,1           ; dx = com_ctl_x
E8F0 83 C2 04 C             out  dx,al           ; send to modem control register
E8F3 EE       C
C             mov  ah,(com_dsr+com_cts) ; wait for DSR & CTS
E8F4 B4 30    C             inc  dx
E8F5 42       C             dx = com_rstat_x
E8F7 42       C             dx = com_rstat_x
E8F8 EB E8 E2 R C             call  rs_ws       ; wait for modem status register
E8FA 75 13    C             jnz  rs_pbe       ; if time-out, take jump
C
C             mov  ah,com_txd     ; wait for transmit ready
E8FD B4 20    C             dec  dx
E8FF 7A       C             dx = com_lstat_x
E900 E8 E8 E2 R C             call  rs_ws       ; wait for line status register
E903 75 0B    C             jnz  rs_pbe       ; if time-out, take jump
C
C             pop  ax             ; restore character to output in al
E905 58       C             mov  bl,al         ; save character input/output in bl
E906 8A D8    C             call  rs_stat     ; get return status
E908 EB E7 B R C             mov  al,bl         ; restore character input/output in al
E90B 8A C3    C             pop  dx
E90D 5A       C             dx = com_data_x
E90E 5A       C             out  dx,al
E90E EE       C             ; else, output the character
C             ; exit for put and get byte

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ROM BIOS Listing

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E90F          C      ra_pb_gb:          ; if SCC Z8530, dx = scc_ctl_x
E90F C3      C      ret
E910          C      ra_pbe:          ; exit for put byte error
E910 5B      C      pop      bx          ; restore character to output in bl
E911 5A      C      pop      dx          ; if SCC Z8530, restore dx = scc_ctl_x
E911          C      ; else IN8250, restore dx = com_data_x
E912 B8 E87B R C      call      rs_atat       ; get return status
E915 8A C3   C      mov      al,bl       ; restore character to output in al
E917 80 CC 80 C      or       ah,com_te      ; indicate timeout error
E91A C3      C      ret
E91B          C      com_pb endp
E91B          C      scc_pb proc near ; ah = 01h
E91B          C      assume cs:code, ds:nothing, es:nothing, ss:nothing
E91B 52      C      push     dx          ; save dx = scc_ctl_x
E91C 50      C      push     ax          ; save character to output in al
E91D B4 04   C      mov      ah,scc_txd     ; wait for transmit ready
E91F E8 E8BE R C      call      rs_ws         ; if time-out, take jump
E922 75 EC   C      jnz      rs_pbe
E924 56      C      pop      ax          ; restore character to output in al
E925 42      C      inc     dx          ; dx = scc_data_x
E926 E8      C      out     dx,al        ; else, output the character
E927 5A      C      pop      dx          ; restore dx = scc_ctl_x
E928 EB E5   C      jmp     short ra_pb_gb
E92A          C      com_pb endp
-----
;
; IN8250 Get Byte (com_gb) & SCC Z8530 Get Byte (scc_gb)
;
; Receive Character to RS-232 Interface.
;
; Input:  cx = RS-232 time-out
;         dx = if dh = 0, then address of Z8530 channel (scc_ctl_x),
;             if dh <> 0, then address of 8250 data port (com_data_x).
;
; Output: al = character received
;         ah = line status
;         bx destroyed.
;
; Assumes: com_mctl_x = com_data_x + 4 = dx + 4
;          com_lstat_x = com_data_x + 5 = dx + 5
;          com_mstat_x = com_data_x + 6 = dx + 6
;
;          scc_data_x = scc_ctl_x + 1 = dx + 1
-----
E92A          C      com_gb proc near ; ah = 02h
E92A          C      assume cs:code, ds:nothing, es:nothing, ss:nothing
E92A 52      C      push     dx          ; save dx = com_data_x
E92B 80 01   C      mov     al,com_dtr     ; signal DTR
E92D E3 C2 04 C      add     dx,4            ; dx = com_mctl_x
E930 E2      C      out     dx,al        ; send to modem control register
E931 B4 20   C      mov     ah,com_dsr     ; wait for DSR
E933 42      C      inc     dx          ; dx = com_mstat_x
E934 42      C      inc     dx          ; wait for modem status register
E935 E8 E8BE R C      call      rs_ws         ; if time-out, take jump
E938 75 0E   C      jnz      rs_gbe
E93A B4 01   C      mov     ah,com_rxd     ; wait for receive ready
E93C 4A      C      dec     dx          ; dx = com_lstat_x
E93D E8 E8BE R C      call      rs_ws         ; wait for line status register
E940 75 06   C      jnz      rs_gbe ; if time-out, take jump
E942 80 E4 0E C      and     ah,0Eh         ; Only interested on low nibble.
E945 5A      C      pop     dx          ; restore dx = com_data_x
E946 EC      C      in     al,dx        ; else get character
E947 C3      C      ret
E948          C      ra_gb:          ; exit for get byte error
E948 5A      C      pop     dx          ; if SCC Z8530, restore dx = scc_ctl_x
E949 80 CC 80 C      or      ah,com_te      ; else IN8250, restore dx = com_data_x
E94C C3      C      ret
E94D          C      com_gb endp
E94D          C      scc_gb proc near ; ah = 02h
E94D          C      assume cs:code, ds:nothing, es:nothing, ss:nothing
E94D 52      C      push     dx          ; save dx = scc_ctl_x
E94E B4 01   C      mov     ah,scc_rxd     ; wait for receive ready
E950 E8 E8BE R C      call      rs_ws         ; if time-out, take jump
E953 75 F3   C      jnz      rs_gbe
E955 42      C      inc     dx          ; dx = scc_data_x

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ROM BIOS Listing

```

E956 EC          C          in     al,dx          ; else get character
C
E957 5A          C          pop     dx          ; restore dx = sec_ctl_x
E958 EB B5        C          jmp     short ra_pb_gb
C
E95A             C          sec_gb  endp
E95A             C          code  ends
C          include kb2.asm
C
C
C ;=====
C ; Filename:      kb2.src
C ;
C ; This module includes INT 09h & 16h.
C ;=====
C
E95A             C          code  segment public 'ROM'
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
C
E987             C          ORG   0E987h
C
C ;=====
C ; INT 09h -- 18041A Keyboard Hardware Interrupt Service Routine
C ;
C ; Note: 'make' -> key is depressed -> 00h + key scan code
C ;       'break' -> key is released -> 80h + key scan code
C ;=====
C
E987             C          k_int  proc  near
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
C
E987 PB          C          sti     ; re-enable interrupts
E988 FC          C          cld     ; clear direction flag
C
E989 50          C          push  ax
E98A 53          C          push  bx
E98B 51          C          push  cx
E98C 52          C          push  dx
E98D 56          C          push  si
E98E 57          C          push  di
E98F 1E          C          push  ds
E990 2E: 8E 1E E5F2 R C          mov  ds,word ptr cs:[set_ds_word] ; avoid potential stack problems
E995 06          C          push  es
C
C          assume cs:code, ds:data, es:nothing, ss:nothing
C
C ; Get the scan code.
C
E996 EA 60        C          in     al,p_kscan    ; get scan code from data port
E998 8A E0        C          mov  ah,al            ; save scan code in ah
C
C ; Reset the keyboard.
C
E99A BA 0061     C          mov  dx,p_kctrl    ; get control port address
E99D EC          C          in     al,dx          ; get the status
E99E 8A D8        C          mov  bl,al          ; save the status in bl
C
E9A0 0C 80       C          or   al,080h       ; set bit #7 -- reset
E9A2 EE          C          out  dx,al          ; reset keyboard
C
E9A3 8A C3       C          mov  al,bl           ; retrieve original status
E9A5 EE          C          out  dx,al          ; send it back to keyboard
C
C ; Retrieve the scan code in both al & ah.
C
E9A6 8A C4       C          mov  al,ah            ; scan code in both registers
C
C ; Test for overrun scan code from keyboard = 0FFh.
C ; Note: 20 key scan codes can be buffered up by the keyboard.
C
E9AB 3C FF       C          cmp  al,0FFh         ; an overrun scan code?
E9AA 75 06       C          jnz  k_ok           ; if not, continue
C
E9AC EB EBC3 R   C          call k_bEEP         ; beep the speaker
E9AF E9 EA5E R   C          jmp  k_noP
E9B2             C          k_ok:
C
C ;-----
C ; ah = scan code (make/break)      al = scan code (make/break)
C ; bx = ?
C ; cx = ?
C ; dx = ?
C ; es:di = ?
C ;-----
C
E9B2 24 7F       C          and  al,07Fh         ; al = scan code make
C
E9B4 C4 3E 0084 R C          les  di,dword ptr ds:[master_tbl_ptr] ; es:di points to master table
E9B8 26: C4 7D 02 C          les  di,dword ptr es:[di+0002h]    ; es:di points to p_kscan table
C
E9BC 33 D8        C          xor  bx,bx           ; clear bh
E9BE 33 C9        C          xor  cx,cx           ; clear cx
E9C0 8A 2E 0017 R C          mov  ch,byte ptr ds:[kb_flag]
C
E9C4 8A D8        C          mov  bl,al           ; bx = scan code make
E9C6 D1 E3        C          shl  bx,1            ; bx = 2*(scan code make)
E9C8 D1 E3        C          shl  bx,1            ; bx = 4*(scan code make)

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ROM BIOS Listing

```

C
C ;-----
C ; ah = scan code (make/break) al = scan code (make)
C ; bx = 4*(scan code make) = 4*al
C ; ch = kb_flag ol = 0
C ; dx = ?
C ; es:di = p_kscan base
C ;-----
E9CA 4B C dec bx ; bx = 4*(scan code make)-1
E9CB F6 C5 08 C test ch,alt_shift ; alt state?
E9CE 75 32 C jnz k_ix ; if so, has highest priority
E9D0 4B C dec bx ; bx = 4*(scan code make)-2
E9D1 F6 C5 04 C test ch,entri_shift ; control state?
E9D4 75 2C C jnz k_ix ; if so, next highest priority
E9D6 4B C dec bx ; bx = 4*(scan code make)-3
C ; Handle CapLk Case.
E9D7 3C 37 C cmp al,55 ; 0 <= scan code <= (7*8)-1
E9D9 77 0C C ja k_no_cap ; test NumLk case.
E9DB F6 C5 40 C test ch,caps_lock_mode ; capslock state?
E9DE 74 1C C jz k_no_lock ; if not, test shift states
E9E0 E8 EB85 R C call k_bit ; get kb_cap_flags bit in of
E9E3 73 17 C jnb k_no_lock ; (jnc) swap if of set
E9E5 EB 0D C jmp short k_lock ; honor caps lock.
E9E7 C k_no_cap:
C ; Handle NumLk Case.
E9E7 3C 47 C cmp al,71 ; scan code >= 71?
E9E9 72 11 C jb k_no_lock
E9EB 3C 53 C cmp al,83 ; scan code <= 83?
E9ED 77 0D C ja k_no_lock
E9EF F6 C5 20 C test ch,num_lock_mode ; numlock state?
E9F2 74 08 C jz k_no_lock ; if not, test shift states
E9F4 C k_lock:
E9F4 F6 C5 03 C test ch,(left_shift+right_shift) ; either caps or num lock.
E9F7 74 09 C jz k_ix ; if so, and shift state
C ; also true
E9F9 4B C dec bx ; bx = 4*(scan code make)-4
E9FA EB 06 C jmp short k_ix ; (base case)
E9FC C k_no_lock:
E9FC F6 C5 03 C test ch,(left_shift+right_shift) ; (shift state)
E9FF 75 01 C jnz k_ix
EA01 4B C dec bx ; bx = 4*(scan code make)-4
C ; (base case) fall through
EAO2 C k_ix:
EA02 D1 E3 C shl bx,1 ; bx = index into p_kscan table
EA04 03 FB C add di,bx ; bx = p_kscan word index
C ; add p_kscan base & index
EA06 26: 8B 15 C mov dx,word ptr es:[di] ; get data word from table
EA09 33 DB C xor bx,bx ; clear bh
EA0B 8A DA C mov bl,dl ; move translated key to bx
EA0D F6 06 0018 R 01 C test byte ptr ds:[kb_flag_1],dl,x_kb ; are we a deluxe keyboard
EA12 74 02 C jz k_xlat ; key
EA14 8A DE C mov bl,dh ; move translated delux
EA16 C k_xlat:
EA16 C ; key to key
EA16 C ; bx has translated byte (bh=0)
C ;-----
C ; ah = scan code (make/break) al = scan code (make)
C ; bx = delux keyboard translated byte (bh = 0)
C ; ch = kb_flag ol = 0
C ; dx = es:[di] (could be delux key code)
C ; es:di = p_kscan base + p_kscan scan code word index
C ;-----
C ; Registers are all loaded up. Start going through the cases.
EA16 0A D2 C or di,dl ; delux scan codes are
EA18 74 1C C jz k_no_case ; NEVER special cases!!!!
C ; Test for special cases.
EA1A 80 FB C0 C cmp bl,0C0h ; xlated byte special case?
EA1D 72 17 C jb k_no_case ; if not, handle unspcial case
EA1F 80 FB D8 C cmp bl,0D8h ; 0C0h <= xlated byte <= 0D8h
EA22 77 12 C ja k_no_case ; if so, do the special function
C ; Test for 'break' of special case.
EA24 80 FB C8 C cmp bl,0C8h ; is xlated byte a shift key?
EA27 72 04 C jb k_jmp ; if so, do 'break' of shift key
EA29 0A E4 C or ah,ah ; 0C0h <= xlated byte < 0C8h

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ROM BIOS Listing

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EA2B 78 2E          C      ja      k_none          ; nothing for 'break' of others.
EA2D              C      k JMP:   mov      si, bx          ; jump to special case routine.
EA2D 8B F3          C      shl      si, 1          ; if so, si gets special index
EA2F D1 E6          C      jmp      cs:[si+((offset k_case)-(2*0C0h))] ; make it a word index
EA31 2E: FF A4 EA66 R C
EA36              C      k_no_case:
EA36              C      ; Test for 'break' of non special case.
EA36 0A E4          C      or       ah, ah
EA38 78 21          C      js       k_none          ; do nothing if 'break' of key.
EA38              C      ; Test for 'unpause' case.
EA3A 76 06 0018 R 08 C      test     byte ptr ds:[kb_flag_1], pause_mode ; are we in hold state?
EA3F 74 08          C      jz       k_no_hold        ; if not, continue.
EAR1 3C 45          C      cmp     al, num_lock_key ; don't clear hold state
EAR3 74 16          C      je      k_none          ; on num_lock_key (Pause).
EAR5 80 26 0018 R F7 C      and     byte ptr ds:[kb_flag_1], not pause_mode ; reset hold state bit &
EAR4 EB 0F          C      jmp     short k_none      ; ignore the key.
EARC              C      k_no_hold:
EARC              C      ; Test for deluxe scan code.
EARC 0A D2          C      or      dl, dl
EARF 75 04          C      jnz     k_no_xcode
EA50 8B C2          C      mov     ax, dx          ; move deluxe key to scan code
EA52 EB 02          C      jmp     short k_buf      ; put ax into the buffer
EA54              C      k_no_xcode:
EA54 8A C3          C      mov     al, bl          ; move translated key to key
EA56              C      k_buf:
EA56              C      ; put ax into kb_buffer.
EA56 E8 EBAD R      C      call    k_try          ; try to put ax into kb_buffer.
EA59 74 03          C      jz      k_nop          ; if set (z) if buffer is full
EA5B              C      k_none:
EA5B              C      ; scan code translate to nothing
EA5B E8 EBAA R      C      ; Send specific end of interrupt (SEOI) to pic 'command' port.
EA5B 8B EBA4 R      C      call    k_eoi          ; send specific end of interrupt
EA5E 07            C      k_nop:   pop     es          ; restore registers without issuing SEOI
EA5F 1F            C      pop     ds
EA60 5F            C      pop     di
EA61 5E            C      pop     si
EA62 5A            C      pop     dx
EA63 59            C      pop     cx
EA64 5B            C      pop     bx
EA65 58            C      pop     ax
EA66 CF            C      iret
EA67 80 E5 0C      C      ;-----
EA6A 80 FD 0C      C      ; Test for system reset sequence. 'make' only.
EA6D 75 EC          C      ;-----
EA67 80 E5 0C      C      k_res:   and     oh, (alt_shift+ontrl_shift)
EA6A 80 FD 0C      C      cmp     oh, (alt_shift+ontrl_shift) ; is it CTL ALT shift?
EA6D 75 EC          C      jne     k_none
EA6F C7 06 0072 R 1234 C      ; CTL ALT DEL system reset.
EA75 89 DD5A R      C      mov     word ptr ds:[reset_flag], 01234h ; set flag for warm boot
EA75 89 DD5A R      C      jmp     diagnostica_1 ; re-boot
EA78              C      ;-----
EA78 80 0E 0018 R 08 C      k_pause: or      byte ptr ds:[kb_flag_1], pause_mode ; set the pause bit.
EA7D E8 EBA4 R      C      call    k_eoi          ; send specific end of interrupt
EA80 80 3E 0049 R 07 C      ; Note: Video not disabled during vertical retrace.
EA85 74 08          C      cmp     byte ptr ds:[v_mode], 7 ; never on a monochrome card
EA87 8B 16 0063 R   C      je      k_hold
EA8B 83 C2 04      C      mov     dx, word ptr ds:[v_base6845] ; get 6845 pointer register
EA8E A0 0065 R     C      add     dx, 4          ; get 6845 mode control register
EA91 EE            C      mov     al, byte ptr ds:[v_3x8] ; get the video mode last sent
EA92 76 06 0018 R 08 C      out     dx, al          ; enable video
EA97 75 F9          C      k_hold: test    byte ptr ds:[kb_flag_1], pause_mode ; test the pause bit.
EA99 EB C3          C      jnz     k_hold        ; loop until pause bit cleared
EA99 EB C3          C      jmp     short k_nop
EA9B E8 EBA4 R      C      ;-----
EA9E CD 05          C      ; Print Screen sequence. 'make' only.
EAA0 EB BC          C      ;-----
EAA0 EB BC          C      kprt:   call    k_eoi          ; send specific end of interrupt
EAA0 EB BC          C      INT     5h          ; issue print screen interrupt
EAA0 EB BC          C      jmp     short k_nop

```

ROM BIOS Listing

```

C
C ;-----
C ; Deluxe code put NUL into kb_buffer. 'make' only.
C ;-----
EAA2 BB 0300          k_nul: mov ax,0300h           ; NUL=IO3
EAA5 EB AF           jmp short k_buf          ; put ax into the buffer
C
C ;-----
C ; Four state shifts. 'make' & 'break' in kb_flag_1 plus history in kb_flag.
C ;-----
EA77 B0 80           k_ins: mov al,insert_shift      ; INS toggle look
EA97 E8 EAD4 R      call k_3togg                ; toggle 4 state
C
C           or ah,ah             ; is INS toggle 'make' ?
EA85 78 AB           js k_none                   ; if not, exit
EAB0 B8 5200          mov ax,(insert_key*100h)+00h ; else, ax gets deluxe INS key
EAB3 EB A1           jmp k_buf                    ; put ax into the buffer
C
C
EAB5 B0 40           k_cap: mov al,caps_lock_shift ; CAPS LOCK toggle look
EAB7 E8 EAD4 R      call k_3togg                ; toggle 4 state
EABA B1 01           mov cl,00000001b           ; CAPS LOCK LED is bit #0.
EABC E8 EB59 R      call k_LED_cap              ; send LED information
EABF EB 9A           k_non1: jmp short k_none
C
C
EAC1 B0 20           k_num: mov al,num_lock_shift   ; NUM LOCK toggle look
EAC3 E8 EAD4 R      call k_3togg                ; toggle 4 state
EAC6 B1 02           mov cl,00000010b           ; NUM LOCK LED is bit #1.
EAC8 E8 EB59 R      call k_LED_num              ; send LED information
EACB EB F2           jmp short k_non1
C
C
EACD B0 10           k_scr: mov al,scroll_lock_shift ; SCROLL LOCK toggle look
EACF E8 EAD4 R      call k_3togg                ; toggle 4 state
EAD2 EB EB           jmp short k_non1
C
C
EAD4 0A E8           k_3tog: or ah,ah                ; is toggle shift 'make' ?
EAD6 78 0F           js k_3res                   ; if 'break' reset kb_flag_1
C
C           test byte ptr ds:[kb_flag_1],al ; if 'make', test bit.
EAD8 84 06 0018 R   jnz k_3ret                   ; return if already pressed
EADC 75 08
C
C           or byte ptr ds:[kb_flag_1],al ; set the bit.
EAD2 08 06 0018 R   xor byte ptr ds:[kb_flag],al ; toggle kb_flag history.
EAD6 C3
C
C           k_3ret: ret
C
EAE7 F6 D0           k_3res: not al
EAE9 20 06 0018 R   and byte ptr ds:[kb_flag_1],al ; if 'break', reset bit only.
EADB C3
C
C ;-----
C ; Two state shifts. 'make' & 'break' in kb_flag only.
C ;-----
EAER B0 08           k_alt: mov al,alt_shift        ; ALT set/reset kb_flag
EAF0 E8 E80F R      call k_2togg                ; toggle 2 state
C
C           xor ax,ax            ; scan code of ah = 0.
EAF3 33 C0           xchg al,byte ptr ds:[alt_input] ; alt_input gets 0.
EAF5 86 06 0019 R   or al,al                    ; was alt_input 0?
EAF9 04 C0           je k_non1                    ; if so, do nothing.
EAFB 74 C2           jmp k_buf                     ; else, put it into buffer.
EAFD E9 EA56 R
C
C
EB00 B0 04           k_ctl: mov al,ctrl_shift       ; CTL set/reset kb_flag
EB02 EB 06           jmp short k_2ret              ; toggle 2 state and return
C
C
EB04 B0 02           k_leh: mov al,left_shift       ; LEFT SHIFT set/reset kb_flag
EB06 EB 02           jmp short k_2ret              ; toggle 2 state and return
C
C
EB08 B0 01           k_rsh: mov al,right_shift      ; RIGHT SHIFT set/reset kb_flag
; jmp short k_2ret             ; fall through
C
C
EB0A           k_2ret: call k_2togg                  ; toggle 2 state
EB0A E8 E80F R      call k_2togg
EB0D EB B0
C
C           k_2tog: or ah,ah            ; is set/reset shift 'make' ?
EB0F 0A E8           js k_2res                     ; if 'break', reset bit only.
EB11 78 05
C
C           or byte ptr ds:[kb_flag],al ; if 'make', set bit only.
EB13 08 06 0017 R   ret
EB17 C3
C
C           k_2res: not al
EB18 F6 D0           and byte ptr ds:[kb_flag],al ; if 'break', reset only.
EB1A 20 06 0017 R   ret
EB1E C3
C
C ;-----
C ; Alternats Numeric Keypad. 'make' only.
C ;-----
EB1F 41           k_alt9: inc ox                ; Alternate Numeric Keypad #9
EB20 41           k_alt8: inc ox                ; Alternate Numeric Keypad #8

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ROM BIOS Listing

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EB21 41          C k_alt7: inc    cx                ; Alternate Numeric Keypad #7
EB22 41          C k_alt6: inc    cx                ; Alternate Numeric Keypad #6
EB23 41          C k_alt5: inc    cx                ; Alternate Numeric Keypad #5
EB24 41          C k_alt4: inc    cx                ; Alternate Numeric Keypad #4
EB25 41          C k_alt3: inc    cx                ; Alternate Numeric Keypad #3
EB26 41          C k_alt2: inc    cx                ; Alternate Numeric Keypad #2
EB27 41          C k_alt1: inc    cx                ; Alternate Numeric Keypad #1
EB28            C k_alto:          cx                ; Alternate Numeric Keypad #0
EB28 80 0A       C          mov     al,10
EB2A F6 26 0019 R  C          mul     byte ptr ds:[alt_input] ; alt_input = (10*alt_input)+cl
EB2E 02 C1       C          add     al,cl
EB30 A2 0019 R   C          mov     byte ptr ds:[alt_input],al
EB33 EB 8A       C          jmp     short k_non1
C
C
C -----
C ; Double Zero on Keypad. 'make' only.
C -----
C
EB35 80 30       C k_00:  mov     al,'0'                ; try to put ax into kb_buffer.
EB37 EB EBAD R   C          call    k_try                    ; zf set (z) if buffer is full
EB3A 74 03       C          js     k_nop1                   ; zf reset (nz) if buffer got ax
EB3C E9 EA56 R   C          jmp     k_buf                      ; put it into buffer, again.
EB3F E9 EA5E R   C k_nop1: jmp     k_nop
C
C
C -----
C ; Break key sequence. 'make' only.
C -----
C
EB42 BB 001E R   C k_brk:  mov     bx,ds:[offset kb_buffer] ; reset buffer to empty
EB45 89 1E 001A R C          mov     word ptr ds:[buffer_head],bx
EB49 89 1E 001C R C          mov     word ptr ds:[buffer_tail],bx
EB4D C6 06 0071 R 80 C          mov     byte ptr ds:[bios_break],80h ; turn on bios_break bit
EB52 CD 1B       C          INT     1Bh                    ; break interrupt vector
EB54 33 C0       C          xor     ax,ax                    ; ax gets deluxe 00h
EB56 E9 EA56 R   C          jmp     k_buf                      ; put ax into the buffer
EB59            C k_int  endp
C
C
C -----
C ; Put keyboard LED's in correct state after CAPS/NUM LOCK.
C -----
C ; Input:  ah = scan code (make or break)
C ;         al = kb_flag bit for CAPS/NUM LOCK (caps_lock_shift or num_lock_shift)
C ;         cl = 00000001b for CAPS LOCK LED or 00000010b for NUM LOCK LED.
C ; Output: None.
C ; Trash:  al & cl destroyed.
C -----
EB59            C k_LED_num  proc  near
C          assume  cs:code, ds:data, es:nothing, ss:nothing
EB59 F6 06 0018 R 01 C          test   byte ptr ds:[kb_flag_1],dlx_kb ; are we a deluxe keyboard
EB5E 74 03       C          js     k_LED_cap                ; if kb_LED is num_lock
EB60 80 F1 80    C          xor     cl,10000000b              ; if deluxe kb_LED is
C                                     ; "num_lock"
EB63            C k_LED_cap:
EB63 0A 2A       C          or     ah,ah                    ; is CAPS/NUM LOCK 'make' ?
EB65 78 1D       C          ja     k_LED_ret                ; if not, exit
EB67 84 06 0017 R C          test   byte ptr ds:[kb_flag],al    ; is CAPS/NUM LOCK kb_flag set ?
EB68 74 03       C          js     k_LED_end                ; if not, LED data is ok.
EB6D 80 F1 80    C          xor     cl,10000000b              ; else, flip sense of LED data.
EB70            C k_LED_end:
EB70 E4 6A       C          in     al,kb_status              ; polling loop to send command.
EB72 A8 02       C          test  al,00000010b              ; get 8041 status
EB74 75 FA       C          jnz   k_LED_end                ; test input buffer bit
C                                     ; if not ok to write end, loop.
EB76 80 13       C          mov     al,013h                  ; keyboard 'LED' command.
EB78 E6 60       C          out    p_kscan,al               ; send keyboard 'LED' command.
EB7A            C k_LED_dat:
EB7A E4 6A       C          in     al,kb_status              ; polling loop to send data.
EB7C A8 02       C          test  al,00000010b              ; get 8041 status
EB7E 75 FA       C          jnz   k_LED_dat                ; test input buffer bit
C                                     ; if not ok to write data, loop.
EB80 8A C1       C          mov     al,cl                    ; retrieve keyboard 'LED' data.
EB82 E6 60       C          out    p_kscan,al               ; send keyboard 'LED' data.
EB84            C k_LED_ret:
EB84 C3          C          ret
EB85            C k_LED_num  endp
C
C
C -----
C ; Get kb_cap_flags bit into the carry flag (cf).
C -----
C ; Input:  al = scan code (make)
C ;         cl = 0
C ;         es:di = p_kscan base
C ; Output: cf set if kb_cap_flags bit
C ; Trash:  si destroyed.
C -----
EB85            C k_bit  proc  near
C          assume  cs:code, ds:data, es:nothing, ss:nothing

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ROM BIOS Listing

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EB85 8B F3          C      mov     si,bx          ; save bx
EB87 33 DB          C      xor     bx,bx          ; clear bh
EB89 8A DB          C      mov     bl,al          ; bx = scan code (make) index
                        ; bx = 00000000 00zxyyy
EB8B B1 03          C      mov     cl,3          ; rotate right bx 3
EB8D D3 CB          C      ror     bx,cl          ; bx = yyy00000 00000xxx
EB8F B1 03          C      mov     cl,3          ; rotate left bh 3
EB91 D2 C7          C      rol     bh,cl          ; bx = 00000yyy 00000xxx
                        ; bh = remainder = (0-7)
                        ; bl = quotient = (0-6)
EB93 8A CF          C      mov     cl,bh          ; cl = remainder = (0-7)
EB95 32 FF          C      xor     bh,bh          ; bx = quotient = (0-6)
EB97 26: 8A 59 F9   C      mov     bl,byte ptr es:[di+bx-7] ; bl = proper cap_flags byte
EB9B D2 D3          C      rcl     bl,cl          ; rotate (0-7) times into bit #7
EB9D 32 C9          C      xor     cl,cl          ; cl = 0
EB9F D0 D3          C      rol     bl,1          ; rotate into of bit #7
EBA1 8B DE          C      mov     bx,si          ; restore bx
EBA3 C3             C      ret
EBA4              C      k_bit  endp
                        ;-----
                        ; Input: None.
                        ; Output: None.
                        ; Trash: al & dx destroyed.
                        ;-----
EBA4              C      k_eoi  proc  near
                        ; Send specific end of interrupt (SEOI) to pic 'oommand' port.
EBA4 FA            C      cli                ; disable interrupts
EBA5 B0 61          C      mov     al,pic_seoi_1 ; specific end of interrupt
EBA7 BA 0020        C      mov     dx,pic_0      ; oommand to pic 'oommand' port.
EBA8 E2            C      out                ;
EBA9 FB            C      sti                ; enable interrupts
EBAE C3             C      ret
EBAD              C      k_eoi  endp
                        ;-----
                        ; Try to put ax into the kb_buffer.
                        ;
                        ; Input: ax = word to put in kb_buffer.
                        ; Output: zf set (z) if buffer is full. (ax trashed)
                        ;       zf reset (nz) if buffer got ax. (ax saved)
                        ;
                        ; Trash: bx, cx, dx, & si destroyed (in general).
                        ;-----
EBAD              C      k_try  proc  near
                        assume es:code, ds:data, es:nothing, ss:nothing
EBAD 8B 1E 001C R   C      mov     bx,word ptr ds:[buffer_tail] ; get buffer end pointer
EBB1 8B F3          C      mov     si,bx          ; save the value
EBB3 E8 E86E R     C      call   k_adv_ptr       ; advance the tail
EBB6 3B 1E 001A R   C      cmp     bx,word ptr ds:[buffer_head] ; has the buffer wrapped around
EBB8 74 07          C      je     k_bEEP         ; zf is reset (nz)
EBBC 89 04          C      mov     word ptr ds:[si],ax ; store the value
EBBE 89 1E 001C R   C      mov     word ptr ds:[buffer_tail],bx ; move the pointer up
EBC2 C3             C      ret                ; return zf reset (nz)
EBC3              C      k_try  endp
                        ;-----
                        ; Input: None.
                        ; Output: zf set (z) always.
                        ;
                        ; Trash: ax, bl, cx, & dx destroyed.
                        ;-----
EBC3              C      k_bEEP proc  near
                        assume es:code, ds:data, es:nothing, ss:nothing
EBC3 E8 EBA4 R     C      call   k_eoi          ; send specific end of interrupt
EBC6 BA 0061        C      mov     dx,p_kctrl    ; get kb control port address
EBC9 EC            C      in     al,dx          ; get control data
EBCA 8A E0          C      mov     ah,al         ; save control data
EBCD B3 80          C      mov     bl,80h        ; outer loop counter
EBCF 24 FC          C      k_lp: and    al,0FCh    ; turn off speaker data
EBD0 EE            C      out    dx,al
EBD1 B9 0048        C      mov     cx,48h        ; set up count
EBD4 E2 FE          C      loop  $              ; delay awhile

```

ROM BIOS Listing

```

EBD6 0C 02      C      or      al,02h
EBD8 EE        C      out     dx,al          ; turn on speaker
EBD9 99 0048   C      mov     cx,48h
EBDC E2 FE     C      loop    $              ; set up count
EBDE FE CB     C      dec     bl              ; delay awhile
EBE0 75 EC     C      jnz     k_lrp          ; decrement outer loop counter
EBE2 8A C4     C      mov     al,ah
EBE4 EE        C      out     dx,al
EBE5 C3        C      ret
EBE6           C      k_beep      endp
EBE6           C      k_data1    proc
EBE6           C      k_case    dw     k_ins      ; kbins (0C0b)
EBE8 EA47 R    C      dw     k_cap      ; kbcap
EBE9 EA48 R    C      dw     k_num      ; kbnum
EBEA EAC1 R    C      dw     k_ser      ; kbser
EBEC EACD R    C      dw     k_alt      ; kbalt
EBEE EAE8 R    C      dw     k_ctl      ; kbctl
EBF0 EB00 R    C      dw     k_lsh      ; kbtlsh
EBF2 EB04 R    C      dw     k_rsh      ; kbtrsh
EBF4 EB08 R    C      dw     k_res      ; kbres (0C8h)
EBF6 EA67 R    C      dw     k_brk      ; kbbrk
EBF8 EB42 R    C      dw     k_pause    ; kpause
EBFA E478 R    C      dw     kprt       ; kbprt
EBFC EA9B R    C      dw     k_nul      ; kbnul
EC00 EA5B R    C      dw     k_none     ; kbnone
EC02 EB1F R    C      dw     k_alt9     ; kdeo9
EC04 EB20 R    C      dw     k_alt8     ; kdeo8
EC06 EB21 R    C      dw     k_alt7     ; kdeo7
EC08 EB22 R    C      dw     k_alt6     ; kdeo6
EC0A EB23 R    C      dw     k_alt5     ; kdeo5
EC0C EB24 R    C      dw     k_alt4     ; kdeo4
EC0E EB25 R    C      dw     k_alt3     ; kdeo3
EC10 EB26 R    C      dw     k_alt2     ; kdeo2
EC12 EB27 R    C      dw     k_alt1     ; kdeo1
EC14 EB28 R    C      dw     k_alt0     ; kdeo0
EC16 EB35 R    C      dw     k_00      ; kdb10 (0D8h)
EC18           C      k_data1    endp
EC18           C      ocode     ends
EC18           C      include  fdul.asm
EC18           C      ;::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
EC18           C      ocode     segment public 'ROM'
EC18           C      assume  cs:ocode, ds:data, es:nothing, ss:nothing
EC18           C      f_nee_reset  proc  near
EC18 BA 03F4 90 C      mov     dx,f_nee_status ; NEC status port
EC1C EC        C      in     al,dx
EC1D 3C 10     C      cmp     al,10h        ; NEC busy.
EC1F 75 0E     C      jne     f_nee_reset_ret ; no.
EC21 A0 0041 R C      mov     al,diskette_status ; save from previous operation.
EC24 50        C      push   ax
EC25 33 C0     C      xor     ax,ax
EC27 8B D0     C      mov     dx,ax          ; reset call.
EC29 CD 13     C      int    13h
EC2B 5B        C      pop    ax
EC2C A2 0041 R C      mov     diskette_status,al ; restore from previous op.
EC2F           C      f_nee_reset_ret:
EC2F C3        C      ret
EC30           C      f_nee_reset  endp
EC30           C      ocode     ends
EC30           C      include  fdul.asm
EC30           C      ;:::::::::::::::::::::::::::::::::::::::::::::::::::: EQUATES ::::::::::::::::::::::
EC30           C      ; Controller constants
= 000C      C      f_art_48      equ    1100h ; 48TPI Step Rate Time (6 ms @ 4 Mhz)
= 000E      C      f_art_96      equ    1110h ; 96TPI Step Rate Time (4 ms @ 4 Mhz)
= 000F      C      f_hut         equ    1111h ; Head Unload Time (480 ms @ 4 Mhz)
= 0001      C      f_hlt         equ    1      ; Head Load Time (4 ms @ 4 Mhz)
= 0000      C      f_ndma        equ    0      ; Not DMA bit (0 = dma on)
= 0025      C      f_motor_wait equ    37    ; no. of RTC ticks before turning
           C      ; motor off. (f_motor_wait x 55ms)
=           C      f_drive      equ    [bp+0] ; byte pointer.
=           C      f_head       equ    [bp+1] ; byte pointer.
=           C      f_numsecs    equ    [bp+2] ; byte pointer.
=           C      f_command   equ    [bp+3] ; word pointer.
=           C      f_buffoff   equ    [bp+4] ; byte pointer.
=           C      f_secnum    equ    [bp+6] ; byte pointer.
=           C      f_oy1       equ    [bp+7] ; byte pointer.
=           C      f_real_drive equ    [bp+8] ; byte pointer.

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ROM BIOS Listing

```

; Floppy Disk port addresses
C
C
= 03F2 C f_motor_port equ 03F2h ; drive select port
= 03F4 C f_neo_status equ 03F4h ; disk controller status port
= 03F5 C f_neo_data equ 03F5h ; disk controller data port
C
; Floppy Disk commands
C
C
= 00B6 C f_read_cmd equ 0E6h ; read data
= 00C5 C f_write_cmd equ 0C5h ; write data
= 004D C f_format_cmd equ 04Dh ; format
= 0007 C f_recal_cmd equ 007h ; recalibrate
= 0008 C f_snsint_cmd equ 008h ; sense interrupt
= 0004 C f_snsdrv_cmd equ 004h ; sense drive
= 0003 C f_specify_cmd equ 003h ; specify
= 000F C f_seek_cmd equ 00Fh ; seek
C
C
; CODE
C
EC30 C code segment public 'ROM'
C assume cs:code, ds:data, es:nothing, ss:nothing
C
C
C
EC59 C ORG 0EC59h
EC59 C fd_lo proc far
C
C sti ; enable interrupts
EC5A C push bp
EC5B C push ds
EC5C C push si
EC5D C push di
EC5E C push dx ; head & drive#
EC5F C push cx ; cyl. & sec#
EC60 C push bx ; buffer offset
EC61 C push ax ; max. drives
EC62 C push dx ; drive out of range.
EC63 C mov bp,sp ; this one gets modified(96 TPI)
; BP preserves SP throughout
C
; test command code & use jump table to jump to appropriate routine
C
EC65 C mov ds,word ptr cs:[set_ds_word] ; DS = data_seg (40h)
EC6A C and motor_status,0Fh ; preserve motor on bits.
EC6F C cmp dl,1 ; max. drives
EC72 C ja f_io1 ; drive out of range.
EC74 C cmp ah,5 ; max. command.
EC77 C jbe diskette_io1 ; command in range
C
f_io1:
EC79 C mov diskette_status,cmd_error ; 01h
EC7E C jmp short f_io_ret ; quick return
C
diskette_io1:
EC80 C cld ; Autoincrement for strings.
EC81 C call f_check_valid ; Will not return if error.
EC84 C mov bh,bh ; clear high byte
EC86 C mov bl,ah ; move selection into low byte
EC88 C shl bx,1 ; multiply by 2
EC8A C jmp cs:[f_table.bx]
C
C
C
EC8F C f_table label word
C
C dw f_reset ; AH = 0 (reset)
EC91 C dw f_io_ret ; AH = 1 (status)
EC93 C dw f_r_data ; AH = 2 (read)
EC95 C dw f_w_data ; AH = 3 (write)
EC97 C dw f_r_data ; AH = 4 (verify)
EC99 C dw f_w_data ; AH = 5 (format)
C
C
C
EC9B C f_io_ret:
C ; f_neo_reset is located in the module called special.sro.
EC9B C call f_neo_reset ; reset if necessary.
EC9E C mov bx,2 ; motor_wait parameter.
ECA1 C call f_get_var ; Returns 0 in AH.
ECA4 C mov motor_count,al ; motor shut off value.
C
C xor al,al ; zero AL.
ECA9 C mov sb,diskette_status
C
C cmp ah,1
ECB0 C oac
C
C mov sp,bp ; for safety sake.
ECB1 C pop bx ; discard DX.
ECB3 C pop bx ; discard AX.
ECB5 C pop bp
ECB6 C pop cx
ECB7 C pop dx
ECB8 C pop di
ECB9 C pop si
ECBA C pop ds
ECBB C pop bp
C
ECBC C ret 2
C
ECBF C fd_lo endp

```


ROM BIOS Listing

```

C
C ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
C ;
C ;           Reset and reprogram the FDC without turning the motors off.
C ;
C ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
EBCF          f_reset proc   near
C
C          EBCF FA                    cli                                ; disable interrupts
C
C          ECC0 B0 66                 mov     al,pic_seoi_6            ; specific end of interrupt
C          ECC2 BA 0020               mov     dx,pic_0                ; to pic 'command' port.
C          ECC5 EE                    out     dx,al
C
C          ECC6 A2                    ino     dx                      ; pic 'data' port.
C          ECC7 EC                    in      al,dx                  ; read mask.
C          ECC8 24 BF                 and     al,10111111h          ; enable IR6.
C          ECCA EE                    out     dx,al
C
C          ; Develop mask for motor control port.
C          ECB8 A0 003F R              mov     al,motor_status        ; which motor is running?
C          ECCE 24 0F                 and     al,0Fh                ; blow off high 4 bits.
C          ECD0 74 0E                 js     f_r2                    ; no motors running.
C          ECD2 8A E0                 mov     ah,al
C          ECD4 B1 04                 mov     cl,4
C          ECD6 D2 E0                 shl     al,cl                  ; move to high nib.
C
C          ; A motor is on. Find out which one.
C          f_r1:
C          ECD8 D0 EC                 shr     ah,1                   ; determine drive select
C          ECDA 72 04                 jc     f_r2                    ; from motor enable bit.
C          ECD4 FE C0                 ino     al
C          ECDE EB F8                 jmp     short f_r1
C          f_r2:
C          ; Reset signal has to be maintained for at least 14 clocks.
C          EC20 C6 05 0041 R 00       mov     diskette_status,0
C          EC2E 0C 08                 or      al,8                   ; set bit 3.
C          EC37 BA 03F2               mov     dx,f_motor_port
C          EC3A EE                    out     dx,al                  ; send reset signal.
C          EC3B 0C 04                 or      al,4                   ; set bit 2.
C          EC3D C6 05 003E R 00       mov     seek_status,0
C          EC3F EE                    out     dx,al                  ; clear reset.
C          EC43 FB                    sti
C          EC44 EB F82 R              call    f_sis                   ; sense int. status
C
C          EC77 B4 03                 mov     ah,f_specify_cmd
C          EC79 EB E0C R              call    f_put_byte
C          EC7C BB 0000               bx,0
C          EC7F EB EFFF R              call    f_get_var                ; 1st specify byte.
C          EDC2 8A E0                 mov     ah,al
C          EDC4 EB E0C R              call    f_put_byte
C          EDC7 BB 0001               mov     bx,1
C          EDBA EB EFFF R              call    f_get_var                ; 2nd specify byte.
C          EDD0 8A E0                 mov     ah,al
C          EDDF EB E0C R              call    f_put_byte
C
C          ED12 EB 87                 jmp     f_io_ret
C          ED14
C          f_reset endp
C
C ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
C ;
C ;           (f_motor_on)
C ;
C ; INPUT:          none
C ;
C ; OUTPUT:         Carry set if motor was off, cleared otherwise.
C ;
C ; DESTROYS:      AX, CX
C ;
C ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
ED14          f_motor_on   proc   near
C
C          ED14 C6 06 0040 R FF       mov     motor_count,0Ffh      ; max. time for motor.
C          ED19 8A 4E 00               mov     cl,f_drive            ; drive.
C          ED1C B0 01                 mov     al,1
C          ED1E D2 E0                 shl     al,cl
C          ED20 84 06 003F R         test    al,motor_status       ; mask for motor status.
C          ED24 75 12                 jnz    f_mo_ret              ; test always clears carry.
C          ED26 A2 003F R             mov     motor_status,al
C          ED29 8A E1                 mov     ah,cl                 ; already running.
C          ED2B B1 04                 mov     al,ah                 ; set correct bit.
C          ED2D D2 E0                 shl     al,cl                 ; drive into AH.
C          ED2F 0C 0C                 or      al,0Ch                ; motor on bit to high nibble.
C          ED31 04 C4                 or      al,sh                 ; set bits 2 & 3 (0000 1100).
C          ED33 BA 03F2               mov     dx,f_motor_port       ; drive bits ( 0 & 1 ).
C          ED36 EE                    out     dx,al                 ; turn on the motor.
C          ED37 F9                    stc                            ; motor was off indicator.
C
C          f_mo_ret:
C          ED38 C3                    ret
C

```

ROM BIOS Listing

```

ED39          C f_motor_on      endp
C
C
C
ED39          C f_wdata proc   near
C
C
C
ED39 E8 ED14 R      call    f_motor_on      ; sets carry if motor was off.
ED3C 73 1E          jnc     f_wd1           ; motor was on, skip delay.
C
C
ED3E E4 67          in     al,sys_conf_b   ; read switch.
ED40 F6 D0          not    al               ; toggle the sense.
ED42 24 02          and    al,2            ; isolate slow motor bit.
C
ED44 8A C8          mov    cx,al           ;
ED46 BA 007D        mov    dx,125          ; 125 ms delay to start with.
ED49 D3 E2          shl    dx,cx           ; 125 x 4
ED4B BB 000A        mov    bx,10           ; motor start delay parameter.
ED4E E8 EDFF R      call    f_get_var      ; returns param. in AL.
ED51 32 E4          xor    ah,ah           ; for good measure.
ED53 F7 E2          mul   dx               ; AX has total delay
ED55 8B C8          mov    cx,ax
C
ED57          C f_wd_loop:
ED57 E8 EF47 R      call    f_wait_one_ms
ED5A E2 FB          loop   f_wd_loop
C
C
ED5C          C f_wd1:
ED5C 80 0E 003F R 80 or     motor_status,080h ; set high bit, indicate write.
ED61 B0 4A          mov    al,04Ah        ; DMA mode byte: channel 2,
C
C
ED63 EB 22          jsp   short f_rw_common ; single mode, read transfer
ED65          C f_wdata endp
C
C
C
ED65          C f_rdata proc   near
C
C
C
ED65 E8 26 003F R 7F and    motor_status,07Fh ; clear high bit, indicate read
ED6A E8 ED14 R      call    f_motor_on    ; motor was on, no delay.
ED6D 73 0E          jnc     f_rd1
C
C
C
ED6F          C ; slow motor delay loop
ED6F E4 67          in     al,sys_conf_b   ; read configuration switch(7M)
ED71 A8 02          test  al,2            ; bit 1 = slow drive bit
ED73 75 08          jnz   f_rd1           ; 1 = 250 ms motors, no delay
ED75 B9 01F4        mov    cx,500          ; approx. 500 ms delay for
C
C
C
ED78          C f_rd_loop:
ED78 E8 EF47 R      call    f_wait_one_ms
ED7B E2 FB          loop   f_rd_loop
C
C
C
ED7D          C f_rd1:
ED7D B0 46          mov    al,046h        ; DMA mode byte: channel 2,
C
C
ED7F 80 7E 03 04    cmp    byte ptr f_command,4 ; Is it a verify command?
ED83 75 02          jne   f_rw_common     ; No, must have been a read.
ED85 B0 42          mov    al,042h        ; DMA mode byte: channel 2,
C
C
C
ED87          C f_rdata endp
C
C
C
ED87          C ;
ED87          C ; Common (f_rw_common)
ED87          C ;
ED87          C ; INPUT:      AL      dma mode byte.
ED87          C ;
ED87          C ; OUTPUT:
ED87          C ;
ED87          C ; DESTROYS:
ED87          C ;
C
C
ED87          C f_rw_common  proc  near
C
C
ED87 C6 06 0040 R FF mov    motor_count,0FFh ; long wait.
ED8C E8 EB73 R      call    f_set_dma      ; pass mode byte on through.
C
C
C
ED8E 06          push  es
ED90 1E          push  ds
ED91 07          pop   es
ED92 32 C0      xor   al,al
ED94 B9 0007        mov    cx,7
ED97 BF 0042 R      mov    di,offset nec_status
ED9A F3 /AA        rep   stosb
ED9C 07          pop   es
C
ED9D E8 EEC4 R      call    f_seek         ; On return, f_drive has
C
C
EDA0 8A 56 03      mov    dl,byte ptr f_command ; get command
EDA3 B4 C5          mov    ah,f_write_cmd
EDA5 80 FA 03      cmp    dl,3
EDA8 74 09          je     f_rw1
EDAA B4 4D          mov    ah,f_format_cmd
EDAC 80 FA 05      cmp    dl,5 ; Is it a format command?

```

ROM BIOS Listing

```

EDAF 74 02          C          je      f_rw1          ; yes
EDB1 B4 E6          C          mov     ah,f_read_cmd      ; must be read or verify.
EDB3               C          f_rw1:          call   f_put_byte        ; send command.
EDB5 E8 E80C R     C          mov     ah,f_drive        ; has head and drive bits.
EDB6 8A 66 00       C          call   f_put_byte
EDB9 E8 E80C R     C          cmp     byte ptr f_command,5 ; was it a format command?
EDBC 74 15          C          je      f_rw_skip        ; yes, skip next 3 params.
EDC2 8A 66 07       C          mov     ah,f_ryl
EDC5 E8 E80C R     C          call   f_put_byte
EDC8 8A 66 01       C          mov     ah,f_head        ; blow off high 7 bits.
EDCB 80 EA 01       C          and    ah,1
EDCE E8 E80C R     C          call   f_put_byte
EDD1 8A 66 06       C          mov     ah,f_seenum
EDD4 E8 E80C R     C          call   f_put_byte
                  C          ; Get bytes 3,4,5,6 from table.
                  C          ; If we are formatting then we need bytes 3,4,7,8 from table.
EDD7               C          f_rw_skip:          mov     cx,4
EDD9 B9 0004        C          mov     bx,3          ; no. bytes per sector.
EDDB               C          f_rw2:          call   f_get_var
EDDE 8A E0          C          mov     ah,al
EDE2 E8 E80C R     C          call   f_put_byte
EDD5 43             C          inc    bx
EDD6 83 FB 05       C          cmp     bx,5          ; time to check for format?
EDD9 75 09          C          jne    f_rw3          ; No.
EDEB 80 7E 03 05   C          cmp     byte ptr f_command,5 ; was it a format command?
EDF1 75 03         C          jne    f_rw3          ; no.
EDF1 B8 0007        C          mov     bx,7          ; 7th parameter in table.
EDF4               C          f_rw3:          loop   f_rw2
EDF6 E8 EF8D R     C          call   f_wait_for_nec
EDF9 E8 EE29 R     C          call   f_get_byte        ; get the results.
EDFC               C          f_rw_ret:          jmp    f_io_ret
EDFF               C          f_rw_common      endp
                  C          ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
                  C          ; Get specified byte from fdu parameter table (f_get_var)
                  C          ; INPUT:      BX      parameter number (0 - 10)
                  C          ; OUTPUT:     AL      The requested byte.
                  C          ; DESTROYS:  AH
                  C          ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
EDFF               C          f_get_var      proc  near
EDFF 1E             C          push   ds
EE00 33 C0          C          xor    ax,ax
EE02 8E D8         C          mov     ds,ax          ; segment 0
                  C          assume ds:abs0      ; tell assembler seg 0:
EE04 C5 36 0078 R  C          lds   si,dword ptr [int!Eloen] ; DS:SI points to table
EE08 8A 00          C          mov     al,[bx+si]
EE0A 1F             C          pop    ds
                  C          assume ds:data      ; tell assembler seg 40:
EE0B C3             C          ret
EE0C               C          f_get_var      endp
                  C          ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
                  C          ; Send a byte to the NEC controller (f_put_byte)
                  C          ; INPUT:      AH      byte to output.
                  C          ; OUTPUT:
                  C          ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
EE0C               C          f_put_byte     proc  near
EE0C E8 EF68 R     C          call   f_nec_rdy        ; returns MSR byte in AL.
EE0F A8 40          C          test   al,80h         ; direction bit.
                  C          .list
EE11 75 05         C          jnz    f_pb_errret     ; wrong direction.
EE13 42             C          inc    dx
EE14 8A C4          C          mov     al,ah
EE16 EE             C          out    dx,al
                  C          f_pb_ret:          ret
EE17               C          f_pb_errret:          mov     diskette_status,fdc_error
EE18 C6 06 00A1 R 20 C          jmp    f_io_ret
EE1D E9 EC9B R     C          f_put_byte     endp
EE20

```

ROM BIOS Listing

```

C
C ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
C ;
C ;               Read the results bytes from the NEC controller (fdu_data)
C ;
C ; INPUT:        none
C ;
C ; OUTPUT:
C ;
C ;
C ; DESTROYS:     DX, SI
C ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
E220          C          fdu_data          proc
E220          C          f_gb_table          label byte
E220 04          C          db          4          ; record not found.
E21 00          C          db          0          ; dummy
E22 10          C          db          10h         ; crc error.
E23 08          C          db          8          ; dma error.
E24 00          C          db          0          ; dummy.
E25 04          C          db          4          ; sector not found.
E26 03          C          db          3          ; write protect.
E27 02          C          db          2          ; address mark error.
E28 20          C          db          20h        ; fdc error.
E29          C          fdu_data          endp
E29          C          f_get_byte          proc near
E29 06          C          push          es
E2A 1E          C          push          ds
E2B 07          C          pop          es
E2C BF 0042 R   C          mov          di,offset nec_status ; ES:DI is now ready for stosb.
E2F 8B F7       C          mov          si,di   ; offset of nec_status in SI.
E31 B9 0007    C          mov          cx,7   ; maximum no. of bytes.
E33          C          f_gb_loop:
E33 8B EF6B R   C          call          f_neo_rdy ; Returns MSR byte in AL.
E37 48 10       C          test          al,10h   ; will not return if error.
E39 74 36       C          jz          f_gb_ret ; busy bit.
E3B 48 40       C          test          al,40h   ; done.
E3D 74 05       C          jz          f_gb_out ; direction bit.
E3F 42          C          inc          dx   ; wrong direction.
E40 EC          C          in          al,dx ; point to nec data port (3F5h)
E41 4A          C          stosb
E42 E2 F0       C          loop          f_gb_loop
E43          C          f_gb_out:
E43 80 7E 03 00 C          cmp          byte ptr f_command,0 ; was it reset command?
E44 74 27       C          jz          f_gb_ret ; yes.
E4A AC          C          lodsb
E4B A8 20       C          test          al,20h   ; get ST0 in AL.
E4D 75 22       C          jnz          f_gb_ret ; seek end?
E4F A8 C0       C          test          al,000h  ; yes.
E51 74 1A       C          jz          f_gb_jmp
E53          C          mov          diskette_status,fdc_error
E53 C6 06 0041 R 20 C          lodsb ; get SI in AL.
E55 89 0008    C          mov          cx,8
E5C 33 DB       C          xor          bx,bx
E5E          C          f_gb_loop1:
E5E D0 C0       C          rol          al,1
E5F 72 03       C          je          f_gb_decode
E62 43          C          inc          bx
E63 E2 F9       C          loop          f_gb_loop1
E65          C          f_gb_decode:
E65 2E: 8A 87 E20 R C          mov          al,es:f_gb_table[bx]
E66 A2 0041 R   C          mov          diskette_status,al
E6D          C          f_gb_jmp:
E6D 07          C          pop          es
E6E E9 EC9B R   C          jmp          f_io_ret
E71          C          f_gb_ret:
E71 07          C          pop          es
E72 C3          C          ret
E73          C          f_get_byte          endp
C ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
C ;
C ; Test for boundary crossing case then program the
C ; DMA controller (f_set_dma).
C ;
C ; INPUT:        AL mode byte
C ;              ES segment of user buffer.
C ;
C ; OUTPUT:
C ;
C ; DESTROYS:     AX, BX, CX, DX
C ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
E73          C          f_set_dma          proc near
E73 C6 06 0041 R 09 C          mov          diskette_status,dma_seg_error
E74 86 C        C          out          dma_ff_clr,al ; set to known state.
E7A 86 0B       C          out          dma_mode,al ; send mode byte.
E7C 8B 5E 04    C          mov          bx,word ptr f_bufoff ; offset of user buffer.
E7F 8C C0       C          mov          ax,es ; offset of user buffer.

```


ROM BIOS Listing

```

EF2C F6 06 0042 R C0      C      test    nec_status,0C0h          ; test for seek end.
C
C
EF31 75 13                C      jnz     f_s_ret
EF33 BB 0009              C      mov     bx,9
EF36 E8 EDDF R           C      call   f_get_var
EF39 0A C0                C      or     al,al
EF3B 74 09                C      jz     f_s_ret          ; head settle = 0.
EF3D 8A C6                C      mov     cl,al          ; use settle parm. al loop index
EF3F 32 ED                C      xor     oh,oh
C
C f_head_settle:
EF41 E8 EF47 R           C      call   f_wait_one_ms
EF44 E2 FB                C      loop  f_head_settle
C
C f_s_ret:
EF46 C3                    C      ret
C
C
EF47                      C      f_seek  endp
C
C
C ;
C ;
C ; One millisecond delay loop (approximately)
C ;
C ; The CALL is 19 clocks.
C ; The callers LOOP statement is 17 clocks.
C ; No flags affected.
C ;
C ;
C ;
C
EF47                      C      f_wait_one_ms  proc  near
EF47 51                    C      push  cx          ; 11 clocks
EF48 B9 0176              C      mov   cx,376       ; 4 clocks
EF4B E2 FE                C      w_one: loop w_one  ; (17 x CX) + 5 clocks
EF4D 59                    C      pop   cx          ; 8 clocks
EF4E C3                    C      ret               ; 16 clocks
EF4F                      C      f_wait_one_ms  endp
C
C
C ;
C ;
C ; This routine is called by the timer_int routine when motor_count = 0
C ;
C ;
C ;
C
EF4F                      C      stop_disk   proc  near
C
C
EF4F B0 0C                C      mov   al,0Ch
EF51 BA 03F2              C      mov   dx,f_motor_port
EF54 EE                  C      out  dx,al
EF55 C3                    C      ret
C
C stop_disk   endp
C
C
C include fdu2.asm
C
C ;
C ;
C ;
C ; INPUT: none
C ;
C ; OUTPUT: MSB of seek_status is set if NEC interrupts.
C ;
C ; DESTROYS: nothing
C ;
C ;
C ;

```


ROM BIOS Listing

```

C ;
C ;
C ; Check Valid (f_check_valid)
C ;
C ; This routine determines the validity of the request based on
C ; drive type (40 or 80 trk) and media type (40 or 80 trk)
C ;
C ; Bit 7 of sys_conf_b port: 0 = 40 trk drive, 1 = 80 trk drive
C ; Bit 7 of head parameter(DH): 0 = 40 trk media, 1 = 80 trk media
C ;
C ;
C ;
C ; drive
C ; |-----|
C ; | 0 | 1 |
C ; |-----|
C ; | 0 | r/w | f/w |
C ; |-----|
C ; media | 1 | n/a | f/w |
C ; |-----|
C ;
C ;
C ; OUTPUT: The MSB of the drive parameter at bp-1 is set
C ; if the drive is 80 track and the media is 40 track.
C ; This is used by seek to determine if double stepping
C ; is necessary.
C ;
C ;
C ;
C ;
C ; f_check_valid proc near
C ;
EFA4 C push ax
EFA5 C in al,sys_conf_b ; switch port
EFA6 C and al,1 ; blow off high 7 bits
EFA7 C ror al,1 ; move it into the high bit
EFA8 C xor f_head,al ; head param. (xor clears carry)
EFA9 C jns f_cv_ret ; media & drive agree
EFAB C test al,80h ; is drive 80 track.
EFAC C jnz f_cv_ret ; it was.
EFAD C mov di,diskette_status,cmd_error
EFAE C jmp f_io_ret
EFAF C f_cv_ret:
EFB0 C pop ax
EFB1 C ret
EFB2 C
EFB3 C f_check_valid endp
EFB4 C
EFC1 C include fd_u3.asm
EFC2 C
EFC3 C ;-----|
EFC4 C ; fd_parms
EFC5 C ; This is the set of parameters required for diskette operation.
EFC6 C ; They are pointed to by interrupt vector 1EH (0:76h). To modify
EFC7 C ; the parameters, build another parameter block and point disk_pointer
EFC8 C ; to it.
EFC9 C ;-----|
EFCF C ORG 0EFC7h
EFD0 C
EFD1 C fdu_data2 proc
EFD2 C
EFD3 C fd_parms label byte
EFD4 C
EFD5 C db (f_srt_48 shl 4) + f_hut ; SRT + HUT
EFD6 C db (f_hlt shl 1) + f_ndma ; HLT + DMA mode
EFD7 C db f_motor_wait ; motor off delay
EFD8 C db 2 ; 512 bytes per sector
EFD9 C db 8 ; EOT last sector on cyl
EFDA C db 02Ah ; gap length
EFD5 C db 0Ffh ; DTL
EFD6 C db 050h ; gap length for format
EFD7 C db 0F6h ; fill byte for format
EFD8 C db 25 ; head settle time (ms)
EFD9 C db 4 ; motor start time
EFD5 C
EFD6 C fdu_data2 endp
EFD7 C
EFD8 C code ends
EFD9 C include prt.asm
EFD0 C
EFD1 C ;-----|
EFD2 C ; Filename: prt.src
EFD3 C ;
EFD4 C ; This module includes INT 17h.
EFD5 C ;-----|
EFD6 C
EFD7 C code segment public 'ROM'
EFD8 C assume cs:code, ds:nothing, es:nothing, ss:nothing
EFD9 C
EFD0 C ;-----|
EFD1 C ; INT 17h -- Printer Software Interrupt Request Routine
EFD2 C ;
EFD3 C ; Input: ah = 0 print character
EFD4 C ; al = character to print
EFD5 C ; dx = printer port number (0,1,2,3)
EFD6 C ; Output: ah = status of printer: bit #0 set if time out
EFD7 C ; al = character to print (preserved)
EFD8 C ;
EFD9 C ;
EFD0 C ; Input: ah = 1 initialize the printer port
EFD1 C ; dx = printer port number (0,1,2,3)
EFD2 C ; Output: ah = status of printer
EFD3 C ;
EFD4 C ;
EFD5 C ;
EFD6 C ;
EFD7 C ;
EFD8 C ;
EFD9 C ;

```


ROM BIOS Listing

```

C ;          al      preserved
C ;
C ;      Input: ah = 2  read the printer status
C ;              dx = printer port number (0,1,2,3)
C ;      Output: ah = status of printer
C ;
C ;      Trash: ah = (ah - 2) if ah > 2
C ;              al      preserved
C ;
C ;      Assumes:      prt_stat_x = prt_data_x + 1 = dx + 1
C ;                   prt_cmd_x = prt_data_x + 2 = dx + 2
C ;
C ;      Printer Status Byte from prt_stat_x:
C ;
C ;      bit #0 = time-out on printing character (p_out).
C ;              set by software; no hardware significance.
C ;      bits #1-2 = no significance (always cleared).
C ;      bit #3 = hardware: I/O error.
C ;      bit #4 = hardware: selected.
C ;      bit #5 = hardware: out of paper.
C ;      bit #6 = hardware: acknowledge.
C ;      bit #7 = hardware: not busy.
C ;
C ;      "Good" Statuses are: 90h & 10h if a printer is connected,
C ;                          30h if printer is disconnected.
C ;
C ;=====
EFD2          ORG      0EFD2h
EFD2          p_io    proc    near
C ;          assume cs:code, ds:nothing, es:nothing, ss:nothing
C ;
EFD2          FB          sti          ; enable interrupts
EFD3          83 FA 04    cmp         dx,4          ; 4 printers allowed max
EFD6          73 32      jse         p_nop
C ;
C ;          assume cs:code, ds:data, es:nothing, ss:nothing
C ;
EFD8          51          push     cx          ; save registers
EFD9          52          push     dx
EFDA          57          push     di
EFDB          86 C4      xchg     al,ah      ; reverse al & ah
EFD4          1E          push     ds          ; ah saves al throughout
EFDE          2E: 8E 1E 5F2 R mov     ds,word ptr cs:[set_ds_word] ; satisfy assumptions
EFD3          8B FA      mov     di,dx      ; get port number (0-3)
EFE5          33 09      xor     cx,cx      ; clear cx
EFE7          8A 8D 0078 R mov     cl,byte ptr ds:[di-printer_t_out] ; get printer time-out
EFEB          D1 E1      sal     cx,1       ; double it 4 faster cpu
EFED          03 FF      add     di,di      ; make word index
EFEF          8B 95 0008 R mov     dx,word ptr ds:[di-printer_addr] ; get address of printer
EFF3          1F          pop      ds          ; restore ds
C ;
C ;          assume cs:code, ds:nothing, es:nothing, ss:nothing
C ;
EFF4          0B D2      or      dx,dx      ; is a printer there?
EFF6          74 0D      jz      p_ret
C ;
EFF8          33 FF      xor     di,di      ; clear di
EFAA          0A C0      or      al,al      ; al = 0?
EFPD          74 0D      jz      p_out      ; dx = prt_data_x
EFFE          42          inc     dx          ; dx = prt_stat_x
EFFF          2C 02      sub     al,2       ; al = 1 < 2?
F001          72 24      jb      p_init      ; dx = prt_stat_x
F003          74 2F      je      p_stat      ; al = 2?
F005          86 C4      jz      p_ret      ; dx = prt_stat_x
C ;
C ;      p_ret: xchg     al,ah      ; reverse al & ah back
F007          5F          pop     di          ; ah saved al throughout
F008          5A          pop     dx          ; restore registers
F009          59          pop     cx
F00A          CF          p_nop:  iret
C ;
C ;-----
C ;      Print Character to Parallel Printer Interface.
C ;
C ;      Input: ah = character to print
C ;              cx = printer time-out
C ;              dx = address of printer data port (prt_data_x).
C ;              di = 0
C ;      Output: ah = character to print
C ;              al = status of printer: bit #0 set if time out
C ;              dx = address of printer status port (prt_stat_x).
C ;      Trash: cx & di destroyed.
C ;
C ;      Assumes:      prt_stat_x = prt_data_x + 1 = dx + 1
C ;                   prt_cmd_x = prt_data_x + 2 = dx + 2
C ;-----
C ;          assume cs:code, ds:nothing, es:nothing, ss:nothing
C ;
F00B          8A C4      p_out:  mov     al,ah      ; get character to print
F00D          EE          out     dx,al          ; output character

```

ROM BIOS Listing

```

F00E 42          C          inc     dx                      ; dx = prt_stat_x
F00F EC          C          p_lp:  in     al,dx                ; get printer status
F010 24 F8       C          and     al,0F8h              ; clear bogus printer bits
F012 34 49       C          xor     al,049h            ; flip acknowledge & I/O err bit
F014 78 07       C          ja     p_ok                ; & set printer time-out bit #0
F016 4F          C          dec     di                      ; inner loop counter
F017 75 F6       C          jnz    p_lp                ; inner loop
F019 E2 F4       C          loop   p_lp                ; outer loop
F01B EB E8       C          jmp     short p_ret          ; return status with time-out

F01D 42          C          p_ok:  inc     dx                      ; dx = prt_cmd_x
F01E B0 0D       C          mov     al,0Dh             ; set strobe high (al = 0Dh)
F020 EE          C          out     dx,al
F021 90          C          nop
F022 48          C          dec     ax                      ; set strobe low (al = 0Ch)
F023 EE          C          out     dx,al
F024 4A          C          dec     dx                      ; dx = prt_stat_x

F025 EB 0D       C          jmp     short p_stat

C          ;-----
C          ; Initialize Parallel Printer Interface.
C          ;
C          ; Input:  ah =   byte to return in al.
C          ;         dx =   address of printer status port (prt_stat_x).
C          ; Output: al =   status of printer
C          ;         dx =   address of printer status port (prt_stat_x).
C          ; Trash: cx =   0 destroyed.
C          ;
C          ; Assumes:   prt_stat_x = prt_data_x + 1 = dx + 1
C          ;             prt_cmd_x = prt_data_x + 2 = dx + 2
C          ;-----
C          assume cs:code, ds:nothing, es:nothing, ss:nothing

F027 B0 08       C          p_init: mov  al,08h            ; request init (hold line low)
F029 42          C          inc     dx                      ; dx = prt_cmd_x
F02A EE          C          out     dx,al

F02B B5 05       C          mov     ch,05h              ; delay awhile (cx = 0577h)
F02D E2 FE       C          loop   $

F02F B0 0C       C          mov     al,0Ch              ; disable interrupts, manual lf
F031 EE          C          out     dx,al                ; (init done - line set high)
F032 90          C          nop

F033 4A          C          dec     dx                      ; dx = prt_stat_x
C          jmp     short p_stat

C          ;-----
C          ; Read Status of Parallel Printer Interface.
C          ;
C          ; Input:  dx =   address of printer status port (prt_stat_x).
C          ; Output: al =   status of printer
C          ;         dx =   address of printer status port (prt_stat_x).
C          ;
C          ; Assumes:   prt_stat_x = prt_data_x + 1 = dx + 1
C          ;-----
C          assume cs:code, ds:nothing, es:nothing, ss:nothing

F034 EC          C          p_stat: in  al,dx                ; get printer status
F035 24 F8       C          and     al,0F8h              ; clear bogus printer bits
F037 34 48       C          xor     al,048h            ; flip acknowledge & I/O err bit
F039 EB CA       C          jmp     short p_ret          ; exit

F03B          C          p_io  endp
F03B          C          code  ends
F03B          C          include vid.asm

C          ;-----
C          ; Filename:      vid.src
C          ;
C          ; This module includes INT 10h, the display routines.
C          ;-----
C          ; These constants must be defined (amount to scroll/clear during vert retrace):
C          ; V_KSCROLL equ 4 ; 4 rows, plus
C          ; V_KCLEAR  equ 7

F03B          C          code  segment public 'ROM'
C          assume cs:code, ds:nothing, es:nothing, ss:nothing

C          ;-----
C          ; ROM data
C          ;-----

F045          C          ORG   0F045h
F045          C          v_data1 proc  near
F045 F0FC R       C          v_tbl  dw   v_set_mode          ; ah = 00h
F047 F1E9 R       C          dw   v_cura_type              ; ah = 01h

```

ROM BIOS Listing

```

F049 F1F7 R      C      dw      v_cura_pos      ; ah = 02h
F04B F215 R      C      dw      v_r_cura_pos      ; ah = 03h
F04D D7CD R      C      dw      grf_light_pen      ; ah = 04b      (see graph.src)
F04F F22C R      C      dw      v_page      ; ah = 05h
F051 F27F R      C      dw      v_scrll_up      ; ah = 06h
F053 F35B R      C      dw      v_scrll_dn      ; ah = 07h
F055 F37C R      C      dw      v_rac      ; ah = 08h
F057 F3A6 R      C      dw      v_wac      ; ah = 09h
F059 F3DF R      C      dw      v_wc      ; ah = 0Ah
F05B F41A R      C      dw      v_col      ; ah = 0Bh
F05D D7EA R      C      dw      grf_write_dot      ; ah = 0Ch      (see graph.src)
F05F D7DD R      C      dw      grf_read_dot      ; ah = 0Dh      (see graph.src)
F061 F446 R      C      dw      v_terminal      ; ah = 0Eh
F063 F4CF R      C      dw      v_stat      ; ah = 0Fh

F065
C      v_data1 endp
C
C      ;=====
C      ; INT 10h -- Video Interrupt Service Routine.
C      ;=====
C      ; -- Set CPU flags.
C      ; -- Segment registers properly loaded.
C      ; -- CALLS routines with: -- al, dx, cx, dx intact
C      ; -- ah = v_mode
C      ; -- si = 2 * (function that was in ah)
C      ; -- di = bits #4 & 5 of switch_bits
C      ; -- bp = value of ax to be returned
C      ;
C      ; Input: ah = function number (00h <= ah <= 0Fh)
C      ;
C      ; Trash: None. (bp, si, di, ds, & es if ROM stack)
C      ;=====
F065
C      ORG      0F065h
F065
C      v_io      proc      near
C
C      assume cs:code, ds:nothing, es:nothing, ss:nothing
C
C      sti      ; enable interrupts
C      cmp      ah,0Fh ; input out of range?
C      ja      v_nop
C
C      push     es ; save 'trashable' registers
C      push     ds
C      mov     dx,word ptr cs:[set_ds_word] ; avoid potential stack problems
C      push     di
C      push     si
C      push     bp
C
C      assume cs:code, ds:data, es:nothing, ss:nothing
C
C      push     ax ; save ax
C
C      mov     al,ah ; al = function number
C      add     al,ah ; # 2
C      cbw
C      push     ax ; save for CALL later.
C
C      mov     di,para_graph ; get screen segment ..
C      mov     al,byte ptr ds:[switch_bits] ; .. check switch bits ..
C      test    al,20h
C      jz      v_colour ; .. if either is 0, it's a
C      test    al,10h ; .. color display board
C      jz      v_colour
C      add     di,para_mono-para_graph ; .. it's a monochrome board
C      v_colour:
C      mov     es,di ; set es = video ram
C
C      pop     di ; Get index to call table.
C
C      pop     ax ; restore ax
C      mov     ah,byte ptr ds:[v_mode] ; get display driver mode
C      mov     bp,ax ; bp saves ax throughout
C      ; (return ah = v_mode
C      ; unless specific ret. value)
C
C      cld
C      ; String ops move UP, mostly.
C      oall    cs:[di+(offset v_tbl)] ; perform display function
C
C      pop     bp ; restore 'trashed' registers
C      pop     si ; (destroyed if ROM stack)
C      pop     di
C      pop     ds
C      pop     es
C      v_nop:
C      irot
C
C      v_io      endp
C      ;=====
C
C      ORG      0F0A4h
F0A4
C      v_data2      proc      near
F0A4
C      v_parms      label      byte
C      ; 6845 Parameters except register 3h (Horizontal Synch Width).
C

```

ROM BIOS Listing

```

FOA4 38 28 2D 06      C v_md_40      db      38h,28h,2Dh,06h ; text 40 x 25
FOA8 1F 06 19 1C      C             db      1Fh,06h,19h,1Ch ; mode 0 -> monochrome
FOAC 02 07 06 07      C             db      02h,07h,06h,07h ; mode 1 -> color
FOB0 00 00 00 00      C             db      00h,00h,00h,00h
FOB4 71 50 5A 0C      C v_md_80      db      71h,50h,5Ah,0Ch ; text 80 x 25
FOB8 1F 06 19 1C      C             db      1Fh,06h,19h,1Ch ; mode 2 -> monochrome
FOBC 02 07 06 07      C             db      02h,07h,06h,07h ; mode 3 -> color
FOC0 00 00 00 00      C             db      00h,00h,00h,00h
FOC4 38 28 2D 06      C v_md_graph   db      38h,28h,2Dh,06h ; graphics
FOC8 7F 06 64 70      C             db      7Fh,06h,64h,70h ; mode 4 -> 320 x 200 color
FOCC 02 01 06 07      C             db      02h,01h,06h,07h ; mode 5 -> 320 x 200 monochrome
FOD0 00 00 00 00      C             db      00h,00h,00h,00h ; mode 6 -> 640 x 200 monochrome
FOD4 61 50 52 0F      C v_md_mono    db      61h,50h,52h,0Fh ; monochrome card 80 x 25
FDD8 19 06 19 19      C             db      19h,06h,19h,19h ; mode 7 -> monochrome card
FDDC 02 0D 08 0C      C             db      02h,0Dh,08h,0Ch
FDE0 00 00 00 00      C             db      00h,00h,00h,00h
FDE4 0800              C .list
FDE6 1000              C v_md_len     dw      2048             ; 40x25      modes 0 & 1
FDE8 4000              C             dw      4096             ; 80x25      modes 2 & 3
FOEA 4000              C             dw      16384            ; graphics   modes 4 & 5
FOEA 4000              C             dw      16384            ;             mode 6
FOEA 4000              C             dw      32768            ;             modes 64 & 72
FOEC 28              C v_md_wid     db      40              ; 0 -> text   40x 25 monochrome
F0ED 28              C             db      40              ; 1 -> text   40x 25 color
FOEE 50              C             db      80              ; 2 -> text   80x 25 monochrome
FOEF 50              C             db      80              ; 3 -> text   80x 25 color
FOF0 28              C             db      40              ; 4 -> graphics 320x200 color
FOF1 28              C             db      40              ; 5 -> graphics 320x200 monochrome
FOF2 50              C             db      80              ; 6 -> graphics 640x200 monochrome
FOF3 50              C             db      80              ; 7 -> text   80x 25 monochrome card
FOF4 2C              C .list
FOF5 28              C v_md_enable  db      2Ch             ; 0 -> text   40x 25 monochrome
FOF6 2D              C             db      28h             ; 1 -> text   40x 25 color
FOF7 29              C             db      2Dh             ; 2 -> text   80x 25 monochrome
FOF8 2A              C             db      29h             ; 3 -> text   80x 25 color
FOF9 2E              C             db      2Ah             ; 4 -> graphics 320x200 color
FOFA 1E              C             db      2Eh             ; 5 -> graphics 320x200 monochrome
FOFB 29              C             db      1Eh             ; 6 -> graphics 640x200 monochrome
FOFB 29              C             db      29h             ; 7 -> text   80x 25 monochrome card
FOFC              C .list
FOFC v_data2end     C             ;
FOFC              C             ;-----
FOFC              C             ; Set Mode & Clear Screen      ah = 00h
FOFC              C             ;
FOFC              C             ; Input: al = mode
FOFC              C             ; = 0 -> text   40x 25 monochrome
FOFC              C             ; = 1 -> text   40x 25 color
FOFC              C             ; = 2 -> text   80x 25 monochrome
FOFC              C             ; = 3 -> text   80x 25 color
FOFC              C             ; = 4 -> graphics 320x200 color
FOFC              C             ; = 5 -> graphics 320x200 monochrome
FOFC              C             ; = 6 -> graphics 640x200 monochrome
FOFC              C             ; = 7 -> text   80x 25 monochrome card
FOFC              C             ; = 64 -> graphics 640x400 monochrome
FOFC              C             ; = 72 -> graphics 640x400 monochrome tinytext
FOFC              C             ;
FOFC              C             ; Output: ah = 00h
FOFC              C             ; al = v_colorpal
FOFC              C             ;
FOFC              C             ; Assume: (contents of v_base6845) = pointer register (3D4h)
FOFC              C             ; (contents of v_base6845)+1 = data register (3D5h)
FOFC              C             ; (contents of v_base6845)+4 = mode control register (3D8h)
FOFC              C             ; (contents of v_base6845)+5 = overscan register (3D9h)
FOFC              C             ; (contents of v_base6845)+6 = status register (3DAh)
FOFC              C             ; (contents of v_base6845)+10 = mode control register #2 (3DEh)
FOFC              C             ;
FOFC              C             ; Trash: si & di destroyed.
FOFC              C             ;-----
FOFC              C v_set_mode    proc  near
FOFC              C             assume cs:code, ds:data, es:v_ram, ss:nothing
FOFC 52              C             push  dx             ; save dx
FOFD 51              C             push  ox             ; save cx
FOFC              C             ; Get Color/Monochrome dependent stuff.
FOFC              C             ;
FOFE 32 E4           C             xor    ah,ah         ; AH = mode ctrl., color board
F100 BA 03D4        C             mov    dx,color_pointer ; color 6845 pointer register.
F103 F6 06 0010 R 10 C             test  byte ptr ds:[switch_bits],10h ; monochrome board?
F108 74 0D           C             jz    v_set_mode_color ; if not, skip monochrome stuff.
F10A F6 06 0010 R 20 C             test  byte ptr ds:[switch_bits],20h
F10F 74 06           C             jz    v_set_mode_color
F111 B8 0107         C             mov    ax,0107h      ; It's a monochrome board, so..
F114 83 C2 E0         C             add    dx,v_pointer-color_pointer; monochrome pointer register.
F117              C v_set_mode_color:
F117              C             ; Save CRT Mode & 6845 address, and reset display monitor with mode control.

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ROM BIOS Listing

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C
F117 A2 0049 R      C      mov     byte ptr ds:[v_mode],al ; save mode.
F11A 89 16 0063 R   C      mov     word ptr ds:[v_base6845],dx ; save 6845 pointer register.
F11E 86 E0          C      xchg   ah,al ; AH=mode, AL=mode ctrl.
F120 83 C2 04      C      add     dx,4 ; get 6845 mode control register
F123 EE            C      out    dx,al ; reset display
F124 83 EA 04      C      sub    dx,4 ; restore 6845 address.
F127 8A C4          C      mov    al,ah ; restore mode in al
C
C ; Get pointer to display parameters.
C
F129 1E            C      push   ds ; save ds = data_seg
C
C      assume cs:code, ds:abs0, es:v_ram, ss:nothing
C
F12A 33 F6          C      xor    si,si
F12C 8E DE          C      mov    di,di ; satisfy assumptions
F12E C5 36 0074 R   C      lds    si,dword ptr ds:[int1dloc] ; display parameter pointer
C
C ; ds:si in effect points to es:v_parms.
C
C      assume cs:code, ds:code, es:v_ram, ss:nothing
C
C ; Determine which set of parameters to use from mode.
C
F132 B9 0010       C      mov    cx,16 ; count of parameters
F135 3C 02          C      cmp    al,2 ; 40x25 mode? (0 & 1?)
F137 72 0E          C      jb     v_set_mode_lp ; if so, we're done
F139 03 F1          C      add    si,cx ; next set of parameters
F13B 3C 04          C      cmp    al,4 ; 80x25 mode? (2 & 3?)
F13D 72 08          C      jb     v_set_mode_lp ; if so, we're done
F13F 03 F1          C      add    si,cx ; next set of parameters
F141 3C 07          C      cmp    al,7 ; graphics mode? (4,5,6,64,7?)
F143 75 02          C      jne   v_set_mode_lp ; if so, we're done
F145 03 F1          C      add    si,cx ; else, monochrome card (7)
C
C ; Loop through 6845 initialization table outputting register number and data
C
C v_set_mode_lp:
C
F147 B0 10          C      mov    al,16 ; get 6845 register number =
C ; = (16 - cl) (unscrambled)
F149 2A C1          C      sub    al,cl
F14B EE            C      out    dx,al ; output to register port
F14C 42            C      inc    dx ; point to 6845 data register
F14D AC            C      lodsb ; get param value: al gets ds:al
F14E EE            C      out    dx,al ; output to data port
F14F 44            C      dec    di ; point back to pointer register
F150 E2 F5          C      loop  v_set_mode_lp ; next register
C ; dx = pointer register
C
C      assume cs:code, ds:data, es:v_ram, ss:nothing
C
F152 1F            C      pop    ds ; restore ds = data_seg
C
F153 8A C4          C      mov    al,ah ; save mode in ah & al
F155 32 E4          C      xor    ah,ah ; ax = mode
F157 8B F0          C      mov    si,ax ; si = mode hence...
C
C ; Clear the screen.
C
F159 B9 2000       C      mov    cx,2000h ; assume 8k words to clear
C
C      cmp    al,4 ; 40x25 or 80x25 text modes 0-3?
F15C 3C 04          C      jb     v_md_clr_8k ; if so, clear 8k words.
F15E 72 0E          C      cmp    al,7 ; monochrome card mode ??
F160 3C 07          C      jb     v_md_clr_2k ; if so, clear 2k words.
F162 74 08          C      jne   v_md_clr_2k ; if so, clear 2k words.
F164 72 02          C      jb     v_md_clr_graphics ; graphics mode 4-6 clear 8k wds
F166 D1 E1          C      shl    cx,1 ; mode 64 & 72 clear 16k wds
F168              C      v_md_clr_graphics:
F16A 33 C0          C      xor    ax,ax ; graphics mode
F16C EB 05          C      jmp    short v_md_clr ; clear screen with zeroes
C
C v_md_clr_2k:
F16E B5 08          C      mov    ch,08h ; cx = 0800h
F16E B8 0720       C      mov    ax,(7*100h)+' ' ; clear with attribute & space
F171              C      v_md_clr:
F171 33 FF          C      xor    di,di ; es:di gets ax
F173 F3/ AB        C      rep    stosw
C
C ; Set mode control register #2
C
C ; Handle underline on shades-of-gray monitor.
C
F175 83 C2 06       C      add    dx,6 ; dx = pointer register
F178 EC            C      in     al,dx ; get 6845 status register
F179 24 10          C      and    al,010h ; get CRT status
F17B D0 E0          C      shl    al,1 ; isolate color/shades bit #4
F17D D0 E0          C      shl    al,1 ; move it to underline bit #6
C
C ; Handle double scan line modes 64 & 72.
C
F17F 83 FE 40       C      cmp    si,64 ; dx = 6845 status register
F182 72 04          C      jb     v_md_dbl ; modes 0 through 7?
F184 40            C      inc    ax ; if so, single scan line mode
F185 BE 0006       C      mov    si,6 ; else mode 64 or 72, set bit #0
C ; modes 64 & 72 look like mode 6
C ; from now on
C
F188              C      v_md_dbl:
C ; double scan line mode.

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ROM BIOS Listing

```

F188 83 C2 04      C      add    dx,4          ; get mode control register #2
F18B EE           C      out    dx,al
C
C
C      ; Enable display monitor with mode control.
C
F18C 2E: 8A 84 F0F4 R  C      mov    al,byte ptr cs:[si-v_md_enable]
F191 A2 0065 R      C      mov    byte ptr ds:[v_3x8],al      ; save the value for later
C                                     ; dx = mode control register #2
C                                     ; get 6845 mode control register #2
F194 83 EA 06      C      sub    dx,6
F197 EE           C      out    dx,al      ; enable display
C
C      ; Determine width & length of screen.
C
F198 33 C0         C      xor    ax,ax      ; clear ah
F19A 2E: 8A 84 F0EC R  C      mov    al,byte ptr cs:[si-v_md_wid]
F19F A3 004A R      C      mov    word ptr ds:[v_width],ax
C
C
F1A2 81 E6 00DE    C      and    si,0Eh      ; make word index divided by 2
F1A6 2E: 8B 84 F0E4 R  C      mov    ax,word ptr cs:[si-v_md_len]
F1AB A3 004C R      C      mov    word ptr ds:[v_height],ax
C
C      ; Set up overscan register & v_colorpal.
C
F1AE 80 30         C      mov    al,030h      ; v_colorpal for modes 0-5 & 7
F1B0 8A 26 0049 R  C      mov    ah,byte ptr ds:[v_mode] ; retrieve v_mode
F1B4 80 FC 06      C      cmp    ah,6        ; modes 0-5 ?
F1B7 72 0D         C      jb    v_ovr_ok      ; if so, we're ok.
C
F1B9 74 09         C      je    v_ovr_not_ok ; 640x200 graphics mode 6 ?
C                                     ; if so, change v_colorpal
C
F1BB 80 FC 80      C      cmp    ah,64       ; 640x400 graphics mode 64, 72 ?
F1BE 72 06         C      jb    v_ovr_ok      ; if not, we're ok.
C
C
F1C0 D1 26 004C R  C      shl    word ptr ds:[v_height],1 ; double v_height from 16k to 32k
C
F1C4             C      v_ovr_not_ok:
F1C4 80 3F         C      mov    al,03Fh      ; v_colorpal for modes 6,64,72
C
C
F1C6             C      v_ovr_ok:
F1C6 A2 0066 R      C      mov    byte ptr ds:[v_colorpal],al ; dx = 6845 mode control register
F1C9 42           C      inc    dx           ; save the value for later
F1CA EE           C      out    dx,al      ; get 6845 overscan register
C
C      ; Clear all cursor positions.
C
C      assume cs:code, ds:data, es:data, ss:nothing
C
F1CB 1E           C      push  ds
F1CC 07           C      pop   es          ; set es = firmware data area
C
C
F1CD BF 0050 R      C      mov    di,ds:(offset v_curpos) ; get address (defined by DB)
F1D0 89 0008      C      mov    cx,8
F1D3 33 C0         C      xor    ax,ax
F1D5 F3/ AB        C      rep  stosw        ; ax = 0
C                                     ; es:di gets ax = 0
C
C      ; Clear other firmware data variables (ax = 0).
C
F1D7 A3 004E R      C      mov    word ptr ds:[v_top],ax ; set starting offset to 0
F1DA A2 0062 R      C      mov    byte ptr ds:[v_apage],al ; set current active page to 0
F1DD C7 06 0060 R 0607 C      mov    word ptr ds:[v_cursize],0607h ; set cursor mode
C
C      ; Clean up.
C
F1E3 A0 0066 R      C      mov    al,byte ptr ds:[v_colorpal]
F1E6 59           C      pop    cx
F1E7 5A           C      pop    dx          ; restore cx
F1E8 C3           C      ret             ; restore dx
C
F1E9             C      v_set_mode     endp
C
C
C      ;-----
C      ; Set Cursor Value          ah = 01h
C      ;
C      ; Input:  ch          = bits #0-4 = starting line for cursor
C      ;         cl          = bits #0-4 = ending line for cursor
C      ; Output: ah         = 10
C      ;         al         = cl
C      ;
C      ; Trash: si & di destroyed. (si = dx; di = cx)
C      ;-----
C
F1E9             C      v_curs_type   proc  near
C      assume      cs:code, ds:data, es:v_ram, ss:nothing
C
F1E9 89 0E 0060 R  C      mov    word ptr ds:[v_cursize],cx ; save the cursor value
F1ED 8B F9        C      mov    di,cx
C
F1EF B4 0A        C      mov    ah,10      ; 6845 cursor set register = 10
F1F1 E8 F262 R      C      call  v_6845      ; set cursor; ah 6845 gets cx
C                                     ; si = dx destroyed
C                                     ; ah = preserved = 10; al = cl
C                                     ; di restores cx
C                                     ; restore al with original cl
F1F4 8A C1        C      mov    al,cl
F1F6 C3           C      ret
F1F7             C      v_curs_type   endp
C
C      ;-----

```

ROM BIOS Listing

```

C ;      Set Curaor Position          ah = 02h
C ;
C ;      Input: bh                    = page number (0-7)
C ;      (dh,dl) = (row,col) of current cursor from (0,0)
C ;      Output: if bh = v_apage,     ah = 14
C ;      else,                        ah = low byte of cursor position
C ;      ah = v_mode
C ;      al = preserved
C ;
C ;      Trash: si & di destroyed. (si = dx, di = cx)
-----
F1F7      v_curs_pos    proc    near
C ;
C ;      assume cs:code, ds:data, es:v_ram, ss:nothing
C ;
C ;      mov     di,cx                ; save cx
C ;
C ;      mov     cl,bh
C ;      mov     si,cx
C ;      and     si,7                  ; mask to 8 pages
C ;      add     si,si                ; *2 => word index
C ;
C ;      mov     word ptr ds:[si+v_curspos],dx    ; save the cursor position
C ;
C ;      cmp     bh,byte ptr ds:[v_apage]        ; if active page, put the cursor
C ;      je     v_set_curs                      ; on the screen.
C ;      mov     cx,di                        ; not active page, so just
C ;      ret                                     ; restore cx
C ;      ; and exit
C ;
C ;      v_set_curs:
C ;      mov     ax,dx                    ; active page, so set cursor..
C ;      mov     v_set_cur_pos            ; ax gets cursor position
C ;      jsp     v_set_cur_pos            ; set cursor; ah 6845 gets cx
C ;      ; si = dx destroyed
C ;      ; ah = preserved = 14
C ;      ; al = low byte of cursor posn
-----
F215      v_curs_pos    endp
-----
C ;      Read Cursor                ah = 03h
C ;
C ;      Input: bh                    = page number (0-7)
C ;      Output: (dh,dl) = (row,col) of current cursor from (0,0)
C ;      (ch,cl) = current cursor mode setting
C ;      ax = dx
C ;
C ;      Trash: None.
-----
F215      v_r_curs_pos  proc    near
C ;
C ;      assume cs:code, ds:data, es:v_ram, ss:nothing
C ;
C ;      mov     ax,dx
C ;      mov     cx,bx                ; save bx
C ;      mov     bl,bh
C ;      and     bx,07h                ; page number mod 8
C ;      shl     bx,1                  ; page number mod 8 word index
C ;      mov     dx,word ptr ds:[bx+v_curspos]
C ;      mov     bx,cx                ; restore bx
C ;      mov     cx,word ptr ds:[v_cursize]
C ;      ret
C ;
C ;      v_r_curs_pos  endp
-----
C ;      Read Light Pen (see graph.src) ah = 04h
-----
C ;      Set Active Display Page     ah = 05h
C ;
C ;      Input: al                    = new page number (0-7 for modes 0-1; 0-3 for 2-3)
C ;      Output: 6845 is reset to display the new active page
C ;      ah = 14
C ;      si = low byte of cursor position
C ;
C ;      Trash: bp, si & di destroyed. (si = dx, di = cx)
-----
F22C      v_page    proc    near
C ;
C ;      assume cs:code, ds:data, es:v_ram, ss:nothing
C ;
C ;      and     ax,07h                ; page number mod 8
C ;      mov     bp,ax                ; save ax = page number mod 8
C ;
C ;      mov     byte ptr ds:[v_apage],al    ; save active page number (0-7)
C ;      jz     v_page_0                ; page number = 0?
C ;
C ;      mov     di,dx                ; save dx
C ;      mul     word ptr ds:[v_height]    ; dx:ax = (page number)*v_height
C ;      mov     dx,di                ; restore dx
C ;
C ;      v_page_0:
C ;      mov     word ptr ds:[v_top],ax    ; save starting address of page
C ;      sar     ax,1                  ; divide by 2 for byte count

```

ROM BIOS Listing

```

F243 8B F9          C      mov     di,cx           ; save cx
F245 8B C8          C      mov     cx,ax           ; cx gets offset of active page
F247 BA 0C          C      mov     ah,12          ; 6845 cursor set address = 12
F249 E8 F262 R     C      call    v_6845         ; set cursor; ah 6845 gets cx
                          C      ; si = dx destroyed
                          C      ; ah = preserved = 12; al = cl
                          C      ; di restores cx

F24C 8B C5          C      mov     ax,bp           ; restore ax = page number mod 8
F24E D1 E0          C      shl     ax,1           ; page number mod 8 word index
F250 8B F0          C      mov     si,ax
F252 8B 84 0050 R   C      mov     ax,word ptr ds:[si+v_curpos] ; get page's cursor position

F256                C      v_set_cur_pos:         ;(ah,al) = (row,col) cursor pos.
                          C      ; di = value to return in cx
F256 E8 F52B R     C      call    v_posn         ; (ah,al) -> ax offset; si trash
F259 03 06 004E R   C      add     ax,word ptr ds:[v_top]   ; add offset of active page
F25D D1 F8          C      sar     ax,1           ; divide by 2 for byte count

F25F B5 0E          C      mov     ch,14          ; 6845 cursor pos register = 14
F261 91             C      xohg    cx,ax
                          C
                          C      ; Now: ah = 6845 register selection
                          C      ;      ch = first data byte to (ah) 6845 internal register
                          C      ;      cl = second data byte to (ah+1) 6845 internal register
                          C      ;      di = value to return in cx

F262                C      v_6845:              ; program 6845 cursor:
F262 8B F2          C      mov     si,dx           ; save dx
F264 E8 F273 R     C      call    v_out_byte     ; output to 6845
F267 FE C4          C      inc     ah             ; next 6845 register
F269 8A E9          C      mov     ch,cl          ; get the register input
F26B E8 F273 R     C      call    v_out_byte     ; output to 6845
F26E 8B D6          C      mov     dx,si          ; restore dx value
F270 8B CF          C      mov     cx,di          ; set up return value
F272 C3             C      ret
F273                C      v_page              endp
                          C
                          C      -----
                          C      ; Output two byte to the selected 6845 registers
                          C      ; Input: ah = 6845 register selection
                          C      ;       ch = first data byte to (ah) 6845 internal register
                          C      ;       cl = second data byte to (ah+1) 6845 internal register
                          C      ;       di = value to return in cx
                          C      ; Assume: contents of v_base6845 = pointer register
                          C      ;       (contents of v_base6845)+1 = data register
                          C      ; Output: ah = 6845 register selection
                          C      ;       al = second data byte
                          C      ;       cx = di
                          C      -----

F273                C      v_out_byte        proc   near
                          C      assume cs:code, ds:data, es:v_ram, ss:nothing
F273 8B 16 0063 R   C      mov     dx,word ptr ds:[v_base6845] ; get 6845 pointer register
F277 8A C4          C      mov     al,ah          ; get the register address
F279 EE          C      out     dx,al         ; select the data register
                          C
F27A 42          C      inc     dx             ; next register
F27B 8A C5          C      mov     al,ah          ; get second data byte
F27D EE          C      out     dx,al         ; output a data byte to 6845
F27E C3             C      ret
F27F                C      v_out_byte        endp
                          C
                          C      -----
                          C      ; Scroll Active Page Up          ah = 06h
                          C      ; Input: if al = 0, then clear entire window with attribute in bh
                          C      ;       else, al = number of rows to 'scroll' up
                          C      ;       bh = number of rows to clear at bottom of window
                          C      ;       attribute to be used on blank row(s)
                          C      ;       (bh,cl) = (row,col) of upper left corner of window from (0,0)
                          C      ;       (dh,dl) = (row,col) of lower right corner of window from (0,0)
                          C      ; Output: ah = attribute to be used on blank row(s)
                          C      ;       if v_mode = 7, al = 20h = space
                          C      ;       else al = v_3x0
                          C      ; Assume: (contents of v_base6845)+6 = status register
                          C      ; Trash: bp, si, & di destroyed. (bx thru dx destroyed if ROM stack)
                          C      -----

F27F                C      v_sori_up         proc   near
                          C      assume cs:code, ds:data, es:v_ram, ss:nothing
F27F E8 F53C R     C      call    v_txt_md       ; all registers preserved
F282 72 03          C      jb     v_txt_up       ; jump if graphics
F284 89 D874 R     C      jmp     graf_graphics_up
F287                C      v_txt_up:

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ROM BIOS Listing

```

C
F287 52          C          push  dx          ; save registers
F288 51          C          push  cx
F289 53          C          push  bx
C
F28A 8A D8       C          mov   bl,al        ; save line count
F28C 8B C1       C          mov   ax,cx
F28E 28 F4DE R  C          call  v_scroll_pos ; pass upper left coordinates...
F291 74 62       C          jz    v_clr_bot   ; to common scroll positioning routine
C                      ; clear rows if nothing to move
C
C                      ; Scroll cl rows up.
C
F293 03 F0       C          ;v_mv_up:
C          add   si,ax          ; add (bytes/row)*(rows to scroll) to
C                      ; 'from' address for scroll
C
C                      ; Scroll cl rows up/down (based on bp & direction flag DF).
C
F295           C          v_mv:
F295 8A E1       C          mov   ah,cl        ; ah gets number of rows to move = cl
C
F297 80 3E 0049 R 07 C          cmp   byte ptr ds:[v_mode],7
F29C 74 49       C          je    v_mv_flg    ; jump to fast loop
C
F29E 8A CA       C          mov   cl,dl        ; no. of columns to move up/down per row
C
F240           C          v_mv_lp:
F240 52          C          push  dx          ; save dx
F241 8B 16 0063 R  C          mov   dx,word ptr ds:[v_base6845] ; get 6845 pointer register
F245 83 C2 06       C          add   dx,6         ; get 6845 status register
C
C                      assume cs:code, ds:v_ram, es:v_ram, ss:nothing
C
F248 06          C          push  es          ; satisfy assumptions
F249 1F          C          pop   ds          ; ds gets es
C
C                      ; Wait for horizontal retrace...
C
F24A           C          v_mv_hi:
F24A EC          C          in   al,dx        ; get CRT status
F24B D0 D8       C          ror  al,1         ; test display enable (bit #0)
F24D 72 FB       C          jc   v_mv_hi     ; wait for display enable low (cf)
C                      ; interrupts are disabled ..
C
F24F FA          C          cli            ; disable now
C
F2B0           C          v_mv_lo:
F2B0 EC          C          in   al,dx        ; 08 get CRT status
F2B1 D0 DB       C          ror  al,1         ; 02 test display enable (bit #0)
F2B3 73 FB       C          jnc  v_mv_lo     ; 16/04 wait for display enable hi (cf)
C                      .list
F2B5 A5          C          movsw         ; 18 move word (es:di gets ds:si)
C
C                      ; Worst case: (8*2+16)+(8*2+4)+(18) = 58 cycles = 72.5% of 80 cycles
C
F2B6 EC          C          in   al,dx        ; 08 get CRT status (vert synch slow)
C
C                      assume cs:code, ds:data, es:v_ram, ss:nothing
C
F2B7 BA 0040      C          mov   dx,data_seg ; 04 satisfy assumptions
F2BA 8E DA       C          mov   ds,dx       ; 02
F2BC 5A          C          pop   dx          ; 08 restore dx
C
F2BD 49          C          dec   cx          ; 03 decrement columns to move
F2BE 75 0A       C          jnz  v_mv_next   ; 04/16 did we move the last column?
C
F2C0 03 F5       C          add   si,bp       ; 03 add/subtract number of bytes
C                      ; to skip in row to/from 'from'
C                      ; address for scroll up/down
C
F2C2 03 FD       C          add   di,bp       ; 03 add/subtract number of bytes
C                      ; to skip in row to/from 'to'
C                      ; address for scroll up/down
C
F2C4 FE CC       C          dec   ah          ; 03 decrement rows to move
F2C6 74 2C       C          jz   v_mv_end    ; 4/16 did we move the last row?
C
F2C8 8A CA       C          mov   cl,dl        ; 02 number of columns to move
C                      ; up/down per row
C
C                      ; Worst case: [58]+(8*4+2*8)+(3*4)+(3*3)+(3*4+2) = 102 cycles = 12.75 usec
C
F2CA           C          v_mv_next:
C
F2CA FB          C          sti            ; enable interrupts immediately
F2CB A8 08       C          test   al,08h     ; 04 check for vertical retrace
F2CD 74 16       C          jz   v_mv_past   ; 16/04 jump past vertical retrace code
C
C                      ; We get here if vertical retrace has started...
C
F2CF B0 04       C          mov   al,V_KSCROLL
C
C                      ; NOTE: interrupts disabled for 1.1ms!
C                      ; 04 at most V_KSCROLL rows per
C                      ; vertical retrace ...
C
F2D1           C          v_mv_row:
F2D1 1E          C          push  ds
F2D2 06          C          push  es
F2D3 1F          C          pop   ds
F2D4 F3/ A5     C          rep  movsw        ; 11*17*80 move row (es:di gets es:si)
F2D6 1F          C          pop   ds
C
F2D7 03 F5       C          add   si,bp       ; 03 add/subtract number of bytes

```

ROM BIOS Listing

```

C
C
C      add     di, bp                ; to skip in row to/from 'from'
C                                         ; address for scroll up/down
F2D9  03 FD                ; 03 add/subtract number of bytes
C                                         ; to skip in row to/from 'to'
C                                         ; address for scroll up/down
C
F2DB  FE CC                ; 03 decrement rows to move
F2DD  74 15                ; 04/16 did we move the last row
C
C      mov     cl, di                ; 02 number of columns to move
F2DF  8A CA                ; up/down per row
C
F2E1  FE C8                ; 03
F2E3  75 EC                ; 04/16
C
C      ; Worst case: [98]*(4+4+4)+[6*(1369+3+3+3+4+2+3)]+[5*16]+(4)
C      ; = 98*12+8322+80+4 = 8516 cycles = 88.71% * 9600 cycles = 1.065ms < 1.2ms
C
F2E5  EB B9                v_mv_past:
C      jmp     short v_mv_lp
C
C-----
C
F2E7  8A CA                v_mv_flg:
F2E7  8A CA                mov     cl, di                ; ah has number of rows to move
F2E9  F3 26: A5           rep     movs   word ptr es:[di], word ptr es:[si] ; number of columns to
C                                         ; move the row (es:di gets es:si)
F2EC  03 F5                add     si, bp                ; add number of bytes to skip in row to
C                                         ; 'from' address for scroll
F2EE  03 FD                add     di, bp                ; add number of bytes to skip in row to
C                                         ; 'to' address for scroll
F2F0  FE CC                dec     ah
F2F2  75 F3                jnz    v_mv_flg
C
C-----
C
F2F4  EB FB                v_mv_end:
C      sti                     ; enable interrupts immediately
C
C      ; Clear bi rows below.
C
F2F5  v_clr_bot:
C      ; Clear bi rows below/above if scroll up/down (based on bp & direction flag DF).
C
F2F5  v_clr:
C
F2F5  8A E7                mov     ah, bh
F2F7  80 3E 0049 R 07     cmp     byte ptr ds:[v_mode], 7
F2FC  74 41                je      v_clr_fast           ; jump to fast loop
C
F2FE  8A CA                mov     cl, di                ; cl = no. of columns to clear per row
C                                         ; (bl = number of rows to clear)
C
F300  B7 20                v_clr_lp:
F300  B7 20                mov     bh, ' '              ; bh = blanking character
C
F302  52                push    dx                    ; save dx
F303  8B 16 0063 R        mov     dx, word ptr ds:[v_base6845] ; get 6845 pointer register
F307  83 C2 06                add     dx, 6                ; get 6845 status register
C
C      ; Wait for horizontal retrace...
C
F30A  EC                v_clr_hi:
F30A  EC                in     al, dx                ; wait till we're in a scanline
F30B  D0 D8                rcr    al, 1                ; get CRT status
F30D  72 FB                jc     v_clr_hi             ; test display enable (bit #0)
F30F  FA                cll                    ; wait for display enable low (cf)
C                                         ; disable inta first.
C
F310  F310                v_clr_lo:
F310  EC                in     al, dx                ; wait till start of horiz. blanking
F311  D0 D8                rcr    al, 1                ; 08 get CRT status
F313  73 FB                jnc   v_clr_lo             ; 02 test display enable (bit #0)
C                                         ; 16/04 wait for display enable hi (cf)
C
F315  8A C7                mov     al, bh              ; 02 al= bh = ' ' = blanking character
C
F317  AB                .list
C      stow                    ; 11 clear word (es:di gets ax)
C
C      ; Worst case: (8+2+16)+(8+2+4)+(2+11) = 53 cycles = 66.25% of 80 cycles
C
F318  EC                in     al, dx                ; 08 get CRT status (vert synch slow)
F319  5A                pop     dx                  ; 08 restore dx
C
F31A  49                dec     cx                  ; 03 decrement columns to clear
F31B  75 08                jnz    v_clr_nxt           ; 04/16 did we move the last column?
C
F31D  03 FD                add     di, bp                ; 03 add/subtract number of bytes
C                                         ; to skip in row to/from 'to'
C                                         ; address for clear for up/down
C
F31F  FE CB                dec     bl                  ; 03 decrement rows to clear
F321  74 28                js     v_scri_ret          ; 04/16 did we clear the last row?
C
F323  8A CA                mov     cl, di                ; 02 number of columns to clear
C                                         ; per row
C
C      ; Worst case: [53]*(8+8)+(3+4)*(3)+(3+4+2) = 88 cycles = 11.00 usec
C
F325  v_clr_nxt:
C
F325  FB                sti                     ; 04 check for vertical retrace
F326  A8 08                test    al, 08h

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ROM BIOS Listing

```

F328 74 12      C          jz      v_clr_past      ; 16/04 jump past vertical retrace code
C              ; We get here if vertical retrace has started...
C
C              ; NOTE: interrupts disabled for 1.1ms!
F32A 8A C7      C          mov     al,bh          ; 02  al= bh= ' ' = blanking character
C              ;
F32C B7 07      C          mov     bh,V_KCLEAR    ; 04  at most 7 (not 10) rows per pass
C
F32E           C          v_clr_row:
F32E F3/ AB      C          rep     stow          ; 09:10*80 clear the row (es:di gets ax)
C
F330 03 FD      C          add     di,bp          ; 03  add/subtract number of bytes
C              ; to skip in row to/from 'to'
C              ; address for clear for up/down
C
F332 FE CB      C          dec     bl          ; 03  decrement rows to clear
F334 74 15      C          jz      v_scri_ret    ; 04/16 did we clear the last row?
C
F336 8A CA      C          mov     cl,dl          ; 02  number of columns to clear
C              ; up/down per row
F338 FE CF      C          dec     bh          ; 03  still working on 10 scan lines??
F33A 75 F2      C          jnz     v_clr_row      ; 04/16
C
C          ; Worst case:[88]+(4+4+2+4)+[10*(809+3+3+4+2+3)]+[9*16]+(4)
C          ; = 88+14+8240+144+4 = 8490 cycles = 88.44% * 9600 cycles = 1.061ms < 1.2ms
C
F33C           C          v_clr_past:
F33C FB          C          sti          ; enable interrupts immediately
F33E EB C1      C          short v_clr_lp
C
C          -----
F33F           C          v_clr_fast:
F33F 80 20      C          mov     al,' '        ; ah has attribute for blank line(s)
C              ; al = blanking character
C              ; (bl = number of rows to clear)
F341           C          v_clr_flp:
F341 8A CA      C          mov     cl,dl          ; number of columns to clear
F343 F3/ AB      C          rep     stow          ; clear the row (es:di gets ax)
F345 03 FD      C          add     di,bp          ; add number of bytes to skip in row to
C              ; 'to' address for scroll
C
F347 FE CB      C          dec     bl          ;
F349 75 F6      C          jnz     v_clr_flp
C
C          -----
F34B           C          v_scri_ret:
F34B FB          C          sti          ; common clean up routine
C              ; enable interrupts immediately
C
F34C 80 3E 0049 R 07 C          cmp     byte ptr ds:[v_mode],7
F351 74 03      C          je      v_scri_mode_7
F353 A0 0065 R   C          mov     al,byte ptr ds:[v_3x8] ;
F356           C          v_scri_mode_7:
C              ; We didn't disable display during vertical retrace...
C              ; Clean up.
C
F356 FC          C          cld          ; in case we are 'call'ed & scroll down
F357 5B          C          pop     bx          ; restore registers
F358 59          C          pop     cx
F359 5A          C          pop     dx
F35A C3          C          ret
C
F35B           C          v_scri_up      endp
C
C          -----
C          ; Scroll Active Page Down      ah = 07h
C          ;
C          ; Input:  if al = 0, then clear entire window with attribute in bh
C          ;          else,  al = number of rows to 'scroll' down
C          ;          = number of rows to clear at top of window
C          ;          bh = attribute to be used on blank row(s)
C          ;          (ch,cl) = (row,col) of upper left corner of window from (0,0)
C          ;          (dh,dl) = (row,col) of lower right corner of window from (0,0)
C          ; Output:  ah = attribute to be used on blank row(s)
C          ;          if v_mode = 7,  al = 20h = space
C          ;          else          al = v_3x8
C          ;
C          ; Assume: (contents of v_base6845)-6 = status register
C          ;
C          ; Trash:  bp, si, & di destroyed. (bx thru dx destroyed if ROM stack)
C          ;
C          -----
F35B           C          v_scri_dn      proc  near
C
C          assume cs:code, ds:data, es:v_ram, ss:nothing
C
F35B FD          C          std          ; NOTE: scroll down everything backwards
C
F35C E8 F53C R   C          oall   v_txt_md      ; all registers preserved
F35F 72 03      C          jb      v_txt_dn
F361 E9 D909 R   C          jmp     grf_graphics_down ; jump if graphics
F364           C          v_txt_dn:
C
F364 52          C          push   dx          ; save registers
F365 51          C          push   cx
F366 53          C          push   bx

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ROM BIOS Listing

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F367 8A D8          C      mov     bl,al          ; save line count
F369 8B C2          C      mov     ax,dx          ; pass lower right coordinates...
F36B E8 F4DE R     C      call    v_scri_pos     ; to common scroll positioning routine
F36E 74 07          C      jz      v_clr_top      ; clear rows if nothing to move
C
C      ; Scroll cl rows down.
C
C      v_mv_dn:
F370              C      sub     si,ax          ; subtract (bytes/row)*(rows to scroll)
F370 2B F0          C      ; from 'from' address for scroll
F372 F7 DD          C      neg     bp              ; negate number of bytes to skip per row
F374 E9 F295 R     C      jmp     v_mv            ; now identical to scroll up!
C
C      ; Clear bl rows above.
C
C      v_clr_top:
F377              C      neg     bp              ; negate number of bytes to skip per row
F377 F7 DD          C      ; now identical to v_clr_bot!
F379 E9 F2F5 R     C      jmp     v_clr_bot
C
C      v_scri_dn      endp
C
C      ;-----
C      ; Read Attribute & Character at Cursor  ah = 08h
C      ;
C      ; Input:  bh = current active display page (0-7)
C      ; Output: al = character read
C      ;        ah = attribute of character read
C      ;
C      ; Assume: (contents of v_base6845)+6 = status register
C      ; Trash:  si & di destroyed. (si = dx; di = bx)
C      ;-----
F37C              C      v_rac  proc  near
C
C      assume  cs:code, ds:data, es:v_ram, ss:nothing
C
C      call    v_txt_md    ; all registers preserved
F37C E8 F53C R     C      jb     v_txt_rac
F37F 72 03          C      jmp     grf_graphics_read ; jump if graphics
F381 E9 D96C R     C      v_txt_rac:
F384              C
C      mov     di,bx          ; save bx
F384 8B FB          C      call    v_fpos         ; ax & si destroyed.
F386 E8 F50D R     C      ; bx = offset into current page
C
C      mov     si,dx          ; save dx
F389 8B F2          C      mov     dx,6           ; get 6845 status reg. offset
F38B BA 0006       C      add     dx,word ptr ds:[v_base6845] ; add 6845 pointer
F38E 03 16 0063 R  C
C      ; Wait for horizontal retrace... we can't read the screen during a trace
C      ; without disturbing the screen image.
C
C      v_rac_inline:
F392              C      in     al,dx          ; make sure we're in a scanline
F392 EC          C      ; get horiz. retrace blanking status
F393 D0 D8          C      rcr    al,1           ; test for horiz. retrace
F395 72 FB          C      jc     v_rac_inline   ; wait for display enable low (cf)
F397 FA          C      cld                    ; disable ints FIRST
C
C      ; wait for blanking:
C
C      v_rac_inblank:
F398              C      in     al,dx          ; get retrace blanking status
F398 EC          C      rcr    al,1           ; test display enable (bit #0)
F399 D0 D8          C      jnc   v_rac_inblank   ; try again if still in scanline.
F39B 73 FB          C
C
C      mov     ax,es:[bx]    ; chr. and attr. now in AX
F39D 26: 8B 07     C      sti                    ; enable interrupts immediately
F3A0 FB          C
C
C      mov     dx,si         ; restore dx
F3A1 8B D6          C      mov     bx,di         ; restore bx
F3A3 8B DF          C
F3A5 C3          C      ret
C
C      v_rac      endp
C
C      ;-----
C      ; Write Attribute & Character at Cursor  ah = 09h
C      ;
C      ; Input:  al = character to write
C      ;        bh = current active display page (0-7)
C      ;        bl = attribute of character to write
C      ;        cx = counter of characters to write
C      ;        bp = value to return in ax
C      ; Output: al = character to write
C      ;        ah = attribute of character to write
C      ;
C      ; Assume: (contents of v_base6845)+6 = status register
C      ; Trash:  bp, si & di destroyed. (si = cx; dx if 80H stack)
C      ;-----
F3A6              C      v_wac  proc  near
C
C      assume  cs:code, ds:data, es:v_ram, ss:nothing
C
C      call    v_txt_md    ; all registers preserved
F3A6 E8 F53C R     C      jb     v_txt_wac
F3A9 72 03          C      jmp     grf_graphics_write ; jump if graphics
F3AB E9 DA59 R     C      v_txt_wac:
F3AE              C

```

ROM BIOS Listing

```

F3AE 8B FB          C      mov     di,bx                ; save bx
F3B0 E8 F50D R     C      call    v_fpos                ; ax & si destroyed.
F3B3 87 DF          C      xchg   bx,di                ; bx = offset into current page
F3B5 8B C5          C      mov     ax,bp                ; restore ax
F3B7 8A E3          C      mov     ah,bl                ; transfer attribute byte to ah
F3B9 8B E8          C      mov     bp,ax                ; save attribute & character in bp
F3BB 8B F1          C      mov     si,cx                ; save cx
F3BD 52             C      push   dx                    ; save dx
F3BE 8B 16 0063 R  C      mov     dx,word ptr ds:[v_base6845] ; get 6845 pointer register
F3C2 83 C2 06       C      add     dx,6                  ; get 6845 status register
C      ; Wait for horizontal retrace blank interval ...
C
C
F3C5              C      v_wac_hi:                    ; wait till we're in a scanline..
F3C5 EC           C      in     al,dx                ; get CRT status
F3C6 D0 DB        C      rcr    al,1                  ; test display enable (bit #0)
F3C8 72 FB        C      jc     v_wac_hi              ; wait for display enable low (cr)
F3CA FA          C      cll                    ; disable ints FIRST
C
F3CB              C      v_wac_lo:                    ; now wait till start of blanking..
F3CB EC           C      in     al,dx                ; 08 get CRT status
F3CC D0 DB        C      rcr    al,1                  ; 02 test display enable (bit #0)
F3CE 73 FB        C      jnc   v_wac_lo              ; 16/04 wait for display enable hi (cr)
C
F3D0 8B C5          C      mov     ax,bp                ; 02 restore ax
F3D2 AB          C      stow   es:di                ; 11 es:di gets ax (attribute & char)
C
F3D3 49            C      dec     cx                    ; 02
C
F3D4 74 04          C      jz     v_wac_end            ; 04/16
F3D6 AB          C      stow   es:di                ; 11 es:di gets ax (attribute & char)
C      ; Worst case: (8+2+16)*(8+2+4)+(2+11)*(2+4+11) = 70 cycles = 87.5% of 80 cycles
C
F3D7 FB          C      sti                    ; enable interrupts immediately
F3D8 E2 EB        C      loop   v_wac_hi              ; do it cx times
C
F3DA FB          C      v_wac_end:                  ; enable interrupts immediately
F3DA FB          C      sti
C
F3DB 5A           C      pop    dx                    ; restore dx
F3DC 8B CE        C      mov     cx,si                ; restore cx
F3DE C3          C      ret
C
F3DF              C      v_wac_endp
C
-----
C      ;
C      ; Write Character at Cursor Position ah = 0Ah
C      ;
C      ; Input: al = character to write
C      ;         bh = current active display page (0-7)
C      ;         cx = counter of characters to write
C      ;         bp = value to return in ax
C      ; Output: al = character to write
C      ;         ah = top byte of offset of character in page 0
C      ;
C      ; Assume: (contents of v_base6845)+6 = status register
C      ;
C      ; Trash: si & di destroyed. (si = cx; dx if ROM stack)
C      ;
-----
F3DF              C      v_wc   proc   near
C
C      assume cs:code, ds:data, es:v_ram, ss:nothing
C
F3DF E8 F53C R     C      call    v_txt_md            ; all registers preserved
F3E2 72 03        C      jb     v_txt_wc            ; jump if graphics
F3E4 E9 DA59 R     C      jmp     $rf_Graphics_write
F3E7              C      v_txt_wc:
F3E7 8B FB          C      mov     di,bx                ; save bx
F3E9 E8 F50D R     C      call    v_fpos                ; si destroyed.
C      ; ax = offset into page 0
C      ; bx = offset into current page
C      ; restore bx; di = transfer offset
F3EC 87 DF          C      xchg   bx,di
C
F3EE 8B F1          C      mov     si,cx                ; save cx
F3F0 52             C      push   dx                    ; save dx
C
F3F1 8B D5          C      mov     dx,bp                ; retrieve character in di
F3F3 8A C2          C      mov     al,dl                ; get char in al (ah = attr.)
F3F5 8B E8          C      mov     bp,ax                ; bp = (attr. char)
C
F3F7 BA 0006       C      mov     dx,6                  ; get 6845 status register
F3FA 03 16 0063 R  C      add     dx,word ptr ds:[v_base6845] ; get 6845 pointer register
C      ; Wait for horizontal retrace...
C
F3FE              C      v_wc_next:
C
C      v_wc_hi:
F3FE EC           C      in     al,dx                ; get CRT status
F3FF EC           C      rcr    al,1                  ; test display enable (bit #0)

```

ROM BIOS Listing

```

F401 72 FB      C      je      v_wc_hi      ; wait for display enable low (cf)
F403 FA        C      cli                      ; disable ints FIRST
C
C      v_wc_lo:
F404          C      in      al,dx      ; 08 get CRT status
F405 EC        C      rcr      al,1      ; 02 test display enable (bit #0)
F407 D0 D8     C      jnc     v_wc_lo     ; 16/04 wait for display enable hi (cf)
F409 8B C5     C      mov     ax,bp      ; 02 restore ax = (attr, char)
F40B AA        C      stob   ; 11 es:di gets al (character)
C
F40C 49        C      dec     cx      ; 02
C
F40D 74 06     C      jz      v_wc_end   ; 04/16
F40F 47        C      inc     di      ; 02 skip past attribute byte
C
F410 AA        C      stob   ; 11 es:di gets al (character)
C
C      ; Worst case: (8+2+16)+(8+2+4)+(2+11)-(2+4+2+11) = 72 cycles = 90% of 80 cycles
C
F411 FB        C      sti      ; enable interrupts immediately
F412 47        C      inc     di      ; skip past attribute byte
F413 E2 E9     C      loop   v_wc_next  ; do it cx times
C
C      v_wc_end:
F415          C      sti      ; enable interrupts immediately
F415 FB        C
C
F416 5A        C      pop     dx      ; restore dx
F417 8B CE     C      mov     cx,si     ; restore cx
F419 C3        C      ret
C
F41A          C      v_wc   endp
C
C      -----
C      ; Set Overscan, Back, & Foreground Colors ah = 0Bh
C      ;
C      ; Input: bh = palette color ID to set (0-127)
C      ;        bl = color value to be used with that color ID
C      ; Output: ah = v_mode
C      ;         al = new v_colorpal
C      ;
C      ; Assume: (contents of v_base6845)*5 = overscan register
C      ;
C      ; Trash: si & di destroyed. (si = bx; di = dx)
C      ;
C      -----
F41A          C      v_col   proc   near
C
C      assume cs:code, ds:data, es:v_ram, ss:nothing
C
F41A          C      mov     al,byte ptr ds:[v_colorpal] ; get current palette
C
F41D 8B FA     C      mov     di,dx      ; save dx
F41F 8B F3     C      mov     si,bx      ; save bx
C
C      or      bh,bh      ; palette color ID = 0?
F421 0A FF     C      jz      v_col_0     ; handle color ID 0
C
C      and     al,0DFh    ; clear palette select bit #5
F425 24 DF     C      rcr      bl,1      ; test new color (bit #0)
F427 D0 DB     C      jnb     v_col_1     ; if bit #0 set, all done
F429 73 0B     C      jnb     v_col_1     ; else set palette select bit #5
F42B 0C 20     C      or      al,20h    ;
F42D EB 07     C      jmp     short v_col_1
C
C      v_col_0:
F42F          C      and     bl,01Fh    ; save bits #0-4 of new color
F42F 80 E3 1F  C      and     al,0E0h    ; clear bits #0-4 of old color
F432 24 E0     C      or      al,bl      ; and combine the two.
F434 0A C3     C
C
C      v_col_1:
F436          C      mov     dx,5      ; get 6845 overscan reg. offset
F436 8A 0005   C      add     dx,word ptr ds:[v_base6845] ; add 6845 pointer register
F439 03 16 0063 R C      out     dx,al      ; output selection
F43D E8        C
C
F43E          C      mov     bx,si     ; restore bx
F43E 8B DE     C      mov     dx,di     ; restore dx
F440 8B D7     C
C
F442 A2 0066 R C      mov     byte ptr ds:[v_colorpal],al ; save the value for later
F445 C3        C      ret
C
F446          C      v_col   endp
C
C      -----
C      ; Write Dot (see graph.src) ah = 0Ch
C      ;
C      ; Read Dot (see graph.src) ah = 0Dh
C      ;
C      -----
C      ; Terminal Emulator to active page ah = 0Eh
C      ;
C      ; Input: al = character to write
C      ;        bl = foreground color in graphics mode
C      ;        bp = value to return in ax
C      ; Output: All registers saved.
C      ;
C      ; Trash: si & di destroyed. (si = cx; di = bx; dx if ROM stack)
C      ;
C      -----

```

ROM BIOS Listing

```

C
C      v_terminal proc near
C
C          assume cs:code, ds:data, es:v_ram, ss:nothing
C
F446 3C 07      cmp     al,BEL                ; is it bell character?
F448 75 03      jne     v_term_nobell
F44A E9 F54E R   jmp     v_bell
C
C      v_term_nobell:
F44D 52          push    dx                    ; save dx
F44E 8B F1      mov     si,cx                 ; save cx
F450 8B FB      mov     di,bx                 ; save bx
C
C      ; Get cursor position in active page.
F452 B7 07      mov     bh,07h                ;mask for page number, MOD 8
F454 22 3E 0062 R and     bh,byte ptr ds:[v_apage] ; get active page number (0-7)
C
C      mov     ah,03h            ; call v_r_curs_pos
F458 B4 03      INT     10h                   ; (dh,dl) = (row,col) of cursor
C
C      ; (ch,cl) = cursor mode setting
F45C 8B C5      mov     ax,bp                 ; restore ax
F45E B9 0001    mov     cx,1                   ; character count for write char
F461 B4 0A      mov     ah,0Ah                ; function code for write char
C
C      ; Handle special cases: dx has (row,col) of current cursor position.
C
F463 3C 0A      cmp     al,LF                 ; is it a line feed?
F465 74 14      je      v_lf                  ; mode 72 has 50 rows
F467 3C 0D      cmp     al,CR                 ; is it a carriage return?
F469 74 60      je      v_cr                  ; modes 4,5,6,64 have 25 rows
F46B 3C 08      cmp     al,BS                 ; are we at last row yet?
F46D 74 54      je      v_bs                  ; if yes, go scroll the screen
C
C      ; Normal Case: write the character
C
F46F CD 10      INT     10h                   ; otherwise, inc to next row
C
C      ; to write the character
F471 FE C2      inc     di                    ; call v_curs_pos to set new
F473 3A 16 004A R and     di,byte ptr ds:[v_width] ; cursor position
F477 72 13      jb      v_set_new_cur         ; column overflow?
C
C      xor     di,di            ; set new cursor position
F479 32 D2      xor     di,di                 ; carriage return cursor
C
C      v_lf: cmp     byte ptr ds:[v_mode],72 ; is this mode 72 ?
F47B 80 3E 0049 R and     bh,49                 ; mode 72 has 50 rows
F480 B4 31      mov     ah,49                 ; mode 72 has 50 rows
F482 74 02      je      v_lrow                ; jump if mode 72
F484 B4 18      mov     ah,24                 ; modes 4,5,6,64 have 25 rows
F486 3A F4      cmp     dh,ah                 ; are we at last row yet?
F488 74 07      je      v_scrolltty            ; if yes, go scroll the screen
F48A FE C6      inc     dh                    ; otherwise, inc to next row
C
C      v_set_new_cur:
F48C B4 02      mov     ah,02h                ; call v_curs_pos to set new
F48E EB 29 90   jmp     v_term_ret            ; cursor position
C
C      v_scrolltty:
F491 B4 02      mov     ah,02h                ; (dh,dl) = (row,col) = (24,0) or (49,0)
F493 CD 10      INT     10h                   ; call v_curs_pos to set cursor
C
C      ; and so that we can read back
C
C      ; the proper attribute byte
F495 32 E4      xor     ah,ah                 ; ah = 0 for graphics
F497 E8 F53C R   call    v_txt_md              ; are we text mode?
F49A 73 04      jnb     v_scrolltty_graphics  ; jump if graphics
C
C      mov     ah,08h            ; call v_rac
F49C B4 08      INT     10h                   ; to get attribute byte in ah
F49E CD 10
C
C      v_scrolltty_graphics:
F4A0 33 C9      xor     cx,cx                 ; (ch,cl)= upper left (row,col)
C
C      ; = (0,0)
F4A2 8A FC      mov     bh,ah                 ; store attribute in bh
F4A4 BB 0601    mov     ax,0601h              ; call v_scroll_up to scroll
C
C      ; one line with attribute bh
F4A7 8A 16 004A R and     bh,16                 ; (dh,dl) = lower right (row,col)
F4AB 80 EA 01   and     dl,1                   ; column = v_width-1
F4AE 80 3E 0049 R and     bh,3E                 ; is this mode 72 ?
F4B3 B6 31      mov     dh,49                 ; if yes then row = 49
F4B5 74 02      je      v_term_ret            ; jump if mode = 72
F4B7 B6 18      mov     dh,24                 ; if not mode 72 then row = 24
C
C      v_term_ret:
F4B9 CD 10      INT     10h
F4BB
C
C      v_term_nop:
C
C      ; Clean up.
C
F4BB 8B C5      mov     ax,bp                 ; restore ax
F4BD 8B DF      mov     bx,di                 ; restore bx
F4BF 8B CE      mov     cx,si                 ; restore cx
F4C1 5A      pop     dx                     ; restore dx
F4C2 C3      ret
C
C
F4C3 0A D2      C      v_bs: or      di,dl                 ; back space -- column = 0 ?
F4C5 74 F9      C      jz      v_term_nop          ; don't change cursor position
F4C7 FE CA      C      dec     di
F4C9 EB C1      C      jmp     v_set_new_cur

```


ROM BIOS Listing

```

F4E9 8B 36 004E R      C      mov     si,word ptr ds:[v_top] ; get offset of active page
F4ED 03 F0             C      add     si,ax                ; add offset in page => 'from'
F4EF 8B FE             C      mov     di,si                ; 'to' addresses.
C
C
C
FRF1 33 C9             C      xor     cx,cx                ; init count register to zero.
FRF3 8A CA             C      mov     cl,dl                ; cx = number of columns = dl
FRF5 A1 004A R          C      mov     ax,word ptr ds:[v_width] ; get screen width
FRF8 8B EB             C      mov     bp,ax                ; bp = v_width
FRFA 2B E9             C      sub     bp,cx                ; bp = (v_width - dl)
FRFC D1 E5             C      shl     bp,1                 ; bp = 2 * (v_width - dl)
C
F4FE D0 E0             C      shl     al,1                 ; al = 2 * v_width
F500 F6 E3             C      mul     bl                    ; ax = 2*v_width*no. of rows
C
F502 8A CE             C      mov     cl,dh                ;
F504 2A CB             C      sub     cl,bl                ; cl <= number of rows to move
C
F506 0A DB             C      or     bl,bl                 ; if rows to scroll,
F508 75 02             C      jnz     v_scri_mv_and_clr    ; then, move & clear row, return nz.
C
F50A 8A DE             C      mov     bl,dh                ; else clear dh rows only, return z.
C
F50C                   C      v_scri_mv_and_clr:
F50C C3                 C      ret                             ; ZF indicates state of BL at entry
C
F50D                   C      v_scri_pos     endp
C
C
C
-----
C      ;
C      ; Calculates video ram buffer offset of a character in text mode
C      ;
C      ; Input: bh = current active display page (0-7)
C      ; Output: bx = offset of character in text mode at display page
C      ;          = (page number)*(v_height)+offset of v_curpos(bh)
C      ;          = offset of character in text mode from page 0
C      ;
C      ; Trash: si = destroyed.
C
-----
F50D                   C      v_fpos     proc     near
C
C      assume cs:code, ds:data, es:v_ram, ss:nothing
C
F50D 8A C7             C      mov     al,bh                ; al gets page number
F50F 33 DB             C      xor     bx,bx                ; bx = 0
F511 25 0007           C      and     ax,07h              ; ax = page number mod 8
F514 8B F0             C      mov     si,ax                ; si keeps page number mod 8
F516 74 07             C      jr     v_fpos_0             ; page number = 0?
C
F518                   C      v_fpos_lp:
F518 03 1E 004C R      C      add     bx,word ptr ds:[v_height] ; optimization: word multipli-
F51C 48                 C      dec     ax                    ; ax by less than 8 without
F51D 75 F9             C      jnz     v_fpos_lp           ; destroying dx (or cx).
C
F51F                   C      v_fpos_0:
F51F D1 E5             C      shl     si,1                 ; bx = (page number)*(v_height)
F521 EB 84 0050 R      C      mov     ax,word ptr ds:[si+v_curpos] ; page number mod 8 word index
F525 E8 F52B R          C      call    v_posn                ; (ah,al) -> ax offset; si trash
F528 03 DB             C      add     bx,ax                ; bx = (page)*(v_height)+offset
F52A C3                 C      ret
C
F52B                   C      v_fpos     endp
C
C
C
-----
C      ;
C      ; Calculates video ram buffer offset of a character in text mode
C      ;
C      ; Input: (ah,al) = [row,col] position
C      ; Output: ax = offset of character in text mode.
C      ;
C      ; Trash: si destroyed.
C
-----
F52B                   C      v_posn     proc     near
C
C      assume cs:code, ds:data, es:v_ram, ss:nothing
C
F52B 8B F0             C      mov     si,ax                ; si keeps column (al)
F52D 81 E6 00FF         C      and     si,0FFh              ; si keeps row (ah)
F531 8A CA             C      mov     al,ah                ; al gets row (ah)
F533 F6 26 004A R      C      mul     byte ptr ds:[v_width]    ; ax gets (row * v_width)
F537 03 C6             C      add     ax,si                 ; ax gets (row * v_width)+ column
F539 D1 E0             C      shl     ax,1                 ; ax gets 2*(row * v_width)+column
F53B C3                 C      ret
C
F53C                   C      v_posn     endp
C
C
C
-----
C      ;
C      ; Is v_mode text or graphics or black/white card?
C      ;
C      ; Input: None.
C      ; Output: carry flag (cf) set if text, carry flag cleared if graphics.
C      ; Text Modes: 0 to 3 and 7
C      ; Graphics Modes: 4 to 6, 64, and 72
C      ;
C      ; Trash: None.
C
-----
F53C                   C      v_txt_md     proc     near

```

ROM BIOS
Listing

```

C
C
C         assume  cs:code, ds:data, es:v_ram, ss:nothing
C
C
F53C 80 3E 0049 R 04  C       cmp     byte ptr ds:[v_mode],4
F541 72 09           C       jb     v_txt_ok
C
C
F543 80 3E 0049 R 07  C       cmp     byte ptr ds:[v_mode],7
F548 74 02           C       je     v_txt_ok
F54A F8             C       cld
F54B C3             C       ret
C
C                           ; graphics mode (CF = 0)
C                           ; modes 4 to 6, 6A, and 72
C
F54C           C       v_txt_ok:
F54C F9             C       stc
F54D C3           C       ret
C                           ; text mode (CF = 1)
C                           ; modes 0 to 3 and 7
C
F54E           C       v_txt_md     endp
C
C-----
C      ; Handle BEL character: Beeps the speaker.
C-----
C      ;
C      ; No parameters.
C-----
C
F54E           C       v_bell proc near
C
C         assume  cs:code, ds:data, es:v_ram, ss:nothing
C
F54E 50           C       push  ax
C
C         mov     al,tzcmd           ; p_8253_2, lsb 1st, mode 3,no BCD
F54F 86 86           C       out     p_8253_ctrl,al
F551 E6 43           C       mov     al,00h             ; p_timer count
F553 80 00           C       out     p_8253_2,al      ; least significant byte
F555 E6 42           C       mov     al,06h           ; most significant byte
F557 80 06           C       out     p_8253_2,al
F559 E6 42           C
C
C         in     al,p_kctrl        ; get control data
F55B E4 61           C       mov     ah,al           ; save control status
F55D 8A E0           C       or     al,03h         ; turn speaker on
F55F 0C 03           C       out     p_kctrl,al
F561 E6 61           C
C
C         push  cx
F563 51           C       push  cx,200           ;512 msec
F564 B9 00C8         C       bell_wait:
F567           C       call  F_wait_one_ms    ;wait for 1 ms
F56A E7 FB           C       loop  bell_wait
F56C 59           C       pop  cx
C
C         mov     al,ah           ; restore control status
F56D 8A C4           C       out     p_kctrl,al
F56F E6 61           C
C
C         pop  ax
F571 58           C       ret
F572 C3           C
C
C       v_bell endp
F573           C
C       code  ends
F573           C
C       include com3.asm
C
C
C-----
C      ;
C      ; filename: com3.asm
C-----
F573           C       code segment public 'ROM'
C         assume  es:code, ds:nothing, es:nothing, ss:nothing
C
C-----
C      ;
C      ; INS8250 Asynchronous Communication Chip Baud Rate Time Constants
C      ; (baud rate generator signal is 3.6864 MHz put through a
C      ; divide-by-2 circuit).
C      ;
C      ; ((3,686,400 Hz)/2) = Input Freq.
C      ; Time Constant = -----
C      ;                       (16)*(baud rate)
C-----
C
F573           C       sec_init   proc  near           ; ah = 00h
C         assume  cs:code, ds:nothing, es:nothing, ss:nothing
C
F573 8A E8           C       mov     cb,al           ; save input parameters.
C
F575 32 C0           C       xor     al,al
F577 EE           C       out     dx,al           ; dummy read on sec_ctl_x
F578 E8 EB22 R      C       call    fs_diy           ; insures proper register addr.
F57B EC           C       in     al,dx
F57C E8 EB22 R      C       call    fs_diy
C
C         mov     al,9           ; select write register #9
F57F B0 09           C       out     dx,al           ; reset and disable int
F582 E8 EB22 R      C       call    ra_diy
F585 B0 C1           C       mov     al,11000001b     ; hw reset, st=0, mie=dis, nvs=1
F587 EE           C       out     dx,al
F588 E8 EB22 R      C       call    fs_diy
C
C         mov     al,4           ; select write register #A
F58B B0 04           C       out     dx,al           ; transfer parameters
F58D EE           C

```

ROM BIOS Listing

```

F58E E8 E8E2 R      C      call    rs_dly
F591 B0 44          C      mov     al,01000100b           ; 16x, 8-bit synch, 1 or 2 stop
F593 8A E5          C      mov     ah,ch                ; get input parameters.
F595 80 E4 04       C      and    ah,00000100b         ; get bit #2
F598 D0 E4          C      shl    ah,1                 ; move to bit #3
F59A 0A C4          C      or     al,ah                ; 'or' the bit
F59C 8A E5          C      mov     ah,ch                ; get input parameters.
F59E 80 E4 18       C      and    ah,00011000b         ; get bits #3 & 4
F5A1 B1 03          C      mov     cl,3                 ;
F5A3 D2 EC          C      shr    ah,cl                 ; move to bits #0 & 1
F5A5 0A C4          C      or     al,ah                ; 'or' the bits
F5A7 EE            C      out    dx,al                ;
F5A8 E8 E8E2 R      C      call    rs_dly              ; all done!!!
F5AB B0 0B          C      mov     al,11                ; select write register #11
F5AD EE            C      out    dx,al                ; clock mode control
F5AE E8 E8E2 R      C      call    rs_dly              ;
F5B1 B0 55          C      mov     al,01010101b         ; no x,r,sbr,t=br,txc o,t,x ck
F5B3 EE            C      out    dx,al                ;
F5B4 E8 E8E2 R      C      call    rs_dly              ;
F5B7 B0 0C          C      mov     al,12                ; select write register #12
F5B9 EE            C      out    dx,al                ; low byte of baud rate const
F5BA E8 E8E2 R      C      call    rs_dly              ;
F5BD 8A DD          C      mov     bl,ch                ; get input parameters.
F5BF 81 E3 00E0     C      and    bx,11100000b         ; get bits #5, 6, & 7 (clear bh)
F5C3 B1 04          C      shl    cl,4                  ;
F5C5 D2 EB          C      shr    bl,cl                 ; move to bits #1,2,& 3
                                C      ; bx is word index
                                C      ; NOTE: These values are the SAME as the com_baud EXCEPT for the - 2!!!!
F5C7 2E: 8B 87 E729 R C      mov     ax,word ptr cs:[bx+acc_baud] ; get 8530 baud count
F5CC 48             C      dec    ax                    ; get 8250 baud count
F5CD 48             C      dec    ax                    ; and subtract 2!!!!
F5CE EE            C      out    dx,al                ;
F5CF E8 E8E2 R      C      call    rs_dly              ; output low byte of baud rate
F5D2 B0 0D          C      mov     al,13                ; select write register #13
F5D4 EE            C      out    dx,al                ; high byte of baud rate const
F5D5 E8 E8E2 R      C      call    rs_dly              ;
F5D8 8A C4          C      mov     al,ah                ; output high byte of baud rate
F5DA EE            C      out    dx,al                ;
F5DB E8 E8E2 R      C      call    rs_dly              ;
F5DE B0 0E          C      mov     al,14                ; select write register #14
F5E0 EE            C      out    dx,al                ; baud rate generator enable
F5E1 E8 E8E2 R      C      call    rs_dly              ;
F5E4 B0 03          C      mov     al,00000011b         ; baud generator enable & source
F5E6 EE            C      out    dx,al                ;
F5E7 E8 E8E2 R      C      call    rs_dly              ;
F5EA B0 01          C      mov     al,1                 ; select write register #1
F5EC EE            C      out    dx,al                ; data xfer mode definition
F5ED E8 E8E2 R      C      call    rs_dly              ;
F5F0 32 C0          C      xor    al,al                 ; rx dis, pty no spec, tx dis
F5F2 EE            C      out    dx,al                ; ext dis
F5F3 E8 E8E2 R      C      call    rs_dly              ;
F5F6 B0 03          C      mov     al,3                 ; select write register #3
F5F8 EE            C      out    dx,al                ; RxD parameters and control
F5F9 E8 E8E2 R      C      call    rs_dly              ;
F5FC B0 01          C      mov     al,00000001b         ; RxD enable
F5FE 8A DD          C      mov     bl,ch                ; get input parameters.
F600 81 E3 0003     C      and    bx,0000011b         ; get bits #0 & 1 (clear bh)
F604 2E: 8A A7 F62E R C      mov     ah,byte ptr cs:[bx+acc_dbit]
F609 B1 06          C      mov     cl,6                 ;
F60B D2 E4          C      shl    ah,cl                 ; move data bits to #6 & 7
F60D 0A C4          C      or     al,ah                ; 'or' the data bits
F60F EE            C      out    dx,al                ;
F610 E8 E8E2 R      C      call    rs_dly              ;
F613 B0 05          C      mov     al,5                 ; select write register #5
F615 EE            C      out    dx,al                ; TxD parameters and control
F616 E8 E8E2 R      C      call    rs_dly              ;
F619 B0 08          C      mov     al,00001000b         ; TxD enabled. (power-up value)
F61B 95            C      xchg  ax,bp                 ; get original function code
F61C 0A E4          C      or     ah,ah                 ; is it 0 or FF?
F61E 95            C      xchg  ax,bp                 ; restore AX
F61F 75 02          C      jnz   acc_pwrup             ; jump if original AH=0FFh
F621 B0 8A          C      mov     al,10001010b         ; TxD,DTR,RTS enabled. (normal)
F623                C      acc_pwrup:
F623 D0 EC          C      shr    ah,1                 ; move bits #6 & 7 to #5 & 6
F625 0A C4          C      or     al,ah                 ; 'or' the bits
F627 EE            C      out    dx,al                ;
F628 E8 E8E2 R      C      call    rs_dly

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ROM BIOS Listing

```

C
C
F62B E9 E88A R      C      jmp     sec_stat      ; return status
C
C
C      -----
C      ;      Z8530 Compatible Data-Bit Definitions for Mapping bits
C      -----
C
F62E 00      C      sec_dbit    db     00b    ; 5 data bits (0) (non- )
F62F 02      C      db     10b    ; 6 data bits (1) (non- )
F630 01      C      db     01b    ; 7 data bits (2)
F631 03      C      db     11b    ; 8 data bits (3)
C
F632      C      sec_init    endp
C
F632      C      code     ends
C
C      include mem.asm
C
C      ;=====
C      ;      Filename:      mem.src
C      ;
C      ;      This module includes INT 12h, 11h, & 15h.
C      ;=====
C
F632      C      code     segment public 'ROM'
C      assume cs:code, ds:nothing, es:nothing, ss:nothing
C
C      ;-----
C      ;      INT 12h -- memory size detect
C      ;-----
C
C
F841      C      org     0F841h
F841      C      _m_size proc near
C      assume cs:code, ds:nothing, es:nothing, ss:nothing
C
C      ;-----
C      ;      at1
C      ;-----
F841 FB      C      push    ds
F842 1E      C      mov     ax,data_seg
F843 B8 0040 C      mov     ds,ax
F846 8E D8   C
C      assume cs:code, ds:data, es:nothing, ss:nothing
C
F848 A1 0013 R C      mov     ax,word ptr ds:[memory_size]
F84B 1F      C      pop     ds
C
F84C CF      C      iret
C
F84D      C      _m_size endp
C
C      ;-----
C      ;      INT 11h -- equipment check
C      ;-----
C
C
F84D      C      org     0F84Dh
F84D      C      _m equip proc near
C      assume cs:code, ds:nothing, es:nothing, ss:nothing
C
C      ;-----
C      ;      at1
C      ;-----
F84D FB      C      push    ds
F84E 1E      C      mov     ax,data_seg
F84F B8 0040 C      mov     ds,ax
F852 8E D8   C
C      assume cs:code, ds:data, es:nothing, ss:nothing
C
F854 A1 0010 R C      mov     ax,word ptr ds:[switch_bits]
F857 1F      C      pop     ds
C
F858 CF      C      iret
C
F859      C      _m equip endp
C
C      ;-----
C      ;      INT 15h -- cassette I/O
C      ;-----
C
C
F859      C      org     0F859h
F859      C      _m_cass proc near
C      assume cs:code, ds:nothing, es:nothing, ss:nothing
C
C      ;-----
C      ;      atc
C      ;-----
F859 F9      C      stc
F85A BA 86   C      mov     ah,86h
F85C C2 0002   C      ret     2
C      ;
C      ;      iret
C
C
F85F      C      _m_cass endp
C
F85F      C      code     ends
C      include nmi.asm
C
C      ;=====
C      ;      Filename:      nmi.src
C      ;
C      ;      This module includes INT 02h.
C      ;=====
C

```

ROM BIOS Listing

```

F85F      C code segment public 'ROM'
          C assume cs:code, ds:nothing, es:nothing, ss:nothing
          C
          C -----
          C INT 02h
          C -----
F85F      C      ORG      0F85Fh
F85F      C n_int proc near
          C assume cs:code, ds:nothing, es:nothing, ss:nothing
          C
F85F CF    C      iredt
F860      C n_int endp
F860      C code ends

C include boot2.asm
C
C ;-----
C ; File name: boot.src
C ;
C ; This module includes INT 19h.
C ;
C ;-----
F860      C code segment public 'ROM'
          C assume cs:code, ds:nothing, es:nothing, ss:nothing
          C ;-----
          C INT 19h -- Cold boot routine:
          C
          C This code reads Track 0, Side 0, Sector 0 into memory at
          C 0000:7C00 and iredt's into the secondary boot-strap loader
          C ;-----
          C Note: The stack looks like this at exit!!!!
          C
          C ;-----
          C ; High Address
          C ; |-----| <-- sp (at entry & exit)
          C ; |-----|
          C ; |-----|
          C ; |-----|
          C ; |-----|
          C ; |-----|
          C ; |-----| <-- sp after INT 19h trap
          C ; |-----|
          C ; |-----| <-- sp at loading of return address
          C ; Low Address
          C
          C Output:
          C (DL) = Driver Number [ 00h -> Floppy Drive (A:);
          C 01h -> Floppy Drive (B:);
          C 80h -> Fixed Disk (C:). ]
          C
          C (DH) = Head Number [ These three parameters will
          C (CH) = Cylinder Number specify the booted partition
          C (CL) = Sector Number in the case of the fixed disk. ]
          C
          C (AH) = Successful status = 0.
          C (AL) = Number of Sectors read [in order to read 512 bytes. ]
          C
          C (ES:BX) = Address of the transfer [0000:7C00]
          C (DS:BX)
          C
          C (CS:IP) = Address of entry point [0000:7C00]
          C (SS:SP) = Stack Segment and Pointer are left intact from the INT
          C 19h invocation for multi-tasking environments.
          C
          C (IF) = The interrupt enable flag is left intact from the INT
          C 19h invocation for multi-tasking environments.
          C
          C Trash: bp destroyed. (si, di, & bp preserved.)
          C ;-----
F860      C bt_int proc near
          C assume cs:code, ds:nothing, es:nothing, ss:nothing
          C
          C F860 FB sti ; enable interrupts
          C F861 55 push bp ; save BP & SI
          C F862 56 push si
          C
          C assume ds:data ; reset master table ptr to ROM
          C mov ds,word ptr cs:[set_da_word] ; satisfy assumption
          C F863 C7 06 0084 R E2CE R mov word ptr ds:[master_tbl_ptr+0000h],cs:[offset mastab]
          C F86E 8C 0E 0086 R ;
          C
          C mov si,cs:[offset bt_m] ; boot strap message
          C F872 BE DBB7 R ; print banner
          C F875 E8 E5FA R ;
          C
          C xor bl,bl ; disable error message blinking
          C F878 32 DB push bx ; save blink status
          C F87A 53
          C
          C assume ds:abs0, es:abs0
          C bt_o:
          C F87B xor ax,ax ; boot strap outer loop
          C F87D 8E D8 ; AX = abs0_seg.
          C F87F 8E C0 mov ds,ax ; satisfy assumptions
          C

```

ROM BIOS Listing

```

C ; Reset fd_parms table vector.
F881 C7 06 0078 R EFC7 R      mov     word ptr ds:[int1Elocn=0],cs:(offset fd_parms)
F887 8C 0E 007A R            mov     word ptr ds:[int1Elocn=2],cs
C ; Initialize retry loop.
F88B BD 0003                mov     bp,3 ; retry counter
F88E                        bt_1:    ; boot retry inner loop
C ; Initialize the driver.
F88E 33 C0                  xor     ax,ax ; AX = 0.
F890 8B DB                mov     bx,ax ; BX = 0.
F892 8B CB                mov     cx,ax ; CX = 0.
F894 8B D0                mov     dx,ax ; DX = 0.
F896 CD 13                INT     13h
F898 72 04                  jc     bt_nxt ; try again, if error
C ; Read the boot sector.
F89A B8 0201                mov     ax,0201h ; read one sector
C ;                               ; bl = 0.
F89D B7 7C                  mov     bh,7Ch ; xfer address = ES:BX = 0:7C00
C ;                               ; cx = 0.
F89F 41                      inc     cx ; track 0; sector 1
C ;                               ; dx = 0.
C ;                               ; head 0; drive 0
F8A0 06                      push    es ; save return registers
F8A1 CD 13                INT     13h ; BX,CX,DX,SI,DI,BP, & DS saved
F8A3 07                      pop     es ; restore return registers
F8A4                        bt_nxt:
F8A4 73 1E                  jnc     bt_ok ; jump if no error during read
C ;                               ; get blink status
F8A6 5B                      pop     bx ; have 3 retries been completed?
F8A7 0A DB                or     bl,bl ;                               ; jump if no
F8A9 74 0E                  jz     bt_dec ;                               ;
C ;                               ; blink error message on
F8AB BE DBD1 R           mov     si,cs:(offset bt_merr) ; blink error message on
F8AE 78 03                js     bt_blink ; blink state from BL above
F8B0 BE DBF6 R           mov     si,cs:(offset bt_spaces) ; blink error message off
C ;                               ;
F8B3                        bt_blink:
F8B3 E8 E5FA R           call    DRomString ; blink error message
F8B6 80 F3 80            xor     bl,10000000b ; toggle blink state
C ;                               ;
F8B9                        bt_dec:
F8B9 53                      push    bx ; re save blink status
F8BA 4D                      dec     bp ; decrement retry count
F8BB 75 D1                jnz    bt_1 ; and, try again
C ;                               ; get blink status
F8BD 5B                      pop     bx ; get blink status
F8BE 80 CB 01            or     bl,1 ; enable error message blinking
F8C1 53                      push    bx ; save new status
C ;                               ; and try again, for now.
F8C2 EB B7                jmp     bt_o ;                               ;
C ;                               ;
F8C4                        bt_ok:
F8C4 BE DBF6 R           mov     si,cs:(offset bt_spaces) ; blink error message off
F8C7 E8 E5FA R           call    DRomString ;                               ;
F8CA 5E                      pop     si ; discard blink status
F8CB 5E                      pop     si ; restore SI
F8CC 8B EC                mov     bp,sp ;                               ;
F8CE 8B 5E 02            mov     word ptr ss:[bp+2],bx ; return IP = BX = 7C00h
F8D1 8C A6 04            mov     word ptr ss:[bp+4],es ; return CS = ES = 0000h
F8D4 5D                      pop     bp ; restore BP
F8D5 CF                      ired   ; return flags
C ;                               ;
F8D6                        bt_int endp
F8D6                        code ends
C include calendar.asm
C ;
C ;=====
C ; Filename: cal.src
C ;
C ; This module includes c_read and c_write of INT 1Ah.
C ;=====
C ;
F8D6                        code segment public 'ROM'
C assume cs:code, ds:nothing, es:nothing, ss:nothing
F8D6                        c_data1 proc
C ; Days per year.
C ;
F8DE 0000                c_dy_yr dw (0*366)+(0*365) ; year 0 = leap year + 0
F8DF 015E                dw (1*366)+(0*365) ; year 1 = leap year + 1
F8DA 02DB                dw (1*366)+(1*365) ; year 2 = leap year + 2
F8DC 0448                dw (1*366)+(2*365) ; year 3 = leap year + 3
F8DE 05B5                dw (1*366)+(3*365) ; year 4 = leap year + 0
F8E0 0723                dw (2*366)+(3*365) ; year 5 = leap year + 1
F8E2 0890                dw (2*366)+(4*365) ; year 6 = leap year + 2
F8E4 09FD                dw (2*366)+(5*365) ; year 7 = leap year + 3
C ; Days per month.

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ROM BIOS Listing

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F8E6 1F      C      c_dy_mo db    31          ; month 0 = Jan
F8E7 1C      C      db    28          ; month 1 = Feb
F8E8 1F      C      db    31          ; month 2 = Mar
F8E9 1E      C      db    30          ; month 3 = Apr
F8EA 1F      C      db    31          ; month 4 = May
F8EB 1E      C      db    30          ; month 5 = Jun
F8EC 1F      C      db    31          ; month 6 = Jul
F8ED 1F      C      db    31          ; month 7 = Aug
F8EE 1E      C      db    30          ; month 8 = Sep
F8EF 1F      C      db    31          ; month 9 = Oct
F8F0 1E      C      db    30          ; month A = Nov
F8F1 1F      C      db    31          ; month B = Dec

F8F2                C      c_data1 endp
C
C      ;=====
C      ; Read or Write Clock Calendar Device (c_read)
C      ;
C      ;
C      ; Input: ah = -1 Write Clock Calendar Device, then:
C      ;         bx = day (from 1-1 of leap year up to 12-31 of leap year*7)
C      ;         cx = {0-2921} = {0-B69h}
C      ;         ch = hour (0-23)
C      ;         cl = minutes (0-59)
C      ; Output: ah = -1 implies date/time error
C      ;         ah = 0 implies date/time OK
C      ;
C      ; Input: ah = -2 Read Clock Calendar Device, then:
C      ; Output: bx = day (from 1-1 of leap year up to 12-31 of leap year*7)
C      ;         ch = hour
C      ;         cl = minutes
C      ;         dh = seconds
C      ;         dl = hundredths of seconds
C      ;
C      ; Trash: None.
C      ;=====
F8F2                C      c_read proc near
C      ; assume cs:code, ds:nothing, es:nothing, ss:nothing
C      ; Save registers.
F8F2 50                C      push    ax
C      ; Years.
F8F3 BA 007F          C      mov     dx,7Fh          ; interrupts (years mod 8)
F8F6 EC              C      in     al,dx
F8F7 EC              C      in     al,dx
F8F8 E8 F945 R        C      call   c_rBCD          ; al = years
F8FB 8A E8            C      mov     ch,al          ; ch = saves year mod 8
C      ; Months.
F8FD B2 7C            C      mov     dl,07Ch        ; dl = tens of months port = 7Ch
F8FF E8 F958 R        C      call   c_rhex          ; Input: dl = tens of mon.s port = 7Ch
C      ; Output: ax = hex of months (1-12)
F902 48              C      dec     ax             ; ax = map month (1-12) to month (0-11)
F903 8B D8            C      mov     bx,ax          ; bx = saves month (0-11)
C      ; Days.
F905 4A              C      dec     dx             ; dl = tens of days port = 79h
F906 E8 F958 R        C      call   c_rhex          ; Input: dl = tens of days port = 79h
C      ; Output: dx = hex of days (1-7)
F909 48              C      dec     ax             ; dx = tens of hours port = 77h
C      ; ax = map days (1-7) to days (0-7)
C      ; Calculate Day (ax has day).
F90A 8B D0            C      mov     dx,ax          ; dx = day
C      ; Calculate Month (bx has month).
F90C 4B              C      dec     bx             ; previous month
F90D 78 08            C      js     c_rm0          ; jump if it was zero
F90F                C      c_rmlp:
F90F E8 F9FD R        C      call   c_gdays        ; get days per month
F912 03 D0            C      add     dx,ax          ; dx = day + current month
F914 4B              C      dec     bx             ; previous month
F915 75 F8            C      jns    c_rmlp
F917                C      c_rm0:
C      ; zero case
C      ; dx = day + month
C      ; Calculate Year (ch has month).
F917 33 DB            C      xor     bx,bx          ; clear bh
F919 84 DD            C      mov     bl,ch         ; get year mod 8
F91B D1 E3            C      shl     bx,-1         ; make word index
F91D 2E: 03 97 F8D6 R C      add     dx,word ptr cs:[bx+c_dy_yr]
F922 8B DA            C      mov     bx,dx          ; bx = day + month + year
C      ; Hours.
F924 B2 77            C      mov     dl,077h       ; dl = tens of hours port = 77h

```

ROM BIOS Listing

```

F926 E8 F958 R      C      call   c_rhex          ; Input:  dl = tens of hours port = 77h
C                  C                  ; Output: ax = hexadecimal of hours
C                  C                  ;          dx = tens of min.s port = 75h
F929 8A E8         C      mov    ch,al          ; ch = hours
C                  C
C      ; Minutes.
C                  C      call   c_rhex          ; dl = tens of minutes port = 75h
F92B E8 F958 R      C      call   c_rhex          ; Input:  dl = tens of min.s port = 75h
C                  C                  ; Output: ax = hexadecimal of minutes
C                  C                  ;          dx = tens of sec.s port = 73h
F92E 8A C8         C      mov    cl,al          ; cl = minutes
C                  C
C      ; Seconds.
C                  C      call   c_rhex          ; dl = tens of seconds port = 73h
F930 E8 F958 R      C      call   c_rhex          ; Input:  dl = tens of sec.s port = 73h
C                  C                  ; Output: ax = hexadecimal of seconds
C                  C                  ;          dx = tenths of secs port = 71h
F933 8A F0         C      mov    dh,al          ; dh = seconds
F935 52            C      push   dx            ; save seconds (dh)
C                  C
C      ; Hundredths of Seconds.
C                  C
C                  C      call   c_rBCD          ; dl = tenths of seconds port = 71h
F936 E8 F945 R      C      call   c_rBCD          ; al = tenths of seconds
F939 8A E0         C      mov    ah,al          ; move tenths of seconds to high byte
F93B 32 C0         C      xor    al,al          ; ax = BCD of hundredths of seconds
F93D E8 F962 R      C      call   c_BCD2hex       ; ax = hex of hundredths of seconds
C                  C
C                  C      pop    dx            ; restore seconds (dh)
F940 5A           C      mov    dl,al          ; dl = hex of hundredths of seconds
F941 8A D0         C
C
C      ; Restore registers.
C                  C      pop    ax
F943 58           C      ret
F944 C3           C
C
C      c_rBCD: push   cx          ; save cx
F945 51           C      mov    cx,3          ; try 3 times only!!!
F946 B9 0003      C      mov    dx,dh          ; clear dh
F949 32 F6         C      xor    dh,dh
C
C      c_rBip: in    al,dx          ; get the byte
F94B EC           C      and   al,'h          ; clear high nibble
F94C 24 0F         C      cmp   al,3           ; is it less than 10?
F94E 3C 0A         C      jb   c_rBret         ; if so, return
F950 72 04         C      loop c_rBip         ; else, try again
F952 E2 F7         C      mov    al,1          ; if timeout, return one.
F954 B0 01         C
C
C      c_rBret:
F956             C      pop    cx            ; restore cx
F956 59           C      ret
F957 C3           C
C
F958             C      c_read endp
C
C
C      -----
C      ;
C      ; Convert to Hex (c_rhex)
C      ;
C      ; Inputs both BCD bytes and converts to hexadecimal word.
C      ;
C      ; Input:  dl = pointer to tens of whatever port
C      ; Output: ax = hexadecimal word (ah = 0)
C      ;          dx = pointer to tens of previous port (dh = 0)
C      ;
C      ; Trash: None.
C      ;
C      -----
F958             C      c_rhex proc near
C                  C      assume es:code, ds:nothing, es:nothing, ss:nothing
C
C                  C      call   c_rBCD          ; in from tens of whatever
F95B E8 F945 R      C      call   c_rBCD          ; move tens of whatever to high byte
F95B 8A E0         C      mov    ah,al          ; dx points to units of whatever port
F95D 4A           C      dec    dx            ; in from units of whatever
F95E E8 F945 R      C      call   c_rBCD          ; dx points to tens of previous port
F961 4A           C      dec    dx
C
C      ; jmp    short c_BCD2hex      ; fall through
F962             C      c_rhex endp
C
C
C      -----
C      ;
C      ; BCD to Hexadecimal (c_BCD2hex)
C      ;
C      ; Input:  ah = high BCD digit
C      ;          al = low BCD digit
C      ; Output: ax = hexadecimal byte (ah = 0)
C      ;          dh = 0
C      ;
C      ; Trash: None.
C      ;
C      -----
F962             C      c_BCD2hex proc near
C                  C      assume es:code, ds:nothing, es:nothing, ss:nothing
C
C                  C      mov    dh,ah          ; dh = hi BCD digit
F962 8A F4         C      mov    dh,ah          ; dh = 2*(hi BCD digit)
F964 D0 E6         C      shl   dh,1           ; dh = 4*(hi BCD digit)
F966 D0 E6         C      shl   dh,1           ; dh = 8*(hi BCD digit)
F968 02 F4         C      add   dh,ah          ; dh = 5*(hi BCD digit)
F96A D0 E6         C      shl   dh,1           ; dh = 10*(hi BCD digit)

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ROM BIOS Listing

```

F96C 02 C6      C      add     al,dh          ; al = 10*(hi BCD digit)+(low BCD digit)
F96E 32 E8      C      xor     ah,ah          ; ah = 0
F970 32 F6      C      xor     dh,dh          ; dh = 0
F972 C3          C      ret
F973           C      o_BCD2hex      endp
C
C      -----
C      ; Write Clock Calendar Device (c_write)
C      ;
C      ; Input: ah = -1
C      ;          bx = day (from 1-1 of leap year up to 12-31 of leap year+7)
C      ;          cx = (0-2921) = (0-B69h)
C      ;          dx = hour (0-23)
C      ;          cx = minutes (0-59)
C      ; Output: ah = -1 implies date/time error
C      ;          ah = 0 implies date/time OK
C      ; Trash: None.
C      -----
F973           C      c_write proc   near
C      ; assume cs:code, ds:nothing, es:nothing, ss:nothing
C      ; Check for errors.
C      ;
F973 80 F9 3C    C      cmp     cl,60          ; cl = minutes (0-59)
F976 73 73      C      jae     c_werr        ;
F978 80 FD 18    C      cmp     ch,24          ; ch = hour (0-23)
F97B 73 6E      C      jae     c_werr        ;
F97D 81 FB 0B6A  C      cmp     bx,(2*366)+(6*365) ; bx = day from leap year mod 8
F981 73 68      C      jae     c_werr        ;          = (0-2921) = (0-B69h)
C      ; Save registers.
C      ;
F983 50          C      push  ax
F984 53          C      push  bx
F985 51          C      push  cx
F986 52          C      push  dx
C      ; Initialize and Stop Clock.
C      ;
F987 33 C0      C      xor     ax,ax          ; ax = 0
F989 E6 70      C      out    70h,al         ; test only port = out of test mode
F98B E6 7E      C      out    7Eh,al         ; stop/start port = stop clock
C      ; Minutes.
C      ;
F98D B2 74      C      mov     dl,07Ah        ; dl = units of minutes port = 74h
F98F 8A C1      C      mov     al,cl          ; al = minutes (0-59)
F991 E8 F9EC R  C      call    c_whex         ; Input: al = hexadecimal of minutes
C      ;          dl = units of min.s port = 74h
C      ;          Output: ax = trash
C      ;          dx = units of hours port = 76h
C      ; Hours.
C      ;
F994 8A C5      C      mov     al,ch          ; dl = units of hours port = 76h
F996 E8 F9EC R  C      call    c_whex         ; Input: al = hexadecimal of hours
C      ;          dl = units of hours port = 76h
C      ;          Output: ax = trash
C      ;          dx = units of days port = 78h
C      ; Calculate Year.
C      ;
F999 8B D3      C      mov     dx,bx          ; dx = day from leap year mod 8
F99B BB 0010     C      mov     bx,(8*2)      ; word index of year
F99E           C      c_wy1p:
F99E 4B          C      dec     bx
F99F 4B          C      dec     bx
F9A0 2E: 3B 97 F8D6 R C      cmp     dx,word ptr es:[bx*c_dy_yr]
F9A5 72 F7      C      jb     c_wy1p
C      ;
F9A7 2E: 2B 97 F8D6 R C      sub     dx,word ptr es:[bx*c_dy_yr] ; dx = saves day of year
F9AC D1 EB      C      shr     bx,1           ; bl = year mod 8
F9AE 8A EB      C      mov     ch,bl          ; ch = saves year mod 8
C      ; Calculate Days & Months.
C      ;
F9B0 BB FFFF     C      mov     bx,-1          ; start at January
F9B3           C      c_wmlp:
F9B3 43          C      inc     bx
F9B4 E8 F9FD R  C      call    c_gdays       ; next month
F9B7 2B D0      C      sub     dx,ax          ; get days per month
F9B9 73 F8      C      jae     c_wmlp
C      ;
F9BB 03 C2      C      add     ax,dx          ; bx = month (0-11)
C      ;          ax = day (0-7)
C      ; Days.
C      ;
F9BD B2 78      C      mov     dl,078h        ; dl = units of days port = 78h
F9BF 40          C      inc     ax
C      ;          al = map days (0-7) to days (1-7)
F9C0 E8 F9EC R  C      call    c_whex         ; Input: al = hexadecimal of days
C      ;          dl = units of days port = 78h
C      ;          Output: ax = trash
C      ;          dx = day of week port = 7Ah
C      ; Months.
C      ;
F9C3 42          C      inc     dx
C      ;          dl = units of months port = 78h
F9C4 8B C3      C      mov     ax,bx
C      ;          al = month (0-11)
F9C6 40          C      inc     ax
C      ;          al = map month (0-11) to month (1-12)
F9C7 E8 F9EC R  C      call    c_whex         ; Input: al = hexadecimal of months
C      ;          dl = units of mon.s port = 78h

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C                                     ; Output: ax = trash
C                                     ;         dx = leap year port = 7Dh
C
C ; Leap Years.
C
F9C4 B0 08      C      mov     al,08h      ; dx = leap year port = 7Dh
F9CC 8A CD      C      mov     cl,ch      ; set leap year bit
F9CE 80 E1 03   C      and     cl,03h     ; get year mod 8
F9D1 D2 E8      C      shr     al,cl      ; get year mod 4
F9D3 E2         C      out     dx,al     ; shift leap year bit into position
C
C ; Years.
C
F9D4 42         C      inc     dx         ; dx = stop/start = 7Eh
F9D5 42         C      inc     dx         ; dx = interrupt = 7Fh
F9D6 8A C5      C      mov     al,ch      ; get year mod 8
F9D8 0C 08      C      or      al,08h    ; set 'repeated interrupt' bit
F9DA EE         C      out     dx,al
F9DB 90         C      nop
F9DC EC         C      in     al,dx
F9DD 90         C      nop
F9DE EC         C      in     al,dx
F9DF 90         C      nop
F9E0 EC         C      in     al,dx
C
C ; Start Clock.
C
F9E1 B0 FF      C      mov     al,0FFh   ; al = 0FFh
F9E3 74         C      dec     dx         ; dx = stop/start = 7Eh
F9E4 EE         C      out     dx,al     ; start clock
C
C ; Restore registers.
C
F9E5 5A         C      pop     dx
F9E6 59         C      pop     cx
F9E7 5B         C      pop     bx
F9E8 58         C      pop     ax
F9E9 32 EA      C      xor     ah,ah      ; ah = 0      no error
C
F9EB           C      c_werr:         ; ah = -1     error
F9EB C3         C      ret
C
F9EC           C      c_write endp
C
C -----
C ;
C ; Converts hexadecimal byte to BCD and outputs both bytes. (c_whex)
C ;
C ; Input:  al = hexadecimal byte
C ;         dl = pointer to units of whatever port
C ; Output: dx = pointer to units of next port (dh = 0)
C ;
C ; Trash:  ax destroyed.
C ; -----
C
F9EC           C      c_whex proc     near
C               assume  cs:code, ds:nothing, es:nothing, ss:nothing
C
F9EC 32 E3      C      xor     ah,ah      ; ax = hexadecimal byte
F9EE B6 0A      C      mov     dh,10     ; dh = divisor
F9F0 F6 F6      C      div     dh        ; ah = remainder = low BCD digit (0-9)
C               ; al = quotient = high BCD digit
F9F2 86 C4      C      xchg  al,ah      ; ah = quotient = high BCD digit
C               ; al = remainder = low BCD digit (0-9)
C
F9F4 32 F6      C      xor     dh,dh      ; dx points to units of whatever port
F9F6 EE         C      out     dx,al     ; out to units of whatever
F9F7 8A C4      C      mov     al,ah      ; move tens of whatever to low byte
F9F9 42         C      inc     dx        ; dx points to tens of whatever port
F9FA EE         C      out     dx,al     ; out to tens of whatever
F9FB 42         C      inc     dx        ; dx points to units of next port
F9FC C3         C      ret
C
F9FD           C      c_whex endp
C
C -----
C ;
C ; Got Days per Month. (c_gdays)
C ;
C ; This routine calculates the number of days
C ; per month based on the year without checking validity of month.
C ;
C ; Input:  bx = month (assumes bx < 12)
C ;        ch = year
C ; Output: ax = days in month, if month valid; else garbage
C ;
C ; Trash:  None.
C ; -----
C
F9FD           C      c_gdays proc  near
C               assume  cs:code, ds:nothing, es:nothing, ss:nothing
C
F9FD 33 C0      C      xor     ax,ax      ; clear ah
F9FF 2E: 8A 87 F8E6 R C      mov     al,cs:[bx+c_dy_mo]
C
FA04 80 FB 01   C      cmp     bl,1        ; is it February?
FA07 75 06      C      jnz     c_gret    ; if not February, return
C
FA09 F6 C5 03   C      test    ch,03h     ; if year = 0 mod 4, leap year
FA0C 75 01      C      jnz     c_gret    ; if not leap year, ax = 28th, so return
C
FA0E 40         C      inc     ax        ; load ax with February 29th

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FA0F C3          C   c_gret: ret
FA10             C   c_gdays endp
FA10             C   code ends
                ;-----
                ; ORG'd Font Tables
                ;-----
FA10             code segment public 'ROM'
                assume cs:code, ds:nothing, es:nothing, ss:nothing

FA6E             ORG   OFA6Eh
FA6E             font_lo_8x8 label byte
                include fontlo8.asm
                C
                C   fontlo8 proc near ; System Font Table for M24
                C
FA6E             DB   00h,00h,00h,00h
FA72             DB   00h,00h,00h,00h
FA76             DB   7E 81 A5 81 ; 0
FA7A             DB   0b4h,099h,081h,07eh ; 1
FA7E             DB   07eh,07fh,04bh,07fh
FA82             DB   0c3h,0e7h,07fh,07eh ; 2
FA86             DB   03eh,07fh,07fh,07fh
FA8A             DB   03eh,01ch,08h,00h ; 3
FA8E             DB   08h,01ch,03eh,07fh
FA92             DB   03eh,01ch,08h,00h ; 4
FA96             DB   018h,03ch,0e7h,0e7h
FA9A             DB   066h,018h,018h,03ch ; 5
FA9E             DB   018h,03ch,07eh,07fh
FAA2             DB   07fh,07eh,018h,03ch ; 6
FAA6             DB   00h,00h,018h,03ch
FAAA             DB   03ch,018h,00h,00h ; 7
FAAE             DB   07fh,07fh,0e7h,0c3h
FAB2             DB   0c3h,0e7h,07fh,07fh ; 8
FAB6             DB   00h,03ch,024h,042h
FABA             DB   042h,024h,03ch,00h ; 9
FABE             DB   07fh,0c3h,099h,0b4h
FAC2             DB   0b4h,099h,0c3h,07fh ; a
FAC6             DB   01fh,07h,04h,019h
FACA             DB   07fh,0e7h,0c3h,07eh ; b
FACC             DB   03ch,066h,066h,03ch
FAD2             DB   018h,07eh,018h,018h ; c
FAD6             DB   018h,014h,012h,012h
FADA             DB   014h,070h,070h,066h ; d
FADE             DB   01fh,011h,01fh,011h
FAE2             DB   013h,037h,072h,020h ; e
FAE6             DB   018h,04bh,03ch,0e7h
FAEA             DB   03ch,04bh,018h,00h ; f
FAEE             DB   040h,070h,07ch,07fh
FAF2             DB   07ch,070h,040h,00h ; 10
FAF6             DB   01h,07h,01fh,07fh
FAFA             DB   01fh,07h,01h,00h ; 11
FAFE             DB   018h,03ch,07eh,018h
FB02             DB   018h,07eh,03ch,018h ; 12
FB06             DB   00h,033h,033h,033h
FB0A             DB   033h,00h,033h,00h ; 13
FB0E             DB   07fh,04bh,04bh,07bh
FB12             DB   018h,01bh,01bh,00h ; 14
FB16             DB   03eh,061h,03ch,066h
FB1A             DB   066h,03ch,086h,07ch ; 15
FB1E             DB   00h,00h,00h,00h
FB22             DB   07eh,07eh,07ch,00h ; 16
FB26             DB   018h,03ch,07eh,018h
FB2A             DB   07eh,03ch,018h,07eh ; 17
FB2E             DB   018h,03ch,07eh,018h
FB32             DB   018h,018h,018h,018h ; 18
FB36             DB   018h,018h,018h,018h
FB3A             DB   018h,07eh,03ch,018h ; 19
FB3E             DB   0ch,06h,07fh,06h
FB42             DB   0ch,00h,00h,00h ; 1a
FB46             DB   018h,030h,07fh,030h
FB4A             DB   018h,00h,00h,00h ; 1b
FB4E             DB   00h,00h,060h,060h
FB52             DB   060h,07fh,07fh,00h ; 1c
FB56             DB   00h,024h,066h,07fh
FB5A             DB   066h,024h,00h,00h ; 1d
FB5E             DB   00h,00h,018h,03ch
FB62             DB   07eh,07fh,00h,00h ; 1e
FB66             DB   00h,07fh,07eh,03ch
FB6A             DB   018h,00h,00h,00h ; 1f
FB6E             DB   00h,00h,00h,00h
FB72             DB   00h,00h,00h,00h ; ' ' 20
FB76             DB   018h,03ch,03ch,018h
FB7A             DB   018h,00h,018h,00h ; '!' 21
FB7E             DB   036h,036h,014h,00h
FB82             DB   00h,00h,00h,00h ; '!' 22
FB86             DB   036h,036h,07fh,036h
FB8A             DB   07fh,036h,036h,00h ; '#' 23
FB8E             DB   018h,03eh,060h,03ch
FB92             DB   06h,07ch,018h,00h ; '*' 24
FB96             DB   00h,063h,066h,0ch
FB9A             DB   018h,033h,033h,00h ; '+' 25
FB9E             DB   01ch,03ch,01ch,03h
FBA2             DB   06eh,066h,03bh,00h ; '+' 26
FBA6             DB   018h,018h,030h,00h
FBAE             DB   00h,00h,00h,00h ; '!' 27
FBAE             DB   0ch,018h,030h,030h ; '!' 28
FB82             DB   030h,030h,018h,0ch ; '!' 28

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FBB6	30	18	0C	0C	C	DB	030h,018h,00h,00h		'J'	29
FBB8	0C	0C	18	30	C	DB	00h,066h,030h,07fh			
FBBE	00	66	3C	FF	C	DB	030h,066h,00h,00h		'8'	2a
FBC2	3C	66	00	00	C	DB	00h,018h,018h,07eh			
FBC6	00	18	18	7E	C	DB	018h,018h,00h,00h		'+'	2b
FBCA	18	18	00	00	C	DB	00h,00h,00h,00h			
FBCF	00	00	00	00	C	DB	00h,018h,018h,030h		'+'	2c
FBD2	00	18	18	30	C	DB	00h,00h,00h,07eh			
FBE6	00	00	00	00	C	DB	00h,00h,00h,00h		'+'	2d
FBD8	00	00	00	00	C	DB	00h,018h,018h,00h		'+'	2e
FBE2	00	18	18	00	C	DB	03h,06h,00h,018h			
FBE6	03	06	0C	18	C	DB	030h,060h,040h,00h		'/'	2f
FBEA	30	60	40	00	C	DB	030h,063h,067h,06fh			
FBE2	3E	63	67	6F	C	DB	07bh,073h,030h,00h		'0'	30
FBE2	7B	73	3E	00	C	DB	00h,010h,00h,00h			
FBE6	0C	0C	0C	0C	C	DB	00h,00h,03fh,00h		'+'	31
FBEA	0C	0C	3F	00	C	DB	01fh,033h,03h,00h		'2'	32
FBEA	1F	33	03	0E	C	DB	01eh,033h,03h,00h		'3'	33
FC02	18	33	3F	00	C	DB	03h,033h,010h,00h		'3'	33
FC06	1E	33	03	0E	C	DB	00h,010h,036h,066h		'A'	34
FC0A	03	33	1E	00	C	DB	07fh,06h,07h,00h			
FC0E	0E	1E	3E	6F	C	DB	03fh,030h,030h,03h		'5'	35
FC12	7F	06	0F	00	C	DB	00h,018h,030h,03eh		'6'	36
FC16	3F	30	3E	03	C	DB	033h,033h,010h,00h			
FC1A	03	33	1E	00	C	DB	03fh,033h,03h,06h		'7'	37
FC1E	0E	18	30	3E	C	DB	00h,00h,00h,00h		'8'	38
FC22	33	33	1E	00	C	DB	01eh,033h,033h,010h		'9'	39
FC26	3F	33	03	06	C	DB	033h,033h,010h,00h		'+'	3a
FC2A	0C	0C	0C	0C	C	DB	00h,018h,018h,00h		'+'	3a
FC2E	1E	33	33	1E	C	DB	00h,018h,018h,00h		'+'	3b
FC32	33	33	1E	00	C	DB	00h,018h,018h,030h		'+'	3b
FC36	1E	33	31	1F	C	DB	06h,00h,018h,030h		'+'	3c
FC3A	03	06	1C	00	C	DB	018h,00h,060h,00h		'+'	3d
FC3E	00	18	18	00	C	DB	00h,00h,070h,00h		'+'	3d
FC42	00	18	18	00	C	DB	030h,018h,00h,06h		'+'	3e
FC46	00	18	18	00	C	DB	00h,063h,03h,06h		'+'	3f
FC4A	00	18	18	30	C	DB	00h,00h,00h,00h			
FC4E	06	0C	06	30	C	DB	030h,063h,06fh,06fh		'0'	40
FC52	18	0C	06	00	C	DB	060h,060h,030h,00h		'0'	41
FC56	00	00	7E	00	C	DB	00h,010h,036h,063h		'A'	41
FC5A	00	7E	00	00	C	DB	07fh,063h,063h,00h		'A'	41
FC5E	30	18	0C	06	C	DB	07eh,033h,033h,030h		'B'	42
FC62	0C	18	30	00	C	DB	033h,033h,070h,00h		'B'	42
FC66	3E	63	06	06	C	DB	01eh,033h,060h,060h		'C'	43
FC6A	0C	0C	0C	0C	C	DB	061h,033h,010h,00h		'C'	43
FC6E	3E	63	6F	6F	C	DB	070h,036h,033h,033h		'D'	44
FC72	6E	60	3E	00	C	DB	033h,036h,070h,00h		'D'	44
FC76	08	1C	3E	63	C	DB	07fh,031h,034h,030h		'E'	45
FC7A	7F	63	63	00	C	DB	07fh,031h,034h,030h		'F'	46
FC7E	7E	33	33	3E	C	DB	034h,030h,078h,00h		'F'	46
FC82	33	33	7E	00	C	DB	010h,033h,060h,060h		'0'	47
FC86	1E	33	60	60	C	DB	06fh,033h,010h,00h		'0'	47
FC8A	61	33	1E	00	C	DB	063h,063h,063h,07fh		'H'	48
FC8E	7C	36	33	33	C	DB	063h,063h,063h,00h		'H'	48
FC92	33	36	7C	00	C	DB	030h,018h,018h,018h		'I'	49
FC96	7F	31	34	3C	C	DB	018h,018h,030h,00h		'I'	49
FC9A	34	31	7F	00	C	DB	07h,060h,06h,06h		'A'	4a
FC9E	7F	31	34	3C	C	DB	066h,066h,030h,00h		'A'	4a
FCA2	34	30	78	00	C	DB	073h,036h,030h,038h		'K'	4b
FCA6	1E	33	60	60	C	DB	030h,036h,073h,00h		'K'	4b
FCAA	67	33	19	00	C	DB	070h,030h,030h,030h		'L'	4c
FCAE	63	63	63	7F	C	DB	030h,033h,07fh,00h		'L'	4c
FCB2	63	63	63	00	C	DB	063h,077h,07fh,06bh		'M'	4d
FCB6	3C	18	18	18	C	DB	063h,063h,063h,00h		'M'	4d
FCBA	18	18	3C	00	C	DB	063h,073h,07bh,06fh		'N'	4e
FCBE	0F	06	06	06	C	DB	067h,063h,063h,00h		'N'	4e
FC02	66	66	30	00	C	DB	010h,036h,063h,063h		'0'	4f
FCC6	73	36	3C	38	C	DB	063h,036h,010h,00h		'0'	4f
FCCA	3C	36	73	00	C	DB	070h,033h,033h,030h		'P'	50
FCC2	78	30	30	30	C	DB	010h,036h,063h,063h		'Q'	51
FCD2	30	33	7F	68	C	DB	063h,036h,010h,07b		'Q'	51
FCD6	63	77	7F	68	C	DB	070h,033h,033h,030h		'R'	52
FCE2	63	63	63	00	C	DB	030h,030h,030h,018h		'S'	53
FCE6	63	63	78	6F	C	DB	063h,063h,063h,00h		'S'	53
FCE2	67	63	63	63	C	DB	070h,050h,018h,018h		'T'	54
FCE6	1C	36	63	63	C	DB	018h,018h,030h,00h		'T'	54
FCEA	63	36	1C	00	C	DB	063h,063h,063h,063h		'U'	55
FCEE	7E	33	33	3E	C	DB	063h,063h,030h,00h		'U'	55
FCF2	30	30	7F	00	C	DB	063h,063h,063h,063h		'V'	56
FCF6	1C	36	63	63	C	DB	036h,010h,00h,00h		'V'	56
FCFA	63	36	1C	07	C	DB	063h,063h,063h,063h		'W'	57
FCFE	7E	33	33	3E	C	DB	06bh,07fh,036h,00h		'W'	57
FD02	36	33	33	00	C	DB	063h,063h,036h,010h		'X'	58
FD06	63	63	30	018	C	DB	036h,066h,060h,030h		'X'	58
FD0A	06	63	3E	00	C	DB	018h,018h,030h,00h		'X'	59
FD0E	7E	5A	18	18	C	DB	07fh,063h,06h,00h		'Z'	5a
FD12	18	18	3C	00	C	DB	018h,033h,07fh,00h			
FD16	63	63	63	63	C					
FD1A	63	63	3E	00	C					
FD1E	63	63	63	63	C					
FD22	36	1C	08	00	C					
FD26	63	63	63	68	C					
FD2A	68	7F	36	00	C					
FD2E	63	63	36	1C	C					
FD32	36	63	63	00	C					
FD36	66	66	66	3C	C					
FD3A	18	18	3C	00	C					
FD3E	7F	63	06	0C	C					
FD42	18	33	7F	00	C					

ROM BIOS Listing

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FD46 3C 30 30 30      C      DB 03eh,030h,030h,030h
FD4A 30 30 3C 0C      C      DB 030h,030h,030h,00h  ;'[' 5b
FD4E 20 30 18 0C      C      DB 020h,030h,018h,00h
FD52 06 03 01 00      C      DB 06h,03h,01h,00h  ;'\ ' 5c
FD56 3C 0C 0C 0C      C      DB 03eh,0ch,0ch,0ch
FD5A 0C 0C 3C 0C      C      DB 0ch,0ch,03ch,00h  ;'] ' 5d
FD5E 08 1C 36 63      C      DB 08h,01ch,036h,063h
FD62 00 00 00 00      C      DB 00h,00h,00h,00h  ;'' ' 5e
FD66 00 00 00 00      C      DB 00h,00' 00h,00h
FD6A 00 00 7F 00      C      DB 00h,00' 7Fh,00h  ;'' ' 5f
FD6E 18 18 0C 00      C      DB 018h,01'0h,0ch,00h
FD72 00 00 00 00      C      DB 00h,00h,00h,00h  ;'' ' 60
FD76 00 00 3C 06      C      DB 00h,00h,03ch,06h
FD7A 3E 66 3B 00      C      DB 03eh,066h,03bh,00h  ;'a ' 61
FD7E 70 30 3E 33      C      DB 070h,030h,03eh,033h
FD82 33 33 6E 00      C      DB 033h,033h,06eh,00h  ;'b ' 62
FD86 00 00 3E 61      C      DB 00h,00h,03eh,061h
FD8A 60 61 3E 00      C      DB 060h,061h,03eh,00h  ;'c ' 63
FD8E 0E 06 3E 66      C      DB 0eh,06h,03eh,066h
FD92 66 66 3B 00      C      DB 066h,066h,03bh,00h  ;'d ' 64
FD96 00 00 3E 63      C      DB 00h,00h,03eh,063h
FD9A 7F 60 3F 00      C      DB 07Fh,060h,03Fh,00h  ;'e ' 65
FD9E 1E 33 30 7C      C      DB 01eh,033h,030h,07ch
FDA2 30 30 78 00      C      DB 030h,030h,078h,00h  ;'f ' 66
FDA6 00 00 3B 66      C      DB 00h,00h,03bh,066h
FDAA 66 3E 46 3C      C      DB 066h,03eh,046h,03ch  ;'g ' 67
FDAE 70 30 3E 3F      C      DB 070h,030h,03eh,03Fh
FDB2 33 33 73 00      C      DB 033h,033h,073h,00h  ;'h ' 68
FDB6 0C 00 1C 0C      C      DB 0ch,00h,01ch,0ch
FDBA 0C 0C 1E 0C      C      DB 0ch,0ch,01eh,00h  ;'i ' 69
FDBE 0C 00 1E 0C      C      DB 0ch,00h,01eh,00h
FDC2 0C CC CC 78      C      DB 0ch,0ch,0ch,078h  ;'j ' 6a
FDC6 70 30 33 36      C      DB 070h,030h,033h,036h
FDCA 3C 3E 73 00      C      DB 03ch,036h,073h,00h  ;'k ' 6b
FDC E 1C 0C 0C 0C      C      DB 01ch,0ch,00h,0ch
FDD2 0C 0C 1E 00      C      DB 0ch,0ch,01eh,00h  ;'l ' 6c
FDD6 00 00 66 7F      C      DB 00h,00h,066h,07Fh
FDDA 6B 6B 6B 00      C      DB 06bh,06bh,06bh,00h  ;'m ' 6d
FDE2 00 00 6E 33      C      DB 00h,00h,06eh,033h
FDE6 33 33 33 00      C      DB 033h,033h,033h,00h  ;'n ' 6e
FDEA 00 00 1E 33      C      DB 00h,00h,01eh,033h
FDEE 33 33 1E 00      C      DB 033h,033h,01eh,00h  ;'o ' 6f
FDEE 00 00 6E 33      C      DB 00h,00h,06eh,033h
FDF2 33 3E 30 78      C      DB 033h,03eh,030h,078h  ;'p ' 70
FDF6 00 00 3B 66      C      DB 00h,00h,03bh,066h
FDF A 66 3E 06 0F      C      DB 066h,03eh,06h,0Fh  ;'q ' 71
FDFE 00 00 6E 3B      C      DB 00h,00h,06eh,03bh
FD02 30 30 78 00      C      DB 030h,030h,078h,00h
FD06 00 00 3F 60      C      DB 00h,00h,03Fh,060h
FD0A 3C 03 7E 00      C      DB 03ch,03h,07eh,00h  ;'a ' 72
FD0E 08 18 3E 18      C      DB 08h,018h,03eh,018h
FD12 18 18 0E 00      C      DB 018h,018h,0eh,00h  ;'t ' 74
FD16 00 00 66 66      C      DB 00h,00h,066h,066h
FD1A 66 66 3B 00      C      DB 066h,066h,03bh,00h  ;'u ' 75
FD1E 00 00 63 63      C      DB 00h,00h,063h,063h
FD22 36 1C 08 00      C      DB 036h,01ch,08h,00h  ;'v ' 76
FD26 00 00 63 6B      C      DB 00h,00h,063h,06bh
FD2A 6B 7F 36 00      C      DB 06bh,07Fh,036h,00h  ;'w ' 77
FD2E 00 00 63 36      C      DB 00h,00h,063h,036h
FD32 1C 36 63 00      C      DB 01ch,036h,063h,00h  ;'x ' 78
FD36 00 00 66 66      C      DB 00h,00h,066h,066h
FD3A 66 3E 06 7C      C      DB 066h,03eh,06h,07ch  ;'y ' 79
FD3E 00 00 7E 4C      C      DB 00h,00h,07eh,04ch
FD42 18 32 7E 00      C      DB 018h,032h,07eh,00h  ;'z ' 7a
FD46 0E 18 18 70      C      DB 0eh,018h,018h,070h
FD4A 18 18 0E 00      C      DB 018h,018h,0eh,00h  ;'[' 7b
FD4E 18 18 18 00      C      DB 018h,018h,018h,00h
FD52 18 18 18 00      C      DB 018h,018h,018h,00h  ;'I ' 7c
FD56 70 18 18 0E      C      DB 070h,018h,018h,0eh
FD5A 18 18 70 00      C      DB 018h,018h,070h,00h  ;'] ' 7d
FD5E 3B 6E 00 00      C      DB 03bh,06eh,00h,00h
FD62 00 00 00 00      C      DB 00h,00h,00h,00h  ;'' ' 7e
FD66 00 08 1C 36      C      DB 00h,08h,01ch,036h
FD6A 63 63 7F 00      C      DB 063h,063h,07Fh,00h  ;'' ' 7f
;End of font matrix
;
; font108 endp
;
; code ends
;
; include rtc.asm
;
; =====
; ; Filename: rtc.arc
; ;
; ; This module includes INT 08h & 1Ah.
; ;
; =====
;
; code segment public 'ROM'
; assume cs:code, ds:nothing, es:nothing, ss:nothing
;
; ; =====
; ; INT 1Ah -- Time of Day Software Interrupt Request Routine
; ;
; ; Input: ah = 0 Read the Clock, then:
; ; Output: 0x = High Portion of Clock (t_hi_order)
; ; dx = Low Portion of Clock (t_low_order)
; ; al = 1 if 24 hours have elapsed (t_overflow); 0 otherwise

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ROM BIOS Listing

```

C ;
C ; Input: ah = 1 Set the Clock, then:
C ; cx = High Portion of Clock (t_hi_order)
C ; dx = Low Portion of Clock (t_low_order)
C ;
C ; Trash: ah = (ah - 1) if ah <> 0,-1, or -2
C ;-----
C ; Input: ah = -1 Write Clock Calendar Device, then:
C ; bx = day (from 1-1 of leap year up to 12-31 of leap year+7)
C ;      = (0-2921) = (0-B69b)
C ;      ch = hour (0-23)
C ;      cl = minutes (0-59)
C ; Output: ah = -1 implies date/time error
C ;          ah = 0 implies date/time OK
C ;
C ; Input: ah = -2 Read Clock Calendar Device, then:
C ; Output: bx = day (from 1-1 of leap year up to 12-31 of leap year+7)
C ;          ch = hour
C ;          cl = minutes
C ;          dh = seconds
C ;          dl = hundredths of seconds
C ;
C ; Trash: None.
C ;-----
FE6E          ORG     0FE6Eh
FE6E          t_day  proc  near
C ;          assume  cs:code, ds:nothing, es:nothing, ss:nothing
FE6F          sti                    ; enable interrupts
FE6F 80 FC FE  cmp     ah,0FEh          ; ZF set if FEh, CF reset if FFh
FE72 75 04     jne     t_nFE          ; ah = -2 = 0FEh ?
FE74 E8 F8F2 R call    c_read           ; read calendar chip
FE77 CF       irt
FE78          t_nFE:
FE78 72 04     jb     t_nFF          ; ah = -1 = 0FFh > 0FEh ?
FE7A E8 F973 R call    c_write          ; set calendar chip
FE7D CF       irt
FE7E          t_nFF:
C ;          assume  cs:code, ds:data, es:nothing, ss:nothing
FE7E 1E       push   ds                ; save registers
FE7F E8 E5F4 R call    set_ds           ; satisfy assumptions
FE82 FA       cli                    ; interrupts off!
C ;          ; (shared variables)
FE83 80 EC 01 sub     ah,1              ; DON'T DECREMENT (CF needed!)
FE86 73 0D     jae     t_set          ; ah = 0 < 1?
C ; Read Time of Day.
FE88 32 E4     xor     ah,ah             ; ah = 0 & ZF set!
FE8A 8B 0E 006 E R mov     cx,word ptr ds:[t_hi_order]
FE8E 8B 16 006 C R mov     dx,word ptr ds:[t_low_order]
FE92 A0 0070 R mov     al,byte ptr ds:[t_overflow]
C ;          ; t_overflow = 0 by setting time!
C ;          ; fall through (ah = 0 & ZF set!)
FE95 75 0C     t_set: jnz     t_end          ; was ah = 1? (is ah = 0 now)?
C ; Set Time of Day.
FE97 89 0E 006 E R mov     word ptr ds:[t_hi_order],cx
FE9B 89 16 006 C R mov     word ptr ds:[t_low_order],dx
FE9F 8B 26 0070 R mov     byte ptr ds:[t_overflow],ah
C ;          ; it's ok, if we fall through.
C ;          ; (a bit slower, but smaller!)
C ;          ; ah = 0 (in all cases...)
FEA3 1F       t_end: pop     ds                ; restore registers
FEA4 CF       irt
FEA5          t_day  endp
C ;-----
C ; INT 08h -- 18253 p_timer Hardware Interrupt Service Routine
C ;-----
FEA5          ORG     0FEA5h
FEA5          t_int  proc  near
C ;          assume  cs:code, ds:nothing, es:nothing, ss:nothing
C ;          ; interrupts off!
C ;          ; (shared variables)
FEA5 50       push   ax                ; preserve registers
FEA6 52       push   dx
FEA7 1E       push   ds
C ;          ;
C ;          assume  cs:code, ds:data, es:nothing, ss:nothing
FEA8 2E: 8E 1E E5F2 R mov     ds,word ptr cs:[set_ds_word]
C ;          ; satisfy assumption
C ; Handle turning off floppy disk drive motor.
FEAD FE 0E 0040 R dec     byte ptr ds:[motor_count]
C ;          ; decrement motor on count

```

ROM BIOS Listing

```

FEB1 75 08          C          jnz     t_inc          ; should we turn off drive?
C
C
FEB3 EB EF4F R    C          call    stop_disk        ; if so, stop disk motor
FEB6 80 26 003F R FO C          and     byte ptr ds:[motor_status],0F0h ; clear low nibble of status
C
FEBB              C          t_inc:
C
C          ; Increment long p_timer count
C
FEBB FF 06 006C R C          inc     word ptr ds:[t_low_order] ; increment low byte of counter
FEBF 75 04          C          jnz     t_hi          ; skip t_hi_order
C
FEC1 FF 06 006E R C          inc     word ptr ds:[t_hi_order] ; increment high byte of counter
FEC5              C
C          ; Handle 24 hour overflow situation
C
FEC5 81 3E 006C R C          cmp     word ptr ds:[t_low_order],00B0h ; has 24 hours elapsed?
FECB 75 14          C          jne     t_of1         ; if not, skip t_overflow
C
FECD 83 3E 006E R C          cmp     word ptr ds:[t_hi_order],24   ; has 24 hours elapsed?
FED2 75 0D          C          jne     t_of1         ; if not, skip t_overflow
C
FED4 C6 06 0070 R C          mov     byte ptr ds:[t_overflow],01h
FED9 33 C0          C          xor     ax,ax
FEDB A3 006C R    C          mov     word ptr ds:[t_low_order],ax
FEDE A3 006E R    C          mov     word ptr ds:[t_hi_order],ax
FEE1              C          t_of1:
C
FEE1 FB           C          sti             ; enable interrupts
C          ; (no more shared variables)
C
FEE2 CD 1C        C          INT          1Ch
C
C          ; Send specific end of interrupt (SEOI) to pic 'command' port AFTER p_timer
C          ; break, because user may be out-to-lunch for quite awhile....
C
FEE4 80 60        C          mov     al,pic_seoi_0 ; specific end of interrupt command
FEE6 E6 20        C          out     pic_0,al     ; to pic 'command port.
C
C
FEE8 1F           C          pop     ds          ; restore registers
FEE9 5A           C          pop     dx
FEEA 58           C          pop     ax
FEEB CF           C          iret
C
FEEC              C          t_int endp
C
FEEC              C          code ends
C          include vector.asm
C
C          ;=====
C          ;          Filename:      vector.arc
C          ;
C          ;          This module includes the table of ROM interrupt vectors & ill_int
C          ;          hardware diagnostic & illegal software interrupt service routine.
C          ;
C          ;=====
C          ;          05-11-84
C
FEEC              C          code segment public 'ROM'
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
C
FEE3              C          ORG          0FEF3h
C
FEE3              C          i_vec_tbl   proc near
C
FEE3 FE45 R        C          dw     t_int          ; int081000 see rtc.src
FEE5 E987 R        C          dw     t_int          ; int091000 see kb.src
FEE7 FF23 R        C          dw     ill_int        ; int0A1000
FEE9 FF23 R        C          dw     ill_int        ; int0B1000
FEEB FF23 R        C          dw     ill_int        ; int0C1000
FEEF FF23 R        C          dw     ill_int        ; int0D1000
FEF1 FF57 R        C          dw     fd_int         ; int0E1000 see dsk.src
FEF3 FF23 R        C          dw     ill_int        ; int0F1000
C
FEF3 F065 R        C          dw     v_io           ; int101000 see vid.src
FEF5 F84D R        C          dw     m equip        ; int111000 see boot.src
FEF7 F841 R        C          dw     m_size         ; int121000 see mem.src
FEF9 BC59 R        C          dw     fd_io          ; int131000 see dsk.src
FEFB B739 R        C          dw     serial_io      ; int141000 see com.src
FEFD F859 R        C          dw     m_cass         ; int151000 see mem.src
FEFF B82E R        C          dw     k_io           ; int161000 see kb.src
FF01 BFD2 R        C          dw     p_io           ; int171000 see prn.src
C
FF13 F860 R        C          dw     bt_int         ; int181000 (We Don't Have BASIC!)
FF15 F860 R        C          dw     bt_int         ; int191000
FF17 FE6E R        C          dw     t_day          ; int1A1000 see rtc.src
FF19 FF4B R        C          dw     dummy_iret     ; int1B1000 see kb.src
FF1B FF4B R        C          dw     dummy_iret     ; int1C1000 see rtc.src
FF1D F048 R        C          dw     v_parms        ; int1D1000 see vid.src
FF1F EFCD R        C          dw     fd_parms       ; int1E1000 see dsk.src
FF21 C860 R        C          dw     font_hi_8x8    ; int1F1000 see graph.src
C
FF23              C          i_vec_tbl   endp
C
C          ;-----
C          ;          Interrupt Routine for Unused Hardware & Illegal Software Interrupts

```

ROM BIOS Listing

```

C -----
C
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
FF23      ORG      0FF23h
C
C          ill_int proc near                ; trap for illegal interrupts
FF23      push    ax                        ; save registers
FF23      50
C          ; ah = -1; illegal software trap
FF24 B8 FF0B mov    ax, (0FFh*100h)+0Bh         ; al = 00h; -- read PIC's
FF27 E6 20  out    pic_0, al                ; in-service register
C
FF29 1E      push    ds                    ; save registers & delay
C
C          ; Determine whether it is a hardware or software interrupt.
C
FF2A EA 20   in     al, pic_0                    ; get active PIC IR#
FF2C 0A C0   or     al, al                          ; are any active?
FF2E 74 0E   jz     ill_sw                          ; if not, illegal software trap.
C
C          ; If hardware interrupt, disable the 8259 PIC from further interrupts.
C
FF30 9A E0   mov    ah, al                          ; return active PIC IR#
FF32 E8 21   in     al, pic_1                    ; OCW1 -- get PIC interrupt mask
FF34 0A C4   or    ah, ah                          ; shut off (set) IR# bit.
FF36 E6 21   out    pic_1, al                       ; send PIC new mask.
C
FF38 B0 20   mov    al, pic_neoi                    ; OCW2 -- send PIC a
FF3A E6 20   out    pic_0, al                       ; nonspecific end_of_int
C
C          ; Return ah = active PIC Interrupt Number in intr_flg.
C
FF3C EB 03   jmp    short ill_flg
C
FF3E      ill_sw:                          ; illegal software trap; ah = -1
C
C          ; Turn off floppy disk drives and notify user
C
FF3E      call   ill_trap                    ; every register but ds saved!
C
FF3E      .list
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
C
FF41      ill_flg:                          ; set illegal trap flag.
C          ; illegal software trap; ah = -1
C
C          assume cs:code, ds:data, es:nothing, ss:nothing
C
FF41      call   set_ds                       ; satisfy assumptions.
FF44 86 26 006B R mov    byte ptr ds:[intr_flg], ah      ; return interrupt flag.
C
FF48 1F      pop    ds                        ; restore registers.
FF49 58      pop    ax                        ; give user a second chance
FF4A CF      iret
C
FF4B      ill_int endp
C
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
C
FF4B      ORG      0FF4Bh                    ; ORG 0FF4Bh through 0FF53h
C
FF4B      dummy_iret proc near                ; 'BREAK' key interrupt (1Bh)
FF4B      CF      iret                       ; p_timer break interrupt (1Ch)
C
FF4C CF      iret                           ; OFF4Ch -- in case someone is
FF4D CF      iret                           ; OFF4Dh
FF4E CF      iret                           ; OFF4Eh
FF4F CF      iret                           ; OFF4Fh
FF50 CF      iret                           ; OFF50h
FF51 CF      iret                           ; OFF51h
FF52 CF      iret                           ; OFF52h
FF53 CF      iret                           ; OFF53h
C
FF54      dummy_iret endp
C
FF54      code ends
C          include prnscr.asm
C
C          ;=====
C          ;      Filename:      prnscr.src
C          ;
C          ;      This module includes INT 05h.
C          ;=====
C
FF54      code segment public 'ROM'
C          assume cs:code, ds:nothing, es:nothing, ss:nothing
C
C          ;-----
C          ;      INT 05h -- Print Screen
C          ;
C          ;      Input:  None.
C          ;      Output: None.
C          ;      Trash: None. (Uses byte at 50:0 = 40:0100 as monitor lock;
C          ;                   0 indicates monitor not locked.
C          ;                   1 indicates monitor locked.
C          ;                   -1 indicates printer error.
C          ;-----

```


ROM BIOS Listing

```

C
C
FF54          C          ORG      OFF54h
C
FF54          C          _s_int  proc   near
C          C          assume  cs:code, ds:nothing, es:nothing, ss:nothing
C
FF54 1E          C          push   ds          ; save ds
C
C          C          assume  cs:code, ds:data, es:nothing, ss:nothing
C
FF55 2E: 8E 1E E5F2 R C          mov     ds,word ptr cs:[set_ds_word] ; satisfy assumptions
C
FF5A 52          C          push   dx
C
FF5B 32 01        C          mov     di,1
C
FF5D F0/ 86 16 0100 C          lock  xchg  byte ptr ds:[100h],di ; l = locked
C
FF62 FE CA        C          dec     di          ; check monitor lock
C
FF64 74 4C        C          jz     _s_nop       ; already locked?
C
FF66 FB          C          sti          ; if set, do nothing
C
C          C          ; enable interrupts after
C          C          ; monitor lock code!!!!
C
FF67 51          C          push   cx          ; save registers
C
FF68 53          C          push   bx
C
FF69 50          C          push   ax
C
C          C          ; Get Current Video Width.
C
FF6A 8A 0F        C          mov     ah,0Fh     ; call v_video_state
C
FF6C CD 10        C          INT     10h     ; Output: ah = crt_cols
C
C          C          ; Input: bh = crt_mode
C          C          ; ah = crt_code
C          C          ; bh = active_page
C
FF6E 8A DC        C          mov     bl,ah     ; save ah = crt_cols
C
C          C          ; Get Current Cursor Position.
C
FF70 8A 03        C          mov     ah,03h     ; call v_read_cursor
C
FF72 CD 10        C          INT     10h     ; Input: bh = active_page
C
C          C          ; Output:
C          C          ; (dh,dl) = (row,col) of cursor
C          C          ; (ch,cl) = cursor mode setting
C
FF74 8A EB        C          mov     ch,bl     ; get crt_cols
C
FF76 52          C          push   dx          ; save row, col of cursor
C
FF77 B1 FF        C          mov     cl,-1     ; initialize cl = printer error
C
C          C          ; Loop Through the Screen.
C
FF79 BA 0000      C          mov     dx,0
C
C          C          ; (dh,dl) = (row,col) of origin
C
FF7C E8 FF85 R    C          call  _s_eol      ; print a new line
C
FF7F 75 24        C          jnz   _s_err      ; any errors?
C
FF81 E8 FFC9 R    C          _s_lp: call  _s_get ; get next character from screen
C
C          C          ; Map Invalid Characters to Space.
C
FF8A 3C 00        C          cmp     al,0
C
FF86 75 02        C          jne   _s_ok
C
FF88 B0 20        C          mov     al,' '
C
FF8A          C          _s_ok:
C
C          C          ; Print the Character.
C
FF8A E8 FFBC R    C          call  _s_out      ; print a character
C
FF8D 75 16        C          jnz   _s_err      ; any errors?
C
C          C          ; Advance to Next Character.
C
FF8F FE C2        C          inc     di          ; advance column (1-crt_cols)
C
FF91 3A D5        C          cmp     dl,ch
C
FF93 7C EC        C          jl     _s_lp
C
C          C          ; if so, continue
C
FF95 E8 FF85 R    C          call  _s_eol      ; else print a new line
C
FF98 75 0B        C          jnz   _s_err      ; any errors?
C
FF9A 32 D2        C          xor     di,di
C
FF9C FE C6        C          inc     dh
C
FF9E 80 FE 19      C          cmp     dh,<25
C
FFA1 7C DE        C          jl     _s_lp
C
C          C          ; if so, continue
C
FFA3 33 C9        C          xor     cx,cx
C
C          C          ; set cl = printer no error
C
C          C          ; fall through
C
FFA5 5A          C          _s_err: pop  dx          ; restore dx=(row,col) of cursor
C
FFA6 B4 02        C          mov     sh,02h    ; call v_set_cpos
C
FFA8 CD 10        C          INT     10h     ; Input: bh = active_page
C
C          C          ; dx = (row,col) of cursor
C
FFAA FB          C          sti          ; disable interrupts during
C
C          C          ; monitor lock code!!!!
C
FFAB 88 0E 0100   C          mov     byte ptr ds:[100h],cl ; reset monitor lock
C
C
FFAF 58          C          pop    ax          ; restore registers
C
FFB0 5B          C          pop    bx
C
FFB1 59          C          pop    cx
C
FFB2 5A          C          _s_nop: pop  dx
C
FFB3 1F          C          pop    ds
C
FFB4 CF          C          iret
C
C

```

ROM BIOS Listing

```

FFB5 B0 0A      C  a_eol:  mov     al,LF           ; print LF & CR
FFB7 E8 FFB8 R  C  a_eol:  call    a_out          ; print CR
FFBA B0 0D      C  ;      mov     al,CR           ; print CR
C              ;      jmp     short a_out       ; fall through
C
FFBC           C  a_out:  push   dx           ; prints out byte in al
FFBD 52         C  push   dx           ; save dx
FFBD BA 0000    C  mov     dx,0        ; address printer port 0.
FFC0 B4 0D     C  mov     ah,0        ; write byte to port 0
FFC2 CD 17     C  INT    17h         ;
FFC4 5A       C  pop    dx           ; restore dx
C ;          C  test   ah,025h      ; test for any errors?
FFC5 F6 C4 D1  C  test   ah,001h     ; test for time out?
FFC8 C3       C  ret
FFC9           C  a_get:  ; Set Cursor Position and get character @ curs. position
C
FFC9 B4 02     C  mov     ah,02h     ; call v_set_cpos
FFCB CD 10     C  INT    10h        ; Input: bh = active_page
C              ;          dx = (row,col) of cursor
C ; Read Character at Cursor Position.
C
FFCD B4 08     C  mov     ah,08h     ; call v_read_sc_current
FFCF CD 10     C  INT    10h        ; Input: bh = active_page
C              ;          Output: al = character read
FFD1 C3       C  ret              ;          ah = attribute
C
FFD2           C  a_int  endp
FFD2           C  code   ends
C
-----
CPU System Reset Vector
-----
FFD2           code  segment public 'ROM'
assume cs:code, ds:nothing, es:nothing, as:nothing
FFD2           vector proc near
FFD2           db    0EAh ; jmp intersegment F000:(offset diagnostics_1)
FFD2           dw    diagnostics_1 ; instruction pointer cs:(offset diagnostics_1)
FFD2           dw    code_seg F000h ; code segment F000h
FFD2           db    '05/03/84' ; release marker (exactly 8 bytes!!!!)
FFD2           db    38 34
FFD2           chk_hi db    0 ; space for checksum of F000:E000 to F000:FFFF
FFD2           vector  endp near
FFD2           code   ends
FFD2           end

Macros:
Name Length
IMPORT . . . . . 0005
JMFF . . . . . 0001
EXPORT . . . . . 0005

Structures and records:
Name Width # fields Mask Initial
Shift Width
CDB_1 . . . . . 0008 0003
ZZP . . . . . 0006 0002 00C0 0000
DRIVENUM . . . . . 0005 0001 0020 0000
HEADNUM . . . . . 0000 0005 001F 0000
H_CHD_STRUC . . . . . 0004 0003
BX_OPCODE . . . . . 0000
H_CHD_SUBR . . . . . 0001
H_CHD_MODE_DNA . . . . . 0003
PARAMETER_TABLE . . . . . 0010 000A
P_CYLS . . . . . 0000
P_HEADS . . . . . 0002
P_WRITE_CUR . . . . . 0003
P_PRECOMP . . . . . 0005
P_ECC_LEN . . . . . 0007
P_CONTROL_BYTE . . . . . 0008
P_TIMEOUT . . . . . 0009
P_FMT_TIMEOUT . . . . . 000A
P_DRVDIAG_TIMEOUT . . . . . 000B
P_ZZJ . . . . . 000C

Segments and groups:
Name Size align combine class
ABSO . . . . . 0080 PARA PUBLIC 'RAM'
CODE . . . . . FFFE PARA PUBLIC 'ROM'
DATA . . . . . 0088 PARA PUBLIC 'RAM'
STACK_RAM . . . . . 0000 PARA PUBLIC 'RAM'
V_RAM . . . . . 0000 PARA PUBLIC 'RAM'

Symbols:

```

ROM BIOS Listing

Name	Type	Value	Attr
ABS0_SEG	Number	0000	
ADDR_MARK_ERROR	Number	0002	
ALLOW_DMA3	Number	0003	
ALT_INPUT	L BYTE	0019	DATA
ALT_KEY	Number	0038	
ALT_RET	L WORD	E2CA	CODE
ALT_SHIFT	Number	0008	
AP_FINISH	L NEAR	D530	CODE
ASSIGN_PARAM	N PROC	D504	CODE Length =002E
ASSIGN_PARAM_1	N PROC	D532	CODE Length =006B
ASSIGN_PARAM_BK	Number	000C	
ASSIGN_PARAM_INT	Number	0009	
A_FINISH	L NEAR	D59C	CODE
BADTRACK_ERR	Number	000B	
BANNER_M	L BYTE	D88C	CODE
BEI	Number	0007	
BELL_WAIT	L NEAR	F567	CODE
BIOS_BREAK	L BYTE	0071	DATA
BOOT_A_DISK	N PROC	D12A	CODE Length =0021
BOOT_INDIRECT	L WORD	D126	CODE
BS	Number	0008	
BT_BLK	L NEAR	F8B3	CODE
BT_DEC	L NEAR	F8B9	CODE
BT_I	L NEAR	F88E	CODE
BT_INT	N PROC	F860	CODE Length =0076
BT_JMP	N PROC	E6F2	CODE Length =0003
BT_M	L BYTE	DBB7	CODE
BT_MERR	L BYTE	DBD1	CODE
BT_MIT	L NEAR	F8A8	CODE
BT_O	L NEAR	F87B	CODE
BT_OK	L NEAR	F8C4	CODE
BT_SPACES	L BYTE	DBF6	CODE
BUFFER_END	L WORD	0082	DATA
BUFFER_HEAD	L WORD	001A	DATA
BUFFER_START	L WORD	0080	DATA
BUFFER_TAIL	L WORD	001C	DATA
BXDIAO_BX	Number	00E4	
BXDIAO_INT	Number	0014	
BX_ERROR_TABLE	L NEAR	D49F	CODE
BX_READY	L NEAR	D438	CODE
B_FAILED	L NEAR	D124	CODE
B_LOST	L NEAR	D144	CODE
B_LLP	L NEAR	D12A	CODE
B_OK	L NEAR	D11F	CODE
B_TRY_HDU	L NEAR	D10C	CODE
CAFS_LOCK_KEY	Number	003A	
CAFS_LOCK_MODE	Number	0040	
CAFS_LOCK_SHIFT	Number	0040	
CHKTRK_BX	Number	0005	
CHK_BI	L BYTE	FFFD	CODE
CHK_LO	L BYTE	C000	CODE
CHD_BLOCK	L BYTE	0042	DATA
CMD_ERROR	Number	0001	
CNTRL_KEY	Number	001D	
CNTRL_SHIFT	Number	0004	
CODE_SEG	Number	F000	
COLOR_POINTER	Number	03D4	
COMMAND	N PROC	D3DD	CODE Length =003B
COMMCONTROL	Number	0065	
COM_BAUD	L WORD	E729	CODE
COM_CTS	Number	0010	
COM_DATA1	N PROC	E729	CODE Length =0010
COM_DATA_A	Number	03F8	
COM_DATA_B	Number	02F8	
COM_DSR	Number	0020	
COM_DTR	Number	0001	
COM_FE	Number	0008	
COM_GB	N PROC	E92A	CODE Length =0023
COM_ID_A	Number	03FA	
COM_ID_B	Number	02FA	
COM_INIT	N PROC	E78F	CODE Length =003A
COM_OS	Number	0002	
COM_PB	N PROC	E8EC	CODE Length =002F
COM_PE	Number	0004	
COM_RTS	Number	0002	
COM_RXD	Number	0001	
COM_STAT	L NEAR	E87F	CODE
COM_TE	Number	0080	
COM_TXD	Number	0020	
CONTROLB	Number	0062	
CONTROL_BYTE	L BYTE	0076	DATA
CR	Number	000D	
CRC_ERROR	Number	0010	
C_BCD2HEX	N PROC	F962	CODE Length =0011
C_DATA1	N PROC	F8D6	CODE Length =001C
C_DI_NO	L BYTE	F856	CODE
C_DI_TR	L WORD	F8D6	CODE
C_FINISH	L NEAR	D417	CODE
C_GDATS	N PROC	F9FD	CODE Length =0013
C_GET	L NEAR	F80F	CODE
C_BRCD	L NEAR	F945	CODE
C_RBLP	L NEAR	F94B	CODE
C_RBRRT	L NEAR	F956	CODE
C_READ	N PROC	F8F2	CODE Length =0066
C_WERR	N PROC	F958	CODE Length =000A
C_RMO	L NEAR	F917	CODE
C_RMLP	L NEAR	F90F	CODE

ROM BIOS Listing

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C_WAIT . . . . . L NEAR D404 CODE
C_WAIT . . . . . L NEAR F92B CODE
C_WHEX . . . . . N PROC F92C CODE Length = 0011
C_WMLP . . . . . L NEAR F9B3 CODE
C_WRITE . . . . . N PROC F973 CODE Length = 0079
C_WTL_P . . . . . L NEAR F99E CODE
DATA_OUT . . . . . N PROC D59D CODE Length = 0014
DATA_SEG . . . . . Number 0040
DCOLON . . . . . N PROC E626 CODE Length = 000C
DCRLF . . . . . N PROC E619 CODE Length = 000D
DELETE_KEY . . . . . Number 0053
DHEXBYTE . . . . . N PROC E643 CODE Length = 000D
DHEXLONG . . . . . N PROC E632 CODE Length = 000A
DHEXIB . . . . . N PROC E650 CODE Length = 0015
DHEXORD . . . . . N PROC E63C CODE Length = 0007
DIAGNOSTICS_1 . . . . . N PROC D55A CODE Length = 033F
DISABLE_DISK_INTERRUPTS . . . . . N PROC D5FA CODE Length = 0035
DISALLOW_DMA3 . . . . . Number 0007
DISKETTE_101 . . . . . L NEAR EC80 CODE
DISKETTE_STATUS . . . . . L BYTE 0041 DATA
DISK_STATUS . . . . . L BYTE 0074 DATA
DISP_PASS . . . . . L NEAR DF1A CODE
DLX_KB . . . . . Number 0001
DMA_ADDR_0 . . . . . Number 0000
DMA_ADDR_1 . . . . . Number 0002
DMA_ADDR_2 . . . . . Number 0004
DMA_ADDR_3 . . . . . Number 0006
DMA_CMD_DISABLE . . . . . Number 0004
DMA_CMD_ENABLE . . . . . Number 0000
DMA_COMMAND . . . . . Number 0008
DMA_COUNT_0 . . . . . Number 0001
DMA_COUNT_1 . . . . . Number 0003
DMA_COUNT_2 . . . . . Number 0005
DMA_COUNT_3 . . . . . Number 0007
DMA_ERROR . . . . . Number 0008
DMA_FF_CLR . . . . . Number 000C
DMA_MASK_BIT . . . . . Number 000A
DMA_MASK_CLR . . . . . Number 000E
DMA_MASK_WRITE . . . . . Number 000F
DMA_MASTER_CLR . . . . . Number 000D
DMA_MODE . . . . . Number 000B
DMA_MODE_0 . . . . . Number 0058
DMA_MODE_1 . . . . . Number 0041
DMA_MODE_2 . . . . . Number 0056
DMA_MODE_3 . . . . . Number 0043
DMA_REQUEST . . . . . Number 0009
DMA_SEG_0 . . . . . Number 0080
DMA_SEG_1 . . . . . Number 0082
DMA_SEG_2 . . . . . Number 0081
DMA_SEG_3 . . . . . Number 0083
DMA_SEG_ERROR . . . . . Number 0009
DMA_STATUS . . . . . Number 0008
DMA_TEMP . . . . . Number 000D
DMA_UNHASK_0 . . . . . Number 0000
DNUM . . . . . N PROC E665 CODE Length = 0008
DNUMW . . . . . N PROC E66D CODE Length = 0031
DNUMW_LOOP . . . . . L NEAR E677 CODE
DNUMW_SKIP . . . . . L NEAR E68D CODE
DNUMW_SPACES . . . . . L NEAR E685 CODE
DO_READY . . . . . L NEAR D5A7 CODE
DROMSTRING . . . . . N PROC E5FA CODE Length = 0008
DRVDIAG_BX . . . . . Number 00E3
DSTRING . . . . . N PROC E602 CODE Length = 0017
DS_LP . . . . . L NEAR E609 CODE
DS_RET . . . . . L NEAR E614 CODE
DUMMY_IRET . . . . . N PROC FF4B CODE Length = 0009
ECC_USED_ERR . . . . . Number 0011
E_LOSE . . . . . L NEAR D3D3 CODE
E_READ_SENSE . . . . . L NEAR D366 CODE
FAIL_H . . . . . L BYTE DC05 CODE
FAR_CALLS . . . . . F PROC C004 CODE Length = 005C
FDC_ERROR . . . . . Number 0020
FDC_DATA1 . . . . . N PROC E620 CODE Length = 0009
FDC_DATA2 . . . . . N PROC E6C7 CODE Length = 000B
FD_INT . . . . . N PROC EF57 CODE Length = 0014
FD_IO . . . . . F PROC EC59 CODE Length = 0066
FD_PARMS . . . . . L BYTE EF67 CODE
FIRMWARED . . . . . L NEAR D693 CODE
FLAGS_DATA1 . . . . . N PROC C000 CODE Length = 0004
FMTBAD_BX . . . . . Number 0007
FMTDRY_BX . . . . . Number 0004
FMTDRY_INT . . . . . Number 0007
FMTTRK_BX . . . . . Number 0006
FONTH16 . . . . . N PROC C860 CODE Length = 0400
FONTL016 . . . . . N PROC C060 CODE Length = 0800
FONTL08 . . . . . N PROC FA6E CODE Length = 0400
FONT_HI_8X8 . . . . . L BYTE C860 CODE
FONT_LO_8X16 . . . . . L BYTE C060 CODE
FONT_LO_8X8 . . . . . L BYTE FA6E CODE
FORMAT_ERROR . . . . . L NEAR D69F CODE
F_BUFFER . . . . . Text [bp+4]
F_CHECK_VALID . . . . . N PROC EFA0 CODE Length = 001A
F_COMMAND . . . . . Text [bp+3]
F_CONT . . . . . L NEAR EF26 CODE
F_CTL_RET . . . . . L NEAR EFC5 CODE
F_CTL . . . . . Text [bp+7]
F_DRIVE . . . . . Text [bp+0]
F_FORMAT_CMD . . . . . Number 004D
F_GB_DCODE . . . . . L NEAR E855 CODE
F_GB_MP . . . . . L NEAR E66D CODE

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ROM BIOS Listing

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F_GB_LOOP . . . . . L NEAR EE34 CODE
F_GB_LOOP1 . . . . . L NEAR EE5E CODE
F_GB_OUT . . . . . L NEAR EE44 CODE
F_GB_RET . . . . . L NEAR EE71 CODE
F_GB_TABLE . . . . . L BYTE EE20 CODE
F_GET_BYTE . . . . . N PROC EE29 CODE Length =004A
F_GET_VAR . . . . . N PROC EDDF CODE Length =000D
F_HEAD . . . . . Text [bp+1]
F_HEAD_SETTLE . . . . L NEAR EF41 CODE
F_HLT . . . . . Number 00D0
F_INT . . . . . Number 000F
F_IO1 . . . . . L NEAR EC79 CODE
F_IO_RET . . . . . L NEAR EC9B CODE
F_MOTOR_ON . . . . . N PROC ED14 CODE Length =0025
F_MOTOR_PORT . . . . . Number 03F2
F_MOTOR_WAIT . . . . . Number 0025
F_NO_RET . . . . . L NEAR ED38 CODE
F_DMA . . . . . Number 0000
F_NBC_DATA . . . . . Number 03F5
F_NEC_RDY . . . . . N PROC EF6B CODE Length =0017
F_NEC_RESET . . . . . N PROC EC18 CODE Length =0018
F_NEC_RESET_RET . . . L NEAR EC2F CODE
F_NEC_STATUS . . . . . Number 03F4
F_R1 . . . . . L NEAR EFE6 CODE
F_NR_RET . . . . . L NEAR EF80 CODE
F_NUMSECS . . . . . Text [bp+2]
F_PB_ERRRET . . . . . L NEAR EE18 CODE
F_PB_RET . . . . . L NEAR EE17 CODE
F_PUT_BYTE . . . . . N PROC EEOC CODE Length =0014
F_R1 . . . . . L NEAR ECDB CODE
F_R2 . . . . . L NEAR EC60 CODE
F_RD1 . . . . . L NEAR ED7D CODE
F_RDATA . . . . . N PROC ED65 CODE Length =0022
F_RD_LOOP . . . . . L NEAR ED78 CODE
F_READ_CMD . . . . . Number 00E6
F_REAL_DRIVE . . . . . Text [bp+8]
F_RECAL_CMD . . . . . Number 0007
F_RESET . . . . . N PROC ECBF CODE Length =0055
F_RW1 . . . . . L NEAR EDB3 CODE
F_RW2 . . . . . L NEAR EDDD CODE
F_RW3 . . . . . L NEAR EDF4 CODE
F_RW_COMMON . . . . . N PROC EDB7 CODE Length =0078
F_RW_RET . . . . . L NEAR EDFC CODE
F_RW_SKIP . . . . . L NEAR EDD7 CODE
F_S1 . . . . . L NEAR EF0C CODE
F_SDI . . . . . L NEAR E929 CODE
F_SD2 . . . . . L NEAR EEBD CODE
F_SD_RET . . . . . L NEAR EECC CODE
F_SECNUM . . . . . Text [bp+6]
F_SEEK . . . . . N PROC EECB CODE Length =007A
F_SEEK_CMD . . . . . Number 000F
F_SET_DMA . . . . . N PROC EE73 CODE Length =005A
F_SIS . . . . . N PROC EF82 CODE Length =000B
F_SNSDRV_CMD . . . . . Number 0004
F_SNSIN_CMD . . . . . Number 0008
F_SSECIPT_CMD . . . . . Number 0003
F_SRT_48 . . . . . Number 000C
F_SRT_96 . . . . . Number 000E
F_S_RECAL . . . . . L NEAR EE81 CODE
F_S_RET . . . . . L NEAR EF46 CODE
P_TABLE . . . . . L WORD EC8F
P_WAIT_FOR_NEC . . . . N PROC EF8D CODE Length =0020
P_WAIT_ON_EHS . . . . N PROC EF47 CODE Length =0008
P_WDI . . . . . L NEAR ED5C CODE
P_WDATA . . . . . N PROC ED39 CODE Length =002C
P_WD_LOOP . . . . . L NEAR ED57 CODE
P_WRITE_CMD . . . . . Number 00C5
GAME_CARD . . . . . Number 0201
GET_DRIVE_TYPE_VECTOR . N PROC D5C1 CODE Length =0039
GRF_GRAPHICS_DOWN . . N PROC D909 CODE Length =0063
GRF_GRAPHICS_READ . . N PROC D96C CODE Length =00ED
GRF_GRAPHICS_UP . . . . N PROC D874 CODE Length =0052
GRF_GRAPHICS_WRITE . . N PROC DA59 CODE Length =0106
GRF_LIGHT_PEN . . . . . N PROC DTDC CODE Length =0003
GRF_READ_DOT . . . . . N PROC DTDO CODE Length =001A
GRF_WRITE_DOT . . . . . N PROC D7EA CODE Length =002B
Q_72 . . . . . L NEAR D86F CODE
Q_B16_2 . . . . . L NEAR D43D CODE
Q_B16_2 . . . . . L NEAR DA7C CODE
Q_ADDR . . . . . N PROC D815 CODE Length =005F
Q_ADDR_TST . . . . . L NEAR DA84 CODE
Q_ALIGN_DOT . . . . . L NEAR DB08 CODE
Q_BITMAP . . . . . L NEAR D862 CODE
Q_CHAR_LP . . . . . L NEAR DB14 CODE
Q_CHP_MOD . . . . . L NEAR D92F CODE
Q_COLOR_TABLE . . . . . L BYTE D85B CODE
Q_CURS_OFF . . . . . N PROC DB5F CODE Length =001E
Q_DETHODE . . . . . L NEAR DA47 CODE
Q_EXP_BIT . . . . . L NEAR DB26 CODE
Q_FILLER . . . . . N PROC D8EB CODE Length =001E
Q_F_CONT . . . . . L NEAR DA15 CODE
Q_F_EXIT . . . . . L NEAR DA53 CODE
Q_F_LP . . . . . L NEAR D8ED CODE
Q_F_MACH . . . . . L NEAR DA1A CODE
Q_F_S_LP . . . . . L NEAR DBEF CODE
Q_H_LP . . . . . L NEAR DACB CODE
Q_I_LP . . . . . L NEAR DB1F CODE
Q_I_LP . . . . . L NEAR DADB CODE
Q_JSPT_DOT . . . . . L NEAR D725 CODE
Q_LDS_R . . . . . L NEAR D98C CODE

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ROM BIOS Listing

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G_LDS_W . . . . . L NEAR D49F CODE
G_LINELP . . . . . L NEAR D4D7 CODE
G_MASK . . . . . L NEAR D5E2 CODE
G_MATCHB . . . . . L NEAR D40F CODE
G_MERGE . . . . . L NEAR D9DC CODE
G_MED_BIT . . . . . L NEAR D9F5 CODE
G_MED_IA . . . . . L NEAR D9E1 CODE
G_MED_STORE . . . . . L NEAR DB3B CODE
G_MED_WR . . . . . L NEAR D803 CODE
G_M_AREA . . . . . L NEAR D8CC CODE
G_RDL0OP . . . . . L NEAR D9AC CODE
G_RD_IA . . . . . L NEAR D9B0 CODE
G_RD_MED . . . . . L NEAR D9DA CODE
G_REP_CHAR . . . . . L NEAR DA00 CODE
G_RETURN . . . . . L NEAR DB57 CODE
G_SCAN_LP . . . . . L NEAR DB1A CODE
G_SCROLLER . . . . . N PROC D8C9 CODE Length = 0022
G_SEL_FONT . . . . . L NEAR D491 CODE
G_SETDOWN . . . . . L NEAR D93D CODE
G_SET_UP . . . . . L NEAR D8A9 CODE
G_SKP_1 . . . . . L NEAR D826 CODE
G_SKP_2 . . . . . L NEAR D82C CODE
G_SKP_3 . . . . . L NEAR D832 CODE
G_SKP_4 . . . . . L NEAR D855 CODE
G_SKP_5 . . . . . L NEAR D873 CODE
G_SUPER_WR . . . . . L NEAR DA C7 CODE
G_TEST_ADDR . . . . . L NEAR DA 99 CODE
G_TINYTEXT . . . . . L NEAR DAC3 CODE
G_TST_MOD . . . . . L NEAR D89A CODE
G_T_XOR . . . . . L NEAR DA E3 CODE
G_UNREVERSE_VIDEO_LOOP . . . . . L NEAR D9D3 CODE
G_W_BYTE . . . . . L NEAR DA6A CODE
G_YORBIT . . . . . L NEAR D7FF CODE
HARD_DISK_INT13 . . . . . L NEAR D1B5 CODE
HDU_BST . . . . . Number 0008
HDU_CD . . . . . Number 0004
HDU_DMA_SEGH . . . . . Number 0082
HDU_IO . . . . . Number 0002
HDU_IRQ5 . . . . . Number 0020
HDU_PARM_TBL . . . . . L NEAR D1AB CODE
HDU_REQ . . . . . Number 0001
HD_ERROR . . . . . L BYTE 0042 DATA
HF_NUM . . . . . L BYTE 0075 DATA
H_ABS_M . . . . . L BYTE D0AE CODE
H_BAD_C0MHAND . . . . . L NEAR D25A CODE
H_BAD_M . . . . . L BYTE D0A2 CODE
H_BOOT . . . . . F PROC D0E9 CODE Length = 0041
H_CMD_TABLE . . . . . L NEAR D26D CODE
H_CMD_WAIT . . . . . N PROC D43B CODE Length = 0064
H_C_ERR . . . . . Number 0002
H_DATA1 . . . . . N PROC D49F CODE Length = 0040
H_DATA2 . . . . . N PROC D6AC CODE Length = 0121
H_DMA . . . . . N PROC D2C1 CODE Length = 007D
H_DMA_BUFF . . . . . L NEAR D32C CODE
H_DMA_ERR . . . . . L NEAR D336 CODE
H_DMA_LEN . . . . . L NEAR D304 CODE
H_DMA_LONG . . . . . L NEAR D322 CODE
H_ERR_CHK . . . . . N PROC D38A CODE Length = 0093
H_ERR_M . . . . . L BYTE D1B7 CODE
H_ERR_RET . . . . . L NEAR D3D2 CODE
H_FINISH . . . . . L NEAR D242 CODE
H_FMT . . . . . N PROC D640 CODE Length = 006C
H_FMT_M . . . . . L BYTE D133 CODE
H_GOOD_M . . . . . L BYTE D0A6 CODE
H_HAD_ERR . . . . . L NEAR D352 CODE
H_INIT . . . . . N PROC CF9F CODE Length = 011C
H_INT . . . . . N PROC D62F CODE Length = 0011
H_INTRO_M . . . . . L BYTE D04C CODE
H_IO . . . . . F PROC D1AB CODE Length = 0116
H_MAKE_CDB . . . . . L NEAR D1DE CODE
H_NDMA . . . . . N PROC D33E CODE Length = 000C
H_NOW_EH . . . . . L BYTE D784 CODE
H_PASS_M . . . . . L BYTE D750 CODE
H_SAVE_REGS . . . . . L NEAR D1C4 CODE
ILL_FLG . . . . . L NEAR FF41 CODE
ILL_INT . . . . . N PROC FF23 CODE Length = 0028
ILL_LW . . . . . L NEAR E5C4 CODE
ILL_LP . . . . . L NEAR E5C9 CODE
ILL_M1 . . . . . L BYTE DC1B CODE
ILL_M2 . . . . . L BYTE DC34 CODE
ILL_M3 . . . . . L BYTE DC3A CODE
ILL_SW . . . . . L NEAR FF3E CODE
ILL_TRAP . . . . . N PROC E58C CODE Length = 0049
INIT_CONTROLLER_LP . . . . . L NEAR CFED CODE
INIT_DRIVE_LP . . . . . L NEAR D0E2 CODE
INIT_DRIVE_WIN . . . . . L NEAR D047 CODE
INIT_ERR . . . . . Number 0007
INIT_START_TIMER . . . . . L NEAR D028 CODE
INIT_TRY_DRIVE . . . . . L NEAR D036 CODE
INSERT_KEY . . . . . Number 0052
INSERT_MODE . . . . . Number 0080
INSERT_SHFT . . . . . Number 0080
INT01LOCN . . . . . L DWORD 0000 ABS0
INT01LOCN . . . . . L DWORD 0004 ABS0
INT02LOCN . . . . . L DWORD 0008 ABS0
INT03LOCN . . . . . L DWORD 000C ABS0
INT04LOCN . . . . . L DWORD 0010 ABS0
INT05LOCN . . . . . L DWORD 0014 ABS0
INT06LOCN . . . . . L DWORD 0018 ABS0
INT07LOCN . . . . . L DWORD 001C ABS0

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ROM BIOS Listing

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INT0SLOCH. . . . . L DWORD 0020 ABS0
INT0SLOCH. . . . . L DWORD 0024 ABS0
INT0AL0CH. . . . . L DWORD 0028 ABS0
INT0BLOCH. . . . . L DWORD 002C ABS0
INT0CLOCH. . . . . L DWORD 0030 ABS0
INT0DLOCH. . . . . L DWORD 0034 ABS0
INT0ELOCH. . . . . L DWORD 0038 ABS0
INT0FLOCH. . . . . L DWORD 003C ABS0
INT10LOCH. . . . . L DWORD 0040 ABS0
INT11LOCH. . . . . L DWORD 0044 ABS0
INT12LOCH. . . . . L DWORD 0048 ABS0
INT13LOCH. . . . . L DWORD 004C ABS0
INT14LOCH. . . . . L DWORD 0050 ABS0
INT15LOCH. . . . . L DWORD 0054 ABS0
INT16LOCH. . . . . L DWORD 0058 ABS0
INT17LOCH. . . . . L DWORD 005C ABS0
INT18LOCH. . . . . L DWORD 0060 ABS0
INT19LOCH. . . . . L DWORD 0064 ABS0
INT1AL0CH. . . . . L DWORD 0068 ABS0
INT1BLOCH. . . . . L DWORD 006C ABS0
INT1CLOCH. . . . . L DWORD 0070 ABS0
INT1DLOCH. . . . . L DWORD 0074 ABS0
INT1ELOCH. . . . . L DWORD 0078 ABS0
INT1FLOCH. . . . . L DWORD 007C ABS0
INTE_FLAG. . . . . L BYTE 0068 DATA
IO_ROM_INIT. . . . . L WORD 0067 DATA
IO_ROM_SEG. . . . . L WORD 0069 DATA
I_ALT_COMT. . . . . L NEAR E4F0 CODE
I_ALT_CPU. . . . . L NEAR E4D7 CODE
I_ALT_ECHO. . . . . L NEAR E534 CODE
I_ALT_END. . . . . L NEAR E567 CODE
I_ALT_FOUMB. . . . . L NEAR E511 CODE
I_ALT_ENC. . . . . L NEAR E522 CODE
I_ALT_RESTART. . . . . L NEAR E545 CODE
I_ALT_SELECT_M. . . . . L BYTE D035 CODE
I_ALT_TEST. . . . . L NEAR E506 CODE
I_CAL. . . . . L NEAR DFF9 CODE
I_CAL_O. . . . . L NEAR E04E CODE
I_CAL_1_80. . . . . L NEAR E01E CODE
I_CAL_END. . . . . L NEAR E07B CODE
I_CAL_ERR. . . . . L NEAR E061 CODE
I_CAL_MAX. . . . . L NEAR E02D CODE
I_CAL_OK. . . . . L NEAR E073 CODE
I_CAL_VAL. . . . . L BYTE D051 CODE
I_CDM_M. . . . . L NEAR DD62 CODE
I_CPU. . . . . L NEAR DD8D CODE
I_CPU_ERR. . . . . L BYTE DC4B CODE
I_CPU_M. . . . . L NEAR DD9E CODE
I_CPU_OK. . . . . L NEAR DDE2 CODE
I_DMAC. . . . . L NEAR DE5E CODE
I_DMAC_ERR. . . . . L NEAR DDF2 CODE
I_DMAC_LP. . . . . L BYTE DC72 CODE
I_DMAC_MIB. . . . . L NEAR DE3E CODE
I_DMAC_OK. . . . . L NEAR DE64 CODE
I_DMAC_PASS2. . . . . L NEAR DDEF CODE
I_DMAC_RET. . . . . L NEAR DE51 CODE
I_DMAT. . . . . L NEAR DDC7 CODE
I_DMAT_ERR. . . . . L NEAR DDE5 CODE
I_DMAT_M. . . . . L BYTE DC65 CODE
I_DMAT_OK. . . . . L NEAR DDD8 CODE
I_DMAT_RET. . . . . L NEAR DDD3 CODE
I_D_80125. . . . . L NEAR E187 CODE
I_D_INIT. . . . . N PROC E148 CODE
I_D_M. . . . . L BYTE DC8C CODE
I_D_MODE. . . . . L NEAR E194 CODE
I_D_OK. . . . . L NEAR E18D CODE
I_FATAL. . . . . N PROC E029 CODE
I_FATAL_RET. . . . . L NEAR E139 CODE
I_FDUA_M. . . . . L BYTE D001 CODE
I_FDUB_M. . . . . L BYTE D00E CODE
I_FDUEND. . . . . L NEAR E4CD CODE
I_FDU_LP. . . . . L NEAR E4A7 CODE
I_FDU_NOT_M. . . . . L BYTE DD1B CODE
I_FDU_OK. . . . . L NEAR E4CA CODE
I_FDURD_M. . . . . L BYTE DD1F CODE
I_HDU_M. . . . . L BYTE DD28 CODE
I_HDU_OK. . . . . L NEAR E47D CODE
I_INIT_END. . . . . L NEAR E56C CODE
I_KB_M. . . . . L BYTE DCBF CODE
I_KB_S1_M. . . . . L BYTE DCCC CODE
I_NO_COM_A. . . . . L NEAR E3AD CODE
I_NO_COM_B. . . . . L NEAR E3BC CODE
I_NO_NAME_CARD. . . . . L NEAR E3D5 CODE
I_NO_SCCS. . . . . L NEAR E3CA CODE
I_NDU_M. . . . . L BYTE DC99 CODE
I_OPTROM_M. . . . . L BYTE DCF4 CODE
I_OUT_MASK. . . . . N PROC E1ED CODE
I_PIC. . . . . L NEAR DE6B CODE
I_PIC_0_OK. . . . . L NEAR DEA9 CODE
I_PIC_1_OK. . . . . L NEAR DEAD CODE
I_PIC_2_OK. . . . . L NEAR DEB1 CODE
I_PIC_3_OK. . . . . L NEAR DEB5 CODE
I_PIC_4_OK. . . . . L NEAR DEB9 CODE
I_PIC_END. . . . . L NEAR DP11 CODE
I_PIC_ERR. . . . . L NEAR DEDC CODE
I_PIC_HARD. . . . . L NEAR DE9E CODE
I_PIC_HOT. . . . . L NEAR DE97 CODE
I_PIC_INIT. . . . . N PROC E1DC CODE
I_PIC_M. . . . . L BYTE DCTF CODE

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Length =0058

Length =005F

Length =0009

Length =0011

ROM BIOS Listing

I_PIC_NO_HOT	L NEAR DF05	CODE	
I_PIC_OK	L NEAR DF08	CODE	
I_PIC_SOFT	L NEAR DE8E	CODE	
I_PIC_TEST	L NEAR DEBB	CODE	
I_PRT_EXIT	L NEAR E398	CODE	
I_PRT_LOOP	L NEAR E382	CODE	
I_PRT_M	L BYTE DCD0	CODE	
I_RAM_M	L BYTE DCEA	CODE	
I_ROM	L NEAR DBB2	CODE	
I_ROM_ERR	L NEAR DBB4	CODE	
I_ROM_M	L BYTE DC58	CODE	
I_ROM_OK	L NEAR DDC0	CODE	
I_ROM_RET	L NEAR DBB8	CODE	
I_RTC	L NEAR E07B	CODE	
I_RTC_END	L NEAR E0E1	CODE	
I_RTC_ERR	L NEAR E0B9	CODE	
I_RTC_HI_M	L BYTE DCB7	CODE	
I_RTC_LO_M	L BYTE DCB3	CODE	
I_RTC_M	L BYTE DCA6	CODE	
I_RTC_NR_M	L BYTE DCBB	CODE	
I_RTC_OK	L NEAR E0D5	CODE	
I_VECC0	L NEAR E1B0	CODE	
I_VECC8	L NEAR E1CC	CODE	
I_VECTOR	N PROC E1A0	CODE	Length =003C
I_VEC_TBL	N PROC FEF3	CODE	Length =0030
KBALT	Number 00C4		
KBBRK	Number 00C9		
KB CAP	Number 00C1		
KB CTL	Number 00C5		
KB INS	Number 00C0		
KB LSH	Number 00C6		
KB MUL	Number 00CC		
KB NUM	Number 00C2		
KB PRT	Number 00CB		
KB RES	Number 00C8		
KB RSH	Number 00C7		
KB SCR	Number 00C3		
KB BUFFER	L WORD 001E	DATA	Length =0010
KB_CAP_FLAGS	L BYTE CC60	CODE	
KB_CHD_SEND	N PROC E581	CODE	Length =000B
KB_CHD_WLUP	L NEAR E581	CODE	
KB_DATA1	N PROC CC60	CODE	Length =033F
KB_DATA_TABLE	L BYTE CC67	CODE	
KB_FLAG	L BYTE 0017	DATA	
KB_FLAG_1	L BYTE 0018	DATA	
KB_FLUSH	L NEAR E304	CODE	
KB_FLUSH_BACK	L NEAR E313	CODE	
KB_NOT_DLX	L NEAR E361	CODE	
KB_STATUS	Number 0064		
KB_TYPE_READ	L NEAR E351	CODE	
KB_TYPE_WAIT	L NEAR E346	CODE	
XDBLO	Number 00D8		
KDECO	Number 00D7		
KDEC1	Number 00D6		
KDEC2	Number 00D5		
KDEC3	Number 00D4		
KDEC4	Number 00D3		
KDEC5	Number 00D2		
KDEC6	Number 00D1		
KDEC7	Number 00D0		
KDEC8	Number 00CF		
KDEC9	Number 00CE		
KNONE	Number 00CD		
K_OO	L NEAR EB35	CODE	
K_2RES	L NEAR EB18	CODE	
K_2RET	L NEAR E80A	CODE	
K_2TOG	L NEAR EB0F	CODE	
K_3RES	L NEAR EAET	CODE	
K_3RET	L NEAR EA86	CODE	
K_3TOG	L NEAR EAD4	CODE	
K_ADV_END	L NEAR EB7A	CODE	
K_ADV_PTR	N PROC EB6E	CODE	Length =000D
K_ALT	L NEAR EA2E	CODE	
K_ALT0	L NEAR EB28	CODE	
K_ALT1	L NEAR EB27	CODE	
K_ALT2	L NEAR EB26	CODE	
K_ALT3	L NEAR EB25	CODE	
K_ALT4	L NEAR EB24	CODE	
K_ALT5	L NEAR EB23	CODE	
K_ALT6	L NEAR EB22	CODE	
K_ALT7	L NEAR EB21	CODE	
K_ALT8	L NEAR EB20	CODE	
K_ALT9	L NEAR EB1F	CODE	
K_BEEP	N PROC EBC3	CODE	Length =0023
K_BIT	N PROC EB85	CODE	Length =001F
K_BRC	L NEAR EB42	CODE	
K_BUF	L NEAR EA56	CODE	
K_CAP	L NEAR EAB5	CODE	
K_CASE	L WORD EB86	CODE	
CTL	L NEAR EB00	CODE	
K_CTL	N PROC EB86	CODE	Length =0032
K_DATA1	N PROC EBA4	CODE	Length =0009
K_E01	N PROC EA92	CODE	
K_HOLD	L NEAR EA47	CODE	
K_INS	L NEAR E987	CODE	Length =01D2
K_INV	N PROC EB2E	CODE	Length =0017
K_10	N PROC EA02	CODE	
K_IX	L NEAR EA2D	CODE	
K_MP	L NEAR EB63	CODE	
K_LED_CAP	L NEAR EB70	CODE	
K_LED_CHD	L NEAR EB70	CODE	

ROM BIOS Listing

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K_LED_DAT . . . . . L NEAR EB7A CODE
K_LED_NUM . . . . . N PROC EB59 CODE Length =002C
K_LED_RET . . . . . L NEAR EB84 CODE
K_LOCK . . . . . L NEAR E9F4 CODE
K_LOOK . . . . . F PROC EB60 CODE Length =0009
K_LP . . . . . L NEAR EBCE CODE
K_LSH . . . . . L NEAR EBO4 CODE
K_NOM1 . . . . . L NEAR EABF CODE
K_NONE . . . . . L NEAR EA5B CODE
K_NOP . . . . . L NEAR E455 CODE
K_NOP1 . . . . . L NEAR EB3F CODE
K_NO_CAP . . . . . L NEAR E9E7 CODE
K_NO_CASE . . . . . L NEAR EA36 CODE
K_NO_HOLD . . . . . L NEAR EA4C CODE
K_NO_LOCK . . . . . L NEAR E9FC CODE
K_NO_XCODE . . . . . L NEAR EA54 CODE
K_NULL . . . . . L NEAR EAA2 CODE
K_NUM . . . . . L NEAR EAC1 CODE
K_OK . . . . . L NEAR E9B2 CODE
K_PAUSE . . . . . L NEAR EA78 CODE
K_PRT . . . . . L NEAR EA9B CODE
K_READ . . . . . N PROC EB45 CODE Length =001B
K_RES . . . . . L NEAR EA67 CODE
K_RET . . . . . L NEAR EB42 CODE
K_RSH . . . . . L NEAR EBO8 CODE
K_SCR . . . . . L NEAR EACD CODE
K_SEE . . . . . L NEAR EB54 CODE
K_STAT . . . . . N PROC EB69 CODE Length =0005
K_TRY . . . . . N PROC EBAD CODE Length =0016
K_XLAT . . . . . L NEAR EA16 CODE
LEFT_SHIFT . . . . . Number 0002
LEFT_SHIFT_KEY . . . . . Number 0024
LF . . . . . Number 000A
MASK_PORT . . . . . Number 0323
MASK_PORT_DMAE . . . . . Number 0001
MASK_PORT_INTE . . . . . Number 0002
MASTAB . . . . . L WORD E2CE CODE
MASTER_TBL_PTR . . . . . L DWORD 0084 DATA
MAX_INT . . . . . Number 0014
MFG_ERR_SHOW_SENSE . . . . . N PROC D0CE CODE Length =001B
MEMORY_SIZE . . . . . L WORD 0013 DATA
MEMTS1 . . . . . N PROC E266 CODE Length =0047
MEMTS1_ERR . . . . . L NEAR E2AB CODE
MEMTS1_ERR_C . . . . . L NEAR E2A7 CODE
MEMTS1_R1 . . . . . L NEAR E279 CODE
MEMTS1_R2 . . . . . L NEAR E290 CODE
MEMTS1_W1 . . . . . L NEAR E26D CODE
MEMTS1_W2 . . . . . L NEAR E286 CODE
MFG_ERR_FLAG . . . . . L BYTE 0015 DATA Length =0002
MFG_TST . . . . . L BYTE 0012 DATA
MOTOR_COUNT . . . . . L BYTE 0040 DATA
MOTOR_STATUS . . . . . L BYTE 003F DATA
MT_END . . . . . L WORD E2E4 CODE
M_CASE . . . . . N PROC F859 CODE Length =0006
M_EQUIP . . . . . N PROC F84D CODE Length =000C
M_EXIT . . . . . L NEAR D0E7 CODE
M_SIZE . . . . . N PROC F841 CODE Length =000C
MFG_STATUS . . . . . L BYTE 0042 DATA Length =0007
NIBOK . . . . . L NEAR E65E CODE
NO_HARD_DISK . . . . . L NEAR D697 CODE
NULL . . . . . Number 0000
NUM_LOCK_KEY . . . . . Number 0045
NUM_LOCK_MODE . . . . . Number 0020
NUM_LOCK_SHIFT . . . . . Number 0020
N_INT . . . . . N PROC F85F CODE Length =0001
OPT_ROM_M . . . . . L BYTE E24D CODE
P0_DATA1 . . . . . N PROC E2AD CODE Length =0037
P1_DATA1 . . . . . N PROC DB7D CODE Length =01DD
P4_DATA1 . . . . . N PROC E5F2 CODE Length =0002
PARA_GRAPH . . . . . Number B800
PARA_MONO . . . . . Number B040
PASS_M . . . . . L BYTE DC3D CODE
PAUSE . . . . . Number 00CA
PAUSE_MODE . . . . . Number 0008
PCINIT . . . . . N PROC E2E4 CODE Length =629D
PIC_0 . . . . . Number 0020
PIC_1 . . . . . Number 0021
PIC_ICW1 . . . . . Number 0013
PIC_ICW2 . . . . . Number 0008
PIC_ICW3 . . . . . Number 0008
PIC_ICW4 . . . . . Number 000D
PIC_NB01 . . . . . Number 0020
PIC_OFF_MSK . . . . . Number 00FF
PIC_SE0_0 . . . . . Number 0060
PIC_SE01_1 . . . . . Number 0061
PIC_SE01_6 . . . . . Number 0066
PORT_OFF . . . . . L BYTE 0077 DATA
POST_LOSE . . . . . L NEAR D071 CODE
POST_NO_MORE_DRIVES . . . . . L NEAR D06A CODE
POST_WIN . . . . . L NEAR D083 CODE
PRINTER_ADDR . . . . . L WORD 0008 DATA Length =0004
PRINTER_T_OUT . . . . . L BYTE 0078 DATA Length =0004
PRT_DATA_A . . . . . Number 03BC
PRT_DATA_B . . . . . Number 0378
PRT_DATA_C . . . . . Number 0278
P_8253_0 . . . . . Number 0040
P_8253_1 . . . . . Number 0041
P_8253_2 . . . . . Number 0042
P_8253_CTRL . . . . . Number 0043
P_DISP . . . . . L NEAR D09B CODE

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ROM BIOS Listing

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P_INIT . . . . . L HEAR F027 CODE
P_IO . . . . . N PROC EFD2 CODE Length =0069
P_KCTRL . . . . . Number 0061
P_KSCAN . . . . . Number 0060
P_LF . . . . . L HEAR F00F CODE
P_NOP . . . . . L HEAR F004 CODE
P_OK . . . . . L HEAR F01D CODE
P_OUT . . . . . L HEAR F00B CODE
P_RET . . . . . L HEAR F005 CODE
P_SOME . . . . . L HEAR D092 CODE
P_STAT . . . . . L HEAR F034 CODE
P_TBL . . . . . L WORD E2BE CODE
RAMDIAG_BX . . . . . Number 0080
RAMDIAG_INT . . . . . Number 0012
RAM_ERR0R . . . . . L HEAR DFC9 CODE
RAM_SIZE_END . . . . . L NEAR DFAB CODE
RAM_SIZE_END_1 . . . . . L NEAR DF85 CODE
RAM_SIZE_LFP . . . . . L HEAR DF6C CODE
RAM_SIZE_TXT . . . . . L HEAR DF43 CODE
RAM_SIZE_TST . . . . . L NEAR DF5C CODE
RBUF BX . . . . . Number 000E
READ_BX . . . . . Number 0008
READ_ECC_BX . . . . . Number 000D
READ_INT . . . . . Number 0002
READ_MODE . . . . . Number 0047
READ_PARAM . . . . . N PROC D4DF CODE Length =0025
READ_PORT . . . . . Number 0320
RECAL_BX . . . . . Number 0001
RECAL_INT . . . . . Number 0011
RESET_BX . . . . . N PROC D5B1 CODE Length =0010
RESET_FLAG . . . . . L WORD 0072 DATA
RESET_INT . . . . . Number 0000
RESET_PORT . . . . . Number 0321
RET_FROM_NO . . . . . L NEAR D1B2 CODE
RIGHT_SHIFT . . . . . Number 0001
RIGHT_SHIFT_KEY . . . . . Number 0036
RLONG_BX . . . . . Number 0025
ROM_CHECKSUM . . . . . N PROC E5E5 CODE Length =000D
ROM_CHECKSUM_CNT . . . . . L HEAR E5E8 CODE
ROM_CHECKSUM_LOOP . . . . . L HEAR E5EA CODE
ROM_CHECKSUM_OK . . . . . L NEAR E335 CODE
ROM_ERR . . . . . N PROC E5D5 CODE Length =0010
ROM_ID . . . . . L BYTE C001 CODE
ROM_INT . . . . . L WORD C002 CODE
ROM_SCAN_EXIT . . . . . L HEAR E44E CODE
ROM_SCAN_LOOP . . . . . L NEAR E3FD CODE
ROM_SCAN_NEXT . . . . . L HEAR E44A CODE Length =0004
RS232_ADDR . . . . . L WORD 0000 DATA Length =000A
RS_DLT . . . . . N PROC E8E2 CODE
RS_GBE . . . . . L HEAR E948 CODE
RS_INIT . . . . . L NEAR E3F0 CODE
RS_LP . . . . . L HEAR E8E7 CODE
RS_NOP . . . . . L HEAR E77D CODE
RS_NORM . . . . . L HEAR E749 CODE
RS_OK . . . . . L NEAR E771 CODE
RS_PBE . . . . . L HEAR E910 CODE
RS_PB_GB . . . . . L HEAR E90F CODE
RS_RET . . . . . L HEAR E77A CODE
RS_STAT . . . . . N PROC E87B CODE Length =0043
RS_TBL . . . . . L WORD E77F CODE
RS_WS . . . . . N PROC E8BE CODE Length =0024
RS_WS_COM . . . . . L HEAR E8CD CODE
RS_WS_EXIT . . . . . L HEAR E8DE CODE
RS_WS_LF . . . . . L NEAR E8C3 CODE
RTC_CHK . . . . . N PROC E1F6 CODE Length =0070
RTC_CHK_HIGH . . . . . L HEAR E265 CODE
RTC_CHK_LOW . . . . . L HEAR E265 CODE
RTC_CHK_RESET_ERR . . . . . L NEAR E217 CODE
RTC_CHK_RESET_LP . . . . . L NEAR E205 CODE
RTC_CHK_RESET_OK . . . . . L HEAR E21A CODE
RTC_CHK_SET_ERR . . . . . L HEAR E238 CODE
RTC_CHK_SET_LP . . . . . L NEAR E224 CODE
RTC_CHK_SET_OK . . . . . L HEAR E23B CODE
R_FINISH . . . . . L HEAR D435 CODE
R_WAITING . . . . . L HEAR D41D CODE
SCC_CTL_A . . . . . Number 0050
SCC_CTL_B . . . . . Number 0052
SCC_DBIT . . . . . L BYTE F62E CODE
SCC_FE . . . . . Number 0040
SCC_GB . . . . . N PROC E94D CODE Length =000D
SCC_INIT . . . . . N PROC F573 CODE Length =00BF
SCC_NO_FE . . . . . L NEAR E8AD CODE
SCC_NO_OE . . . . . L NEAR E8BB CODE
SCC_NO_FE . . . . . L NEAR E884 CODE
SCC_NO_RD . . . . . L HEAR E89F CODE
SCC_NO_TXD . . . . . L NEAR E898 CODE
SCC_OE . . . . . Number 0020
SCC_PB . . . . . N PROC E91B CODE Length =000F
SCC_PE . . . . . Number 0010
SCC_PWRUP . . . . . L NEAR F623 CODE
SCC_RXD . . . . . Number 0001
SCC_STAT . . . . . L NEAR E88A CODE
SCC_TBL . . . . . L WORD E2C6 CODE
SCC_TID . . . . . Number 0004
SCRL_LOCK_KEY . . . . . Number 0046
SCRL_LOCK_MODE . . . . . Number 0010
SCRL_LOCK_SHIF . . . . . Number 0010
SECTORS_PER_TRACK . . . . . Number 0011
SECT_NOT_FOUND . . . . . Number 0004
SEK_BX . . . . . Number 000B

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ROM BIOS Listing

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SERR_ERRORS . . . . . Number 0040
SERR_STATUS . . . . . L BYTE 003E DATA
SELECT_PORT . . . . . Number 0322
SEND_CDB_BYTE . . . . . L NEAR D3F8 CODE
SENSE_MSK . . . . . Number 003F
SENSE_BX . . . . . Number 0003
SENSE_ERR . . . . . Number 00FF
SERIAL_IO . . . . . N PROC E739 CODE Length =0056
SERIAL_T_OUT . . . . . L BYTE 007C DATA Length =0004
SET_DS . . . . . N PROC E5F4 CODE Length =0006
SET_DS_WORD . . . . . L WORD E5F2 CODE
SHOW_SENSE . . . . . N PROC D0BB CODE Length =0013
STACK_ROM . . . . . L WORD DB7E CODE
STACK_SEG . . . . . Number 0030
STATUS . . . . . L NEAR D263 CODE
STATUS_INT . . . . . Number 0001
STATUS_PORT . . . . . Number 0321
STOP_DISK . . . . . N PROC E2F4 CODE Length =0007
SWITCH_BITS . . . . . L WORD 0010 DATA
SWITCH_PORT . . . . . Number 0322
SYS_CONF_A . . . . . Number 0066
SYS_CONF_B . . . . . Number 0067
S_EOL . . . . . L NEAR FF85 CODE
S_ERR . . . . . L NEAR FF45 CODE
S_GET . . . . . L NEAR FFC9 CODE
S_INT . . . . . N PROC FF54 CODE Length =007E
S_LP . . . . . L NEAR FF81 CODE
S_NOP . . . . . L NEAR FF82 CODE
S_OK . . . . . L NEAR FF8A CODE
S_OUT . . . . . L NEAR FFBC CODE
TOCMD . . . . . Number 0036
TOCOUNT . . . . . Number 0000
TICMD . . . . . Number 0074
TICOUNT . . . . . Number 0013
T2CMD . . . . . Number 00B6
T2COUNT . . . . . Number 0266
TIME_OUT . . . . . Number 0080
TST_DRV_RDY_BX . . . . . Number 0000
TST_DRV_RDY_INT . . . . . Number 0010
T_DAY . . . . . N PROC FE6E CODE Length =0037
T_END . . . . . L NEAR FE43 CODE
T_HI . . . . . L NEAR FEC5 CODE
T_HI_ORDER . . . . . L WORD 006E DATA
T_INC . . . . . L NEAR FEBB CODE
T_INT . . . . . N PROC FE45 CODE Length =0047
T_LO_ORDER . . . . . L WORD 006C CODE
T_NPE . . . . . L NEAR FE78 CODE
T_NPF . . . . . L NEAR FE7E CODE
T_OFL . . . . . L NEAR FE21 CODE
T_OVERFLOW . . . . . L BYTE 0070 DATA
T_SET . . . . . L NEAR FE95 CODE
VECTOR . . . . . N PROC FFF0 CODE Length =000E
V_3X8 . . . . . L BYTE 0065 DATA
V_6845 . . . . . L NEAR F262 CODE
V_4PAGE . . . . . L BYTE 0062 DATA
V_BASE6845 . . . . . L WORD 0063 DATA
V_BELL . . . . . N PROC F54E CODE Length =0025
V_BS . . . . . L NEAR F4C3 CODE
V_CLR . . . . . L NEAR F2F5 CODE
V_CLR_BOT . . . . . L NEAR F2F5 CODE
V_CLR_FAST . . . . . L NEAR F33F CODE
V_CLR_PLP . . . . . L NEAR F341 CODE
V_CLR_HI . . . . . L NEAR F30A CODE
V_CLR_LO . . . . . L NEAR F310 CODE
V_CLR_LP . . . . . L NEAR F300 CODE
V_CLR_NXT . . . . . L NEAR F325 CODE
V_CLR_PAST . . . . . L NEAR F33C CODE
V_CLR_ROM . . . . . L NEAR F32E CODE
V_CLR_TOP . . . . . L NEAR F377 CODE
V_COL . . . . . N PROC F41A CODE Length =002C
V_COLORPAL . . . . . L BYTE 0066 DATA
V_COLORB . . . . . L NEAR F08E CODE
V_COL_0 . . . . . L NEAR F42F CODE
V_COL_1 . . . . . L NEAR F436 CODE
V_CR . . . . . L NEAR F4CB CODE
V_CURPOS . . . . . L WORD 0050 DATA Length =0008
V_CURSIZE . . . . . L WORD 0060 DATA
V_CURS_POS . . . . . N PROC F1F7 CODE Length =001E
V_CURS_TYPE . . . . . N PROC F1E9 CODE Length =000E
V_DATA1 . . . . . N PROC F045 CODE Length =0020
V_DATA2 . . . . . N PROC F048 CODE Length =0058
V_DISALLOW . . . . . L NEAR D626 CODE
V_FPOS . . . . . N PROC F50D CODE Length =001E
V_FPOS_0 . . . . . L NEAR F51F CODE
V_FPOS_LP . . . . . L NEAR F518 CODE
V_HEIGHT . . . . . L WORD 004C DATA
V_IO . . . . . N PROC F065 CODE Length =003F
V_KCLEAR . . . . . Number 0007
V_ESCROLL . . . . . Number 0004
V_LP . . . . . L NEAR F47B CODE
V_LROW . . . . . L NEAR F486 CODE
V_MD_80 . . . . . L BYTE F0A4 CODE
V_MD_80 . . . . . L BYTE F0B4 CODE
V_MD_80 . . . . . L NEAR F171 CODE
V_MD_CLR_2K . . . . . L NEAR F16C CODE
V_MD_CLR_8K . . . . . L NEAR F16E CODE
V_MD_CLR_GRAPHICS . . . . . L NEAR F168 CODE
V_MDBL . . . . . L NEAR F168 CODE
V_MD_ENABLE . . . . . L BYTE F0F4 CODE
V_MD_GRAPH . . . . . L BYTE F0C4 CODE

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ROM BIOS Listing

```

V_MD_LEN . . . . . L WORD F0E4 CODE
V_MD_MONO . . . . . L BYTE F0D4 CODE
V_MD_WID . . . . . L BYTE F0E8 CODE
V_MODE . . . . . L BYTE 0049 DATA
V_MV . . . . . L NEAR F295 CODE
V_MV_DH . . . . . L NEAR F370 CODE
V_MV_END . . . . . L NEAR F2F4 CODE
V_MV_FLP . . . . . L NEAR F2E7 CODE
V_MV_HI . . . . . L NEAR F2AA CODE
V_MV_LO . . . . . L NEAR F2B0 CODE
V_MV_LP . . . . . L NEAR F2A0 CODE
V_MV_MVT . . . . . L NEAR F2CA CODE
V_MV_PAST . . . . . L NEAR F2E5 CODE
V_MV_ROW . . . . . L NEAR F2D1 CODE
V_HOP . . . . . N PROC F043 CODE
V_OUT_BYTE . . . . . N PROC F273 CODE Length =000C
V_OVR_NOT_OK . . . . . L NEAR F1C4 CODE
V_OVR_OK . . . . . L NEAR F1C6 CODE
V_PAGE . . . . . N PROC F22C CODE Length =0047
V_PAGE_0 . . . . . L NEAR F23E CODE
V_PARMS . . . . . L BYTE F04A CODE
V_POINTER . . . . . Number 03B8
V_POSH . . . . . N PROC F52B CODE Length =0011
V_RAC . . . . . N PROC F37C CODE Length =002A
V_RAC_INBLANK . . . . . L NEAR F398 CODE
V_RAC_INLINE . . . . . L NEAR F392 CODE
V_RESET_BX . . . . . L NEAR D616 CODE
V_R_CURS_POS . . . . . N PROC F215 CODE Length =0017
V_SCLR_DN . . . . . N PROC F35B CODE Length =0021
V_SCLR_MODE_7 . . . . . L NEAR F356 CODE
V_SCLR_MV_AND_CLR . . . . . L NEAR F50C CODE
V_SCLR_POS . . . . . N PROC F4DE CODE Length =002F
V_SCLR_RET . . . . . L NEAR F34B CODE
V_SCLR_TTY . . . . . L NEAR F491 CODE
V_SCLR_TTY_GRAPHICS . . . . . L NEAR F4A0 CODE
V_SCLR_UP . . . . . N PROC F27F CODE Length =00DC
V_SET_CURS . . . . . L NEAR F210 CODE
V_SET_CUR_POS . . . . . L NEAR F256 CODE
V_SET_MODE . . . . . N PROC F0FC CODE Length =00E0
V_SET_MODE_COLOR . . . . . L NEAR F117 CODE
V_SET_MODE_LP . . . . . L NEAR F147 CODE
V_SET_NEW_CUR . . . . . L NEAR F48C CODE
V_STAT . . . . . N PROC F4CF CODE Length =000F
V_TBL . . . . . L WORD F045 CODE
V_TERMINAL . . . . . N PROC F446 CODE Length =0089
V_TERM_NOBELL . . . . . L NEAR F44D CODE
V_TERM_NOP . . . . . L NEAR F4BB CODE
V_TERM_RET . . . . . L NEAR F4B9 CODE
V_TOP . . . . . L WORD D08E DATA
V_TXT_DN . . . . . L NEAR F364 CODE
V_TXT_MD . . . . . N PROC F53C CODE Length =0012
V_TXT_OK . . . . . L NEAR F54C CODE
V_TXT_RAC . . . . . L NEAR F384 CODE
V_TXT_UP . . . . . L NEAR F287 CODE
V_TXT_WAC . . . . . L NEAR F3AE CODE
V_TXT_WC . . . . . L NEAR F3E7 CODE
V_WAC . . . . . N PROC F3A6 CODE Length =0039
V_WAC_END . . . . . L NEAR F3DA CODE
V_WAC_HI . . . . . L NEAR F3C5 CODE
V_WAC_LO . . . . . L NEAR F3CB CODE
V_WC . . . . . N PROC F3DF CODE Length =003B
V_WC_END . . . . . L NEAR F415 CODE
V_WC_HI . . . . . L NEAR F3FE CODE
V_WC_LO . . . . . L NEAR F404 CODE
V_WC_WEXIT . . . . . L NEAR F3FE CODE
V_WIDTH . . . . . L WORD 004A DATA
W1 . . . . . L NEAR D460 CODE
W2 . . . . . L NEAR D46B CODE
WAIT_FOR_IRQS . . . . . L NEAR D46D CODE
WAIT_FOR_STATUS . . . . . N PROC D418 CODE Length =0023
WBUF BX . . . . . Number 000F
WBUF INT . . . . . Number 000F
WLONG BX . . . . . Number 0026
WRITE BX . . . . . Number 000A
WRITE_MODE . . . . . Number 004B
WRITE_PORT . . . . . Number 0320
WRITE_PROTECT . . . . . Number 0003
W_FINISH . . . . . L NEAR D494 CODE
W_INTS_DONE . . . . . L NEAR D486 CODE
W_NEC . . . . . L NEAR E992 CODE
W_NEC_RET . . . . . L NEAR EFA6 CODE
W_ONF . . . . . L NEAR EFA8 CODE

```

```

Warning Severe
Errors Errors
0 0

```

ROM BIOS Change List

ROM Rev 1.1 August 10, 1984

Aug 8 16:40 1984 fdu1.src:

Fix random value in DX during reset causing
problem

```
Line 73  Add
        push  es
        cmp   ah, 0           ;Is it a reset command?
        jz    diskette_i01    ;Yes, so ignore drive
                                ;param.
```

```
Line 123 Add
        pop   es
```

Aug 8 16:40 1984 fdu1.src:

Allow verify operation without valid buffer pointer
(buffer not required)

```
        xor   bx,bx          ;Fool the DMAC into
        mov   es,bx          ;thinking there is a full
                                ;segment to play with.
```

Do not range check head number

Change

```
        and   ah,1           ;blow off high 7 bits.
to
        and   ah,07Fh       ;blow off bit 7.
```

Aug 8 16:41 1984 flags.src:

Change date of release in ROM

```
        db   '05/03/84'     ;release marker (exactly
                                ;8 bytes!!!!)
to
        db   '08/10/84'     ;release marker (exactly
                                ;8 bytes!!!!)
```

Aug 8 16:43 1984 fontl08.src:

Change 8 X 8 font to improve italics as displayed
by 3rd party software

ROM BIOS
Change List

Changed

DB	00h,00h,00h,00h		
DB	00h,00h,00h,00h	;	0
DB	07eh,081h,0a5h,081h		
DB	0bdh,099h,081h,07eh	;	1
DB	07eh,0ffh,0dbh,0ffh		
DB	0c3h,0e7h,0ffh,07eh	;	2
DB	036h,07fh,07fh,07fh		
DB	03eh,01ch,08h,00h	;	3
DB	08h,01ch,03eh,07fh		
DB	03eh,01ch,08h,00h	;	4
DB	018h,03ch,0e7h,0e7h		
DB	066h,018h,018h,03ch	;	5
DB	018h,03ch,07eh,0ffh		
DB	0ffh,07eh,018h,03ch	;	6
DB	00h,00h,018h,03ch		
DB	03ch,018h,00h,00h	;	7
DB	0ffh,0ffh,0e7h,0c3h		
DB	0c3h,0e7h,0ffh,0ffh	;	8
DB	00h,03ch,024h,042h		
DB	042h,024h,03ch,00h	;	9
DB	0ffh,0c3h,099h,0bdh		
DB	0bdh,099h,0c3h,0ffh	;	a
DB	01fh,07h,0dh,019h		
DB	078h,0cch,0cch,078h	;	b
DB	03ch,066h,066h,03ch		
DB	018h,07eh,018h,018h	;	c
DB	018h,014h,012h,012h		
DB	014h,070h,0f0h,060h	;	d
DB	01fh,011h,01fh,011h		
DB	013h,037h,072h,020h	;	e
DB	018h,0dbh,03ch,0e7h		
DB	03ch,0dbh,018h,00h	;	f
DB	040h,070h,07ch,07fh		
DB	07ch,070h,040h,00h	;	10
DB	01h,07h,01fh,07fh		
DB	01fh,07h,01h,00h	;	11
DB	018h,03ch,07eh,018h		
DB	018h,07eh,03ch,018h	;	12

DB	00h,033h,033h,033h		
DB	033h,00h,033h,00h	;	13
DB	07fh,0dbh,0dbh,07bh		
DB	01bh,01bh,01bh,00h	;	14
DB	03eh,061h,03ch,066h		
DB	066h,03ch,086h,07ch	;	15
DB	00h,00h,00h,00h		
DB	07eh,07eh,07eh,00h	;	16
DB	018h,03ch,07eh,018h		
DB	07eh,03ch,018h,07eh	;	17
DB	018h,03ch,07eh,018h		
DB	018h,018h,018h,018h	;	18
DB	018h,018h,018h,018h		
DB	018h,07eh,03ch,018h	;	19
DB	0ch,06h,07fh,06h		
DB	0ch,00h,00h,00h	;	1a
DB	018h,030h,07fh,030h		
DB	018h,00h,00h,00h	;	1b
DB	00h,00h,060h,060h		
DB	060h,07fh,07fh,00h	;	1c
DB	00h,024h,066h,0ffh		
DB	066h,024h,00h,00h	;	1d
DB	00h,00h,018h,03ch		
DB	07eh,0ffh,00h,00h	;	1e
DB	00h,0ffh,07eh,03ch		
DB	018h,00h,00h,00h	;	1f
DB	00h,00h,00h,00h		
DB	00h,00h,00h,00h	;	' ' 20
DB	018h,03ch,03ch,018h		
DB	018h,00h,018h,00h	;	'!' 21
DB	036h,036h,014h,00h		
DB	00h,00h,00h,00h	;	'"' 22
DB	036h,036h,07fh,036h		
DB	07fh,036h,036h,00h	;	'#' 23
DB	018h,03eh,060h,03ch		
DB	06h,07ch,018h,00h	;	'\$' 24
DB	00h,063h,066h,0ch		
DB	018h,033h,033h,00h	;	'%' 25

ROM BIOS
Change List

DB 01ch,036h,01ch,03bh		
DB 06eh,066h,03bh,00h	;	'&' 26
DB 018h,018h,030h,00h		
DB 00h,00h,00h,00h	;	' ' ' 27
DB 0ch,018h,030h,030h		
DB 030h,030h,018h,0ch	;	'(' 28
DB 030h,018h,0ch,0ch		
DB 0ch,0ch,018h,030h	;	'),' 29
DB 00h,066h,03ch,0ffh		
DB 03ch,066h,00h,00h	;	'*' 2a
DB 00h,018h,018h,07eh		
DB 018h,018h,00h,00h	;	'+' 2b
DB 00h,00h,00h,00h		
DB 00h,018h,018h,030h	;	',' 2c
DB 00h,00h,00h,07eh		
DB 00h,00h,00h,00h	;	'_' 2d
DB 00h,00h,00h,00h		
DB 00h,018h,018h,00h	;	'.' 2e
DB 03h,06h,0ch,018h		
DB 030h,060h,040h,00h	;	',' 2f
DB 03eh,063h,067h,06fh		
DB 07bh,073h,03eh,00h	;	'0' 30
DB 0ch,01ch,0ch,0ch		
DB 0ch,0ch,03fh,00h	;	'1' 31
DB 01fh,033h,03h,0eh		
DB 018h,033h,03fh,00h	;	'2' 32
DB 01eh,033h,03h,0eh		
DB 03h,033h,01eh,00h	;	'3' 33
DB 0eh,01eh,036h,066h		
DB 07fh,06h,0fh,00h	;	'4' 34
DB 03fh,030h,03eh,03h		
DB 03h,033h,01eh,00h	;	'5' 35
DB 0eh,018h,030h,03eh		
DB 033h,033h,01eh,00h	;	'6' 36
DB 03fh,033h,03h,06h		
DB 0ch,0ch,0ch,00h	;	'7' 37
DB 01eh,033h,033h,01eh		
DB 033h,033h,01eh,00h	;	'8' 38

DB	01eh,033h,031h,01fh			
DB	03h,06h,01ch,00h	;	'9'	39
DB	00h,018h,018h,00h			
DB	00h,018h,018h,00h	;	'.'	3a
DB	00h,018h,018h,00h			
DB	00h,018h,018h,030h	;	'.'	3b
DB	06h,0ch,018h,030h			
DB	018h,0ch,06h,00h	;	'<'	3c
DB	00h,00h,07eh,00h			
DB	00h,07eh,00h,00h	;	'='	3d
DB	030h,018h,0ch,06h			
DB	0ch,018h,030h,00h	;	'>'	3e
DB	03eh,063h,03h,06h			
DB	0ch,00h,0ch,00h	;	'?'	3f
DB	03eh,063h,06fh,06fh			
DB	06eh,060h,03eh,00h	;	'@'	40
DB	08h,01ch,036h,063h			
DB	07fh,063h,063h,00h	;	'A'	41
DB	07eh,033h,033h,03eh			
DB	033h,033h,07eh,00h	;	'B'	42
DB	01eh,033h,060h,060h			
DB	061h,033h,01eh,00h	;	'C'	43
DB	07ch,036h,033h,033h			
DB	033h,036h,07ch,00h	;	'D'	44
DB	07fh,031h,034h,03ch			
DB	034h,031h,07fh,00h	;	'E'	45
DB	07fh,031h,034h,03ch			
DB	034h,030h,078h,00h	;	'F'	46
DB	01eh,033h,060h,060h			
DB	067h,033h,01dh,00h	;	'G'	47
DB	063h,063h,063h,07fh			
DB	063h,063h,063h,00h	;	'H'	48
DB	03ch,018h,018h,018h			
DB	018h,018h,03ch,00h	;	'I'	49
DB	0fh,06h,06h,06h			
DB	066h,066h,03ch,00h	;	'J'	4a
DB	073h,036h,03ch,038h			
DB	03ch,036h,073h,00h	;	'K'	4b

ROM BIOS
Change List

DB	078h,030h,030h,030h			
DB	030h,033h,07fh,00h	;	'L'	4c
DB	063h,077h,07fh,06bh			
DB	063h,063h,063h,00h	;	'M'	4d
DB	063h,073h,07bh,06fh			
DB	067h,063h,063h,00h	;	'N'	4e
DB	01ch,036ch,063h,063h			
DB	063h,036h,01ch,00h	;	'O'	4f
DB	07eh,033h,033h,03eh			
DB	030h,030h,078h,00h	;	'P'	50
DB	01ch,036h,063h,063h			
DB	063h,036h,01ch,07h	;	'Q'	51
DB	07eh,033h,033h,03eh			
DB	036h,033h,033h,00h	;	'R'	52
DB	03eh,063h,030h,018h			
DB	06h,063h,03eh,00h	;	'S'	53
DB	07eh,05ah,018h,018h			
DB	018h,018h,03ch,00h	;	'T'	54
DB	063h,063h,063h,063h			
DB	063h,063h,03eh,00h	;	'U'	55
DB	063h,063h,063h,063h			
DB	036h,01ch,08h,00h	;	'V'	56
DB	063h,063h,063h,06bh			
DB	06bh,07fh,036h,00h	;	'W'	57
DB	063h,063h,036h,01ch			
DB	036h,063h,063h,00h	;	'X'	58
DB	066h,066h,066h,03ch			
DB	018h,018h,03ch,00h	;	'Y'	59
DB	07fn,063h,06h,0ch			
DB	018h,033h,07fh,00h	;	'Z'	5a
DB	03ch,030h,030h,030h			
DB	030h,030h,03ch,00h	;	'['	5b
DB	020h,030h,018h,0ch			
DB	06h,03h,01h,00h	;	'\'	5c
DB	03ch,0ch,0ch,0ch			
DB	0ch,0ch,03ch,00h	;	']'	5d
DB	08h,01ch,036h,063h			
DB	00h,00h,00h,00h	;	' '	5e

DB	00h,00h,00h,00h		
DB	00h,00h,07fh,00h	;	'_' 5f
DB	018h,018h,0ch,00h		
DB	00h,00h,00h,00h	;	' ' 60
DB	00h,00h,03ch,06h		
DB	03eh,066h,03bh,00h	;	'a' 61
DB	070h,030h,03eh,033h		
DB	033h,033h,06eh,00h	;	'b' 62
DB	00h,00h,03eh,061h		
DB	060h,061h,03eh,00h	;	'c' 63
DB	0eh,06h,03eh,066h		
DB	066h,066h,03bh,00h	;	'd' 64
DB	00h,00h,03eh,063h		
DB	07fh,060h,03fh,00h	;	'e' 65
DB	01eh,033h,030h,07ch		
DB	030h,030h,078h,00h	;	'f' 66
DB	00h,00h,03bh,066h		
DB	066h,03eh,046h,03ch	;	'g' 67
DB	070h,030h,036h,03fh		
DB	033h,033h,073h,00h	;	'h' 68
DB	0ch,00h,01ch,0ch		
DB	0ch,0ch,01eh,00h	;	'i' 69
DB	0ch,00h,01eh,0ch		
DB	0ch,0cch,0cch,078h	;	'j' 6a
DB	070h,030h,033h,036h		
DB	03ch,036h,073h,00h	;	'k' 6b
DB	01ch,0ch,0ch,0ch		
DB	0ch,0ch,01eh,00h	;	'l' 6c
DB	00h,00h,066h,07fh		
DB	06bh,06bh,06bh,00h	;	'm' 6d
DB	00h,00h,06eh,033h		
DB	033h,033h,033h,00h	;	'n' 6e
DB	00h,00h,01eh,033h		
DB	033h,033h,01eh,00h	;	'o' 6f
DB	00h,00h,06eh,033h		
DB	033h,03eh,030h,078h	;	'p' 70
DB	00h,00h,03bh,066h		
DB	066h,03eh,06h,0fh	;	'q' 71
DB	00h,00h,06eh,03bh		

ROM BIOS
Change List

	DB 030h,030h,078h,00h	;	'r'	72
	DB 00h,00h,03fh,060h			
	DB 03ch,03h,07eh,00h	;	's'	73
	DB 08h,018h,03eh,018h			
	DB 018h,01bh,0eh,00h	;	't'	74
	DB 00h,00h,066h,066h			
	DB 066h,066h,03bh,00h	;	'u'	75
	DB 00h,00h,063h,063h			
	DB 036h,01ch,08h,00h	;	'v'	76
	DB 00h,00h,063h,06bh			
	DB 06bh,07fh,036h,00h	;	'w'	77
	DB 00h,00h,063h,036h			
	DB 01ch,036h,063h,00h	;	'x'	78
	DB 00h,00h,066h,066h			
	DB 066h,03eh,06h,07ch	;	'y'	79
	DB 00h,00h,07eh,04ch			
	DB 018h,032h,07eh,00h	;	'z'	7a
	DB 0eh,018h,018h,070h			
	DB 018h,018h,0eh,00h	;	'{'	7b
	DB 0ch,0ch,00h,00h			
	DB 0ch,0ch,0ch,00h	;	'|'	7c
	DB 070h,018h,018h,0eh			
	DB 018h,018h,070h,00h	;	'}'	7d
	DB 03bh,06eh,00h,00h			
	DB 00h,00h,00h,00h	;	'~'	7e
	DB 00h,08h,01ch,036h			
	DB 063h,063h,07fh,00h	;		7f
to				
	DB 00h,00h,00h,00h,00h,00h,00h,00h	;		0
	DB 7eh,81h,0a5h,81h,0bdh,99h,81h,7eh	;		1
	DB 7eh,0ffh,0dbh,0ffh,0c3h,0e7h,0ffh,7eh	;		2
	DB 6ch,0feh,0feh,0feh,7ch,38h,10h,00h	;		3
	DB 10h,38h,7ch,0feh,7ch,38h,10h,00h	;		4
	DB 38h,7ch,38h,0feh,0feh,7ch,38h,7ch	;		5
	DB 10h,10h,38h,7ch,0feh,7ch,38h,7ch	;		6
	DB 00h,00h,18h,3ch,3ch,18h,00h,00h	;		7
	DB 0ffh,0ffh,0e7h,0c3h,0c3h,0e7h,0ffh,0ffh	;		8
	DB 00h,3ch,66h,42h,42h,66h,3ch,00h	;		9
	DB 0ffh,0c3h,99h,0bdh,0bdh,99h,0c3h,0ffh	;		a

DB	0fh,07h,0fh,7dh,0cch,0cch,0cch,78h	;	b
DB	3ch,66h,66h,66h,3ch,18h,7eh,18h	;	c
DB	3fh,33h,3fh,30h,30h,70h,0f0h,0e0h	;	d
DB	7fh,63h,7fh,63h,63h,67h,0e6h,0c0h	;	e
DB	99h,5ah,3ch,0e7h,0e7h,3ch,5ah,99h	;	f
DB	80h,0e0h,0f8h,0feh,0f8h,0e0h,80h,00h	;	10
DB	02h,0eh,3eh,0feh,3eh,0eh,02h,00h	;	11
DB	18h,3ch,7eh,18h,18h,7eh,3ch,18h	;	12
DB	66h,66h,66h,66h,66h,00h,66h,00h	;	13
DB	7fh,0dbh,0dbh,7bh,1bh,1bh,1bh,00h	;	14
DB	3eh,63h,38h,6ch,6ch,38h,0cch,78h	;	15
DB	00h,00h,00h,00h,7eh,7eh,7eh,00h	;	16
DB	18h,3ch,7eh,18h,7eh,3ch,18h,0ffh	;	17
DB	18h,3ch,7eh,18h,18h,18h,18h,00h	;	18
DB	18h,18h,18h,18h,7eh,3ch,18h,00h	;	19
DB	00h,18h,0ch,0feh,0ch,18h,00h,00h	;	1a
DB	00h,30h,60h,0feh,60h,30h,00h,00h	;	1b
DB	00h,00h,0c0h,0c0h,0c0h,0feh,00h,00h	;	1c
DB	00h,24h,66h,0ffh,66h,24h,00h,00h	;	1d
DB	00h,18h,3ch,7eh,0ffh,0ffh,00h,00h	;	1e
DB	00h,0ffh,0ffh,7eh,3ch,18h,00h,00h	;	1f
DB	00h,00h,00h,00h,00h,00h,00h,00h	;,'	20
DB	30h,78h,78h,30h,30h,00h,30h,00h	;,'!	21
DB	6ch,6ch,6ch,00h,00h,00h,00h,00h	;,'"	22
DB	6ch,6ch,0feh,6ch,0feh,6ch,6ch,00h	;,'#'	23
DB	30h,7ch,0c0h,78h,0ch,0f8h,30h,00h	;,'\$'	24
DB	00h,0c6h,0cch,18h,30h,66h,0c6h,00h	;,'%'	25
DB	38h,6ch,38h,76h,0dch,0cch,76h,00h	;,'&'	26
DB	60h,60h,0c0h,00h,00h,00h,00h,00h	;,'"'	27
DB	18h,30h,60h,60h,60h,30h,18h,00h	;,'('	28
DB	60h,30h,18h,18h,18h,30h,60h,00h	;,'.)'	29
DB	00h,66h,3ch,0ffh,3ch,66h,00h,00h	;,'*'	2a
DB	00h,30h,30h,0fch,30h,30h,00h,00h	;,'+'	2b
DB	00h,00h,00h,00h,00h,30h,30h,60h	;,','	2c
DB	00h,00h,00h,0fch,00h,00h,00h,00h	;,'—'	2d
DB	00h,00h,00h,00h,00h,30h,30h,00h	;,'-'	2e
DB	06h,0ch,18h,30h,60h,0c0h,80h,00h	;,'/'	2f
DB	7ch,0c6h,0ceh,0deh,0f6h,0e6h,7ch,00h	;,'0'	30

ROM BIOS
Change List

DB	30h,70h,30h,30h,30h,30h,0fch,00h	;'1'	31
DB	78h,0cch,0ch,38h,60h,0cch,0fch,00h	;'2'	32
DB	78h,0cch,0ch,38h,0ch,0cch,78h,00h	;'3'	33
DB	1ch,3ch,6ch,0cch,0feh,0ch,1eh,00h	;'4'	34
DB	0fch,0c0h,0f8h,0ch,0ch,0cch,78h,00h	;'5'	35
DB	38h,60h,0c0h,0f8h,0cch,0cch,78h,00h	;'6'	36
DB	0fch,0cch,0ch,18h,30h,30h,30h,00h	;'7'	37
DB	78h,0cch,0cch,78h,0cch,0cch,78h,00h	;'8'	38
DB	78h,0cch,0cch,7ch,0ch,18h,70h,00h	;'9'	39
DB	00h,30h,30h,00h,00h,30h,30h,00h	;'.'	3a
DB	00h,30h,30h,00h,00h,30h,30h,60h	;'.'	3b
DB	18h,30h,60h,0c0h,60h,30h,18h,00h	;'<'	3c
DB	00h,00h,0fch,00h,00h,0fch,00h,00h	;'='	3d
DB	60h,30h,18h,0ch,18h,30h,60h,00h	;'>'	3e
DB	78h,0cch,0ch,18h,30h,00h,30h,00h	;'?'	3f
DB	7ch,0c6h,0deh,0deh,0deh,0c0h,78h,00h	;'@'	40
DB	30h,78h,0cch,0cch,0fch,0cch,0cch,00h	;'A'	41
DB	0fch,66h,66h,7ch,66h,66h,0fch,00h	;'B'	42
DB	3ch,66h,0c0h,0c0h,0c0h,66h,3ch,00h	;'C'	43
DB	0f8h,6ch,66h,66h,66h,6ch,0f8h,00h	;'D'	44
DB	0feh,62h,68h,78h,68h,62h,0feh,00h	;'E'	45
DB	0feh,62h,68h,78h,68h,60h,0f0h,00h	;'F'	46
DB	3ch,66h,0c0h,0c0h,0ceh,66h,3eh,00h	;'G'	47
DB	0cch,0cch,0cch,0fch,0cch,0cch,0cch,00h	;'H'	48
DB	78h,30h,30h,30h,30h,30h,78h,00h	;'I'	49
DB	1eh,0ch,0ch,0ch,0cch,0cch,78h,00h	;'J'	4a
DB	0e6h,66h,6ch,78h,6ch,66h,0e6h,00h	;'K'	4b
DB	0f0h,60h,60h,60h,62h,66h,0feh,00h	;'L'	4c
DB	0c6h,0eeh,0feh,0feh,0d6h,0c6h,0c6h,00h	;'M'	4d
DB	0c6h,0e6h,0f6h,0deh,0ceh,0c6h,0c6h,00h	;'N'	4e
DB	38h,6ch,0c6h,0c6h,0c6h,6ch,38h,00h	;'O'	4f
DB	0fch,66h,66h,7ch,60h,60h,0f0h,00h	;'P'	50
DB	78h,0cch,0cch,0cch,0dch,78h,1ch,00h	;'Q'	51
DB	0fch,66h,66h,7ch,6ch,66h,0e6h,00h	;'R'	52
DB	78h,0cch,0e0h,70h,1ch,0cch,78h,00h	;'S'	53
DB	0fch,0b4h,30h,30h,30h,30h,78h,00h	;'T'	54
DB	0cch,0cch,0cch,0cch,0cch,0cch,0fch,00h	;'U'	55
DB	0cch,0cch,0cch,0cch,0cch,78h,30h,00h	;'V'	56

DB	0c6h,0c6h,0c6h,0d6h,0feh,0eeh,0c6h,00h;	'W'	57
DB	0c6h,0c6h,6ch,38h,38h,6ch,0c6h,00h;	'X'	58
DB	0cch,0cch,0cch,78h,30h,30h,78h,00h;	'Y'	59
DB	0feh,0c6h,8ch,18h,32h,66h,0feh,00h;	'Z'	5a
DB	78h,60h,60h,60h,60h,60h,78h,00h;	'['	5b
DB	0c0h,60h,30h,18h,0ch,06h,02h,00h;	'\'	5c
DB	78h,18h,18h,18h,18h,18h,78h,00h;	']'	5d
DB	10h,38h,6ch,0c6h,00h,00h,00h,00h;	' '	5e
DB	00h,00h,00h,00h,00h,00h,00h,0ffh;	'_'	5f
DB	30h,30h,18h,00h,00h,00h,00h,00h;	'"'	60
DB	00h,00h,78h,0ch,7ch,0cch,76h,00h;	'a'	61
DB	0e0h,60h,60h,7ch,66h,66h,0dch,00h;	'b'	62
DB	00h,00h,78h,0cch,0c0h,0cch,78h,00h;	'c'	63
DB	1ch,0ch,0ch,7ch,0cch,0cch,76h,00h;	'd'	64
DB	00h,00h,78h,0cch,0fch,0c0h,78h,00h;	'e'	65
DB	38h,6ch,60h,0f0h,60h,60h,0f0h,00h;	'f'	66
DB	00h,00h,76h,0cch,0cch,7ch,0ch,0f8h;	'g'	67
DB	0e0h,60h,6ch,76h,66h,66h,0e6h,00h;	'h'	68
DB	30h,00h,70h,30h,30h,30h,78h,00h;	'i'	69
DB	0ch,00h,0ch,0ch,0cch,0cch,78h;	'j'	6a
DB	0e0h,60h,66h,6ch,78h,6ch,0e6h,00h;	'k'	6b
DB	70h,30h,30h,30h,30h,30h,78h,00h;	'l'	6c
DB	00h,00h,0cch,0feh,0feh,0d6h,0c6h,00h;	'm'	6d
DB	00h,00h,0f8h,0cch,0cch,0cch,0cch,00h;	'n'	6e
DB	00h,00h,78h,0cch,0cch,0cch,78h,00h;	'o'	6f
DB	00h,00h,0dch,66h,66h,7ch,60h,0f0h;	'p'	70
DB	00h,00h,76h,0cch,0cch,7ch,0ch,1eh;	'q'	71
DB	00h,00h,0dch,76h,66h,60h,0f0h,00h;	'r'	72
DB	00h,00h,7ch,0c0h,78h,0ch,0f8h,00h;	's'	73
DB	10h,30h,7ch,30h,30h,34h,18h,00h;	't'	74
DB	00h,00h,0cch,0cch,0cch,0cch,76h,00h;	'u'	75
DB	00h,00h,0cch,0cch,0cch,78h,30h,00h;	'v'	76
DB	00h,00h,0c6h,0d6h,0feh,0feh,6ch,00h;	'w'	77
DB	00h,00h,0c6h,6ch,38h,6ch,0c6h,00h;	'x'	78
DB	00h,00h,0cch,0cch,0cch,7ch,0ch,0f8h;	'y'	79
DB	00h,00h,0fch,98h,30h,64h,0fch,00h;	'z'	7a
DB	1ch,30h,30h,0e0h,30h,30h,1ch,00h;	'{'	7b
DB	18h,18h,18h,00h,18h,18h,18h,00h;	'|'	7c

ROM BIOS
Change List

```
DB 0e0h,30h,30h,1ch,30h,30h,0e0h,00h ;'} 7d
DB 76h,0dch,00h,00h,00h,00h,00h,00h ;'~' 7e
DB 00h,10h,38h,6ch,0c6h,0c6h,0feh,00h ;' ' 7f
```

Aug 8 16:44 1984 graph.src:
Solved 640 X 400 inverse video mode problem

Changed

```
test byte ptr [si],80H ;is upper left bit of
                        ;char = 0 or 1?
to
test byte ptr ss:[si],80H ;is upper left bit of
                        ;char = 0 or 1?
```

Changed

```
not byte ptr [si] ;reverse the reversed
                  ;byte for matching
to
not byte ptr ss:[si] ;reverse the reversed
                    ;byte for matching
```

Aug 8 16:48 1984 pwrup1.src:
Changed release date and display on boot

Changed

```
banner_m db "Resident Diagnostics",CR,LF
          db "Rev 1.0 May 1984",CR,LF,LF,
          NUL
to
          db "Rev 1.1 Aug 1984",CR,LF,LF
banner_m db "Resident Diagnostics",CR,LF,
          LF
          db NUL
```


Notes on Enhancements in ROM BIOS 1.21

Introduction These notes describe the differences between the 1.0, 1.1 and 1.21 ROM BIOS for the AT&T PC 6300. The notes first describe the differences between the 1.0 and 1.1 ROMs, then describe the differences between the 1.1 and 1.21 ROMs.

**Differences
Between
ROM 1.0
and
ROM 1.1**

The differences between the 1.0 and 1.1 ROM are:

- In the floppy disk utility, the random value of the DX register is fixed.
- In the floppy disk utility, the verify operation without a valid buffer pointer is allowed.
- In the floppy disk utility, the value checking for head number has been eliminated.
- The ROM release date has been changed to 08/10/84.
- The 8x8 font has been changed to improve italics displayed by some third-party software.
- The 640x400 inverse video mode now works properly.
- The displayed release marker has been changed to "Rev 1.1."
- LOTUS™ Symphony runs on the 1.1 ROM.

These changes are explained in detail in the "System Programmer's Guide" on pages 8-177 to 8-188.

**Differences
Between
ROM 1.1
and
ROM 1.21**

ROM BIOS 1.21 was introduced to solve problems with the use of external vendor's hard disk expansion boxes, to support the 20 megabyte hard disk drives, and to better initialize the second communications port.

The differences between ROM 1.1 and 1.21 are:

- The code sent to the parallel port during power up diagnostics has been changed from 80H to 3fH.
- In INT 15H, a near return has been changed to a far return.
- INT 18H is enhanced to display a message "ROM BASIC not present, Press RESET to reboot ..." and wait for a key press before re-booting.
- Code has been added to reset the Display Enhancement Board during a warm boot.
- The reset code has been changed to origin at 0E05Bh.
- The floppy disk drive motor delay has been changed from a range of 0-500 milliseconds to 250-750 milliseconds.
- The order of executing HDU code and external ROM code has been reversed to execute the internal HDU code, then check for optional ROMs.

- In order to simplify support for external hard disk drives with controllers other than the DTC controller, a check of DIPSW-1 position 3 on the motherboard (at location 7W) has been added. Position 3 of DIPSW-1 has been defined as:

ON = use indigenous hard disk code
OFF = use external hard disk code

- A test has been added to check for the presence of the 8530 alternate communications chip.
- The initialization of COM2: has been improved.
- Code has been added in an INT 10H routine that enables the video after scroll up is performed.
- An incompatibility that prevented the Softech P-System from booting has been corrected.
- The high 128 characters of the 8x8 font and the low 128 characters of the 8x16 font have been changed to provide better alignment of the characters within the 8x8 and 8x16 fonts.
- Support for 20 megabyte disk drives has been added to the disk parameter table. Drive type 6 is a Seagate ST225, drive type 7 is a Miniscribe 3425, and drive type 8 is a CMI 6426.

- The disk parameters for the CDC WREN drive have been changed to 697 cylinders to allow for the full capacity of the drive.
- Support in INT 11H was added for 8087 switch setting.
- The ROM release date has been changed to 02/28/85.
- The displayed release marker has been changed to "Rev 1.21."

ROM Revision 1.1 to ROM Revision 1.21 Source File Differences

8/10/84 2/14/85
< = rom1.1 > = rom1.20

Source Module: comm2.src

```
<    call rs_stat                    ; get return status
---
> ;; call rs_stat            *E912*    ; get return status
```

Source Module: fdul.src

```
> * mikef     9/18/84            Changed motor delay routine.
> * mikef     01/11/85          If reset cmd don't do check valid.
> * mikef     02/14/85          Made the reset code callable.

<    jz    diskette_io1            ; Yes, so ignore drive parm.
---
>    jz    diskette_io2   *EC73*    ; Yes, so ignore drive parm.

<    cld                            ; Autoincrement for strings.
```

```
<    jnz   f_rd1                    ; 1 = 250 ms motors, no delay
---
>    mov   cx,250                    *ED60*                    ;
>    jnz   f_rd_loop *ED63*        ; 1 = 500 ms motors.
```

Source Module: flags.src

```
> * mikef     9/18/84            Changed reset pointer to point to org'ed
> *                                location.
> * mikef     10/02/84          Included hdu1.asm

> include pwrup1a.asm

> include hdu1.asm
>
>
> include int18.asm
>

<    dw    diagnostics_1    ; instruction pointer cs:(offset diagnostics_1)
---
>    dw    i_hard_reset    ; instruction pointer cs:(offset i_hard_reset)

<    db    '08/10/84'       ; release marker (exactly 8 bytes!!!!)
---
>    db    '02/14/85'       ; release marker (exactly 8 bytes!!!!)
```

ROM BIOS

1.21

Source Module: fonthi8.src

```
<
<
< * NAME DATE ACTION
< * ---- ----
< * robert 4/30/84 Corrected '^'
< * robert 5/01/84 Corrected char 182
---
> * name date action
> * ---- ----
> * seagrave 12/13/84 new font table
< fonthi8 endp
---
> fonthi8 endp
```

Source Module: fontlo16.src

```
< * NAME DATE ACTION
< * ---- ----
< * robert 4/30/84 corrected 'p'.
< * robert 5/4/84 corrected 'i'
---
> * NAME DATE ACTION
> * ---- ----
> * seagrave 12/14/84 new font table
> * yin 2/5/85 new font table
```

Source Module: graph.src

```
> * mikef 2/13/85 Moved grf_light_pen to vid.src.
```

```
<
<
;=====
< ;
< ; Read Light Pen function code = 04h
< ;
< ; Input: None.
< ; Output: ah = 0 light pen switch not down/not triggered
< ; ah = 1 implies:
< ; (dh,d1) = (row,col) of character light pen
< ; position from (0,0)
< ; ch = raster line (0-199)
< ; bx = pixel column (0-319,0-639)
< ;
< ; Trash: None. ???
< ;
;=====
<
< grf_light_pen proc near
<
< xor ah,ah ; return ah = 0 for now (al intact)...
```

```

<   ret
<
<   grf_light_pen      endp

Source Module:      hdu.src

< /*
<  *
<  * NAME DATE        ACTION
---
> /* NAME DATE        ACTION

>  * mikef      10/02/84  Moved h_data2 to hdu1.src to make rom in
>  *             low rom for an ORG.
>  * mikef      10/23/84  Changed documentation describing dip
>  *             switches.
>  * mikef      11/02/84  Fixed bug in reset call.
>  * mikef      12/06/84  Corrected no. of cyls for CDC drive.
>  * mikef      12/18/84  Added type 6 and type 7 drives.
>  * mikef      12/20/84  Corrected write precomp for Seagate ST225.
>  * mikef      01/08/84  Changed int 19 to jmp bt_int.
>  * mikef      01/21/84  Added type 8 in parameter_table and changed
>  *             some other parameters per Olivetti memo.

<   int      18h          ; initiate reboot through ROM BASIC INT.
---
>   jmp bt_int      *D124*    ; initiate reboot through floppy.
> ; int      19h          ; initiate reboot through ROM BASIC
INT.

<   hdu_parm_tbl:
---
>   hdu_parm_tbl proc near

< ; The next six are the supported drives:
---
> ; The next nine are the supported drives:

<       parameter_table <>                ;type 3: 10mb drive
---
>   *D17C*   parameter_table <,,128>      ;type 3: 10mb drive

<       parameter_table <644d,5d,128d,128d> ;type 5: CDC Wren
---
>       parameter_table <697d,5d,697d,0>   ;type 5: CDC Wren
>       parameter_table <612,4,256,256,,3> ;type 6: Seagate ST225.
>       parameter_table <612,4,128,128,,3> ;type 7: Miniscribe 3425
>                               ; and CMI CM 4426.
>   *D1CC*   parameter_table <640,4,256,256,,3> ;type 8: CMI CM6426.

>   hdu_parm_tbl endp
>

<   int 40h          ; if not, pass to the FDU driver

```

ROM BIOS
1.21

```
<
---
> ;; int 40h          ; if not, pass to the FDU driver
> jmp near ptr fd_io  *D1E1*  ;; rom floppy driver.
>                    ;; will not return.

<   int 40h          ; if so, must reset FDU also
---
> ;; int 40h          ; if so, must reset FDU also
> pushf              ;; simulate an int because
>                    ;; fd_io simulates an iret.
> push cs            *D1EE*  ;; Make it look like a far call.
> call near ptr fd_io *D1EF*  ;; rom floppy driver.

> ; Test to see if the vector at location 0:100 points to me. If it does it
> ; means that an optional rom thinks I'm the floppy driver so I'll just
return.
>

< ; drive 0          0  1      2  3      2  3
< ; drive 1          0  1      0  1      2  3
---
> ;; drive 0          0  1      0  1      2  3
> ;; drive 1          0  1      2  3

>

<   and al,07fh      ; ignore top switch!
---
> ;; and al,07fh      ; ignore top switch!

< h_data2 proc
<
< h_intro_m  db  'Fixed Disk Formatting Utility',CR,LF
<             db  'All data on the specified fixed disk will be erased.'
<             db  CR,LF
<             db  'Enter fixed disk number (1 to 8) or "Q" to quit: ',NUL
<
< h_fmt_m    db  CR,LF,'Formatting Fixed Disk...',CR,LF,NUL
<
< h_pass_m   db  'Format is complete.',CR,LF
<             db  'Proceed with FDISK and FORMAT.',NUL
<
< h_none_m   db  'Error: No fixed disk drive exists for this
number.',NUL
<
< h_err_m    db  'Format Error. Code: ',NUL
<
< h_data2 endp
```


Source Module: mem.src

< /*

< *

< * NAME DATE ACTION

> /* NAME DATE ACTION

< *

> * mikef 9/18/84 Changed m_cass proc to far.

>

< m_cass proc near

> m_cass proc far *F8F9*

Source Module: nmi.src

< /*

< *

< * NAME DATE ACTION

> /* NAME DATE ACTION

> * mikef 12/06/84 Added code to inform user that a parity
> * error happend.

> ; And ENABLE_PARITY

> ;

< assume cs:code, ds:nothing, es:nothing, ss:nothing

> push ax *F85F*

> in al,ControlC ; High two bits indicate parity.

> and al,0C0h ; Mask of low 6 bits.

> jz n_out ; It wasn't a parity interrupt!

> mov si,offset parity1_m ; System board message.

> rol al,1

> jc n_1

> mov si,offset parity2_m ; Expansion board message.

> n_1:

> call DRomString

> hlt

> n_out:

> pop ax *F874*

Source Module: pwrup0.src

<

<

< /*

< *

< * NAME DATE ACTION

> /* NAME DATE ACTION

> * mikef 9/18/84 Changed OK code to parallel port for mfg.

ROM BIOS

1.21

```
> * mikef      10/02/84  Changed int 18 trap to go to 'basic_trap'.
> * mikef      10/11/84  Added test to see if 8530 is really there.
> * mikef      11/20/84  Now executes internal HDU code before
> *              optional ROM checking.
> * mikef      12/07/84  Changed OK code to '3Fh' for mfg.
> * mikef      12/13/84  Added call to enable parity interrupt.
> * mikef      12/17/84  Added switch reading for indigenous HDU code.
```

```
>
> mov al,0Fh                *E2FB*    ;;
> out scc_ctl_a,al         ;; read register 15.
> in al,scc_ctl_a         ;;
> test al,1                ;;
> jnz i_no_sccs           *E303*    ;; LSB of rr15 is always 0.
>
```

```
> ; Call internal HDU init code.
```

```
> ;-----
```

```
> ;-----
```

```
> assume cs:code, ds:abs0, es:nothing, ss:stack_ram
```

```
> xor ax,ax                *E33D*    ; satisfy assumptions
> mov ds,ax
```

```
> in al,sys_conf_b        ;; port 67h.
> test al,4                ;; test switch bit 2
> jnz i_hdu_ok            ;; if set, skip init
```

```
> mov si,cs:(offset i_hdu_m)
> call DRomString         ; print test message
```

```
> call h_init
```

```
> assume cs:code, ds:data, es:nothing, ss:stack_ram
```

```
> mov ds,word ptr cs:[set_ds_word] ; satisfy assumptions
> cmp byte ptr ds:[hf_num],0       ; number of hard disks.
> jnz i_hdu_ok                    ; if ok, leave everything alone.
```

```
> mov sp,100h                    ; re-initialize stack
> cli                            ; disable interrupts
> call i_vector                  ; re-install old vectors
> sti                            *E363*
```

```
> i_hdu_ok:
```

```
> ;-----
```

```
> ;-----
```

```
> ; HDU Test
```

```
> ;-----
```

```
> ;-----
```

```
< assume cs:code, ds:abs0, es:nothing, ss:stack_ram
```

```

<
<   xor  ax,ax           ; satisfy assumptions
<   mov  ds,ax
<
< ; Check int 41h to see if any one installed a HDU parameter table
pointer.
<
<   mov  ax,word ptr ds:[(4*41h)+0000h]
<   or   ax,word ptr ds:[(4*41h)+0002h]
<   jnz  i_hdu_ok       ; if so, let them be...
<
< ; If not, call HDU initialization routine.
<
<   mov  si,cs:(offset i_hdu_m)
<   call DRomString     ; print test message
<
<   call h_init
<
<   assume  cs:code, ds:data, es:nothing, ss:stack_ram
<
<   mov  ds,word ptr cs:[set_ds_word] ; satisfy assumptions
<   cmp  byte ptr ds:[hf_num],0       ; number of hard disks.
<   jnz  i_hdu_ok                     ; if ok, leave everything alone.
<
<   mov  sp,100h                      ; re-initialize stack
<   cli                               ; disable interrupts
<   call i_vector                     ; re-install old vectors
<
< i_hdu_ok:
<
>   call DCrLf                        *E3BE*  ;;
<
< ; and al,10111100b                 ; p_timer & kb & dsk at this point.
<
<   assume  cs:code, ds:abs0, es:nothing, ss:stack_ram
<
<   xor  ax,ax
<   mov  ds,ax
<   mov  word ptr ds:[int18locn+0000h],cs:(offset bt_int)
<   mov  word ptr ds:[int18locn+0002h],cs ; (ROM BASIC not
available)
<
< ; Initialize & enable NMI's (parity register).
<
<   mov  dx,p_kctrl
<   in  al,dx
<   or  al,030h                ; enable bits #5 & #4
<   out dx,al

```

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```
<   mov  al,80h                ; OK status
---
>   mov  al,3Fh                *E49E*        ; OK status

Source Module:      pwrup1.src

> * mikef      09/18/84  Put in org for reset vector.
> * mikef      12/10/84  Added parity stuff.
> * mikef      01/08/85  Clear the screen before printing messages.

<       db  'Rev 1.1',CR,LF,LF
---
>       db  'Rev 1.20',CR,LF,LF

>   or   cx,cx                *DD68*        ;; if zero then it was a parity error.
>   jnz  i_d_e                ;;
>   mov  si,cs:(offset parity1_m) *DD6C*    ;;
> i_d_e:                ;;

>   mov  ax,3                *DD2B*        ; mode co80
>   int  10h                *DD2B*        ; Clear screen.
>

> skip_parity:

<       assume  cs:code, ds:data, es:abs0, ss:stack_ram
<
>   ORG  0E05Bh                ;;
>
> i_hard_reset proc                ;;
>   jmp  diagnostics_1        ;;
> i_hard_reset endp            ;;
>

<   push ds                    ; save registers
---
> ;; Here is the code for putting the DEB in Transparent Mode.

>   push ax                    *E05E*
>   push dx
>   mov  dx,03DDh              ;; DEB I/O Address Register port address
>   mov  al,1                  ;; select Mode Control Register
>   out  dx,al
>
>   inc  dx                    ;; DEB Mode Control Register address
>   inc  dx
>   dec  al                    ;; set DEB Transparent Mode
>   out  dx,al                ;;
>   pop  dx
>   pop  ax                    *E06C*
```

```

>   push ds                ; save registers
>
<   mov  al,cl              ; get data from switches.
---
>   in   al,sys_conf_a     *E0B4*      ; Read port 66h.
>   and  al,010h           ; Keep 80B7 bit only.
>   shr  al,1              ; Move to bit one.
>   shr  al,1
>   shr  al,1
>   or   al,cl             *E0BE*      ; get data from switches.
> ; NOTE:                  If CX is zero and ZF is nz then parity error occurred.
>
> ;; Toggle parity latch
> in   al,p_kctrl         *E1A1*      ;; read B port. (61h)
> or   al,30h             ;; toggle bits 4 & 5.
> out  p_kctrl,al         ;;
> and  al,0CFh           ;;
> out  p_kctrl,al         *E1A9*      ;;
>

```

Source Module: pwrup4.src

```

< /*
< *
< * NAME DATE      ACTION
---
> /* NAME DATE      ACTION
> * mikef      12/06/84  Added 'enable_parity'
>
>
> enable_parity   proc                ;;
>
>   push ax                *E5C5*
>   in   al,p_kctrl        ;; read B port. (61h)
>   or   al,30h            ;; enable bits 4 & 5.
>   out  p_kctrl,al        ;;
>   and  al,0CFh          ;;
>   out  p_kctrl,al        ;;
>   mov  al,nmi_enable     ;; 80h.
>   out  nmi_enable_port,al ;; defined in sysdata.src (A0h)
>   pop  ax                ;;
>   ret                    ;;
>
> parity1_m      db  'Parity error on system board',NUL ;;
> parity2_m      db  'Parity error on expansion board',NUL ;;
>                *E61C*
> enable_parity  endp                ;;

```

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Source Module: sysdata.src

```
< ControlB equ 062h ; 8087, etc.
---
> ControlC equ 062h ; bit #7: Ram parity check.
> ; bit #6: I/O channel parity check.
> ; bit #1: 8087 installed

< ; bits #3 - #2: reserved for HDU type
---
> ; bit #3 not defined.
> ; bit #2 - 0 = use indiginous HDU code.
> ; 1 = do not use indiginous HDU code.

> nmi_enable equ 80h
> nmi_enable_port equ 0A0h
```

Source Module: vector.src

```
< dw bt_int ; int18locn (We Don't Have BASIC!)
---
> dw basic_trap ; int18locn see int18.src
```

Source Module: vid.src

```
< /*
< *
< * NAME DATE ACTION
---
> /* NAME DATE ACTION

> * mikef 10/25/84 Added code in scroll up to enable video.
> * mikef 02/13/85 Moved grf_light_pen from graph.src to here.

> mov dx,03D8h *F356* ;; video enable register.
> out dx,al *F359* ;; enable video.

< ; We didn't disable display during vertical retrace...
---
> ; We didn't disable display during vertical retrace...but enable it
anyway.
>
>
> ;=====
> ;
> ; Read Light Pen function code = 04h
> ;
> ; Input: None.
> ; Output: ah = 0 light pen switch not down/not triggered
> ; ah = 1 implies:
> ; (dh,d1) = (row,col) of character light pen
> ; position from (0,0)
> ; ch = raster line (0-199)
> ; bx = pixel column (0-319,0-639)
```

```
> ;  
> ; Trash:  None.  ???  
> ;  
> ;-----  
>  
> grf_light_pen      proc near  
>     xor  ah,ah      ; return ah = 0 for now (al intact)...  
>     ret  
>  
> grf_light_pen      endp
```



9

MS-DOS Device Drivers

- **Overview**
- **MS-DOS Device Drivers**
- **Asynchronous Communications Element**
- **DMA Controller**
- **Floppy Diskette Interface and Controller**
- **Hard Disk Controller**
- **Keyboard Interface**
- **Parallel Printer Interface**
- **Programmable Interrupt Controller**
- **Programmable Interval Timer**
- **Real Time Clock and Calendar**
- **Serial Communications Controller**
- **Speaker**
- **Video Controller**

Overview

Interested Audience

This section contains information on how to write device drivers. You may not use it often since many input and output capabilities are implemented by the BIOS routines discussed in Section 6. BIOS routines allow you to do general input and output without a detailed understanding of the hardware and shield your program from hardware changes.

However, there are times when BIOS routines do not perform the necessary function or do so in an inefficient fashion. Then your own driver is necessary. Implementation of operating systems, of high speed graphics packages, and of unusual keyboard mapping are examples of software which require specialized drivers.

Programmable Devices

This is a list of programmable devices.

INS	8350B	Asynchronous Communications Element
INTEL	8237A	DMA Controller
NECE	uPD765	Floppy Diskette Controller
DTC	5150BX	Hard Disk Controller
INTEL	8041	Keyboard Interface
INTEL	8259A	Programmable Interrupt Controller
INTEL	8253	Programmable Interval Timer
	58174A	Real Time Clock and Calendar
AMD	Z8530	Serial Communications Controller
		Speaker Interface
HD	6845	Video Controller

Port Addresses

A port is a place to read or write information to an I/O device. An I/O device is hardware which the CPU controls. It is both input and output peripherals as well as hardware such as the DMA controller, the Interrupt controller and the Interval Timer. Each device needs different information, but they all need some combination of control, status, and data.

Each port has an address. Sixteen of the twenty possible address lines are available for I/O addressing. This means there are 65,535 possible port addresses.

I/O Instructions

IN and OUT instructions distinguish an I/O access from a memory access. These instructions translate into control signals which define the direction and path of the data.

The port address can be specified in one of two ways — fixed or variable. In the fixed method, the absolute port address is specified in the instruction. The following instruction is an example of fixed port addressing:

```
OUT 020H, AL
```

Only 8-bit port addresses can be used in this format.

The variable method allows 16-bit port addresses to be specified. In this case, the port address is loaded into the DX register and then the DX register is used in the I/O instruction. An example of variable port addressing follows:

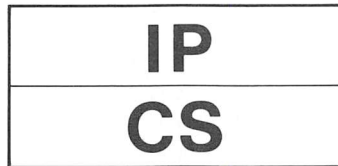
```
MOV DX,03F2H  
OUT DX,AL
```

Interrupts

External devices do not need the CPU's attention all the time. When they need servicing, they ask for it either by interrupting or by setting a polled flag. External interrupts are ignored when the CLI instruction has cleared the interrupt enable flag and are recognized when the STI instruction has set the flag.

The first 1024 bytes of memory contain an interrupt table. This table has 255 interrupt pointers defining the start address of interrupt service routines. This is the pointer format.

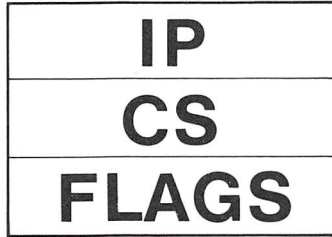
INTERRUPT POINTER



When the CPU recognizes the interrupt, an 8-bit interrupt type identifies the device. The interrupt type is an index into the table of pointers. To obtain the interrupt pointer address, the type is multiplied by four. The CPU saves the flag register on the stack, disables interrupts and single step mode, and saves the CS and IP registers on the stack. Then the interrupt pointer is loaded into IP and CS, and control is transferred to the interrupt service routine. The stack looks like this when the service routine gets control.

Interrupt Devices

SYSTEM STACK



When the service routine begins, interrupts are disabled. Depending on the nature of the application, interrupts can be enabled immediately or just prior to releasing control.

The service routine must preserve the value of all internal registers. Therefore it saves the registers it uses on the stack. Before returning, it restores these registers from the stack.

To return control to the interrupt program, the service routine executes IRET. All the information necessary to do this was carefully placed on the stack

Interrupt Devices

INS	8250B	Asynchronous Communications Element
INTEL	8237A	DMA Controller
NEC	uPD765	Floppy Diskette Controller
DTC	5150BX	Hard Disk Controller
INTEL	8041	Keyboard Interface
INTEL	8259A	Programmable Interrupt Controller
INTEL	8253	Programmable Interval Timer
	58174A	Real Time Clock and Calendar
AMD	Z8530	Serial Communications Controller

Block Diagrams

Block diagrams are a pictorial description of the electrical connection between the CPU, the interface, and the external device. In general, the CPU's bus signals appear on the left. The middle of the diagram describes the internals of the interface. The right side of the diagram describes the electrical interface. This physically connects the interface to the external device. The connection is often through a dual inline package (DIP) of pins. Each pin carries one signal.

Individual signals are represented by lines. Busses are shown as double lines. Each of these have arrows which indicate the direction of the data. Often they are bidirectional.

There are several common CPU control bus signals. Their mnemonics and definitions follow:

- **A0-A19**
These are the lines used to transmit the address of memory or the address of an I/O port. Only A0-A15 are used for I/O addressing.
- **CS**
This signal selects the chip. No reading or writing will occur unless the device is selected.
- **D0-D7**
These are the bidirectional data lines used to exchange information with a memory location or an I/O port. D7 is the most significant bit.
- **INT0-INT7**
These are the priority interrupt request lines. See the description of the Interrupt Controller.

-
- **IORD**
This signal indicates that an input port address has been placed on the address bus. The data at the specified port is to be placed on the data bus.
 - **IOWR**
This signal indicates that an output port address has been placed on the address bus and the data has been placed on the data bus to be output to the specified port.
 - **RESET**
This signal resets the system to a predetermined state.

MS-DOS Device Drivers

What Is a Device Driver?

A device driver is binary code which manipulates hardware in the MS-DOS environment. A special header at the beginning identifies it as a driver, defines the strategy and interrupt entry points, and describes various attributes of the device. The file must have an origin of zero.

There are two kinds of devices:

- Character devices
- Block devices

Character devices perform serial character I/O like CONSOLE, AUXILIARY, and PRINTER. These devices are named and users open channels to do I/O to them.

Block devices are the disk drivers on the system. They perform random I/O in pieces called blocks. This is usually the physical sector size. These devices are not named as the character devices are, and cannot be opened directly. Instead they are identified by drive letters (A:,B:,C:, etc.).

Drive letters are assigned to device drivers based on their ordering in the CONFIG.SYS file. Starting with the letter 'A', each device driver is assigned as many consecutive alphabetic characters as the driver has units. The theoretical limit is 63, but after 26 the drive letters are non-alphabetic (such as] and ^).

Character devices cannot define multiple units because they have only one name.

Device Headers

A device header is required at the beginning of a device driver. A device header looks like this:

<p>DWORD pointer to next device (Must be set to -1)</p>
<p>WORD attributes Bit 15 = 1 if char device, 0 if blk if bit 15 is 1 Bit 0 = 1 if current sti device Bit 1 = 1 if current sto device Bit 2 = 1 if current NUL device Bit 3 = 1 if current CLOCK dev Bit 4 = 1 if special Bits 5-12 Reserved; must be set to 0 Bit 14 is the IOCTL bit Bit 13 is the NON IBM FORMAT bit</p>
<p>WORD pointer to device strategy entry point</p>
<p>WORD pointer to device interrupt entry point</p>
<p>8-BYTE character device name field Character devices set a device name. For block devices the first byte is the number of units</p>

The strategy and interrupt routines are in the same segment as this device header.

**Pointer to
Next Device
Field**

The pointer to the next device header field is a double word field, offset followed by segment. MS-DOS chains the device headers together using this field. If you have a single device header in your driver, initialize this field to -1. If you have more than one device header, the first word of the double word pointer is the offset of the next driver's Device Header.

**Attribute
Field**

The attribute field is used to tell the system whether this device is a block or character device (Bit 15). Most other bits are used to give selected character devices special treatment and are meaningless on a block device. For example, assume that you have a new standard input and output device driver. Besides installing the driver, you must tell MS-DOS that you want this new driver to override the current standard input and standard output device. This is accomplished by setting the attributes to the desired characteristics, so you set Bits 0 and 1 to 1. Similarly, a new CLOCK device could be installed by setting the appropriate attribute. Although there is a NUL device attribute, it is reserved for MS-DOS.

The NON PC-DOS FORMAT bit applies only to block devices and affects the operation of the BUILD BPB (Bios Parameter Block) device call. The implementation of all block devices is PC-DOS software and hardware compatible.

The IOCTL bit is meaningful for both types of devices. This bit tells MS-DOS whether the device can handle control strings with the IOCTL system call, Function 44H.

If a driver cannot process control strings, this bit is 0. MS-DOS returns an error if an attempt is made to handle control strings. A device which can process control strings sets the IOCTL bit to 1. For drivers of this type, MS-DOS calls IOCTL INPUT and OUTPUT device functions to send and receive IOCTL strings.

The IOCTL functions allow data outside of the normal user's reads and writes to be sent to the driver. The interpretation of this information is up to the driver.

Strategy and Interrupt Routines

These two fields are the entry points of the strategy and interrupt routines. They are word values and they must be in the same segment as the Device Header.

Name Field

This 8-byte field contains the name of a character device or the number of units of a block device. If it is a block device, the number of units can be put in the first byte. This is optional because MS-DOS fills in this location with the value returned by the driver's INIT code.

How to Create a Device Driver

To create a device driver, write a binary file with a Device Header at the beginning of the file. The code originates at 0.

MS-DOS always processes installable device drivers before handling the default devices. To install a new CON device, simply name the device CON. Remember to set the standard input device and standard output device bits in the attribute word on the new CON device. The scan of the device list stops on the first match, so the installable device driver takes precedence.

MS-DOS installs the driver anywhere in memory; therefore, be careful with memory references. Do not expect the driver to be loaded in the same place.

Installation of Device Drivers

MS-DOS allows new device drivers to be installed dynamically at boot time. This is accomplished by INIT code in the BIOS which processes the CONFIG.SYS file.

At load time, DOS searches the root directory for a file named CONFIG.SYS. Declare the files containing your device drivers using the DEVICE command.

```
DEVICE = [C:] [path] filename [.ext]
```

DOS loads your drivers as an extension of itself. Include a separate DEVICE command for each driver to be loaded.

Request Header

When MS-DOS calls a device driver to perform a function, it passes a Request Header in ES:BX to the strategy entry point. This is a fixed length header followed by data pertinent to the operation being performed. It is the device driver's responsibility to preserve the machine state. For example, save all registers on entry and restore them on exit. There is enough room on the stack when strategy or interrupt is called to do about 20 pushes. If more stack is needed, the driver sets up its own stack.

The following figure illustrates a Request Header.

REQUEST HEADER ->

0	BYTE length of record (the length in bytes of pertinent data, plus the length of this Request Header)
1	BYTE unit code The subunit the operation is for (minor device) (no meaning on character devices)
2	BYTE command code
3	WORD status
5	8 bytes RESERVED

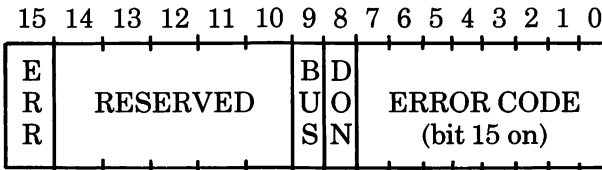
Unit Code

If your device driver has three units, then the possible values of the unit code field are 0, 1, and 2.

Command Code Field The command code field in the Request Header can have the following values:

Command Code	Function
0	INIT
1	MEDIA CHECK (Block only, NOP for character)
2	BUILD BPB
3	IOCTL INPUT (Only called if device has IOCTL)
4	INPUT (Read)
5	NON-DESTRUCTIVE INPUT NO WAIT (Char devices only)
6	INPUT STATUS
7	INPUT FLUSH
8	OUTPUT (Write)
9	OUTPUT (Write) with verify
10	OUTPUT STATUS
11	OUTPUT FLUSH
12	IOCTL OUTPUT (Only called if device has IOCTL)

Status Word The following figure illustrates the status word in the Request Header.



The status word is set by the driver interrupt routine.

Bit 8 is the done bit. When set, it means the operation is complete.

Bit 15 is the error bit. If it is set, then the low 8 bits indicate the error. The errors are:

- 0 Write protect violation
- 1 Unknown Unit
- 2 Drive not ready
- 3 Unknown command
- 4 CRC error
- 5 Bad drive request structure length
- 6 Seek error
- 7 Unknown media
- 8 Sector not found
- 9 Printer out of paper
- A Write fault
- B Read Fault
- C General failure

Bit 9 is the busy bit which is set only by status calls.

- For output on character devices:
If bit 9 is 1 on return, a write request waits for completion of a current request. If it is 0, there is no current request and a write request starts immediately.
- For input on character devices with a buffer:
If bit 9 is 1 on return, a read request goes to the physical device. If it is 0 on return, then there are characters in the device buffer and a read returns quickly. MS-DOS assumes all character devices have an input type-ahead buffer. Devices that do not have a type-ahead buffer return busy=0 so that MS-DOS does not wait for non-existent buffer input.

**Media Check
and Build
BPB**

MEDIA CHECK and BUILD BPB are used with block devices only. MS-DOS calls MEDIA CHECK first for a drive unit and passes its current media descriptor byte. MEDIA CHECK returns one of the following results:

- Media Not Changed — current DPB and media byte are OK.
- Media Changed — Current DPB and media are wrong. MS-DOS invalidates buffers for this unit and calls the device driver to build the BPB.
- Not Sure — If there are dirty buffers for this unit, MS-DOS assumes the DPB and media byte are OK. If nothing is dirty, MS-DOS assumes the media has changed. It invalidates buffers for the unit and calls the device driver to build the BPB.
- Error — If an error occurs, MS-DOS sets the error code.

MS-DOS calls BUILD BPB under the following conditions:

- If Media Changed is returned
- If Not Sure is returned and there are no dirty buffers

Init Routine

The Init Routine is called only once when the device is installed. It returns a location DS:DX which is a pointer to the first free byte of memory after the device driver. To save space, this pointer method can be used to delete initialization code that is only used once.

Additional information that block drivers return is:

- The number of units
- A pointer to a BPB
- The media decriptor

The number of units determines the logical device names. This mapping is determined by the position of the driver in the device list and by the number of units on the device.

BPB blocks are used to build an internal MS-DOS data structure for each of the units. The driver passes MS-DOS a pointer to an array of n word BPB pointers, where n is the number of units. If all units are the same, they can share a BPB to save space. This array must be before the free space pointer since MS-DOS builds an internal DOS structure starting at this free byte. The defined sector size must be less than or equal to the maximum sector size defined at INIT time; otherwise, the install fails.

The media descriptor byte means nothing to MS-DOS. It is passed to drivers so that they know what parameters MS-DOS is currently using for a drive unit.

Block devices are either dumb or smart. A dumb device defines a unit and an internal DOS structure for each possible media drive combination. For example, unit 0 = drive 0 single side, unit 1 = drive 0 double side. In this case, media descriptor bytes mean nothing.

A smart device allows multiple media per unit. In this case, the BPB table returned by INIT defines space large enough to accommodate the largest possible media supported. Smart drivers use the media descriptor byte to pass information about the media currently in a unit.

Function Call Parameters

Strategy routines are called with ES:BX pointing to the Request Header. The interrupt routines get the pointers to the Request Header from the queue that the strategy routines store them in. The command code in the Request Header tells the driver which function to perform.

All DWORD pointers are stored offset first, then segment.

INIT

Command code = 0

INIT - ES:BX ->

		13-BYTE Request Header
0D	13	BYTE # of units
0E	14	DWORD break address
10	16	DWORD pointer to BPB array (Not set by character devices)

The number of units, break address, and BPB pointer are set by the driver. On entry, the DWORD points to the character after the '=' on the line in CONFIG.SYS. This allows drivers to scan the CONFIG.SYS invocation line for arguments.

If there are multiple device drivers in a single .COM file, the ending address returned by the last INIT is the one MS-DOS uses. All of the device drivers in a single .COM file return the same ending address.

Media Check Command Code = 1

MEDIA CHECK - ES:BX ->

13-BYTE	Request Header
BYTE	media descriptor from DPB
BYTE	returned

In addition to setting the status word, the driver sets the return byte to one of the following:

- 1 Media has been changed
- 0 Don't know if media has been changed
- 1 Media has not been changed

If the driver can return -1 or 1 because it has a door-lock or other interlock mechanism, MS-DOS performance is enhanced because MS-DOS does not need to reread the FAT for each directory access.

**Build BPB
(BIOS
Parameter
Block)**

Command code = 2

BUILD BPB - ES:BX ->

13-BYTE Request Header
BYTE media descriptor from DPB
DWORD transfer address (Points to one sector worth of scratch space or first sector of FAT depending on the value of the NON PC-DOS FORMAT bit)
DWORD pointer to BPB

If the NON PC-DOS FORMAT bit is 1, then the DWORD transfer address points to a sector scratch buffer.

If the NON PC-DOS FORMAT bit is 0, then this buffer contains the first sector of the first FAT and the driver must not alter this buffer.

The first sector of the first FAT must be located in the same sector for all media. This is because the FAT sector is read BEFORE the media is actually determined. Use this mode to read the FAT ID byte.

In addition to setting status word, the driver must set the pointer to the BPB on return.

To allow different OEMs to read each other's disks, the information relating to the BPB for the media is kept in the boot sector of the media. The format of the boot sector is:

	3 BYTE near JUMP to boot code
	8 BYTES OEM name and version
B P B	WORD bytes per sector
	BYTE sectors per allocation unit
	WORD reserved sectors
	BYTE number of FATs
	WORD number of root dir entries
	WORD number of sectors in logical image
	BYTE media descriptor
	WORD number of FAT sectors
	WORD sectors per track
	WORD number of heads
WORD number of hidden sectors	

Sectors per track, number of heads, and number of hidden sectors are optional. They are intended to help the BIOS understand the media. Sectors per track may be redundant since it can be calculated from total size of the disk. Number of heads supports different multi-head drives with the same storage capacity but a different number of surfaces. Number of hidden sectors supports drive-partitioning schemes.

**Media
Descriptor
Byte**

The last two digits of the FAT ID byte are called the media descriptor byte. Currently, the media descriptor byte has been defined for a few media types.

Bit	Meaning
0	1 = 2 sided; 0 = not 2 sided
1	1 = 8 sector; 0 = not 8 sector
2	1 = removable; 0 = not removable
3-6	must be set to 1
7	1 = not 80 track; 0 = 80 track
5 1/4" disks:	
FEh	160K
FCh	180K
FFh	320K formatted single sided
FDh	360K formatted single sided
7Dh	720K
HDU:	F8h

Although these media bytes map directly to FAT ID bytes which must be F8-FF, media bytes can, in general, be any value in the range 0-FF.

**Read or
Write**

Command codes = 3,4,8,9, and 12

READ or WRITE - ES:BX (Including IOCTL) ->

C	13-BYTE Request Header
D	BYTE media descriptor from DPB
E	DWORD transfer address
12	WORD byte/sector count
12)	WORD starting sector number (Ignored on character devices)

In addition to setting the status word, the driver must set the sector count to the actual number of sectors (or bytes) transferred. No error check is performed on an IOCTL I/O call. The driver must set the return sector (byte) count to the actual number of bytes transferred.

A user program can not request an I/O of more than FFFFH bytes and cannot wrap around in the transfer segment.

**Non
Destructive
Read No
Wait**

Command code = 5

NON DESTRUCTIVE READ NO WAIT -
ES:BX ->

13-BYTE Request Header
BYTE read from device

If the character device returns busy bit = 0 (characters in buffer), then the next character that would be read is returned. This character is not removed from the input buffer, hence the term Non Destructive Read. Basically, this call allows MS-DOS to look ahead one input character.

Status Command codes = 6 and 10

STATUS Calls - ES:BX ->

13-BYTE Request Header

The driver sets the status word and the busy bit as follows:

- For output on character devices:
If bit 9 is 1 on return, a write request waits for completion of a current request. If it is 0, there is no current request and a write request starts immediately.
- For input on character devices with a buffer:
A return of 1 means a read request goes to the physical device. If it is 0 on return, then there are characters in the device's buffer and a read returns quickly. A return of 0 also indicates that the user has typed something. MS-DOS assumes that all character devices have an input type-ahead buffer. Devices that do not have a type-ahead buffer return busy = 0 so that the DOS does not wait for something to get into a non-existent buffer.

Flush

Command codes = 7 and 11

FLUSH Calls - ES:BX ->

13-BYTE Request Header

The FLUSH call tells the driver to terminate all pending requests. This call is used to flush the input queue on character devices.

Clock Device

One of the special enhancements for the Safari-3 is the battery-backed 58174A clock-calender chip and related driver. This chip is integrated into the system as the CLOCK device and is accessed with the TIME and DATE command.

This CLOCK device defines and performs functions like any other character device. When a read or write to this device occurs, exactly 6 bytes are transferred. The first two bytes are the count of days since 1-1-80. The third byte is minutes, the fourth, hours, the fifth, hundredths of seconds, and the sixth, seconds.

Reading the CLOCK device gets the date and time; writing to it sets the date and time.

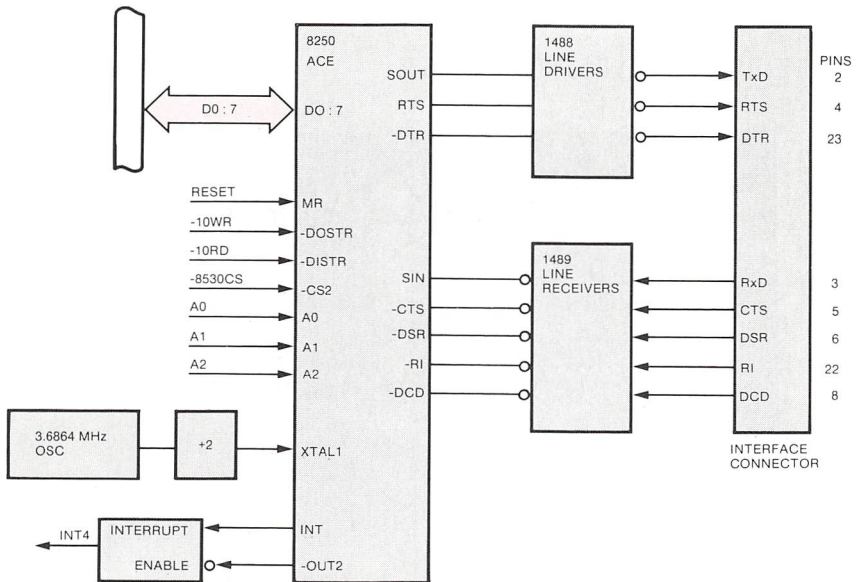
Asynchronous Communications Element

Functional Description

The Asynchronous Communications Element (ACE) performs serial-to-parallel conversion on input data characters received from a modem and parallel-to-serial conversion on output data characters received from the CPU. You can read the status of transfer operations at any time. This device gives you modem control capability.

The baud rate and serial interface characteristics are programmable. The ACE has a software-tailored interrupt system whose interrupt request is on INT4.

Block Diagram

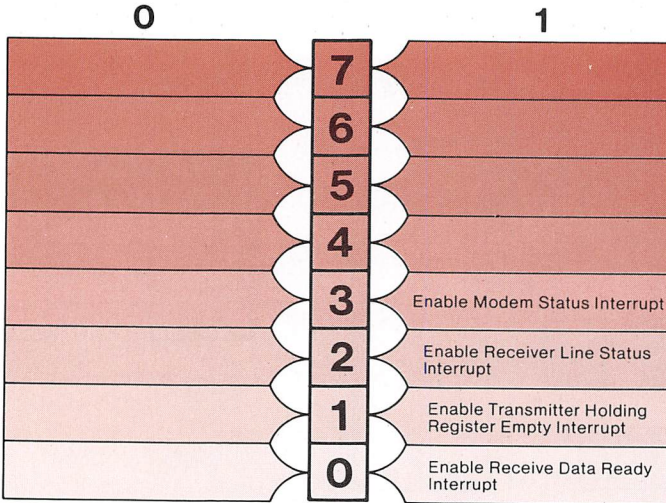


Registers

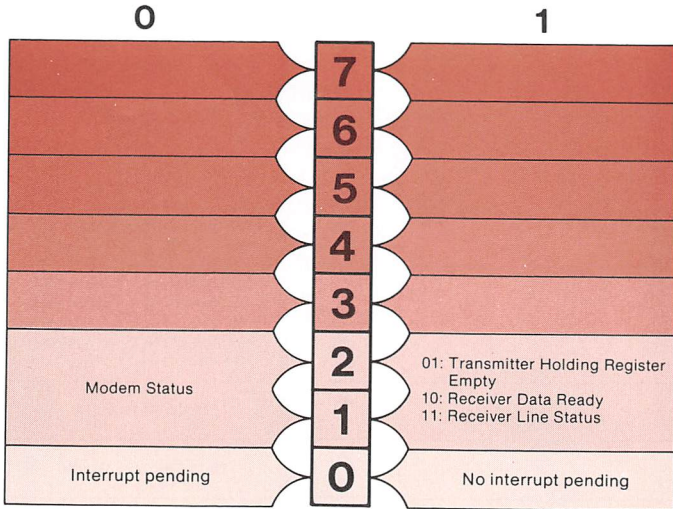
PORT A	NAME B	READ/ WRITE	DESCRIPTION
3F8	2F8 DATA	R/W	Receive Buffer, Transmitter Holding Register
3F9	2F9 INTERRUPT ENABLE	W	See layout
3FA	2FA INTERRUPT IDENTIFICATION	R	See layout
3FB	2FB LINE CONTROL	R/W	See layout
3FC	2FC MODEM CONTROL	R/W	See layout
3FD	2FD LINE STATUS	R	See layout
3FE	2FE MODEM STATUS	R/W	See layout
3FF	2FF SCRATCH	R/W	Scratch pad register
3F8	2F8 DIVISOR LATCH	W	Least significant byte
3F9	2F9 DIVISOR LATCH	W	Most significant byte

Layout

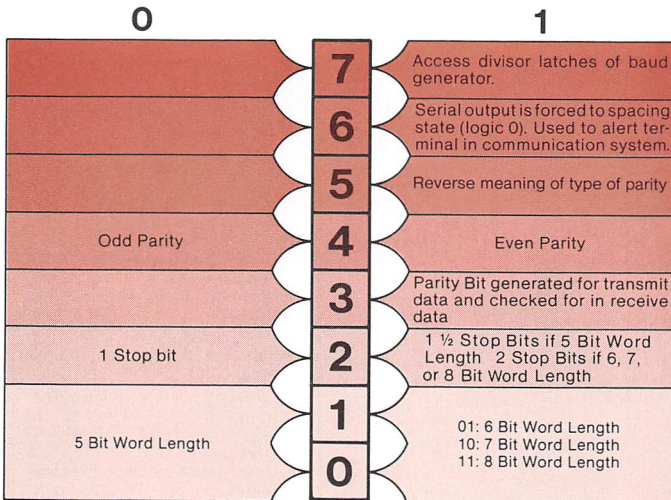
INTERRUPT ENABLE REGISTER



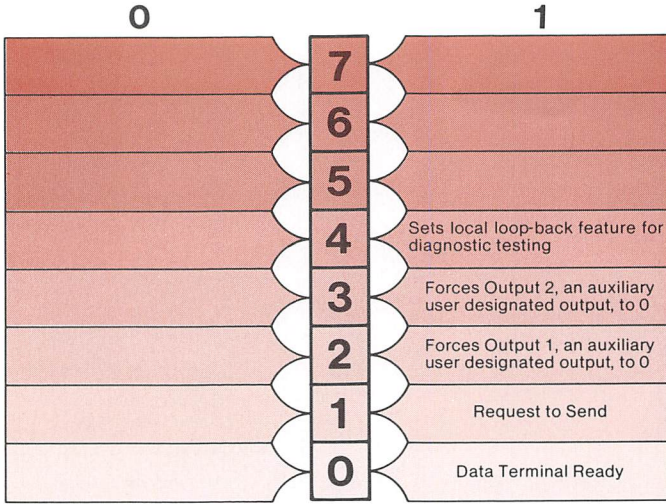
INTERRUPT IDENTIFICATION REGISTER



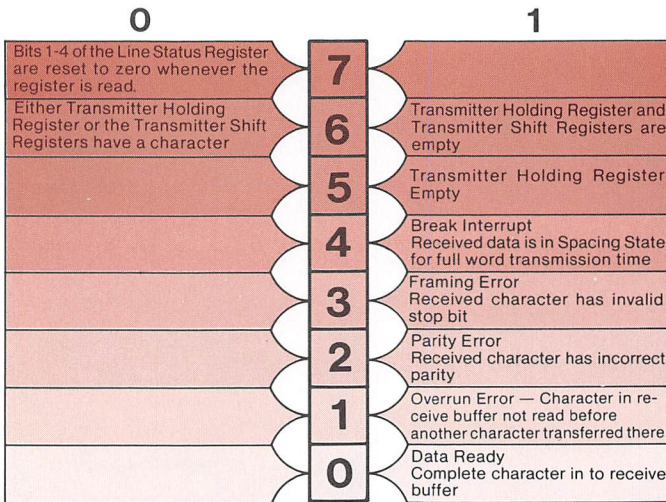
LINE CONTROL REGISTER



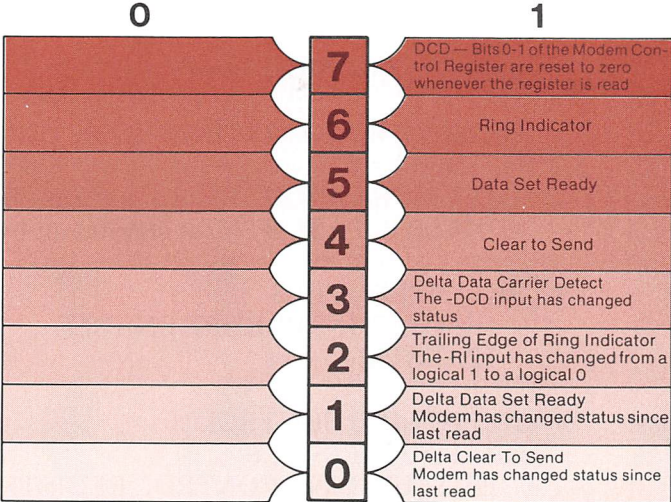
MODEM CONTROL REGISTER



LINE STATUS



MODEM STATUS REGISTER



- Functions**
- IDENTIFY INTERRUPTS
INPUT: INTERRUPT IDENTIFICATION REGISTER
 - READ LINE STATUS
INPUT: LINE STATUS REGISTER
 - READ MODEM STATUS
INPUT: MODEM STATUS REGISTER
 - RECEIVE CHARACTER
INPUT: DATA
 - SEND CHARACTER
OUTPUT: DATA

- **SET BAUD RATE**
To set the baud rate, you load the divisor which yields the correct rate ($16 \times \text{divisor} = \text{clock frequency (1.8432 MHz) / \text{baud rate} \times 16$)

OUTPUT: LINE CONTROL REGISTER
BIT 7 = 1
DIVISOR LATCH - Least significant byte
DIVISOR LATCH - Most significant byte
- **SET INTERRUPTS**
OUTPUT: INTERRUPT ENABLE REGISTER
- **WRITE LINE CONTROL CHARACTERISTICS**
OUTPUT: LINE CONTROL REGISTER
- **WRITE MODEM CONTROL CHARACTERISTICS**
OUTPUT: MODEM CONTROL REGISTER

Sequencing and Timing

To transmit a character, first issue a Request to Send and Data Terminal Ready to the Modem Control Register. Then wait for the Modem Status to have Data Set Ready and Clear to Send set. When the Transmitter Holding Register is empty as indicated in the Line Status Register, write the character to the data register.

To receive a character, set Data Terminal Ready in the Modem Control Register. Then wait for Data Set Ready in the Modem Status Register. When Data Ready in the Line Status Register is set, input the character from the data register.

The following table states the divisors to use to obtain a given baud rate.

BAUD RATES USING 1.8432 MHz CLOCK

BAUD RATE	DIVISOR
110	1047
150	768
300	384
600	192
1200	96
1800	64
2000	58
2400	48
3600	32
4800	24
7200	16
9600	12

If you wish to use the break control feature to alert a terminal in a communication system, the following sequence assures that no erroneous or extraneous characters are transmitted.

- Load an all 0's pad character into the transmitter holding register.
- Set break when the transmitter holding register is empty.
- Wait for transmitter empty (Bit 6 = 1 in Line Status Register) and clear break.

Note that the transmitter operates normally during a break sequence and can be used as a character timer to establish an accurate break length.

If the ACE is programmed to interrupt, the interrupt is on INT4. The ACE acknowledges the highest priority interrupt as indicated in this chart. The Interrupt Identification Register states which interrupt is pending.

TYPE	SOURCE	— RESET
Receiver Line Status	Overrun Error	Read Line Status Register
	Parity Error	
	Framing Error	
	Break Interrupt	
Received Data Ready	Receive Data Ready	Read data
Transmitter Holding Register Empty	Transmitter Holding Register Empty	Write data
Modem Status	Clear To Send	Read Modem Status Register
	Data Set Ready	
	Ring Indicator	
	Data Carrier Detect	

**Sample
Program**

;This program sets the baud rate to 1200 baud
LINE_CTL EQU 3FB
DVSRL EQU 3F8
DVSRM EQU 3F9

SET_BAUD:

MOV AL,080H ;access divisor
MOV DX,LINE_CTL ;latch
OUT DX,AL

MOV AX,096 ;divisor for 1200 baud
MOV DX,DVSR_L
OUT DX,AL ;least significant byte

MOV DX,DVSR_M
MOV AL,AH
OUT DX,AL ;most significant byte

XOR AL,AL ;turn off access to latch
MOV DX,LINE_CTL
OUT DX,AL
RET

DMA Controller

Functional Description

The DMA controller allows devices to transfer data directly to and from memory without CPU involvement. It has four channels.

Channel 0 has the highest priority and is used to refresh memory. The Interval Timer is programmed to periodically request a dummy DMA transfer. This creates a memory read cycle which refreshes memory.

Channel 1 is available on the I/O expansion bus to support high speed transfer between I/O devices and memory. Channel 3 has the lowest priority.

Channel 3 is dedicated to the hard disk controller. Channel 2 is dedicated to the floppy disk controller.

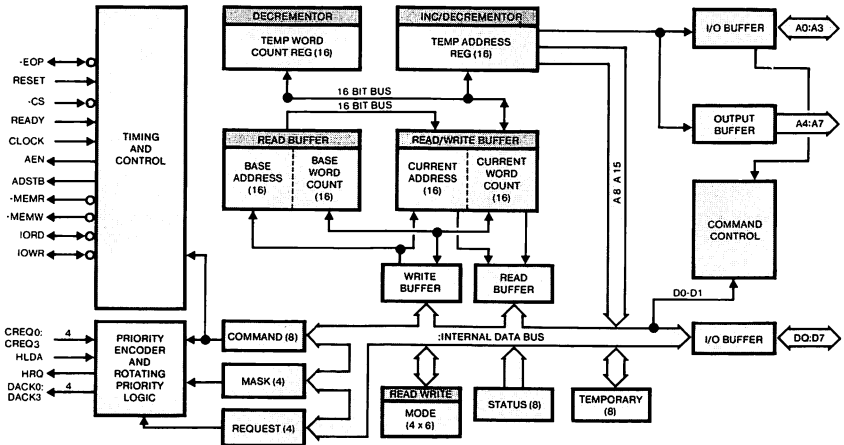
The DMA controller has four transfer modes. Single transfer mode makes only one transfer. Block transfer mode continues transferring until the count goes from 0 to FFFFH. Demand transfer allows transfers to continue until the I/O device has exhausted its capacity. The cascade mode allows more than one DMA controller to be used and is not applicable in the AT&T Personal Computer 6300.

When autoinitialize is requested, the original values of the Current Address and Current Count registers are restored at the end of the operation.

The DMA controller has two types of priority schemes. The fixed scheme bases the priority on the descending value of their numbers. In this scheme, Channel 3 has the lowest priority. The second scheme is rotating priority. The last channel to get service becomes the lowest priority channel.

Compressed Timing allows greater throughput by compressing the transfer time into two clock cycles.

Block Diagram



Registers

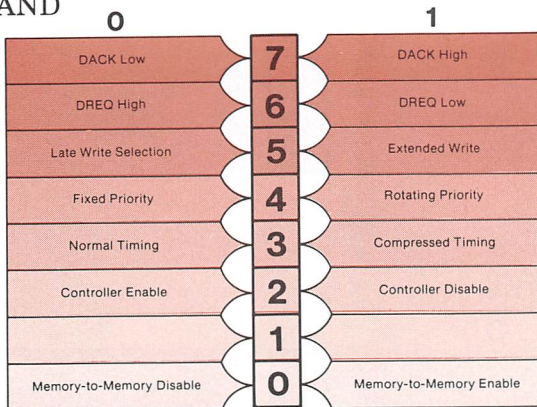
PORT	NAME	READ/ WRITE	DESCRIPTION
0	CHANNEL 0 ADDRESS	W	16 bit address
1	CHANNEL 0 COUNT	W	1's complement of # of bytes to transfer
0	CHANNEL 0 CURRENT ADDRESS	R	16 bit address
1	CHANNEL 0 CURRENT COUNT	R	1's complement of # of bytes to transfer
2	CHANNEL 1 ADDRESS	W	16 bit address
3	CHANNEL 1 COUNT	W	1's complement of # of bytes to transfer
2	CHANNEL 1 CURRENT ADDRESS	R	16 bit address
3	CHANNEL 1 CURRENT COUNT	R	1's complement of # of bytes to transfer
4	CHANNEL 2 ADDRESS	W	16 bit address
5	CHANNEL 2 COUNT	W	1's complement of # of bytes to transfer
4	CHANNEL 2 CURRENT ADDRESS	R	16 bit address
5	CHANNEL 2 CURRENT COUNT	R	1's complement of # of bytes to transfer
6	CHANNEL 3 ADDRESS	W	16 bit address
7	CHANNEL 3 COUNT	W	1's complement of # of bytes to transfer
6	CHANNEL 3 CURRENT ADDRESS	R	16 bit address
7	CHANNEL 3 CURRENT COUNT	R	1's complement of # of bytes to transfer
8	STATUS	R	See layout
8	COMMAND	W	See layout
9	REQUEST	W	See layout
A	SINGLE MASK	W	See layout
B	MODE	W	See layout
C	CLEAR FLIP/FLOP	W	Execute prior to read or write of address or count
D	TEMPORARY	R	Contains last byte of memory-to-memory transfer

Registers

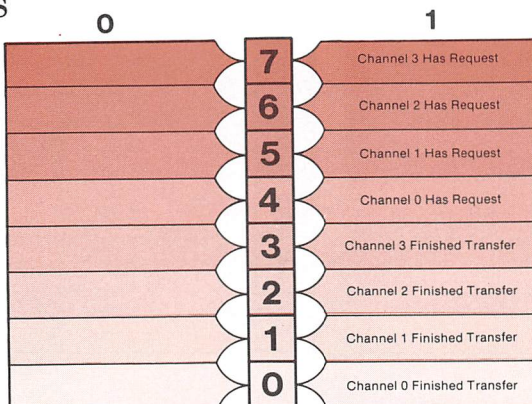
D	MASTER CLEAR	W	Any write clears controller
E	CLEAR MASK	W	Clear mask, all channels accept DMA commands
F	WRITE ALL MASK	W	See layout
80	CHANNEL 0 SEGMENT	W	Address segment nybble
82	CHANNEL 1 SEGMENT	W	Address segment nybble
81	CHANNEL 2 SEGMENT	W	Address segment nybble
83	CHANNEL 3 SEGMENT	W	Address segment nybble

Layout

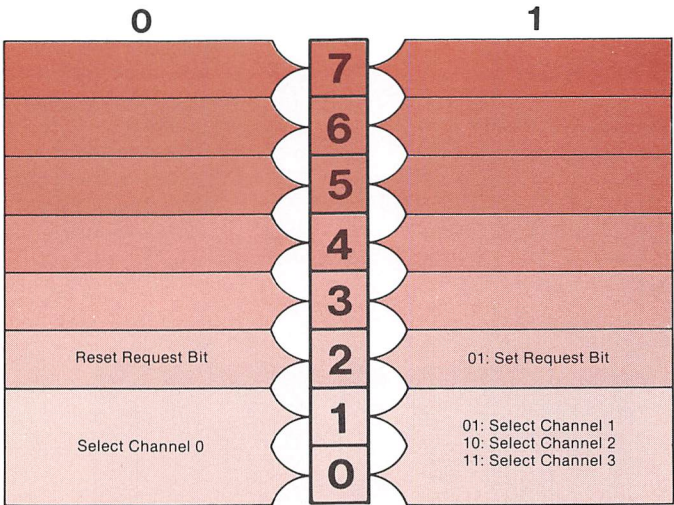
COMMAND



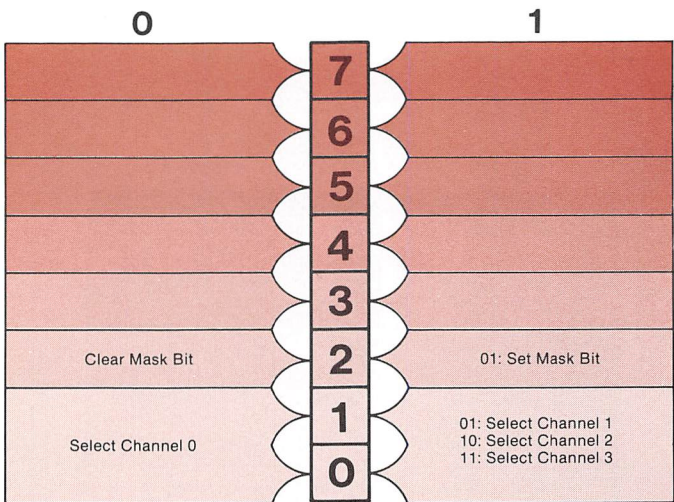
STATUS



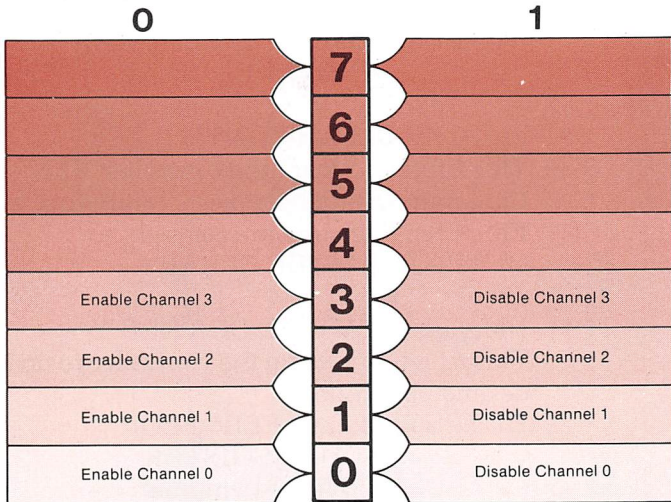
REQUEST REGISTER



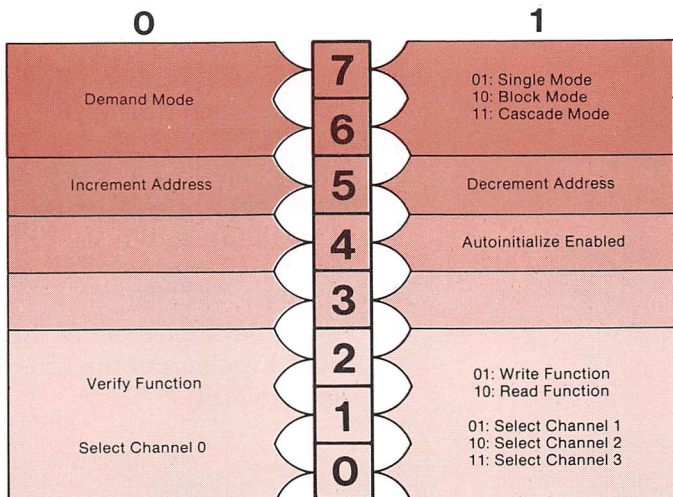
MARK REGISTER



WRITE ALL MASK REGISTER



MODE



Functions

- **DISABLE CONTROLLER**
This function disables the controller.
OUTPUT: COMMAND REGISTER
BIT 2 = 1

- **MASTER CLEAR CONTROLLER**
This function clears the controller. The Command, Status, Request, Temporary and Flip/Flop Registers are cleared.
OUTPUT: MASTER CLEAR

- **DMA READ, WRITE OR VERIFY**
This function sets up the controller to do the desired operation.
OUTPUT: CLEAR FLIP/FLOP
MODE REGISTER
BITS 0-1 channel
BITS 2-3 function
BIT 4 autoinitialize
BIT 5 address increment or decrement
BITS 6-7 mode
ADDRESS REGISTER
16 BIT address, first output the LSB and then the MSB
SEGMENT NYBBLE
One nybble. The significant nybble of the segment register is in bits 12-15. Rotate to Bits 0-3 before output.
COUNT REGISTER
16 bit 1's complement of the # of bytes. First output the LSB and then the MSB.

-
- **REQUEST DMA SERVICE**
This is a software request for DMA services.
OUTPUT: REQUEST REGISTER
 - **READ STATUS**
This function reads the channel status.
INPUT: STATUS REGISTER
 - **WRITE COMMAND REGISTER**
This function controls the operation of the DMA controller.
OUTPUT: COMMAND REGISTER
 - **WRITE ALL MASK REGISTER**
This function enables and disables automatic DMA transfer for all channels.
OUTPUT: WRITE ALL MASKS REGISTER
 - **WRITE MASK REGISTER**
This function enables and disables automatic DMA transfers for a channel.
OUTPUT: MASK REGISTER
 - **WRITE MODE REGISTER**
This function specifies the mode for the specified channel.
OUTPUT: MODE REGISTER
 - **CLEAR MASKS**
This function clears all the masks so that all channels accept DMA commands.
OUTPUT: CLEAR MASK REGISTER

Sequencing and Timing

When the system is powered-up, it is recommended that all mode registers be set with valid data even if the channel is not used.

Before loading the address and count registers, disable the controller (BIT 2 of COMMAND REGISTER) or mask the channel. This prevents erroneous transfers before a complete address is loaded.

A write to the Clear Flip/Flop sets the controller so that an access to an address or count is to the upper and lower byte in the correct sequence.

Sample Program

```

;This program initializes an unused channel
;at start-up
COMMAND      EQU 8
MODE         EQU B
INIT_CHAN:
    MOV AL,04H           ;disable controller
    OUT COMMAND,AL
    MOV AL,041H         ;channel 1, verify, inc.
                        ;addr
    OUT MODE,AL         ;single mode
    RET                 ;now setup other
                        ;channels

```

Floppy Diskette Interface and Controller

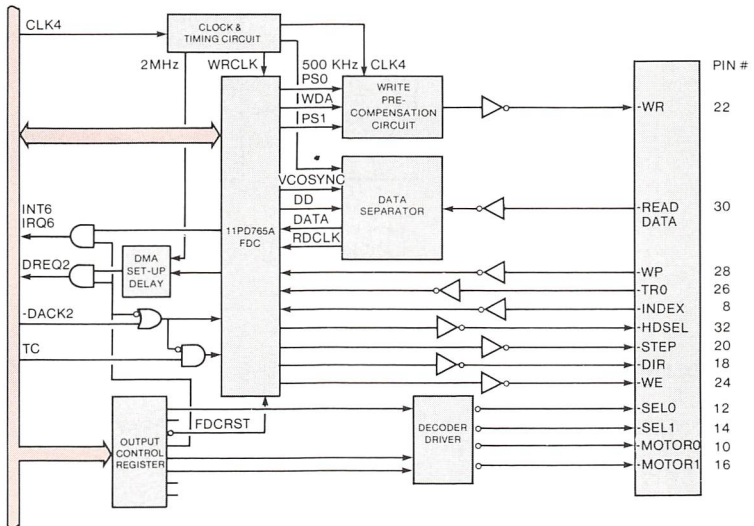
Functional Description

The diskette interface and NEC uPD765 controller read and write 5 1/4 inch diskettes on as many as two drives. Single density (FM) or double density (MFM) formats are supported. Single density diskettes contain 163,840 bytes and double density diskettes contain 327,680 bytes.

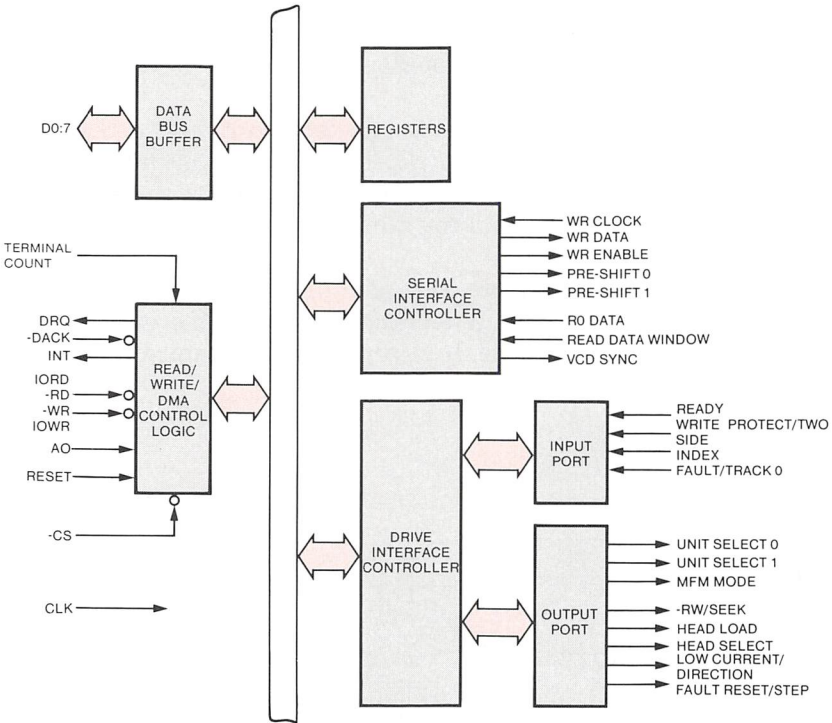
Each sector on the diskette contains an ID field and the Data field. The ID field contains the cylinder number, the head number, the sector number and the number of bytes per sector.

The diskette controller performs 15 separate functions. It operates in either DMA or non-DMA mode. Interrupts can be enabled on INT6.

Block Diagrams



Floppy Diskette Interface and Controller

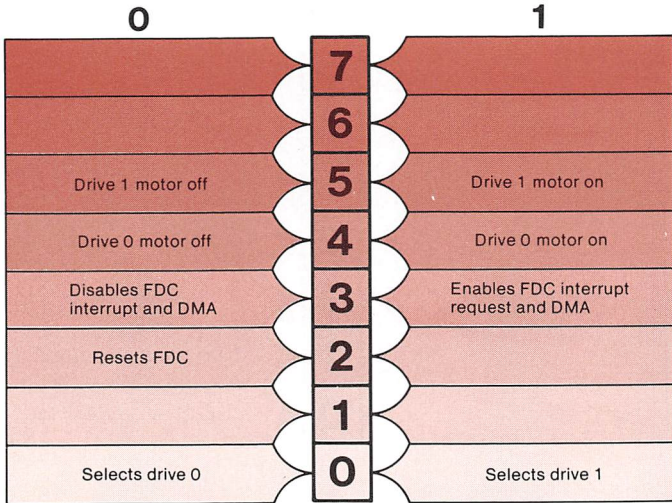


Registers

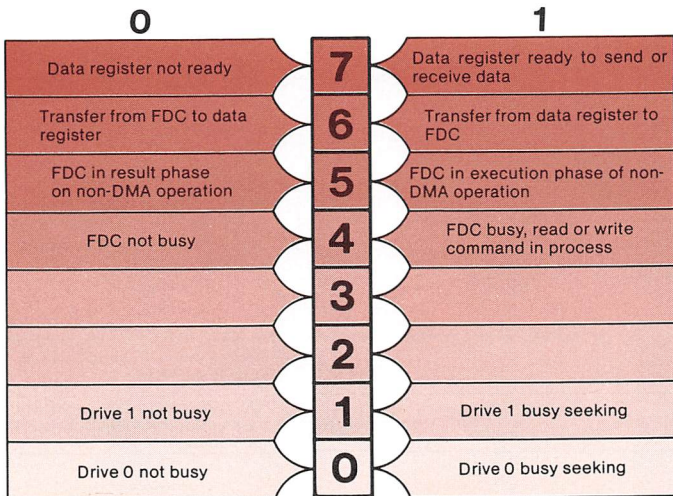
PORT NAME	READ/ WRITE	DESCRIPTION
3F2 INTERFACE OUTPUT CONTROL	W	See layout
3F4 FDC MAIN STATUS REGISTER	R	See layout
3F5 FDC DATA	R/W	Transfers data, commands, parameters, and status

Layout

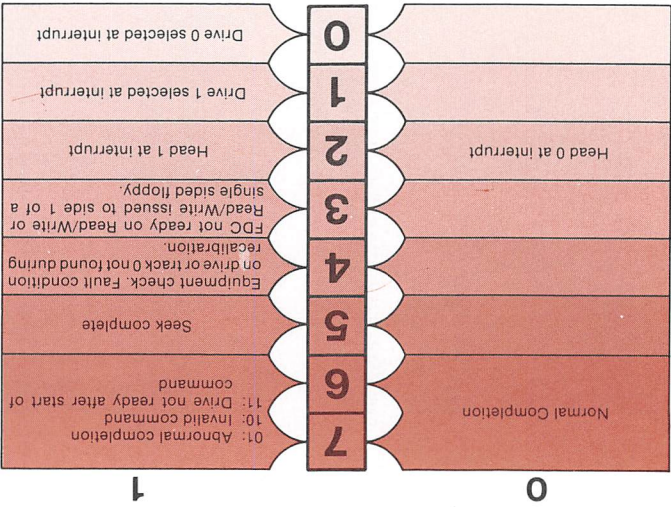
INTERFACE OUTPUT CONTROL



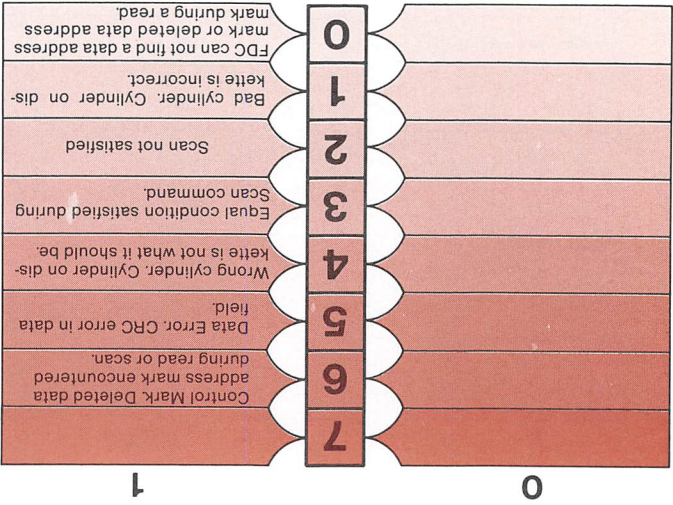
FDC MAIN STATUS REGISTER (MSR)



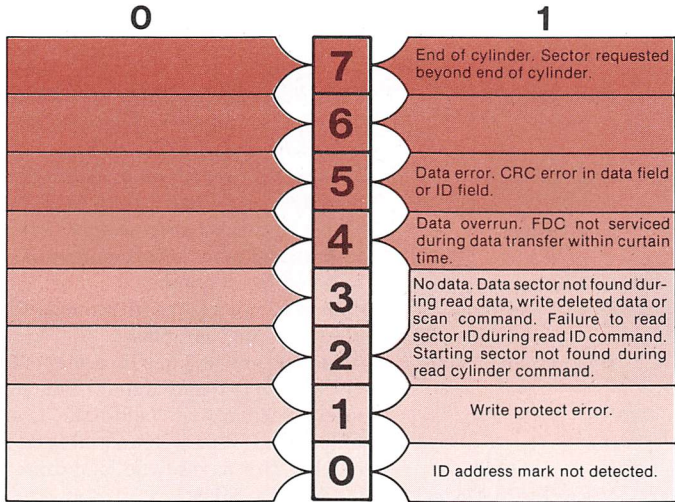
STATUS REGISTER 0



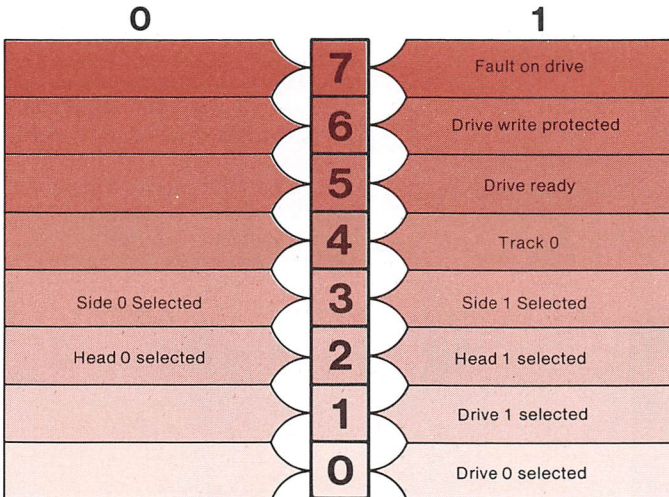
STATUS REGISTER 1



STATUS REGISTER 2



STATUS REGISTER 3



Parameters

SYMBOL	NAME	DESCRIPTION
DTL	Data Length	Only applies when there are 128 bytes per sector. If so, number of bytes to read or write. Otherwise, DTL = FF.
EOT	End of Track	Last sector number on cylinder. If there are 8 sectors per cylinder, then EOT = 8.
GPL	Gap Length	Gap 3 length between sectors. Different for format and read/write commands.
HD	Head	Selected Head number.
HLT	Head Load Time	4ms to 508ms in 4ms increments for 8Mhz clock. In this case, 4ms.
HUT	Head Unload Time	0ms to 480ms in 32ms increments for 8Mhz clock. This is the amount of time to wait after a read or write before the heads are unloaded. If a new command is issued quickly, this saves head load time.
MF	MF or MFM Mode	0 = MF, 1 = MFM
MT	Multi-track	MT = 1, multi-track operation. After completing an operation on side 0, the FDC continues on side 1.
N	Number of bytes/ sector	0 = 128 bytes, 1 = 256 bytes, 2 = 512 bytes 3 = 1024 bytes
ND	Non-DMA	0 = DMA mode, 1 = non-DMA mode
SRT	Step Rate Time	32ms to 2ms in 2 ms increments for 8Mhz clock. This is the amount of time to move the head from track to track. At 48 TPI, SRT = 6 ms. At 96 TPI, SRT = 4ms.
ST0-ST3	Status Registers	See layout
STP	Scan Test Flag	STP = 1, sector by sector compare STP = 2, alternate sectors
US0,US1	Unit Select	USx = 0, drive not selected USx = 1, drive selected

Functions • **FORMAT A TRACK**

This function formats an entire track. The ID Field for each sector is supplied by the programmer during the execution phase.

OUTPUT:

0	MF	0	0	1	1	0	1
---	----	---	---	---	---	---	---

0	0	0	0	0	HD	US1	US0
---	---	---	---	---	----	-----	-----

Number of bytes/sector

Sector/track

Gap Length

Filler Byte

EXECUTION: Sector ID Field transfer

INPUT: Status Register 0

Status Register 1

Status Register 2

Cylinder

Head

Sector

Number of bytes/sector

POSSIBLE

ERRORS: Equipment check, and not ready

- READ DATA

This function reads data from the diskette.

OUTPUT:

MT	MF	SK	0	0	1	1	0
0	0	0	0	0	HD	US1	US0

Cylinder

Head

Sector

Number of bytes/sector

End of Track

Gap Length

Data Length

EXECUTION: Data Transfer

INPUT: Status Register 0

Status Register 1

Status Register 2

Cylinder

Head

Sector

Number of bytes/sector

POSSIBLE

ERRORS: No data, data error, data error
in data field, and control mark

- **READ DELETED DATA**
This function reads deleted data.

OUTPUT:

MT	MF	SK	0	1	1	0	0
0	0	0	0	0	HD	US1	US0

Cylinder
Head
Sector
Number of bytes/sector
End of Track
Gap Length
Data Length

EXECUTION:

INPUT:

Data Transfer
Status Register 0
Status Register 1
Status Register 2
Cylinder
Head
Sector
Number of bytes/sector

- **READ ID**
This function reads the first correct sector ID field.

OUTPUT:

0	MF	0	0	1	0	1	0
0	0	0	0	0	HD	US1	US0

EXECUTION:

INPUT:

Status Register 0
Status Register 1
Status Register 2
Cylinder
Head

POSSIBLE
ERRORS:

Sector
Number of bytes/sector

Missing address mark and
no data

- READ TRACK

This function reads all data fields from the index hole to EOT. The FDC continues reading even if it finds a CRC error in the ID or data fields.

OUTPUT:

0	MF	SK	0	0	0	1	0
0	0	0	0	0	HD	US1	US0

EXECUTION:

INPUT:

POSSIBLE
ERRORS:

Cylinder
Head
Sector
Number of bytes/sector
End of Track
Gap Length
Data Length

Status Register 0
Status Register 1
Status Register 2
Cylinder
Head
Sector
Number of bytes/sector

No data, data error and missing
address mark

- **RECALIBRATE**

This function positions the head to head 0, cylinder or track 0.

OUTPUT:

0	0	0	0	0	1	1	1
0	0	0	0	0	0	US1	US0

EXECUTION: Head repositioned

POSSIBLE

ERRORS: Equipment check

- **SCAN EQUAL**

This function scans for an equal data compare.

OUTPUT:

MT	MF	SK	1	0	0	0	1
0	0	0	0	0	HD	US1	US0

Cylinder

Head

Sector

Number of bytes/sector

End of track

Gap Length

Contiguous or alternate sectors

EXECUTION: Data transfer

INPUT: Status Register 0

Status Register 1

Status Register 2

Cylinder

Head

Sector

Number of bytes/sector

- **SCAN LOW OR EQUAL**
This function scans for a low or equal data compare.

OUTPUT:

MT	MF	SK	1	1	0	0	1
0	0	0	0	0	HD	US1	US0

Cylinder

Head

Sector

Number of bytes/sector

End of track

Gap Length

Contiguous or alternate sectors

EXECUTION: Data transfer

INPUT: Status Register 0

Status Register 1

Status Register 2

Cylinder

Head

Sector

Number of bytes/sector

- **SCAN HIGH OR EQUAL**

This function scans for a high or equal data compare.

OUTPUT:

MT	MF	SK	1	1	1	0	1
0	0	0	0	0	HD	US1	US0

Cylinder

Head

Sector

Number of bytes/sector

End of track

Gap Length

Contiguous or alternate sectors

EXECUTION: Data transfer

INPUT: Status Register 0

Status Register 1

Status Register 2

Cylinder

Head

Sector

Number of bytes/sector

- **SEEK**

This function positions the head at the requested cylinder.

OUTPUT:

0	0	0	0	1	1	1	1
0	0	0	0	0	HD	US1	US0

New cylinder number

EXECUTION: Heads repositioned

- SENSE DRIVE STATUS

This function obtains the current drive status.

OUTPUT:

0	0	0	0	0	1	0	0
0	0	0	0	0	HD	US1	US0

INPUT:

Status Register 0

- SPECIFY

This function defines the drive parameters.

OUTPUT:

0	0	0	0	0	0	1	1
SRT				HUT			
HLT						ND	

- WRITE DATA

This function writes data.

OUTPUT:

MT	MF	0	0	0	1	0	1
0	0	0	0	0	HD	US1	US0

Cylinder

Head

Sector

Number of bytes/sector

End of Track

Gap Length

Data Length

EXECUTION: Data Transfer

INPUT: Status Register 0

Status Register 1

Status Register 2

Cylinder

Head

Sector

Number of bytes/sector

- **WRITE DELETE DATA**
This function writes deleted data.

OUTPUT:

MT	MF	0	0	1	0	0	1
0	0	0	0	0	HD	US1	US0

Cylinder
Head
Sector
Number of bytes/sector
End of Track
Gap Length
Data Length

EXECUTION:

INPUT:

Data Transfer
Status Register 0
Status Register 1
Status Register 2
Cylinder
Head
Sector
Number of bytes/sector

Sequencing and Timing

There are three phases to each function:

- command - The programmer writes the required information to the FDC.
- execution - The FDC performs the operation.
- result - The programmer reads the FDC's status.

Before any data can be read or written to the FDC the Main Status Register (MSR) must be read to determine the status of Bit 6 and Bit 7. In the command phase, Bit 6 must be 0 and Bit 7 must be 1. In the result phase both bits must be 1. You must wait 12 usec after a data read or write before reading the MSR.

In the command phases, all output must be written. The same is true in the result stage. All status information must be read.

During the execution phase, the FDC operates in DMA mode or non-DMA mode. In DMA mode, there is one interrupt at the end of the phase. In non-DMA mode, there is an interrupt after the transfer of each byte. In the format command, the ID field information for all the sectors in a track is sent to the FDC (cylinder, head, sector and bytes/sector). In DMA mode, 4 DMA requests per sector are issued. In non-DMA mode, there are 4 interrupts per sector. If interrupts cannot be handled every 13 ms in MFMM mode or every 27 ms in FM then the FDC is polled. When polling, Bit 7 in the MSR functions just like the interrupt.

When it is not executing a command, the FDC polls the drives looking for a change in drive ready. If there is a change, the FDC interrupts. You can determine the cause of the unexpected interrupt with the Sense Drive Status function.

The drive motors should be off when the drives are not in use. However, they must be on prior to a drive select.

During the execution phase of read and write commands, the following occurs:

- The heads are loaded if unloaded.
- The FDC waits for the head settle time to elapse.
- The FDC begins reading the ID address marks and ID field.
- When the requested sector number compares with the one on the diskette, the transfer begins.
- After completion of the transfer, the FDC waits the head unload time before unloading the heads.

The amount of data that can be transferred in one instruction depends on MT, MF, and N.

Multi-Track MT	MFM/FM MF	Bytes/Sector N	Maximum Transfer (Bytes/Sector)(Number of Sectors)
0	0	00	$128 * 26 = 3,328$
0	1	01	$256 * 26 = 6,656$
1	0	00	$128 * 52 = 6,656$
1	1	01	$256 * 52 = 13,312$
0	0	01	$256 * 15 = 3,840$
0	1	02	$512 * 15 = 7,680$
1	0	01	$256 * 30 = 7,680$
1	1	02	$512 * 30 = 15,360$
0	0	02	$512 * 8 = 4,096$
0	1	03	$1024 * 8 = 8,192$
1	0	02	$512 * 16 = 8,192$
1	1	03	$1024 * 16 = 16,384$

If a read or write terminates on error, then the values for cylinder, head, sector, and number of bytes per cylinder depends on the state of MT and EOT.

MT	HD	LAST SECTOR	ID INFORMATION IN RESULTS			
		TRANSFERRED EOT	C	H	S	N
0	0	Less than EOT	NC	NC	S+1	NC
0	0	Equal to EOT	C+1	NC	S=1	NC
0	1	Less than EOT	NC	NC	S+1	NC
0	1	Equal to EOT	C+1	NC	S=1	NC
1	0	Less than EOT	NC	NC	S+1	NC
1	0	Equal to EOT	NC	LSB	S=1	NC
1	1	Less than EOT	NC	NC	S+1	NC
1	1	Equal to EOT	C+1	LSB	S=1	NC

NC = No Change

LSB = Least Significant Bit

The Write Deleted Data is the same as Write Data except that the FDC writes a Deleted Data Address mark at the beginning of the Data Field instead of the normal Data Address Mark. When reading deleted data, the FDC sets the CM error in Status Register 2 and reads the data. A Read Data would not read the data. If SK = 1, then the FDC skips the sector with the Deleted Data Address mark and reads the next one.

The Gap Length is different for read, write, and format commands. This table suggests appropriate values.

FORMAT	SECTOR SIZE	N	SC	GPL(1)	GPL(2)
FM	128	00	12	07	09
FM	128	00	10	10	19
FM	256	01	08	18	30
FM	512	02	04	46	87
FM	1024	03	02	C8	FF
FM	2048	04	01	C8	FF
MFM	256	01	12	0A	0C
MFM	256	01	10	20	32
MFM	512	02	08	2A	50
MFM	1024	03	04	80	F0
MFM	2048	04	02	C8	FF
MFM	4096	05	01	C8	FF

GPL(1) - Suggested GPL in read and write commands

GPL(2) - Suggested GPL in format commands

The scan commands terminate when a scan condition is met, last sector on the track is reached, or a terminal count is received. The DMA issues the terminal count when it has no more data to send. This chart determines the result of the scan.

COMMAND	STATUS REGISTER 2		COMMENT
	BIT 2	BIT 3	
SCAN EQUAL	0	1	DISKETTE DATA = PROCESSOR DATA
SCAN EQUAL	1	0	DISKETTE DATA >< PROCESSOR DATA
SCAN LOW OR EQUAL	0	1	DISKETTE DATA = PROCESSOR DATA
SCAN LOW OR EQUAL	0	0	DISKETTE DATA < PROCESSOR DATA
SCAN LOW OR EQUAL	1	0	DISKETTE DATA > PROCESSOR DATA
SCAN HIGH OR EQUAL	0	1	DISKETTE DATA = PROCESSOR DATA
SCAN HIGH OR EQUAL	0	0	DISKETTE DATA > PROCESSOR DATA
SCAN HIGH OR EQUAL	1	0	DISKETTE DATA < PROCESSOR DATA

Scans allow the compare to be on contiguous sectors (STP = 1) or alternate sectors (STP = 2). However, for normal termination of the command the last sector on the track must be compared.

When a seek is requested, the FDC checks its current position and decides in which direction to move. Then step pulses are issued to move the heads. The speed of the pulse is controlled by the Step Rate Time in the Specify function. While the drive is seeking, the seek bit in the MSR is set. It must be cleared by Sense Interrupt Status at the completion interrupt. While a drive is seeking, the FDC is not busy. Another seek command to the other drive can be requested.

Interrupts occur as the result of:

- 1) Entering Result Phase of:
 - Read Data
 - Read Track
 - Read Deleted Data
 - Write Data
 - Write Deleted Data
 - Format Track
 - Scans
- 2) The execution phase in non-DMA mode
- 3) The Drive Ready line changing state
- 4) The end of Seek or Recalibrate

When the latter two occur, a Sense Drive Status determines the cause of the interrupt. It is mandatory to follow Seek and Recalibrate functions with a Sense Drive Status. This chart shows how to interpret the results of a Sense Drive Status.

STATUS REGISTER 0			CAUSE
BIT 5	BIT 6	BIT 7	
0	1	1	Ready line changed state
1	0	0	Normal termination of Seek or Recalibrate
1	1	0	Abnormal termination of Seek or Recalibrate

The Specify command defines internal timers. Head Unload Time (HUT) is programmable from 32ms to 480ms in increments of 32ms. Therefore 1 = 32ms, 2 = 64ms, and F = 480ms. The Step Rate Time is programmable from 2ms to 32ms in increments of 2ms. In this case, F = 2ms, E = 4ms, and 1 = 32ms. The Head Load Time is programmable from 4ms to 508ms in increments of 4ms. In this case, 1 = 4ms, 2 = 8ms, 7F = 508ms.

**Sample
Program**

```

;
; GET_RESULTS
;   This subroutine obtains a variable amount
;   of status information in the result phase.
; INPUT: ES:DI points to the area that receives
;   the status bytes
;
NEC_STATUS    EQU 3F4

GET_RESULTS:
    MOV CX,7           ;max. bytes in status

GET1:
    MOV DX, NEC_STATUS ;port address of MSR
    IN AL,DX           ;get MSR
    TEST AL,080H       ;Data register ready to
                        ;send or receive
    JZ GET1            ;jump if not ready yet
    TEST AL,40H        ;direction bit
    JZ GET2            ;jump if wrong
                        ;direction
    INC DX              ;port addr of data
                        ;register
    IN AL,DX           ;get one byte of status
    STOSB              ;move it to status area
    DEC CX              ;maximum number
    JNZ GET1           ;jump if not max yet

GET2:RET

```

Hard Disk Controller

Functional Description

The DTC-5150BX hard disk controller reads and writes to a maximum of two standard 5 1/4" Winchester disk drives. A sector size of 256, 512, or 1024 bytes is selectable. The sectors can be interleaved in 16 different ways.

The hard disk controller operates in DMA or non-DMA mode. Interrupts can be enabled on INT5.

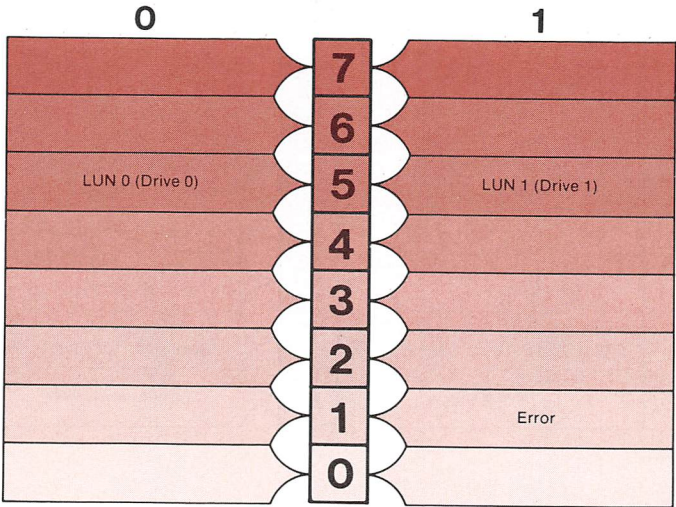
Extensive diagnostics are implemented. If a correctable data error is discovered, the error is automatically corrected using ECC.

Registers

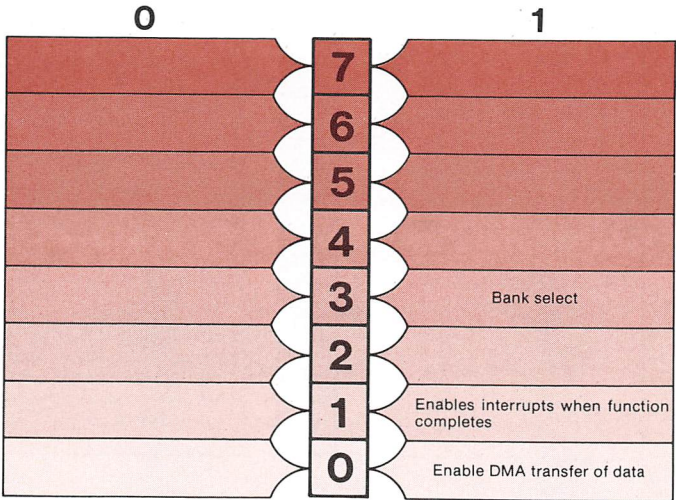
PORT #	NAME	READ/ WRITE	DESCRIPTION
320	COMPLETION STATUS REGISTER	R	See layout
320	DATA	R/W	Transfers data, function bytes, and controller sense bytes. See layout.
321	RESET CONTROLLER	W	Initialize Controller
321	STATUS	R	See layout
322	SELECT CONTROLLER	W	Select Controller
322	DRIVE TYPE	R	See layout
323	CONTROL REGISTER	W	See layout

Layout

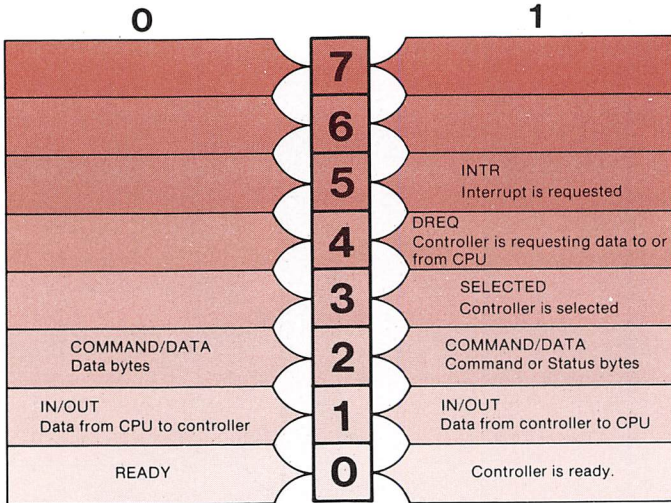
COMPLETION STATUS REGISTER



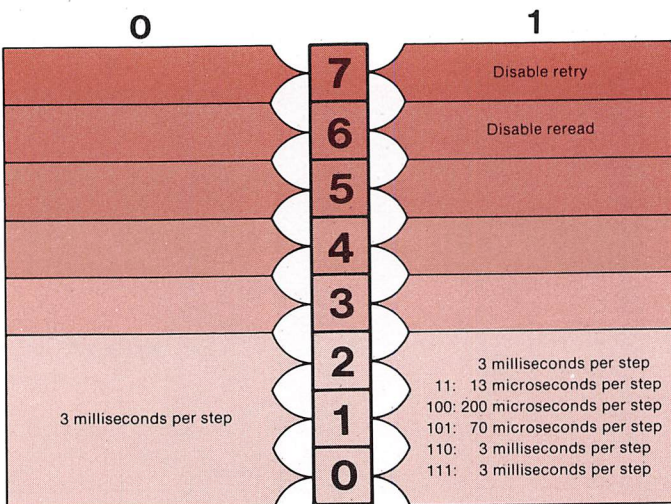
CONTROL REGISTER



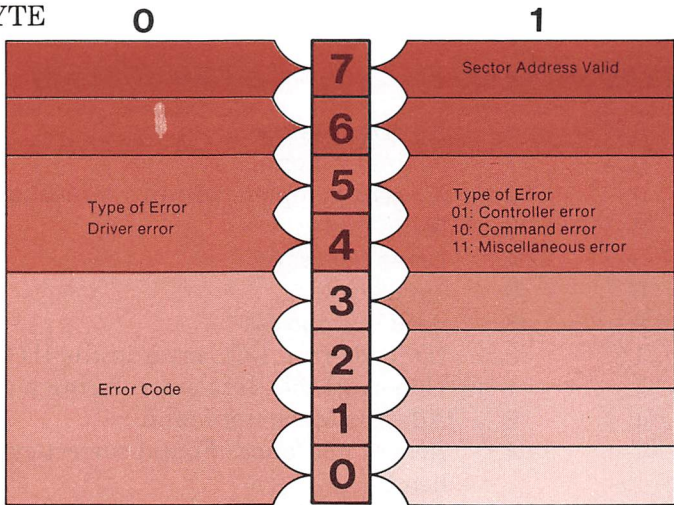
STATUS REGISTER



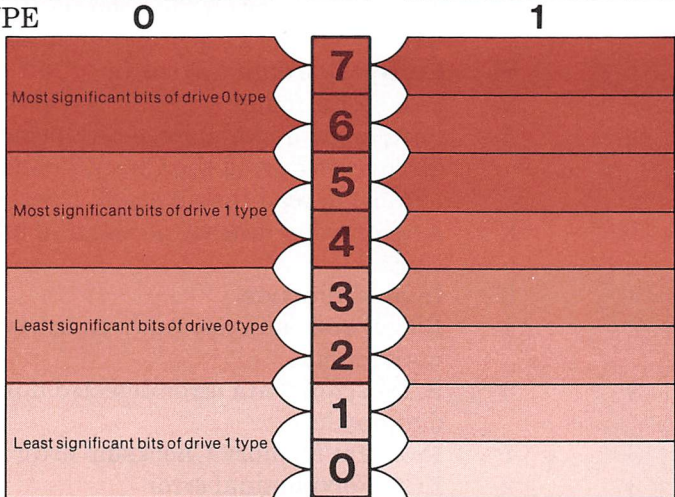
CONTROL COMMAND



SENSE BYTE



DRIVE TYPE



NUMBER

- 0
- 1
- 2
- 3
- 4
- 5

DRIVE TYPE

- 5 MB
- 24 MB
- 15 MB
- 10 MB
- SQ306
- CDC Wren

Error Codes

TYPE	CODE	DESCRIPTION
0	0	No error status
0	1	No index signal
0	2	No seek complete within 1.0 seconds
0	3	Write fault
0	4	Drive not ready
0	6	No track 0
0	8	Seek in progress
1	0	ID read error. ECC error in the ID field.
1	1	Uncorrectable data error during a read
1	2	Address Mark not found
1	4	Record not found. Found correct cylinder and head.
1	5	Seek error. Read/Write head positioned on wrong cylinder and/or wrong head selected.
1	8	Correctable data field error
1	9	Bad sector found
1	A	Format error. An unexpected format discovered during the Check Track function.
1	C	Unable to read the alternate track address
1	E	Attempted to directly access and alternate track
2	0	Invalid function
2	1	Illegal disk address. Address is beyond maximum.
3	0	RAM error. Data error detected during RAM diagnostic
3	1	Program Memory Checksum error
3	2	ECC Polynominal error

**Function
Parameters**

NAME	DESCRIPTION
CONTROL COMMAND	Tells controller how to react to an error condition and defines step mode. See layout.
CYLINDER LOW	Eight least significant bits of the cylinder number
CYLINDER HIGH	Two most significant bits of the cylinder number
ECC0,ECC1,ECC2	ECC bytes of sector. ECC0 is least significant byte.
HEAD #	Head number
LUN #	Logical Unit Number. Winchester Drive 1 = Lun 0, Winchester Drive 2 = Lun 1.
SECTOR #	Sector number
SENSE BYTE	Gives detailed error information. See layout.
TYPE	0 = good track, 1 = alternate track, 2 = bad track, 3 = alternate bad track

Functions • **ASSIGN ALTERNATE TRACK**

This function formats the primary track specified in the function block with the alternated and bad track flags set in the ID fields and with the track address of the alternate track written in the data fields. The data field is written with the data in the sector buffer.

Future read/write accesses to the primary track cause the drive to seek to the alternate track and to perform the operation there. This is transparent to the software. Alternate tracks can be assigned once. An alternate track cannot point to another alternate track.

OUTPUT:

7	6	5	4	3	2	1	0
							11
LUN			PRIMARY HEAD #				
CYL HI		0					
PRIMARY CYLINDER LOW							
INTERLEAVE							
CONTROL							

DATA
OUTPUT:

7	6	5	4	3	2	1	0
0	0	0	SECONDARY HEAD #				
CYL HI		0					
SECONDARY CYLINDER LOW							
0							

- CHECK TRACK**
This function checks the track format on the specified track for the correctness of the ID fields and the interleave of the sectors. It does not read the data.

OUTPUT:

7	6	5	4	3	2	1	0
							10
LUN				HEAD #			
CYL HI		0					
CYLINDER LOW							
INTERLEAVE							
CONTROL							

- CONTROLLER INTERNAL DIAGNOSTICS**
This function performs the controller internal diagnostics. The controller checks the internal processor, data buffer, ECC circuit and the checksum.

OUTPUT:

7	6	5	4	3	2	1	0
							E4
0							
0							
0							
0							
0							

- COPY**
This function transfers the data blocks from the source unit to the destination unit. The number of sectors to copy is specified in the number of blocks field. If the field is zero, 15,777,216 sectors are copied.

OUTPUT:

7	6	5	4	3	2	1	0
A0							
LUN/S				HEAD #/S			
CYL HI/S			SECTOR #/S				
CYLINDER LOW/S							
LUN/D				HEAD #/D			
CYL HI/D			SECTOR #/D				

CYLINDER LOW/D
OF BLOCKS 2
OF BLOCKS 1
OF BLOCKS 0
0
CONTROL

S = Source D = Destination

- DRIVE DIAGNOSTIC**
 This function performs a diagnostic on the specified unit. It reads sector 0 on sequential tracks and then reads sector 0 on 256 random tracks.

OUTPUT:

7	6	5	4	3	2	1	0
							E3
LUN			0				
0							
0							
0							
CONTROL							

- **FORMAT BAD TRACK**

This function formats the track with the bad block flag set in all ID fields. It fills the data field with the data pattern in the sector buffer. The interleave must be the same for the entire drive.

OUTPUT:

7	6	5	4	3	2	1	0
							7
LUN			HEAD #				
CYL HI		0					
CYLINDER LOW							
INTERLEAVE							
CONTROL							

- **FORMAT TRACK**

This function formats the specified track with no flags set in the ID fields. It fills the data field with the data pattern in the sector buffer. The interleave must be the same for the entire drive.

OUTPUT:

7	6	5	4	3	2	1	0
							6
LUN			HEAD #				
CYL HI		0					
CYLINDER LOW							
INTERLEAVE							
CONTROL							

- **FORMAT DRIVE**

This function formats all of the tracks starting with the one specified in the function block to the end of the drive. The selected track format is used. The sectors are placed on the tracks according to the interleave code. The data fields are filled with the data pattern from the sector buffer.

OUTPUT:

7	6	5	4	3	2	1	0
							4
LUN			HEAD #				
CYL HI		0					
CYLINDER LOW							
INTERLEAVE							
CONTROL							

- **INITIALIZE DRIVE CHARACTERISTICS**
This function sets up the drive with different capacities and characteristics.

OUTPUT:

7	6	5	4	3	2	1	0
							C
LUN				0			
0							
0							
0							
0							

DATA
OUTPUT:

MAX # OF CYLINDERS HIGH
MAX # OF CYLINDERS LOW
MAX # OF HEADS
REDUCED WR. CUR. CYLINDER HIGH
REDUCED WR. CUR. CYLINDER LOW
WRITE PRECOMP. CYLINDER HIGH
WRITE PRECOMP. CYLINDER LOW
MAX ECC DATA BURST LENGTH

- RAM DIAGNOSTIC**
 This function performs a data pattern test on the controller RAM.

OUTPUT:

7	6	5	4	3	2	1	0
							E0
							0
							0
							0
							0
							0

- READ**
 This function reads the specified number of blocks. The function specifies the initial sector address. The data is transferred to the CPU.

OUTPUT:

7	6	5	4	3	2	1	0
							8
LUN			HEAD #				
CYL HI		SECTOR #					
CYLINDER LOW							
# OF BLOCKS							
CONTROL							

- READ ECC BURST ERROR LENGTH**
 This function transfers one byte of data to the CPU. This byte contains the ECC burst length that the controller detected for the correctable ECC data error during the last read function.

OUTPUT:

7	6	5	4	3	2	1	0
							D
				0			
				0			
				0			
				0			
				0			

DATA
INPUT:

ECC BURST LENGTH

- **READ ID**
This function reads three bytes and three ECC bytes from the specified sector address given in the function block and transfers them to the CPU.

OUTPUT:

7	6	5	4	3	2	1	0
							E2
LUN				HEAD #			
CYL HI			SECTOR #				
CYLINDER LOW							
INTERLEAVE							
CONTROL							

DATA
INPUT:

7	6	5	4	3	2	1	0
CYLINDER LOW							
TYPE		CYL HI		HEAD #			
SECTOR #							
ECC 2							
ECC 1							
ECC 0							

- READ LONG**
 This function reads sectors of data and ECC bytes from the disk and transfers them to the CPU. If an ECC error occurs during the read, the controller does not attempt to correct the data.

OUTPUT:

7	6	5	4	3	2	1	0
							E5
LUN			HEAD #				
CYL HI		SECTOR #					
CYLINDER LOW							
# OF BLOCKS							
CONTROL							

DATA
INPUT:

256/512/1024	E	E	E	0
BYTES OF DATA	C	C	C	0
	2	1	0	

- READ SECTOR BUFFER**
 This function reads one sector from the controller sector buffer. No data transfer occurs between the controller and the drives.

OUTPUT:

7	6	5	4	3	2	1	0
							E
							0
							0
							0
							0
							0

- READ VERIFY**
 This function reads the specified number of blocks but does not transfer the data to the CPU. The function specifies the sector number where verification begins.

OUTPUT:

7	6	5	4	3	2	1	0
							5
LUN				HEAD #			
CYL HI				SECTOR #			
CYLINDER LOW							
# OF BLOCKS							
CONTROL							

- RECALIBRATE**
 This function positions the read/write arm at track 0 and clears errors in the drive.

OUTPUT:

7	6	5	4	3	2	1	0
							1
LUN			0				
							0
							0
							0
CONTROL							

- **REQUEST LOGOUT**

This function retrieves the four bytes of error log for the specified unit. Each device has its own error log which is incremented every time certain errors occur and is cleared after this function is executed.

OUTPUT:

7	6	5	4	3	2	1	0
							E7
LUN			0				
							0
							0
							0
							0

DATA
INPUT:

RETRY COUNT HIGH
RETRY COUNT LOW
PERMANENT ERROR HIGH
PERMANENT ERROR LOW

- REQUEST SENSE
This function sends the four Sense Bytes to the CPU as data.

OUTPUT:

7	6	5	4	3	2	1	0
							3
LUN			0				
							0
							0
							0
							0

DATA
INPUT:

7	6	5	4	3	2	1	0
SENSE BYTE							
LUN			HEAD #				
CYL HI		SECTOR #					
CYLINDER LOW							

- **REQUEST SYNDROME**

This function returns the four bytes of the ECC syndrome to the CPU as data.

OUTPUT:

7	6	5	4	3	2	1	0
							2
LUN				0			
							0
							0
							0
							0

DATA
INPUT:

7	6	5	4	3	2	1	0
MSB bit offset							
LSB bit offset							
0							
0				MASK			

- **SEEK**

This function seeks to the cylinder of the specified block. For Winchester drives capable of overlap seeks, this function returns completion status before the seek is complete.

OUTPUT:

7	6	5	4	3	2	1	0
							B
LUN				HEAD #			
CYL HI				0			
CYLINDER LOW							
0							
CONTROL							

- **TEST DRIVE READY**

This function selects the specified drive and verifies the drive is ready, the seek is complete, and there are no drive faults.

OUTPUT:

7	6	5	4	3	2	1	0
							0
LUN				0			
							0
							0
							0
							0

- **WRITE**

This function writes the data starting at the initial block address given in the function.

OUTPUT:

7	6	5	4	3	2	1	0
A							
LUN				HEAD #			
CYL HI				SECTOR #			
CYLINDER LOW							
# OF BLOCKS							
CONTROL							

- **WRITE LONG**

This function writes blocks of data and ECC bytes from the CPU to the disk without generating ECC for the data.

OUTPUT:

7	6	5	4	3	2	1	0
E6							
LUN				HEAD #			
CYL HI				SECTOR #			
CYLINDER LOW							
# OF BLOCKS							
CONTROL							

DATA

OUTPUT:

256/512/1024	E	E	E	0
BYTES OF DATA	C	C	C	0
	2	1	0	

- **WRITE SECTOR BUFFER**
This function writes one sector's worth of data to the controller sector buffer. No data transfer occurs between the controller and the drives.

OUTPUT:

7	6	5	4	3	2	1	0
							F
							0
							0
							0
							0

**Sequencing
and Timing**

There are three phases to each function:

- function initiation
- function execution
- function results

To initiate a function, you select the controller with the Select Controller Register. Then you wait for Ready in the Status Register to be set. The In/Out bit and the Command/Data bit should indicate function transfer to the controller. You then write six function bytes to the Data Register.

If the Ready is set after this transfer, either there was an error in the function bytes or the controller is ready to receive another group of six function bytes and/or data.

Data can be transferred in DMA or non-DMA mode. If the transfer is in DMA mode, the DMA Controller is programmed in Single Transfer mode (See DMA Controller). The count word is set to:

$(\text{number of sectors to transfer})(\text{bytes/sector}) - 1$

If data is transferred in non-DMA, you use Ready, In/Out, Command/Data and Interrupt Request to time the transfer during execution.

Execution begins when the last function byte is received. In data transfer functions, the controller temporarily stores the data in the sector buffer. This prevents data overruns. When the function completes and the Completion Status byte is loaded, the controller issues interrupts if requested.

You clear the Interrupt Enable and the DMA enable bits in the Control Register after reading the Completion Status. This allows the controller to clear Interrupt Request and Data Request in the Status Register. It also clears the Selected bit.

The controller does extensive error recovery. If an error is found, four retries are attempted. If a retry is successful, the error is not reported; however, the retry count is incremented.

The following errors result in a retry:

- Seek error
- Sector not found
- Uncorrectable data error

- Correctable data error
- No data address mark
- No ID address mark
- ECC error in ID field

On a seek error, a recalibrate and reseek is done by the controller.

The following errors are accumulated in the log:

- ECC error in ID field
- Correctable error in data field
- Uncorrectable error in data field
- No ID address mark
- No data address mark
- Seek error
- Record not found

If rereads are disabled, the controller does not reread before applying the ECC correction.

When a reset is done, the controller defaults to the following characteristics:

- Maximum number of cylinders = 306
- Maximum number of heads = 4
- Starting reduced write current cylinder = 306
- Starting write precompensation cylinder = 0
- Maximum ECC data burst length = 4 bits

The interleave factor states how many physical sectors logical sectors are apart. For example, if the Interleave Factor is 6 and there are 16 sectors in a track, then a sector looks like this:

Physical																			
Sector	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
Logical																			
Sector	0	3	6	9	12	15	1	4	7	10	13	16	2	5	8	11	14		

The track layout for 256 bytes per sector, 33 sectors per track is:

13 bytes 00's	a m	F E	c y l	h d	s e c	0 0	0 0	13 bytes 00's	a m	F 8	256 bytes data	e c	0 0	0 0	10 bytes 4E's
---------------------	--------	--------	-------------	--------	-------------	--------	--------	---------------------	--------	--------	----------------------	--------	--------	--------	---------------------

am, FE, cyl, hd, sec, 00, F8 = 1 byte
ecc = 3 bytes

Track capacity = 10416

$$\begin{aligned}
 &16 = \text{Index Gap (4E)} \\
 &10197 = 33 \text{ sectors @ } 309 \text{ bytes/sector} \\
 &\underline{203} = \text{Speed Tolerance Gap (4E)} \\
 &10416
 \end{aligned}$$

309 bytes/sector including ID and overhead

The track layout for 512 bytes per sector, 17 sectors per track is:

13 bytes 00's	a m	F E	c y l	h d	s e c	0 0	0 0	13 bytes 00's	a m	F 8	512 bytes data	e c	0 0	0 0	37 bytes 4E's
---------------------	--------	--------	-------------	--------	-------------	--------	--------	---------------------	--------	--------	----------------------	--------	--------	--------	---------------------

am, FE, cyl, hd, sec, 00, F8 = 1 byte
ecc = 3 bytes

Track capacity = 10416

16 = Index Gap (4E)
 10064 = 17 sectors @ 592 bytes/sector
 336 = Speed Tolerance Gap (4E)
 10416

592 bytes/sector including ID and overhead

The track layout for 1024 bytes per sector, 9 sectors per track is:

13 bytes 00's	a m	F E	c y l	h d	s e c c	0 0	0 0	13 bytes 00's	a m	F 8	1024 bytes data	e c	0 0	0 0	58 bytes 4E's
---------------------	--------	--------	-------------	--------	------------------	--------	--------	---------------------	--------	--------	-----------------------	--------	--------	--------	---------------------

am, FE, cyl, hd, sec, 00, F8 = 1 byte
 ecc = 3 bytes

Track capacity = 10416

16 = Index Gap (4E)
 10125 = 9 sectors @ 1125 bytes/sector
275 = Speed Tolerance Gap (4E)
 10416

1125 bytes/sector including ID and overhead

Sample Program ; INIT_CTLR
; This routine prepares the controller to
; receive a function.
; OUTPUT: Carry set if error
SELECT EQU 322
STATUS EQU 321
CONTROL EQU 323
INIT_CTLR:
MOV DX,SELECT ;Select Port Address
OUT DX,AL ;Output anything
MOV DX,CONTROL ;Control Port Address
MOV AL,3H ;Enable interrupts and
;DMA
OUT DX,AL
MOV DX,STATUS ;Status Port Address
INIT1:
IN AL,DX ;Get status
TEST AL,1H ;Is it ready?
LOOPZ INIT1 ;Loop if not ready
CMP AL,DH ;Jump if ready for a
JE INIT2 ;function and selected
STC ;Flag error
RET
INIT2:
CLC
RET

Keyboard Interface

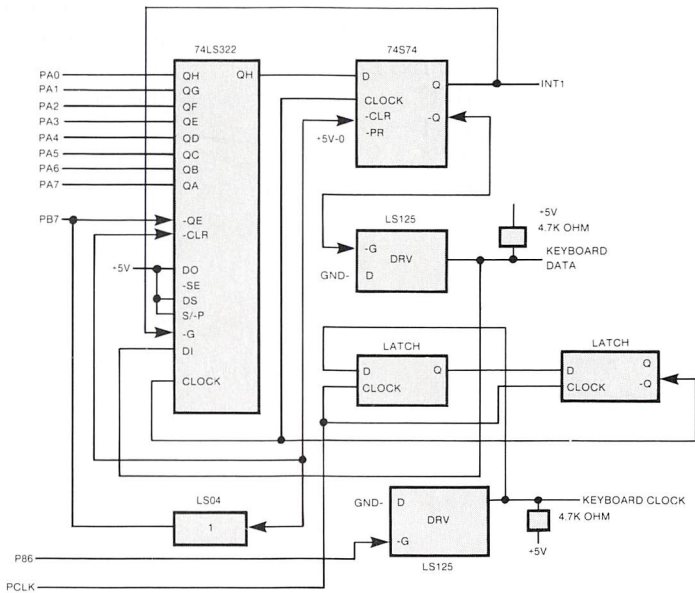
Functional Description

The keyboard interface converts the parallel data into serial data for transmission to and from the keyboard.

To provide maximum flexibility in defining keyboard operations, the keyboard uses scan codes rather than ASCII codes. In addition, all keys generate a make scan code when pressed and a break scan code when released. The break scan code is 80H plus the make scan code.

The keyboard is responsible for keeping track of the amount of time a key is depressed and for generating the repeat key signal. All the keys have this repeat function.

Block Diagram

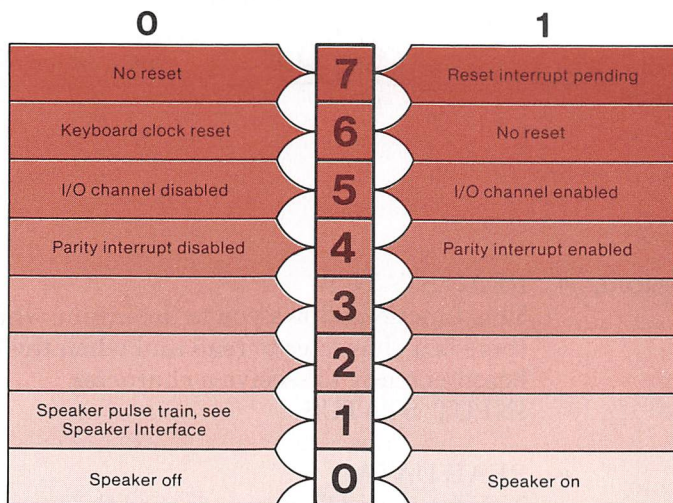


Registers

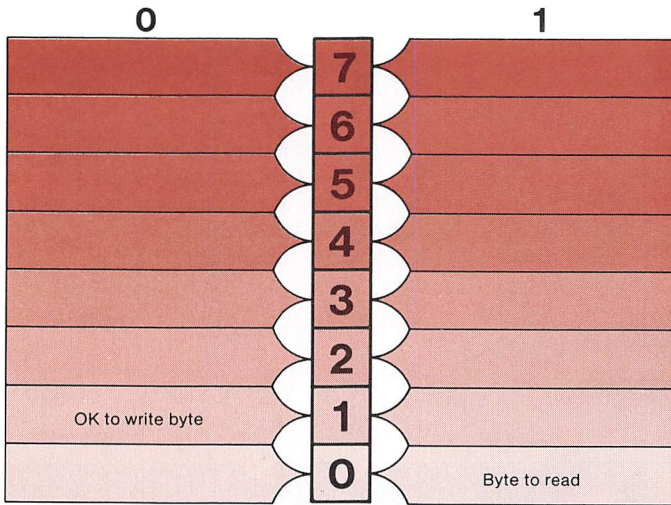
PORT	NAME	READ/ WRITE	DESCRIPTION
60	DATA	R	8 bit scan code when pressed, 8 bit scan code plus 80H when released See scan code chart.
60	DATA	W	Keyboard command codes
60	CONTROL	R/W	See layout
64	STATUS	R	See layout

Layout

CONTROL



STATUS



- Functions**
- **READ STATUS**
This function allows you to determine when there is a character to read and when the keyboard is ready to receive a character.
INPUT: STATUS
 - **READ DATA**
This function allows you to read the scan code of the key that was pressed or released.
INPUT: DATA
 - **WRITE CONTROL**
This function allows you to issue control commands to the keyboard.
OUTPUT: CONTROL

-
- **GET KEYBOARD TYPE**
 This function determines if the keyboard is an Olivetti M20 type keyboard.
 OUTPUT: DATA REGISTER
 5
 INPUT: DATA REGISTER
 1 = Olivetti M20 keyboard

 - **KEYBOARD LEDS**
 This function controls the illuminations of the CAPS LOCK and NUM LOCK LEDS.
 OUTPUT: DATA REGISTER
 13H

Value	Operation
00h	No operation
01h	Cap lock LED OFF
02h	Num lock LED OFF
03h	Both LEDS OFF
80h	No operation
81h	Caps lock LED ON
82h	Num lock LED ON
83h	Both LEDS ON

Any other value will cause one of the above operations.

Scan Codes

KEY NO	SCAN CODE	KEY NO	SCAN CODE	KEY NO	SCAN CODE
1	01H	36	24H	71	47H
2	02H	37	25H	72	48H
3	03H	38	26H	73	49H
4	04H	39	27H	74	4AH
5	05H	40	28H	75	4BH
6	06H	41	29H	76	4CH
7	07H	42	2AH	77	4DH
8	08H	43	2BH	78	4EH
9	09H	44	2CH	79	4FH
10	0AH	45	2DH	80	50H
11	0BH	46	2EH	81	51H
12	0CH	47	2FH	82	52H
13	0DH	48	30H	83	53H
14	0EH	49	31H	84	54H
15	0FH	50	32H	85	55H
16	10H	51	33H	86	56H
17	11H	52	34H	87	57H
18	12H	53	35H	88	58H
19	13H	54	36H	89	59H
20	14H	55	37H	90	5AH
21	15H	56	38H	91	5BH
22	16H	57	39H	92	5CH
23	17H	58	3AH	93	5DH
24	18H	59	3BH	94	5EH
25	19H	60	3CH	95	5FH
26	1AH	61	3DH	96	60H
27	1BH	62	3EH	97	61H
28	1CH	63	3FH	98	62H
29	1DH	64	40H	99	63H
30	1EH	65	41H	100	64H
31	1FH	66	42H	101	65H
32	20H	67	43H	102	66H
33	21H	68	44H	103	67H
34	22H	69	45H	104	68H
35	23H	70	46H	-	-

Sequencing and Timing To send a character to the keyboard, wait for Bit 1 of the Status Register to be set and write the byte to the data register.

To receive a character, wait for Bit 0 of the Status Register to be set and read the character. The keyboard interface can be programmed to interrupt on INT1 when there is a character to read.

Sample Program ;This program sets the CAPS LOCK LED

```
STATUS      EQU 64
DATA        EQU 60
SET_LED:
    IN AL,STATUS      ;read status
    TEST AL,2         ;keyboard ready to receive
    JNZ SET_LED       ;input? Jump if ready.
    MOV AL,013H       ;keyboard LED command
    OUT DATA,AL

SET1:
    IN AL,STATUS      ;read status
    TEST AL,2         ;ready to receive input?
    JNZ SET1          ;jump if not
    MOV AL,81         ;CAPS LOCK
    OUT DATA,AL      ;write out code
    RET
```

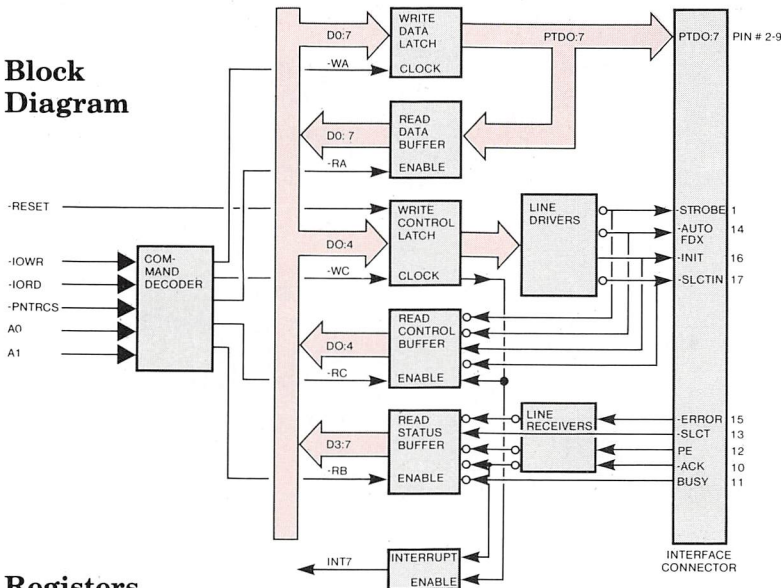
Parallel Printer Interface

Functional Description

The parallel printer interface connects to printers with a Centronics-like parallel interface or any other device with identical interface characteristics. The input and output signals are presented to the external device through a 25-pin "D" type connector.

The interface has 5 buffered outputs — data, strobe, initialize printer, automatic linefeed, and select. These can be read and written. In addition, the interface has five inputs — acknowledge, busy, paper out, error and select. An interrupt can be enabled on INT7.

Block Diagram

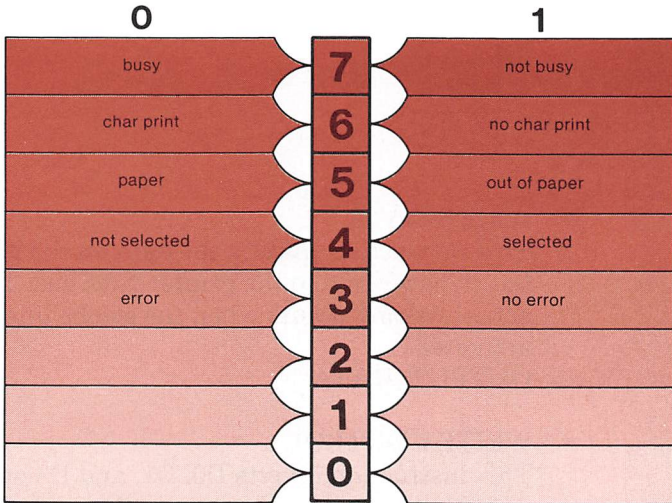


Registers

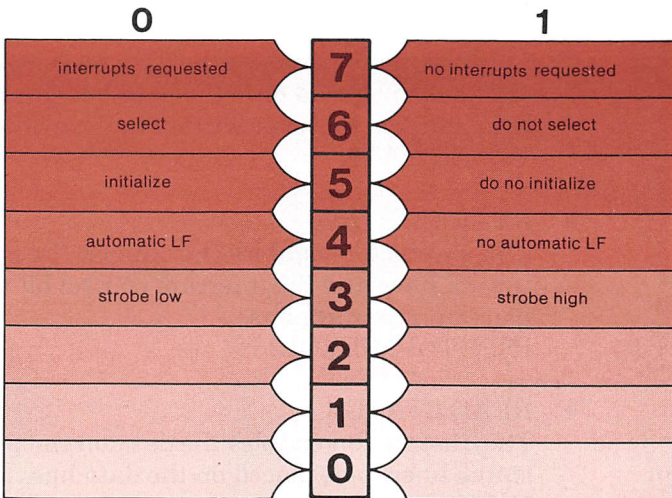
PORT #	NAME	READ/ WRITE	DESCRIPTION
378	DATA	R/W	Print character
379	STATUS	R	See layout
37A	CONTROL	R/W	See layout

Layout

STATUS



CONTROL



Functions • **RESET**

After a power on or a hardware reset, the data buffer is cleared and the control register is initialized to:

bit 0: 0

bit 1: 0

bit 2: 0

bit 3: 0

bit 4: 0

• **WRITE DATA**

This instruction enables the data on the data bus to be written to the printer data bus. The actual writing occurs when the strobe line is activated.

OUTPUT: DATA

• **WRITE CONTROL**

This instruction inverts D0, D1, and D3 on the data bus and writes the data to the control register. If D4 is a 1 then interrupts are requested.

OUTPUT: CONTROL

• **READ DATA**

This instruction enables the data on the printer data bus to be read onto the data bus. It normally is the last character written to the printer.

INPUT: DATA

• **READ CONTROL**

This instruction enables the data on the printer control lines and the interrupt control bit to be placed on the data bus.

INPUT: CONTROL

• **READ STATUS**

This instruction enables the data on the printer status lines to be placed on the data bus.

INPUT: STATUS

Sequencing and Timing

To send a character to the printer, the character is put on the data bus. When the printer is not busy, it is ready to accept the next character. The character must be strobed into the printer by setting the strobe bit to 1 for at least 5 μ -seconds and then resetting it.

Interrupt can be enabled on INT7 by writing D4 = 1 in the control register. An interrupt will be triggered everytime Bit 6 of the status register goes from 0 to 1 (end of the acknowledge cycle from the printer).

To initialize the printer, first select it. Then issue the initialize command setting the automatic line feed and interrupt parameters.

```
Sample Program ; PRINT_CHAR
; Send character to printer and get status
; INPUT AL - character to print
; OUTPUT: AL - status
;
DATA EQU 378H
PRINT_CHAR:
MOV DX,DATA ;get data port
OUT DX,AL ;put char on data
;line
INC DX ;get status port
IN AL,DX ;read in status
TEST AL,080H ;is the printer busy?
JNZ PRINT_NOT_BUSY ;jump if not busy
.
.
.
PRINT_NOT_BUSY:
MOV AL,0DH ;strobe high
INC DX ;get control port
OUT DX,AL ;to control register
NOP ;wait
NOP ;wait
MOV AL,0CH ;strobe low
OUT DX,AL ;to control register
DEC DX ;get status port
IN AL,DX ;read in status
RET
```


Programmable Interrupt Controller

Functional Description

The Intel 8259A Programmable Interrupt Controller (PIC) manages external interrupts. It receives requests from peripheral equipment, decides which request has the highest priority, and issues an interrupt to the CPU. Each PIC handles 8 maskable priority interrupts. PIC's can be cascaded allowing up to 64 priority interrupts. However, on the AT&T Personal Computer 6300 this is not done.

Each interrupt device runs to one of eight interrupt lines (INT0-INT7). If more than one device interrupts at once, the PIC decides which device to service according to one of several schemes.

The following schemes apply to a single PIC:

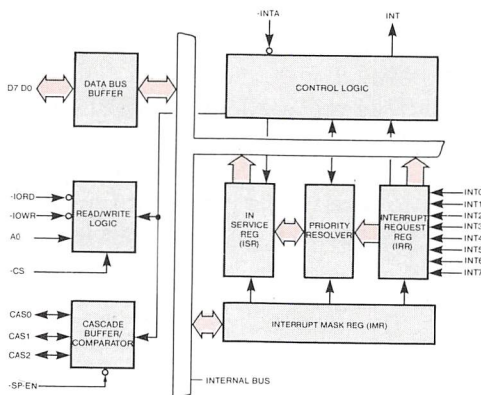
- **Fully Nested Mode**
This is the default mode. The interrupt requests have an ordered priority from 0 (highest) to 7 (lowest). The highest priority is acknowledged first and those of lower priority are inhibited.
- **Special Mask Mode**
This mode is similar to fully nested mode except that the interrupt mask register (IMR) determines which interrupts are disabled.
- **Polled**
This mode allows the CPU to poll the devices. It is selected by disabling interrupts with the CLI instruction. Periodically the CPU polls the PIC to receive the interrupt type of the highest priority device requesting service.

- Automatic Rotation**
 In this mode, a device receives the lowest priority after it is serviced. All other devices have their priorities adjusted accordingly. The next highest interrupt line receives the highest priority.
- Programmable Rotation**
 In this mode, the programmer declares the lowest priority device.

The PIC keeps track of devices that are waiting for service in the interrupt request register (IRR). If not in polled mode, the PIC notifies the CPU of the pending interrupt. When it receives an interrupt acknowledge from the CPU (INTA), it sends the interrupt type of the device to the CPU. The device is then in-service. This is noted in the in-service register (ISR). The type of INTO is programmable. It must be a multiple of 8.

After the interrupt service routine services the interrupt, it notifies the PIC of end of interrupt (EOI). The device is then removed from the in-service register.

Block Diagram



- **ROTATION OF PRIORITIES INDEPENDENT OF EOI**
This function requests an immediate change in priorities.
OUTPUT: OCW2 BITS 5-7 = 6
OCW2 BITS 0-2 = level of lowest priority
- **SPECIFIC END OF INTERRUPT (SEOI)**
This function is issued in an interrupt service routine to declare end of interrupt service for the specified level.
OUTPUT: OCW2 BITS 5-7 = 3
BITS 0-2 = interrupt level
- **NON-SPECIFIC END OF INTERRUPT (EOI)**
When the PIC is operating in Fully Nested Mode, it can determine which interrupt is completing. This function signals completion of an interrupt service routine.
OUTPUT: OCW2 BITS 5-7 = 1
- **AUTOMATIC END OF INTERRUPT**
This function requests the PIC to declare end of interrupt automatically after delivering the interrupt to the CPU.
OUTPUT: ICW4 BIT 1 = 1
- **READ IRR**
This function reads the devices requesting service.
OUTPUT: OCW3 BITS 0-1 = 2
INPUT: IRR
- **READ ISR**
This function reads the in-service register.
OUTPUT: OCW3 BITS 0-1 = 3
INPUT: ISR

- **READ IMR**
This function reads the interrupt mask register.
INPUT: OCW1

Sequencing and Timing

When the ICW1 command is issued, the initialization process begins. The following automatically occurs:

- IMR is cleared.
- INT7 is assigned the lowest priority.
- Single mode is assumed.
- Special Mask Mode is cleared.
- A status read fetches IRR.
- If Bit 0 equals zero, then ICW4 functions are set to zero.

Next ICW2 is output. ICW3 is skipped in all single PIC systems. If the ICW4 was requested by ICW1 then it is output. This completes initialization.

Once the initialization process is complete, the PIC is ready to accept interrupts. Any of the functions to change the priority scheme can be executed. In addition, the IRR, IMR, and ISR can be read.

If automatic EOI is not specified then the interrupt service routine must declare EOI. Either specific or non-specific EOI can be used depending on the priority scheme in use.

When a write command is issued to the PIC, 480 nanoseconds must elapse before another command is issued. In the read case, 395 nanoseconds must elapse.

```

Sample      ;
Program ; SEND_SEOI
            ;   Send end of INT1 service at the end of the
            ;   interrupt service routine.
            ;
            OCW2      EQU 20  ;port address of OCW2
            COMMAND   EQU 61  ;6 = SEOI, 1 = INT1

SEND_SEOI:
    MOV AL,COMMAND    ;set AL = command
    MOV DX,OCW2       ;set DX = port address
    OUT DX,AL         ;send command
    STI                ;enable external interrupts
    RET               ;return to service routine

```

Programmable Interval Timer

Functional Description

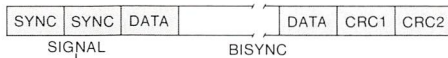
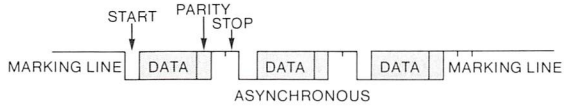
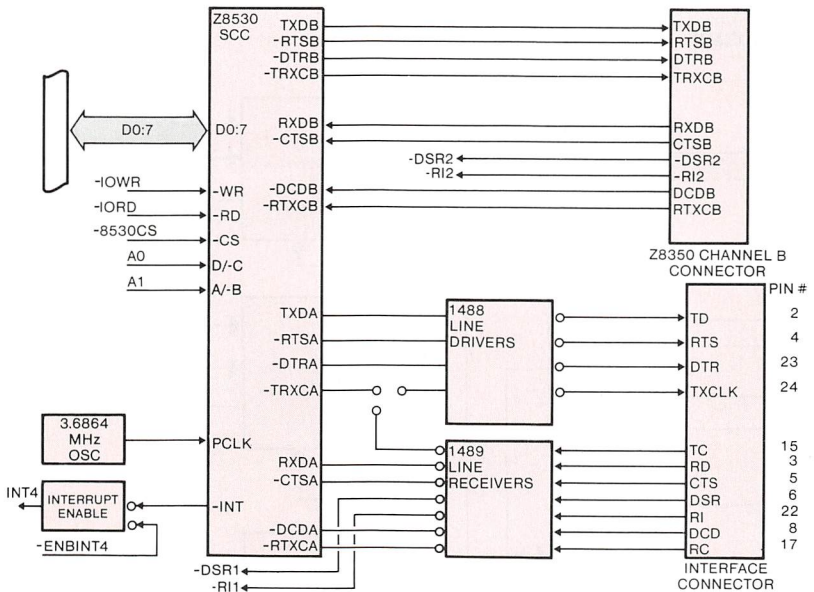
The Intel 8253 Interval Timer has three identical, 16-bit, settable, decrementing counters. Each counter is totally independent. The counters have either a BCD or binary value and operate in one of five modes:

- **Interrupt on Terminal Count**
The output remains low after the mode is set. It continues low after the counter is loaded until the counter counts down to zero. Then the output goes high. It remains high until a new mode is selected or a new count is loaded.
- **Programmable One-Shot**
The output goes low one count following the rising edge of the gate input. The output goes high on the terminal count.
- **Rate Generator**
The output is low for one period of the input clock. The period from one output pulse to the next equals the number of input counts in the count register.
- **Square Wave Rate Generator**
The output remains low for one period of the input clock. The output remains high until one half the count has elapsed. If the count is odd, the output is high for $(n+1)/2$ and low for $(n-1)/2$.
- **Software Triggered Strobe**
After the mode is set, the output will be high. When the count is loaded, the counter begins counting. On the terminal count, the output goes low for one clock period and then goes high.

- **Hardware Triggered Strobe**

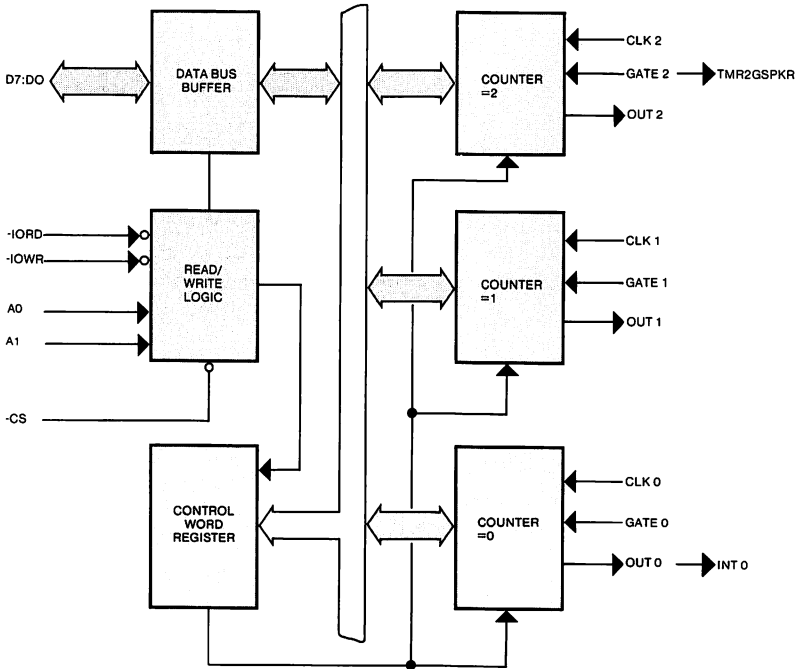
The counter starts counting after the rising edge of the trigger input and goes low for one clock period when terminal count is reached.

These timing diagrams illustrate the different modes.



In the AT&T Personal Computer 6300 system, Counter 0 provides real time interrupts on INT0, counter 1 requests memory refreshes, and counter 2 generates a pulse train for the audio speaker.

Block Diagram

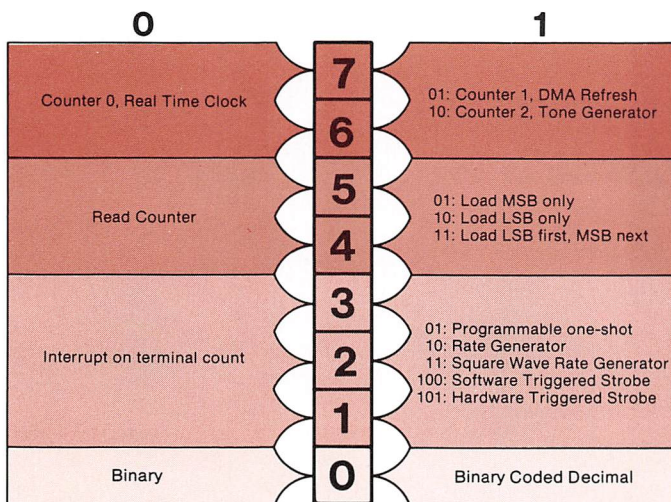


Registers

PORT #	NAME	READ/ WRITE	DESCRIPTION
40	COUNTER 0	R/W	Provides real time interrupt INTO
41	COUNTER 1	R/W	Provides signals to refresh memory
42	COUNTER 2	R/W	Generate pulse train for the audio speaker
43	CONTROL	W	See Layout

Layout

CONTROL



Functions

- **LOAD COUNTER**
This function allows you to set a specific counter.
OUTPUT: CONTROL REGISTER
 BITS 0 binary or BCD
 BITS 1-3 mode
 BITS 4-5 1,2 or 3
 BITS 6-7 counter
 8 or 16 bit count value

- **READ COUNTER**
This function allows you to read a specific counter.
OUTPUT: CONTROL REGISTER
 BITS 4-5 0
 BITS 6-7 counter

Sequencing and Timing

All counters must be initialized with the control register. The control register specifies the number of bytes which must be loaded.

Whenever a read or a load command is issued, the requested counter bytes must be read or written. In the read case, two reads are necessary, the first for the least significant byte (LSB) and the last for the most significant byte (MSB). In the write case, the control register specifies the byte to write.

1 microsecond recovery time is required between a read or a load and any other control signal.

Input to the timer is 1.2288MHz. Therefore, there are 18.75 interrupts per second. To generate a 1.00 KHz tone with the audio speaker, a square wave rate generator is used with a count of 614 ($1.2288\text{MHz}/2 \cdot 614 = 1\text{KHz}$).

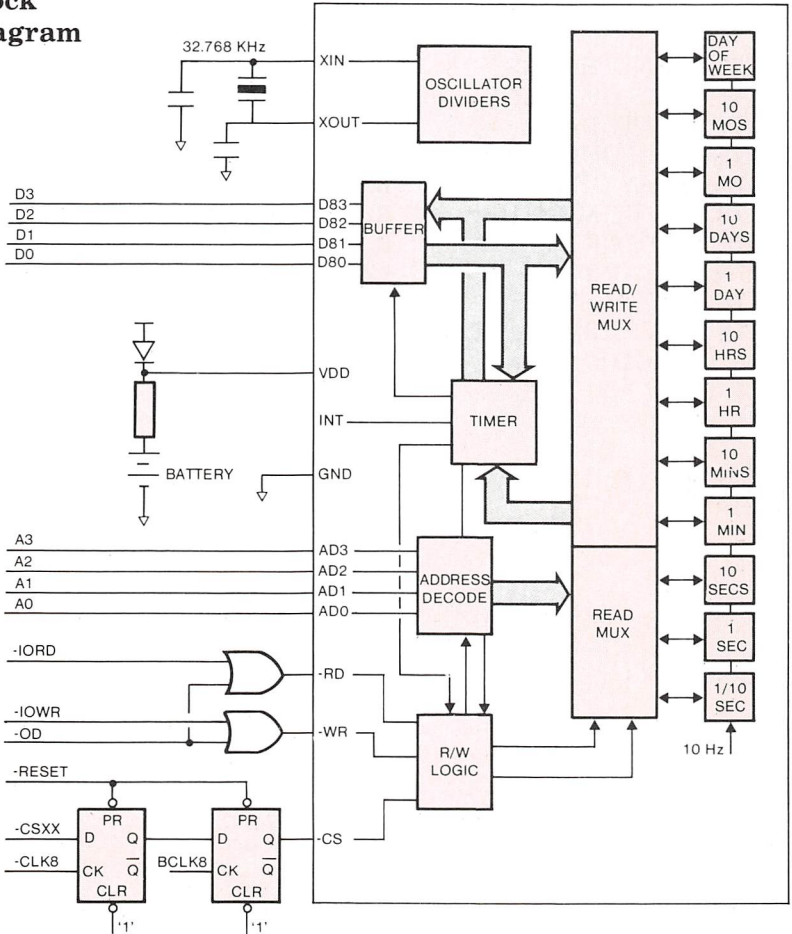
```
Sample ;  
Program ; ASK_FOR_INTR  
; This program requests an interrupt in  
; approximately 10 usec (9765.6 nsec)  
;  
TIMER_CONTROL EQU 43  
TIMER0 EQU 40  
  
INT_MASK EQU 21  
  
ASK_FOR_INTR:  
MOV AL,0FEH ;allow only INTO  
;interrupt  
OUT INT_MASK,AL ;send mask  
MOV AL,00110000B ;binary counter,  
;interrupt on terminal  
;count, set counter 0  
OUT TIME_CONTROL,AL  
MOV AX,12 ;12 * 813.8 nsec  
OUT TIMER0,AL  
MOV AL,AH ;output counter, LSB  
;then MSB  
OUT TIMER0,AL  
RET
```

Real Time Clock and Calendar

Functional Description

The real time clock and calendar keep the current date and time. All of the date and time fields can be read but the second fields cannot be written. The calendar keeps up to eight years. A rechargeable battery keeps the unit running even when the computer is turned off.

Block Diagram

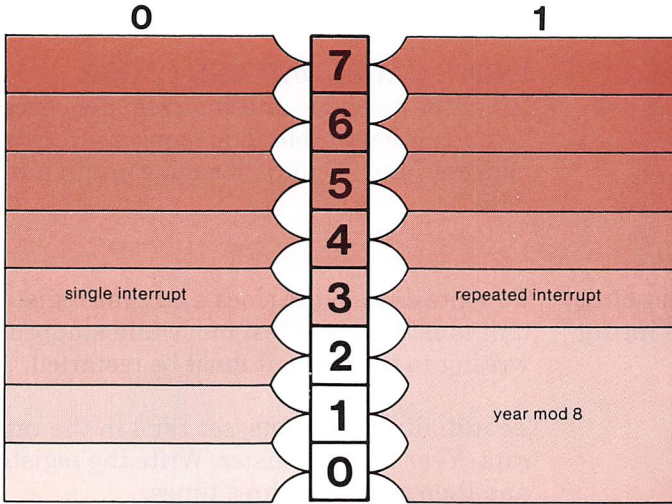


Registers

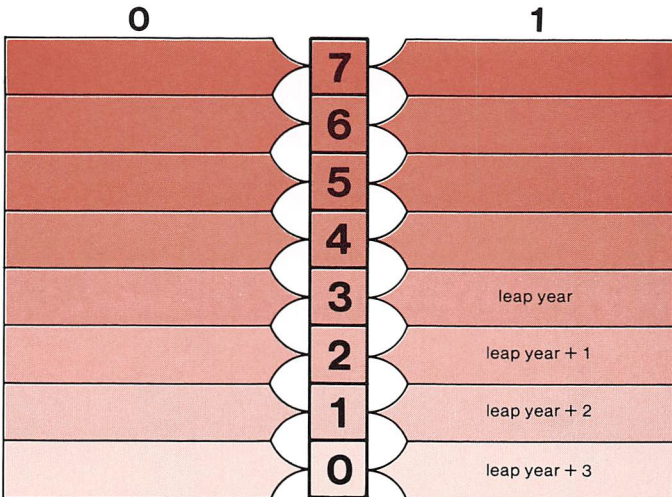
PORT #	NAME	READ/ WRITE	DESCRIPTION
70	TEST PORT	W	0=not test mode, 1=test mode
71	1/10 OF A SECOND	R	nybble, 0-9
72	UNIT SECONDS	R	nybble, 0-9
73	10'S OF SECONDS	R	nybble, 0-5
74	UNIT MINUTES	R/W	nybble, 0-9
75	10'S OF MINUTES	R/W	nybble, 0-5
76	UNIT HOURS	R/W	nybble, 0-9
77	10'S OF HOURS	R/W	nybble, 0-1
78	UNIT DAYS	R/W	nybble, 0-9
79	10'S OF DAYS	R/W	nybble, 0-3
7A	DAY OF WEEK	R/W	nybble, 1-7
7B	UNIT MONTHS	R/W	nybble, 0-9
7C	10'S OF MONTHS	R/W	nybble, 0-1
7D	LEAP YEAR	W	See layout
7E	STOP/START	W	0 = stop, FF = start
7F	INTERRUPT/YEAR MOD 8	R/W	See layout

Layout

INTERRUPT/YEAR MOD 8



LEAP YEAR



- Functions**
- **READ CALENDAR AND CLOCK**
All of the calendar and time registers are readable. Those from port address 71 to 7D and 7F contain a nibble of data.
 - **WRITE CALENDAR AND CLOCK**
All of the calendar and time registers except seconds are writable. The registers from port address 74 to 7D and 7F each contain a nibble of data.

Sequencing and Timing To write data to the clock and time registers, the unit must be out of test mode and stopped. After writing to the clock, it must be restarted.

To initialize interrupts, set Bit 4 in the Interrupt/Year mod 8 register. Write the register once and then read it in three times.

If an update occurs while reading a register, the illegal code of F is returned.

**Sample
Program**

```

; SET TIME
;   This routine sets the time to 12:00 noon
;
TEST_PORT      EQU 70
STOP_START     EQU 7E
TENS_HOURS     EQU 77
WRITE_TIME:
    XOR AX,AX           ;AX = 0
    MOV DX,TEST_PORT   ;setup dx
    OUT DX,AL          ;take out of
                       ;test mode
    OUT STOP_START,AL  ;stop the clock

    MOV DX,TENS_HOURS  ;port addr of
                       ;10's of hours

    MOV AL,1
    OUT DX,AL          ;ten's of hours
                       ;= 1

    DEC DX
    MOV AL,2
    OUT DX,AL          ;unit hours = 2

    DEC DX
    XOR AL,AL
    OUT DX,AL          ;tens of minutes
                       ;= 0

    DEC DX
    OUT DX,AL          ;minutes = 0

    MOV AL,0FFH
    OUT STOP_START,AL  ;start the clock

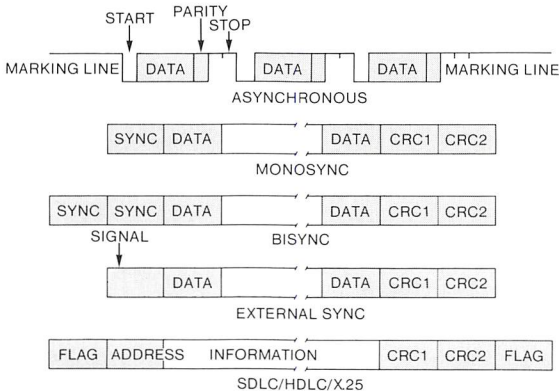
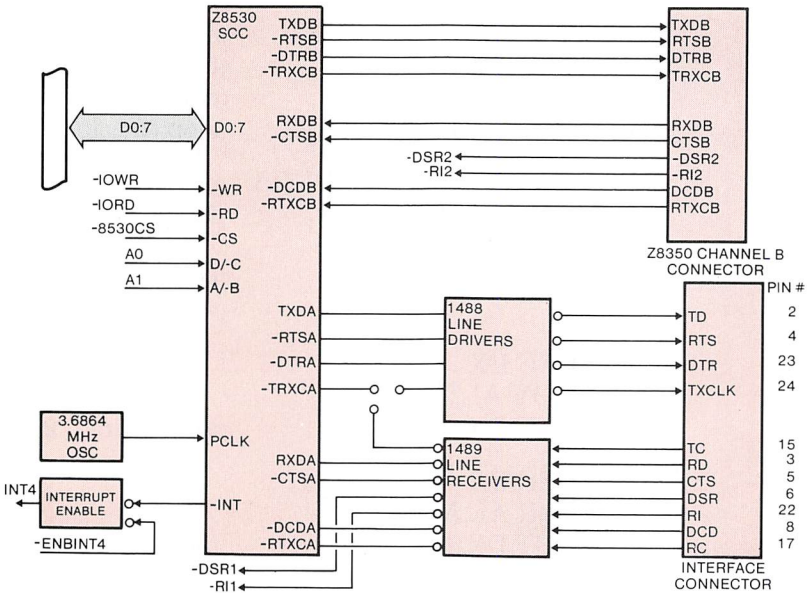
    RET

```

Serial Communications Controller

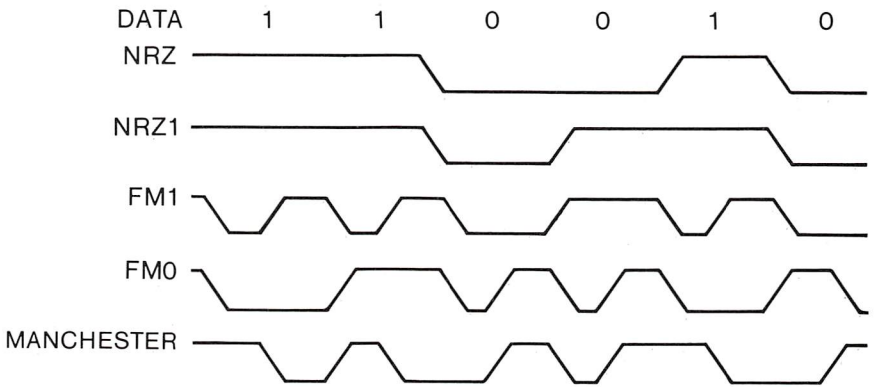
Functional Description

Z8530 Serial Communications Controller (SCC) performs serial-to-parallel conversion on input data characters received from a modem and parallel-to-serial conversion on output data characters received from the CPU. It supports the following common asynchronous and synchronous data communication protocols.



In addition, the SCC supports five encoding methods — NRZ, NRZI, FM1 (bi-phase mark), FM0 (bi-phase space), and Manchester (bi-phase level).

Figure 20



The SCC has the following capabilities:

Asynchronous

- 5, 6, 7, or 8 bits per character
- 1, 1 1/2, or 2 stop bits
- Odd or even parity
- Times 1, 16, 32, or 64 clock modes
- Break generation and detection
- Parity, overrun and framing error detection

Byte-oriented synchronous

- Internal or external character synchronization
- 1 or 2 sync characters in separate registers
- Automatic sync character insertion and deletion
- Cyclic redundancy check (CRC) generation/detection
- 6- or 8-bit sync character

SDLC/HDLC

- Abort sequence generation and checking
- Automatic zero insertion and deletion
- Automatic flag insertion between messages
- Address field recognition
- I-field residue handling
- CRC generation/detection
- SDLC loop mode with EOP recognition/loop entry and exit

The baud rate is programmable for both channels.

Registers

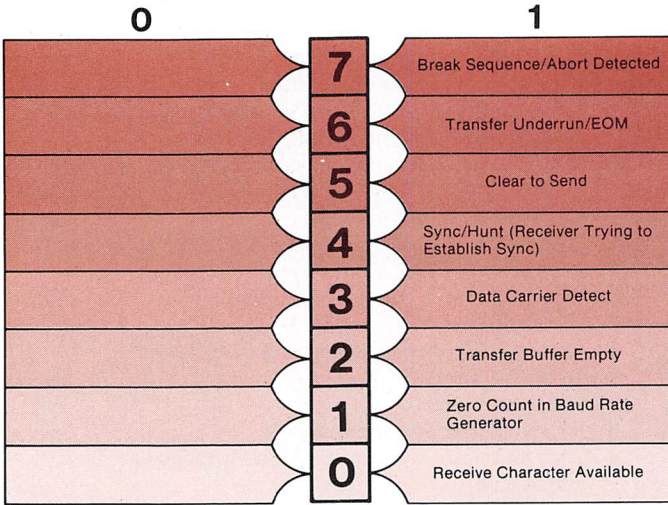
PORT #		NAME	READ/ WRITE	DESCRIPTION
A	B			
51	53	DATA	R/W	Transfer data
50	52	SCC REGISTER POINTER	R/W	Transfer SCC register number and SCC register data

SCC Registers

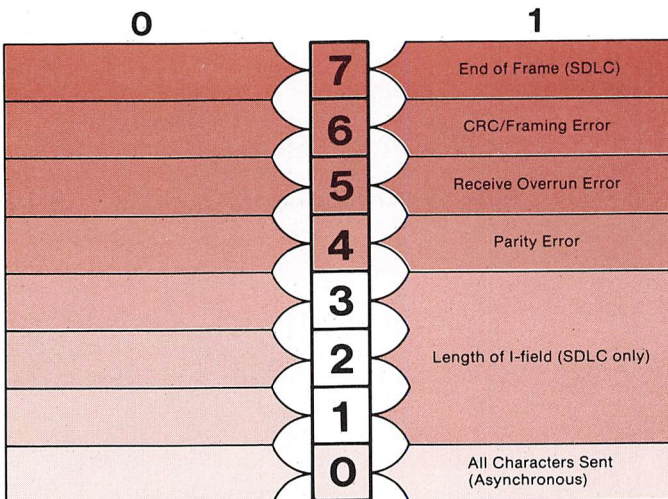
READ/ WRITE	NO	NAME	DESCRIPTION
R	0	Buffer and External Status	See layout
R	1	Special Receive Condition Status	See layout
R	2	Modified Interrupt Vector (Channel B) Unmodified Interrupt Vector (Channel A)	
R	3	Interrupt Pending Bits (Channel A)	See layout
R	8	Receive Buffer	See layout
R	10	Miscellaneous Status	See layout
R	12	Low Byte of Baud Rate Generator Constant	
R	13	High Byte of Baud Rate Generator Constant	
R	15	External/Status Interrupt Information	See layout
W	0	CRC Initialize	See layout
W	1	Transmit/Receive Interrupt and Data Transfer Mode Definition	See layout
W	2	Interrupt Vector	
W	3	Receive Parameters and Control	See layout
W	4	Transmit/Receive Miscellaneous Parameters and Modes	See layout
W	5	Transmit Parameters and Control	See layout
W	6	Sync Characters or SDLC Address Field	See layout
W	7	Sync Characters or SDLC Flag	See layout
W	8	Transmit Buffer	See layout
W	9	Master Interrupt Control and Reset	See layout
W	10	Miscellaneous Transmit/Receive Control Bits	See layout
W	11	Clock Mode Control	See layout
W	12	Low Byte of Baud Rate Generator Constant	
W	13	High Byte of Baud Rate Generator Constant	
W	14	Miscellaneous Control Bits	See layout
W	15	External/Status Interrupt Control	See layout

Layout

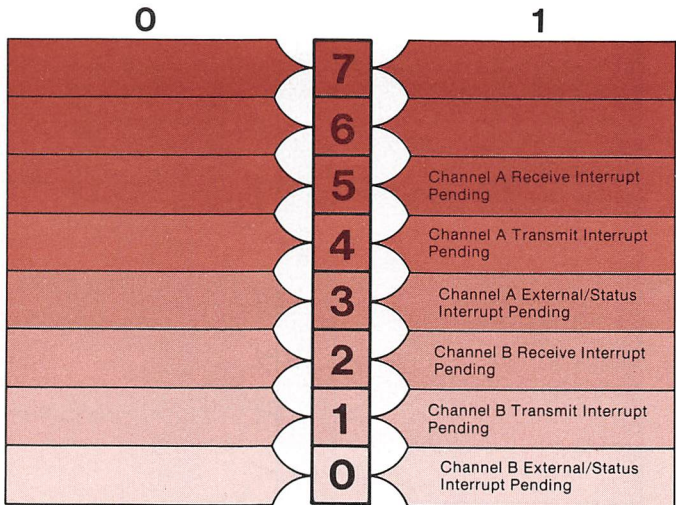
READ REGISTER 0



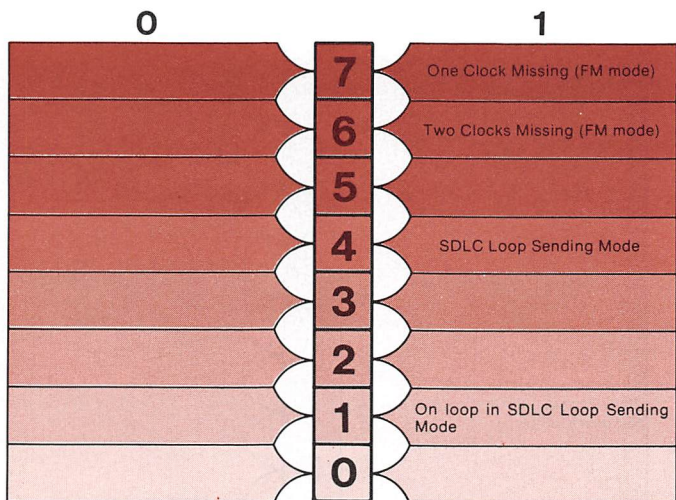
READ REGISTER 1



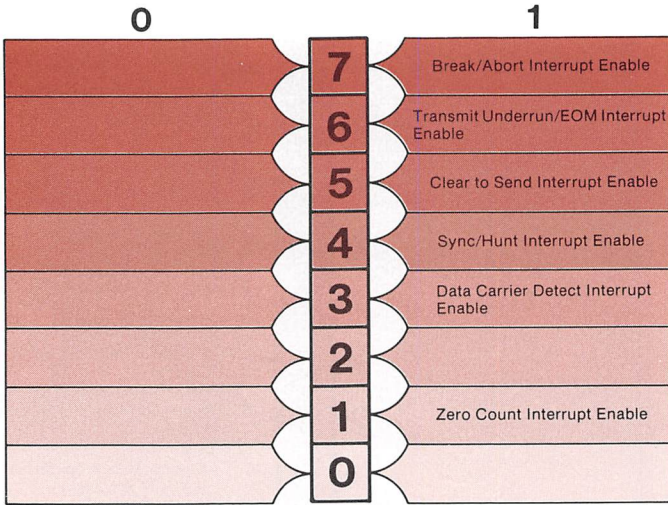
READ REGISTER 3



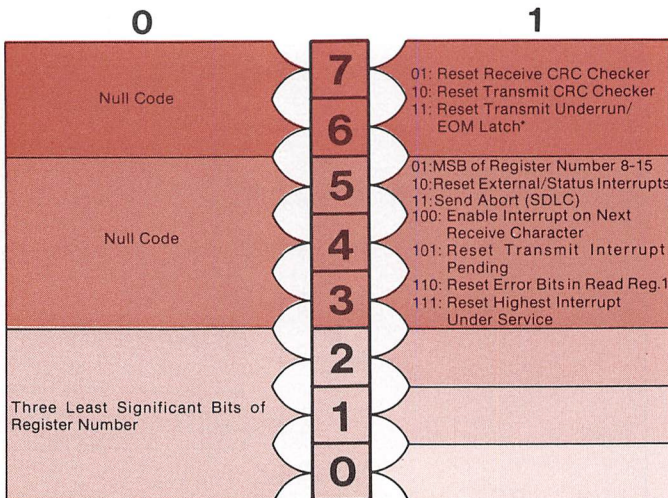
READ REGISTER 10



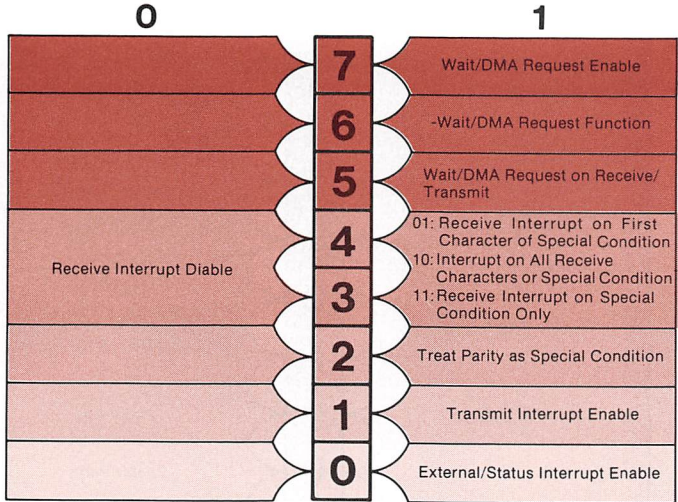
READ REGISTER 15



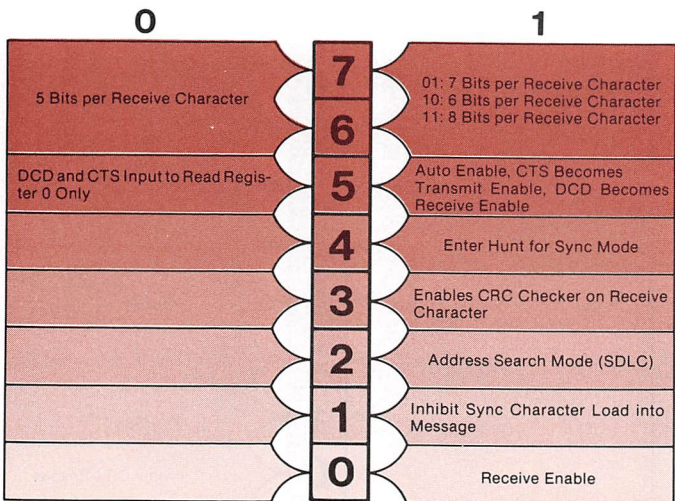
WRITE REGISTER 0



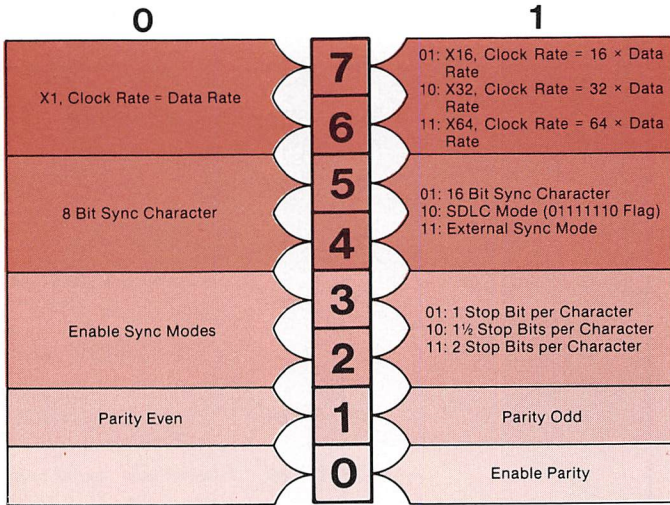
WRITE REGISTER 1



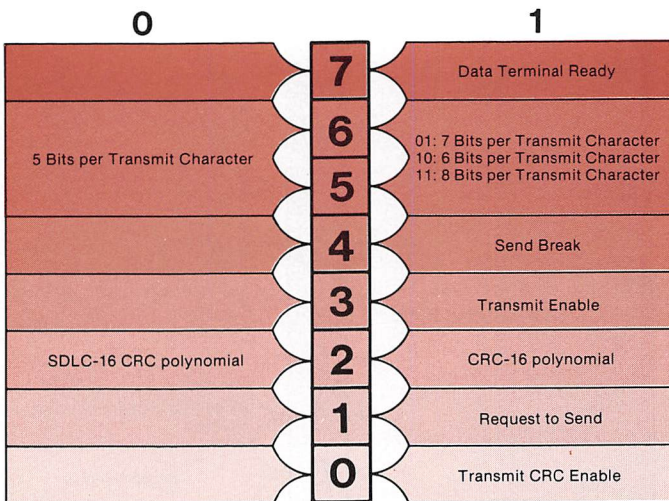
WRITE REGISTER 3



WRITE REGISTER 4



WRITE REGISTER 5



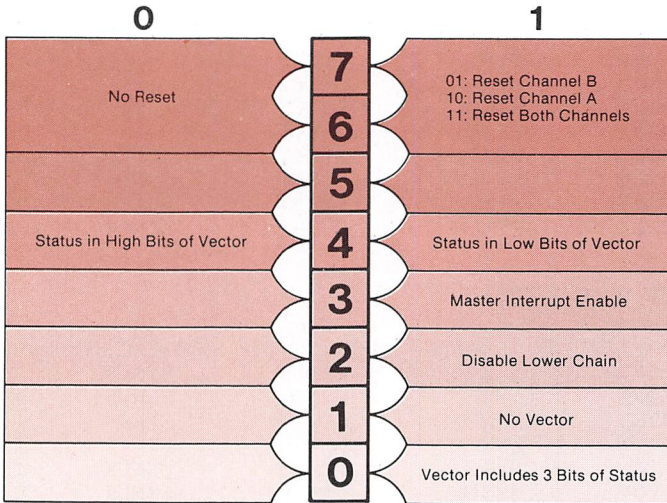
WRITE REGISTER 6

	MONO,8 BITS	MONO,16 BITS	BISYNC,16 BITS	BISYNC,12 BITS	SDLC	SDLC
0	SYNC0	SYNC0	SYNC0	1	ADR0	X
1	SYNC1	SYNC1	SYNC1	1	ADR1	X
2	SYNC2	SYNC2	SYNC2	1	ADR2	X
3	SYNC3	SYNC3	SYNC3	1	ADR3	X
4	SYNC4	SYNC4	SYNC4	SYNC0	ADR4	ADR4
5	SYNC5	SYNC5	SYNC5	SYNC1	ADR5	ADR5
6	SYNC6	SYNC0	SYNC6	SYNC2	ADR6	ADR6
7	SYNC7	SYNC1	SYNC7	SYNC3	ADR7	ADR7

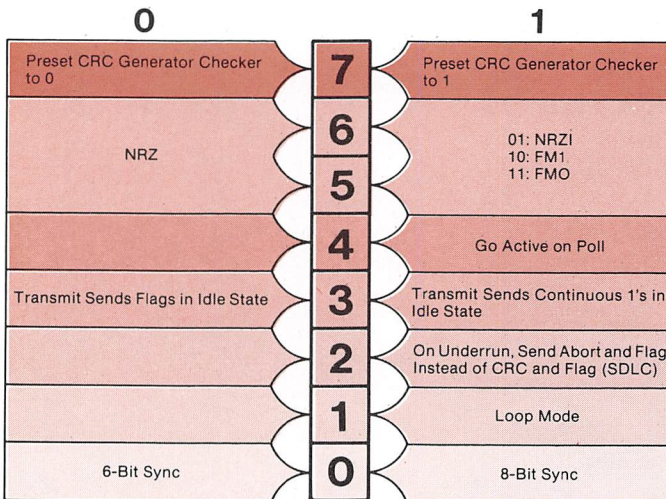
WRITE REGISTER 7

	MONO,8 BITS	MONO,16 BITS	BISYNC,16 BITS	BISYNC,12 BITS	SDLC
0	SYNC0	X	SYNC8	SYNC4	0
1	SYNC1	X	SYNC9	SYNC5	1
2	SYNC2	SYNC0	SYNC10	SYNC6	1
3	SYNC3	SYNC1	SYNC11	SYNC7	1
4	SYNC4	SYNC2	SYNC12	SYNC8	1
5	SYNC5	SYNC3	SYNC13	SYNC9	1
6	SYNC6	SYNC4	SYNC14	SYNC10	1
7	SYNC7	SYNC5	SYNC15	SYNC11	0

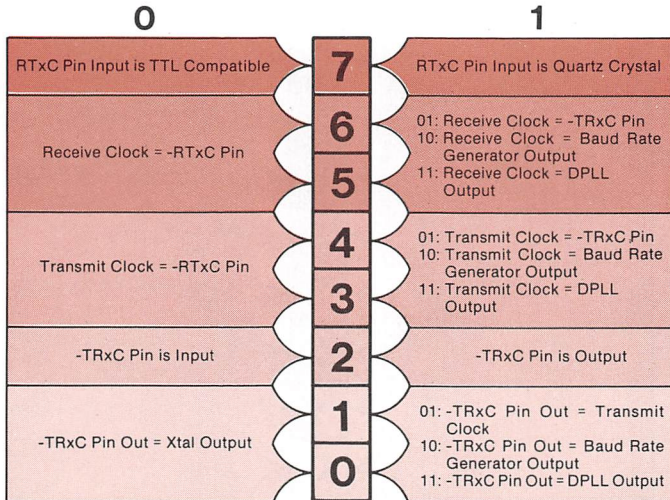
WRITE REGISTER 9



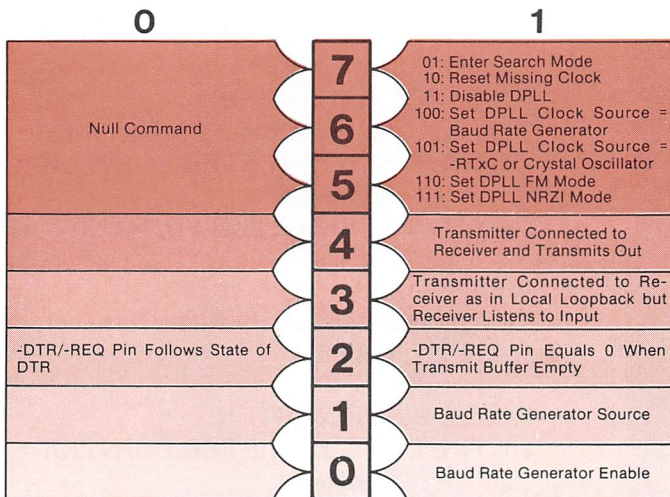
WRITE REGISTER 10



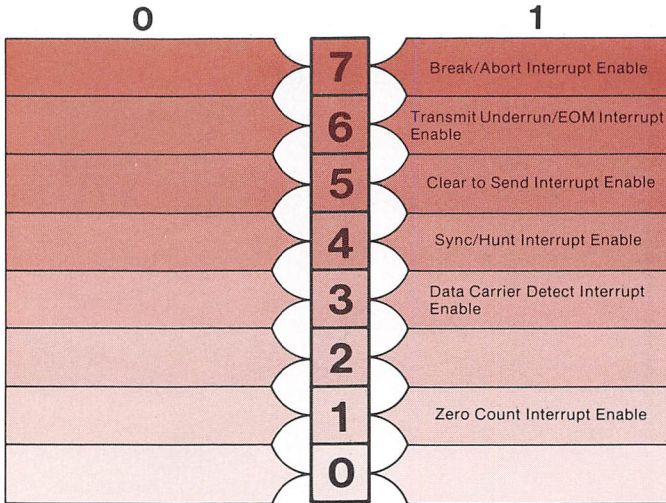
WRITE REGISTER 11



WRITE REGISTER 14



WRITE REGISTER 15



Functions

- **READ DATA**
This function reads character data.
INPUT: DATA
- **READ SCC REGISTERS**
This function reads Read Register 0-15.
OUTPUT: SCC REGISTER POINTER =
register #
INPUT: SCC REGISTER POINTER = data
- **WRITE DATA**
This function writes character data.
OUTPUT: DATA
- **WRITE SCC REGISTER**
OUTPUT: SCC REGISTER POINTER =
register #
OUTPUT: SCC REGISTER POINTER = data

Sequencing and Timing

The SCC has direct addressing for the data register only. To access the other SCC registers, first write the register number to the SCC Register Pointer and then read or write the register using the SCC Register Pointer.

The SCC can operate in three basic modes to transfer data, status and control information:

- polling
- interrupt
- block

The block mode is not used on the AT&T Personal Computer 6300.

In the polling mode, Receive Character Available and Transmit Buffer Empty in Read Register 0 are examined before receiving and sending a character. All interrupt functions must be disabled. To do this, clear the Master Bit Enable and set the No Vector bit in Write Register 9. Then clear Write Register 1. This disables specific types of interrupts.

For interrupt mode, the Master Interrupt Enable in Write Register 9 must be set. In addition, bits 3-4 in Write Register 1 specify interrupts on receive character conditions. Bit 1 in Write Register 1 enables interrupts on Transmit Buffer Empty. Bit 0 enables External/Status interrupt. This interrupt is caused by transmit underrun condition, a zero count in the baud rate generator, a break detection (Asynchronous Mode), Abort (SDLC Mode), or EOP (SDLC Loop Mode). Write Register 15 enables or disables more specific types of interrupts.

Interrupt sources have the following priority:

Receive Channel A
Transmit Channel A
External/Status Channel A
Receive Channel B
Transmit Channel B
Receive Channel B

A bit in Read Register 3 is set to indicate the highest priority device needing service. You can read the vector address of the interrupt service routine in Read Register 2 if it was programmed. If this vector is read on Channel B, it includes status bits. Vectors are initialized with Write Register 2. The interrupt service routine resets the Highest Interrupt Under Service in Write Register 0. Other interrupts are reset in Write Register 0.

To set the baud rate, first clear bits 0-1 in Write Register 14. Then load Write Register 12 and 13 with the time constant. Last set bit 0-1 in Write Register 14 to enable the baud rate generator. To use the baud rate, set the transmit and receive clocks in Write Register 11 to the baud rate generator.

To determine the time constant to use for a given baud rate, use this formula:

$$3,686,400 \div (16)(2)(\text{Baud Rate}) - 2 = \text{Time Constant}$$

The following table states the divisors to use to obtain a given baud rate.

BAUD RATES USING 3.6864 MHZ CLOCK

BAUD RATE	TIME CONSTANT
110	1045
150	766
300	382
600	190
1200	94
2400	46
4800	22
9600	10

In Asynchronous mode, you initialize:

- Write Register 1 to disable DMA transfers and to enable or disable interrupts,
- Write Register 3 to set Receive Enable and the number of bits per receive character, to disable synchronous functions, and to enable or disable Auto Enable,
- Write Register 4 to set parity, stop bits, and data rate, and to disable synchronous mode,
- Write Register 5 to set Transmit Enable and the number of bits per transmit character, to enable or disable Request to Send, Data Terminal Ready and Send Break, and disable synchronous functions,
- Write Register 9 to force a reset and set interrupt parameters,
- Write Register 10 to choose an encoding method,
- Write Register 11 to select clock sources,
- Write Register 12 and 13 to set the baud rate time constant, and
- Write Register 15 to enable the baud rate generator.

To transmit a character, wait for Transmit Buffer Empty to be set in Read Register 1 of the SCC. Then write the character to the Data Register.

To receive a character, wait for Receive Character Ready in the Read Register 1 of the SCC. Then read the character from the Data Register.

In synchronous mode, you must transfer the data using interrupts. The External/Status interrupt is used to monitor the status of Clear to Send and Transmit Underrun/EOM latch.

In bisynchronous mode, you initialize:

- Write Register 0 to reset Transmit Underrun/EOM Latch, receive CRC checker, external/status interrupts, and enable interrupts on next receive character,
- Write Register 3 to enable the receiver, and to program Sync Character Load Inhibit, Enter Hunt For Sync Character, and number of bits per receive character,
- Write Register 4 to set parity, enable sync modes, number of bits per sync character, and clock mode,
- Write Register 5 to enable Transmit CRC, to request 16-bit CRC polynomial, enable transmit, transmit 8 bits per character, and to set Data Terminal Ready and Request to Send,
- Write Register 6 and 7 to set the sync bytes,
- Write Register 9 first to reset the hardware and later to set interrupts and vector variables,

- Write Register 10 to set length of sync character, the encoding method, to preset the CRC generator and to set the loop mode and go active on poll if wanted,
- Write Register 11 to set the clock sources, and
- Write Register 15 to set interrupt enable conditions.

The monosync transmitter is initialized as a biphase asynchronous transmitter with two exceptions:

- Only one sync character is written, and
- The 6-bit or 8-bit selection in Write Register 10 must be made.

In SDLC mode, you initialize:

- Write Register 0 to reset the transmit CRC generator after transmit enable has been done and to enable interrupts,
- Write Register 1 to enable interrupts,
- Write Register 3 to select bits per receive character, to set address search mode, to enable CRC receiver and receive enable,
- Write Register 4 to set SDLC mode before anything else is initialized and later to set clock mode,
- Write Register 5 to select the SDLC-CRC polynomial, to set Request to Send, Data Terminal Ready, transmit character length, transmit enable, and transmit CRC enable
- Write Register 6 to contain the secondary address field,

- Write Register 7 to contain flag character 01111110,
- Write Register 9 to reset the hardware and to set interrupt parameters,
- Write Register 10 to set loop mode, Go Active on Poll, Mark/Idle Flag, Abort on Underrun, the CRC preset condition, and the encoding mode,
- Write Register 11 to set clock sources,
- Write Register 14 to set the clock source for the DPLL, and
- Write Register 15 to set interrupt enable condition.

**Sample
Program**

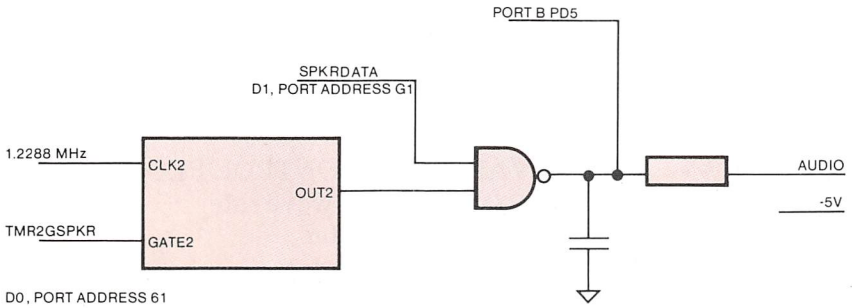
```
; RECEIVE
;   This routine receives one character
;
PTER      EQU 50
DATA      EQU 51
RECEIVE:
    MOV DX,PTER    ;Pointer Port Address
    XOR AL,AL      ;AL = 0
    OUT DX,AL      ;Select Read Register 0
REC1:
    IN AL,DX       ;Get Read Register 0
    TEST AL,1      ;Receive character available
    JZ REC1        ;Jump if no character
    MOV DX,DATA    ;Data Port Address
    IN AL,DX       ;Read character
    RET
```

Speaker

Functional Description

The speaker uses a permanent magnet speaker which is driven by one of two sources. Counter 2 of the Interval Timer can be programmed to automatically generate a pulse train. A bit in the Keyboard Control Register controls this pulse train. A bit in the Keyboard Control Register can also be programmed to manually generate a pulse train.

Block Diagram



Registers

PORT #	NAME	READ/ WRITE	DESCRIPTION
61	KEYBOARD CONTROL	W	Contains speaker enable and manual pulse train bits. See Keyboard documentation.
42	COUNTER 2	R/W	Counter for audio speaker tone generation. See Timer documentation.
43	TIMER CONTROL	W	Control register for Interval Timer. See Interval Timer documentation.

Functions

- **AUTOMATIC PULSE TRAIN**
 This function automatically generates an audible sound.
 OUTPUT:
 INTERVAL TIMER CONTROL REGISTER
 BITS 1-3 = 3, square wave rate generator
 BITS 4-5 = 3, set counter
 BITS 6-7 = 2, generator
 INTERVAL TIME COUNTER 2
 KEYBOARD CONTROL
 BIT 0 = 1, turns on speaker
- **MANUAL PULSE TRAIN**
 This function manually generates an audible sound.
 OUTPUT: KEYBOARD CONTROL
 BIT 1 This bit is set and cleared to generate a pulse train.

Sequencing and Timing

Input to the timer is 1.2288MHz. To generate a 1.00 KHz tone with the audio speaker, a square wave rate generator is used with a count of 614 ($1.2288\text{MHz}/2*614 = 1\text{KHz}$).

Sample Program

```

;
BEEP
: This program sounds the beep manually
;
KEY_CONTROL      EQU 61
TIMER_CONTROL    EQU 43
BEEP:
    MOV DX, TIMER_CONTROL ;port address
    MOV AL, B8H           ;of timer
    OUT DX, AL           ;set channel 2
                           ;in mode 4

    MOV DX, KEY_CONTROL
    IN AL,DX
    MOV AH,AL
    OR AH, 01H           ;turn on Gate
    MOV BL, 80H
BEEP1:
    MOV AL, AH           ;restore value
    AND AL, OFDH
    OUT DX, AL
    MOV CX, 48H
    LOOP $
    MOV AL, AH
    OR AL, 02H
    OUT DX, AL
    MOV CX, 48H
    LOOP $
    DEC BL
    JNZ BEEP1
    MOV AL,AH
    OUT DX,AL
    RET

```

Video Controller

Functional Description

The AT&T Personal Computer 6300 Display Controller interfaces the CPU to either monochrome or color displays. It uses a HD6845 CRT Controller. The Display Controller operates in two basic modes — text or all points addressable (APR) graphics. Several resolutions are available depending on the mode and display.

RESOLUTION	PC COMPATIBLE	GRAPHIC/TEXT	COLOR/MONOCROME
80X25	YES	T	C/M
40X25	YES	T	C/M
640X400	NO	G	M
640X200	YES	G	M
320X200	YES	G	C

In text mode, character attributes include reverse video, blinking, highlight, hide and underline. In color mode if blinking is not requested, one of 16 colors can be chosen. Otherwise, one of 8 colors can be chosen.

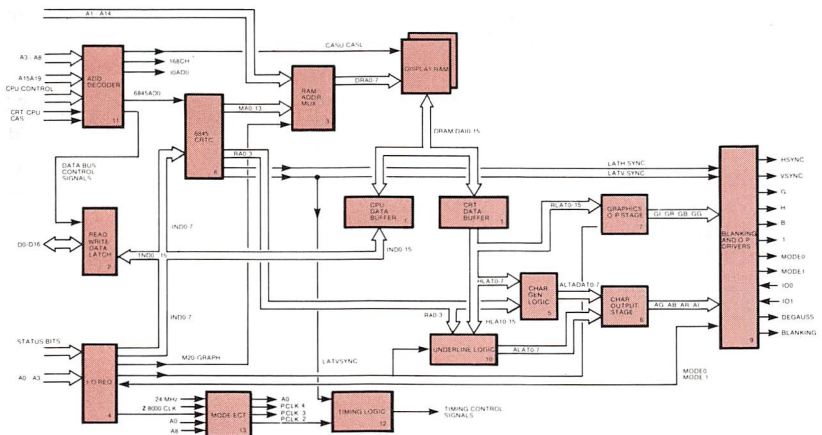
In graphic mode, each pixel on a color monitor is one of four selected colors. These four colors are from a choice of 16. In a monochrome monitor, these 16 colors are shades of gray from black to white.

The Display Controller has 32K of RAM to refresh one screen page.

The Display Controller can be upgraded with an optional board. This board gives you the following features:

- Up to three additional screen pages in RAM
- Software controlled look-up table for an international character set
- High resolution characters (16 X 16 pixels instead of 8 X 16 pixels)
- Hardware smooth scroll
- The ability to mix text and graphic modes simultaneously
- Up to 16 colors can be displayed at once

Block Diagram



Registers

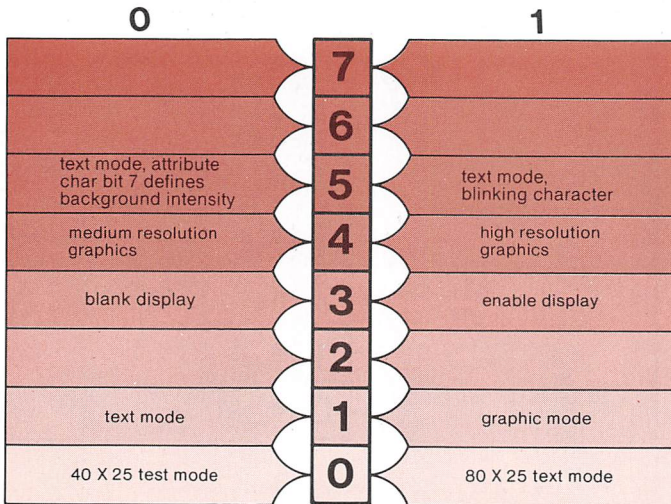
PORT #	NAME	READ/ WRITE	DESCRIPTION
3D8	MODE SELECT REGISTER 1	W	See layout
3D9	COLOR SELECT REGISTER	W	See layout
3DA	STATUS REGISTER	R	See layout
3DE	MODE SELECT REGISTER 2	W	See layout
3D4	POINTER TO HD6845 REGISTER	W	
3D5	HD6845 DATA REGISTER	R/W	

HD6845 Registers

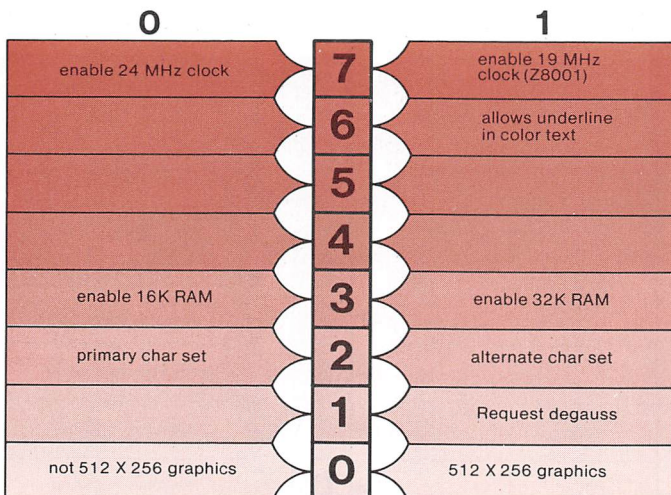
NO	NAME	READ/ WRITE	INITIALIZATION VALUE		
			40X25	80X25	GRAPHIC
0	HORIZONTAL TOTAL	W	38	71	38
1	HORIZONTAL DISPLAYED	W	28	50	28
2	HORIZONTAL SYNC POSITION	W	2D	5A	2D
3	HORIZONTAL SYNC WIDTH	W	06	0C	06
4	VERTICAL TOTAL	W	1F	1F	7F
5	VERTICAL TOTAL ADJUST	W	06	06	06
6	VERTICAL DISPLAYED	W	19	19	64
7	VERTICAL SYNC POSITION	W	1C	1C	70
8	INTERLACE MODE	W	02	02	02
9	MAX. SCAN LINE ADDRESS	W	07	07	01
A	CURSOR START LINE (SIZE)	W	06	06	06
B	CURSOR END LINE	W	07	07	07
C	ACTIVE PAGE START ADDR (H)	W	00	00	00
D	ACTIVE PAGE START ADDR (L)	W	00	00	00
E	CURSOR ADDRESS (H)	R/W			
F	CURSOR ADDRESS (L)	R/W			
10	LIGHT PEN (H)	R			
11	LIGHT PEN (L)	R			

Layout

MODE SELECT REGISTER 1



MODE SELECT REGISTER 2



COLOR SELECT REGISTER 1 (Graphics Mode Only)

0		7	1	
N/A			N/A	
N/A			N/A	
Select Foreground Palette (320 x 200) Cyan, Magenta, White			Select Foreground Palette (320 x 200) Green, Red, Yellow	
Set Foreground Intensity Off (320 x 200)			Set Foreground Intensity On (320 x 200)	
			Modify Color Selected By Bits 0-2	
Modified Colors (Bit 3)			Select Color Shade	
640 x 200	320 x 200 Background		320 x 200 Background	640 x 200
640 x 400	000: Dark Gray		000: Black	640 x 400
Foreground	001: Light Blue		001: Blue	Foreground
	010: Light Green		101: Green	
	011: Light Cyan		010: Cyan	
	100: Light Red		100: Red	
	101: Light Magenta		101: Magenta	
	110: Yellow		110: Brown	001: Darkest Gray
	111: White		111: Light Gray	

STATUS REGISTER

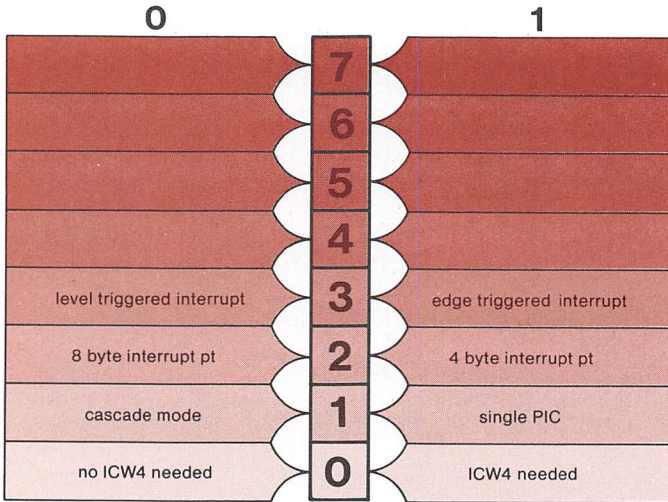
0	7	1
Display option board present		11: No expansion
		01: 12" Color monitor
		11: 12" Monochrome monitor
		First half of vertical retrace
		Light Pen switched off
		Light Pen triggered
		Horizontal Retracing

Registers

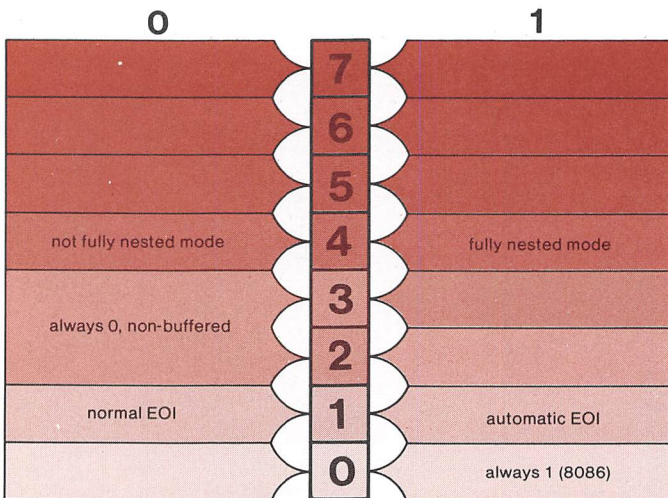
PORT #	NAME	READ/ WRITE	DESCRIPTION
20	INIT COMMAND WORD 1 (ICW1)	W	See layout
21	INIT COMMAND WORD 2 (ICW2)	W	INT0 interrupt type, multiple of 8
21	INIT COMMAND WORD 3 (ICW3)	W	Cascade mode only
21	INIT COMMAND WORD 4 (ICW4)	W	See layout
21	OPERATION COMMAND WORD 1 (OCW1, IMR)	R/W	Interrupt Mask Register See layout
20	OPERATION COMMAND WORD 2 (OCW2)	W	See layout
20	OPERATION COMMAND WORD 3 (OCW3)	W	See layout
20	IN-SERVICE REGISTER (ISR)	R	See layout
21	INTERRUPT LEVEL	R	See layout
20	INTERRUPT REQUEST REGISTER (IRR)	R	See layout

Layout

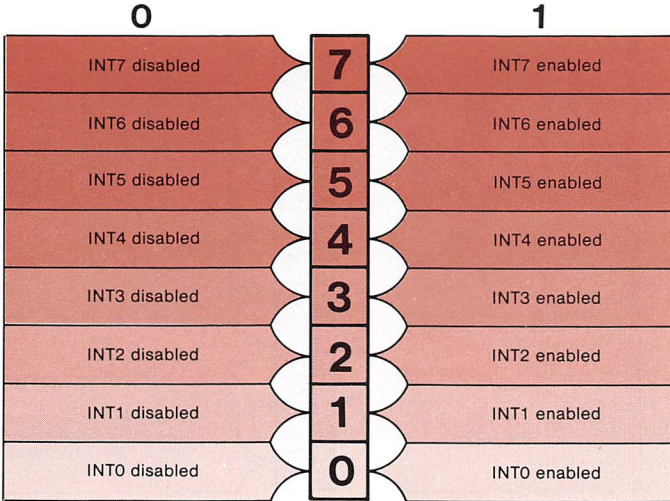
ICW1



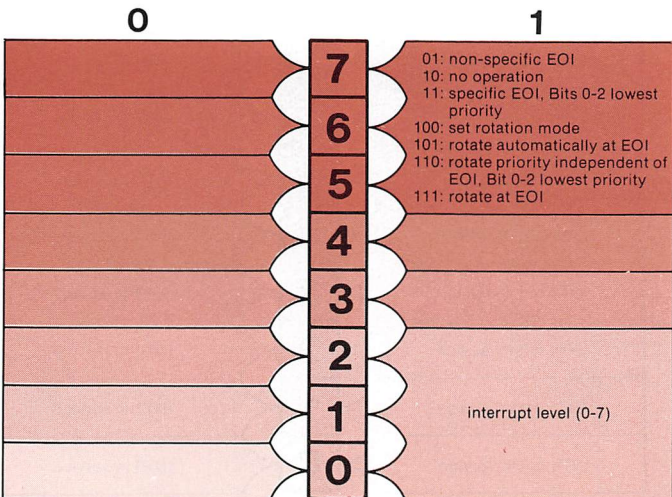
ICW4



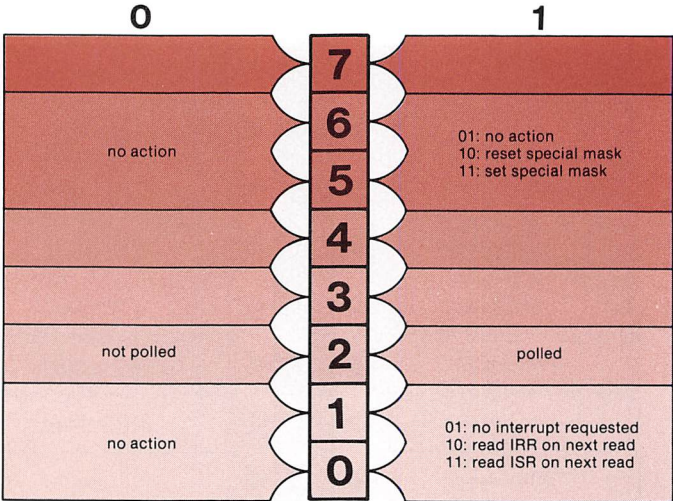
OCW1 or INTERRUPT MASK REGISTER



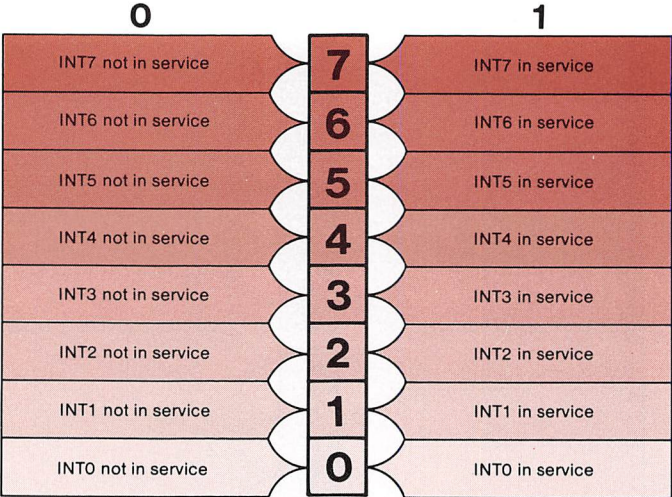
OCW2



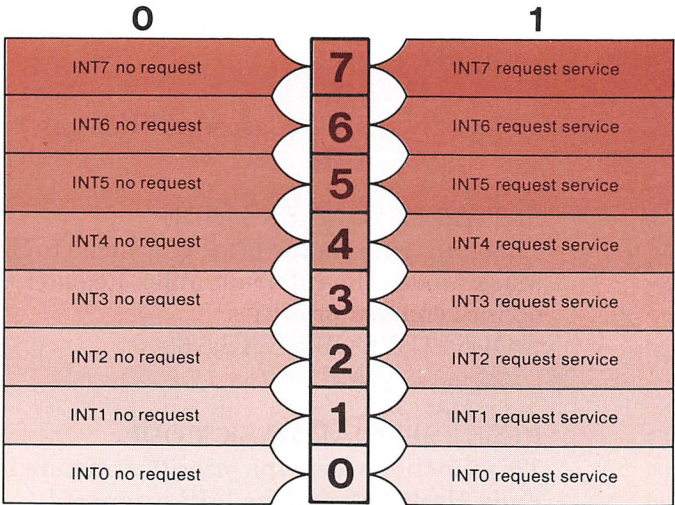
OCW3



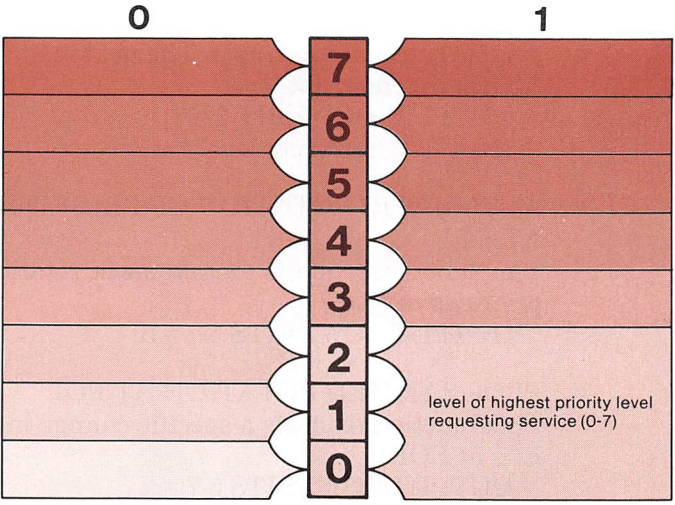
IN SERVICE REGISTER



INTERRUPT REQUEST REGISTER



INTERRUPT LEVEL



Functions • **INITIALIZATION**

This function prepares the PIC to accept interrupts by setting it to an initial state.

OUTPUT: ICW1
ICW2
ICW3 (Cascaded PIC's only)
ICW4

• **SET SPECIAL MASK MODE**

This function sets the priority scheme to Special Mask Mode. The Interrupt Mask Register (IMR) defines enabled priorities.

OUTPUT: OCW3 BITS 5-6 = 3
IMR

• **RESET SPECIAL MASK MODE**

This function resets the priority structure to the Fully Nested Mode. The IMR is ignored.

OUTPUT: OCW3 BITS 5-6 = 1

• **SET POLLED MODE**

This function sets the priority scheme to Polled Mode. The CLI instruction must be executed to disable external interrupts. The next read fetches the interrupt level.

OUTPUT: OCW3 BIT 2 = 1
INPUT: interrupt level

• **AUTOMATIC ROTATION OF PRIORITIES AT EOI**

This function requests an automatic rotation of priorities at EOI.

OUTPUT: ICW2 BITS 5-7 = 5

• **PROGRAMMED ROTATION AT EOI**

This function requests a specific change in priorities at EOI.

OUTPUT: ICW2 BITS 5-7 = 7
ICW2 BITS 0-2 = level of lowest
priority

Text Mode

Every character position is defined by two bytes:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
I	R	G	B	I	R	G	B	ASCII CHAR CODE							

Background Foreground
Attribute Byte

If neither the underline or blinking capabilities are specified, the color choice for foreground and background with a color monitor is:

Black	Red
Blue	Magenta
Green	Brown
Cyan	Light Gray
Dark Gray	Light Red
Light Blue	Light Magenta
Light Green	Yellow
Light Cyan	White

With a monochrome monitor, the color choice is:

Black
Darkest Gray
.
Lightest Gray
.
White

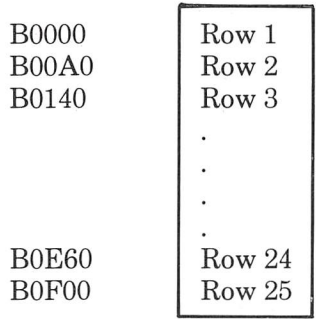
The codes for common monochrome choices follow:

normal	00001111
reverse video	11110000
non-display black	00000000
non-display white	11111111

When the blinking capability is specified in Mode Select 1, then Bit 15 of the attribute byte specifies whether the character blinks.

If the underline capability is specified in the Mode Select Register 2, then Bit 11 specifies whether the character is underlined.

The first position in the left-hand corner of the screen is defined in the first two bytes of memory starting at B0000. The next position, one column to the right, is defined in the next two bytes of memory at B0002. The first character in the next row follows immediately after the definition for the last character in the first row. For 80 column X 25 rows, memory looks like this:



The 80 column display uses 4K of RAM and the 40 column display uses 2K of RAM. The rest of the 32K is used for multiple screen images called pages. There are either 16 or eight pages available.

Graphics Mode

In graphics mode, the display screen is a grid of pixels, the smallest displayable unit on a video monitor. In medium resolution, there are 640 across and either 200 or 400 down.

In high resolution, each pixel is defined by one bit. Bit 7 of each byte defines the first pixel and bit 0 defines the last pixel to be displayed. The background color is always black and is displayed when the pixel is off. When the pixel is on, the foreground color is one of 16 shades of gray as defined in the Color Select Register Bits 0-2 and 3.

In medium resolution, each pixel is defined by two bits:

7 6	5 4	3 2	1 0	
1st	2nd	3rd	4th	PIXELS

The value of two bits define one of four preselected colors.

- 0 — background color
- 1 — color 1
- 2 — color 2
- 3 — color 3

The background color is defined by Bits 0-3 in the Color Select Register. Colors 1, 2, and 3 are cyan, magenta and white if Bit 5 of the Color Select Register is zero and are green, red, and yellow if Bit 5 is one.

Unlike the text mode, rows of pixels do not follow one after another in memory. The following memory maps illustrate the layouts.

MEMORY MAP (640 X 400 GRAPHICS MODE)

B8000		LINES 0,4,8,...396 8000 BYTES
B9F3F	NOT USED	
BA000		LINES 1,5,9,...397 8000 BYTES
BBF3F	NOT USED	
BC000		LINES 2,6,10,...398 8000 BYTES
BDF3F	NOT USED	
BE000		LINES 3,7,11,...399 8000 BYTES
BFF3F		

MEMORY MAP (320 X 200 GRAPHICS MODE)

B8000		EVEN LINES 0,2,4,.....198 8000 BYTES PAGE 0
B9F3F	NOT USED	
BA000		ODD LINES 1,3,5,.....199 8000 BYTES PAGE 0
BBF3F	NOT USED	
BC000		EVEN LINES 8000 BYTES PAGE 1
BDF3F	NOT USED	
BE000		ODD LINES 8000 BYTES
BFF3F		

- Functions**
- **INITIALIZE HD6845**
This function initializes the 16 registers of the HD6845 with predetermined values.
OUTPUT: POINTER TO HD6845 REGISTER
Number of HD6845 register
HD6845 DATA REGISTER
Value of HD6845 register
(Repeat 16 times for each register)
 - **SET MODE**
Set different mode characteristics such as text or graphics, type of graphics, blinking character, etc.
OUTPUT: MODE SELECT 1
MODE SELECT 2
 - **SET COLOR TYPE**
Choose the different color or shades of gray to display.
OUTPUT: COLOR SELECT REGISTER
 - **SET CURSOR SIZE**
Set starting and ending line for cursor.
OUTPUT: POINTER TO HD6845 REGISTER
0AH
HD6845 DATA REGISTER
start line
POINTER TO HD6845 REGISTER
0BH
HD6845 DATA REGISTER
end line

-
- **SET CURSOR POSITION**
Set cursor to location in memory.
OUTPUT: POINTER TO HD6845 REGISTER
0EH
HD6845 DATA REGISTER
most significant byte of address
POINTER TO H36845 REGISTER
0FH
HD6845 DATA REGISTER
least significant byte of address
 - **READ CURSOR POSITION**
Read the current position of the cursor.
INPUT: POINTER TO HD6845 REGISTER
0EH
HD6845 DATA REGISTER
most significant byte of address
POINTER TO H36845 REGISTER
0FH
HD6845 DATA REGISTER
least significant byte of address
 - **SET ACTIVE PAGE**
Set the address of the current page to display.
OUTPUT: POINTER TO HD6845 REGISTER
0CH
HD6845 DATA REGISTER
most significant byte of address
POINTER TO H36845 REGISTER
0DH
HD6845 DATA REGISTER
least significant byte of address

Sequencing and Timing

There are two methods of communicating with the video display. One is with I/O commands. This method is used to set the modes of operation, the cursor position, the cursor size or the current active page.


```

0200 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10 11 .....
0210 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F 20 21 ..... !
0220 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F 30 31 ~#%&'()*+,-./01
0230 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 40 41 23456789:;<=>?@A
0240 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F 50 51 BCDEFGHIJKLMNOPQ
0250 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F 60 61 RSTUVWXYZ[\]^_`a
0260 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F 70 71 bcdefghijklmnopq
0270 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F 80 81 rstuvwxyz{|}~...
0280 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F .....
0290 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F .....
02A0 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F !"#%&'()*+,-./
02B0 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 0123456789:;<=>?
02C0 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F @ABCDEFGHIJKLMNO
02D0 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F PQRSTUWXYZ[\]^_
02E0 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F `abcdefghijklmno
02F0 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F pqrstuvwxyz{|}~.
0300 06 06 06 06 06 06 06 06 06 06 06 06 06 06 06 .....
0310 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
0320 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
0330 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
0340 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
0350 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
0360 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
0370 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
0380 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
0390 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
03A0 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
03B0 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
03C0 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
03D0 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
03E0 09 09 09 09 09 09 09 09 09 09 09 09 09 09 09 .....
03F0 09 09 09 09 09 09 09 09 09 09 09 09 09 09 06 .....
0400 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A .....
0410 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A .....
0420 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A .....
0430 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A .....
0440 1A 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... ,kkkkkkkkkkkkkkkkkkkk
0450 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
0460 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
0470 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
0480 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
0490 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
04A0 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
04B0 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
04C0 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
04D0 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
04E0 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
04F0 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B ..... kkkkkkkkkkkkkkkkkkkkk
0500 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0510 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0520 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0530 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....

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Video Controller

```
0540 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0550 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0560 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0570 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0580 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0590 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
05A0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
05B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
05C0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
05D0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
05E0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
05F0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0600 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F .....
0610 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F .....
0620 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F      !"#%&'()*+,-./
0630 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F      0123456789:;<=>?
0640 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F      @ABCDEFGHIJKLMNO
0650 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F      PQRSTUVWXYZ[\]^_
0660 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F      `abcdefgijklmno
0670 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F      pqrstuvwxyz{|}~.
0680 80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F .....
0690 90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F .....
06A0 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF .....
06B0 B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF .....
06C0 C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF .....
06D0 D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE DF .....
06E0 E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC ED EE EF .....
06F0 F0 F1 F2 F3 F4 F5 F6 F7 F8 F9 FA FB FC FD FE FF .....
0700 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 .....
0710 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 .....
0720 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 .....
0730 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 .....
0740 19 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0750 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0760 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0770 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0780 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0790 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
07A0 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
07B0 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
07C0 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
07D0 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
07E0 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
07F0 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0800 00 00 00 03 00 00 00 00 00 00 00 00 00 00 .....
0810 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0820 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0830 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0840 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0850 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0860 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0870 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
```

```

0880 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0890 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08A0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08C0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08D0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08E0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08F0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0900 01 03 05 03 09 0B 0D 0F 11 13 15 17 19 1B 1D 0F .....
0910 21 23 25 27 29 2B 2D 2F 31 33 35 37 39 3B 3D 3F !#%' )+~/13579;=?
0920 41 43 45 47 49 4B 4D 4F 51 53 55 57 59 5B 5D 5F ACEGIKMOQSUNWY[ ]_
0930 61 63 65 67 69 6B 6D 6F 71 73 75 77 79 7B 7D 7F acegikmoqsunwy}{.
0940 81 83 85 87 89 8B 8D 8F 91 93 95 97 99 9B 9D 9F .....
0950 A1 A3 A5 A7 A9 AB AD AF B1 B3 B5 B7 B9 BB BD BF .....
0960 C1 C3 C5 C7 C9 CB CD CF D1 D3 D5 D7 D9 DB DD DF .....
0970 E1 E3 E5 E7 E9 EB ED EF F1 F3 F5 F7 F9 FB FD FF .....
0980 01 03 05 07 09 0B 0D 0F 11 13 15 17 19 1B 1D 1F .....
0990 21 23 25 27 29 2B 2D 2F 31 33 35 37 39 3B 3D 3F !#%' )+~/13579;=?
09A0 41 43 45 47 49 4B 4D 4F 51 53 55 57 59 5B 5D 5F ACEGIKMOQSUNWY[ ]_
09B0 61 63 65 67 69 6B 6D 6F 71 73 75 77 79 7B 7D 7F acegikmoqsunwy}{.
09C0 81 83 85 87 89 8B 8D 8F 91 93 95 97 99 9B 9D 9F .....
09D0 A1 A3 A5 A7 A9 AB AD AF B1 B3 B5 B7 B9 BB BD BF .....
09E0 C1 C3 C5 C7 C9 CB CD CF D1 D3 D5 D7 D9 DB DD DF .....
09F0 E1 E3 E5 E7 E9 EB ED EF F1 F3 F5 F7 F9 FB FD FF .....
0A00 00 02 04 06 08 0A 0C 0E 10 10 10 10 10 10 10 10 .....
0A10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 .....
0A20 20 22 24 26 28 2A 2C 2E 30 30 30 30 30 30 30 30 " $& (*, .00000000
0A30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 0000000000000000
0A40 40 42 44 46 48 4A 4C 4E 50 50 50 50 50 50 50 50 @BDFHJLNPppppppp
0A50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 Pppppppppppppppppp
0A60 60 62 64 66 68 6A 6C 6E 70 70 70 70 70 70 70 70 *'bdfhjlnppppppppp
0A70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 pppppppppppppppppp
0A80 00 02 04 06 08 0A 0C 0E 10 10 10 10 10 10 10 10 .....
0A90 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 .....
0AA0 20 22 24 26 28 2A 2C 2E 30 30 30 30 30 30 30 30 " $& (*, .00000000
0AB0 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 0000000000000000
0AC0 40 42 44 46 48 4A 4C 4E 50 50 50 50 50 50 50 50 @BDFHJLNPppppppp
0AD0 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 Pppppppppppppppppp
0AE0 60 62 64 66 68 6A 6C 6E 70 70 70 70 70 70 70 70 *'bdfhjlnppppppppp
0AF0 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 pppppppppppppppppp
0B00 00 02 04 06 08 0A 0C 0E 10 12 14 16 18 1A 1C 1E .....
0B10 20 22 24 26 28 2A 2C 2E 30 32 34 36 38 3A 3C 3E " $& (*, .02468;< >
0B20 40 42 44 46 48 4A 4C 4E 50 52 54 56 58 5A 5C 5E @BDFHJLNPRTVXZ\
0B30 60 62 64 66 68 6A 6C 6E 70 72 74 76 78 7A 7C 7E *'bdfhjlnprtvxz ~
0B40 80 82 84 86 88 8A 8C 8E 90 92 94 96 98 9A 9C 9E .....
0B50 A0 A2 A4 A6 A8 AA AC AE B0 B2 B4 B6 B8 BA BC BE .....
0B60 C0 C2 C4 C6 C8 CA CC CE D0 D2 D4 D6 D8 DA DC DE .....
0B70 E0 E2 E4 E6 E8 EA EC EE F0 F2 F4 F6 F8 FA FC FE .....
0B80 00 02 04 06 08 0A 0C 0E 10 12 14 16 18 1A 1C 1E .....
0B90 20 22 24 26 28 2A 2C 2E 30 32 34 36 38 3A 3C 3E " $& (*, .02468;< >
0BA0 40 42 44 46 48 4A 4C 4E 50 52 54 56 58 5A 5C 5E @BDFHJLNPRTVXZ\
0BB0 60 62 64 66 68 6A 6C 6E 70 72 74 76 78 7A 7B 7E *'bdfhjlnprtvxz ~

```

0BC0	80 82 84 86 88 8A 8C 8E	90 92 94 96 98 9A 9C 9E	.....
0BD0	A0 A2 A4 A6 A8 AA AC AE	B0 B2 B4 B6 B8 BA BC BE	.....
0BE0	C0 C2 C4 C6 C8 CA CC CE	D0 D2 D4 D6 D8 DA DC DE	.....
0BF0	E0 E2 E4 E6 E8 EA EC EE	F0 F2 F4 F6 F8 FA FC FE	.....
0C00	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0C10	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
0C20	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	! "#\$%&'()*+,-./
0C30	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789:;<=>?
0C40	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
0C50	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_
0C60	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklmnop
0C70	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	qrstuvwxyz{|}~.
0C80	80 81 82 83 84 85 86 87	88 89 8A 8B 8C 8D 8E 8F	.....
0C90	90 91 92 93 94 95 96 97	98 99 9A 9B 9C 9D 9E 9F	.....
0CA0	A0 A1 A2 A3 A4 A5 A6 A7	A8 A9 AA AB AC AD AE AF	.....
0CB0	B0 B1 B2 B3 B4 B5 B6 B7	B8 B9 BA BB BC BD BE BF	.....
0CC0	C0 C1 C2 C3 C4 C5 C6 C7	C8 C9 CA CB CC CD CE CF	.....
0CD0	D0 D1 D2 D3 D4 D5 D6 D7	D8 D9 DA DB DC DD DE DF	.....
0CE0	E0 E1 E2 E3 E4 E5 E6 E7	E8 E9 EA EB EC ED EE EF	.....
0CF0	F0 F1 F2 F3 F4 F5 F6 F7	F8 F9 FA FB FC FD FE FF	.....
0D00	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0D10	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
0D20	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	! "#\$%&'()*+,-./
0D30	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789:;<=>?
0D40	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
0D50	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_
0D60	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklmnop
0D70	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	qrstuvwxyz{|}~.
0D80	80 81 82 83 84 85 86 87	88 89 8A 8B 8C 8D 8E 8F	.....
0D90	90 91 92 93 94 95 96 97	98 99 9A 9B 9C 9D 9E 9F	.....
0DA0	A0 A1 A2 A3 A4 A5 A6 A7	A8 A9 AA AB AC AD AE AF	.....
0DB0	B0 B1 B2 B3 B4 B5 B6 B7	B8 B9 BA BB BC BD BE BF	.....
0DC0	C0 C1 C2 C3 C4 C5 C6 C7	C8 C9 CA CB CC CD CE CF	.....
0DD0	D0 D1 D2 D3 D4 D5 D6 D7	D8 D9 DA DB DC DD DE DF	.....
0DE0	E0 E1 E2 E3 E4 E5 E6 E7	E8 E9 EA EB EC ED EE EF	.....
0DF0	F0 F1 F2 F3 F4 F5 F6 F7	F8 F9 FA FB FC FD FE FF	.....
0E00	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0E10	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
0E20	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	! "#\$%&'()*+,-./
0E30	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789:;<=>?
0E40	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
0E50	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_
0E60	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklmnop
0E70	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	qrstuvwxyz{|}~.
0E80	80 81 82 83 84 85 86 87	88 89 8A 8B 8C 8D 8E 8F	.....
0E90	90 91 92 93 94 95 96 97	98 99 9A 9B 9C 9D 9E 9F	.....
0EA0	A0 A1 A2 A3 A4 A5 A6 A7	A8 A9 AA AB AC AD AE AF	.....
0EB0	B0 B1 B2 B3 B4 B5 B6 B7	B8 B9 BA BB BC BD BE BF	.....
0EC0	C0 C1 C2 C3 C4 C5 C6 C7	C8 C9 CA CB CC CD CE CF	.....
0ED0	D0 D1 D2 D3 D4 D5 D6 D7	D8 D9 DA DB DC DD DE DF	.....
0EE0	E0 E1 E2 E3 E4 E5 E6 E7	E8 E9 EA EB EC ED EE EF	.....
0EF0	F0 F1 F2 F3 F4 F5 F6 F7	F8 F9 FA FB FC FD FE FF	.....

0F00	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0F10	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
0F20	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	!"#%&'()*+,-./
0F30	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789:;<=>?
0F40	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
0F50	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_
0F60	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklnmo
0F70	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	pqrstuvwxyxzyz{|}~.
0F80	80 81 82 83 84 85 86 87	88 89 8A 8B 8C 8D 8E 8F	.....
0F90	90 91 92 93 94 95 96 97	98 99 9A 9B 9C 9D 9E 9F	.....
0FA0	A0 A1 A2 A3 A4 A5 A6 A7	A8 A9 AA AB AC AD AE AF	.....
0FB0	B0 B1 B2 B3 B4 B5 B6 B7	B8 B9 BA BB BC BD BE BF	.....
0FC0	C0 C1 C2 C3 C4 C5 C6 C7	C8 C9 CA CB CC CD CE CF	.....
0FD0	D0 D1 D2 D3 D4 D5 D6 D7	D8 D9 DA DB DC DE DF	.....
0FE0	E0 E1 E2 E3 E4 E5 E6 E7	E8 E9 EA EB EC ED EE EF	.....
0FF0	F0 F1 F2 F3 F4 F5 F6 F7	F8 F9 FA FB FC FD FE FF	.....

At end of current range
*

SCRAMB (USED ON REV. P3 AND LATER)

Unrecognized command

*DIS ..350

0000	39 39 39 39 39 39 39 39	39 39 39 39 39 39 39 39	9999999999999999
0010	39 39 39 39 39 39 39 39	39 39 39 39 39 39 39 39	9999999999999999
0020	39 39 39 39 39 39 39 39	39 39 39 39 39 39 39 39	9999999999999999
0030	39 39 39 39 39 39 39 39	39 39 39 39 39 39 39 39	9999999999999999
0040	39 39 39 39 39 39 39 39	39 39 39 39 39 39 39 39	9999999999999999
0050	39 39 39 39 39 39 73 73	73 73 73 73 73 73 73 73	9999999ssssssssss
0060	73 73 73 73 73 73 73 73	73 73 73 73 73 73 73 73	ssssssssssssssssss
0070	73 73 73 73 73 73 73 73	73 73 73 73 73 73 73 73	ssssssssssssssssss
0080	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0090	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
00A0	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	!"#%&'()*+,-./
00B0	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789:;<=>?
00C0	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
00D0	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_
00E0	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklnmo
00F0	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	pqrstuvwxyxzyz{|}~.
0100	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0110	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
0120	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	!"#%&'()*+,-./
0130	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789:;<=>?
0140	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
0150	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_
0160	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklnmo
0170	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	pqrstuvwxyxzyz{|}~.
0180	80 81 82 83 84 85 86 87	88 89 8A 8B 8C 8D 8E 8F	.....
0190	90 91 92 93 94 95 96 97	98 99 9A 9B 9C 9D 9E 9F	.....
01A0	A0 A1 A2 A3 A4 A5 A6 A7	A8 A9 AA AB AC AD AE AF	.....
01B0	B0 B1 B2 B3 B4 B5 B6 B7	B8 B9 BA BB BC BD BE BF	.....

Video Controller

```
0100 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F .....
01D0 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F .....
01E0 E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC ED EE EF .....
01F0 F0 F1 F2 F3 F4 F5 F6 F7 F8 F9 FA FB FC FD FE FF .....
0200 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10 11 .....
0210 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F 20 21 .....
0220 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F 30 31 "#%&'()*+,-./01
0230 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 40 41 23456789:;<=>?@A
0240 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F 50 51 BCDEFGHIJKLMNO PQ
0250 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F 60 61 RSTUVWXYZ[\]^_`a
0260 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F 70 71 bcdefghijklmnopq
0270 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F 80 81 rstuvwxyz{|}~...
0280 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F .....
0290 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F .....
02A0 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F !"#%&'()*+,-./
02B0 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 0123456789:;<=>?
02C0 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F @ABCDEFGHIJKLMNO
02D0 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F PQRSTUVWXYZ[\]^_`a
02E0 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F `abcdefghijklmnop
02F0 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F qrstuvwxyz{|}~.
0300 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0310 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0320 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0330 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0340 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0350 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0360 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0370 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0380 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0390 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
03A0 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
03B0 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
03C0 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
03D0 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
03E0 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
03F0 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E 0E .....
0400 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A .....
0410 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A .....
0420 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A .....
0430 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A 1A .....
0440 1A 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B .....
0450 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B .....
0460 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B .....
0470 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B 6B .....
0480 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F .....
0490 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F .....
04A0 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F !"#%&'()*+,-./
04B0 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 0123456789:;<=>?
04C0 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F @ABCDEFGHIJKLMNO
04D0 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F PQRSTUVWXYZ[\]^_`a
04E0 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F `abcdefghijklmnop
04F0 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F qrstuvwxyz{|}~.
```


Video Controller

```
0500 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0510 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0520 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0530 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0540 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0550 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0560 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0570 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0580 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 08 09 0A 0B 0C 0D 0E 0F .....
0590 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F 18 19 1A 1B 1C 1D 1E 1F .....
05A0 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F 28 29 2A 2B 2C 2D 2E 2F .....
05B0 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 38 39 3A 3B 3C 3D 3E 3F .....
05C0 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F 48 49 4A 4B 4C 4D 4E 4F .....
05D0 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F 58 59 5A 5B 5C 5D 5E 5F .....
05E0 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F 68 69 6A 6B 6C 6D 6E 6F .....
05F0 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F 78 79 7A 7B 7C 7D 7E 7F .....
0600 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 08 09 0A 0B 0C 0D 0E 0F .....
0610 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F 18 19 1A 1B 1C 1D 1E 1F .....
0620 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F 28 29 2A 2B 2C 2D 2E 2F .....
0630 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 38 39 3A 3B 3C 3D 3E 3F .....
0640 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F 48 49 4A 4B 4C 4D 4E 4F .....
0650 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F 58 59 5A 5B 5C 5D 5E 5F .....
0660 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F 68 69 6A 6B 6C 6D 6E 6F .....
0670 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F 78 79 7A 7B 7C 7D 7E 7F .....
0680 80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F 88 89 8A 8B 8C 8D 8E 8F .....
0690 90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F 98 99 9A 9B 9C 9D 9E 9F .....
06A0 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF A8 A9 AA AB AC AD AE AF .....
06B0 B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF B8 B9 BA BB BC BD BE BF .....
06C0 C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF C8 C9 CA CB CC CD CE CF .....
06D0 D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE DF D8 D9 DA DB DC DD DE DF .....
06E0 E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC ED EE EF E8 E9 EA EB EC ED EE EF .....
06F0 F0 F1 F2 F3 F4 F5 F6 F7 F8 F9 FA FB FC FD FE FF F8 F9 FA FB FC FD FE FF .....
0700 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 .....
0710 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 .....
0720 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 .....
0730 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 19 .....
0740 19 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0750 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0760 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0770 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 64 .....
0780 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 08 09 0A 0B 0C 0D 0E 0F .....
0790 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F 18 19 1A 1B 1C 1D 1E 1F .....
07A0 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F 28 29 2A 2B 2C 2D 2E 2F .....
07B0 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 38 39 3A 3B 3C 3D 3E 3F .....
07C0 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F 48 49 4A 4B 4C 4D 4E 4F .....
07D0 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F 58 59 5A 5B 5C 5D 5E 5F .....
07E0 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F 68 69 6A 6B 6C 6D 6E 6F .....
07F0 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F 78 79 7A 7B 7C 7D 7E 7F .....
0800 00 00 00 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0810 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0820 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0830 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
```

Video Controller

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0840 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0850 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0860 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0870 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0880 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0890 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08A0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08C0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08D0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08E0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
08F0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0900 01 03 05 03 09 0B 0D 0F 11 13 15 17 19 1B 1D 0F .....
0910 21 23 25 27 29 2B 2D 2F 31 33 35 37 39 3B 3D 3F !#%' )+~/13579;=?
0920 41 43 45 47 49 4B 4D 4F 51 53 55 57 59 5B 5D 5F ACEGIKMQSUWY[_]_
0930 61 63 65 67 69 6B 6D 6F 71 73 75 77 79 7B 7D 7F acegikmqsuwy}_{.
0940 81 83 85 87 89 8B 8D 8F 91 93 95 97 99 9B 9D 9F .....
0950 A1 A3 A5 A7 A9 AB AD AF B1 B3 B5 B7 B9 BB BD BF .....
0960 C1 C3 C5 C7 C9 CB CD CF D1 D3 D5 D7 D9 DB DD DF .....
0970 E1 E3 E5 E7 E9 EB ED EF F1 F3 F5 F7 F9 FB FD FF .....
0980 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F .....
0990 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F .....
09A0 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F !"#%&'()*+,-./
09B0 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 0123456789;:<=>?
09C0 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F @ABCDEFGHIJKLMNO
09D0 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F PQRSTUVWXYZ[\]^_
09E0 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F `abcdefgijklmno
09F0 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F pqrstuvwxyz{|}~.
0A00 00 02 04 06 08 0A 0C 0E 10 10 10 10 10 10 10 10 .....
0A10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 .....
0A20 20 22 24 26 28 2A 2C 2E 30 30 30 30 30 30 30 30 `#&(*,.,00000000
0A30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 30 0000000000000000
0A40 40 42 44 46 48 4A 4C 4E 50 50 50 50 50 50 50 50 @BDFHJLNPpppppppp
0A50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 Ppppppppppppppppp
0A60 60 62 64 66 68 6A 6C 6E 70 70 70 70 70 70 70 70 `bdfhjlnpppppppppp
0A70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 ppppppppppppppppppp
0A80 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F .....
0A90 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F .....
0AA0 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F !"#%&'()*+,-./
0AB0 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F 0123456789;:<=>?
0AC0 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F @ABCDEFGHIJKLMNO
0AD0 50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F PQRSTUVWXYZ[\]^_
0AE0 60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F `abcdefgijklmno
0AF0 70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F pqrstuvwxyz{|}~.
0B00 00 02 04 06 08 0A 0C 0E 10 12 14 16 18 1A 1C 1E .....
0B10 20 22 24 26 28 2A 2C 2E 30 32 34 36 38 3A 3C 3E `#&(*,.,02468;<>
0B20 40 42 44 46 48 4A 4C 4E 50 52 54 56 58 5A 5C 5E @BDFHJLNPrtvxz\
0B30 60 62 64 66 68 6A 6C 6E 70 72 74 76 78 7A 7B 7E `bdfhjlnprtvxz ~
0B40 80 82 84 86 88 8A 8C 8E 90 92 94 96 98 9A 9C 9E .....
0B50 A0 A2 A4 A6 A8 AA AC AE B0 B2 B4 B6 B8 BA BC BE .....
0B60 C0 C2 C4 C6 C8 CA CC CE D0 D2 D4 D6 D8 DA DC DE .....
0B70 E0 E2 E4 E6 E8 EA EC EE F0 F2 F4 F6 F8 FA FC FE .....
```

0B80	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0B90	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
0BA0	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	!"#\$%&'()*+,-./
0BB0	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789;=<=>?
0BC0	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
0BD0	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_`
0BE0	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklmnop
0BF0	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	qrstuvwxyz{|}~.
0C00	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0C10	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
0C20	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	!"#\$%&'()*+,-./
0C30	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789;=<=>?
0C40	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
0C50	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_`
0C60	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklmnop
0C70	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	qrstuvwxyz{|}~.
0C80	80 81 82 83 84 85 86 87	88 89 8A 8B 8C 8D 8E 8F	.....
0C90	90 91 92 93 94 95 96 97	98 99 9A 9B 9C 9D 9E 9F	.....
0CA0	A0 A1 A2 A3 A4 A5 A6 A7	A8 A9 AA AB AC AD AE AF	.....
0CB0	B0 B1 B2 B3 B4 B5 B6 B7	B8 B9 BA BB BC BD BE BF	.....
0CC0	C0 C1 C2 C3 C4 C5 C6 C7	C8 C9 CA CB CC CD CE CF	.....
0CD0	D0 D1 D2 D3 D4 D5 D6 D7	D8 D9 DA DB DC DD DE DF	.....
0CE0	E0 E1 E2 E3 E4 E5 E6 E7	E8 E9 EA EB EC ED EE EF	.....
0CF0	F0 F1 F2 F3 F4 F5 F6 F7	F8 F9 FA FB FC FD FE FF	.....
0D00	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0D10	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
0D20	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	!"#\$%&'()*+,-./
0D30	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789;=<=>?
0D40	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
0D50	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_`
0D60	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklmnop
0D70	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	qrstuvwxyz{|}~.
0D80	80 81 82 83 84 85 86 87	88 89 8A 8B 8C 8D 8E 8F	.....
0D90	90 91 92 93 94 95 96 97	98 99 9A 9B 9C 9D 9E 9F	.....
0DA0	A0 A1 A2 A3 A4 A5 A6 A7	A8 A9 AA AB AC AD AE AF	.....
0DB0	B0 B1 B2 B3 B4 B5 B6 B7	B8 B9 BA BB BC BD BE BF	.....
0DC0	C0 C1 C2 C3 C4 C5 C6 C7	C8 C9 CA CB CC CD CE CF	.....
0DD0	D0 D1 D2 D3 D4 D5 D6 D7	D8 D9 DA DB DC DD DE DF	.....
0DE0	E0 E1 E2 E3 E4 E5 E6 E7	E8 E9 EA EB EC ED EE EF	.....
0DF0	F0 F1 F2 F3 F4 F5 F6 F7	F8 F9 FA FB FC FD FE FF	.....
0E00	00 01 02 03 04 05 06 07	08 09 0A 0B 0C 0D 0E 0F	.....
0E10	10 11 12 13 14 15 16 17	18 19 1A 1B 1C 1D 1E 1F	.....
0E20	20 21 22 23 24 25 26 27	28 29 2A 2B 2C 2D 2E 2F	!"#\$%&'()*+,-./
0E30	30 31 32 33 34 35 36 37	38 39 3A 3B 3C 3D 3E 3F	0123456789;=<=>?
0E40	40 41 42 43 44 45 46 47	48 49 4A 4B 4C 4D 4E 4F	@ABCDEFGHIJKLMNO
0E50	50 51 52 53 54 55 56 57	58 59 5A 5B 5C 5D 5E 5F	PQRSTUVWXYZ[\]^_`
0E60	60 61 62 63 64 65 66 67	68 69 6A 6B 6C 6D 6E 6F	*abcdefghijklmnop
0E70	70 71 72 73 74 75 76 77	78 79 7A 7B 7C 7D 7E 7F	qrstuvwxyz{|}~.
0E80	80 81 82 83 84 85 86 87	88 89 8A 8B 8C 8D 8E 8F	.....
0E90	90 91 92 93 94 95 96 97	98 99 9A 9B 9C 9D 9E 9F	.....
0EA0	A0 A1 A2 A3 A4 A5 A6 A7	A8 A9 AA AB AC AD AE AF	.....
0EB0	B0 B1 B2 B3 B4 B5 B6 B7	B8 B9 BA BB BC BD BE BF	.....

Video Controller

0EC0	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF	.....
0ED0	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF	.....
0EE0	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF	.....
0EF0	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF	.....
0F00	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	.....
0F10	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	.....
0F20	20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F	!@#%&'()*+,-./
0F30	30	31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F	0123456789:;<=>?
0F40	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	@ABCDEFGHIJKLMNO
0F50	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	PQRSTUVWXYZ[\]^_
0F60	60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F	*abcdefghijklmnop
0F70	70	71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F	pqrstuvwxyz[!}~.
0F80	80	81	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F	.....
0F90	90	91	92	93	94	95	96	97	98	99	9A	9B	9C	9D	9E	9F	.....
0FA0	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF	.....
0FB0	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	BA	BB	BC	BD	BE	BF	.....
0FC0	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF	.....
0FD0	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF	.....
0FE0	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF
0FF0	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF

At end of current range

*

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The Display Enhancement Board

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5

Programming the LUT

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1 DEB Capabilities

- **Introduction**
 - **The DEB Driver**
 - **16-Color Graphics**
 - **Look-Up Table (LUT)**
 - **Overlay Modes**
- 
- 

Introduction

The Display Enhancement Board (DEB) option adds improved color and graphics functionality to your AT&T PC 6300. When you use the DEB with the PC 6300 color monitor, you can display graphics in up to 16 color combinations simultaneously or treat the screen as two screens in one and overlay one screen treatment on top of the other. When you use the DEB with the PC 6300 monochrome monitor, you have the same capabilities you have with the color monitor, except that colors are displayed as “shades of green.”

The DEB is compatible with existing software, so all the programs you have already can be used now as if the DEB were not installed. Of course, these programs may not have access to any of the new capabilities.

This supplement describes the functionality of the DEB device driver. Although it is not necessary to use the driver in order to use the DEB, the driver is designed to work with MS-DOS, GWBASIC, and other AT&T software products. If you wish to program the DEB hardware directly, you must consult the *AT&T Technical Reference Manual*. Such programming is considered a circumvention of the AT&T operating system and we advise against it.

This supplement assumes that you are familiar with video programming through the Interrupt 10H interface and with INTEL® 8086 assembler programming. Information on the Interrupt 10H interface can be found in the *System Programmer's Guide*, in the section on the ROM BIOS Service Routines.

Before you begin writing programs for the DEB, follow the procedures in the DEB Installation Manual for installing the DEB hardware and device driver software.

The DEB is an optional hardware component for the AT&T PC 6300 that works in conjunction with the PC 6300's built-in Video Display Controller (VDC) to provide improved color and graphics functionality.

The built-in VDC contains circuitry and memory that support either 4 color medium resolution (320×200 pixels) graphics, 1 color high resolution (640×200 pixels) graphics, or 1 color super resolution (640×400 pixels) graphics.

The DEB contains additional circuitry and memory that can be combined with the capabilities of the built-in VDC to produce up to 16 color combinations in either high or super resolution. You can also program the VDC and DEB separately, treating them as two separate images that are combined on one screen to produce an overlaying effect. The overlay modes let you use up to 8 colors on the DEB screen and up to 16 colors on the VDC screen.

The DEB Driver

You load the DEB device driver by entering a "DEVICE" statement in the CONFIG.SYS file (see **Chapter 2, Programming Tips**). The driver installs an Interrupt 10H "filter" during the loading process.

When you are using the DEB and are running some programs that use the DEB and some that do not, the "filter" provides video support for both kinds of programs. For programs that do not use the DEB, the filter passes control to the standard Interrupt 10H ROM BIOS routine.

The DEB driver installs a filter for Interrupt 9H. This filter resets the DEB to transparent mode whenever you warmstart the system through **CTRL/ALT/DEL**. The filter controls scrolling when you press **CTRL/NUMLOCK**.

16-Color Graphics

This feature lets you display 16 color combinations in either high resolution (640×200) or super resolution (640×400). Not only can you use the standard 16 colors, you can also combine colors to form new colors and cause pixels to blink from one color to another.

The DEB provides 5 palettes for you to use when programming in color. At any point in your program, you select one of the palettes as the “active” palette. The color combinations contained in that palette determine what colors and effects show on the screen.

Each of the first 4 palettes contains a default set of 16 color combinations, but to suit the needs of your program you can change the contents of the palette to any one of the following:

- any of the 16 standard colors with which you are already familiar from the standard applications. The standard colors are:

0 = black	8 = gray
1 = blue	9 = light blue
2 = green	10 = light green
3 = cyan	11 = light cyan
4 = red	12 = light red
5 = magenta	13 = light magenta
6 = brown	14 = yellow
7 = white	15 = high intensity white
- a mixture, or “dithering,” of any 2 of the 16 standard colors
- an alternation, or blinking, between any 2 of the standard 16 colors

The last palette contains no default combinations. You program the fifth palette by loading color values into a 256-byte array. The DEB device driver uses this special palette to program the DEB's color Look-Up Table (LUT). By using the LUT you can add the capability of dithering or blinking between any four colors.

Look-Up Table (LUT)

The LUT resides in RAM on the DEB board, and is accessed through write-only hardware registers. The device driver keeps a copy of the register values in the LUT. The register values are accessible to software applications through the device driver. The LUT contains 256 values that determine the colors, blinking, and dithering that appear on the screen. Whether you need to learn about the use and layout of the LUT depends on the application you are writing.

If you use the standard palettes, you need not be concerned with the LUT. The DEB device driver automatically programs the LUT to correspond to the way you set up the palettes. If you program a custom LUT, you greatly increase the color combinations and blinking effects available to you.

Overlay Modes

The overlay modes let you use the screen to display two images at once, independently. For example, you can display a high resolution color graphics image with its own foreground and background. Then, on “top” of that image, you can display a box of text and scroll the text without affecting the graphics image.

The overlay modes use the DEB to control one image and use the standard controller board to control the other image. You can select from many combinations of graphics, text, color, and high or super resolution in designing the two images.

The overlay modes offer 5 palettes. Each of the first 4 palettes has 8 positions. These four palettes have default colors that you can change to suit your needs. You can choose 8 color combinations from any of the 16 standard colors, or blink between 2 of the standard colors. The dithering combinations of the 16-color graphics modes are not available. You can also use the last palette to custom program the LUT.

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2 Programming Tips

- **Presence of Hardware/Software**
- **Hardware/Software Compatibility**
- **Setup**

Presence of Hardware/Software

Whenever you plan an application, it is important to use the DEB device driver to test for the presence of both the DEB and the associated driver. Test for the presence of the hardware by checking for DEB video memory. This is accomplished by writing and reading back data patterns into memory, in the range A000H:0H to B800H:0H. Test for the software device driver by issuing a function call to open the device called "DEBDRIVE," then immediately issuing a call to close "DEBDRIVE." If the open fails (carry set on return from Interrupt 21H) then the driver is not present. No functions are implemented in the driver, which is used only to detect the presence of the software.

Hardware/Software Compatibility

The driver software has been designed to fit into the structure of MS-DOS programs. The DEB hardware uses the same range of addresses as the standard video ports on any compatible machine. If your application uses a light pen, consult the DEB supplement in the *AT&T Personal Computer Technical Reference Guide*.

The DEB driver makes minor modifications to the ROM BIOS video interrupt. Mode setting and color selection offer additional functionality. Be careful when you use the following functions.

- SET MODE — uses an additional register BL
- SCROLLING — uses an additional register BH
- STATUS — returns an additional register pair ES:DI. No application should count on ES:DI not changing.

Setup

Install the DEB driver just as you would install any device driver. Be sure the CONFIG.SYS file is in the root directory. Put the line `DEVICE = DEDRIVER.DEV` in CONFIG.SYS. This line puts the DEB driver in the device driver chain. The driver makes patches in INT 10H and INT 9H to add the new functionality. The driver has two features:

- the INIT function, which deallocates itself after it runs
- chaining, which allows you to test for the driver's presence by issuing an open function call

3

How to Program the DEB

- **Overview**
- **Mode Setting**
- **Setting Colors and Effects**
- **Displaying Graphics Images**

Overview

There are three steps for video programming that apply whether or not you are using the DEB capability:

- 1** Set the hardware's mode. You also must set the active page if you are in an overlay mode and want to select the DEB screen.
- 2** Select the color combinations and effects you want to use.
- 3** Construct the graphics images you want to display.

This chapter describes each of these steps in detail. This chapter does **not** describe how to program the LUT directly (see **Chapter 5, "Programming the LUT"**).

Mode Setting

The DEB is controlled by invoking one of the DEB video modes through the Set Mode function (INT 10H, function 0H). The Set Mode function establishes the mode for both the DEB and the VDC. These modes fall into four categories: 16-color graphics, overlay, transparent, and disabled.

16-Color Graphics Modes

There are two DEB modes that provide 16-color graphics: high resolution and super resolution. Both these modes let you use 5 palettes and display up to 16 color combinations simultaneously.

Overlay Modes

When overlaying the VDC on the DEB output, you specify one of the modes for the VDC and one mode for the DEB. The VDC modes are a subset of the modes for non-DEB graphics: 80 × 25 text mode, high and super resolution modes. The DEB modes are both graphics modes: high and super resolution.

If you are using one of the four standard palettes, the VDC's output takes precedence over the output of the DEB, so that if each board writes a pixel to the same screen location, the pixel sent by the VDC is displayed. This precedence is programmed into the LUT. If you want to have the DEB take precedence over the VDC, you must change the values in the LUT. (For more information, see **Chapter 5, "Programming the LUT."**)

**Transparent
Mode**

The non-DEB modes, modes 0-40H and mode 48H, work exactly as they work without the DEB device driver installed.

**Disabled
Mode**

In the disabled mode, you can cause the output of the VDC, the DEB, or both to be blacked out. This allows you to draw a graphics image or to fill a screen with text and not have them displayed while you are building them. You can then have the image “pop up” by taking VDC or DEB out of the disabled mode. You can also achieve this result by using the programmable palettes and the LUT.

Setting Colors and Effects

Colors and effects are controlled by the Set Color Palette command, (INT 10H function 0BH). Use this function to set color values in one of the four palettes, to switch between palettes, or to reset palettes to their default values. You also use Set Color Palette to program the LUT directly.

Displaying Graphics Images

There are two methods for displaying graphics images using the DEB: writing dots at screen locations or directly programming the VDC and DEB memory.

To write dots (pixels) to the screen, use the Write Dot function (INT 10H, function 0CH). Write Dot requires that you specify the display page, the row and column where you want the dot to appear, and the color or pattern for the dot.

If you want to program the VDC and DEB graphics memory directly, you need to learn the details of how the LUT is structured and how LUT addresses are formed (see the section on “Programming the Bit Planes” in Chapter 5).

4

Interrupt 10H Functions

- Introduction
- Functions

Introduction

The following section describes the DEB device driver software functions. This interface is an extension of the INT 10H software function to the PC6300 ROM BIOS that controls the VDC. The ROM BIOS screen driver has 16 functions:

- 0H set the display mode
- 2H set the cursor position
- 3H read the cursor position
- 5H select the active display page
- 6H scroll the active page up
- 7H scroll the active page down
- 8H read character/attribute at the current cursor position
- 9H write character/attribute at cursor position
- AH write only the character at current cursor position
- BH change the color palette
- CH write a point on the screen

- DH read a point on the screen
- EH write in teletype style to the active page
- FH return information about the active video state

Not all these functions are applicable to the DEB. The filter receives the Interrupt 10H function call, filters the functions that are applicable to the DEB and performs them. The functions that are not applicable to the DEB are passed on to the ROM BIOS INT 10H routine or to a previously installed filter or driver routine. The following section describes the functions which are processed by the DEB Interrupt 10H filter.

Functions

Set Mode The function establishes the mode for both the DEB and the VDC. If you select a non-DEB related mode, control is passed to the ROM resident Set Mode function. Set Mode initializes palette 0 as the active palette.

Input (AH) = 0H function number for Set Mode
 (AL) = new mode
 (BL) = optional overlay mode

Setting AL bit 7 = 0 puts you in either the DEB transparent mode or 16-color graphics mode:

(AL) = 0H 40 × 25 monochrome, text
(AL) = 1H 40 × 25 color, text
(AL) = 2H 80 × 25 monochrome, text
(AL) = 3H 80 × 25 color, text
(AL) = 4H 320 × 200 color
(AL) = 5H 320 × 200 monochrome
(AL) = 6H 640 × 200 color
(AL) = 40H 640 × 400 with 2-position program-
 mable palette, defaulting to black
 and white
(AL) = 41H 640 × 200 16-color graphics with
 four palettes
(AL) = 42H 640 × 400 16-color graphics with
 four palettes
(AL) = 44H Disable mode (disables both DEB
 and VDC output)

Setting AL bit 7 = 1 puts you in overlay mode. The following values are only used in overlay mode. AL contains the setting for the VDC; BL contains the mode setting for the DEB. In overlay modes, the active page defaults to zero.

VDC Settings

(AL) = 82H	80 × 25 monochrome, text
(AL) = 83H	80 × 25 color, text
(AL) = 86H	640 × 200 color graphics
(AL) = 0C0H	640 × 400 color graphics
(AL) = 0C4H	Disable mode. Disables only the VDC.

DEB settings

(BL) = 6H	640 × 200 graphics with four 8-position palettes.
(BL) = 40H	640 × 400 graphics with four 8-position palettes.
(BL) = 44H	Disable mode. Disables only the DEB.

Output Contents of all registers are preserved.

Example

```

MOV AH,0      ; Select Set Mode
MOV AL,41H    ; Select 16 color graphics
INT 10H       ; Change the mode
    
```

Set Cursor Position	This function sets the cursor position for either the DEB, the VDC, or both.
Input	(AH) = 2H Function number for Set Cursor Position (DH,DL) = row, column of new position (BH) = page number Valid page numbers for DEB modes are 0 for the VDC and 80H for the DEB in overlay mode. Row values are 0 thru 23, column values are 0 thru 79, in DEB modes.
Output	Contents of all registers are preserved.
Example	MOV AH,2 ; SCP function MOV DH,ROW MOV DL,COL MOV BH,PAGE INT 10H ; Moves cursor to position defined in above variables.

Read Cursor Position This function returns the position of the cursor for the DEB, VDC, or both.

Input

(AH) = 3H Function number for Read Cursor Position

(BH) = page number
Valid page numbers for DEB modes are 0 for VDC and 80H for the DEB in overlay mode. Row values are 0 thru 23, column values are 0 thru 79, in DEB modes.

Output

(DH,DL) = row, column of current position.
Contents of all other registers are preserved.

Example

```
MOV AH,3  
MOV BH,PAGE  
INT 10H  
MOV ROW,DH  
MOV COL,DL
```

Interrupt 10H
Functions

**Select
Active
Display**

This command allows selection of the DEB display in overlay mode.

Input

(AH) = 5H Function number for Select Action Display

(AL) = active page
Values for the active page in DEB modes are, 0 for the VDC and 80H for the DEB.

Output

Contents of all registers are preserved.

Example

```
MOV AH,5  
MOV AL,PAGE  
INT 10H
```

Input

- (AH) = 0BH Function number for Set Color Palette
- (AL) = palette function selector
- (BH) = positional pointer
- (BL) = color value

For simple palette programming functions, use the following

- (AL) = 0
- (BH) = palette color ID
 - BH = FFH switches to the palette specified in BL, without changing to the default palettes unless there is a change in palette type (e.g., change from a 16-position palette to an 8-position palette).
 - BH = 80H switches to the palette specified in BL and resets the palette to its default.
 - BH = 0-16 sets this palette position to the color or attribute in BL.
- (BL) = actual color value or code for blinking and dithering

The special settings for using a customized LUT in Set Color Palette are as follows:

Input

(AL) = non-zero (a zero here selects a standard palette)

AL bit 0 = 1 means use ES:SI to program the palette and registers BH and BL to indicate an offset and length into the LUT. ES:SI points to the LUT table (in the above example, LUT-STRING).

In this case, BH = offset into LUT and BL = length of portion of LUT to be changed. If you are loading an entire new table, set BH and BL to 0.

AL bit 1 = 1 means use BH and BL to program the LUT one location at a time.

In this case, BH = position in LUT and BL = the value to put in that position.

AL bit 2 = 1 means use the short LUT addressing mode. (Only uses the first 16 LUT entries).

The DEB driver lets you automatically load your customized LUT and use it in place of one of the standard palettes.

The steps for loading and using the customized LUT are:

- 1** Define the table with DB (Define Byte) statements.
- 2** Load the table in by using the Set Color Palette command.
- 3** Use the Read Dot and Write Dot commands to access the LUT (see **Chapter 4, “Interrupt 10H Functions”**).

The code for defining the table would be similar to this:

```
LUT-STRING  DB  4          ! Signifies active palette 4
              DB  1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,
              DB  1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,
              DB  1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,
              DB  1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,
              .
              .
              .
              DB  1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,
```

To load a new table of values into the LUT, where the table in your program is named LUT-STRING, you can use these statements:

```
PUSH DS      ! save the data segment address  
POP ES  
MOV SI,LUT-STRING  
MOV AL,1  
MOV AH,11  
XOR BH,BX   ! Sets BH = BL = 0  
INT 10
```

The defaults for each of the four palettes are:

**Default
Palettes**

Palette Number 0
Position Color

0	0 = black
1	2 = green
2	4 = red
3	6 = brown
4	1 = blue
5	3 = cyan
6	5 = magenta
7	7 = white
8	8 = gray
9	9 = light blue
10	10 = light green
11	11 = light cyan
12	12 = light red
13	13 = light magenta
14	14 = yellow
15	15 = high-intensity white

Palette Number 1

Position	Color
0	0 = black
1	3 = cyan
2	5 = magenta
3	7 = white
4	1 = blue
5	2 = green
6	4 = red
7	6 = brown
8	8 = gray
9	9 = light blue
10	10 = light green
11	11 = light cyan
12	12 = light red
13	13 = light magenta
14	14 = yellow
15	15 = high-intensity white

Palettes 2 and 3 are the same, and they contain the standard colors in numerical order.

Palette Number 2 and Palette Number 3

Position	Color
0	0 = black
1	1 = blue
2	2 = green
3	3 = cyan
4	4 = red
5	5 = magenta
6	6 = brown
7	7 = white
8	8 = gray
9	9 = light blue
10	10 = light green
11	11 = light cyan
12	12 = light red
13	13 = light magenta
14	14 = yellow
15	15 = high-intensity white

DITHER COMBINATIONS FOR DEB PALETTES 0-3

Color combinations 136-255 have been pre-assigned to allow you easy access to dithering effects while using the standard palettes. The following table describes the available combinations.

A ↓	B →	black	blue	green	cyan	red	magenta	brown	white	gray	light blue	light green	light cyan	light red	light magenta	yellow
black																
blue		136														
green		137	138													
cyan		139	140	141												
red		142	143	144	145											
magenta		146	147	148	149	150										
brown		151	152	153	154	155	156									
white		157	158	159	160	161	162	163								
gray		164	165	166	167	168	169	170	171							
light blue		172	173	174	175	176	177	178	179	180						
light green		181	182	183	184	185	186	187	188	189	190					
light cyan		191	192	193	194	195	196	197	198	199	200	201				
light red		202	203	204	205	206	207	208	209	210	211	212	213			
light magenta		214	215	216	217	218	219	220	221	222	223	224	225	226		
yellow		227	228	229	230	231	232	233	234	235	236	237	238	239	240	
high-intensity white		241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

NOTE: To select a value that combines colors A and B to create a new color, find the number at the intersection of row A and column B.

BLINKING COLOR EFFECTS FOR DEB PALETTES 0-3

Color combinations 16-135 have been pre-assigned to allow you easy access to blinking effects while using the standard palettes. The following table describes the available combinations.

	B →	blue	green	cyan	red	magenta	brown	white	gray	light blue	light green	light cyan	light red	light magenta	yellow	high-intensity white
A ↓	black	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	blue		31	32	33	34	35	36	37	38	39	40	41	42	43	44
	green			45	46	47	48	49	50	51	52	53	54	55	56	57
	cyan				58	59	60	61	62	63	64	65	66	67	68	69
	red					70	71	72	73	74	75	76	77	78	79	80
	magenta						81	82	83	84	85	86	87	88	89	90
	brown							91	92	93	94	95	96	97	98	99
	white								100	101	102	103	104	105	106	107
	gray									108	109	110	111	112	113	114
	light blue										115	116	117	118	119	120
	light green											121	122	123	124	125
	light cyan												126	127	128	129
	light red													130	131	132
	light magenta														133	134
	yellow															135

NOTE: To select a value that will cause blinking between colors A and B, find the number at the intersection of row A and column B.

Write Dot The Write function writes a pixel to the location on the screen that you specify. If the screen is in the DEB mode, Write Dot may also write a pattern.

Input (AH) = 0CH, Function number for Write Dot
 (AL) = Palette position to be written.
 (BH) = display page designator (bit 7 = 1 selects the DEB)
 (CX) = column number
 (DX) = row number

Output Contents of all registers are preserved.

Example **MOV AH,0CH**
 MOV AL,PALPOS
 MOV BH,PAGE
 MOV CX,COL
 MOV DX,ROW
 INT ;Write the Dot

Read Dot This function reads a dot from the screen. If the screen is in the DEB mode this function returns the value in the LUT that corresponds to this dot. (For more information, see **Chapter 5, “Programming the LUT.”**)

Input (AH) = 0DH Function number for Read Dot
(BH) = display page designator (bit 7 = 1 selects the DEB)
(CX) = column number
(DX) = row number

Output (AH) = VDC value or DEB palette position
Contents of all other registers are preserved.

Example

```
MOV AH,0DH  
MOV BH,PAGE  
MOV CX,COL  
MOV DX,ROW  
INT  
MOV DOTCOL,AH ;Save the Dot
```

Interrupt 10H
Commands

Input (AH) = 0EH, Function number for Write Teletype
 (AL) = character to write
 (BL) = foreground color (in graphics modes)
 If bit 7 = 1, color is XOR'd to current contents.

Output Contents of all registers are preserved.

Example **MOV AH,0EH**
 MOV AL,CHAR
 MOV BL,FGCOL
 INT 10H

**Read
Current
Video
State**

This function returns the current video state. It indicates whether the DEB or VDC is active in the overlay mode and returns the number of the active palette.

Input

(AH) = 0FH Function number for Read Current Video State

Output

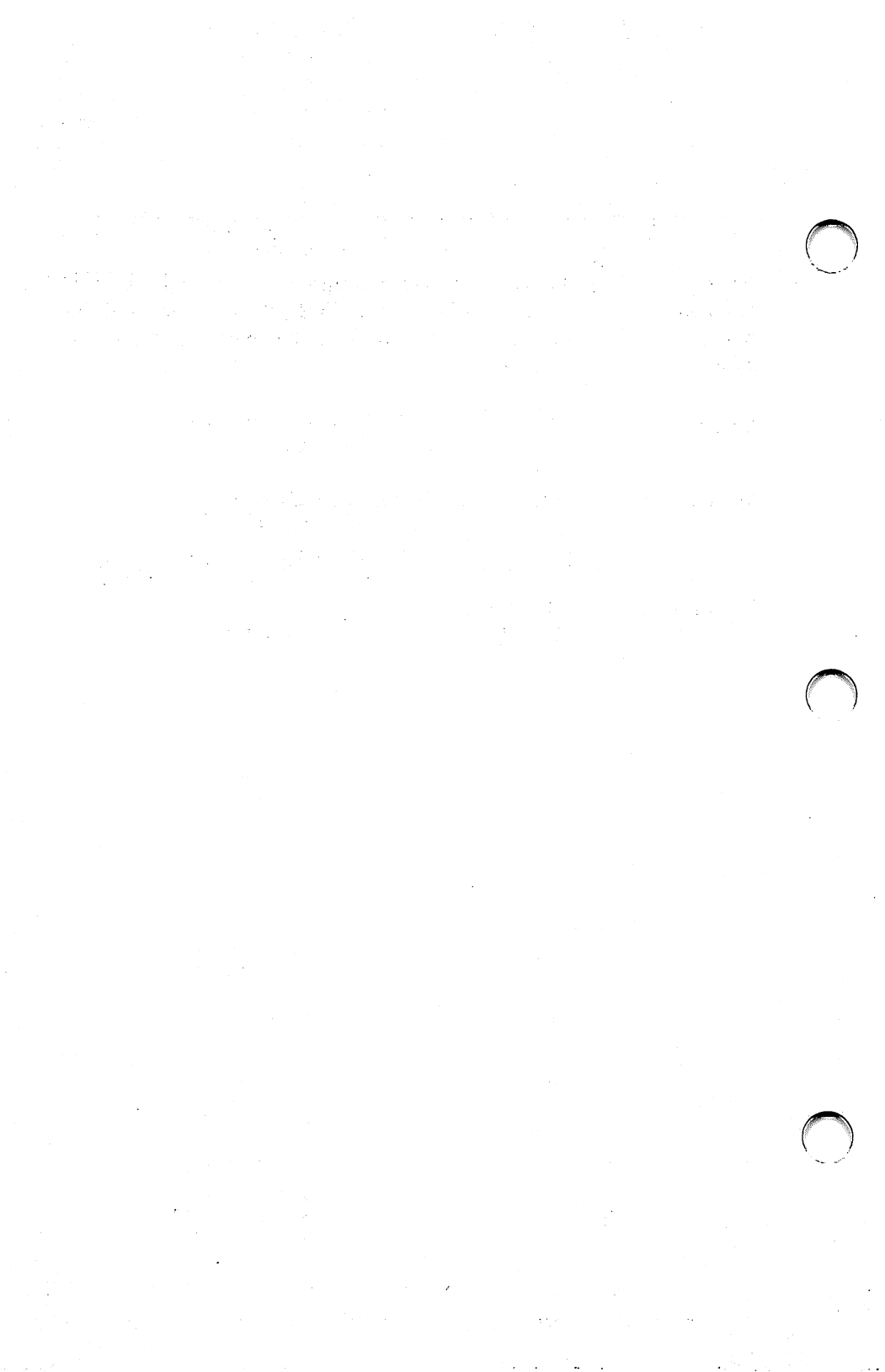
(BH) = display page designator

(AL) = mode currently set

(ES:DI) = pointer to a copy of the current LUT

Example

```
MOV AH,0FH  
INT 10H
```



5 Programming the LUT

- Overview
- 16-Color Graphics LUT Programming
- Overlay Modes LUT Programming
- Programming the Bit Planes

Overview

This chapter describes programming the DEB Look-Up Table (LUT). By programming the LUT yourself, you can create color patterns that are not available when you use standard palettes. You need not read this chapter if you do not want to use this extended functionality.

The hardware uses the LUT to translate the contents of video memory patterns into graphics effects. In the standard palettes, INT 10H filter programs the LUT for you and thereby provides the preassigned color combinations and effects as described in previous chapters.

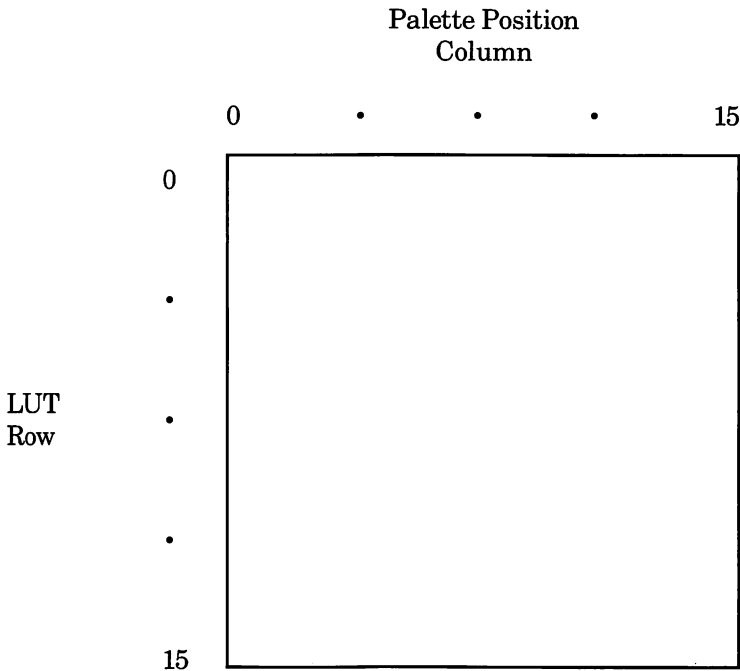
To program the LUT directly, you select Palette 4 in Set Color Palette function. Palette 4, also called the “LUT palette,” has a minimum of 256 positions. Each palette position contains a value between 0 and 15. These values map into the LUT locations on the DEB. The 256 locations on the DEB collectively determine the color and special effects displayed when you specify a particular palette position. The color and special effect for each pixel on the screen are determined by:

- the palette position you specify
- the values in the LUT
- the active mode

There are some differences in the way the LUT is structured for 16-color graphics modes and overlay modes. This chapter describes LUT operation for 16-color graphics modes and overlay modes separately.

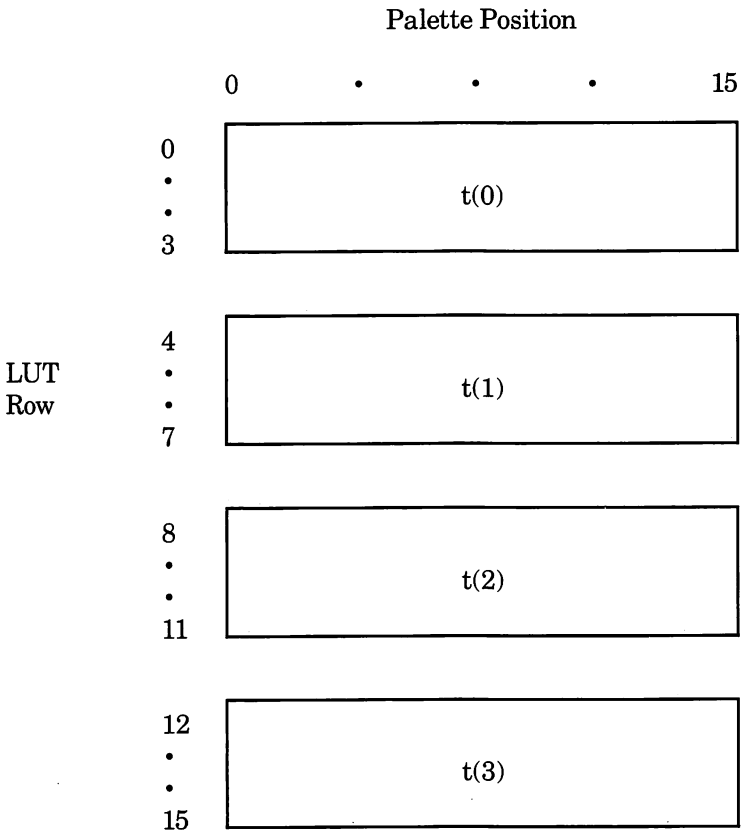
16-Color Graphics Lut Programming

In these modes, the LUT can be viewed as a two-dimensional array (16×16). Each location contains one of the standard 16 colors.



The locations in the LUT are numbered consecutively from left to right and top to bottom. Thus, location 17 corresponds to Row 1, palette position 1.

In the 16-color graphics mode, the LUT is divided into four “time states.” At any one time, only one quarter of the LUT determines the display on the screen.



The hardware cycles through the LUT every second, so each quarter of the LUT is active for $\frac{1}{4}$ of each second. The cycling mechanism produces blinking. The following examples show the details of how you can produce several different blinking effects by setting different values in the LUT.

In this example, the Write Dot or Write Character functions specify palette position 7 and the LUT is set up as shown. Pixels are displayed as a solid red color. In the first $\frac{1}{4}$ second, the DEB displays the color in the first quarter of the LUT, which in this case is red. In the second, third, and fourth $\frac{1}{4}$ seconds, the DEB displays the color in the second, third, and fourth quarters of the LUT, respectively. In this example, the DEB keeps finding the color value for red, so what you see on the screen is a solid (non-blinking) red color.

Palette Position

LUT Row	0	7	15
t(0)	0	r	
	•	e	
	•	d	
	3		
t(1)	4	r	
	•	e	
	•	d	
	7		
t(2)	8	r	
	•	e	
	•	d	
	11		
t(3)	12	r	
	•	e	
	•	d	
	15		

Non-Blinking Color

In this example, any item displayed on the screen with palette position 7 blinks between red and blue. For the first two $\frac{1}{4}$ seconds, the DEB picks up the color value for red from the first and second quarters of the LUT. For the second two $\frac{1}{4}$ seconds, the DEB obtains the color value of blue from the LUT. The net effect is a slow blink between red and blue.

Palette Position

LUT Row	0	7	15
t(0)	0 • • 3	r e d	
t(1)	4 • • 7	r e d	
t(2)	8 • • 11	b l u e	
t(3)	12 • • 15	b l u e	

Slow Blink

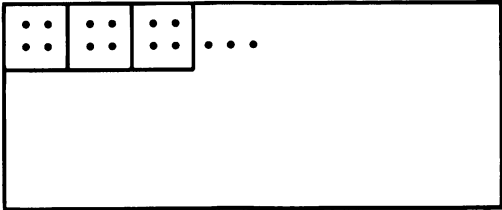
In this example, any item displayed using palette position 7 blinks rapidly between red, blue, green, and brown.

Palette Position

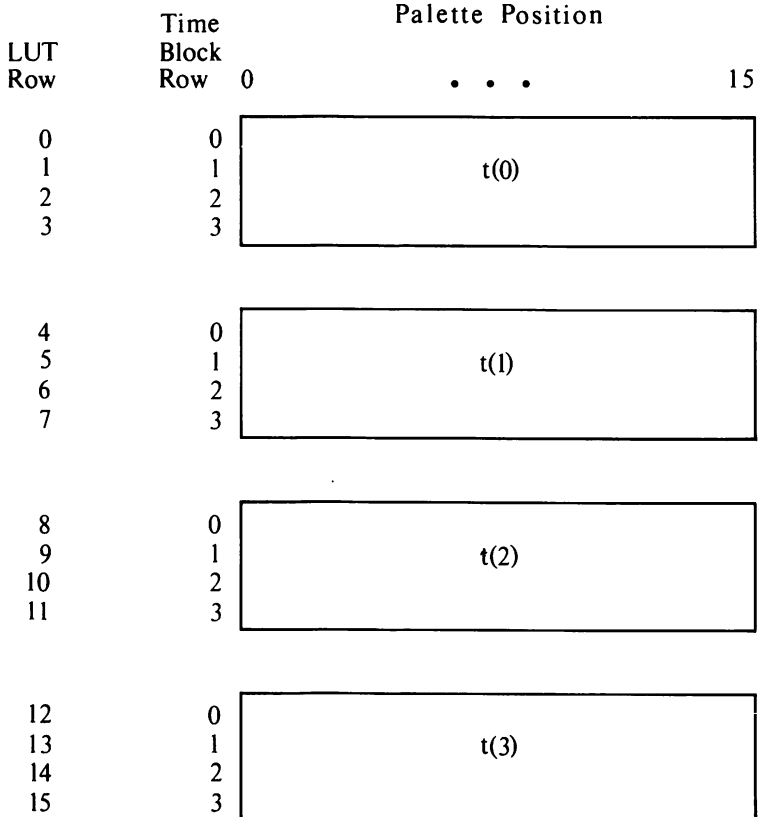
LUT		Palette Position		
Row	0	7	15	
t(0)	0	r e d		
	•			
	•			
	3			
t(1)	4	b l u e		
	•			
	•			
	7			
t(2)	8	g r e e n		
	•			
	•			
	11			
t(3)	12	b r o w n		
	•			
	•			
	15			

4-Color Fast Blink

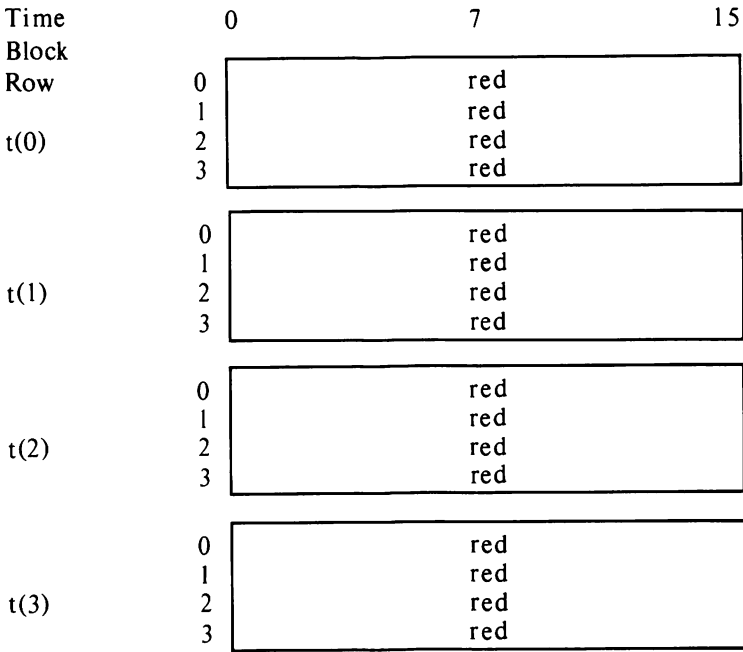
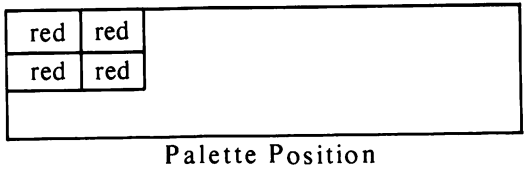
For dithering colors, the DEB uses a scheme similar to the blinking scheme. Dithering is accomplished by manipulating groups of 4 adjacent pixels. The screen is divided into blocks of 4 pixels.



Each of the 4 time states is divided into four dither states that determine the dithering effect. The rows of the time state blocks correspond to the 4-pixel blocks on the screen in the following way:

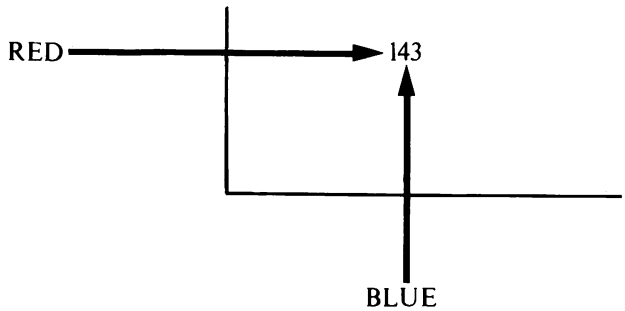


The pixels in the pixel blocks are so close together that our eyes cannot perceive them as separate. If each of the pixels in a pixel block is a different color, our eyes perceive the pixel block as one color — a combination of the color of the individual pixels. If the adjacent pixels are the same color, our eyes see just that one color.

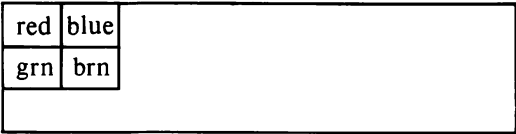


“Solid” Dither showing correspondence between pixel positions in a pixel block and time state rows

Remember the table of “pre-assigned” dithered colors. To combine colors, you check the table for the color number for a particular dither effect. For example, you would choose this number to produce a dither between red and blue.

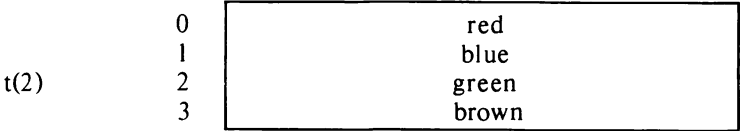


You can set up the LUT to dither two, three, or four colors together.



Palette Position

Time			
Block			
Row	0	7	15



4-Color Dither

The following examples show the actual LUT values for each of the previous cases of blinking and dithering.

Palette Position

LUT		Palette Position	
Row	0	7	15
t(0)	0	4 (red)	
	1	4	
	2	4	
	3	4	
t(1)	4	4	
	5	4	
	6	4	
	7	4	
t(2)	8	4	
	9	4	
	10	4	
	11	4	
t(3)	12	4	
	13	4	
	14	4	
	15	4	

Palette Position 7 programmed for Non-Blinking Red

Palette Position

LUT			
Row	0	7	15
t(0)	0	4 (red)	
	1	4	
	2	4	
	3	4	
t(1)	4	4	
	5	4	
	6	4	
	7	4	
t(2)	8	1 (blue)	
	9	1	
	10	1	
	11	1	
t(3)	12	1	
	13	1	
	14	1	
	15	1	

Palette Position 7 programmed to blink slowly between red and blue.

Palette Position

LUT			
Row	0	7	15
t(0)	0	4 (red)	
	1		
	2		
	3		
t(1)	4	1 (blue)	
	5		
	6		
	7		
t(2)	8	2 (green)	
	9		
	10		
	11		
t(3)	12	6 (brown)	
	13		
	14		
	15		

4-Color Fast Blink

		Palette Position		
LUT	Row	0	7	15
t(0)	0	4 (red)		
	1			
	2			
	3			
t(1)	4	4		
	5			
	6			
	7			
t(2)	8	4		
	9			
	10			
	11			
t(3)	12	4		
	13			
	14			
	15			

Solid Red Dither

LUT		Palette Position	
Row	0	7	15
t(0)	0	1 (blue)	
	1	4 (red)	
	2	1 (blue)	
	3	4 (red)	
t(1)	4	1	
	5	4	
	6	1	
	7	4	
t(2)	8	1	
	9	4	
	10	1	
	11	4	
t(3)	12	1	
	13	4	
	14	1	
	15	4	

2-Color Dither: Red and Blue

Palette Position

LUT	Row	0	7	15
t(0)	0		4 (red)	
	1		2 (green)	
	2		1 (blue)	
	3		6 (brown)	
t(1)	4		4	
	5		2	
	6		1	
	7		6	
t(2)	8		4	
	9		2	
	10		1	
	11		6	
t(3)	12		4	
	13		2	
	14		1	
	15		6	

4-Color Dither Between Red, Green, Blue, and Brown

The following is an example that combines blinking and dithering:

Palette Position

LUT	0	7	15
t(0)	0	1 (blue)	
	1	4 (red)	
	2	1	
	3	4	
t(1)	4	1	
	5	4	
	6	1	
	7	4	
t(2)	8	2 (green)	
	9	6 (brown)	
	10	2	
	11	6	
t(3)	12	2	
	13	6	
	14	2	
	15	6	

The following table of values can be used to program the LUT for normal 16-color graphics.

Palette Position

LUT		Row	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
t(0)	0	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	1	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	2	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	3	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
t(1)	4	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	5	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	6	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	7	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
t(2)	8	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	9	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	10	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	11	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
t(3)	12	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	13	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	14	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	15	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																

Non-Blinking Standard Colors

Note that palette position 7 in the first two time states has been programmed to show white and in the second two time states to show red.

Palette Position

LUT		Row	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
t(0)	0	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	1	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	2	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	3	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
t(1)	4	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	5	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	6	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
	7	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,																
t(2)	8	0, 1, 2, 3, 4, 5, 6, 4, 8, 9, 10, 11, 12, 13, 14, 15,																
	9	0, 1, 2, 3, 4, 5, 6, 4, 8, 9, 10, 11, 12, 13, 14, 15,																
	10	0, 1, 2, 3, 4, 5, 6, 4, 8, 9, 10, 11, 12, 13, 14, 15,																
	11	0, 1, 2, 3, 4, 5, 6, 4, 8, 9, 10, 11, 12, 13, 14, 15,																
t(3)	12	0, 1, 2, 3, 4, 5, 6, 4, 8, 9, 10, 11, 12, 13, 14, 15,																
	13	0, 1, 2, 3, 4, 5, 6, 4, 8, 9, 10, 11, 12, 13, 14, 15,																
	14	0, 1, 2, 3, 4, 5, 6, 4, 8, 9, 10, 11, 12, 13, 14, 15,																
	15	0, 1, 2, 3, 4, 5, 6, 4, 8, 9, 10, 11, 12, 13, 14, 15,																

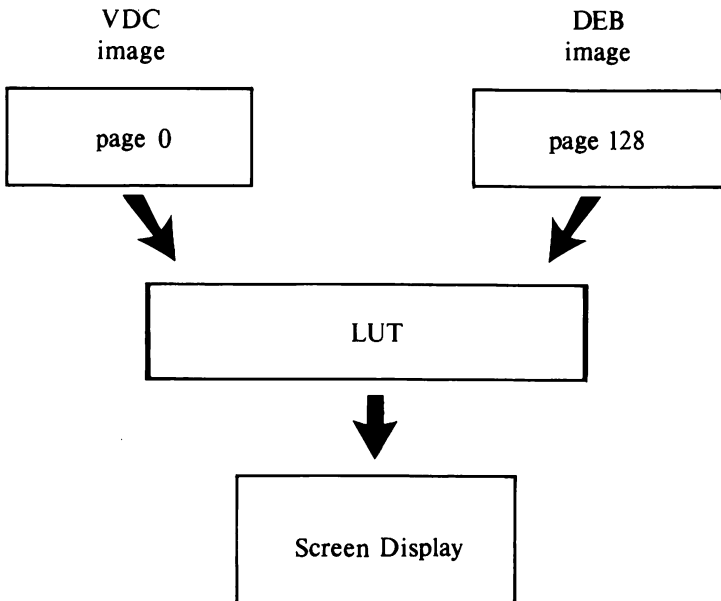
LUT for Blinking Between White and Red in Palette Position 7

Overlay Modes LUT Programming

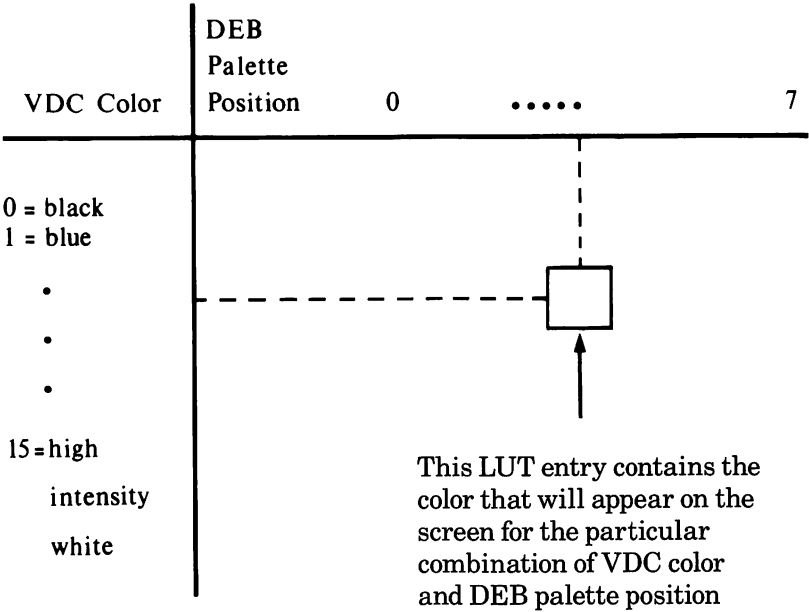
Overlay Modes LUT Programming

When the LUT is used in the overlay modes it can be viewed as a two-dimensional array with 8 columns and 32 rows. The column values are DEB palette positions. The row values are VDC color values.

In overlay modes, there are 2 separately controlled images: the VDC image and the DEB image. The 2 images are combined on the display screen. Each pixel on the screen has 2 values associated with it: the VDC color and the DEB palette position. The LUT is used to resolve contention between the 2 values associated with each pixel.



The LUT for overlay modes looks like this:

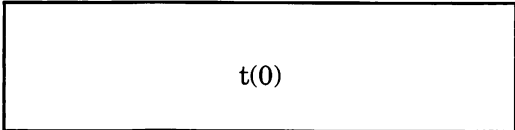
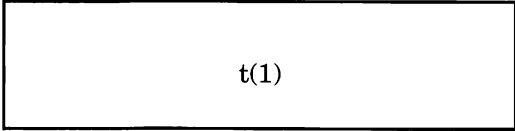


As in the 16-color graphics modes, the locations in the LUT are numbered consecutively from left to right and top to bottom. For example, location 17 corresponds to Row 2, Palette Position 0.

In the overlay modes, as in the 16-color graphics mode, the LUT is divided into time states that control blinking effects. However, in the overlay modes, the LUT is only divided into two time states. Half of the LUT determines what is being displayed at any time. The top half is used for the first $\frac{1}{2}$ of each second and the bottom half is used for the second $\frac{1}{2}$ of each second.

Using the overlay modes, you create blinking by making the values in the top half of the table different from the corresponding values in the bottom half of the table.

DEB Palette Position

LUT	0	•	•	•	7
Row					
0					
•					
•					
15					
16					
•					
•					
31					

The following example shows the LUT values for standard Palette 2 of an overlay mode. The LUT is programmed so that the DEB image is displayed only if the VDC color is 0 (black). If the VDC requests any other color, then that color is displayed no matter what the DEB requests. This has the effect of overlaying the VDC image “on top” of the DEB image.

		DEB Palette Position							
VDC Color Values		0	1	2	3	4	5	6	7
t(0)	0	0,	1,	2,	3,	4,	5,	6,	7,
	1	1,	1,	1,	1,	1,	1,	1,	1,
	2	2,	2,	2,	2,	2,	2,	2,	2,
	3	3,	3,	3,	3,	3,	3,	3,	3,
	4	4,	4,	4,	4,	4,	4,	4,	4,
	5	5,	5,	5,	5,	5,	5,	5,	5,
	6	6,	6,	6,	6,	6,	6,	6,	6,
	7	7,	7,	7,	7,	7,	7,	7,	7,
	8	8,	8,	8,	8,	8,	8,	8,	8,
	9	9,	9,	9,	9,	9,	9,	9,	9,
	10	10,	10,	10,	10,	10,	10,	10,	10,
	11	11,	11,	11,	11,	11,	11,	11,	11,
	12	12,	12,	12,	12,	12,	12,	12,	12,
	13	13,	13,	13,	13,	13,	13,	13,	13,
	14	14,	14,	14,	14,	14,	14,	14,	14,
	15	15,	15,	15,	15,	15,	15,	15,	15,

DEB Palette Position

VDC Color Values	0	1	2	3	4	5	6	7
t(1)	0	0, 1, 2, 3, 4, 5, 6, 7,						
	1	1, 1, 1, 1, 1, 1, 1, 1,						
	2	2, 2, 2, 2, 2, 2, 2, 2,						
	3	3, 3, 3, 3, 3, 3, 3, 3,						
	4	4, 4, 4, 4, 4, 4, 4, 4,						
	5	5, 5, 5, 5, 5, 5, 5, 5,						
	6	6, 6, 6, 6, 6, 6, 6, 6,						
	7	7, 7, 7, 7, 7, 7, 7, 7,						
	8	8, 8, 8, 8, 8, 8, 8, 8,						
	9	9, 9, 9, 9, 9, 9, 9, 9,						
	10	10, 10, 10, 10, 10, 10, 10, 10,						
	11	11, 11, 11, 11, 11, 11, 11, 11,						
	12	12, 12, 12, 12, 12, 12, 12, 12,						
	13	13, 13, 13, 13, 13, 13, 13, 13,						
	14	14, 14, 14, 14, 14, 14, 14, 14,						
	15	15, 15, 15, 15, 15, 15, 15, 15,						

In this example, the standard Palette 2 is modified so that position 2 is a blinking between blue (color 1) and red (color 4).

DEB Palette Position

VDC Color Values	0	1	2	3	4	5	6	7
t(0) 0	0,	1,	1,	3,	4,	5,	6,	7,
1	1,	1,	1,	1,	1,	1,	1,	1,
2	2,	2,	2,	2,	2,	2,	2,	2,
3	3,	3,	3,	3,	3,	3,	3,	3,
4	4,	4,	4,	4,	4,	4,	4,	4,
5	5,	5,	5,	5,	5,	5,	5,	5,
6	6,	6,	6,	6,	6,	6,	6,	6,
7	7,	7,	7,	7,	7,	7,	7,	7,
8	8,	8,	8,	8,	8,	8,	8,	8,
9	9,	9,	9,	9,	9,	9,	9,	9,
10	10,	10,	10,	10,	10,	10,	10,	10,
11	11,	11,	11,	11,	11,	11,	11,	11,
12	12,	12,	12,	12,	12,	12,	12,	12,
13	13,	13,	13,	13,	13,	13,	13,	13,
14	14,	14,	14,	14,	14,	14,	14,	14,
15	15,	15,	15,	15,	15,	15,	15,	15,

		DEB Palette Position							
VDC									
Color									
Values		0	1	2	3	4	5	6	7
t(1)	0	0,	1,	4,	3,	4,	5,	6,	7,
	1	1,	1,	1,	1,	1,	1,	1,	1,
	2	2,	2,	2,	2,	2,	2,	2,	2,
	3	3,	3,	3,	3,	3,	3,	3,	3,
	4	4,	4,	4,	4,	4,	4,	4,	4,
	5	5,	5,	5,	5,	5,	5,	5,	5,
	6	6,	6,	6,	6,	6,	6,	6,	6,
	7	7,	7,	7,	7,	7,	7,	7,	7,
	8	8,	8,	8,	8,	8,	8,	8,	8,
	9	9,	9,	9,	9,	9,	9,	9,	9,
	10	10,	10,	10,	10,	10,	10,	10,	10,
	11	11,	11,	11,	11,	11,	11,	11,	11,
	12	12,	12,	12,	12,	12,	12,	12,	12,
	13	13,	13,	13,	13,	13,	13,	13,	13,
	14	14,	14,	14,	14,	14,	14,	14,	14,
	15	15,	15,	15,	15,	15,	15,	15,	15,

In this example, values in the LUT cause the DEB's output to take precedence over the VDC's output. The VDC's output is only displayed when you specify DEB palette position 0 in a graphics statement.

		DEB Palette Positions							
VDC		0	1	2	3	4	5	6	7
Color									
Values		0	1	2	3	4	5	6	7
t(0)	0	0, 1, 2, 3, 4, 5, 6, 7,							
	1	1, 1, 2, 3, 4, 5, 6, 7,							
	2	2, 1, 2, 3, 4, 5, 6, 7,							
	3	3, 1, 2, 3, 4, 5, 6, 7,							
	4	4, 1, 2, 3, 4, 5, 6, 7,							
	5	5, 1, 2, 3, 4, 5, 6, 7,							
	6	6, 1, 2, 3, 4, 5, 6, 7,							
	7	7, 1, 2, 3, 4, 5, 6, 7,							
	8	8, 1, 2, 3, 4, 5, 6, 7,							
	9	9, 1, 2, 3, 4, 5, 6, 7,							
	10	10, 1, 2, 3, 4, 5, 6, 7,							
	11	11, 1, 2, 3, 4, 5, 6, 7,							
	12	12, 1, 2, 3, 4, 5, 6, 7,							
	13	13, 1, 2, 3, 4, 5, 6, 7,							
	14	14, 1, 2, 3, 4, 5, 6, 7,							
	15	15, 1, 2, 3, 4, 5, 6, 7,							

DEB Palette Positions

VDC
Color
Values 0 1 2 3 4 5 6 7

t(1)

1	0 , 1, 2, 3, 4, 5, 6, 7,
1	0 , 1, 2, 3, 4, 5, 6, 7,
2	2 , 1, 2, 3, 4, 5, 6, 7,
3	3 , 1, 2, 3, 4, 5, 6, 7,
4	4 , 1, 2, 3, 4, 5, 6, 7,
5	5 , 1, 2, 3, 4, 5, 6, 7,
6	6 , 1, 2, 3, 4, 5, 6, 7,
7	7 , 1, 2, 3, 4, 5, 6, 7,
8	8 , 1, 2, 3, 4, 5, 6, 7,
9	9 , 1, 2, 3, 4, 5, 6, 7,
10	10 , 1, 2, 3, 4, 5, 6, 7,
11	11 , 1, 2, 3, 4, 5, 6, 7,
12	12 , 1, 2, 3, 4, 5, 6, 7,
13	13 , 1, 2, 3, 4, 5, 6, 7,
14	14 , 1, 2, 3, 4, 5, 6, 7,
15	15 , 1, 2, 3, 4, 5, 6, 7,

The following LUT entirely blocks out VDC output:

DEB Palette Positions

VDC Color Values	0	1	2	3	4	5	6	7
t(0)	0	0, 1, 2, 3, 4, 5, 6, 7,						
	1	0, 1, 2, 3, 4, 5, 6, 7,						
	2	0, 1, 2, 3, 4, 5, 6, 7,						
	3	0, 1, 2, 3, 4, 5, 6, 7,						
	4	0, 1, 2, 3, 4, 5, 6, 7,						
	5	0, 1, 2, 3, 4, 5, 6, 7,						
	6	0, 1, 2, 3, 4, 5, 6, 7,						
	7	0, 1, 2, 3, 4, 5, 6, 7,						
	8	0, 1, 2, 3, 4, 5, 6, 7,						
	9	0, 1, 2, 3, 4, 5, 6, 7,						
	10	0, 1, 2, 3, 4, 5, 6, 7,						
	11	0, 1, 2, 3, 4, 5, 6, 7,						
	12	0, 1, 2, 3, 4, 5, 6, 7,						
	13	0, 1, 2, 3, 4, 5, 6, 7,						
	14	0, 1, 2, 3, 4, 5, 6, 7,						
	15	0, 1, 2, 3, 4, 5, 6, 7,						

DEB Palette Positions

VDC Color Values	0	1	2	3	4	5	6	7
0	0	1	2	3	4	5	6	7
1	0	1	2	3	4	5	6	7
2	0	1	2	3	4	5	6	7
3	0	1	2	3	4	5	6	7
4	0	1	2	3	4	5	6	7
5	0	1	2	3	4	5	6	7
6	0	1	2	3	4	5	6	7
7	0	1	2	3	4	5	6	7
8	0	1	2	3	4	5	6	7
9	0	1	2	3	4	5	6	7
10	0	1	2	3	4	5	6	7
11	0	1	2	3	4	5	6	7
12	0	1	2	3	4	5	6	7
13	0	1	2	3	4	5	6	7
14	0	1	2	3	4	5	6	7
15	0	1	2	3	4	5	6	7

t(1)

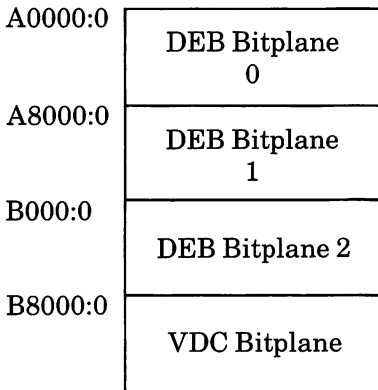
Programming the Bit Planes

Introduction Once you have learned to program the LUT directly using the Set Color Palette command, you can make further use of the LUT's capabilities by programming the VDC and DEB video memory directly.

By directly programming the video memory of the VDC and DEB boards, you can increase the graphics display speed. The values you load into the video memory planes determine how the LUT is accessed. This section assumes that you have read and understood how to program the LUT directly.

In the 16-color graphics modes, the device driver combines the 3 bit planes of the DEB with one bit plane from the VDC to create the four bit planes necessary for 16-color graphics.

In the overlay modes, the device driver uses the 3 DEB bit planes for 8-color graphics output and uses the VDC board separately for either text or graphics output.



Memory Map

LUT Addressing

A LUT address is an 8-bit value that points to one of the 256 locations within the LUT. The method of address formation depends on the current video mode.

For transparent and disabled modes, LUT addressing is irrelevant. In the transparent mode, VDC color values bypass the LUT processing and go directly to the monitor output. In the disabled mode, all output from the LUT is forced to the value of zero.

For the 16-color graphics and overlay modes, the LUT address is composed of bits from the DEB video bit planes, the VDC's video output, and DEB timing bits.

Timing Bits

The timing bits are called BLINK1, BLINK2, PAT1, and PAT2. BLINK1 and BLINK2 effect blinking; PAT1 and PAT2 effect patterning (dithering).

All of the timing bits are applicable in the 16-color graphics mode; only BLINK1 is part of the address formation in the overlay mode. Therefore, you have fewer options for blinking and no ability to dither in the overlay mode.

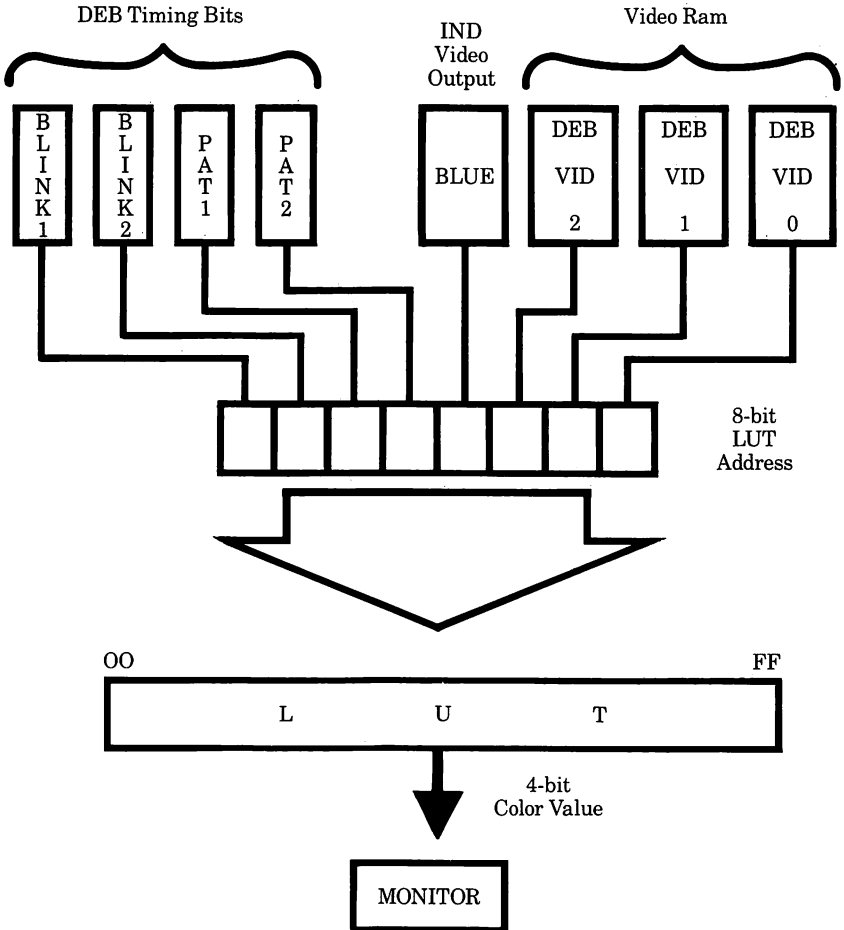
The operation of the timing bits is very fundamental to creation of special effects. The bits always cycle on and off, each at a different rate. BLINK1 cycles on and off each 1/4 second. BLINK2 cycles on and off each 1/8 second.

PAT1 and PAT2 cycle on and off so fast that the eye cannot perceive a blink (PAT1 is the fastest). A dithered color is really 2-4 separate colors that are changing so rapidly that the eye perceives them as one solid color.

PAT1 changes value at the same rate that the monitor's cathode ray moves from one pixel to the next. PAT1's effect on LUT addressing is that it switches the address by 16 LUT entries — in the previous table, between pairs of rows. PAT2 changes value at the same rate that the cathode ray changes scanlines — in the previous table, between one pair of rows and the next pair of rows.

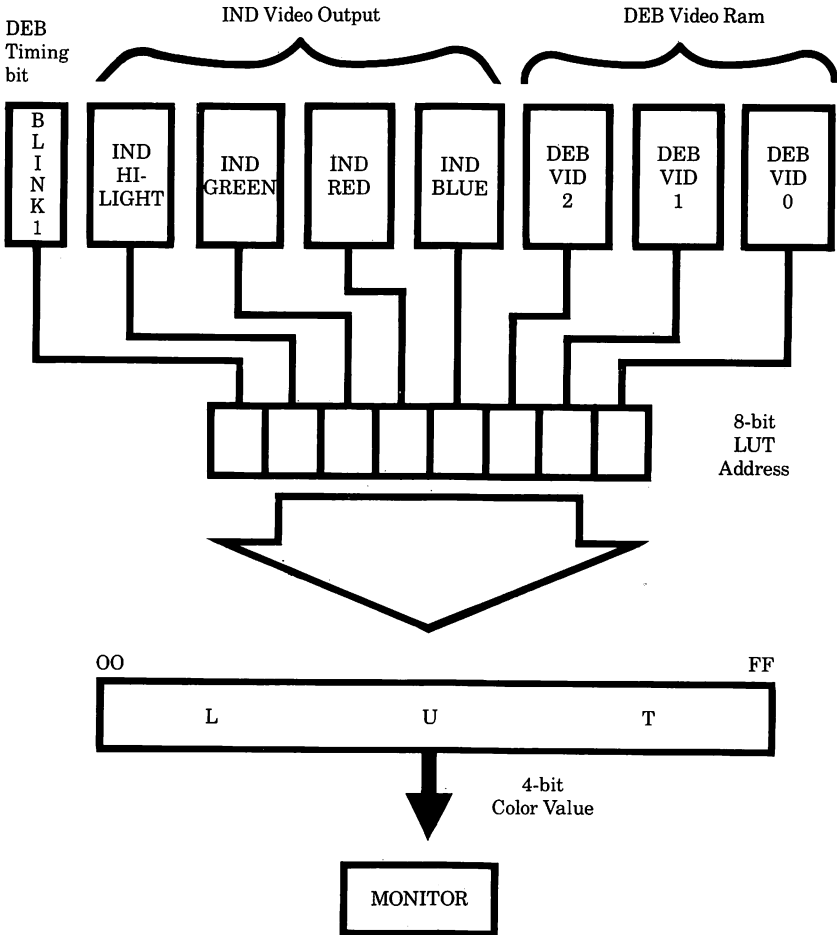
PAT2	PAT1	Portion of LUT
0	0	1st 16 entries of each quarter
0	1	2nd 16 entries of each quarter
1	0	3rd 16 entries of each quarter
1	1	4th 16 entries of each quarter

1. 16-color Graphics Mode



To output a color to the monitor, the DEB concatenates the DEB timing bits BLINK1, BLINK2, PAT1, PAT2, the BLUE output bit from the VDC, and a bit from corresponding locations on each of the three DEB bit planes.

2. Overlay Mode



To output a color to the monitor, the DEB concatenates the following bits: BLINK1, the HILIGHT, GREEN, RED, and BLUE output bits from the VDC, and a bit from corresponding locations on each of the three DEB bit planes.

**Write
Character
Only at
Current
Cursor
Position**

In DEB modes, this function is the same as “Write Character and Attribute.”

Set Color Palette

This function is used to set color values in one of the four palettes, to switch between palettes, or to reset palettes to their default values.

In the overlay modes, the Set Color Palette function works on the active page. If the active page is set to display to the VDC board, this function works the same as the standard ROM BIOS INT 10H (function 0BH).

If you specify a palette position greater than the value allowed for the mode in which you are working, the value you specify will be put in that palette's highest position. For example, if you attempted to set palette position 13 to red when working in overlay mode, which has 8-position palettes, the 8th palette position would be set to red.

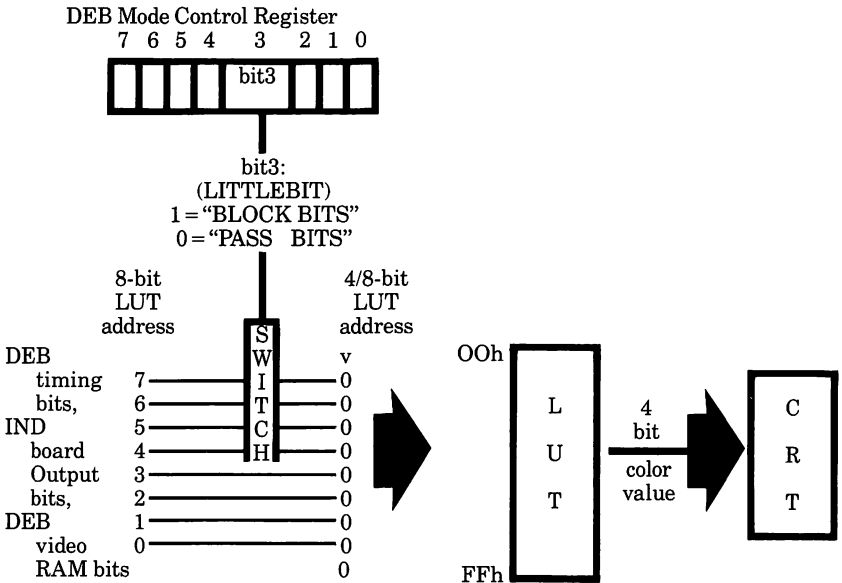
Note:

The following discussion covers the use of the simple palette programming functions. You can also use "Set Color Palette" to program the LUT. (For more information, see **Chapter 5, "Programming the LUT"**).

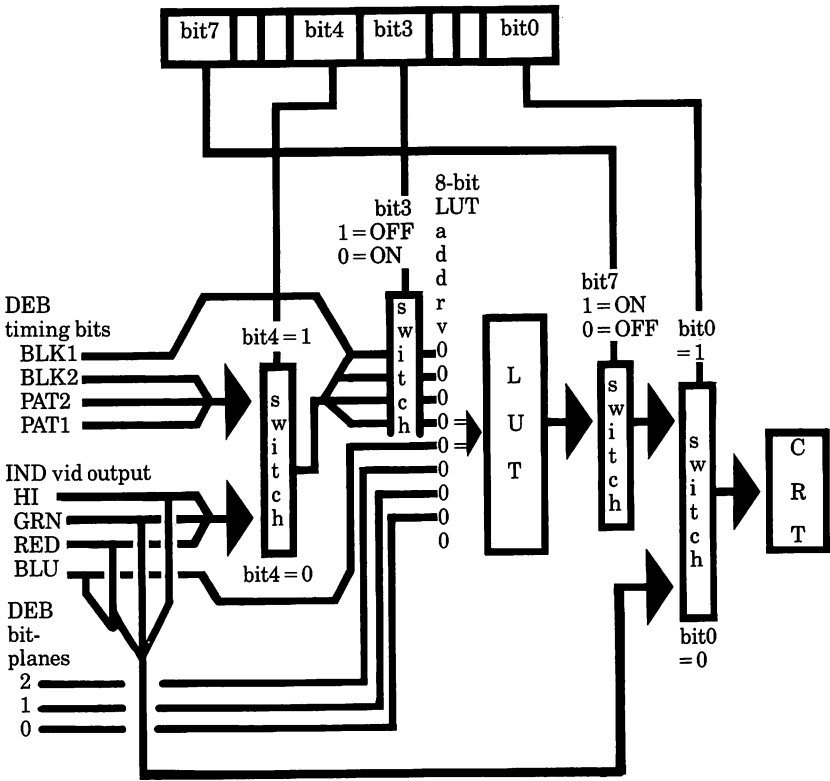
Short LUT Addresses

The DEB supports a method for you to access only the first sixteen LUT locations. This lets you use normal 16-color graphics without needing to manage all of the 256 LUT locations. You invoke this short addressing mode by a setting bit 2 in AL in the “Set Color Palette” command.

3. Short LUT Addresses



4. Modes, Address Formation, & DEB Mode Control Register



**Scroll
Active
Page Up**

This function defines a pattern that is to be displayed on the blank lines as the screen scrolls. The pattern consists of ones and zeros. Zeros are interpreted as the background color (palette position zero). Ones are interpreted as the foreground color, which is defined in BL. Care should be taken when scrolling in DEB modes, to insure that all applications set the additional argument in BH correctly.

Input

- (AH) = 6H function number for Scroll Active Page Up
- (AL) = number of lines to scroll
- (CH,CL) = row, column of upper left corner to scroll
- (DH,DL) = row, column of lower right corner to scroll
- (BH) = pattern to be used on blank lines
- (BL) = foreground color

The range of lines to be scrolled is 0 thru 23 (where 0 specifies clear screen).

Row values are 0 thru 23, column values are 0 thru 79, in DEB modes. Valid foreground colors are specified by palette position 0-FH for 16-color graphics, and 0-7H for 8-color graphics.

Output

Contents of all registers are preserved.

Example

```

MOV AH,6 ;Scroll Active Page Up
MOV AL,LINES
MOV CH,UPROW
MOV CL,UPCOL
MOV DH,LOWROW
MOV DL,LOWCOL
MOV BH,0
MOV BL,FGCOLOR
INT 10H

```

**Scroll
Active
Page Down**

This function permits you to define a pattern that is to be displayed on the blank lines as the screen scrolls downward. The pattern consists of ones and zeros. Zeros are interpreted as the background color (palette position zero). Ones are interpreted as the foreground color, which is defined in BL. Care should be taken when scrolling in DEB modes, to insure that all applications set the additional argument in BH correctly.

Input

(AH) = 7H function number for Scroll Active Page Down
(AL) = number of lines to scroll
(CH,CL) = row, column of upper left corner to scroll
(DH,DL) = row, column of lower right corner to scroll
(BH) = pattern to be used on blank lines
(BL) = foreground color
The range of lines to be scrolled is 0 thru 23 (where 0 specifies clear screen).
Row values are 0 thru 23, column values are 0 thru 79, in DEB modes. Valid foreground colors are specified by palette position 0-FH for 16-color graphics, and 0-7H for 8-color graphics.

Output

Contents of all registers are preserved.

Example

```
MOV AH,7 ; Scroll Active Page Down  
MOV AL,LINES  
MOV CH,UPROW  
MOV CL,UPCOL  
MOV DH,LOWROW  
MOV DL,LOWCOL  
MOV BH,0  
MOV BL,FGCOLOR  
INT 10H
```

**Read
Character
and
Attribute
at Current
Cursor
Position**

This function returns the value of the character at the current cursor position. The value of the character's foreground color is returned in AH.

Input

(AH) = 8 Function number for Read Character and Attribute at Current Cursor Position.

(BH) = Valid page numbers for DEB modes are 0 for the VDC and 80H for the DEB in overlay mode.

Output

(AL) = ASCII character code

(AH) = foreground palette position or VDC attribute

Contents of all other registers are preserved.

Example

```
MOV AH,8 ;Read CHR function  
MOV BH,PAGE  
INT 10H  
MOV CHAR,AL ;Save CHAR/COLOR  
MOV CURCOLOR,AH
```

**Write
Character
and
Attribute
at Current
Cursor
Position**

This function displays the character whose ASCII code is in register AL. The character is displayed according to the color values in BL.

Input

(AH) = 9H Write Character function
(AL) = ASCII character code
(BL) = foreground color
(BH) = page
(CX) = count of characters to write

If bit 7 of BL = 1, the color value is XOR'd with the current dots in that location. Valid page numbers for DEB modes are 0 for the VDC and 80H for the DEB in overlay mode.

Valid foreground colors are specified by palette position 0-FH for 16-color graphics, and 0-7H for 8-color graphics.

Output

Contents of all registers are preserved.

Example

```
MOV AH,9  
MOV AL,CHAR  
MOV BL,CURCOLOR  
MOV BH,PAGE  
MOV CX,1  
INT 10H
```