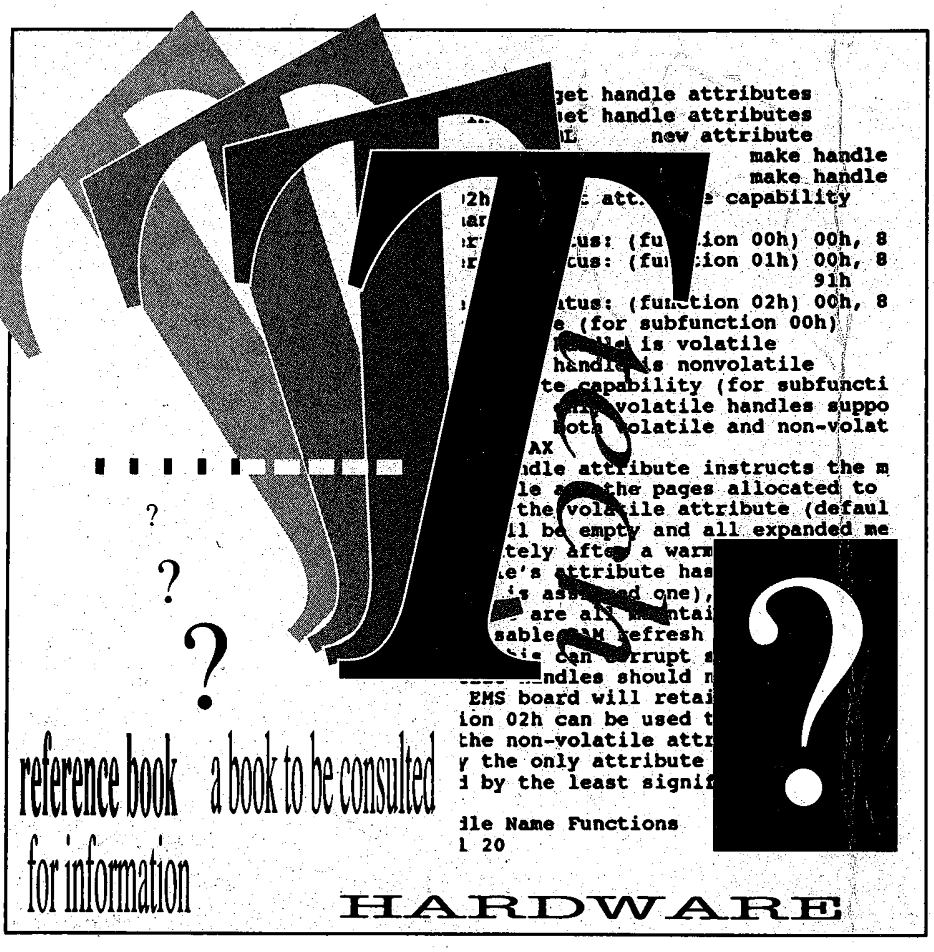
The PROGRAMMER'S TECHNICAL REFERENCE

MS - DOS, IBM PC & COMPATIBLES



DAVE WILLIAMS

SIGMA

THE PROGRAMMER'S TECHNICAL REFERENCE:
MS-DOS, IBM PC & Compatibles

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Preface

This book is a technical reference. It is NOT a tutorial. It is intended to replace the various (expensive) references needed to program for the DOS environment, that stack of magazines threatening to take over your work area, and those odd tables and charts you can never find when you need them.

The various Microsoft and IBM publications and references don't always have the same information. This has caused some consternation about the 'undocumented' features to be found in DOS. In general, if a call doesn't appear in the IBM DOS Technical Reference it is considered 'undocumented' although it may be in common use.

Microsoft's offical policy toward DOS has been to put the burden of documenting and supporting their product to their vendors. Microsoft will not answer any questions concerning DOS directly since they don't officially support it. This leaves what information IBM and other OEMs (DEC, Zenith, et al) have chosen to publish, and the information obtained from programmers who've poked around inside it.

Now that Microsoft is selling MSDOS 3.3 and 4.0 over the counter they seem to be dragging their feet over whether they will have to support the generic version since it doesn't have an OEM name on it anymore. In view of their push to OS/2 (OS/2! Just Say No!) further support of DOS seems unlikely.

A project this size takes a LOT of time and effort. I've tried to verify as much of the information I've received as I could, but there's just too much for absolute certainty.

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1

DOS and the IBM PC

Some History

Development of MS-DOS/PCDOS began in October 1980, when IBM began searching the market for an operating system for the yet-to-be-introduced IBM PC. Microsoft had no real operating system to sell, but after some research licensed Seattle Computer Products' 86-DOS operating system, which had been written by a man named Tim Paterson earlier in 1980 for use on that company's line of 8086, S100 bus micros. 86-DOS (also called QDOS, for Quick and Dirty Operating System) had been written as more or less a 16-bit version of CP/M, since Digital Research was showing no hurry in introducing CP/M-86.

This code was hurriedly polished up and presented to IBM for evaluation. IBM had originally intended to use Digital Research's CP/M operating system, which was the industry standard at the time. Folklore reports everything from obscure legal entanglements to outright snubbing of the IBM representatives by Digital. Irregardless, IBM found itself left with Microsoft's offering of "Microsoft Disk Operating System 1.0". An agreement was reached between the two, and IBM agreed to accept 86-DOS as the main operating system for their new PC. Microsoft purchased all rights to 86-DOS in July 1981, and "IBM PC-DOS 1.0" was ready for the introduction of the IBM PC in October 1981. IBM subjected the operating system to an extensive quality-assurance program, reportedly found well over 300 bugs, and decided to rewrite the programs. This is why PC-DOS is copyrighted by both IBM and Microsoft.

It is sometimes amusing to reflect on the fact that the IBM PC was not originally intended to run MS-DOS. The target operating system at the end of the development was for a (not yet in existence) 8086 version of CP/M. On the other hand, when DOS was originally written the IBM PC did not yet exist! Although PC-DOS was bundled with the computer, Digital Research's CP/M-86 would probably have been the main operating system for the PC except for two things - Digital Research wanted \$495 for CP/M-86 (considering PC-DOS was essentially free) and many software developers found it easier to port existing CP/M software to DOS than to the new version of CP/M. Several computer magazines claimed that Digital Research aided IBM in writing DOS 4.0, which was subsequently licensed back to Microsoft, which has dropped further development of the operating system to tilt at the windmills of OS/2. OS/2? Not yet! After using DR-DOS 3.4 and noting its behaviour, I now tend to seriously doubt Digital had any dealings with PC-DOS 4.0.

MS-DOS and PC-DOS have been run on more than just the IBM-PC and clones. Some of the following have been done:

Hardware PC Emulation:	
Commodore Amiga 2000	8088 or A2286D 80286 Bridge Board
IBM PC/AT	80286 AT adapter
Atari 400/800	Co-Power 88 board
Apple Macintosh	AST 80286 board
Atari ST	PC-Ditto II cartridge
Apple II	TransPC 8088 board, QuadRam QuadLink
Software PC Emulation:	
Atari ST	PC-Ditto I
Apple Macintosh	SoftPC
DOS Emulation:	
OS/2	DOS emulation in "Compatibility Box"
QNX	DOS window
SunOS	DOS window
Xenix	DOS emulation with DOSMerge

What is DOS?

DOS exists as a high-level interface between an application program and the computer. DOS stands for "Disk Operating System", which reflects the fact that its main original purpose was to provide an interface between the computer and its disk drives.

DOS now lets your programs do simple memory management, I/O from the system console, and assorted system tasks (time and date, etc) as well as managing disk operations. Versions 3.1 and up also incorporate basic networking functions.

With the introduction of installable device drivers and TSR (terminate but stay resident) programs in DOS 2.0, the basic DOS functions may be expanded to cover virtually any scale of operations required.

Other Operating Systems

There are a number of compatible replacements for Microsoft's MS-DOS. Some are:

Consortium Technologies MultiDOS	(multitasking, multiuser)
Digital Research Concurrent DOS	(multitasking)
Digital Research Concurrent DOS 386	(for 80386 computers)
Digital Research Concurrent DOS XM	(multitasking, multiuser)
Digital Research DR-DOS 3.31 and 4.0	(PC-DOS clones)
PC-MOS/386	(multitasking, multiuser)
Wendin-DOS	(multitasking, multiuser)
VM/386	(multitasking)

Various other operating systems are available for the IBM PC. These include:

Digital Research CP/M-86
Digital Research Concurrent CP/M-86 (multitasking)
Minix (multitasking UNIX workalike)
Pick (database-operating system)

QNX (multitasking, multiuser)
UNIX (various systems from IBM itself, Microsoft-SCO, Bell, and various UNIX clones, single and multi user) (AIX, Xenix, AT&T System V, etc.)

"Shell" programs exist which use DOS only for disk management while they more or less comprise a new operating system. These include:

DesQview
Windows
OmniView
GEM
TopView
TaskView

Specific Versions of MS/PC-DOS

DOS 1.x is essentially 86-DOS. DOS 2.x kept the multiple file layout (the two hidden files and COMMAND.COM) but for all practical purposes is an entirely different operating system with backwards compatibility with 1.x. I seriously doubt there has been much code from 1.x retained in 2.x. DOS 3.x is merely an enhancement of 2.x; there seems little justification for jumping a whole version number. DOS 4.0, originating as it did from outside Microsoft, can justify a version jump. Unfortunately, 4.x seems to have very little reason to justify its existence - virtually all of its core features can be found in one version or another of DOS 3.x.

DOS version nomenclature: major.minor.minor. The digit to the left of the decimal point indicates a major DOS version change. 1.0 was the first version. 2.0 added support for subdirectories, 3.0 added support for networking, 4.0 added some minimal support for Lotus-Intel-Microsoft EMS.

The first minor version indicates customization for a major application. For example, 2.1 for the PCjr, 3.3 for the PS/2s. The second minor version does not seem to have any particular meaning.

The main versions of DOS are:

PC-DOS 1.0	August 1981	original release
PC-DOS 1.1	May 1982	bugfix, double sided drive support
MS-DOS 1.25	June 1982	for early compatibles
PC-DOS 2.0	March 1983	for PC/XT, Unix-type subdirectory support
PC-DOS 2.1	October 1983	for PCjr, bugfixes for 2.0
MS-DOS 2.11	October 1983	compatible equivalent to PC-DOS 2.1
PC-DOS 3.0	August 1984	1.2 meg drive for PC/AT, some new system calls
PC-DOS 3.1	November 1984	bugfix for 3.0, implemented network support
MS-DOS 2.25	October 1985	compatible; extended foreign language support
PC-DOS 3.2	December 1985	720k 3.5 inch drive support for Convertible
PC-DOS 3.3	April 1987	for PS/2 series, 1.44 meg, multiple DOS partitions
MS-DOS 3.31	November 1987	over-32 meg DOS partitions, new function calls
PC-DOS 4.0	August 1988	minor EMS support, some new function calls
MS-DOS 4.01	January 1989	Microsoft version with some bugfixes

IBM's PC-DOS is considered to be the "standard" version of DOS; Microsoft has sold MS-DOS over the counter only since version 3.2 (previously, Microsoft sold its versions only to OEMs).

Most versions of DOS functionally duplicate the external DOS commands such as DISKCOPY, etc. Although Microsoft announced that they would sell MS-DOS 4.0 only to OEMs, they apparently changed the policy and are now selling it over the counter.

Some versions of MS-DOS varied from PC-DOS in the available external commands. Some OEMs only licensed the basic operating system code (the xDOS and xBIO programs, and COMMAND.COM) from Microsoft, and either wrote the rest themselves or contracted them from outside software houses like Phoenix. Most of the external programs for DOS 3.x and 4.x are written in "C" while the 1.x and 2.x utilities were written in assembly language. Other OEMs required customized versions of DOS for their specific hardware configurations, such as Sanyo 55x and early Tandy computers, which were unable to exchange their DOS with the IBM version.

At least two versions of DOS have been modified to be run entirely out of ROM. The Sharp PC5000 had MS-DOS 1.25 in ROM, and the Toshiba 1000 and some Tandy 1000 models have MS-DOS 2.11 in ROM. Digital Research has also announced its DR-DOS is available in a ROM version and Award Software is marketing DOS cards to OEMs as a plug-in.

PC-DOS 3.0 was extremely buggy on release. It does not handle the DOS environment correctly and there are numerous documented problems with the batch file parser. The network support code is also nonfunctional in this DOS version. It is recommended that users upgrade to at least version 3.1.

DEC MS-DOS versions 2.11 for the Rainbow had the ANSI.SYS device driver built into the main code. The Rainbow also used a unique quad density, single-sided floppy drive and its DOS had special support for it.

IBM had a version 1.85 of PC-DOS in April 1983, after the introduction of DOS 2.0. It was evidently for internal use only, supported multiple drive file searches (a primitive form of PATH), built in MODE commands for screen support, a /P parameter for TYPE for paused screens, an editable command stack like the public domain DOSEDIT.COM utility, and could be set up to remain completely resident in RAM instead of a resident/transient part like normal DOS. It is a pity some of the neat enhancements didn't make it into DOS 2.0. IBM also had an "internal use only" version 3.4, evidently used while developing DOS 4.0.

Some versions of DOS used in compatibles do not maintain the 1.x, 2.x, ... numbering system. Columbia Data Products computers labelled DOS 1.25 as DOS 2.0. Early Compaqs labelled DOS 2.0 as DOS 1.x. Other versions incorporated special features - Compaq DOS 3.31 and Wyse DOS 3.21 both support 32-bit file allocation tables in the same fashion as DOS 4.x.

According to PC Week Magazine, July 4, 1988, Arabic versions of MS-DOS are shipping with a hardware copy-protection system from Rainbow Technologies. This is similar to the short-lived system used by AutoCAD 2.52 and a very few other MS-DOS programs, where an adapter block is plugged into the parallel port and software makes use of coded bytes within the block. This type of copy protection has been common on Commodore products for several years, where it is called a "dongle".

The AutoCAD dongle was defeated by a small program written within weeks of version 2.52's debut. Version 2.62 was released 3 months later, without the dongle. The DOS dongle will, however, prevent the system from booting at all unless it is found.

This makes the Arabic version of MS-DOS the first copy-protected operating system, a dubious distinction at best. The modifications to the operating system to support the dongle are not known at this time. Frankly, it would seem that burning the operating system into ROMs would be cheaper and simpler.

Versions of DOS sold in Great Britain are either newer than those sold in the US or use a different numbering system. DOS 3.4, 4.0, 4.1, 4.2, and 4.3 had been released here between the US releases of 3.3 and 4.0.

Microsoft changed their OEM licensing agreements between DOS versions 2.x and 3.x. OEM versions of DOS 3.x must maintain certain data areas and undocumented functions in order to provide compatibility with the networking features of the operating system. For this reason, resident programs will be much more reliable when operating under DOS 3.x.

IBM's release of DOS 4.0 (and the immediate subsequent release of a bugfix) is a dubious step "forward". DOS 4.0 is the first version of DOS to come with a warranty; the catch is that IBM warrants it only for a very slim list of IBM-packaged software. 4.0 has some minor EMS support, support for large hard disks, and not much else. With its voracious RAM requirements and lack of compatibility with previous versions of DOS (many major software packages crash under DOS 4.0), plus the increase in price to a cool $150, there has been no great rush to go to the newest DOS

The Operating System Hierarchy

The Disk Operating System (DOS) and the ROM BIOS serve as an insulating layer between the application program and the machine, and as a source of services to the application program.

As the term 'system' might imply, DOS is not one program but a collection of programs designed to work together to allow the user access to programs and data. Thus, DOS consists of several layers of "control" programs and a set of "utility" programs.

The system hierarchy may be thought of as a tree, with the lowest level being the actual hardware. The 8088 or V20 processor sees the computer's address space as a ladder two bytes wide and one million bytes long. Parts of this ladder are in ROM, parts in RAM, and parts are not assigned. There are also various "ports" that the processor can use to control devices.

The hardware is normally addressed by the ROM BIOS, which will always know where everything is in its particular system. The chips may usually also be written to directly, by telling the processor to write to a specific address or port. This sometimes does not work as the chips may not always be at the same addresses or have the same functions from machine to machine.

DOS Structure

DOS consists of four components:

The boot record
The ROM BIOS interface (IBMBIO.COM or IO.SYS)
The DOS program file (IBMDOS.COM or MS-DOS.SYS)
The command processor (COMMAND.COM or aftermarket replacement)

The Boot Record

The boot record begins on track 0, sector 1, side 0 of every diskette formatted by the DOS FORMAT command. The boot record is placed on diskettes to produce an error message if you try to start up the system with a non-system diskette in drive A. For hard disks, the boot record resides on the first sector of the DOS partition. All media supported by DOS use one sector for the boot record.

Read Only Memory (ROM) BIOS Interface and Extensions

The file IBMBIO.COM or IO.SYS is the interface module to the ROM BIOS. This file provides a low-level interface to the ROM BIOS device routines and may contain extensions or changes to the system board ROMs. Some compatibles do not have a ROM BIOS to extend, and load the entire BIOS from disk (Sanyo 55x, Viasyn machines). Some versions of MS-DOS, such as those supplied to Tandy, are named IBMBIO.COM but are not IBM files.

These low-level interface routines include the instructions for performing operations such as displaying information on the screen, reading the keyboard, sending data out to the printer, operating the disk drives, and so on. It is the operating system's means of controlling the hardware. IBMBIO.COM contains any modifications or updates to the ROM BIOS that are needed to correct any bugs or add support for other types of hardware such as new disk drives. By using IBMBIO.COM to update the ROM BIOS on the fly when the user turns on their computer, IBM does not need to replace the ROM BIOS chip itself, but makes any corrections through the cheaper and easier method of modifying the IBMBIO.COM file instead.

IBMBIO.COM also keeps track of hardware operations on an internal stack or "scratch pad" area for the operating system to save information such as addresses it will need, etc. An example of the use for this stack can be seen when running a program such as a word processor. If you have told the word processor to save your letter, it will write the data to your disk. During this time, if you start typing some more information, the keyboard generates a hardware interrupt. Since you don't want the process of writing the information to the disk to be interrupted, DOS allocates a slot in the stack for the keyboard's hardware interrupt and when it gets a chance, (probably after the data has been written to the disk), it can process that interrupt and pick up the characters you may have been typing. The STACKS= command in DOS 3.2+'s CONFIG.SYS file controls the number of stack frames available for this purpose.

IBMBIO.COM also reads your CONFIG.SYS file and installs any device drivers (i.e. DEVICE=ANSI.SYS) or configuration commands it may find there.

The DOS Program

The actual DOS program is the file IBMDOS.COM or MS-DOS.SYS. It provides a high-level interface for user (application) programs. This program consists of file management routines, data blocking/deblocking for the disk routines, and a variety of built-in functions easily accessible by user programs.

When a user program calls these function routines, they accept high-level information by way of register and control block contents. When a user program calls DOS to perform an operation, these functions translate the requirement into one or more calls to IBMBIO.COM, MS-DOS.SYS or system hardware to complete the request.

The Command Interpreter

The command interpreter, COMMAND.COM, is the part you interact with on the command line. COMMAND.COM has three parts. IBM calls them the "resident portion", the "initialization portion" and the "transient portion".

IBM's original documentation spoke of installing alternate command interpreters (programs other than COMMAND.COM) with the SHELL= statement in CONFIG.SYS. Unfortunately, IBM chose not to document much of the interaction between IBMDOS.COM and IBMBIO.COM. By the time much of the interaction was widely understood, many commercial software programs had been written to use peculiarities of COMMAND.COM itself.

Two programs exist that perform as actual "shells" by completely replacing COMMAND.COM and substituting their own command interpreter to use with the hidden DOS files. These are Command Plus, a commercial package, and the very interesting shareware 4DOS package. Both supply greatly enhanced batch language and editing capabilities.

Note: DOS 3.3+ checks for the presence of a hard disk, and will default to COMSPEC=C:\. Previous versions default to COMSPEC=A:\. Under some DOS versions, if COMMAND.COM is not immediately available for reloading (i.e., swapping to a floppy with COMMAND.COM on it) DOS may crash.

Resident Portion

The resident portion resides in memory immediately following IBMDOS.COM and its data area. This portion contains routines to process interrupts 22h (Terminate Address), 23h (Ctrl-Break Handler), and 24h (Critical Error Handler), as well as a routine to reload the transient portion if needed. For DOS 3.x, this portion also contains a routine to load and execute external commands, such as files with extensions of COM or EXE.

When a program terminates, a checksum is used to determine if the application program overlaid the transient portion of COMMAND.COM. If so, the resident portion will reload the transient portion from the area designated by COMSPEC= in the DOS environment. If COMMAND.COM cannot be found, the system will halt.

All standard DOS error handling is done within the resident portion of COMMAND.COM. This includes displaying error messages and interpreting the replies to the "Abort, Retry, Ignore, Fail?" message.

Since the transient portion of COMMAND.COM is so large (containing the internal commands and all those error messages), and it is not needed when the user is running an application it can be overlaid that program if that application needs the room. When the application is through, the resident portion of COMMAND.COM brings the transient portion back into memory to show the prompt. This is why you will sometimes see the message "Insert disk with COMMAND.COM". It needs to get the transient portion off the disk since it was overlaid with the application program.

The initialization portion of COMMAND.COM follows the resident portion and is given control during the boot-up procedure. This section actually processes the AUTOEXEC.BAT file. It also decides where to load the user's programs when they are executed. Since this code is only needed during start-up, it is overlaid by the first program which COMMAND.COM loads.
The transient portion is loaded at the high end of memory and it is the command processor itself. It interprets whatever the user types in at the keyboard, hence messages such as 'Bad command or file name' for when the user misspells a command. This portion contains all the internal commands (i.e. COPY, DIR, RENAME, ERASE), the batch file processor (to run .BAT files) and a routine to load and execute external commands which are either .COM or .EXE files.

The transient portion of COMMAND.COM produces the system prompt, (C), and reads what the user types in from the keyboard and tries to do something with it. For any .COM or .EXE files, it builds a command line and issues an EXEC function call to load the program and transfer control to it.

DOS Initialization

The system is initialized by a software reset (Ctrl-Alt-Del), a hardware reset (reset button), or by turning the computer on. The Intel 80x8x series processors always look for their first instruction at the end of their address space (0FFFF0h) when powered up or reset. This address contains a jump to the first instruction for the ROM BIOS.

Built-in ROM programs (Power-On Self-Test, or POST, in the IBM) check machine status and run inspection programs of various sorts. Some machines set up a reserved RAM area with bytes indicating installed equipment (AT and PCjr).

When the ROM BIOS finds a ROM on an adapter card, it lets that ROM take control of the system so that it may perform any set up necessary to use the hardware or software controlled by that ROM. The ROM BIOS searches absolute addresses 0C8000h through 0E0000h in 2K increments in search of a valid ROM. A valid ROM is determined by the first few bytes in the ROM. The ROM will have the bytes 55h, 0AAh, a length indicator and then the assembly language instruction to CALL FAR (to bring in a 'FAR' routine). A checksum is done on the ROM to verify its integrity, then the BIOS performs the CALL FAR to bring in the executable code. The adapter's ROM then performs its initialization tasks and hopefully returns control of the computer back to the ROM BIOS so it can continue with the booting process.

The ROM BIOS routines then look for a disk drive at A: or an option ROM (usually a hard disk) at absolute address C:800h. If no floppy drive or option ROM is found, the BIOS calls int 19h (ROM BASIC if it is an IBM) or displays an error message.

If a bootable disk is found, the ROM BIOS loads the first sector of data from the disk and then jumps into the RAM location holding that code. This code normally is a routine to load the rest of the code off the disk, or to 'boot' the system.

The following actions occur after a system initialization:

1. The boot record is read into memory and given control.
2. The boot record then checks the root directory to assure that the first two files are IBMBIO.COM and IBMDOS.COM. These two files must be the first two files, and they must be in that order (IBMBIO.COM first, with its sectors in contiguous order).
   Note: IBMDOS.COM need not be contiguous in version 3.x+.
3. The boot record loads IBMBIO.COM into memory.
4. The initialization code in IBMBIO.COM loads IBMDOS.COM, determines equipment status, resets the disk system, initializes the attached devices, sets the system parameters and loads any installable device drivers according to the CONFIG.SYS file in the root directory (if present), sets the low-numbered interrupt vectors, relocates IBMDOS.COM downward, and calls the firstbyte of DOS.
   Note: CONFIG.SYS may be a hidden file.
5. DOS initializes its internal working tables, initializes the interrupt vectors for interrupts 20h through 27h, and builds a Program Segment Prefix for COMMAND.COM at the lowest available segment. For DOS versions 3.10 up, DOS also initializes the vectors for interrupts

0Fh through 3Fh. An initialization routine is included in the resident portion and assumes control during start-up. This routine contains the AUTOEXEC.BAT file handler and determines the segment address where user application programs may be loaded. The initialization routine is then no longer needed and is overlaid by the first program COMMAND.COM loads.
Note: AUTOEXEC.BAT may be a hidden file.

6. IBMBIO.COM uses the EXEC function call to load and start the top-level command processor. The default command processor is COMMAND.COM in the root directory of the boot drive. If COMMAND.COM is in a subdirectory or another command processor is to be used, it must be specified by a SHELL= statement in the CONFIG.SYS file. A transient portion is loaded at the high end of memory. This is the command processor itself, containing all of the internal command processors and the batch file processor. For DOS 2.x, this portion also contains a routine to load and execute external commands, such as files with extensions of COM or EXE. This portion of COMMAND.COM also produces the DOS prompt (such as 'A'), reads the command from the standard input device (usually the keyboard or a batch file), and executes the command. For external commands, it builds a command line and issues an EXEC function call to load and transfer control to the program.

Note 1. COMMAND.COM may be a hidden file.

2. For IBM DOS 2.x, the transient portion of the command processor contains the EXEC routine that loads and executes external commands. For MS-DOS 2.x+ and IBM DOS 3.x+, the resident portion of the command processor contains the EXEC routine.

3. IBMBIO only checks for a file named COMMAND.COM. It will load any file of that name if no SHELL= command is used.

That pretty much covers the boot-up process. After COMMAND.COM is loaded, it runs the AUTOEXEC.BAT file and then the user gets a prompt to begin working.

2

CPU Port Assignments, System Memory Map, BIOS Data Area, Interrupts 00h to 09h

Introduction

For consistency in this reference, all locations and offsets are in hexadecimal unless otherwise specified. All hex numbers are prefaced with a leading zero if they begin with an alphabetic character, and are terminated with a lowercase H (h). The formats vary according to common usage.

System Memory Map

The IBM PC handles its address space in 64k segments, divided into 16k fractions and then furthen as necessary.

start addr. (dec)	start addr. (hex) end addr	usage
640k RAM Area		
0k		start of RAM, first K is interrupt vector table
16k	00000-03FFF	PC-0 system board RAM ends
32k	04000-07FFF	
48k	08000-0BFFF	
64k	10000-13FFF	PC-1 system board RAM ends
80k	14000-17FFF	
96k	18000-1BFFF	
112k	1C000-1FFFF	
128k	20000-23FFF	
144k	24000-27FFF	
160k	28000-2BFFF	
176k	2C000-2FFFF	
192k	30000-33FFF	
208k	34000-37FFF	
224k	38000-3BFFF	
240k	3C000-3FFFF	

```
256k  40000-43FFF   PC-2 system board RAM ends
272k  44000-47FFF
288k  48000-4BFFF
304k  4C000-4FFFF

320k  50000-53FFF
336k  54000-57FFF
352k  58000-5BFFF
368k  5C000-5FFFF

384k  60000-63FFF
400k  64000-67FFF
416k  68000-6BFFF
432k  6C000-6FFFF

448k  70000-73FFF
464k  74000-77FFF
480k  78000-7BFFF
496k  7C000-7FFFF

512k  80000-83FFF
528k  84000-87FFF
544k  88000-8BFFF   the original IBM PC-1 BIOS limited memory to 544k
560k  8C000-8FFFF

576k  90000-93FFF
592k  94000-97FFF
609k  98000-9BFFF
624k  9C000-9FFFF   to 640k (top of RAM address space)

 A0000 ***** 64k ***** EGA address

640k  A0000-A95B0  MCGA 320x200 256 colour video buffer
           -AF8C0  MCGA 640x480 2 colour video buffer
           -A3FFF
656k  A4000-A7FFF
672k  A8000-ABFFF      this 64k segment may be used for contiguous DOS
688k  AC000-AFFFF      RAM with appropriate hardware and software

 B0000 ***** 64k ***** mono and CGA address

704k  B0000-B3FFF  4k  monochrome display    PCjr and early Tandy 1000
720k  B4000-B7FFF                            BIOS revector direct write to the
                                             B8 area to the Video Gate Array
736k  B8000-BBFFF  16k CGA uses              and reserved system RAM
756k  BC000-BFFFF

 C0000 ***** 64k *************** expansion ROM

768k  C0000-C3FFF  16k EGA BIOS C000:001E EGA BIOS signature (letters IBM
784k  C4000-C5FFF
      C6000-C63FF  256 bytes Professional Graphics Display comm. area
      C6400-C7FFF
800k  C8000-CBFFF  16k hard disk controller BIOS, drive 0 default
      CA000            some 2nd floppy (high density) controller BIOS
816k  CC000-CDFFF   8k IBM PC Network NETBIOS
      CE000-CFFFF

 D0000 ***** 64k ***** expansion ROM

832k  D0000-D7FFF  32k IBM Cluster Adapter   PCjr first ROM cartridge
            DA000  voice communications      address area.
848k  D4000-D7FFF                            Common expanded memory
864k  D8000-DBFFF                            board paging area.
880k  DC000-DFFFF

 E0000 ***** 64k ***** expansion ROM

896k  E0000-E3FFF                            PCjr second ROM cartidge
912k  E4000-E7FFF                            address area
928k  E8000-EBFFF
```

```
944k  EC000-EFFFF                           |    spare ROM sockets on AT

 F0000 ***** 64k ***** system

960k  F0000-F3FFF  reserved by IBM          |    cartridge address
976k  F4000-                                |    area (PCjr cartridge
      F6000        ROM BASIC Begins         |    BASIC)
992k  F8000-FB000                           |
1008k FC000-FFFFF  ROM BASIC and original   |
                   BIOS (Compatibility BIOS |
                   in PS/2)                 |
1024k       FFFFF  end of memory (1024k) for 8088 machines

384k  100000-15FFFF 80286/AT extended memory area, 1Mb motherboard
15Mb  100000-FFFFFF 80286/AT extended memory address space
15Mb  160000-FDFFFF Micro Channel RAM expansion (15Mb extended memory)
128k  FE0000-FFFFFF system board ROM          (PS/2 Advanced BIOS)
```

Note that the ROM BIOS has a duplicated address space which causes it to 'appear' both at the end of the 1 megabyte real mode space and at the end of the 16 megabyte protected mode space. The addresses from 0E0000 to 0FFFFF are equal to 0FE0000 to 0FFFFFF. This is necessary due to differences in the memory addressing between Real and Protected Modes.

PC Port Assignment

hex address	Function	Models PCjr	PC	XT	AT	CVT	M30	PS2
0000-000F	8237 DMA controller		PC					
0010-001F	8237 DMA controller				AT			PS2
0020-0027	8259A interrupt controller							
0020-003F	8259A interrupt controller (AT)							
0020-0021	Interrupt controller 1, 8259A		PC		AT			PS2
0040-0043	Programmable timer 8253		PC					
0040-0047	Programmable timers							PS2
0040-005F	8253-5 programmable timers				AT			
	(note: 0041 was memory refresh in PCs. Not used in PS/2)							
0060-0063	Keyboard controller 8255A		PC					
0060-006F	8042 keyboard controller				AT			
0060	IOSGA keyboard input port							PS2
0061	speaker	PCjr	PC	XT	AT	CVT		
0061	IOSGA speaker control						M30	PS2
0061	On some clones, setting or clearing bit 2 controls Turbo mode							
0062	IOSGA configuration control						M30	PS2
0063	SSGA, undocumented							PS2
0064	keyboard auxiliary device							PS2
0065-006A	SSGA, undocumented							PS2
006B	SSGA, RAM enable/remap							PS2
006C-006F	SSGA, undocumented							PS2
0070	AT CMOS write internal register							
0071	AT CMOS read internal register							
0070-0071	CMOS real-time clock, NMI mask							PS2
0070-007F	CMOS real-time clock, NMI mask				AT			
0074-0076	reserved							PS2
0800-008F	SSGA DMA page registers							PS2
0080-009F	DMA page registers, 74LS612				AT			
0090	central arbitration control port				(Micro Channel)			
0091	card selected feedback				(Micro Channel)			
0092	system control port A				(Micro Channel)			
0093	reserved				(Micro Channel)			
0094	system board setup				(Micro Channel)			
0096	POS 'CD SETUP' selector				(Micro Channel)			
00A0-00A1	Interrupt controller 2, 8259A				AT			PS2
00A0-00AF	IOSGA NMI mask register							PS2
00B0-00BF	realtime clock/calendar, (undocumented)							PS2
00C0-00DF	reserved	PCjr	PC	XT	AT	CVT	M30	

00C0-00DF	DMA controller 2, 8237A-5		AT		PS2
00E0-00EF	realtime clock/calendar, (undocumented)			M30	PS2
00F0-00FF	PS/2 math coprocessor I/O (Model 50+) (diskette IO on PCjr)				
0100-0101	PS/2 POS adapter ID response (Micro Channel)				
0102-0107	PS/2 POS adapter configuration response (Micro Channel)				
01F0-01F8	Fixed disk		AT		PS2
0200-0201	game-control adapter (joystick)				
0200-020F	Game controller	PC	AT		
0020-002F	IOSGA interrupt function				PS2
020C-020D	reserved by IBM				
0210-0217	expansion box (PC, XT)				
021F	reserved by IBM				
0278-027F	Parallel printer port 2		AT		
0278-027B	Parallel printer port 3				PS2
02B0-02DF	EGA (alternate)	PC	AT		
02E1	GPIB (adapter 0)		AT		
02E2-02E3	Data acquisition (adapter 0)		AT		
02F8-02FF	Serial communications (COM2)	PC	AT		PS2
0300-031F	Prototype card	PC	AT		
0320-032F	hard disk controller	PC			
0348-0357	DCA 3278				
0360-0367	PC Network (low address)				
0368-036F	PC Network (high address)		AT		
0378-037F	Parallel printer port 1	PC	AT		
0378-037B	Parallel printer port 2				PS2
0380-038F	SDLC, bi-synchronous 2	PC	AT		
0380-0389	BSC communications (alternate)	PC			
0390-0393	Cluster (adapter 0)	PC	AT		
03A0-03A9	BSC communications (primary)	PC	AT		
03B0-03BF	Monochrome/parallel printer adapter	PC	AT		
03B4-03B5	Video subsystem				PS2
03BA	Video subsystem				PS2
03BC-03BF	Parallel printer port 1				PS2
03C0-03CF	Enhanced Graphics Adapter				
03C0-03DA	Video subsystem and DAC				PS2
03D0-03DF	CGA, MCGA, VGA adapter control				
03F0-03F7	Floppy disk controller	PC	AT		PS2
03F8-03FF	Serial communications (COM1)	PC	AT		PS2
06E2-06E3	Data acquisition (adapter 1)		AT		
0790-0793	Cluster (adapter 1)	PC	AT		
0AE2-0AE3	Data acquisition (adapter 2)		AT		
0B90-0B93	Cluster (adapter 2)	PC	AT		
0EE2-0EE3	Data acquisition (adapter 3)		AT		
1390-1393	Cluster (adapter 3)	PC	AT		
22E1	GPIB (adapter 1)				
2390-2393	Cluster (adapter 4)	PC	AT		
42E1	GPIB (adapter 2)		AT		
62E1	GPIB (adapter 3)		AT		
82E1	GPIB (adapter 4)		AT		
A2E1	GPIB (adapter 5)		AT		
C2E1	GPIB (adapter 6)		AT		
E2E1	GPIB (adapter 7)		AT		

Notes:

1. These are functions common across the IBM range. The PCjr, PC-AT, PC Convertible and PS/2 (both buses) have enhancements. In some cases, the AT and PS/2 series ignore, duplicate, or reassign ports arbitrarily. If your code incorporates specific port addresses for video or system board control it would be wise to have your application determine the machine type and video adapter and address the ports as required.
2. I/O Addresses, hex 000 to 0FF, are reserved for the system board I/O. Hex 100 to 3FF are available on the I/O channel.
3. These are the addresses decoded by the current set of adapter cards. IBM may use any of the unlisted addresses for future use.
4. SDLC Communication and Secondary Binary Synchronous Communications cannot be used together because their port addresses overlap.
5. IOSGA = I/O Support Gate Array; SSGA = System Support Gate Array.

Reserved Memory Locations

Interrupt Vector Table

```
000-3FF  - 1k DOS interrupt vector table, 4 byte vectors for ints 00h-0FFh.
   30:00   used as a stack area during POST and bootstrap routines. This stack
to 3F:FF   area may be revectored by an application program.
```

The BIOS Data Area

addr. size description

```
40:00  word   COM1 port address  | These addresses are zeroed out in the OS/2
40:02  word   COM2 port address  | DOS Compatibility Box if any of the OS/2
40:04  word   COM3 port address  | COMxx.SYS drivers are loaded.
40:06  word   COM4 port address
40:08  word   LPT1 port address
40:0A  word   LPT2 port address
40:0C  word   LPT3 port address
40:0E  word   LPT4 port address      (not valid in PS/2 machines)
40:0E  word   PS/2 pointer to 1k extended BIOS Data Area at top of RAM
40:10  word   equipment flag (see int 11h), bits:
              0        0      no floppy drive present
                       1      if floppy drive present (see bits 6&7)
              1        0      no math coprocessor installed
                       1      if 80x87 installed  (not valid in PCjr)
              2,3      system board RAM   (not used on AT or PS/2)
                       0,0    16k             0,1     32k
                       1,0    48k             1,1     64k
              4,5      initial video mode
                       0,0    no video adapter
                       0,1    40column colour  (PCjr default)
                       1,0    80column colour
                       1,1    MDA
              6,7      number of diskette drives
                       0,0    1 drive          0,1     2 drives
                       1,0    3 drives         1,1     4 drives
              8        0      DMA present
                       1      DMA not present (PCjr, Tandy 1400, Sanyo
                              55x)
              9,A,B    number of RS232 serial ports
              C        game adapter  (joystick)
                       0      no game adapter
                       1      if game adapter
              D        serial printer (PCjr only)
                       0      no   printer
                       1      serial printer present
              E,F      number of parallel printers installed
```

Note The IBM PC and AT store the settings of the system board switches or CMOS RAM setup information (as obtained by the BIOS in the Power-On Self Test (POST)) at addresses 40:10h and 40:13h. 00000001b indicates 'on', 00000000b is 'off'.

```
40:12  byte  reserved (PC, AT) number of errors detected by infrared keyboard
             link (PCjr); POST status (Convertible)
40:13  word  available memory size in Kbytes (less display RAM in PCjr)
             this is the value returned by int 12h
40:15  word  reserved
40:17  byte  keyboard flag byte 0 (see int 9h)
             bit 7  insert mode on       3  alt pressed
                 6  capslock on          2  ctrl pressed
                 5  numlock on           1  left shift pressed
                 4  scrollock on         0  right shift pressed
40:18  byte  keyboard flag byte 1 (see int 9h)
             bit 7  insert pressed       3  ctrl-numlock (pause) toggled
                 6  capslock pressed     2  PCjr keyboard click active
                 5  numlock pressed      1  PCjr ctrl-alt-capslock held
                 4  scrollock pressed    0
```

```
40:19    byte   storage for alternate keypad entry (not normally used)
40:1A    word   pointer to keyboard buffer head character
40:1C    word   pointer to keyboard buffer tail character
40:1E 32bytes 16 2-byte entries for keyboard circular buffer, read by int 16h
40:3E    byte   drive seek status - if bit=0, next seek will recalibrate by
                repositioning to Track 0.
                bit 3  drive D          bit 2  drive C
                    1  drive B              0  drive A
40:3F    byte   diskette motor status (bit set to indicate condition)
                bit 7  write in progress     3  motor on (floppy 3)
                    6                        2  motor  on  (floppy 2)
                    5                        1  B: motor on (floppy 1)
                    4                        0  A: motor on (floppy 0)
40:40    byte   motor off counter
                starts at 37 and is decremented 1 by each system clock tick.
                motor is shut off when count = 0.
40:41    byte   status of last diskette operation     where:
                bit 7 timeout failure                3 DMA overrun
                    6 seek failure                   2 sector not found
                    5 controller failure             1 address not found
                    4 CRC failure                    0 bad command
40:42 7 bytes NEC floppy controller chip status
40:49    byte   Video Control Data Area 1 from 0040:0049 through 0040:0066
                current CRT mode (hex value)
                  00h 40x25 BW        (CGA)        01h 40x25 colour    (CGA)
                  02h 80x25 BW        (CGA)        03h 80x25 colour    (CGA)
                  04h 320x200 colour (CGA)         05h 320x200 BW      (CGA)
                  06h 640x200 BW      (CGA)        07h monochrome      (MDA)
               extended video modes  (EGA/MCGA/VGA or other)
                  08h lores,16 colour              09h med res,16 colour
                  0Ah hires,4 colour               0Bh n/a
                  0Ch med res,16 colour            0Dh hires,16 colour
                  0Eh hires,4 colour               0Fh hires,64 colour
40:4A    word   number of columns on screen, coded as hex number of columns
                20 col = 14h  (video mode 8, low res 160x200 CGA graphics)
                40 col = 28h
                80 col = 46h
40:4C    word   screen buffer length in bytes
                - (number of bytes used per screen page, varies with video mode)
40:4E    word   current screen buffer starting offset (active page)
40:50 8 words cursor position pages 1-8
                the first byte of each word gives the column (0-19, 39, or 79); the
                second byte gives the row (0-24)
40:60    byte   end line for cursor   (normally 1)
40:61    byte   start line for cursor (normally 0)
40:62    byte   current video page being displayed  (0-7)
40:63    word   base port address of 6845 CRT controller or equivalent
                for active display          3B4h=mono, 3D4h=colour
40:65    byte   current setting of the CRT mode register
40:66    byte   current palette mask setting  (CGA)
40:67 5 bytes temporary storage for SS:SP during shutdown (cassette interface)
40:6C    word   timer counter low word
40:6E    word   timer counter high word
40:69    byte   HD_INSTALL (Columbia PCs) (not valid on most clone computers)
                bit  0     0  8 inch external floppy drives
                           1  5.25" external floppy drives
                    1,2      highest drive address which int 13 will accept (since
                             the floppy drives are assigned 0-3, subtract 3 to
                             obtain the number of hard disks installed)
                    4,5      # of hard disks connected to expansion controller
                    6,7      # of hard disks on motherboard controller (if bit 6 or
                             7 = 1, no A: floppy is present and the maximum number
                             of floppies from int 11 is 3)
40:70    byte   24 hour timer overflow 1 if timer went past midnight it is reset to
                0 each time it is read by int 1Ah
40:71    byte   BIOS break flag (bit 7 = 1 means break key hit)
40:72    word   reset flag PCjr keeps 1234h here for softboot when a cartridge is
                installed
                bits 1234h = soft reset, memory check will be bypassed
                     4321h = preserve memory          (PS/2 other only)
                     5678h = system suspended         (Convertible)
```

```
                 9ABCh = manufacturing test mode (Convertible)
                 ABCDh = system POST loop mode   (Convertible)
40:74   byte   status of last hard disk operation; PCjr special disk control
40:75   byte   # of hard disks attached (0-2)    ; PCjr special disk control
40:76   byte   HD control byte; temp holding area for 6th param table entry
40:77   byte   port offset to current hd adapter ; PCjr special disk control
40:78 4 bytes  timeout value for LPT1,LPT2,LPT3,LPT4
40:7C 4 bytes  timeout value for COM1,COM2,COM3,COM4 (0-0FFh secs, default 1)
40:80   word   pointer to start of circular keyboard buffer, default 03:1E
40:82   word   pointer to end of circular keyboard buffer, default 03:3E
40:84          Video Control Data Area 2, 0040:0084 through 0040:008A
40:84   byte   rows on the screen minus 1 (EGA only)
40:84   byte   PCjr interrupt flag; timer channel 0  (used by POST)
40:85   word   bytes per character (EGA only)
40:85 2 bytes  (PCjr only) typamatic character to repeat
40:86 2 bytes  (PCjr only) typamatic initial delay
40:87   byte   mode options (EGA only)
               bit 1   0   EGA is connected to a colour display
                       1   EGA is monochrome.
               bit 3   0   EGA is the active display,
                       1    'other' display is active.
               mode combinations:
               bit 3  Bit 1     Meaning
                   0      0     EGA is active display and is colour
                   0      1     EGA is active display and is monochrome
                   1      0     EGA is not active, a mono card is active
                   1      1     EGA is not active, a CGA is active
40:87   byte   (PCjr only) current Fn key code
                           80h bit indicates make/break key code?
40:88   byte   feature bit switches (EGA only) 0=on, 1=off
               bit 3   switch 4
                   2   switch 3
                   1   switch 2
                   0   switch 1
40:88   byte   (PCjr only) special keyboard status byte
               bit 7 function flag  3 typamatic (0=enable,1=disable)
                   6 Fn-B break     2 typamatic speed (0=slow,1=fast)
                   5 Fn pressed     1 extra delay bef.typamatic (0=enable)
                   4 Fn lock        0 write char, typamatic delay elapsed
40:89   byte   PCjr, current value of 6845 reg 2 (horizontal synch)
               used by ctrl-alt-cursor screen positioning routine in ROM
40:8A   byte   PCjr CRT/CPU Page Register Image, default 3Fh
40:8B   byte   last diskette data rate selected
               bit 7,6 Starting data transfer rate to use
                       00       500 kb/sec
                       01       300 kb/sec
                       10       250 kb/sec
                       11       reserved
                   5,4 Last step rate selected
                   3   Ending data transfer rate to use
                   2   Reserved
                   1   Reserved
                   0   1  combination floppy/fixed disk controller detected
                       0  XT floppy only controller (for 360kb drive) detected
                                Data Transfer Rates
                       Kbits/sec      Media   Drive   Sectors/Track
                        250           360K    360K          9
                        300           360K    1.2M          9
                        500           1.2M    1.2M         15
                        250           720K    720K          9
                        250           720K    1.4M          9
                        500           1.4M    1.4M         18
40:8C   byte   hard disk status returned by controller
40:8D   byte   hard disk error returned by controller
40:8E   byte   hard disk interrupt (bit 7=working interrupt)
40:8F   byte   combo_card - status of drives 0 and 1
               bit 7   reserved
                   6   drive type determined for drive 1
                   5   drive multiple data rate capability for drive 1
                       0        no multiple data rate
                       1        multiple data rate
```

```
                      4    1 then drive 1 has 80 tracks
                           0 then drive 1 has 40 tracks
                      3      reserved
                      2      drive type determined for drive 0
                      1      drive multiple data rate capability for drive 0
                             0       no multiple data rate
                             1       multiple data rate
                      0      1       then drive 0 has 80 tracks
                      0              then drive 0 has 40 tracks
40:904    bytes media state drive 0, 1, 2, 3
                        floppy_media_state
                 bit7,6 Data transfer rate
                            00 - 500 K/sec
                            01 - 300 K/sec
                            10 - 250 K/sec
                            11 - reserved
                      5     double stepping required
                      4     media/drive determined
                      3     reserved
                      2-0   present state
                            000  360k in 360k unestablished
                            001  360k in 1.2M unestablished
                            010  1.2M in 1.2M unestablished
                            011  360k in 360k established
                            100  360k in 1.2M established
                            101  1.2M in 1.2M established
                            110  reserved
                            111  none of the above
40:94 2 bytes track currently seeked to drive 0, 1
40:96   byte  keyboard flag byte 3 (see int 9h)
40:97   byte  keyboard flag byte 2 (see int 9h)
40:98  dword  segment:offset pointer to users wait flag
40:9C  dword  users timeout value in microseconds
40:A0   byte  real time clock wait function in use
              bits 7    wait time elapsed and posted flag
                   6-1  reserved
                   0    int 15h, function 86h (WAIT) has occurred
40:A1   byte  LAN A DMA channel flags
40:A2 2 bytes status LAN A 0,1
40:A4  dword  saved hard disk interrupt vector
40:A8  dword  EGA pointer to table of 7 parameters. Format of table:
              dword   pointer to 1472 byte table containing 64 video parms
              dword   reserved
              dword   reserved
              dword   reserved
              dword   reserved
              dword   reserved
              dword   reserved
40:B0 2 words international support                              (Tandy 1000 TX)
40:B4   byte  keyboard NMI control flags                           (Convertible)
40:B4   byte  monochrome monitor hookup detect                   (Tandy 1000 TX)
              00h not present    0FFh  present
40:B5  dword  keyboard break pending flags                         (Convertible)
40:B5   byte  extended equipment detect  (5 bits)                (Tandy 1000 TX)
              bit 0 = 0   drive A is 5
                      1   drive A is 3
                  1 = 0   drive A is 5
                      1   drive A is 3
                  2 = 0   Tandy 1000 keyboard layout
                      1   IBM keyboard layout
                  3 = 0   CPU slow mode
                      1   CPU fast mode
                  4 = 0   internal colour video support enabled
                      1   internal colour video support disabled, external video
                          enabled (chg from mb'd to expansion card)
                  5 = 0   no external monochrome video installed
                      1   external monochrome video installed
40:B6   byte extended equipment detect  (1 bit)                  (Tandy 1000 TX)
            bit 0 = 0   drive C is 5
                    1   drive C is 3
40:B9   byte port 60 single byte queue                             (Convertible)
```

```
40:BA    byte   scan code of last key                             (Convertible)
40:BB    byte   pointer to NMI buffer head                        (Convertible)
40:BC    byte   pointer to NMI buffer tail                        (Convertible)
40:BD 16bytes   NMI scan code buffer                              (Convertible)
40:CE    word   day counter                             (Convertible and after)
to -04:8F                end of BIOS Data Area
```

DOS and BASIC Data Areas

```
40:90 -40:EF    reserved by IBM
04:F0 16bytes   Inter-Application Communications Area (for use by applications
04:FF           to transfer data or parameters to each other)
05:00    byte   DOS print screen status flag
                     00h     not active or successful completion
                     01h     print screen in progress
                     0FFh    error during print screen operation
05:01           Used by BASIC
05:02-03        PCjr POST and diagnostics work area
05:04    byte   Single drive mode status byte
                     00      logical drive A
                     01      logical drive B
05:05-0E        PCjr POST and diagnostics work area
05:0F           BASIC: SHELL flag (set to 02h if there is a current SHELL)
05:10    word   BASIC: segment address storage (set with DEF SEG)
05:12 4 bytes   BASIC: int 1Ch clock interrupt vector segment:offset storage
05:16 4 bytes   BASIC: int 23h ctrl-break interrupt segment:offset storage
05:1A 4 bytes   BASIC: int 24h disk error int vector segment:offset storage
05:1B-1F        Used by BASIC for dynamic storage
05:20-21        Used by DOS for dynamic storage
05:22-2C        Used by DOS for diskette parameter table. See int 1Eh for values
                In DOS 1.0 this is located in the ROM BIOS, but in DOS 1.1 and
                subsequently it is a part of DOS located at 05:22. The first byte
                (out of eleven) of the Disk Parameter contains the hexadecimal
                value CF in DOS 1.0 and DF in DOS 1.1 and later. DOS 1.0   24ms;
                DOS 1.1   26ms
05:30-33        Used by MODE command
05:34-FF        Unknown - Reserved for DOS Model and BIOS ID
```

At absolute addresses:

```
0008:0047       IO.SYS or IBMBIO.COM IRET instruction. This is the dummy routine
                that interrupts 01h, 03h, and 0Fh are initialized to during POST.
C000:001E       EGA BIOS signature (the letters IBM)
F000:FA6E       table of characters 00h-7Fh used by int 10h video BIOS.
                The first 128 characters are stored here and each occupies 8
                bytes. The high bit ones are somewhere on the video adapter card.
F000:FFF5       BIOS release date
F000:FFFE       PC model identification
```

ROM BIOS

copyright date	model byte	sub-model byte	revision	machine
09/02/86	FA	00	00	PS/2 Model 30
01/10/86	FB	00	01	XT
01/10/86	FB	00	00	XT-2 (early) (640k motherboard
05/09/86	FB	01		XT-2 (revised) (640k motherboard)
01/10/84	FC	--	--	AT
06/10/85	FC	00	01	AT Model 239 6mHz (6.6 max governor)
11/15/85	FC	01	00	AT Model 319, 339 8mHz (8.6 max governor)
04/21/86	FC	02	00	XT/286
02/13/87	FC	04	00	PS/2 Model 50
02/13/87	FC	05	00	PS/2 Model 60
	FC	00		7531/2 Industrial AT

	FC	06		7552 'Gearbox'	
06/01/83	FD			PCjr	
11/08/82	FE			XT, Portable PC, XT/370, 3270PC	
04/24/81	FF			PC-0	(16k motherboard)
10/19/81	FF			PC-1	(64k motherboard)+
08/16/82	FF			PC, XT, XT/370	(256k motherboard)
10/27/82	FF			PC, XT, XT/370	(256k motherboard)
1987	F8			PS/2 Model 80	
1987	F8	01	00	PS/2 Model 80 20mHz	
09/13/85	F9	00	00	Convertible	
	2D			Compaq PC	(4.77mHz original)
	9A			Compaq Plus	(XT compatible)

The IBM PC System Interrupts (Overview)

The interrupt table is stored in the very lowest location in memory, starting at 0000:0000h. The locations are offset from segment 0, i.e. location 0000h has the address for int 0, etc. The table is 1024 bytes in length and contains 256 four byte vectors from 00h to 0FFh. Each address' location in memory can be found by multiplying the interrupt number by 4. For example, int 7 could be found by (7x4=28) or 1Bh (0000:001Bh).

These interrupt vectors normally point to ROM tables or are taken over by DOS when an application is run. Some applications revector these interrupts to their own code to change the way the system responds to the user. DOS provides int 21h function 25h to change interrupts from a high level; altering the interrupt vector table directly is not recommended, nor would it really get you anywhere.

Interrupt Address

Number	(Hex)	Type	Function
0	00-03	CPU	Divide by Zero
1	04-07	CPU	Single Step
2	08-0B	CPU	Nonmaskable
3	0C-0F	CPU	Breakpoint
4	10-13	CPU	Overflow
5	14-17	BIOS	Print Screen
6	18-1B	hdw	Reserved
7	1C-1F	hdw	Reserved
8	20-23	hdw	Time of Day
9	24-27	hdw	Keyboard
A	28-2B	hdw	Reserved
B	2C-2F	hdw	Communications (8259)
C	30-33	hdw	Communications
D	34-37	hdw	Disk
E	38-3B	hdw	Diskette
F	3C-3F	hdw	Printer
10	40-43	BIOS	Video
11	44-47	BIOS	Equipment Check
12	48-4E	BIOS	Memory
13	4C-4F	BIOS	Diskette/Disk
14	50-53	BIOS	Serial Communications
15	54-57	BIOS	Cassette, System Services
16	58-5B	BIOS	Keyboard
17	5C-5F	BIOS	Parallel Printer
18	60-63	BIOS	ROM BASIC Loader
19	64-67	BIOS	Bootstrap Loader
1A	68-6B	BIOS	Time of Day
1B	6C-6F	BIOS	Keyboard Break
1C	70-73	BIOS	Timer Tick
1D	74-77	BIOS	Video Initialization
1E	78-7B	BIOS	Diskette Parameters
1F	7C-7F	BIOS	Video Graphics Characters, second set
20	80-83	DOS	General Program Termination

```
   21    84-87      DOS     DOS Services Function Request
   22    88-8B      DOS     Called Program Termination Address
   23    8C-8F      DOS     Control Break Termination Address
   24    90-93      DOS     Critical Error Handler
   25    94-97      DOS     Absolute Disk Read
   26    98-9B      DOS     Absolute Disk Write
   27    9C-9F      DOS     Terminate and Stay Resident
 28-3F   A0-FF      DOS     Reserved for DOS
                           *29h   Fast Screen Write
                           *2Ah   Microsoft Networks - Session Layer Interrupt
                            2Fh   Multiplex Interrupt
                           *30h   Far jump instruction for CP/M-style calls
                            33h   Used by Microsoft Mouse Driver
 40-43   100-115    BIOS    Reserved for BIOS
                            40h   Hard Disk BIOS
                            41h   Hard Disk Parameters  (except PC1)
                            42h   Pointer to screen BIOS entry  (EGA, VGA, PS/2)
                            43h   Pointer to EGA initialization parameter table
   44    116-119    BIOS    First 128 Graphics Characters
 45-47   120-131    BIOS    Reserved for BIOS
                            45h   Reserved by IBM  (not initialized)
                            46h   Pointer to hard disk 2 params (AT, PS/2)
                            47h   Reserved by IBM  (not initialized)
   48    132-135    BIOS    PCjr Cordless Keyboard Translation
   49    136-139    BIOS    PCjr Non-Keyboard Scancode Translation Table
                            4Ah   Real-Time Clock Alarm (Convertible, PS/2)
 50-5F   140-17F    BIOS    Reserved for BIOS
                            5Ah   Cluster Adapter BIOS entry address
                           *5Bh   IBM  (cluster adapter?)
                            5Ch   NETBIOS interface entry port
 60-67   180-19F    User Program Interrupts (available for general use)
                            60h   10-Net Network
                            67h   Used by LIM & AQA EMS, EEMS
 68-7F   1A0-1FF    Reserved by IBM
                            6Ch   System Resume Vector (Convertible)
                            6Fh   some Novell and 10-Net API functions
                            70h   IRQ 8, Real Time Clock Interrupt (AT, PS/2)
                            71h   IRQ 9, LAN Adapter 1
                            72h   IRQ 10  (AT, XT/286, PS/2)  Reserved
                            73h   IRQ 11  (AT, XT/286, PS/2)  Reserved
                            74h   IRQ 12  Mouse Interrupt (PS/2)
                            75h   IRQ 13, Coprocessor Error
                            76h   IRQ 14, Hard Disk Controller (AT, PS/2)
                            77h   IRQ 15 (AT, XT/286, PS/2)  Reserved
                            7Ch   IBM REXX88PC command language
 80-85   200-217    ROM BASIC
 86-F0   218-3C3    Used by BASIC Interpreter When BASIC is running
 F1-FF   3C4-3FF    Reserved by IBM
                            0F1h-0FFh  Interprocess Communications Area
                           *0F8h  Set Shell Interrupt (OEM)
                           *0F9h  OEM SHELL service codes
                            0FAh  USART ready (RS-232C)
                            0FBh  USART RS ready (keyboard)
                           *0FEh  used on '283 & '386
                           *0FFh  used on '283 & '386
* = "undocumented"
```

The IBM-PC System Interrupts (in detail)

Interrupt 00h Divide by Zero
(0:0000h)
(processor error). Automatically called at end of DIV or IDIV operation that results in error. Normally set by DOS to display an error message and abort the program.

Interrupt 01h Single step
(0:0004h)

Taken after every instruction when CPU Trap Flag indicates single-step mode (bit 8 of FLAGS is 1). This is what makes the 'T' command of DEBUG work for single stepping. Is not generated after MOV to segment register or POP of segment register. (unless you have a very early 8088 with the microcode bug).

Interrupt 02h Non-maskable interrupt
(0:0008h)
Vector not disabled via CLI. Generated by NMI signal in hardware. This signal has various uses:

```
POST parity error:                 all except PCjr and Convertible
80x87 coprocessor interrupt:       all except PCjr and Convertible
Keyboard interrupt:                PCjr, Convertible
I/O channel check:                 Convertible, PS/2 50+
Disk controller power-on request: Convertible
System suspend:                    Convertible
Realtime clock:                    Convertible
System watchdog timer:             PS/2 50+
Timeout interrupt:                 PS/2 50+
DMA timer time-out interrupt:      PS/2 50+
Infrared keyboard link:            PCjr
```

Interrupt 03h Breakpoint
(0:000Ch)
Taken when CPU executes the 1-byte int 3 (0CCh). Similar to 8080's

(internal)
RST instruction. Generally used to set breakpoints for DEBUG. Also used by Turbo Pascal versions 1,2,3 when {$U+} specified

Interrupt 04h Divide overflow
(0:0010h)
Generated by INTO instruction if OF flag is set. If flag isnot set,(internal) INTO is effectively a NOP. Used to trap any arithmetic errors when program is ready to handle them rather than immediately when they occur.

Interrupt 05h Print Screen
(0:0014h)
Service dumps the screen to the printer. Invoked by int 9 for shifted key 55 (PrtSc). Automatically called by keyboard scan when PrtSc key is pressed. Normally executes a routine to print the screen, but may call any routine that can safely be executed from inside the keyboard scanner. Status and result byte are at address 0050:0000.

(internal) BOUND Check Failed (80286+)
Generated by BOUND instruction when the value to be tested is less than the indicated lower bound or greater than the indicated upper bound.

```
entry   AH      05h
return  absolute address 50:0
        00h     print screen has not been called, or upon return from a call
                there were no errors
        01h     print screen is already in progress
        0FFh    error encountered during printing
note 1. Uses BIOS services to read the screen.
     2. Output is directed to LPT1.
     3. Revectored into GRAPHICS.COM if GRAPHICS.COM is loaded.
```

Interrupt 06h Reserved by IBM
(0:0018h)
(internal) Undefined Opcode (80286+)

Interrupt 07h Reserved by IBM
(0:00C0h)
(internal) No Math Unit Available (80286+)

Interrupt 08h Timer
(0:0020h)
55ms timer 'tick' taken 18.2 times per second. Updates BIOS clock and turns off diskette drive motors after 2 seconds of inactivity.
(IRQ0)
(internal) Double Fault (80286+ protected mode)
Called when multiple exceptions occur on one instruction, or an exception occurs in an exception handler. If an exception occurs in the double fault handler, the CPU goes into SHUTDOWN mode (which circuitry in the PC/AT converts to a reset).

```
entry   AH      08h
return  absolute addresses:
        40:6C   number of interrupts since power on (4 bytes)
        40:70   number of days since power on       (1 byte)
        40:67   day counter on all products after AT
        40:40   motor control count - gets decremented and shuts off diskette
                motor if zero
note    Int 1Ch is invoked by int 08h as a user interrupt.
```

(internal) Double Fault (80286+ protected mode)
Called when multiple exceptions occur on one instruction, or an exception occurs in an exception handler. If an exception occurs in the double fault handler, the CPU goes into SHUT DOWN mode (which circuitry in the PC/AT converts to a reset).

Interrupt 09h Keyboard
(0:0024h)
Taken whenever a key is pressed or released. This is normally a scan code, but may also be an ACK or NAK of a command on AT-type keyboards.
(IRQ1)

```
note       Stores characters/scan-codes in status at absolute addr. [0040:0017,18]

(internal) Math Unit Protection Fault (80286+ protected mode)
entry   AH      09h
return  at absolute memory addresses:
        40:17   bit
                0       right shift key depressed
                1       left shift key depressed
                2       control key depressed
                3       alt key depressed
                4       ScrollLock state has been toggled
                5       NumLock state has been toggled
                6       CapsLock state has been toggled
                7       insert state is active
        40:18   bit
                0       left control key depressed
                1       left alt key depressed
                2       SysReq key depressed
                3       Pause key has been toggled
                4       ScrollLock key is depressed
                5       NumLock key is depressed
                6       CapsLock key is depressed
                7       Insert key is depressed
        40:96   bit
                0       last code was the E1h hidden code
                1       last code was the E0h hidden code
                2       right control key down
                3       right alt key down
                4       101 key Enhanced keyboard installed
                5       force NumLock if rd ID & kbx
```

```
                6       last character was first ID character
                7       doing a read ID (must be bit 0)
        40:97   bit
                0       ScrollLock indicator
                1       NumLock indicator
                2       CapsLock indicator
                3       circus system indicator
                4       ACK received
                5       resend received flag
                6       mode indicator update
                7       keyboard transmit error flag
        40:1E   keyboard buffer (20h bytes)
        40:1C   buffer tail pointer
        40:72   1234h if ctrl-alt-del pressed on keyboard
     AL         scan code
note 1. Int 05h invoked if PrtSc key pressed.
     2. Int 1Bh invoked if Ctrl-Break key sequence pressed.
     3. Int 15h, AH=85h invoked on AT and after if SysReq key is pressed.
     4. Int 15h, AH=4Fh invoked on machines after AT.
     5. Int 16h, BIOS keyboard functions, uses this interrupt.
```

Interrupt 0Ah EGA Vertical Retrace
(0:0028h) used by EGA vertical retrace
(IRQ2)
Note: The TOPS and PCnet adapters use this IRQ line by default.

(internal) Invalid Task State Segment (80286+ protected mode)

Interrupt 0Bh Communications Controller (serial port) hdw. entry
(0:002Ch) Serial Port 2 (COM2)
(IRQ3)
Note 1. *IRQ 3 may be used by SDLC (synchronous data-link control) or bisynchronous* communications cards instead of a serial port.
2. The TOPS and PCnet adapters use this interrupt request line as an alternate.
3. On PS/2s, COM2 through COM8 share this interrupt.
4. On many PCs, COM4 shares this interrupt.
5. On the Commodore Amiga 2000 with the PC Bridge Board, this interrupt is used for communication between the Amiga system board and the Bridge Board. This was probably the lowest IRQ level they felt safe using, but limits the A2000's use of network cards, etc.

(internal) Not Present (80286+ protected mode)
Generated when loading a segment register if the segment descriptor indicates that the segment is not currently in memory. May be used to implement virtual memory.

Interrupt 0Ch Communications Controller (serial port) hdw. entry
(0:0030h) Serial Port 1 (COM1) or internal modem in PCjr or Convertible
(IRQ4)
Note 1. IRQ 4 may be used by SDLC (synchronous data-link control) or bisynchronous communications cards instead of a serial port.
2. On some PCs, this interrupt is shared by COM3.
3. Tandy computers use IRQ4 instead of IRQ5 for the hard disk interrupt.
4. Best performance of mice sometimes happens when they are configured for IRQ4 instead of IRQ3, since some mouse drivers may lock system interrupts for long periods.

(internal) Stack Fault (80286+ protected mode)
Generated on stack overflow/underflow. Note that the 80286 will shut down in real mode if SP=1 before a push.

Interrupt 0Dh Alternate Printer, AT 80287
(0:0034h) used by hard disk on IBM and most compatibles, 60 Hz RAM
(IRQ5)
refresh, LPT2 on AT, XT/286, and PS/2, dummy CRT vertical retrace on PCjr
Note: Various Tandy 1000 models may use this line for the 60Hhz RAM refresh or as 'optional bus interrupt'.

(internal) General Protection Violation (80286+)
Called in real mode when an instruction attempts to access a word operand located at offset 0FFFFh or a PUSH MEM or POP MEM instruction contains an invalid bit code in the second byte.

Interrupt 0Eh Diskette Interrupt
(0:0038h)
Generated by floppy controller on completion of an operation
(IRQ6) (sets bit 8 of 40:3E)

(internal) Page Fault (80386+ native mode)

Interrupt 0Fh Reserved by IBM
(0:003Ch) IRQ7 used by PPI interrupt (LPT1, LPT2)
(IRQ7)
Note: Generated by the LPT1 printer adapter when printer becomes ready. Many printer adapters do not reliably generate this interrupt.

3

THE PC ROM BIOS

Calling the ROM BIOS

The BIOS services are invoked by placing the number of the desired function in register AH, subfunction in AL, setting the other registers to any specific requirements of the function, and invoking any of ints 10h through int 20h.

When the interrupt is called, all register and flag values are pushed into the stack. The interrupt address contains a pointer into an absolute address in the ROM BIOS chip address space. This location may be further vectored into the IBMBIO.COM (or equivalent) file or user file.

The address vector points to a particular BIOS command handler. The handler pops the register values, compares them to its list of functions, and executes the function if valid. When the function is complete, it may pass values back to the command handler. The handler will push the values into the stack and then return control to the calling program.

Most functions will return an error code; some return more information. Details are contained in the listings for the individual functions.

Register settings listed are the ones used by the BIOS. Some functions will return with garbage values in unused registers. Do not test for values in unspecified registers; your program may exhibit odd behaviour.

Interrupt 10h Video Service
(0:0040h) The BIOS Video Services may be found in Chapter 16.

(internal) Coprocessor Error (80286+)
Generated by the CPU when the -ERROR pin is asserted by the coprocessor (usually 80x87, but may be any multimaster CPU or alternate NDP such as Weitek, etc.). ATs and clones usually wire the coprocessor to use IRQ13, but not all get it right.

Interrupt 11h Equipment Check
(0:0044h) Reads the BIOS Data Area and returns two bytes of setup info. entry. No parameters are required

```
return  AX      Equipment listing word. Bits are:
                0    number of floppy drives
                     0      no drives
                     1      bootable (IPL) diskette drive installed
```

```
                1    math chip
                     0        no math coprocessor (80x87) present
                     1        math coprocessor (80x87) present
         (PS/2) 2    0        mouse not installed
                     1        mouse installed
          (PC)  2,3  system board RAM
                     0,0      16k    (PC-0, PC-1)
                     0,1      32k
                     1,0      48k
                     1,1      64k    (PC-2, XT)
                     note 1. not commonly used. Set both bits to 1
                          2. both bits always 1 in AT
                4,5  initial video mode
                     0,0 no video installed (use with dumb terminal)
                     0,1      40x25 colour  (CGA)
                     1,0      80x25 colour  (CGA, EGA, PGA, MCGA, VGA)
                     1,1      80x25 monochrome (MDA or Hercules, most superhires
                                    mono systems)
                6,7  number of diskette drives (only if bit 0 is 1)
                     0,0      1 drives
                     0,1      2 drives
                     1,0      3 drives
                     1,1      4 drives
                8    0        DMA present
                     1        no DMA (PCjr, some Tandy 1000s, 1400LT)
                9,A,Bnumber of RS232 serial ports (0-3)
                     0,0,0    none
                     0,0,1    1
                     0,1,0    2
                     0,1,1    3
                     1,0,0    4
                C    0        no game I/O attached
                     1        game I/O attached (default for PCjr)
                D    serial accessory installation
                     0        no serial accessories installed
                     1        Convertible - internal modem installed or PCjr -
                              serial printer attached
                E,F  number of parallel printers
                     0,0      none
                     0,1      one    (LPT1, PRN)
                     1,0      two    (LPT2)
                     1,1      three (LPT3)
                     note     Models before PS/2 would allow a fourth parallel
                              printer. Remapping of the BIOS in the PS/2s does
                              not allow the use of LPT4.
```

Interrupt 12h Memory Size

(0:0048h) get system memory

```
entry   no parameters required
return  AX        number of contiguous 1K RAM blocks available for DOS
```

Note 1. This is the same value stored in absolute address 04:13h..
2. For some early PC models, the amount of memory returned by this call is determined by the settings of the dip switches on the motherboard and may not reflect all the memory that is physically present.
3. For the PC/AT, the value returned is the amount of functional memory found during the power-on self-test, regardless of the memory size configuration information stored in CMOS RAM.
4. The value returned does not reflect any extended memory (above the 1 Mb boundary) that may be present on 80286 or 80386 machines.

Interrupt 13h Disk Functions

(0:0049h) The service calls for BIOS disk functions are located in Chapter 8.

Interrupt 14h Initialize and Access Serial Port For Int 14

(0:0050h) the following status is defined:

```
serial status byte:
bits    0 delta clear to send
        1 delta data set ready
        2 trailing edge ring detector
        3 delta receive line signal detect
        4 clear to send
        5 data set ready
        6 ring indicator
        7 receive line signal detect

line status byte:
bits    0 data ready
        1 overrun error
        2 parity error
        3 framing error
        4 break detect
        5 transmit holding register empty
        6 transmit shift register empty
        7 time out  note: if bit 7 set then other bits are invalid
```

All routines have AH=function number and DX=RS232 card number (0 based). AL=character to send or received character on exit, unless otherwise noted.

```
entry   AH      00h     Initialize And Access Serial Communications Port
                        bit pattern: BBBPPSLL
                        BBB = baud rate:   110, 150, 300, 600, 1200,
                                           2400, 4800, 9600
                        PP  = parity:      01 = odd, 11 = even
                        S   = stop bits:   0 = 1, 1 = 2
                        LL  = word length: 10 = 7-bits, 11 = 8-bits
        AL      parms for initialization:
                bit pattern:
                0       word length
                1       word length
                2       stop bits
                3       parity
                4       parity
                5       baud rate
                6       baud rate
                7       baud rate
                word length     10      7 bits
                                11      8 bits
                stop bits       0       1 stop bit
                                1       2 stop bits
                parity          00      none
                                01      odd
                                11      even
                baud rate       000     110 baud
                                001     150 baud
                                010     300 baud
                                011     600 baud
                                100     1200 baud
                                101     2400 baud
                                110     4800 baud
                                111     9600 baud  (4800 on PCjr)
        DX      port number (0=COM1, 1=COM2, etc.)
return  AH      line status
        AL      modem status
note    To initialize the serial port to 9600 baud on PS/2 machines, seefns 04h
        and 05h.

Function 01h    Send Character in AL to Comm Port
entry   AH      01h
        AL      character
        DX      port number (0 - 3)
return  AH      RS232 status code
                bit     0       data ready
                        1       overrun error
                        2       parity error
                        3       framing error
```

```
                        4       break detected
                        5       transmission buffer register empty
                        6       transmission shift register empty
                        7       timeout
        AL      modem status
                bit
                        0       delta clear-to-send
                        1       delta data-set-ready
                        2       trailing edge ring detected
                        3       change, receive line signal detected
                        4       clear-to-send
                        5       data-set-ready
                        6       ring received
                        7       receive line signal detected

Function 02h    Wait For A Character From Comm Port DX
entry   AH      02h
        DX      port number (0-3)
return  AL      character received
        AH      error code (see above)(00h for no error)

Function 03h    Fetch the Status of Comm Port DX (0 or 1)
entry   AH      03h
        DX      port (0-3)
return  AH      set bits (01h) indicate comm-line status
                bit     7       timeout
                bit     6       empty transmit shift register
                bit     5       empty transmit holding register
                bit     4       break detected ('long-space')
                bit     3       framing error
                bit     2       parity error
                bit     1       overrun error
                bit     0       data ready
        AL      set bits indicate modem status
                bit     7       received line signal detect
                bit     6       ring indicator
                bit     5       data set ready
                bit     4       clear to send
                bit     3       delta receive line signal detect
                bit     2       trailing edge ring detector
                bit     1       delta data set ready
                bit     0       delta clear to send

Function 04h    Extended Initialize                     (Convertible, PS/2)
entry   AH      04h
        AL      break status
                01h     if break
                00h     if no break
        BH      parity
                00h     no parity
                01h     odd parity
                02h     even parity
                03h     stick parity odd
                04h     stick parity even
        BL      number of stop bits
                00h     one stop bit
                01h     2 stop bits (1 if 5 bit word length)
        CH      word length
                00h     5 bits
                01h     6 bits
                02h     7 bits
                03h     8 bits
        CL      baud rate
                00h     110
                01h     150
                02h     300
                03h     600
                04h     1200
                05h     2400
                06h     4800
                07h     9600
```

```
                08h     19200
        DX      comm port (0-3)
return  AH      line control status
        AL      modem status
note    Provides a superset of fn 00h capabilities for PS/2 machines.

Function 05h    Extended Communication Port Control          (Convertible, PS/2)
entry   AH      05h
        AL      00h     read modem control register
                01h     write modem control register
        BL      modem control register
           bits 0       DTR data terminal ready
                1       RTS request to send
                2       out1
                3       out2
                4       loop
                5,6,7   reserved
        DX      port number (0=COM1, 1=COM2, etc.)
return  AH      port status (see 00h above)
        AL      modem status (see 00h above)
        BL      modem control register (see 01h above)
```

FOSSIL Drivers

Interrupt 14h FOSSIL (Fido/Opus/Seadog Standard Interface Level) drivers
A FOSSIL is a device driver for handling the IBM PC serial communications ports in a standard fashion from an application (communications) program. A FOSSIL chains into the int 14h BIOS communications vector and replaces many functions with enhanced routines that may be easily accessed by an application.

For all functions, all registers not specifically containing a function return value must be preserved across the call.

```
entry   AH      00h     Set baud rate and parameters
        AL      byte
                bits 7,6,5 baudrate
                000     19200 baud
                001     38400 baud
                010     300 baud
                011     600 baud
                100     1200 baud
                101     2400 baud
                110     4800 baud
                111     9600 baud
                bits 4,3 parity
                00      none
                01      odd
                10      none
                11      even
                bit 2 stop bits
                0       1 stop bit
                1       2 stop bits
                bit 1 char length
                0       5 bits plus value
                other   optional
        DX      port number (NOP if DX=00FFh)
return  AX      status (see fn 03h)
note    Low-order 5 bits are undefined by FOSSIL 1.0 spec.

entry   AH      01h     Transmit character with wait
        AL      ASCII value of character to be sent
        DX      port number (NOP if DX=00FFh)
return  AX      status bits (see function 03h)
note    1 Character is queued for transmission. If there is room in the
        transmitter buffer when this call is made, the character will be stored
```

```
        and control returned to caller. If the buffer is full, the driver will
        wait for room. Use this function with caution when flow control is
        enabled.

entry   AH      02h     FOSSIL: Receive a character with wait
        DX      port number (0-3) (NOP if DX=00FFh)
return  AH      RS-232 status code (see AH=00h above)
        AL      ASCII value of character received from serial port
note    Will timeout if DSR is not asserted, even if function 03h returns data
        ready.

entry   AH      03h     FOSSIL: Request status
        DX      port number  (NOP if DX=00FFh)
return  AX      status bit mask
                AH      bit 0 set  RDA     input data is available in buffer
                            1 set  OVRN    input buffer overrun
                            2 N/A
                            3 N/A
                            4 N/A
                            5 set  THRE    room is available in output buffer
                            6 set  TSRE    output buffer is empty
                            7 N/A
                AL      bit 0 N/A
                            1 N/A
                            2 N/A
                            3 set          this bit is always set
                            4 N/A
                            5 N/A
                            6 N/A
                            7 set  DCD     carrier detect
note    Bit 3 of AL is always returned set to enable programs to use it as a
        carrier detect bit on hardwired (null modem) links.

entry   AH      04h     Initialize FOSSIL driver
        BX      4F50h                          (optional)
        DX      port number                    (DX=00FFh special)
        ES:CX   pointer to ^C flag address (optional)
return  AX      1954h if successful
        BL      maximum function number supported (excluding 7Eh-0BFh)
        BH      revision of FOSSIL supported
note 1. DTR is raised when FOSSIL inits.
     2. Existing baudrate is preserved.
     3. If BX contains 4F50h, the address specified in ES:CX is that of a ^C flag
        byte in the application program, to be incremented when ^C is detected
        in the keyboard service routines. This is an optional service and only
        need be supported on machines where the keyboard service can't (or
        won't) perform an int 1Bh or int 23h when a control-C is entered.

entry   AH      05h     Deinitialize FOSSIL driver
        DX      port number  (DX=00FFh special)
return  none
note 1. DTR is not affected.
     2. Disengages driver from comm port. Should be done when operations on the
        port are complete.
     3. If DX=00FFh, the initialization that was performed when FOSSIL function
        04h with DX=00FFh should be undone.

entry   AH      06h     FOSSIL: Raise/lower DTR
        AL      DTR state to be set
                00h     lower DTR
                01h     raise DTR
        DX      comm port (NOP if DX=00FFh)
return  none
entry   AH      07h     FOSSIL: Return timer tick parameters
return  AH      ticks per second on interrupt number shown in AL
        AL      timer tick interrupt number (not vector!)
        DX      milliseconds per tick (approximate)

entry   AH      08h     FOSSIL: Flush output buffer
        DX      port number (NOP if DX=00FFh)
return  none
```

```
note     Waits until all output is done.
entry    AH       09h      FOSSIL: Purge output buffer
         DX       port number (NOP if DX=00FFh)
return   none
note     Returns to caller immediately.

entry    AH       0Ah      FOSSIL: Purge input buffer
         DX       port number (NOP if DX=00FFh)
return   none
note 1.  If any flow control restraint has been employed (dropping RTS or
         transmitting XOFF) the port will be 'released' by doing the reverse,
         raising RTS or sending XON.
     2.  Returns to caller immediately.

entry    AH       0Bh      FOSSIL: Transmit no wait
         AL       ASCII character value to be sent
         DX       port number (NOP if DX=00FFh)
return   AX       0000h    character not accepted
                  0001h    character accepted
note     This is exactly the same as the 'regular' transmit call except that if
         there is no space available in the output buffer a value of zero is
         returned in AX, if room is available a value 1 (one) is returned.

entry    AH       0Ch      FOSSIL: Nondestructive Read no Wait
         DX       port number (NOP if DX=00FFh)
return   AH       character
                  0FFFFh   character not available
note 1.  Reads async buffer.
     2.  Does not remove keycode from buffer.

entry    AH       0Dh      FOSSIL: Keyboard read no wait
return   AX       IBM keyboard scan code or
                  0FFFFh if no keyboard character available
note 1.  Use IBM-style function key mapping in the high order byte.
     2.  Scan codes for non function keys are not specifically required but may be
         included.
     3.  Does not remove keycode from buffer.

entry    AH       0Eh      FOSSIL: Keyboard input with wait
return   AX       IBM keyboard scan code
note     Returns the next character from the keyboard or waits if no
          character is available.

entry    AH       0Fh      Enable or Disable flow control
         AL       bit mask describing requested flow control
              bits 0       XON/XOFF on transmit (watch for XOFF while sending)
                  1        CTS/RTS (CTS on transmit/RTS on receive)
                  2        reserved
                  3        XON/XOFF on receive (send XOFF when buffer near full)
                  4-7      not used, FOSSIL spec calls for setting to 1
         DX       port number (NOP if DX=00FFh)
return   none
note 1.  Bit 2 is reserved for DSR/DTR,  but is not currently supported in any
         implementation.
     2.  TRANSMIT flow control allows the other end to restrain the transmitter
         when you are overrunning it. RECEIVE flow control tells the FOSSIL to
         attempt to do just that if it is being overwhelmed.
     3.  Enabling transmit Xon/Xoff will cause the FOSSIL to stop transmitting
         upon receiving an Xoff. The FOSSIL will resume transmitting when an Xon
         is received.
     4.  Enabling CTS/RTS will cause the FOSSIL to cease transmitting when CTS is
         lowered. Transmission will resume when CTS is raised. The FOSSIL will
         drop RTS when the receive buffer reaches a predetermined percentage
         full. The FOSSIL will raise RTS when the receive buffer empties below
         the predetermined percentage full. The point(s) at which this occurs is
         left to the individual FOSSIL implementor.
     5.  Enabling receive Xon/Xoff will cause the FOSSIL to send a Xoff when the
         receive buffer reaches a pre-determined percentage full. An Xon will be
         sent when the receive buffer empties below the predetermined percentage
         full. The point(s) at which this occurs is left to the individual FOSSIL
         implementor.
```

```
      6. Applications using this function should set all bits ON in the high
         nibble of AL as well. There is a compatible (but not identical) FOSSIL
         driver implementation that uses the high nibble as a control mask. If
         your application sets the high nibble to all ones, it will always work,
         regardless of the method used by any given driver.

entry    AH      10h    Extended Ctrl-C/Ctrl-K checking and transmit on/off
         AL      flags bit mask byte (bit set if activated)
            bits 0        enable/disable Ctrl-C/Ctrl-K checking
                 1        disable/enable the transmitter
                 2-7      not used
         DX      port number (NOP if DX=00FFh)
return   AX      status byte
                 0000h    control-C/K has not been received
                 0001h    control-C/K has been received
note     This is used primarily for programs that can't trust XON/XOFF at FOSSIL
          le vel (such as BBS software).

entry    AH      11h      FOSSIL: Set current cursor location.
         DH      row (line) 0-24
         DL      column     0-79
return   none
note 1. This function looks exactly like the int 10h, fn 02h on the IBM PC. The
         cursor location is passed in DX: row in DH and column in DL. This
         function treats the screen as a coordinate system whose origin (0,0) is
         the upper left hand corner of the screen.
      2. Row and column start at 0.

entry    AH      12h      FOSSIL: Read current cursor location.
return   DH      row (line)
         DL      column
note 1. Looks exactly like int 10h/fn 03h in the IBM PC BIOS. The current cursor
         location (same coordinate system as function 16h) is passed back in DX.
      2. Row and column start at 0.

entry    AH      13h      FOSSIL: Single character ANSI write to screen.
         AL      value of character to display
return   none
note     This call might not be reentrant since ANSI processing may be through DOS.

entry    AH      14h      FOSSIL: Enable or disable watchdog processing
         AL      00h      to disable watchdog
                 01h      to enable watchdog
         DX      port number (NOP if DX=00FFh)
return   none
note 1. This call will cause the FOSSIL to reboot the system if Carrier Detect
         for the specified port drops while watchdog is turned on.
      2. The port need not be active for this function to work.

entry    AH      15h      Write character to screen using BIOS support routines
         AL      ASCII code of character to display
return   none
note 1. This function is reentrant.
      2. ANSI processing may not be assumed.

entry    AH      16h      Insert or Delete a function from the timer tick chain
         AL      00h      to delete a function
                 01h      to add a function
         ES:DX   address of function
return   AX      0000h    successful
                 0FFFFh   unsuccessful

entry    AH      17h      FOSSIL: Reboot system
         AL      boot type
                 00h      cold boot
                 01h      warm boot
return   none

entry    AH      18h      FOSSIL: Read block
         CX      maximum number of characters to transfer
         DX      port number (NOP if DX=00FFh)
```

```
        ES:DI   pointer to user buffer
return  AX      number of characters transferred
note 1. This function does not wait for more characters to become available if
        the value in CX exceeds the number of characters currently stored.
     2. ES:DI are left unchanged by the call; the count of bytes actually
        transferred will be returned in AX.

entry   AH      19h     FOSSIL: Write block
        CX      maximum number of characters to transfer
        DX      port number  (NOP if DX=00FFh)
        ES:DI   pointer to user buffer
return  AX      number of characters transfered
note    ES and DI are not modified by this call.

entry   AH      1Ah     FOSSIL: Break signal begin or end
        AL      00h     stop sending 'break'
                01h     start sending 'break'
        DX      port number  (NOP if DX=00FFh)
return  none
note 1. Resets all transmit flow control restraints such as an XOFF received from
        remote.
     2. Init (fn 04h) or UnInit (fn 05h) will stop an in-progress break.
     3. The application must determine the 'length' of the break.
entry   AH      1Bh     FOSSIL: Return information about the driver
        CX      size of user buffer in bytes
        DX      port number  (if DX=00FFh, port data will not be valid)
        ES:DI   pointer to user buffer
return  AX      number of characters transferred
        ES:DI   user buffer structure:
                00h     word    size of structure in bytes
                02h     byte    FOSSIL driver version
                03h     byte    revision level of this specific driver
                04h     dword   FAR pointer to ASCII ID string
                08h     word    size of the input buffer in bytes
                0Ah     word    number of bytes in input buffer
                0Ch     word    size of the output buffer in bytes
                0Eh     word    number of bytes in output buffer
                10h     byte    width of screen in characters
                11h     byte    screen height in characters
                12h     byte    actual baud rate, computer to modem (see mask in
                                function 00h)
note 1. The baud rate byte contains the bits that fn 00h would use to set the
        port to that speed.
     2. The fields related to a particular port (buffer size, space left in the
        buffer, baud rate) will be undefined if port=0FFh or an invalid port is
        contained in DX.
     3. Additional information will always be passed after these, so that the
        fields will never change with FOSSIL revision changes.

entry   AH      7Eh     FOSSIL: Install an external application function
        AL      code assigned to external application
        ES:DX   pointer to entry point
return  AX      1954h   FOSSIL driver present
            not 1954h   FOSSIL driver not present
        BH      00h     failed
                01h     successful
        BL      code assigned to application (same as input AL)
note 1. Application codes 80h-0BFh are supported. Codes 80h-83h are reserved.
     2. An error code of BH=00h with AX=1954h should mean that another external
        application has already been installed with the code specified in AL.
     3. Applications are entered via a FAR call and should make a FAR return.

entry   AH      7Fh     FOSSIL: Remove an external application function
        AL      code assigned to external application
        ES:DX   pointer to entry point
return  AX      1954h
        BH      00h     failed
                01h     successful
        BL      code assigned to application (same as input AL)
```

Interrupt 15h Cassette I/O

(0:0054h)Renamed 'System Services' on PS/2 line. Issuing int 15h on an XT may cause a system crash. On AT and after, interrupts are disabled with CLI when the interrupt service routine is called, but most ROM versions do not restore interrupts with STI.

```
Function 00h    Turn Cassette Motor On                             (PC, PCjr only)
entry   AH      00h
return  CF      set on error
                AH      error code
                        00h     no errors
                        01h     CRC error
                        02h     bad tape signals
                                no data transitions (PCjr)
                        03h     no data found on tape
                                not used (PCjr)
                        04h     no data
                                no leader (PCjr)
                        80h     invalid command
                        86h     no cassette present
                                not valid in PCjr
note    NOP for systems where cassette not supported.

Function 01h    Turn Cassette Motor Off                            (PC, PCjr only)
entry   AH      01h
return  CF      set on error
        AH      error code (86h)
note    NOP for systems where cassette not supported.

Function 02h    Read Blocks From Cassette                          (PC, PCjr only)
entry   AH      02h
        CX      count of bytes to read
        ES:BX   segment:offset + 1 of last byte read
return  CF      set on error
                AH      error code (01h, 02h, 04h, 80h, 86h)
        DX      count of bytes actually read
        ES:BX   pointer past last byte written
note 1. NOP for systems where cassette not supported.
     2. Cassette operations normally read 256 byte blocks.

Function 03h    Write Data Blocks to Cassette                      (PC, PCjr only)
entry   AH      03h
        CX      count of bytes to write
        ES:BX   pointer to data buffer

return  CF      set on error
                AH      error code (80h, 86h)
        CX      00h
        ES:BX   pointer to last byte written+1
note 1. NOP for systems where cassette not supported.
     2. The last block is padded to 256 bytes with zeroes if needed.
     3. No errors are returned by this service.

Function 0Fh    ESDI Format Unit Periodic Interrupt                     (PS/2 50+)
entry   AH      0Fh
        AL      phase code
                00h     reserved
                01h     surface analysis
                02h     formatting
return  CF      clear   if formatting should continue
                set     if it should terminate
note 1. Called the BIOS on the ESDI Fixed Disk Drive Adapter/A during a format or
        surface analysis operation after each cylinder is completed.
     2. This function call can be captured by a program so that it will be
        notified as each cylinder is formatted or analyzed. The program can count
        interrupts for each phase to determine the current cylinder number.
     3. The BIOS default handler for this function returns with CF set.
```

```
Function 10h TopView API Function Calls                              (TopView)
entry    AH        00h      PAUSE    Give Up CPU Time
                            return   00h      after other processes run
                   01h      GETMEM   allocate 'system' memory
                            BX       number of bytes to allocate
                            return   ES:DI   pointer to a block of memory
                   02h      PUTMEM   deallocate 'system' memory
                            ES:DI    pointer to previously allocated block
                            return   block freed
                   03h      PRINTC   display character/attribute on screen
                            BH       attribute
                            BL       character
                            DX       segment of object handle for window
                            note     BX=0 does not display anything, it positions the
                                     hardware cursor.
                   04h-09h unknown
                   10h      unknown
                            AL       04h thru 12h
                            return   TopView - unimplemented in DV 2.0x pops up
                                     'Programming error' window in DV 2.0x
                   11h      unknown
                   12h      unknown
                   13h      GETBIT   define a 2nd-level interrupt handler
                            ES:DI    pointer to FAR service routine
                            return   BX        bit mask indicating which bit was
                                               allocated 0 if no more bits availble
                   14h      FREEBIT undefine a 2nd-level interrupt handler
                            BX       bit mask from int 15/fn1013h
                   15h      SETBIT   schedule one or more 2nd-level interrupts
                            BX       bit mask for interrupts to post
                            return   indicated routines will be called at next ???
                   16h      ISOBJ    verify object handle
                            ES:DI    possible object handle
                            return   BX       -1 if ES:DI is a valid object handle
                                               0 if ES:DI is not
                   17h      TopView - unimplemented in DV 2.00
                            return   pops up 'Programming Error' window in DV 2.00
                   18h      LOCATE   Find Window at a Given Screen Location
                            BH       column
                            BL       row
                            ES       segment of object handle for ?
                                     (0 = use default)
                            return   ES        segment of object handle for window which
                                               is visible at the indicated position
                   19h      SOUND    Make Tone
                            BX       frequency in Hertz
                            CX       duration in clock ticks (18.2 ticks/sec)
                            return   immediately, tone continues to completion
                            note     If another tone is already playing, the new tone
                                     does not start until completion of the
                                     previous one. In DV 2.00, it is possible to
                                     enqueue about 32 tones before the process is
                                     blocked until a note completes. In DV 2.00, the
                                     lowest tone allowed is 20 Hz
                   1Ah      OSTACK   Switch to Task's Internal Stack
                            return   stack switched
                   1Bh      BEGINC   Begin Critical Region
                            return   task-switching temporarily disabled
                            note     Will not task-switch until End Critical
                                     Region (AH=101Ch) is called
                   1Ch      ENDC     End Critical Region
                            return   task-switching enabled
                   1Dh      STOP     STOP TASK
                            ES       segment of object handle for task to be stopped
                                     (= handle of main window for that task)
                            return   indicated task will no longer get CPU time
                            note     At least in DV 2.00, this function is ignored
                                     unless the indicated task is the current task.
                   1Eh      START    Start Task
                            ES       segment of object handle for task to be started
                                     (= handle of main window for that task)
```

```
        return  Indicated task is started up again
1Fh     DISPEROR Pop-Up Error Window
        BX      bit fields:
                0-12    number of characters to display
                13,14   which mouse button may be pressed
                        to remove window
                        00      either
                        01      left
                        10      right
                        11      either
                15      beep if 1
        CH      width of error window (0 = default)
        CL      height of error window (0 = default)
        DS:DI   pointer to text of message
        DX      segment of object handle
        return  BX      status:
                        1       left button pressed
                        2       right button pressed
                        27      ESC key pressed
        note    Window remains on-screen until ESC or indicated
                mouse button is pressed
20h     TopView - unimplemented in DV 2.0x
        return  pops up 'Programming Error' window in DV 2.0x
21h     PGMINT  Interrupt Another Task (TopView)
        BX      segment of object handle for task to interrupt
        DX:CX   address of FAR routine to jump to next time task
                is run
        return  nothing?
        note    The current ES, DS, SI, DI, and BP are passed to
                the FAR routine
22h     GETVER  Get Version
        BX      00h
        return  BX      nonzero, TopView or compatible loaded
                BH      minor version
                BL      major version
        notes   TaskView v1.1C returns BX = 0001h
                DESQview  v2.0 returns BX = 0A01h
23h     POSWIN  Position Window
        BX      segment of object handle for parent window within
                which to position the window (0 = full screen)
        CH      # columns to offset from position in DL
        CL      # rows to offset from position in DL
        DL      bit flags
                0,1     horizontal position
                        00      current
                        01      center
                        10      left
                        11      right
                2,3     vertical position
                        00      current
                        01      center
                        10      top
                        11      bottom
                4       don't redraw screen if set
                5-7     not used
        ES      segment of object handle for window to be
                positioned
        return  nothing
24h     GETBUF  Get Virtual Screen Information
        BX      segment of object handle for window (0=default)
        return  CX      size of virtual screen in bytes
                DL      0 or 1, unknown
                ES:DI   address of virtual screen
25h     USTACK  Switch Back to User's Stack
        return  stack switched back
        note    Call only after int 15h, fn101Ah
26h-2Ah DesQview (TopView?) - unimplemented in DV 2.0x
        return  pops up 'Programming Error' window in DV 2.0x
2Bh     POSTTASK  Awaken Task
        DesQview 2.0 (Top View?)
        BX      segment of object handle for task
```

```
                 return  nothing
        2Ch      Start New Application in New Process
                 DesQview 2.0 (TopView?)
                 ES:DI   pointer to contents of .PIF/.DVP file
                 BX      size of .PIF/.DVP info
                 return  BX      segment of object handle for new task
                                 00h     if error
        2Dh      Keyboard Mouse Control                       DesQview 2.0+
                 BL      subfunction
                         00h     determine whether using keyboard mouse
                         01h     turn keyboard mouse on
                         02h     turn keyboard mouse off
                 return  (calling BL was 00h)
                         BL      0       using real mouse
                                 1       using keyboard mouse

Function 11h    Topview commands
entry   AH      11h
        AL      various
note    In DesQview 2.0x, these function calls are identical to AH=0DEh, so those
        below.

Function 20h    PRINT.COM  (DOS internal)              (AT, XT-286, PS/2 50+)
entry   AH      20h
        AL      subfunction
                00h     unknown (PRINT)
                01h     unknown (PRINT)
                10h     sets up SysReq routine on AT, XT/286, PS/2
                11h     completion of SysReq routine (software only)
note    AL=0 or 1 sets or resets some flags which affect what PRINT does when it
        tries to access the disk.

Function 21h    Read Power-On Self Test (POST) Error Log            (PS/2 50+)
entry   AH      21h
        AL      00h     read POST log
                01h     write POST log
                        BH      device ID
                        BL      device error code
return  CF      set on error
        AH      status
                00h     successful read
                        BX      number of POST error codes stored
                        ES:DI   pointer to error log
                01h     list full
                80h     invalid command
                86h     function unsupported
note  The log is a series of words, the first byte of which identifies the error
      code and the second is the device ID.

Function 40h    Read/Modify Profiles                             (Convertible)
entry   AH      40h
        AL      00h     read system profile in CX,BX
                01h     write system profile from CX, BX
                02h     read internal modem profile in BX
                03h     write internal modem profile from BX
        BX      profile info
return  BX      internal modem profile (from 02h)
        CX,BX   system profile (from 00h)

Function 41h Wait On External Event                             (Convertible)
entry   AH      41h
        AL      condition type
           bits 0-2     condition to wait for
                        0,0,0   any external event
                        0,0,1   compare and return if equal
                        0,1,0   compare and return if not equal
                        0,1,1   test and return if not zero
                        1,0,0   test and return if zero
                3       reserved
                4       0       user byte
                        1       port address
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                5-7     reserved
        BH      condition compare or mask value
                condition codes:
                00h     any external event
                01h     compare and return if equal
                02h     compare and return if not equal
                03h     test and return if not zero
                04h     test and return if zero
        BL      timeout value times 55 milliseconds
                00h     if no time limit
        DX      I/O port address (if AL bit 4=1)
        ES:DI   pointer to user byte (if AL bit 4=0)

Function 42h Request System Power Off                         (Convertible)
entry   AH      42h
        AL      00h     to use system profile
                01h     to force suspend regardless of profile
return  unknown

Function 43h Read System Status                               (Convertible)
entry   AH      43h
return  AL      status byte
            bit 0       LCD detached
                1       reserved
                2       RS232/parallel powered on
                3       internal modem powered on
                4       power activated by alarm
                5       standby power lost
                6       external power in use
                7       battery low

Function 44h (De)activate Internal Modem Power                (Convertible)
entry   AH      44h
        AL      00h      to power off
                01h      to power on
return  unknown

Function 4Fh OS Hook - Keyboard Intercept         (except PC, PCjr, and XT)
entry   AH      4Fh
        AL      scan code, CF set
return  AL      scan code
        CF      set     processing desired
                clear   scan code should not be used
note 1. Called by int 9 handler for each keystroke to translate scan codes.
     2. An OS or a TSR can capture this function to filter the raw keyboard data
        stream. The new handler can substitute a new scan code, return the same
        scan code, or return the carry flag clear causing the keystroke to be
        discarded. The BIOS default routine simply returns the scan code
        unchanged.
     3. A program can call Int 15h fn 0C0h to determine whether the host
        machine's BIOS supports keyboard intercept.

Function 70h    EEROM handler                               (Tandy 1000HX)
entry   AH      00h     read from EEROM
                BL      00h
                01h     write to EEROM
                BL      word number to write (0-15)
                DX      word value to write
return  DX      (AH=00h) word value
        CF      set on error (system is not a Tandy 1000 HX)

Function 80h OS Hook - Device Open                        (AT, XT/286, PS/2)
entry   AH      80h
        BX      device ID
        CX      process ID
return  CF      set on error
        AH      status
note 1. Acquires ownership of a logical device for a process.
     2. This call, along with fns 81h and 82h, defines a simple protocol that can
        be used to arbitrate usage of devices by multiple processes. A
        multitasking program manager would be expected to capture int 15h and
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        provide the appropriate service.
     3. The default BIOS routine for this function simply returns with CF clear
        and AH=00h.

Function 81h    OS Hook - Device Close                         (AT, XT/286, PS/2)
entry   AH      81h
        BX      device ID
        CX      process ID
return  CF      set on error
        AH      status
note 1. Releases ownership of a logical device for a process.
     2. A multitasking program manager would be expected to capture int 15h and
        provide the appropriate service.
     3. The BIOS default routine for this function simply returns with the CF
        clear and AH=00h.

Function 82h    Program Termination                            (AT, XT/286, PS/2)
        AH      82h
        BX      device ID
return  CF      set on error
        AH      status
note 1. Closes all logical devices opened with function 80h.
     2. A multitasking program manager would be expected to capture int
        15h and provide the appropriate service.
     3. The BIOS default routine for this function simply returns with CF
        clear and AH=00h.

Function 83h    Event Wait                    (AT, XT/286, Convertible, PS/2 50+)
entry   AH      83h
        AL      00h     to set interval
                01h     to cancel
        CX:DX   number of microseconds to wait (granularity is 976 micro seconds)
        ES:BX   pointer to semaphore flag (bit 7 is set when interval expires)
                (pointer is to caller's memory)
return  CF      set (1) if function already busy
note 1. Requests setting of a semaphore after a specified interval or cancels a
        previous request.
     2. The calling program is responsible for clearing the semaphore before
        requesting this function.
     3. The actual duration of an event wait is always an integral multiple of
        976 microseconds. The CMOS date/clock chip interrupts are used to
        implement this function.
     4. Use of this function allows programmed, hardware-independent delays at a
        finer resolution than can be obtained through use of the MS-DOS Get Time
        function (int 21h/fn 2Ch) which returns time in hundredths of a second.

Function 84h    Read Joystick Input Settings                   (AT, XT/286, PS/2)
entry   AH      84h
        DX      00h     to read the current switch settings (return in AL)
                01h     to read the resistive inputs
return  CF      set on error
        (fn 00h)
        AL      switch settings (bits 7-4)
        (fn 01h)
        AX      stick A (X) value
        BX      stick A (Y) value
        CX      stick B (X) value
        DX      stick B (Y) value
note 1. An error is returned if DX does not contain a valid subfunction number.
     2. If no game adapter is installed, all returned values are 00h.
     3. Using a 250K Ohm joystick, the potentiometer values usually lie within
        the range 0-416 (0000h-01A0h).

Function 85h System Request (SysReq) Key Pressed          (except PC, PCjr, XT)
entry   AH      85h
        AL      00h       key pressed
                01h       key released
return  CF      set on error
        AH      error code
note 1. Called by BIOS keyboard decode routine when the SysReq key is detected.
     2. The BIOS handler for this call is a dummy routine that always returns a
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        success status unless called with an invalid subfunction number in AL.
     3. A multitasking program manager would be expected to capture int 15h so
        that it can be notified when the user strikes the SysReq key.

Function 86h    Delay                                    (except PC, PCjr, XT)
        AH      86h
        CX,DX   number of microseconds to wait
return  CF      clear   after wait elapses
        CF      set     immediately due to error
note 1. Suspends the calling program for a specified interval in microseconds.
     2. The actual duration of the wait is always an integral multiple of 976
        microseconds.
     3. Use of this function allows programmed, hardware-independent delays at a
        finer resolution than can be obtained through use of the MS-DOS Get Time
        function (int 21h fn 2Ch) which returns time in hundredths of a second).

Function 87h    Memory Block Move                       (2-3-486 machines only)
        AH      87h
        CX      number of words to move
        ES:SI   pointer to Global Descriptor Table (GDT)
                offset 00h-0Fh  reserved, set to zero
                           00h  null descriptor
                           08h  uninitialized, will be made into GDT descriptor
                       10h-11h  source segment length in bytes (2*CX-1 or greater)
                       12h-14h  24-bit linear source address
                       15h      access rights byte (always 93h)
                       16h-17h  reserved, set to zero
                       18h-19h  destination segment length in bytes (2*CX-1 or
                                greater)
                       1Ah-1Ch  24-bit linear destination address
                       1Dh      access rights byte (always 93h)
                       1Eh-2Fh  reserved, set to zero
                           20h  uninitialized, used by BIOS
                           28h  uninitialized, will be made into SS descriptor
return  CF      set on error
        AH      status
                00h     source copied into destination
                01h     parity error
                02h     exception interrupt error
                03h     address line 20 gating failed
note 1. The GDT table is composed of six 8-byte descriptors to be used by the CPU
        in protected mode. The four descriptors in offsets 00h-0Fh and 20h-2Fh
        are filled in by the BIOS before the CPU mode switch.
     2. The addresses used in the descriptor table are linear (physical) 24-bit
        addresses in the range 000000h-0FFFFFFh - not segments and offsets -
        with the least significant byte at the lowest address and the most
        significant byte at the highest address.
     3. Interrupts are disabled during this call; use may interfere with the
        operation of comm programs, network drivers, or other software that
        relies on prompt servicing of hardware interrupts.
     4. This call is not valid in the OS/2 Compatibility Box.
     5. This call will move a memory block from any real or protected mode
        address to any other real or protected mode address.

Function 88h    Get Extended Memory Size                    (AT, XT/286, PS/2)
entry   AH      88h
return  AX      number of contiguous 1K blocks of extended memory starting at
                address 1024k
note    This call will not work in the OS/2 Compatibility Box.

Function 89h   Switch Processor to Protected Mode (AT, XT/286, PS/2)
entry   AH     89h
        BH     interrupt number for IRQ0, written to ICW2 of 8259 PIC #1
               (must be evenly divisible by 8, determines IRQ0-IRQ7)
        BL     interrupt number for IRQ8, written to ICW2 of 8259 PIC #2
               (must be evenly divisible by 8, determines IRQ8-IRQ15)
        ES:SI  pointer to 8-entry Global Descriptor Table for protected mode:
               offset  00h     null descriptor, initialized to zero
                       08h     GDT descriptor
                       10h     IDT (Interrupt Descriptor Table) descriptor
                       18h     DS, user's data segment
```

```
                        20h     ES, user's extra segment
                        28h     SS, user's stack segment
                        30h     CS, user's code segment
                        38h     uninitialized, used to build descriptor for BIOS
                                code segment
return  CF      set on error
                AH      0FFh  error enabling address line 20
        CF      clear   function successful (CPU is in protected mode)
                AH      00h
                CS      user-defined selector
                DS      user-defined selector
                ES      user-defined selector
                SS      user-defined selector
note    The user must initialize the first seven descriptors; the eighth is
        filled in by the BIOS to provide addressability for its own execution.
        The calling program may modify and use the eighth descriptor for any
        purpose after return from this function call.

Function 90h    Device Busy Loop                        (except PC, PCjr, XT)
entry   AH      90h
        AL      predefined device type code:
                00h     disk                                    (may timeout)
                01h     diskette                                (may timeout)
                02h     keyboard                                 (no timeout)
                03h     PS/2 pointing device                    (may timeout)
                80h     network
                                                                 (no timeout)
                0FCh    hard disk reset (PS/2)                  (may timeout)
                0FDh    diskette motor start                    (may timeout)
                0FEh    printer                                 (may timeout)
        ES:BX   pointer to request block for type codes 80h through 0FFh
                (for network adapters ES:BX is a pointer to network control block)
return  CF      1 (set) if wait time satisfied
                0 (clear) if driver must perform wait
note 1. Used by NETBIOS.
     2. Generic type codes are allocated as follows:
        00h-7Fh   non-reentrant devices; OS must arbitrate access serially
                  reusable devices
        80h-0BFh  reentrant devices; ES:BX points to a unique control block
        0C0h-0FFh wait-only calls, no complementary POST int 15/fn 91h call
     3. Invoked by the BIOS disk, printer, network, and keyboard handlers prior
        to performing a programmed wait for I/O completion.
     4. A multitasking program manager would be expected to capture int 15h/fn
        90h so that it can dispatch other tasks while I/O is in progress.
     5. The default BIOS routine for this function simply returns with the CF
        clear and AH=00h.

Function 91h    Device POST                             (AT, XT/286, PS/2 50+)
entry   AH      91h
        AL      type code (see AH=90h above)
                00h-7Fh  serially reusable devices
                80h-0BFh reentrant devices
        ES:BX   pointer to request block for type codes 80h through 0BFh
return  AH       00h
note 1. Used by NETBIOS.
     2. Invoked by the BIOS disk network, and keyboard handlers to signal that
        I/O is complete and/or the device is ready.
     3. Predefined device types that may use Device POST are:
        00H  disk                  (may timeout)
        01H  floppy disk           (may timeout)
        02H  keyboard              (no timeout)
        03H  PS/2 pointing device  (may timeout)
        80H  network               (no timeout)
     4. The BIOS printer routine does not invoke this function because printer
        output is not interrupt driven.
     5. A multitasking program manager would be expected to capture int 15h/fn
        91h so that it can be notified when I/O is completed and awaken the
        requesting task.
     6. The default BIOS routine for this function simply returns with the CF
        flag clear and AH=00h.
```

```
Function 0C0h Get System Configuration
                          (XT after 1/10/86, PC Convertible, XT/286, AT, PS/2)

entry   AH      0C0h
return  CF      set     if BIOS doesn't support call
        ES:BX   pointer to ROM system descriptor table
          bytes 00h-01h number of bytes in the following table (norm. 16 bytes)
                02h     system ID byte; see Chapter 2 for interpretation
                03h     secondary ID distinguishes between AT and XT/286, etc.
                04h     BIOS revision level, 0 for 1st release, 1 for 2nd, etc.
                05h     feature information byte
                   bits 7       DMA channel 3 used by hard disk BIOS
                        6       second 8259 installed (cascaded IRQ2)
                        5       realtime clock installed
                        4       kbd intrcpt:int 15h, fn 04h called upon int 09h
                        3       wait for external event supported (int 15fn41)
                                used on Convertible; reserved on PS/2 systems
                        2       extended BIOS area allocated at 640k
                        1       bus is Micro Channel instead of PC
                        0       reserved
                06h     unknown (set to 0) (reserved by IBM)
                07h     unknown (set to 0) (reserved by IBM)
                08h     unknown (set to 0)
                09h     unknown (set to 0) (Award copyright here)
note 1. Int 15h is also used for the Multitask Hook on PS/2 machines. No register
        settings available yet.
     2. The 1/10/86 XT BIOS returns an incorrect value for the feature byte.

Function 0C1h  Return Extended BIOS Data Area Segment Address (PS/2)
entry   AH      0C1h
return  CF      set on error
        ES      segment of XBIOS data area
note 1. The XBIOS Data Area is allocated at the high end of conventional memory
        during the POST (Power-On-Self-Test) sequence.
     2. The word at 0040:0013h (memory size) is updated to reflect the reduced
        amount of memory available for DOS and application programs.
     3. The 1st byte in the XBIOS Data Area is initialized to its length in K.
     4. A program can determine whether the XBIOS Data Area exists by using int
        15h/fn 0C0h.

Function 0C2h   Pointing Device BIOS Interface (DesQview 2.x) (PS/2)
entry   AH      0C2h
        AL      00h     enable/disable pointing device
                        BH      00h     disable
                                01h     enable
                01h     reset pointing device
                        Resets the system's mouse or other pointing device, sets
                        the sample rate, resolution, and other characteristics
                        to their default values.
                        return  BH      device ID
                        note 1. After a reset operation, the state of the
                                pointing device is as follows:
                                disabled;
                                sample rate at 100 reports per second;
                                resolution at 4 counts per millimeter;
                                scaling at 1 to 1.
                             2. The data package size is unchanged by this fn.
                             3. Apps can use the fn 0C2h subfunctions to
                                initialize the pointing device to other parms,
                                then enable the device with fn 00h.
                02h     set sampling rate
                        BH      00h     10/second
                                01h     20/second
                                02h     40/second
                                03h     60/second
                                04h     80/second
                                05h     100/second (default)
                                06h     200/second
                03h     set pointing device resolution
                        BH      00h     one count per mm
                                01h     two counts per mm
                                02h     four counts per mm  (default)
```

```
                03h     eight counts per mm
        04h     get pointing device type
                return  BH      ID code for the mouse or other
                                pointing device.
        05h     initialize pointing device interface
                Sets the data package size for the system's mouse or
                other pointing device, and initializes the resolution,
                sampling rate, and scaling to their default values.
                BH      data package size (1 - 8 bytes)
                note    After this operation, the state of the
                        pointing device is as follows:
                        disabled;
                        sample rate at 100 reports per second;
                        resolution at 4 counts per millimeter;
                        and scaling at 1 to 1.
        06h     get status or set scaling factor
                Returns the current status of the system's mouse or other
                pointing device or sets the device's scaling factor.
                BH      00h     return device status
                        return  BL      status byte
                          bits  0       set if right button pressed
                                1       reserved
                                2       set if left button pressed
                                3       reserved
                                4       0       1:1 scaling
                                        1       2:1 scaling
                                5       0       device disabled
                                        1       device enabled
                                6       0       stream mode
                                        1       remote mode
                                7       reserved
                                CL      resolution
                                        00h     1 count per millimeter
                                        01h     2 counts per millimeter
                                        02h     4 counts per millimeter
                                        03h     8 counts per millimeter
                                DL      sample rate
                                        0Ah     10 reports per second
                                        14h     20 reports per second
                                        28h     40 reports per second
                                        3Ch     60 reports per second
                                        50h     80 reports per second
                                        64h     100 reports per second
                                        0C8h    200 reports per second
                        01h     set scaling at 1:1
                        02h     set scaling at 2:1
        07h     set pointing device handler address
                Notifies BIOS pointing device driver of the address for a
                routine to be called each time pointing device data is
                available.
                ES:BX   address user device handler
                return  AL      00h
return  CF      set on error
        AH      status
                00h     successful
                01h     invalid function
                02h     invalid input
                03h     interface error
                04h     need to resend
                05h     no device handler installed
note 1. The values in BH for those functions that take it as input are stored in
        different locations for each subfunction.
     2. The user's handler for pointing device data is entered via a far call
        with four parameters on the stack:
        SS:SP+0Ah   status
        SS:SP+08h   x coordinate
        SS:SP+06h   y coordinate
        SS:SP+04h   z coordinate (always 0)
        The handler must exit via a far return without removing the parameters
        from the stack.
     3. The status parameter word passed to the user's handler is interpreted as
```

```
        follows:
        bits    0       left button pressed
                1       right button pressed
                2-3     reserved
                4       sign of x data is negative
                5       sign of y data is negative
                6       x data has overflowed
                7       y data has overflowed
                8-0Fh   reserved

Function 0C3h Enable/Disable Watchdog Timeout  (PS/2 50+)
entry   AH      0C3h
        AL      00h     disable
                01h     enable
                        BX      timer counter
return  CF      set on error
note    The watchdog timer generates an NMI.

Function 0C4h  Programmable Option Select                          (PS/2 50+)
entry   AH      04Ch
        AL      00h     return base POS register address
                01h     enable slot
                        BL      slot number
                02h     enable adapter
return  CF      set on error
        DX      base POS register address (if function 00h)
note 1. Returns the base Programmable Option Select register address, enables a
        slot for setup, or enables an adapter.
     2. Valid on machines with Micro Channel Architecture (MCA) bus only.
     3. After a slot is enabled with fn 01h, specific information can be obtained
        for the adapter in that slot by performing port input operations:
        Port    Function
        100h    MCA ID (low byte)
        101h    MCA ID (high byte)
        102h    Option Select Byte 1
            bit 0       0       if disabled
                        1       if enabled
        103h    Option Select Byte 2
        104h    Option Select Byte 3
        105h    Option Select Byte 4
                bits 6-7 are channel check indicators
        106h    Subaddress Extension (low byte)
        107h    Subaddress Extension (high byte)

Function 0DEh DesQview Services                                    (DesQview)
entry   AH      0DEh
        AL      00h     Get Program Name
                        return  AX      offset into DESQVIEW.DVO of current
                                        program's record:
                                        byte    length of name
                                      n bytes   name
                                      2 bytes   keys to invoke program (second =
                                                00h if only one key used)
                                        word    ? (normally 0)
                                        byte    end flag: 00h for all but last
                                                entry, which is 0FFh
                01h     Update 'Open Window' Menu
                        return  none
                        note    Reads DESQVIEW.DVO, disables Open menu if file
                                not in current directory
                02h     unimplemented in DV 2.0x
                        return  nothing (NOP in DV 2.0x)
                03h     unimplemented in DV 2.0x
                        return  nothing (NOP in DV 2.0x)
                04h     Get Available Common Memory
                        return  BX      bytes of common memory available
                                CX      largest block available
                                DX      total common memory in bytes
                05h     Get Available Conventional Memory
                        return  BX      K of memory available
                                CX      largest block available
```

```
                DX      total conventional memory in K
06h     Get Available Expanded Memory
        return  BX      K of expanded memory available
                CX      largest block available
                DX      total expanded memory in K
07h     APPNUM  Get Current Program's Number
        return  AX      number of program as it appears
                        on the 'Switch Windows' menu
08h     GET (unknown)
        return  AX      00h     unknown
                        01h     unknown
09h     unimplemented in DV 2.00
        return  nothing (NOP in DV 2.00)
0Ah     DBGPOKE Display Character on Status Line          (DV 2.0+)
        BL      character
        return  character displayed, next call will display
                in next position (which wraps back to the start
                of the line if off the right edge of screen)
        note 1. Displays character on bottom line of *physical*
                screen, regardless of current size of window
                (even entirely hidden)
             2. Does not know about graphics display modes, just
                pokes the characters into display memory
0Bh     APILEVEL Define Minimum API Level Required        (DV 2.0+)
        BL      API level. A value higher than 02h pops up 'You
                need a newer version' error window in DV 2.00.
        BH      unknown
        return  AX      maximum API level?
0Ch     GETMEM  Allocate 'System' Memory                  (DV 2.0+)
        BX      number of bytes
        return  ES:DI   pointer to allocated block
0Dh     PUTMEM  Deallocate 'System' Memory                (DV 2.0+)
        ES:DI   pointer to previously allocated block
        return  nothing
0Eh     Find Mailbox by Name                              (DV 2.0+)
        ES:DI   pointer to name to find
        CX      length of name
        return  BX      00h     not found
                        01h     found
                DS:SI   object handle
0Fh     Enable DesQview Extensions                        (DV 2.0+)
        return  AX and BX destroyed (seems to be bug, weren't
                saved & restored)
        note 1. Sends a manager stream with opcodes 0AEh, 0BDh,
                and 0BFh to task's window
             2. Enables an additional mouse mode
10h     PUSHKEY  Put Key Into Keyboard Input Stream       (DV 2.0+)
        BH      scan code
        BL      character
        return  BX      unknown (sometimes, but not always, same
                        as BX passed in)
        note    A later read will get the keystroke as if it had
                 been typed by the user
11h     Enable/Disable Auto Justification of Window       (DV 2.0+)
        BL      00h     viewport will not move automatically
                nonzero viewport will move to keep cursor visible
        return  none
12h     unknown                                           (DV 2.0+)
        BX      00h     clear something?
                nonzero set something?
        return  none
```

Interrupt 16h Keyboard I/O

(0:0058h) Access the keyboard. Scancodes are found in Appendix 1. ASCII codes are found in Appendix 2.

```
Function  00h   Get Keyboard Input - read the next character in keyboard buffer,
                 if no key ready, wait for one.
entry     AH    00h
return    AH    scan code
```

```
        AL      ASCII character
note    Removes keystroke from buffer (destructive read)

Function 01h    Check Keystroke Buffer - Do Not Clear
entry   AH      01h
return  ZF      0 (clear) if character in buffer
                1 (set)   if no character in buffer
        AH      scan code of character (if ZF=0)
        AL      ASCII character if applicable
note    Keystroke is not removed from buffer. The same character and scan code
        will be returned by the next call to Int 16h/fn 00h.

Function 02h    Shift Status - fetch bit flags indicating shift status
entry   AH      02h
return  AL      status byte (same as [0040:0017])
           bits 7   Insert on
                6   CapsLock on
                5   NumLock on
                4   ScrollLock on
                3   Alt key down
                2   Control key down
                1   Left shift (left caps-shift key) down
                0   Right shift (right caps-shift key) down
note    The keyboard flags byte is stored in the BIOS Data Area at 0000:0417h.

Function 03h    Keyboard - Set Repeat Rate             (PCjr, AT, XT/286, PS/2)
entry   AH      03h
        AL      00h      reset typematic defaults                    (PCjr)
                01h      increase initial delay                      (PCjr)
                02h      decrease repeat rate by 1                   (PCjr)
                03h      increase both delays by 1/2                 (PCjr)
                04h      turn off typematic                          (PCjr)
                05h      set typematic rate                          (AT, PS/2)
        BH      00h-03h for delays of 250ms, 500ms, 750ms, or 1 second
                         0,0     250ms
                         0,1     500ms
                         1,0     750ms
                         1,1     1 second
        BL      00h-1Fh for typematic rates of 30cps down to 2cps
                         00000 30      01011 10.9    10101 4.5
                         00001 26.7    01100 10      10110 4.3
                         00010 24      01101 9.2     10111 4
                         00011 21.8    01110 8.6     11000 3.7
                         00100 20      01111 8       11001 3.3
                         00101 18.5    10000 7.5     11010 3
                         00110 17.1    10001 6.7     11011 2.7
                         00111 16      10010 6       11100 2.5
                         01000 15      10011 5.5     11101 2.3
                         01001 13.3    10011 5.5     11110 2.1
                         01010 12      10100 5       11111 2
return  nothing
note    Subfunction 05h is available on ATs with ROM BIOS dated 11/15/85 and
        later, the XT/286, and the PS/2.

Function 04h    Keyboard Click Toggle                  (PCjr and Convertible)
entry   AH      04h
        AL      00h      for click off
                01h      for click on
return  nothing

Function 05h    Keyboard Buffer Write            (AT or PS/2 with enhanced kbd)
                (XT/286, PS/2, AT with 'Enhanced' keyboard)
entry   AH      05h
        CH      scan code
        CL      ASCII character
return  CF      set on error
        AL      01h      if buffer full
note    Places a character and scan code in the keyboard type-ahead buffer.
```

```
Function 10h    Get Enhanced Keystroke And Read       (F11, F12 Enhanced Keyboard)
               (XT/286, PS/2, AT with 'Enhanced' keyboard)
entry   AH      10h
return  AH      scan code
        AL      ASCII character if applicable
note 1. Reads a character and scan code from the keyboard type-ahead buffer.
     2. Use this function for the enhanced keyboard instead of Int 16h fn 00h. It
        allows applications to obtain the scan codes for the additional F11, F12,
        and cursor control keys.

Function 11h    Check Enhanced Keystroke            (F11-F12 on enhanced keyboard)
                (XT/286, PS/2, AT with 'Enhanced' keyboard)
entry   AH      11h
return  ZF      0       (clear) if key pressed
                        AH      scan code
                        AL      ASCII character if applicable
                1       if buffer is empty
note 1. Keystroke is not removed from buffer. The same char and scan code will be
        returned by the next call to Int 16h/fn 10h.
     2. Use this function for the enhanced keyboard instead of Int 16h/fn 00h. It
        allows applications to test for the additional F11, F12, and cursor
        control keys.

Function 12h  Extended Shift Status                   (F11, F12 Enhanced keyboard)
entry   AH      12h
return  AX      status word
                AL bit  0       right Shift key depressed
                        1       left Shift key depressed
                        2       Control key depressed
                        3       Alt key depressed
                        4       ScrollLock state active
                        5       NumLock state active
                        6       CapsLock state active
                        7       insert state is active
                AH bit  0       left Control key pressed
                        1       left Alt key depressed
                        2       right Control key pressed
                        3       right Alt key depressed
                        4       Scroll Lock key depressed
                        5       NumLock key depressed
                        6       CapsLock key depressed
                        7       SysReq key depressed
note    Use this function for the enhanced keyboard instead of int 16h/fn 02h.

Function  79h   pcAnywhere
entry   AH      79h     pcAnywhere function
        AL      00h     installation check
return  AX      0FFFFh  installed, otherwise not present

Function  79h   pcAnywhere
entry   AH      7Bh     Enable/Disable Operation
        AL      state
                00h     disabled
                01h     enabled
return  unknown

Function 0EDh   Borland Turbo Lightning API  (partial)
entry   AH      0EDh
        BH      0EDh
        BL      function
                00h     installation check
                02h     pointer to Lightning internal data structure lobyte
                03h     pointer to Lightning internal data structure hibyte
                04h     load auxiliary dictionary
                06h     autoproof mode
                0Fh     get number of substitutions (segment)
        DS:DI   pointer to string to be processed
return  AX      error code (unknown)

Function 0F0h   Set CPU speed    (Compaq 386)
entry   AH      0F0h    set speed
```

```
        AL      speed
                00h     equivalent to 6 mHz 80286 (COMMON)
                01h     equivalent to 8 mHz 80286 (FAST)
                02h     full 16 mHz (HIGH)
                03h     toggles between 8 mHz-equivalent and speed set by system
                        board switch (AUTO or HIGH)
                04h-07h unknown
                08h     full 16 mHz except 8 mHz-equivalent during floppy disk
                        access
                09h     specify speed directly
                        CX      speed value, 1 (slowest) to 50 (full), 3 ~=8088
return  none?
note    Used by Compaq DOS MODE command.

Function 0F1h   Read Current CPU Speed                          (Compaq 386)
entry   AH      0F1h
return  AL      speed code (see function 0F0h above)
                if AL=09h, CX=speed code

Function 0F2h   Determine Attached Keyboard Type                (Compaq 386)
entry   AH      0F2h
return  AL      type
                00h     if 11-bit AT keyboard is in use
                01h     if 9-bit PC keyboard is in use
```

Interrupt 17h Printer

(0:005Ch) access the parallel printer(s). AH is changed. All other registers left alone.

```
Function  00h   Print Character/send AL to printer DX (0, 1, or 2)
entry   AH      00h
        AL      ASCII character code
        DX      printer to be used
                00h     PRN or LPT1
                01h     LPT2
                02h     LPT3
return  AH      status byte
           bits 0       time out
                1       unused
                2       unused
                3       I/O error
                4       printer selected
                5       out of paper
                6       acknowledge
                7       not busy

Function 01h    Initialize Printer - set init line low, send 0Ch to printer DX
entry   AH      01h
        DX      printer port to be initialized (0,1,2)
return  status as below

Function  02h   Printer Status - read status of printer DX into AH
entry   AH      02h
        DX      printer port to be used (0,1,2)
return  AH      status byte
           bits 7       0       printer is busy
                        1       ready
                6   ACKnowledge line state
                5   out-of-paper line state
                4   printer selected line state
                3   I/O error
                2   unused
                1   unused
                0   time-out error
```

Interrupt 18h ROM BASIC

(0:0060h) Execute ROM BASIC at address 0F600h:0000h

```
entry   no parameters used
return  jumps into ROM BASIC on IBM systems
note 1. Often reboots a compatible.
```

```
     2. Used by Turbo C 1.5. 2.0 and later do not use it.
     3. On IBM systems, this interrupt is called if disk boot failure occurs.
```

Interrupt 19h Bootstrap Loader / Extended Memory VDISK ID
(0:0064h)

```
entry   no parameters used
return  nothing
note 1. Reads track 0, sector 1 into address 0000h:7C00h, then transfers control
        to that address. If no diskette drive available, transfers to ROM-BASIC
        via int 18h or displays loader error message.
     2. Causes reboot of disk system if invoked while running. (no memory test
        performed).
     3. If location 0000:0472h does not contain the value 1234h, a memory test
        will be performed before reading the boot sector.
     4. VDISK from DOS 3.x+ traps this vector to determine when the CPU has
        shifted from protected mode to real mode. A detailed discussion can be
        found by Ray Duncan in PC Magazine, May 30, 1989.
     5. Reportedly, some versions of DOS 2.x and all versions of DOS 3.x+
        intercept int 19h in order to restore some interrupt vectors DOS takes
        over, in order to put the machine back to a cleaner state for the
        reboot, since the POST will not be run on the int 19h. These vectors are
        reported to be: 02h, 08h, 09h, 0Ah, 0Bh, 0Ch, 0Dh, 0Eh, 70h, 72h, 73h,
        74h, 75h, 76h, and 77h. After restoring these, it restores the original
        int 19h vector and calls int 19h.
```

Interrupt 1Ah Time of Day
(0:0068h) Access the PC internal clock

```
Function 00h Read System Timer Tick Counter                      (except PC)
entry   AH      00h
return  AL      00h     if clock was read or written (via AH=0,1) within the
                         current 24-hour period.
                nonzero midnight was passed since last read
        CX:DX   tick count (high 16 bits in CX)
note 1. The returned value is the cumulative number of clock ticks since
        midnight. There are 18.2 clock ticks per second. When the counter
        reaches 1,573,040, it is cleared to zero, and the rollover flag is set.
     2. The rollover flag is cleared by this function call, so the flag will only
        be returned nonzero once per day.
     3. Int 1Ah/fn 01h can be used to set the counter to an arbitrary 32 bit
        value.

Function 01h Set Clock Tick Counter Value                        (except PC)
entry   AH      01h
        CX:DX   high word/low word count of timer ticks
return  none
note 1. The clock ticks are incremented by timer interrupt at 18.2065 times per
        second or 54.9254 milliseconds/count. Therefore:
             counts per second   18      (12h)
             counts per minute   1092    (444h)
             counts per hour     65543   (10011h)
             counts per day      1573040 (1800B0h)
     2. The counter is zeroed when system is rebooted.
     3. Stores a 32-bit value in the clock tick counter.
     4. The rollover flag is cleared by this call.

Function 02h    Read Real Time Clock Time                    (AT and after)
entry   AH      02h
return  CH      hours in BCD
        CL      minutes in BCD
        DH      seconds in BCD
        DL      00h     standard time
                01h     daylight savings time
        CF      0       if clock running
                1       if clock not operating
note    Reads the current time from the CMOS time/date chip.
```

```
Function 03h    Set Real Time Clock Time                    (AT and after)
entry    AH     03h
         CH     hours in BCD
         CL     minutes in BCD
         DH     seconds in BCD
         DL     0 (clear) if standard time
                1 (set)   if daylight savings time option
return   none
note   Sets the time in the CMOS time/date chip.

Function 04h    Read Real Time Clock Date                   (AT and after)
entry    AH     04h
return   CH     century in BCD (19 or 20)
         CL     year in BCD
         DH     month in BCD
         DL     day in BCD
         CF     0 (clear) if clock is running
                1 (set)   if clock is not operating
note     Reads the current date from the CMOS time/date chip.

Function 05h    Set Real Time Clock Date                    (AT and after)
entry    AH     05h
         CH     century in BCD (19 or 20)
         CL     year in BCD
         DH     month in BCD
         DL     day in BCD
return   none
note     Sets the date in the CMOS time/date chip.

Function 06h    Set Real Time Clock Alarm                   (AT and after)
entry    AH     06h
         CH     hours in BCD
         CL     minutes in BCD
         DH     seconds in BCD
return   CF     set if alarm already set or clock inoperable
note 1.  Sets alarm in the CMOS date/time chip. Int 4Ah occurs at specified alarm
         time every 24hrs until reset with Int 1Ah/fn 07h.
     2.  A side effect of this function is that the clock chip's interrupt level
         (IRQ8) is enabled.
     3.  Only one alarm may be active at any given time.
     4.  The program using this function must place the address of its interrupt
         handler for the alarm in the vector for Int 4Ah.

Function 07h    Reset Real Time Clock Alarm   (AT and after)
entry    AH     07h
return   none
note 1.  Cancels any pending alarm request on the CMOS date/time chip.
     2.  This function does not disable the clock chip's interrupt level (IRQ8).

Function 08h Set Real Time Clock Activated Power On Mode        (Convertible)
entry    AH     08h
         CH     hours in BCD
         CL     minutes in BCD
         DH     seconds in BCD

Function 09h    Read Real Time Clock Alarm Time and Status
                                       (Convertible and PS/2 Model 30)
entry    AH     09h
return   CH     hours in BCD
         CL     minutes in BCD
         DH     seconds in BCD
         DL     alarm status:
                00h     if alarm not enabled
                01h     if alarm enabled but will not power up system
                02h     if alarm will power up system

Function 0Ah Read System-Timer Day Counter                           (PS/2)
entry    AH     0Ah
return   CF     set on error
         CX     count of days since Jan 1,1980
note     Returns the contents of the system's day counter.
```

```
Function 0Bh Set System-Timer Day Counter                          (PS/2)
entry    AH      0Bh
         CX      count of days since Jan 1,1980
return   CF      set on error
note     Stores an arbitrary value in the system's day counter.

Function 80h     Set Up Sound Multiplexor            (PCjr) (Tandy 1000?)
entry    AH      80h
         AL      sound source
                 00h     source is 8253 timer chip, channel 2
                 01h     source is cassette input
                 02h     source is I/O channel 'audio in' line
                 03h     source is TI sound generator chip
return   none
note     Sets up the source for tones that will appear on the PCjr's Audio Out bus
         line or RF modulator.

Function 1Ah Read Time and Date                                (AT&T 6300)
entry    AH      0FEh
return   BX      days count (1=Jan 1, 1984)
         CH      hours
         CL      minutes
         DH      seconds
         DL      hundredths
note     Day count in BX is unique to AT&T/Olivetti computers.
```

Interrupt 1Bh Control-Break
(0:006Ch) This interrupt is called when the keyboard scanner of the IBM machines detects Ctrl and Break pressed at the same time.

Note
1. If the break occurred while processing an interrupt, one or more end of interrupt commands must be send to the 8259 Programmable Interrupt Controller.
2. All I/O devices should be reset in case an operation was underway at the time.
3. It is normally pointed to an IRET during system initialization so that it does nothing, but some programs change it to return a ctrl-C scan code and thus invoke int 23h.

Interrupt 1Ch Timer Tick
(0:0070h)

Note
1. Taken 18.2065 times per second
2. Normally vectors to dummy IRET unless PRINT.COM has been installed.
3. If an application moves the interrupt pointer, it is the responsibility of that application to save and restore all registers that may be modified.

Interrupt 1Dh Vector of Video Initialization Parameters
(0:0074h) This doubleword address points to 3 sets of 16-bytes containing data to initialize for video modes for video modes 0 & 1 (40 column), 2 & 3 (80 column), and 4, 5 & 6 (graphics) on the Motorola 6845 CRT controller chip.

```
6845 registers:
         R0      horizontal total (horizontal sync in characters)
         R1      horizontal displayed (characters per line)
         R2      horizontal sync position (move display left or right)
         R3      sync width (vertical and horizontal pulse: 4-bits each)
         R4      vertical total (total character lines)
         R5      vertical adjust (adjust for 50 or 60 Hz refresh)
         R6      vertical displayed (lines of chars displayed)
         R7      vertical sync position (lines shifted up or down)
         R8      interlace (bits 4 and 5) and skew (bits 6 and 7)
         R9      max scan line addr (scan lines per character row)
         R10     cursor start (starting scan line of cursor)
         R11     cursor stop (ending scan line of cursor)
         R12     video memory start address high byte (6-bits)
         R13     video memory start address low byte (8-bits)
         R14     cursor address high byte (6-bits)
```

```
        R15      cursor address low byte (8-bits)

 6845 Video Init Tables:
        table for modes 0 and 1    \
        table for modes 2 and 3     \ each table is 16 bytes long and
        table for modes 4,5, and 6 / contains values for 6845 registers
        table for mode 7           /
        4 words:   size of video RAM for modes 0/1, 2/3, 4/5, and 6/7
        8 bytes:   number of columns in each mode
        8 bytes:   video controller mode byte for each mode
note 1. There are 4 separate tables, and all 4 must be initialized if all video
        modes will be used.
     2. The power-on initialization code of the computer points this vector to
        the ROM BIOS video routines.
     3. IBM recommends that if this table needs to be modified, it should be
        copied into RAM and only the necessary changes made.
```

Interrupt 1Eh Vector of Diskette Controller Parameters

(0:0078h) Dword address points to data base table that is used by BIOS. Default location is at 0F000:0EFC7h. 11-byte table format:

```
                bytes:
                00h      4-bit step rate, 4-bit head unload time
                01h      7-bit head load time, 1-bit DMA flag
                02h      54.9254 ms counts - delay till motor off (36-38 typ)
                03h      sector size:
                         00h     128 bytes
                         01h     256 bytes
                         02h     512 bytes
                         03h     1024 bytes
                04h      last sector on track (8 or 9 typical)
                05h      inter-sector gap on read/write (42 typical)
                06h      data length for DMA transfers (0FFh typical)
                07h      gap length between sectors for format (80 typical)
                08h      sector fill byte for format (0F6h typical)
                09h      head settle time (in milliseconds) (15 to 25 typical)
                         DOS 1.0    0
                         DOS 1.10   0
                         DOS 2.10   15
                         DOS 3.1    1
                10h      motor start time (in 1/8 second intervals) (2 to 4 typ.)
                         DOS 2.10   2
note 1. This vector is pointed to the ROM BIOS diskette tables on system
        initialization
     2. IBM recommends that if this table needs to be modified, it should be
        copied into RAM and only the necessary changes made.
```

Interrupt 1Fh Ptr to Graphics Character Extensions (Graphics Set 2)

(0:007Ch) This is the pointer to data used by the ROM video routines to display characters above ASCII 127 while in CGA medium and high res graphics modes.

Note
1. Doubleword address points to 1K table composed of 28 8-byte character definition bit-patterns. First byte of each entry is top row, last byte is bottom row.
2. The first 128 character patterns are located in system ROM.
3. This vector is set to 000:0 at system initialization.
4. Used by DOS' external GRAFTABL command.

4

DOS Interrupts and Function Calls

DOS Registers

DOS uses the following registers, pointers, and flags when it executes interrupts and function calls:

General Registers

register	definition	
AX	accumulator	(16 bit)
AH	accumulator high-order byte	(8 bit)
AL	accumulator low order byte	(8 bit)
BX	base	(16 bit)
BH	base high-order byte	(8 bit)
BL	base low-order byte	(8 bit)
CX	count (16 bit)	
CH	count high order byte	(8 bit)
CL	count low order byte	(8 bit)
DX	data	(16 bit)
DH	date high order byte	(8 bit)
DL	data low order byte	(8 bit)

Segment Registers

register	definition	
CS	code segment	(16 bit)
DS	data segment	(16 bit)
SS	stack segment	(16 bit)
ES	extra segment	(16 bit)

Index Registers

register	definition	
DI	destination index	(16 bit)
SI	source index	(16 bit)

Pointers

register	definition	
SP	stack pointer	(16 bit)
BP	base pointer	(16 bit)
IP	instruction pointer	(16 bit)

Flags
`AF, CF, DF, IF, OF, PF, SF, TF, ZF`

These registers, pointers, and flags are 'lowest common denominator' 8088-8086 CPU oriented. DOS makes no attempt to use any of the special or enhanced instructions available on the later CPUs which will execute 8088 code, such as the 80186, 80286, 80386, or NEV V20, V30, V40, or V50.

DOS Stacks

When DOS takes control after a function call, it switches to an internal stack. Registers which are not used to return information (other than 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 interrupts.

DOS actually maintains three stacks -

stack 1: 384 bytes (in DOS 3.1)
for functions 00h and for 0Dh and up, and for ints 25h and 26h.

stack 2: 384 bytes (in DOS 3.1)
for function calls 01h through 0Ch.

stack 3: 48 bytes (in DOS 3.1)
for functions 0Dh and above. This stack is the initial stack used by the int 21h handler before it decides which of the other two to use. It is also used by function 59h (get extended error), and 01h to 0Ch if they are called during an int 24h (critical error) handler. Functions 33h (get/set break flag), 50h (set process ID), 51h (get process ID) and 62h (get PSP address) donot use any DOS stack under DOS 3.x (under 2.x, 50h and 51h use stack number 2).

IBM and Microsoft made a change back in DOS 3.0 or 3.1 to reduce the size of DOS. They reduced the space allocated for scratch areas when interrupts are being processed. The default seems to vary with the DOS version and the machine, but 8 stack frames seems to be common. That means that if you get more than 8 interrupts at the same time, clock, disk, printer spooler, keyboard, com port, etc., the system will crash. It happens usually on a network. STACKS=16,256 means allow 16 interrupts to interrupt each other and allow 256 bytes for each for scratch area. Eight is marginal.

DOS 3.2 does some different stack switching than previous versions. The interrupts which are switched are 02h, 08h, 09h, 0Ah, 0Bh, 0Ch, 0Dh, 0Eh, 70h, 72h, 73h, 74h, 75h, 76h, and 77h. DOS 3.2 has a special check in the initialization code for a PCjr and don't enable stack switching on that machine. DOS 3.3 was changed so that no stack switching occurs on PC, PC-XT, or the PC-Portable, and defaults to 9 stacks of 128 bytes in an AT.

DOS Interrupts

Microsoft recommends that a program wishing to examine or set the contents of any interrupt vector use the DOS function calls 35h and 25h provided for those purposes and avoid referencing the interrupt vector locations directly.

DOS reserves interrupt numbers 20h to 3Fh for its own use. This means absolute memory locations 80h to 0FFh are reserved by DOS. The defined interrupts are as follows with all values in hexadecimal.

DOS Services (quick list)

Interrupt 21h Function Call Request
(0:0084h)
DOS provides a wide variety of function calls for character device I/O, file management, memory management, date and time functions, execution of other programs, and more. They are grouped as follows:

call	description
00h	program terminate
01h-0Ch	character device I/O, CP/M compatibility format
0Dh-24h	file management, CP/M compatibility format
25h-26h	nondevice functions, CP/M compatibility format
27h-29h	file management, CP/M compatibility format
2Ah-2Eh	nondevice functions, CP/M compatibility format
2Fh-38h	extended functions
39h-3Bh	directory group
3Ch-46h	extended file management
47h	directory group
48h-4Bh	extended memory management
54h-57h	extended functions
5Eh-5Fh	networking
60h-62h	extended functions
63h-66h	enhanced foreign language support

List of DOS services:
* = undocumented

00h	terminate program
01h	get keyboard input
02h	display character to STDIO
03h	get character from STDAUX
04h	output character to STDAUX
05h	output character to STDPRN
06h	direct console I/O - keyboard to screen
07h	get char from std I/O without echo
08h	get char from std I/O without echo, checks for ^C
09h	display a string to STDOUT
0Ah	buffered keyboard input
0Bh	check STDIN status
0Ch	clear keyboard buffer and invoke keyboard function
0Dh	flush all disk buffers
0Eh	select disk
0Fh	open file with File Control Block
10h	close file opened with File Control Block
11h	search for first matching file entry
12h	search for next matching file entry
13h	delete file specified by File Control Block
14h	sequential read from file specified by File Control Block
15h	sequential write to file specified by File Control Block
16h	find or create firectory entry for file
17h	rename file specified by file control block
18h*	unknown
19h	return current disk drive
1Ah	set disk transfer area (DTA)
1Bh	get current disk drive FAT
1Ch	get disk FAT for any drive
1Dh*	unknown
1Eh*	unknown
1Fh*	read DOS disk block, default drive
20h*	unknown

21h	random read from file specified by FCB
22h	random write to file specified by FCB
23h	return number of records in file specified by FCB
24h	set relative file record size field for file specified by FCB
25h	set interrupt vector
26h	create new Program Segment Prefix (PSP)
27h	random file block read from file specified by FCB
28h	random file block write to file specified by FCB
29h	parse the command line for file name
2Ah	get the system date
2Bh	set the system date
2Ch	get the system time
2Dh	set the system time
2Eh	set/clear disk write VERIFY
2Fh	get the Disk Transfer Address (DTA)
30h	get DOS version number
31h	TSR, files opened remain open
32h*	read DOS Disk Block
33h	get or set Ctrl-Break
34h*	INDOS Critical Section Flag
35h	get segment and offset address for an interrupt
36h	get free disk space
37h*	get/set option marking character (SWITCHAR)
38h	return country-dependent information
39h	create subdirectory
3Ah	remove subdirectory
3Bh	change current directory
3Ch	create and return file handle
3Dh	open file and return file handle
3Eh	close file referenced by file handle
3Fh	read from file referenced by file handle
40h	write to file referenced by file handle
41h	delete file
42h	move file pointer (move read-write pointer for file)
43h	set/return file attributes
44h	device IOCTL (I/O control) info
45h	duplicate file handle
46h	force a duplicate file handle
47h	get current directory
48h	allocate memory
49h	release allocated memory
4Ah	modify allocated memory
4Bh	load or execute a program
4Ch	terminate prog and return to DOS
4Dh	get return code of subprocess created by 4Bh
4Eh	find first matching file
4Fh	find next matching file
50h*	set new current Program Segment Prefix (PSP)
51h*	puts current PSP into BX
52h*	pointer to the DOS list of lists
53h*	translates BPB (Bios Parameter Block, see below)
54h	get disk verification status (VERIFY)
55h*	create PSP: similar to function 26h
56h	rename a file
57h	get/set file date and time
58h	get/set allocation strategy (DOS 3.x)
59h	get extended error information
5Ah	create a unique filename
5Bh	create a DOS file
5Ch	lock/unlock file contents
5Dh*	network
5Eh*	network printer
5Fh*	network redirection
60h*	parse pathname
61h*	unknown
62h	get program segment prefix (PSP)
63h*	get lead byte table (DOS 2.25)
64h*	unknown
65h	get extended country information (DOS 3.3)
66h	get/set global code page table (DOS 3.3)
67h	set handle count (DOS 3.3)

```
68h     commit file                         (DOS 3.3)
69h     disk serial number                  (DOS 4.0)
6Ah     unknown
6Bh     unknown
6Ch     extended open/create                (DOS 4.0)
```

Calling the DOS Services

The DOS services are invoked by placing the number of the desired function in register AH, subfunction in AL, setting the other registers to any specific requirements of the function, and invoking int 21h.

When the interrupt is called, all register and flag values are pushed into the stack. Int 21h contains a pointer into an absolute address in the IBMDOS.COM file. This address is the main loop for the DOS command handler. The handler pops the register values, compares them to its list of functions, and executes the function if valid. When the function is complete, it may pass values back to the command handler. The handler will push the values into the stack and then return control to the calling program.

Most functions will return an error code; some return more information. Details are contained in the listings for the individual functions. Extended error return codes for most functions may be obtained by calling function 59h.

Register settings listed are the ones used by DOS. Some functions will return with garbage values in unused registers. Do not test for values in unspecified registers; your program may exhibit odd behaviour.

DS:DX pointers are the data segment register (DS) indexed to the DH and DL registers (DX). DX always contains the offset address, DS contains the segment address.

The File Control Block services (FCB services) were part of DOS 1.0. Since the release of DOS 2.0, Microsoft has recommended that these services not be used. A set of considerably more enhanced services (handle services) were introduced with DOS 2.0. The handle services provide support for wildcards and subdirectories, and enhanced error detection via function 59h.

The data for the following calls was compiled from various Intel, Microsoft, IBM, and other publications. There are many subtle differences between MSDOS and PCDOS and between the individual versions. Differences between the versions are noted as they occur.

There are various ways of calling the DOS functions. For all methods, the function number is loaded into register AH, subfunctions and/or parameters are loaded into AL or other registers, and call int 21 by one of the following methods:

A. call interrupt 21h directly (the recommended procedure).
B. perform a long call to offset 50h in the program's PSP.
   1. This method will not work under DOS 1.x.
   2. Though recommended by Microsoft for DOS 2.0, this method takes more time and is no longer recommended.
C. place the function number in CL and perform an intrasegment call to location 05h in the current code segment. This location contains a long call to the DOS function dispatcher.
   1. IBM recommends this method be used only when using existing programs written for different calling conventions (such as converting CP/M programs). This method should be avoided unless you have some specific use for it.
   2. AX is always destroyed by this method.

3. This method is valid only for functions 00h-24h.

There are also various ways of exiting from a program. (assuming it is not intended to be a TSR). All methods except call 4Ch must ensure that the segment register contains the segment address of the PSP.

A. Interrupt 21h, function 4Ch (Terminate with Result Code). This is the 'official' recommended method of returning to DOS.
B. Interrupt 21h, function 00h (Exit Program). This is the early style int 21 function call. It simply calls int 20h.
C. Interrupt 20h (Exit).
D. A JMP instruction to offset 00h (int 20h vector) in the Program Segment Prefix. This is just a roundabout method to call int 20h. This method was set up in DOS 1.0 for ease of conversion for CP/M programs. It is no longer recommended for use.
E. A JMP instruction to offset 05h (int 21 vector) in the Program Segment Prefix, with AH set to 00h or 4Ch. This is another CP/M type function.

Version Specific Information

Function Calls:

DOS 2.x supports function calls 00h to 57h.

DOS 2.25 is the only version to support function 63h (foreign keyboard)

DOS 3.x has more sophisticated error handling and detection function calls available than 2.x.

DOS 3.0 supports function calls 00h to 5Ch and 62h, including new and changed function calls for version 3.0:

3Dh	Open File
59h	Get Extended Error
5Ah	Create Temporary File
5Bh	Create New File
5Ch	Lock/Unlock File Access
62h	Get Program Segment Prefix Address

DOS 3.1 supports function calls 00h to 62h, including the new and changed function calls for DOS 3.1:

5E00h	Get Machine Name
5E02h	Set Printer Setup
5E03h	Get Printer Setup
5F02h	Get Redirection List Entry
5F03h	Redirect Device
5F04h	Cancel Redirection

DOS 3.2 supports the following new functions:

44h	extended IOCTL functions

DOS 3.3 supports the following new functions:

44h	extended IOCTL functions	
65h	get extended country information	(DOS 3.3)
66h	get/set global code page table	(DOS 3.3)

	67h	set handle count	(DOS 3.3)
	68h	commit file	(DOS 3.3)
DOS 4.0	supports the following new functions:		
	44h	extended IOCTL functions	
	69h	disk serial number	
	6Ch	extended open/create	

DOS Services in Detail

Interrupt 20h Terminate Current Program

(0:0080h) Issue int 20h to exit from a program. This vector transfers to the logic in DOS to restore the terminate address, the Ctrl-Break address, and the critical error exit address to the values they had on entry to the program. All the file buffers are flushed and all handles are closed. You should close all files changed in length (see function calls 10h and 3Eh) before issuing this interrupt. If the changed file is not closed, its length, time, and date are not recorded correctly in the directory.

For a program to pass a completion code or an error code when terminating, it must use either function call 4Ch (Terminate a Process) or 31h (Terminate Process and Stay Resident). These two methods are preferred over using int 20h and the codes returned by them can be interrogated in batch processing.

Important: Before you issue an interrupt 20h, your program must ensure that the CS register contains the segment of its Program Segment Prefix.

Interrupt 20h DOS - Terminate Program

```
entry   no parameters
return  The following vectors are restored from the Program Segment Prefix:
        0Ah     Program Terminate
        0Eh     Control-C
        12h     Critical Error
note 1. IBM and Microsoft recommend using int 21 Fn 4Ch. Using int 20 is
        officially frowned upon since the introduction of DOS 2.0
     2. In DOS 3.2 at least, int 20h merely calls int 21h, fn 00h.
```

INT 21H DOS services
Function (hex)

* Indicates functions not documented in the IBM DOS Technical Reference.

Note: some functions have been documented in other Microsoft or licensed OEM documentation.

```
Function  00h   Terminate Program
     Ends program, updates, FAT, flushes buffers, restores registers
entry   AH      00h
        CS      segment address of PSP
return  none
note 1. Program must place the segment address of the PSP control block in CS
        before calling this function.
     2. The terminate, ctrl-break, and critical error exit addresses (0Ah, 0Eh,
        12h) are restored to the values they had on entry to the terminating
        program, from the values saved in the program segment prefix at
        locations PSP:000Ah, PSP:000Eh, and PSP:0012h.
     3. All file buffers are flushed and the handles opened by the process are
        closed.
     4. Any files that have changed in length and are not closed are not
```

```
          recorded properly in the directory.
       5. Control transfers to the terminate address.
       6. This call performs exactly the same function as int 20h.
       7. All memory used by the program is returned to DOS. DOS just goes up the
          chain of memory blocks and marks any that are owned by the PSP which is
          terminating as free.
       8. Files opened with FCBs are not automatically closed.

Function  01h     Get Keyboard Input
          Waits for char at STDIN (if necessary), echoes to STDOUT
entry     AH      01h
return    AL      ASCII character from STDIN (8 bits)
note 1.   Checks char for Ctrl-C, if char is Ctrl-C, executes int 23h.
       2. For function call 06h, extended ASCII codes require two function calls.
          The first call returns 00h as an indicator that the next call will be an
          extended ASCII code.
       3. Input and output are redirectable. If redirected, there is no way to
          detect EOF.

Function  02h     Display Output
       Outputs char in DL to STDOUT
entry     AH      02h
          DL      8 bit data (usually ASCII character)
return    none
note 1.   If char is 08 (backspace) the cursor is moved 1 char to the left
          (nondestructive backspace).
       2. If Ctrl-C is detected after input, int 23h is executed.
       3. Input and output are redirectable. If redirected, there is no way to
          detect disk full.

Function  03h     Auxiliary Input
       Get (or wait until) character from STDAUX
entry     AH      03h
return    AL      ASCII char from auxiliary device
note 1.   AUX, COM1, COM2 is unbuffered and not interrupt driven
       2. This function call does not return status or error codes. For greater
          control it is recommended that you use ROM BIOS routine (int 14h) or
          write an AUX device driver and use IOCTL.
       3. At startup, PC-DOS initializes the first auxiliary port (COM1) to 2400
          baud, no parity, one stop bit, and an 8-bit word. MSDOS may differ.
       4. If Ctrl-C is has been entered from STDIN, int 23h is executed.

Function  04h     Auxiliary Output
       Write character to STDAUX
entry     AH      04h
          DL      ASCII char to send to AUX
return    none
note 1.   This function call does not return status or error codes. For greater
          control it is recommended that you use ROM BIOS routine (int 14h) or
          write an AUX device driver and use IOCTL.
       2. If Ctrl-C is has been entered from STDIN, int 23h is executed.
       3. Default is COM1 unless redirected by DOS.
       4. If the device is busy, this function will wait until it is ready.

Function  05h     Printer Output
       Write character to STDPRN
entry     AL      05h
          DL      ASCII code for character to send
return    none
note 1.   If Ctrl-C is has been entered from STDIN, int 23h is executed.
       2. Default is PRN or LPT1 unless redirected with the MODE command.
       3. If the printer is busy, this function will wait until it is ready.

Function  06h     Direct Console I/O
       Get character from STDIN; echo character to STDOUT
entry     AH      06h
          DL      0FFh for console input, or 00h-0FEh for console output
return    ZF      set     no character available
                  clear   character received
          AL      ASCII code for character
note 1.   Extended ASCII codes require two function calls. The first call
```

```
          returns 00h to indicate the next call will return an extended code
       2. If DL is not 0FFh, DL is assumed to have a valid character that is output
          to STDOUT.
       3. This function does not check for Ctrl-C or Ctrl-PrtSc.
       4. Does not echo input to screen.
       5. If I/O is redirected, EOF or disk full cannot be detected.

Function 07h Direct Console Input Without Echo (does not check BREAK)
      Get or wait for char at STDIN, returns char in AL
entry   AH      07h
return  AL      ASCII character from standard input device
note 1. Extended ASCII codes require two function calls. The first call returns
        00h to indicate the next call will return an extended code.
     2. No checking for Ctrl-C or Ctrl-PrtSc is done.
     3. Input is redirectable.

Function  08h   Console Input Without Echo           (checks BREAK)
      Get or Wait for char at STDIN, return char in AL
entry   AH      08h
return  AL      char from standard input device
note 1. Char is checked for Ctrl-C. If Ctrl-C is detected, executes int 23h.
     2. For function call 08h, extended ASCII characters require two function
        calls. The first call returns 00h to signify an extended ASCII code. The
        next call returns the actual code.
     3. Input is redirectable. If redirected, there is no way to check EOF.

Function  09h   Print String
      Outputs Characters in the Print String to the STDOUT
entry   AH      09h
        DS:DX   pointer to the Character String to be displayed
return  none
note 1. The character string in memory must be terminated by a $ (24h). The $ is
        not displayed.
     2. Output to STDOUT is the same as function call 02h.
     3. The $ is not displayed but remains in AL forever unless popped.

Function  0Ah   Buffered Keyboard Input
      Reads characters from STDIN and places them in the buffer beginning at the
      third byte.
entry   AH      0Ah
        DS:DX   pointer to an input buffer
return  none
note 1. Min buffer size = 1, max = 255.
     2. Char is checked for Ctrl-C. If Ctrl-C is detected, executes int 23h.
     3. Format of buffer DX:
        byte        contents
          1     Maximum number of chars the buffer will take, including CR. Reading
                STDIN and filling the buffer continues until a carriage return (or
                0Dh) is read. If the buffer fills to one less than the maximum
                number the buffer can hold, each additional number read is ignored
                and ASCII 7 (BEL) is output to the display until a carriage return
                is read. (you must set this value)
          2     Actual number of characters received, excluding the carriage
                return, which is always the last character (the function sets is
                value)
         3-n    Characters received are placed into the buffer starting here.
                Buffer must be at least as long as the number in byte 1.
     4. Input is redirectable. If redirected, there is no way to check EOF.
     5. The string may be edited with the standard DOS editing commands as it is
        being entered.
     6. Extended ASCII characters are stored as 2 bytes, the first byte being
        zero.

Function  0Bh   Check Standard Input (STDIN) status
      Checks for character available at STDIN
entry   AH      0Bh
return  AL      0FFh    if a character is available from STDIN
                00h     if no character is available from STDIN
note 1. Checks for Ctrl-C. If Ctrl-C is detected, int 23h is executed.
     2. Input can be redirected.
     3. Checks for character only, it is not read into the application
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     4. IBM reports that this call does not work properly under the DOSSHELL
        program in DOS 4.00 and 4.01. DOSSHELL will return all zeroes. This
        function works correctly from the command line or application.

Function  0Ch   Clear Keyboard Buffer & Invoke a Keyboard Function (FCB)
      Dumps buffer, executes function in AL (01h, 06h, 07h, 08h, 0Ah only)
entry   AH      0Ch
        AL      function number (must be 01h, 06h, 07h, 08h, or 0Ah)
return  AL      00h     buffer was flushed, no other processing performed
                other   any other value has no meaning
note 1. Forces system to wait until a character is typed.
     2. Flushes all type-ahead input, then executes function specified by AL
        (by moving it to AH and repeating the int 21 call).
     3. If AL contains a value not in the list above, the keyboard buffer is
        flushed and no other action is taken.

Function  0Dh   Disk Reset
      Flushes all currently open file buffers to disk
entry   AH      0Dh
return          none
note 1. Does not close files. Does not update directory entries; files changed
        in size but not closed are not properly recorded in the directory.
     2. Sets DTA address to DS:0080h
     3. Should be used before a disk change, Ctrl-C handlers, and to flush the
        buffers to disk.

Function  0Eh   Select Disk
      Sets the drive specified in DL (if valid) as the default drive
entry   AL      0Eh
        DL      new default drive number (0=A:,1=B:,2=C:,etc.)
return  AL      total number of logical drives (not necessarily physical)
note 1. For DOS 1.x and 2.x, the minimum value for AL is 2.
     2. For DOS 3.x and 4.x, the minimum value for AL is 5.
     3. The drive number returned is not necessarily a valid drive.
     4. For DOS 1.x: 16 logical drives are available, A-P.
        For DOS 2.x: 63 logical drives are available. (Letters are only used for
                     the first 26 drives. If more than 26 logical drives are
                     used, further drive letters will be other ASCII characters
                     ie {,], etc.
        For DOS 3.x: 26 logical drives are available, A-Z.
        For DOS 4.x: 26 logical drives are available, A-Z.

Function  0Fh   Open Disk File                                          (FCB)
      Searches current directory for specified filename and opens it
entry   AH      0Fh
        DS:DX   pointer to an unopened FCB
return  AL      00h     if file found
                0FFh    if file not not found
note 1. If the drive code was 0 (default drive) it is changed to the actual
        drive used (1=A:,2=B:,3=C:, etc). This allows changing the default
        drive without interfering with subsequent operations on this file.
     2. The current block field (FCB bytes C-D, offset 0Ch) is set to zero.
     3. The size of the record to be worked with (FCB bytes E-F, offset 0Eh) is
        set to the system default of 80h. The size of the file (offset 10h) and
        the date (offset 14h) are set from information obtained in the root
        directory. You can change the default value for the record size (FCB
        bytes E-F) or set the random record size and/or current record field.
        Perform these actions after open but before any disk operations.
     4. With DOS 3.x the file is opened in compatibility mode (network).
     5. Microsoft recommends handle function call 3Dh be used instead.
     6. This call is also used by the APPEND command in DOS 3.2+
     7. 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 of 128 bytes is incorrect, set it to
        the correct value.

Function 10h Close File                                                 (FCB)
     Closes a File After a File Write
entry   AH      10h
        DS:DX   pointer to an opened FCB
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return  AL      00h      if the file is found and closed
                0FFh     if the file is not found in the current directory
note 1. This function call must be done on open files that are no longer needed,
        and after file writes to insure all directory information is updated.
     2. If the file is not found in its correct position in the current
        directory, it is assumed that the diskette was changed and AL returns
        0FFh. This error return is reportedly not completely reliable with DOS
        version 2.x.
     3. If found, the directory is updated to reflect the status in the FCB, the
        buffers to that file are flushed, and AL returns 00h.
     4. There is a subtle but dangerous bug in this function. If a Close request
        is issued using a File Control Block that has not been previously
        activated by a successful Open command, the file's length will be
        truncated to zero and the clusters previously assigned to the file are
        left floating.

Function  11h   Search For First Matching Entry                          (FCB)
        Searches current disk & directory for first matching filename
entry   AH      11h
        DS:DX   pointer to address of FCB
return  AL      00h      successful match
                0FFh     no matching filename found
note 1. The FCB may contain the wildcard character ? under Dos 2.x, and ? or *
        under 3.x and 4.x.
     2. The original FCB at DS:DX contains information to continue the search
        with function 12h, and should not be modified.
     3. If a matching filename is found, AL returns 00h and the locations at the
        Disk Transfer Address are set as follows:
        a. If the FCB provided for searching was an extended FCB, then the first
           byte at the disk transfer address is set to 0FFh followed by 5 bytes
           of zeros, then the attribute byte from the search FCB, then the
           drive number used (1=A, 2=B, etc) then the 32 bytes of the directory
           entry. Thus, the disk transfer address contains a valid unopened FCB
           with the same search attributes as the search FCB.
        b. If the FCB provided for searching was a standard FCB, then the first
           byte is set to the drive number used (1=A, 2=b, etc)), and the next
           32 bytes contain the matching directory entry. Thus, the disk transfer
           address contains a valid unopened normal FCB.
     4. If an extended FCB is used, the following search pattern is used:
        a. If the FCB attribute byte is zero, only normal file entries are found.
           Entries for volume label, subdirectories, hidden or system files, are
           not returned.
        b. If the attribute byte is set for hidden or system files, or
           subdirectory 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).
        c. If the attribute field is set for the volume label, it is considered
           an exclusive search, and ONLY the volume label entry is returned.
     5. This call is also used by the APPEND command in DOS 3.2+

Function 12h  Search For Next Entry Using FCB                            (FCB)
        Search for next matching filename
entry   AH      12h
        DS:DX   pointer to the unopened FCB specified from the previous Search
                 First (11h) or Search Next (12h)
return  AL      00h      if matching filename found
                0FFh     if matching filename was not found
note 1. After a matching filename has been found using function call 11h,
         function 12h may be called to find the next match to an ambiguous
        request. For DOS 2.x, ?'s are allowed in the filename. For DOS 3.x and
        4.x, global (*) filename characters are allowed.
     2. The DTA contains info from the previous Search First or Search Next.
     3. All of the FCB except for the name/extension field is used to keep
        information necessary for continuing the search, so no disk operations
        may be performed with this FCB between a previous function 11h or 12h
        call and this one.
     4. If the file is found, an FCB is created at the DTA address and set up to
        open or delete it.
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Function  13h  Delete File Via FCB                                          (FCB)
      Deletes file specified in FCB from current directory
entry    AH      13h
         DS:DX   pointer to address of FCB
return   AL      00h     file deleted
                 0FFh    if file not found or was read-only
note 1.  All matching current directory entries are deleted. The global filename
         character '?' is allowed in the filename.
      2. Will not delete files with read-only attribute set.
      3. Close open files before deleting them.
      4. Requires Network Access Rights.

Function  14h   Sequential Disk File Read                                   (FCB)
      Reads record sequentially from disk via FCB
entry    AH  14h
         DS:DX   pointer to an opened FCB
return   AL      00h     successful read
                 01h     end of file (no data read)
                 02h     Data Transfer Area too small for record size specified or
                         segment overflow
                 03h     partial record read, EOF found
note 1. The record size is set to the value at offset 0Eh in the FCB.
     2. The record pointed to by the Current Block (offset 0Ch) and the Current
        Record (offset 20h) fields is loaded at the DTA, then the Current Block
        and Current Record fields are incremented.
     3. The record is read into memory at the current DTA address as specified by
        the most recent call to function 1Ah. If the size of the record and
        location of the DTA are such that a segment overflow or wraparound would
        occur, the error return is set to AL=02h.
     4. If a partial record is read at the end of the file, it is passed to the
        requested size with zeros and the error return is set to AL=03h.

Function  15h   Sequential Disk Write                                       (FCB)
      Writes record specified by FCB sequentially to disk
entry    AH      15h
         DS:DX   pointer to address of FCB
return   AL      00h     successful write
                 01h     diskette full, write cancelled
                 02h     disk transfer area (DTA. too small or segment wrap
note 1. The data to write is obtained from the disk transfer area.
     2. The record size is set to the value at offset 0Eh in the FCB.
     3. This service cannot write to files set as read-only.
     4. The record pointed to by the Current Block (offset 0Ch) and the Current
        Record (offset 20h) fields is loaded at the DTA, then the Current Block
        and Current Record fields are incremented.
     5. If the record size is less than a sector, the data in the DTA is written
        to a buffer; the buffer is written to disk when it contains a full sector
        of data, the file is closed, or a Reset Disk (function 0Dh) is issued.
     6. The record is written to disk at the current DTA address as specified by
        the most recent call to function 1Ah. If the size of the record and
        location of the DTA are such that a segment overflow or wraparound would
        occur, the error return is set to AL=02h.

Function  16h   Create A Disk File                                          (FCB)
      Search and open or create directory entry for file
entry    AH      16h
         DS:DX   pointer to an FCB
return   AL      00h     successful creation
                 0FFh    no room in directory
note 1. If a matching directory entry is found, the file is truncated to zero
        bytes.
     2. If there is no matching filename, a filename is created.
     3. This function calls function 0Fh (Open File) after creating or truncating
        a file.
     4. A hidden file can be created by using an extended FCB with the attribute
        byte (offset FCB-1) set to 2.

Function  17h   Rename File Specified by File Control Block                 (FCB)
      Renames file in current directory
entry    AH      17h
         DS:DX   pointer to an FCB (see note 4)
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return  AL      00h     successfully renamed
                0FFh    file not found or filename already exists
note 1. This service cannot rename read-only files
     2. The '?' wildcard may be used.
     3. If the '?' wildcard is used in the second filename, the corresponding
        letters in the filename of the directory entry are not changed.
     4. The FCB must have a drive number, filename, and extension in the usual
        position, and a second filename starting 6 bytes after the first, at
        offset 11h.
     5. The two filenames cannot have the same name.
     6. FCB contains new name starting at byte 17h.

Function  18h  Internal to DOS
 *   Unknown - reportedly not used
entry   AH      18h
return  AL      00h

Function  19h   Get Current Disk Drive
      Return designation of current default disk drive
entry   AH      19h
return  AL      current default drive (0=A, 1=B,etc.)
note    Some other DOS functions use 0 for default, 1=A, 2=B, etc.

Function  1Ah   Set Disk Transfer Area Address (DTA)
      Sets DTA address to the address specified in DS:DX
entry   AH      1Ah
        DS:DX   pointer to buffer
return  none
note 1. The default DTA is 128 bytes at offset 80h in the PSP. DOS uses the DTA
        for all file I/O.
     2. Registers are unchanged.
     3. No error codes are returned.
     2. Disk transfers cannot wrap around from the end of the segment to the
        beginning or overflow into another segment.

Function  1Bh   Get Current Drive File Allocation Table Information
      Returns information from the FAT on the current drive
entry   AH      1Bh
return  AL      number of sectors per allocation unit (cluster)
        CX      number of bytes per sector
        DS:BX   address of the current drive's media descriptor byte
        DX      number of allocation units (clusters) for default drive
note 1. Save DS before calling this function.
     2. This call returned a pointer to the FAT in DOS 1.x. Beginning with DOS
        2.00, it returns a pointer only to the table's ID byte.
     3. IBM recommends programmers avoid this call and use int 25h instead.

Function  1Ch   Get File Allocation Table Information for Specific Device
      Returns information on specified drive
entry   AH      1Ch
        DL      drive number (1=A, 2=B, 3=C, etc)
return  AL      number of sectors per allocation unit (cluster)
        DS:BX   address of media descriptor byte for drive in DL
        CX      sector size in bytes
        DX      number of allocation units (clusters)
note 1. DL = 0 for default.
     2. Save DS before calling this function.
     3. Format of media-descriptor byte:
        bits:   0       0   (clear)   not double sided
                        1   (set)     double sided
                1       0   (clear)   not 8 sector
                        1   (set)     8 sector
                2       0   (clear)   nonremovable device
                        1   (set)     removable device
                3-7     always set (1)
     4. This call returned a pointer to the FAT in DOS 1.x. Beginning with DOS
        2.00, it returns a pointer only to the table's ID byte.
     5. IBM recommends programmers avoid this call and use int 25h instead.

Function  1Dh   Not Documented by Microsoft
 *    Unknown - reportedly not used
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entry   AH      1Dh
return  AL      00h

Function  1Eh   Not Documented by Microsoft
 *   Unknown - reportedly not used
entry   AH      1Eh
return  AL      00h
note    Apparently does nothing.

Function  1Fh Get Default Drive Parameter Block
*     Same as function call 32h (below), except that the table is
      accessed from the default drive
entry   AH      1Fh
        other registers unknown
return  AL      00h     no error
                0FFh    error
        DS:BX   pointer to DOS Disk Parameter Block for default drive.
note 1. Unknown vector returned in ES:BX.
     2. For DOS 2, 3, 4.x, this just invokes function 32h (undocumented, Read
        DOS Disk Block) with DL=0.

Function  20h  Unknown
 *   Internal - does nothing?
entry   AH      20h
return  AL      00h

Function 21h Random Read from File Specified by File Control Block          (FCB)
     Reads one record as specified in the FCB into the current DTA.
entry   AH      21h
        DS:DX   address of the opened FCB
return  AL      00h     successful read operation
                01h     end of file (EOF), no data read
                02h     DTA too small for the record size specified
                03h     end of file (EOF), partial data read
note 1. The current block and current record fields are set to agree with the
        random record field. Then the record addressed by these fields is read
        into memory at the current Disk Transfer Address.
     2. The current file pointers are NOT incremented this function.
     3. If the DTA is larger than the file, the file is padded to the requested
        length with zeros.

Function  22h  Random Write to File Specified by FCB                        (FCB)
     Writes one record as specified in the FCB to the current DTA
entry   AH      22h
        DS:DX   address of the opened FCB
return  AL      00h     successful write operation
                01h     disk full; no data written (write was cancelled)
                02h     DTA too small for the record size specified (write was
                        cancelled)
note 1. This service cannot write to read-only files.
     2. The record pointed to by the Current Block (offset 0Ch) and the Current
        Record (offset 20h) fields is loaded at the DTA, then the Current Block
        and Current Record fields are incremented.
     3. If the record size is less than a sector, the data in the DTA is written
        to a buffer; the buffer is written to disk when it contains a full sector
        of data, the file is closed, or a Reset Disk (function 0Dh) is issued.
     4. The current file pointers are NOT incremented this function.
     5. The record is written to disk at the current DTA address as specified by
        the most recent call to function 1Ah. If the size of the record and
        location of the DTA are such that a segment overflow or wraparound
        would occur, the error return is set to AL=02h.

Function  23h  Get File Size                                                (FCB)
     Searches current subdirectory for matching file, returns size in FCB
entry   AH      23h
        DS:DX   address of an unopened FCB
return  AL      00h file found
                0FFh file not found
note 1. Record size field (offset 0Eh) must be set before invoking this function
     2. The disk directory is searched for the matching entry. If a matching
        entry is found, the random record field is set to the number of records
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        in the file. If the value of the Record Size field is not an even
        divisor of the file size, the value set in the relative record field is
        rounded up. This gives a returned value larger than the actual file size
     3. This call is used by the APPEND command in DOS 3.2+

Function  24h  Set Relative Record Field                                  (FCB)
     Set random record field specified by an FCB
entry   AH      24h
        DS:DX   address of an opened FCB
return  Random Record Field of FCB is set to be same as Current Block
        and Current Record.
note 1. You must invoke this function before performing random file access.
     2. The relative record field of FCB (offset 21h) is set to be same as the
        Current Block (offset 0Ch) and Current Record (offset 20h).
     3. No error codes are returned.
     4. The FCB must already be opened.

Function  25h  Set Interrupt Vector
     Sets the address of the code DOS is to perform each time the specified
     interrupt is invoked.
entry   AH      25h
        AL      int number to reassign the handler to
        DS:DX   address of new interrupt vector
return  none
note 1. Registers are unchanged.
     2. No error codes are returned.
     3. The interrupt vector table for the interrupt number specified in AL is
        set to the address contained in DS:DX. Use function 35h (Get Vector) to
        get the contents of the interrupt vector and save it for later use.
     4. When you use function 25 to set an interrupt vector, DOS 3.2 doesn't
        point the actual interrupt vector to what you requested. Instead, it
        sets the interrupt vector to point to a routine inside DOS, which does
        this:
                1. Save old stack pointer
                2. Switch to new stack pointer allocated from DOS's stack pool
                3. Call your routine
                4. Restore old stack pointer
        The purpose for this was to avoid possible stack overflows when there are
        a large number of active interrupts. IBM was concerned (this was an IBM
        change, not Microsoft) that on a Token Ring network there would be a lot
        of interrupts going on, and applications that hadn't allocated very much
        stack space would get clobbered.

Function  26h  Create New Program Segment Prefix (PSP)
This service copies the current program-segment prefix to a new memory location
for the creation of a new program or overlay. Once the new PSP is in place, a DOS
program can read a DOS COM or over lay file into the memory location immediately
following the new PSP and pass control to it.
entry   AH      26h
        DX      segment number for the new PSP
return  Current PSP is copied to specified segment
note 1. Microsoft recommends you use the newer DOS service 4Bh (EXEC) instead.
     2. The entire 100h area at location 0 in the current PSP is copied into
        location 0 of the new PSP. The memory size information at location 6 in
        the new segment is updated and the current termination, ctrl-break, and
        critical error addresses from interrupt vector table entries for ints
        22h, 23h, and 24 are saved in the new program segment starting at 0Ah.
        They are restored from this area when the program terminates.

Function  27h  Random Block Read From File Specified by FCB
     Similar to 21h (Random Read) except allows multiple files to be read.
entry   AH      27h
        CX      number of records to be read
        DS:DX   address of an opened FCB
return  AL      00h     successful read
                01h     end of file, no data read
                02h     DTA too small for record size specified (read
                        cancelled)
                03h     end of file
        CX      actual number of records read (includes partial if AL=03h)
note 1. The record size is specified in the FCB. The service updates the Current
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     Block (offset 0Ch) and Current Record (offset 20h) fields to the next
     record not read.
  2. If CX contained 0 on entry, this is a NOP.
  3. If the DTA is larger than the file, the file is padded to the requested
     length with zeros.
  4. This function assumes that the FCB record size field (0Eh) is correctly
     set. If not set by the user, the default is 128 bytes.
  5. The record is written to disk at the current DTA address as specified by
     the most recent call to function 1Ah. If the size of the record and
     location of the DTA are such that a segment overflow or wraparound would
     occur, the error return is set to AL=02h.

Function  28h  Random Block Write to File Specified in FCB
     Similar to 27h (Random Write) except allows multiple files to be read.
entry   AH       28h
        CX       number of records to write
        DS:DX    address of an opened FCB
return  AL       00h      successful write
                 01h      disk full, no data written
                 02h      DTA too small for record size specified (write cancelled)
        CX       number of records written
note 1. The record size is specified in the FCB.
     2. This service allocates disk clusters as required.
     3. This function assumes that the FCB Record Size field (offset 0Eh) is
        correctly set. If not set by the user, the default is 128 bytes.
     4. The record size is specified in the FCB. The service updates the Current
        Block (offset 0Ch) and Current Record (offset 20h) fields to the next
        record not read.
     5. The record is written to disk at the current DTA address as specified by
        the most recent call to function 1Ah. If the size of the record and
        location of the DTA are such that a segment overflow or wraparound would
        occur, the error return is set to AL=02h.
     6. If called with CX=0, no records are written, but the FCB's File Size
        entry (offset 1Ch) is set to the size specified by the FCB's Relative
        Record field (offset 21h).

Function  29h  Parse the Command Line for Filename
     Parses a text string into the fields of a File Control Block
entry   AH       29h
        DS:SI    pointer to string to parse
        ES:DI    pointer to memory buffer to fill with unopened FCB
        AL       bit mask to control parsing
            bit 0    0     parsing stops if file separator found
                     1     causes service to scan past leading chars such as
                           blanks. Otherwise assumes the filename begins in the
                           first byte
                1    0     drive number in FCB set to default (0) if string
                           contains no drive number
                     1     drive number in FCB not changed
                2    0     filename in FCB set to 8 blanks if no filename no
                           string
                     1     filename in FCB not changed if string does not contain
                           a filename
                3    0     extension in FCB set to 3 blanks if no extension in
                           string
                     1     extension left unchanged
                4-7  must be zero
return  AL       00h     no wildcards in name or extension
                 01h     wildcards appeared in name or extension
                 0FFh    invalid drive specifier
        DS:SI    pointer to the first byte after the parsed string
        ES:DI    pointer to a buffer filled with the unopened FCB
note 1. If the * wildcard characters are found in the command line, this service
        will replace all subsequent chars in the FCB with question marks.
     2. This service uses the characters as filename separators
        DOS 1        : ; . , + / [ ] = " TAB SPACE
        DOS 2,3,4    : ; . , + = TAB SPACE
     3. This service uses the characters
        : ; . , +  < > | / \ [ ] = " TAB SPACE
        or any control characters as valid filename separators.
     4. A filename cannot contain a filename terminator. If one is encountered,
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        all processing stops. The handle functions will allow use of some of
        these characters.
     5. If no valid filename was found on the command line, ES:DI +1 points to a
        blank (ASCII 32).
     6. This function cannot be used with filespecs which include a path
     7. Parsing is in the form D:FILENAME.EXT. If one is found, a corresponding
        unopened FCB is built at ES:DI.

Function  2Ah  Get Date
     Returns day of the week, year, month, and date
entry   AH      2Ah
return  CX      year    (1980-2099)
        DH      month   (1-12)
        DL      day     (1-31)
        AL      weekday 00h     Sunday
                        01h     Monday
                        02h     Tuesday
                        03h     Wednesday
                        04h     Thursday
                        05h     Friday
                        06h     Saturday
note 1. Date is adjusted automatically if clock rolls over to the next day, and
        takes leap years and number of days in each month into account.
     2. Although DOS cannot set an invalid date, it can read one, such as
        1/32/80, etc.
     3. DesQview also accepts CX = 4445h and DX = 5351h, i.e. 'DESQ' as valid
     4. DOS will accept CH=0 (midnight) as a valid time, but if a file's time is
        set to exactly midnight the time will not be displayed by the DIR command.


Function  2Bh  Set Date
     set current system date
entry   AH      2Bh
        CX      year    (1980-2099)
        DH      month   (1-12)
        DL      day     (1-31)
return  AL      00h     no error (valid date)
                0FFh    invalid date specified
note 1. On entry, CX:DX must have a valid date in the same format as returned by
        function call 2Ah.
     2. DOS 3.3+ also sets CMOS clock.
     3. Under the DesQview system shell, this is the DV_GET_VERSION check.
        entry   AH      2Bh
                AL      01h     DesQ call
                CX      4445h   'DE'            (invalid date used
                DX      5351h   'SQ'             for DesQview ID)
        return  AH      major version
                AL      minor version
                AX      0FFh    DesQ not installed (DOS error code)
     4. For DESQview 2.00+, installation check
        entry   AH      2Bh
                AL      subfunction (DV v2.00+)
                        01h     Get Version
        return  BX      version (BH = major, BL = minor)
        note    Early copies of v2.00 return 0002h.
                        02h     Get Shadow Buffer Info, and Start
        return  BH      Shadowing rows in shadow buffer
                BL      columns in shadow buffer
                DX      segment of shadow buffer
                        04h     Get Shadow Buffer Info
        return  BH      rows in shadow buffer
                BL      columns in shadow buffer
                DX      segment of shadow buffer
                        05h     Stop Shadowing
                CX      4445h ('DE')
                DX      5351h ('SQ')
        return  AL      0FFh    if DESQview not installed
        note    In DESQview v1.x, there were no subfunctions; this call only
                identified whether or not DESQview was loaded.
```

```
Function  2Ch  Get Time
     Get current system time from CLOCK$ driver
entry   AH      2Ch
return  CH      hours   (0-23)
        CL      minutes (0-59)
        DH      seconds (0-59)
        DL      hundredths of a second (0-99)
note 1. Time is updated every 5/100 second.
     2. The date and time are in binary format.

Function  2Dh  Set Time
     Sets current system time
entry   AH      2Dh
        CH      hours   (0-23)
        CL      minutes (0-59)
        DH      seconds (0-59)
        DL      hundredths of seconds (0-99)
return  AL      00h     if no error
                0FFh    if bad value sent to routine
note 1. DOS 3.3+ also sets CMOS clock.
     2. CX and DX must contain a valid time in binary.

Function  2Eh  Set/Reset Verify Switch
     Set verify flag
entry   AH      2Eh
        AL      00      to turn verify off (default)
                01      to turn verify on
return  none
note 1. This is the call invoked by the DOS VERIFY command.
     2. Setting of the verify switch can be obtained by calling call 54h.
     3. This call is not supported on network drives.
     4. DOS checks this flag each time it accesses a disk.

Function  2Fh  Get Disk Transfer Address (DTA)
     Returns current disk transfer address used by all DOS read/write operations
entry   AH      2Fh
return  ES:BX   address of DTA
note 1. The DTA is set by function call 1Ah
     2. Default DTA address is a 128 byte buffer at offset 80h in that program's
        Program Segment Prefix.

Function  30h  Get DOS Version Number
     Return DOS version and/or user number
entry   AH      30h
return  AH      minor version number  (i.e., DOS 2.10 returns AX = 0A02h)
        AL      major version number  (0 for DOS 1.x)
        BH      OEM ID number
                00h     IBM
                16h     DEC     (others not known)
        BL:CX   24-bit user serial number
note 1. If AL returns a major version number of zero, the DOS version is below
        1.28 for MSDOS and below 2.00 for PCDOS.
     2. IBM PC-DOS always returns 0000h in BX and CX.
     3. OS/2 v1.0 Compatibility Box returns a value of 10 for major version.
     4. Due to the OS/2 return and the fact that some European versions of DOS
        carry higher version numbers than IBM's DOS, utilities which check for a
        DOS version should not abort if a higher version than required is found
        unless some specific problems are known.

Function  31h  Terminate Process and Stay Resident
     KEEP, or TSR
entry   AH      31h
        AL      exit code
        DX      program memory requirement in 16 byte paragraphs
return  AX      return code (retrievable by function 4Dh)
note 1. Files opened by the application are not closed when this call is made.
     2. Memory can be used more efficiently if the block containing the copy of
        the DOS environment is deallocated before terminating. This can be done
        by loading ES with the segment contained in 2Ch of the PSP and issuing
        function call 49h (Free Allocated Memory).
     3. Unlike int 27h, more than 64k may be made resident with this call.
```

```
Function  32h  Read DOS Disk Block
 *   Retrieve the pointer to the drive parameter block for a drive
entry    AH      32h
         DL      drive (0=default, 1=A:, etc.).
return   AL      00h     if drive is valid
                 0FFh    if drive is not valid
         DS:BX   pointer to DOS Drive Parameter Table. Format of block:
Bytes    Type    Value
00h      byte    Drive: 0=A:, 1=B:, etc.
01h      byte    Unit within device driver (0, 1, 2, etc.)
02h-03h word     Bytes per sector
04h      byte    largest sector number in cluster (one less than sectors per
                 cluster)
05h      byte    Cluster to sector shift (i.e., how far to shift-left the
                  bytes/sector to get bytes/cluster)
06h-07h word     Number of reserved (boot) sectors
08h      byte    Number of copies of the FAT
09h-0Ah word     Number of root directory entries
0Bh-0Ch word     Sector # of 1st data. Should be same as # of sectors/track.
0Dh-0Eh word     largest possible cluster number (one more than the number of data
                 clusters)

DOS 2.x only
0Fh      byte    sectors for one copy of the FAT
10h-11h word     First sector of root directory
12h-15h dword    Address of device driver header for this drive
16h      byte    Media Descriptor Byte for this drive
17h      byte    0FFh indicates block must be rebuilt (DOS 3.x) 00h indicates
                 block device has been accessed
18h-1Bh dword    address of next DOS Disk Block (0FFFFh means last in chain)
1Ch      word    starting cluster of current dir (0 = root)
1Eh      64byts  ASCIIZ current directory path string
22h      byte    Current Working Directory (2.0 only) (64 bytes)

DOS 3.x
0Fh      byte    number of sectors in one FAT copy
10h      word    first sector of root directory
12h      dword   address of device driver for this drive
16h      byte    media descriptor byte for medium
17h      byte    0FFh = block must be rebuilt, 00h indicates block accessed
18h      dword   address of next device block, offset = 0FFFFh indicates last word
                 cluster at which to start search for free space when writing
1Ch      word    00h, probably unused, values left from before
1Eh      word    0FFFFh indicates block was built

DOS 4.0
0Fh      word    number of sectors in one FAT copy
11h      word    first sector of root directory
13h      dword   address of device driver for this drive
17h      byte    media descriptor byte for medium
18h      byte    0FFh = block must be rebuilt, 00h indicates block accessed
19h      dword   address of next device block, offset = 0FFFFh indicates last
1Dh      word    cluster at which to start search for free space when writing
1Fh      word    unknown
note 1. Use [BX+0D] to find no. of clusters (1000h, 16-bit FAT; if not, 12-bit
        (exact dividing line is probably a little below 1000h to allow for bad
        sectors, EOF markers, etc.)
     2. Short article by C.Petzold, PC Magazine  Vol.5,no.8, and the article
        'Finding Disk Parameters' in the May 1986 issue of PC Tech Journal.
     3. This call is mostly supported in OS/2 1.0's DOS Compatibility
        Box. The dword at 12h will not return the address of the next
        device driver when in the Compatibility Box.
     4. Used by CHKDSK.

Function  33h  Control-Break Check
     Get or set control-break checking at CON
entry    AH      33h
         AL      00h     to test for break checking
                 01h     to set break checking
                         DL      00h     to disable break checking
                                 01h     to enable break checking
```

```
                02h     internal, called by PRINT.COM (DOS 3.1)
                03h     unknown
                04h     unknown
                05h     boot drive (DOS 4.0+)
return  DL      break setting (AL=00h)
                00h     if break=off
                01h     if break=on
                (if AL=05h) boot drive, A=1, B=2, etc)
        AL      0FFh    error
```

```
Function  34h  Return INDOS Flag
 *    Returns ES:BX pointing to Critical Section Flag, byte indicating whether it
      is safe to interrupt DOS.
entry   AH      34h
return  ES:BX   points to 1-byte DOS "critical section flag"
```

```
note 1. If byte is 0, it is safe to interrupt DOS. This was mentioned in some
        documentation by Microsoft on a TSR standard, and 'PC Magazine' reports
        it functions reliably under DOS versions 2.0 through 3.3. Chris Dunford
        (of CED fame) and a number of anonymous messages on the BBSs indicate it
        may not be totally reliable.
     2. The byte at ES:BX+1 is used by the Print program for this same purpose,
        so it's probably safer to check the WORD at ES:BX.
     3. Reportedly, examination of DOS 2.10 code in this area indicates that the
        byte immediately following this 'critical section flag' must be 00h to
        permit the PRINT.COM interrupt to be called. For DOS 3.0 and 3.1
        (except Compaq DOS 3.0), the byte before the 'critical section flag'
        must be zero; for Compaq DOS 3.0, the byte 01AAh before it must be zero.
      4. In DOS 3.10 this reportedly changed to word value, with preceding byte.
      5. This call is supported in OS/2 1.0's DOS Compatibility Box
      6. Gordon Letwin of Microsoft discussed this call on ARPAnet in 1984. He
         stated:
         a. this is not supported under any version of the DOS
         b. it usually works under DOS 2, but there may be circumstances when it
            doesn't (general disclaimer, don't know of a specific circumstance)
         c. it will usually not work under DOS 3 and DOS 3.1; the DOS is
            considerably restructured and this flag takes on additional
            meanings and uses
         d. it will fail catastrophically under DOS 4.0 and forward.
            Obviously this information is incorrect since the call works
            fine through DOS 3.3. Microsoft glasnost?
```

```
Function  35h  Get Vector
     Get interrupt vector
entry  AH     35h
       AL     interrupt number (hexadecimal)
return ES:BX address of interrupt vector
note   Use function call 25h to set the interrupt vectors.
```

```
Function  36h  Get Disk Free Space
     get information on specified drive
entry  AH     36h
       DL     drive number (0=default, 1=A:, 2=B:, etc)
return AX     number of sectors per cluster
              0FFFFh means drive specified in DL is invalid
       BX     number of available clusters
       CX     bytes per sector
       DX     clusters per drive
note 1. Mult AX * CX * BX for free space on disk.
     2. Mult AX * CX * DX for total disk space.
     3. Function 36h returns an incorrect value after an ASSIGN command. Prior to
        ASSIGN, the DX register contains 0943h on return, which is the free space
        in clusters on the HC diskette. After ASSIGN, even with no parameters,
        0901h is returned in the DX register; this is an incorrect value.
        Similar results occur with DD diskettes on a PC-XT or a PC-AT. This
        occurs only when the disk is not the default drive. Results are as
        expected when the drive is the default drive. Therefore, the
        circumvention is to make the desired drive the default drive prior to
        issuing this function call.
     4. Int 21h, function call 36h returns an incorrect value after an ASSIGN
        command. Prior to ASSIGN, the DX register contains 0943h on return, which
```

```
        is the free space in clusters on the HC diskette. After ASSIGN, even
        with no parameters, 0901h is returned in the DX register; this is an
        incorrect value. Similar results occur with DD diskettes on a PC-XT or
        a PC-AT. This occurs only when the disk is not the default drive.
        Results are as expected when the drive is the default drive. Therefore,
        the circumvention is to make the desired drive the default drive prior
        to issuing this function call.
     5. This function supercedes functions 1Bh and 1Ch.

Function  37h  SWITCHAR / AVAILDEV
 *   Get/set option marking character (is usually "/"), and device type
entry  AH       37h
       AL       00h      read switch character (returns current character in DL)
                01h      set character in DL as new switch character
     (DOS 2.x. 02h      read device availability (as set by function AL=3)
                         into DL. A 0 means devices that devices must be accessed
                         in file I/O calls by /dev/device. A non-zero value means
                         that devices are accessible at every level of the
                         directory tree (e.g., PRN is the printer and not a file
                         PRN).
                         AL=2 to return flag in DL, AL=3 to set from DL (0
                         = set,1 = not set).
     (DOS 2.x) 03h      get device availability, where:
       DL       00h      means /dev/ must precede device names
                01h      means /dev/ need not precede device names
return DL       switch character (if AL=0 or 1)
                device availability flag (if AL=2 or 3)
       AL       0FFh     the value in AL was not in the range 0-3.
note 1. Functions 2 & 3 appear not to be implemented for DOS 3.x.
     2. It is documented on page 4.324 of the MS-DOS (version 2) Programmer's
        Utility Pack (Microsoft - published by Zenith).
     3. Works on all versions of IBM PC-DOS from 2.0 through 3.3.1.
     4. The SWITCHAR is the character used for "switches" in DOS command
        arguments (defaults to '/', as in "DIR/P"). '-' is popular to make a
        system look more like UNIX; if the SWITCHAR is anything other than '/',
        then '/' may be used instead of '\' for pathnames.
     5. Ignored by XCOPY, PKARC, LIST.
     6. SWITCHAR may not be set to any character used in a filename.
     7. In DOS 3.x you can still read the "AVAILDEV" byte with subfunction 02h
        but it always returns 0FFh even if you try to change it to 0 with
        subfunction 03h.
     8. AVAILDEV=0 means that devices must be referenced in an imaginary
        subdirectory "\dev" (similar to UNIX's /dev/*); a filename 'PRN.DAT' can
        be created on disk and manipulated like any other. If AVAILDEV != 0 then
        device names are recognized anywhere (this is the default): 'PRN.DAT' is
        synonymous with 'PRN:'.
     9. These functions reportedly are not supported in the same fashion in
        various implementations of DOS.
    10. Used by DOS 3.3 CHKDSK, BASIC, DEBUG.

Function  38h   Return Country-Dependent Information
                (PCDOS 2.0, 2.1, MSDOS 2.00 only)
entry   AH      38h
        AL      function code  (must be 0 in DOS 2.x)
        DS:DX   pointer to 32 byte memory buffer for returned information
return  CF      set on error
                AX       error code (02h)
        BX      country code
        DS:DX   pointer to buffer filled with country information:
          bytes 00h,01h date/time format
                         0000h   USA standard        H:M:S   M/D/Y
                         0001h   European standard   H:M:S   D/M/Y
                         0002h   Japanese standard   H:M:S   D:M:Y
                02h      ASCIIZ string currency symbol
                03h      byte of zeros
                04h      ASCIIZ string thousands separator
                05h      byte of zeros
                06h      ASCIIZ string decimal separator
                07h      byte of zeros
       24 bytes 08h-1Fh reserved
```

```
Function  38h    Get Country-Dependent Information
                 (PCDOS 3.x+, MSDOS 2.01+)
entry     AH     38h
          AL     function code
                 00h      to get current country information
                 01h-0FEh country code to get information for, for countries with
                          codes less than 255
                 0FFh     to get country information for countries with a greater
                          than 255
                          BX       16 bit country code if AL=0FFh
          DS:DX  pointer to the memory buffer where the data will be returned
                 DX       0FFFFh if setting country code rather than getting info
return    CF     0 (clear) function completed
                 1 (set) error
                    AX    error code
                          02h      invalid country code (no table for it)
          (if DX  0FFFFh)
          BX     country code (usually international telephone code)
          DS:DX  pointer to country data buffer
            bytes 0,1     date/time format
                          0        USA standard       H:M:S    M/D/Y
                          1        European standard  H:M:S    D/M/Y
                          2        Japanese standard  H:M:S    D:M:Y
            bytes 02h-06h currency symbol null terminated
            byte  07h     thousands separator null terminated
            byte  08h     byte of zeros
            byte  09h     decimal separator null terminated
            byte  0Ah     byte of zeros
            byte  0Bh     date separator null terminated
            byte  0Ch     byte of zeros
            byte  0Dh     time separator null terminated
            byte  0Eh     byte of zeros
            byte  0Fh     currency format byte
                      bit 0        0  if currency symbol precedes the value
                                   1  if currency symbol is after the value
                          1        0  no spaces between value and currency symbol
                                   1  one space between value and currency symbol
                          2        set if currency symbol replaces decimal point
                          3-7      not defined by Microsoft
            byte  10h     number of significant decimal digits in currency
                          (number of places to right of decimal point)
            byte  11h     time format byte
                      bit 0        0        12 hour clock
                                   1        24 hour clock
                          1-7      unknown, probably not used
            bytes 12h-15h address of case map routine (FAR CALL, AL = char)
                          entry    AL  ASCII code of character to be converted to
                                       uppercase
                          return   AL  ASCII code of the uppercase input character
            byte  16h     data-list separator character
            byte  17h     zeros
            bytes 18h-21h 5 words reserved
```

note 1. When an alternate keyboard handler is invoked, the keyboard routine is loaded into user memory starting at the lowest portion of available user memory. The BIOS interrupt vector that services the keyboard is redirected to the memory area where the new routine resides. Each new routine takes up about 1.6K of memory and has lookup tables that return values unique to each language. (KEYBxx in the DOS book) Once the keyboard interrupt vector is changed by the DOS keyboard routine, the new routine services all calls unless the system is returned to the US format by the ctrl-alt-F1 keystroke combination. This does not change the interrupt vector back to the BIOS location; it merely passes the table lookup to the ROM locations.

2. Ctrl-Alt-F1 will only change systems with US ROMS to the US layout. Some systems are delivered with non-US keyboard handler routines in ROM

3. Case mapping call: the segment/offset of a FAR procedure that performs country-specific lower-to-upper case mapping on ASCII characters 80h to 0 0FFh. It is called with the character to be mapped in AL. If there is an uppercase code for the letter, it is returned in AL, if there is no code or the function was called with a value of less than 80h AL is returned unchanged.

```
     4. This call is fully implemented in MS-DOS version 2.01 and higher. It is
        in version 2.00 but not fully implemented (according to Microsoft).

Function  38h   Set Country Dependent Information
entry   AH      38h
        AL      code     country code to set information for, for countries with
                         codes less than 255
                0FFh     to set country information for countries with a code
                         greater than 255
        BX      16 bit country code if AL=0FFh
        DX      0FFFFh
return  CF      clear    successful
                set      if error
                         AX       error code (02h)

Function  39h   Create Subdirectory (MKDIR)
                Makes a subdirectory along the indicated path
entry   AH      39h
        DS:DX   address of ASCIIZ pathname string
return  flag CF 0        successful
                1        error
                         AX       error code if any  (03h, 05h)
note 1. The ASCIIZ string may contain drive and subdirectory.
     2. Drive may be any valid drive (not necessarily current drive).
     3. The pathname cannot exceed 64 characters.

Function  3Ah   Remove Subdirectory  (RMDIR)
entry   AH      3Ah
        DS:DX   address of ASCIIZ pathname string
return  CF      clear      successful
                set        AX       error code if any  (3, 5, 16)
note 1. The ASCIIZ string may contain drive and subdirectory.
     2. Drive may be any valid drive (not necessarily current drive).
     3. The pathname cannot exceed 64 characters.

Function  3Bh   Change Current Directory  (CHDIR)
entry   AH      3Bh
        DS:DX   address of ASCIIZ string
return  flag CF 0        successful
                1        error
        AX      error code if any (03h)
note 1. The pathname cannot exceed 64 characters.
     2. The ASCIIZ string may contain drive and subdirectory.
     3. Drive may be any valid drive (not necessarily current drive).

Function  3Ch   Create A File (CREAT)
                Create a file with handle
entry   AH      3Ch
        CX      byte, attributes for file
                00h      normal
                01h      read only
                02h      hidden
                03h      system
        DS:DX   address of ASCIIZ filename string
return  CF      0        successful creation
                1        error
        AX      16 bit file handle
              or error code  (03h, 04h, 05h)
note 1. The ASCIIZ string may contain drive and subdirectory.
     2. Drive may be any valid drive (not necessarily current drive).
     3. If the volume label or subdirectory bits are set in CX, they are ignored
     4. The file is opened in read/write mode
     5. If the file does not exist, it is created. If one of the same name
        exists, it is truncated to a length of 0.
     6. Good practice is to attempt to open a file with fn 3Dh and jump to an
        error routine if successful, create file if 3Dh fails. That way an
        existing file will not be truncated and overwritten

Function  3Dh   Open A File
                Open disk file with handle
entry   AH      3Dh
```

```
        AL      access code byte
(DOS 2.x)  bits 0-2     file attribute
                        000     read only
                        001     write only
                        010     read/write
                3-7     reserved, should be set to zero
(DOS 3.x)  bits 0-2     file attribute
                        000     read only
                        001     write only
                        010     read/write
                3       reserved, should be set to zero
                4-6     sharing mode (network)
                        000     compatibility mode (the way FCBs open files)
                        001     read/write access denied (exclusive)
                        010     write access denied
                        011     read access denied
                        100     full access permitted
                7       inheritance flag
                        0       file inherited by child process
                        1       file private to child process
        DS:DX   address of ASCIIZ pathname string
return  CF set on error
                AX      error code (01h, 02h, 03h, 04h, 05h, 0Ch)
        AX      16 bit file handle
note 1. Opens any normal, system, or hidden file.
     2. Files that end in a colon are not opened.
     3. The rear/write pointer is set at the first byte of the file and the
        record size of the file is 1 byte (the read/write pointer can be changed
        through function call 42h). The returned file handle must be used for
        all subsequent input and output to the file.
     4. If the file handle was inherited from a parent process or was duplicated
        by DUP or FORCEDUP, all sharing and access restrictions are also
        inherited.
     5. A file sharing error (error 01h) causes an int 24h to execute with an
        error code of 02h.

Function  3Eh   Close A File Handle
                Close a file and release handle for reuse
entry   AH      3Eh
        BX      file handle
return  flag CF 0       successful close
                1       error
        AX      error code if error (06h)
note 1. When executed, the file is closed, the directory is updated, and all
        buffers for that file are flushed. If the file was changed, the time and
        date stamps are changed to current.
     2. If called with the handle 00000h, it will close STDIN (normally the
        keyboard).

Function  3Fh   Read From A File Or Device
                Read from file with handle
entry   AH      3Fh
        BX      file handle
        CX      number of bytes to read
        DS:DX   address of buffer
return  flag CF 0       successful read
                1       error
        AX      0       pointer was already at end of file
                        or number of bytes read
                        or error code (05h, 06h)
note 1. This function attempts to transfer the number of bytes specified to a
        buffer location. It is not guaranteed that all bytes will be read. If
        AX < CX a partial record was read.
     2. If performed from STDIN (file handle 0000), the input can be redirected
     3. If used to read the keyboard, it will only read to the first CR.
     4. The file pointer is incremented to the last byte read.

Function  40h   Write To A File Or Device
                Write to file with handle
entry   AH      40h
        BX      file handle
```

```
        CX      number of bytes to write
        DS:DX   address of buffer
return  flag CF 0       successful write
                1       error
        AX      number of bytes written
                or error code  (05h, 06h)
note 1. This call attempts to transfer the number of bytes indicated in CX from a
        buffer to a file. If CX and AX do not match after the write, an error
        has taken place; however no error code will be returned for this
        problem. This is usually caused by a full disk.
     2. If the write is performed to STDOUT (handle 0001), it may be redirected
     3. To truncate the file at the current position of the file pointer, set the
        number of bytes in CX to zero before calling int 21h. The pointer can
        be moved to any desired position with function 42h.
     4. This function will not write to a file or device marked read-only.
     5. May also be used to display strings to CON instead of fn 09h. This
        function will write CX bytes and stop; fn 09h will continue to write
        until a $ character is found.
     6. This is the call that DOS actually uses to write to the screen in DOS 2.x
        and above.

Function  41h   Delete A File From A Specified Subdirectory              (UNLINK)
entry   AH      41h
        DS:DX   pointer to ASCIIZ filespec to delete
return  CF      0       successful
                1       error
                AX      error code if any  (02h, 05h)
note 1. This function will not work on a file marked read-only.
     2. Wildcards are not accepted.

Function  42h   Move a File Read/Write Pointer  (LSEEK)
entry   AH      42h
        AL      method code byte
                00h     offset from beginning of file
                01h     offset from present location
                02h     offset from end of file
        BX      file handle
        CX      most significant half of offset
        DX      least significant half of offset
return  AX      low offset of new file pointer
        DX      high offset of new file pointer
        CF      0       successful move
                1       error
                AX      error code (01h, 06h)
note 1. If pointer is at end of file, reflects file size in bytes.
     2. The value in DX:AX is the absolute 32 bit byte offset from the beginning
        of the file.

Function   43h  Get/Set file attributes  (CHMOD)
entry   AH      43h
        AL      00h     get file attributes
                01h     set file attributes
                CX      file attributes to set
                    bit 0       read only
                        1       hidden file
                        2       system file
                        3       volume label
                        4       subdirectory
                        5       written since backup (archive bit)
                        6,7     not used
                        8       shareable (Novell NetWare)
                        9,F     not used
        DS:DX   pointer to full ASCIIZ file name
return  CF      set if error
        AX      error code  (01h, 02h, 03h, 05h)
        CX      file attributes on get
                attributes:
                01h     read only
                02h     hidden
                04h     system
                0FFh    archive
```

```
note: This call will not change the volume label or directory bits.

Function  44h   I/O Control for Devices (IOCTL)
                Get or Set Device Information
entry   AH      44h
        AL      00h     Get Device Information
                        BX      file or device handle
                        return  DX      device info
                                  bit 7 set = character device
                                  bit 0       console input device
                                      1       console output device
                                      2       NUL device
                                      3       CLOCK$ device
                                      4       device is special
                                      5       binary (raw) mode
                                      6       not EOF
                                      12      network device (DOS 3.x)
                                      14      can process IOCTL control
                                              strings (subfns 2-5)
                                  bit 7 clear = file
                                  bit 0-5     block device number
                                      6       file has not been written
                                      12      Network device (DOS 3.x)
                                      14      unknown        (DOS 3.x)
                                      15      file is remote (DOS 3.x)
                01h     Set Device Information
                        BX      device handle
                        DH      0   (DH must be zero for this call)
                        DL      device info to set (bits 0-7 from
                                function 0)
                note    DX bits:
                        0    1  console input device
                        1    1  console output device
                        2    1  null device
                        3    1  clock device
                        4    1  reserved
                        5    0  binary mode - don't check for control chars
                             1  cooked mode - check for control chars
                        6    0  EOF - End Of File on input
                        7       device is character device if set, if not, EOF is
                                0 if channel has been  written, bits 0-5 are
                                block device number
                        12      network device
                        14   1  can process control strings (AL 2-5, can only be
                                read, cannot be set)
                        15   n  reserved
                02h     Read Character Device Control String
                        BX      device handle
                        CX      number of bytes to read
                        DS:DX   pointer to control string buffer
                        return  AX      number of bytes read
                03h     Write Device Control String
                        BX      device handle
                        CX      number of bytes to write
                        DS:DX   pointer to buffer
                        return  AX      number of bytes written
                04h     Read From Block Device (drive number in BL)
                        BL      drive number (0=default)
                        CX      number of bytes to read
                        DS:DX   pointer to buffer
                        return  AX      number of bytes read
                05h     Write Block Device Control String
                        BL      drive number (0=default)
                        CX      number of bytes to write
                        DS:DX   pointer to buffer
                        return  AX      number of bytes transferred
                06h     Get Input Handle Status
                        BX      file or device handle
                        return  AL      0FFh    device ready
                                        00h     device not ready
                07h     Get Output Handle Status
```

```
                return  AL      00h     not ready
                                0FFh    ready
                note    For DOS 2.x, files are always ready for output.
        08h     Removable Media Bit                              (DOS 3.x+)
                BL      drive number (0=default)
                return  AX      00h     device is removable
                                01h     device is nonremovable
                                0Fh     invalid drive specification
        09h     Test whether Local or Network Device             (DOS 3.x+)
                BL      drive number (0=default)
                return  DX      attribute word, bit 12 set if
                                device is remote
        0Ah     Is Handle in BX Local or Remote?                 (DOS 3.x+)
                BX      file handle
                return  DX (attribute word) bit 15 set if file is remote
                note    If file is remote, Novell Advanced NetWare
                        2.0 returns the number of the file server
                        on which the handle is located in CX.
        0Bh     Change  Sharing Retry Count to DX                (DOS 3.x+)
                CX      delay (default=1)
                DX      retry count (default=3)
        0Ch     General IOCTL (DOS 3.3 [3.2?]) allows a device
                driver to prepare, select, refresh, and query Code Pages
                BX      device handle
                CH      category code
                        00h     unknown (DOS 3.3)
                        01h     COMn:   (DOS 3.3)
                        03h     CON     (DOS 3.3)
                        05h     LPTn:
                CL      function
                        45h     set iteration count
                        4Ah     select code page
                        4Ch     start code-page preparation
                        4Dh     end code-page preparation
                        65h     get iteration count
                        6Ah     query selected code page
                        6Bh     query prepare list
                DS:DX   pointer to parameter block. Format:
           (for CL=45h) word    number of times output is
                                attempted driver assumes device is busy
  (for CL=4Ah,4Dh,6Ah) word     length of data
                        word    code page ID
           (for CL=4Ch) word    flags
                        word    length of remainder of parameter block
                        word    number of code pages following
                      n words   code page 1,...,N
           (for CL=6Bh) word    length of following data
                        word    number of hardware code pages
                      n words   hardware code pages 1,...,N
                        word    number of prepared code pages
                      n words   prepared code pages 1,...,N
        0Dh     Block Device Request                             (DOS 3.3+)
                BL      drive number (0=default)
                CH      category code
                        08h     disk drive
                CL      subfunction
                        40h     set device parameters
                        41h     write logical device track
                        42h     format and verify logical device
                        60h     get device parameters
                        61h     read logical device track
                        62h     verify logical device track
                DS:DX   pointer to parameter block
    (for fns 40h, 60h) byte     special functions
                            bit 0 set if fn to use current BPB, clear if
                                  Device BIOS Parameter Block field
                                  contains new default BPB
                                1 set if function to use track fields
                                  only. Must be clear if CL=60h
                                2 set if all sectors in track same size
                                  (should be set)
```

```
                                    3-7 reserved
                              byte    device type
                                      00h      320K/360K disk
                                      01h      1.2M disk
                                      02h      720K disk
                                      03h      single-density 8-inch disk
                                      04h      double-density 8-inch disk
                                      05h      fixed disk
                                      06h      tape drive
                                      07h      other type of block device
                              word    device attributes
                                 bit 0 set if nonremovable medium
                                     1 set if door lock supported
                                     2-15 reserved
                              word    number of cylinders
                              byte    media type
                                      00h 1.2M disk (default)
                                      01h 320K/360K disk
                           31 bytes   device BPB (see function 53h)
                              word    # of sectors per track (start of track
                                      layout field)
                       N word pairs:  number,size of each sector in track
     (for functions 41h, 61h) byte    reserved, must be zero
                              word    number of disk head
                              word    number of disk cylinder
                              word    number of first sector to
                                      read/write
                              word    number of sectors
                             dword    transfer address
     (for functions 42h, 62h) byte    reserved, must be zero
                              word    number of disk head
                              word    number of disk cylinder
                      note    DOS 4.01 seems to ignore the high byte of the
                              number of directory entries in the BPB for
                              diskettes.
              0Eh     Get Logical Device Map (DOS 3.2+)
                      BL      drive number (0=default)
                      return  AL=0 block device has only one logical drive
                              assigned 1..n the last letter used to
                              reference the device (1=A:,etc) (1..26 DOS 3.0+)
              0Fh     Set Logical Device Map (DOS 3.2+)
                      BL      physical drive number (0=default)
                      note    Maps logical drives to physical drives, similar
                              to DOS's treatment of a single physical
                              floppy drive as both A: and B:
        BL    drive number:  0=default, 1=A:, 2=B:, etc.
        BX    file handle
        CX    number of bytes to read or write
        DS:DX data or buffer
        DX    data
return  AX    number of bytes transferred
              or error code (call function 59h for extended error codes)
              or status  00h     not ready
                        0FFh     ready
        CF    set if error

Function  45h   Duplicate a File Handle (DUP)
entry   AH      45h
        BX      file handle to duplicate
return  CF      clear   AX      duplicate handle
                set     AX      error code  (04h, 06h)
note 1. If you move the pointed of one handle, the pointer of the other will also
        be moved.
     2. The handle in BX must be open.

Function  46h   Force Duplicate of a Handle (FORCEDUP or CDUP)
                Forces handle in CX to refer to the same file at the same
                position as BX
entry   AH      46h
        BX      existing file handle
        CX      new file handle
```

```
return  CF      clear   both handles now refer to existing file
                set     error
                AX      error code (04h, 06h)
note 1. If CX was an open file, it is closed first.
     2. If you move the read/write pointer of either file, both will move.
     3. The handle in BX must be open.

Function  47h   Get Current Directory
                Places full pathname of current directory/drive into a buffer
entry   AH      47h
        DL      drive (0=default, 1=A:, etc.)
        DS:SI   pointer to 64-byte buffer area
return  CF      clear   DS:DI   pointer to ASCIIZ pathname of current directory
                set     AX      error code (0Fh)
note:   String does not begin with a drive identifier or a backslash.

Function  48h   Allocate Memory
                Allocates requested number of 16-byte paragraphs of memory
entry   AH      48h
        BX      number of 16-byte paragraphs desired
return  CF      clear   AX      segment address of allocated space
                        BX      maximum number paragraphs available
                set     AX      error code (07h, 08h)
note:   BX indicates maximum memory availible only if allocation fails.

Function  49h   Free Allocated Memory
                Frees specified memory blocks
entry   AH      49h
        ES      segment address of area to be freed
return  CF      clear   successful
                set     AX      error code (07h, 09h)
note 1. This call is only valid when freeing memory obtained by function 48h.
     2. A program should not try to release memory not belonging to it.

Function  4Ah   Modify Allocated Memory Blocks (SETBLOCK)
                Expand or shrink memory for a program
entry   AH      4AH
        BX      new size in 16 byte paragraphs
        ES      segment address of block to change
return  CF      clear   nothing
                set     AX      error code (07h, 08h, 09h)
                    or  BX      max number paragraphs available
note 1. Max number paragraphs availible is returned only if the call fails.
     2. Memory can be expanded only if there is memory available.

Function  4Bh   Load or Execute a Program  (EXEC)
entry   AH      4Bh
        AL      00h     load and execute program. A PSP is built for the
                        program the ctrl-break and terminate addresses are set to
                        the new PSP.
               *01h     load but don't execute (internal, DOS 3.x & DESQview)
                        (see note 1)
               *02h     load but do not execute (internal, DOS 2.x only)
                03h     load overlay (do not create PSP, do not begin execution)
        DS:DX   points to the ASCIIZ string with the drive, path, and filename to
                be loaded
        ES:BX   points to a parameter block for the load
               (AL=00h) word     segment address of environment string to passed
                                 (0=use current)
                        dword    pointer to the command line to be placed at
                                 PSP+80h
                        dword    pointer to default FCB to be passed at PSP+5Ch
                        dword    pointer to default FCB to be passed at PSP+6Ch
              (*AL=01h) word     segment of environment (0 = use current)
                        dword    pointer to command line
                        dword    pointer to FCB 1
                        dword    pointer to FCB 2
         (DOS 3.x+)     dword    will hold SS:SP on return
         (DOS 3.x+)     dword    will hold program entry point (CS:IP) on return
              (*AL=02h) word     segment of environment (0 = use current)
                        dword    pointer to command line
```

```
                         dword    pointer to FCB 1
                         dword    pointer to FCB 2
                (AL=03h) word     segment address where file will be loaded
                         word     relocation factor to be applied to the image
return  CF      set      error
                         AX       error code (01h, 02h, 05h, 08h, 0Ah, 0Bh)
        CF      clear    if successful
                for fn 00h, process ID set to new program's PSP; get with function
                         62h
                for fn 01h and DOS 3.x+ or DESQview, process ID set to program's
                         PSP; get with function 62h
                for fn 01h and DOS 2.x, new program's initial stack and entry
                         point returned in registers
                for fn 02h, new program's initial stack and entry point are
                         returned in the registers
```

note 1. If you make this call with AL=1 the program will be loaded as if you made the call with AL=0 except that the program will not be executed. Additionally, with AL=1 the stack segment and pointer along with the program's CS:IP entry point are returned to the program which made the 4B01h call. These values are put in the four words at ES:BX+0Eh. On entry to the call ES:BX points to the environment address, the command line and the two default FCBs. This form of EXEC is used by DEBUG.COM.

2. Application programs may invoke a secondary copy of the command processor (normally COMMAND.COM) by using the EXEC function. Your program may pass a DOS command as a parameter that the secondary command processor will execute as though it had been entered from the standard input device. The procedure is:
   A. Assure that adequate free memory (17k for 2.x and 3.0, 23k for 3.1 up) exists to contain the second copy of the command processor and the command it is to execute. This is accomplished by executing function call 4Ah to shrink memory allocated to that of your current requirements. Next, execute function call 48h with BX=0FFFFh. This returns the amount of memory available.
   B. Build a parameter string for the secondary command processor in the form:

```
                  1 byte   length of parameter string
                 xx bytes  parameter string
                  1 byte   0Dh (carriage return)
```

   For example, the assembly language statement below would build the string to cause execution of the command FOO.EXE:

```
                         DB 19,"/C C:FOO",13
```

   C. Use the EXEC function call (4Bh), function value 0 to cause execution of the secondary copy of the command processor. (The drive, directory, and name of the command processor can be gotten from the COMSPEC variable in the DOS environment passed to you at PSP+2Ch.)
   D. Remember to set offset 2 of the EXEC control block to point to the string built above.

3. All open files of a process are duplicated in the newly created process after an EXEC, except for files originally opened with the inheritance bit set to 1.

4. The environment is a copy of the original command processor's environment. Changes to the EXECed environment are not passed back to the original. The environment is followed by a copy of the DS:DX filename passed to the child process. A zero value will cause the child process to inherit the environment of the calling process. The segment address of the environment is placed at offset 2Ch of the PSP of the program being invoked.

5. This function uses the same resident part of COMMAND.COM, but makes a duplicate of the transient part.

6. How EXEC knows where to return to: Basically the vector for int 22h holds the terminate address for the current process. When a process gets started, the previous contents of int 22h get tucked away in the PSP for that process, then int 22h gets modified. So if Process A EXECs process B, while Process B is running, the vector for int 22h holds the address to return to in Process A, while the save location in Process B's PSP holds the address that process A will return to when *it* terminates. When Process B terminates by one of the usual legal means, the contents of int 22h are (surmising) shoved onto the stack, the old terminate vector contents are copied back to int 22h vector from Process B's PSP, then a RETF or equivalent is executed to return control to process A.

```
    7. To load an overlay file with 4B: first, don't de-allocate the memory that
       the overlay will load into. With the other 4Bh functions, the opposite
       is true--you have to free the memory first, with function 4Ah. Second,
       the 'segment address where the file will be loaded' (first item in the
       parameter block for sub-function 03) should be a paragraph boundary
       within your currently-allocated memory. Third, if the procedures within
       the overlay are FAR procs (while they execute, CS will be equal to the
       segment address of the overlay area), the relocation factor should be
       set to zero. On the other hand, if the CS register will be different
       from the overlay area's segment address, the relocation factor should be
       set to represent the difference. You  determine where in memory the
       overlay file will load by using the segment address mentioned above.
       Overlay files are .EXEs (containing header, relocation table, and memory
       image).
    8. When function 00h returns, all registers are changed, including the
       stack. You must resore SS, SP, and any other required registers.
    9. PCDOS EXEC function 3 (overlay) lives in the transient piece of
       COMMAND.COM and gets loaded when needed, thus the requirement for enough
       free space to load the EXEC loader (about 1.5k). Under MSDOS the EXEC
       system call lives in system space.
   10. If you try to overlay an .EXE file with the high/low switch set to load
       the in high memory nothing will happen. The high/Low switch is only for
       process creation, not for overlays.
   11. DOS 2.x destroys all registers, including SS:SP.

Function  4Ch   Terminate a Process (EXIT)
                Quit with ERRORLEVEL exit code
entry   AH      4Ch
        AL      exit code in AL when called, if any, is passed to next process
return  none
note 1. Control passes to DOS or calling program.
     2. Return code from AL can be retrieved by ERRORLEVEL or function 4Dh.
     3. All files opened by this process are closed, buffers are flushed, and the
        disk directory is updated.
     4. Restores: Terminate vector from PSP:000Ah
                  Ctrl-C vector from PSP:000Eh
                  Critical Error vector from PSP:0012h

Function  4Dh   Get Return Code of a Subprocess (WAIT)
                Gets return code from functions 31h and 4Dh  (ERRORLEVEL)
entry   AH      4Dh
return  AL      exit code of subprogram (functions 31h or 4Ch)
        AH      circumstance which caused termination
                00h     normal termination
                01h     control-break or control-C
                02h     critical device error
                03h     terminate and stay resident (function 31h)
note    The exit code is only returned once (the first time).

Function  4Eh   Find First Matching File (FIND FIRST)
entry   AH      4Eh
        CX      search attributes
        DS:DX   pointer to ASCIIZ filename (with attributes)
return  CF      set     AX      error code (02h, 12h)
                clear   data block written at current DTA
                        format of block is:  (info from BIX)
  documented by Micro-  |00h      1 byte   attribute byte of search
  soft as 'reserved for |01h      1 byte   drive letter for search
  DOS' use on subsquent |02h     11 bytes  the search name used
  Find Next calls'      |0Ch      2 bytes  word value of last entry
  function 4Fh          |0Fh      4 bytes  dword pointer to this DTA
                        |13h      2 bytes  word directory start
                        | PC-DOS 3.10 (from INTERRUP.ARC)
                        |00h      1 byte   drive letter
                        |01h-0Bh   bytes   search template
                        |0Ch      1 byte   search attributes
                        | DOS 2.x (and DOS 3.x except 3.1?)
                        |00h      1 byte   search attributes
                        |01h      1 byte   drive letter
                        |02h-0Ch   bytes   search template
                        |0Dh-0Eh 2 bytes  entry count within directory
```

```
                                |0Fh-12h 4 bytes  reserved
                                |13h-14h 2 bytes  cluster number of parent directory

                                 15h    1 byte   file attribute
                                 16h    2 bytes  file time
                                 18h    2 bytes  file date
                                 1Ah    2 bytes  low word of file size
                                 1Ch    2 bytes  high word of file size
                                 1Eh   13 bytes  name and extension of file found, plus
                                                 1 byte of 0s. All blanks are moved from
                                                 the name and extension, and if an
                                                 extension is present it is preceded by a
                                                 period.
note 1. This function does not support network operations.
     2. Wildcards are allowed in the filespec.
     3. If the attribute is zero, only ordinary files are found. If the volume
        label bit is set, only volume labels will be found. Any other attribute
        will return that attribute and all normal files together.
     4. To look for everything except the volume label, set the hidden, system,
        and subdirectory bits all to 1.

Function  4Fh    Find Next Matching File (FIND NEXT)
                 Find next ASCIIZ file
entry   AH       4Fh
return  CF       clear   data block written at current DTA
                 set     AX       error code (02h, 12h)
note 1. If file found, DTA is formatted as in call 4Eh
     2. Volume label searches using 4Eh/4Fh reportedly aren't 100% reliable under
        DOS 2.x. The calls sometime report there's a volume label and point to a
        garbage DTA, and if the volume label is the only item they often won't
        find it. Most references recommend the use of the older FCB calls for
        dealing with the volume labels.
     3. This function does not support network operations.
     4. Use of this call assumes that the original filespec contained wildcards

Function  50h    'Used Internally by DOS' - Set PSP
 *               Set new Program Segment Prefix (current Process ID)
entry   AH       50h
        BX       segment address of new PSP
return  none - swaps PSPs regarded as current by DOS
note 1. By putting the PSP segment value into BX and issuing call 50h DOS stores
        that value into a variable and uses that value whenever a file call is
        made.
     2. Note that in the PSP (or PDB) is a table of 20 (decimal) open file
        handles. The table starts at offset 18h into the PSP. If there is an
        0FFh in a byte then that handle is not in use. A number in one of the
        bytes is an index into an internal FB table for that handle. For
        instance the byte at offset 18h is for handle 0, at offset 19h handle 1,
        etc. up to 13h. If the high bit is set then the file associated by the
        handle is not shared by child processes EXEC'd with call 4Bh.
     3. Function 50h is dangerous in background operations prior to DOS 3.x as it
        uses the wrong stack for saving registers (same as functions 0..0Ch in
        DOS 2.x)
     4. Under DOS 2.x, this function cannot be invoked inside an int 28h handler
        without setting the Critical Error flag.
     5. Open File information, etc. is stored in the PSP DOS views as current. If
        a program (eg. a resident program) creates a need for a second PSP, then
        the second PSP should be set as current to make sure DOS closes that as
        opposed to the first when the second application finishes.
     6. See PC Mag Vol.5, No 9, p.314 for discussion, also used in BCOPY.ASM
     7. Used by DOS 3.3 PRINT & DEBUG, DesQview 2.01, Windows 1.03, SYMDEB from
        MASM 4.0.

Function  51h    "Used Internally by DOS" - Get Program Segment Prefix
 *               Returns the PSP address of currently executing program
entry   AH       51h
return  BX       address of currently executing program
                 offset
                 00h   2 bytes   program exit point
                 02h   word      memory size in paragraphs
                 04h   byte      unused (0)
```

```
                    05h   5 bytes   CP/M style entry point (far call to DOS)
                    0Ah   word      terminate address (old int 22h)
                    0Ch   word      terminate segment
                    0Eh   word      break address (old int 23h)
                    10h   word      break segment
                    12h             error address (old int 24h)
                    14h             error segment
                    16h   word      parent PSP segment
                    18h   20 bytes  DOS 2.0+ open files, 0FFh = unused
                    2Ch   word      DOS 2.0+ environment segment
                    2Eh   dword     far pointer to process's SS:SP
                    32h   word      DOS 3.x+ max open files
                    34h             DOS 3.x+ open file table address
                    36h   dword     DOS 3.x+ open file table segment
                    38h   24 bytes  unused by DOS versions before 3.3
                    50h   3 bytes   DOS function dispatcher (FAR routine)
                    53h   9 bytes   unused
                    55h             FCB #1 extension
                    5Ch   16 bytes  FCB #1, filled in from first cmdline argument
                    6Ch   20 bytes  FCB #2, filled in from second cmdline argument
                    80h  128 bytes  command tail / default DTA buffer
note 1. Used in DOS 2.x, 3.x uses 62h.
     2. Function 51h is dangerous in background operations prior to DOS 3.x as it
        uses the wrong stack for saving registers (same as functions 0..0Ch in
        DOS 2.x)
     3. 50h and 51h might be used if you have more than one process in a PC. For
        instance if you have a resident program that needs to open a file you
        could first call 51h to save the current ID and then call 50h to set the
        ID to your PSP.
     4. Under DOS 2.x, this function cannot be invoked inside an int 28h handler
        without setting the Critical Error flag.
     5. Used by DOS 3.3 PRINT, DEBUG.

Function  52h   'Used Internally by DOS' - IN-VARS
 *              Returns a FAR pointer to a linked list of DOS data variables
entry    AH     52h
return   ES:BX  pointer to the DOS list of lists, for disk information. Does not
                access the disk, so information in tables might be incorrect if
                disk has been changed. Returns a pointer to the following array
                of longword pointers:
                Bytes   Value          Description
      (common) -02h     word     segment of first memory control block available
                                 through MALLOC
                00h     dword    far pointer to first DOS Disk Parameter Block
                04h     dword    far pointer to linked list of DOS open file
                                 tables. (Open File Table List)
                08h     dword    far pointer to CLOCK$: device driver, whether
                                 installable or resident
                0Ch     dword    far pointer to actual CON: device driver, whether
                                 installable or resident
        (DOS 2.x only)
                10h     word     number of logical drives in system
                11h     word     largest logical sector size supported
                13h     dword    far pointer to first disk buffer used by
                                 the logical drives. The size of each
                                 sector buffer is equal to the logical
                                 sector size plus a 16 byte header.
                                 (Sector Buffer Header) The number of
                                 these buffers is set by CONFIG.SYS.
                                 (Sector Buffer Structure)
                17h     ----     beginning (not a pointer. The real
                                 beginning!) of NUL device driver. This
                                 is the first device on DOS's linked list
                                 of device drivers.
        (DOS 3.x+)
                10h     word     largest logical sector sector size
                                 supported (most versions of DOS are
                                 hardcoded to 200h)
                12h     dword    far pointer to sector buffer structure
                                 used by the logical drives. (Sector
                                 Buffer Structure)
```

16h	dword	far pointer to drive path and seek information table. (Drive Path Table)
1Ah	dword	far pointer to a table of FCBs. This table is only valid if FCBS=xx was used in CONFIG.SYS
1Eh	word	size of FCB table
20h	byte	number of logical drives presently supported
21h	byte	value of LASTDRIVE= in CONFIG.SYS (default 5)
22h	----	beginning (not a pointer-the real beginning!) of the NUL device driver. This is the first device on DOS's linked list of device drivers.

note 1. This call is not supported in OS/2 1.0's DOS Compatibility Box.
2. Used by DOS 4.0 MEM.EXE, DOS 3.3 ASSIGN.COM, PRINT.COM, SUBST.EXE.
3. Disk Parameter Block

offset	size	description
00h	byte	disk unit number, 0=A, 1=B, etc. If this and the next byte are 0FFh this entry is the end of the list and is not valid
01h	byte	disk unit number passed to the block device driver responsible for this logical drive
02h	word	the drive's logical sector size in bytes
04h	byte	number of sectors per cluster -1. The number of sectors per cluster must be a power of 2
05h	byte	allocation shift. The shift value used to calcu late the number of sectors from the number of clusters without having to use division. Number of sectors = number of clusters < allocation shift.
06h	word	number of reserved sectors at the beginning of the logical drive. May contain partition information.
08h	byte	number of FATs. Default 2
09h	word	number of root directory entries
0Bh	word	first sector containing data (disk files)
0Dh	word	last cluster number. Number of clusters in data area +1. If less than 0FF6h the FAT uses 12-bit directory entries, otherwise 16 bit entries
0Fh	byte	FAT size. Size of one FAT in logical sectors
10h	word	sector number of first root directory entry
12h	dword	far pointer to the block device driver
16h	byte	media descriptor byte (see Chapter 8)
17h	byte	media flag. If this is 0, the drive has been accessed. If it is -1 or set to -1 DOS will rebuild all data structures associated with this drive on the next access
18h	dword	far pointer to the next Disk Parameter Block

4. Open File Table List

offset	size	description
00h	dword	far pointer to the next table in the list. If the offset of this pointer is 0FFFFh, then the next table is the final entry and invalid
04h	word	number of table entries. Each table entry is 53 bytes long. There will be at least one entry in each table except the terminal entry
06h	---	beginning of the Open File Table entries (note 5)

5. Open File Table Entry (35h bytes long)

offset	size	description
00h	word	number of file handles referring to this file
02h	byte	access mode (see function 3Dh)
03h	word	unknown
05h	word	Device Information Word (see function 44h/00h)
06h	dword	far pointer to device info header if this is a character device. If block device, this will be a far pointer to the Disk Parameter Block
07h	dword	pointer to device driver header if character device; pointer to DOS Device Control Block if block device

```
        0Bh      word    starting cluster of file
        0Dh      word    file time in packed format
        0Fh      word    file date in packed format
        11h      dword   file size
        15h      dword   current offset in file
        19h      word    unknown
        1Bh      word    last cluster read
        1Dh      word    number of sector containing directory entry
        1Fh      byte    offset of directory entry within sector (byte offset/32)
        20h   11 bytes   filename in FCB format (no path, no period, blank padded)
        2Bh    6 bytes   PSP segment of file's owner
        2Dh    3 bytes   unknown - normally 0
        31h      word    PSP segment of file's owner
        33h-34h word     unknown - normally 0

     6. Sector Buffer Header:    (DOS 2.x+)
        offset  size     description
        00h      dword   pointer to next disk buffer, 0FFFFh if last
        04h    4 bytes   unknown
        08h      word    logical sector number
        10h    2 bytes   unknown
        12h      dword   pointer to DOS Device Control Block
     7. Sector Buffer Structure, followed by 512 byte buffer
        offset  size     description
        00h      dword   far pointer to the next sector buffer. Buffers are filled
                         in the order of their appearance on this linked list.
                         The last buffer is valid and has the value 0FFFFFFFFh
        04h      byte    drive number. This is the drive that the data currently
                         in the buffer refers to. 0FFh if never used.
        05h      byte    data type flags. Bit fields which show the area of the
                          drive the buffer refers to
                    bits 1       FAT data
                         2       subdirectory data
                         3       file data
                         5       contents of buffer may be overwritten if set
        06h      word    logical sector number of buffered data
        08h      word    access number
        0Ah      dword   far pointer to Disk Parameter Block
        0Eh      word    not used, normally 0

     8. Drive Path Table Entry   (array, one 51h-byte entry per drive):
        offset  size     description
        00h   64 bytes   current default ASCIIZ pathname with drive letter, colon,
                         and leading backslash
        44h      byte    flags byte. All valid entries contain a 40h, last entry
                         contains 00h
        45h      dword   far pointer to current Disk Parameter Block
        49h      word    current block or track/sector number for this directory.
                         0 if root dir, -1 if never accessed
        4Bh      dword   unknown. Usually -1
        4Fh      word    offset of '\' in current path field representing root of
                         directory of logical drive (2 if not SUBSTed or JOINed,
                         otherwise number of bytes in SUBST/JOIN path)

Function  53h   "Used Internally by DOS" - Translate BPB
 *              Translates BPB (BIOS Parameter Block, see below) into a DOS Disk
                Block (see function call 32h).
entry   AH      53h
        DS:SI   pointer to BPB (BIOS Parameter Block)
        ES:BP   pointer to area for DOS Disk Block
                Layout of Disk Block:
                bytes        value
                00h-01h bytes per sector, get from DDB bytes 02h-03h.
                02h     sectors per cluster, get from (DDB byte 4) + 1
                03h-04h reserved sectors, get from DDB bytes 06h-07h
                05h     number of FATs, get from DDB byte 08h
                06h-07h number of root dir entries, get from DDB bytes 09h-0Ah
                08h-09h total number of sectors, get from:
                        ((DDB bytes 0Dh-0Eh) - 1) * (sectors per cluster (BPB
                        byte 2)) + (DDB bytes 0Bh-0Ch)
                0Ah     media descriptor byte, get from DDB byte 16h
```

```
                0Bh-0Ch number of sectors per FAT, get from DDB byte 0Fh
return  unknown

Function  54h   Get Verify Setting
                Get verify flag status
entry   AH      54h
return  AL      00h if flag off
                01h if flag on
note    Flag can be set with function 2Eh.

Function  55h   'Used Internally by DOS' - Create 'Child' PSP
 *              Create PSP: similar to function 26h (which creates a new
                Program Segment Prefix at segment in DX) except creates a 'child'
                PSP rather than copying the existing one.
entry   AH      55h
        DX      segment number at which to create new PSP.
return  unknown
note 1. This call is similar to call 26h which creates a PSP except that unlike
        call 26h the segment address of the parent process is obtained from the
        current process ID rather than from the CS value on the stack (from the
        INT 21h call). DX has the new PSP value and SI contains the value to be
        placed into PSP:2 (top of memory).
     2. Function 55 is merely a substitute for function 26h. It will copy the
        current PSP to the segment address DX with the addition that SI is
        assumed to hold the new memory top segment. This means that function
        26h sets SI to the segment found in the current PSP and then calls
        function 55h.

Function  56h   Rename a File
entry   AH      56h
        DS:DX   pointer to ASCIIZ old pathname
        ES:DI   pointer to ASCIIZ new pathname
return  CF      clear   successful rename
                set     AX      error code (02h, 03h, 05h, 11h)
note 1. Works with files in same logical drive only.
     2. Global characters not allowed in filename.
     3. The name of a file is its full pathname. The file's full pathname can be
        changed, while leaving the actual FILENAME.EXT unchanged. Changing the
        pathname allows the file to be 'moved' from subdirectory to subdirectory
        on a logical drive without actually copying the file.
     4. DOS 3.x allows renaming of directories.

Function  57h  Get/Set a File's Date and Time
               Read or modify time and date stamp on a file's directory entry
entry   AH      57h
        AL      function code
                00h     Get Date and Time
                01h     Set Date and Time
                        CX      time to be set
                        DX      date to be set
                02h     unknown (DOS 4.0+)
                03h     unknown
                04h     unknown (DOS 4.0+)
        BX      file handle
return  CF      clear   CX      time of last write (if AL = 0)
                        DX      date of last write (if AL = 0)
                set     AX      error code (01h, 06h)
note    Date/time formats are:
        CX bits 0Bh-0Fh hours (0-23)    DX bits 09h-0Fh year (relative to
                                                        1980)
                05h-0Ah minutes (0-59)          05h-08h month (0-12)
                00h-04h #2 sec. incr. (0-29)    00h-04h day of the month
                                                        (0-31)

Function  58h   Get/Set Allocation Strategy   (DOS 3.x+)
entry   AH      58h
        AL      00h     Get Current Strategy
                01h     Set New Current Strategy
        BL      new strategy if AH=1
                00h     First Fit - chooses the lowest block in memory which will
                        fit (this is the default) (use first memory block large
```

```
                        enough)
                01h     Best Fit - chooses the smallest block which will fill the
                        request.
                02h     Last Fit - chooses the highest block which will fit.
return  CF      clear   (0)     successful
                set     (1)     error
                                AX      error code (01h)
        AX      strategy code (CF=0)
note 1. Documented in Zenith DOS version 3.1, some in Advanced MSDOS.
     2. The set subfunction accepts any value in BL; 2 or greater means last fit.
        The get subfunction returns the last value set, so programs should check
        whether the value is greater than or equal to 2.
```

Function 59h Get Extended Error Code (DOS 3.x+)
The Get Extended Error function call (59h) is intended to provide a commonset of error codes and to supply more extensive information about the error to the application. The information returned from function call 59h, in addition to the error code, is the error class, the locus, and the recommended action. The error class provides information about the error type (hardware, internal, system, etc.). The locus provides information about the area involved in the failure (serial device, block device, network, or memory). The recommended action provides a default action for programs that do not understand the specific error code.

Newly written programs should use the extended error support both from interrupt 24h hard error handlers and after any int 21h function calls. FCB function calls report an error by returning 0FFh in AL. Handle function calls report an error by setting the carry flag and returning the error code in AX. Int 21h handle function calls for DOS 2.x continue to return error codes 0-18. Int 24h handle function calls continue to return error codes 0-12. But the application can obtain any of the error codes used in the extended error codes table by issuing function call 59h. Handle function calls for DOS 3.x can return any of the error codes. However, it is recommended that the function call be followed by function call 59h to obtain the error class, the locus, and the recommended action.

The Get Extended Error function (59h) can always be called, regardless of whether the previous DOS call was old style (error code in AL) or new style (carry bit). It can also be used inside an int 24h handler. You can either check AL or the carry bit to see if there was no error, and call function 59h only if there was an error, or take the simple approach of always calling 59h and letting it tell you if there was an error or not. When you call function 59h it will return with AX=0 if the previous DOS call was successful.

```
entry   AH      59h
        BX      version code (0000 for DOS 3.0 and 3.1)
return  AX      extended error code:
                01h     Invalid function number
                02h     File not found
                03h     Path not found
                04h     Too many open files, no file handles left
                05h     Access denied
                06h     Invalid handle
                07h     Memory control blocks destroyed
                08h     Insufficient memory
                09h     Invalid memory block address
                0Ah     Invalid environment
                0Bh     Invalid format
                0Ch     Invalid access code
                0Dh     Invalid data
                0Eh     Reserved
                0Fh     Invalid drive was specified
                10h     Attempt to remove the current directory
                11h     Not same device
                12h     No more files
                13h     Attempt to write on write-protected diskette
                14h     Unknown unit
                15h     Drive not ready
                16h     Unknown command
                17h     Bad CRC check
                18h     Bad request structure length
                19h     Seek error
                1Ah     Unknown media type
```

	1Bh	Sector not found
	1Ch	Printer out of paper
	1Dh	Write fault
	1Eh	Read fault
	1Fh	General Failure
	20h	Sharing violation
	21h	Lock violation
	22h	Invalid disk change
	23h	FCB unavailable
	24h	Sharing buffer overflow
	25h	Reserved
	26h	"
	27h	"
	28h	"
	29h	"
	2Ah	"
	2Bh	"
	2Ch	"
	2Dh	"
	2Eh	"
	2Fh	"
	30h	"
	31h	Reserved
	32h	Network: request not supported (DOS 3.1 + MS Networks)
	33h	Remote computer not listening
	34h	Duplicate name on network
	35h	Network: name not found
	36h	Network: busy
	37h	Network: device no longer exists
	38h	NETBIOS command limit exceeded
	39h	Network: adapter hardware error
	3Ah	Incorrect response from network
	3Bh	Unexpected network error
	3Ch	Incompatible remote adapter
	3Dh	Print queue full
	3Eh	Not enough space for print file
	3Fh	Print file was deleted
	40h	Network: name was deleted
	41h	Network: Access denied
	42h	Network: device type incorrect
	43h	Network: name not found
	44h	Network: name limit exceeded
	45h	NETBIOS session limit exceeded
	46h	Temporarily paused
	47h	Network: request not accepted
	48h	Print or disk redirection paused (DOS 3.1 + MS Networks)
	49h	Reserved
	4Ah	"
	4Bh	"
	4Ch	"
	4Dh	"
	4Eh	"
	4Fh	Reserved
	50h	File exists
	51h	Reserved
	52h	Cannot make directory entry
	53h	Fail on interrupt 24h
	54h	Too many redirections
	55h	Duplicate redirection
	56h	Invalid password
	57h	Invalid parameter
	58h	Network: device fault
BH	class of error:	
	01h	Out of resource
	02h	Temporary situation
	03h	Authorization (denied access)
	04h	Internal
	05h	Hardware failure
	06h	System failure

```
                07h     Application program error
                08h     Not found
                09h     Bad format
                0Ah     Locked
                0Bh     Media error (wrong volume ID, disk failure)
                0Ch     Already exists
                0Dh     Unknown
        BL      suggested action code:
                01h     Retry
                02h     Delayed retry
                03h     Prompt user
                04h     Abort after cleanup
                05h     Immediate abort
                06h     Ignore
                07h     Retry after user intervention
        CH      locus (where error occurred):
                01h     Unknown or not appropriate
                02h     Block device
                03h     Network related
                04h     Serial device
                05h     Memory related
note 1. Not all DOS functions use the carry flag to indicate an error. Carry
        should be tested only on those functions which are documented to use it.
     2. None of the DOS functions which existed before 2.0 use the carry
        indicator. Many of them use register AL as an error indication instead,
        usually by putting 0FFh in AL on an error. Most, but not all, the 'new'
        (2.x, 3.x) functions do use carry, and most, but not all, of the 'old'
        (1.x) functions use AL.
     3. On return, CL, DI, DS, DX, ES, BP, and SI are destroyed - save before
        calling this function if required.
     4. DOS 2.x Error Codes:  If you are using function calls 38h-57h with DOS
        2.x, to check if an error has occurred, check for the following error
        codes in the AX register:
```

call	error code	call	error code	call	error code
38h	2	41h	2,3,5	4Ah	7,8,9
39h	3,5	42h	1,6	4Bh	1,2,3,5,8,10,11
3Ah	3,5,15	43h	1,2,3,5	4Eh	2,3,18
3Bh	3	44h	1,3,5,6	4Fh	18
3Ch	3,4,5	45h	4,6	56h	2,3,5,17
3Dh	2,3,4,5,12	46h	4,6	57h	1,6
3Eh	6	47h	15		
3Fh	5,6	48h	7,8		
40h	5,6	49h	7,9		

```
    5. Note that extended error codes 13h through 1Fh correspond to error codes
       00h through 0Ch returned by int 24h.

Function  5Ah   Create Temporary File
                Create unique filename (for temporary use) (DOS 3.x)
entry   AH      5Ah
        DS:DX   pointer to ASCIIZ directory pathname ending with a
                 backslash (\)
        CX      file attribute
return  CF      clear   DS:DX   new ASCIIZ pathname
                        AX      handle
                set     AX      error code (03h, 05h)
note 1. The file created is not truly 'temporary'. It must be removed by the user.
     2. If the filename created already exists in the current directory, this
        function will call itself again with another unique filename until a
        unique filename is found.
     3. The temporary filename usually consists of mixed letters and numbers. No
        file extension appears to be generated.

Function  5Bh   Create a New File   (DOS 3.x+)
entry   AH      5Bh
        DS:DX   pointer to directory ASCIIZ pathname
        CX      file attribute
return  CF      clear   AX      file handle
                        DS:DX   new ASCIIZ pathname
                set     AX      error code (03h, 04h, 05h, 50h)
note 1. Unlike function 3Ch, function 5Bh will fail if the file already exists.
     2. The new file is opened in read/write mode.
```

```
Function  5Ch   Lock/Unlock File Access   (DOS 3.x+)
entry   AH      5Ch
        AL      00h     To lock file
                01h     To unlock file
        BX      file handle
        CX:DX   starting offset of region to lock
        SI:DI   size of region  to lock
return  CF      clear   successful
                set     AX      error code (01h, 06h, 21h)
note 1. Close all files before exiting or undefined results may occur.
     2. Programs spawned with EXEC inherit all the parent's file handles but not
        the file locks.

Function  5Dh   undocumented - Multifunction
 *              DOS  Internal - partial (DOS 3.x+)
entry   AH      5Dh
        AL      subfunction
                00h     Indirect Function Call
                        DS:DX   pointer to buffer containing register values AX,
                                BX, CX, DX, SI, DI, DS, ES for a call to int 21h
                        return  as appropriate for function being called
                        note    Does not check AH. Out of range values will crash
                                the system.
                01h     SYNC?  (DOS 3.1+)
                        parameters unknown
                        note 1. Does something to each disk file in the System
                                File Table which has been written to.
                             2. If remote file, calls int 2Fh/fn1107h.
                             3. Seems to update the time stamp of all open files
                                which have been written to.
                02h-05h Network functions? (DOS 3.1+)
                        parameters unknown
                        note    Error unless network is loaded.
                06h     Get Address of Critical Error Flag
                        return  CX      unknown value
                                DX      unknown value
                                DS:SI   pointer to critical error flag
                08h     (unknown - used by COMMAND.COM)
                09h     (unknown - used by COMMAND.COM)
                0Ah     Set Error Info (Error, Class, Action, and Locus)
                        DS:DX   address of 11-word error information table
                                words 0 to 7: values of AX, BX, CX, DX, SI, DI,
                                              DS, ES that function 59h will
                                              return
                                words 8 to 10: zero (reserved)
return  CX      unknown
        DX      unknown
        DS:SI   (for 06h) pointer to critical error flag
note 1. This call seems to have many different functions.
     2. Function 0Ah; DOS 3.1+.
     3. Function 06h; setting CritErr flag allows use of functions 50h/51h from
        int 28h under DOS 2.x by forcing the use of the correct stack.
     4. Functions 07h, 08h, 09h are identical in DOS 3.1 and call int 2Fh fn1125h.

Function  5Eh   Network Printer  (Partially documented by Microsoft)
                DOS 3.1+ with Networks software
entry   AH      5Eh
        AL      00      Get Machine Name
                        DS:DX   pointer to 16-byte buffer for ASCIIZ name
                        return  CH      0       if name not defined
                                CL      NETBIOS name number if CH  0
                                DS:DX   pointer to identifier if CH  0
                        note    the ASCIIZ name is a 15 byte string padded to
                                length with zeroes
                01      Set Machine Name
                        DS:DX   pointer to ASCIIZ name
                        CH      unknown
                        CL      name number
                02      Set Printer Control String
                        BX      redirection list index
                        CX      length of setup string (max 64 bytes)
```

```
                         DS:SI   pointer to string buffer
               03        Get Printer Control String
                         BX      redirection list index
                         ES:DI   pointer to string buffer
                         return  CX      length of setup string (max 64 bytes)
return  CF     clear     successful
               set       error
                         AX      error code (01h for all listed subfunctions)
note 1. Used in IBM's & Microsoft's Network programs.
     2. Partial documentation in Fall 1985 Byte.
     3. These services require that the network software be installed.
     4. Partial documentation in Advanced MS-DOS.
     5. SHARE must be loaded or results can be unpredictable on 00h, or fail with
        02h or 03h.

Function  5Fh  Network Redirection
               (DOS 3.1 + Microsoft Networks)
entry   AH     5Fh
        AL    *00h       Unknown
              *01h       Unknown
               02h       Get Redirection List Entry
                         BX      redirection list index
                         DS:SI   pointer to 16 byte buffer for local device name
                         ES:DI   pointer to 128 byte buffer for network name
                         return  BH      device status flag (bit 0=0 if valid)
                                                            (bit 0=1 if invalid)
                                 BL      device type
                                         03      printer device
                                         04      drive device
                                 CX      stored parameter value (user data)
                                 DS:SI   pointer to 16 byte local device
                                         name
                                 ES:DI   pointer to 128 byte network name
                         note    DX and BP are destroyed by this call!
               03h       Redirect Device - Make Assign List Entry
                         Redirects a workstation drive or device to a server
                         directory or device.
                         BL      device type
                                 03      printer device
                                 04      file device
                         CX      stored parameter value
                         DS:SI   pointer to ASCIIZ source device name
                         ES:DI   pointer to destination ASCIIZ network path +
                                 ASCIIZ password
               04h       Cancel Redirection Assignment
                         DS:SI   pointer to ASCIIZ device name or network path to
                                 be cancelled
return  CF     clear     successful
               set       if error
                         AX      error code
                                 (fn 02h) 01h, 12h
                                 (fn 03h) 01h, 03h, 05h, 08h
                                 (fn 04h) 01h, 0Fh
note 1. Used in IBM's Network program.
     2. Partial documentation in Fall 1985 Byte.
     3. These services require that the network software be installed.
     4. Partial documentation in Advanced MS-DOS.
     5. SHARE must be loaded or the call will fail.
     6. The network device name requires a password.

Function  60h  undocumented - Parse pathname (DOS 3.x+)
 *             Perform name processing on a string (internal to DOS)
entry   AH     60h
        DS:SI  pointer to ASCIIZ source string (null terminated)
        ES:DI  pointer to destination 67 byte (?) ASCIIZ string buffer
return  ES:DI  buffer filled with qualified name in form (drive):(path)
        CF     0         no error
               1         error
                         AX      error code (unknown)
note 1. Documented in Zenith 3.05 Tech Ref.
     2. All name processing is performed on the input string: string substitution
```

```
        is performed on the components, current drive/directories are prepended,
        . and .. are removed.
     3. Example: If current drive/directory is c:\test,  myfile.x is translated
        to c:\test\myfile.x; ..\source\sample.asm is tranlated to c:\source\
        sample.asm.
     4. It is the caller's responsibility to make sure DS:SI does not point to a
        null string. If it does, SI is incremented, a null byte is stored at
        ES:DI, and the routine returns.
     5. Used by CHKDSK, at least in DOS 3.3, and DOS 3.x.
     6. If path string is on a JOINed drive, the returned name is the one that
        would be needed if the drive were not JOINed; similarly for a SUBSTed
        drive letter. Because of this, it is possible to get a qualified name
        that is not legal with the current combination of SUBSTs and JOINs.

Function  61h   undocumented - (DOS 3.x)
 *              Internal to DOS - parameters not known
entry     AH    61h
return    AL    0
note      Supposedly documented in Zenith DOS 3.05 Tech Ref.

Function  62h   Get Program Segment Prefix (PSP) (DOS 3.x+)
entry     AH    62h
return    BX    segment address of PSP

Function  63h   Get Lead Byte Table  (MS-DOS 2.25 only)
                Added in DOS 2.25 for additional foreign character set support.
entry     AH    63h
          AL    subfunction
                00h     Get System Lead Byte Table Address
                01h     Set/Clear Interim Console Flag
                        DL      0000h   to clear interim console flag
                                0001h   to set interim console flag
                02h     get interim console flag
return    DS:SI pointer to lead byte table (AL = 00h)
          DL    interim console flag (AL = 02h)
note 1. Function 63h destroys all registers except SS:SP on return.
     2. Not supported in DOS 3.x or 4.x.
     3. Note fn 63h does not return errors in AL or CF.

Function  64h   Undocumented - Used internally by DOS
entry     AH    64h
          AL    00h     Get (something)
                return  DL      unknown
                01h     Set (something)
                DL      unknown
                02h     Get and set (something)
                DL      new (something)
                return  DL      old (something)
note      DOS 3.2+ internal function of some type? May be a network function.

Function  65h   Get Extended Country Information (DOS 3.3+)
                Returns information about the selected country formats,
                code pages, and conversion tables
entry     AH    65h
          AL    info ID code
                01h     get general internationalization info
                02h     get pointer to uppercase table
                03h     unknown
                04h     get pointer to filename uppercase table
                05h     unknown
                06h     get pointer to collating sequence table
                07h     get pointer to double-byte character set table
          BX    code page (-1 = global code page)
          CX    size of buffer (=5)
          DX    country ID (-1 = current country)
          ES:DI pointer to country information buffer
return    CF    set on error
                AX      error code (unknown)
                        otherwise:
          CX    size of country information returned
          ES:DI pointer to country information:
```

```
           1 byte    info ID
        If info ID  1:
                dword  pointer to information
        If info ID = 1:
                word    size
                word    country ID
                word    code page
             34 bytes   (see function 38h)
        If info ID = 2:
                dword   pointer to uppercase table
                word    table size
            128 bytes uppercase equivalents (if any) of chars 80h-0FFh
        If info ID = 4:
                dword   pointer to collating table
                word    table size
            256 bytes   values used to sort characters 00h-0FFh
        If info ID = 6:
                dword   pointer to filename uppercase table
                word    table size
            128 bytes   uppercase equivalents (if any) of chars 80h-0FFh
        If info ID = 7: (DOS 4.0)
                unknown

Function  66h   Get/Set Global Code Page Table (DOS 3.3+)
                Query/reset code page defaults
entry   AH      66h
        AL      00h     Get Global Code Page
                01h     Set Global Page
                        BX      active code page
                        DX      system code page (active page at boot time)
return  CF      clear  successful
                set     AX      error code (unknown)
        if 00h          BX      active code page
                        DX      system code page (active page at boot time)
note    BX = active code page: 437 = US, 860 = Portugal, 863 = Canada (French)
                               865 = Norway/Denmark, 850 = multilingual

Function  67h   Set Handle Count  (DOS 3.3+)
                Supports more than 20 open files per process
entry   AH      67h
        BX      desired number of handles (max 255)
return  CF      clear if OK
        CF      set if error
                AX      error code (unknown)
note    This function changes the 20-byte handle table pointer in the PSP
        to point to a new, larger handle table elsewhere in memory.

Function  68h   Commit File (DOS 3.3+)
                Write all buffered data to disk
entry   AH      68h
        BX      file handle
return  CF      set     AX      error code (unknown)
                clear   successful
note 1. Faster and more secure method of closing a file in a network than current
        close commands.
     2. This is effectively the same as DUPing the handle for a file and then
        closing the new one, except that this call won't fail if the system is
        out of handles.
     3. If BX  20, no action is taken.

Function  69h   Disk Serial Number  DOS 4.0+ (US versions)
                Handles 'Volume Serial Number' on disks formatted with 4.0+
entry   AH      69h     Get Volume Serial Number
        DS:DX   pointer to table
return  DS:DX   data table. Format:
                word     unknown (zeroes on my system.
                dword    disk serial number (binary)
             11 bytes    volume label or 'NO NAME    ' if none
              8 bytes    FAT type - string 'FAT12   ' or 'FAT16
note    The FAT type field refers to the number of bits per directory entry.
```

```
Function  6Ah   Unknown  (DOS 4.0?)

Function  6Bh   Unknown  (DOS 4.0?)

Function  6Ch   Extended Open/Create  DOS 4.0+ (US)
                Combines functions available with Open, Create, Create New, and
                Commit File
entry    AH     6Ch
         AL     00h  reserved  [which means there might be other subfunctions?]
         BX     mode    format  0WF0 0000 ISSS 0AAA
                                AAA is access code (read, write, read/
                                write) SSS is sharing mode
                                I       0       pass handle to child
                                        1       no inherit [interesting!]
                                F       0       use int 24h for errors
                                        1       disable int 24h for all I/O on
                                                this handle; use own error routine
                                W       0       no commit
                                        1       auto commit on all writes
         CX     create attribute
         DL     action if file exists/does not exists
            bits 7-4    action if file does not exist
                        0000    fail
                        0001    create
                3-0     action if file exists
                        0000    fail
                        0001    open
                        0010    replace/open
         DH     00h
         DS:SI  pointer to ASCIIZ file name
return   CF     set on error
                AX      error code (unknown)
                clear
                AX      file handle
                CX      action taken
                        01h     file opened
                        02h     file created/opened
                        03h     file replaced/opened
Function  89h   undocumented - DOS_Sleep
 *              Not documented by Microsoft
entry    AH     89h
return   unknown
note 1.  Function included in Microsoft C 4.0 startup code MSDOS.INC
     2.  Debugging shows that the first instruction on entry to DOS compares AH
         with 64h (at least in DOS 3.2) and aborts the call if AH 64.
     3.  Possibly used in European MSDOS 4.0?
```

Aftermarket Application Installed Function Calls

Novell Netware 2.11:

Novell no longer recommends the int 21h method for invoking the Netware functions. Int 21h will be supported indefinitely, but the net API calls for addressing the software through the Multiplex Interrupt (2Fh). You may address the API through int 2Fh in the same manner as int 21h; only the interrupt number is different.

Novell API calls are referenced in Chapter 13. Most functions from 0B6h through 0F9h are pre-empted by NetWare; if your software uses any of these calls for another purpose it will likely not run under NetWare.

Note: Novell (and most others') network software and SoftLogic's DoubleDOS conflict on the following int 21h functions 0EAh-0EEh. Netware must use int 2Fh functions instead of 21h functions if DoubleDOS will be used on the network.

```
Function  0EAh  DoubleDOS - Turn off task switching
entry   AX      0EAh
return  Task switching turned off.

Function  0EBh  DoubleDOS - Turn on task switching
entry   AH      0EBh
return  Task switching turned on.

Function  0ECh  DoubleDOS -  Get virtual screen address
entry   AH      0ECh
return  ES      segment of virtual screen
note    Screen address can change if task switching is on!

Function  0EEh  DoubleDOS - Release Timeslice
                Give away time to other tasks
entry   AH      0EEh
        AL      number of 55ms time slices to give away
return  Returns after giving away time slices.

Function  0FFh  CED   (CJ Dunford's DOS macro and command-line editor)
                CED installable commands
entry   AH      0FFh
        AL      00h     Add Installable Command
                01h     Remove Installable Command
                02h     Reserved, may be used to test for CED installation
        BL      mode byte
            bit 0       callable from DOS prompt
                1       callable from application
                2-7     not used in public domain CED
        DS:SI   pointer to CR-terminated command name
        ES:DI   pointer to far routine entry point
return  CF      set on error
        AX      01h     invalid function
                02h     command not found (subfunction 1 only)
                08h     insufficient memory (subfunction 0 only)
                0Eh     bad data (subfunction 0 only)
        AH      0FFh    if CED not installed
```

5

Interrupts 22h Through 86h

Interrupt 22h Terminate Address
(0:0088h)
This interrupt transfers control to the far (dword) address at this interrupt location when an application program terminates. The default address for this interrupt is 0:0088h through 0:008Bh. This address is copied into the program's Program Segment Prefix at bytes 0Ah through 0Dh at the time the segment is created and is restored from the PSP when the program terminates. The calling program is normally COMMAND.COM or an application. Do not issue this interrupt directly, as the EXEC function call does this for you. If an application spawns a child process, it must set the Terminate Address prior to issuing the EXEC function call, otherwise when the second program terminated it would return to the calling program's Terminate Address rather than its own. This address may be set with int 21, function 25h.

Interrupt 23h Ctrl-Break Exit Address
(0:008Ch)
If the user enters a Ctrl-Break during STDIN, STDOUT, STDPRN, or STDAUX, int 23h is executed. If BREAK is on, int 23h is checked on MOST function calls (notably 06h). If the user written Ctrl-Break routine saves all registers, it may end with a return-from-interrupt instruction (IRET) to continue program execution. If the user-written interrupt program returns with a long return, the carry flag is used to determine whether the program will be aborted. If the carry flag is set, the program is aborted, otherwise execution continues (as with a return by IRET). If the user-written Ctrl-Break interrupt uses function calls 09h or 0Ah, (Display String or Buffered Keyboard Input) then a three-byte string of 03h-0Dh-0Ah (ETX/CR/LF) is sent to STDOUT. If execution is continued with an IRET, I/O continues from the start of the line. When the interrupt occurs, all registers are set to the value they had when the original function call to DOS was made. There are no restrictions on what the Ctrl-Break handler is allowed to do, including DOS function calls, as long as the registers are unchanged if an IRET is used. If the program creates a new segment and loads a second program which itself changes the Ctrl-Break address, the termination of the second program and return to the first causes the Ctrl-Break address to be restored from the PSP to the value it had before execution of the second program.

Interrupt 24h Critical Error Handler
(0:0090h)
When an unrecoverable I/O error occurs, control is transferred to an error handler in the resident part of COMMAND.COM with an int 24h. This may be the standard DOS error handler (Abort, Retry, Ignore?) or a user-written routine.

On entry to the error handler, AH will have its bit 7=0 (high order bit) if the error was a disk error (probably the most common error), bit 7=1 if not.

BP:SI contains the address of a Device Header Control Block from which additional information can be retrieved (see below). The register is set up for a retry operation and an error code is in the lower half of the DI register with the upper half undefined.

The user stack is in effect and contains the following from top to bottom:

```
   IP      DOS registers from the issuing int 24h
   CS      int 24h
flags
   AX      user registers at time of original
   BX      int 21h request
   CX
   SI
   DI
   BP
   DS
   ES
   IP      from original int 21h
   CS      from the user to DOS
flags
```

To reroute the critical error handler to a user-written critical error handler, the following should be done:

Before an int 24h occurs:

1. The user application initialization code should save the int 24h vector and replace the vector with one pointing to the user error routine.

When the int 24h occurs:

2. When the user error routine received control it should push the flag registers onto the stack and execute a far call to the original int 24h vector saved in step 1.
3. DOS gives the appropriate prompt, and waits for user input (Abort, Retry, Ignore, Fail). After the user input, DOS returns control to the user error routine instruction following the far call.
4. The user error routine can now do any tasks necessary. To return to the original application at the point the error occurred, the error routine needs to execute an IRET instruction. Otherwise, the user error routine should remove the IP, CS, and flag registers from the stack. Control can then be passed to the desired routine.

Int 24h provides the following values in registers on entry to the interrupt handler:

```
entry  AH      status byte (bits)
               7      0       disk I/O hard error
                      1       other error - if block device, bad FAT
                              - if char device, code in DI
               6      unused
               5      0       if IGNORE is not allowed
                      1       if IGNORE is allowed
               4      0       if RETRY  is not allowed
                      1       if RETRY  is allowed
               3      0       if FAIL   is not allowed
                      1       if FAIL   is allowed
               2 \    disk area of error  00 = DOS area  01 = FAT
               1 /                        10 = root dir  11 = data area
               0      0       if read operation
                      1       if write operation
       AL      drive number if AH bit 7 = 1, otherwise undefined
               If it is a hard error on disk (AH bit 7=0), register AL contains
               the failing drive number (0=A:, 1=B:, etc.).
       BP:SI   address of a Device Header Control Block for which error
               occurred. Block device if high bit of BP:SI+4 = 1
       DI      (low byte) error code (note: high byte is undefined) error code
```

	description	
00h	attempt to write on write-protected diskette	
01h	unknown unit	
02h	drive not ready	
03h	unknown command	
04h	data error (bad CRC)	
05h	bad request structure length	
06h	seek error	
07h	unknown media type	
08h	sector not found	
09h	printer out of paper	
0Ah	write fault	
0Bh	read fault	
0Ch	general failure	
0Fh	invalid disk change	(DOS 3.0+)
10h	FCB unavailable	(DOS 3.0+)
11h	sharing buffer overflow	(DOS 3.0+)

The handler must return this information:

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

```
AL      00h     IGNORE the error
        01h     RETRY the operation
        02h     ABORT via int 22h (jump to terminate address)
        03h     FAIL the system call that is in progress (DOS 3.0+)
note 1. Be careful when choosing to ignore a response because this causes DOS to
        believe that an operation has completed successfully when it may not have.
     2. If the error was a character device, the contents of AL are invalid.
```

Other Errors

If AH bit 7=1, the error occurred on a character device, or was the result of a bad memory image of the FAT. 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.

If a character device is involved, the contents of AL are unpredictable, and the error code is in DI as above.

1. Before giving this routine control for disk errors, DOS performs several retries. The number of retries varies according to the DOS version.
2. For disk errors, this exit is taken only for errors occurring during an int 21h function call. It is not used for errors during an int 25h or 26h.
3. This routine is entered in a disabled state.
4. All registers must be preserved.
5. This interrupt handler should refrain from using DOS function calls. If necessary, it may use calls 01h through 12h. Use of any other call destroys the DOS stack and leaves DOS in an unpredictable state.
6. The interrupt handler must not change the contents of the device header.
7. If the interrupt handler handles errors itself rather than returning to 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 DOS will be in an unstable state until a function call higher than 12h is issued, therefore not recommended.
8. For DOS 3.x+, IGNORE requests (AL=0) are converted to FAIL for critical errors that occur on FAT or DIR sectors.
9. For DOS 3.10 up, IGNORE requests (AL=0) are converted to FAIL requests for network critical errors (50-79).

10. The device header pointed to by BP:SI is as follows:

```
dword  pointer to next device (OFFFFh if last device)
 word  attributes:
       bit    15     1      if character device.
                            If bit 15 is 1:
                            bit 0 = 1 if current standard input
                            bit 1 = 1 if current standard output
                            bit 2 = 1 if current NULL device
                            bit 3 = 1 if current CLOCK device
                           0       if block device.
           bit     14      is the IOCTL bit
  word    pointer to device driver strategy entry point
  word    pointer to device driver interrupt entry point
 8 bytes  character device named field for block devices. The first byte is
          the number of units.
```

11. To tell if the error occurred on a block or character device, look at bit 15 in the attribute field (WORD at BP:SI+4).
12. If the name of the character device is desired, look at the eight bytes starting at BP:SI+10.

Handling of Invalid Responses (DOS 3.0+)

A. If IGNORE (AL=0) is specified by the user and IGNORE is not allowed (bit 5=0), make the response FAIL (AL=3).
B. If RETRY (AL=1) is specified by the user and RETRY is not allowed (bit 4=0), make the response FAIL (AL=3).
C. If FAIL (AL=3) is specified by the user and FAIL is not allowed (bit 3=0), make the response ABORT. (AL=2)

Interrupt 25h Absolute Disk Read

Interrupt 26h Absolute Disk Write
(0:0094h, 0:0098h)
These transfer control directly to the device driver. On return, the original flags are still on the stack (put there by the INT instruction). This is necessary because return information is passed back in the current flags.

The number of sectors specified is transferred between the given drive and the transfer address. Logical sector numbers are obtained by numbering each sector sequentially starting from track 0, head 0, sector 1 (logical sector 0) and continuing along the same head, then to the next head until the last sector on the last head of the track is counted. Thus, logical sector 1 is track 0, head 0, sector 2; logical sector 2 is track 0, head 0, sector 3; and so on. Numbering then continues wih sector 1 on head 0 of the next track. Note that although the sectors are sequentially numbered (for example, sectors 2 and 3 on track 0 in the example above), they may not be physically adjacent on disk, due to interleaving. Note that the mapping is different from that used by DOS 1.10 for double-sided diskettes.

The request is as follows:

```
int 25 for Absolute Disk Read,   | except Compaq DOS 3.31 or DOS 4.0+
int 26 for Absolute Disk Write   | over-32Mb partitions
entry   AL      drive number (0=A:, 1=B:, etc)
        CX      number of sectors to read (int 25h) or write (int 26h)
        DS:BX   disk transfer address buffer (DTA)
        DX      first relative sector to read - beginning logical sector number
return  CF      set if error
        AL      error code issued to int 24h in low half of DI
        AH      01h     bad command
                02h     bad address mark
```

```
                03h     write-protected disk
                04h     requested sector not found
                08h     DMA failure
                10h     data error (bad CRC)
                20h     controller failed
                40h     seek operation failed
                80h     attachment failed to respond
note 1. Original flags on stack! Be sure to pop the stack to prevent uncontrolled
        growth.
     2. Ints 25 and 26 will try rereading a disk if they get an error the first
        time.
     3. All registers except the segment registers are destroyed by these calls

int 25 for Absolute Disk Read,  | Compaq DOS 3.31 or DOS 4.0+
int 26 for Absolute Disk Write  | over-32Mb partitions
entry   AL      drive number (0=A:, 1=B:, etc)
        CX      0FFFFh
        DS:BX   packet address. Packet format:
               dword    sector number
                word    number of sectors to read
               dword    transfer address
return  same as above?
note 1. Original flags on stack! Be sure to pop the stack to prevent uncontrolled
        growth.
     2. Partition is potentially 32M (and requires this form of the call) if bit
        1 of device attribute word in device driver is set.
```

Interrupt 27h Terminate And Stay Resident
(0:009Ch) (obsolete)
This vector is used by programs that are to remain resident when COMMAND.COM regains control.

After initializing itself, the program must set DX to its last address plus one relative to the program's initial DS or ES value (the offset at which other programs can be loaded), then execute interrupt 27h. DOS then considers the program as an extension of itself, so the program is not overlaid when other programs are executed. This is useful for loading programs such as utilities and interrupt handlers that must remain resident.

```
entry   CS      current program segment
        DX      last program byte + 1
return  none
note 1. This interrupt must not be used by .EXE programs that are loaded into the
        high end of memory.
     2. This interrupt restores the interrupt 22h, 23h, and 24h vectors in the
        same manner as interrupt 20h. Therefore, it cannot be used to install
        permanently resident Ctrl-Break or critical error handler routines.
     3. The maximum size of memory that can be made resident by this method is
        64K.
     4. Memory can be more efficiently used if the block containing a copy of the
        environment is deallocated before terminating. This can be done by
        loading ES  with the segment contained in 2Ch of the PSP, and issuing
        function call 49h (Free Allocated Memory).
     5. DOS function call 4Ch allows a program to pass a completion code to DOS,
        which can be interpreted with processing (see function call 31h).
     6. Terminate and stay resident programs do not close files.
     7. Int 21, function 31h is the preferred method to cause a program to remain
        resident because this allows return information to be passed and allows
        a program larger than 64K to remain resident.
     8. It is possible to make an EXE program resident with this call by putting
        a 27h in the second byte of the PSP and terminating with a RET FAR.
```

Interrupt 28h (not documented by Microsoft)
* DOS Idle Interrupt
Int 28h has been provided by DOS since release 2.0. The int 28h process is similar to the 'Timer Tick' process provided by BIOS via int 1Ch in that it is an 'outbound' (from DOS) call which an application can 'hook onto' to get service at a particular entry point. DOS normally only issues

int 28h when it receives a function call (int 21h) from a foreground application with an argument in the range of 0 thru 12 (0Ch) in the AH register, or when it is idling waiting for keyboard input. In effect, when DOS issues int 28, it is saying to the background task 'I'm not doing anything hot right now, if you can use the time, go ahead'. This means that a foreground application which doesn't do many low-number DOS functions can preempt CPU time easily.

When int 28h is being issued it is usually safe to do DOS calls. You won't get int 28hs if a program is running that doesn't do its keyboard input through DOS. You should rely on the timer interrupt for these. It is used primarily by the PRINT.COM routines, but any number of other routines can be chained to it by saving the original vector and calling it with a FAR call (or just JMPing to it) at the end of the new routine.

Int 28h is not called at all when any non-trivial foreground task is running. As soon as a foreground program has a file open, int 28h no longer gets called. Could make a good driver for for a background program that works as long as there is nothing else going on in the machine.

DOS uses 3 separate internal stacks: one for calls 01h through 0Ch; another for calls 0Dh and above; and a third for calls 01h through 0Ch when a Critical Error is in progress. When int 28h is called, any calls above 0Ch can be executed without destroying the internal stack used by DOS at the time.

The byte which is pushed on the stack before an int 28h just indicates which stack area is being used by the current int 21h call. In DOS 3.1, the code sequence that calls int 28h looks like this:

```
PUSH    SS:[0304]
INT     28
POP     SS:[0304]
```

The low-order byte of the word pushed contains 1 if the int 21h call currently in progress is for services 1 through 0Ch, and 0 for service 0 and for 0Dh and up. Assuming that the last DOS call was not a reentrant one, this tells you which set of DOS services should be safe to call.

```
entry   no parameters available
return  none
note 1. The int 28h handler may invoke any int 21h function except functions 00h
        through 0Ch (and 50h/51h under DOS 2.x unless DOS CritErr flag is set).
     2. Apparently int 28h is also called during screen writes.
     3. Until some program installs its own routine, this interrupt vector simply
        points to an IRET opcode.
     4. Supported in OS/2 1.0's DOS Compatibility Box.
     5. It is possible, if you are careful, to enhance the background priority by
        providing more int 28h calls than DOS normally would issue.
     6. If the InDOS flag is zero on int 28h, then it was called by someone other
        than DOS, and the word on the stack should NOT be examined.
```

Interrupt 29h (not documented by Microsoft)
* Internal - Quick Screen Output

This method is extremely fast (much faster than DOS 21h subfunctions 2 and 9, for example), and it is portable, even to 'non-compatible' MS-DOS computers.

```
entry   AL      ASCII value for character to output to screen
return  unknown
note 1. Documented by Digital Research's DOS Reference as provided with the DEC
        Rainbow.
     2. If ANSI.SYS is installed, character output is filtered through it.
     3. Works on the IBM PC and compatibles, Wang PC, HP-150 and Vectra, DEC
        Rainbow, NEC APC, Texas Instruments PC and others.
     4. This interrupt is called from the DOS's output routines if output is
        going to a device rather than a file, and the device driver's attribute
        word has bit 3 (04h) set to '1'.
```

5. This call has been tested with MSDOS 2.11, PCDOS 2.1, PCDOS 3.1, PCDOS 3.2, PCDOS 3.3, PCDOS 4.01, and Compaq DOS 3.31.
6. Used in IBMBIO.COM as a vector to int 10, function 0Eh (write TTY) followed by an IRET.
7. Most of the fast ANSI device drivers use this interrupt - ZANSI.SYS, NANSI.SYS, and PCMag's ANSI.COM.

Interrupt 2Ah Microsoft Networks - Session Layer Interrupt
* (not documented by Microsoft)

```
entry   AH      00h     Check Network BIOS Installed
                        return  AH      nonzero if installed
                01h     Execute NETBIOS Request
                02h     Set Net Printer Mode
                03h     Get Shared-Device Status (Check Direct I/O)
                        AL      00h
                        DS:SI   pointer to ASCIIZ disk device name
                        return  CF      0       if allowed
                04h     Execute NETBIOS
                        AL      00h     for error retry
                                01h     for no retry
                        ES:BX   pointer to network control block
                        return  AX      0000h   for no error
                                AH      01h     if error
                                AL      error code (unknown)
                05h     Get Network Resource Information
                        AL      00h
                        return  AX      reserved
                                BX      number of network names
                                CX      number of commands
                                DX      number of sessions
                06h     Network Print-Stream Control
                        note    NETBIOS 1.10
                07h-19h unknown
                20h     unknown
                        note    AL=01h intercepted by DESQview 2.0.
                80h     Begin DOS Critical Section
                        AL      1 to 6
                81h     End DOS Critical Section
                        AL      1 to 6
                82h     Server Hook
                        stack   AX from call to int 21h
                        return  stack unchanged
                        note    Called by the int 21h function dispatcher in DOS
                                3.10+ for function 0 and functions greater than
                                0Ch except 59h.
                84h     Keyboard Busy Loop
                        note    Similar to DOS's int 28h.
```

Interrupt 2Bh (not documented by Microsoft)
* Unknown - Internal Routine for DOS (IRET)

Interrupt 2Ch (not documented by Microsoft)
* Unknown - Internal Routine for DOS (IRET)

Interrupt 2Dh (not documented by Microsoft)
* Unknown - Internal Routine for DOS (IRET)

Interrupt 2Eh (undocumented by Microsoft) (DOS 2.0+)
* Internal Routine for DOS (Alternate EXEC)

This interrupt passes a command line addressed by DS:SI to COMMAND.COM. The command line must be formatted just like the unformatted parameter area of a Program Segment Prefix. That is, the first byte must be a count of characters, and the second and subsequent bytes must be a command line with parameters, terminated by a carriage return character.

When executed, int 2Eh will reload the transient part of the command interpreter if it is not currently in memory. If called from a program that was called from a batch file, it will abort the batch file. If executed from a program which has been spawned by the EXEC function, it will abort the whole chain and probably lock up the computer. Int 2Eh also destroys all registers including the stack pointer.

Int 2Eh is called from the transient portion of the program to reset the DOS PSP pointers using the above Functions #81 & #80, and then reenters the resident program.

When called with a valid command line, the command will be carried out by COMMAND.COM just as though you had typed it in at the DOS prompt. Note that the count does not include the carriage return. This is an elegant way to perform a SET from an application program against the master environment block for example.

```
entry   DS:SI   pointer to an ASCIIZ command line in the form:
                        count byte
                        ASCII string
                        carriage return
                        null byte
note 1. Destroys all registers including stack pointer.
     2. Seems to work OK in both DOS 2.x and 3.x.
     3. It is reportedly not used by DOS.
     4. As far as known, int 2Eh is not used by DOS 3.1, although it was called
        by COMMAND.COM of PCDOS 3.0, so it appears to be in 3.1 only for the
        sake of compatibility.
```

Interrupt 2Fh Multiplex Interrupt

Interrupt 2Fh is the multiplex interrupt. A general interface is defined between two processes. It is up to the specific application using interrupt 2Fh to define specific functions and parameters.

This interrupt is becoming more commonly used as the availible interrupt 21 functions are getting to be in short supply. Int 2Fh doesn't require any support from DOS itself for it to be used in application programs. It's not handled by DOS, but by the programs themselves.

Every multiplex interrupt handler is assigned a specific multiplex number. The multiplex number is specified in the AH register; the AH value tells which program your request is directed toward. The specific function that the handler is to perform is placed in the AL register. Other parameters are places in the other registers as needed. The handlers are chained into the 2Fh interrupt vector and the multiplex number is checked to see if any other application is using the same multiplex number. There is no predefined method for assigning a multiplex number to a handler. You must just pick one. To avoid a conflict if two applications choose the same multiplex number, the multiplex numbers used by an application should be patchable. In order to check for a previous installation of the current application, you can search memory for a unique string included in your program. If the value you wanted in AH is taken but you don't find the string, then another application has grabbed that location.

Int 2Fh was not documented under DOS 2.x. There is no reason not to use int 2Fh as the multiplex interrupt in DOS 2.x. The only problem is that DOS 2.x does not initialize the int 2Fh vector, so when you try to chain to it like you are supposed to, it will crash. If your program checks the vector for being zero and initializes it itself or doesn't chain in that case, it will work for you n 2.x just the same as 3.x.

DOS 3.2 itself contains some int 2Fh handlers - it uses values of 08h, 13h, and 0F8h. There may be more. NLSFUNC from DOS 3.3 up uses part of int 2Fh and so does GRAFTABL.

For int 2Fh calls, register AH identifies which program is to handle the interrupt. AH values

00h-7Fh are reserved for DOS, not that anyone cares much. Values 0C0h-0FFh are reserved for applications. Register AL contains the subfunction code if used.

```
Function    00h  unknown
            Reportedly somehow used by PRINT.COM in DOS 3.3+.

Function    01h  PRINT.COM
            PC-DOS 3.3's PRINT.COM hooks the following interrupt vectors:
                 05h      PrintScreen Interrupt
                 13h      BIOS Disk Interrupt
                 14h      BIOS Serial Communications Interrupt
                 15h      BIOS 'System Services' Interrupt
                 17h      BIOS Printer Interrupt
                 19h      Bootstrap Loader Interrupt
                 1Ch      Timer Tick
                 23h      Control-C Terminate Address
                 24h      Critical Error Handler Address
                 28h      DOS Idle Interrupt (undocumented)
                 2Fh      Multiplex Interrupt

entry   AH       01h
                 AL       00h     PRINT  Get Installed State
                          This call must be defined by all int 2Fh handlers. It is
                          used by the caller of the handler to determine if the
                          handler is present. On entry,
         AL=0. On return, AL contains the installed state as follows:
                return  AL      0FFh    installed
                                01h     not installed, not OK to install
                                00h     not installed, OK to install

                          01h     PRINT  Submit File
                          DS:DX   pointer to submit packet
                                  format  byte     level
                                          dword    pointer to ASCIIZ filename
                 return   CF      set if error
                                  AX      error code
                 note     A submit packet contains the level (BYTE) and a pointer
                          to the ASCIIZ string (DWORD in offset:segment form). The
                          ASCIIZ string must contain the drive, path, and filename
                          of the file you want to print. The filename cannot
                          contain global filename characters.
                 return   CF      set if error
                                  AX      error code

                          02h     PRINT Cancel File
                          On entry, AL=2 and DS:DX points to the ASCIIZ string for
                          the print file you want to cancel. Global filename
                          characters are allowed in the filename.
                 DS:DX    pointer to ASCIIZ file name to cancel (wildcards OK)
                 return   CF      set if error
                                  AX      error code

                          03h     PRINT Remove All Files
                 return   CF      set if error
                                  AX      error code

                          04h     PRINT Hold Queue/Get Status
                          This call holds the jobs in the print queue so that you
                          can scan the queue. Issuing any other code releases the
                          jobs. On entry, AL=4. On return, DX contains the error
                          count. DS:SI  points to the print queue. The printqueue
                          consists of a series of filename entries. Each entry is
                          64 bytes long. The first entry in the queue is the file
                          currently being printed. The end of the queue is marked
                          by the entry having a null as the first character.
                return    DX      error count
                          DS:SI   pointer to print queue (null-string
                                  terminated list of 64-byte ASCIIZ filenames)
                          CF      set if error
                                  AX      error code
```

```
                                        01h     function invalid
                                        02h     file not found
                                        03h     path not found
                                        04h     too many open files
                                        05h     access denied
                                        08h     queue full
                                        09h     spooler busy
                                        0Ch     name too long
                                        0Fh     drive invalid

                        05h     PRINT restart queue
                return  CF      set if error
                                AX      error code
                        06h     unknown - may be used in DOS 3.3+ PRINT

Function    05h DOS 3.0+ Critical Error Handler
entry   AH      05h
                AL      00h     Installation Check
                        return  AL      00h     not installed, OK to
                                                install
                                        01h     not installed, not OK to
                                                install
                                        0FFh    installed
                        note    This set of functions allows a user program to
                                partially or completely override the default
                                critical error handler in COMMAND.COM.
                AL      xxh     Handle Error - nonzero error code in AL (xxh
                                indicates nonzero extended error code)
                        return  CF      clear
                                        ES:DI   pointer to ASCIIZ error message
                                AL      (?)
                                CF      set     use default error handler

Function    06h ASSIGN
entry   AH      06h
        AL      00h     Installation Check
                01h     Get Memory Segment
return (AH=00h) AH      nonzero if ASSIGN is installed
       (AH=01h) ES      segment of ASSIGN work area

Function    08h DRIVER.SYS
entry   AH      08h
        AL      00h     Installation Check
                return  AL      00h     not installed, OK to install
                                01h     not installed, not OK to install
                                0FFh    installed
                01h     unknown

other parameters unknown

Function    10h SHARE
entry   AH      10h
        AL      00h     Installation Check
return  AL      00h     not installed, OK to install
                01h     not installed, not OK to install
                0FFh    installed

Function    11h Multiplex - Network Redirection
entry   AH      11h
        AL      00h     Installation Check
                        return  AL      00h     not installed, OK to install
                                        01h     not installed, not OK to install
                                        0FFh    installed
                01h-05h unknown
                06h     Close Remote File
                07h-0Dh unknown
                0Eh     Do Redirection
                        stack   word    function to execute
                        return  CF      set on error
                0Fh     Printer Setup
                10h-1Eh unknown
```

```
                    1Eh     Do Redirection
                            stack   word     function to execute
                            return  CF       set on error
                    1Fh     Printer Setup
                            stack   word     function (?)
                            return  CF       set on error (?)
                    20h-26h unknown

Function    12h     Multiplex, DOS 3.x Internal Services
entry   AH          12h
        AL          00h     Installation Check
                            return  AL       0FFh    for compatibility with other int
                                                     2Fh functions
                    01h     Close File (?)
                            stack   word value - unknown
                            return  BX       unknown
                                    CX       unknown
                                    ES:DI    pointer to unknown value
                            note    Can be called only from within DOS.
                    02h     Get Interrupt Address
                            stack   word     vector number
                            return  ES:BX    pointer to interrupt vector
                                    stack    unchanged
                    03h     Get DOS Data Segment
                            return  DS       segment of IBMDOS.COM file
                    04h     Normalize Path Separator
                            stack   word     character to normalize
                            return  AL       normalized character (forward slash
                                             turned to backslash)
                                    stack    unchanged
                    05h     Output Character
                            stack   word     character to output
                            return  stack    unchanged
                            note    Can be called only from within DOS.
                    06h     Invoke Critical Error
                            return  AL       0-3 for Abort, Retry, Ignore, Fail
                            note    Can be called only from within DOS.
                    07h     Move Disk Buffer (?)
                            DS:DI   pointer to disk buffer
                            return  buffer moved to end of buffer list
                            note    Can be called only from within DOS.
                    08h     Decrement Word
                            ES:DI   pointer to word to decrement
                            return  AX       new value of word
                            note    Word pointed to by ES:DI decremented,
                                    skipping zero.
                    09h     unknown
                            DS:DI   pointer to disk buffer(?)
                            return  (?)
                            note    Can be called only from within DOS.
                    0Ah     unknown
                            note    Can be called only from within DOS.
                    0Bh     unknown
                            ES:DI   pointer to system file table entry (?)
                            return  AX       (?)
                            note    Can be called only from within DOS.
                    0Ch     unknown
                            note    Can be called only from within DOS.
                    0Dh     Get Date and Time
                            return  AX       current date in packed format
                                    DX       current time in packed format
                            note    Can be called only from within DOS.
                    0Eh     Do Something to All Disk Buffers (?)
                            return  DS:DI    pointer to first disk buffer
                            note    Can be called only from within DOS.
                    0Fh     unknown
                            DS:DI   pointer to (?)
                            return  DS:DI pointer to (?)
                            note 1. Can be called only from within DOS.
                                 2. Calls on function 1207h.
                    10h     Find Dirty Buffer
```

```
        DS:DI   pointer to first disk buffer
        return  DS:DI   pointer to first disk buffer
                        which has clean flag clear
                ZF      clear   if found
                        set     if not found
11h     Normalize ASCIIZ Filename
        DS:SI   pointer to ASCIIZ filename to normalize
        ES:DI   pointer to buffer for normalized filename
        return  destination buffer filled with uppercase
                filename, with slashes turned to backslashes
12h     Get Length of ASCIIZ String
        ES:DI   pointer to ASCIIZ string
        return  CX      length of string
13h     Uppercase Character
        stack   word    character to convert to uppercase
        return  AL      uppercase character
                stack   unchanged
14h     Compare FAR Pointers
        DS:SI   first pointer
        ES:DI   second pointer
        return  ZF      set if pointers are equal
                ZF      clear if not equal
15h     unknown
        DS:DI   pointer to disk buffer
        stack   word    (?)
        return  stack unchanged
        note    Can be called only from within DOS.
16h     Get Address of System FCB
        BX      system file table entry number
        return  ES:DI pointer to system file table entry
17h     Set Default Drive (?)
        stack   word    drive (0=A:, 1=B:, etc)
        return  DS:SI   pointer to drive data block for
                        specified drive
                stack   unchanged
        note    Can be called only from within DOS.
18h     Get Something (?)
        return  DS:SI pointer to (?)
19h     unknown
        stack   word    drive (0=default, 1=A:, etc)
        return  (?)
                stack   unchanged
        note 1. Can be called only from within DOS.
             2. Calls function 1217h.
1Ah     Get File's Drive
        DS:SI   pointer to filename
        return  AL      drive
                        (0=default, 1=A:, etc, 0FFh=invalid)
1Bh     Set Something (?)
        CL      unknown
        return  AL      (?)
        note    Can be called only from within DOS.
1Ch     Checksum Memory
        DS:SI   pointer to start of memory to checksum
        CX      number of bytes
        DX      initial checksum
        return  DX      checksum
        note 1. Can be called only from within DOS.
             2. Used to determine when transient portion of
                COMMAND.COM has been overlaid by application.
1Dh     unknown
1Eh     Compare Filenames
        DS:SI   pointer to first ASCIIZ filename
        ES:DI   pointer to second ASCIIZ filename
        return  ZF      set     if filenames equivalent
                        clear   if not
        note    Used by COPY command.
1Fh     Build Drive Info Block
        stack   word    drive letter
        return  ES:DI pointer to drive info block
                      (will be overwritten by next call)
```

```
                  stack unchanged
          note    Can be called only from within DOS.
    20h   Get System File Table Number
          BX      file handle
          return  CF      set on error, error code in AL
                          AL      06h (invalid file handle)
                  CF      clear if successful
                          byte ES:[DI]    system file table entry
                                          number for file handle
    21h   unknown
          DS:SI   pointer to (?)
          return  (?)
          note    Can be called only from within DOS.
    22h   unknown
          SS:SI   pointer to (?)
          return  nothing(?)
          note    Can be called only from within DOS.
    23h   Check if Character Device (?)
          return  DS:SI   pointer to device driver with same name
                          as (?)
          note    Can be called only from within DOS.
    24h   Delay
          return  after delay of (?) ms
          note    Can be called only from within DOS.
    25h   Get Length of ASCIIZ String
          DS:SI   pointer to ASCIIZ string
          return  CX      length of string

Function  14h  NLSFUNC.COM
entry  AH      14h
other parameters unknown

Function  15h  CD-ROM extensions
          Microsoft CD-ROM driver versions 1.0 through 2.0 will work only up
          to DOS 3.31. DOS 4.0 and up require 2.1 drivers.
entry  AH      15h     CD-ROM services
       AL      subfunctions
               00h     Installation Check
               BX      00h
               return  BX      number of CD-ROM drive letters used
                               CX      starting drive letter (0=A:)
               note    This installation check DOES NOT follow the format
                       used by other software.

               01h     Get Drive Device List
               ES:BX   pointer to buffer to hold drive letter list (5 bytes per
                       drive letter)
               return  buffer filled, for each drive letter:
                       byte    subunit number in driver
                       dword   address of device driver header
               02h     Get Copyright File Name
               CX      drive number (0=A:)
               ES:BX   pointer to 38-byte buffer for name of copyright file
               return  CF      set if drive is not a CD-ROM drive
                       AX      error code  (15h)

               03h     Get Abstract File Name
               ES:BX   pointer to 38-byte buffer for name of abstract file
               CX      drive number (0=A:)
               return  CF      set if drive is not a CD-ROM drive
                       AX      error code  (15h)

               04h     Get Bibliographic Doc File Name
               CX      drive number (0=A:)
               ES:BX   pointer to 38-byte buffer for name of bibliographic
                       documentation file
               return  CF      set if drive is not a CD-ROM drive
                       AX      error code  (15h)

               05h     Read VTOC (Volume Table of Contents)
               CX      drive number (0=A:)
```

```
DX      sector index (0=first volume descriptor,
        m1=second,...)
ES:BX   pointer to 2048-byte buffer
return  CF      set on error
                AX      error code (15h, 21h)
        CF      clear if successful
                AX      volume descriptor type
                        (1=standard, 0FFh=terminator, 00h=other)

06h     Turn Debugging On
BX      debugging function to enable
note    Reserved for development.

07h     Turn Debugging Off
BX      debugging function to disable
note    Reserved for development.

08h     Absolute Disk Read
CX      drive number (0=A:)
DX      number of sectors to read
ES:BX   pointer to buffer
SI:DI   starting sector number
return  CF      set on error
        AL      error code  (15h, 21h)

09h     Absolute Disk Write
CX      drive number (0=A:)
DX      number of sectors to write
ES:BX   pointer to buffer
SI:DI   starting sector number
note    Corresponds to int 26h and is currently reserved and
        nonfunctional.

0Ah     Reserved by Microsoft

0Bh     CD-ROM 2.00 - Drive Check
CX      drive number (0=A:)
return  BX      0ADADh if MSCDEX.EXE installed
        AX      0       if drive not supported
                <> 0    if supported

0Ch     CD-ROM 2.00 - Get MSCDEX.EXE Version
return  BH      major version
        BL      minor version
note    MSCDEX.EXE versions prior to 1.02 return BX=0.

0Dh     CD-ROM 2.00 - Get CD-ROM Drive Letters
ES:BX   pointer to buffer for drive letter list
        (1 byte per drive)
return  Buffer filled with drive numbers (0=A:). Each byte
        corresponds to the drive in the same position for
        function 1501h.

0Eh     CDROM 2.00 - Get/Set Volume Descriptor Preference
BX      subfunction
        00h     Get Preference
        DX      00h
        return  DX      preference settings
        01h     Set Preference
        DH      volume descriptor preference
                1       primary volume descriptor
                2       supplementary volume descriptor
        DL      supplementary volume descriptor preference
                1       shift-Kanji
        CX      drive number (0=A:)
        return  CF      set on error
                AX      error code  (01h, 15h)

0Fh     CD-ROM 2.00 - Get Directory Entry
CX      drive number (0=A:)
ES:BX   pointer to ASCIIZ pathname
```

```
                SI:DI   pointer to 255-byte buffer for directory entry
                return  CF      set on error
                        AX      error code
                        CF      clear if succesful
                        AX      disk format (0=High Sierra, 1=ISO 9660)
                note    Directory entry format:
                        byte    length of directory entry
                        byte    length of XAR in LBN's
                        dword   LBN of data, Intel (little-Endian) format
                        dword   LBN of data, Motorola (big-Endian) format
                        dword   length of file, Intel format
                        dword   length of file, Motorola format
               ---High Sierra---
                      6 bytes   date and time
                        byte    bit flags
                        byte    reserved
               ---ISO 9660---
                      7 bytes   data and time
                        byte    bit flags
               ---both formats---
                        byte    interleave size
                        byte    interleave skip factor
                        word    volume set sequence number, Intel format
                        word    volume set sequence number, Motorola format
                        byte    length of file name
                      n bytes   file name
                        byte    (optional) padding if filename is odd length
                      n bytes   system data

                Error codes:
                        01h     invalid function
                        15h     invalid drive
                        21h     not ready

Function    43h Microsoft Extended Memory Specification (XMS)
                The XMS version 2.00 for MS-DOS allows DOS programs to utilize
                additional memory found in 80286 and 80386  machines. With some
                restrictions, XMS adds about 64K to the 640K which DOS programs
                can access directly. XMS also provides DOS programs with a
                standard method of storing data in extended memory.

entry   AH      XMS (extended memory) services
                Perform a FAR call to the driver entry point with AH set
                to the function code
                00h     Get XMS Version Number
                        return  AX      16 bit BCD version number (AX=0285h would
                                        be XMS version 2.85)
                                BX      driver internal revision number
                                DX      0000h   HMA does not exist
                                        0001h   HMA exists
                        note 1. No error codes are returned from this function.
                             2. DX indicates the presence of HMA, not its
                                availability.
                01h     Request High Memory Area (1M to 1M + 64K)
                        DX      HMA memory request in bytes (for TSR or
                                device drivers)
                                0FFFFh if application program
                        return  AX      0000h   failure
                                        0001h   success
                                BL      error code (80h, 81h, 90h, 91h, 92h)
                02h     Release High Memory Area
                        return  AX      0000h   failure
                                        0001h   success
                                BL     error code (80h, 81h, 90h, 93h)
                03h     Global Enable A20
                        return  AX      0000h   failure
                                        0001h   success
                                BL      error code (80h, 81h, 82h)
                        note    Should only be used by programs which have
                                control of the HMA. The A20 line should be
                                turned off via Function 04h (Global Disable A20)
                                before a program releases control of the system.
```

```
04h     Global Disable A20
        return AX       0000h   failure
                        0001h   success
               BL       error code (80h, 82h, 94h)
        note 1. This function attempts to disable the A20 line.
                It should only be used by programs which have
                control of the HMA.
             2. The A20 line should be disabled before a program
                releases control of the system.
05h     Local Enable A20
        return AX       0000h   failure
                        0001h   A20 is enabled
               BL       error code (80h, 81h, 82h)
        note    This function attempts to enable the A20 line. It
                should only be used by programs which need
                direct access to extended memory. Programs which
                use this function should call Function 06h (Local
                Disable A20) before releasing control of the
                system.
06h     Local disable A20
        return AX       0000h   failure
                        0001h   success
               BL       error code (80h, 81h, 82h, 94h)
        note    This function cancels a previous call to Fn 05h
                (Local Enable A20). It should only be used by
                programs which need direct access to extended
                memory. Previous calls to Fn 05h must be
                cancelled before releasing control of the system.
07h     Query A20
        return AX       0000h   failure
                        0001h   success (A20 line is
                                physically enabled)
               BL       error code (00h, 80h, 81h)
08h     Query Free Extended Memory
        return AX       size of largest free extended memory block
                        in K
               BL       error code (80h, 81h, 0A0h)
               DX       total free extended memory in K
        note    The 64K HMA is not included in the returned value
                even if it is not in use.
09h     Allocate Extended Memory Block
        DX      Amount of extended memory being requested in
                K-bytes
        return AX       0000h   failure
                        BL      error code (80h 81h A0h A1h)
                        0001h   success
               DX       16 bit handle for memory block
0Ah     Free Extended Memory Block
        DX      handle of block to free
        return AX       0000h   failure
                        BL      error code (80h, 81h,
                                0A2h, 0ABh)
                        0001h   success
0Bh     Move Extended Memory Block
        DS:SI pointer to EMM structure
                4 bytes number of bytes to move
                2 bytes source handle
                4 bytes offset into source block
                2 bytes destination handle
                4 bytes offset into destination block
        return AX       0000h   failure
                        BL      error code (80h, 81h, 82h, 0A3h,
                                0A4h, 0A5h, 0A6h, 0A7h, 0A8h,
                                0A9h)
                        0001h   success
0Ch     Lock Extended Memory Block
        DX      XMS handle of block to lock
        return AX       0000h   failure
                        BL      error code (80h, 81h, 0A2h, 0ACh,
                                0ADh)
                        0001h   block is successfully locked
```

```
                    DX:BX    32-bit linear address of locked block
        0Dh     Unlock Extended Memory Block
                DX       XMS handle of block to unlock
                return AX       0000h    failure
                                BL       error code (80h, 81h, 0A2h, 0AAh)
                                0001h    success
        0Eh     Get EMB Handle Information
                DX       handle for which to get info
                return AX       0000h    failure
                                BL       error code (80h, 81h, 0A2h)
                                0001h    success
                                BH       block's lock count
                                BL       number of free handles left
                                DX       block size in K
                note     To get the block's base address, use Fn 0Ch (Lock
                          Extended Memory Block).
        0Fh     Reallocate Extended Memory Block
                BX       New size for the extended memory block in K
                DX       Unlocked extended memory block handle to
                         reallocate
                return AX       0000h    failure
                                BL       error code (80h, 81h,
                                         0A0h, 0A1h, 0A2h, 0ABh)
                                0001h    success
        10h     Request Upper Memory Block (nonEMS memory above 640K)
                DX       Size of requested memory block in paragraphs
                return AX       0000h    failure
                                BL       error code (80h, 0B0h, 0B1h)
                                DX       size of largest available block
                                         in paragraphs
                                0001h    success
                                BX       segment address of UMB
                                DX       actual block size in paragraphs
                note 1. UMBs are paragraph aligned.
                     2. To determine the size of the largest available
                        UMB, attempt to allocate one with a size of
                        0FFFFh.
        11h     Release Upper Memory Block
                DX       segment address of UMB to release
                return AX       0000h    failure
                                BL       error code (80h, 0B2h)
                                0001h    success
```

```
note 1. UMBs cannot occupy memory addresses that can be banked by EMS 4.0. EMS
        4.0 takes precedence over UMBs for physically addressable memory.
     2. Programs should make sure that at least 256 bytes of stack space is
        available before calling XMS API functions.
     3. On many machines, toggling the A20 line is a relatively slow operation.
     4. Error codes:
        80h     Function not implemented
        81h     VDISK was detected
        82h     An A20 error occurred
        8Eh     A general driver error
        8Fh     Unrecoverable driver error
        90h     HMA does not exist
        91h     HMA is already in use
        92h     DX is less than the /HMAMIN= parameter
        93h     HMA is not allocated
        0A0h    All extended memory is allocated
        0A1h    All available extended memory handles are allocated
        0A2h    Invalid handle
        0A3h    Source handle is invalid
        0A4h    Source offset is invalid
        0A5h    Destination handle is invalid
        0A6h    Destination offset is invalid
        0A7h    Length is invalid
        0A8h    Move has an invalid overlap
        0A9h    Parity error occurred
        0AAh    Block is not locked
        0ABh    Block is locked
        0ACh    Block lock count overflowed
```

```
        0ADh    Lock failed
        0B0h    Only a smaller UMB is available
        0B1h    No UMB's are available
        0B2h    UMB segment number is invalid

Function 5453h TesSeRact Standard for Ram-Resident Program Communication
entry   AX      5453h   TesSeRact function request
        CX      function select word:
           bits 0       function 00h (check install - required)
                1       function 01h (return userparms - required)
                2       function 02h (check hotkey)
                3       function 03h (replace int 24h)
                4       function 04h (return Data Pointer)
                5       function 05h (set extra hotkeys)
                6-7     undefined - reserved for future use
                8       function 10h (enable TSR)
                9       function 11h (disable TSR)
                10      function 12h (release TSR from RAM)
                11      function 13h (restart TSR)
                12      function 14h (get current status)
                13      function 15h (set TSR status)
                14      function 16h (get popup type)
                15      undefined - reserved for future use
                16      function 20h (call user procedure)
                17      function 21h (stuff keyboard)
                18-31   undefined - reserved for future use
Functions:
        00h     Check Install
                DS:SI   pointer to 8-character blank-padded name
                return  AX      0FFFFh  the TSR has already been loaded
                                Any other value indicates that it is safe to
                                install this TSR, using the ID number in CX
                        CX      TSR ID Number
        01h     Return User Parameters
                CX      TSR ID number
                return  AX      00h     no matching TSR ID Number found
                        Otherwise,
                        ES:BX   pointer to TsrParms structure (note 3)
        02h     Check Hotkey
                        CL      scan code of hot key
                return  AX      0FFFFh  hotkey conflicts with TSR already loaded.
                                        Any other value means OK to use hotkey.
        03h     Replace Default Interrupt 24h Handler
                CX      TSR ID number
                DS:SI   pointer to new routine for int 24h
                return  AX      <>0     unable to install handler (invalid ID
                                        number)
                                00h     successful installation
        04h     Return TesSeRact Internal Data Area Pointer
                CX      TSR ID number
                return  AX      00h     no matching TSR ID Number found.
                                Otherwise, FAR pointer to TsrData structure
                        ES:BX   pointer to TSR's internal data area (note 4)
        05h     Set Multiple Hot Keys
                CX      TSR ID number
                DL      number of additional hot keys to allocate
                DS:SI   pointer to table of hot keys
                        byte    hotkey scan code
                        byte    hotkey shift state
                        byte    flag value to pass to TSR (nonzero)
                return  AX      <>0     unable to install hotkeys (invalid ID
                                        number)
                                00h     successful set
        06h-0Fh not used
        10h     Enable TSR
                CX      TSR ID number
                return  AX      <>0     unable to enable TSR (invalid ID number)
                                00h     TSR enabled
        11h     Disable TSR
                CX      TSR ID number
                return  AX      <>0     unable to disable
```

```
        12h     Release TSR [unload from RAM]
                CX      TSR ID number
                return  AX      <>0     invalid TSR number
                note    If any interrupts used by TSR have been grabbed by
                        another TSR, the TesSeRact routines will wait until it
                        is safe to remove the indicated TSR from memory.
        13h     Restart TSR
                CX      TSR ID number of TSR which was unloaded but is still in
                        memory
                return  AX      <>0     unable to restart TSR
                                        (invalid ID #)
                                00h     success
        14h     Get TSR Status Word
                CX      TSR ID number
                return  AX      0FFFFh  invalid TSR ID Code
                                Any other value is current status flags
                        BX      bit flags
        15h     Set TSR Status Word
                CX      TSR ID number
                DX      new bit flags
                return  AX      <>0     unable to set status word
        16h     Get InDOS State at Popup
                CX      TSR ID number
                return  AX      0FFFFh  invalid TSR ID Code
                                Any other value is current status flags
                        BX      value of INDOS flag
        20h     Call User Procedure
                CX      TSR ID number
                ES:DI   pointer to user-defined data
                return  AX      <>0     unable to pass pointer (invalid ID #)
                                00h     success
        21h     Stuff Keyboard
                CX      TSR ID number
                DH      scan code flag
                        00h     buffer contains alternating ASCII & scan codes
                        <>0     buffer contains only ASCII codes
                DL      speed
                        00h     stuff keystrokes only when buffer is empty
                        01h     stuff up to four keystrokes per clock tick
                        02h     stuff up to 15 keystrokes per clock tick
                SI      number of keystrokes
                ES:DI   pointer to buffer to stuff
                return  AX      0F0F0h  user aborted paste with ^C or ^Break
                                <>0     unable to stuff buffer (invalid ID #)
                                00h     Success
            22h - 2Fh reserved
note 1. TesSeRact is based in part on work done by the Ringmaster Development
        Team, in efforts to develop a public domain TSR standard.
     2. Borland's THELP.COM popup help system for Turbo Pascal and Turbo C fully
        supports the TesSeRact API.
     3. TsrParms structure:
      8 bytes   blank-padded TSR name
        word    TSR ID number
       dword    bitmap of supported functions
        byte    scan code of primary hotkey
                00h     pop up when shift states match
                0FFh    no popup (if shift state also 0FFh)
        byte    shift state of primary hotkey
                0FFh    no popup (if scan code also 0FFh)
        byte    number of secondary hotkeys
       dword    pointer to extra hotkeys set by fn 05h
        word    current TSR status flags
        word    PSP segment of TSR
       dword    DTA for TSR
        word    default DS for TSR
       dword    stack at popup
       dword    stack at background invocation
     4. TesSeRact TSR Internal Data Area
        byte    revision level of TesSeRact library
        byte    type of popup in effect
        byte    int 08h occurred since last invocation
```

```
         byte     int 13h occurred since last invocation
         byte     active interrupts
         byte     active soft interrupts
         byte     DOS major version
         byte     how long to wait before popping up
        dword     pointer to INDOS flag
        dword     pointer to DOS critical error flag
         word     PSP segment of interrupted program
         word     PSP segment of prog interrupted by INT 28
        dword     DTA of interrupted program
        dword     DTA of program interrupted by INT 28
         word     SS of interrupted program
         word     SP of interrupted program
         word     SS of program interrupted by INT 28
         word     SP of program interrupted by INT 28
        dword     INT 24 of interrupted program
      3 words     DOS 3+ extended error info
         byte     old BREAK setting
         byte     old VERIFY setting
         byte     were running MS WORD 4.0 before popup
         byte     MS WORD 4.0 special popup flag
         byte     enhanced keyboard call in use
         byte     delay for MS WORD 4.0
             11 times:
        dword     old interrupt vector
         byte     interrupt number
        dword     new interrupt vector

Function   64h    SCRNSAV2.COM
entry    AH       64h
         AL       00h      installation check
return   AL       00h      not installed
                  0FFh     installed
note     SCRNSAV2.COM is a screen saver for PS/2's with VGA by Alan Ballard.

Function  7Ah     Novell NetWare
entry    AH       7Ah
         AL       00h      installation check
return   AL       00h      not installed
                  0FFh     installed
         ES:DI    pointer to FAR entry point for routines otherwise accessed
                  through int 21h
note 1. Returns address of entry point for IPX and SPX.
     2. Parameters are listed under int 21.

Function  087h    APPEND
entry    AH       087h
         AL       00h      APPEND installation check
                  return   AH  0 if installed
                  01h      APPEND - unknown
                  02h      APPEND - version check
return   unknown

Function  088h    Microsoft Networks
entry    AH       088h
         AL       00h      network program installation check
                  return   AH  0 if installed
                           BX      installed component flags (test in this order!)
                              bits 2       messenger
                                   3       redirector
                                   6       server
                                   7       receiver
                                   other bits not used, do not test
                  01h      unknown
                  02h      unknown
                  03h      get current POST address
                           return  ES:BX   POST address
                  04h      set new POST address
                           ES:BX   new POST address
                  09h      network version check
```

```
Function  0AAh  VIDCLOCK.COM
entry   AH      0AAh
        AL      00h     installation check
return  AL      00h     not installed
                0FFh    installed
note    VIDCLOCK.COM is a memory-resident clock by Thomas G. Hanlin III.

Function  0B0h  GRAFTABL.COM or DISPLAY.SYS
parameters unknown

Function  0BBh  Network Functions
entry   AH      0BBh
        AL      00h     net command installation check
                01h, 02h unknown
                03h     get server POST address
                04h     get server POST address

Function 0D44Dh 4DOS Command Interpreter  (COMMAND.COM replacement)
entry   AX      0D44Dh  4DOS installation check
        BX      00h
return  If 4DOS is present in memory the following values will be returned:
        AX      44DDh
        BH      minor 4DOS version number
        BL      major 4DOS version number
                (same format as DOS int 21h/fn 30)
        CX      4DOS PSP segment address
        DL      4DOS shell number (0 for the first shell, 1 for the second, etc.;
                incremented each time a new copy of 4DOS is loaded over a root
                copy, either in a different multitasker window or via nested
                shells)
note 1. If you issue this call with BX  0 you will invoke some other function of
        4DOS's low-memory server, and probably hang the system.
     2. This function is available in swapping mode ONLY. Also note that this
        tells you if 4DOS is loaded in memory somewhere - but not whether it is
        the parent process of your program. For example if there is a root 4DOS
        shell and a secondary copy of COMMAND.COM this function will still work.
        However, you can determine if 4DOS is your parent process by comparing
        the value returned in the CX register with the PSP chain pointer at
        location 16 in your own PSP.

Function  0F7h  AUTOPARK.COM  (PD TSR hard disk parking utility)
entry   AH      0F7h
        AL      00h     installation check
                return  AL      00h     not installed
                                0FFh    installed
        01h     set parking delay
                BX:CX   32 bit count of 55ms timer ticks
note    AUTOPARK is a TSR HD parker by Alan D. Jones.

Function        Intel Communicating Applications Standard (CAS 1.01A)
entry   AH              (default; CAS multiplex number can be user-adjusted)
        AL      00h     Get Installed State
                        return  AL      00h     not installed
                                        01h     not installed, not OK to
                                                install
                                        0FFh    installed
                        note    No errors are returned.
                01h     Submit a Task
                        DS:DX   ptr to ASCIIZ path and name of Task Control File
                        return  AX      positive event handle or neg. error code
                        note    Files associated with a task must stay in
                                existence until the task is complete or an error
                                will result.
                02h     Abort the Current Event
                        return  AX      event handle of aborted event or negative
                                        error code
                        note    Terminating an event is not instantaneous. It
                                might take up to 30 seconds.
                03h     reserved
                04h     reserved
                05h     Find First Entry in Queue
```

```
        CX      Status of the event you are seeking. This value
                is compared with the field at offset 2 of the
                Control File
                0 - event has successfully completed
                1 - event is waiting to be processed
                2 - number has been dialed
                3 - connection has been made (sending)
                4 - connection has been made (receiving)
                5 - event was aborted
               -1 - chooses an event without regard to status
                This value will probably be used most often
                Other negative values match error codes in Control
                File.
        DH      direction:
                0 - Search forward chronologically (from the
                    first to the last occurring event)
                1 - Search backward chronologically (from the
                    last to the first occurring event)
        DL      queue to search:
                0 - Find first control file in Task Queue
                1 - Find first control file in Receive Queue
                2 - Find first control file in Log Queue
        return  AX      0, if successful, or negative error code
                BX      event handle for this file
06h     Find Next Entry in Queue
        DL      queue to search:
                0 - Find next control file in Task Queue
                1 - Find next control file in Receive
                    Queue
                2 - Find next control file in Log Queue
        return  AX      0, if successful, or negative error code
                BX      event handle for this file
07h     Open a File
        BX      event handle
        CX      receive file number
                0 - the Receive Control File
                1 - first received file
                2 - second received file
                3 - third received file
                n - nth received file
        DL      queue:
                0 - open control file in Task Queue
                1 - open control file in Receive Queue or the
                    received data
 file specified in the CX register.
                2 - Open control file in Log Queue.
        return  AX      0 if successful, or negative error code
                BX      DOS file handle for the requested file
08h     Delete a File
        BX      event handle
        CX      receive file number
                0 - delete all files associated with a specific
                    Receive Control File (including the RCF)
                1 - delete first received file associated with
                    the event handle
                2 - delete the second received file associated
                    with the event handle.
                n - delete the nth received file associated with
                    the event handle
        DL      queue:
                0 - delete control file in Task Queue
                1 - delete a file or files associated with an
                    event in the Receive Queue.
                2 - delete control file in Log Queue. It is
                    strongly recommended that this function NOT
                    be used to delete individual Log Control
                    Files to maintain the integrity of the log.
        return  AX      0 if successful, or negative error code
09h     Delete All Files (in a queue)
        DL      queue:
                0 - delete all control files in the Task Queue
```

```
                1 - delete all control files in the Receive Queue
                    and all received files
                2 - delete all control files in the Log Queue
        return  AX      0 if successful or negative error code
0Ah     Get Event Date
        BX      event handle of event whose date you want to get
        DL      queue:
                0 - task queue
                1 - receive queue
                2 - log queue
        return  AX      0 if successful or negative error code
                CX      year  (1980-2099)
                DH      month (1-12)
                DL      day   (1-31)
0Bh     Set Task Date
        BX      event handle
        CX      year  (1980-2099)
        DH      month (1-12)
        DL      day   (1-31)
        return  AX      0 if successful or negative error code
0CH     Get Event Time
        BX      event handle
        DL      queue:
                0 - task queue
                1 - receive queue
                2 - log queue
        return  AX      0 if successful or negative error code
                CH      hour    (0-23)
                CL      minutes (0-59)
                DH      seconds (0-59)
                DL      0
0DH     Set Task Time
        BX      event handle
        CH      hour    (0-23)
        CL      minutes (0-59)
        DH      seconds (0-59)
        DL      unused
        return  AX      0 if successful or negative error code
0EH     Get External Data Block
        DS:DX points to a 256-byte EDB area
        return  AX      0 if successful or negative error code
        note    EDB area is filled with the External Data Block
                block format: (values in decimal)
              Offset Length        Description
                0     1    CAS major version number
                1     1    CAS minor version number
                2     68   ASCIIZ path to directory containing
                           Resident Manager and CAS software.
                           The path must end with a backslash
                70    13   ASCIIZ name of current phonebook (the
                           CAS subdirectory is assumed)
                83    13   AZCIIZ name of current logo file (the
                           CAS subdirectory is assumed)
                96    32   ASCIIZ default sender name
                128   21   ASCIIZ CSID (CCITT fax device ID)
                149   107  Reserved
0Fh     Get/Set Autoreceive State
        DL      function code:
                0 - get current autoreceive state
                1 - set current state to value in DH
                DH      # rings before answer or 0 to disable
        return  AX      current state or negative error code
                        0 - Autoreceive disabled
                        positive # - # rings before hdw answers
10h     Get Current Event Status
        DS:DX   pointer to a 444 byte status area
        return  AX      0 if successful or negative error code
                BX      number of the current event (AX=0)
11h     Get Queue Status
        DL      queue:
                0 - find status of Task Queue
```

```
                1 - find status of Receive Queue
                2 - find status of Log Queue
        return  AX      # changes to queue since Resident Manager
                        started or negative error code If
                        changes exceeds 7FFFH, the count begins
                        again at 0.
                BX      current # of Control Files in queue
                CX      current # of received files
12h     Get Hardware Status
        DS:DX   pointer to a 128-byte status area
        return  AX      0 if successful, negative if not
        DS:DX   pointer to filled 128-byte status area
13h     Run Diagnostics
        DL      Mode
                0 - report progress of diagnostics
                1 - start running diagnostics
        return  if DL=1, AX=0 or a negative error code.
                if DL=0, AX=40h or positive number indicating
                         diagnostics passed. A negative value
                         indicates failure and containes the
                         error code
14h     Move Received File
        BX      event handle
        CX      receive file number
                (must be nonzero to specify a received file)
                1 - first received file
                2 - second received file
                3 - third received file
                n - nth received file
        DS:DX   pointer to new ASCIIZ pathname and
                filename. This file must not exist already
        return  AX      0 if successful or negative error code
        note    The path to the new directory must exist. This
                function cannot create directories.
15h     Submit a Single File to Send
        DS:DX   pointer to variable-length data area
        return  AX      positive event handle or neg. error code
        note 1. variable-length data area format:
             Offset Length    Description
                0     1     Transfer type:
                            0 - 200x200 dpi, facsimile mode
                            1 - 100x200 dpi, facsimile mode
                            2 - file transfer mode
                            3-127 - Reserved.
                1     1     Text size (if ASCII file, fax mode)
                            0 - 80-column
                            1 - 132-column
                            2-127 - reserved
                2     2     time to send, in DOS file time format
                4     2     date to send, in DOS file time format
                            note: Setting both the time and date
                            fields to 0 schedules the file to be
                            sent immediately
                6     32    ASCIIZ Destination Name  (To: field)
                38    80    ASCIIZ pathname of the file to send
                118   47    ASCIIZ phone number to call
                165   64    ASCIIZ application-specific tag field
                229   1     reserved; set to zero
                230   1     cover page flag:
                            0 - don't send cover page
                            1 - send cover page
                            2-127 - Reserved
                231   23    reserved; set to zero
                254   var   ASCIIZ cover text (if offset 230=1)
             2. The individual fields have the same meaning as in
                a Task Control File
             3. You must set all fields, except for the
                Application-Specific Tag field, before calling
                this function. However, you can set the
                Destination Name and Cover Text fields to an
                empty string 16h-80h Reserved by Intel for future
```

```
                                  expansion

MSDOS 2Fh functions 01h (PRINT), 02h (ASSIGN), 10h (SHARE):
return  AX       Error
                 Codes       Description
                 01h      invalid function number
                 02h      file not found
                 03h      path not found
                 04h      too many open files
                 05h      access denied
                 06h      invalid handle
                 08h      queue full
                 09h      busy
                 0Ch      name too long
                 0Fh      invalid drive was specified
        CF       clear (0) if OK
                 set   (1) if error - error returned in AX
note 1. The multiplex numbers AH=0h through AH=7Fh are reserved for DOS.
        Applications should use multiplex numbers 80h through 0FFh.
     2. When in the chain for int 2Fh, if your code calls DOS or if you execute
        with interrupts enabled, your code must be reentrant/recursive.
     3. Important! In versions of DOS prior to 3.0, the int 2Fh vector was
        initialized to zero rather than being pointed into the DOS service area.
        You must initialize this vector manually under DOS 2.x.
```

Miscellaneous Interrupts - in numeric order

Interrupt 30h FAR jump instruction for CP/M-style calls

note The CALL 5 entry point does a FAR jump to here (not a vector!)

Interrupt 31h Unknown

Interrupt 32h Unknown

Interrupt 33h Used by Microsoft Mouse Driver Function Calls

See Chapter 14.

Interrupt 3Fh Overlay Manager Interrupt (Microsoft LINK.EXE)

Default overlay interrupt; may be changed with LINK command line switch.

Interrupt 40h Hard Disk BIOS

Pointer to disk BIOS entry when a hard disk controller is installed. The BIOS routines use int 30h to revector the diskette handler (original int 13h) here so int 40 may be used for hard disk control.

Interrupt 41h Hard Disk Parameters

Pointer to first Hard Disk Parameter Block, normally located in the controller card's ROM. This table may be copied to RAM and changed, and this pointer revectored to the new table.

```
note 1. XT, AT,XT/2, XT/286, PS/2 except ESDI disks
     2. format of parameter table is:
        word    cylinders
        byte    heads
        word    starting reduced write current cylinder (XT only, 0 for others)
        word    starting write pre-comp cylinder
        byte    maximum ECC burst length
        byte    control byte
           bits 0-2     drive option (XT only, 0 for others)
                3       set if more than 8 heads
                4       always 0
                5       set if manufacturer's defect map on max cylinder+1
                6       disable ECC retries
```

```
          7       disable access retries
     byte    standard timeout (XT only, 0 for others)
     byte    formatting timeout (XT only, 0 for others)
     byte    timeout for checking drive (XT only, 0 for others)
     word    landing zone    (AT, PS/2)
     byte    sectors/track   (AT, PS/2)
     byte    0  (zeroes)
  3. normally vectored to ROM table when system is initialized.
```

Interrupt 42h Pointer to screen BIOS entry
EGA, VGA, PS/2. Relocated (by EGA, etc.) video handler (original int 10h). Revectors int 10 calls to EGA BIOS. Also used by Zenith Z-100

Interrupt 43h Pointer to EGA graphics character table
The POST initializes this vector pointing to the default table located in the EGA ROM BIOS. (PC-2 and up). Not initialized if EGA not present. This vector was referred to (mistakenly) as the Video Parameters table in the original EGA BIOS listings.

Interrupt 44h Pointer to graphics character table
(0:0110h) This table contains the dot patterns for the first 128 characters in video modes 4,5, and 6, and all 256 characters in all additional graphics modes. Not initialized if EGA not present.

1. EGA/VGA/CONV/PS - EGA/PCjr fonts, characters 00h to 7Fh.
2. Novell NetWare - High-Level Language API.
3. This interrupt is not used by some EGA cards.
4. Also used by Zenith Z-100.

Interrupt 45h Reserved by IBM (not initialized)
also used by Zenith Z-100

Interrupt 46h Pointer to second hard disk parameter block
AT, XT/286, PS/2 (see int 41h) (except ESDI hard disks) (not initialized unless specific user software calls for it)

Interrupt 47h Reserved by IBM (not initialized)

Interrupt 48h Cordless Keyboard Translation
(0:0120h) This vector points to code to translate the cordless keyboard scancodes into normal 83-key values. The translated scancodes are then passed to int 9. (not initialized on PC or AT) (PCjr, XT [never delivered])

Interrupt 49h Non-keyboard Scan Code Translation Table Address (PCjr)
(0:0124h) This interrupt is used for operation of non-keyboard devices on the PCjr, such as the Keystronic Numeric Keypad. This interrupt has the address of a table used to translate non-keyboard scancodes (greater than 85 excepting 255). This interrupt can be revectored by a user application. IBM recommends that the default table be stored at the beginning of an application that required revectoring this interrupt, and that the default table be restored when the application terminates. (not initialized on PC or AT)

The PCjr BIOS can interpret scancodes other than those generated by the keyboard to allow for expansion. The keyboard generates scancodes from 01h to 055h, including 0FFh. Any scancodes above 55h (56h through 7Eh for make codes and 0D6h through 0FEh for break codes) are processed in the following manner:

1. if the incoming make code falls within the range of the translate table whose address is pointed to by int 49h, it is translated into the corresponding scancode. Any incoming break

codes above 0D5h are ignored.

2. if the new translated scancode is less than 56h, it is processed by the BIOS as a keyboard scancode and the same data is placed in the BIOS keyboard buffer.
3. if the translated scancode is higher than 55h or the incoming scancode is outside the range of the translate table, 40h is added creating a new extended scancode. The extended scancode is placed in the BIOS keyboard buffer with the character code of 00h (NUL). This utilizes the range of 96h through 0BEh for scancodes 56h through 7Eh.

The default translate-table maps scancodes 56h through 6Ah to existing keyboard values. Codes 6Bh theough 0BEh are mapped (by adding 40h) to extended codes 0ABh through 0FEh since they are outside the range of the default translate table.

The format of the translate table is:

```
0       length - the number of nonkeyboard scancodes that are
        mapped within the table (from 1 to n)
1 to n  word  high byte 00h (NUL) byte scancode with low order
        byte representing the scancode mapped values relative to
        their input values within the range of 56h through 7Eh
```

With this layout, all keyboard scancodes can be intercepted through int 9h and and non-keyboard scancodes can be intercepted through int 48h.

Interrupt 4Ah Real-Time Clock Alarm (Convertible, PS/2)
(not initialized on PC or AT) Invoked by BIOS when real-time clock alarm occurs.

Interrupts 4Bh-4DhReserved by IBM (not initialized)

Interrupt 4Eh Reserved by IBM (not initialized)
Used instead of int 13h for disk I/O on TI Professional PC

Interrupt 4Fh Reserved by IBM (not initialized)

Interrupt 50-57 IRQ0-IRQ7 Relocation
IRQ0-IRQ7 relocated by DesQview (normally not initialized)
IRQ0-IRQ7 relocated by IBM 3278 Emulation Control Program

Interrupt 58h Reserved by IBM (not initialized)

Interrupt 59h Reserved by IBM (not initialized)
GSS Computer Graphics Interface (GSS*CGI)

```
entry   DS:DX   Pointer to block of 5 array pointers
return  CF      0
        AX      return code
        CF      1
        AX      error code
note 1. Int 59h is the means by which GSS*CGI language bindings communicate with
        GSS*CGI device drivers and the GSS*CGI device driver controller.
     2. Also used by the IBM Graphic Development Toolkit
```

Interrupt 5Ah Reserved by IBM (not initialized)
IBM Cluster Adapter BIOS entry address

Interrupt 5Bh Reserved by IBM (not initialized)

Interrupt 5Ah Cluster Adapter BIOS entry address
(normally not initialized)

Interrupt 5Bh Reserved by IBM (not initialized)
Used by cluster adapter?

Interrupt 5Ch NETBIOS interface entry port, TOPS
See Chapter 13

Interrupts 5Dh -5Fh Reserved by IBM (not initialized)

Interrupt 60h-67h User Program Interrupts
(available for general use) Various major programs make standardized use of this group of interrupts. Details of common use follows:

Interrupt 60h 10-Net Network
See Chapter 13.

Interrupt 60h FTP Driver - PC/TCP Packet Driver Specification
See Chapter 13.

Interrupt 67h Used by Lotus-Intel-Microsoft Expanded Memory Specification
and Ashton-Tate/Quadram/AST Enhanced Expanded Memory Specification. See Chapter 10.

Interrupt 68h Not Used (not initialized)
APPC/PC Network Interface. See Chapter 13.

Interrupts 69h -6Bh Not Used (not initialized)

Interrupt 6Ch System Resume Vector (Convertible)
(not initialized on PC) DOS 3.2 Realtime Clock update

Interrupt 6Dh Not Used (not initialized)
Paradise VGA - internal

Interrupt 6Eh Not Used (not initialized)

Interrupt 6Fh 10-Net API
See Chapter 13.

Interrupt 70h IRQ 8, Real Time Clock Interrupt (AT, XT/286, PS/2)

Interrupt 71h IRQ 9, Redirected to IRQ 8 (AT, XT/286, PS/2)
LAN Adapter 1 (rerouted to int 0Ah [IRQ2] by BIOS)

Interrupt 72h IRQ 10 (AT, XT/286, PS/2) Reserved

Interrupt 73h IRQ 11 (AT, XT/286, PS/2) Reserved

Interrupt 74h IRQ 12 Mouse Interrupt (PS/2)

Interrupt 75h IRQ 13, Coprocessor Error (AT)
BIOS Redirects NDP errors to int 2 (NMI).

Interrupt 76h IRQ 14, Hard Disk Controller (AT, XT/286, PS/2)

Interrupt 77h IRQ 15 (AT, XT/286, PS/2) Reserved

Interrupts 78h-79h Not Used

Interrupt 7Ah Reserved
Novell NetWare - Low-Level API
AutoCAD Device Interface

Interrupt 7Bh-7Eh Not Used by IBM

Interrupt 7Ch REXX-PC API

IBM REXX-PC macro language

```
entry   AX      0000h   Initialize
        DS:SI   pointer to null terminated name of program to be executed
        EB:BX   pointer to null terminated argument string to be passed to the
                program
        DX:DI   pointer to an environment control block in the format:
                dword   offset in segment to signature string
                        The segment is that contained in DX and the signature is
                        the uppercase ASCIIZ string 'REXX'.
                dword   offset in DX to environment name ASCIIZ string
                        note: The environment name will be truncated if longer
                        than 32 characters.
                dword   offset in DX to the file extension ASCIIZ string
                dword   path search - word value of 0 or non-zero.
                        This controls the searching of the path for commands that
                        might be REXX programs. 0 means no search made, n-zero
                        means search first.
                dword   x'AAAA'
                        This is a signature that allows REXXPC88 to call your own
                        defined routine when a command expression needs to be
                        processed.
                DD      Segment:offset (standard INTEL format) of environment
                        work buffer, the first double word of the buffer MUST be
                        the entry point address of the environment service
                        routine to be called. The rest of the buffer may be used
                        in any way you choose and will NOT be examined or
                        modified by REXXPC88.
return  none
note 1. The only way to tell if the program exists and can be executed is by
        examining a value returned by the program in the next call described
        below. If the program returns an end of program indication and a string
        was expected instead, it means that the program was not found or could
        not be executed for some reason.
     2. All registers except SS and SP are destroyed. The caller must save any
        other registers of interest.

Function 01h Interpret REXX Command
        This call tells REXXPC88 to interpret the REXXPC88 program until a
        value is produced.
entry   AX      0001h
return  DS:DX   points to a result string, terminated by a CR + LF +  NULL. The
                final result string (which marks the end of the program)
                consists of nothing but EOF + NULL. REXXPC88 will continue to
                return this 'end of program' string until reinitialized via an
                AX=01h call as described above.
note    All registers except SS and SP are destroyed. The caller must save any
        other registers of interest.

Function 02h  Termination
        This call allows resident REXXPC88 extensions to terminate execution of a
        REXXPC88 program, typically after detecting an error.
entry   AX      0002h
        DS:SI   points to null terminated string to be displayed as an error
                message before terminating the REXXPC88 program.
return  none
note    Terminates the REXXPC88 program and returns control to DOS.

Function 03h  Load
        This call tells REXXPC88 to look up a program variable and return  its
        current value (if any).
entry   AX      0003h
        DS:SI   points to null terminated name of REXXPC88 program variable.
        DS:DX   points to the null terminated string value of the program
                variable. DX is zero if the program variable is currently
                undefined. This string is in REXXPC88's data area and must be
                treated as read-only.
```

```
return  none
note 1. All registers except SS and SP are destroyed. The caller must save any
        other registers of interest.

Function 04h  Store
        This call tells REXXPC88 to store a null terminated string as the value
        of a program variable.
entry   AX       0004h
        DS:SI    points to null terminated name of REXXPC88 program variable
        ES:BX    points to null terminated string to be assigned to the variable
return  none
note 1. The string is copied into REXXPC88's data dictionary. If there is
        insufficient storage to store the string, REXXPC88 terminates execution
        of the program with an error message and returns to DOS.
     2. Registers: all registers except SS and SP are destroyed. The caller must
        save any other registers of interest.

Function 05h  User-Written Extensions
entry   AX        0005h
        SS:BP     points to a C stack frame containing a two-byte pointer to the
                  null terminated function name, a two-byte integer specifying
                  the number of arguments, and a two-byte pointer to an array of
                  pointers (each two bytes) to the arguments (each argument is a
                  null terminated   string).
return  DS:SI     must point to a null terminated result string. A pointer of NIL
                  (DS = 0, SI = 0) is reserved by REXXPC88 and indicates that 'no
                  REXXPC88 extensions answered the function'.
note 1. Registers: all registers except SS, SP, and BP are available for use.
     2. Stack: Since the amount of REXXPC88 stack space remaining for growth
        can't be ascertained by the user extension program, the user may wish to
        switch to a local stack if he requires more than about 128 bytes of
        stack growth.

Function 06h Queue
        This call tells REXXPC88 to place data on the data or external interrupt
        queue either FIFO or LIFO.
entry   AX       06h
        BH       00h     Internal data queue accessible via PULL and PARSE PULL
                 01h     External interrupt queue accessible via LINEIN(EXQUE)
        BL       00h     Queue data FIFO on selected queue
                 01h     Queue data LIFO on selected queue
        DS:SI    points to null terminated string to be queued.
return  AX       0000h   Message queued successfully.
                 0001h   No REXXPC88 program running at current time. Message not
                         queued.
                 0002h   Not enough storage available for message. Message not
                         queued.
                 0003h   Either BH (queue number) or BL (FIFO/LIFO flag) out of
                         range. Message not queued.
note 1. For the Internal data queue a string may not exceed 127 characters.
     2. For the External int. queue a string may not exceed available storage.
     3. Registers: all registers except SS and SP are destroyed. The caller must
        save any other registers of interest.

Function 07h  Check for Loaded Extension
         This call provides a way for a REXXPC88 extension to find out if  a copy
          is already loaded, and to exchange information with a resident version.
entry   AX       0007h
        SS:BP    points to a C stack frame containing a two-byte pointer to the
                   null terminated name of the REXXPC88 extension.
return  If the extension is already loaded, then DS:SI points to an ASCIIZ string
        '1', and other registers are used as desired by the extension to
        communicate with its non-resident copy. (Generally, this involves
        pointing ES:BX to the resident portion's entry point). If the extension
        is not yet resident, then DS:SI points to an ASCIIZ '0'.
note    Registers: all registers except SS, SP and BP are available for use.

Function 08h Reserved
        This call is reserved for communication between REXXSYS.SYS and  REXXIBMR.
entry   AX       0008h
return  none
```

```
entry   AX      0008h
return  none
Function 09h Check for REXX Installed
        This call provides external applications a way to determine if REXXIBMR
        is installed.
entry   AX      09h
return  AX      0FFFFh  REXXIBMR is not installed
        AX      0AAAAh  REXXIBMR is installed
note    It is assumed that your application will inspect the value of the 7Ch
        interrupt vector prior to issuing this interrupt. If the vector is
        0000:0000 then REXXIBMR is not installed and this function will cause
        the system to crash.

Function 0Ah  Uninstall resident version of REXX
        This call is used to uninstall a resident version
entry   AX      000Ah
        BX      0AAAAh
return  AX      0000h   Resident version uninstalled
                0001h   Resident version cannot uninstall, as one interrupt
                        vector has been modified by some other program in a non-
                        conforming manner.
                0FFFFh  The installed resident version does NOT support
                        the uninstall request code (i.e., it is pre 0.55 level).
```

Interrupt 7Fh IBM 8514/A Graphics Adapter API
59 API functions available, parameters unknown.

1. Used by second copy of COMMAND set with SHELL=
2. Not used by COMMAND /C at DOS prompt

Interrupt 80h-85h Reserved by BASIC

Note Interrupts 80h through 0ECh are apparently unused and not initialized in most clone systems.

Interrupt 86h Int 18 when relocated by NETBIOS

Interrupt 86h-0F0h Used by BASIC when BASIC interpreter is running

Interrupt 0E0h Digital Research CP/M-86 function calls

Interrupt 0E4h Logitech Modula-2 v2.0 Monitor Entry

```
entry   AX      05h     monitor entry
                06h     monitor exit
        BX      priority
return  unknown
```

Interrupt 0EFh GEM interface (Digital Research)

```
entry   CX      0473h
        DS:DX   pointer to GEM parameter block
note    no other parameters are known
```

Interrupt 0F0h unknown

1. Used by secondary copy of COMMAND when SHELL= set
2. Not used by COMMAND /C at DOS prompt
3. Used by BASIC while in interpreter

Interrupts 0F1h-0FFh (absolute addresses 3C4h-3FFh)
Location of Interprocess Communications Area

Interrupt 0F8h Set Shell Interrupt (OEM)
Set OEM handler for int 21h calls from 0F9h through 0FFh

```
entry   AH      0F8h
        DS:DX   pointer to handler for Functions 0F9h thru 0FFh
note 1. To reset these calls, pass DS and DX with 0FFFFh. DOS is set up to allow
        ONE handler for all 7 of these calls. Any call to these handlers will
```

```
   result in the carry bit being set and AX will contain 1 if they are not
   initialized. The handling routine is passed all registers just as the
   user set them. The OEM handler routine should be exited through an IRET.
2. 10 ms interval timer (Tandy?)
```

Interrupt 0F9h Reserved

First of 8 SHELL service codes, reserved for OEM shell (WINDOW); use like HP Vectra user interface?

Interrupt 0FAh USART ready (RS-232C)

Interrupt 0FBh USART RS ready (keyboard)

Interrupt 0FCh Unknown

Interrupt 0FDh reserved for user interrupt

Interrupt 0FEh reserved by IBM

Interrupt 0FFh reserved by IBM

6

DOS Control Blocks and Work Areas

DOS Address Space

Contrary to popular belief, DOS is not limited to 640k of work space. This constraint is enforced by the mapping of ROM and video RAM into the default 1 megabyte CPU address space. Some MSDOS compatible machines, such as the Sanyo 55x series, can have as much as 768k of contiguous DOS workspace with the appropriate option boards. Since DOS has no real memory management, it cannot deal with a fragmented workspace. Fragmented RAM (such as RAM mapped into the option ROM address space) can be dealt with as a RAMdisk or other storage area by using a device driver or other software.

The 80386 CPU and appropriate control software can create a DOS workspace of more than one megabyte. Certain add-on boards can also add more than a megabyte of workspace, but only for specially written software. Since these are all proprietary schemes, little information is available at present.

Storage Blocks

A storage block is used by DOS to record the amount and location of allocated memory within the machine's address space.

A storage block, a Program Segment Prefix, and an environment area are built by DOS for each program currently resident in the address space. The storage block is used by DOS to record the address range of memory allocated to a program. It is used by DOS to find the next available area to load a program and to determine if there is enough memory to run that porogram. When a memory area is in use, it is said to be allocated. Then the program ends, or releases memory, it is said to be deallocated.

A storage block contains a pointer to the Program Segment Prefix associated with each program. This control block is constructed by IBMDOS for the purpose of providing standardized areas for DOS/program communication. Within the PSP are areas which are used to save interrupt vectors, pass parameters to the program, record disk directory information, and to buffer disk reads and writes. This control block is 100h bytes in length and is followed by the program module loaded by DOS.

The PSP contains a pointer to the environment area for that program. This area contains a copy of the current DOS SET, PROMPT, COMSPEC, and PATH values as well as any user-set variables. The program may examine and modify this information as desired.

Each storage block is 10h bytes long, although only 5 bytes are currently used by DOS. The first byte contains 4Dh (a capital M) to indicate that it contains a pointer to the next storage block. A 5Ah (a capital Z) in the first byte of a storage block indicatres there are no more storage blocks following this one (it is the end of the chain). The identifier byte is followed by a 2 byte segment number for the associated PSP for that program. The next 2 bytes contain the number of segments what are allocated to the program. If this is not the last storage block, then another storage block follows the allocated memory area.

When the storage block contains zero for the number of allocated segments, then no storage is allocated to this block and the next storage block immediately follows this one. This can happen when memory is allocated and then deallocated repeatedly.

IBMDOS constructs a storage block and PSP before loading the command interpreter (default is COMMAND.COM).

If the copy of COMMAND.COM is a secondary copy, it will lack an environment address at PSP+2Ch.

Disk Transfer Area (DTA)

DOS uses an area in memory to contain the data for all file reads and writes that are performed with FCB function calls. This are is known as the disk transfer area. This disk transfer area (DTA) is sometimes called a buffer. It can be located anywhere in the data area of your application program and should be set by your program.

Only one DTA can be in effect at a time, so your program must tell DOS what memory location to use before using any disk read or write functions. Use function call 1Ah (Set Disk Transfer Address) to set the disk transfer address. Use function call 2Fh (Get Disk Transfer Address) to get the disk transfer address. Once set, DOS continues to use that area for all disk operations until another function call 1Ah is issued to define a new DTA. When a program is given control by COMMAND.COM, a default DTA large enough to hold 128 bytes is established at 80h into the program's Program Segment Prefix.

For file reads and writes that are performed with the extended function calls, there is no need to set a DTA address. Instead, specify a buffer address when you issue the read or write call.

Program Segment Prefix

When DOS loads a program, it first sets aside a section of memory for the program called the program segment, or code segment. Then it constructs a control block called the program segment prefix, or PSP, in the first 256 (100h) bytes. Usually, the program is loaded directly after the PSP at 100h.

The PSP contains various information used by DOS to help run the program. The PSP is always located at offset 0 within the code segment. When a program recieves control certain registers are set to point to the PSP. For a COM file, all registers are set to point to the beginning of the PSP and the program begins at 100h. For the more complex EXE file structures, only DS and ES registers are set to point to the PSP. The linker determines the settings for the CS, IP, SS, and SP registers and may set the starting location in CS:IP to a location other than 100h.

IBMBIO provides an IRET instruction at absolute address 847h for use as a dummy routine for interrupts that are not used by DOS. This lets the interruptsdo nothing until their vectors are re-routed to their appropriate handlers.

The PSP (with offsets in hexadecimal) is formatted as follows:
(* = undocumented)

PROGRAM SEGMENT PREFIX

```
offset size   C O N T E N T S
 00h    2  bytes  int 20h
 02h    2  bytes  segment address, end of allocation block
 04h    1  byte   reserved, normally 0
 05h    5  bytes  FAR call to MSDOS function dispatcher   (int 21h)
 0Ah    4  bytes  previous termination handler interrupt vector (int 22h)
 0Eh    4  bytes  previous contents of ctrl-C interrupt vector (int 23h)
 12h    4  bytes  prev. critical error handler interrupt vector (int 24h)
 16h    22 bytes  reserved for DOS
  *     2  bytes  (16) parent process' PSP
  *     20 bytes  (18) 'handle table ' used for redirection of files
 2Ch    2  bytes  segment address of the program's environment block
 2Eh    34 bytes  reserved, DOS work area
  *     4  bytes  (2Eh) stores the calling process's stack pointer when switching
                  to DOS's internal stack.
  *               (32h) DOS 3.x max open files
  *     2  bytes  (3Ah) size of handle table  |these functions are in here
  *     4  bytes  3Ch) handle table address   |but reported addresses vary
 50h    3  bytes  int 21h, RETF instruction
 53h    2  bytes  reserved - unused?
 55h    7  bytes  reserved, or FCB#1 extension
 5Ch    16 bytes  default unopened File Control Block #1
 6Ch    16 bytes  default unopened FCB #2 (overlaid if FCB #1 opened)
 80h    1  byte   parameter length (number of chars entered after filename)
 81h    ...       parameters
 0FFh  128 bytes command tail and default Disk Transfer Area (DTA)
```

1. The first segment of available memory is in segment (paragraph) form. For example, 1000h would respresent 64k.
2. Offset 2Ch contains the segment address of the environment.
3. Programs must not alter any part of the PSP below offset 5Ch.

PSP (comments)

offset 00h contains hex bytes 'CD 20', the int 20h opcode. A program can end by making a jump to this location when the CS points to the PSP. For normal cases, int 21h/fn4Ch should be used.

offset 02h contains the segment-paragraph address of the end of memory as reported by DOS. (which may not be the same as the real end of RAM). Multiply this number by 10h or 16 to get the amount of memory available. ex. 1000h would be 64k.

offset 04h 'reserved or used by DOS' according to Microsoft

offset 05h contains a long call to the DOS function dispatcher. Programs may jump to this address instead of calling int 21h if they wish. Used by BASIC and other CPM object-code translated programs. It is slower than standard int 21h.

offset 0Ah, 0Eh, 12h
vectors (IP, CS)

offset 16h PSP:16h is the segment address of the invoking program's PSP, which * will most often be COMMAND.COM but perhaps may be a secondary non-permanent COMMAND or a multitasking shell, etc. At any rate, the resident shell version of COMMAND.COM has PSP:16h = PSP, which indicates 'don't look any lower in memory' for the command interpreter. To find the beginning of the allocation chain, look backwards through the PSP link addresses until the link address is equal to the PSP segment address that it resides in. This should be COMMAND.COM. To find COMMAND.COM's environment, look at the word stored at offset 0BD3h (PC-DOS 3.1 only). This is a segment address, so look there at offset 0.

18h handle alias table (networking). Also you can make PRN go to CON, * CON go to PRN, ERR go to PRN, etc. 0FFh = available.

offset 2Ch is the segment:offset address of the environment for the program using this particular PSP. This pointer does not point to COMMAND.COM's environment unless it is a second copy of COMMAND.

offset 2Eh the DWORD at PSP+2Eh is used by DOS to store the calling process's * stack pointer when switching to DOS's own private stack - at the end of a DOS function call, SS:SP is restored from this address.

offset 32h, 34h
* table of number of file handles (up to 64k of handles!)

offset 40h 2 byte field points to the segment address of COMMAND.COM's PSP in * 'weird' EXE files produced by Digital Research RASMPC/LINKPC. EXE files created with these tools can cause all sorts of problems with standard MSDOS debugging tools.

offset 50h contains a long call to the DOS int 21 function dispatcher.

offset 5Ch, 65h, 6Ch
contain FCB information for use with FCB function calls. The first FCB may overlay the second if it is an extended call; your program should revector these areas to a safe place if you intend to use them.

offset 5Ch 16 bytes first command-line argument (formatted as uppercase 11 character filename)

offset 6Ch 16 bytes second command-line argument (formatted as uppercase 11 character filename)

offset 7Ch-7Fh
'reserved or used by DOS'

offset 80h 1 byte number of bytes in command line argument

offset 80h, 81h
contain the length and value of parameters passed on the command line.

offset 81h 97 bytes unformatted command line and/or default DTA

offset 0FFh contains the DTA

The PSP is created by DOS for all programs and contains most of the information you need to know about a program running. You can change the environment for the current process, however, but for the parent process, DOS in this case, you need to literally backtrack to DOS or COMMAND.COM's PSP. In order to get there you must look at the current PSP. At offset 16h of the current PSP segment there is a 2 byte segment address to the parent or previous process PSP. From there you can manipulate the enviroment by looking at offset 2Ch.

Try this under debug and explore the addresses located at these offsets;

offset	length	description
16h	2	segment address of parent process PSP
2Ch	2	segment address of environment block.

Remember under debug you will have to backtrack two times.

Programs	Parent
command.com	none
debug.com	command.com
program	debug.com

Memory Control Blocks

DOS keeps track of allocated and available memory blocks, and provides four function calls for application programs to communicate their memory needs to DOS. These calls are:

```
48h --- allocate memory                (MALLOC)
49h --- free allocated memory
4Ah --- modify allocated memory blocks (SETBLOCK)
4Bh --- load or execute program        (EXEC)
```

DOS manages memory as follows:

DOS builds a control block for each block of memory, whether free or allocated. For example, if a program issues an 'allocate' (48h), DOS locates a block of free memory that satisfies the request, and then 'carves' the requested memory out of that block. The requesting program is passed the location of the first byte of the block that was allocated for it - a memory management control block, describing the allocated block, has been built for the allocated block and a second memory management control block describes the amount of space left in the original free block of memory. When you do a SETBLOCK to shrink an allocated block, DOS builds a memory management control block for the area being freed and adds it to the chain of control blocks. Thus, any program that changed memory that is not allocated to it stands a chance of destroying a DOS memory management control block. This causes unpredictable results that don't show up until an activity is performed where DOS uses its chain of control blocks. The normal result is a memory allocation error, which means a system reset will be required.

When a program (command or application program) is to be loaded, DOS uses the EXEC function call 4Bh to perform the loading. This is the same function call that is available to applications programs for loading other programs. This function call has two options:

Function 00h, to load and execute a program (this is what the command processor uses to load and execute external commands)

Function 03h, to load an overlay (program) without executing it.

Although both functions perform their loading in the same way (relocation is performed for EXE files) their handling of memory management is different.

FUNCTION 0

For function 0 to load and execute a program, EXEC first allocates the largest available block of memory (the new program's PSP will be at offset 0 in that block). Then EXEC loads the program. Thus, in most cases, the new program owns all the memory from its PSP to the end of memory, including memory occupied by the transient parent of COMMAND.COM. If the program were to issue its own EXEC function call to load and execute another program, the request would fail because no available memory exists to load the new program into.

Note For EXE programs, the amount of memory allocated is the size of the program's memory image plus the value in the MAX_ALLOC field of the file's header (offset 0Ch, if that much memory is available. If not, EXEC allocates the size of the program's memory image plus the value in the MIN_ALLOC field in the header (offset 0Ah). These fields are set by the Linker).

A well-behaved program uses the SETBLOCK function call when it receives control, to shrink its allocated memory block down to the size it really needs. A COM program should remember to set up its own stack before doing the SETBLOCK, since it is likely that the default stack supplied by DOS lies in the area of memory being used. This frees unneeded memory, which can be used for loading other programs.

If the program requires additional memory during processing, it can obtain the memory using the allocate function call and later free it using the free memory function call.

When a program is loaded using EXEC function call 00h exits, its initial allocation block (the block beginning with its PSP) is automatically freed before the calling program regains control. It is the responsibility of all programs to free any memory they allocate before exiting to the calling program.

FUNCTION 3

For function 3, to load an overlay, no PSP is built and EXEC assumes the calling program has already allocated memory to load the new program into - it will NOT allocate memory for it. Thus the calling program should either allow for the loading of overlays when it determines the amount of memory to keep when issuing the SETBLOCK call, or should initially free as much memory as possible. The calling program should then allocate a block (based on the size of the program to be loaded) to hold the program that will be loaded using the 'load overlay' call. Note that 'load overlay' does not check to see if the calling program actually owns the memory block it has been instructed to load into - it assumes the calling program has followed the rules. If the calling program does not own the memory into which the overlay is being loaded, there is a chance the program being loaded will overlay one of the control blocks that DOS uses to keep track of memory blocks.

Programs loaded using function 3 should not issue any SETBLOCK calls since they don't own the memory they are operating in. (This memory is owned by the calling program.)

Because programs loaded using function 3 are given control directly by (and return contrrol directly to) the calling program, no memory is automatically freed when the called program exits. It is up to the calling program to determine the disposition of the memory that had been occupied by the exiting program. Note that if the exiting program had itself allocated any memory, it is responsible for freeing that memory before exiting.

Memory control blocks, sometimes called 'arena headers' after their UNIX counterpart, are 16 bytes long. Only the first 5 bytes are used. 16 bytes areused for the memory control block, which always starts at a paragraph boundary. When DOS call 48h is made to allocate 'x' many paragraphs of memory, the amount used up is actually one more than the figure in the BX register to provide space for the associated memory control block. The location of the memory control block is at the paragraph immediately before the segment value returned in AX by the DOS int 21h/fn 48h call i.e. ((AX-1):0).

MEMORY CONTROL BLOCK

Offset	Size	Function
0	1 byte	ASCII M or Z
1-2	2 bytes	PSP segment address of program owning this block of memory
3-4	2 bytes	Size of next MCB in 16-byte paragraphs
5-F	11 bytes	unused

byte 1 — will always have the value of 4Dh or 5Ah. The value 5Ah (Z) indicates the block is the last in a chain, all memory above it is unused. 4Dh (M) means that the block is intermediate in a chain, the memory above it belongs to the next program or to DOS.

bytes 2,3 — hold the PSP segment address of the program that owns the corresponding block of memory. A value of 0 means the block is free to be claimed, any other value represents a segment address.

bytes 3, 4 — indicate the size in paragraphs of the memory block. If you know the address of the first block, you can find the next block by adding the length of the memory block plus 1 to the segment address of the control block. Finding the first block can be difficult, as this varies according to the DOS version and the configuration.

The remaining 11 bytes are not currently used by DOS, and may contain 'trash' characters left in memory from previous applications.

If DOS determines that the allocation chain of memory control blocks has been corrupted, it will halt the system and display the message 'Memory Allocation Error', and the system will halt, requiring a reboot.

Each memory block consists of a signature byte (4Dh or 5Ah) then a word which is the PSP value of the owner of the block (which allocated it), followed by a word which is the size in paragraphs of the block. The last block has a signature of 5Ah. All others have 4Dh. If the owner is 0000 then the block is free.

Once a memory control block has been created it should only be manipulated with the appropriate DOS function calls. Accidentally writing over any of the first 5 bytes of a memory control block can cause a memory allocation error and cause the system to lock up. If the first byte is overwritten with something other than an 'M' or a 'Z' then DOS will complain with an error return code of 7 signifying 'Memory Control Blocks destroyed'. However, should you change the ownership or block size bytes, you've had it.

When a .COM program is first loaded by DOS and given control, the memory control block immediately preceding the Program Segment Prefix contains the following data:

```
ID    = 'Z'
Owner = segment address of PSP (= CS register of .COM program)
Size  = number of available paragraphs in DOS memory pool
```

An .EXE file will have the following data in the memory control block for the program (just prior to the PSP):

```
ID    = 'M'
Owner = segment address of PSP (= DS register of program)
Size  = the number of paragraphs allocated to the program according to
        the information in the .EXE program header
```

In the case of an .EXE program file the amount of memory allocated depends on the contents of the program header which informs the DOS loader how much to allocate for each of the segments in the program. With an .EXE program file there will always be a 'Z' memory control block created in memory immediately after the end of the space allocated to the program itself.

One important fact to remember about DOS memory allocation is that blocks of RAM allocated by different calls to DOS function 48H will NOT be contiguous. At the very best, they will be separated by the 16 bytes of the memory control block, and at worst they could be anywhere in RAM that DOS manages to find a existing memory control block of sufficient size to accomodate the memory request.

DOS treats the memory control blocks as a kind of linked list (term used loosely). It uses the earlier MCBs to find the later ones by calculating the location of the next one from the size of the prior one. As such, erasing any of the MCB data in the chain of MCBs will upset DOS severely, as each call for a new memory allocation causes DOS to scan the whole chain of MCBs looking for a free one that is large enough to fulfill the request.

A separate MCB is created for the DOS environment strings at each program load, so there will be many copies of the environment strewn through memory when you have a lot of memory resident programs loaded. The memory control blocks for the DOS environment strings are not returned to the DOS memory pool if the program goes resident, as DOS will need to copy this enviroment for the next program loaded.

DOS Program Segment

When you enter an external command or call a program through the EXEC function call, DOS determines the lowest available address space to use as the start of available memory for the program being started. This area is called the Program Segment.

At offset 0 within the program segment, DOS builds the Program Segment Prefix control block. EXEC loads the program after the Program Segment Prefix (at offset 100h) and gives it control.

The program returns from EXEC by a jump to offset 0 in the Program Segment Prefix, by issuing an int 20h, or by issuing an int 21h with register AH=00h or 4Ch, or by calling location 50h in the PSP with AH=00h or 4Ch.

It is the responsibility of all programs to ensure that the CS register contains the segment address of the Program Segment Prefix when terminating by any of these methods except call 4Ch.

All of these methods result in returning to the program that issued the EXEC. During this returning process, interrupt vectors 22h, 23h, and 24h (Terminate, Ctrl-Break, and Critical Error Exit addresses) are restored from the values saved in the PSP of the terminating program. Control is then given to the terminate address.

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

For all programs:

1. The segment address of the passed environment is contained at offset 2Ch in the Program Segment Prefix.
2. The environment is a series of ASCII strings totalling less than 32k bytes in the form: 'NAME=value' The default environment is 160 bytes. Each string is a maximum of 127 bytes terminated by a byte of zeroes for a total of 128 bytes, and the entire set of strings is terminated by another byte of zeroes. Following the byte of zeroes that terminates the set of environment string is a set of initial arguments passed to a program that contains a word count followed by an ASCIIZ string. The ASCIIZ string contains the drive, path, and filename.ext of the executable program. Programs may use this area to determine where the program was loaded from. The environment built by the command processor (and passed to all programs it invokes) contains a COMSPEC=string at a minimum (the parameter on COMSPEC is the path used by 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 entered through the SET command.

   The environment that you are passed is actually a copy of the invoking process's environment. If your application terminates and stays resident through int 27h, you should be aware that the copy of the environment passed to you is static. That is, it will not change even if subsequent PATH, PROMPT, or SET commands are issued.

   The size of the environment may be changed from its default of 160 bytes by using the SHELL= command in the CONFIG.SYS from in DOS version 3.1 up, or COMMAND.COM may be patched in earlier versions.

   The environment can be used to transfer information between processes or to store strings for later use by application programs. The environment is always located on a paragraph boundary. This is its format:

   ```
   byte    ASCIIZ string 1
   byte    ASCIIZ string 2
       ....
   byte    ASCIIZ string n
   byte    of zeros (0)
   ```

   Typically the environment strings have the form:

   ```
   NAME = VALUE
   ```

   The length of NAME or VALUE can be anything desired as long as it still fits into the 123 byte space (4 bytes are used by 'SET '). Following the byte of zeros in the environment, a WORD indicates the number of other strings following.

   If the environment is part of an EXECed command interpreter, it is followed by a copy of the DS:DX filename passed to the child process. A zero value causes the newly created process to inherit the parent's environment.

3. Offset 05h in the PSP contains code to invoke the DOS function dispatcher. Thus, by placing the desired function number in AH, a program can issue a long call to PSP+05h to invoke a DOS function rather than issuing an int 21h.

4. The disk transfer address (DTA) is set to 80h (default DTA in PSP).

5. File Control Blocks 5Ch and 6Ch are formatted from the first two parameters entered when the command was invoked. Note that if either parameter contained a path name, then the corresponding FCB will contain only a valid drive number. The filename field will not be valid.

6. An unformatted parameter area at 81h contains all the characters entered after the command name (including leading and imbedded delimiters), with 80h set to the number of characters. If the , , or | parameters were entered on the command line, they (and the filenames associated with them) will not appear in this area, because redirection of standard input and output is transparent to applications.

(For EXE files only)

7. DS and ES registers are set to point to the PSP.

8. CS, IP, SS, and SP registers are set to the values passed by the linker.

(For COM files only)

9. For COM files, offset 6 (one word) contains the number of bytes available in the segment.

10. Register AX reflects the validity of drive specifiers entered with the first two parameters as follows:

```
AH=0FFh if the second parameter contained an invalid drive specifier,
        otherwise AH=00h.
AL=0FFh is the first parameter contained an invalid drive specifier,
        otherwise AL=00h.
```

11. All four segment registers contain the segment address of the inital allocation block, that starts within the PSP control block. All of user memory is allocated to the program. If the program needs to invoke another program through the EXEC function call (4Bh), it must first free some memory through the SETBLOCK function call to provide space for the program being invoked.

12. The Instruction Pointer (IP) is set to 100h.

13. The SP register is set to the end of the program's segment. The segment size at offset 6 is rounded down to the paragraph size.

14. A word of zeroes is placed on top of the stack.

7

DOS File Structure

File Management Functions

Use DOS function calls to create, open, close, read, write, rename, find, and erase files. There are two sets of function calls that DOS provides for support of file management. They are:

```
* File Control Block function calls   (0Fh-24h)
* Handle function calls               (39h-69h)
```

Handle function calls are easier to use and are more powerful than FCB calls. Microsoft recommends that the handle function calls be used when writing new programs. DOS 3.0 up have been curtailing use of FCB function calls; it is possible that future versions of DOS may not support FCB function calls.

The following table compares the use of FCB calls to Handle function calls:

FCB Calls	Handle Calls
Access files in current directory only.	Access files in ANY directory
Requires the application program to maintain a file control block to open, create, rename or delete a file. For I/O requests, the application program also needs an FCB	Does not require use of an FCB. Requires a string with the drive, path, and filename to open, create, rename, or delete a file. For file I/O requests, the application program must maintain a 16 bit file handle that is supplied by DOS.

The only reason an application should use FCB function calls is to maintain the ability to run under DOS 1.x. To to this, the program may use only function calls 00h-2Eh. Though the FCB function calls are frowned upon, many of the introductory assembly language programming texts use the FCB calls as examples.

FCB Function Calls

FCB function calls require the use of one File Control Block per open file, which is maintained by the application program and DOS. The application program supplies a pointer to the FCB and fills in the appropriate fields required by the specific function call. An FCB function call can perform file management on any valid drive, but only in the current logged directory. By using the current block, current record, and record length fields of the FCB, you can perform sequential I/O by using the sequential read or write function calls. Random I/O can be performed by filling in the random record and record length fields.

Several possible uses of FCB type calls are considered programming errors and should not be done under any circumstances to avoid problems with file sharing and compatibility with later versions of DOS.

Some errors are:

1. If program uses the same FCB structure to access more than one open file. By opening a file using an FCB, doing I/O, and then replacing the filename field in the file control block with a new filename, a program can open a second file using the same FCB. This is invalid because DOS writes control information about the file into the reserved fields of the FCB. If the program replaces the filename field with the original filename and then tries to perform I/O on this file, DOS may become confused because the control information has been changed. An FCB should never be used to open a second file without closing the one that is currently open. If more than one File Control Block is to be open concurrently, separate FCBs should be used.
2. A program should never try to use the reserved fields in the FCB, as the function of the fields may change with different versions of DOS.
3. A delete or a rename on a file that is currently open is considered an error and should not be attempted by an application program.

It is also good programming practice to close all files when I/O is done. This avoids potential file sharing problems that require a limit on the number of files concurrently open using FCB function calls.

Handle Function Calls

The recommended method of file management is by using the extended 'handle' set of function calls. These calls are not restricted to the current directory. Also, the handle calls allow the application program to define the type of access that other processes can have concurrently with the same file if the file is being shared.

To create or open a file, the application supplies a pointer to an ASCIIZ string giving the name and location of the file. The ASCIIZ string contains an optional drive letter, optional path, mandatory file specification, and a terminal byte of 00h. The following is an example of an ASCIIZ string:

```
format:        [drive][path] FILENAME.EXT,0

in MASM:       db 'A:\PATH\FILENAME.EXT',0
```

If the file is being created, the application program also supplies the attribute of the file. This is a set of values that defines the file read-only, hidden, system, directory, or volume label.

If the file is being opened, the program can define the sharing and access modes that the file is opened in. The access mode informs DOS what operations your program will perform on this file (read-only, write-only, or read/write) The sharing mode controls the type of operations other processes may perform concurrently on the file. A program can also control if a child process inherits the open files of the parent. The sharing mode has meaning only if file sharing is loaded when the file is opened.

To rename or delete a file, the appplication program simply needs to provide a pointer to the ASCIIZ string containing the name and location of the file and another string with the new name if the file is being renamed.

The open or create function calls return a 16-bit value referred to as the file handle. To do any I/O to a file, the program uses the handle to reference the file. Once a file is opened, a program no longer needs to maintain the ASCIIZ string pointing to the file, nor is there any need to stay in the same directory. DOS keeps track of the location of the file regardless of what directory is current.

Sequential I/O can be performed using the handle read (3Fh) or write (40h) function calls. The offset in the file that I/O is performed to is automatically moved to the end of what was just read or written. If random I/O is desired, the LSEEK (42h) function call can be used to set the offset into the file where I/O is to be performed.

Special File Handles

DOS reserves five special file handles for use by itself and applications programs. They are:

```
0000h  STDIN   standard input device        (input can be redirected)
0001h  STDOUT  standard output device       (output can be redirected)
0002h  STDERR  standard error output device (output cannot be redirected)
               Note: DOS opens STDERR for both writing and reading. Since STDIN
               can be redirected, using STDERR to read the keyboard is a re
               liable way to ensure that your program is actually reading the
               keyboard, if that's what you want to do.
0004h  STDAUX  standard auxiliary device
0005h  STDPRN  standard printer device (PRN, normally LPT1)
```

These handles are predefined by DOS and can be used by an application program. They do not need to be opened by a program, although a program can close these handles. STDIN should be treated as a read-only file, and STDOUT and STDERR should be treated as write-only files. STDIN and STDOUT can be redirected. All handles inherited by a process can be redirected, but not at the command line. These handles are very useful for doing I/O to and from the console device. For example, you could read input from the keyboard using the read (3Fh) function call and file handle 0000h (STDIN), and write output to the console screen with the write function call (40h) and file handle 0001h (STDOUT). If you wanted an output that could not be redirected, you could output it using file handle 0002h (STDERR). This is very useful for error messages that must be seen by a user.

File handles 0003h (STDAUX) and 0004h (STDPRN) can be both read from and written to. STDAUX is typically a serial device and STDPRN is usually a parallel device.

Raw and Cooked File I/O

Raw and cooked modes originated in the Unix world and were provided with DOS 2.x+. They apply only to character I/O (including the keyboard, screen, printer and serial ports - but not block devices like disk drives), and only to the 'new' 2.x file handle I/O functions (not the old FCB file I/O functions). Raw mode is called 'binary' mode in DOS 3.x+, and cooked mode is called 'ASCII'. The common raw-cooked convention is from DOS 2.x and other operating systems.

The five predefined DOS file handles are all devices, so the mode can be changed from raw to cooked via IOCTL. These handles are in cooked mode when initialized by DOS. Regular file handles that are not devices are always in raw mode and cannot be changed to cooked mode.

The predefined file handles STDIN (0000h) and STDOUT (0001h) and STDERR (0002h) are all duplicate handles. If the IOCTL function call is used to change the mode of any of these three handles, the mode of all three handles is changed. For example, if IOCTL was used to change STDOUT to raw, then STDIN and STDERR would also be changed to raw mode.

In the default cooked mode, DOS examines the character I/O data stream for certain special control characters, and takes specific actions if they are found. For example, Ctrl-C is treated as a Break interrupt, Ctrl-S pauses the screen display, and Ctrl-Z is treated as end-of-file. (If you try to send Ctrl-Z to a printer through a DOS file handle in cooked mode, DOS closes the printer file!) Also, input is buffered within DOS until a CR is detected - so you can't process each key as it is pressed.

In raw mode, DOS ignores special characters, passing them through without any special processing, and does not buffer input lines. So to use file handle I/O and send bit-mapped graphics to a printer through DOS, or process individual keystrokes immediately, or bypass Ctrl-C checking, you need to switch the file handle to raw mode. Raw mode is not automatically reset to cooked mode by DOS when a program terminates, so it is a good idea to reset the file into cooked mode before your program exits if the system was in cooked mode to begin with. I/O to files is done in raw mode.

To set a file handle into raw mode or back into cooked mode, use DOS IOCTL (int 21h Fn 44h, Chapter 4):

1. Get the current mode bits (Subfunction 0).
2. Check that the file is a character file. (If not, exit.)
3. Switch the cooked mode bit to raw or vice versa.
4. Set the mode bits (Subfunction 1).

Microsoft C v4 and later do NOT set raw mode for binary files. When running with the CON driver set to raw mode (to enhance display speed) programs compiled in MSC will crash the computer. A letter to Microsoft reporting this odd behaviour got the somewhat bizarre reply that 'Microsoft does not support the use of any TSRs' from their techs. Raw mode is clearly documented by both IBM and Microsoft, and their own tools should take it into account.

File I/O in Binary (Raw) Mode

The following is true when a file is read in binary mode:

1. The characters ^S (scroll lock), ^P (print screen), ^C (control break) are not checked for during the read. Therefore, no printer echo occurs if ^S or ^P are read.
2. There is no echo to STDOUT (0001h).

3. Read the number of specified bytes and returns immediately when the last byte is received or the end of file reached.

4. Allows no editing of the input using the function keys if the input is from STDIN (0000h).

The following is true when a file is written to in binary mode:

1. The characters ^ S (scroll lock), ^ P (print screen), ^ C (control break) are not checked for during the write. Therefore, no printer echo occurs.

2. There is no echo to STDOUT (0001h).

3. The exact number of bytes specified are written.

4. Does not caret (^) control characters. For example, Ctrl-D is sent out as byte 04h instead of the two bytes ^ and D.

5. Does not expand tabs into spaces.

File I/O in ASCII (Cooked) Mode

The following is true when a file is read in ASCII mode:

1. Checks for the characters ^ C, ^ S, and ^ P.

2. Returns as many characters as there are in the device input buffer, or the number of characters requested, whichever is less. If the number of characters requested was less than the number of characters in the device buffer, then the next read will address the remaining characters in the buffer.

3. If there are no more bytes remaining in the device input buffer, read a line (terminated by ^ M) into the buffer. This line may be edited with the function keys. The characters returned terminated with a sequence of 0Dh, 0Ah (^ M, ^ J) if the number of characters requested is sufficient to include them. For example, if 5 characters were requested, and only 3 were entered before the carriage return (0Dh or ^ M) was presented to DOS from the console device, then the 3 characters entered and 0Dh and 0Ah would be returned. However, if 5 characters were requested and 7 were entered before the carriage return, only the first 5 characters would be returned. No 0Dh, 0Ah sequence would be returned in this case. If less than the number of characters requested are entered when the carriage return is received, the characters received and 0Dh, 0Ah would be returned. The reason the 0Ah (linefeed or ^ J) is added to the returned characters is to make the devices look like text files.

4. If a 1Ah (^ Z) is found, the input is terminated at that point. No 0Dh, 0Ah (CR,LF) sequence is added to the string.

5. Echoing is performed.

6. Tabs are expanded.

The following is true when a file is written to in ASCII mode:

1. The characters ^ S, ^ P, and ^ C are checked for during the write operation.

2. Expands tabs to 8-character boundaries and fills with spaces (20h).

3. Carets control chars, for example, ^ D is written as two bytes, ^ and D.
4. Bytes are output until the number specified is output or a ^ Z is encountered. The number actually output is returned to the user.

Number of Open Files Allowed

The number of files that can be open concurrently is restricted by DOS. This number is determined by how the file is opened or created (FCB or handle function call) and the number specified by the FCBS and FILES commands in the CONFIG.SYS file. The number of files allowed open by FCB function calls and the number of files that can be opened by handle type calls are independent of one another.

Restrictions on FCB Usage

If file sharing is not loaded using the SHARE command, there is no restriction on the number of files concurrently open using FCB function calls.

However, when file sharing is loaded, the maximum number of FCBs open is set by the the FCBS command in the CONFIG.SYS file.

The FCBS command has two values you can specify, 'm' and 'n'. The value for 'm' specifies the number of files that can be opened by FCBs, and the value 'n' specifies the number of FCBs that are protected from being closed.

When the maximum number of FCB opens is exceeded, DOS automatically closes the least recently used file. Any attempt to access this file results in an int 24h critical error message 'FCB not available'. If this occurs while an application program is running, the value specified for 'm' in the FCBS command should be increased.

When DOS determines the least recently used file to close, it does not include the first 'n' files opened, therefore the first 'n' files are protected from being closed.

Restrictions on Handle Usage

The number of files that can be open simultaneously by all processes is determined by the FILES command in the CONFIG.SYS file. The number of files a single process can open depends on the value specified for the FILES command. If FILES is greater than or equal to 20, a single process can open 20 files. If FILES is less than 20, the process can open less than 20 files. This value includes the three predefined handles STDIN, STDOUT, and STDERR. This means only 17 additional handles can be added. DOS 3.3+ includes a function to use more than 20 files per application.

Allocating Space to a File

Files are not necessarily written sequentially on a disk. Space is allocated as needed and the next location available on the disk is allocated as space for the next file being written. Therefore, if considerable file generation has taken place, newly created files will not be written in sequential sectors. However, due to the mapping (chaining) of file space via the File Allocation Table (FAT) and the function calls available, any file may be used in either asequential or random manner.

Space is allocated in increments called clusters. Cluster size varies according to the media type. An application program should not concern itself with the way that DOS allocates space to a file. The size of a cluster is only important in that it determines the smallest amount of space that can be allocated to a file. A disk is considered full when all clusters have been allocated to files.

MSDOS / PCDOS Differences

There is a problem of compatibility between MS-DOS and IBM PC-DOS having to do with FCB Open and Create. The IBM 1.0, 1.1, and 2.0 documentation of OPEN (call 0Fh) contains the following statement:

> 'The current block field (FCB bytes C-D) is set to zero [when an FCB is opened].'

This statement is NOT true of MS-DOS 1.25 or MS-DOS 2.00. The difference is intentional, and the reason is CP/M 1.4 compatibility. Zeroing that field is not CP/M compatible. Some CP/M programs will not run when machine translated if that field is zeroed. The reason it is zeroed in the IBM versions is that IBM specifically requested that it be zeroed. This is the reason for the complaints from some vendors about the fact that IBM MultiPlan will not run under MS-DOS. It is probably the reason that some other IBM programs don't run under MS-DOS.

Note: Do what all MS/PC-DOS systems programs do: Set every single FCB field you want to use regardless of what the documentation says is initialized.

.COM File Structure

The COM file structure was designed for DOS 1.0 and maximum compatibility with programs ported from the CP/M operating system. COM files normally comprise one segment only. A COM file is loaded as a memory image of the disk file and the Instruction Pointer is set to offset 100h within the program.

.EXE File Structure

The EXE file is the native mode for DOS. EXE files may make use of multiple segments for code, stack, and data. The design of the EXE file reflects the segmented design of the Intel 80x86 CPU architecture. EXE files may be as large as available memory and may make references to specific segment addresses.

The EXE files produced by the Linker program consist of two parts, control and relocation information and the load module itself.

The control and relocation information, which is described below, is at the beginning of the file in an area known as the header. The load module immediately follows the header. The load module begins in the memory image of the module contructed by the Linker.

When you are loading a file with the name *.EXE, DOS does NOT assume that it is an EXE format file. It looks at the first two bytes for a signature (the letters MZ) telling it that it is an EXE file. If it has the proper signature, then the load proceeds. Otherwise, it presumes the file to be a .COM format file.

If the file has the EXE signature, then the internal consistency is checked. Pre-2.0 versions of MSDOS did not check the signature byte for EXE files.

The .EXE format can support programs larger than 64K. It does this by allowing separate segments to be defined for code, data, and the stack, each of which can be up to 64K long. Programs in EXE format may contain explicit references to segment addresses. A header in the EXE file has information for DOS to resolve these references.

Offset	Size	CONTENTS
00h	BYTE	4Dh The Linker's signature to mark the file as a valid .EXE file (ASCII letters M and Z, for Mark Zbikowski,
01h	BYTE	5Ah one of the major DOS programmers at Microsoft)
02h-03h	WORD	Length of the image mod 512 (remainder after dividing the load module image size by 512)
04h-05h	WORD	Size of the file in 512 byte pages including the header.
06h-07h	WORD	Number of relocation table items following the header.
08h-09h	WORD	Size of the header in 16 byte (paragraphs). This is used to locate the beginning of the load module in the file
0Ah-0Bh	WORD	Minimum number of 16 byte paragraphs required above the end of the loaded program.
0Ch-0Dh	WORD	Max number of 16 byte paragraphs required above the end of the loaded program. If the minimum and maximum number of paragraphs are both zero, the program will be loaded as high in memory as possible.
0Eh-0Fh	WORD	Displacement in paragraphs of stack segment within load module. This size must be adjusted by relocation.
10h-11h	WORD	Offset to be in SP register when the module is given control (stack offset)
12h-13h	WORD	Word Checksum - negative sum of all the words in the file, ignoring overflow.
14h-15h	WORD	Offset for the IP register when the module is given control (initial instruction pointer)
16h-17h	WORD	Displacement in paragraphs of code segment within load. module. This size must be adjusted by relocation. (CS)
18h-19h	WORD	Displacement in bytes of first relocation item in the file.
1Ah-1Bh	WORD	Overlay number (0 for the resident part of the program)

The Relocation Table

The word at 18h locates the first entry in the relocation table. The relocation table is made up of a variable number of relocation items. The number of items is contained at offset 06h. The relocation item contains two fields - a 2 byte offset value, followed by a 2 byte segment value. These two fields represent the displacement into the load module before the module is given control. The process is called relocation and is accomplished as follows:

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 in offsets 0Ah and 0Ch. DOS always tries to allocate 0FFFFh paragraphs. Since this call will always fail, the function returns the amount of free memory. If this block is larger than the minimum specified at offset 0Ah and the loaded program size, DOS will allocate the size specified at offset 0Ch or the largest free memory space, whichever is less.

3. A Program Segment Prefix is built following the resident portion of the program that is performing the load operation.
4. The formatted part of the header is read into memory (its size is at offset 08h)
5. The load module size is determined by subtracting the header size from the file size. Offsets 04h and 08h can be used for this calculation. The actual size is downward adjusted based on the contents of offset 02h. Note that all files created by the Linker programs prior to version 1.10 always placed a value of 4 at this location, regardless of the actual program size. Therefore, Microsoft recommends that this field be ignored if it contains a value of 4. Based on the setting of the high/low loader switch, an appropriate segment is determined for loading the load module. This segment is called the start segment.
6. The load module is read into memory beginning at the start segment. The relocation table is an ordered list of relocation items. The first relocation item is the one that has the lowest offset in the file.
7. The relocation table items are read into a work area one or more at a time.
8. Each relocation table item segment value is added to the start segment value. The calculated segment, in conjunction with 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.
9. Once all the relocation items have been processed, the SS and SP registers are set from the values in the header and 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 used to give the module control.

'NEW' .EXE Format (Microsoft Windows and OS/2)

The 'old' EXE format is documented here. The 'new' EXE format puts more information into the header section and is currently used in applications that run under Microsoft Windows. The linker that creates these files comes with the Microsoft Windows Software Development Kit and is called LINK4. If you try to run a Windows-linked program under DOS, you will get the error message 'This program requires Microsoft Windows'. The OS/2 1.x file format is essentially the same as the Windows format.

Standard File Control Block

The standard file control block is defined as follows, with offsets in hex:

FILE CONTROL BLOCK

```
offset  size       Function
0       1 byte   Drive number. For example:
                 Before open:     00h = default drive
                                  01h = drive A:
                                  02h = drive B: etc.
                 After open:      00h = drive C:
                        01h = drive A:
                        02h = drive B: etc.
```

```
                  An 0 is replaced by the actual drive number during open.
1-8      8 bytes  Filename, left justified with blanks.
                  If a reserved device name is placed here (such as PRN), do not
                  include the optional colon.
9-B      3 bytes  Filename extension, left justified with trailing blanks.
C-D      2 bytes  Current block # relative to start of file, starting with 0
                  (set to 0 by the open function call). A block consists of 128
                  records, each of the size specified in the logical record size
                  field. The current block number is used with the current record
                  field (below) for sequential reads and writes.
E-F      2 bytes  Logical record size in bytes.
                  Set to 80h by OPEN function. If this is not correct, you must
                  set the value because DOS uses it to determine the proper
                  locations in the file for all disk reads and writes.
10-13    4 bytes  File size in bytes.
                  In this field, the first word is the low-order part of the size.
14-15    2 bytes  Date file was created or last updated.
                  MM/DD/YY are mapped as follows:
                  15  14  13  12  11  10  9  8  7  6  5  4  3  2  1  0
                  y   y   y   y   y   y   y  m  m  m  m  d  d  d  d  d
                  where:           mm is 1-12
                                   dd is 1-31
                                   yy is 0-119 (1980-2099)
16-17    2 bytes  Time file was created or last updated.
                  These bytes contain the time when the file was created or last
                  updated.
                  The time is mapped in the bits as follows:
                            B Y T E   16h                B Y T E   17h
                  F   E   D   C   B   A   9   8   7   6   5   4   3   2   1   0
                  H   H   H   H   H   M   M   M   M   M   M D   D   D   D   D
                  binary # hrs 0-23  binary # minutes 0-59  bin. # 2-sec incr
                  note: The time is stored with the least significant byte first.
18-19    2 bytes  Reserved for DOS.
20       1 byte   Current relative record number
                  (0-127) within the current block. This field and the Current
                  Block field at offset 0Ch make up the record pointer. This
                  field is not initialized by the OPEN function call. You must
                  set this field before doing sequential read-write operations to
                  the diskette.
21-25    4 bytes  Relative Record.
                  Points to the currently selected record, counting from the
                  beginning of the file starting with 0. This field is not
                  initialized by the OPEN system call. You must set this field
                  before doing a random read or write to the file. If the record
                  size is less than 64 bytes, both words are used. Otherwise,
                  only the first 3 bytes are used. Note that if you use the File
                  Control Block at 5Ch in the program segment, the last byte of
                  the FCB overlaps the first byte of the unformatted parameter
                  area.
```

Note 1. An unopened FCB consists of the FCB prefix (if used), drive number, and filename.ext properly filled in. An open FCB is one in which the remaining fields have been filled in by the CREAT or OPEN function calls.

2. Bytes 0-5 and 32-36 must be set by the user program. Bytes 16-31 are set by DOS and must not be changed by user programs.

3. All word fields are stored with the least significant byte first. For example, a record length of 128 is stored as 80h at offset 14, and 00h at offset 15.

Extended File Control Block

The extended file control block is used to create or search for files in the disk directory that have special attributes.
It adds a 7 byte prefix to the FCB, formatted as follows:

EXTENDED FILE CONTROL BLOCK

Offset	Size	Function
00h	1 byte	Flag byte containing 0FFh to indicate an extended FCB
01h	4 bytes	Reserved by Microsoft
06h	2 bytes	Attribute byte

Refer to int 21h/fn11h (search first) for details on using the attribute bits during directory searches. This function is present to allow applications to define their own files as hidden (and thereby excluded from normal directory searches) and to allow selective directory searches

Any reference in the DOS function calls to an FCB, whether opened or unopened, may use either a normal or extended FCB. If you are using an extended FCB, the appropriate register should be set to the first byte of the prefix, rather than the drive-number field.

Common practice is to refer to the extended FCB as a negative offset from the first byte of a standard File Control Block.

8

DOS Disk Information

The DOS Area

All disks and diskettes formatted by DOS are created with a sector size of 512 bytes. The DOS area (entire area for a diskette, DOS partition for hard disks) is formatted as follows:

DOS AREA

partition table	-	variable size (hard disk only)
boot record	-	1 sector
first copy of the FAT	-	variable size
second copy of the FAT	-	same size as first copy
root directory	-	variable size
data area	-	variable depending on disk size

The following sections describe each of the allocated areas:

The Boot Record

The boot record resides on track 0, sector 1, side 0 of every diskette formatted by the DOS FORMAT program. For hard disks the boot record resides on the first sector of the DOS partition. It is put on all disks to provide an error message if you try to start up with a nonsystem disk in drive A:. If the disk is a system disk, the boot record contains a JMP instruction pointing to the first byte of the operating system.

If the device is IBM compatible, it must be true that the first sector of the first FAT is located at the same sector for all possible media. This is because the FAT sector is read before the media is actually determined. The information relating to the BPB for a particular media is kept in the boot sector for the media. In particular, the format of the boot sector is:

DOS BOOT RECORD

```
00h 3 bytes  JMP to executable code. For DOS 2.x, 3 byte near jump (0E9h).
             For DOS 3.x, 2 byte near jump (0EBh) followed by a NOP (90h)
03h 8 bytes  optional OEM name and version  (such as IBM 2.1)
0Dh byte     sectors per allocation unit (must be a power of 2)
0Eh 2 bytes  B    reserved sectors (starting at logical sector 0)
10h byte          number of FATs
```

```
11h 2 bytes        maximum number of root directory entries
13h 2 bytes   P    number of sectors in logical image (total number of sectors in
                   media, including boot sector directories, etc.). If logical
                   disk size is greater than 32Mb, this value is 0 and the actual
                   size is reported at offset 26h
15h   byte    B    media descriptor byte
16h 2 bytes        number of sectors occupied by a single FAT
18h 2 bytes   sectors per track
1Ah 2 bytes   number of heads
1Ch 2 bytes   number of hidden sectors

EXTENDED BOOT RECORD (DOS 4.0+)
1Eh 2 bytes   number of sectors per track
20h 2 bytes   number of heads
22h 2 bytes   number of hidden sectors
26h 4 bytes   total number of sectors in media (32MB or larger indicated here)
27h   byte    physical drive number
28h   byte    reserved
29h   byte    extended boot record signature
30h 4 bytes   volume serial number (assigned with a random function)
34h 11bytes   volume label
3Fh 8 bytes   reserved
```

The three words at the end return information about the media. The number of heads is useful for supporting different multihead drives that have the same storage capacity but a different number of surfaces. The number of hidden sectors is useful for drive partitioning schemes.

DOS 3.2 uses a table called the BIOS Parameter Block (BPB) to determine if a disk has a valid File Allocation Table. The BPB is located in the first sector of a floppy disk. Although the BPB is supposed to be on every formatted floppy disk, some earlier versions of DOS did not create a BPB and instead assumed that the FAT begins at the second sector of the disk and that the first FAT byte (Media Descriptor Byte) describes the disk format.

DOS 3.2 reads in the whole of the BPB and tries to use it - although strangely enough, it seems as if DOS is prepared to cope with a BPB that is more or less totally blank (it seems to ignore the descriptor byte and treat it as a DSDD 9-sector disk).

DOS 3.2 determines if a disk has a valid boot sector by examining the first byte of logical sector 0. If that byte it a jump instruction 0E9h, DOS 3.2 assumes the rest of the sector is a valid boot sector with a BPB. If the first byte is not 0E9h DOS 3.2 behaves like previous versions, assumes the boot sector is invalid and uses the first byte of the FAT to determine the media type. If the first byte on the disk happens to be 0E9h, but the disk does not have a BPB, DOS 3.2 will return a disk error message.

The real problems occur if some of the BPB data is valid and some isn't. Apparently some OEMs have assumed that DOS would continue to ignore the formatting data on the disk, and have failed to write much there during FORMAT except the media descriptor byte (or, worse, have allowed random junk to be written there). While this error is understandable, and perhaps even forgivable, it remains their problem, not IBMs, since the BPB area has always been documented as containing the format information that IBM DOS 3.2 now requires to be there.

The DOS File Allocation Table (FAT)

The File Allocation Table, or FAT, has three main purposes:

1. to mark bad sectors on the media
2. to determine which sectors are free for use

3. to determine the physical location(s) of a file on the media.

DOS uses one of two different schemes for defining the File Allocation Table:

1. a 12-bit FAT, for DOS 1.x, 2.x, all floppies, and small hard disks
2. a 16-bit FAT, for DOS 3.x+ hard disks from 16.8 to 32Mb

This section explains how DOS uses the FAT to convert the clusters of a file into logical sector numbers. It is recommended that system utilities use the DOS handle calls rather than interpreting the FAT, particularly since aftermarket disk partitioning or formatting software may have been used.

The FAT is used by DOS to allocate disk space for files, one cluster at a time. In DOS 4.0, clusters are referred to as 'allocation units'. It means the same things; the smallest logical portion of a drive.

The FAT consists of a 12 bit entry (1.5 bytes) for each cluster on the disk or a 16 bit (2 bytes) entry when a hard disk has more than 20740 sectors as is the case with fixed disks larger than 10Mb.

The first two FAT entries map a portion of the directory; these FAT entries contain indicators of the size and format of the disk. The FAT can be in a 12 or 16 bit format. DOS determines whether a disk has a 12 or 16 bit FAT by looking at the total number of allocation units on a disk. For all diskettes and hard disks with DOS partitions less than 20,740 sectors, the FAT uses a 12 bit value to map a cluster. For larger partitions, DOS uses a 16 bit value.

The second, third, and fourth bit applicable for 16 bit FAT bytes always contains 0FFFFh. The first byte is used as follows:

Media Descriptor Byte

MEDIA DESCRIPTOR BYTE

hex value	meaning	normally used
00	hard disk	3.3+ extended DOS partition
ED	double sided 9 sector 80 track	Tandy 2000 720k 5 floppy
F0	double sided 18 sector diskette	PS/2 1.44 meg DSHD
F8	hard disk	bootable hard disk at C:800
F9	double sided 15 sector diskette	AT 1.2 meg DSHD
	double sided 9 sector diskette	Convertible 720k DSQD
FA	IBM Displaywriter System disk	287k
FB	IBM Displaywriter System disk	1 meg
FC	single sided 9 sector diskette	DOS 2.0, 180k SSDD
FD	double sided 9 sector diskette	DOS 2.0, 360k DSDD
FE	single sided 8 sector diskette	DOS 1.0, 160k SSDD
FF	double sided 8 sector diskette	DOS 1.1, 320k SSDD

for 8 inch diskettes:

FD	double sided 26 sector diskette	IBM 3740 format DSSD
FE	single sided 26 sector diskette	IBM 3740 format SSSD
	double sided 8 sector diskette	IBM 3740 format DSDD

The third FAT entry begins mapping the data area (cluster 002).

Note: These values are provided as a reference. Therefore, programs should not make use of these values.

Each entry contains a hexadecimal character (or 4 for 16 bit FATs). () indicates the high order four bit value in the case of 16 bit FAT entries. They can be:

(0)000h	if the cluster is unused and available
(0F)FF8h - (0F)FFFh	to indicate the last cluster of a file
(X)XXXh	any other hexadecimal numbers that are the cluster number of the next cluster in the file. The cluster number is the first cluster in the file that is kept in the file's directory entry.

The values (0F)FF0h - (0F)FF7h are used to indicate reserved clusters. (0F)FF7h indicates a bad cluster if it is not part of the allocation chain. (0F)FF8h - (0F)FFFh are used as end of file markers.

The file allocation table always occupies the sector or sectors immediately following the boot record. If the FAT is larger than 1 sector, the sectors occupy consecutive sector numbers. Two copies of the FAT are written, one following the other, for integrity. The FAT is read into one of the DOS buffers whenever needed (open, allocate more space, etc).

12 Bit File Allocation Table

Obtain the starting cluster of the file from the directory entry.

Now, to locate each subsequent sector 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 offset into the FAT, pointing to the entry that maps the cluster just used. That entry contains the cluster number of the next cluster in the file.
3. Use a MOV instruction to move the word at the calculated FAT into a register.
4. If the last cluster used was an even number, keep the low order 12 bits of the register, otherwise, keep the high order 12 bits.
5. If the resultant 12 bits are (0FF8h-0FFFh) no more clusters are in the file. Otherwise, the next 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 int 25h and 26h and DEBUG):

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

12-bit FAT if DOS partition is smaller than 32,680 sectors (16.340 MB).

16 Bit File Allocation Table

Obtain the starting cluster of the file from the directory entry. Now to locate each subsequent cluster of the file:

1. Multiply the cluster number used by 2 (each FAT entry is 2 bytes long).
2. Use the MOV word instruction to move the word at the calculated FAT offset into a register.
3. If the resultant 16 bits are (0FF8h-0FFFFh) no more clusters are in the file. Otherwise, the 16 bits contain the cluster number of the next cluster in the file.

Compaq DOS makes available a new disk type (6) with 32 bit partition values, allowing 512 megabytes per hard disk (Compaq DOS 3.3.1)

DOS Disk Directory

The FORMAT command initially builds the root directory for all disks. Its location (logical sector number) and the maximum number of entries are available through the device driver interfaces.

Since directories other than the root directory are actually files, there is no limit to the number of entries that they may contain.

All directory entries are 32 bytes long, and are in the following format:

```
offset   size              DISK DIRECTORY ENTRY
00h      8 bytes   Filename
                   The first byte of the filename indicates the file status.
                   The file status byte may contain the following values:
                   00h   Directory entry has never been used. This is used to
                         limit the length of directory searches, for performance
                         reasons.
                   05h   Indicates that the first character of the filename
                         actually has an 0EDh character.
                   0E5h  Filename has been used but the file has been erased.
                   2Eh   This entry is for a directory. If the second byte is
                         also 2Eh, the cluster field contains the cluster number
                         of this directory's parent directory. (0000h if the
                         parent directory is the root directory). Otherwise,
                         bytes 00h-0Ah are all spaces and the cluster field
                         contains the cluster number of the directory.
                         Any other character is the first character of a
                         filename. Filenames are left-aligned and if necessary
                         padded with blanks.
08h      3 bytes   Filename extension if any
                   Three characters, left-aligned and padded with blanks if
                   necessary. If there is no file extension, this field contains
                   all blanks
0Bh      1 byte    File attributes
                   The attribute byte is mapped as follows:
                   hex  bit             meaning
                   00h       (no bits set) normal; can be read or written without
                             restriction
                   01h   0   file is marked read-only. An attempt to open the
                             file for out put using int 21h/fn 3Dh will fail and
                             an error code will be returned. This value can be
                             used with other values below.
                   02h   1   indicates a hidden file. The file is excluded from
                             normal directory searches.
                   04h   2   indicates a system file. The file is excluded from
                             normal directory searches.
                   08h   3   indicates that the entry contains the volume label
                             in the first 11 bytes. The entry has no other usable
                             information and may exist only in the root directory.
```

```
                    10h   4   indicates that the file is a subdirectory
                    20h   5   indicates an archive bit. This bit is set to on
                              whenever the file is written to and closed. Used by
                              BACKUP and RESTORE.
                          6   reserved, set to 0
                          7   reserved, set to 0
                    note 1. Bits 6 and 7 may be used in OS/2.
                    note 2. Attributes 08h and 10h cannot be changed using
                            int21/43h.
                    note 3. The system files IBMBIO.COM and IBMDOS.COM (or
                            customized equivalent) are marked as read-only,
                            hidden, and system files. Files can be marked hidden
                            when they are created.
                    note 4. Read-only, hidden, system and archive attributes may
                            be changed with int21h/fn43h.
0Ch                 10 bytes  Reserved by DOS; value unknown
16h      2 bytes    File timestamp
                    These bytes contain the time when the file was created or last
                    updated. The time is mapped in the bits as follows:
                           B Y T E   16h            B Y T E   17h
                    F  E  D  C  B  A  9  8    7  6  5  4  3  2  1  0
                    H  H  H  H  H  M  M  M    M  M  M  D  D  D  D  D
                    binary # hrs 0-23    binary # minutes 0-59 bin. # 2-sec incr
                    note: The time is stored with the least significant byte first.
18h      2 bytes    File datestamp
                    This area contains the date when the file was created or last
                    updated. The mm/dd/yy are mapped in the bits as follows:
                           B Y T E   18h             B Y T E   19h
                    F  E  D  C  B  A  9  8    7  6  5  4  3  2  1  0
                    Y  Y  Y  Y  Y  Y  Y  M    M  M  M  D  D  D  D  D
                      0-119 (1980-2099)         1-12        1-31
                    note: The date is stored with the least significant byte first.
1Ah      2 bytes    First file cluster number
                    * (reserved in DOS 2, documented in DOS 3+)
                    This area contains the starting cluster number of the first
                    cluster in the file. The first cluster for data space on all
                    fixed disks and floppy disks is always cluster 002. The
                    cluster number is stored with the least significant byte first.
1Ch      4 bytes    File size
                    This area contains the file size in bytes. The first word
                    contains the low order part of the size. Both words are stored
                    with the least significant byte first.
```

The Data Area

Allocation of space for a file (in the data area) is done only when needed (it is not pre-allocated). The space is allocated one cluster (unit allocation) at a time. A cluster is always one or more consecutive sector numbers, and all of the clusters in a file are 'chained' together in the FAT.

The clusters are arranged on disk to minimize head movement for multisided 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 sector numbers on the lowest-numbered head, then all the sector numbers on the next head, and so on until all sectors of all heads of the track are used. Then the next sector used will be sector 1 of head 0 on the next track.

An interesting innovation that was introduced in MS-DOS 3.0: disk space that is freed by erasing a file is not re-used immediately, unlike earlier versions of DOS. Instead, free space is obtained from the area not yet used during the current session, until all of it is used up. Only then will space that is freed during the current session be re-used.

This feature minimizes fragmentation of files, since never-before-used space is always contiguous. However, once any space has been freed by deleting a file, that advantage vanishes at the next system boot. The feature also greatly simplifies un-erasing files, provided that the need to do an un-erase is found during the same session and also provided that the file occupies contiguous clusters.

However, when one is using programs which make extensive use of temporary files, each of which may be created and erased many times during a session, the feature becomes a nuisance; it forces the permanent files to move farther and farther into the inner tracks of the disk, thus increasing rather than decreasing the amount of fragmentation which occurs.

The feature is implemented in DOS by means of a single 16-bit 'last cluster used' (LCU) pointer for each physical disk drive; this pointer is a part of the physical drive table maintained by DOS. At boot time, the LCU pointer is zeroed. Each time another cluster is obtained from the free-space pool (the FAT), its number is written into the LCU pointer. Each time a fresh cluster is required, the FAT is searched to locate a free one; in older versions of DOS this search always began at Cluster 0000, but in 3.x it begins at the cluster pointed to by the LCU pointer.

For hard disks, the size of the file allocation table and directory are determined when FORMAT initializes it and are based on the size of the DOS partition.

Floppy Disk Types

The following tables give the specifications for floppy disk formats:

IBM PC-DOS disk formats:

			# of sides	sectors /track	FAT size sectors	DIR sectors	DIR (entries)	sectors /cluster	total sectors	
160k	$5^{1}/_{4}$	DOS 1.0	1	8 (40)	1	4	64	1	320	Original PC-0, 16k mbd
320k	$5^{1}/_{4}$	DOS 1.1	2	8 (40)	1	7	112	2	360	PC-1, 64k mbd
180k	$5^{1}/_{4}$	DOS 2.0	1	9 (40)	2	4	64	1	640	PC-2, 256k mbd
360k	$5^{1}/_{4}$	DOS 2.0	2	9 (40)	2	7	112	2	720	PC/XT
1.2M	$5^{1}/_{4}$	DOS 3.0	2	15 (80)	7	14	224	1	2400	PC/AT, PC/RT, XT/286
720k	$3^{1}/_{2}$	DOS 3.2	2	9 (80)	3	7	112	2	1440	Convertible, PS/2 25+
1.44M	$3^{1}/_{2}$	DOS 3.3	2	18 (80)	9	14	224	1	2880	PS/2 50+

various MS-DOS disk formats:

200k	$5^{1}/_{4}$	*	1	10 (40)						
400k	$5^{1}/_{4}$	* **	2	10 (40)						
800k	$5^{1}/_{4}$	*	2	10 (80)						
720k	$5^{1}/_{4}$	DOS2.11	2	9 (80)	3	7	112	2	1440	Tandy 2000 (discontinued)

* Michtron DS-DOS 2.11 Plus and one version of MS-DOS 3.11 (vendor unknown)
** TallTree JFormat program

720k	5	DOS2.11	1	(80)	DEC Rainbow SS/HD (disc.)
720k	5	DOS2.11	2	variable number of sectors per track, more sectors on outer tracks than innertracks. Special DSDD drive.	Victor 9000 PC (discont'd)

Files in the data area are not necessarily written sequentially. The data area space is allocated one cluster at a time, skipping over clusters already allocated. The first free cluster found is the next cluster allocated, regardless of its physical location on the disk. This permits the most efficient utilization of disk space because clusters freed by erasing files can be allocated for new files. Refer back to the description of the DOS FAT in this chapter for more information.

SSDD single sided, double density (160-180k) $5^{1}/_{4}$

DSDD	double sided, double density	(320-360k)	$5^1/_4$
DSQD	double sided, quad density	(720k)	$5^1/_4$, $3^1/_2$
DSHD	double sided, high density	(1.2-1.44M)	$5^1/_4$, $3^1/_2$

Much of the trouble with AT 1.2 meg drives has been through the inadvertent use of quad density disks in the high density drives. The high density disks use a higher-coercivity media than the quads, and quads are not completely reliable as 1.2Mb. Make sure you have the correct disk for your application.

Hard Disk Layout

The DOS hard disk routines perform the following services:

1. Allow multiple operating systems to be installed on the hard disk at the same time.
2. Allow a user-selected operating system to be started from the hard disk.
   i. In order to share the hard disk among operating systems, the disk may be logically divided into 1 to 4 partitions. The space within a given partition is contiguous, and can be dedicated to a specific operating system. Each operating system may 'own' only one partition in DOS versions 2.0 through 3.2. DOS 3.3 introduced the 'Extended DOS Partition' which allows multiple DOS partitions on the same hard disk. FDISK (or a similar program from other DOS vendors) utility allows the user to select the number, type, and size of each partition. The partition information is kept in a partition table that is embedded in the master hard disk boot record on the first sector of the disk. The format of this table varies from version to version of DOS.
   ii. An operating system must consider its partition to be the entire disk, and must ensure that its functions and utilities do not access other partitions on the disk.
   iii. Each partition may contain a boot record on its first sector, and any other programs or data that you choose, including a different operating system. For example, the DOS FORMAT command may be used to format and place a copy of DOS in the DOS partition in the same manner that a diskette is formatted. You can use FDISK to designate a partition as 'active' (bootable). The master hard disk boot record causes that partition's boot record to receive control when the system is initialized. Additional disk partitions could be FORTH, UNIX, Pick, CP/M-86, OS/2, or the UCSD p-System.

SYSTEM INITIALIZATION

The boot sequence is as follows:

1. System initialization first attempts to load an operating system from diskette drive A. If the drive is not ready or a read error occurs, it then attempts to read a master hard disk boot record on the first sector of the first hard disk in the system. If unsuccessful, or if no hard disk is present, it invokes ROM BASIC in an IBM PC or displays a disk error message on most compatibles.
2. If initialization is successful, the master hard disk boot record is given control and it examines the partition table embedded within it. If one of the entries indicates an active (bootable) partition, its boot record is read from the partition's first sector and given control. If none of the partitions is bootable, ROM BASIC is invoked on an IBM PC or a disk error on most compatibles.
4. If any of the boot indicators are invalid, or if more than one indicator is marked as bootable, the message 'INVALID PARTITION TABLE' is displayed and the system stops.

5. If the partition's boot record cannot be successfully read within five retries due to read errors, the message 'ERROR LOADING OPERATING SYSTEM' appears and the system stops.

6. If the partition's boot record does not contain a valid 'signature', the message 'MISSING OPERATING SYSTEM' appears, and the system stops.

Note: When changing the size or location of any partition, you must ensure that all existing data on the disk has been backed up. The partitioning program will destroy the data on the disk.

System programmers designing a utility to initialize/manage a hard disk must provide the following functions at a minimum:

1. Write the master disk boot record/partition table to the disk's first sector to initialize it.

2. Perform partitioning of the disk - that is, create or update the partition table information (all fields for the partition) when the user wishes to create a partition. This may be limited to creating a partition for only one type of operating system, but must allow reparatitioning the entire disk, or adding a partition without interfering with existing partitions (user's choice).

3. Provide a means for marking a user-specified partition as bootable and resetting the bootable indicator bytes for all other partitions at the same time.

4. Such utilities should not change or move any partition information that belongs to another operating system.

Boot Record/Partition Table

A boot record must be written on the first sector of all hard disks, and must contain the following:

1. Code to load and give control to the boot record for one of four possible operating systems.

2. A partition table at the end of the boot record. Each table entry is 16 bytes long, and contains the starting and ending cylinder, sector, and head for each of four possible partitions, as well as the number of sectors preceding the partition and the number of sectors occupied by the partition. The 'boot indicator' byte is used by the boot record to determine if one of the partitions contains a loadable operating system. FDISK initialization utilities mark a user-selected partition as 'bootable' by placing a value of 80h in the corresponding partition's boot indicator (setting all other partitions' indicators to 0 at the same time). The presence of the 80h tells the standard boot routine to load the sector whose location is contained in the following three bytes. That sector is the actual boot record for the selected operating system, and it is responsible for the remainder of the system's loading process (as it is from the diskette). All boot records are loaded at absolute address 0:7C00.

The partition table with its offsets into the boot record is: (except for Wyse DOS 3.2 with 32 bit allocation table, and DOS 3.3-up)

```
Offset Partit'n   Purpose                Head     Sector   Cylinder
1BEh   part 1    begins          boot ind  H         s         cyl
```

1C2h		ends	syst ind	H	S	cyl
1C6h		relative sector	low word		high word	
1CAh		# sectors	low word		high word	
1CEh	part 2	begins	boot ind	H	S	cyl
1D2h		ends	syst ind	H	S	cyl
1D6h		relative sector	low word		high word	
1DAh		# sectors	low word		high word	
1DEh	part 3	begins	boot ind	H	S	cyl
1E2h		ends	syst ind	H	S	cyl
1E6h		relative sector	low word		high word	
1EAh		# sectors	low word		high word	
1EEh	part 4	begins	boot ind	H	S	cyl
1F2h		ends	syst ind	H	S	cyl
1F6h		relative sector	low word		high word	
1FAh		# sectors	low word		high word	
1FEh		signature	hex 55	hex AA		

Boot indicator (boot ind): The boot indicator byte must contain 0 for a non-bootable partition or 80h for a bootable partition. Only one partition can be marked as bootable at a time.

System Indicator (sys ind): The sys ind field contains an indicator of the operating system that 'owns' the partition. IBM PC-DOS can only 'own' one partition, though some versions of MSDOS allow all four partitions to be used by DOS.

The system indicators are:

	System Indicator (sys ind)
00h	unknown or unspecified
01h	DOS 12 bit FAT (DOS 2.x all and 3.x under 10 Mb)
04h	DOS 16 bit FAT (DOS 3.0+. Not recognized by 2.x)
0DBh	DRI Concurrent DOS
0F2h	2nd DOS partition, some 3.2 and all 3.3+

There are bytes for XENIX, and other operating systems. Some manufacturers (such as Zenith, Wyse, and Tandon) diddle with these system bytes to implement more than one DOS partition per disk.

Cylinder (CYL) and Sector (S): The 1 byte fields labelled CYL contain the low order 8 bits of the cylinder number - the high order 2 bits are in the high order 2 bits of the sector (S) field. This corresponds with the ROM BIOS interrupt 13h (disk I/O) requirements, to allow for a 10 bit cylinder number.

The fields are ordered in such a manner that only two MOV instructions are required to properly set up the DX and CX registers for a ROM BIOS call to load the appropriate boot record (hard disk booting is only possible from the first hard disk in the system, where a BIOS drive number of 80h corresponds to the boot indicator byte).

All partitions are allocated in cylinder multiples and begin on sector 1, head 0, with the exception that the partition that is allocated at the beginning of the disk starts at sector 2, to account for the hard disk's master boot record.

Relative Sector (rel sect): The number of sectors preceding each partition on the disk is kept in the 4 byte field labelled 'rel sect'. This value is obtained by counting the sectors beginning with cylinder 0, sector 1, head 0 of the disk, and incrementing the sector, head, and then track values up to the beginning of the partition. This, if the disk has 17 sectors per track and 4 heads, and the second partition begins at cylinder 1, sector 1, head 0, and the partition's starting relative sector is 68 (decimal) - there were 17 sectors on each of 4 heads on 1 track allocated ahead of it. The field is stored with the least significant word first.

Number of sectors (#sects): The number of sectors allocated to the partition is kept in the '# of sects' field. This is a 4 byte field stored least significant word first.

Signature: The last 2 bytes of the boot record (55AAh) are used as a signature to identify a valid boot record. Both this record and the partition boot record are required to contain the signature at offset 1FEh.

Hard Disk Technical Information

Western Digital's hard disk installation manuals make the claim that MSDOS can support only 2 hard drives. This is entirely false, and their purpose for making the claim is unclear. DOS merely performs a function call pointed at the hard disk driver, which is normally in one of three locations; a ROM at absolute address C:800, the main BIOS ROM if the machine is an AT, or a device driver installed through the CONFIG.SYS file. Two hard disk controller cards can normally not reside in the same machine due to lack of interrupt arbitration. Perstor's ARLL controller and some cards marketed by Novell can coexist with other controllers. Perstor's technical department has had four controllers and eight hard disks in the same IBM XT functioning concurrently.

A valid hard disk has a boot record arranged in the following manner:

```
DB    drive   ; 0 or 80h  (80h marks a bootable, active partition)
DB    head1   ; starting heads
DW    trksec1 ; starting track/sector (CX value for INT 13)
DB    system  ; see below
DB    head2   ; ending head
DW    trksec2 ; ending track/sector
DD    sector1 ; absolute # of starting sector
DD    sector2 ; absolute # of last sector
```

The master disk boot record invokes ROM BASIC if no indicator byte reflects a bootable system.

When a partition's boot record is given control, it is passed its partition table entry address in the DS:SI registers.

Determining Hard Disk Allocation

DOS determines disk allocation using the following formula:

$$SPF = \frac{TS - RS - \dfrac{D * BPD}{BPS}}{CF + \dfrac{BPS * SPC}{BPC}}$$

where:

```
TS     total sectors on disk
RS     the number of sectors at the beginning of the disk that are reserved
       for the boot record. DOS reserves 1 sector.
D      The number of directory entries in the root directory.
BPD    the number of bytes per directory entry. This is always 32.
BPS    the number of bytes per logical sector. Typically 512, but you can
       specify a different number with VDISK.
CF     The number of FATS per disk. Usually 2. VDISK is 1.
SPF    the number of sectors per FAT. Maximum 64.
```

```
SPC     The number of sectors per allocation unit.
BPC     the number of bytes per FAT entry. BPC is 1.5 for 12 bit FATs. 2 for
        16 bit FATS.
```

To calculate the minimum partition size that will force a 16-bit FAT:

```
CYL = (max clusters * 8)/(HEADS * SPT)
```

where:

```
CYL           number of cylinders on the disk
max clusters  4092 (maximum number of clusters for a 12 bit FAT)
HEADS         number of heads on the hard disk
SPT           sectors per track  (normally 17 on MFM)
```

DOS 2.0 uses a 'first fit' algorithm when allocating file space on the hard disk. Each time an application requests disk space, it will scan from the beginning of the FAT until it finds a contiguous piece of storage large enough for the file.

DOS 3.0 keeps a pointer into the disk space, and begins its search from the point it last left off. This pointer is lost when the system is rebooted. This is called the 'next fit' algorithm. It is faster than the first fit and helps minimize fragmentation.

In either case, if the FCB function calls are used instead of the handle function calls, the file will be broken into pieces starting with the first available space on the disk.

BIOS Disk Routines

Interrupt 13h Disk I/O - access the disk drives (floppy and hard disk)
(0:004Ch) These calls do not try rereading disk if an error is returned

```
Function 00h    Reset - reset the disk controller chip
entry   AH      00h
        DL      drive (if bit 7 is set both hard disks and floppy disks reset)
                00h-7Fh  floppy disk
                80h-0FFh hard disk
return  AH      status (see 01h below)
note 1. Forces controller chip to recalibrate read/write heads.
     2. Some systems (Sanyo 55x) this resets all drives.
     3. This function should be called after a failed floppy disk Read, Write,
        Verify, or Format request before retrying the operation.
     4. If called with DL = 80h (i.e., selecting a hard drive), the floppy
        controller and then the hard disk controller are reset.
     5. Function 0Dh allows the hard disk controller to be reset without
        affecting the floppy controller.

Function 01h    Get Status of Disk System
entry   AH      01h
        DL      drive (hard disk if bit 7 set)
                00h-7Fh  floppy disk
                80h-0FFh hard disk
return  AH      00h
        AL      status of most recent disk operation
                00h     successful completion, no errors
                01h     bad command
                02h     address mark not found
                03h     tried to write on write-protected disk      (floppy only)
                04h     sector not found
                05h     reset failed                                  (hard disk)
                06h     diskette removed or changed                 (floppy only)
                07h     bad parameter table                           (hard disk)
                08h     DMA overrun                                 (floppy only)
                09h     attempt to DMA across 64K boundary
                0Ah     bad sector detected                           (hard disk)
                0Bh     bad track detected                            (hard disk)
                0Ch     unsupported track or media type not found   (floppy disk)
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              0Dh      invalid number of sectors on format         (hard disk)
              0Eh      control data address mark detected          (hard disk)
              0Fh      DMA arbitration level out of range          (hard disk)
              10h      uncorrectable CRC/EEC on read
              11h      ECC corrected data error                    (hard disk)
              20h      controller failure
              40h      seek failed
              80h      timeout
              0AAh     drive not ready                             (hard disk)
              0BBh     undefined error                             (hard disk)
              0CCh     write fault                                 (hard disk)
              0E0h     status error                                (hard disk)
              0FFh     sense operation failed                      (hard disk)
note    For hard disks, error code 11h (ECC data error) indicates that a
        recoverable error was detected during a preceding int 13h fn 02h
       (Read Sector) call.

Function 02h      Read Sectors - read one or more sectors from diskette
entry   AH        02h
        AL        number of sectors to read
        BX        address of buffer (ES=segment)
        CH        track (cylinder) number (0-39 or 0-79 for floppies)
                  (for hard disk, bits 8,9 in high bits of CL)
        CL        sector number (1 to 18, not value checked)
        DH        head number (0 or 1)
        DL        drive (0=A, 1=B, etc.) (bit 7=0)  (drive 0-7)
                  00h-7Fh   floppy disk
                  80h-FF0h  hard disk
        ES:BX     address to store/fetch data  (buffer to fill)
       [0000:0078]  dword pointer to diskette parameters
return  CF        0        successful
                           AL       number of sectors transferred
                  1        error
                           AH       status (00h, 02h, 03h, 04h, 08h, 09h, 10h,
                                           0Ah, 20h, 40h, 80h)
note 1. Number of sectors begins with 1, not 0.
     2. Trying to read zero sectors is considered a programming error; results
        are not defined.
     3. For hard disks, the upper 2 bits of the 10-bit cylinder number are placed
        in the upper 2 bits of register CL.
     4. For hard disks, error code 11h indicates that a read error occurred that
        was corrected by the ECC algorithm; in this case, AL contains the burst
        length. The data read is good within the limits of the ECC code. If a
        multisector transfer was requested, the operation was terminated after
        the sector containing the  read error.
     5. For floppy drives, an error may result from the drive motor being off at
        the time of the request. The BIOS does not automatically wait for the
        drive to come up to speed before attempting the read operation. The
        calling program should reset the floppy disk system with function 00h
        and retry the operation three times before assuming that the error
        results from some other cause.

Function 03h      Write Sectors - write from memory to disk
entry   AH        03h
        AL        number of sectors to write (1-8)
        CH        track number (for hard disk, bits 8,9 in high bits of CL)
        CL        beginning sector number
                  (if hard disk, high two bits are high bits of track #)
        DH        head number
        DL        drive number (0-7)
                  00h-7Fh   floppy disk
                  80h-FF0h  hard disk
        ES:BX     address of buffer for data
return  CF        0        success
                  AL       number of sectors written
                  1        error
                  AH       status (see 01h above)
note 1. Number of sectors begins with 1, not 0.
     2. Trying to write zero sectors is considered a programming error; results
        are not defined.
     3. For hard disks, the upper 2 bits of the 10-bit cylinder number are placed
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        in the upper 2 bits of register CL.
     4. For floppy drives, an error may result from the drive motor being off at
        the time of the request. The BIOS does not automatically wait for the
        drive to come up to speed before attempting the read operation. The
        calling program should reset the floppy disk system with function 00h
        and retry the operation three times before assuming that the error
        results from some other cause.

Function 04h    Verify - verify that a write operation was successful
entry   AH      04h
        AL      number of sectors to verify (1-8)
        CH      track number  (for hard disk, bits 8,9 in high bits of CL)
        CL      beginning sector number
        DH      head number
        DL      drive number (0-7)
        DL      drive number (0-7)
                00h-7Fh   floppy disk
                80h-FF0h  hard disk
        ES:BX   address of buffer for data
return  CF      set on error
                AH      status (see 01h above)
        AL      number of sectors verified
note 1. With IBM PC, XT, and AT with ROM BIOS earlier than 11/15/85, ES:BX should
        point to a valid buffer.
     2. For hard disks, the upper 2 bits of the 10-bit cylinder number are placed
        in the upper 2 bits of register CL.
     3. This function can be used to test whether a readable media is in a floppy
        drive. An error may result from the drive motor being off at the time of
        the request since the BIOS does not automatically wait for the drive to
        come up to speed before attempting the verify operation. The requesting
        program should reset the floppy disk system with function 00h and retry
        the operation three times before assuming that a readable disk is not
        present.

Function 05h Format Track - write sector ID bytes for 1 track (floppy
             disk)
entry   AH      05h
        AL      number of sectors to create on this track
                interleave (for XT hard disk only)
        CH      track (or cylinder) number (bits 8,9 in high bits of CL)
        CL      sector number
        DH      head number (0, 1)
        DL      drive number (0-3)
                00h-7Fh   floppy disk
                80h-0FFh  hard disk
        ES:BX   pointer to 4-byte address field (C-H-R-N) (except XT hard
                disk)
                byte 1 = (C) cylinder or track
                byte 2 = (H) head
                byte 3 = (R) sector
                byte 4 = (N) bytes/sector (0 = 128, 1 = 256, 2 = 512, 3 =
                         1024)
return  CF      set if error occurred
                AH      status code (see 01h above)
note 1. Not valid for ESDI hard disks on PS/2.
     2. For floppy disks, the number of sectors per track is taken from the BIOS
        floppy disk parameter table whose address is stored in the vector for
        int 1Eh.
     3. When this function is used for floppies on ATs or the PS/2, it should be
        preceded by a call to int 13h/fn 17h to select the type of media to
        format.
     4. For hard disks, the upper 2 bits of the 10-bit cylinder number are
        placed in the upper 2 bits of CL.
     5. On the XT/286, AT, and PS/2 hard disks, ES:BX points to a 512-byte buffer
        containing byte pairs for each physical disk sector as follows:
        Byte  Contents
        0       00h     good sector
                80h     bad sector
        1       sector number
        For example, to format a track with 17 sectors and an interleave of two,
        ES:BX would point to the following 34-byte array at the beginning of a
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        512-byte buffer:
        db      00h, 01h, 00h, 0Ah, 00h, 02h, 00h, 0Bh, 00h, 03h, 00h, 0Ch
        db      00h, 04h, 00h, 0Dh, 00h, 05h, 00h, 0Eh, 00h, 06h, 00h, 0Fh
        db      00h, 07h, 00h, 10h, 00h, 08h, 00h, 11h, 00h, 09h

Function 06h    Hard Disk - format track and set bad sector flags
                                        (PC2, PC-XT, and Portable)
entry   AH      06h
        AL      interleave value (XT only)
        CH      cylinder number (bits 8,9 in high bits of CL)
        CL      sector number
        DH      head
        DL      drive (80h-0FFh for hard disk)
        ES:BX   512 byte format buffer
                the first 2*(sectors/track) bytes contain f,n for each sector
                f       00h     good sector
                        80h     bad sector
                n       sector number
return  CF      error
                AH      status code (see 01h above)

Function 07h    Hard Disk - format the drive starting at the desired track
                                        (PC2, PC-XT and Portable)
entry   AH      07h
        AL      interleave value (XT only) (01h-10h)
        CH      cylinder number (bits 8,9 in high bits of CL) (00h-03FFh)
        CL      sector number
        DH      head number (0-7)
        DL      drive number (80h-0FFh, 80h=C, 81h=D,...)
        ES:BX   format buffer, size = 512 bytes
                the first 2*(sectors/track) bytes contain f,n for each sector
                f       00h     good sector
                        80h     bad sector
                n       sector number
return  CF      set on error
        AH      status code (see 01h above)
note    Award AT BIOS routines are extended to handle more than 1024 cylinders.
        AL      number of sectors
        CH      cylinder number low 8 bits
        CL      sector number bits 0-5, bits 6-7 are high 2 cylinder bits
        DH      head number (bits 0-5) bits 6-7 are extended high cyls (1024)
        DL      drive number (0-1 for diskette, 80h-81h for hard disk)
        ES:BX   transfer address

Function 08h    Read Drive Parameters                   (except PC, Jr)
entry   AH      08h
        DL      drive number
                00h-7Fh   floppy disk
                80h-0FFh  hard disk
return  CF      set on error
                AH      status code (see above)
        BL      drive type  (AT/PS2 floppies only)
                01h     if 360 Kb, 40 track, 5"
                02h     if 1.2 Mb, 80 track, 5"
                03h     if 720 Kb, 80 track, 3"
                04h     if 1.44 Mb, 80 track, 3"
        CH      low 8 bits of maximum useable value for cylinder number
        CL bits 6-7     high-order 2 bits of maximum cylinder number
                0-5     maximum sector number
        DH      maximum usable value for head number
        DL      number of consecutive acknowledging drives (0-2)
        ES:DI   pointer to drive parameter table
note    On the PC and PC/XT, this function is supported on hard disks only.

Function 09h  Initialize Two Fixed Disk Base Tables     (XT, AT, XT/286, PS/2)
              (install nonstandard drive)
entry   AH      09h
        DL      80h-0FFh  hard disk number
return  CF      set on error
                AH      status code (see 01h above)
                For PC, XT hard disks, the disk parameter block format is:
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                00h-01h maximum number of cylinders
                02h     maximum number of heads
                03h-04h starting reduced write current cylinder
                05h-06h starting write precompensation cylinder
                07h     maximum ECC burst length
                08h     drive options
                   bits 7       1       disable disk access retries
                        6       1       disable ECC retries
                        3-5     set to 0
                        0-2     drive option
                09h     standard timeout value
                0Ah     timeout value for format drive
                0Bh     timeout value for check drive
                0Ch-0Fh reserved

                For AT and PS/2 hard disks:
                00h-01h maximum number of cylinders
                02h     maximum number of heads
                03h-04h reserved
                05h-06h starting write precompensation cylinder
                07h     maximum ECC burst length
                08h     drive options byte
                   bits 6-7     nonzero (10, 01, or 11) if retries disabled
                        5       1       if manufacturer's defect map present at
                                         maximum cylinder + 1
                        4       not used
                        3       1       if more than 8 heads
                        0-2     not used
                09h-0Bh reserved
                0Ch-0Dh landing zone cylinder
                0Eh     sectors per track
                0Fh     reserved
note 1. For the XT, int 41h must point to the Disk Parameter Block.
     2. For the AT and PS/2, Int 41h points to table for drive 0 and Int 46h
        points to table for drive 1.
     3. Initializes the hard disk controller for subsequent I/O operations using
        the values found in the BIOS disk parameter block(s).
     4. This function is supported on hard disks only.

Function 0Ah    Read Long   (Hard disk)                (XT, AT, XT/286, PS/2)
entry   AH      0Ah
        CH      cylinder number (bits 8,9 in high bits of CL)
        CL      sector number (upper 2 bits of cyl # in upper 2 bits of CL)
        DH      head number
        DL      drive ID  (80h-0FFh hard disk)
        ES:BX   pointer to buffer to fill
return  CF      set on error
                AH      status code (see 01h above)
        AL      number of sectors actually transferred
note 1. A 'long' sector includes a 4 byte EEC (Extended Error Correction) code.
     2. Used for diagnostics only on PS/2 systems.
     3. This function is supported on fixed disks only.
     4. Unlike the normal Read Sector (02h) function, ECC errors are not
        automatically corrected. Multisector transfers are terminated after any
        sector with a read error.

Function 0Bh    Write Long                             (XT, AT, XT/286, PS/2)
entry   AH      0Bh
        AL      number of sectors
        CH      cylinder (bits 8,9 in high bits of CL)
        CL      sector number
        DH      head number
        DL      drive ID (80h-0FFh hard disk)
        ES:BX   pointer to buffer containing data
return  CF      set on error
                AH      status code (see 01h above)
        AL      number of sectors actually transferred
note 1. A 'long' sector includes a 4 byte EEC (Extended Error Correction) code.
     2. Used for diagnostics only on PS/2 systems.
     3. Valid for hard disks only.
```

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Function 0Ch     Seek To Cylinder                              (except PC, PCjr)
entry    AH      0Ch
         CH      lower 8 bits of cylinder
         CL      upper 2 bits of cylinder in bits 6-7
         DH      head number
         DL      drive number (0 or 1)  (80h-0FFh for hard disk)
return   CF      set on error
                 AH       status code (see 01h above)
note 1. Positions heads over a particular cylinder, but does not move anydata.
     2. This function is supported on hard disks only.
     3. The upper 2 bits of the 10-bit cylinder number are placed in the upper 2
        bits of CL.
     4. The Read Sector, Read Sector Long, Write Sector, and Write Sector Long
        functions include an implied seek operation and need not be preceded by
        an explicit call to this function.

Function 0Dh     Alternate Hard Disk Reset                     (except PC, PCjr)
entry    AH      0Dh
         DL      hard drive number (80h-0FFh hard disk)
return   CF      set on error
                 AH       status code (see 01h above)
note 1. Not for PS/2 ESDI hard disks.
     2. Resets the hard disk controller, recalibrates attached drives (moves the
        read/write arm to cylinder 0), and prepares for subsequent disk I/O.
     3. This function is for hard disks only. It differs from fn 00h by not
        resetting the floppy disk controller.

Function 0Eh     Read Sector Buffer                          (XT, Portable, PS/2)
entry    AH      0Eh
         ES:BX   pointer to buffer
return   CF      set on error
                 AH       status code (see 01h above)
         AL      number of sectors actually transferred
note 1. Transfers controller's sector buffer. No data is read from the drive.
     2. Used for diagnostics only on PS/2 systems.
     3. This fn is supported by the XT's hard disk adapter only. It is 'not
        defined' for hard disk adapters on the AT or PS/2.

Function 0Fh     Write sector buffer                               (XT, Portable)
entry    AH      0Fh
         ES:BX   pointer to buffer
return   CF      set if error
                 AH       status code (see 01h above)
         AL      number of sectors actually transferred
note 1. Should be called before formatting to initialize the controller's sector
        buffer.
     2. Used for diagnostics only on PS/2 systems.
     3. Transfers data from system RAM to the hard disk adapter's internal sector
        buffer.
     4. No data is written to the physical disk drive.
     5. This fn is for the XT hard disk controller only. It is 'not defined' for
        AT or PS/2 controllers.

Function 10h     Test For Drive Ready                      (XT, AT, XT/286, PS/2)
entry    AH      10h
         DL      hard drive number 0 or 1 (80h-0FFh)
return   CF      set on error
                 AH       status code (see 01h above)
note 1. Tests whether the specified hard disk drive is operational and
        returns the drive's status.
     2. This function is supported on hard disks only.
     3. Perstor and Novell controllers allow more than one hard drive.

Function 11h     Recalibrate Drive                         (XT, AT, XT/286, PS/2)
entry    AH      11h
         DL      hard drive number (80h-0FFh hard disk)
return   CF      set on error
                 AH       status code (see 01h above)
note 1. Causes the HD controller to recalibrate itself for the specified drive,
        positioning the read/arm to cylinder 0, and returns the drive's status.
     2. This function is for hard disks only.
```

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Function 12h    Controller RAM Diagnostics              (XT, Portable, PS/2)
entry   AH      12h
return  CF      set on error
                AH      status code (see fn 01h above)
note 1. Used for diagnostics only on PS/2 systems.
     2. Makes the hard disk controller carry out a built-in diagnostic test on
        its internal sector buffer.

Function 13h    Controller Drive Diagnostic             (XT, Portable, PS/2)
entry   AH      13h
return  CF      set on error
                AH      status code (see 01h above)
note 1. Used for diagnostics only on PS/2 systems.
     2. Causes HD controller to run internal diagnostic tests of the attached
        drive, indicating whether the test was passed by the returned status.
     3. This function is supported on XT HDs only.

Function 14h    Controller Internal Diagnostic                 (AT, XT/286)
entry   AH      14h
return  CF      set on error
        AH      status code (see 01h above)
note 1. OEM is Western Digital 1003-WA2 hard/floppy combination controller in AT
        and XT/286.
     2. Used for diagnostics only in PS/2 systems.
     3. Causes HD controller to do a built-in diagnostic self-test, indicating
        whether the test was passed by the returned status.
     4. This function is supported on hard disks only.
Function 15h    Get Disk Type                          (except PC and XT)
entry   AH      15h
        DL      drive ID
                00h-7Fh   floppy disk
                80h-0FFh  fixed disk
return  CF      set on error
                AH      error code (see 01h above)
        AH      disk type
                00h     no drive is present
                01h     diskette, no change detection present
                02h     diskette, change detection present
                03h     fixed disk
                        CX:DX   number of 512-byte sectors
note 1. Returns a code indicating the type of disk referenced by the specified
        drive code.
     2. This function is not supported on the PC or XT.

Function 16h    Get Disk Change Status (diskette)      (except PC, XT, & Jr)
entry   AH      16h
        DL      drive to check
return  CF      set on error
        AH      disk change status
                00h     no disk change
                01h     disk changed
        DL      drive that had disk change (00h-07Fh floppy disk)
note    Returns the status of the change line, indicating whether the disk in the
        drive may have been replaced since the last disk access. If this
        function returns with CF set, the disk has not necessarily been changed;
        the change line can be activated by simply unlocking and relocking the
        disk drive door without removing the floppy disk.

Function 17h    Set Disk Type for Format (diskette)      (except PC and XT)
entry   AH      17h
        AL      00h     not used
                01h     160, 180, 320, or 360Kb diskette in 360kb drive
                02h     360Kb diskette in 1.2Mb drive
                03h     1.2Mb diskette in 1.2Mb drive
                04h     720Kb diskette in 720Kb drive
        DL      drive number (0-7)
return  CF      set on error
        AH      status of operation (see 01h above)
note 1. This function is probably enhanced for the PS/2 series to detect 1.44 in
        1.44 and 720k in 1.44.
```

```
     2. This function is not supported for floppy disks on the PC or XT.
     3. If the change line is active for the specified drive, it is reset.
     4. The BIOS sets the data rate for the specified drive and media type. The
        rate is 250k/sec for double-density media and 500k/sec for high density
        media. The proper hardware is required.

Function 18h  Set Media Type For Format (diskette)        (AT, XT2, XT/286, PS/2)
entry   AH      18h
        CH      lower 8 bits of number of tracks
        CL      high 2 bits of number of tracks (6,7) sectors per track (bits 0-5)
        DL      drive number (0-7)
return  CF      clear   no errors
        AH      00h      if requested combination supported
                01h      if function not available
                0Ch      if not supported or drive type unknown
                80h      if there is no media in the drive
        ES:DI   pointer to 11-byte disk parameter table for media type
        CF      set     error code (see 01h above)
note 1. A floppy disk must be present in the drive.
     2. This function should be called prior to formatting a disk with Int 13h Fn
        05h so the BIOS can set the correct data rate for the media.
     3. If the change line is active for the specified drive, it is reset.

Function 19h    Park Hard Disk Heads                                      (PS/2)
entry   AH      19h
        DL      drive number (80h-0FFh)
return  CF      set on error
                AH      error code (see fn 01h)
note    This function is defined for PS/2 fixed disks only.

Function 1Ah    ESDI Hard Disk - Low Level Format                         (PS/2)
entry   AH      1Ah
        AL      Relative Block Address (RBA) defect table count
                0       if no RBA table
                0      if RBA table used
        CL      format modifiers byte
           bits 0       ignore primary defect map
                1       ignore secondary defect map
                2       update secondary defect map
                3       perform extended surface analysis
                4       generate periodic interrupt
                5       reserved - must be 0
                6       reserved - must be 0
                7       reserved - must be 0
        DL      drive  (80h-0FFh)
        ES:BX   pointer to RBA defect table
return  CF      set on error
                AH      error code (see fn 01h above)
note 1. Initializes disk sector and track address fields on a drive attached to
        the IBM 'ESDI Fixed Disk Drive Adapter/A'.
     2. If periodic interrupt selected, int 15h/fn 0Fh is called after each
        cylinder is formatted
     3. If bit 4 of CL is set, Int 15h, AH=0Fh, AL=phase code after each cylinder
         is formatted or analyzed. The phase code is defined as:
        0       reserved
        1       surface analysis
        2       formatting
     4. If bit 2 of CL is set, the drive's secondary defect map is updated to
        reflect errors found during surface analysis. If both bit 2 and bit 1
        are set, the secondary defect map is replaced.
     5. For an extended surface analysis, the disk should first be formatted by
        calling this function with bit 3 cleared and then analyzed by calling
        this function with bit 3 set.

Function 1Bh    ESDI Hard Disk - Get Manufacturing Header                 (PS/2)
entry   AH      1Bh
        AL      number of record
        DL      drive
        ES:BX   pointer to buffer for manufacturing header (defect list)
return  CF      set on error
        AH      status
```

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note     Manufacturing header format (Defect Map Record format) can be found in
         the 'IBM 70Mb, 115Mb Fixed Disk Drives Technical Reference'.

Function 1Ch     ESDI Hard Disk - Get Configuration                    (PS/2)
entry    AH      1Ch
         AL      0Ah     Get Device Configuration
                         DL       drive
                         ES:BX    pointer to buffer for device configuration
                                  (drive physical parameter)
                 0Bh     Get Adapter Configuration
                         ES:BX    pointer to buffer for adapter configuration
                 0Ch     Get POS Information
                         ES:BX    pointer to POS information
                 0Eh     Translate RBA to ABA
                         CH       low 8 bits of cylinder number
                         CL       sector number, high two bits of cylinder number
                                  in bits 6 and 7
                         DH       head number
                         DL       drive number
                         ES:BX    pointer to ABA number
return   CF      set on error
         AH      status (see 01h)
note 1.  Device configuration format can be found in IBM ESDI Fixed Disk Drive
         Adapter/A Technical Reference.
     2.  ABA (absolute block address) format can be found in IBM ESDI Adapter
         Technical Reference by using its Device Configuration Status Block.
```

9

Installable Device Drivers

Device Driver Format

A device driver is a handler for communication between the system software and hardware devices. The motherboard ROM and IBMBIO.COM or IO.SYS files contain the basic drivers for allowing DOS to talk to the console, disk drives, serial and parallel ports, clock, and other resources.

DOS has five builtin drivers, STDIN, STDOUT, STERR, STDPRN, or STDAUX. An 'installable' driver may be loaded in the CONFIG.SYS file, and either replace one of the built-in drivers or define a new resource, such as a mouse or expanded memory driver.

The device driver is a COM (memory image) file that contains all of the code needed to control an add-in device. An EXE file cannot be used since the EXE loader is part of COMMAND.COM, which is not present when the device driver is being loaded by IBMBIO.COM or IO.SYS. The COM file must not load at the usual ORG 100h. Since the driver does not use the Program Segment Prefix, it is simply loaded without offset, therefore the driver file must have an origin of 0 (ORG 0 or no ORG statement). Driver files should not have a declared stack segment.

DOS can install the device driver anywhere in memory, so care must be taken in any FAR memory references. You should not expect that your driver will be loaded in the same place every time.

Types of Devices

There are two types of devices: Character devices and Block devices. Their attributes are as follows:

Character devices are designed to do serial I/O in a byte-by-byte manner. These devices have names like CON, AUX, or PRN, and you can open channels (handles or FCBs) to do I/O much like a disk file. I/O may be in either cooked or raw mode. (see Chapter 7 for discussion of cooked and raw modes). Because character devices have only one name, they can only support one device.

Block devices are normally implemented as disk drives. They can do random I/O in pieces called blocks, which are usually the physical sector size of the disk. These devices are not named as character devices are, and cannot be opened directly. Instead they are accessed by using drive letters such as A, B, C, etc. Block devices can have units within them. In this way, a single block driver can be responsible for one or more disk drives. For example, the first block device driver can be responsible for drives A, B, C, and D. This means it has four units defined and therefore takes up four drive letters. The position of the driver in the chain of all drives determines the way in which the drive letters correspond, i.e, if a second block device driver defines three units, then those units are E, F, and G.

DOS 1.x allows 16 block devices. DOS 2.x allows 63, and DOS 3.x allows 26. It is recommended that drivers limit themselves to 26 devices for compatibility with DOS 3.x and 4.x. When DOS 2.x passes the Z: drivespec, the drivespecs get a little weird, such as ^, [, or #. DOS 3.x+ will return an error message.

Creating a Device Driver

To create a device driver that DOS can install, you must do the following:

1. Create a memory image (COM) file with a device header at the start of the file.
2. Originate the code (including the device header) at 0, instead of 100h.
3. Set the next device header field. Refer to 'Pointer to Next Device Header Attribute Field' for more information.
4. Set the attribute field of the device header. Refer to 'Attribute Field' for more information.
5. Set the entry points for the interrupt and strategy routines.
6. Fill in the name/unit field with the name of the character device or the unit numberof the block device.

DOS always processes installable character device drivers before handling the default devices. So to install a new CON device, simply name the device CON. Be sure to set the standard input device and standard output device bits in the attribute field of a new CON device. The scan of the device list stops on the first match so the installable device driver takes precedence. For instance, installing ANSI.SYS replaces the built-in CON driver.

DOS doesn't care about the position of installed character devices versus block devices.

Structure of a Device Driver

A device driver consists of three major parts:

- a device header
- a strategy routine
- an interrupt routine

Device Header

The driver has a special header to identify it as a device and to define the strategy and interrupt entry points and its various attributes. This header is located at the beginning of the file. It contains a pointer to the next driver in the chain, the attributes of the device, offsets into the strategy and interrupt routines, and the device ID.

This is the format of the device header:

DEVICE HEADER

Offset	Length	Description
00h	word	Pointer to next device header field, offset value
02h	word	Pointer to next device header field, segment value
04h	word	Attribute
06h	word	Pointer to device strategy routine (offset only)
08h	word	Pointer to device interrupt routine (offset only)
0Ah	8 bytes	Name/Unit field

Pointer to Next Device Header Field

The device header field is a pointer to the device header of the next device driver. It is a doubleword field that is set by DOS at the time the device driver is loaded. The first word is the offset and the second word is the segment.

If you are loading only one device driver, set the device header field to -1 before loading the device. If you are loading more than one device driver, set the first word of the device driver header to the offset of the next device driver's header. Set the device driver header field of the last device driver to -1.

Attribute Field

The attribute field is a word field used to identify the type of device this driver is responsible for. This field distinguishes between block and character devices and determines which selected devices are given special treatment. That describes the attributes of the device driver to the system. The attributes are:

ATTRIBUTE FIELD

word bits	attr. set	description
0	0	not current standard input device
	1	current standard input device
1	0	not current standard output device
	1	current standard output device
2	0	not current NUL device
	1	current NUL device
3	0	not current CLOCK device
	1	current CLOCK device
4	0	standard CON I/O routines should be used
	1	fast screen I/O (int 29h) should be used
5 - 10		'reserved for DOS' - unknown - should be set to 0
11	0	doesn't support removable media (default for DOS 2.x)
	1	supports removable media (DOS 3.0+ only)
12		'reserved for DOS' - unknown - should be set to 0
13	0	IBM format (block devices)
	1	non-IBM format (block devices)
	1	output till busy (character devices)
14	0	doesn't support IOCTL
	1	supports IOCTL

```
15      0       block device
        1       character device
```

Note: if a bit in the attribute word is defined only for one type of device, a driver for the other type of device must set that bit to 0.

BIT 1 is the standard input and output bit. It is used for character devices only. Use this bit to tell DOS if your character device driver is the new standard input device or standard output device.

BIT 2 is the NUL attribute bit. It is used for character devices only. Use it to tell DOS if your character device driver is a NUL device. Although there is a NUL device attribute bit, you cannot reassign the NUL device or replace it with your own routine. This attribute exists for DOS so that DOS can tell if the NUL device is being used.

BIT 3 is the clock device bit. It is used for character devices only. Default is 0. You can use it to tell DOS if your character device driver is the new CLOCK device.

BIT 4 is the 'fast video output' bit. The default is 0, which uses the BIOS for writing to the screen. When set, this bit uses int 29h for much faster screen updates.

BITS 5-10 reserved for DOS, unknown. Should be set to 0.

BIT 11 is the open/close removable media bit. Use it to tell DOS if the device driver can handle removable media. This bit is valid for DOS 3.0+ only. This bit was reserved in DOS 2.x. Since DOS 2.x does not look at this bit, its use is backward compatible.

BIT 12 reserved for DOS, unknown. Should be set to 0.

BIT 13 is the non-IBM format bit. When used for block devices it affects the operation of the BUILD BPB (BIOS parameter block) device call. For character devices it indicates that the devices implements the OUTPUT UNTIL BUSY device call.

BIT 14 is the IOCTL bit. It is used for both character and block devices. Use it to tell DOS whether the device driver can handle control strings through the IOCTL function call 44h. If a device driver cannot process control strings, it should set bit 14 to 0. This way DOS can return an error if an attempt is made through the IOCTL function call to send or receive control strings to the device. If a device can process control strings, it should set bit 14 to 1. This way, DOS makes calls to the IOCTL input and output device function to send and receive IOCTL strings. The IOCTL functions allow data to be sent to and from the device without actually doing a normal read or write. In this way, the device driver can use the data for its own use, (for example, setting a baud rate or stop bits, changing form lengths, etc.) It is up to the device to interpret the information that is passed to it, but the information must not be treated as a normal I/O request.

BIT 15 is the device type bit. Use it to tell the system the that driver is a block or character device.

Pointer to Strategy Routine

This field contains a pointer to 'device strategy' function in the driver. This function is called whenever a request is made to the driver, and must store the location of the request header from DOS. This pointer is a word value, and so must be in the same segment as the device header.

Pointer to Interrupt Routine

This field contains a pointer to the function which activates driver routines to perform the command in the current request header. This is called by DOS after the call to the strategy function, and should reset to the request header address stored by 'strategy', to allow for the possibility of interrupts between the two calls. This pointer is a word value, and so must be in the same segment as the device header.

Name/Unit Field

This is an 8-byte field that contains the name of a character device or the number of units in a block device. For the character names, the name is left-justified and the space is filled to 8 bytes. For block devices, the number of units can be placed in the first byte. This is optional because DOS fills in this location with the value returned by the driver's INIT code. The other 7 bytes of the block device ID are reserved and should not be used.

Installing Device Drivers

DOS installs new device drivers dynamically at boot time by reading and processing the DEVICE command in the CONFIG.SYS file. For example, if you have written a device driver called RAMDISK, to install it put this command in the CONFIG.SYS file:

```
DEVICE=[drive][path] RAMDISK [parameters]
```

DOS makes a FAR call to the device driver at its strategy entry point first, using the request header to pass information describing what DOS wants the device driver to do.

This strategy routine does not perform the request but rather queues the request or saves a pointer to the request header. The second entry point is the interrupt routine and is called by DOS immediately after the strategy routine returns. The interrupt routine is called with no parameters. Its function is to perform the operation based on the queued request and set up any return information.

DOS passes the pointer to the request header in ES:BX. This structure consists of a fixed length header (Request Header) followed by data pertinent to the operation to be performed.

Note: It is the responsibility of the device driver to preserve the machine state. For example, save all registers on entry and restore them on exit.

The stack used by DOS has enough room on it to save all the registers. If more stack space is needed, it is the device driver's responsibility to allocate and maintain another stack.

All calls to execute device drivers are FAR calls. FAR returns should be executed to return to DOS.

Installing Character Devices

One of the functions defined for each device is INIT. This routine is called only once when the device is installed and never again. The INIT routine returns the following:

A. A location to the first free byte of memory after the device driver, like a TSR that is stored in the terminating address field. This way, the initialization code can be used once and then thrown away to save space.

B. After setting the address field, a character device driver can set the status word and return.

Installing Block Devices

Block devices are installed in the same way as character devices. The difference is that block devices return additional information. Block devices must also return:

A. The number of units in the block device. This number determines the logical names the devices will have. For example, if the current logical device letter is F at the time of the install call, and the block device driver INIT routine returns three logical units, the letters G, H, and I are assigned to the units. The mapping is determined by the position of the driver in the device list and the number of units in the device. The number of units returned by INIT overrides the value in the name/unit field of the device header.

B. A pointer to a BPB (BIOS Parameter Block) pointer array. This is a pointer to an array of 'N' word pointers there 'N' is the number of units defined. These word pointers point to BPBs. This way, if all of the units are the same, the entire array can point to the same BPB to save space. The BPB contains information pertinent to the devices such as the sector size, number of sectors per allocation unit, and so forth. The sector size of the BPB cannot be greater than the maximum allotted size set at DOS initialization time. This array must be protected below the free pointer set by the return.

C. The media descriptor byte. This byte is passed to devices so that they know what parameters DOS is currently using for a particular drive unit.

Block devices can take several approaches. They can be 'dumb' or 'smart'. A dumb device would define a unit (and therefore a BPB) for each possible media drive combination. Unit 0=drive 0;single side, unit 1=drive 0;double side, etc. For this approach, the media descriptor bytes would mean nothing. A smart device would allow multiple media per unit. In this case, the BPB table returned at INIT must define space large enough to accommodate the largest possible medias supported (sector size in BPB must be as large as maximum sector size DOS is currently using). Smart drivers will use the media descriptor byte to pass information about what media is currently in a unit.

Request Header

The request header passes the information describing what DOS wants the device driver to do.

When a valid device driver command code or function is called by your application program, DOS develops a data structure called the 'Request Header' in ES:BX and passes it to the strategy entry point. This structure consists of a 13-byte defined header which may be followed by other data bytes depending on the function requested. It is the device driver's responsibility to preserve the machine state, for example, saving all registers including flags on entry and restoring 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 should set aside its own stack space. The fixed ('static') part of the request header is as follows:

REQUEST HEADER

Offset	Length	Field
00h	byte	Length in bytes of the request header
01h	byte	Unit code. Determines subunit to use in block devices Has no meaning for character devices

```
02h       byte      Command code
03h       word      Status
05h       8 bytes   Reserved for DOS
0Ch       varies    Data appropriate for the operation
```

Request Header Length Field

The length in bytes of the total request header (0-255) plus any data at the end of the header.

Unit Code Field

The unit code field identifies which unit in a block device driver the request is for. For example, if a block device driver has three units defined, then the possible values of the unit code field would be 0, 1, and 2. This field is not valid for character devices.

Command Code Field

The command code invokes a specific device driver function. Functions 0 through 12 are supported in all device drivers. Functions 13-15 are available only in DOS 3.0 or higher. Some functions are relevant for either character or block devices but not both; nonetheless all functions must have an executable routine present even if it does nothing but set the done flag in the return status word in the request header.

The command code field in the request header can have the following values:

```
code name                function
0    INIT                initialize driver for later use (used once only)
1    MEDIA CHECK         block devices only, NOP for character devices
2    BUILD BPB           block devices only, NOP for character devices
3    IOCTL input         called only if device has IOCTL bit set
4    INPUT               read data
5    NON-DESTRUCTIVE INPUT NO
     WAIT                character devices only
6    INPUT STATUS        character devices only
7    INPUT FLUSH         character devices only
8    OUTPUT              write data
9    OUTPUT              write data with verify
10   OUTPUT STATUS       character devices only
11   OUTPUT FLUSH        character devices only
12   IOCTL OUTPUT        called only if device has IOCTL bit is set
13   DEVICE OPEN         called only if OPEN/CLOSE/RM bit is set
14   DEVICE CLOSE        called only if OPEN/CLOSE/RM bit is set
15   REMOVABLE MEDIA     only if OPEN/CLOSE/RM bit set & device is block
16   OUTPUT UNTIL BUSY   only called if bit 13 is set & device is character
```

The individual command codes are described later in this chapter.

Status Field

The status word field is zero on entry and is set by the driver interrupt routine on return.

The status field in the request header contains:

DEVICE DRIVER STATUS FIELD

```
size  bit  definition
byte   0
       1
       2
```

```
        3   Error message return code
        4   (with bit 15=1)
        5
        6
        7
byte    8   DONE
        9   BUSY
        A   Reserved by DOS, unknown
        B
        C
        D
        E
        F   Error
```

The low 8 bits of the status word define an error message if bit 15 is set. These errors are:

00h	write protect violation	01h	unknown unit
02h	device not ready	03h	unknown command
04h	CRC error	05h	bad drive request structure length
06h	seek error	07h	unknown media
08h	sector not found	09h	printer out of paper
0Ah	write fault	0Bh	read fault
0Ch	general failure	0Dh	reserved
0Eh	reserved	0Fh	invalid disk change

BIT 8 is the done bit. If it is set, it means the operation is complete. The driver sets the bit to 1 when it exits.

BIT 9 is the busy bit. It is only set by status calls and the removable media call.

BITS 10-14 are reserved.

BIT 15 is the error bit. If this bit is set, the low 8 bits of the status word(7-0) indicate the error code.

Reserved For DOS

Official sources label this area as 'reserved for DOS'. Another source indicates that this consists of two double-word (4-byte) pointers to be used to maintain a linked list of request headers for this device and a list of all current device requests being processed by DOS. This was apparently to be used for the undelivered multitasking version of DOS.

Device Driver Functions

All 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 the strategy routines stores them in. The command code in the request header tells the driver which function to perform.

Note: All DWORD pointers are stored offset first, then segment.

INIT

```
Command code = 0        (all devices)
```

```
        Performs all initialization required at DOS boot time to install the
        driver and set local driver variables. This function is called only
        once, when the driver is loaded.

        ES:BX   pointer to 26-byte request header and data structure
 Format of structure:
   offset     length          field
    00h     13 bytes   request header
    0Dh       dword    number of units (not set by character devices)
    11h       dword    ending address of the driver's resident code
    15h       dword    pointer to BPB array (not set by character devices)/pointer
                       to remainder of arguments
    19h       byte     drive number (DOS 3.0+ only)
```

When INIT is called, the driver must do the following:

A. set the number of units (block devices only)

B. set up the pointer to the BPB array (block devices only)

C. perform any initialization code (to modems, printers, etc)

D. set the ending address of the resident program code

E. set the status word in the request header

To obtain information obtained from CONFIG.SYS to a device driver at INIT time, the BPB pointer field points to a buffer containing the information passed from CONFIG.SYS following the =. The buffer that DOS passes to the driver at INIT after the file specification contains an ASCII string for the file OPEN. The ASCII string (ending in 0h) is terminated by a carriage return (0Dh) and linefeed (0Ah). If there is no parameter information after the file specification, the file specification is immediately followed by a linefeed (0Ah). This information is read-only and only system calls 01h-0Ch and 30h can be issued by the INIT code of the driver.

The last byte parameter contains the drive letter for the first unit of a block driver. For example, 0=A, 1=B etc.

If an INIT routine determines that it cannot set up the device and wants to abort without using any memory, follow this procedure:

A. set the number of units to 0

B. set the ending offset address at 0

C. set the ending offset segment address to the code segment (CS)

Note: If there are multiple device drivers in a single memory image file, the ending address returned by the last INIT called is the one DOS uses. It is recommended that all device drivers in a single memory image file return the same ending address.

Media Check

```
command code = 1        (block devices only)
         Checks to see if disk had been changed since last access.

         ES:BX pointer to 19-byte request header and data structure
Format of structure:
offset     length   field
00h        13 bytes request header
0Dh           byte   media descriptor from BPB
0Eh           byte   returned
```

```
0Fh         dword  returns a pointer to the previous volume ID (if bit
                   11=1 and disk change is returned) (DOS 3.0+)
```

When the command code field is 1, DOS calls MEDIA CHECK for a drive unit and passes its current media descriptor byte. See 'Media Descriptor Byte' later in this chapter for more information about the byte. MEDIA CHECK returns one of the following:

A. media not changed
B. media changed
C. not sure
D. error code

The driver must perform the following:

A. set the status word in the request header

B. set the return byte

```
00h  don't know if media has been changed
01h  media has not been changed
-1   media has been changed
```

DOS 3.0+: If the driver has set the removable media bit 11 of the device header attribute word to 1 and the driver returns -1 (media changed), the driver must set the DWORD pointer to the previous volume identification field. If DOS determines that the media changed is an error, DOS generates an error 0Fh (invalid disk change) on behalf of the device. If the driver does not implement volume identification support, but has bit 11 set to 1, the driver should set a pointer to the string 'NO NAME',0.

Media Descriptor

Currently the media descriptor byte has been defined for a few media types. This byte should be identical to the media byte if the device has the non-IBM format bit off. These predetermined values are:

```
media descriptor byte =   1  1  1  1  1  0  0  0
 (numeric order)          7  6  5  4  3  2  1  0

     BIT                MEANING
      0       0       not double sided
              1       double sided
      1       0       not 8 sector
              1       8 sector
      2       0       nonremovable
              1       REMOVABLE
     3-7     must be set to 1
```

Build BPB (BIOS Parameter Block)

```
command code = 2          (block devices only)

       ES:BX   pointer to 22-byte request header and data structure
Format of structure:
offset   length          field
00h     13 bytes    request header
0Dh        byte     media descriptor from DOS
0Eh       dword     transfer address (buffer address)
12h       dword     pointer to BPB table
```

DOS calls BUILD BPB under the following two conditions:

A. If 'media changed' is returned.

B. If 'not sure' is returned. If so, there are no used buffers. Used buffers are buffers with changed data that have not yet been written to the disk.

The driver must do the following:

A. set the pointer to the BPB.

B. set the status word in the request header.

The driver must determine the correct media type currently in the unit to return the pointer to the BPB table. The way the buffer is used (pointer passed by DOS) is determined by the non-IBM format bit in the attribute field of the device header. If bit 13=0 (device is IBM compatible), the buffer contains the first sector of the FAT (most importantly the FAT ID byte). The driver must not alter this buffer in this case. If bit 13=1 the buffer is a one sector scratch area which can be used for anything.

For drivers that support volume identification and disk change, the call should cause a new volume identification to be read off the disk. This call indicates that the disk has been legally changed.

If the device is IBM compatible, it must be true that the first sector of the first FAT is located at the same sector for all possible media. This is because the FAT sector is read before the media is actually determined.

The information relating to the BPB for a particular media is kept in the boot sector for the media. In particular, the format of the boot sector is:

For DOS 2.x, 3 byte near jump (0E9h). For DOS 3.x+, 2 byte near jump (0EBh) followed by a NOP (90h)

```
8 bytes    OEM name and version
  BYTE     .    sectors per allocation unit (must be a power of 2)
  WORD     B    reserved sectors (starting at logical sector 0)
  BYTE          number of FATs
  WORD     P    max number of root directory entries
  WORD          number of sectors in logical image (total number of sectors in
                media, including boot sector directories, etc.)
           B
  BYTE          media descriptor
  WORD          number of sectors occupied by a single FAT
  WORD          sectors per track
  WORD          number of heads
  WORD          number of hidden sectors
```

The three words at the end return information about the media. The number of heads is useful for supporting different multihead drives that have the same storage capacity but a different number of surfaces. The number of hidden sectors is useful for drive partitioning schemes.

INPUT / OUTPUT (IOCTL)

```
command code = 3 IOCTL Read
               4 Read              (block or character devices)
               8 Write             (block or character devices)
               9 Write With Verify
              12 IOCTL Write
              16 Output Until Busy (character devices only)

      ES:BX    pointer to 24-byte request header and data structure
```

```
Format of structure:
offset    length     field
00h      13 bytes    request header
0Dh        byte      media descriptor byte from BPB
0Eh       dword      transfer address (buffer address)
12h        word      byte/sector count
14h        word      starting sector number (block devices)
16h       dword      (DOS 3.0+) pointer to the volume ID if error code 0Fh is
                     returned
```

The driver must perform the following:

A. set the status word in the request header

B. perform the requested function

C. set the actual number of sectors or bytes transferred

No error checking is performed on an IOCTL I/O call. However, the driver must set the return sector or byte count to the actual number of bytes transferred.

Under certain circumstances a block device driver may be asked to do a write operation of 64k bytes that seems to be a 'wrap around' of the transfer address in the BIOS I/O packet. This arises due to an optimization added to write code in DOS. It will only happen in writes that are within a sector size of 64k on files that are being extended past the current end of file. It is allowable for the device driver to ignore the balance of the write that wraps around, if it so chooses. For example, a write of 10000h bytes worth of sectors with a transfer address of XXX:1 ignores the last two bytes. A user program can never request an I/O of more than 0FFFFh bytes and cannot wrap around (even to 0) in the transfer segment, so in that case the last two bytes can be ignored.

A program that uses DOS function calls can never request an input or output function of more than 0FFFFh bytes, therefore, a wrap around in the transfer (buffer) segment can never occur. It is for this reason you can ignore bytes that would have wrapped around in the transfer segment.

If the driver returns an error code of 0Fh (invalid disk change) it must put a DWORD pointer to an ASCIIZ string which is the correct volume ID to ask the user to reinsert the disk.

DOS 3.0+:
The reference count of open files on the field (maintained by the OPEN and CLOSE calls) allows the driver to determine when to return error 0Fh. If there are no open files (reference count=0) and the disk has been changed, the I/O is all right, and error 0Fh is not returned. If there are open files (reference count 0) and the disk has been changed, an error 0Fh condition may exist.

Nondestructive Input No Wait

```
command code = 5             (character devices only)
         Reads a character from input stream but does not remove it from the
         buffer

        ES:BX     pointer to 14-byte request header and data structure
Format of structure:
offset    length          field
00h      13 bytes   request header
0Dh        byte     read from device
```

The driver must do the following:

A. return a byte from the device

B. set the status word in the request header.

If the character device returns busy bit=0 (characters in the buffer), then the next character that would be read is returned. This character is not removed form the buffer (hence the term nondestructive input). This call allows DOS to look ahead one character.

Status

```
command codes =  6   Input Status      (character devices only)
                10   Output Status     (character devices only)
        Check for characters waiting in input buffer

        ES:BX   pointer to 13-byte request header
```

This driver must perform the following:

A. perform the requested function

B. set the busy bit

C. set the status word in the request header.

The busy bit is set as follows:

For input on unbuffered character devices: if the busy bit (bit 9) is 1 on return, a write request would wait for completion of a current request. If the busy bit is 0, there is no current request. Therefore, a write request would start immediately.

For input on buffered character devices: if the busy bit is 1 on return, a read request does to the physical device. If the busy bit is 0, there are characters in the device buffer and a read returns quickly. It also indicates that a user has typed something. DOS assumes all character devices have a type-ahead input buffer. Devices that do not have this buffer should always return busy=0 so that DOS does not hang waiting for information to be put in a buffer that does not exist.

Flush Input Buffers

```
command code = 7         (character devices only)
        Forces all data in buffers to specified device.

        ES:BX   pointer to 13-byte request header
```

This call tells the driver to flush (terminate) all pending requests that it has knowledge of. Its primary use is to flush the input queue on character devices.

The driver must set the status word in the request header upon return.

Flush Output Buffers

```
command code 11          (character devices only)
        Forces all data in buffers to specified device.

        ES:BX   pointer to 13-byte request header
```

This call tells the driver to flush all output buffers and discards any pending requests. Its primary use is to flush the output queue on character devices.

The driver must set the status word in the request header upon return.

Open or Close (DOS 3.0+)

```
command code = 13   Open      (block or character devices)
               14   Close     (block or character devices)

        ES:BX   pointer to 13-byte static request header
```

These calls are designed to give the device information about the current file activity on the device if bit 11 of the attribute word is set. On block devices, these calls can be used to manage local buffering. The device can keep a reference count. Every OPEN causes the device to increment the reference count. Every CLOSE causes the device to decrement the reference count. When the reference count is 0, if means there are no open files in the device. Therefore, the device should flush buffers inside the device it has written to because now the user can change the media on a REMOVABLE media drive. If the media had been changed, it is advisable to reset the reference count to 0 without flushing the buffers. This can be thought of as 'last close causes flush'. These calls are more useful on character devices. The OPEN call can be used to send a device initialization string. On a printer, this could cause a string to be sent to set the font, page size, etc. so that the printer would always be in a known state in the I/O stream. Similarly, a CLOSE call can be used to send a post string (like a form feed) at the end of an I/O stream. Using IOCTL to set these pre and post strings provides a flexible mechanism of serial I/O device stream control.

Since all processes have access to STDIN, STDOUT, STDERR, STDAUX, and STDPRN (handles 0, 1, 2, 3, and 4) the CON, AUX, and PRN devices are always open.

Removable Media (DOS 3.0+)

```
command code = 15       (block devices only)
        This call identifies the media type as removable or nonremovable.

        ES:BX   pointer to 13-byte static request header
```

To use this call, set bit 11 (removable media) of the attribute field to 1. Block devices can only use this call through a subfunction of the IOCTL function call (int 21h fn44h).
This call is useful because it allows a utility to know whether it is dealing with a nonremovable media drive or with a removable media drive. For example, the FORMAT utility needs to know whether a drive is removable or nonremovable because it prints different versions of some prompts.

Note: No error checking is performed. It is assumed that this call always succeeds.

10

Expanded and Enhanced Expanded Memory Specifications

History

The Lotus/Intel/Microsoft Expanded Memory Manager was originally a Lotus and Intel project and was announced as version 3.0 in the second quarter of 1985 primarily as a means of running larger Lotus worksheets by transparently paging unused sections to bank-switched memory. Shortly afterward Microsoft announced support of the standard and version 3.2 was subsequently released with support for Microsoft Windows. LIM 3.2 supported up to 8 megabytes of paged memory. The LIM 4.0 supports up to 32 megabytes of paged memory.

Uses of Expanded Memory

The most common use for expanded memory is as a RAMdisk outside of DOS memory. The Lotus 1-2-3 Release 2 spreadsheet and many of its imitators can use EMS for storing part of the spreadsheet. AutoCAD, DesignCAD, and some other CAD programs can make use of EMS, as well as disk caching, etc. The MultiEdit word processor can also use EMS, and it looks like new applications are slowly starting to join the ranks of EMS-aware software.

The most striking use of expanded memory is Quarterdeck's DesQview. DesQview and the AQA EEMS were designed for each other. When EEMS is available, DesQview can manage multiple DOS partitions as a true multitasking manager. A program running under DesQview sees EEMS as conventional memory.

DOS and Expanded Memory

DOS 4.0 supports expanded memory for the internal functions of BUFFERS as well as various external programs (FASTOPEN and VDISK, for example). 4.0 checks for the presence of the Expanded Memory Manager device driver and passes calls to it like any other application. DOS 4.0 had a number of bugs with its EMS functions (such as not recognizing various non-IBM EMS managers and performing operations with the EMS board prohibited by the LIM 4.0 specification it supposedly embraces). DOS 4.01 was quietly released immediately afterward but still has problems. I have a real IBM 2Mb Expanded Memory Adapter in my AT (at $1395, I may have the only one in captivity!). Under DOS 4.01, XMA2EMS.SYS will initialize only 1664k of my 2048k. The card passes its own ROM and disk diagnostics perfectly. VDISK will also not function, aborting with a 'not enough memory' error.

The bug in DOS 4.00 can cause DOS 4.00 to corrupt files or entire directories when running programs that use expanded memory. The problem arises when using the DOS 4.00 /X option with BUFFERS, FASTOPEN, and VDISK commands. DOS 4.0 makes assumptions that are fundamentally inconsistent with standard EMS 4.0 usage. EMS 4.0 contains functions for saving and restoring the entire memory mapping context. Programs that need to change the memory map use these functions to save the current map, map in whatever memory they need, and then restore the original map. These functions change the entire map, including the pages of memory being used by DOS 4.0 /X option. DOS 4.0, however, assumes that the map for its pages NEVER get changed. The result is that DOS 4.0 gets confused about which buffers are currently in memory and corrupts the file data and/or directory data that is buffered.

Since the only really practical use for EMS in DOS 4.0 is in BUFFERS=, and any cache program (including IBM's own IBMCACHE) will blow BUFFERS= away, there's not much reason to worry about DOS 4.0's supposed EMS functionality.

One very good and one very bad result should come about from DOS 4.0's EMS support. First, since IBM now officially recognizes EMS, sells EMS cards, and DOS supports EMS (somewhat), we may see more programs making better use of EMS hardware.

The bad result is that IBM, for some idiotic reason, chooses to refer to EMS as 'XMA'. There already *IS* an XMA standard, which is defined by Microsoft, which uses 80286/80386 extended over-1-megabyte memory in a fashion much like EMS. Unfortunately, the XMA standard is little-known and I've seen advertisements for 'XMA' expanded memory adapters (sigh). As if extended, expanded, enhanced expanded, EMS, EEMS, conventional, HMA, and XMA weren't confusing enough already.

What Was That Again?

Conventional Memory:	Normal 0-640k address space, 8088 and 286/386 real mode
High Memory:	the 384k between the end of 640 and the 1 meg limit of the 8088 microprocessor
High Memory Area:	(HMA) the first 64k of the over-1-meg 286/386 address space
Extended Memory:	the over-1-meg address space of the 286/386, including HMA Use of this memory is defined by the Microsoft Extended Memory Specification, or XMA
Expanded Memory:	Paged memory swapped in and out of a predetermined area of the 0-1meg real mode address area. The current specifications are LIM 4.1 and AQA EEMS 3.2.
Display Memory:	memory between 640k and 1 meg where memory-mapped RAM from video cards is accessed.

AST/QuadRAM/Ashton-Tate Enhanced Expanded Memory Specification

The AQA EEMS maintains upward compatibility with the LIM, but is a superset of functions.

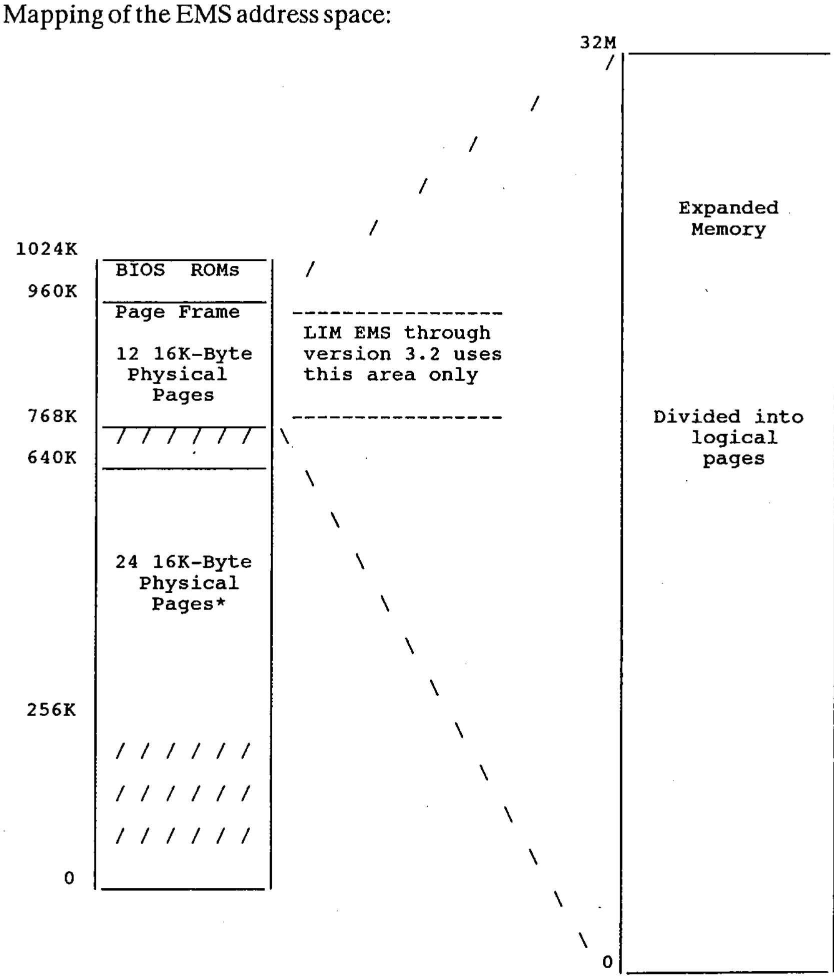
The AQA EEMS permits its pages to be scattered throughout the unused portion of the machine's address space. On August 19, 1987, the new version of the Expanded Memory Specification (EMS) was announced by Lotus, Intel and Microsoft. This new version of the specification includes many features of the Enhanced Expanded Memory Specification (EEMS) originally developed by AST Research, Quadram and Ashton-Tate, although the three original sponsoring companies elected not to make the new specification upward compatible with EEMS. AST Research says that they will endorse EMS 4.0 without reservation.

The definitive document for the LIM-EMS is Intel part number 300275-004, August, 1987. The definitive document for the AQA EEMS standard is AST part number 00048-001 B, June, 1987.

Both of these documents are free for the asking (Intel will even send you a floppy with the latest drivers). Unfortunately, the Intel documentation makes determining which functions are not available under LIM 3.x a bit difficult. There are very few LIM 4.0 or EEMS cards in the hands of users; most hardware is LIM 3.1 or 3.2 spec.

EMS Address Space Map

Mapping of the EMS address space:



The page frame is located above the 640k system RAM area, anywhere from 0A000h to 0FFFFh. This area is used by the video adapters, network cards, and add-on ROMs (as in hard disk controllers). The page frames are mapped around areas that are in use.

Writing Programs That Use Expanded Memory

In order to use expanded memory, applications must perform these steps in the following order:

1. Determine if EMM is installed.
2. Determine if enough expanded memory pages exist for your application. (Function3)
3. Allocate expanded memory pages (Functions 4 or 18).
4. Get the page frame base address (Function 2).
5. Map in expanded memory pages (Functions 5 or 17).
6. Read/write/execute data in expanded memory, just as if it were conventional memory.
7. Return expanded memory pages to expanded memory pool before exiting (Functions 6 or 18).

Programming Guidelines

The following section contains guidelines for programmers writing applications that use EMM.

1. Do not put a program's stack in expanded memory.
2. Do not replace interrupt 67h. This is the interrupt vector the EMM uses. Replacing interrupt 67h could result in disabling the Expanded Memory Manager.
3. Do not map into conventional memory address space your application doesn't own. Applications that use the EMM to swap into conventional memory space, must first allocate this space from the operating system. If the operating system is not aware that a region of memory it manages is in use, it will think it is available. This could have disastrous results. EMM should not be used to 'allocate' conventional memory. DOS is the proper manager of conventional memory space. EMM should only be used to swap data in conventional memory space previously allocated from DOS.
4. Applications that plan on using data aliasing in expanded memory must check for the presence of expanded memory hardware. Data aliasing occurs when mapping one logical page into two or more mappable segments. This makes one 16K-byte expanded memory page appear to be in more than one 16K-byte memory address space. Data aliasing is legal and sometimes useful for applications. Software-only expanded memory emulators cannot perform data aliasing. A simple way to distinguish software emulators from actual expanded memory hardware is to attempt data aliasing and check the results. For example, map one logical page into four physical pages. Write to physical page 0. Read physical pages 1-3 to see if the data is there as well. If the data appears in all four physical pages, then expanded memory hardware is installed in the system, and data aliasing is supported.
5. Applications should always return expanded memory pages to the expanded memory manager upon termination. These pages will be made available for other applications. If unneeded pages are not returned to the expanded memory manager, the system could run

out of expanded memory pages or expanded memory handles.

6. Terminate and stay resident programs (TSRs) should always save the state of the map registers before changing them. Since TSRs may interrupt other programs which may be using expanded memory, they must not change the state of the page mapping registers without first saving them. Before exiting, TSRs must restore the state of the map registers. The following sections describe the three ways to save and restore the state of the map registers.
   i. Save Page Map and Restore Page Map (Functions 8 and 9). This is the simplest of the three methods. The EMM saves the map register contents in its own data structures - the application does not need to provide extra storage locations for the mapping context. The last mapping context to be saved, under a particular handle, will be restored when a call to Restore Page Map is issued with the same handle. This method is limited to one mapping context for each handle and saves the context for only LIM standard 64K-byte page frames.
   ii. Get/Set Page Map (Function 15). This method requires the application to allocate space for the storage array. The EMM saves the mapping context in an array whose address is passed to the EMM. When restoring the mapping context with this method, an application passes the address of an array which contains a previously stored mapping context. This method is preferable if an application needs to do more than one save before a restore. It provides a mechanism for switching between more than one mapping context.
   iii. Get/Set Partial Page Map (Function 16). This method provides a way for saving a partial mapping context. It should be used when the application does not need to save the context of all mappable memory. This function also requires that the storage array be part of the application's data.

7. All functions using pointers to data structures must have those data structures in memory which will not be mapped out. Functions 22 and 23 (Alter Map & Call and Alter Map & Jump) are the only exceptions.

Page Frames

The bank switched memory chunks are referred to as 'page frames'. These frame consist of four 16K memory blocks mapped into some of the normally unused system ROM address area, 0C0000-0EFFFF. Each 16K page is independent of the other and they can map to discrete or overlapping areas of the 8 megabyte expanded memory address area. Most cards allow selection of addresses to prevent conflict with other cards, such as hard disk controllers and other expanded memory boards.

Calling the Manager

Applications programs communicate with the EMM device driver directly via user interrupt 67h. All communication between the application program and the driver by-passes DOS completely. To call the driver, register AH is loaded with the number of the EMM service requested; DX is loaded with the file handle; and interrupt 67h is called. ES:DI is used to pass the address of a buffer or array if needed.

On return AH contains 00h if the call was successful or an error code from 80h to 8Fh if unsuccessful.

Testing For the Presence of the Expanded Memory Manager

Before an application program can use the Expanded Memory Manager, it must determine whether the manager is present. The two recommended methods are the 'open handle' technique and the 'get interrupt vector' technique.

The majority of application programs can use either the 'open handle' or the 'get interrupt vector' method. However, if your program is a device driver or if it interrupts DOS during file system operations, you must use only the 'get interrupt vector' method.

Device drivers execute from within DOS and can't access the DOS file functions; programs that interrupt DOS during file operations have a similar restriction. During their interrupt processing procedures, they can't access the DOS file functions because another program may be using the system. Since the 'get interrupt vector' method doesn't require the DOS file functions, you must use it for programs of this type.

The 'Open Handle' Method

Most application programs can use the DOS 'Open Handle' method to test for the presence of the EMM. To use this method, follow these steps in order:

1. Issue an 'open handle' command (DOS function 3Dh) in 'read only' access mode (register AL = 0). This function requires your program to point to an ASCII string which contains the path name of the file or device in which you're interested (register set DS:DX contains the pointer). In this case the file is actually the reserved name of the expanded memory manager.

   You should format the ASCII string as follows:

   ```
   ASCII_device_name  DB  'EMMXXXX0', 0
   ```

   The ASCII codes for the capital letters EMMXXXX0 are terminated by a byte containing a value of zero.

2. If DOS returns no error code, skip Steps 3 and 4 and go to Step 5. If DOS returns a 'Too many open files' error code, go to Step 3. If DOS returns a 'File/Path not found' error code, skip Step 3 and go to Step 4.

3. If DOS returns a 'Too many open files' (not enough handles) status code, your program should invoke the 'open file' command before it opens any other files. This will guarantee that at least one file handle will be available to perform the function without causing this error. After the program performs the 'open file' command, it should perform the test described in Step 6 and close the 'file handle' (DOS function 3Eh). Don't keep the manager 'open' after this status test is performed since 'manager' functions are not available through DOS. Go to Step 6.

4. If DOS returns a 'File/Path not found", the memory manager is not installed. If your application requires the memory manager, the user will have to reboot the system with a disk containing the memory manager and the appropriate CONFIG.SYS file before proceeding.

5. If DOS doesn't return an error status code you can assume that either a device with the name EMMXXXX0 is resident in the system, or a file with this name is on disk in the current disk drive. Go to Step 6.

6. Issue an 'I/O Control for Devices' command (DOS function 44h) with a 'get device information' command (register AL = 0). DOS function 44h determines whether EMMXXXX0 is a device or a file. You must use the file handle (register BX) which you obtained in Step 1 to access the 'EMM' device. This function returns the 'device information' in a word (register DX). Go to Step 7.

7. If DOS returns any error code, you should assume that the memory manager device driver is not installed. If your application requires the memory manager, the user will have to reboot the system with a disk containing the memory manager and the appropriate CONFIG.SYS file before proceeding.

8. If DOS didn't return an error status, test the contents of bit 7 (counting from 0) of the 'device information' word (register DX) the function returned. Go to Step 9.

9. If bit 7 of the 'device information' word contains a zero, then EMMXXXX0 is a file, and the memory manager device driver is not present. If your application requires the memory manager, the user will have to reboot the system with a disk containing the memory manager and the appropriate CONFIG.SYS file before proceeding. If bit 7 contains a one, then EMMXXXX0 is a device. Go to Step 10.

10. Issue an 'I/O Control for Devices' command (DOS function 44h) with a 'get output status' command (register AL = 7). You must use the file handle you obtained in Step 1 to access the 'EMM' device (register BX). Go to Step 11.

11. If the expanded memory device driver is ready, the memory manager passes a status value of 0FFh in register AL. The status value is 00h if the device driver is not ready. If the memory manager device driver is 'not ready' and your application requires its presence, the user will have to reboot the system with a disk containing the memory manager and the appropriate CONFIG.SYS file before proceeding. If the memory manager device driver is 'ready', go to Step 12.

12. Issue a 'Close File Handle' command (DOS function 3Eh) to close the expanded memory device driver. You must use the file handle you obtained in Step 1 to close the 'EMM' device (register BX).

The 'Get Interrupt Vector' technique

Any type of program can use this method to test for the presence of the EMM.

Use this method (not the 'Open Handle' method) if your program is a device driver or if it interrupts DOS during file system operations.

Follow these steps in order:

1. Issue a 'get vector' command (DOS function 35h) to obtain the contents of interrupt vector array entry number 67h (addresses 0000:019Ch through 0000:019Fh). The memory manager uses this interrupt vector to perform all manager functions. The offset portion of this interrupt service routine address is stored in the word located at address 0000:019Ch; the segment portion is stored in the word located at address 0000:019Eh.

2. Compare the 'device name field' with the contents of the ASCII string which starts at the address specified by the segment portion of the contents of interrupt vector address 67h and a fixed offset of 000Ah. If DOS loaded the memory manager at boot time this name field will have the name of the device in it. Since the memory manager is implemented as a character device driver, its program origin is 0000h. Device drivers are required to have a 'device header' located at the program origin. Within the 'device header' is an 8 byte 'device name field'. For a character mode device driver this name field is always located at offset 000Ah within the device header. The device name field contains the name of the device which DOS uses when it references the device. If the result of the 'string compare' in this technique is positive, the memory manager is present.

Terminate and Stay Resident (TSR) Program Cooperation

In order for TSR's to cooperate with each other and with other applications, a TSR must only remap the DOS partition it lives in. This rule applies at all times, even when no expanded memory is present.

Expanded Memory Services Quick List

```
              1 (40h) Get Manager Status
              2 (41h) Get Page Frame Segment
              3 (42h) Get Number of Pages
              4 (43h) Get Handle and Allocate Memory
              5 (44h) Map Memory
              6 (45h) Release Handle and Memory
              7 (46h) Get EMM Version
              8 (47h) Save Mapping Context
              9 (48h) Restore Mapping Context
             10 (49h) Reserved
             11 (4Ah) Reserved
             12 (4Bh) Get Number of EMM Handles
             12 (4Ch) Get Pages Owned By Handle
             14 (4Dh) Get Pages for All Handles
             15 (4Eh) Get Or Set Page Map

new LIM 4.0 specification:
             16 (4Fh) Get/Set Partial Page Map
             17 (50h) Map/Unmap Multiple Pages
             18 (51h) Reallocate Pages
             19 (52h) Handle Attribute Functions
             20 (53h) Get Handle Name
             21 (54h) Get Handle Directory
             22 (55h) Alter Page Map & Jump
             23 (56h) Alter Page Map & Call
             24 (57h) Move Memory Region
             25 (58h) Get Mappable Physical Address Array
             26 (59h) Get Expanded Memory Hardware
             27 (5Ah) Allocate Raw Pages
             28 (5Bh) Get Alternate Map Register Set
             29 (5Ch) Prepare Expanded Memory Hardware
             30 (5Dh) Enable OS/E Function Set
             31 (5Eh) Unknown
             32 (5Fh) Unknown
             33 (60h) (EEMS) Get Physical Window Array
             34 (61h) AST Generic Accelerator Card Support
```

Expanded Memory Services

Functions Defined in EMS 3.2 Specification

Interrupt 67h

```
Function 40h Get Manager Status
LIM Function Call 1
                Returns a status code indicating whether the memory manager is
                present and the hardware is working correctly.
entry    AH         40h
return   AH         error status: 00h, 80h, 81h, 84h
note 1. Upward and downward compatible with both EMS and EEMS 3.2.
     2. This call can be used only after establishing that the EMS driver is in
        fact present
     3. Uses register AX
     4. This function doesn't require an EMM handle.

Function 41h Get Page Frame Segment Address
LIM Function Call 2
                Obtain segment address of the page frame used by the EMM.
entry    AH         41h
return   AH         error status: 00h, 80h, 81h, 84h
         BX         page frame segment address (error code 0)
note 1. Upward and downward compatible with both EMS and EEMS 3.2.
     2. Uses registers AX & BX
     3. This function doesn't require an EMM handle.
     4. The value in BX has no meaning if AH  0.

Function 42h Get Unallocated Page Count
LIM Function Call 3
                Obtain total number of logical expanded memory pages present in the
                system and the number of those pages not already allocated.
entry    AH         42h
return   AH         error status: 00h, 80h, 81h, 84h
         BX         00h      All EMS pages in have already been allocated. None are
                             currently available for expanded memory.
                    value    number of unallocated pages currently available
         DX         total number of EMS pages
note 1. Upward and downward compatible with both EMS and EEMS 3.2. Note that EMS
        and EEMS 3.2 had no mechanism to return the maximum number of handles
        that can be allocated by programs. This is handled by the EMS 4.0 new
        function 54h/02h.
     2. Uses registers AX, BX, DX
     3. This function doesn't require an EMM handle.

Function 43h Get Handle and Allocate Memory
LIM Function Call 4
                Notifies the EMM that a program will be using extended memory,
                obtains a handle, and allocates a certain number of logical pages
                of extended memory to be controlled by that handle
entry    AH         43h
         BX         number of 16k logical pages requested (zero OK)
return   AH         error status: 00h, 80h, 81h, 84h, 85h, 87h, 88h, 89h
         DX         unique EMM handle (see note 2)
note 1. Upward compatible with both EMS and EEMS 3.2; EMS and EEMS 3.2 do not
        allow the allocation of zero pages (returns error status 89h). EMS 4.0
        does allow zero pages to be requested for a handle, allocating pages
        later using function 51h
     2. Your program must use this EMM handle as a parameter in any function that
        requires it. You can use up to 255 handles. The uppermost byte of the
        handle will be zero and cannot be used by the application.
     3. Regs AX & DX are used

Function 44h Map Memory
LIM Function Call 5
                Maps one of the logical pages of expanded memory assigned to a
                handle onto one of the four physical pages within the EMM's page
                frame.
```

```
entry   AH      44h
        AL      physical page to be mapped (0-3)
        BX      the logical page to be mapped (zero through [number of pages
                allocated to the EMM handle - 1]). If the logical page number is
                0FFFFh, the physical page specified in AL will be unmapped (made
                inaccessible for reading or writing).
        DX      the EMM handle your program received from Function 4 (Allocate
                Pages).
return  AH      error status: 00h, 80h, 81h, 83h, 84h, 8Ah, 8Bh
note 1. downward compatible with both EMS and EEMS 3.2; EMS and EEMS 3.2 do not
        support unmap (logical page 0FFFFh) capability. Also, EEMS 3.2 specified
        there were precisely four physical pages; EMS 4.0 uses the subfunctions
        of function 58h to return the permitted number of physical pages. This
        incorporates the functionality of function 69h ("function 42") of EEMS.
     2. uses register AX

Function 45h Release Handle and Memory
LIM Function Call 6
             Deallocates the logical pages of expanded memory currently assigned
             to a handle and then releases the handle itself.
entry   AH      45h
        DX      handle
return  AH      error status: 00h, 80h, 81h, 83h, 84h, 86h
note 1. upward and downward compatible with both EMS and EEMS 3.2.
     2. uses register AX
     3. when a handle is deallocated, its name is set to all ASCII nulls (binary
        zeros).
     4. a program must perform this function before it exits to DOS or no other
        programs can use these pages or the EMM handle.

Function 46h Get EMM Version
LIM Function Call 7
             Returns the version number of the Expanded Memory Manager software.
entry   AH      46h
return  AH      error status: 00h, 80h, 81h, 84h
        AL      version number byte (if AL=00h)
                binary coded decimal (BCD) format if version byte:
                high nibble: integer digit of the version number
                low nibble : fractional digit of version number
                i.e., version 4.0 is represented like this:
                          0100 0000
                            /   \
                           4  .  0
note 1. upward and downward compatible with both EMS and EEMS 3.2. It appears
        that the intended use for this function is to return the version of the
        vendor implementation of the expanded memory manager instead of the
        specification version.
     2. uses register AX

Function 47h Save Mapping Context
LIM Function Call 8
             Save the contents of the expanded memory page-mapping registers on
             the expanded memory boards, associating those contents with a
             specific EMM handle.
entry   AH      47h
        DX      caller's EMM handle (NOT current EMM handle)
return  AH      error status:  00h, 80h, 81h, 83h, 84h, 8Ch, 8Dh
note 1. upward and downward compatible with both EMS and EEMS 3.2.
     2. This only saves the context saved in EMS 3.2 specification; if a driver,
        interrupt routine or TSR needs to do more, functions 4Eh (Page Map
        functions) or 4Fh (Partial Page Map functions) should be used.
     3. no mention is made about the number of save contexts to provide. AST
        recommends in their Rampage AT manual one save context for each handle
        plus one per possible interrupt (5 + handles).
     4. uses register AX
     5. this function saves the state of the map registers for only the 64K page
        frame defined in versions 3.x of the LIM. Since all applications written
        to LIM versions 3.x require saving the map register state of only this
        64K page frame, saving the entire mapping state for a large number of
        mappable pages would be inefficient use of memory. Applications that use
        a mappable memory region outside the LIM 3.x page frame should use
```

functions 15 or 16 to save and restore the state of the map registers.

```
Function 48h Restore Page Map
LIM Function Call 9
                Restores the contents of all expanded memory hardware page-mapping
                registers to the values associated with the given handle by a
                previous function 08h (Save Mapping Context).
entry   AH      48h
        DX      caller's EMM handle (NOT current EMM handle)
return  AH      error status: 00h, 80h, 81h, 83h, 84h, 8Eh
note 1. upward and downward compatible with both EMS and EEMS 3.2.
     2. This only restores the context saved in EMS 3.2 specification; if a
        driver, interrupt routine or TSR needs to do more, functions 4Eh (Page
        Map functions) or 4Fh (Partial Page Map functions) should be used.
     3. uses register AX
     4. this function saves the state of the map registers for only the 64K page
        frame defined in versions 3.x of the LIM. Since all applications written
        to LIM versions 3.x require saving the map register state of only this
        64K page frame, saving the entire mapping state for a large number of
        mappable pages would be inefficient use of memory. Applications that use
        a mappable memory region outside the LIM 3.x page frame should use
        functions 15 or 16 to save and restore the state of the map registers.

Function 49h Reserved
LIM Function Call 10
                This function was used in EMS 3.0, but was no longer documented in
                EMS 3.2. It formerly returned the page mapping register I/O port
                array. Use of this function is discouraged, and in EMS 4.0 may
                conflict with the use of the new functions 16 through 30 (4Fh through
                5Dh) and functions 10 and 11. Functions 10 and 11 are specific to the
                hardware on Intel expanded memory boards and may not work correctly
                on all vendors' expanded memory boards.

Function 4Ah Reserved
LIM Function Call 11
                This function was used in EMS 3.0, but was no longer documented in
                EMS 3.2. It was formerly Get Page Translation Array. Use of this
                function is discouraged, and in EMS 4.0 may conflict with the use of
                the new functions (4Fh through 5Dh).

Function 4Bh Get Number of EMM Handles
LIM Function Call 12
                The Get Handle Count function returns the number of open EMM handles
                (including the operating system handle 0) in the system.
entry   AH      4Bh
return  AH      error status: 00h, 80h, 81h, 84h
        BX      handle count (AH=00h) (including the operating system handle
                [0]). max 255.
note 1. upward and downward compatible with EMS and EEMS 3.2.
     2. uses registers AX and BX

Function 4Ch Get Pages Owned by Handle
LIM Function Call 13
                Returns number of logical expanded memory pages allocated to a
                specific EMM handle.
entry   AH      4Ch
        DX      handle
return  AH      error status: 00h, 80h, 81h, 83h, 84h
        BX      pages allocated to handle, max 2048 because the EMM
                allows a maximum of 2048 pages (32M bytes) of expanded memory.
note 1. This function is upward compatible with EMS and EEMS 3.2.
     2. programmers should compare the number returned in BX with the maximum
        number of pages returned by function 42h register DX, total number of
        EMM pages. This should be an UNSIGNED comparison, just in case the spec
        writers decide to use 16 bit unsigned numbers (for a maximum space of
        one gigabyte) instead of signed numbers (for a maximum space of 512 mega
        bytes). Unsigned comparisons will work properly in either case
     3. uses registers AX and BX
Function 4Dh Get Pages for All Handles
LIM Function Call 14
                Returns an array containing all active handles and the number of
```

```
                logical expanded memory pages associated with each handle.
entry    AH     4Dh
         ES:DI  pointer to 1020 byte array to receive information on an array of
                structures where a copy of all open EMM handles and the number of
                pages allocated to each will be stored.
return   AH     error status: 00h, 80h, 81h, 84h
         BX     number of active handles (1-255); array filled with 2-word en
                tries, consisting of a handle and the number of pages allocated
                to that handle. (including the operating system handle [0]). BX
                cannot be zero because the operating system handle is always
                active and cannot be deallocated.
note 1. NOT COMPATIBLE with EMS or EEMS 3.2, since the new special OS handle
        0000h is returned as part of the array. Unless benign use of this
        information is used (such as displaying the handle and count of pages
        associated with the handle) code should be changed to only work with
        handles between 01h and FFh and to specifically ignore handle 00h.
     2. The array consists of an array of 255 elements. The first word of each
        element is the handle number, the second word contains the number of
        pages allocated.
     3. There are two types of handles, 'standard' and 'raw'. The specification
        does not talk about how this function works when both raw and standard
        handles exist in a given system. There is no currently known way to
        differentiate between a standard handle and a raw handle in EMS 4.0.
     4. uses registers AX and BX

Function 4Eh Get or Set Page Map
LIM Function Call 15
             Gets or sets the contents of the EMS page-mapping registers on the
             expanded memory boards. This group of four subfunctions is provided
             for context switching required by operating environments and
             systems. These functions are upward and downward compatible with
             both EMS and EEMS 3.2; in addition, these functions now include the
             functionality of EEMS function 6Ah ("function 43") involving all
             pages. The size and contents of the map register array will vary
             from system to system based on hardware vendor, software vendor,
             number of boards and the capacity of each board in the system. Note
             the array size can be determined by function 4Eh/03h. Use these
             functions (except for 03h) instead of Functions 8 and 9 if you need
             to save or restore the mapping context but don't want (or have) to
             use a handle.

        00h  Get Page Map
             This call saves the mapping context for all mappable memory regions
             (conventional and expanded) by copying the contents of the mapping
             registers from each expanded memory board to a destination array.
             The application must pass a pointer to the destination array.

entry    AH     4Eh
         AL     00h
         ES:DI  pointer to target array
return   AH     error status: 00h, 80h, 81h, 84h, 8Fh
note 1. uses register AX
     2. does not use an EMM handle

         01h  Set Page Map
              This call the mapping context for all mappable memory regions
              (conventional and expanded. by copying the contents of a source
              array into the mapping registers on each expanded memory board in
              the system. The application must pass a pointer to the source array

entry    AH     4Eh
         AL     01h
         DS:SI  pointer to source array
return   AH     error status: 00h, 80h, 81h, 84h, 8Fh, 0A3h
note 1. uses register AX
     2. does not use an EMM handle

        02h  Get & Set Page Map
             This call simultaneously saves the current mapping context and
             restores a previous mapping context for all mappable memory regions
             (both conventional and expanded). It first copies the contents of
```

```
            the mapping registers from each expanded memory board in the system
            into a destination array. Then the subfunction copies the contents
            of a source array into the mapping registers on each of the expanded
            memory boards.

entry   AH      4Eh
        AL      02h
        DS:SI   pointer to source array
        ES:DI   pointer to target array
return  AH      error status: 00h, 80h, 81h, 84h, 8Fh, 0A3h
note    uses register AX

          03h  Get Size of Page Map Save Array
entry   AH      4Eh
        AL      03h
return  AH      error status:  00h, 80h, 81h, 84h, 8Fh
        AL      size in bytes of array
note 1. this subfunction does not require an EMM handle
     2. uses register AX
```

Functions New to EMS 4.0

```
Function 4Eh Get or Set Page Map
LIM Function Call 16
entry   AH      4Eh
        AL      00h     if getting mapping registers
                01h     if setting mapping registers
                02h     if getting and setting mapping registers at once
                03h     if getting size of page-mapping array
        DS:SI   pointer to array holding information (AL=01h, 02h)
        ES:DI   pointer to array to receive information (AL=00h, 02h)
return  AH      error status: 00h, 80h, 81h, 84h, 8Fh, 0A3h
        AL      bytes in page-mapping array (fn 03h only)
        ES:DI   array of received information (fn 00h, 02h)
note.   this function was designed to be used by multitasking operating systems
        and should not ordinarily be used by application software.

Function 4Fh Get/Set Partial Page Map
LIM Function Call 16
            These four subfunctions are provided for context switching required
            by interrupt routines, operating environments and systems. This set
            of functions provides extended functionality over the EEMS function
            6Ah (function 43) involving subsets of pages. In EEMS, a subset of
            pages could be specified by starting position and number of pages;
            in this function a list of pages is specified, which need not be
            contiguous. Interrupt routines can use this function in place of
            functions 47h and 48h, especially if the interrupt routine wants to
            use more than the standard four physical pages.

        AH      4Fh
        AL      subfunction
                00h     get partial page map
                        DS:SI   pointer to structure containing list of segments
                                whose mapping contexts are to be saved
                        ES:DI   pointer to array to receive page map
                01h     set partial page map
                        DS:SI   pointer to structure containing saved partial
                                page map
                02h     get size of partial page map
                        BX      number of mappable segments in the partial map to
                                be saved
return  AH      error status (00h): 00h, 80h, 81h, 84h, 8Bh, 8Fh, 0A3h
                error status (01h): 00h, 80h, 81h, 84h, 8Fh, 0A3h
                error status (02h): 00h, 80h, 81h, 84h, 8Bh, 8Fh
        AL      size of partial page map for subfunction 02h
        DS:SI   (call 00h) pointer to array containing the partial mapping con
                text and any additional information necessary to restore this
                context to its original state when the program invokes a Set
```

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              subfunction.
note    uses register AX

Function 50h Map/Unmap Multiple Pages
LIM Function Call 17
entry   AH      50h
        AL      00h     (by physical page)
                01h     (by segment number)
        CX      contains the number of entries in the array. For example, if the
                array contained four pages to map or unmap, then CX would
                contain 4.
        DX      handle
        DS:SI   pointer to an array of structures that contains the information
                necessary to map the desired pages.
return  AH      error status: 00h, 80h, 81h, 83h, 84h, 8Ah, 8Bh, 8Fh
note 1. New function permits multiple logical-to-physical assignments to be made
        in a single call.(faster than mapping individual pages)
     2. The source map array is an array of word pairs. The first word of a pair
        contains the logical page to map (0FFFFh if the physical page is to be
        totally unmapped) and the second word of a pair contains the physical
        page number (subfunction 00h) or the segment selector (subfunction 01h)
        of the physical page in which the logical page shall be mapped.
     3. A map of available physical pages (by physical page number and segment
        selectors) can be obtained using function 58h/00h, Get Mappable Physical
        Address Array.
     4. uses register AX
     5. Both mapping and unmapping pages can be done simultaneously.
     6. If a request to map or unmap zero pages is made, nothing is done and no
        error is returned.
     7. Pages can be mapped or unmapped using one of two methods. Both methods
        produce identical results.
        A. A logical page and a physical page at which the logical page is to be
           mapped. This method is an extension of Function 5 (Map Handle Page).
        B. Specifies both a logical page and a corresponding segment address at
           which the logical page is to be mapped. While functionally the same
           as the first method, it may be easier to use the actual segment
           address of a physical page than to use a number which only
           represents its location. The memory manager verifies whether the
           specified segment address falls on the boundary of a mappable
           physical page. The manager then translates the segment address
           passed to it into the necessary internal representation to map the
           pages.

Function 51h Reallocate pages
LIM Function Call 18
            This function allows an application to change the number of logical
            pages allocated to an EMM handle.
entry   AH      51h
        BX      number of pages desired at return
        DX      handle
return  AH      error status: 00h, 80h, 81h, 83h, 84h, 87h, 88h
        BX      number of pages now associated with handle
note 1. uses registers AX, BX
     2. Logical pages which were originally allocated with Function 4 are called
        pages and are 16K bytes long. Logical pages which were allocated with
        Function 27 are called raw pages and might not be the same size as pages
        allocated with Function 4.
     3. If the status returned in BX is not zero, the value in BX is equal to the
        number of pages allocated to the handle prior to calling this function.
        This information can be used to verify that the request generated the
        expected results.

Function 52h Get/Set Handle Attributes
LIM Function Call 19
entry   AH      52h
        AL      subfunction
                00h     get handle attributes
                01h     set handle attributes
                        BL      new attribute
                                00h     make handle volatile
                                01h     make handle non-volatile
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                02h     get attribute capability
        DX      handle
return  AH      error status: (function 00h) 00h, 80h, 81h, 83h, 84h, 8Fh, 91h
                error status: (function 01h) 00h, 80h, 81h, 83h, 84h, 8Fh, 90h,
                                             91h
                error status: (function 02h) 00h, 80h, 81h, 84h, 8Fh
        AL      attribute (for subfunction 00h)
                00h     handle is volatile
                01h     handle is nonvolatile
        AL      attribute capability (for subfunction 02h)
                00h     only volatile handles supported
                01h     both volatile and non-volatile supported
note 1. uses register AX
     2. A volatile handle attribute instructs the memory manager to deallocate
        both the handle and the pages allocated to it after a warm boot. If all
        handles have the volatile attribute (default) at warm boot the handle
        directory will be empty and all expanded memory will be initialized to
        zero immediately after a warm boot.
     3. If the handle's attribute has been set to non-volatile, the handle, its
        name (if it is assigned one), and the contents of the pages allocated
        to the handle are all maintained after a warm boot.
     4. Most PCs disable RAM refresh signals for a considerable period during a
        warm boot. This can corrupt some of the data in memory boards.
        Non-volatile handles should not be used unless it is definitely known
        that the EMS board will retain proper function through a warm boot.
     5. subfunction 02h can be used to determine whether the memory manager can
        support the non-volatile attribute.
     6. Currently the only attribute supported is non-volatile handles and pages,
        indicated by the least significant bit.

Function 53h Handle Name Functions
LIM Function Call 20
            EMS handles may be named. Each name may be any eight characters. At
            installation, all handles have their name initialized to ASCII nulls
            (binary zeros). There is no restriction on the characters which may
            be used in the handle name (ASCII chars 00h through 0FFh). A name of
            eight nulls (zeroes) is special, and indicates a handle has no name.
            Nulls have no special significance, and they can appear in the
            middle of a name. The handle name is 64 bits of binary information
            to the EMM.
            Functions 53h and 54h provide a way of setting and reading the names
            associated with a particular handle. Function 53h manipulates names
            by number.
            When a handle is assigned a name, at least one character in the name
            must be a non-null character in order to distinguish it from a
            handle without a name.

        00h Get Handle Name
            This subfunction gets the eight character name currently assigned to
            a handle.
            The handle name is initialized to ASCII nulls (binary zeros) three
            times: when the memory manager is installed, when a handle is
            allocated, and when a handle is deallocated.
entry   AH      53h
        AL      00h
        DX      handle
        ES:DI   pointer to 8-byte handle name array into which the name currently
                assigned to the handle will be copied.
return  AH      error status: 00h, 80h, 81h, 83h, 84h, 8Fh
note    uses register AX

        01h Set Handle Name
            This subfunction assigns an eight character name to a handle. A
            handle can be renamed at any time by setting the handle's name to a
            new value. When a handle is deallocated, its name is removed (set
            to ASCII nulls).
entry   AH      53h
        AL      01h
        DX      handle
        DS:SI   pointer to 8-byte handle name array that is to be assigned to the
                handle. The handle name must be padded with nulls if the name is
```

```
                less than eight characters long.
return  AH      error status: 00h, 80h, 81h, 83h, 84h, 8Fh, 0A1h
note    uses register AX

Function 54h Handle Directory Functions
LIM Function Call 21
             Function 54h manipulates handles by name.

        00h  Get Handle Directory
             Returns an array which contains all active handles and the names
             associated with each.
entry   AH      54h
        AL      00h
        ES:DI   pointer to 2550 byte target array
return  AH      error status: 00h, 80h, 81h, 84h, 8Fh
        AL      number of active handles
note 1. The name array consists of 10 byte entries; each entry has a word
        containing the handle number, followed by the eight byte (64 bit) name.
     2. uses register AX
     3. The number of bytes required by the target array is:
                10 bytes * total number of handles
     4. The maximum size of this array is:
                (10 bytes/entry) * 255 entries = 2550 bytes.

        01h  Search for Named Handle
             Searches the handle name directory for a handle with a particular
             name. If the named handle is found, this subfunction returns the
             handle number associated with the name.
entry   AH      54h
        AL      01h
        DS:SI   pointer to an 8-byte string that contains the name of the handle
                 being searched for
return  AH      error status: 00h, 80h, 81h, 84h, 8Fh, A0h, 0A1h
        DX      handle number
note    uses registers AX and DX

        02h  Get Total Handles
             Returns the total number of handles the EMM supports, including the
             operating system handle (handle value 0).
entry   AH      54h
        AL      02h
return  AH      error status: 00h, 80h, 81h, 84h, 8Fh
        BX      total number of handles available
note 1. This is NOT the current number of handles defined, but the maximum number
        of handles that can be supported in the current environment.
     2. uses registers AX and BX

Function 55h Alter Page Map and Jump (cross page branch)
LIM Function Call 22
             Alters the memory mapping context and transfers control to the
             specified address. Analogous to the FAR JUMP in the 8086 family
             architecture. The memory mapping context which existed before
             calling function is lost.
entry   AH      55h
        AL      00h     physical page numbers provided by caller
                01h     segment addresses provided by caller
        DX      handle
        DS:SI   pointer to structure containing map and jump address
return  AH      error status: 00h, 80h, 81h, 83h, 84h, 8Ah, 8Bh, 8Fh
note 1. Flags and all registers except AX are preserved across the jump.
     2. uses register AX
     3. Values in registers which don't contain required parameters maintain the
        values across the jump. The values in registers (with the exception of
        AX) and the flag state at the beginning of the function are still in the
        registers and flags when the target address is reached.
     4. Mapping no pages and jumping is not considered an error. If a request to
        map zero pages and jump is made, control is transferred to the target
        address, and this function performs a far jump.

Function 56h Alter Page Map and Call (cross page call)
LIM Function Call 23
```

```
         00h and 01h
              These subfunctions save the current memory mapping context, alter
              the specified memory mapping context, and transfer control to the
              specified address.
entry    AH       56h
         AL       00h physical page numbers provided by caller
                  01h segment addresses provided by caller
         DS:SI    pointer to structure containing page map and call address
         DX       handle
return   AH       error status: 00h, 80h, 81h, 83h, 84h, 8Ah, 8Bh, 8Fh
note 1.  Flags and all registers except AX are preserved to the called routine. On
         return, flags and all registers except AX are preserved; AL is set to
         zero and AX is undefined.
     2.  uses register AX
     3.  Values in registers which don't contain required parameters maintain the
         values across the call. The values in registers (with the exception of
         AX) and the flag state at the beginning of the function are still in the
         registers and flags when the target address is reached.
     4.  Developers using this subfunction must make allowances for the additional
         stack space this subfunction will use.

         02h  Get Page Map Stack Space Size
              Since the Alter Page Map & Call function pushes additional
              information onto the stack, this subfunction returns the number of
              bytes of stack space the function requires.
entry    AH       56h
         AL       02h
return:  BX       number of bytes of stack used per call
         AH       error status: 00h, 80h, 81h, 84h, 8Fh
note 1.  if successful, the target address is called. Use a RETF to return and
         restore mapping context
     2.  uses registers AX, BX

Function 57h Move/Exchange Memory Region
LIM Function Call 24

         00h  Move Memory Region
              Moves data between two memory areas. Includes moves between paged
              and non-paged areas, or between two different paged areas.
entry    AH       57h
         AL       00h
         DS:SI    pointer to request block
return   AH       error status: 00h, 80h, 81h, 83h, 84h, 8Ah, 8Fh, 92h,
                   93h, 94h, 95h, 96h, 98h, 0A2h
note 1.  uses register AX

         01h  Exchange Memory Region
              Exchanges data between two memory areas. Includes exchanges between
              paged and non-paged areas, or between two different paged areas.
entry    AH       57h
         AL       01h
         DS:SI    pointer to the data structure which contains the source and
                  destination information for the exchange.
return   AH       error status: 00h, 80h, 81h, 83h, 84h, 8Ah, 8Fh, 93h, 94h, 95h,
                               96h, 97h, 98h, 0A2h
note 1.  The request block is a structure with the following format:
         dword    region length in bytes
         byte     0=source in conventional memory
                  1=source in expanded memory
         word     source handle
         word     source offset in page or selector
         word     source logical page (expanded) or selector (conventional)
         byte     0=target in conventional memory
                  1=target in expanded memory
         word     target handle
         word     target offset in page or selector
         word     target logical page (expanded) or selector (conventional)
     2.  Expanded memory allocated to a handle is considered to be a linear array,
         starting from logical page 0 and progressing through logical page 1, 2,
         ... n, n+1, ... up to the last logical page in the handle.
     3.  uses register AX
```

```
Function 58h Mappable Physical Address Array
LIM Function Call 25
             These functions let you obtain a complete map of the way physical
             memory is laid out in a vendor independent manner. This is a
             functional equivalent of EEMS function 68h ('function 41'). EEMS
             function 60h ('function 33') is a subset call of 68h.

        00h  Get Array
             Returns an array containing the segment address and physical page
             number for each mappable physical page in a system. This array
             provides a cross reference between physical page numbers and the
             actual segment addresses for each mappable page in the system.
entry   AH      58h
        AL      00h
        ES:DI   pointer to target array
return  AH      error status: 00h, 80h, 81h, 84h, 8Fh
        CX      entries in target array
note 1. The information returned is in an array composed of word pairs. The first
        word is the physical page's segment selector, the second word the
        physical page number. Note that values are not necessarily returned in a
        particular order, either ascending/descending segment selector values or
        as ascending/descending physical page number.
     2. For compatibility with earlier EMS specifications, physical page zero
        contains the segment selector value returned by function 41h, and
        physical pages 1, 2 and 3 return segment selector values that correspond
        to the physical 16 KB blocks immediately following physical page zero.
     3. uses registers AX and CX
     4. The array is sorted in ascending segment order. This does not mean that
        the physical page numbers associated with the segment addresses are also
        in ascending order.

        01h   Get Physical Page Address Array Entries.
              Returns a word which represents the number of entries in the array
              returned by the previous subfunction. This number also indicates
              the number of mappable physical pages in a system.
entry   AH      58h
        AL      01h
return  AH      error status: 00h, 80h, 81h, 84h, 8Fh
        CX      number of entries returned by 58h/00h
note 1. multiply CX by 4 for the byte count.
     2. uses registers AX and CX

Function 59h Get Expanded Memory Hardware Information
LIM Function Call 26
             These functions return information specific to a given hardware
             implementation and to use of raw pages as opposed to standard pages.
             The intent is that only operating system code ever need use these
             functions.

        00h  Get EMS Hardware Info
             Returns an array containing expanded memory hardware configuration
             information for use by an operating system.
entry   AH      59h
        AL      00h
        ES:DI   pointer to 10 byte target array
                The target array has the following format:
                word: raw page size in paragraphs (multiples of 16 bytes)
                word: number of alternate register sets
                word: size of page maps (function 4Eh [15])
                word: number of alternate registers sets for DMA
                word: DMA operation -- see full specification
return  AH      error status: 00h, 80h, 81h, 84h, 8Fh, 0A4h
note 1. uses register AX
     2. This function is for use by operating systems only.
     3. This function can be disabled at any time by the operating system.

        01h  Get Unallocated Raw Page Count
             Returns the number of unallocated non-standard length mappable pages
             as well as the total number of non-standard length mappable pages
             of expanded memory
entry   AH      59h
```

```
        AL      01h
return  AH      error status: 00h, 80h, 81h, 84h, 8Fh
        BX      unallocated raw pages available for use
        DX      total raw 16k pages of expanded memory
note 1. uses registers AX, BX, CX
     2. An expanded memory page which is a sub-multiple of 16K is termed a raw
        page. An operating system may deal with mappable physical page sizes
        which are sub-multiples of 16K bytes.
     3. If the expanded memory board supplies pages in exact multiples of 16K
        bytes, the number of pages this function returns is identical to the
        number Function 3 (Get Unallocated Page Count) returns. In this case,
        there is no difference between a page and a raw page.

Function 5Ah Allocate Raw Pages
LIM Function Call 27
             Allocates the number of nonstandard size pages that the operating
             system requests and assigns a unique EMM handle to these pages.
entry   AH      5Ah
        AL      00h      allocate standard pages
                01h      allocate raw pages
        BX      number of pages to allocate
return  AH      error status: 00h, 80h, 81h, 84h, 85h, 87h, 88h
        DX      unique raw EMM handle (1-255)
note 1. it is intended this call be used only by operating systems
     2. uses registers AX and DX
     3. for all functions using the raw handle returned in DX, the length of the
        physical and logical pages allocated to it are some non-standard length
        (that is, not 16K bytes).
     4. this call is primarily for use by operating systems or EMM drivers
        supporting hardware with a nonstandard EMS page size.

Function 5Bh Alternate Map Register Set - DMA Registers
LIM Function Call 28
entry   AH      00h      Get Alternate Map Register Set
                01h      Set Alternate Map Register Set
                         BL       new alternate map register set number
                         ES:DI    pointer to map register context save area if BL=0
                02h      Get Alternate Map Save Array Size
                03h      Allocate Alternate Map Register Set
                04h      Deallocate Alternate Map Register Set
                         BL       number of alternate map register set
                05h      Allocate DMA Register Set
                06h      Enable DMA on Alternate Map Register Set
                         BL       DMA register set number
                         DL       DMA channel number
                07h      Disable DMA on Alternate Map Register Set
                         BL       DMA register set number
                08h      Deallocate DMA Register Set
                         BL       DMA register set number
return  AH      status: 00h, 02h   00h, 80h, 84h, 81h, 8Fh, 0A4h
                        01h        00h, 80h, 81h, 84h, 8Fh, 9Ah, 9Ch, 9Dh,
                                   0A3h, 0A4h
                        03h, 05h   00h  80h  81h  84h, 8Fh, 9Bh, 0A4h
                        04h        00h, 80h, 81h, 84h, 8Fh, 9Ch, 9Dh, 0A4h
                        06h, 07h   00h, 80h, 81h, 84h, 8Fh, 9Ah, 9Ch, 9Dh, 9Eh,
                                   9Fh, 0A4h
        BL      current active alternate map register set number if nonzero (AL=0)
        BL      number of alternate map register set; zero if not supported (AL=3)
        DX      array size in bytes (subfunction 02h)
        ES:DI   pointer to a map register context save area if BL=0 (AL=0)
note 1. this call is for use by operating systems only, and can be enabled or
        disabled at any time by the operating system
     2. This set of functions performs the same functions at EEMS function 6Ah
        subfunctions 04h and 05h ("function 43").
     3. 00h uses registers AX, BX, ES:DI
        01h uses register AX
        02h uses registers AX and DX
        03h uses registers AX and BX
        04h uses register AX
        05h uses registers AX, BX
        06h uses register AX
```

```
        07h uses register AX

Function 5Ch Prepare EMS Hardware for Warm Boot
LIM Function Call 29
             Prepares the EMM hardware for a warm boot.
entry   AH      5Ch
return  AH      error status: 00h, 80h, 81h, 84h
note 1. uses register AX
     2. this function assumes that the next operation that the operating system
        performs is a warm boot of the system.
     3. in general, this function will affect the current mapping context, the
        alternate register set in use, and any other expanded memory hardware
        dependencies which need to be initialized at boot time.
     4. if an application decides to map memory below 640K, the application must
        trap all possible conditions leading to a warm boot and invoke this
        function before performing the warm boot itself.

Function 5Dh Enable/Disable OS Function Set Functions
LIM Function Call 30
             Lets the OS allow other programs or device drivers to use the OS
             specific functions. This capability is provided only for an OS
             which manages regions of mappable conventional memory and cannot
             permit programs to use any of the functions which affect that
             memory, but must be able to use these functions itself.
entry   AH      5Dh
        AL      00h     enable OS function set
                01h     disable OS function set
                02h     return access key (resets memory manager, returns access
                        key at next invocation)
        BX,CX   access key returned by first invocation
return  BX,CX   access key, returned only on first invocation of function
        AH      status  00h, 80h, 81h, 84h, 8Fh, 0A4h
note 1. this function is for use by operating systems only. The operating system
        can disable this function at any time.
     2. 00h uses registers AX, BX, CX
        01h uses registers AX, BX, CX
        02h uses register AX
     3. 00h, 01h: The OS/E (Operating System/Environment) functions these
        subfunctions affect are:
        Function 26, Get Expanded Memory Hardware Information
        Function 28, Alternate Map Register Sets
        Function 30, Enable/Disable Operating System Functions

Function 5Eh Unknown
LIM Function call (not defined under LIM)

Function 5Fh Unknown
LIM Function call (not defined under LIM)

Function 60h EEMS - Get Physical Window Array
LIM Function call (not defined under LIM)
entry   AH      60h
        ES:DI   pointer to buffer
return  AH      status
        AL      number of entries
        buffer at ES:DI filled

Function 61h Generic Accelerator Card Support
LIM Function Call 34
entry   _ Contact AST Research for a copy of the Generic Accelerator Card
return  _ Driver (GACD) Specification
note    Can be used by accelerator card manufacturer to flush RAM cache,ensuring
        that the cache accurately reflects what the processor would see without
        the cache.

Function 68h EEMS - Get Addresses of All Page Frames in System
LIM Function Call (not defined under LIM)
entry   AH      68h
        ES:DI   pointer to buffer
return  AH      status
        AL      number of entries
```

```
        buffer at ES:DI filled
note    Equivalent to LIM 4.0 function 58h

Function 69h EEMS - Map Page Into Frame
LIM Function Call (not defined under LIM)
entry   AH      69h
        AL      frame number
        BX      page number
        DX      handle
return  AH      status
note    Similar to EMS function 44h

Function 6Ah  EEMS - Page Mapping
LIM Function Call (not defined under LIM)
entry   AH      6Ah
        AL      00h     Save Partial Page Map
                        CH      first page frame
                        CL      number of frames
                        ES:DI   pointer to buffer which is to be filled
                01h     Restore Partial Page Map
                        CH      first page frame
                        CL      number of frames
                        DI:SI   pointer to previously saved page map
                02h     Save And Restore Partial Page Map
                        CH      first page frame
                        CL      number of frames
                        ES:DI   buffer for current page map
                        DI:SI   new page map
                03h     Get Size Of Save Array
                        CH      first page frame
                        CL      number of frames
                return  AL      size of array in bytes
                04h     Switch to Standard Map Register Setting
                05h     Switch to Alternate Map Register Setting
                06h     Deallocate Pages Mapped To Frames in Conventional Mem.
                        CH      first page frame
                        CL      number of frames
return  AH      status
note    Similar to LIM function 4Eh, except that a subrange of pages can be
        specified
```

Expanded Memory Manager Error Codes

EMM error codes are returned in AH after a call to the EMM (int 67h).

code	meaning
00h	function successful
80h	internal error in EMM software (possibly corrupted driver)
81h	hardware malfunction
82h	EMM busy (dropped in EEMS 3.2)
83h	invalid EMM handle
84h	function requested not defined - unknown function code in AH.
85h	no more EMM handles available
86h	error in save or restore of mapping context
87h	more pages requested than exist
88h	allocation request specified more logical pages than currently available in system (request does not exceed actual physical number of pages, but some are already allocated to other handles); no pages allocated
89h	zero pages; cannot be allocated (dropped in EMS 4.0)
8Ah	logical page requested to be mapped outside range of logical pages assigned to handle
8Bh	illegal page number in mapping request (valid numbers are 0 to 3)
8Ch	page-mapping hardware state save area full
8Dh	save of mapping context failed; save area already contains context associated with page handle
8Eh	restore of mapping context failed; save area does not contain context for requested handle
8Fh	subfunction parameter not defined (unknown function)

```
LIM 4.0 extended error codes:
90h     attribute type undefined
91h     warm boot data save not implemented
92h     move overlaps memory
93h     move/exchange larger than allocated region
94h     conventional/expanded regions overlap
95h     logical page offset outside of logical page
96h     region larger than 1 MB
97h     exchange source/destination overlap
98h     source/destination undefined or not supported
99h     (no status assigned)
9Ah     alternate map register sets supported, specified set is not
9Bh     all alternate map & DMA register sets allocated
9Ch     alternate map & DMA register sets not supported
9Dh     alternate map register or DMA set not defined, allocated or is currently
        defined set
9Eh     dedicated DMA channels not supported
9Fh     dedicated DMA channels supported; specified channel is not
0A0h    named handle could not be found
0A1h    handle name already exists
0A2h    move/exchange wraps around 1 MB boundary
0A3h    data structure contains corrupted data
0A4h    access denied
```

11

Conversion Between MSDOS and Foreign Operating Systems

Overview

Software portability is a popular topic in programming texts. In real life, very little software is ported from one system to another, and then normally only by necessity. When software must be portable, it is often written in a proprietary high-level language designed for system portability. InfoCom games and various CAD packages fall into this category.

From time to time the programmer may wish to target his software for a wider base of systems than the one he is currently working with. The usual reason is to broaden the market in which the software will be sold without having to write a specific version for each machine. In other cases it may be necessary to move existing software between machines when a particular machine becomes obsolescent, but there is a heavy investment in software. Many companies have custom or proprietary software (engineering and inventory control are the most usual) which must be ported from such machines.

Programs from many different operating systems may be ported easily to MSDOS. Though single-tasking and single-user, MSDOS provides a rich applications program interface (API) for the programmer. Porting software *from* MSDOS to a foreign OS can frequently be a source of consternation to the programmer, as many functions taken for granted by DOS programmers (nondestructive keyboard read, for example) do not exist in most microcomputer and many mainframe operating systems.

When noncongruent function calls must be used between systems, it is probably best to build a macro library in whatever language is being used and simply pass parameters to it as a data structure. If data from a windowing OS such as AmigaDOS or MacOS is to be ported, use of a windowing shell is more efficient than trying to duplicate all the various functions yourself.

Porting of software depends on 'good' practice, i.e. placing hardware-dependent routines in their own modules or noting such use in the main code.

Special Considerations

When porting from machines using the Motorola 68000 or another processor with a large linear address space (non-segmented architecture) and you should take care that data structures moved from the ST to not exceed the 8088's 64k segment size limit. A program which requires structures larger than 64k could be ported to 80386 machines but the large structures would only be accessible in protected mode and would require switching in and out of protected mode to access the data. The difficulty involved would preclude such a solution unless absolutely necessary. A partial solution would be to port the software to a non-DOS OS having an MSDOS 'window' or emulation mode. Another solution would be to use one of the scientific number-crunching boards such as the MicroWay TransPuter module and pass structures back and forth to it.

If you are writing a program from scratch for multiple-platform operation, it would be wise to check into using a compiler vendor who supports the platforms in question. Some vendors have a wide range of products. For instance:

Borland:	Turbo Pascal	CP/M-80 CP/M-86 MSDOS MacIntosh
Lattice:	C	MSDOS Atari ST Amiga

Some vendors offer similar products to run under Unix, VMS, or OS/2 as well.

One thing MSDOS programmers may find to be eerily different is the way some other operating systems (Unix, for example) perform functions. In MSDOS, operating system functions are accessed by setting various CPU registers to specified values and calling the appropriate CPU interrupt. MSDOS' function dispatcher examines the values in the registers and takes the appropriate action.

'Portable' operating systems such as Unix and many networking systems cannot be certain of having any specific registers of CPU modes available, and thus build 'request packets' or 'call blocks', which are data structures the operating system can interpret, and then calling an interrupt. The OS kernel examines the structure and takes the appropriate action. Systems operating this way are (relatively) easily transported among CPU types and make both multitasking and multiprocessing much easier at the expense of some overhead.

Should it be necessary to do any extensive porting work, I highly recommend Arthur S. Tanenbaum's *'Operating System Design and Implementation'* by Prentice-Hall. Tanenbaum discusses operating systems from philosophy down to actual code and is an invaluable reference for anyone doing low-level OS programming.

Example Operating Systems

Atari ST

The Atari ST's operating system is called TOS, for Tramiel Operating System. TOS is single-user, single-tasking, and almost call-for-call compatible with MSDOS. Typically, the ST runs TOS as a low-level interface for Digital Research's GEM windowing environment.

Applications moved from MSDOS to TOS should require no unusual modifications, though applications moved from the Atari ST to MSDOS would be easiest to port by using GEM on the PC. TOS services are accessible through assembly language by manipulating the CPU registers, as in MSDOS. TOS duplicates the UNIX-style file handling calls of MSDOS but not the 'unsupported' CP/M style FCB calls.

CP/M

When Tim Paterson designed DOS he made it easy to port the CP/M functions to his new operating system. All CP/M-80 calls are duplicated in MSDOS. These are the so-called FCB or File Control Block calls which are now officially discouraged by IBM and Microsoft. Newer handle calls exist for most FCB calls. Porting software from MSDOS to CP/M may be difficult due to the sparseness of system calls and limited (64k address space) CPU resources. CP/M was written in a language called PL/M, but both CP/M and MSDOS were designed for easy use from an assembly-language level.

MacOS

Porting from MSDOS to the Apple MacIntosh OS should require no special handling. Porting from MacOS to MSDOS involves duplicating the massive windowing functions built into MacOS. Microsoft's Windows is a licensee of Apple and would probably be the best choice, though Aldus' PageMaker program uses DRI's GEM. The MacOS was written in Pascal and uses Pascal data structures and calling conventions.

AmigaDOS

AmigaDOS is a Unix variant with a windowing shell. Newer versions have the Bourne shell as an option for their CLI, or Command Line Interface. Most Amiga programs make little or no use of the piping or multitasking structures available under Unix and should not be too difficult to port. The Amiga's windowing and mouse routines are fairly simple and could be duplicated by a set of library routines or Quarterdeck's DesQview could be used, which would also duplicate the multitasking and interprocess data transfer available under AmigaDOS.

OS/2

Most new Microsoft language updates come with OS/2 and DOS variants. Microsoft Windows can duplicate most OS/2 windowing and piping functions if needed. Microsoft provides 'dual mode' libraries for programs to run under either DOS or OS/2. The official Microsoft interface to OS/2's 221 function calls is through the C language.

UNIX

Most versions of Unix appear very much like CP/M from the programmer's stand-point. Unix has memory management and hierarchic directory structures absent in CP/M. Most Unix systems use some sort of paged virtual memory and code generated by some Unix compilers tends to be very large. Should it be necessary to port a large Unix system to DOS, it would probably be best to use Quarterdeck's DesQview API and EEMS or LIM 4.0. Virtually all Unix software is written in C.

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Microsoft Windows A.P.I.

Overview

First released in November 1985, Microsoft Windows was originally designed as a high-level interface for display, sort of like a super-ANSI.SYS driver. An application program running under Windows could write to its output device without knowing or caring if the display was a screen or a printer, or what the resolution of the output device was. Windows also includes graphics primitives for applications, arbitration for multiple programs accessing the screen or devices, and simple program-swapping and memory management capability.

Windows was a grand concept, and worthy of serious consideration. However, Microsoft pre-announced it by almost two years, and when the program finally did ship, it had a number of problems. Microsoft got snarled up in making Windows into a super-goombah pseudo-Macintosh 'operating environment' with enough code overhead to turn a standard AT into a reasonable facsimile of an asthmatic PCjr. It was SLOW. It was a RAM and disk hog, unsuitable for use on small floppy-based machines common at the time. It was expensive, priced four times higher than DOS, and programming in Windows required tools available only in the Windows Development kit, priced at a princely $350 (now $500). And as a final blow, it could not perform its task with normal DOS programs, requiring applications developed specially for Windows.

Later versions of Windows, tailored to the 80286 or 80386 processors, were able to increase the speed and functionality of the program somewhat. Despite the hard sell by some of the programmer types at PC-Magazine and others, Windows has been a dead player since its introduction. Interest in Windows picked up when Microsoft announced that programs running under Windows would be easy to port to the (then as yet unreleased) OS/2 operating system. Interest in Windows died again when OS/2's API turned out to be sufficiently different from Windows to make it about as difficult to port Windows applications as anything else.

Microsoft's original idea of a universal display interface would be very useful in today's world of multiple graphics standards, but few programmers want to haul Windows' overhead around. Microsoft could have made Windows an operating system in its own right, but has chosen not to do so. As part of their latest push, Microsoft has announced it will bundle Windows with MSDOS in the second half of 1989.

Programming Windows

The Windows Application Program Interface (API) is designed to be accessible through the linkable code libraries provided in the Windows Software Development Kit (SDK). The suggested calling conventions are set up for the 'C' programming language.

Windows has its own built-in mouse driver and will ignore any other drivers or mouse control utilities.

Versions

The following versions of Windows have been released:

```
1.0     November 1985, original release
1.03    (common to Zenith and aftermarket packaged products)
2.0     third quarter 1987, overlapping windows, EMS support
286     customized for maximum performance on the 80286 CPU
386     customized for use of the 80386 special instructions
```

Various 'runtime kits' of Windows have been provided for some commercial software packages such as Ami or Ventura Publisher.

Windows 2.0 added increased output performance (claimed up to 400%) for Windows applications, enhanced data exchange support for non-Windows based applications, a new visual interface with overlapping windows (1.x windows could not overlap), support for running multiple applications in expanded memory, a new memory manager to allow efficient use of expanded memory hardware, allowing a single application to be larger than 640Kb, and for the user to switch rapidly between large applications which are running simultaneously.

All versions of Windows are reported to be backward-compatible.

Functions

The following function call listing is for Windows 1.03. Later versions of Windows have enhanced capabilities. All conventions are for the C language.

```
AccessResource
        Sets file pointer for read access to resource hResInfo.
entry   AccessResource()
        AccessResource(hInstance, hResInfo):nFile
        handle  hInstance;
        handle  hResInfo;
return  int (DOS file handle)

AddAtom
        Creates an atom for character string lpString.
entry   AddAtom()
        #undef  NoAtom
        AddAtom(lpString):wAtom
        lpStr   lpString;
return  atom

AddFontResource
        Adds font resource in lpFilename to system font table.
entry   AddFontResource()
        AddFontResource(lpFilename):nFonts
```

```
        lpStr   lpFilename;
return  short

AdjustWindowRect
        Converts client rectangle to a window rectangle.
entry   AdjustWindowRect()
        #undef  NoRect
        AdjustWindowRect(lpRect, lStyle, bMenu)
        lpRect  lpRect;
        long    lStyle;
        Boolean bMenu;
return  void

AllocResource
        Allocates dwSize bytes of memory for resource hResInfo.
entry   AllocResource()
        AllocResource(hInstance, hResInfo, dwSize):hMem
        handle  hInstance;
        handle  hResInfo;
        dword   dwSize;
return  handle

AnsiLower
        Converts character string lpStr to lower-case.
entry   AnsiLower()
        AnsiLower(lpStr):cChar
        lpStr   lpStr;
return  byte

AnsiNext
        Returns long pointer to next character in string lpCurrentChar.
entry   AnsiNext()
        AnsiNext(lpCurrentChar):lpNextChar
        lpStr   lpCurrentChar;
return  lpStr

AnsiPrev
        Returns long pointer to previous character in string lpStart.
        lpCurrentChar points to current character.
entry   AnsiPrev()
        AnsiPrev(lpStart, lpCurrentChar):lpPrevChar
        lpStr   lpStart;
        lpStr   lpCurrentChar;
return  lpStr

AnsiToOem
        Converts ANSI string to OEM character string.
entry   AnsiToOem()
        AnsiToOem(lpAnsiStr, lpOemStr):bTranslated
        lpStr   lpAnsiStr;
        lpStr   lpOemStr;
return  Boolean

AnsiUpper
        Converts character string (or character if lpString high word is zero) to
        uppercase.
entry   AnsiUpper()
        AnsiUpper(lpStr):cChar
        lpStr   lpStr;
return  byte

AnyPopup
        Tells if a pop-up style window is visible on the screen.
entry   AnyPopup()
        AnyPopup():bVisible
return  Boolean

Arc
        Draws arc from X3, Y3 to X4, Y4, using current pen and moving
        counter-clockwise. The arc's centre is at centre of rectangle given by
        X1, Y1 and X2, Y2.
```

```
entry   Arc()
        #undef  NohDC
        Arc(hDC, X1, Y1, X2, Y2, X3, Y3, X4, Y4):BDrawn
        hDC     hDC;
        short   X1;
        short   Y1;
        short   X2;
        short   Y2;
        short   X3;
        short   Y3;
        short   X4;
        short   Y4;
return  Boolean

BeginPaint
        Prepares window for painting, filling structure at lpPaint with
        painting data.
entry   BeginPaint()
        #undef  NoRect
        #undef  NohDC
        BeginPaint(hWnd, lpPaint):hDC
        hWnd    hWnd;
 lpPaintStruct lpPaint;
return  hDC

BitBlt
        Moves bitmap from source device to destination device. Source origin is
        at XSrc, YSrc. X,Y,,nWidth, nHeight give bitmap origin and dimensions on
        destination device. DwRop defines how source and destination bits are
        combined.
entry   BitBlt()
        #undef  NohDC
        BitBlt(hDestDC, X, Y, nWidth, nHeight, hSrcDC, XSrc, YSrc,
              dwRop):bDrawn
        hDC     hDestDC;
        short   X;
        short   Y;
        short   nWidth;
        short   nHeight;
        hDC     hSrcDC;
        short   XSrc;
        short   YSrc;
        dword   dwRop;
return  Boolean

BringWindowToTop
        Brings pop-up or child window to top of stack of overlapping windows.
entry   BringWindowToTop()
        BringWindowToTop(hWnd)
        hWnd    hWnd;
return  void

BuildCommDCB
        Fills device control block lpDCB with control codes named by lpDef.
entry   BuildCommDCB()
        #undef  NoComm
        BuildCommDCB(lpDef, lpDCB):nResult
        lpStr   lpDef;
      DCB FAR * lpDCB;
return  short

CallMsgFilter
        Passes message and code to current message-filter function.
        Message-filter function is set using SetWindowsHook.
entry   CallMsgFilter()
        #undef  NoMsg
        CallMsgFilter(lpMsg, nCode):bResult
        lpMsg   lpMsg;
        int     nCode;
return  Boolean
```

```
CallWindowProc
        Passes message information to the function specified by lpPrevWndFunc.
entry   CallWindowProc()
        #undef  NoWinMessages
        CallWindowProc(lpPrevWndFunc, hWnd, wMsg, wparam, lParam):lReply
        FarProc lpPrevWndFunc;
        hWnd    hWnd;
       unsigned wMsg;
        word    wparam;
        long    lParam;
return  long

Catch
        Copies current execution environment to buffer lpCatchBuf.
entry   Catch()
        Catch(lpCatchBuf):Throwback
     lpCatchBuf lpCatchBuf;
return  int

ChangeClipboardChain
        Removes hWnd from clipboard viewer chain, making hWndNext descendant of
        hWnd's ancestor in the chain.
entry   ChangeClipboardChain()
        #undef  NoClipBoard
        ChangeClipboardChain(hWnd, hWndNext):bRemoved
        hWnd    hWnd;
        hWnd    hWndNext;
return  Boolean

ChangeMenu
        Appends, inserts, deletes, or modifies a menu item in hMenu.
entry   ChangeMenu()
        #undef  NoMenus
        ChangeMenu(hMenu, wlDChangeItem, lpNewItem, wlIDNewItem,
                   wChange):bChanged
        hMenu   hMenu;
        word    wlDChangeItem;
        lpStr   lpNewItem;
        word    wlIDNewItem;
        word    wChange;
return  Boolean

CheckDlgButton
        Places or removes check next to button, or changes state of 3-state
        button.
entry   CheckDlgButton()
        #undef  NoCtlMgr
        CheckDlgButton(hDlg, nIDButton, wCheck)
        hWnd    hDlg;
        int     nIDButton;
        word    wCheck;
return  void

CheckMenuItem
        Places or removes checkmarks next to pop-up menu items in hMenu.
entry   CheckMenuItem()
        #undef  NoMenus
        CheckMenuItem(hMenu, wIDCheckItem, wCheck):bOldCheck
        hMenu   hMenu;
        word    wIDCheckItem;
        word    wCheck;
return  Boolean

CheckRadioButton
        Checks nIDCheckButton and unchecks all other radio buttons in the group
        from nIDFirstButton to nIDLastButton.
entry   CheckRadioButton()
        #undef  NoCtlMgr
        CheckRadioButton(hDlg, nIDFirstButton, nIDLastButton, nIDCheckButton)
        hWnd    hDlg;
        int     nIDFirstButton;
```

```
        int     nIDLastButton;
        int     nIDCheckButton;
return  void

ChildWindowFromPoint
        Determines which, if any, child window of hWndParent contains Point.
entry   ChildWindowFromPoint()
        #undef  NoPoint
        ChildWindowFromPoint(hWndParent, Point):hWndChild
        hWnd    hWndParent;
        point   Point;
return  hWnd

ClearCommBreak
        Clears communication break state from communication device nCid.
entry   ClearCommBreak()
        #undef  NoComm
        ClearCommBreak(nCid):nResult
        short   nCid;
return  short

ClientToScreen
        Converts client coordinates to equivalent screen coordinates in place
entry   ClientToScreen()
        #undef  NoPoint
        ClientToScreen(hWnd, lpPoint)
        hWnd    hWnd;
        lpPoint lpPoint;
return  void

ClipCursor
        Restricts the mouse cursor to a given rectangle on the screen.
entry   ClipCursor()
        #undef  NoRect
        ClipCursor(lpRect)
        lpRect  lpRect;
return  void

CloseClipboard
        Closes the clipboard
entry   CloseClipboard()
        #undef  NoClipBoard
        CloseClipboard():bClosed
return  Boolean

CloseComm
        Closes communication device nCid after transmitting current output buffer.
entry   CloseComm()
        #undef  NoComm
        CloseComm(nCid):nResult
        short   nCid;
return  short

CloseMetaFile
        Closes the metafile and creates a metafile handle.
entry   CloseMetaFile()
        CloseMetaFile(hDC):hMF
        handle  hDC;
return  handle

CloseSound
        Closes play device after flushing voice queues and freeing buffers.
entry   CloseSound()
        #undef  NoSound
        CloseSound()
return  int

CloseWindow
        Closes the specified window.
entry   CloseWindow()
        CloseWindow(hWnd):nClosed
```

```
        hWnd    hWnd;
return  int

CombineRgn
        Combines, using nCombineMode, two existing regions into a new region.
entry   CombineRgn()
        #undef  NoRegion
        CombineRgn(hDestRgn, hSrcRgn1, hSrcRgn2, nCombineMode):RgnType
        hRgn    hDestRgn;
        hRgn    hSrcRgn1;
        hRgn    hSrcRgn2;
        short   nCombineMode;
return  short

CopyMetaFile
        Copies source metafile to lpFilename and returns the new metafile.
entry   CopyMetaFile()
        CopyMetaFile(hSrcMetaFile, lpFilename):hMF
        handle  hSrcMetaFile;
        lpStr   lpFilename;
return  handle

CopyRect
        Makes a copy of an existing rectangle.
entry   CopyRect()
        #undef  NoRect
        CopyRect(lpDestRect, lpSourceRect)
        lpRect  lpDestRect;
        lpRect  lpSourceRect;
return  int

CountClipboardFormats
        Retrieves a count of the number of formats the clipboard can render.
entry   CountClipboardFormats()
        #undef  NoClipboard
        CountClipboardFormats():nCount
return  int

CountVoiceNotes
        Returns number of notes in voice queue nVoice.
entry   CountVoiceNotes()
        #undef  NoSound
        CountVoiceNotes(nVoice):nNotes
        int     nVoice;
return  int

CreateBitmap
        Creates a bitmap having the specified width, height, and bit pattern.
entry   CreateBitmap()
        #undef  NoBitmap
        CreateBitmap(nWidth, nHeight, cPlanes, cBitCount, lpBits):hBitmap
        short   nWidth;
        short   nHeight;
        byte    cPlanes;
        byte    cBitCount;
        lpStr   lpBits;
return  hBitmap

CreateBitmapIndirect
        Creates a bitmap with the width, height, and bit pattern given by
        lpBitmap.
entry   CreateBitmapIndirect()
        #undef  NoBitmap
        CreateBitmapIndirect(lpBitmap):hBitmap
   Bitmap FAR * lpBitmap;
return  hBitmap

CreateBrushIndirect
        Creates a logical brush with the style, colour, and pattern given by
        lpLogBrush.
entry   CreateBrushIndirect()
```

```
        #undef  NoGDI
        #undef  NoBrush
        CreateBrushIndirect(lpLogBrush):hBrush
 LogBrush FAR * lpLogBrush;
return  hBrush

CreateCaret
        Creates caret or hWnd using hBitmap. If hBitmmap is NULL, creates solid
        flashing black block nWidth by nHeight pixels; if hBitmap is 1, caret is
        grey.
entry   CreateCaret()
        #undef  NoBitmap
        CreateCaret(hWnd, hBitmap, nWidth, nHeight)
        hWnd    hWnd;
        hBitmap hBitmap;
        int     nWidth;
        int     nHeight;
return  void

CreateCompatibleBitmap
        Creates a bitmap that is compatible with the device specified by hDC.
entry   CreateCompatibleBitmap()
        #undef  NoHDC
        #undef  NoBitmap
        CreateCompatibleBitmap(hDC, nWidth, mnHeight):hBitmap
        hDC     hDC;
        short   nWidth;
        short   mnHeight;
return  hBitmap

CreateCompatibleDC
        Creates a memory display context compatible with the device specified by
        hDC.
entry   CreateCompatibleDC()
        #undef  NoHdc
        CreateCompatibleDC(hDC):hMemDC
        hDC     hDC;
return  hDC

CreateDC
        Creates a display context for the specified device.
entry   CreateDC()
        #undef  NohDC
        CreateDC(lpDriverName, lpDeviceName, lpOutput, lpInitData):hDC
        lpStr   lpDriverName;
        lpStr   lpDeviceName;
        lpStr   lpOutput;
        lpStr   lpInitData;
return  hDC

CreateDialog
        Creates a modeless dialogue box.
entry   CreateDialog()
        #undef  NoCtlmgr
        CreateDialog(hInstance, lpTemplateName, hWndParent,
        lpDialogFunc):hDlg
        handle  hInstance;
        lpStr   lpTemplateName;
        hWnd    hWndParent;
        farproc lpDialogFunc;
return  hWND

CreateDiscardableBitmap
        Creates a discardable bitmap.
entry   CreateDiscardableBitmap()
        #undef  NohDC
        #undef  NoBitmap
        CreateDiscardableBitmap(hDC, X, Y):hBitmap
        hDC     hDC;
        short   X;
        short   Y;
```

```
return  hBitmap

CreateEllipticRgn
        Creates an elliptical region whose bounding rectangle is defined by X1,
        Y1, X2, and Y2.
entry   CreateEllipticRgn()
        #undef  NoRegion
        CreateEllipticRgn(X1, Y1, X2, Y2):hRgn
        short   X1;
        short   Y1;
        short   X2;
        short   Y2;
return  hRgn

CreateEllipticRgnIndirect
        Creates an elliptical region whose bounding rectangle is given by lpRect.
entry   CreateEllipticRgnIndirect()
        #undef  NoRect
        #undef  NoRegion
        CreateEllipticRgnIndirect(lpRect):hRgn
        lpRect  lpRect;
return  hRGN

CreateFont
        Creates a logical font having the specified characteristics.
entry   CreateFont()
        #undef  NoFont
        CreateFont(nheight, nWidth, nEscapement, nOrientation, nWeight,
        cItalic, cUnderline, cStrikeOut, nCharSet, cOutputPrecision,
        cClipPrecision, cQuality, cPitchAndFamily, lpFacename):hFont
        short   nheight;
        short   nWidth;
        short   nEscapement;
        short   nOrientation;
        short   nWeight;
        byte    cItalic;
        byte    cUnderline;
        byte    cStrikeOut;
        byte    nCharSet;
        byte    cOutputPrecision;
        byte    cClipPrecision;
        byte    cQuality;
        byte    cPitchAndFamily;
        lpStr   lpFacename;
return  hFont

CreateFontIndirect
        Creates a logical font with characteristics given by lpLogFont.
entry   CreateFontIndirect()
        #undef  NoGDI
        #undef  NoFont
        CreateFontIndirect(lpLogFont):hFont
  LogFont FAR * lpLogFont;
return  hFont

CreateHatchBrush
        Creates a logical brush having the specified hatched pattern and colour.
entry   CreateHatchBrush()
        #undef  NoBrush
        CreateHatchBrush(nIndex, rgbColor):Brush
        short   nIndex;
        dword   rgbColor;
return  hBrush

CreateIC
        Creates an information context for the specified device.
entry   CreateIC()
        #undef  NohDC
        CreateIC(lpDriverName, lpDeviceName, lpOutput, lpInitData):hIC
        lpStr   lpDriverName;
        lpStr   lpDeviceName;
```

```
        lpStr   lpOutput;
        lpStr   lpInitData;
return  hDC

CreateMenu
        Creates an empty menu.
entry   CreateMenu()
        #undef  NoMenus
        CreateMenu():hMenu
return  hMenu

CreateMetaFile
        Creates a metafile display context.
entry   CreateMetaFile()
        CreateMetaFile(lpFilename):hDC
        lpStr   lpFilename;
return  handle

CreatePatternBrush
        Creates a logical brush having the pattern specified by hBitmap.
entry   CreatePatternBrush()
        #undef  NoBitmap
        #undef  NoBrush
        CreatePatternBrush(hBitmap):hBrush
        hBitmap hBitmap;
return  hBrush

CreatePen
        Creates a logical pen having the specified style, width, and colour.
entry   CreatePen()
        #undef  nOpen
        CreatePen(nPenStyle, nWidth, rgbColor):hPen
        short   nPenStyle;
        short   nWidth;
        dword   rgbColor;
return  hPen

CreatePenIndirect
        Creates a logical pen with the style, width, and colour given by lpLogPen.
entry   CreatePenIndirect()
        #undef  nOpen
        CreatePenIndirect(lpLogPen):hPen
   LogPen FAR * lpLogPen;
return  hPen

CreatePolygonRgn
        Creates a polygon region having nCount vertices as given by lpPoints.
entry   CreatePolygonRgn()
        #undef  NoPoint
        #undef  NoRegion
        CreatePolygonRgn(lpPoints, nCount, nPolyFillMode):hRgn
        lpPoint lpPoints;
        short   nCount;
        short   nPolyFillMode;
return  hRgn

CreateRectRgn
        Creates a rectangular region.
entry   CreateRectRgn()
        #undef  NoRegion
        CreateRectRgn(X1, Y1, X2, Y2):hRgn
        short   X1;
        short   Y1;
        short   X2;
        short   Y2;
return  hRgn

CreateRectRgnIndirect
        Creates a rectangular region with the dimensions given by lpRect.
entry   CreateRectRgnIndirect()
        #undef  NoRect
```

```
        #undef  NoRegion
        CreatRectRgnIndirect(lpRect):hRgn
        lpRect  lpRect;
return  hRgn

CreateSolidBrush
        Creates a logical brush having the specified solid colour.
entry   CreateSolidBrush()
        #undef  NoBrush
        CreateSolidBrush(rgbColor):hBrush
        dword   rgbColor;
return  hBrush

CreateWindow
        Creates tiled, pop-up, and child windows.
entry   CreateWindow()
        CreateWindow(lpClassName, lpWindowName, dwStyle, X,Y,nWidth, nHeight,
                hWndParent, hMenu, hInstance, lpParam):hWnd
        lpStr   lpClassName;
        lpStr   lpWindowName;
        dword   dwStyle;
        int     X;
        int     Y;
        int     nWidth;
        int     nHeight;
        hWnd    hWndParent;
        hMenu   hMenu;
        handle  hInstance;
        lpStr   lpParam;
return  hWnd

DefWindowProc
        Provides default processing for messages an application chooses not to
        process.
entry   DefWindowProc()
        #undef  NoWinMessages
        DefWindowProc(hWnd, wMsg, wParam, lParam):lReply
        hWnd    hWnd;
        unsigned wMsg;
        word    wParam;
        long    lParam;
return  long

DeleteAtom
        Deletes an atom nAtom if its reference count is zero.
entry   DeleteAtom()
        #undef  NoAtom
        DeleteAtom(nAtom):nOldAtom
        atom    nAtom;
return  atom

DeleteDC
        Deletes the specified display context.
entry   DeleteDC()
        #undef  NohDC
        DeleteDC(hDC):bDeleted
        hDC     hDC;
return  Boolean

DeleteMetaFile
        Deletes access to a metafile by freeing the associated system resources
entry   DeleteMetaFile()
        DeleteMetaFile(hMF):bFreed
        handle  hMF;
return  Boolean

DeleteObject
        Deletes the logical pen, brush, font, bitmap, or region by freeing all
        associated system storage.
entry   DeleteObject()
        DeleteObject(hObject):bDeleted
```

```
        handle  hObject;
return  Boolean

DestroyCaret
        Destroys the current caret and frees any memory it occupied.
entry   DestroyCaret()
        DestroyCaret()
        hWnd    hWnd;
return  int

CombineRgn
        Combines, using nCombineMode, two existing regions into a new region.
entry   CombineRgn()
        #undef  NoRegion
        CombineRgn(hDestRgn, hSrcRgn1, hSrcRgn2, nCombineMode):RgnType
        hRgn    hDestRgn;
        hRgn    hSrcRgn1;
        hRgn    hSrcRgn2;
        short   nCombineMode;
return  short

CopyMetaFile
        Copies source metafile to lpFilename and returns the new metafile.
entry   CopyMetaFile()
        CopyMetaFile(hSrcMetaFile, lpFilename):hMF
        handle  hSrcMetaFile;
        lpStr   lpFilename;
return  handle

CopyRect
        Makes a copy of an existing rectangle.
entry   CopyRect()
        #undef  NoRect
        CopyRect(lpDestRect, lpSourceRect)
        lpRect  lpDestRect;
        lpRect  lpSourceRect;
return  int

CountClipboardFormats
        Retrieves a count of the number of formats the clipboard can render.
entry   CountClipboardFormats()
        #undef  NoClipboard
        CountClipboardFormats():nCount
return  void

DestroyMenu
        Destroys the menu specified by hMenu and frees any memory it occupied.
entry   DestroyMenu()
        #undef  NoMenus
        DetroyMenu(hMenu):bDestroyed
        hMenu   hMenu;
return  Boolean

DestroyWindow
        Sends a WM_DESTROY message to hWnd and frees any memory it occupied.
entry   DestroyWindow()
        DestroyWindow(hWnd):bDestroyed
        hWnd    hWnd;
return  Boolean

DeviceModes
        Displays a dialogue box that prompts user to set printer modes.
entry   DeviceModes()
        DeviceModes(hWnd, hItem, lpString, lpString):lpString
        hWnd    hWnd;
        handle  hItem;
        lpStr   lpString;
        lpStr   lpString;
return  lpStr
```

```
DialogBox
        Creates a modal dialogue box.
entry   DialogBox()
        #undef  NoCtlMgr
        DialogBox(hInstance, lpTemplateName, hWndParent,
        lpDialogFuncc):nResult
        handle  hInstance;
        lpStr   lpTemplateName;
        hWnd    hWndParent;
        FarProc lpDialogFuncc;
return  int

DispatchMessage
        Passes message to window function of window specified in MSG structure.
entry   DispatchMessage()
        #undef  NoMsg
        DispatchMessage(lpMsg):lResult
        lpMsg   lpMsg;
return  long

DlgDirList
        Fills nIDListBox with names of files matching path specification.
entry   DlgDirList()
        #undef  NoCtlMgr
        #undef  NoCtlMgr
        DlgDirList(hDlg, lpPathSpec, nIDListBox, nIDStaticPath,
                   wFiletype):nListed
        hWnd    hDlg;
        lpStr   lpPathSpec;
        int     nIDListBox;
        int     nIDStaticPath;
       unsigned wFiletype;
return  int

DlgDirSelect
        Copies current selection from nIDListBox to lpString.
entry   DlgDirSelect()
        #undef  NoCtlMgr
        #undef  NoCtlMgr
        DlgDirSelect(hDlg, lpString, nIDListBox):bDirectory
        hWnd    hDlg;
        lpStr   lpString;
        int     nIDListBox;
return  Boolean

DPtoLP
        Converts into logical points the nCount device points given by lpPoints
entry   DPtoLP()
        #undef  NoPoint
        #undef  NohDC
        DPtoLP(hDC, lpPoints, nCount):bConverted
        hDC     hDC;
        lpPoint lpPoints;
        short   nCount;
return  Boolean

DrawIcon
        Draws an icon with its upper left corner at X, Y.
entry   DrawIcon()
        #undef  NohDC
        #undef  NoDrawText
        DrawIcon(hDC, X, Y, hIcon):bDrawn
        hDC     hDC;
        int     X;
        int     Y;
        hIcon   hIcon;
return  Boolean

DrawMenuBar
        Redraws the menu bar.
entry   DrawMenuBar()
```

```
        #undef   NoMenus
        DrawMenuBar(hWnd)
        hWnd     hWnd;
return  void

DrawText
        Draws nCount characters of lpString in format specified by wFormat, using
        current text and background colours. Clips output to rectangle given by
        lpRect.
entry   DrawText()
        #undef   NoRect
        #undef   NohDC
        #undef   NoDrawText
        DrawText(hDC, lpString, nCount, lpRect, wFormat)
        hDC      hDC;
        lpStr    lpString;
        int      nCount;
        lpRect   lpRect;
        word     wFormat;
return  void

Ellipse
        Draws ellipse with centre at the centre of the given bounding rectangle.
        Draws border with current pen. Fills interior with current brush.
entry   Ellipse()
        #undef   NohDC
        Ellipse(hDC, X1, Y1, X2, Y2):bDrawn
        hDC      hDC;
        short    X1;
        short    Y1;
        short    X2;
        short    Y2;
return  Boolean

EmptyClipboard
        Empties clipboard, frees data handles, and assigns clipboard ownership to
        the window that currently has the clipboard open.
entry   EmptyClipboard()
        #undef   NoClipBoard
        EmptyClipboard():bEmptied
return  Boolean

EnableMenuItem
        Enables, disables, or greys a menu item, depending on wEnable.
entry   EnableMenuItem()
        #undef   NoMenus
        EnableMenuItem(hMenu, wIDEnableItem, wEnable):bEnabled
        hMenu    hMenu;
        word     wIDEnableItem;
        word     wEnable;
return  Boolean

EnableWindow
        Enables and disables mouse and keyboard input to the specified window.
entry   EnableWindow()
        EnableWindow(hWnd, bEnable):bDone
        hWnd     hWnd;
        Boolean bEnable;
return  Boolean

EndDialog
        Frees resources and destroys windows associated with a modal dialogue box.
entry   EndDialog()
        #undef   NoCtlMgr
        EndDialog(hDlg, nResult)
        hWnd     hDlg;
        int      nResult;
return  void

EndPaint
        Marks the end of window repainting; required after each BeginPaint call.
```

```
entry   EndPaint()
        #undef  NoRect
        #undef  NohDC
        EndPaint(hWnd, lpPaint)
        hWnd    hWnd;
  lpPaintStruct lpPaint;
return  void

EnumChildWindows
        Enumerates the child style windows belonging to hWndParent by passing
        each child window handle and lParam to the lpEnumFunc function.
entry   EnumChildWindows()
        EnumChildWindows(hWndParent, lpEnumFunc, lParam):bDone
        hWnd    hWndParent;
        FarProc lpEnumFunc;
        long    lParam;
return  Boolean

EnumClipboardFormats
        Enumerates formats from list of available formats belonging to the
        clipboard.
entry   EnumClipboardFormats()
        #undef  NoClipBoard
        EnumClipboardFormats(wFormats):wNextFormat
        word    wFormats;
return  word

EnumFonts
        Enumerates fonts available on a given device, passing font information
         through lpData to lpFontFunc function.
entry   EnumFonts()
        #undef  NohDC
        EnumFonts(hDC, lpFacenname, lpFontfunc, lpData):nResult
        hDC     hDC;
        lpStr   lpFacenname;
        FarProc lpFontfunc;
        lpStr   lpData;
return  short

EnumObjects
        Enumerates pens or brushes (depending on nObjectType) available on a
        device, passing object information through lpData to lpObjectFunc
        function.
entry   EnumObjects()
        #undef  NohDC
        EnumObjects(hDC, nObjectType, lpObjectFunc, lpData):nResult
        hDC     hDC;
        short   nObjectType;
        FarProc lpObjectFunc;
        lpStr   lpData;
return  short

EnumProps
        Passes each property of hWnd, in turn, to the lpEnumFunc function
entry   EnumProps()
        EnumProps(hWnd, lpEnumFunc):nResult
        hWnd    hWnd;
        FarProc lpEnumFunc;
return  int

EnumWindows
        Enumerates windows on the screen by passing handle of each tiled, iconic,
        pop-up, and hidden pop-up window (in that order) to the lpEnumFunc
        function.
entry   EnumWindows()
        EnumWindows(lpEnumFunc, lParam):bDone
        FarProc lpEnumFunc;
        long    lParam;
return  Boolean
```

```
EqualRgn
        Checks the two given regions to determine if they are identical.
entry   EqualRgn()
        #undef  NoRegion
        EqualRgn(hSrc1, hSrcRgn2):bEqual
        hRgn    hSrc1;
        hRgn    hSrcRgn2;
return  Boolean

Escape
        Accesses device facilities not directly available through GDI.
entry   Escape()
        #undef  NohDC
        Escape(hDC, nEscape, nCount, lpInData, lpOutData):nResult
        hDC     hDC;
        short   nEscape;
        short   nCount;
        lpStr   lpInData;
        lpStr   lpOutData;
return  short

Escape - AbortDoc
        Aborts the current job. lpInData, lpOutData, and nCount are not used.
entry   Escape()
        #undef  NohDC
        Escape(hDC, AbortDoc, nCount, lpInData, OutData):nResult
        hDC     hDC;
        short   AbortDoc;
        short   nCount;
        lpStr   lpInData;
        lpStr   OutData;
return  short

Escape - DraftMode
        Turns draft mode off or on. lpInData points to 1 (on) or 0 (off).
        nCount is number of bytes at lpInData. lpOutData is not used.
entry   Escape()
        #undef  NohDC
        Escape(hDC, DraftMode, nCount, lpInData, lpOutData);nResult
        hDC     hDC;
        short   DraftMode;
        short   nCount;
        lpStr   lpInData;
        lpStr   lpOutData;
return  short

Escape - EndDoc
        Ends print job started by StartDoc. nCount, lpInData, lpOutData are not
        used.
entry   Escape()
        #undef  NohDC
        Escape(hDC, EndDoc, nCount, lpInData, lpOutData):nResult
        hDC     hDC;
        short   ENDDOC;
        short   nCount;
        lpStr   lpInData;
        lpStr   lpOutData;
return  short

Escape - FlushOutput
        Flushes output in device buffer; lpInData, lpOutData, and nCount are not
        used.
entry   Escape()
        #undef  NohDC
        Escape(hDC, FlushOutput, nCount, lpInData, lpOutData):nResult
        hDC     hDC;
        short   FlushOutput;
        short   nCount;
        lpStr   lpInData;
        lpStr   lpOutData;
return  short
```

```
Escape - GetColourTable
       Copies RGB colour table entry to lpOutData. lpInData is colour table
       index. nCount is not used.
entry  Escape()
       #undef  NohDC
       Escape(hDC, GetColourTable, nCount, lpInData, lpOutData):nResult
       HDC     hDC;
       short   GetColourTable;
       short   nCount;
       lpStr   lpInData;
       lpStr   lpOutData;
return short

Escape - GetPhysPageSize
       Copies physical page size to POINT structure at lpOutData. lpInData and
       nCount are not used.
entry  Escape()
       #undef  NohDC
       Escape(hDC, GetPhysPageSize, nCount, lpInData, lpOutData);nResult
       hDC     hDC;
       short   GetPhysPageSize;
       short   nCount;
       lpStr   lpInData;
       lpStr   lpOutData;
return short

Escape - GetPrintingOffset
       Copies printing offset to POINT structure at lpOutData. lpInData and
       nCount are not used.
entry  Escape()
       #undef  NohDC
       Escape(hDC, GetPrintingOffset, nCount, lpInData,
       lpOutData):nResult
       HDC     hDC;
       short   GetPrintingOffset;
       short   nCount;
       lpStr   lpInData;
       lpStr   lpOutData;
return short

Escape - GetScalingFactor
       Copies scaling factors to POINT structure at lpOUtData. lpInData and
       nCount are not used.
entry  Escape()
       #undef  NohDC
       Escape(hDC, GetScalingFactor, nCount, lpInData, lpOutData):nResult
       hDC     hDC;
       short   GetScalingFactor;
       short   nCount;
       lpStr   lpInData;
       lpStr   lpOutData;
return short

Escape - NewFrame
       Ends writing to a page. nCount, lpInData and lpOutData are not used.
entry  Escape()
       #undef  NohDC
       Escape(hDC, NewFrame, nCount, lpInData, lpOutData):nResult
       hDC     hDC;
       short   NewFrame;
       short   nCount;
       lpStr   lpInData;
       lpStr   lpOutData;
return short

Escape - NextBand
       Ends writing to a band. lpOutData gives rectangle to hold device
       coordinates of next band. nCount and lpInData are not used.
entry  Escape()
       #undef  NohDC
       Escape(hDC, NextBand, nCount, lpInData, lpOutData):nResult
```

```
        hDC      hDC;
        short    NextBand;
        short    nCount;
        lpStr    lpInData;
        lpStr    lpOutData;
return  short

Escape - QueryEcSupport
        Tests whether an escape is supported by device driver. lpInData points to
        the escape. nCount is the number of bytes at lpInData. lpOutData is not
        used.
entry   Escape()
        #undef  NohDC
        Escape(hDC, QueryEcSupport, nCount, lpInData, lpOutData):nResult
        hDC      hDC;
        short    QueryEcSupport;
        short    nCount;
        lpStr    lpInData;
        lpStr    lpOutData;
return  short

Escape - SetAbortProc
        Sets abort function for print job. lpInData, lpOutData, and nCount are
        not used.
entry   Escape()
        #undef  NohDC
        Escape(hDC, SetAbortProc, nCount, lpInData, lpOutData):nResult
        hDC      hDC;
        short    SetAbortProc;
        short    nCount;
        lpStr    lpInData;
        lpStr    lpOutData;
return  short

Escape - SetColourTable
        Sets RGB colour table entry. lpInData points to table index and colour.
        lpOutData points to RGB colour value to be set by device driver. nCount
        is not used.
entry   Escape()
        #undef  NohDC
        Escape(hDC, SetColourTable, nCount, lpInData, lpOutData):nResult
        hDC      hDC;
        short    SetColourTable;
        short    nCount;
        lpStr    lpInData;
        lpStr    lpOutData;
return  short

Escape - StartDoc
        Starts print job, spooling NewFrame calls under same job until it
        reaches ENDDOC. lpInData is name of document; nCount is its
        length. lpOutData not used.
entry   Escape()
        #undef  NohDC
        Escape(hDC, StartDoc, nCount, lpInData, OutData):nResult
        hDC      hDC;
        short    StartDoc;
        short    nCount;
        lpStr    lpInData;
        lpStr    OutData;
return  short

EscapeCommFunction
        Executes escape function nFunc for communication device nCid.
entry   EscapeCommFunction()
        #undef  NoComm
        EscapeCommFunction(nCid, nFunc):nResult
        short    nCid;
        int      nFunc;
return  short
```

```
ExcludeClipRect
        Creates new clipping region from existing clipping region less the given
        rectangle.
entry   ExcludeClipRect()
        #undef  NohDC
        ExcludeClipRect(hDC, X1, Y1, X2, Y2):nRgnType
        hDC     hDC;
        short   X1;
        short   Y1;
        short   X2;
        short   Y2;
return  short

FatalExit
        Halts Windows and prompts through auxiliary port (AUX) for instructions
        on how to proceed.
entry   FatalExit()
        FatalExit(Code):Result
        int     Code;
return  void

FillRect
        Fills given rectangle using the specified brush.
entry   FillRect()
        #undef  NoBrush
        #undef  NohDC
        #undef  NoRect
        FillRect(hDC, lpRect, hBrush):nResult
        hDC     hDC;
        LPRECT  lpRect;
        HBRUSH  hBrush;
return  int

FillRgn
        Fills given region with brush specified by hBrush.
entry   FillRgn()
        #undef  NoBrush
        #undef  NohDC
        #undef  NoRegion
        FillRgn(hDC, hRgn, hBrush):bFilled
        hDC     hDC;
        hRgn    hRgn;
        hBrush  hBrush;
return  Boolean

FindAtom
        Retrieves atom (if any) associated with character string lpString.
entry   FindAtom()
        #undef  NoAtom
        FindAtom(lpString):wAtom
        lpStr   lpString;
return  atom

FindResource
        Locates resource lpname having lpType and returns handle for accessing
        and loading the resource.
entry   FindResource()
        FindResource(hInstance, lpname, lpType):hResInfo
        handle  hInstance;
        lpStr   lpname;
        lpStr   lpType;
return  handle

FindWindow
        Returns the handle of the window having the given class and caption.
entry   FindWindow()
        FindWindow(lpClassName, lpWindowname):hWnd
        lpStr   lpClassName;
        lpStr   lpWindowname;
return  hWnd
```

```
FlashWindow
        Flashes the given window once by inverting its active/inactive state.
entry   FlashWindow()
        FlashWindow(hWnd, bInvert):bInverted
        hWnd    hWnd;
        Boolean    bInvert;
return  Boolean

FloodFill
        Fills area of the display surface with current brush, starting at X, Y,
        and continuing in all directions to the boundaries with the given
        rgbColour.
entry   FloodFill()
        #undef  NohDC
        FloodFill(hDC, X, Y, rgbColour):bFilled
        hDC     hDC;
        short   X;
        short   Y;
        dword   rgbColour;
return  Boolean

FlushComm
        Flushes characters from nQueue of communication device nCid.
entry   FlushComm()
        #undef  NoComm
        FlushComm(nCid, nQueue):nResult
        short   nCid;
        int     nQueue;
return  short

FrameRect
        Draws border for the given rectangle using the specified brush.
entry   FrameRect()
        #undef  NoBrush
        #undef  NohDC
        #undef  NoRect
        FrameRect(hDC, lpRect, hBrush):nResult
        hDC     hDC;
        lpRect  lpRect;
        hBrush  hBrush;
return  int

FrameRgn
        Draws border for given region using hBrush. nWidth is width of vertical
        brush strokes. nHeight is height of horizontal strokes.
entry   FrameRgn()
        #undef  NoBrush
        #undef  NohDC
        #undef  NoRegion
        FrameRgn(hDC, hRgn, hBrush, nWidth, nHeight):bFramed
        hDC     hDC;
        hRgn    hRgn;
        hBrush  hBrush;
        short   nWidth;
        short   nHeight;
return  Boolean

FreeLibrary
        Removes library module hLibModule from memory if reference count is zero.
entry   FreeLibrary()
        FreeLibrary(hLibModule)
        handle  hLibModule;
return  handle

FreeProcInstance
        Removes the function instance entry at address lpProc.
entry   FreeProcInstance()
        FreeProcInstance(lpProc)
        FarProc lpProc;
return  void
```

```
FreeResource
        Removes resource hResInfo from memory if reference count is zero.
entry   FreeResource()
        FreeResource(hResData):bFreed
        handle  hResData;
return  Boolean         Returns handle to the active window.

GetActiveWindow
entry   GetActiveWindow()
        GetActiveWindow():hWnd
return  hWnd

GetAtomHandle
        Returns the handle (relative to the local heap) of the atom string.
entry   GetAtomHandle()
        #undef  NoAtom
        GetAtomHandle(wAtom):hMem
        atom    wAtom;
return  handle

GetAtomName
        Copies character string (up to nSize characters) associated with wAtom to
        lpBuffer.
entry   GetAtomName()
        #undef  NoAtom
        GetAtomName(wAtom, lpBuffer, nSize):nLength
        atom    wAtom;
        lpStr   lpBuffer;
        int     nSize;
return  word

GetBitmapBits
        Copies lCount bits of specified bitmap into buffer pointed to by lpBits.
entry   GetBitmapBits()
        #undef  NoBitmap
        GetBitmapBits(hBitmap, lCount, lpBits):lcopied
        hBitmap hBitmap;
        long    lCount;
        lpStr   lpBits;
return  long

GetBitmapDimension
        Returns the width and height of the bitmap specified by hBitmap.
entry   GetBitmapDimension()
        #undef  NoBitmap
        GetBitmapDimension(hBitmap):ptDimensions
        hBitmap hBitmap;
return  dword

GetBkColour
        Returns the current background colour of the specified device.
entry   GetBkColour()
        #undef  NohDC
        GetBkColour(hDC):rgbColour
        hDC     hDC;
return  dword

GetBkMode
        Returns the background mode of the specified device.
entry   GetBkMode()
        #undef  NohDC
        GetBkMode(hDC):BkMode
        hDC     hDC;
return  short

GetBrushOrg
        Retrieves the current brush origin for the given display context.
entry   GetBrushOrg()
        #undef  NoBrush
        GetBrushOrg(hDC):dwOrigin
        hDC     hDC;
```

```
return  dword

GetBValue
        Retrieves the blue value of the given colour.
entry   GetBValue()
        GetBValue(rgbColour):cBlue

GetCaretBlinkTime
        Returns the current caret flash rate.
entry   GetCaretBlinkTime()
        GetCaretBlinkTime():wMSeconds
return  word

GetClassLong
        Retrieves information at nIndex in the WNDCLASS structure.
entry   GetClassLong()
        #undef  NoWinOffsets
        GetClassLong(hWnd, nIndex):long
        hWnd    hWnd;
        int     nIndex;
return  LONG

GetClassName
        Copies hWnd's class name (up to nMaxCount characters) into lpClassName.
entry   GetClassName()
        GetClassName(hWnd, nClassName, nMaxCount):nCopied
        hWnd    hWnd;
        lpStr   nClassName;
        int     nMaxCount;
return  int

GetClassWord
        Retrieves information at nIndex in the WNDCLASS structure.
entry   GetClassWord()
        #undef  NoWinOffsets
        GetClassWord(hWnd, nIndex):word
        hWnd    hWnd;
        int     nIndex;
return  word

GetClientRect
        Copies client coordinates of the window client area to lpRect.
entry   GetClientRect()
        #undef  NoRect
        GetClientRect(hWnd, lpRect)
        hWnd    hWnd;
        lpRect  lpRect;
return  void

GetClipboardData
        Retrieves data from the clipboard in the format given by wFormat.
entry   GetClipboardData()
        #undef  NoClipboard
        GetClipboardData(wFormat):hClipData
        word    wFormat;
return  handle

GetClipboardFormatName
        Copies wFormat's format name (up to nMaxCount characters) into
        lpFormatName.
entry   GetClipboardFormatName()
        #undef  NoClipboard
        GetClipboardFormatName(wFormat, lpFormatName, nMaxCount):nCopied
        word    wFormat;
        lpStr   lpFormatName;
        int     nMaxCount;
return  int

GetClipboardOwner
        Retrieves the window handle of the current owner of the clipboard.
entry   GetClipboardOwner()
```

```
        #undef  NoClipboard
        GetClipboardOwner():hWnd
return  hWnd

GetClipboardViewer
        Retrieves the window handle of the first window in the clipboard viewer
        chain.
entry   GetClipboardViewer()
        #undef  NoClipboard
        GetClipboardViewer():hWnd
return  hWnd

GetClipBox
        Copies dimensions of bounding rectangle of current clip boundary to
        lpRect.
entry   GetClipBox()
        #undef  NoRect
        #undef  NohDC
        GetClipBox(hDC, lpRect):nRgnType
        hDC     hDC;
        lpRect  lpRect;
return  short

GetCodeHandle
        Retrieves the handle of the code segment containing the given function.
entry   GetCodeHandle()
        GetCodeHandle(lpFunc):hInstance
        FarProc  lpFunc;
return  handle

GetCommError
        Fills buffer lpStat with communication status of device nCid. Returns
        error code, if any.
entry   GetCommError()
        #undef  NoComm
        GetCommError(nCid, lpStat):nError
        short   nCid;
 ComStat FAR * lpStat;
return  short

GetCommEventMask
        Fills buffer lpStat with communication status of device nCid. Returns
        error code, if any.
entry   GetCommEventMask()
        #undef  NoComm
        GetCommEventMask(nCid, lpStat):nError
        short   nCid;
        int     lpStat;
return  word

GetCommState
        Fills buffer lpDCB with the device control block of communication
        device nCid.
entry   GetCommState()
        #undef  NoComm
        GetCommState(nCid, lpDCB):nResult
        short   nCid;
      DCB FAR * lpDCB;
return  short

GetCurrentPosition
        Retrieves the logical coordinates of the current position.
entry   GetCurrentPosition()
        #undef  NohDC
        GetCurrent Position(hDC):ptPos
        hDC     hDC;
return  dword

GetCurrentTask
        Returns task handle of the current task.
entry   GetCurrentTask()
```

```
        GetCurrentTask():hTask
return  handle

GetCurrentTime
        Returns the time elapsed since the system was booted to the current time.
entry   GetCurrentTime()
        GetCurrentTime():lTime
return  long

GetCursorPos
        Stores mouse cursor position, in screen coordinates, in POINT structure.
entry   GetCursorPos()
        #undef  NoPoint
        GetCursorPos(lpPoint)
        lpPoinT lpPoint;
return  void

GetDC
        Retrieves the display context for the client area of the specified window.
entry   GetDC()
        #undef  NohDC
        GetDC(hWnd):hDC
        hWnd    hWnd;
return  hDC

GetDeviceCaps
        Retrieves the device-specific information specified by nIndex.
entry   GetDeviceCaps()
        #undef  NohDC
        GetDeviceCaps(hDC, nIndex):nValue
        hDC     hDC;
        short   nIndex;
return  short

GetDlgItem
        Retrieves the handle of a dialogue item (control) from the given dialogue
        box.
entry   GetDlgItem()
        #undef  NoCtlMgr
        GetDlgItem(hDlg, nIDDlgItem):hCtl
        hWnd    hDlg;
        int     nIDDlgItem;
return  hWnd

GetDlgItemInt
        Translates text of nIDDlgItem into integer value. Value at lpTranslated
        is zero if errors occur. bSigned is nonzero if minus sign might be
        present.
entry   GetDlgItemInt()
        #undef  NoCtlMgr
        GetDlgItemInt(hDlg, nIDDlgItem, lpTranslated, bSigned):wValue
        hWnd    hDlg;
        int     nIDDlgItem;
        Boolean FAR * lpTranslated;
        Boolean bSigned;
return  unsigned
GetDlgItemText
        Copies nIDDlgItem's control text (up to nMaxCount characters) into
        lpString.
entry   GetDlgItemText()
        #undef  NoCtlMgr
        GetDlgItemText(hDlg, nIDDlgItem, lpString, nMaxCount):nCopied
        hWnd    hDlg;
        int     nIDDlgItem;
        lpStr   lpString;
        int     nMaxCount;
return  int

GetDoubleClickTime
        Retrieves the current double-click time of the system mouse.
entry   GetDoubleClickTime()
```

```
        GetDoubleClickTime():wClickTime
return  word

GetEnvironment
        Copies to lpEnviron the environment associated with the device attached
        to a given port.
entry   GetEnvironment()
        GetEnvironment(lpPortName, lpEnviron, nmaxCount):nCopied
        lpStr   lpPortName;
        lpStr   lpEnviron;
        word    nmaxCount;
return  short

GetFocus
        Retrieves the handle of the window currently owning the input focus.
entry   GetFocus()
        GetFocus():hWnd
return  hWnd

GetGValue
        Retrieves the green value of the given colour.
entry   GetGValue()
        GetGValue(rgbColour):cGreen

GetInstanceData
        Copies nCount bytes of data from offset pData in instance hInstance to
        same offset in current instance.
entry   GetInstanceData()
        GetInstanceData(hInstance, pData, nCount):nBytes
        handle  hInstance;
        npStr   pData;
        int     nCount;
return  int

GetKeyState
        Retrieves the state of the virtual key specified by nVirtKey.
entry   GetKeyState()
        GetKeyState(nVirtKey):nState
        int     nVirtKey;
return  int


GetMapMode
        Retrieves the current mapping mode.
entry   GetMapMode()
        #undef  NohDC
        GetMapMode(hDC):nMapMode
        hDC     hDC;
return  short

GetMenu
        Retrieves a handle to the menu of the specified window.
entry   GetMenu()
        #undef  NoMenus
        GetMenu(hWnd):hMenu
        hWnd    hWnd;
return  HMENU

GetMenuString
        Copies wIDItem's menu label (up to nMaxCount characters) into lpString.
        wFlag is MF_BYPOSITION or MF_BYCOMMAND.
entry   GetMenuString()
        #undef  NoMenus
        GetMenuString(hMenu, wIDItem, lpString, nMaxCount, wFlag):nCopied
        hMenu   hMenu;
        word    wIDItem;
        lpStr   lpString;
        int     nMaxCount;
        word    wFlag;
return  int
```

```
GetMessage
        Retrieves message in range wMsgFilterMin to wMsgFilterMax; stores at
        IpMsg.
entry   GetMessage()
        #undef  NoMsg
        GetMessage(lpMsg, hWnd, wMsgFilterMin, wMsgFilterMax):bContinue
        lpMsg   lpMsg;
        hWnd    hWnd;
       unsigned wMsgFilterMin;
       unsigned wMsgFilterMax;
return  Boolean

GetMessagePos
        Returns mouse position, in screen coordinates, at the time of the last
        message retrieved by GetMessage.
entry   GetMessagePos()
        GetMessagePos():dwPos
return  dword

GetMessageTime
        Returns the message time for the last message retrieved by GetMessage.
entry   GetMessageTime()
        GetMessageTime():lTime
return  long

GetMetaFile
        Creates a handle for the metafile named by lpFilename.
entry   GetMetaFile()
        GetMetaFile(lpFilename):hMF
        lpStr   lpFilename;
return  handle

GetMetaFileBits
        Stores specified metafile as collection of bits in global memory block.
entry   GetMetaFileBits()
        GetMetaFileBits(hMF):hMem
        handle  hMF;
return  handle

GetModuleFileName
        Copies module filename (up to nSize characters) to lpFilename
entry   GetModuleFileName()
        GetModuleFileName(hModule, lpfilename, nSize):nLength
        handle  hModule;
        lpStr   lpfilename;
        int     nSize;
return  int

GetModuleHandle
        Returns module handle of module named by lpModuleName.
entry   GetModuleHandle()
        GetModuleHandle(lpModuleName):hModule
        lpStr   lpModuleName;
return  handle

GetModuleUsage
        Returns reference count of module hModule.
entry   GetModuleUsage()
        GetModuleUsage(hMModule):nCount
        handle  hMModule;
return  int

GetNearestColour
        Returns the device colour closest to rgbColour.
entry   GetNearestColour()
        #undef NohDC
        GetNearestColour(hObject, nCount, lpObject):nCopied
        hDC     hObject;
        dword   nCount;
return  dword
```

```
GetObject
        Copies nCount bytes of logical data defining hObject to lpObject.
entry   GetObject()
        GetObject(hObject, NCount, lpObject):nCopied
        handle  hObject;
        short   NCount;
        lpStr   lpObject;
return  short

GetParent
        Retrieves the window handle of the specified window's parent (if any).
entry   GetParent()
        GetParent(hWnd):hWndParent
        hWnd    hWnd;
return  hWnd

GetPixel
        Retrieves the RGB colour value of the pixel at the point specified by X
        and Y.
entry   GetPixel()
        #undef  NohDC
        GetPixel(hDC, X, Y,):rgbcolour
        hDC     hDC;
        short   X;
        short   Y;
return  dword

GetPolyFillMode
        Retrieves the current polygon-filling mode.
entry   GetPolyFillMode()
        #undef  NohDC
        GetPolyFillMode(hDC):nPolyFillMode
        hDC     hDC;
return  short

GetProcAddress
        Returns address of the function named by lpProcName in module hModule.
entry   GetProcAddress()
        GetProcAddress(hModule, lpProcName):lpAddress
        handle  hModule;
        lpStr   lpProcName;
return  FarProc

GetProfileInt
        Returns integer value named by lpKeyName in section lpSectionName from
        the WIN.INI file. If name or section not found, nDefault is returned.
entry   GetProfileInt()
        GetProfileInt(lpSectionName, lpKeyName, nDefault):nnKeyValue
        lpStr   lpSectionName;
        lpStr   lpKeyName;
        int     nDefault;
return  int

GetProfileString
        Returns character string named by lpKeyName in section lpSectionName from
        the WIN.INI file. String is copied (up to nSize characters) to
        lpReturnedString. If name or section are not found, lpDefault is returned.
entry   GetProfileString()
        GetProfileString(lpSectionName, lpKeyName, lpDefault,
        lpReturnedString, nSize):nLength
        lpStr   lpSectionName;
        lpStr   lpKeyName;
        lpStr   lpDefault;
        lpStr   lpReturnedString;
        int     nSize;
return  int

GetProp
        Retrieves data handle associated with lpString from window property list.
entry   GetProp()
        GetProp(hWnd, lpString):hData
```

```
        hWnd     hWnd;
        lpStr    lpString;
return  handle

GetRelAbs
        Retrieves the relabs flag.
entry   GetRelAbs()
        #undef  NohDC
        GetRelAbs(hDC):nRelAbsMode
        hDC      hDC;
return  short

GetROP2
        Retrieves the current drawing mode.
entry   GetROP2()
        #undef  NohDC
        GetROP2(hDC):nDrawMode
        hDC      hDC;
return  short

GetRValue
        Retrieves the red value of the given colour.
entry   GetRValue()
        GetRValue(rgbColour):cRed

GetScrollPos
        Retrieves current position of scroll bar elevator identified by hWnd and
        nBar.
entry   GetScrollPos()
        #undef  NoScroll
        GetScrollPos(hWnd, nBar):nPos
        hWnd     hWnd;
        int      nBar;
return  int

GetScrollRange
        Copies minimum and maximum scroll bar positions for given scroll bar to
        lpMinPos and lpMaxPos.
entry   GetScrollRange()
        #undef  NoScroll
        GetScrollRange(hWnd, nBar, lpMinPos, lpMaxPos)
        hWnd     hWnd;
        int      nBar;
        lpInt    lpMinPos;
        lpInt    lpMaxPos;
return  void

GetStockObject
        Retrieves a handle to a predefined stock pen, brush, or font.
entry   GetStockObject()
        GetStockObject(nIndex):hObject
        short    nIndex;
return  handle
GetStretchBltMode
        Retrieves the current stretching mode.
entry   GetStretchBltMode()
        #undef  NohDC
        GetStretchBltMode(hDC):nStretchMode
        hDC      hDC;
return  short

GetSubMenu
        Retrieves the menu handle of the pop-up menu at the given position in
        hmenu.
entry   GetSubMenu()
        #undef  NoMenus
        GetSubMenu(hMenu, nPos):hPopupmenu
        hMenu    hMenu;
        int      nPos;
return  hMenu
```

```
GetSysColour
        Retrieves the system colour identified by nIndex.
entry   GetSysColour()
        #undef  NoColour
        GetSysColour(nIndex):rgbColour
        int     nIndex;
return  dword

GetSysModalWindow
        Returns the handle of a system-modal window, if one is present.
entry   GetSysModalWindow()
        GetSysModalWindow():hWnd
return  hWnd

GetSystemMenu
        Allows access to the System menu for copying and modification. bRevert is
        nonzero to restore the original System menu.
entry   GetSystemMenu()
        #undef  NoMenus
        GetSystemMenu(hWnd, bRevert):hSysMenu
        hWnd    hWnd;
        Boolean bRevert;
return  hMenu

GetSystemMetrics
        Retrieves information about the system metrics identified by nIndex.
entry   GetSystemMetrics()
        #undef  NoSysMetrics
        GetSystemMetrics(nIndex):nValue
        int     nIndex;
return  int

GetTempDrive
        Returns letter for the optimal drive for a temporary file. cDriveLOetter
        is a proposed drive.
entry   GetTempDrive()
        #undef  NoOpenFile
        GetTempDrive(cDriveLetter):cOptDriveLetter
        byte    cDriveLetter;
return  byte

GetTempFileName
        Creates a temporary filename.
entry   GetTempFileName()
        #undef  NoOpenFile
        GetTempFileName(cDriveLetter, lpPrefixString, wUnique,
                        lpTempFileName):wUniqueNumber
        byte    cDriveLetter;
        lpStr   lpPrefixString;
        word    wUnique;
        lpStr   lpTempFileName;
return  int

GetTextCharacterExtra
        Retrieves the current intercharacter spacing.
entry   GetTextCharacterExtra()
        #undef  NohDC
        GetTextCharacterExtra(hDC):nCharExtra
        hDC     hDC;
return  short

GetTextColour
        Retrieves the current text colour.
entry   GetTextColour()
        #undef  NohDC
        GetTextColour(hDC):rgbColour
        hDC     hDC;
return  dword

GetTextExtent
        Uses current font to compute width and height of text line given by
```

```
        lpString.
entry   GetTextExtent()
        #undef  NohDC
        GetTextExtent(hDC, lpString, nCount):dwTextExtents
        hDC     hDC;
        lpStr   lpString;
        short   nCount;
return  dword

GetTextFace
        Copies the current font's facename (up to nCount characters) into
        lpFacename.
entry   GetTextFace()
        #undef  NohDC
        GetTextFace(hDC, nCount, lpFacename):nCopied
        hDC     hDC;
        short   nCount;
        lpStr   lpFacename;
return  short

GetTextMetrics
        Fills buffer given by lpMetrics with metrics for currently selected font.
entry   GetTextMetrics()
        #undef  NoTextMetric
        #undef  NohDC
        GetTextMetrics(hDC, lpMetrics):bRetrieved
        hDC     hDC;
   lpTextMetric lpMetrics;
return  Boolean

GetThresholdEvent
        Returns long pointer to a threshold flag. The flag is set if any voice
        queue is below threshold (i.e., below a given number of notes).
entry   GetThresholdEvent()
        #undef  NoSound
        GetThresholdEvent():lpInt
return  lpInt

GetThresholdStatus
        Returns a bit mask containing the threshold event status. If a bit is
        set, the given voice queue is below threshold.
entry   GetThresholdStatus()
        #undef  NoSound
        GetThresholdStatus():fStatus
return  int

GetUpdateRect
        Copies dimensions of bounding rectangle of window region that needs
        updating to lpRect. bErase is nonzero if background needs erasing.
        bUpdate is zero if window is up-to-date.
entry   GetUpdateRect()
        #undef  NoRect
        #undef  NohDC
        GetUpdateRect(hWnd, lpRect, bErase):bUpdate
        hWnd    hWnd;
        lpRect  lpRect;
        Boolean bErase;
return  Boolean

GetVersion
        Returns the current version of Windows.
entry   GetVersion()
        GetVersion():wVersion
return  word

GetViewportExt
        Retrieves the x and y-extents of the display context's viewport.
entry   GetViewportExt()
        #undef  NohDC
        GetViewportExt(hDC):ptExtents
        hDC     hDC;
```

```
return  dword

GetViewportOrg
        Retrieves X and Y coordinates of the origin of the display context's
        viewport.
entry   GetViewportOrg()
        #undef  NohDC
        GetViewportOrg(hDC):ptOrigin
        hDC     hDC;
return  dword

GetWindowDC
        Retrieves display context for entire window, including caption bar,
 menus, scroll bars.
entry   GetWindowDC()
        #undef  NohDC
        GetWindowDC(hWnd):hDC
        hWnd    hWnd;
return  hDC

GetWindowExt
        Retrieves X and Y extents of the display context's window.
entry   GetWindowExt()
        #undef  NohDC
        GetWindowExt(hDC):ptExtents
        hDC     hDC;
return  dword

GetWindowLong
        Retrieves information identified by nIndex about the given window.
entry   GetWindowLong()
        #undef  NoWinOffsets
        GetWindowLong(hWnd, nIndex):long
        hWnd    hWnd;
        int     nIndex;
return  long

GetWindowOrg
        Retrieves X and Y coordinates of the origin of the display context's
        window.
entry   GetWindowOrg()
        #undef  NohDC
        GetWindowOrg(hDC):ptOrigin
        hDC     hDC;
return  dword

GetWindowRect
        Copies dimensions, in screen coordinates, of entire window (including
        caption bar, border, menus, and scroll bars..) to lpRect.
entry   GetWindowRect()
        #undef  NoRect
        GetWindowRect(hWnd, lpRect)
        hWnd    hWnd;
        lpRect  lpRect;
return  void

GetWindowText
        Copies hWnd's window caption (up to nMaxCount characters) into lpString.
entry   GetWindowText()
        GetWindowText(hWnd, lpString, nMaxCount):nCopied
        hWnd    hWnd;
        lpStr   lpString;
        int     nMaxCount;
return  int

GetWindowTextLength
        Returns the length of the given window's caption or text.
entry   GetWindowTextLength()
        GetWindowTextLength(hWnd):nLength
        hWnd    hWnd;
return  int
```

```
GetWindowWord
        Retrieves information identified by nIndex about the given window.
entry   GetWindowWord()
        #undef  NoWinOffsets
        GetWindowWord(hWnd, nIndex):word
        hWnd    hWnd;
        int     nIndex;
return  word

GlobalAlloc
        Allocates dwBytes of memory from the global heap. Memory type (e.g.,
        fixed or moveable) is set by wFlags.
entry   GlobalAlloc()
        #undef  NoMemMgr
        GlobalAlloc(wFlags, dwBytes):hMem
        word    wFlags;
        dword   dwBytes;
return  handle

GlobalCompact
        Compacts global memory to generate dwMinFree free bytes.
entry   GlobalCompact()
        #undef  NoMemMgr
        GlobalCompact(dwMinFree):dwLargest
        dword   dwMinFree;
return  dword

GlobalDiscard
        Discards global memory block hMem if reference count is zero.
entry   GlobalDiscard()
        GlobalDiscard(hMem):hOldMem

GlobalFlags
        Discards memory type of global memory block hMem.
entry   GlobalFlags()
        #undef  NoMemMgr
        GlobalFlags(hMem):wFlags
        handle  hMem;
return  word

GlobalFree
        Removes global memory block hMem from memory if reference count is zero.
entry   GlobalFree()
        #undef  NoMemMgr
        GlobalFree(hmem):hOldMem
        handle  hmem;
return  handle

GlobalHandle
        Retrieves the handle of the global memory if reference count is zero.
entry   GlobalHandle()
        #undef  NoMemMgr
        GlobalHandle(wMem):dwmem
        word    wMem;
return  dword

GlobalLock
        Returns address of global memory block hMem, locks block in memory, and
        increases the reference count by one.
entry   GlobalLock()
        #undef  NoMemMgr
        GlobalLock(hMem):lpAddress
        handle  hMem;
return  lpStr

GlobalReAlloc
        Reallocates the global memory block hMem to dwBytes and memory type
        wFlags.
entry   GlobalReAlloc()
        #undef  NoMemMgr
        GlobalReAlloc(hMem, dwBytes, wFlags):hNewMem
```

```
        handle  hMem;
        dword   dwBytes;
        word    wFlags;
return  handle

GlobalSize
        Returns the size, in bytes, of global memory block hMem.
entry   GlobalSize()
        #undef  NoMemMgr
        GlobalSize(hMemmj):dwBytes
        handle  hMemmj;
return  dword

GlobalUnlock
        Unlocks global memory block hMem and decreases the reference count by one.
entry   GlobalUnlock()
        #undef  NoMemMgr
        GlobalUnlock(hMem):bResult
        handle  hMem;
return  Boolean

GreyString
        Writes nCount characters of string at X, Y, using lpOutputFunc (or
        TextOut if NULL). Grays text using hBrush. lpData specifies output
        string (if lpOutputFunc is NULL) or data are passed to output function.
        nWidth and nHeight give dimensions of enclosing rectangle (if zero,
        dimensions are calculated).
entry   GreyString()
        GreyString(hDC, hBrush, lpOutputFunc, lpData, nCount, X, Y, nWidth,
                  nHeight):bDrawn
        hDC     hDC;
        hBrush  hBrush;
        FarProc lpOutputFunc;
        dword   lpData;
        int     nCount;
        int     X;
        int     Y;
        int     nWidth;
        int     nHeight;
return  Boolean

HiByte
        Returns the high-order byte of nInteger.
entry   HiByte()
        HiByte(nInteger):cHighByte

HideCaret
        Removes system caret from the given window.
entry   HideCaret()
        HideCaret(hWnd)
        hWnd    hWnd;
return  void

HiliteMenuItem
        Highlights or removes the highlighting from a top-level (menu-bar) menu
        item.
entry   HiliteMenuItem()
        #undef  NoMenus
        HiliteMenuItem(hWnd, hMenu, wIDHiliteItem, wHilite):bHilited
        hWnd    hWnd;
        hMenu   hMenu;
        word    wIDHiliteItem;
        word    wHilite;
return  Boolean

HIword
        Returns the high-order word of lInteger.
entry   HIword()
        HIword(lInteger):wHighWord

InflateRect
```

```
        Expands or shrinks the rectangle specified by lpRect by X units on the
        left and right ends of the rectangle and Y units on the top and bottom.
entry   InflateRect()
        #undef  NoRect
        InflateRect(lpRect, X, Y):nResult
        lpRect  lpRect;
        int     X;
        int     Y;
return  int

InitAtomTable
        Initializes atom hash table and sets it to nSize atoms.
entry   InitAtomTable()
        InitAtomTable(nSize):bResult
        int     nSize;
return  Boolean

InSendMessage
        Returns TRUE if window function is processing a message sent with
        SendMessage.
entry   InSendMessage()
        #undef  NoWinMessages
        InSendMessage():bInSend
return  Boolean

IntersectClipRect
        Forms new clipping region from intersection of current clipping region
        and given rectangle.
entry   IntersectClipRect()
        #undef  NohDC
        IntersectClipRect(hDC, X1, Y1, X2, Y2):nRgnType
        hDC     hDC;
        short   X1;
        short   Y1;
        short   X2;
        short   Y2;
return  short

IntersectRect
        Finds the intersection off two rectangles and copies it to lpDestRect.
entry   IntersectRect()
        #undef  NoRect
        IntersectRect(lpDestRect, lpSrc1Rect, lpSrc2Rect):nIntersection
        lpRect  lpDestRect;
        lpRect  lpSrc1Rect;
        lpRect  lpSrc2Rect;
return  int

InvalidateRect
        Marks for repainting the rectangle specified by lpRect (in client
        coordinates). The rectangle is erased if bErase is nonzero.
entry   InvalidateRect()
        #undef  NoRect
        InvalidateRect(hWnd, lpRect, bErase)
        hWnd    hWnd;
        lpRect  lpRect;
        Boolean bErase;
return  void

InvalidateRgn
        Marks hRgn for repainting. The region is erased if bErase is nonzero.
entry   InvalidateRgn()
        #undef  NoRegion
      InvalidateRgn(hWnd, lpRect, bErase)
        hWnd    hWnd;
        hRgn    lpRect;
        Boolean bErase;
return  void

InvertRect
        Inverts the display bits of the specified rectangle.
```

```
entry   InvertRect()
        #undef  NohDC
        #undef  NoRect
        InvertRect(hDC, lpRect):nResult
        hDC     hDC;
        LPRECT  lpRect;
return  int

InvertRgn
        Inverts the colours in the region specified by hRgn.
entry   InvertRgn()
        #undef  NohDC
        #undef  NoRegion
        InvertRgn(hDC, hRgn):bInverted
        hDC     hDC;
        hRgn    hRgn;
return  Boolean

IsChild
        Returns TRUE if given window is a child of hParentWnd.
entry   IsChild()
        IsChild(hParentWnd, hWnd):bChild
        hWnd    hParentWnd;
        hWnd    hWnd;
return  Boolean

IsClipboardFormatAvailable
        Returns TRUE if data in given format is available.
entry   IsClipboardFormatAvailable()
        #undef  NoClipBoard
        IsClipboardFormatAvailable(wFormat):bAvailable
        word    wFormat;
return  Boolean

IsDialogMessage
        Determines whether lpMsg is intended for the given modeless dialogue box.
        If so, the message is processed and bUsed is nonzero
entry   IsDialogMessage()
        #undef  NoMsg
        #undef  NoCtlMgr
        IsDialogMessage(hDlg, lpMsg):bUsed
        hWnd    hDlg;
        lpMsg   lpMsg;
return  Boolean

IsDlgButtonChecked
        Tests whether nIDButton is checked. For a 3-state button, returns 2 for
        greyed, 1 for checked, zero for neither.
entry   IsDlgButtonChecked()
        #undef  NoCtlMgr
        IsDlgButtonChecked(hDlg, lpMsg):bUsed
        hWnd    hDlg;
        int     lpMsg;
return  word

IsIconic
        Specifies whether or not a window is open or closed (iconic).
entry   IsIconic()
        IsIconic(hWnd):bIconic
        hWnd    hWnd;
return  Boolean

IsRectEmpty
        Determines whether or not the specified rectangle is empty.
entry   IsRectEmpty()
        #undef  NoRect
        IsRectEmpty(lpRect):bEmpty
        lpRect  lpRect;
return  Boolean

IsWindow
```

```
        Determines whether or not hWnd is a valid, existing window.
entry   IsWindow()
        IsWindow(hWnd):bExists
        hWnd    hWnd;
return  Boolean

IsWindowEnabled
        Specifies whether or not hWnd is enabled for mouse and keyboard input.
entry   IsWindowEnabled()
        IsWindowEnabled(hWnd):bEnabled
        hWnd    hWnd;
return  Boolean

IsWindowVisible
        Determines whether or not the given window is visible on the screen.
entry   IsWindowVisible()
        IsWindowVisible(hWnd):bVisible
        hWnd    hWnd;
return  Boolean

KillTimer
        Kills the timer event identified by hWnd and nIDEvent.
entry   KillTimer()
        KillTimer(hWnd, nIDEvent):bKilled
        hWnd    hWnd;
        short   nIDEvent;
return  Boolean

LineDDA
        Computes successive points in line starting at X1, Y1 and ending at X2,
        Y2, passing each point and lpData parameter to lpLineFunc function.
entry   LineDDA()
        LineDDA(X1, Y1, X2, Y2, lpLineFunclpData)
        short   X1;
        short   Y1;
        short   X2;
        short   Y2;
        FarProc lpLineFunclpData;
return  void

LineTo
        Draws line with current pen from the current position up to, but not
        including, the point X, Y.
entry   LineTo()
        #undef  NohDC
        LineTo(hDC, X, Y):bDrawn
        hDC     hDC;
        short   X;
        short   Y;
return  Boolean

LoadAccelerators
        Loads accelerator table named by lpTableName.
entry   LoadAccelerators()
        LoadAccelerators(hInstance, lpTableName):hRes
        handle  hInstance;
        lpStr   lpTableName;
return  handle

LoadBitmap
        Loads bitmap resource named by lpBitmapName.
entry   LoadBitmap()
        #undef  NoBitmap
        LoadBitmap(hInstance, lpBitmapName):hBitmap
        handle  hInstance;
        lpStr   lpBitmapName;
return  hBitmap

LoadCursor
        Loads cursor resource named by lpCursorName.
entry   LoadCursor()
```

```
        LoadCursor(hInstance, lpCursorName):hCursor
        handle  hInstance;
        lpStr   lpCursorName;
return  hCursor

LoadIcon
        Loads icon resource named by lpIconName.
entry   LoadIcon()
        LoadIcon(hInstance, lpIconName):hIcon
        handle  hInstance;
        lpStr   lpIconName;
return  hIcon

LoadLibrary
        Loads the library module named by lpLibFilename.
entry   LoadLibrary()
        LoadLibrary(lpLibFileName):hLibModule
        lpStr   lpLibFileName;
return  handle

LoadMenu
        Loads menu resource named by lpMenuName.
entry   LoadMenu()
        #undef  NoMenus
        LoadMenu(hInstance, lpMenuName):hMenu
        handle  hInstance;
        lpStr   lpMenuName;
return  hMenu

LoadResource
        Loads the resource hResInfo and returns a handle to the resource.
entry   LoadResource()
        LoadResource(hInstance, hResInfo):hResData
        handle  hInstance;
        handle  hResInfo;
return  handle

LoadString
        Loads string resource wID into the buffer lpBuffer. Up to nBufferMax
        characters are copied.
entry   LoadString()
        LoadString(hInstance, wID, lpBuffer, nBufferMax):nSize
        handle  hInstance;
       unsigned wID;
        lpStr   lpBuffer;
        int     nBufferMax;
return  int

LoBype
        Returns the low-order byte of nInteger.
entry   LoByte()
        LoByte(nInteger):cLowByte

LocalAlloc
        Allocates wBytes of memory from the local heap. Memory type (e.g., fixed
        or moveable) is set by wFlags.
entry   LocalAlloc()
        #undef  NoMemMgr
        LocalAlloc(wFlags, wBytes):hMem
        word    wFlags;
        word    wBytes;
return  handle

LocalCompact
        Compacts local memory to generate wMinFree free bytes.
entry   LocalCompact()
        #undef  NoMemMgr
        LocalCompact(wMinFree):wLargest
        word    wMinFree;
return  word
```

```
LocalDiscard
        Discards local memory block hMem if reference count is zero.
entry   LocalDiscard()
        LocalDiscard(hmem):hOldMem

LocalFlags
        Returns memory type of local memory block hMem.
entry   LocalFlags()
        #undef  NoMemMgr
        LocalFlags(hmem):wFlags
        handle  hmem;
return  word

LocalFree
        Frees local memory block hMem from memory if reference count is zero.
entry   LocalFree()
        #undef  NoMemMgr
        LocalFree(hMem):hOldMem
        handle  hMem;
return  handle

LocalFreeze
        Prevents compaction of the local heap.
entry   LocalFreeze()
        LocalFreeze(Dummy)

LocalHandle
        Retrieves the handle of the local memory object whose address is wMem.
entry   LocalHandle()
        #undef  NoMemMgr
        LocalHandle(wMem):hmem
        word    wMem;
return  handle

LocalHandleDelta
        Sets the entry count for each new handle table created in the local heap.
entry   LocalHandleDelta()
        LocalHandleDelta(nNewDelta):nCurrentDelta

LocalInit
        Initializes the local heap.
entry   LocalInit()
        #undef  NoMemMgr
        LocalInit(wValue, pString, pString):bResult
        word    wValue;
    char NEAR * pString;
    char NEAR * pString;
return  Boolean

LocalLock
        Returns the address of the local memory block hMem, locks the block in
        memory, and increases the reference count by one.
entry   LocalLock()
        #undef  NoMemMgr
        LocalLock(hMem):pAddress
        handle  hMem;
return  char NEAR *

LocalMelt
        Permits compaction of the local heap.
entry   LocalMelt()
        LocalMelt(Dummy)

LocalNotify
        Sets the callback function for handling notification messages from local
        memory.
entry   LocalNotify()
        #undef  NoMemMgr
        LocalNotify(lpFunc):lpPrevFunc
        FarProc lpFunc;
return  FarProc
```

```
LocalReAlloc
        Reallocates the local memory block hMem to wBytes and memory type wFlags.
entry   LocalReAlloc()
        #undef  NoMemMgr
        LocalReAlloc(hMem, wBytes, wFlags):hNewMem
        handle  hMem;
        word    wBytes;
        word    wFlags;
return  handle

LocalSize
        Returns the size, in bytes, of local memory block hMem.
entry   LocalSize()
        #undef  NoMemMgr
        LocalSize(hmem):wBytes
        handle  hmem;
return  word

LocalUnlock
        Unlocks local memory block hMem and decreases the reference count by one.
entry   LocalUnlock()
        #undef  NoMemMgr
        LocalUnlock(hMem):bResult
        handle  hMem;
return  Boolean

LockData
        Locks the data segment in memory.
entry   LockData()
        LockData(Dummy):hMem

LockResource
        Returns the memory address of the resource hResInfo, locks the resource
        in memory, and increases the reference count by one.
entry   LockResource()
        LockResource(hResInfo):lpResInfo
        handle  hResInfo;
return  lpStr

LockSegment Function
        Locks the segment whose segment address is wSegment.
entry   LockSegment()
        #undef  NoMemMgr
        LockSegment(wSegment):hSegment
        word    wSegment;
return  handle

LOword
        Returns the low-order word of lInteger.
entry   LOword()
        LOword(lIntger):wLowWord

LPtoDP
        Converts logical points into device points.
entry   LPtoDP()
        #undef  NoPoint
        #undef  NohDC
        LPtoDP(hDC, lpPoints, nCount):bConverted
        hDC     hDC;
        LPPoint lpPoints;
        short   nCount;
return  Boolean

MakeIntAtom
        Casts an integer for use as an argument in AddAtom.
entry   MakeIntAtom()
        MakeIntAtom(wInteger):nAtom

MakeIntResource
        Casts an integer for use as an argument in AddAtom.
entry   MakeIntResource()
```

```
        MakeIntResource(nInteger):lpIntegerID

MakeLong
        Creates an unsigned long integer.
entry   MakeLong()
        MakeLong(nLowWord, nHighWord):dwInteger

MakePoint
        Converts a long value into a Point structure.
entry   MakePoint()
        MakePoint(lValue):ptPoint

MakeProcInstance
        Returns function instance address for function lpProc. Calls to the
        instance address ensure that the function uses the data segment of
        instance hInstance.
entry   MakeProcInstance()
        MakeProcInstance(lpProc, hInstance):lpAddress
        FarProc lpProc;
        handle  hInstance;
return  FarProc

MapDialogRect
        Converts the dialogue box coordinates given in lpRect to client
        coordinates.
entry   MapDialogRect()
        #undef  NoRect
        #undef  NoCtlMgr
        MapDialogRect(hDlg, lpRect)
        hWnd    hDlg;
        lpRect  lpRect;
return  void

Max
        Returns the maximum value of A and B.
entry   max()
        max(A, B):nMaximum

MessageBeep
        Generates a beep at the system speaker when a message box is displayed.
entry   MessageBeep()
        #undef  NoMb
        MessageBeep(wType):bBeep
        word    wType;
return  Boolean

MessageBox
        Creates a window with given lpText and lpCaption containing the
        predefined icons and push buttons defined by wType.
entry   MessageBox()
        #undef  NoMb
        MessageBox(hWndParent, lpText, lpCaption, wType):nMenuItem
        hWnd    hWndParent;
        lpStr   lpText;
        lpStr   lpCaption;
        word    wType;
return  int

Min
        Returns the minimum value of A and B.
entry   min()
        min(A, B):nMinimum

MoveTo
        Moves the current position to the point specified by X and Y.
entry   MoveTo()
        #undef  NohDC
        MoveTo(hDC, X, Y):ptPrevPos
        hDC     hDC;
        short   X;
        short   Y;
```

```
return  dword

MoveWindow
        Causes WM_SIZE message to be sent to hWnd. X, Y, nWidth, and nHeight give
        the new size of the window.
entry   MoveWindow()
        MoveWindow(hWnd, X, Y, nWidth, nHeight, bRepaint)
        hWnd    hWnd;
        int     X;
        int     Y;
        int     nWidth;
        int     nHeight;
        Boolean bRepaint;
return  void

OemToAnsi
        Converts the OEM character string to an ANSI string.
entry   OemToAnsi()
        OemToAnsi(lpOemStr, lpAnsiStr):bTranslated
        lpStr   lpOemStr;
        lpStr   lpAnsiStr;
return  Boolean

OffsetClipRgn
        Moves clipping region X units along the X-axis and Y units along the
        Y-axis.
entry   OffsetClipRgn()
        #undef  NohDC
        OffsetClipRgn(hDC, X, Y):nRgnType
        hDC     hDC;
        short   X;
        short   Y;
return  short

OffsetRect
        Moves given rectangle X units along the X-axis and Y units along the
        Y-axis.
entry   OffsetRect()
        #undef  NoRect
        OffsetRect(lpRect, X, Y):nResult
        lpRect  lpRect;
        int     X;
        int     Y;
return  int

OffsetRgn
        Moves the given region X units along the X-axis and Y units along
        the Y-axis.
entry   OffsetRgn()
        #undef  NoRegion
        OffsetRgn(hRgn, X, Y):nRgntype
        hRgn    hRgn;
        short   X;
        short   Y;
return  short

OpenClipboard
        Opens clipboard; prevents other applications from modifying its contents.
entry   OpenClipboard()
        #undef  NoClipBoard
        OpenClipboard(hWnd):bOpened
        hWnd    hWnd;
return  Boolean

OpenComm
        Opens communication device named by lpCommName. Transmit-queue and
        receive-queue sizes are set by wInQueue and wOutQueue.
entry   OpenComm()
        #undef  NoComm
        OpenComm(lpComName, wInWueue, wOutQueue):nCid
        lpStr   lpComName;
```

```
        word    wInWueue;
        word    wOutQueue;
return  short

OpenFile
        Creates, opens, reopens, or deletes file named by lpFileName.
entry   OpenFile()
        #undef  NoOpenFile
        OpenFile(lpFileName, lpReOpenBuff, wStyle):nFile
        lpStr   lpFileName;
     lpOfStruct lpReOpenBuff;
        word    wStyle;
return  int

OpenIcon
        Opens the specified window.
entry   OpenIcon()
        OpenIcon(hWnd):bOpened
        hWnd    hWnd;
return  Boolean


OpenSound
        Opens the play device for exclusive use.
entry   OpenSound()
        #undef  NoSound
        OpenSound():nVoices
return  int

PaintRgn
        Fills the region specified by hRgn with the currently selected brush.
entry   PaintRgn()
        #undef  NohDC
        #undef  NoRegion
        PaintRgn(hDC, hRgn):bFilled
        hDC     hDC;
        hRgn    hRgn;
return  Boolean

PatBlt
        Creates a bit pattern on the specified device, using dwRop to combine the
        current brush with the pattern already on the device.
entry   PatBlt()
        #undef  NohDC
        PatBlt(hDC, X, Y, nWidth, nHeight5, dwRop):bDrawn
        hDC     hDC;
        short   X;
        short   Y;
        short   nWidth;
        short   nHeight5;
        dword   dwRop;
return  Boolean

PeekMessage
        Checks application queue and places message (if any) at lpMsg.
entry   PeekMessage()
        #undef  NoMsg
        PeekMessage(lpMsg, hWnd, wMsgFilterMin, wMsgFilterMax,
                    bRemoveMsg):bPresent
        lpMsg   lpMsg;
        hWnd    hWnd;
       unsigned wMsgFilterMin;
        word    wMsgFilterMax;
        Boolean bRemoveMsg;
return  Boolean

Pie
        Draws arc starting at X3, Y3 and ending at X4, Y4 and connects centre and
        two endpoints, using current pen. Moves counter-clockwise. Fills with
        current brush. Arc's centre is centre of bounding rectangle given by X1,
        Y1, X2, Y2.
```

```
entry   Pie()
        #undef  NohDC
        Pie(hDC, X1, Y1, X2, Y2, X3, Y3, X4, Y4):bDrawn
        hDC     hDC;
        short   X1;
        short   Y1;
        short   X2;
        short   Y2;
        short   X3;
        short   Y3;
        short   X4;
        short   Y4;
return  Boolean

PlayMetaFile
        Plays the contents of the specified metafile on the given device context.
entry   PlayMetaFile()
        #undef  NohDC
        PlayMetaFile(hDC, hMF):bPlayed
        hDC     hDC;
        handle  hMF;
return  Boolean

Polygon
        Draws a polygon by connecting the nCount vertices given by lpPoints.
entry   Polygon()
        #undef  NoPoint
        #undef  NohDC
        Polygon(hDC, lpPoints, nCount):bDrawn
        hDC     hDC;
        LPPoint lpPoints;
        short   nCount;
return  Boolean

Polyline
        Draws a set of line segments, connecting the nCount points given by
        lpPoints.
entry   Polyline()
        #undef  NoPoint
        #undef  NohDC
        Polyline(hDC, lpPoints, nCount):bDrawn
        hDC     hDC;
        LPPoint lpPoints;
        short   nCount;
return  Boolean

PostAppMessage
        Posts message to application; returns without waiting for processing.
entry   PostAppMessage()
        #undef  NoWinMessages
        PostAppMessage(hTask, wMsg, wParam, lParam):bPosted
        handle  hTask;
       unsigned wMsg;
        word    wParam;
        long    lParam;
return  Boolean

PostMessage
        Places message in application queue; returns without waiting for
        processing.
entry   PostMessage()
        #undef  NoWinMessages
        PostMessage(hWnd, wMsg, wParam, lParam):bPosted
        hWnd    hWnd;
       unsigned wMsg;
        word    wParam;
        long    lParam;
return  Boolean

PostQuitMessage
        Posts a WM_QUIT message to the application and returns immediately.
```

```
entry   PostQuitMessage()
        #undef  NoWinMessages
        PostQuitMessage(nExitCode)
        int     nExitCode;
return  void

PtInRect
        Indicates whether or not a specified point lies within a given rectangle.
entry   PtInRect()
        #undef  NoPoint
        #undef  NoRect
        PtInRect(lpRect, Point):bInRect
        lpRect  lpRect;
        Point   Point;
return  Boolean

PtInRegion
        Tests if X, Y is within the given region.
entry   PtInRegion()
        #undef  NohDC
        #undef  NoRegion
        PtInRegion(hRgn, S, Y):bSuccess
        hRgn    hRgn;
        short   S;
        short   Y;
return  Boolean

PtVisible
        Tests if  X, Y is within the clipping region of the given display context.
entry   PtVisible()
        #undef  NohDC
        PtVisible(hDC, X, Y):bVisible
        hDC     hDC;
        short   X;
        short   Y;
return  Boolean

ReadComm
        Reads up to nSize bytes from the communication device nCid into buffer
        lpBuf.
entry   ReadComm()
        #undef  NoComm
        ReadComm(nCid, lpBuf, nSize):nBytes
        short   nCid;
        lpStr   lpBuf;
        int     nSize;
return  short
Rectangle
        Draws rectangle, using current pen for border and current brush for
        filling.
entry   Rectangle()
        #undef  NohDC
        Rectangle(hDC, X1, Y1, X2, Y2):bDrawn
        hDC     hDC;
        short   X1;
        short   Y1;
        short   X2;
        short   Y2;
return  Boolean

RectVisible
        Determines if any part of given rectangle lies within clipping region.
entry   RectVisible()
        #undef  NohDC
        #undef  NoRect
        RectVisible(hDC,lpRect):bVisible
        hDC     hDC;
        lpRect  lpRect;
return  Boolean

RegisterClass
```

```
        Registers a window class.
entry   RegisterClass()
        #undef  NoBrush
        #undef  NoWndClass
        RegisterClass(lpWndClass):bRegistered
     lpWndClass lpWndClass;
return  Boolean

RegisterClipboardFormat
        Registers a new clipboard format whose name is pointed to by lpFormatName.
entry   RegisterClipboardFormat()
        #undef  NoClipBoard
        RegisterClipboardFormat(lpFormatName):wFormat
        lpStr lpFormatName;
return  word

RegisterWindowMessage
        Defines a new window message that is guaranteed to be unique.
entry   RegisterWindowMessage()
        #undef  NoWinMessages
        RegisterWindowMessage(lpString):wMsg
        lpStr   lpString;
return  unsigned

ReleaseCapture
        Releases mouse input and restores normal input processing.
entry   ReleaseCapture()
        ReleaseCapture()
return  void

ReleaseDC
        Releases a display context when an application is finished drawing in it.
entry   ReleaseDC()
        #undef  NohDC
        ReleaseDC(hWnd, hDC):nReleased
        hWnd    hWnd;
        hDC     hDC;
return  int

RemoveFontResource
        Removes from the font table the font resource named by lpFilename.
entry   RemoveFontResource()
        RemoveFontResource(lpFilename):bSuccess
        lpStr   lpFilename;
return  Boolean

RemoveProp
        Removes lpString from property list; retrieves corresponding data handle.
entry   RemoveProp()
        RemoveProp(hWnd, lpString):hData
        hWnd    hWnd;
        lpStr   lpString;
return  handle

ReplyMessage
        Replies to message without returning control to the SendMessage caller.
nentry  ReplyMessage()
        #undef  NoWinMessages
        ReplyMessage(lReply)
        long    lReply;
return  void

RestoreDC
        Restores display context given by hDC to previous state given by nSavedDC.
entry   RestoreDC()
        #undef  NohDC
        RestoreDC(hDC, nSavedDC):bRestored
        hDC     hDC;
        short   nSavedDC;
return  Boolean
```

```
RGB
        Creates an RGB colour value from individual red, green, and blue values.
entry   RGB()
        RGB(r,g,b):dword
return  none

RoundRect
        Draws rounded rectangle, using current pen for border, current brush for
        filling.
entry   RoundRect()
        #undef  NohDC
        RoundRect(hDC, X1, Y1, X2, Y2.X3, Y3):bDrawn
        hDC     hDC;
        short   X1;
        short   Y1;
        short   X2;
        short   Y2 . X3;
        short   Y3;
return  Boolean

SaveDC
        Saves the current state of the display context hDC.
entry   SaveDC()
        #undef  NohDC
        SaveDC(hDC):nSavedDC
        hDC     hDC;
return  short

ScreenToClient
        Converts the screen coordinates at lpPoint to client coordinates.
entry   ScreenToClient()
        #undef  NoPoint
        ScreenToClient(hWnd,lpPoint)
        hWnd    hWnd;
        lpPoint lpPoint;
return  void

ScrollWindow
        Moves contents of client area XAmount along screen's x-axis and YAmount
        units along y-axis (right for positive XAmount; down for positive
        YAmount).
entry   ScrollWindow()
        #undef  NoRect
        ScrollWindow(hWnd, XAmount, YAmount, lpRect, lpClipRect)
        hWnd    hWnd;
        int     XAmount;
        int     YAmount;
        lpRect  lpRect;
        lpRect  lpClipRect;
return  void

SelectClipRgn
        Selects given region as current clipping region for the specified display
        context.
entry   SelectClipRgn()
        #undef  NohDC
        #undef  NoRegion
        SelectClipRgn(hDC, hRgn):nRgnType
        hDC     hDC;
        hRgn    hRgn;
return  short

SelectObject
        Selects hObject as current object, replacing previous object of same type.
entry   SelectObject()
        #undef  NohDC
        SelectObject(hDC, hObject):hOldObject
        hDC     hDC;
        handle  hObject;
return  handle
```

```
SendDlgItemMessage
        Sends a message to nIDDlgItem within the dialogue box specified by hDlg.
entry   SendDlgItemMessage()
        #undef  NoCtlMgr
        SendDlgItemMessage(hDlg, nIDDlgItem, wMsg, wParam, lParam):lResult
        hWnd    hDlg;
        int     nIDDlgItem;
       unsigned wMsg;
        word    wParam;
        long    lParam;
return  long

SendMessage
        Sends a message to a window or windows.
entry   SendMessage()
        #undef  NoWinMessages
        SendMessage(hWnd, wMsg, wParam, lParam):lReply
        hWnd    hWnd;
       unsigned wMsg;
        word    wParam;
        long    lParam;
return  long

SetActiveWindow
        Makes a tiled or pop-up style window the active window.
entry   SetActiveWindow()
        SetActiveWindow(hWnd):hWndPrev
        hWnd    hWnd;
return  hWnd

SetBitmapBits
        Sets bitmap bits to values given at lpBits. dwCount is byte count at
        lpBits.
entry   SetBitmapBits()
        #undef  NoBitmap
        SetBitmapBits(hBitmap, dwCount, lpBits):bCopied
        hBitmap hBitmap;
        dword   dwCount;
        lpStr   lpBits;
return  Boolean

SetBitmapDimension
        Associates a width and height, in 0.1 millimeter units, with a bitmap.
entry   SetBitmapDimension()
        #undef  NoBitmap
        SetBitmapDimension(hBitmap, X, Y):ptOldDimensions
        hBitmap hBitmap;
        short   X;
        short   Y;
return  Dword

SetBkColour
        Sets the background colour to the device colour closest to rgbColour.
entry   SetBkColour()
        #undef  NohDC
        SetBkColour(hDC, rgbColour):nOldColour
        hDC     hDC;
        dword   rgbColour;
return  dword

SetBkMode
        Sets the background mode used with text, hatched brushes, and line styles.
entry   SetBkMode()
        #undef  NohDC
        SetBkMode(hDC, nBkMode):nOldMode
        hDC     hDC;
        short   nBkMode;
return  short

SetBrushOrg
        Sets the origin of all brushes selected into the given display context.
```

```
 entry   SetBrushOrg()
         #undef  NoBrush
         SetBrushOrg(hDC, X, Y):dwOldOrigin
         hDC     hDC;
         int     X;
         int     Y;
 return  dword

 SetCapture
         Causes mouse input to be sent to hWnd, regardless of mouse cursor
         position.
 enter   SetCapture()
         SetCapture(hWnd):hWndPrev
         hWnd    hWnd;
 return  hWnd

 SetCaretBlinkTime
         Establishes the caret flash rate.
 entry   SetCaretBlinkTime()
         SetCaretBlinkTime(wMSeconds)
         word    wMSeconds;
 return  void

 SetCaretPos
         Moves caret to the position specified by X and Y.
 entry   SetCaretPos()
         SetCaretPos(X, Y)
         int     X;
         int     Y;
 return  void

 SetClassLong
         Replaces long value at nIndex in the WNDCLASS structure.
 entry   SetClassLong()
         #undef  NoWinOffsets
         SetClassLong(hWnd, nIndex, lNewLong):lOldLong
         hWnd    hWnd;
         int     nIndex;
         long    lNewLong;
 return  long

 SetClassWord
         Replaces word at the given nIndex in the WNDCLASS structure.
 entry   SetClassWord()
         #undef  NoWinOffsets
         SetClassWord(hWnd, nIndex, wNewWord):wOldword
         hWnd    hWnd;
         int     nIndex;
         word    wNewWord;
 return  word

 SetClipboardData
         Copies hMem, a handle for data having wFormat format, into the clipboard.
 entry   SetClipboardData()
         #undef  NoClipboard
         SetClipboardData(wformat, hMem):hClipData
         word    wformat;
         handle  hMem;
 return  handle

 SetClipboardViewer
         Adds hWnd to clipboard viewer chain. hWndNext is next window in chain.
 entry   SetClipboardViewer()
         #undef  NoClipboard
         SetClipboardViewer(hWnd):hWndNext
         hWnd    hWnd;
 return  hWnd

 SetCommBreak
         Sets a break state on communication device nCid and suspends character
         transmission.
```

```
entry   SetCommBreak()
        #undef  NoComm
        SetCommBreak(nCid):nResult
        short   nCid;
return  short

SetCommEventMask
        Sets the event mask of the communication device nCid.
entry   SetCommEventMask()
        #undef  NoComm
        SetCommEventMask(nCid, nEvtMask):lpEvent
        short   nCid;
        word    nEvtMask;
return  word FAR *

SetCommState
        Sets a communication device to the state specified by the device control
        block lpDCB. The device to be set is identified by the ID field of the
        control block.
entry   SetCommState()
        #undef  NoComm
        SetCommState(lpDCB):nResult
        DCB FAR * lpDCB;
return  short

SetCursor
        Sets cursor shape in hCursor, removes cursor from screen if hCursor is
        NULL.
entry   SetCursor()
        SetCursor(hCursor):hOldCursor
        hCursor hCursor;
return  hCursor

SetCursorPos
        Sets position of mouse cursor to screen coordinates given by X and Y.
entry   SetCursorPos()
        SetCursorPos(X, Y)
        int     X;
        int     Y;
return  void

SetDlgItemInt
        Sets text of nIDDlgItem to string representing an integer.
entry   SetDlgItemInt()
        #undef  NoCtlMgr
        SetDlgItemInt(hDlg, nIDDlgItem, wValue, bSigned)
        hWnd    hDlg;
        int     nIDDlgItem;
        unsigned wValue;
        Boolean    bSigned;
return  void

SetDlgItemText
        Sets caption or text of nIDDlgItem to lpString.
entry   SetDlgItemText()
        #undef  NoCtlMgr
        SetDlgItemText(hDlg, nIDDlgItem, lpString)
        hWnd    hDlg;
        int     nIDDlgItem;
        lpStr   lpString;
return  void

SetEnvironment
        Copies data at lpEnviron to environment associated with device attached
        to given port.
entry   SetEnvironment()
        SetEnvironment(lpPortName, lpEnviron, nCount):nCopied
        lpStr   lpPortName;
        lpStr   lpEnviron;
        word    nCount;
```

```
return  short

SetFocus
        Assigns the input focus to the window specified by hWnd.
entry   SetFocus()
        SetFocus(hWnd):hWndPrev
        hWnd    hWnd;
return  hWnd

SetMapMode
        Sets the mapping mode of the specified display context.
entry   SetMapMode()
        #undef  NohDC
        SetMapMode(hDC, nMapMode):nOldMapMode
        hDC     hDC;
        short   nMapMode;
return  short

SetMenu
        Sets window menu to hmenu. Removes menu if hMenu is NULL.
entry   SetMenu()
        #undef  NoMenus
        SetMenu(hWnd, hMenu):bSet
        hWnd    hWnd;
        hMenu   hMenu;
return  Boolean

SetMetaFileBits
        Creates memory metafile from data in the given global memory block.
entry   SetMetaFileBits()
        SetMetaFileBits(hMem):hMF
        handle  hMem;
return  handle

SetPixel
        Sets pixel at X, Y to the device colour closest to rgbColour.
entry   SetPixel()
        #undef NohDC
        SetPixel(hDC, X, Y, rgbColour):rgbActualColour
        hDC     hDC;
        short   X;
        short   Y;
        dword   rgbColour;
return  dword

SetPolyFillMode
        Sets the polygon-filling mode for the specified display context.
entry   SetPolyFillMode()
        #undef  NohDC
        SetPolyFillMode(hDC, nPolyFillMode):nOldPolyFillMode
        hDC     hDC;
        short   nPolyFillMode;
return  short

SetPriority
        Sets the task priority of the task hTask, and returns new priority.
SetPriority()
        SetPriority(hTask, nChangeAmount):nNew
        handle  hTask;
        int     nChangeAmount;
return  int

SetProp
        Copies string and data handle to property list of hWnd.
entry   SetProp()
        SetProp(hWnd, lpString, hData):bSet
        hWnd    hWnd;
        lpStr   lpString;
        handle  hData;
return  Boolean
```

```
SetRect
        Fills RECT structure at lpRect with given coordinates.
entry   SetRect()
        #undef  NoRect
        SetRect(lpRect, X1, Y1, X2, Y2):nResult
        lpRect  lpRect;
        int     X1;
        int     Y1;
        int     X2;
        int     Y2;
return  int

SetRectEmpty
        Sets the rectangle to an empty rectangle (all coordinates are zero).
entry   SetRectEmpty()
        #undef  NoRect
        SetRectEmpty(lpRect):nResult
        lpRect  lpRect;
return  int

SetRelAbs
        Sets the relabs flag.
entry   SetRelAbs()
        #undef  NohDC
        SetRelAbs(hDC, nRelAbsMode):nOldRelAbsMode
        hDC     hDC;
        short   nRelAbsMode;
return  short

SetResourceHandler
        Sets the function address of the resource handler for resources with type
        lpType. A resource handler provides for loading of custom resources.
entry   SetResourceHandler()
        SetResourceHandler(hInstance, lpType, lpLoadFunc):lpLoadFunc
        handle  hInstance;
        lpStr   lpType;
        FarProc lpLoadFunc;
return  FARPROC

SetROP2
        Sets the current drawing mode.
entry   SetROP2()
        #undef  NohDC
        SetROP2(hDC, nDrawMode):nOldDrawMode
        hDC     hDC;
        short   nDrawMode;
return  short

SetScrollPos
        Sets scroll bar elevator to nPos; redraws scroll bar if bRedraw is
        nonzero.
entry   SetScrollPos()
        #undef  NoScroll
        SetScrollPos(hWnd, nBar, nPos, bRedraw):nOldPos
        hWnd    hWnd;
        int     nBar;
        int     nPos;
        Boolean    bRedraw;
return  int

SetScrollRange
        Set minimum and maximum scroll bar positions for a given scroll bar.
entry   SetScrollRange()
        #undef  NoScroll
        SetScrollRang(hWnd, nBar, nMinPos, nMaxPos, bRedraw)
        hWnd    hWnd;
        int     nBar;
        int     nMinPos;
        int     nMaxPos;
        Boolean bRedraw;
return  void
```

```
SetSoundNoise
        Sets the source and duration of a noise from the play device
entry   SetSoundNoise()
        #undef  NoSound
        SetSoundNoise(nSource, nDuration):nResult
        int     nSource;
        int     nDuration;
return  int

SetStretchBltMode
        Sets the stretching mode for the StretchBlt function.
entry   SetStretchBltMode()
        #undef  NohDC
        SetStretchMode(hDC, nStretchMode):nOldStretchMode
        hDC     hDC;
        short   nStretchMode;
return  short

SetSysColours
        Changes one or more system colours.
entry   SetSysColours()
        #undef  NoColour
        SetSysColours(nChange, lpSysColour, lpColourValues)
        int     nChange;
        lpInt   lpSysColour;
    long FAR *  lpColourValues;
return  void

SetSysModalWindow
        Makes the specified window a system-modal window.
entry   SetSysModalWindow()
        SetSysModalWindow(hWnd):hPrevWnd
        hWnd    hWnd;
return  hWnd

SetTextCharacterExtra
        Sets the amount of intercharacter spacing.
entry   SetTextCharacterExtra()
        #undef  NohDC
        SetTextCharacterExtra(hDC, nCharExtra):nOldCharExtra
        hDC     hDC;
        short   nCharExtra;
return  short

SetTextColour
        Sets text colour to the device colour closest to rgbColour.
entry   SetTextColour()
        #undef  NohDC
        SetTextcolour(hDC, rgbColour):rgbOldColour
        hDC     hDC;
        dword   rgbColour;
return  dword

SetTextJustification
        Prepares GDI to justify a text line using nBreakExtra and nBreakCount.
entry   SetTextJustification()
        #undef  NohDC
        SetTextJustification(hDC, nBreakExtra, nBreakCount):nSet
        hDC     hDC;
        short   nBreakExtra;
        short   nBreakCount;
return  short

SetTimer
        Creates system timer event identified by nIDEvent. wElapse is elapsed
        milliseconds. lpTimerFunc receives timer messages; if NULL, messages go
        to application queue.
entry   SetTimer()
        SetTimer(hWnd, nIDEvent, wElapse, lpTimerFunc):nIDNewEvent
        hWnd    hWnd;
        short   nIDEvent;
```

```
        unsigned wElapse;
        FarProc lpTimerFunc;
return  short

SetViewportExt
        Sets the X and Y extents of the viewport of the specified display context.
entry   SetViewportExt()
        #undef  NohDC
        SetViewportExt(hDC, X, Y):ptOldExtents
        hDC     hDC;
        short   X;
        short   Y;
return  Dword

SetViewportOrg
        Sets the viewport origin of the specified display context.
entry   SetViewportOrg()
        #undef  NohDC
        SetViewportOrg(hDC, X, Y):ptOldOrigin
        hDC     hDC;
        short   X;
        short   Y;
return  Dword
SetVoiceAccent
        Places an accent (tempo, volume, mode, and pitch) in the voice queue
        nVoice.
entry   SetVoiceAccent()
        #undef  NoSound
        SetVoiceAccent(nVoice, nTempo, nVolume, nMmode, nPitch):nResult
        int     nVoice;
        int     nTempo;
        int     nVolume;
        int     nMmode;
        int     nPitch;
return  int

SetVoiceEnvelope
        Places the envelope (wave shape and repeat count) in the voice queue
        nVoice.
entry   SetVoiceEnvelope()
        #undef  NoSound
        SetVoiceEnvelope(nVoice, nShape, nRepeat):nResult
        int     nVoice;
        int     nShape;
        int     nRepeat;
return  int

SetVoiceNote
        Places a note in the voice queue nVoice.
entry   SetVoiceNote()
        #undef  NoSound
        SetVoiceNote(nVoice, nValue, nLength, nCdots):nResults
        int     nVoice;
        int     nValue;
        int     nLength;
        int     nCdots;
return  int

SetVoiceQueueSize
        Allocates nBytes of memory for the voice queue nVoice.
entry   SetVoiceQueueSize()
        #undef  NoSound
        SetVoiceQueueSize(nVoice, nBytes):nResult
        int     nVoice;
        int     nBytes;
return  int
note    Default is 192 bytes.

SetVoiceSound
        Places a sound (frequency and duration) in the voice queue nVoice.
entry   SetVoiceSound()
```

```
        #undef  NoSound
        SetVoiceSound(nVoice, nFrequency, nDuration):nResult
        int     nVoice;
        int     nFrequency;
        int     nDuration;
return  int

SetVoiceThreshold
        Sets the threshold level to nNotes for the voice queue nVoice.
entry   SetVoiceThreshold()
        #undef  NoSound
        SetVoiceThreshold(nVoice, nNotes):nResult
        int     nVoice;
        int     nNotes;
return  int

SetWindowExt
        Sets the X and Y extents of the window of the specified display context.
entry   SetWindowExt()
        #undef  NohDC
        SetWindowExt(hDC, X, Y):ptOldExtents
        hDC     hDC;
        short   X;
        short   Y;
return  dword

SetWindowLong
        Changes the window attribute identified by nIndex.
entry   SetWindowLong()
        #undef  NoWinOffsets
        SetWindowLong(hWnd, nIndex, lNewLong):lOldLong
        hWnd    hWnd;
        int     nIndex;
        long    lNewLong;
return  long

SetWindowOrg
        Sets the window origin of the specified display context.
entry   SetWindowOrg()
        #undef  NohDC
        SetWindowOrg(hDC, X, Y):ptOldOrigin
        hDC     hDC;
        short   X;
        short   Y;
return  dword

SetWindowsHook
        Installs a system and/or application hook function.
entry   SetWindowsHook()
        #undef  NoWH
        SetWindowsHook(nFilterType, lpFilterFunc):lpPrevFilterFunc
        int     nFilterType;
        FarProc lpFilterFunc;
return  FarProc

SetWindowText
        Sets window caption (if any) or text (if a control) to lpString.
entry   SetWindowText()
        SetWindowText(hWnd, lpString)
        hWnd    hWnd;
        lpStr   lpString;
return  void

SetWindowWord
        Changes the window attribute specified by nIndex.
entry   SetWindowWord()
        #undef  NoWinOffsets
        SetWindowWord(hWnd, nIndex, nNewWord):wOldWord
        hWnd    hWnd;
        int     nIndex;
        word    nNewWord;
```

```
return  word

ShowCaret
        Displays newly-created caret or redisplays hidden caret.
entry   ShowCaret()
        ShowCaret(hWnd)
        hWnd    hWnd;
return  void

ShowCursor
        Adds 1 to cursor display count if bShow is nonzero. Subtracts 1 if bShow
        is zero.
entry   ShowCursor()
        ShowCursor(bShow):nCount
        Boolean bShow;
return  int

ShowWindow
        Displays or removes the given window as specified by nCmdShow.
entry   ShowWindow()
        ShowWindow(hWnd, nCmdShow):bShown
        hWnd    hWnd;
        int     nCmdShow;
return  Boolean

SizeofResource
        Returns the size, in bytes, of resource hResInfo.
entry   SizeofResource()
        SizeofResource(hInstance, hResInfo):wBytes
        handle  hInstance;
        handle  hResInfo;
return  word

StartSound
        Starts play in each voice queue.
entry   StartSound()
        #undef  NoSound
        StartSound():nResult
return  int

StopSound
        Stops playing all voice queues and flushes the contents of the queues.
entry   StopSound()
        #undef  NoSOund
        StopSound():nResult
return  int

StretchBlt
        Moves bitmap from source rectangle into destination rectangle, stretching
        or compressing as necessary. Source origin is at XSrc, YSrc. X, Y,
        nWidth, and nHeight give origin and dimensions of rectangle on
        destination device. dwROP defines how source and destination bits are
        combined.
entry   StretchBlt()
        #undef  NohDC
        StretchBlt(hDestDC, X, Y, nWidth, nHeight, hSrcDC, XSrc, YSrc,
                   nSrcWidth, nSrcHeight, dwROP):bDrawn
        hDC     hDestDC;
        short   X;
        short   Y;
        short   nWidth;
        short   nHeight;
        hDC     hSrcDC;
        short   XSrc;
        short   YSrc;
        short   nSrcWidth;
        short   nSrcHeight;
        dword   dwROP;
return  Boolean
```

```
SwapMouseButton
        Swaps the meaning of the left and right mouse buttons if bSwap is TRUE.
entry   SwapMouseButton()
        SwapMouseButton(bSwap):bSwapped
        Boolean bSwap;
return  Boolean

SyncAllVoices
        Places a sync mark in each voice queue. Voices wait at the sync mark
        until all queues have encountered it.
entry   SyncAllVoices()
        #undef  NoSound
        SyncAllVoices():nResult
return  int

TextOut
        Writes character string using current font and starting at X, Y.
entry   TextOut()
        #undef  NohDC
        TextOut(hDC, X, Y, lpString, nCount):bDrawn
        hDC     hDC;
        short   X;
        short   Y;
        lpStr   lpString;
        short   nCount;
return  Boolean

Throw
        Restores the execution environment to the values in buffer lpCatchBuf.
        Execution continues at the location specified by the environment with
        the return value nThrowBack available for processing.
entry   Throw()
        Throw(lpCatchBuf, nThrowBacki)
     lpCatchBuf lpCatchBuf;
        int     nThrowBacki;
return  void

TranslateAccelerator
        Processes keyboard accelerators for menu commands.
entry   TranslateAccelerator()
        #undef  NoMsg
        TranslateAccelerator(hWnd, hAccTable, lpMsg):nTranslated
        hWnd    hWnd;
        handle  hAccTable;
        lpMsg   lpMsg;
return  int

TranslateMessage
        Translates virtual keystroke messages into character messages.
entry   TranslateMessage()
        #undef  NoMsg
        TranslateMessage(lpMsg):bTranslated
        lpMsg   lpMsg;
return  Boolean

TransmitCommChar
        Places the character cChar at the head of the transmit queue for
        immediate transmission.
entry   TransmitCommChar()
        #undef  NoComm
        TransmitCommChar(nCid, cChar):nResult
        short   nCid;
        char    cChar;
return  short

UngetCommChar
        Makes the character cChar the next character to be read from the receive
        queue.
entry   UngetCommChar()
        #undef  NoComm
        UngetCommChar(nCid, cChar):nResult
```

```
        short   nCid;
        char    cChar;
return  short

UnionRect
        Stores the union of two rectangles at lpDestRect.
entry   UnionRect()
        #undef  NoRect
        UnionRect(lpDestRect, lpSrc1Rect, lpSrc2Rect):nUnion
        lpRect  lpDestRect;
        lpRect  lpSrc1Rect;
        lpRect  lpSrc2Rect;
return  int

UnlockData
        Unlocks the data segment.
entry   UnlockData()
        UnlockData(Dummy)

UnlockSegment
        Unlocks the segment whose segment address is wSegment.
entry   UnlockSegment()
        #undef  NoMemMgr
        UnlockSegment(wSegment):hMem
        word    wSegment;
return  handle

UnrealizeObject
        Directs GDI to reset the origin of the given brush the next time it is
        selected.
entry   UnrealizeObject()
        #undef  NoBrush
        UnrealizeObject(hBrush):bUnrealized
        hBrush  hBrush;
return  Boolean

UpdateWindow
        Notifies application when parts of a window need redrawing after changes.
entry   UpdateWindow()
        UpdateWindow(hWnd)
        hWnd    hWnd;
return  void

ValidateRect
        Releases from repainting rectangle specified by lpRect (in client
        coordinates). If lpRect is NULL, entire window is validated.
entry   ValidateRect()
        #undef  NoRect
        ValidateRect(hWnd, lpRect)
        hWnd    hWnd;
        lpRect  lpRect;
return  void

ValidateRgn
        Releases hRgn from repainting. If hRgn is NULL, entire region is
        validated.
entry   ValidateRgn()
        #undef  NoRegion
        ValidateRgn(hWnd, hRgn)
        hWnd    hWnd;
        hRgn    hRgn;
return  void

WaitMessage
        Yields control to other applications when application has no tasks to
        perform.
entry   WaitMessage()
        #undef  NoWinMessages
        WaitMessage()
return  void
```

```
WaitSoundState
        Waits until the play driver enters the state nState.
entry   WaitSoundState()
        #undef  NoSound
        WaitSoundState(nState):nResult
        int     nState;
return  int

WindowFromPoint
        Identifies the window containing Point (in screen coordinates).
entry   WindowFromPoint()
        #undef  NoPoint
        WindowFromPoint(Point):hWnd
        Point   Point;
return  hWnd

WinMain
        Serves as entry point for execution of a Windows application.
entry   WinMain()
        WinMain(hInstance, hPrevInstance, lpCmdLine, nCmdShow):nExitCode

WndProc
        Processes  messages sent to it by Windows or the application's main
        function.
entry   WndProc()
        WndProc(hWnd, wMsg, wParam, lParam):lReply

WriteComm
        Writes up to nSize bytes from buffer lpBuf to communication
        device nCid.
entry   WriteComm()
        #undef  NoComm
        WriteComm(nCid, lpBuf, nSize):nbytes
        short   nCid;
        lpStr   lpBuf;
        int     nSize;
return  short

WriteProfileString
        Copies character string lpString to the WIN.INI file. The string replaces
        the current string named by lpKeyName in section lpSectionname. If the
        key or section does not exist, a new key and section are created.
entry   WriteProfileString()
        WriteProfileString(lpApplicationName, lpKeyName, lpString):bResult
        lpStr   lpApplicationName;
        lpStr   lpKeyName;
        lpStr   lpString;
return  Boolean

Yield
        Halts the current task and starts any waiting task.
entry   Yield()
        Yield():bResult
return  Boolean
```

Errors

The following error codes are returned by Windows 1.03:

Error	Description
001h	Insufficient memory for allocation
002h	Error reallocating memory
003h	Memory cannot be freed
004h	Memory cannot be locked
005h	Memory cannot be unlocked
007h	Window handle not valid
008h	Cached display contexts are busy

010h	Clipboard already open
013h	Mouse module not valid
014h	Display module not valid
015h	Unlocked data segment should be locked
016h	Invalid lock on system queue
100h	Lock memory errors
140h	Local heap is busy
180h	Invalid local handle
1C0h	LocalLock count overflow
1F0h	LocalUnlock count underflow
200h	Global memory errors
240h	Critical section problems
280h	Invalid global handle
2C0h	GlobalLock count overflow
2F0h	GlobalUnlock count underflow
300h	Task schedule errors
301h	Invalid task ID
302h	Invalid exit system call
303h	Invalid BP register chain
400h	Dynamic loader/linker errors
401h	Error during boot process
402h	Error loading a module
403h	Invalid ordinal reference
404h	Invalid entry name reference
405h	Invalid start procedure
406h	Invalid module handle
407h	Invalid relocation record
408h	Error saving forward reference
409h	Error reading segment contents
410h	Error reading segment contents
411h	Insert disk for specified file
412h	Error reading non-resident table
4FFh	int 3Fh handler unable to load segment
500h	Resource manager/user profile errors
501h	Missing resource table
502h	Bad resource type
503h	Bad resource type
504h	Bad resource type
505h	Error reading resource
600h	Atom manager errors
700h	Input/output package errors

13

Network Interfacing

Interrupt 60h FTP Driver - PC/TCP Packet Driver Specification
The handler for the interrupt will start with a 3-byte jump instruction, followed by the ASCIIZ string 'PKT DRVR'. To find the interrupt being used by the driver, an application should scan through interrupt vectors 60h to 80h until it finds one with the 'PKT DRVR' string.

Network Interface classes/types:

```
Class   01h     Ethernet/IEEE 802.3
                01h     3COM 3C500/3C501
                02h     3COM 3C505
                03h     MICOM-Interlan NI5010
                04h     BICC Data Networks 4110
                05h     BICC Data Networks 4117
                06h     MICOM-Interlan NP600
                08h     Ungermann-Bass PC-NIC
                09h     Univation NC-516
                0Ah     TRW PC-2000
                0Bh     MICOM-Interlan NI5210
                0Ch     3COM 3C503
                0Dh     3COM 3C523
                0Eh     Western Digital WD8003
                0Fh     Spider Systems S4
Class   02h     ProNET-10
        01h     Proteon p1300
Class   03h     IEEE 802.5/ProNet-4
        01h     IBM Token-Ring Adapter
        02h     Proteon p1340
        03h     Proteon p1344
Class   04h     Omninet
Class   05h     Appletalk
Class   06h     Serial Line
Class   07h     StarLAN
Class   08h     ARCnet
                01h     Datapoint RIM

entry   AX      01FFh   Get Class
        BX      handler returned by function 02h
return  CF      set on error
        DH      error code
                01h     invalid handle number
                02h     no interfaces of the specified class found
                03h     no interfaces of the specified type found
                04h     no interfaces of the specified number found
                05h     bad packet type
                06h     interface does not support multicast messages
                07h     this packet driver cannot terminate
                08h     invalid receiver mode
```

```
                09h     insufficient space
                0Ah     type accessed but never released
                0Bh     bad command
                0Ch     packet could not be sent
        CF      clear if successful
        BX      version
        CH      class
        DX      type
        CL      number
        DS:SI   pointer to name
        AL      driver type
                01h     basic
                02h     extended
                0FFh    not installed

entry   AH      02h - FTP Driver - Access Type
        AL      interface class
        BX      interface type
        CX      length of type
        DL      interface number
        DS:SI   pointer to type
        ES:DI   pointer to receiver
return  CF      set on error
                DH      error code (see above)
        CF      clear if successful
                AX      handle
note    Receiver called with:
        AX      subfunction
                00h     application to return pointer to buffer in ES:DI
                        ES:DI   0:0 means throw away packet
                01h     copy to DS:SI buffer completed
        BX      handle
        CX      buffer length when a packet is received

entry   AH      03h - FTP Driver - Release Type
        BX      handle
return  CF      set on error
                DH      error code (see above)
        CF      clear if successful

entry   AH      04h - FTP Driver - Send Packet
        CX      length
        DS:SI   pointer to buffer
return  CF      set on error
                DH      error code (see above)

entry   AH      05h - FTP Driver - Terminate Driver For Handle
        BX      handle
return  CF      set on error
                DH      error code (see above)

entry   AH      06h - FTP Driver - Get Address
        BX      handle
        CX      length
        ES:DI   pointer to buffer
return  CF      set on error
                DH      error code (see above)
        CF      clear if successful
                CX      length
note    Copies the local net address associated with the handle into the buffer

entry   AH      07h - FTP Driver - Reset Interface
        BX      handle
return  CF      set on error
                DH      error code (see above)

Interrupt 60h   10-Net Network
entry   AH      11h     Lock and Wait
        AL      drive number or 0
        DX      number of seconds to wait
        ES:SI   Ethernet address or 0
```

```
        DS:BX   pointer to 31-byte ASCIIZ semaphore name
return  AL      status
                00h     successful
                01h     timeout
                02h     server not responding
                03h     invalid semaphore name
                04h     semaphore list is full
                05h     invalid drive ID
                06h     invalid Ethernet address
                07h     not logged in
                08h     write to network failed
                09h     semaphore already logged for this CPU

entry   AH      12h     Lock
        AL      drive number or 0 for default
        ES:SI   Ethernet address or 0
        DS:BX   pointer to 31-byte ASCIIZ semaphore name
return  AL      status (see function 11h)
                01h     semaphore currently logged
note    Unlike function 11h, this function returns immediately.

entry   AH      13h     Unlock
        AL      drive number or 0
        ES:SI   Ethernet address or 0
        DS:BX   pointer to 31-byte ASCIIZ semaphore name
return  AL      status (see function 11h)
                01h   semaphore not logged

entry   AH      20h - FTP Driver - Set Receive Mode
        BX      handle
        CX      mode
                01h     turn off receiver
                02h     receive only packets sent to this interface
                03h     mode 2 plus broadcast packets
                04h     mode 3 plus limited multicast packets
                05h     mode 3 plus all multicast packets
                06h     all packets
return  CF      set on error
                DH      error code

entry   AH      21h - FTP Driver - Get Receive Mode
        BX      handle
return  CF      set on error
                DH      error code (see function 01h above)
        CF      clear if successful
                AX      mode

entry   AH      24h - FTP Driver - Get Statistics
        BX      handle
return  CF      set on error
                DH      error code
        CF      clear if successful
                DS:SI   pointer to statistics buffer
                        dword   packets in
                        dword   packets out
                        dword   bytes in
                        dword   bytes out
                        dword   errors in
                        dword   errors out
                        dword   packets dropped

Interrupt 5Ch   NETBIOS interface entry port, TOPS
entry   AH      5Ch
        ES:BX   pointer to network control block
                Subfunction in first NCB field (or with 80h for non-waiting call)
                10h     start session with NCB_NAME name (call)
                11h     listen for call
                12h     end session with NCB_NAME name (hangup)
                14h     send data via NCB_LSN
                15h     receive data from a session
                16h     receive data from any session
```

```
                17h     send multiple data buffers
                20h     send unACKed message (datagram)
                21h     receive datagram
                22h     send broadcast datagram
                23h     receive broadcast datagram
                30h     add name to name table
                31h     delete name from name table
                32h     reset adapter card and tables
                33h     get adapter status
                34h     status of all sessions for name
                35h     cancel
                36h     add group name to name table
                70h     unlink from IBM remote program (no F0h function)
                71h     send data without ACK
                72h     send multiple buffers without ACK
                78h     find name
                79h     token-ring protocol trace
return  AL      status
                00h     successful
                01h     bad buffer size
                03h     invalid NETBIOS command
                05h     timeout
                06h     receive buffer too small
                08h     bad session number
                09h     LAN card out of memory
                0Ah     session closed
                0Bh     command has been cancelled
                0Dh     name already exists
                0Eh     local name table full
                0Fh     name still in use, can't delete
                11h     local session table full
                12h     remote PC not listening
                13h     bad NCB_NUM field
                14h     no answer to CALL or no such remote
                15h     name not in local name table
                16h     duplicate name
                17h     bad delete
                18h     abnormal end
                19h     name error, multiple identical names in use
                1Ah     bad packet
                21h     network card busy
                22h     too many commands queued
                23h     bad LAN card number
                24h     command finished while cancelling
                26h     command can't be cancelled
                0FFh    NETBIOS busy
return  AL      error code (0 if none)
note 1. When the NETBIOS is installed ints 13h and 17h are interrupted by the
        NETBIOS. Int 18h is moved to int 86h and one of int 02h or 03h is used
        by NETBIOS. Also, NETBIOS extends the int 15h/fns 90h and 91h functions
        (scheduler functions).
     2. Normally not initialized.
     3. TOPS network card uses DMA 1, 3 or none.
     4. Sytek PCnet card uses DMA 3.
     5. Structure of Network Control Block:
        byte    ncb_command
        byte    ncb_retcode
        byte    ncb_lsn
        byte    ncb_num
        dword   pointer to ncb_buffer
        word    ncb_length
     16 bytes   ncb_callname
     16 bytes   ncb_name
        byte    ncb_rto
        byte    ncb_sto
        dword   pointer to ncb_post
        byte    ncb_lana_num
        byte    ncb_cmd_cplt
     14 bytes   ncb_reserve
     6. Structure name:
     16 bytes   nm_name
```

```
        byte     nm_num
        byte     nm_status
     7. Structure A-status:
      6 bytes    as_ID
        byte     as_jumpers
        byte     as_post
        byte     as_major
        byte     as_minor
        word     as_interval
        word     as_crcerr
        word     as_algerr
        word     as_colerr
        word     as_abterr
        dword    as_tcount
        dword    as_rcount
        word     as_retran
        word     as_xresrc
      8 bytes    as_res0
        word     as_ncbfree
        word     as_ncbmax
        word     as_ncbx
      4 bytes    as_res1
        word     as_sespend
        word     as_msp
        word     as_sesmax
        word     as_bufsize
        word     as_names
     16 name     structures  as_name

Interrupt    6Fh 10-Net
entry   AH       00h      Login
        DS:DX    pointer to login record
               8 bytes    user name
               8 bytes    password
              12 bytes    name of SuperStation
return  CL       security level
        AX       status
                 0000h    successful
                 01FFh    time out on response
                 02FFh    network (hardware) error
                 03FFh    invalid password
                 04FFh    local resource not available
                 05FFh    server resource not available
                 06FFh    already logged in under different name
                 07FFh    login security failure (node)
                 08FFh    not logged in
                 09FFh    position calc error
                 0AFFh    receive subfunction does not equal send subfunction
                          (i.e. read, write)
                 0BFFh    request function not in range
                 0CFFh    no more server file handle entries left
                 0DFFh    no more shared file table entries left
                 0EFFh    no more user file handle entries left
                 0FFFh    chat permit not on
                 10FFh    not a server on request
                 11FFh    no transporter board error
                 12FFh    time out on send
                 13FFh    item not found (spool item not in queue)
                 14FFh    DOS access incompatible
                 15FFh    record already locked
                 16FFh    invalid parameter
                 17FFh    record lock time out error
                 18FFh    currently spooling to named device
                 19FFh    dropped receive message (throttle)
                 1AFFh    open sharing violation
                 1BFFh    no more tuf entries left
                 1CFFh    not file owner on open
                 1DFFh    read security not passed
                 1EFFh    write security not passed
                 1FFFh    group security not passed
                 20FFh    security file failure
```

```
                21FFh   activity file failure
                22FFh   spool control file failure
                23FFh   device not mounted (spooling)
                24FFh   spool file has not been terminated
                25FFh   device not mounted or is not being shared
                26FFh   duplicate node ID
                27FFh   file not found error
                28FFh   no more files
                29FFh   unknown internal system error
                2AFFh   print queue is full or corrupted
                2BFFh   invalid function
                2CFFh   invalid handle
                2DFFh   too many files opened
                2EFFh   path not found
                2FFFh   named file is active
                0FF01h  timeout
                0FF02h  network error
                0FF03h  invalid password
                0FF04h  no local buffer
                0FF05h  superstation not available
                0FF06h  node already logged in
                0FF07h  login not valid from this node
                0FF08h  node ID already in use
                0FF16h  invalid parameter (bad length, invalid node ID, etc)
                0FF17h  record locked by another user
                0FF18h  sent message has been dropped

        AH      01h     Logoff
        DS:DX   pointer to superstation ID or nulls (12 bytes)
return  CX      number of files closed
        AX      status  (see function 00h)
                0FF08h  superstation ID not already logged in

entry   AH      02h     Status of Node
        DS:DX   pointer to 512-byte record
              8 bytes   user name (0 if none)
                byte    station type
                        00h     workstation
                        01h     superstation
                        02h     gateway station
                        03h     gateway active
                        04h     logged into multiple superstations
                        05h     reserved
             24 bytes   list of superstations logged into more than one
                        superstation
             12 bytes node ID
                word    message count for this station (send for user node,
                        receive for superstations)
        for superstations only:
                word    drives allocated (bit 0=A:, bit 1=B:,...)
                byte    user service flag
                    bit 7       gate
                        6       print permit on
                        5       ?
                        4       SUBMIT is on
                        3       mail waiting for node
                        2       calendar waiting for you
                        1       news waiting for you
                        0       mail waiting for you
                byte    printers allocated (bit 0=LPT1,...)
                byte    number of unprinted spool files
                byte    number of opened files
                byte    number of logged on nodes
                byte    primary drive (1=A:)
                byte    reserved
              n bytes   list of logged on node IDs (each 12 bytes, max 37 IDs)
                        (continues at offset 1F4h)
              3 bytes   time: sec/min/hrs
              3 bytes   date: day/mon/year (since 1980)
return  CF      set on error
                AX      error code (see function 00h)
```

```
entry   AH      03h     Get Address of Configuration Table
        DS:DI   pointer to node ID (optional)
return  ES:BX   pointer to record (actually starts at [BX-41])
                word    local device table address
                word    extended network error mapping table address
                word    shared device table address
                word    mounted device table address
                byte    receive buffer counter
                byte    collect buffer counter
                word    TUF address
                byte    enable flag
                byte    FCB keep flag
                word    reserved
---up to here, 10-Net v3.3---
                word    count of dropped Send6F
                word    buffer start address
                word    comm driver base address
                word    send/receive retry count
                byte    number of 550ms loops before timeout
                word    UFH address
                word    CDIR address
                word    LTAB address
                word    SFH address
                word    FTAB address
                word    RLTAB address
                word    SMI address
                word    NTAB address
        ES:BX   pointer to word address of first CT_DRV
                byte    number of DRV entries
              8 bytes   login name
             12 bytes   node ID (blank-padded)
              6 bytes   node address
                byte    flag
                byte    CT_CFLG (chat permit)
                    bit 0       CHAT permit
                        1       sound bell
                        2-7     ?
                byte    CT_PSFLG
                    bit 0       SUBMIT permit
                        1       SUBMIT received
                        2       SUBMIT active
                        3       CHAT called FOXPTRM
                        4       KB initiated
                        5       PRINT permit
                        6-7     ?
                byte    in 10-Net flag
                word    receive message count
                word    send message count
                word    retry count
                word    failed count
                word    driver errors
                word    dropped responses/CHATs
              9 bytes   LIST ID/NTAB address (3 entries, LPT1-3)
              6 bytes   AUX ID/NTAB address (2 entries, COM1-2)
                byte    active CB channel
                byte    received 6F messages on queue
              9 bytes   activity counters for channels 1-9
---beyond here, 10-Net v3.3---
                byte    bit 0     RS232 gate
                            1     Send6F gate (user set)
                            2-7   ?
                dword   pointer into gate (user set)
                dword   pointer into 10-Net send
              N words   addresses of timer blocks

entry   AH      04h     Send
        DS:BX   pointer to record
             12 bytes   receiving node's ID
                        if first byte has high-order bit set, message is directed
                           to the CT_RGATE vector at the receiver
```

```
                        if second byte is 00h, first byte is taken as a CB
                           channel number and delivered to all nodes on same
                           channel
                word    length of data at DX
         DS:DX  pointer to data (max 1024 bytes)
return   CF     set on error
                AX      error code (see function 00h)

entry    AH     05h     Receive
         CX     number of seconds before timeout
         DS:DX  pointer to receive buffer
             12 bytes   sending node's ID
                word    length of message
              N bytes   message (maximum 1024 bytes)
return   CF     set on error
                AX      error code (see function 00h)
         CF     clear if successful
                AH      0FEh if dequeued message is a CB message

entry    AH     07h     Lock Handle
         BX     file handle
         CX:DX  starting offset in file
         SI     record length
return   CF     set on error
                AX      error code (see also function 00h)
                        02h     file not found

entry    AH     08h     Unlock Handle
         BX     file handle
         AL     mode
                00h     unlock all
                01h     unlock record at CX:DX
return   CF     set on error
                AX      error code (see also function 00h)
                        02h     file not found

entry    AH     09h     Submit
         DS:BX  pointer to record
             12 bytes   destination node ID (must be logged in)
                word    length+2 of following 'command line' text
              n bytes   command line text (<=100 bytes), system adds CR
return   none?

entry    AH     0Ah     Chat
         DS:BX  pointer to control parameters
              8 bytes   sender ID, if nulls defaults to node's userID
              8 bytes   destination user ID, 'EVERYONE' may be used
             12 bytes   destination node ID
         DS:DX  pointer to chat message
                word    length+2 of following text
              n bytes   text, max 101 bytes

entry    AH     0Bh     Lock Semaphore, Return Immediately
         AL     drive number or 00h
         ES:SI  Ethernet address or 00h
         DS:BX  pointer to 31-byte ASCIIZ semaphore name
return   AL     status
                00h     successful
                01h     semaphore currently locked
                02h     server not responding
                03h     invalid semaphore name
                04h     semaphore list is full
                05h     invalid drive ID
                06h     invalid Ethernet address
                07h     not logged in
                08h     write to network failed
                09h     semaphore already logged in this CPU
note     Same as int 60h/fn 12h.

entry    AH     0Ch     Unlock Semaphore
         AL     drive number or 0
```

```
        ES:SI   Ethernet address or 0
        DS:BX   pointer to 31-byte ASCIIZ semaphore name
return  AL      status (see AH=0Bh)
                01h     semaphore not locked
note    Same as int 60h/fn13h.

entry   AH      0Dh     Who
        AL      type code
                01h     return superstations only
                02h     return non-superstations only
                otherwise return all
        CX      length of data
        DS:DX   pointer to array of records to be filled
            12 bytes    node ID
                byte    flags
                    bit 1       workstation
                        2       superstation
                        3       xgate
                        4       active gate
                        5-7     ?
                (if AL=01h, record continues)
                byte    version number
                word    level number of 10Net software in responding node
                (if AL=02h, record continues)
             8 bytes    user ID
                byte    version number
                word    level number
return  CL      number of records returned (responding stations)

entry   AH      0Eh     Spool/Print
        DS:DX   pointer to record
                word    operation code
                        00h     initiate spool
                        01h     abort print
                        02h     close spool
                        03h     delete spool
                        04h     print
                        05h     get report info
                        06h     set chat template
                        07h     queue
                        08h     return queue
                        09h     queue non-spooled file for printing
            11 bytes    file name in FCB format
        (if operation code = 00h or 06h, record continues)
                byte    notification
                    bit 0       notify at print start
                        1       notify server operator/reply
                        2       notify at print completion
                        3       explicit queuing only
                        4       reserved
                        5       no form feed
                        6       do ID page
                        7       queue to top
                byte    days to keep (0FFh=forever)
                byte    bits 0,1: device (1=LPT1)
                        bits 4-7: remote drive to store spool file
                                  (1=A,...)
                word    length of following data area
             n bytes    up to 64 bytes of description
        (if operation code = 03h, record continues)
             8 bytes    user ID to associate with filename
        (if operation code = 04h, record continues)
                word    block number
             8 bytes user ID to associate with filename
        (if operation code = 05h, record continues)
                byte    RRN to start retrieve
                byte    bits 0,1  local print device (LPTx)
                        bit 3     if set, return entries for all users
                        bits 4-7  not used?
                word    length of following area
             n bytes    up to 1500 bytes to receive $SCNTL records returned
```

```
        (if operation code = 07h, record continues)
               byte     queue number
               byte     bits 0,1  local print device (LPTx)
                        bits 2-7  not used?
               word     number of bytes of test print to be done
               byte     test code
                        01h       print device
                        02h       test print count
                        03h       PRN
        (if operation code = 08h, record continues)
               byte     queue location or $SCNTL location to start access
                        returns next item for access:
                        00h-7Fh queued items
                        80h-FEh non-queued, non-printed items
                        0FFh    no more items
               word     unused
               word     length of following area
             n bytes    up to 64 bytes to receive $SCNTL records (see note)
        (if operation code = 09h, record continues)
             3 bytes    unused
             n bytes    path to non-spooled file to be queued for printing
return  CF          set on error
                AX      error code (see also function 00h)
                        0FF17h  device not mounted
                        0FF18h  already spooling to named device

note    $SCNTL record:
     8 bytes    user ID
    11 bytes    filename in FCB format
     6 bytes    node ID
     3 bytes    creation date
      byte      flags
          bit 0         notify at start
              1         notify server operator/reply
              2         notify at completion
              3         explicit queueing only
              4         reserved
              5         no form feed at end
              6         do ID page
              7         queue to top
      byte      retention time in days
      byte      printing device (LPTx)
    3 bytes     date last printed (0=never)
      byte      device containing spool file
      word      bytes to print for test print
      word      block number to start print
      byte      reserved

entry   AH      10h     Attach/Detach Printer
        AL      subfunction
                00h     initiate spooling if LPT1 is mounted
                01h     terminate spooling if LPT1 is mounted

entry   AH      11h     Lock FCB
        AL      mode
                01h     sequential
                02h     random
                03h     random block
        CX      number of records
        DS:DX   pointer to FCB
return  CF      set on error
                AX      error code (see also function 00h)
                        02h     file not found

entry   AH      12h     Unlock FCB
        AL      mode
                00h     sequential
                01h     random
                02h     random block
        CX      number of records
        DS:DX   pointer to FCB
return  CF      set on error
```

```
                AX      error code (see also function 00h)
                        02h     file not found

entry   AH      13h     10-Net v3.3 - Get Remote Configuration Table
                        Address
        DS:DX   pointer to node ID, 12 bytes blank-padded
return  CF      set on error
                AX      error code (see function 00h)
        CF      clear if successful
                ES:BX   configuration table address on given machine

entry   AH      14h     10-Net v3.3 - Get Remote Memory
        BX:SI   address of remote memory
        CX      length (<=1024 bytes)
        DS:DX   pointer to node ID, 12 bytes blank-padded
        DS:DI   pointer to area to receive remote memory image
return  CF      set on error
                AX      error code (see function 00h)
        CF      clear if successful
                CX      amount of memory copied to DS:SI

entry   AH      15h     Shared Device Information
        AL      01h     10-Net v3.3 - Get Shared Device Entry
                BX      zero-based index
                DS:SI   pointer to node ID, 12 bytes blank-padded
                ES:DI   pointer to 85-byte buffer
        return  CF      set on error
                        AX      error code (see function 00h)
                CF      clear if successful
                        ES:DI buffer contains shared device table entry of
                        BXth device:
                      8 bytes   device
                      8 bytes   alias
                     64 bytes   path
                      8 bytes   password
                        byte    access
                      4 bytes   mask

                02h     10-Net v3.3 - Set Shared Device Entry
                DS:SI   pointer to node ID, 12 bytes blank-padded
                ES:DI   pointer to valid shared device table entry
        return  CF      set on error
                        AX      error code (see function 00h)

                03h     10-Net v3.3 - Delete Shared Device Entry
                BX      zero-based index
                DS:SI   pointer to node ID, 12 bytes blank-padded
        return  CF      set on error
                        AX      error code (see function 00h)

entry   AH      17h     10-Net v3.3 - Mount
        AL      local drive number (0=A:)
        BL      remote drive letter or '1'..'3' for LPTx or '4' or '5' for COMx
        DS:DX   pointer to node ID, 12 bytes blank-padded
return  CF      set on error
                AX      error code (see function 00h)

entry   AH      18h     10-NET v3.3 - Unmount
        AL      local drive number (0=A:)
        BL      type
                00h     disk
                01h-03h LPTx
                04h,05h COMx
return  CF      set on error
                AX      error code (see function 00h)
```

Interrupt 68h APPC/PC

```
Function  01h   APPC/PC
entry   AH      01h
        DS:DX   pointer to control block
```

```
  12 bytes   reserved
     word    verb (action)
   6 bytes   0
     dword   (high byte first) return code
             0000h   successful
             0001h   BAD_TP_ID
             0002h   BAD_CONV_ID
             0003h   bad logical unit ID
             0008h   no physical unit attached
             0110h   bad state
             01B1h   BAD_PART_LUNAME
             01B2h   bad mode name
             0201h   physical unit already active
             0211h   logical unit already active
             0212h   BAD_PART_SESS
             0213h   BAD_RU_SIZES
             0214h   BAD_MODE_SESS
             0216h   BAD_PACING_CNT
             0219h   EXTREME_RUS
             021Ah   SNASVCMG_1
             0223h   SSCP_CONNECTED_LU
             0230h   invalid change
             0243h   too many TPs
             0272h   adapter close failure
             0281h   GET_ALLOC_BAD_TYPE
             0282h   unsuccessful
             0283h   DLC failure
             0284h   unrecognized DLC
             0286h   duplicate DLC
             0301h   SSCP_PU_SESSION_NOT_ACTIVE
             0302h   data exceeds RU size
             0401h   invalid direction
             0402h   invalid type
             0403h   segment overlap
             0404h   invalid first character
             0405h   table error
             0406h   conversion error
             0F0010000h  APPC disabled
             0F0020000h  APPC busy
             0F0030000h  APPC abended
             0F0040000h  incomplete
if verb = 1B00h (DISPLAY), control block continues
     word    0
   8 bytes   (high byte first) logical unit ID
   8 bytes   (high byte first) partner logical unit name
   8 bytes   (high byte first) mode name
     byte    logical unit session limit
     byte    partner logical unit session limit
     byte    mode maximum negotiable session limit
     byte    current session limit
     byte    minimum negotiated winner limit
     byte    maximum negotiated loser limit
     byte    active session count
     byte    active CONWINNER session count
     byte    active CONLOSER session count
     byte    session termination count
     byte    bit 7: SESSION_TERMINATION_TARGET_DRAIN
             bit 6: SESSION_TERMINATION_SOURCE_DRAIN
     if verb=2000h (Attach Physical Unit), control block continues
     word    0
     byte    version
     byte    release
   8 bytes   (high byte first) net name
   8 bytes   (high byte first) physical unit name
   8 bytes   0
     dword   pointer to SYSTEM_LOG_EXIT routine, 0FFFFFFFFh means
             don't log errors
     dword   0
     byte    0        RETURN_CONTROL: COMPLETE
             1        RETURN_CONTROL: INCOMPLETE
if verb=2100h (Attach Logical Unit), control block continues
```

```
                word     70  offset to partner logical unit record
              8 bytes    (high byte first) logical unit name
              8 bytes    (high byte first) logical unit ID
                byte     logical unit local address
                byte     logical unit session limit
                dword    pointer to CREATE_TP_EXIT routine,
                         0FFFFFFFFh    reject incoming ALLOCATEs
                         00000000h     queue ALLOCATEs
                dword    0
                dword    pointer to SYSTEM_LOG_EXIT routine, 0FFFFFFFFh means
                         don't log errors
                dword    0
                byte     maximum TPs
                byte     queue depth
                dword    pointer to LU_LU_PASSword_EXIT routine, 0FFFFFFFFh means
                         no password exit
                dword    0
                word     total length of partner records
                         for each partner logical unit:
                         word     length of this partner logical unit record
                         word     42  offset to mode records
                       8 bytes    (high byte first) partner logical unit name
                         byte     partner logical unit security capabilities
                             bit 7        already verified
                                 6        conversation level security
                                 5        session level security
                                 4-0      not used?
                         byte     partner logical unit session limit
                         word     partner logical unit maximum MC_SEND_LL
                       8 bytes    (high byte first) partner logical unit DLC name
                         byte     partner logical unit adapter number
                      17 bytes    (counted string) partner logical unit adapter
                                  address
                         word     total length of mode records
                                  for each mode:
                                  word     16  length of this mode record
                                8 bytes    (high byte first) mode name
                                  word     RU_SIZE high bound
                                  word     RU_SIZE low bound
                                  byte     mode maximum negotiable session limit
                                  byte     pacing size for receive
        if verb=2200h (Detach Logical Unit), control block continues:
              8 bytes    (high byte first) logical unit ID
                byte     0
        if verb=2700h (Detach Physical Unit), control block continues:
                byte     Physical Unit type
                         00h      hard
                         01h      soft
        if verb=2B00h (Activate DLC), control block continues:
              8 bytes    (high byte first) DLC name
                byte     adapter number
                Routines defined by LU_LU_PASSword_EXIT, CREATE_TP_EXIT, and
                SYSTEM_LOG_EXIT pointers are called by pushing the dword pointer
                to the verb on the stack and then performing a FAR call.
ACCESS_LU_LU_PW verb:
     12 bytes   reserved
        word    1900h
      8 bytes   (high byte first) logical unit ID
      8 bytes   (high byte first) logical unit name
      8 bytes   (high byte first) partner logical unit name
     17 bytes   (counted string) partner fully qualified logical unit name
        byte    password available (0=no, 1=yes)
      8 bytes   password
CREATE_TP verb:
     12 bytes   reserved
        word    2300h
      6 bytes   0
        dword   (high byte first) sense code
                00000000h     Ok
                080F6051h     SECURITY_NOT_VALID
                084B6031h     TP_NOT_AVAIL_RETRY
```

```
                084C0000h     TP_NOT_AVAIL_NO_RETRY
                10086021h     TP_NAME_NOT_RECOGNIZED
                10086034h     CONVERSATION_TYPE_MISMATCH
                10086041h     SYNC_LEVEL_NOT_SUPPORTED
      8 bytes   (high byte first) TP ID
      8 bytes   (high byte first) logical unit ID
        dword   (high byte first) conversation ID
        byte    0 basic conversation, 1 mapped conversation
        byte    0 no sync level, 1 confirm
        byte    reserved
     65 bytes   (counted string) transaction program name
      6 bytes   0
        word    length of ERROR_LOG_DATA to return
        dword   pointer to ERROR_LOG_DATA buffer
      8 bytes   (high byte first) partner logical unit name
     18 bytes   (counted string) partner fully qualified logical unit name
      8 bytes   (high byte first) mode name
     12 bytes   0
     11 bytes   (counted string) password
     11 bytes   (counted string) user ID
        byte    0 verification should be performed
                1 already verified

SYSLOG verb:
     12 bytes   reserved
        word    2600h
     10 bytes   0
        word    (high byte first) type
        dword   (high byte first) subtype
        dword   pointer to ADDITIONAL_INFO
        dword   (high byte first) conversation ID
      8 bytes   (high byte first) TP ID
      8 bytes   (high byte first) physical unit or logical unit name
        word    length of data
        dword   pointer to data
        byte    0

Function  02h   APPC/PC
entry     AH    02h
          DS:DX pointer to control block
             12 bytes   reserved
                word    verb (action)
                byte    00h     if basic verb
                        01h     if MC_ (mapped conversation) form of verb
              5 bytes   0
                word    (high byte first) primary return code
                        0000h   successful
                        0001h   parameter check
                        0002h   state check
                        0003h   allocation error
                        0005h   deallocate abended
                        0006h   deallocate abended program
                        0007h   deallocate abended SVC
                        0008h   deallocate abended timer
                        0009h   deallocate normal return
                        000Ah   data posting blocked
                        000Bh   posting not active
                        000Ch   PROG_ERROR_NO_TRUNC
                        000Dh   PROG_ERROR_TRUNC
                        000Eh   PROG_ERROR_PURGING
                        000Fh   CONV_FAILURE_RETRY
                        0010h   CONV_FAILURE_NO_RETRY
                        0011h   SVC_ERROR_NO_TRUNC
                        0012h   SVC_ERROR_TRUNC
                        0013h   SVC_ERROR_PURGING
                        0014h   unsuccessful
                        0018h   CNOS partner logical unit reject
                        0019h   conversation type mixed
                        F001h   APPC disabled
                        F002h   APPC busy
                        F003h   APPC abended
                        F004h   incomplete
```

```
     dword    (high byte first) error code
              0001h   bad TP ID
              0002h   bad conversation ID
              0004h   allocation error, no retry
              0005h   allocation error, retry
              0006h   data area crosses segment boundary
              0010h   bad TPN length
              0011h   bad CONV length
              0012h   bad SYNC level
              0013h   bad security selection
              0014h   bad return control
              0015h   SEC_TOKENS too big
              0016h   PIP_LEN incorrect
              0017h   no use of SNASVCMG
              0018h   unknown partner mode
              0031h   confirm: SYNC_NONE
              0032h   confirm: bad state
              0033h   confirm: NOT_LL_BDY
              0041h   confirmed: bad state
              0051h   deallocate: bad type
              0052h   deallocate: flush bad state
              0053h   deallocate: confirm bad state
              0055h   deallocate: NOT_LL_BDY
              0057h   deallocate: log_LL_WRONG
              0061h   flush: not send state
              0091h   post on receipt: invalid length
              0092h   post on receipt: not in receive state
              0093h   post on receipt: bad fill
              00A1h   prepare to receive:invalid type
              00A2h   prepare to receive: unfinished LL
              00A3h   prepare to receive: not in send state
              00B1h   receive and wait: bad state
              00B2h   receive and wait: NOT_LL_BDY
              00B5h   receive and wait: bad_fill
              00C1h   receive immediate: not in receive state
              00C4h   receive immediate: bad fill
              00E1h   request to send: not in receive state
              00F1h   send data: bad LL
              00F2h   send data: not in send state
              0102h   send error: log LL wrong
              0103h   send error: bad type
              0121h   test: invalid type
              0122h   test: not in receive state
   8 bytes    (high byte first) TP_ID
     dword    (high byte first) conversation ID
if verb=0100h (Allocate or MC_Allocate), control block continues:
     byte     (MC_Allocate only) 0 basic conversation
                                 1 mapped conversation
     byte     SYNC_LEVEL
              00h     none
              01h     confirm
     word     0
     byte     RETURN_CONTROL
              00h     when session allocated
              01h     immediate
              02h     when session free
   8 bytes    0
   8 bytes    (high byte first) partner logical unit name
   8 bytes    (high byte first) mode name
  65 bytes    (counted string) TP name
     byte     Security
              00h     none
              01h     same
              02h     pgm
  11 bytes    0
  11 bytes    (counted string) password
  11 bytes    (counted string) user ID
     word     PIP_DATA length
     dword    pointer to PIP_DATA
if verb=0300h (Confirm or MC_Confirm), then control block
continues:
```

```
        byte    request to send received (0=no, 1=yes)
if verb=0400h (Confirmed or MC_Confirmed), no additional fields
if verb=0500h (Deallocate or MC_Deallocate), control block continues:
        byte    0
        byte    Type
                00h     SYNC_LEVEL
                01h     FLUSH
                02h     ABEND_PROC
                03h     ABEND_SVC
                04h     ABEND_TIMER
                05h     ABEND
        word    (MC_Deallocate only) length of error log data
        dword   (MC_Deallocate only) pointer to error log data
if verb=0600h (Flush or MC_Flush), no additional fields
if verb=0700h (Get_Attributes or MC_Get_Attributes), control block
 continues:
      8 bytes   (high byte first) logical unit ID
        byte    0
        byte    SYNC_LEVEL (0=none, 1=confirm)
      8 bytes   (high byte first) mode name
      8 bytes   (high byte first) own net name
      8 bytes   (high byte first) own logical unit name
      8 bytes   (high byte first) partner logical unit name
     18 bytes   (counted string) partner's fully qualified logical unit
                name
        byte    0
     11 bytes   (counted string) user ID
if verb=0800h (Get_Type), then control block continues:
        byte    type (0=basic conversation, 1=mapped conversation)
if verb=0900h (Post_on_Receipt), then control block continues:
        word    maximum length
        byte    fill (0=buffer, 1=LL)
if verb=0A00h (Prepare_to_Receive or MC_Prepare_to_Receive):
        byte    type (0=SYNC_LEVEL, 1=FLUSH)
        byte    locks (0=short, 1=long)
if verb=0B00h (Receive_and_Wait or MC_Receive_and_Wait),
                control block continues:
        byte    What Received
                00h     data
                01h     data complete
                02h     data incomplete
                03h     confirm
                04h     confirm send
                05h     confirm deallocate
                06h     send
        byte    (MC_Receive_and_Wait only) fill (0=buffer, 1=LL)
        byte    Request_to_Send_Received (0=no, 1=yes)
        word    maximum length
        word    data length
        dword   pointer to data
if verb=0C00h   (Receive_Immediate or MC_Receive_Immediate),
                control block continues:
        byte    What Received
                00h     data
                01h     data complete
                02h     data incomplete
                03h     confirm
                04h     confirm send
                05h     confirm deallocate
                06h     send
        byte    (MC_Receive_Immediate only) fill (0=buffer, 1=LL)
        byte    Request_to_Send_Received (0=no, 1=yes)
        word    maximum length
        word    data length
        dword   pointer to data
if verb=0E00h   (Request_to_Send or MC_Request_to_Send), no additional
                fields
if verb=0F00h   (Send_Data or MC_Send_Data), control block continues:
        byte    request to send received (0=no, 1=yes)
        byte    0
        word    data length
```

```
              dword    pointer to data
       if verb=1000h   (Send_Error or MC_Send_Error)
              byte     request to send received (0=no, 1=yes)
              byte     type (0=program, 1=SVC)
              dword    0
              word     (MC_Send_Error only) LOG_DATA length
              dword    (MC_Send_Error only) pointer to LOG_DATA
       if verb=1200h   (Test or MC_Test), then control block continues:
              byte     (MC_Test only) test
                       (0=posted, 1=request_to_send received)
                       note    error code has different interpretations for:
                       0       posted data
                       1       posted not data (primary return code = 0)
                       1       bad TP_ID (primary return code = 1)
       if verb=1300h   (Wait), then control block continues:
              byte     number of conversations to wait on
                      note     error codes have interpretations as for 1200h
                               (Test) above

Function  03h   APPC/PC
entry   AH      03h
        DS:DX   pointer to control block
             12 bytes reserved
                word     verb (action)
              6 bytes    0
                dword    (high byte first) return code (see AH=01h)
                word     0
              8 bytes    (high byte first) logical unit ID
        if verb=2400h    (TP Started), control block continues:
              8 bytes    (high byte first) TP ID
        if verb=2800h    (Get ALLOCATE), control block continues:
                byte     Type
                         00h     dequeue
                         01h     test
                dword    pointer to CREATE_TP record
        if verb=2A00h    (Change Logical Unit). control block continues:
                dword    pointer to CREATE_TP_EXIT routine
                         0FFFFFFFFh reject incoming ALLOCATEs
                         00000000h  queue ALLOCATEs
                dword    0
                dword    pointer to SYSTEM_LOG_EXIT routine, 0FFFFFFFFh means
                         don't log errors
                dword    0
                byte     maximum TPs
                byte     QUEUE_ALLOCATEs
                         00h     stop
                         01h     resume
                dword    pointer to LU_LU_PASSword_EXIT routine, 0FFFFFFFFh means
                         no exit
                dword    0

Function  04h   APPC/PC
entry   AH      04h
        DS:DX   pointer to control block
             12 bytes    reserved
                word     verb (action)
                         2500h   TP_ENDED
                         2900h   TP_VALID
              6 bytes    0
                dword    (high byte first) return code (see AH=01h)
                word     0
              8 bytes    (high byte first) TP_ID
                dword    pointer to CREATE_TP record (only if verb = 2900h)

Function  05h   Transfer Message Data
entry   AH      05h
        DS:DX   pointer to control block
             12 bytes reserved
                word     1C00h
                byte     00h     user defined
                         01h     NMVT
```

```
                  02h     alert subvectors
                  03h     PDSTATS subvectors
          5 bytes 0
            dword (high byte first) return code (see AH=01h)
         12 bytes 0
            byte  if bit 0 clear, add correlation subvector
                  if bit 1 clear, add product set ID subvector
                  if bit 2 clear, do SYSLOG
                  if bit 3 clear, send SSCP_PU_SESSION
                  bits 4-7 unknown
            byte  0
            word  length of data
          N bytes data

Function  06h   Change Number of Sessions
entry   AH      06h
        DS:DX   pointer to control block
         12 bytes reserved
            word  1500h
          6 bytes 0
            word  (high byte first) primary return code (see AH=02h)
            dword (high byte first) secondary return code (see AH=01h)
                  0000h   accepted
                  0001h   negotiated
                  0003h   bad logical unit ID
                  0004h   allocation failure, no retry
                  0005h   allocation failure, retry
                  0151h   can't raise limits
                  0153h   all modes must reset
                  0154h   bad SNASVCMG limits
                  0155h   minimum greater than total
                  0156h   mode closed (prim return code = 1)
                          CNOS mode closed (prim return code = 18h)
                  0157h   bad mode name (prim return code = 1)
                          CNOS bad mode name (prim return code = 18h)
                  0159h   reset SNA drains
                  015Ah   single not SRC response
                  015Bh   bad partner logical unit
                  015Ch   exceeds maximum allowed
                  015Dh   change SRC drains
                  015Eh   logical unit detached
                  015Fh   CNOS command race reject
          8 bytes (high byte first) logical unit ID
          8 bytes blanks
          8 bytes (high byte first) partner logical unit name
          8 bytes (high byte first) mode name
            byte
                bit 7       use MODE_NAME_SELECT_ALL rather than MODE_NAME
                    6       set negotiable values
                    5-0     ?
            byte  partner logical unit mode session limit
            byte  minimum CONWINNERS_SOURCE
            byte  maximum CONWINNERS_TARGET
            byte  automatic activation
            byte  0
            byte  Drain
                bit 7       drain target
                    6       drain source
                    5       target responsible, not source
                    4-0     ?

Function  07h   Passthrough
entry   AH      07h
        DS:DX   pointer to control block
                (format depends on application subsystem)
return  unknown


Function  0FAh  Enable/Disable APPC
entry   AH      0FAh
        AL  bit 0       0       enable
```

```
                    1       disable
return  unknown

Function  0FBh  Convert
entry   AH      0FBh
        DS:DX   pointer to control block
             12 bytes   reserved
                word    1A00h
              6 bytes   0
                dword   (high byte first) return code
                byte    conversion
                        00h     ASCII to EBCDIC
                        01h     EBCDIC to ASCII
                byte    character set
                        00h     AE
                        01h     A
                        02h     G
                word    length of string to convert
                dword   pointer to source
                dword   pointer to target
return  unknown

Function  0FCh  Enable/Disable Message Tracing
entry   AH      0FCh
        AL      00h     disable tracing
                01h     enable tracing
        DX      number of bytes to keep (0=all)
return  unknown

Function  0FDh  Enable/Disable API Verb Tracing
entry   AH      0FDh
        AL      00h     disable tracing
                01h     enable tracing
return  none

Function  0FEh  Trace Destination
entry   AH      0FEh
        AL      trace destinations
                bits
                0       storage (DS:DX pointer to trace stats record)
                1       display
                2       file (trace written to file OUTPUT.PC)
                3       printer
return  unknown
note 1. Do not move record while trace is active.
     2. Trace Statistics Record
        dword   pointer to storage trace buffer
        word    max number of 80-byte records in trace
        word    (high-order byte first) current record number (must init to 0)
        dword   (high-order byte first) number of records written (init to 0)
        dword   reserved

Function  0FFh  Set Passthrough
entry   AH      0FFh
        DS:DX   pointer to passthrough exit routine
return  unknown

Interrupt 6Fh   Novell NetWare - PCOX API (3270 PC terminal interface)
Interrupt 6Fh   10-Net Network API
entry   AH      00h     Login
        DS:DX   login   record
              8 bytes   user name
              8 bytes   password
             12 bytes   name of super-station
                return  CL      security level
                        AX      status
                                0000h   good login
                                0FF01h  no response from superstation
                                0FF02h  network error
                                0FF03h  invalid password
                                0FF04h  no local buffer
```

```
                 0FF05h  superstation not available
                 0FF06h  node already logged in
                 0FF07h  login not valid from this node
                 0FF08h  node ID already in use
01h      Logoff
return   CX      number of files closed
         AX      status
                 0000h   successful
                 0FF08h  superstation ID not already logged in
02h      Status of node
DS:DX    pointer to 512-byte record
       8 bytes   user name (0 if none)
         byte    station type
                 00h     workstation
                 01h     superstation
                 04h     logged into multiple superstations
      24 bytes list of superstations logged into more than one
         superstation
      12 bytes node ID
         word    message count for this station (send for user
                 node, receive for superstations)
         for superstations only:
         word    drives allocated (bit 0=A:, bit 1=B:,...)
         byte    user service flag
             bit 0       mail waiting for you
                 1       news waiting for you
                 2       calendar waiting for you
                 3       mail waiting for node
                 4       SUBMIT is on
                 5-7     ?
         byte    printers allocated (bit 0=LPT1,...)
         byte    number of unprinted spool files
         byte    number of opened files
         byte    number of logged on files
         byte    primary drive (1=A:)
         byte    reserved
       n bytes   list of logged on node IDs (each 12 bytes, max 38
                 IDs)
return   CF      set on error
                 AX      error code
                         0FF01h  no response from node
                         0FF02h  network error
                         0FF04h  no local buffer
                         0FF16h  invalid node ID
03h      Get Address of Configuration Table
return   ES:BX   pointer to record (actually starts at [BX-25])
                 word    count of dropped Send6F
                 word    buffer start address
                 word    comm driver base address
                 word    send/receive retry count
                 byte    number of 550ms loops
                 word    UFH address
                 word    CDIR address
                 word    LTAB address
                 word    SFH address
                 word    FTAB address
                 word    RLTAB address
                 word    SMI address
                 word    NTAB address
         ES:BX   pointer to word address of first CT_DRV
                 byte    number of DRV entries
               8 bytes   login name
              12 bytes   node ID
               6 bytes   node address
                 byte    flag
                 byte    CT_CFLG
                     bit 0       CHAT permit
                         1       sound bell
                 byte    CT_PSFLG
                         0       SUBMIT permit
                         1       SUBMIT received
```

```
                        2       SUBMIT active
                        3       CHAT called FOXPTRM
                        4       KB initiated
                        5       PRINT permit
                        6,7     ?
                byte    reserved
                word    receive message count
                word    send message count
                word    retry count
                word    failed count
                word    driver errors
                word    dropped responses/CHATs
              9 bytes   list ID/NTAB address (3 entries-LPT1-3?)
              6 bytes   AUX ID/NTAB address (2 entries-COM1-2?)
                byte    active CB channel
                byte    received int 6Fh messages on queue
              9 bytes   activity counters for channels 1-9
04h     Send
        DS:BX   pointer to record
             12 bytes   receiving node's ID
                word    length of data at DX
        DS:DX   pointer to data (max 1024 bytes)
return  CF      set on error
        AX      error code
                0FF01h  timeout
                0FF02h  network error
                0FF04h  no local buffer
                0FF16h  invalid parameter (bad length)
05h     Receive
        CX      number of seconds before timeout
        DS:DX   pointer to receive buffer
             12 bytes   sending node's ID
                word    length of message
              n bytes   message (maximum 1024 bytes)
return CF       set on error
                AX      error code
                        0FF01h  timeout
                        0FF18h  sent message has been dropped
06h     Unknown
07h     Lock Handle
        BX      file handle
        CX:DX   starting offset in file
        SI      record length
return  CF      set on error
                AX      error code
                        0FF01h  timeout
                        02h     file not found
                        0FF17h  record locked by another user
08h     Unlock Handle
        BX      file handle
        AL      mode
                00h     unlock all
                01h     unlock record at CX:DX
return  CF      set on error
                AX      error code
                        02h     file not found
0Bh     Lock Semaphore, Return Immediately
        AL      drive number or 0
        ES:SI   Ethernet address or 0
        DS:BX   pointer to 31-byte ASCIIZ semaphore name
return  AL      status
                00h     successful
                01h     semaphore currently locked
                02h     server not responding
                03h     invalid semaphore name
                04h     semaphore list is full
                05h     invalid drive ID
                06h     invalid Ethernet address
                07h     not logged in
                08h     write to network failed
                09h     semaphore already logged in this CPU
```

```
0Ch     unlock semaphore
        AL      drive number or 0
        ES:SI   Ethernet address or 0
        DS:BX   pointer to 31-byte ASCIIZ semaphore name
return  AL      status (see AH=0Bh)
                1 semaphore not locked
0Dh     Who
        CX      length of data
        DS:DX   pointer to array of records to be filled
            12 bytes   node ID
                byte    flag (1=workstation,
                        2=superstation)
return  CL      number of records returned (responding stations)
0Eh     spool/print
DS:DX   pointer to record
        word    00h     initiate spool
                01h     abort print
                02h     close spool
                03h     delete spool
                04h     print
                05h     get report info
     11 bytes file name
        byte    notification
            bit 0       no notification
                1       notify at print start
                2       notify at print start and reply?
                3       notify at print completion
                4       ?
                5       no form feed
                6       do ID page
                7       ?
        byte    days to keep (0FFh=forever)
        byte    device (1=LPT1)
        word    length of following data area
      n bytes   $SCNT records returned if code in first word is
                05h
return  CF      set on error
                AX      error code
                        0FF16h  invalid parameter
                        0FF17h  device not mounted
                        0FF18h  already spooling to named device
11h     Lock FCB
        AL      mode
                00h     sequential
                01h     random
                02h     random block
        DS:DX   pointer to FCB
return  CF      set on error
                AX      02h     file not found
                        0FF01h  timeout
                        0FF17h  record locked by another user
12h     Unlock FCB
        AL      mode
                00h     sequential
                01h     random
                02h     random block
        DS:DX   pointer to FCB
return  CF      set on error
                AX      02h     file not found
```

Aftermarket Application Installed Function Calls

Novell Netware 2.11

Novell no longer recommends the int 21h method for invoking the Netware functions. Int 21h will be supported indefinitely, but the net API calls for addressing the software through the Multiplex Interrupt (2Fh). You may address the API through int 2Fh in the same manner as int 21h; only the interrupt number is different.

```
Function  0B6h  Novell NetWare SFT Level II - Extended File Attributes
entry   AH      0B6h
        AL      00h     Get Extended File Attributes)
                01h     Set Extended File Attributes)
        CL      attributes
            bit 0-3     ?
                4       transaction tracking file
                5       indexing file (to be implemented)
                6       read audit    (to be implemented)
                7       write audit   (to be implemented)
        DS:DX   pointer to ASCIIZ pathname
return  CF      set on error
        AL      error code
                0FFh    file not found
                8Ch     caller lacks privileges
        CL      current extended file attributes

Function  0B7h  unknown or not used. Novell?

Function  0B8h  Novell Advanced NetWare 2.0+ - Printer Functions
entry   AH      0B8h
        AL      00h     Get Default Print Job Flags)
                01h     Set Default Capture Flags)
                02h     Get Specific Capture Flags)
                03h     Set Specific Print Job Flags)
                04h     Get Default Local Printer)
                05h     Set Default Local Printer)
                06h     Set Capture Print Queue)
                07h     Set Capture Print Job)
                08h     Get Banner User Name)
                09h     Set Banner User Name)
        CX      buffer size
        ES:BX   pointer to buffer
return  none

Function  0BBh Novell NetWare 4.0 - Set End Of Job Statush
entry   AH 0BBh
        AL      new EOJ flag
                00h     disable EOJs
                otherwise enable EOJs
return  AL      old EOJ flag

Function  0BCh  Novell NetWare 4.6 - Log Physical Recordh
entry   AH    0BCh
        AL      flags
            bit 0       lock as well as log record
                1       non-exclusive lock
                2-7     ?
        BX      file handle
        CX:DX   offset
        BP      timeout in timer ticks (1/18 sec)
        SI:DI   length
return  AL      error code

Function  0BDh  Novell NetWare 4.6 - Release Physical Recordh
entry   AH 0BDh
        BX      file handle
        CX:DX   offset
return  AL      error code

Function  0BEh  Novell NetWare 4.6 - Clear Physical Recordh
entry   AH   0BEh
        BX      file handle
        CX:DX   offset
return  AL      error code

Function  0BFh  Novell NetWare 4.6 - Log Record (FCB)
entry   AH      0BFh
        AL      flags
            bit 0       lock as well as log record
                1       non-exclusive lock
```

```
                2-7       ?
        DS:DX   pointer to FCB
        BX:CX   offset
        BP      timeout in timer ticks (1/18 sec)
        SI:DI   length
return  AL      error code

Function  0C0h  Novell NetWare 4.6 - Release Record (FCB)
entry   AH      0C0h
        DS:DX   pointer to FCB
        BX:CX   offset
return  AL      error code

Function  0C1h  Novell NetWare 4.6 - Clear Record (FCB)
entry   AH      0C1h
        DS:DX   pointer to FCB
        BX:CX   offset
return  AL      error code

Function 0C2h Novell NetWare 4.6 - Lock Physical Record Seth
entry   AH  0C2h
        AL      flags
            bit 0         ?
                1         non-exclusive lock
                2-7       ?
        BP      timeout in timer ticks (1/18 sec)
return  AL      error code

Function  0C3h Novell NetWare 4.6 - Release Physical Record Seth
entry   0C3h
return  AL      error code

Function  0C4h Novell NetWare 4.6 - Clear Physical Record Seth
entry   AH      C4h
return  AL      error code

Function  0C5h  Novell NetWare 4.6 - Semaphores
entry   AH      0C5h
        AL      00h      Open Semaphore)
                DS:DX    pointer semaphore name
                CL       initial value
                return   CX:DX    semaphore handle
                         BL       open count
                01h      Examine Semaphore)
                return   CX       semaphore value (sign extended)
                         DL       open count
                02h      Wait On Semaphore)
                         BP       timeout in timer ticks (1/18 sec)
                03h      Signal Semaphore)
                04h      Close Semaphore)
        CX:DX   semaphore handle (except function 00h)
return  AL      error code

Function  0C6h  Novell NetWare 4.6 - Get or Set Lock Mode
entry   AH      0C6h
        AL      00h      set old 'compatibility' mode
                01h      set new extended locks mode
                02h      get lock mode
return  AL      current lock mode

Function  0C7h  Novell NetWare 4.0 - TTS
entry   AH      0C7h
        AL      00h      TTS Begin Transaction (NetWare SFT level II)
                01h      TTS End Transaction   (NetWare SFT level II)
                02h      TTS Is Available      (NetWare SFT level II)
                03h      TTS Abort Transaction (NetWare SFT level II)
                04h      TTS Transaction Status)
                05h      TTS Get Application Thresholds)
                06h      TTS Set Application Thresholds)
                07h      TTS Get Workstation Thresholds)
                08h      TTS Set Workstation Thresholds)
```

```
return  AL      varies according to function called
                (00h)   error code
                        CX:DX   transaction reference number
                (01h)   error code
                (02h)   completion code
                        00h     TTS not available
                        01h     TTS available
                        0FDh    TTS available but disabled
                (03h)   error code
                (04h-08h) unknown

Function  0C8h  Novell NetWare 4.0 - Begin Logical File Locking
entry   AH      0C8h
                if function 0C6h lock mode 00h:
                DL      mode
                        00h     no wait
                        01h     wait
                if function 0C6h lock mode 01h:
                BP      timeout in timer ticks (1/18 sec)
return  AL      error code

Function  0C9h  Novell NetWare 4.0 - End Logical File Locking
entry   AH      0C9h
return  AL      error code

Function  0CAh  Novell NetWare 4.0  Log Personal File (FCB)
entry   AH      0CAh
        DS:DX   pointer to FCB
                if function 0C6h lock mode 01h:
                AL      log and lock flag
                        00h     log file only
                        01h     lock as well as log file
                BP      timeout in timer ticks (1/18 sec)
return  AL      error code

Function  0CBh  Novell NetWare 4.0 - Lock File Set
entry   AH      0CBh
                if function 0C6h lock mode 00h:
                DL      mode
                        00h     no wait
                        01h     wait
                if function 0C6h lock mode 01h:
                BP      timeout in timer ticks (1/18 sec)
return  AL      error code

Function  0CCh  Novell NetWare 4.0 - Release File (FCB)
entry   AH      0CCh
        DS:DX   pointer to FCB
return  none

Function  0CDh  Novell NetWare 4.0 - Release File Set
entry   AH      0CDhhreturn  none

Function  0CEh  Novell NetWare 4.0 - Clear File (FCB)
entry   AH      0CEh
        DS:DX   pointer to FCB
return  AL      error code

Function  0CFh  Novell NetWare 4.0 - Clear File Set
entry   AH      0CFhhreturn  AL      00h

Function  0D0h  Novell NetWare 4.6 - Log Logical Record
entry   AH      0D0h
        DS:DX   pointer record string
                if function 0C6h lock mode 01h:
                AL      flags
                    bit 0       lock as well as log the record
                        1       non-exclusive lock
                        2-7     ?
                BP      timeout in timer ticks (1/18 sec)
return  AL      error code
```

```
Function  0D1h Novell NetWare 4.6 - Lock Logical Record Seth
entry   AH 0D1h
                if function 0C6h lock mode 00h:
        DL      mode
                00h     no wait
                01h     wait
                if function 0C6h lock mode 01h:
        BP      timeout in timer ticks (1/18 sec)
return  AL      error code

Function  0D2h  Novell NetWare 4.0 - Release Logical Record Seth
entry   AH 0D2h
        DS:DX   pointer to record string
return  AL      error code

Function  0D3h  Novell NetWare 4.0 - Release Logical Record Seth
entry   AH 0D3h
return  AL      error code

Function  0D4h  Novell NetWare 4.0 - Clear Logical Record Seth
entry   AH    0D4h
        DS:DX   pointer to record string
return  AL      error code

Function 0D5h Novell NetWare 4.0 - Clear Logical Record Seth
entry   AH 0D5h
return  AL      error code

Function  0D6h  Novell NetWare 4.0 - End Of Jobh
entry   AH      0D6h
return  AL      error code

Function  0D7h  Novell NetWare 4.0 - System Logouth
entry      AH      0D7h
return  AL      error code

Functions 0D8h, 0D9h unknown - Novell NetWare?

Function  0DAh  Novell NetWare 4.0 - Get Volume Statistics
entry   AH      0DAh
        DL      volume number
        ES:DI   pointer to reply buffer
return  AL      00h
                reply buffer
                word    sectors/block
                word    total blocks
                word    unused blocks
                word    total directory entries
                word    unused directory entries
             16 bytes   volume name, null padded
                word    removable flag, 0 = not removable

Function 0DBh Novell NetWare 4.0 - Get Number Of Local Drivesh
entry   AH 0DBh
return  AL      number of local disks

Function  0DCh  Novell NetWare 4.0 - Get Station Number (Logical ID)
entry   AH      0DCh
return  AL      station number
                00h     if NetWare not loaded or this machine is a
                        non-dedicated server
        CX      station number in ASCII

Function  0DDh  Novell NetWare 4.0 - Set Error Modeh
entry   AH      0DDh
        DL      error mode
                00h     display critical I/O errors
                01h     extended errors for all I/O in AL
                02h     extended errors for critical I/O in AL
return  AL      previous error mode
```

```
Function  0DEh  Novell NetWare 4.0 - Get/Set Broadcast Mode
entry   AH      0DEh
        AL      broadcast mode
                00h     receive console and workstation broadcasts
                01h     receive console broadcasts only
                02h     receive no broadcasts
                03h     store all broadcasts for retrieval
                04h     get broadcast mode
                05h     disable shell timer interrupt checks
                06h     enable shell timer interrupt checks
return  AL      old broadcast mode

Function  0DFh  Novell NetWare 4.0 - Capture
entry   AH      0DFh
        AL      00h     Start LPT Capture)
                01h     End LPT Capture)
                02h     Cancel LPT Capture)
                03h     Flush LPT Capture)
                04h     Start Specific Capture)
                05h     End Specific Capture)
                06h     Cancel Specific Capture)
                07h     Flush Specific Capture)
return  AL      error code

Function  0E0h  Novell NetWare - Print Spooling
entry   AH      0E0h
        DS:SI   pointer to request buffer
                subfunction in third byte of request buffer:
                00h     spool data to a capture file
                01h     close and queue capture file
                02h     set spool flags
                03h     spool existing file
                04h     get spool queue entry
                05h     remove entry from spool queue
                06h     get printer status
                09h     create a disk capture file
        ES:DI   pointer to reply buffer
return  AL      error code

Function  0E1h  Novell NetWare 4.0 - Broadcast Messages
entry   AH      0E1h
        DS:SI   pointer to request buffer
                subfunction in third byte of request buffer:
                00h     send broadcast message
                01h     get broadcast message
                02h     disable station broadcasts
                03h     enable station broadcasts
                04h     send personal message
                05h     get personal message
                06h     open message pipe
                07h     close message pipe
                08h     check pipe status
                09h     broadcast to console
        ES:DI   pointer to reply buffer
return  AL      error code

Function  0E2h  Novell NetWare 4.0 - Directory Functions
entry   AH      0E2h
        DS:SI   pointer to request buffer
        ES:DI   pointer to reply buffer
                subfunction in third byte of request buffer:
                00h     Set Directory Handle)
                01h     Get Directory Path)
                02h     Scan Directory Information)
                03h     Get Effective Directory Rights)
                04h     Modify Maximum Rights Mask)
                05h     unknown
                06h     Get Volume Name)
                07h     Get Volume Number)
                08h     unknown
```

```
                09h     unknown
                0Ah     Create Directory)
                0Bh     Delete Directory)
                0Ch     Scan Directory For Trustees)
                0Dh     Add Trustee To Directory)
                0Eh     Delete Trustee From Directory)
                0Fh     Rename Directory)
                10h     Purge Erased Files)
                11h     Restore Erased File)
                12h     Allocate Permanent Directory Handle)
                13h     Allocate Temporary Directory Handle)
                14h     Deallocate Directory Handle)
                15h     Get Volume Info With Handle)
                16h     Allocate Special Temporary Directory Handle)
                17h     retrieve a short base handle (Advanced NetWare 2.0)
                18h     restore a short base handle (Advanced NetWare 2.0)
                19h     Set Directory Information)
return  AL      error code

Function  0E3h  Novell NetWare 4.0 - Connection Control
entry   AH      E3h
        DS:SI   pointer to request buffer
        ES:DI   pointer to reply buffer
                subfunction in third byte of request buffer
                00h     login
                01h     change password
                02h     map user to station set
                03h     map object to number
                04h     map number to object
                05h     get station's logged information
                06h     get station's root mask (obsolete)
                07h     map group name to number
                08h     map number to group name
                09h     get memberset M of group G
                0Ah     Enter Login Area)
                0Bh     unknown
                0Ch     unknown
                0Dh     Log Network Message)
                0Eh     get disk utilization (Advanced NetWare 1.0)
                0Fh     scan file information (Advanced NetWare 1.0)
                10h     set file information (Advanced NetWare 1.0)
                11h     get file server information (Advanced NetWare 1.0)
                12h     unknown
                13h     get internet address (Advanced NetWare 1.02)
                14h     login to file server (Advanced NetWare 2.0)
                15h     get object connection numbers (Advanced NetWare 2.0)
                16h     get connection information (Advanced NetWare 1.0)
                17h-31h unknown
                32h     create object (Advanced NetWare 1.0)
                33h     delete object (Advanced NetWare 1.0)
                34h     rename object (Advanced NetWare 1.0)
                35h     get object ID (Advanced NetWare 1.0)
                36h     get object name (Advanced NetWare 1.0)
                37h     scan object (Advanced NetWare 1.0)
                38h     change object security (Advanced NetWare 1.0)
                39h     create property (Advanced NetWare 1.0)
                3Ah     delete property (Advanced NetWare 1.0)
                3Bh     change property security (Advanced NetWare 1.0)
                3Ch     scan property (Advanced NetWare 1.0)
                3Dh     read property value (Advanced NetWare 1.0)
                3Eh     write property value (Advanced NetWare 1.0)
                3Fh     verify object password (Advanced NetWare 1.0)
                40h     change object password (Advanced NetWare 1.0)
                41h     add object to set (Advanced NetWare 1.0)
                42h     delete object from set (Advanced NetWare 1.0)
                43h     is object in set? (Advanced NetWare 1.0)
                44h     close bindery (Advanced NetWare 1.0)
                45h     open bindery (Advanced NetWare 1.0)
                46h     get bindery access level (Advanced NetWare 1.0)
                47h     scan object trustee paths (Advanced NetWare 1.0)
                48h-0C7h unknown
```

```
                        0C8h    Check Console Privileges)
                        0C9h    Get File Server Description Strings)
                        0CAh    Set File Server Date And Time)
                        0CBh    Disable File Server Login)
                        0CCh    Enable File Server Login)
                        0CDh    Get File Server Login Status)
                        0CEh    Purge All Erased Files)
                        0CFh    Disable Transaction Tracking)
                        0D0h    Enable Transaction Tracking)
                        0D1h    Send Console Broadcast)
                        0D2h    Clear Connection Number)
                        0D3h    Down File Server)
                        0D4h    Get File System Statistics)
                        0D5h    Get Transaction Tracking Statistics)
                        0D6h    Read Disk Cache Statistics)
                        0D7h    Get Drive Mapping Table)
                        0D8h    Read Physical Disk Statistics)
                        0D9h    Get Disk Channel Statistics)
                        0DAh    Get Connection's Task Information)
                        0DBh    Get List Of Connection's Open Files)
                        0DCh    Get List Of Connections Using A File)
                        0DDh    Get Physical Record Locks By Connection and File)
                        0DEh    Get Physical Record Locks By File)
                        0DFh    Get Logical Records By Connection)
                        0E0h    Get Logical Record Information)
                        0E1h    Get Connection's Semaphores)
                        0E2h    Get Semaphore Information)
                        0E3h    Get LAN Driver's Configuration Information)
                        0E4h    unknown
                        0E5h    Get Connection's Usage Statistics)
                        0E6h    Get Object's Remaining Disk Space)
                        0E7h    Get Server LAN I/O Statistics)
                        0E8h    Get Server Miscellaneous Information)
                        0E9h    Get Volume Information)
return   AL             error code

Function  0E4h          DoubleDOS
entry    AH             0E4h
         AL             00h     Check status
return   AL              0 if DoubleDOS is active

Function  0E4h          Novell NetWare 4.0 - Set File Attributes (FCB)
entry    AH             0E4h
         CL             file attributes byte
               bit      0       read only
                        1       hidden
                        2       system
                        3-6     undocumented
                        7       shareable
         DX:DX          pointer to FCB
return   AL             error code

Function  0E5h          Novell NetWare 4.0 - Update File Size (FCB)
entry    AH             0E5h
         DS:DX          pointer to FCB
return   AL             error code

Function  0E6h          Novell NetWare 4.0 - Copy File To File (FCB)
entry    AH             0E6h
         CX:DX          number of bytes to copy
         DS:SI          pointer to source FCB
         ES:DI          pointer to destination FCB
return   AL             error code

Function  0E7h          Novell NetWare 4.0 - Get File Server Date and Timeh
entry    AH             0E7h
         DS:DX          pointer to 7-byte reply buffer
                        byte    year - 1900
                        byte    month
                        byte    day
                        byte    hours
```

```
                byte    minutes
                byte    seconds
                byte    day of week (0 = Sunday)
return  unknown

Function  0E7h  Novell NetWare 4.6 - Set FCB Re-open Mode
entry   AH      0E8h
        DL      mode
                00h     no automatic re-open
                01h     auto re-open
return  AL      error code

Function  0E9h  Novell NetWare 4.6 - Shell's 'Get Base Status'
entry   AH      0E9h
        AL      00h     Get Directory Handle
        DX      drive number to check (0 = A:)
return  AL      network pathbase
        AH      base flags:
                00h     drive not currently mapped to a base
                01h     drive is mapped to a permanent base
                02h     drive is mapped to a temporary base
                03h     drive exists locally

Function  0EAh  Novell NetWare 4.6 - Return Shell Version
entry   AH      0EAh
        AL      00h     get specialized hardware information
                return  AL      hardware type
                                00h     IBM PC
                                01h     Victor 9000
                01h     Get Workstation Environment Information)
                ES:DI   pointer to 40-byte buffer
                return  buffer filled with three null-terminated entries:
                        major operating system
                        version
                        hardware type
return  AH      00h if MSDOS system

Function  0EBh  Novell NetWare 4.6 - Log File
entry   0EBh    Log File
        DS:DX   pointer to ASCIIZ filename
                if function 0C6h lock mode 01h:
                AL      flags
                        00h     log file only
                        01h     lock as well as log file
                BP      timeout in timer ticks (1/18 second)
return  AL      error code

Function  0ECh  Novell NetWare 4.6 - Release Fileh
entry   AH      0ECh
        DS:DX   pointer to ASCIIZ filename
return  none

Function  0EDh  Novell NetWare - Clear Fileh
entry   AH      0EDh
        DS:DX   pointer to ASCIIZ filename
return  AL      error code

Function  0EEh  Novell NetWare - Get Node Address  (Physical ID)
entry   AH      0EEh
return  CX:BX:AX = six-byte address

Function  0EFh  Novell Advanced NetWare 1.0+ - Get Drive Info
entry   AH      0EFh
        buffer  00h     Get Drive Handle Table)
                01h     Get Drive Flag Table)
                02h     Get Drive Connection ID Table)
                03h     Get Connection ID Table)
                04h     Get File Server Name Table)
return  ES:DI   pointer to shell status table
```

```
Function  0F0h   Novell Advanced NetWare 1.0+ - Connection ID
entry     AH     0F0h
          AL     00h      Set Preferred Connection ID)
                 01h      Get Preferred Connection ID)
                 02h      Get Default Connection ID)
                 03h      LPT Capture Active)
                 04h      Set Primary Connection ID)
                 05h      Get Primary Connection ID)
                 06h      Get Printer Status)
          DL     preferred file server
return    AL     selected file server

Function  0F1h   Novell Advanced NetWare 1.0+ - File Server Connection
entry     AH     0F1h
          AL     00h      Attach To File Server)
                          DL      preferred file server
                 01h      Detach From File Server)
                 02h      Logout From File Server)
return    AL     completion code

Function  0F1h   Novell NetWare - unknown
entry     AH     0F2h
return    unknown

Function  0F3h   Novell Advanced NetWare 2.0+ - File Server File Copy
entry     AH     0F3h
          ES:DI  pointer to request string
                 word     source file handle
                 word     destination file handle
                 dword    starting offset in source
                 dword    starting offset in destination
                 dword    number of bytes to copy
return    AL     status/error code
          CX:DX  number of bytes copied

Function  0F3h   Novell NetWare
                 File Server File Copyh
entry     AH     0F3h
return    unknown
```

14

Mouse Programming

General Information

The current generation of PC mice are all based on the Microsoft design originally introduced in June 1983. The Microsoft design (now de facto industry standard) uses a CPU software interrupt and a set of interrupt function calls to interpret data obtained from the pointing device. The original Microsoft mice used a card plugged into the system bus and a proprietary connection to the mouse. Later designs and most clones use a serial connection, a major exception being the IBM PS/2 series' 'pointing device port'.

There are various types of mice on the market. Various arrangements of wheels, balls, or a light-reflecting grid are used to detect mouse motion. Other systems often emulate the mouse in software while providing a different hardware implementation. These include trackballs, some joy-sticks, and some touch pads (such as the Koala pad). There is at least one program which will let a standard joy-stick emulate a mouse. Trackballs and joy-sticks are useful when desk space is at a premium. Most of these devices communicate with the system through some form of the Microsoft mouse API.

Mouse movement is defined in terms of mickeys (according to Bill Gates, this unit of measurement was named for the cartoon character Mickey Mouse). There are approximately 200 mickeys per inch of mouse movement. The mouse polls the current mickey count and sends the information to the mouse driver at regular intervals.

The mouse driver transforms the mickey count into screen pixels. The number of mickeys required to move the cursor one pixel is adjustable through a function call. The default mickey-to-pixel ratio is 1:1 on the X axis (horizontal) and 2:1 on the Y axis (vertical).

In graphics modes the mouse cursor can be moved one pixel at a time. In text modes the mouse cursor usually moves one character cell at a time. For example, on a Hercules screen in text mode, the smallest increment the mouse cursor can move is 9 pixels horizontally or 14 vertically.

When the mouse is moved, the cursor moves a set amount. In order to allow fine positioning of the cursor, the ratio between mouse movement and cursor movement must be small. This would make it difficult to make large adjustments of cursor position without excessive mouse movement. To solve this problem, some simple mouse drivers implement a 'double-speed threshold'. The mouse and cursor move in a 1:1 ratio up to a certain speed (mickeys per second) and then the driver multiplies the mickey count by two before processing it, effectively doubling the cursor speed. Double-speed mouse drivers are common.

A better solution is the 'ballistic' driver. The mouse driver monitors the mickey count and modifies the count according to an arithmetic function or table. The mickey/pixel rate is varied in a smooth ratio from slowest to fastest.

The Microsoft mouse driver is not re-entrant. That is, a driver function may not call another driver function and return to its previous state.

Register Usage

The mouse driver is accessed much the same as DOS. Appropriate values are placed in the CPU registers and interrupt 33h is called. On return, the requested action is performed and whatever return codes are given are in he registers.

With the Microsoft Mouse device driver the registers are used as follows:

```
AX        mouse event flags:
              bit        significance
              0          mouse movement
              1          left button pressed
              2          left button released
              3          right button pressed
              4          right button released
              5-15       reserved
BX        button state
              bit        significance
              0          left button is down
              1          right button is down
              2-15       reserved
CX        X coordinate
DX        Y coordinate
DS        mouse driver data segment
DI        raw horizontal mickey count
SI        raw vertical mickey count
```

Interrupt 33h Function Requests

Interrupt 33h Microsoft Mouse Driver Extensions

The Microsoft mouse driver hooks into the int 10h video BIOS vector and watches for a change in screen mode. The mouse driver will automatically adapt to any supported BIOS video mode. The Microsoft driver makes 35 functions available to applications. Other brands of mouse drivers may add more. The mouse driver does not check input values, so all registers used by a call must be set by the application program.

Function Requests

```
Function  00h   Reset Driver and Read Status
entry    AX     0000h
return   AX     status
                0000h   hardware or driver not installed
                0FFFFh  reset successful
         BX     number of buttons
                0000h   other than two
                0002h   two buttons
```

```
                0003h   Mouse Systems mouse
note 1. Checks current screen mode and resets mouse mode if required.
     2. Hides cursor and positions it to centre of screen, sets all defaults.
Function  01h   Show Mouse Cursor
entry   AX      0001h
return  none

Function  02h   Hide Mouse Cursor
entry   AX      0002h
return  none
note    Multiple calls to hide the cursor will require multiple calls to function
        01h to unhide it.

Function  03h   Get Button Status
entry   AX      0003h
return  BX      button status byte
           bits 0        left button
                1        right button
                2        middle button (Mouse Systems mouse)
                3-7      not used
        CX      column
        DX      row
note    If bit is 0, button is normal. If bit is 1, button is pressed.

Function  04h   Set Mouse Cursor Position
entry   AX      0004h
        CX      column
        DX      row
return  none
note    PCM v8n8 reports Microsoft as saying, 'If the screen is not in a mode
        with a cell size of 1x1, the parameter values are rounded to the nearest
        horizontal or vertical coordinate values permitted for the current
        screen mode.' Mefford reports that the Microsoft driver actually
        truncates instead of rounding. This may explain the reported tendencies
        of some Microsoft products toward not recognizing non-MS mice.

Function  05h   Return Button Press Data
entry   AX      0005h
        BX      button ID byte (BL)
           bits 0        left
                1        right
                2        middle (Mouse Systems mouse)
return  AX      button states (AL)
           bits 0        left button
                1        right button
                2        middle button (Mouse Systems mouse)
        BX      # times specified button pressed since last call
        CX      column at time specified button was last pressed
        DX      row at time specified button was last pressed
note    If bit is 0, button is normal. If bit is 1, button is pressed.

Function  06h   Return Button Release Data
entry   AX      0006h
        BX      button ID byte (BL)
           bits 0        left
                1        right
                2        middle (Mouse Systems mouse)
return  AX      button states (AL)
           bits 0        left button
                1        right button
                2        middle button (Mouse Systems mouse)
        BX      no. of times specified button released since last call
        CX      column at time specified button was last released
        DX      row at time specified button was last released
note    If bit is 0, button is normal. If bit is 1, button is pressed.

Function  07h   Define Horizontal Cursor Range
entry   AX      0007h
        CX      minimum column
        DX      maximum column
return  none
```

```
Function  08h   Define Vertical Cursor Range
entry   AX      0008h
        CX      minimum row
        DX      maximum row
return  none
note    If the minimum value is greater than the maximum value, the values are
        swapped.

Function  09h   Define Graphics Cursor
entry   AX      0009h
        BX      column of cursor hot spot in bitmap (-16 to 16)
        CX      row of cursor hot spot  (-16 to 16)
        ES:DX   pointer to bitmap
            16 words   screen mask
            16 words   cursor mask
return  none
note    Each word defines the sixteen pixels of a row, low bit rightmost.

Function  0Ah   Define Text Cursor
entry   AX      000Ah
        BX      select hardware/software text cursor
                00h     software
        CX      screen mask value or scan line start
        DX      cursor mask value or scan line stop
                01h     hardware
return  none
note    When the software cursor is selected, the char/attribute data at the
        current screen position is ANDed with the screen mask and then XORed
        with the cursor mask.

Function  0Bh   Read Motion Counters
entry   AX      000Bh
return  CX      number of mickeys mouse moved horiz. since last call
        DX      number of mickeys mouse moved vertically
note 1. A mickey is the smallest increment the mouse can sense.
     2. Positive values indicate up/right.
     3. This call ignores overflow and sets mickey count to 0 on completion.

Function  0Ch   Define Interrupt Subroutine Parameters
entry   AX      000Ch
        CX      bit mask
            bit 0       call if mouse moves (note 3)
                1       call if left button pressed
                2       call if left button released
                3       call if right button pressed
                4       call if right button released
                5       call if middle button pressed  (Mouse Systems)
                6       call if middle button released (Mouse Systems)
                7-15    not used
        DX      address of FAR routine (note 4)
return  unknown
note 1. When the subroutine is called, it is passed these values:
        AH      condition mask (same bit assignments as call mask)
        BX      button state
        CX      cursor column
        DX      cursor row
        DI      vertical mickey count
        SI      horizontal mickey count
     2. According to PCM v8n8, the DI and SI registers shown above are correct
        for the Microsoft Mouse and were shown reversed in some versions of the
        Microsoft Mouse Programmer's Reference Guide.
     3. The Microsoft documentation reads 'cursor' instead of 'mouse'. The
        Microsoft driver looks at mouse position, though. (PCM v8n8). Logitech
        and Mouse Systems watch for cursor position.
     4. The complete call is DS:DX. The segment value (DS) is taken care of by
        the mouse driver. You need only pass DX.

Function  0Dh   Light Pen Emulation On
entry   AX      000Dh
return  none
note 1. Light pen emulation is on by default when using the Microsoft driver.
```

```
     2. If a real light pen is present in the system, fn 0Eh must be used to
        disable emulation.
Function  0Eh   Light Pen Emulation Off
entry    AX     000Eh
return   none

Function  0Fh   Define Mickey/Pixel Ratio
entry    AX     000Fh
         CX     mickeys per 8 pixels horizontally  (default 8)
         DX     mickeys per 8 pixels vertically    (default 16)
return   none

Function  10h   Define Screen Region for Updating (Conditional Off)
entry    AX     0010h
         DX     pointer to region you want to update (note 2)
return   none
note 1.  Mouse cursor is hidden during updating, and needs to be explicitly turned
         on again.
     2.  The complete call is DS:DX. The segment value (DS) is taken care of by
         the mouse driver. You need only pass DX.
     3.  Array format:
         offset  value
         01h     left x-screen coordinate
         02h     top y-screen coordinate
         03h     right x-screen coordinate
         04h     bottom y-screen coordinate

Function  11h   not documented by Microsoft

Function  12h   Set Large Graphics Cursor Block
entry    AX     0012h
         BH     cursor width in words
         CH     rows in cursor
         BL     horizontal hot spot (-16 to 16)
         CL     vertical hot spot (-16 to 16)
         DX     pointer to bit map of screen and cursor maps (note 2)
return   AH     0FFFFh  successful
note 1.  PC Mouse. Not documented by Microsoft
     2.  The complete call is DS:DX. The segment value (DS) is taken care of by
         the mouse driver. You need only pass DX.

Function  13h   Define Double-Speed Threshold
entry    AX     0013h
         DX     threshold speed in mickeys/second,
                0000h   default of 64/second
return   none
note     If speed exceeds threshold, the cursor's on-screen motion is doubled.

Function  14h   Exchange Interrupt Subroutines
entry    AX     0014h
         BX:DX  pointer to FAR routine
         CX     call mask (see function 000Ch)
return   BX:DX  FAR address of previous interrupt routine
         CX     call mask of previous interrupt routine

Function  15h   Return Driver State Storage Requirements
entry    AX     0015h
return   BX     size of buffer needed to store driver state

Function  16h   Save Driver State
entry    AX     0016h
         DX     offset into buffer
return   none

Function  17h   Restore Driver State
entry    AX     0017h
         DX     offset into buffer containing saved state
return   none

Function  18h-1Ch not documented by Microsoft
```

```
Function  18h   Set Alternate Mouse User Handler
entry    AX     0018h
         CX     call mask
            bit 0       call if mouse moves
                1       call if left button pressed
                2       call if left button released
                3       call if right button pressed
                4       call if right button released
                5       call if shift button pressed during event
                6       call if ctrl key pressed during event
                7       call if alt key pressed during event
                8-15    not used
         DX     offset to user subroutine
return   AX     0FFFFh  error
note 1. When the subroutine is called, it is passed the following values:
         AX     condition mask (same bit assignments as call mask)
         BX     button state
         CX     cursor column
         DX     cursor row
         DI     horizontal mickey count
         SI     vertical mickey count
     2. Up to three handlers can be defined by separate calls to this function.

Function  19h   Return User Alternate Interrupt Vector
entry    AX     0019h
         CX     call mask (same as 0018h above)
return   AX     status  0FFFFh no vector or mask found
         BX:DX  pointer to user interrupt vector (0 if AX=0FFFFh)
         CX     call mask (0 if AX=0FFFFh)
note     Attempts to find a user event handler (defined by function 18h) whose
         call mask matches CX.

Function  1Ah   Set Mouse Sensitivity
entry    AX     001Ah
         BX     horizontal speed
         CX     vertical speed
         DX     double speed threshold in mickeys/second,
                0000h   sets default of 64/second
return   none

Function  1Bh   Return Mouse Sensitivity
entry    AX     001Bh
return   BX     horizontal speed
         CX     vertical speed
         DX     double speed threshold

Function  1Ch   Set Mouse Interrupt Rate
entry    AX     001Ch
         BX     interrupt rate desired (BL)
                00h     no interrupts allowed
                01h     30 interrupts per second
                02h     50 interrupts per second
                03h     100 interrupts per second
                04h     200 interrupts per second
                04h-FFh not defined
return   none
note     If a value larger than 04h is used, the Microsoft InPort driver may be
         have unpredictably.

Function  1Dh   Define Display Page Number
entry    AX     001Dh
         BX     display page number
note     The cursor will be displayed on the specified page.

Function  1Eh   Return Display Page Number
entry    AX     001Eh
return   BX     display page number

Function  1Fh   Disable Mouse Driver
entry    AX     001Fh
return   AX     001Fh   successful
```

```
               0FFFFh  unsuccessful
        ES:BX  old int 33h vector
note 1. Restores vectors for int 10h and int 71h (8086) or int 74h (286/386).
     2. If you restore int 33h to ES:BX, driver will be completely disabled.

Function  20h  Enable Mouse Driver
entry   AX     0020h
return  none
note    Restores vectors for int 10h and int 71h (8086) or int 74h (286/386)
        which were removed by function 1Fh.

Function  21h  Software Reset
entry   AX     0021h
return  AX     0021h  mouse driver not installed
               0FFFFh mouse driver installed
        BX     0002h  mouse driver is installed
note    Identical to function 0000h, but does not reset the mouse.

Function  22h  Set Message Language
entry   AX     0022h
        BX     language number (BL)
               00h     English
               01h     French
               02h     Dutch
               03h     German
               04h     Swedish
               05h     Finnish
               06h     Spanish
               07h     Portuguese
               08h     Italian
               other values not used
return  none
note    Values other than 00h are valid only for Microsoft international mouse
        driver software.

Function  23h  Get Message Language
entry   AX     0023h
return  BX     current language number (BL)
note    See function 0022h.

Function  24h  Get Software Version, Mouse Type, and IRQ Number
entry   AX     0024h
return  AX     0FFFFh  on error, else
        BH     major version
        BL     minor version
        CH     mouse interface type
               01h     bus mouse
               02h     serial mouse
               03h     Microsoft InPort
               04h     IBM PS/2 Pointing Device port
               05h     Hewlett-Packard mouse
        CL     IRQ interrupt request number
               00h     PS/2 pointing device
               01h     not defined
               02h     IRQ2
               03h     IRQ3
               ...     ...
               07h     IRQ7)

Function  42h  PCMouse - Get MSmouse Storage Requirements
entry   AX     0042h
return  AX     0FFFFh successful
        BX     buffer size in bytes for functions 50h and 52h
               00h     MSmouse not installed
               42h     functions 42h, 50h, and 52h not supported

Function  43-49h  unknown

Function  50h  PCmouse - Save MSmouse State
entry   AH     50h
        BX     buffer size
```

```
        ES:DX    pointer to buffer
return  AX       0FFFFh  successful

Function  51h    unknown

Function  52h    PCMouse - Save MSmouse State
entry   AH       50h
        BX       buffer size
        ES:DX    pointer to buffer
return  AX       0FFFFh  successful
```

Interrupt 10h (Video BIOS) Microsoft Mouse Driver EGA Support

The following functions are appended to BIOS int 10h and implemented as the EGA Register Interface Library:

```
        0F0h     read one register
        0F1h     write one register
        0F2h     read consecutive register range
        0F3h     write consecutive register range
        0F4h     read non-consecutive register set
        0F5h     write non-consecutive register set
        0F6h     revert to default register values
        0F7h     define default register values
        0FAh     get driver status

Function 0F0h    Microsoft Mouse driver EGA support - Read One Register
entry   AH       0F0h
        BH       pointer for register/data chips
        BL       pointer
        DX       port number
                 (pointer/data chips)
                 00h     CRT Controller (25 registers)     (3B4h mono, 3D4h colour)
                 08h     sequencer (5 registers)                     (3C4h)
                 10h     graphics controller (9 registers)           (3CEh)
                 18h     attribute controller (20 registers)         (3C0h)
                 (single registers)
                 20h     miscellaneous output register               (3C2h)
                 28h     Feature Control register          (3BAh mono, 3DAh colour)
                 30h     graphics 1 position register                (3CCh)
                 38h     graphics 2 position register                (3CAh)
return  BL       data
note    All other registers are restored.

Function 0F1h    Microsoft Mouse driver EGA support - Write One Register
entry   AH       0F1h
        BH       pointer for pointer/data chips (ignored for single registers)
        BL       pointer for pointer/data chips or data for single registers
        DX       port number (see function 0F0h)
return  BH and DX are not restored, all other registers are restored

Function 0F2h    Microsoft Mouse driver EGA support - Read Register Range
entry   AH       0F2h
        CH       starting pointer value
        CL       number of registers (must be 1)
        DX       port number
                 00h     CRT controller        (3B4h mono modes, 3D4h colour modes)
                 08h     sequencer                             (3C4h)
                 10h     graphics controller                   (3CEh)
                 18h     attribute controller                  (3C0h)
        ES:BX    pointer to buffer, CL bytes
return  CX is not restored, all other registers are restored

Function 0F3h    Microsoft Mouse driver EGA support - Write Register Range
entry   AH       0F3h
        CH       starting register
        CL       number of registers (must be 1)
        DX       port number
                 00h     CRT controller        (3B4h mono modes, 3D4h colour modes)
                 08h     sequencer                             (3C4h)
                 10h     graphics controller                   (3CEh)
```

```
                18h     attribute controller                    (3C0h)
        ES:BX   pointer to buffer, CL bytes
return  BX, CX, DX are not restored, all other registers are restored
Function 0F4h   Microsoft Mouse driver EGA support - Read Register Set
entry   AH      0F4h
        CX      number of registers (must be 1)
        ES:BX   pointer to 4-byte table of records in this format:
           byte 0-2     port number
                (pointer/data chips)
                        00h     CRTC        (3B4h mono modes, 3D4h colour modes)
                        08h     sequencer                       (3C4h)
                        10h     graphics controller             (3CEh)
                        18h     attribute controller            (3C0h)
                (single registers)
                        20h     miscellaneous output register   (3C2h)
                        28h     Feature Control register (3BAh mono modes,
                                3DAh colour)
                        30h     graphics 1 position register    (3CCh)
                        38h     graphics 2 position register    (3CAh)
           byte 1       must be zero
           byte 2       pointer value (0 for single registers)
           byte 3       EGA Register Interface fills in data read from register
                        specified in bytes 0-2.
return  CX is not restored, all other registers are restored

Function 0F5h   Microsoft Mouse driver EGA support - Read Register Set
entry   AH      0F5h
        CX      number of registers (must be greater than 1)
        ES:BX   pointer to 4-byte table of records in this format:
           byte 0-2     port number
                (pointer/data chips)
                        00h     CRT controller (3B4h mono modes,3D4h colour modes)
                        08h     sequencer                       (3C4h)
                        10h     graphics controller             (3CEh)
                        18h     attribute controller            (3C0h)
                (single registers)
                        20h     miscellaneous output register   (3C2h)
                        28h     Feature Control register (3BAh mono modes,
                                3DAh colour)
                        30h     graphics 1 position register    (3CCh)
                        38h     graphics 2 position register    (3CAh)
           byte 1       must be zero
           byte 2       pointer value (0 for single registers)
           byte 3       data to be written to register specified in bytes 0-2.
return  CX is not restored, all other registers are restored

Function 0F6h   MS Mouse driver EGA support - Revert to Default Registers
entry   AH      0F6h
return  all registers restored

Function 0F7h  MS Mouse driver EGA support - Define Default Register Table
entry   AH      0F7h
        CX      VGA colour select flag
                5448h   allows EGA Register Interface to recognise byte
                        offset 14h of the table pointed to by ES:BX as the value
                        for the VGA colour select register
        DX      port number
                (pointer/data chips)
                00h     CRT controller       (3B4h mono modes, 3D4h colour modes)
                08h     sequencer                               (3C4h)
                10h     graphics controller                     (3CEh)
                18h     attribute controller                    (3C0h)
                (single registers)
                20h     miscellaneous output register           (3C2h)
                28h     Feature Control register     (3BAh mono, 3DAh colour)
                30h     graphics 1 position register            (3CCh)
                38h     graphics 2 position register            (3CAh)
        ES:BX   pointer to table of one byte entries, one byte to be
                written to each register (all registers must be written)
return  BX and DX are not restored, all other registers are restored
```

```
Functions 0F8h, 0F9h unknown

Function 0FAh   Microsoft Mouse driver EGA support - Interrogate Driver
entry   AH      0FAh
        BX      00h
return  AX      restored
        BX      0000h   if mouse driver not present
        ES:BX   pointer to EGA Register Interface version number, if present:
                byte 0  major release number
                byte 1  minor release number (in 100ths)
```

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Register-Level Hardware Access

8255 Peripheral Interface Chip (PIC)

The Intel 8255 has 3 1-byte registers, referred to as ports A, B, or C. They are located at port addresses 60h-62h. Ports A and C are read-only, B is read/write. In the IBM PC, setting bit 7 of port B changes information in port A, and setting bit 2 determines the contents of the lower 4 bits of port C. (bit 3 in the XT)

```
60h     port A  read-only
        byte    (normal)    8-bit scancodes from keyboard   (all machines)
                (PC: port B bit 7-1)   equipment byte as returned by int 11h
            bit 0       0 = no diskette drives installed
                1       not used
                2,3     banks of RAM on motherboard
                4,5     display
                        1,1     monochrome
                        1,0     80x25 colour
                        0,1     40x25 colour
                6,7     number of diskette drives

61h     port B  read/write
        byte
            bit 0       PC,XT,jr    controls gate of 8253 timer chip channel 2
                1       PC,XT,jr    output to speaker
                2       PC          select contents of port C
                3       PC,jr       0    text mode (default)
                                    1    graphics mode
                        XT          select contents of port C
                4       PC,XT       0    enable RAM  (default)
                                    1    disable RAM (not very useful)
                5       PC,XT       0    enable expansion slot error signals
                                    1    disable expansion slot error signals
                5,6     jr          select sound source
                                    0,0  8253 chip
                                    0,1  cassette port
                                    1,0  sound line on expansion bus
                                    1,1  TI 76496 sound chip
                7       PC          select contents of port A, acknowledge keyboard
                        XT          keyboard acknowledge only

62h     port C  read only
        (when port B bit 2=1 on PC or port B bit 3=1 on XT)
        byte
            bit 0-3     PC          bottom half of configuration switch 2
                                    (RAM in expansion slots)
                0       PCjr        1    incoming keystroke lost
                1       XT          0    no math coprocessor installed (default)
                                    1    math coprocessor installed
```

2	PCjr	0	modem card installed
2,3	XT	banks of RAM on system board	
3	PCjr	0	128k RAM upgrade installed
		1	64k RAM (default)
4	PC,jr	cassette input	
	XT	not used	
5	PC,XT,jr	output of 8253 channel 2	
6	PC,XT	1	expansion slot error check
	jr	1	keyboard data
7	PC,XT	1	parity error check
	jr	0	keyboard cable connected
		1	keyboard cable not connected (default)
(when port B bit 2=0 on PC or port B bit 3=0 on XT)			
bit 0-3	PC	top half of configuration switch 2 (unused)	
0,1	XT	display type	
		1,1	monochrome
		1,0	80x25 colour
		0,1	40x25 colour
2,3	XT	number of diskette drives	
4,7	PC,XT	same as if port B bit 2=1	

The AT keeps its configuration settings in a Motorola MC146818 chip along with the real-time clock. It has no 8255 chip as such, although the same port addresses are used to control the timer chip and receive data from the keyboard. The chip has 64 registers numbered 00h-3Fh. To read a register, first send its number to port address 70h and then read it from 71h.

CMOS RAM map, PC/AT:

offset	contents
00h	Seconds
01h	Second Alarm
02h	Minutes
03h	Minute Alarm
04h	Hours
05h	Hour Alarm
06h	Day of the Week
07h	Day of the Month
08h	Month
09h	Year
0Ah	Status Register A
0Bh	Status Register B
0Ch	Status Register C
0Dh	Status Register D
0 0Eh	Diagnostic Status Byte
1 0Fh	Shutdown Status Byte
2 10h	Disk Drive Type for Drives A: and B: The drive-type bytes use bits 0:3 for the first drive and 4:7 for the other Disk drive types: 00h no drive present 01h double sided 360k 02h high capacity (1.2 meg) 03h-0Fh reserved
3 11h	(AT):Reserved (PS/2):drive type for hard disk C:
4 12h	(PS/2):drive type for hard disk D: (AT, XT/286):hard disk type for drives C: and D: Format of drive-type entry for AT, XT/286: 0 number of cyls in drive (0-1023 allowed) 2 number of heads per drive (0-15 allowed) 3 starting reduced write compensation (not used on AT) 5 starting cylinder for write compensation 7 max. ECC data burst length, XT only 8 control byte Bit 7 disable disk-access retries 6 disable ECC retries 5-4 reserved, set to zero 3 more than 8 heads 2-0 drive option on XT (not used by AT)

```
                 9        timeout value for XT (not used by AT)
                12        landing zone cylinder number
                14        number of sectors per track (default
                          17, 0-17 allowed)
   13h          Reserved
   14h          Equipment Byte (corresponds to sw. 1 on PC and XT)
   15h-16h      Base Memory Size      (low,high)
   17h-18h      Expansion Memory Size (low,high)
   19h-20h      Reserved
                (PS/2) POS information Model 50 (60 and 80 use a 2k
                CMOS RAM that is not accessible through software)
   21h-2Dh      Reserved (not checksummed)
   2Eh-2Fh      Checksum of bytes 10 through 20  (low,high)
   30h-31h      Exp. Memory Size as Determined by POST (low,high)
   32h          Date Century Byte
   33h          Information Flags (set during power-on)
   34h-3Fh      Reserved
3. The alarm function is used to drive the BIOS WAIT function (int
   15h function 90h).
4. To access the configuration RAM write the byte address (00-3Fh)
   you need to access to I/O port 70h, then access the data via I/O
   port 71h.
5. CMOS RAM chip is a Motorola 146818.
6. The equipment byte is used to determine the configuration for the
   POST power-on diagnostics.
7. Bytes 00-0Dh are defined by the chip for timing functions, bytes
   0Eh-3Fh are defined by IBM.
8. Compaq 386 uses came CMOS chip as IBM AT. Extra functions:
   byte 45 (2Dh) stores additional info not maintained by AT.
   bit 0   indicates is Compaq dual-mode monitor installed
       1   indicates whether keyclick is enabled
       2   not used
       3   if non-Compaq graphics adapter installed
```

8259 Interrupt Controller

The 8259 Interrupt Controller chip provides vital support services for the CPU. In a typical PC, interrupt signals can originate from several different places (i.e. keyboard, disk drive, etc.). The 8088, however, has only one input line on which to receive an interrupt signal. The 8259 chip is therefore employed to manage the various interrupt sources and present a single, controllable interrupt signal to the central processor.

As configured for use in the PC, the 8259 chip can accept up to eight independent signals numbered 0 through 7. For each interrupt it receives, the 8259 can present an interrupt signal to the CPU. Furthermore it presents to the CPU a unique interrupt type code for each of the eight interrupt sources. This allows us to assign a unique interrupt service routine to each different interrupt source. The eight signal inputs to the 8259 are wired onto the control bus so that any device tied into the bus system can access this interrupt mechanism. On the control bus, the signals are named IRQ0 through IRQ7.

Because each signal is independent, provision must be made for the possibility of two or more signals occurring at the same time. The 8259 manages such an event by holding on to the secondary interrupt(s) while the processor services the first. When that interrupt has been serviced, the next one is signalled to the processor. For events that occur at exactly the same moment, the 8259 passes them to the processor in a priority order, where interrupt source 0 has the highest priority and interrupt source 7 has the lowest. One very important consequence of this scheme is that the CPU must indicate to the 8259 when it has completed the servicing of each interrupt. This must be kept in mind whenever an interrupt service routine is written.

Because it has been designed for use in many different applications, the 8259 is an extremely complex chip. Fortunately most of this complexity is handled by the BIOS, which programs the proper configuration information into the 8259 on power-up. The 8259 is thus configured to signal interrupt type codes 08h-0Fh to correspond with interrupt sources 0-7. Note that the two highest-priority interrupts, IRQ0 and IRQ1, are wired directly on the system board. The rest of the interrupt sources are obtained from adapter cards plugged into the expansion slots.

Programming the 8259 consists of two basic actions. First, you can enable or disable each interrupt source independently by writing a value into the interrupt mask register, or IMR. The IMR is a one-byte register within the 8259 that we can access via I/O port 21h. Each bit in the IMR corresponds to the interrupt source with its bit number (i.e. bit 0-IRQ0, bit 1-IRQ1, etc). If a bit in the IMR is 0, then its corresponding interrupt source in enabled. A signal appearing on that input to the 8259 will cause an interrupt to be sent to the CPU. If the IMR bit is 1, then the interrupt source is disabled (or masked) and cannot generate an interrupt. Keep in mind that the state of the interrupt flag within the CPU will ultimately determine whether or not any interrupt signal is received.

The second 8259 programming action that we must be concerned with is the signalling of the end of an interrupt service routine. This is accomplished by sending the 'end of interrupt' (EOI) command, represented by 20h, to the interrupt command register within the 8259. Coincidentally, this one-byte register is accessed via I/O port 20h.

Interrupt Sources

8259 Input	Type Code	Device
IRQ0	08h	system timer (channel 0)
IRQ1	09h	keyboard
IRQ2	0Ah	EGA and CGA
IRQ3	0Bh	COM2
IRQ4	0Ch	COM1
IRQ5	0Dh	hard disk
IRQ6	0Eh	floppy drive
IRQ7	0Fh	parallel printer

Interrupt Mask Register:

```
if Interrupt Flag (in CPU) = 0: All interrupts disabled (use CLI instruction)
if Interrupt Flag (in CPU) = 1: Interrupts enabled      (use STI instruction)

7  6  5  4  3  2  1  0         Interrupt Mask Register
|  |  |  |  |  |  |  |         IMR bit=0: IRQ enabled
|  |  |  |  |  |  |  IRQ0      IMR bit=1: IRQ disabled
|  |  |  |  |  |  IRQ1        Set IMR with MOV  AL,xyz
|  |  |  |  |  IRQ2                        OUT  21H,AL
|  |  |  |  IRQ3
|  |  |  IRQ4
|  |  IRQ5
|  IRQ6
IRQ7
```

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Video Subsystems and Programming

Quick List of Interrupt 10h Functions

00h	Determine or Set Video State	
01h	Set Cursor Type	
02h	Set Cursor Position	
03h	Read Cursor Position	
04h	Read Light Pen	
05h	Select Active Page	
06h	Scroll Page Up	
07h	Scroll Page Down	
08h	Read Character Attribute	
09h	Write Character and Attribute	
0Ah	Write Character	
0Bh	Set Colour Palette	
0Ch	Write Dot	
0Dh	Read Dot	
0Eh	Write TTY	
0Fh	Return Current Video State	
10h	Set Palette Registers	
11h	Character Generator Routine	
12h	Alternate Select	
13h	Enhanced String Write	
14h	Load LCD Character Font	
15h	Return Physical Display Parameters	
1Ah	Display Combination Code	
1Bh	Functionality/State Information	
1Ch	Save/Restore Video State	
40h	Set Graphics Mode	(Hercules Graphics Card)
41h	Set Text Mode	(Hercules Graphics Card)
42h	Clear Current Page	(Hercules Graphics Card)
43h	Select Drawing Page	(Hercules Graphics Card)
44h	Select Drawing Function	(Hercules Graphics Card)
45h	Select Page to Display	(Hercules Graphics Card)
46h	Draw One Pixel	(Hercules Graphics Card)
47h	Find Pixel Value	(Hercules Graphics Card)
48h	Move to Point	(Hercules Graphics Card)
49h	Draw to Point	(Hercules Graphics Card)
4Ah	Block Fill	(Hercules Graphics Card)
4Bh	Display Character	(Hercules Graphics Card)
4Ch	Draw Arc	(Hercules Graphics Card)
4Dh	Draw Circle	(Hercules Graphics Card)
4Eh	Fill Area	(Hercules Graphics Card)
6Ah	Direct Graphics Interface Standard	(DGIS)
6Fh	Set Video Mode	(VEGA Extended EGA/VGA)

70h	Get Video RAM Address	(Tandy 1000)
71h	Get INCRAM Addresses	(Tandy 1000)
72h	Scroll Screen Right	(Tandy 1000)
73h	Scroll Screen Left	(Tandy 1000)
81h	unknown	(DesQview)
82h	Get Current Window Info	(DesQview)
0BFh	Compaq Portable Extensions	
0F0h	Microsoft Mouse driver EGA support - Read One Register	
0F1h	Microsoft Mouse driver EGA support - Write One Register	
0F2h	Microsoft Mouse driver EGA support - Read Register Range	
0F3h	Microsoft Mouse driver EGA support - Write Register Range	
0F4h	Microsoft Mouse driver EGA support - Read Register Set	
0F5h	Microsoft Mouse driver EGA support - Read Register Set	
0F6h	Microsoft Mouse driver EGA support - Revert to Default Registers	
0F7h	Microsoft Mouse driver EGA support - Define Default Reg. Table	
0FAh	Microsoft Mouse driver EGA support - Interrogate Driver	
0FEh	Get Virtual Buffer Address	(Topview/DesQview/Taskview)
0FFh	Update Video Buffer	(Topview/DesQview/Taskview)

Interrupt 10h Video I/O - services to handle video output

(0:0040h)

The ROM video routines in the original PC BIOS are designed for use with the Colour Graphics Adapter and incorporate code to test for the horizontal retrace before writing. The check is performed no matter what actual display adapter is installed. The ROM character table for the first 128 characters is located at 0FA6Eh in the PC. Int 01Fh can be used to point to a second table of 128 characters. CS, SS, DS, ES, BX, CX, DX are preserved during call. All others are destroyed.

Function 00h — Determine or Set Video State

entry AH — 00h — set video mode

AL	display	mode:		CGA	PCjr	MDA	MCGA	EGA	VGA	8514
	00h	40x25 B/W text	8x8	CGA	PCjr			EGA		
16 Colour		40x25, 320x400 graphics					MCGA			
16 Colour		40x25, 360x400 graphics							VGA	
		40x25 B/W tet	8x14		ATI VIP					
16 Colour	01h	40x25 colour text	8x8	CGA	PCjr			EGA		
16 Colour		40x25	8x14		ATI VIP					
	02h	80x25 B/W text	8x8	CGA	PCjr			EGA		
16 Colour		640x400 80x25	8x8				MCGA			
16 Colour		720x400 80x25						VGA		
		80x25 B/W	8x14		ATI VIP					
16 Colour	03h	80x25 colour text	8x8	CGA	PCjr		MCGA	EGA	VGA	
4 Colour	04h	320x200 colour graphics		CGA	PCjr			EGA		
4 tone grey	05h	320x200 B/W graphics	8x8	CGA	PCjr			EGA		
2 Colour	06h	640x200 B/W graphics	8x8	CGA	PCjr			EGA		
monochrome	07h	80x25 monochrome text	9x14			MDA		EGA	VGA	
16 Colour	08h	160x200 colour graphics		CGA	PCjr					
16 Colour	09h	320x200 colour graphics			PCjr				VGA	
4 Colour	0Ah	640x200 colour graphics			PCjr					
N/A	0Bh	BIOS font load						EGA	VGA	
N/A	0Ch	BIOS font load						EGA	VGA	
16 Colour	0Dh	320x200 graphics 40x25	8x8					EGA	VGA	
16 Colour	0Eh	640x200 graphics 80x25	8x8					EGA	VGA	
monochrome	0Fh	640x350 graphics 80x25	8x14					EGA	VGA	
16&64 Colour	10h	640x350 colour 80x25	8x14					EGA	VGA	
2 Colour	11h	640x480 graphics					MCGA		VGA	
	13h = 40x25	8x8 320x200 256/256k		A000	VGA,MCGA,ATI VIP					
	14h = 80x25	8x8 640x200			Lava Chrome II EGA					
	=	640x400 16			Tecmar VGA/AD					
16 Colour	12h	640x480 graphics	8x16						VGA	
16&64 Colour		640x480 80x30	8x16		ATI EGA Wonder					
256Colour	13h	320x200 graphics	8x8				MCGA		VGA	8514
	14h-20h	used by EGA and VGA graphics modes								
	14h	640x200 80x25	8x8		Lava Chrome II EGA					
	15h	640x350 80x25	8x14		Lava Chrome II EGA					
	16h	640x350 80x25	8x14		Lava Chrome II EGA					

16 Colour		800x600			Tecmar VGA/AD
	17h	640x480	80x34	8x14	Lava Chrome II EGA
			132x25		Tecmar VGA/AD
monochrome	18h		132x44	8x8	Tseng Labs EVA
		640x480	80x34	8x14	Lava Chrome II EGA
16 Colour		1024x768			Tecmar VGA/AD
monochrome	19h		132x25	8x14	Tseng Labs EVA
monochrome	1Ah		132x28	8x13	Tseng Labs EVA
256 Colour		640x350			Tecmar VGA/AD
256 Colour	1Bh	640x400			Tecmar VGA/AD
256 Colour	1Ch	640x480			Tecmar VGA/AD
256 Colour	1Dh	800x600			Tecmar VGA/AD
monochrome	21h	Hercules Graphics, Graphics Page 1			
monochrome	22h	Hercules Graphics, Graphics Page 2			
	22h		132x44	8x8	Tseng Labs EVA
			132x44	8x8	Ahead Systems EGA2001
			132x43		Allstar Peacock (VGA)
	23h		132x25	6x14	Tseng Labs EVA
			132x25	8x14	Ahead Systems EGA2001
16 Colour			132x25	8x8	ATI EGA Wonder/ ATI VIP
			132x28		Allstar Peacock (VGA)
	24h		132x28	6x13	Tseng Labs EVA
			132x25		Allstar Peacock (VGA)
	25h	640x480	80x60	8x8	Tseng Labs EVA
16 Colour		640x480	80x60		VEGA VGA
	26h		80x60	8x8	Tseng Labs EVA
		640x480	80x60	8x8	Ahead Systems EGA2001
			80x60		Allstar Peacock (VGA)
16 Colour	27h	720x512			VEGA VGA
monochrome			132x25	8x8	ATI EGA Wonder, ATI VIP
	28h	unknown			VEGA VGA
16 Colour	29h	800x600			VEGA VGA
16 Colour		800x600			Allstar Peacock (VGA)
	2Ah		100x40		Allstar Peacock (VGA)
256 Colour	2Dh	640x350			VEGA VGA
256 Colour	2Eh	640x480			VEGA VGA
256 Colour	2Fh	720x512			VEGA VGA
256 Colour	30h	800x600			VEGA VGA
		unknown			AT&T 6300
16 Colour		640x400	80x25	8x16	Logitech EGA
16 Colour	31h	1056x350	132x25	8x14	Logitech EGA
16 Colour	32h	640x400	80x25	8x16	Logitech EGA
16 Colour	33h	640x480	80x30	8x16	Logitech EGA
16 Colour			132x44	8x8	ATI EGA Wonder/ATI VIP
monochrome	34h	720x348	90x25	8x14	Logitech EGA
16 Colour	35h	720x350	90x25	8x16	Logitech EGA
16 Colour	36h	960x720			VEGA VGA
16 Colour	37h	1024x768			VEGA VGA
monochrome			132x44	8x8	ATI EGA Wonder/ATI VIP
2 Colour	40h	640x400	80x25	8x16	Compaq Portable II
2 Colour		640x400	80x25	8x16	AT&T 6300, AT&T VDC600
			80x43		VEGA VGA, Tecmar VGA/AD
			80x43		Video7 V-RAM VGA
			80x43		Tatung VGA
16 Colour	41h	640x200			AT&T 6300
			132x25		VEGA VGA
			132x25		Tatung VGA
			132x25		Video7 V-RAM VGA
16 Colour	42h	640x400	80x25	8x16	AT&T 6300, AT&T VDC600
			132x43		VEGA VGA
16 Colour		640x400	80x25	8x16	Logitech EGA
			132x43		Tatung VGA
			132x43		Video7 V-RAM VGA
	43h	unsupported 640x200 of 640x400 viewport			AT&T 6300
			80x60		VEGA VGA
16 Colour		640x400	80x25	8x16	Logitech EGA
			80x60		Tatung VGA
			80x60		Video7 V-RAM VGA
	44h	disable VDC and DEB output			AT&T 6300
		100x60			VEGA VGA
4 Colour		320x200	40x25	8x16	Logitech EGA

			100x60		Tatung VGA
			100x60		Video7 V-RAM VGA
4 Colour	45h	320x200	40x25	8x16	Logitech EGA
			132x28		Tatung VGA
			132x28		Video7 V-RAM VGA
2 Colour	46h	640x400	80x25	8x16	Logitech EGA
2 Colour		800x600	100x40	8x15	AT&T VDC600
16 Colour	47h	800x600	100x37	8x16	AT&T VDC600
2 Colour	48h	640x400	80x50	8x8	AT&T 6300, AT&T VDC600
	49h	640x480	80x30	8x16	Lava Chrome II EGA
	4Dh		120x25		VEGA VGA
	4Eh		120x43		VEGA VGA
	4Fh		132x25		VEGA VGA
monochrome	50h		132x25	9x14	Ahead Systems EGA2001
16 Colour		640x480		8x16	Paradise EGA-480
monochr.			80x43		VEGA VGA
monochr.?		640x480			Taxan 565 EGA
			80x34		Lava Chrome II EGA
	51h		80x30	8x16	Paradise EGA-480
monochrome			132x25		VEGA VGA
16 Colour		640x480	80x34	8x14	ATI EGA Wonder
			80x30		Lava Chrome II EGA
monochrome	52h		132x44	9x8	Ahead Systems EGA2001
monochrome			132x43		VEGA VGA
16 Colour		752x410	94x29	8x14	ATI EGA Wonder
			80x60		Lava Chrome II EGA
16 Colour	53h	800x560	100x40	8x14	ATI EGA Wonder/ATI VIP
			132x43		Lava Chrome II EGA
	54h		132x43	8x8	Paradise EGA-480
16 Colour			132x43	7x9	Paradise VGA 256k
16 Colour			132x43	8x9	Paradise VGA on multisync
			132x43		Taxan 565 EGA
16 Colour		800x600	100x42	8x14	ATI EGA Wonder
			132x25		Lava Chrome II EGA
			132x43		AST VGA Plus
			132x43		Hewlett-Packard D1180A
16 Colour			132x43	7x9	AT&T VDC600
	55h		132x25	8x14	Paradise EGA-480
16 Colour			132x25	7x16	Paradise VGA 256k
16 Colour			132x25	8x16	Paradise VGA on multisync
			132x25		Taxan 565 EGA
			132x25		AST VGA Plus
			132x25		Hewlett-Packard D1180A
16 Colour			132x25	7x16	AT&T VDC600
16 Colour			80x66	8x8	ATI VIP 256k
		752x410	94x29	8x14	Lava Chrome II EGA
2 Colour	56h		132x43	8x8	NSI Smart EGA+
4 Colour			132x43	7x9	Paradise VGA
4 Colour			132x43	8x9	Paradise VGA on multisync
monochrome			132x43		Taxan 565 EGA
2 Colour			132x43	7x9	AT&T VDC600
4 Colour	57h		132x25	8x14	NSI Smart EGA+
4 Colour			132x25	7x16	Paradise VGA
4 Colour			132x25	8x16	Paradise VGA on multisync
monochrome			132x25		Taxan 565 EGA
2 Colour			132x25	7x16	AT&T VDC600
16 Colour	58h	800x600	100x75		Paradise VGA 256k
16 Colour			80x33	8x14	ATI EGA Wonder/ATI VIP
16 Colour		800x600	100x75	8x8	AT&T VDC600
16 Colour		800x600			AST VGA Plus
16 Colour		800x600			Hewlett-Packard D1180A
	59h	800x600	100x75		Paradise VGA
2 Colour		800x600	100x75	8x8	AT&T VDC600
2 Colour		800x600		8x8	AST VGA Plus
2 Colour		800x600		8x8	Hewlett-Packard D1180A
16 Colour			80x66	8x8	ATI VIP 256k
256 Colour	5Eh	640x400			Paradise VGA,VEGA VGA
256 Colour		640x400			AST VGA Plus
256 Colour		640x400	80x25	8x16	AT&T VDC600
256 Colour	5Fh	640x480			Paradise VGA
256 Colour		640x480			AST VGA Plus

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256 Colour             640x480                      | Hewlett-Packard D1180A
256 Colour             640x480  80x30         8x16  | AT&T VDC600 (512K)
            60h        ?x400    80x?                | Corona/Cordata BIOS
                                                    | v4.10+
                       752x410                      | VEGA VGA
            60h        400 line graphics+80col text | Corona/Cordata BIOS
                                                    | v4.10+
                       752x410                      | VEGA VGA
16 Colour              752x410                      | Tatung VGA
16 Colour              752x410                      | Video7 V-RAM VGA
            61h        400 line graphics            | Corona/Cordata BIOS
                                                    | v4.10+
                       720x540                      | VEGA VGA
16 Colour              720x540                      | Tatung VGA
16 Colour              720x540                      | Video7 V-RAM VGA
            62h        800x600                      | VEGA VGA
16 Colour              800x600                      | Tatung VGA
16 Colour              800x600                      | Video7 V-RAM VGA
2 Colour    63h        1024x768                     | Video7 V-RAM VGA
4 Colour    64h        1024x768                     | Video7 V-RAM VGA
16 Colour   65h        1024x768                     | Video7 V-RAM VGA
256 Colour  66h        640x400                      | Tatung VGA
256 Colour             640x400                      | Video7 V-RAM VGA
256 Colour  67h        640x480                      | Video7 V-RAM VGA
256 Colour  69h        720x540                      | Video7 V-RAM VGA
            70h        extended mode set            | Everex Micro Enhancer EGA
                       AX      0070h
                       BL      mode (graphics mode if graphics res. listed)
                               00h             640x480 multisync
                               01h             752x410 multisync
                               02h     reserved
                               03h     80x34           multisync
                               04h     80x60           multisync
                               05h     94x29           multisync
                               06h     94x51           multisync
                               07h     reserved
                               08h     reserved
                               09h     80x44           EGA
                               0Ah     132x25          EGA
                               0Bh     132x44          EGA
                               0Ch     132x25          CGA
                               0Dh     80x44           TTL mono
                               0Eh     132x25          TTL mono
                               0Fh     132x44          TTL mono
16 Colour   71h        800x600  100x35        8x16  | NSI Smart EGA+
2 Colour    74h        640x400                      | Toshiba 3100
            7Eh        Special Mode Set             | Paradise VGA, AT&T VDC600
                       BX      horizontal dimension of the mode desired
                       CX      vertical dimension of the mode desired
                               (both BX/CX in pixels for graphics modes, rows
                               for text modes)
                       DX      number of colours of the mode desired
                               (use 00h for monochrome modes)
                       return  AL      7Eh     if successful (AT&T VDC600)
                               BH      7Eh     if successful (Paradise VGA)
            7Fh        Special Function Set         | Paradise VGA, AT&T VDC600
                       BH      00h     Set VGA Operation
                               01h     Set Non-VGA Operation
                               02h     Query Mode Status
                       return  BL      00h     if operating in VGA mode
                                       01h     if non-VGA mode.
                               CH      total video RAM size in 64k byte units
                               CL      video RAM used by the current mode
                               03h  Lock Current Mode
                                    Allows current mode (VGA or non-VGA) to
                                    survive reboot.
                              04h  Enter CGA Mode (AT&T VDC600 only)
                              05h  Enter MDA Mode (AT&T VDC600 only)
                       BH     0Ah,0Bh,0Ch,0Dh,0Eh,0Fh
                              write Paradise registers 0,1,2,3,4,5
                              (port 03CEh indices A,B,C,D,E,F)
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                BL      value to set in the Paradise register.
                BH      1Ah,1Bh,1Ch,1Dh,1Eh,1Fh
                        read Paradise registers 0,1,2,3,4,5
                        (port 03CEh indices A,B,C,D,E,F)
                return AL       7Fh     if successful (AT&T VDC600)
                       BH       7Fh     if successful (Paradise VGA)
                       BL       value of the Paradise register
                note    colour modes (0,1,2,3,4,5,6) will set non-VGA CGA
                        operation. Monochrome mode 7 will set non-VGA
                        MDA/Hercules operation.
        82h     80x25 B&W                   | AT&T VDC overlay mode *
        83h     80x25                       | AT&T VDC overlay mode *
        86h     640x200 B&W                 | AT&T VDC overlay mode *
        0C0h    640x400   2/prog palette    | AT&T VDC overlay mode *
        0C4h    disable output              | AT&T VDC overlay mode *
        0D0h    640x400                     | DEC VAXmate AT&T mode
note 1. If the high bit in AL is set, the display buffer is not cleared when a
        new mode is selected. This may be used to mix modes on the display; for
        example, characters of two difference sizes might be displayed
     2. Modes 8-10 are available on the PCjr, Tandy 1000, and PS/2
     3. IBM claims 100% software and hardware emulation of the CGA with the MCGA
        chipset. All registers may be read and written as CGA. All charactersare
        double-scanned to give 80x25 with 400 line resolution. The attributes
        for setting border colour may be set on MCGA, but the borders will
        remain the default colour (they cannot actually be set)
     4. The IBM Colour Graphics Adapter (CGA) is too slow for the screen to be
        updated before the vertical retrace of the monitor is completed. If the
        video RAM is addressed directly, the screen will have 'snow' or
        interference. IBM's default is to turn the adapter off when it is being
        updated, ie 'flickering' when the display is scrolled.
     5. The vertical retrace signal may be ignored when using the MCGA adapter.
        The MCGA will not generate snow when written to. There is no flicker with
        the MCGA.
     6. The PCjr Video Gate Array uses a user-defined block of main system RAM
        from 4 to 32k in size instead of having dedicated memory for the display.
        Vertical retrace may be ignored when writing to the PCjr. There is no
        flicker with the PCjr display.
     7. The Hercules Graphics Card has 750x348 resolution
     8. The Hercules Graphics Card takes 64k beginning at B:000 (same as MDA)
     9. The CGA, MCGA, and VGA adapters use hardware address B:800
    10. The BIOS clears the screen when the mode is set or reset.
    11. For AT&T VDC overlay modes, BL contains the DEB mode, which may be 06h,
        40h, or 44h
    12. Int 10 will take the shapes of the first 128 characters (00h-7Fh) from
        the table located in ROM at absolute address F000:FA6E. The EGA and VGA
        have hardware capability to change this.
    13. The presence or absence of colour burst is only significant when a compo
        site monitor is being used. For RGB monitors, there is no functional
        difference between modes 00h and 01h or modes 02h and 03h.
    14. On the CGA, two palettes are available in mode 04h and one in mode 05h.
    15. The Corona built-in hi-res mono adapter similar to the Hercules but not
        identical. The Corona graphics memory address is not fixed; instead one
        of the control registers must be loaded with the buffer address. This
        makes it impossible to run most commercial graphics software, unless
        there is specifically a Corona option. The design was actually quite
        impressive - you could do hi-speed animation by switching buffers
        (similar to switching pages on other configurations) but you could use as
        many as you could fit in available memory, at 32k per page. In addition,
        the mono text buffer is always available, and independent of graphics,
        making it easy to overlay text and graphics on the same screen.
        Unfortunately the Corona never really took off, and no one else picked
        up on the design.

Function 01h   Set Cursor Type - set the size of the cursor or turn it off
entry   AH      01h
        CH      bit values:
           bits 0-4     top line for cursor in character cell
                5-6     blink attribute
                        0,0     normal
                        0,1     invisible (no cursor)
                        1,0     slow       (not used on original IBM PC)
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                  1,1      fast       (may be erratic on Tandy 1000TX)
          CL      bit values:
            bits 0-4    bottom line for cursor in character cell
return  none
note 1. The ROM BIOS default cursors are:  start    end
                 monochrome mode 07h:    11       12
                  text modes 00h-03h:     6        7
     2. The blinking in text mode is caused by hardware and cannot be turned off,
        though some kludges can temporarily fake a nonblinking cursor.
     3. The cursor is automatically turned off in graphics mode.
     4. The cursor can be turned off in several ways. On the MDA, CGA, and VGA,
        setting register CH = 20h causes the cursor to disappear. Techniques
        that involve setting illegal starting and ending lines for the current
        display mode tend to be unreliable. Another method of turning off the
        cursor in text mode is to position it to a non-displayable address, such
        as (X,Y)=(0,25).
     5. For the EGA, MCGA, and VGA in text modes 00h-03h, the BIOS accepts cursor
        start and end values as though the character cell were 8x8, and remaps
        the values as appropriate for the true character cell dimensions. This
        mapping is called cursor emulation. One problems is that the BIOS remaps
        BIOS cursor shape in 43 line modes, but returns the unmapped cursor shape.

Function 02h    Set Cursor Position - reposition the cursor to (X,Y)
entry   AH      02h
        BH      video page
                00h     graphics mode
                03h     modes 2 and 3
                07h     modes 0 and 1
        DH      row    (Y=0-24)
        DL      column (X=0-79 or 0-39)
return  none
note 1. (0,0) is upper left corner of the screen
     2. A separate cursor is maintained for each display page, and each can be
        set independently with this function regardless of the currently active
        page.
     3. The maximum value for each text coordinate depends on the video adapter
        and current display mode, as follows:
        19,24   08h
        39,24   00h, 01h, 04h, 05h, 09h, 0Dh, 13h
        79,26   02h, 03h, 06h, 07h, 0Ah, 0Eh, 0Fh, 10h,
        79,29   11h, 12h

Function 03h    Read Cursor Position - return the position of the cursor
entry   AH      03h
        BH      page number
                00h     in graphics modes
                03h     in modes 2 & 3
                07h     in modes 0 & 1
return  CH      top line for cursor     (bits 4-0)
        CL      bottom line for cursor (bits 4-0)
        DH      row number     (Y=0-24)
        DL      column number (X=0-79 or 0-39)
note    A separate cursor is maintained for each display page, and each can be
        checked independently with this function regardless of the currently
        active page.

Function 04h  Read Light Pen - fetch light pen information          (CGA, Jr, EGA)
entry   AH      04h
return  AH      00h     light pen not triggered
        AH      01h     light pen is triggered, values in registers
                BX      pixel column              (X=0-319,639)     graphics mode
                CH      raster line               (Y=0-199)     old graphics modes
                CX      (EGA) raster line (0-nnn)               new graphics modes
                DH      row of current position    (Y=0-24)              text mode
                DL      column of current position (X=0-79 or 0-39)      text mode
note 1. Not supported on PS/2.
     2. The range of coordinates returned by this function depends on the current
        display mode.
     3. On the CGA, the graphics coordinates returned by this function are not
        continuous. The y coordinate is always a multiple of two; the x
        coordinate is either a multiple of four (for 320-by-200 graphics modes)
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        or a multiple of eight (for 640-by-200 graphics modes).
     4. Careful selection of background and foreground colours is necessary to
        obtain maximum sensitivity from the light pen across the full screen
        width.

Function 05h    Select Active Page - set page number for services 6 and 7
entry   AH      05h
        AL      number of new active page
                0-7     modes 00h and 01h (CGA)
                0-3     modes 02h and 03h (CGA)
                0-7     modes 02h and 03h (EGA)
                0-7     mode 0Dh (EGA)
                0-3     mode 0Eh (EGA)
                0-1     mode 0Fh (EGA)
                0-1     mode 10h (EGA)
                0       set address of graphics bitmap buffer (modes 60h,61h)
                        BX      segment of buffer
                0Fh     get address of graphics bitmap buffer (modes 60h,61h)
                        BX      segment of buffer
for PCjr, most Tandy 1000s only:
        AL      80h     to read CRT/CPU page registers
                81h     to set CPU page register to value in BL
                82h     to set CRT page register to value in BH
                83h     to set both CPU and page registers
                        (and Corona/Cordata BIOS v4.10+)
Corona/Cordata BIOS v4.10+
                00h     set address of graphics bitmap buffer (video modes
                        60h,61h)
                        BX      segment of buffer
                0Fh     get address of graphics bitmap buffer (video modes
                        60h,61h)
        BH      CRT page number for subfunctions 82h and 83h
        BL      CPU page register for subfunctions 81h and 83h
return  standard PC  none
        PCjr         if called with AH bit 7=1 then
                     BH      CRT page register (if AL = 80h)
                     BL      CPU page register (if AL = 80h)
        DX      segment of graphics bitmap buffer (video modes 60h,61h; AL=0Fh)
note 1. Mono adapter has only one display page
     2. CGA has four 80x25 text pages or eight 40x25 text pages
     3. A separate cursor is maintained for each display page
     4. Switching between pages does not affect their contents
     5. Higher page numbers indicate higher memory positions

Function 06h    Scroll Page Up - scroll up or initialize a display 'window'
entry   AH      06h
        AL      number of lines blanked at bottom of page
                00h     blank entire window
        BH      attributes to be used on blank line
        CH      row    (Y) of upper left corner or window
        CL      column (X) of upper left corner of window
        DH      row    (Y) of lower right corner of window
        DL      column (X) of lower right corner of window
return  none
note 1. Push BP before scrolling, pop after
     2. Affects current video page only

Function 07h    Scroll Page Down - scroll down or clear a display 'window'
entry   AH      07h
        AL      number of lines to be blanked at top of page
                00h     blank entire window
        BH      attributes to be used on blank line
        CH      row    (Y) of upper left corner or window
        CL      column (X) of upper left corner of window
        DH      row    (Y) of lower right corner of window
        DL      column (X) of lower right corner of window
return  none
note 1. Push BP before scrolling, pop after
     2. Affects current video page only
```

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Function 08h Read Character Attribute-of character at current cursor pos.
entry   AH      08h
        BH      display page number - text mode
return  AH      character attribute - text mode
        AL      ASCII code of character at current cursor position
note    In video modes that support multiple pages, characters and their
        attributes can be read from any page, regardless of the page currently
        being displayed.

Function  09h   Write Character and Attribute - at current cursor position
entry   AH      09h
        AL      ASCII code of character to display
        BH      display page number - text mode
        BL      attribute (text modes) or colour (graphics modes)
        CX      number of characters to write
return  none
note 1. CX should not exceed actual rows available, or results may be erratic.
     2. Setting CX to zero will cause runaway.
     3. All values of AL result in some sort of display; the various control
        characters are not recognized as special and do not change the current
        cursor position.
     4. Does not change cursor position when called - the cursor must be advanced
        with int 10 function 0Ah.
     5. If used to write characters in graphics mode with bit 7 of AH set to 1
        the character will by XORed with the current display contents. This
        feature can be used to write characters and then 'erase' them.
     6. In graphics mode the bit patterns for ASCII character codes 80h-0FFh are
        obtained from a table. On the standard PC and AT, the location is at
        interrupt vector 01Fh (0000:007Ch). For ASCII characters 00h-07Fh, the
        table is at an address in ROM. On the PCjr the table is at interrupt
        vector 44h (0000:00110h) and is in addressable RAM (may be replaced by
        the user).
     7. All characters are displayed, including CR, LF, and BS.
     8. In graphics modes, the dup factor in CX produces a valid result only for
        the current row. If more characters are written than there are remaining
        columns in the current row, the result is unpredictable.
     9. For the EGA, MCGA, and VGA in graphics modes, the address of the
        character definition table is stored in the vector for int 43h.

Function 0Ah Write Character-display character(s) (use current attribute)
             at current cursor position
entry   AH      0Ah
        AL      ASCII code of character to display
        BH      display page - text mode
        BL      colour of character (graphics mode, PCjr only)
        CX      number of times to write character
return  none
note 1. CX should not exceed actual rows available, or results may be erratic.
     2. All values of AL result in some sort of display; the various control
        characters are not recognized as special and do not change the current
        cursor position.
     3. If used to write characters in graphics mode with bit 7 of BL set to 1
        the character will by XORed with the current display contents. This
        feature can be used to write characters and then 'erase' them.
     4. In graphics mode the bit patterns for ASCII character codes 80h-0FFh are
        obtained from a table. On the standard PC and AT, the location is at
        interrupt vector 01Fh (0000:007C). For ASCII characters 00h-07Fh, the
        table is at an address in ROM. On the PCjr the table is at interrupt
        vector 44h (0000:00110) and is in addressable RAM (may be replaced by
        the user).
     5. In graphics modes, replication count in CX works correctly only if all
        characters written are contained on the same row.
     6. All characters are displayed, including CR, LF, and BS.
     7. For EGA, MCGA, and VGA in graphics modes, the address of the character
        definition table is stored in the vector for int 43h.
     8. After a character is written, the cursor must be moved explicitly with Fn
        02h to the next position.

Function 0Bh  Set Colour Palette - set palette for graphics or text border
              Selects a palette, background, or border colour.
entry   AH      0Bh
```

```
        BH       00h      select border (text mode)
                 BL       colour 0-15, 16-31 for high-intensity characters
        BH       01h      set graphics palette with value in BL
         (CGA)   BL       0        green/red/yellow
                          1        cyan/magenta/white
  (EGA) (graphics modes)
        BH       0
        BL       has border colour (0-15) & high intensity bkgr'd colour (16-31)
        BH       1
        BL       contains palette being selected (0-1)
return  none
note 1. Valid in CGA mode 04h, PCjr modes 06h, 08h-0Ah.
     2. Although the registers in the MCGA may be set as if to change the border,
        the MCGA will not display a border no matter what register settings are
        used.
     3. In text modes, this function selects only the border colour. The
        background colour of each individual character is controlled by the
        upper 4 bits of that character's attribute byte.
     4. On the CGA and EGA, this function is valid for palette selection only in
        320-by-200 4-colour graphics modes.
     5. In 320-by-200 4-colour graphics modes, if BH=01h, the following palettes
        may be selected:
        Palette  Pixel value      Colour
            0        0         same as background
                     1         green
                     2         red
                     3         brown or yellow
            1        0         same as background
                     1         cyan
                     2         magenta
                     3         white
     6. On the CGA in 640-by-200 2-colour graphics mode, the background colour
        selected with this function actually controls the display colour for non
        zero pixels; zero pixels are always displayed as black.
     7. On the PCjr in 640-by-200 2-colour graphics mode, if BH=00h and bit 0 of
        BL is cleared, pixel value 1 is displayed as white; if bit 0 is set,
        pixel value 1 is displayed as black.

Function 0Ch    Write Dot - plot one graphics pixel
entry   AH      0Ch
        AL      dot colour code  (0/1 in mode 6, 0-3 in modes 4 and 5)
                (set bit 7 to XOR the dot with current colour)
                0-3 mode 04h, 05h
                0-1 mode 06h
        BH      page number (ignored if adapter supports only one page)
        CX      column (X=0000h - 027Fh)
                (0 - 319 in modes 4,5,13,  0 - 639 in modes 6,14,15,16)
        DX      row     (Y=0000h - 00C7h) (0 - 199 CGA).
return  none
note 1. Video graphics modes 4-6 only.
     2. The range of valid pixel values and (x,y) coordinates depends on the
        current video mode.
     3. If bit 7 of AL is set, the new pixel value will be XORed with the current
        contents of the pixel.

Function 0Dh    Read Dot - determine the colour of one graphics pixel
entry   AH      0Dh
        BH      page
        CX      column (X=0000h - 027Fh)  (0-319 or 639)
        DX      row    (Y=0000h - 00C7h)  (0-199)
return  AL      colour of dot
note 1. Only valid in graphics modes.
     2. The range of valid (x,y) coordinates and possible pixel values depends on
        the current video mode.
     3. Register BH is ignored for display modes that support only one page.

Function 0Eh    Write TTY-write one character and update cursor. Also handles
                CR (0Dh), beep (07h), backspace (10h), and scrolling
entry   AH      0Eh
        AL      ASCII code of character to be written
        BH      page number (text)
```

```
        BL      foreground colour (video modes 6 & 7 only) (graphics)
return  none
note 1. The ASCII codes for bell, backspace, carriage return, and line-feed are
        recognized and appropriate action taken. All other characters are
        written to the screen and the cursor is advanced to the next position.
     2. Text can be written to any page regardless of current active page.
     3. Automatic linewrap and scrolling are provided through this function.
     4. This is the function used by the DOS CON console driver.
     5. This function does not explicitly allow the use of attributes to the
        characters written. Attributes may be provided by first writing an ASCII
        27h (blank) with the desired attributes using function 09h, then over
        writing with the actual character using this function. While clumsy
        this allows use of the linewrap and scrolling services provided by this
        function.
     6. The default DOS console driver (CON) uses this function to write text to
        the screen.

Function 0Fh    Return Current Video State - mode and size of the screen
                Obtains the current display mode of the active video controller.
entry   AH      0Fh
return  AH      number of character columns on screen
        AL      mode currently set (see AH=00h for display mode codes)
        BH      current active display page
note 1. If mode was set with bit 7 set ("no blanking"), the returned mode will
        also have bit 7 set.
     2. This function can be called to obtain the screen width before clearing
        the screen with Fns 06h or 07h.

Function 10h    Set Palette Registers          (PCjr, Tandy 1000, EGA, MCGA, VGA)
entry   AH      10h
        AL      00h     Set Individual Palette Register
                        BH      colour value to store
                        BL      palette register to set
                                (on MCGA, only BX = 0712h is supported)
                        return  none
                        note    On the MCGA, this function can only be called
                                with BX=0712h and selects a colour register set
                                with eight consistent colours.

                01h     Set Border Colour     (overscan)          (Jr, EGA, VGA)
                        BH      colour value to store
                return  none

                02h     Set All Palette Registers and Border
                        ES:DX   pointer to 17-byte colour list
                                bytes 0-15    values for palette regs. 0-15
                                byte 16       value for border colour
                                              register
                return  none
                note    In 16-colour graphics modes, the following default
                        palette is set up:
                    Pixel value   Colour
                        01h     blue
                        02h     green
                        03h     cyan
                        04h     red
                        05h     magenta
                        06h     brown
                        07h     white
                        08h     grey
                        09h     light blue
                        0Ah     light green
                        0Bh     light cyan
                        0Ch     light red
                        0Dh     light magenta
                        0Eh     yellow
                        0Fh     intense white

                03h     Toggle Blink/Intensity Bit          (Jr & later exc Conv.)
                        BL      00h     enable intensity
                                01h     enable blink
```

```
        return  none

04h     unknown

05h     unknown

06h     unknown

07h     Get Palette Register Value                          (VGA)
        BL      palette register number
return  BH      palette register colour value

08h     Get Border Colour  (overscan)                       (VGA)
return  BH      colour value

09h     Read All Palette Registers and Overscan Register    (VGA)
        ES:DX   pointer to buffer address (17 bytes)
return  ES:DX   buffer contains palette values in bytes
                00h-0Fh and border colour in byte 10h.

10h     Set Individual Video DAC Colour Register      (MCGA, VGA)
        BX      register number
        CH      new value for green (0-63)
        CL      new value for blue  (0-63)
        DH      new value for red   (0-63)
return  none
        note    If greyscale summing is enabled, the weighted
                greyscale value for each register is calculated
                as described under Subfn 1Bh and is stored into
                all three components of the colour register.

11h     unknown

12h     Set Block of Video DAC Colour Registers       (MCGA, VGA)
        BX      starting colour register
        CX      number of registers to set
        ES:DX   pointer to a table of 3*CX bytes where each
                3-byte group represents one byte each of red,
                green and blue (0-63) in that order.
        return  none
        note    If greyscale summing is enabled, the weighted
                greyscale value for each register is calculated
                as described under Subfn 1Bh and is stored into
                all three components of the colour register.

13h     Set Video DAC Colour Page                           (VGA)
        BL      00h     select paging mode
                BH      00h     select 4 pages of 64 registers
                        01h     select 16 pages of 16 registers
                01h     select register page
                BH      page number (00h to 03h or 00h to 0Fh)
        return  none
        note    This function not valid in mode 13h (320-by-200
                256-colour graphics).

14h     unknown

15h     Read Individual Video DAC Colour Register     (MCGA, VGA)
        BX      palette register number
return  CH      green value
        CL      blue value
        DH      red value

16h     unknown

17h     Read Block of Video DAC Colour Registers      (MCGA, VGA)
        BX      starting palette register
        CX      number of palette registers to read
        ES:DX   pointer for palette register list (3 * CX bytes
                in size)
return  CX      number of red, green and blue triples in buffer
```

```
                ES:DX    address of buffer with colour list
        note    The colour list returned in the caller's buffer consists
                of a series of 3-byte entries corresponding to the
                colour registers. Each 3-byte entry contains the
                register's red, green, and blue components in that order.

        18h     Set Pixel Mask (undocumented)
                BL       new pixel value

        19h     Read Pixel Mask (undocumented)
                BL       value read

        1Ah     Read Video DAC Colour-Page State                  (VGA)
        return  BH       current page
                BL       paging mode
                         00h     four pages of 64 registers
                         01h     sixteen pages of 16 registers

        1Bh     Perform Greyscale Summing                  (MCGA, VGA)
                BX       starting palette register
                CX       number of registers to convert
        return  none
        note 1. For each colour register, the weighted sum of its red,
                green, and blue values is calculated (30 red + 59 green
                + 11 blue) and written back into all three components of
                the colour register.
             2. The original red, green, and blue values are lost.

        BH      colour value
        BL      if AL=00h        palette register to set (00h-0Fh)
                if AL=03h        00h     to enable intensity
                                 01h     to enable blinking
        ES:DX   if AL=02h        pointer to 16-byte table of register values
                                  followed by the overscan value:
                          bytes 0-15     values for palette registers 0-15
                          byte  16       value for border register
return  none
note    DAC is Digital to Analog Convertor circuit in MCGA/VGA chips.

Function 11h    Character Generator Routine (EGA and after)
entry   AH      11h
                The following functions will cause a mode set, completely
                resetting the video environment, but without clearing the video
                buffer.
        AL     00h, 10h  Load User-Specified Patterns or Fonts     (EGA, MCGA, VGA)
                         BH      number of bytes per character pattern
                         BL      block to load in map 2
                         CX      count of patterns to store
                         DX      character offset into map 2 block (1st code)
                         ES:BP   pointer to user font table
                return   none
                note 1.  If AL=10h, page 0 must be active. The bytes per
                         character, rows, and length of the refresh buffer are
                         recalculated.
                     2.  The controller is reprogrammed with the maximum scan line
                         (points-1), cursor start (points-2), cursor end (points-
                         1), vertical display end ((rows*points)-1), and
                         underline locations (points-1, mode 7 only).
                     3.  If subfn 10h is called at any time other than immediately
                         after a mode set, the results are unpredictable.
                     4.  On the MCGA, a subfn 00h call should be followed by a
                         subfn 03h call so that the BIOS will load the font into
                         the character generator's internal font pages.
                     5.  Subfn 10h is reserved on the MCGA. If it is called, subfn
                         00h is performed.
                     6.  Text modes only.

               01h, 11h  Load ROM 8 by 14 Character Set                 (EGA, VGA)
                         BL      block to load
                return   none
                note 1.  Text modes only.
```

```
          2. For AL=11h, page 0 must be active. The points (bytes per
             character), rows, and length of the refresh buffer are
             recalculated.
          3. The controller is reprogrammed with the maximum scan line
             (points-1), cursor start (points-2), cursor end (points-
             1), vertical display end ((rows*points)-1), and
             underline location (points-1, mode 7 only).
          4. If subfn 11h is called at any time other than right after
             a mode set, the results are unpredictable.
          5. Subfns 01h and 11h are reserved on the MCGA. If either is
             called, subfn 04h is performed instead.

 02h, 12h    Load ROM 8x8 Double-Dot Patterns           (EGA, MCGA, VGA)
             BL      block to load
   return    none
   note 1.   Text modes only.
          2. If AL=12h, page 0 must be active. The points (bytes per
             character), rows, and length of the refresh buffer are
             recalculated.
          3. The controller is reprogrammed with the maximum scan line
             (points-1), cursor start (points-2), cursor end (points-
             1), vertical display end ((rows*points)-1), and underline
             location (points-1, mode 7 only).
          4. If subfn 12h is called at any time other than right after
             a mode set, the results are unpredictable.
          5. For the MCGA, a subfn 02h call should be followed by a
             subfn 03h call so the BIOS will load the font into the
             character generator's internal font pages.
          6. Subfn 12h is reserved on the MCGA. If it is called, subfn
             02h is executed.

 03h         Set Block Specifier                        (EGA, MCGA, VGA)
             BL      block specifier select mode
(EGA/MCGA) bits 0-1  char block selected by attr bytes with bit 3=0
             2-3     char block selected by attr bytes with bit 3=1
             4-7     not used (should be 0)
     (VGA) bits 0,1,4 char block selected by attr bytes with bit 3=0
             2,3,5   char block selected by attr bytes with bit 3=1
             6-7     not used (should be 0)
   return    none
   note 1.   Determines the char blocks selected by bit 3 of char
             attribute bytes in text display modes.
          2. When using a 256 character set, both fields of BL should
             select the same character block. In such cases,
             character attribute bit 3 controls the foreground
             intensity. When using 512-character sets, the fields of
             BL designate the blocks holding each half of the
             character set, and bit 3 of the character attribute
             selects the upper or lower half of the character set.
          3. When using a 512-char set, a call to int 10h/fn10h/ subfn
             00h with BX=0712h is recommended to set the colour
             planes to eight consistent colours.

 04h,14h     Load ROM 8x16 Text Character Set                (MCGA,VGA)
             BL      block
   return    none
   note 1.   For text modes.
          2. If AL=14h, page 0 must be active. The points (bytes per
             char), rows, and refresh buffer length are recalculated
          3. The controller is reprogrammed with the maximum scan line
             (points-1), cursor start (points-2), cursor end (points-
             1), vertical display end (rows*points -1 for 350 and 400
             line modes, or rows*points*2 -1 for 200 line modes), and
             underline location (points -1, mode 7 only).
          4. If subfn 14h is called any time other than just after a
             mode set, the results are unpredictable.
          5. For MCGA, a subfn 04h call should be followed by a subfn
             03h call so that the BIOS will load the font into the
             character generator's internal font pages.
          6. Subfn 14h is reserved on the MCGA. If it is called, subfn
             04h is executed.
```

```
20h     Set User 8x8 Graphics Chars       (int 1Fh)(EGA, MCGA, VGA)
        ES:BP   pointer to user font table
return  none
note 1. This table is used for chars 80h-0FFh in graphics modes
        04h-06h.
     2. If this subfn is called at any time other than just after
        a mode set, the results are unpredictable.

21h     Set int 43h for User Graphics Chars       (EGA, MCGA, VGA)
        BL      character rows specifier
                00H if user specified (see register DL)
                01h     14 (0Eh) rows
                02h     25 (19h) rows
                03h     43 (2Bh) rows
        CX      bytes per character (points)
        DL      character rows per screen if BL=00h
        ES:BP   pointer to user table
return  none
note 1. The video controller is not reprogrammed.
     2. This function works for graphics modes.
     3. If this subfn is called at any time other than right
        after a mode set, the results are unpredictable.

22h     Set int 43h for ROM 8x14 Font             (EGA, MCGA, VGA)
        BL      character rows specifier
                00h     if user specified (see register DL)
                01h     14 (0Eh) rows
                02h     25 (19h) rows
                03h     43 (2Bh) rows
        DL      character rows per screen (if BL=00h)
return  none
note 1. The video controller is not reprogrammed.
     2. This function works for graphics modes.
     3. If this subfn is called at any time other than right
        after a mode set, the results are unpredictable.
     4. When this subfn is called on the MCGA, subfn 24h is
        substituted.

23h     Set int 43h for ROM 8x8 Double Dot Font (EGA, MCGA, VGA)
        BL      character row specifier
                00h     if user specified (see register DL)
                01h     14 (0Eh) rows
                02h     25 (19h) rows
                03h     43 (2Bh) rows
        DL      character rows per screen (BL=00h)
        return  none
        note 1. Updates the video BIOS data area. The video
                controller is not reprogrammed.
             2. Provides font selection in graphics modes.
             3. If called at any time other than immediately
                after a mode set the results are unpredictable.

24h     Set int 43h for 8x16 Graphics Font             (MCGA, VGA)
        BL      character row specifier
                00h     if user specified (see register DL)
                01h     14 (0Eh) rows
                02h     25 (19h) rows
                03h     43 (2Bh) rows
        DL      character rows per screen (BL=00h)
        return  none
        note 1. Updates the video BIOS data area. The video
                controller is not reprogrammed.
             2. Provides font selection in graphics modes.
             3. If called at any time other than immediately
                after a mode set the results are unpredictable.

30h     Get Font Information                      (EGA, MCGA, VGA)
        BH      pointer specifier
                00h     current int 1Fh pointer
                01h     current int 43h pointer
```

```
                     02h      ROM 8x14 char font ptr     (EGA, VGA only)
                     03h      ROM 8x8 double dot font pointer
                              (characters 00h-7Fh)
                     04h      ROM 8x8 double dot font (top half)
                              (characters 80h-0FFh)
                     05h      ROM text alternate (9x14) pointer
                                                         (EGA, VGA only)
                     06h      ROM 8x16 font             (MCGA, VGA only)
                     07h      ROM alternate 9x16 font        (VGA only)
            return   CX       points (bytes per character)
                     DL       rows (character rows on screen -1)
                     ES:BP    pointer to font table

Function 12h  Alternate Select (EGA and after)
entry    AH   12h
         BL   10h    Return Configuration Information          (EGA, VGA)
              return BH       00h      if colour mode is in effect     (3Dx)
                              01h      if mono mode is in effect       (3Bx)
                     BL       00h      if 64k EGA memory installed
                              01h      if 128k EGA memory installed
                              02h      if 192k EGA memory installed
                              03h      if 256k EGA memory installed
                              10h      EGA adapter is installed (use to check)
                     CH       feature bits (see note 2)
                     CL       switch settings (see note 3)
              note 1. Obtains information for the active video subsystem.
                   2. The feature bits are set from Input Status register 0 in
                      response to an output on the specified Feature Control
                      register bits:
                              Feature  Feature Control  Input Status
                              Bit(s)   Output Bit       Bit
                              0        0                5
                              1        0                6
                              2        1                5
                              3        1                6
                              4-7      not used
                   3. The bits in the switch settings byte indicate the state
                      of the EGA's configuration DIP switch (1=off, 0=on).
                  bit 0       configuration switch 1
                      1       configuration switch 2
                      2       configuration switch 3
                      3       configuration switch 4
                      4-7     not used
              20h     Select Alternate Print Screen Routine          (EGA, VGA)
              return  none
              note    Selects PrtSc routine for screen modes using more than
                      the default BIOS 25 lines.

              30h     Select Vertical Resolution for Text Modes          (VGA)
                      AL      00h      200 scan lines
                              01h      350 scan lines
                              02h      400 scan lines
              return  AL      12h      if function supported
                              00h      VGA not active
              note    The selected value takes effect the next time int 10h/Fn
                      00h is called to select the display mode.

              31h     Enable/Disable Default Palette Loading       (MCGA, VGA)
                      AL      00h      enable default palette loading
                              01h      disable default palette loading
              return  AL      12h      if function was supported

              32h     Enable/Disable Video Addressing              (MCGA, VGA)
                      AL      00h      enable video access
                              01h      disable video access
              return  AL      12h      if function was supported
              note    Enables or disables CPU access to the video adapter's I/O
                       ports and video refresh buffer.

              33h     Enable/Disable Default Greyscale Summing     (MCGA, VGA)
                      AL      00h      enable greyscale summing
```

```
                    01h       disable greyscale summing
return    AL        12h       if function was supported
note 1.   Works for the currently active display.
     2.   When enabled, greyscale summing occurs during display
          mode selection, palette programming, and colour register
          loading.

34h       Enable/Disable Text Cursor Emulation                 (VGA)
          AL        00h       enable cursor emulation
                    01h       disable cursor emulation
return    AL        12h       if function was supported
note 1.   Works for currently active display.
     2.   When cursor emulation is enabled the BIOS automatically
          remaps int 10h/Fn 01h (Cursor Starting & Ending Lines)
          for the current character cell dimensions.

35h       Switch Active Display          (PS/2)          (MCGA, VGA)
          AL        00h       disable initial video adapter
                    01h       enable motherboard video adapter
                    02h       disable active video adapter
                    03h       enable active video adapter
                    80h       *undocumented* set system board video
                              active flag
          ES:DX     128 byte save area buffer if AL=00h, 02h or 03h
return    AL        12h       if function was supported
note 1.   Allows selection of one of two video adapters in the
          system when memory or port addresses conflict.
     2.   This subfn cannot be used unless both video adapters have
          a disable capability (int 10h/Fn12h subfn 32h).
     3.   If there is no conflict between the system board video
          and the adapter board video in memory or port usage,
          both video controllers can be active simultaneously.

36h       Enable/Disable Video Refresh                         (VGA)
          AL        00h       enable refresh
                    01h       disable refresh
return    AL        12h       if function supported
note      Enables or disables the video refresh for the currently
          active display.

55h       unknown (used by ATI and Taxan video boards) fns 00h and
          02h

Function 13h   Enhanced String Write              (except original PC)
entry     AH   13h
          AL   00h       Write String, Don't Move Cursor
               01h       Write String and Update Cursor
               02h       Write String of Alternating Characters and Attributes;
                         Don't Move Cursor
                         bit 0: set in order to move cursor after write
                         bit 1: set if string contains alternating chars and
                                attributes
               03h       Write String of Alternating Characters and Attributes;
                         Move Cursor
                         bit 0: set in order to move cursor after write
                         bit 1: set if string contains alternating characters and
                                attributes
          BH        display page number
          BL        attribute (if AL=00h or 01h)
          CX        length of string
          DH        row of starting cursor position (y)
          DL        column of starting cursor position (x)
          ES:BP     pointer to start of string
return    none
note 1.   Recognizes CR, LF, BS, and bell.
     2.   This function is not available on the original IBM PC or XT unless an EGA
          or later video adapter is installed.

Function 14h   Load LCD Character Font                    (Convertible)
entry     AH   14h
          AL   00h       load user-specified font
```

```
                BH      number of bytes per character
                BL      00h     load main font (block 0)
                        01h     load alternate font (block 1)
                CX      number of characters to store
                DX      character offset into RAM font area
                ES:DI   pointer to character font
        AL      01h     load system ROM default font
                BL      00h     load main font (block 0)
                        01h     load alternate font (block 1)
        AL      02h     set mapping of LCD high intensity attribute
                BL      00h     ignore high intensity attribute
                        01h     map high intensity to underscore
                        02h     map high intensity to reverse video
                        03h     map high intensity to selected alternate font
return  unknown

Function 15h    Return Physical Display Parameters                  (Convertible)
entry   AH      15h
return  AX      Alternate display adapter type
                0000h   none
                5140h   LCD
                5151h   mono
                5153h   CGA
        ES:DI   pointer to parameter table:
               word #       Information
                01h     monitor model number
                02h     vertical pixels per meter
                03h     horizontal pixels per meter
                04h     total number of vertical pixels
                05h     total number of horizontal pixels
                06h     horizontal pixel separation in micrometers
                07h     vertical pixel separation in micrometers

Functions 15h-19h  apparently not used

Function 1Ah    Get or Set Display Combination Code         (PS/2)  (MCGA, VGA)
                Using the compatibility BIOS of the PS/2 Models 50, 60, 80
                there is a way to determine which video controller and attached
                display are on the system. The Display Combination Code (DCC) is
                a Video BIOS function that provides the capability.
entry   AH      1Ah
        AL      00h     read display combination code
                01h     write display combination code
                BH      inactive display code (if AL=01h)
                BL      active display code   (if AL=01h)
return  AL      1Ah     indicates Compatibility BIOS is supported, any other
                        value is invalid
        BH      Display Combination Code (DCC) (if AH=00h)
                00h     no display
                01h     IBM monochrome adapter and 5151 display
                02h     IBM colour/graphics adapter w/5153 or 5154 colour display
                03h     reserved
                04h     IBM EGA, 5153 or 5154 colour display
                05h     IBM EGA, 5151 monochrome display
                06h     IBM PGA, 5175 colour display
                07h     VGA, analog monochrome display
                08h     VGA, analog colour display
                09h     reserved
                0Ah     MCGA, digital colour display
                0Bh     MCGA, analog monochrome display
                0Ch     MCGA, analog colour display
                0Dh-0FEh reserved
                0FFh    unknown display type
        BL      active display device code  (if AH=00h)
note    This function may be used to test for VGA, since it is not supported in
        earlier adapters. If AL is still 1Ah when the call completes, a VGA or
        MCGA compatible adapter is present.

Function 1Bh    Functionality/State Information       (PS/2)           (MCGA, VGA)
entry   AH      1Bh
        BX      implementation type (always 0000h)
```

```
        ES:DI    pointer to 64 byte buffer
return  AL       1Bh if function supported
        ES:DI    buffer filled
                 00h-03h address of functionality table  (see note 1)
                 04h     current video mode
                 05h-06h number of columns
                 07h-08h length of regen buffer in bytes
                 09h-0Ah starting address in regen buffer of upper left corner of
                         display
                 0Bh-0Ch cursor position for page 0  (y,x)
                 0Dh-0Eh cursor position for page 1  (y,x)
                 0Fh-10h cursor position for page 2  (y,x)
                 11h-12h cursor position for page 3  (y,x)
                 13h-14h cursor position for page 4  (y,x)
                 15h-16h cursor position for page 5  (y,x)
                 17h-18h cursor position for page 6  (y,x)
                 19h-1Ah cursor position for page 7  (y,x)
                 1Bh     cursor starting line
                 1Ch     cursor ending line
                 1Dh     active display page
                 1Eh-1Fh adapter base CRTC port address (3BXh mono, 3DXh colour)
                 20h     current setting of register 3B8h or 3D8h
                 21h     current setting of register 3B9h or 3D9h
                 22h     number of character rows
                 23h-24h character height in scan lines
                 25h     DCC of active display
                 26h     DCC of alternate (inactive) display
                 27h-28h number of colours supported in current mode (0 for mono)
                 29h     number of pages supported in current mode
                 2Ah     number of scan lines active
                         00h     200 scan lines
                         01h     350 scan lines
                         02h     400 scan lines
                         03h     480 scan lines
                         04h-0FFh reserved
                 2Bh     primary character block
                 2Ch     secondary character block
                 2Dh     miscellaneous flags byte
                     bit 0       all modes on all displays on (always 0 on MCGA)
                         1       greyscale summing on
                         2       monochrome display attached
                         3       default palette loading disabled
                         4       cursor emulation enabled (always 0 on MCGA)
                         5       0=intensity; 1=blinking
                         6       reserved
                         7       reserved
                 2Eh-30h reserved
                 31h     video memory available
                         00h     64k
                         01h     128k
                         02h     192k
                         03h     256k
                 32h     save pointer state flags byte
                     bit 0       512 character set active
                         1       dynamic save area active
                         2       text mode font override active
                         3       graphics font override active
                         4       palette override active
                         5       DCC override active
                         6       reserved
                         7       reserved
                 33h-3Fh reserved
note    State Functionality Table format (16 bytes)
        00h      modes supported #1
            bit 0        mode 00h supported
                1        mode 01h supported
                2        mode 02h supported
                3        mode 03h supported
                4        mode 04h supported
                5        mode 05h supported
                6        mode 06h supported
```

```
              7         mode 07h supported
        01h       modes supported #2
            bit 0         mode 08h supported
              1         mode 09h supported
              2         mode 0Ah supported
              3         mode 0Bh supported
              4         mode 0Ch supported
              5         mode 0Dh supported
              6         mode 0Eh supported
              7         mode 0Fh supported
        02h       modes supported #3
            bit 0         mode 10h supported
              1         mode 11h supported
              2         mode 12h supported
              3         mode 13h supported
              4-7       reserved
        03h to 06h reserved
        07H       scan lines available in text modes
            bit 0         200 scan lines
              1         350 scan lines
              2         400 scan lines
              3-7       reserved
        08h       total number of character blocks available in text modes
        09h       maximum number of active character blocks in text modes
        0Ah       miscellaneous BIOS functions #1
            bit 0         all modes on all displays function supported (0 on MCGA)
              1         greyscale summing function supported
              2         character font loading function supported
              3         default palette loading enable/disable supported
              4         cursor emulation function supported
              5         EGA 64-colour palette present
              6         colour palette present
              7         colour paging function supported
        0Bh       miscellaneous BIOS functions #2
            bit 0         light pen supported
              1         save/restore state function 1Ch supported (0 on MCGA)
              2         intensity blinking function supported
              3         Display Combination Code supported
              4-7       reserved
        0Ch to 0Dh reserved
        0Eh       Save pointer function flags
            bit 0         512 character set supported
              1         dynamic save area supported
              2         text font override supported
              3         graphics font override supported
              4         palette override supported
              5         DCC extension supported
              6         reserved
              7         reserved
        0Fh       reserved

Function 1Ch    Save/Restore Video State                  (PS/2 50+)  (VGA)
entry   AH      1Ch
        AL      00h     return state buffer size
                01h     save video state
                        ES:BX   buffer address
                02h     restore video state
                        ES:BX   buffer address of previously saved state
        CX      requested states  (1 byte)
           bits 0       save or restore video hardware state
                1       save or restore BIOS data areas
                2       save or restore colour registers and DAC state
                3-0Fh   reserved
return  AL      1Ch if function supported
        BX      number of 64 byte blocks needed (function 00h)
note 1. VGA only.
     2. Saves or restores the digital-to-analog converter (DAC) state and colour
        registers, BIOS video driver data area, or video hardware state.
     3. Subfn 00h is used to determine the size of buffer to contain the
        specified state information. The caller must supply the buffer.
     4. The current video state is altered during a save state operation
```

```
        (AL=01h). If the requesting program needs to continue in the same video
        state, it can follow the save state request with an immediate call to
        restore the video state.

Function 40h    Set Graphics Mode (Hercules Graphics Card)
entry   AH      40h
return  unknown

Function 41h    Set Text Mode (Hercules Graphics Card)
entry   AH      41h
return  unknown

Function 42h    Clear Current Page (Hercules Graphics Card)
entry   AH      42h
return  unknown

Function 43h    Select Drawing Page (Hercules Graphics Card)
entry   AH      43h
        AL      page number (0 or 1)
return  unknown

Function 44h    Select Drawing Function (Hercules Graphics Card)
entry   AH      44h
        AL      00h     clear pixels
                01h     set pixels
                02h     invert pixels
return  unknown

Function 45h    Select Page to Display (Hercules Graphics Card)
entry   AH      45h
        AL      page number (0 or 1)
return  unknown

Function 46h    Draw One Pixel (Hercules Graphics Card)
entry   AH      46h
        DI      x       (0-720)
        BP      y       (0-347)
return  unknown
note    Function 44h determines operation and function 43h which page to use.

Function 47h    Find Pixel Value (Hercules Graphics Card)
entry   AH      47h
        DI      x       (0-720)
        BP      y       (0-347)
return  AL      00h     pixel clear
                01h     pixel set
note    Function 43h specifies page that is used.

Function 48h    Move to Point (Hercules Graphics Card)
entry   AH      48h
        DI      x       (0-720)
        BP      y       (0-347)
return  unknown

Function 49h    Draw to Point (Hercules Graphics Card)
entry   AH      49h
        DI      x       (0-720)
        BP      y       (0-347)
return  unknown
note    Function 48h or 49h specify first point, 44h operation and 43h page to
        use.

Function 4Ah    Block Fill (Hercules Graphics Card)
entry   AH      4Ah
return  unknown

Function 4Bh    Display Character (Hercules Graphics Card)
entry   AH      4Bh
        AL      ASCII code for character to display
        DI      x       (0-720)
        BP      y       (0-347)
```

```
return  unknown
note    Unlike the other BIOS character functions character position is specified
        in pixels rather than rows and columns.

Function 4Ch    Draw Arc (Hercules Graphics Card)
entry   AH      4Ch
return  unknown

Function 4Dh    Draw Circle (Hercules Graphics Card)
entry   AH      4Dh
return  unknown

Function 4Eh    Fill Area (Hercules Graphics Card)
entry   AH      4Eh
return  unknown

Function 6Ah    Direct Graphics Interface Standard (DGIS)
entry   AH      6Ah
        AL      00h     Inquire Available Devices
                        BX      00h
                        CX      00h
                        DX      buffer length (may be zero)
                        ES:DI   address of buffer
                return  BX      number of bytes stored in buffer
                        CX      bytes req'd for all descriptions (0 if no DGIS)
                note    Buffer contains descriptions and addresses of
                        DGIS-compatible display(s) and printer(s)
                01h     Redirect Character Output
                        CX      00h
                        ES:DI   address of device to send INT 10 output to
                return  CX      00h     output could not be redirected
                            not 00h     int 10h output now routed to requested
                                        display
                02h     Inquire int 10h Output Device
                        ES:DI   0:0
                return  ES:DI   0:0  if current display is non-DGIS
                                else address of current DGIS int 10h display

Function 6Fh    Set Video Mode (VEGA Extended EGA/VGA)
entry   AH      6F
        AL      05h
        BL      mode    resoltn   colours
                62h     800x600    16
                65h     1024x768   16
                66h     640x400    256
                67h     640x480    256
                68h     720x540    256
                69h     800x600    256

Function 70h    Get Video RAM Address                               (Tandy 1000)
entry   AH      70h
return  AX      Segment addresses of the following
                BX      Offset address of green plane
                CX      segment address of green plane
                DX      segment address of red/blue plane
note    (red offset = 0, blue offset = 4000)

Function 71h    Get INCRAM Addresses                                (Tandy 1000)
entry   AH      71h
return  AX      segment address of the following
                BX      segment address of INCRAM
                CX      offset address of INCRAM

Function 72h    Scroll Screen Right                                 (Tandy 1000)
entry   AH      72h
        AL      number of columns blanked at left of page
                00h     blank window
        BH      attributes to be used on blank columns
        CH,CL   row, column address of upper left corner
        DH,DL   row, column address of lower right corner
```

```
Function 73h    Scroll Screen Left                                   (Tandy 1000)
entry    AH     73h
         AL     number of columns blanked at right of page
                00h     blank window
         BH     attributes to be used on blank columns
         CH,CL  row, column address of upper left corner
         DH,DL  row, column address of lower right corner

Function 81h    DESQview video - Get Video Buffer Segment
entry    AH     81h
         DX     4456h ('DV')
return   ES     segment of DESQview data structure for video buffer
                byte ES:[0]    current window number (DV 2.0+)
note     This function is probably meant for internal use only, due to the magic
         value required in DX.

Function 82h    DESQview - Get Current Window Info
entry    AH     82h
         DX     4456h ('DV')
return   AH     unknown
         AL     current window number
         BH     unknown
         BL     direct screen writes
                0       program does not do direct writes
                1       program does direct writes, so shadow buffer not usable
         CH     unknown
         CL     current video mode
         DS     segment in DESQview for data structure
                for DV 2.00+, structure is:
                byte    DS:[0]  window number
                word    DS:[1]  segment of other data structure
                word    DS:[3]  segment of window's object handle
         ES     segment of DESQview data structure for video buffer
note     This function is probably meant for internal use only, due to the magic
         value required in DX.

Function 0BFh   Compaq Portable Extensions
entry    AH     0BFh
         AL     subfunction
                00h     Select External Monitor
                        (all registers preserved, the internal monitor is blanked
                        and the external monitor is now the active monitor)
                01h     Select Internal Monitor
                        (all registers preserved, the external monitor is blanked
                        and internal monitor is now active monitor)
                02h     Set Master Mode of Current Active Video Controller
                        BH      04h     CGA
                                05h     EGA
                                07h     MDA
                03h     Get Environment
                        BX      0000h
                return  BH      active monitor
                                00h     external
                                01h     internal
                        BL      master mode
                                00h     switchable VDU not present
                                04h     CGA
                                05h     EGA
                                07h     MDA
                        CH      00h     (reserved)
                        CL      switchable VDU mode supported (1 byte) bits:
                                0       CGA supported
                                1,2     reserved (1)
                                3       MDA supported
                                4-7     reserved (1)
                        DH      internal monitor type
                                00h     none
                                01h     dual-mode monitor
                                02h     5153 RGB monitor
                                03h     Compaq colour monitor
                                04h     640x400 flat panel display
```

```
                  DL      external monitor type
                          00h     none
                          01h     dual-mode monitor
                          02h     5153 RGB monitor
                          03h     Compaq colour monitor
                          04h     640x400 flat panel display
          04h     Set Mode Switch Delay
                  BH      switch
                          00h     enable delay
                          01h     disable delay

Function  0EFh  MSHERC.COM - Installation Check?
entry     AH     0EFh
return    DX     unknown value
note      MSHERC.COM is a program included with the PC Tech Journal high-level
          benchmark suite that adds video modes 08h and 88h for Hercules cards,
          and supports text in the new graphics modes.

Functions  0F0h, 0F1h, 0F2h, 0F3h, 0F4h, 0F5h, 0F6h, 0F7h, 0FAh
           Microsoft Mouse Driver EGA Support.
           See Chapter 14 for details.

Function 0FEh   Get Virtual Buffer Address            (text mode only)
                                                      (Topview/DesQview/Taskview)
entry   AH     0FEh
        ES:DI  pointer to assumed video buffer
return  ES:DI  pointer to actual video buffer
note 1. This alternate video buffer can be written to directly, in the same
        manner as writing to B:000 or B:800. The MT program will manage the
        actual display.
     2. There is no need to synchronize vertical retrace when writing to the
        alternate buffer; this is managed by the MT program
     3. If TopView or DESQview is not running, ES:DI is returned unchanged.
     4. TopView requires that function 0FFh be called every time you write into
        the buffer to tell TopView that something changed
     5. This function returns the address of the virtual screen in the ES:DI
        registers. If TaskView returns a virtual screen address, you can use a
        combination of BIOS functions and writing directly to the virtual screen
        which will automatically update the real screen when it is visible. You
        do not have to synchronize screen writing to the virtual screen even if
        the screen is in a colour text mode. A common way of using this function
        is to place the real screen address in the ES:DI registers, put 0FEh in
        the AH register, then issue an interrupt 10h. If neither TopView nor
        TaskView are present, the values of ES and DI will remain the same.

Function 0FFh   Update Real Display (text mode only)   (TopView)
                Update Video Buffer                    (Topview/DesQview/Taskview)
entry   AH      0FFh
        CX      number of sequential characters that have been modified
        DI      offset of first character that has been modified
        ES      segment of video buffer
return  unknown
note 1. DesQview supports this call, but does not require it
     2. Avoid CX=0.
     3. This function is unnecessary in TaskView, but using it will provide
        compatibility with TopView as well. After you have written information
        directly to the virtual screen, place the start address of the changed
        information in ES:DI, the number of integers (not bytes) changed in CX,
        0FFh in AH, and call int 10h. In TopView, the screen will be updated to
        reflect your changes. In TaskView, the visible screen will automatically
        reflect your changes.
```

Appendix 1

Keyboard Scan Codes

These scan codes are generated by pressing a key on the PC's keyboard. This is the 'make' code. A 'break' code is generated when the key is released. The break scancode is 128 higher than the make code, and is generated by setting bit 7 of the scan code byte to 1.

IBM PC Keyboard Extended Codes

The keyboard returns an 0 in the ASCII code byte to indicate that the code passed in the Scan Code byte is 'special'.

Codes marked with an asterisk (*) are available only on the 'enhanced' keyboard.

key	Normal	Shift	Control	Alt	
escape	1				
1	2			0;120	
2	3			0;121	
3	4			0;122	
4	5			0;123	
5	6			0;124	
6	7			0;125	
7	8			0;126	
8	9			0;127	
9	10			0;128	
0	11			0;129	
-	12			0;130	
=	13			0;131	
tab	15	0;15	0;148*	0;165*	
backtab	none			0;15	
RETURN	28			0;166*	
Home	0;71		0;119	0;151*	7
UpArrow	0;72		0;141*	0;152*	8
PgUp	0;73		0;132	0;153*	9
grey -	0;74				0;74
LArrow	0;75		0;115	0;154*	4
keypad 5	none		none	none	5
RArrow	0;77		0;116	0;155*	6
grey +	0;78				0;78
End	0;79		0;117	0;156*	1
DnArrow	0;80		0;145*	0;160*	2
PgDn	0;81		0;118	0;161*	3
Ins	0;82		0;146*	0;162*	11
Del	0;83		0;128	0;163*	52
PrtSc	55		0;114		
L shift	42				

R shift	54				
alt key	56				
capslock	58				
spacebar	57				
control	29				
numlock	69				
scrollck	70				
;	39				
[	26				
]	27				
"	40				
\	43				
/	53		0;149*	0;164*	
,	51				
.	52				
Ctrl -			0;142*		
Ctrl 5			0;143*		
Ctrl +			0;144*		
Ctrl-*			0;150*		
a	30			0;30	
b	48			0;48	
c	46			0;46	
d	32			0;32	
e	18			0;18	
f	33			0;33	
g	34			0;34	
h	35			0;35	
i	23			0;23	
j	36			0;36	
k	37			0;37	
l	38			0;38	
m	50			0;50	
n	49			0;49	
o	24			0;24	
p	25			0;25	
q	16			0;16	
r	19			0;19	
s	31			0;31	
t	20			0;20	
u	22			0;22	
v	47			0;47	
w	17			0;17	
x	45			0;45	
y	21			0;21	
z	44			0;44	
F1	0;59	0;84	0;94	0;104	
F2	0;60	0;85	0;95	0;105	
F3	0;61	0;86	0;96	0;106	
F4	0;62	0;87	0;97	0;107	
F5	0;63	0;88	0;98	0;108	
F6	0;64	0;89	0;99	0;109	
F7	0;65	0;90	0;100	0;110	
F8	0;66	0;91	0;101	0;111	
F9	0;67	0;92	0;102	0;112	
F10	0;68	0;93	0;103	0;113	
F11	0;152	0;162	0;172	0;182	Tandy
F12	0;153	0;163	0;173	0;183	Tandy
F11	0;133	0;135	0;137	0;139	IBM
F12	0;134	0;136	0;138	0;140	IBM

Shift Byte

Right Shift	01
Left Shift	02
Control	04
Alt	08

A shift byte can be created by adding together as many of the above as desired. That is, the shift combination Control + Alt would be represented by a hex C, which is 04 + 08.

BIOS keystroke codes in hexadecimal

key	Normal		Shift		Control		Alt	
Esc	011B		011B		011B		--	
1!	0231	'1'	0221	'!'	--		7800	
2@	0332	'2'	0340	'@'	0300		7900	
3#	0433	'3'	0423	'#'	--		7A00	
4$	0534	'4'	0524	'$'	--		7B00	
5%	0635	'5'	0625	'%'	--		7C00	
6^	0736	'6'	075E	'^'	071E		7D00	
7&	0837	'7'	0826	'&'	--		7E00	
8*	0938	'8'	092A	'*'	--		7F00	
9(	0A39	'9'	0A28	'('	--		8000	
0)	0B30	'0'	0B29	')'	--		8100	
-_	0C2D	'-'	0C5F	'_'	0C1F		8200	
=∓	0D3D	'='	0D2B	'∓'	--		8300	
BkSp	0E08		0E08		0E7F		--	
Tab	0F09		0F00		--		--	
q	1071	'q'	1051	'Q'	1011		1000	
w	1177	'w'	1157	'W'	1117		1100	
e	1265	'e'	1245	'E'	1205		1200	
r	1372	'r'	1352	'R'	1312		1300	
t	1474	't'	1454	'T'	1414		1400	
y	1579	'y'	1559	'Y'	1519		1500	
u	1675	'u'	1655	'U'	1615		1600	
i	1769	'i'	1749	'I'	1709		1700	
o	186F	'o'	184F	'O'	180F		1800	
p	1970	'p'	1950	'P'	1910		1900	
[{	1A5B	'['	1A7B	'{'	1A1B		--	
]}	1B5D	']'	1B7D	'}'	1B1D		--	
Enter	1C0D		1C0D		1C0A		--	
Ctrl	--		--		--		--	
a	1E61	'a'	1E41	'A'	1E01		1E00	
s	1F73	's'	1F53	'S'	1F13		1F00	
d	2064	'd'	2044	'D'	2004		2000	
f	2166	'f'	2146	'F'	2106		2100	
g	2267	'g'	2247	'G'	2207		2200	
h	2368	'h'	2348	'H'	2308		2300	
j	246A	'j'	244A	'J'	240A		2400	
k	256B	'k'	254B	'K'	250B		2500	
l	266C	'l'	264C	'L'	260C		2600	
;:	273B	';'	273A	':'	--		--	
''	2827	'''	2822	'"'	--		--	
'~	2960	'''	297E	'~'	--		--	
Lshift	--		--		--		--	
|	2B5C	'\'	2B7C	'|'	2B1C		--	
z	2C7A	'z'	2C5A	'Z'	2C1A		2C00	
x	2D78	'x'	2D58	'X'	2D18		2D00	
c	2E63	'c'	2E43	'C'	2E03		2E00	
v	2F76	'v'	2F56	'V'	2F16		2F00	
b	3062	'b'	3042	'B'	3002		3000	
n	316E	'n'	314E	'N'	310E		3100	
m	326D	'm'	324D	'M'	320D		3200	
,<	332C	','	333C	''	--		--	
.>	342E	'.'	343E	''	--		--	
/?	352F	'/'	353F	'?'	--		--	
Rshift	--		--		--		--	
PrtSc	372A	'*'	--		7200		--	
Alt	--		--		--		--	
Space	3920	' '	3920	' '	3920	' '	3920	' '
CapsL	--		--		--		--	
F1	3B00		5400		5E00		6800	
F2	3C00		5500		5F00		6900	
F3	3D00		5600		6000		6A00	
F4	3E00		5700		6100		6B00	
F5	3F00		5800		6200		6C00	
F6	4000		5900		6300		6D00	
F7	4100		5A00		6400		6E00	
F8	4200		5B00		6500		6F00	
F9	4300		5C00		6600		7000	
F10	4400		5D00		6700		7100	

NumLock	--		--		--	--
Scroll	--		--		--	--
7 Home	4700		4737	'7'	7700	--
8 up	4800		4838	'8'	--	--
9 PgUp	4900		4939	'9'	8400	--
Grey -	4A2D	'-'	4A2D	'-'	--	--
4 left	4B00		4B34	'4'	7300	--
5	--		4C35	'5'	--	--
6 right	4D00		4D36	'6'	7400	--
Grey +	4E2B	'+'	4E2B	'+'	--	--
1 End	4F00		4F31	'1'	7500	--
2 down	5000		5032	'2'	--	--
3 PgDn	5100		5133	'3'	7600	--
Ins	5200		5230	'0'	--	--
Del	5300		532E	'.'	--	--

An entry of "--" means you can't get that combination out of the BIOS.

Appendix 2

Standard ASCII Character Codes

dec	hex	char	control code		dec	hex	chr	dec	hex	chr	dec	hex	chr
0	0	Ctrl-@	NUL	Null	32	20	SP	64	40	@	96	60	`
1	1	Ctrl-A	SOH	Start of Heading	33	21	!	65	41	A	97	61	a
2	2	Ctrl-B	STX	Start of Text	34	22	"	66	42	B	98	62	b
3	3	Ctrl-C	ETX	End of Text	35	23	#	67	43	C	99	63	c
4	4	Ctrl-D	EOT	End of Transmit	36	24	$	68	44	D	100	64	d
5	5	Ctrl-E	ENQ	Enquiry	37	25	%	69	45	E	101	65	e
6	6	Ctrl-F	ACK	Acknowledge	38	26	&	70	46	F	102	66	f
7	7	Ctrl-G	BEL	Bell	39	27	'	71	47	G	103	67	g
8	8	Ctrl-H	BS	Back Space	40	28	(	72	48	H	104	68	h
9	9	Ctrl-I	HT	Horizontal Tab	41	29	)	73	49	I	105	69	i
10	0A	Ctrl-J	LF	Line Feed	42	2A	*	74	4A	J	106	6A	j
11	0B	Ctrl-K	VT	Vertical Tab	43	2B	+	75	4B	K	107	6B	k
12	0C	Ctrl-L	FF	Form Feed	44	2C	,	76	4C	L	108	6C	l
13	0D	Ctrl-M	CR	Carriage Return	45	2D	-	77	4D	M	109	6D	m
14	0E	Ctrl-N	SO	Shift Out	46	2E	.	78	4E	N	110	6E	n
15	0F	Ctrl-O	SI	Shift In	47	2F	/	79	4F	O	111	6F	o
16	10	Ctrl-P	DLE	Data Line Escape	48	30	0	80	50	P	112	70	p
17	11	Ctrl-Q	DC1	Device Control 1	49	31	1	81	51	Q	113	71	q
18	12	Ctrl-R	DC2	Device Control 2	50	32	2	82	52	R	114	72	r
19	13	Ctrl-S	DC3	Device Control 3	51	33	3	83	53	S	115	73	s
20	14	Ctrl-T	DC4	Device Control 4	52	34	4	84	54	T	116	74	t
21	15	Ctrl-U	NAK	Negative Acknowledge	53	35	5	85	55	U	117	75	u
22	16	Ctrl-V	SYN	Synchronous Idle	54	36	6	86	56	V	118	76	v
23	17	Ctrl-W	ETB	End of Transmit Blk	55	77	7	87	57	W	119	77	w
24	18	Ctrl-X	CAN	Cancel	56	38	8	88	58	X	120	78	x
25	19	Ctrl-Y	EM	End of Medium	57	39	9	89	59	Y	121	79	y
26	1A	Ctrl-Z	SUB	Substitute	58	3A	:	90	5A	Z	122	7A	z
27	1B	Ctrl-[	ESC	Escape	59	3B	;	91	5B	[	23	7B	{
28	1C	Ctrl-\	FS	File Separator	60	3C	<	92	5C	\	124	7C	|
29	1D	Ctrl-]	GS	Group Separator	61	3D	=	93	5D	]	125	7D	}
30	1E	Ctrl-^	RS	Record Separator	62	3E	>	94	5E	^	126	7E	~
31	1F	Ctrl-_	US	Unit Separator	63	3F	?	95	5F	_	127	7F	DEL

ASCII = The American National Standard Code for Information Interchange

The complete document describing the ASCII standard, 'X3.4-1977: American National Standard Code for Information Interchange' can be ordered for $5.00 (plus $4 postage) from

American National Standards Institute
1430 Broadway
New York, NY 10018
212/354-3300

1968 ASCII CODE

X3.64	Dec	Oct	Hex	EBCDIC			meaning
0/0	000	000	00	00	NUL	^@	Null, Ctrl-@
0/1	001	001	01	01	SOH	^A	Start of Header
0/2	002	002	02	02	STX	^B	Start of Text
0/3	003	003	03	03	ETX	^C	End of Text
0/4	004	004	04	37	EOT	^D	End of Transmission
0/5	005	005	05	2D	ENQ	^E	Enquire, WRU
0/6	006	006	06	2E	ACK	^F	HEREIS
0/7	007	007	07	2F	BEL	^G	Bell
0/8	008	010	08	16	BS	^H	Backspace, \b
0/9	009	011	09	05	HT	^I	TAB, \t
0/10	010	012	0A	25	LF	^J	Newline, NL, \n
0/11	011	013	0B	0B	VT	^K	Vertical Tab
0/12	012	014	0C	0C	FF	^L	Form Feed, \f
0/13	013	015	0D	0D	CR	^M	Return, \r,
0/14	014	016	0E	0E	SO	^N	Shift Out
0/15	015	017	0F	0F	SI	^O	Shift in
1/0	016	020	10	10	DLE	^P	
1/1	017	021	11	11	DC1	^Q	XON, Start Reader
1/2	018	022	12	12	DC2	^R	DC2, Tape Punch ON
1/3	019	023	13	13	DC3	^S	XOFF, Stop Reader
1/4	020	024	14	3C	DC4	^T	DC4, Tape Punch OFF
1/5	021	025	15	3D	NAK	^U	Nak
1/6	022	026	16	32	SYN	^V	Sync
1/7	023	027	17	26	ETB	^W	End of Tape Block
1/8	024	030	18	18	CAN	^X	Cancel
1/9	025	031	19	19	EM	^Y	End of Medium
1/10	026	032	1A	3F	SUB	^Z	CP/M End of File
1/11	027	033	1B	27	ESC	^[	Escape, \E
1/12	028	034	1C	1C	FS	^\	File Separator
1/13	029	035	1D	1D	GS	^]	Group Separator
1/14	030	036	1E	1E	RS	^^	Record Separator
1/15	031	037	1F	1F	US	^_	Unit Separator
2/0	032	040	20	40	SP		Space
2/1	033	041	21	5A	!		Exclamation mark
2/2	034	042	22	7F	"		Double Quote
2/3	035	043	23	7B	#		
2/4	036	044	24	5B	$		
2/5	037	045	25	6C	%		
2/6	038	046	26	50	&		
2/7	039	047	27	7D	'		Apostrophe, Single Quote
2/8	040	050	28	4D	(		
2/9	041	051	29	5D	)		
2/10	042	052	2A	5C	*		Splat, Star, asterisk
2/11	043	053	2B	4E	+		
2/12	044	054	2C	6B	,		Comma
2/13	045	055	2D	60	-		
2/14	046	056	2E	4B	.		Period
2/15	047	057	2F	61	/		Slash, Stroke
3/0	048	060	30	F0	0		
3/1	049	061	31	F1	1		
3/2	050	062	32	F2	2		
3/3	051	063	33	F3	3		
3/4	052	064	34	F4	4		
3/5	053	065	35	F5	5		
3/6	054	066	36	F6	6		
3/7	055	067	37	F7	7		
3/8	056	070	38	F8	8		
3/9	057	071	39	F9	9		
3/10	058	072	3A	7A	:		
3/11	059	073	3B	5E	;		
3/12	060	074	3C	4C			
3/13	061	075	3D	7E	=		
3/14	062	076	3E	6E			
3/15	063	077	3F	6F	?		Question Mark
4/0	064	100	40	7C	@		Commercial AT
4/1	065	101	41	C1	A		
4/2	066	102	42	C2	B		

4/3	067	103	43	C3	C	
4/4	068	104	44	C4	D	
4/5	069	105	45	C5	E	
4/6	070	106	46	C6	F	
4/7	071	107	47	C7	G	
4/8	072	110	48	C8	H	
4/9	073	111	49	C9	I	
4/10	074	112	4A	D1	J	
4/11	075	113	4B	D2	K	
4/12	076	114	4C	D3	L	
4/13	077	115	4D	D4	M	
4/14	078	116	4E	D5	N	
4/15	079	117	4F	D6	O	
5/0	080	120	50	D7	P	
5/1	081	121	51	D8	Q	
5/2	082	122	52	D9	R	
5/3	083	123	53	E2	S	
5/4	084	124	54	E3	T	
5/5	085	125	55	E4	U	
5/6	086	126	56	E5	V	
5/7	087	127	57	E6	W	
5/8	088	130	58	E7	X	
5/9	089	131	59	E8	Y	
5/10	090	132	5A	E9	Z	
5/11	091	133	5B	AD	[	Left square bracket
5/12	092	134	5C	E0	\	Backslash
5/13	093	135	5D	BD	]	Right Square Bracket
5/14	094	136	5E	5F	^	Circumflex
5/15	095	137	5F	6D	_	Underline or Back Arrow(old)
5/16						Back Arrow on older codes
6/0	096	140	60	79	`	Accent Grave
6/1	097	141	61	81	a	
6/2	098	142	62	82	b	
6/3	099	143	63	83	c	
6/4	100	144	64	84	d	
6/5	101	145	65	85	e	
6/6	102	146	66	86	f	
6/7	103	147	67	87	g	
6/8	104	150	68	88	h	
6/9	105	151	69	89	i	
6/10	106	152	6A	91	j	
6/11	107	153	6B	92	k	
6/12	108	154	6C	93	l	
6/13	109	155	6D	94	m	
6/14	110	156	6E	95	n	
6/15	111	157	6F	96	o	
7/0	112	160	70	97	p	
7/1	113	161	71	98	q	
7/2	114	162	72	99	r	
7/3	115	163	73	A2	s	
7/4	116	164	74	A3	t	
7/5	117	165	75	A4	u	
7/6	118	166	76	A5	v	
7/7	119	167	77	A6	w	
7/8	120	170	78	A7	x	
7/9	121	171	79	A8	y	
7/10	122	172	7A	A9	z	
7/11	123	173	7B	C0	{	Left Brace
7/12	124	174	7C	4F	|	Vertical Bar, Pipe, (Confirm on some older systems)
7/13	125	175	7D	D0	}	Right Brace
7/14	126	176	7E	7E	~	Tilde (ESC on some old sys)
7/15	127	177	7F	07	^?	DEL, RUBOUT

ASCII = American Standard Code for Information Exchange

EBCDIC = Extended Binary-Coded Decimal Interchange Code

Appendix 3

ASCII Control Codes

dec	hex	char	name	control code	
0	0	☺	Ctrl-@	NULL	Null
1	1	☻	Ctrl-A	SOH	Start of Heading
2	2	♥	Ctrl-B	STX	Start of Text
3	3	♦	Ctrl-C	ETX	End of Text
4	4	♣	Ctrl-D	EOT	End of Transmit
5	5	♠	Ctrl-E	ENQ	Enquiry
6	6	•	Ctrl-F	ACK	Acknowledge
7	7	◘	Ctrl-G	BEL	Bell
8	8	○	Ctrl-H	BS	Back Space
9	9	◙	Ctrl-I	HT	Horizontal Tab
10	A	♂	Ctrl-J	LF	Line Feed
11	B	♀	Ctrl-K	VT	Vertical Tab
12	C	♪	Ctrl-L	FF	Form Feed
13	D	♫	Ctrl-M	CR	Carriage Return
14	E	☼	Ctrl-N	SO	Shift Out
15	F	►	Ctrl-O	SI	Shift In
16	10	◄	Ctrl-P	DLE	Data Line Escape
17	11	↕	Ctrl-Q	DC1	Device Control 1
18	12	‼	Ctrl-R	DC2	Device Control 2
19	13	¶	Ctrl-S	DC3	Device Control 3
20	14	§	Ctrl-T	DC4	Device Control 4
21	15	▬	Ctrl-U	NAK	Negative Acknowledge
22	16	↨	Ctrl-V	SYN	Synchronous Idle
23	17	↑	Ctrl-W	ETB	End of Transmit Block
24	18	↓	Ctrl-X	CAN	Cancel
25	19	→	Ctrl-Y	EM	End of Medium
26	1A	←	Ctrl-Z	SUB	Substitute
27	1B	∟	Ctrl-[	ESC	Escape
28	1C	↔	Ctrl-\	FS	File Separator
29	1D	▲	Ctrl-]	GS	Group Separator
30	1E	▼	Ctrl-^	RS	Record Separator
31	1F		Ctrl-_	US	Unit Separator

Standard ASCII Codes

dec	hex	char	dec	hex	char	dec	hex	char	dec	hex	char
0	0	NUL	32	20	space	64	40	@	96	60	'
1	1	SOH	33	21	!	65	41	A	97	61	a
2	2	STX	34	22	"	66	42	B	98	62	b
3	3	ETX	35	23	#	67	43	C	99	63	c
4	4	EOT	36	24	$	68	44	D	100	64	d
5	5	ENQ	37	25	%	69	45	E	101	65	e
6	6	ACK	38	26	&	70	46	F	102	66	f
7	7	BEL	39	27	'	71	47	G	103	67	g
8	8	BS	40	28	(	72	48	H	104	68	h

9	9	HT	41	29	)	73	49	I	105	69	i
10	A	LF	42	2A	*	74	4A	J	106	6A	j
11	B	VT	43	2B	+	75	4B	K	107	6B	k
12	C	FF	44	2C	,	76	4C	L	108	6C	l
13	D	CR	45	2D	-	77	4D	M	109	6D	m
14	E	SO	46	2E	.	78	4E	N	110	6E	n
15	F	SI	47	2F	/	79	4F	O	111	6F	o
16	10	DLE	48	30	0	80	50	P	112	70	p
17	11	DC1	49	31	1	81	51	Q	113	71	q
18	12	DC2	50	32	2	82	52	R	114	72	r
19	13	DC3	51	33	3	83	53	S	115	73	s
20	14	DC4	52	34	4	84	54	T	116	74	t
21	15	NAK	53	35	5	85	55	U	117	75	u
22	16	SYN	54	36	6	86	56	V	118	76	v
23	17	ETB	55	37	7	87	57	W	119	77	w
24	18	CAN	56	38	8	88	58	X	120	78	x
25	19	EM	57	39	9	89	59	Y	121	79	y
26	1A	SUB	58	3A	:	90	5A	Z	122	7A	z
27	1B	ESC	59	3B	;	91	5B	[	123	7B	{
28	1C	FS	60	3C	<	92	5C	\	124	7C	|
29	1D	GS	61	3D	=	93	5D	]	125	7D	}
30	1E	RS	62	3E	>	94	5E	^	126	7E	~
31	1F	US	63	3F	?	95	5F	_	127	7F	

Extended ASCII Codes

dec	hex	char	dec	hex	char	dec	hex	char	dec	hex	char
128	80	Ç	160	A0	á	192	C0	└	224	E0	α
129	81	ü	161	A1	í	193	C1	┴	225	E1	β
130	82	é	162	A2	ó	194	C2	┬	226	E2	Γ
131	83	â	163	A3	ú	195	C3	├	227	E3	π
132	84	ä	164	A4	ñ	196	C4	─	228	E4	Σ
133	85	à	165	A5	Ñ	197	C5	┼	229	E5	σ
134	86	å	166	A6	ª	198	C6	╞	230	E6	µ
135	87	ç	167	A7	º	199	C7	╟	231	E7	τ
136	88	ê	168	A8	¿	200	C8	╚	232	E8	Φ
137	89	ë	169	A9	⌐	201	C9	╔	233	E9	Θ
138	8A	è	170	AA	¬	202	CA	╩	234	EA	Ω
139	8B	ï	171	AB	½	203	CB	╦	235	EB	δ
140	8C	î	172	AC	¼	204	CC	╠	236	EC	∞
141	8D	ì	173	AD	¡	205	CD	═	237	ED	φ
142	8E	Ä	174	AE	«	206	CE	╬	238	EE	ε
143	8F	Å	175	AF	»	207	CF	╧	239	EF	∩
144	90	É	176	B0	░	208	D0	╨	240	F0	≡
145	91	æ	177	B1	▒	209	D1	╤	241	F1	±
146	92	Æ	178	B2	▓	210	D2	╥	242	F2	≥
147	93	ô	179	B3	│	211	D3	╙	243	F3	≤
148	94	ö	180	B4	┤	212	D4	╘	244	F4	⌠
149	95	ò	181	B5	╡	213	D5	╒	245	F5	⌡
150	96	û	182	B6	╢	214	D6	╓	246	F6	÷
151	97	ù	183	B7	╖	215	D7	╫	247	F7	≈
152	98	ÿ	184	B8	╕	216	D8	╪	248	F8	•
153	99	Ö	185	B9	╣	217	D9	┘	249	F9	•
154	9A	Ü	186	BA	║	218	DA	┌	250	FA	.
155	9B	¢	187	BB	╗	219	DB	█	251	FB	√
156	9C	£	188	BC	╝	220	DC	▄	252	FC	η
157	9D	¥	189	BD	╜	221	DD	▌	253	FD	▪
158	9E	¤	190	BE	╛	222	DE	▐	254	FE	•
159	9F	ƒ	191	BF	┐	223	DF	▀	255	FF	reserved

Appendix 4

IBM PC Interrupt Usage

Interrupt	Used for	Model
00h	Divide by zero	PC, AT, PS/2
01h	Single step	PC, AT, PS/2
02h	NMI	PC, AT, PS/2
03h	Breakpoint	PC, AT, PS/2
04h	Overflow	PC, AT, PS/2
05h	ROM BIOS PrintScreen	PC, AT, PS/2
06h	Reserved	PC
07h	Reserved	PC
08h	IRQ0 timer tick	PC, AT, PS/2
09h	IRQ1 keyboard	PC, AT, PS/2
0Ah	IRQ2 reserved	PC
	IRQ2 cascade from slave 8259 PIC	AT, PS/2
0Bh	IRQ3 serial communications (COM2)	PC, AT, PS/2
0Ch	IRQ4 serial communications (COM1)	PC, AT, PS/2
0Dh	IRQ5 hard disk	PC
	IRQ5 parallel printer (LPT2)	AT
	Reserved	PS/2
0Eh	IRQ6 floppy disk	PC, AT, PS/2
0Fh	IRQ7 parallel printer (LPT1)	PC, AT, PS/2
10h	ROM BIOS video driver	PC, AT, PS/2
11h	ROM BIOS equipment check	PC, AT, PS/2
12h	ROM BIOS conventional memory size	PC, AT, PS/2
13h	ROM BIOS disk drives	PC, AT, PS/2
14h	ROM BIOS communications driver	PC, AT, PS/2
15h	ROM BIOS cassette driver	PC
	ROM BIOS I/O system extensions	AT, PS/2
16h	ROM BIOS keyboard driver	PC, AT, PS/2
17h	ROM BIOS printer driver	PC, AT, PS/2
18h	ROM BASIC	PC, AT, PS/2
19h	ROM BIOS bootstrap	PC, AT, PS/2
1Ah	ROM BIOS time of day	AT, PS/2
1Bh	ROM BIOS Ctrl-break	PC, AT, PS/2
1Ch	ROM BIOS timer tick	PC, AT, PS/2
1Dh	ROM BIOS video parameter table	PC, AT, PS/2
1Eh	ROM BIOS floppy disk parameters	PC, AT, PS/2
1Fh	ROM BIOS font (characters 80h-0FFh)	PC, AT, PS/2
20h	DOS terminate process	
21h	DOS function dispatcher	
22h	DOS terminate address	
23h	DOS Ctrl-C handler address	
24h	DOS critical-error handler address	
25h	DOS absolute disk read	
26h	DOS absolute disk write	
27h	DOS terminate and stay resident	
28h	DOS idle interrupt	
29h	DOS fast screen output	

2Ah	DOS network redirector	
2Bh-2Eh	DOS reserved	
2Fh	DOS multiplex interrupt	
30h-3Fh	DOS reserved	
40h	ROM BIOS floppy disk driver (if hard disk installed)	PC, AT, PS/2
41h	ROM BIOS hard disk parameters	PC
	ROM BIOS hard disk params (drive 0)	AT, PS/2
42h	ROM BIOS default video driver (if EGA installed)	PC, AT, PS/2
43h	EGA, MCGA, VGA character table	PC, AT, PS/2
44h	ROM BIOS font (characters 00-7Fh)	PCjr
46h	ROM BIOS hard disk params (drive 1)	AT, PS/2
4Ah	ROM BIOS alarm handler	AT, PS/2
5Ah	Cluster adapter	PC, AT
5Bh	Used by cluster program	PC, AT
60h-66h	User interrupts	PC, AT, PS/2
67h	LIM EMS driver	PC, AT, PS/2
70h	IRQ8 CMOS real-time clock	AT, PS/2
71h	IRQ9 software diverted to IRQ2	AT, PS/2
72h	IRQ10 reserved	AT, PS/2
73h	IRQ11 reserved	AT, PS/2
74h	IRQ12 reserved	AT
	IRQ12 mouse	PS/2
75h	IRQ13 80x87 math coprocessor	AT, PS/2
76h	IRQ14 hard disk controller	AT, PS/2
77h	IRQ15 reserved	AT, PS/2
80h-0F0h	BASIC	PC, AT, PS/2
0F1h-0FFh	Not used	PC, AT, PS/2

Appendix 5

List of IBM PC-XT-AT-PS/2 Diagnostic Error Codes

This list has been compiled from a variety of sources, including the IBM Technical Reference manuals, IBM Hardware Maintenance and Service manuals, technical articles, and other BBS listings.

The IBM PC family of computers (PC, Portable, XT, AT,and PS/2s) comes complete with built-in diagnostic procedures to assist you in identifying many problems that may occur with the computer's components. These diagnostics are called the Power-On Self Test (POST) and are performed whenever a PC is turned on. This test process provides error or warning messages whenever a faulty component is encountered. Two types of messages are provided: audible codes and screen messages or codes.

Audio codes consist of beeps that identify the faulty component. If your computer is functioning normally, you will hear one short beep when the system is started up. If a problem is detected, a different series of beeps will be sounded. These audio codes and corresponding problem areas are:

Audio Code	Problem Area
No beep, continuous beep, or repeating short beeps	Power Supply
1 long beep and 1 short beep	System Board
1 long beep and 2 short beeps, or 1 short beep and blank or incorrect display	Monitor adapter card and/or monitor cable and/or display
1 short beep and either the red drive LED staying on or Personal Computer BASIC statement	Drive and/or drive adapter card
1 long 3 short beeps	Enhanced Graphics Adapter card
3 long beeps	Keyboard card

On the XT and AT, the POST procedures also display system memory as it is read. The last number displayed (640KB, for example) should be the total amount of memory in your system, including system board memory and any expansion memory.

During the POST procedures, error messages or numeric codes will be displayed whenever a problem is detected. In most cases, the error code will be a three or four digit number that, when checked against the list provided in Table 1, will help identify the malfunctioning component.

All personal computer error codes for the Power On Self Test, General Diagnostics, and Advanced Diagnostics consist of a device number followed by two digits other than 00. (The device number plus 00 indicates successful completion of the test.)

Note: Not all computers can generate all codes!

```
Code   Description
0xx    Miscellaneous errors
  01x   undetermined problem errors
  02x   power supply errors

1xx    System board errors
  101   system board error - interrupt controller failure
  102   system board error - system timer 2 failure
  103   system board error - system timer 0 failure
  104   system board error - protected mode failure
  105   system board error - last 8042 DMA command not accepted
  106   system board error - converting logic test
  107   system board error - hot NMI test
  108   system board error - timer bus test
  109   Direct Memory Access (DMA) test error
  111   80C88 microprocessor failed
  121   unexpected hardware interrupts occurred
  131   cassette wrap test failed
  110   system board memory
  111   adapter memory
  112   (any adapter in system unit)
  113   (any adapter in system unit)
  121   unexpected hardware interrupts occurred
  131   cassette wrap test failed
  151   system board error; defective battery
  152   system board error; real time clock failure
  161   system options error-(Run SETUP) [Battery failure]
  162   system options not set correctly-(Run SETUP)
  163   time and date not set-(Run SETUP)
  164   memory size error-(Run SETUP)
  165   system options not set - (Run SETUP)
  166   (any adapter in system unit)
  170   LCD not in use when suspended
  171   base 128K checksum failure
  172   diskette active when suspended
  173   LCD not active when suspended
  174   LCD configuration changed
  175   LCD alternate mode failed
  199   user-indicated configuration not correct

2xx    Memory (RAM) errors
  201   memory test failed. Displayed in the form XXXXX YY 201 where XXXXX
        represents the memory bank and YY represents the bit (actual chip)
  202   memory address error
  203   memory address error
  215   (system board memory failure)
  216   (system board memory failure)

3xx    Keyboard or keyboard card errors
  301   keyboard did not respond to software reset correctly, or a stuck key
        failure was detected. If a stuck key was detected, the scancode for the
        key is displayed in hexadecimal. For example, the error code 49 301
        indicates that key 73, the PgUp key, has failed (49 hex=73 dec)
  302   user-indicated error from the keyboard test, or AT keylock is locked.
  303   keyboard or system unit error
  304   keyboard or system unit error; CMOS does not match system, or keyboard
        cable not attached
  305   PS/2 models 50 and 60 fuse or keyboard cable error, or typamatic error
  341   replace keyboard
```

342 replace interface cable
343 replace enhancement card or cable

4xx Monochrome monitor errors
401 monochrome memory test, horizontal sync frequency test, or video test failed
408 user-indicated display attributes failure
416 user-indicated character set failure
424 user-indicated 80 X 25 mode failure
432 parallel port test failed (monochrome adapter)

5xx Colour monitor errors
501 colour memory test failed, horizontal sync frequency test, or video test failed
503 CRT display adapter controlled failed
508 user-indicated display attribute failure
516 user-indicated character set failure
524 user-indicated 80 X 25 mode failure
532 user-indicated 40 X 25 mode failure
540 user-indicated 320 X 200 graphics mode failure
548 user-indicated 640 X 200 graphics mode failure
564 user indicated a paging test failure

6xx Diskette drive errors
601 diskette power-on diagnostics test failed
602 diskette test failed; boot record is not valid
606 diskette verify function failed
607 write-protected diskette
608 bad command diskette status returned
610 diskette initialization failed
611 timeout - diskette status returned
612 bad NEC controller chip - diskette status returned
613 bad DMA - diskette status returned
614 DMA Boundary error
621 bad seek - diskette status returned
622 bad CRC - diskette status returned
623 record not found - diskette status returned
624 bad address mark - diskette status returned
625 bad NEC (controller) seek - diskette status returned
626 diskette data compare error
627 diskette change line error
628 diskette removed

7xx NDP (math coprocessor) errors (8087, 80287, 80387)
701 math coprocessor test failed

8xx undefined

9xx Parallel printer adapter errors
901 printer adapter data register latch error
902 printer adapter control register latch error
903 printer adapter register address decode error
904 printer adapter address decode error
910 status line(s) wrap connector error (pn 8529228 ?)
911 status line bit 7 wrap error
912 status line bit 7 wrap error
913 status line bit 6 wrap error
914 status line bit 5 wrap error
915 status line bit 4 wrap error
916 printer adapter interrupt wrap failed
917 unexpected printer adapter interrupt
92x feature register error (special card)

10xx Alternate Parallel Printer Adapter (LPT2)
1001 alternate printer port (LPT2) test failed

11xx Asynchronous communications adapter errors
1101 asynchronous communications adapter test failed (int. modem 8250 chip)
1102 any serial device (system board), or internal modem failed
1103 dial tone test 1 failed (internal modem)
1104 dial tone test 2 failed (internal modem)

1106 any serial device (system board)
1107 communications cable (system board)
1108 any serial device (system board)
1109 any serial device (system board)
1110 modem status register not clear
1111 ring indicate failure
1112 trailing edge ring indicate failure
1113 receive and delta receive line signal detect failure
1114 receive line signal detect failure
1115 delta receive line signal detect failure
1116 line control register; all bits cannot be set
1117 line control register; all bits cannot be reset
1118 xmit holding and/or shift register is stuck on
1119 data ready stuck on
1120 interrupt enable register, all bits cannot be set
1121 interrupt enable register, all bits cannot be reset
1122 interrupt pending stuck on
1123 interrupt ID register stuck on
1124 modem control register, all bits cannot be set
1125 modem control register, all bits cannot be reset
1126 modem status register, all bits cannot be set
1127 modem status register, all bits cannot be reset
1128 interrupt ID failure
1129 cannot force overrun error
1130 no modem status interrupt
1131 invalid interrupt pending
1132 no data ready
1133 no data available interrupt
1134 no transmit holding interrupt
1135 no interrupts
1136 no received line status interrupt
1137 no receive data available
1138 transmit holding register not empty
1139 no modem status interrupt
1140 transmit holding register not empty
1141 no interrupts
1142 no IRQ4 interrupt
1143 no IRQ3 interrupt
1144 no data transferred
1145 max baud rate failed
1146 min baud rate failed
1148 timeout error
1149 invalid data returned
1150 modem status register error
1151 no DSR and delta DSR
1152 no data set ready
1153 no delta
1154 modem status register not clear
1155 no CTS and delta CTS
1156 no clear to send
1157 no delta CTS

12xx Alternate asynchronous communications adapter errors
1201 Alternate asynchronous communications adapter test failed
1101 if internal modem is not installed
1202 Dual Asynch Adapter/A (any serial device)
1102 if internal modem is not installed
1206 Dual Asynch Adapter/A (any serial device)
1207 Dual Asynch Adapter/A board error
1208 Dual Asynch Adapter/A (any serial device)
1209 Dual Asynch Adapter/A (any serial device)

13xx Game control adapter errors
1301 game control adapter test failed
1302 joystick test failed

14xx Printer errors
1401 printer test failed
1402 printer not ready error
1403 printer paper error
1404 matrix printer failed

1405 user indicated a print-pattern error

15xx Synchronous data link control (SDLC) communications adapter errors
1510 8255 port B failure
1511 8255 port A failure
1512 8255 port C failure
1513 8253 timer 1 did not reach terminal count
1514 8253 timer 1 stuck on
1515 8253 timer 0 did not reach terminal count
1516 8253 timer 0 stuck on
1517 8253 timer 2 did not reach terminal count
1518 8253 timer 2 stuck on
1519 8273 port B error
1520 8273 port A error
1521 8273 command/read timeout
1522 interrupt level 4 failure
1523 ring Indicate stuck on
1524 receive clock stuck on
1525 transmit clock stuck on
1526 test indicate stuck on
1527 ring indicate not on
1528 receive clock not on
1529 transmit clock not on
1530 test indicate not on
1531 data set ready not on
1532 carrier detect not on
1533 clear to send not on
1534 data set ready stuck on
1536 clear to send stuck on
1537 level 3 interrupt failure
1538 receive interrupt results error
1539 wrap data miscompare
1540 DMA channel 1 error
1541 DMA channel 1 error
1542 error in 8273 error checking or status reporting
1547 stray interrupt level 4
1548 stray interrupt level 3
1549 interrupt presentation sequence timeout

16xx Display emulation errors (327x, 5520, 525x)

17xx Fixed disk errors
1701 fixed disk POST error
1702 fixed disk adapter error
1703 fixed disk drive error
1704 fixed disk adapter or drive error
1780 fixed disk 0 failure
1781 fixed disk 1 failure
1782 fixed disk controller failure
1790 fixed disk 0 error
1791 fixed disk 1 error

18xx I/O expansion unit errors
1801 I/O expansion unit POST error
1810 enable/disable failure
1811 extender card wrap test failed (disabled)
1812 high order address lines failure (disabled)
1813 wait state failure (disabled)
1814 enable/Disable could not be set on
1815 wait state failure (disabled)
1816 extender card wrap test failed (enabled)
1817 high order address lines failure (enabled)
1818 disable not functioning
1819 wait request switch not set correctly
1820 receiver card wrap test failure
1821 receiver high order address lines failure

19xx 3270 PC attachment card errors

20xx Binary synchronous communications (BSC) adapter errors
2010 8255 port A failure

```
  2011  8255 port B failure
  2012  8255 port C failure
  2013  8253 timer 1 did not reach terminal count
  2014  8253 timer 1 stuck on
  2016  8253 timer 2 did not reach terminal count, or timer 2 stuck on
  2017  8251 Data set ready failed to come on
  2018  8251 Clear to send not sensed
  2019  8251 Data set ready stuck on
  2020  8251 Clear to send stuck on
  2021  8251 hardware reset failed
  2022  8251 software reset failed
  2023  8251 software "error reset" failed
  2024  8251 transmit ready did not come on
  2025  8251 receive ready did not come on
  2026  8251 could not force "overrun" error status
  2027  interrupt failure - no timer interrupt
  2028  interrupt failure - transmit, replace card or planar
  2029  interrupt failure - transmit, replace card
  2030  interrupt failure - receive, replace card or planar
  2031  interrupt failure - receive, replace card
  2033  ring indicate stuck on
  2034  receive clock stuck on
  2035  transmit clock stuck on
  2036  test indicate stuck on
  2037  ring indicate stuck on
  2038  receive clock not on
  2039  transmit clock not on
  2040  test indicate not on
  2041  data set ready not on
  2042  carrier detect not on
  2043  clear to send not on
  2044  data set ready stuck on
  2045  carrier detect stuck on
  2046  clear to send stuck on
  2047  unexpected transmit interrupt
  2048  unexpected receive interrupt
  2049  transmit data did not equal receive data
  2050  8251 detected overrun error
  2051  lost data set ready during data wrap
  2052  receive timeout during data wrap

21xx   Alternate binary synchronous communications adapter errors
  2110  8255 port A failure
  2111  8255 port B failure
  2112  8255 port C failure
  2113  8253 timer 1 did not reach terminal count
  2114  8253 timer 1 stuck on
  2115  8253 timer 2 did not reach terminal count, or timer   2 stuck on
  2116  8251 Data set ready failed to come on
  2117  8251 Clear to send not sensed
  2118  8251 Data set ready stuck on
  2119  8251 Clear to send stuck on
  2120  8251 hardware reset failed
  2121  8251 software reset failed
  2122  8251 software "error reset" failed
  2123  8251 transmit ready did not come on
  2124  8251 receive ready did not come on
  2125  8251 could not force "overrun" error status
  2126  interrupt failure - no timer interrupt
  2128  interrupt failure - transmit, replace card or planar
  2129  interrupt failure - transmit, replace card
  2130  interrupt failure - receive, replace card or planar
  2131  interrupt failure - receive, replace card
  2133  ring indicate stuck on
  2134  receive clock stuck on
  2135  transmit clock stuck on
  2136  test indicate stuck on
  2137  ring indicate stuck on
  2138  receive clock not on
  2139  transmit clock not on
  2140  test indicate not on
```

```
  2141  data set ready not on
  2142  carrier detect not on
  2143  clear to send not on
  2144  data set ready stuck on
  2145  carrier detect stuck on
  2146  clear to send stuck on
  2147  unexpected transmit interrupt
  2148  unexpected receive interrupt
  2149  transmit data did not equal receive data
  2150  8251 detected overrun error
  2151  lost data set ready during data wrap
  2152  receive timeout during data wrap

22xx   Cluster adapter errors

23xx   undefined

24xx   Enhanced Graphics Adapter errors (and VGA)
  2401  \
  2402  / both are used, meanings unknown

25xx   undefined

26xx   XT/370 error codes
  2601-2655  XT/370-M card  (Note: P-Processor, M-Memory, EM-Emulator)
  2657-2668  XT/370-M card
  2672       XT/370-M card
  2673-2674  XT/370-P card
  2677-2680  XT/370-P card
  2681       XT/370-M card
  2682-2694  XT/370-P card
  2697       XT/370-P card
  2698       XT/370 diagnostic diskette error
  2701-2703  XT/370-EM card

27xx   XT/370 error codes, 3277 emulator card

28xx   Distributed functions card

29xx   Colour matrix printer errors
  2901  \
  2902   - unknown
  2904  /
30xx   Primary PC Network Adapter Error
  3001  CPU failure
  3002  ROM failure
  3003  ID failure
  3004  RAM failure
  3005  HIC failure
  3006  +/- 12v failed
  3007  digital loopback failure
  3008  host detected HIC failure
  3009  sync fail & no go bit
  3010  HIC test OK & no go bit
  3011  go bit & no CMD 41
  3012  card not present
  3013  digital failure (fall thru)
  3015  analog failure
  3041  hot carrier (not this card)
  3042  hot carrier (this card)

31xx   Secondary PC Network Adapter Error
  3101  CPU failure
  3102  ROM failure
  3103  ID failure
  3104  RAM failure
  3105  HIC failure
  3106  +/- 12v failed
  3107  digital loopback failure
  3108  host detected HIC failure
  3109  sync fail & no go bit
```

```
  3110  HIC test OK & no go bit
  3111  go bit & no CMD 41
  3112  card not present
  3113  digital failure (fall thru)
  3115  analog failure
  3141  hot carrier (not this card)
  3142  hot carrier (this card)

32xx   Display/program symbols/XGA card

33xx   Compact printer errors

36xx   GPIB card

38xx   Data acquisition card

39xx   Professional graphics adapter card (PGA)

50xx   Liquid crystal display
  5001  display buffer failed
  5002  font buffer failed
  5003  controller failed
  5004  user indicated a pel/drive test failure
  5008  user indicated a display attribute test failed
  5016  user indicated a character set test failure
  5020  user indicated an alternate character set test failure
  5024  user indicated a 80 x 25 mode test failure
  5032  user indicated a 40 x 25 mode test failure
  5040  user indicated a 320 x 200 graphics test failure
  5048  user indicated a 640 x 200 graphics test failure
  5064  user indicated a paging test failure

51xx   Portable printer
  5101  printer port failure
  5102  busy error
  5103  paper or ribbon error
  5104  time out
  5105  user indicated a print-pattern error

56xx   Financial input card, connector, 4700 keyboard, pin kbd

71xx   Voice communications adapter
  7101  I/O control register
  7102  instruction or external data memory
  7103  PC to VCA interrupt
  7104  internal data memory
  7105  DMA
  7106  internal registers
  7107  interactive shared memory
  7108  VCA to PC interrupt
  7109  DC wrap
  7111  external analog wrap & tone output
  7112  mic to spkr wrap
  7114  telephone attach test

73xx   3.5" external diskette drive

74xx   Display adapter 8514/A

850x   80286 Expanded Memory Adapter/A

851x   80286 Expanded Memory Adapter/A

852x   Memory module package on the 80286 Expanded Memory Adapter/A

860x   Personal Series 2 pointing device errors
  8601  pointing device (IBM mouse)
  8602  pointing device
  8603  system board error
  8604  system board : Pointing device
```

```
100xx  Multiprotocol Adapter/A
 10002  Multiprotocol Adapter/A any serial device
 10006  Multiprotocol Adapter/A any serial device
 10007  communications cable Multiprotocol Adapter/A
 10008  Multiprotocol Adapter/A any serial device
 10009  Multiprotocol Adapter/A any serial device

101xx  Modem Adapter/A
 10102  Modem Adapter/A any serial device
 10106  Modem Adapter/A any serial device
 10108  Modem Adapter/A any serial device
 10109  Modem Adapter/A any serial device

104xx  Fixed disk adapter (ESDI) drives 0 or 1 (C or D)
 10480  fixed disk C, adapter (ESDI) or system board error
 10481  fixed disk D, adapter (ESDI) or system board error
 10482  fixed disk C or system board error
 10483  fixed disk adapter (ESDI) or system board error
 10490  fixed disk C or adapter (ESDI) error
 10491  fixed disk C or adapter (ESDI) error

16500  6157 Tape Attachment Adapter

16520  6157 Streaming Tape Drive

16540  6157 Streaming Tape Drive or tape attachment adapter

C0000  Keyboard/keyboard card

C8000  Fixed disk/fixed disk card

CA000  Keyboard/keyboard card
```

Appendix 6

Pinouts For Various Interfaces

PC expansion card sizes:

XT 13-1/8x4.0,	1 62 pin connector
XT/286	62 and 36 pin connectors
AT 13-1/8x4.8	62 and 36 pin connectors

Original PC slot spacing was 1 inch on centre. XT, AT and most clone systems are $^{13}/_{16}$ inch on centre. Some modem and hard disk cards are advertised as 'one slot wide' but they often refer to PC slots. Make sure the card will fit if you have the narrower slot spacing.

'Half cards' vary in size from almost as long as a standard card to no longer than the expansion connector itself. If you have a space problem (like the centre drive bay or a hard disk card with a two slot wide far end) make sure the 'half card' you buy will be short enough to actually fit.

Many XT type (8 bit) expansion cards drop down at the end of the connector and hug the motherboard closely for more room on the card. These cards will not fit in an AT type 16 bit slot since the extra connector gets in the way. When ordering cards for an AT, remember you only have two or three 8 bit slots which are able to hold these drop-down type cards.

PC/XT Slot J8

The slot next to the power supply in the XT is slightly different from the slots in the PC and the other seven slots in the XT. Timing requirements are much stricter for cards in J8, and the computer expects a 'card selected' signal to be pulled high by any card in that slot. Early PC Portables with the PC Portable motherboard (these were supposed to have been recalled and replaced with XT motherboards, but you never know!) lacked some of the memory lines, and cards with memory access won't work there at all.

Due to the different timing of the slot, some cards will not work in J8. The IBM parallel card will not work there, but many were delivered with the serial card in that location.

J8 was likely developed for the synchronous mainframe communications adapter or something similar.

8-bit Expansion Card Slot

female 62 pin female card edge

PC/XT 8 bit bus slot:

```
GND            B1       A1 I/O CH CK
RESET                      D7
+5VDC                      D6
IRQ2                       D5
-5VDC                      D4
DRQ2                       D3
-12VDC                     D2
-HRQ I/O CHAN              D1
+12VDC                     D0
GND            B10     A10 I/O CH RDY
-MEMW                      AEN
-MEMR                      A19
-IOW                       A18
-IOR                       A17
-DACK3                     A16
DRQ3                       A15
-DACK1                     A14
DRQ1                       A13
-DACK0                     A12
CLK            B20     A20 A11
IRQ7                       A10
IRQ6                       A9
IRQ5                       A8
IRQ4                       A7
IRQ3                       A6
-DACK2                     A5
TC                         A4
ALE                        A3
+5VDC                      A2
OSC          B30       A30 A1
GND                        A0
```

XT/286, AT 16 bit bus extension slot:

36 pin edge card connector

```
-MEM C516  D1        C1  SBHE
-I/O CS16  D2        C2  LA23
IRQ10      D3        C3  LA22
IRQ11      D4        C4  LA21
IRQ12      D5        C5  LA20
IRQ15      D6        C6  LA19
IRQ14      D7        C7  LA18
-DACK0     D8        C8  LA17
DRQ0       D9        C9  -MEMR
-DACK5     D10       C10 -MEMW
DRQ5       D11       C11 SD08
-DACK6     D12       C12 SD09
DRQ6       D13       C13 SD10
-DACK7     D14       C14 SD11
DRQ7       D15       C15 SD12
+5vdc      D16       C16 SD13
-MASTER    D17       C17 SD14
GND        D18       C18 SD15
```

Game Port

DB15

```
1       +5 VDC
2       button 1
3       position 0  (X Coordinate)
4       ground
5       ground
6       position 1  (Y Coordinate)
7       button 2
8       +5 VDC                   JOY-STICK 'A'

9       +5 VDC                   JOY-STICK 'B'
10      button 3
11      position 2  (X Coordinate)
12      ground
13      position 3  (Y Coordinate)
14      button 4
15      +5 VDC
```

The Kraft KC-3 joy-stick is supplied with two potentiometers. They measure 880k ohms, probably 1Meg pots. It should be noted that the effective wiper travel is very limited, say around 45 degrees from stop to stop, and the internal wiring is arranged so as to leave one end of the pot unconnected. That is to say, the wiper (middle) post is connected, and one end post is connected as well (I assume the wires would be called signal and +5v, respectively).

hard disk 34-pin

34 pin card edge connector

```
pin
#'s             function
2       RWC     reduced write current
4       HS2     head select 2 (2)
6               write gate
8               seek complete
10              track 0
12              write fault
14      HS0     head select 2  (0)
16         reserved
18      HS1     head select 2  (1)
20      IDX     index
22      RDY     ready
24              step
26      DS1     drive select 1
28      DS2     drive select 2
30         reserved
32         reserved
34              direction in
```

all odd numbers are ground

hard disk 20 pin

20-pin card edge connector

```
13      + MFM write data
14      - MFM write data
17      + MFM read data
18      - MFM read data

2,4,6,11,12,15,16,19,20 ground
all other pins unused
```

Note: The IBM AT 20-pin connector and some clones have one pin clipped off to 'key' the connector. If your card has 20 pins but your cable has only 19 holes, you can usually safely clip off the offending pin.

IBM expansion chassis

Expansion connector, IBM Expansion Chassis

If you decide to make one, pins 13 and 18 are reversed in the Technical Reference Manual. Pin 13 is WRITE DATA and pin 18 is SELECT HEAD 1.

```
              DB-62 connector

        ____________________________________________
 21    ( o o o o o o o o o o o o o o o o o o o o o  )  1
 42     \ o o o o o o o o o o o o o o o o o o o o o /  22
 62      \ o o o o o o o o o o o o o o o o o o o o /   43
          \_______________________________________/
```

PIN	signal	pin	signal	pin	signal
1	+E IRQ6	22	+E D5	43	+E IRQ7
2	+E DRQ2	23	+E DRQ1	44	+E D6
3	+E DIR	24	+E DRQ3	45	+E I/O CH RDY
4	+E enable	25	reserved	46	+E IRQ3
5	+E clk	26	+E ALE	47	+E D7
6	-E mem in exp	27	+E T/C	48	+E D1
7	+E A17	28	+E reset	49	+E I/O CH CK
8	+E A16	29	+E AEN	50	+E IRQ2
9	+E A5	30	+E A19	51	+E D0
10	-E DACK0	31	+E A14	52	+E D2
11	+E A15	32	+E A12	53	+E D4
12	+E A11	33	+E A16	54	+E IRQ5
13	+E A10	34	-E MEMR	55	+E IRQ4
14	+E A19	35	-E MEMW	56	+E D3
15	+E A1	36	+E A0	57	GND
16	+E A3	37	-E DACK3	58	GND
17	-E DACK1	38	+E A6	59	GND
18	+E A4	39	-E IOR	60	GND
19	-E DACK2	40	+E A8	61	GND
20	-E IOW	41	+E A2	62	GND
21	+E A13	42	+E A7		

IBM PC Tech Ref says the expansion chassis has its own clock, the clock signals are not carried over the cable. There is 1 wait state inserted to allow for the asynchronopus operation of the expansion chassis. IBM uses an amplifier and reciever card to make up for signal losses, with a very short cable it may be possible ot hook the busses directly.

5.25 inch floppy connector (to drive)

34 pin card edge connector

all odd numbers are grounds

2,4,6	unused
8	index
10	motor enable A
12	Drive Select B
14	Drive Select A
16	Motor Enable B
18	Direction (Step Motor)
20	Step Pulse
22	Write Data
24	Write Enable
26	Track 0
28	Write Protect
30	Read Data
32	Select head 1
34	Unused

Colour Graphics Adapter

RGB monitor (standard digital) 8 colour, intensity signal gives 16

DB9

```
1  o o o o o  5
6   o o o o   9
```

1	ground
2	shield ground
3	red
4	green
5	blue
6	intensity
7	reserved
8	horizontal sync
9	vertical sync

Colour Graphics Adapter

RCA female

(CGA, EGA, VGA composite output)

Centre - composite video signal, approximately 1.5vDC
Outside - ground

RGB monitor (some analog)

DB-15 connector

(not IBM - some Apple)

```
1  o o o o o o o o  8
9   o o o o o o o   15
```

1	shield ground	6	ground	11	B&W NTSC video
2	green	7	-5v	12	colour NTSC video
3	sync	8	+12v	13	ground
4	not used	9	blue	14	-12v
5	red	10	intensity	15	+5v

Monochrome Display Adapter, Hercules

DB9

```
5 o o o o o 1
6  o o o o  9
```

1	ground
2	shield ground
3	N/C
4	N/C
5	N/C
6	+ intensity
7	+ video
8	+ horizontal
9	- vertical

Signal voltages are: 0 to .6 VDC at the Low Level
+5 VDC at the High Level

IBM VGA

Pin	function
1	red
2	green
3	blue
4	reserved
5	digital ground
6	red rtn (a return signal that informs the VGA that this is a colour on monochrome monitor?)
7	green rtn
8	blue rtn
9	plug (no function?)
10	digital ground
11	reserved
12	reserved
13	horizontal sync
14	vertical sync
15	reserved

Keyboard Connector

XT/AT except XT/286

DIN 5 pin round

1	+clock +5vDC
2	+data +5vDC
3	-keyboard reset (not used by keyboard)
4	ground
5	+5vDC

Cassette Port Connector

PC-0, PC-1, PC-2

DIN-5 round

pin	use
1	cassette motor control, common from relay
2	ground
3	cassette motor control, 6vDC @1A
4	data in, 500nA @+/-13v, 1000-2000 baud
5	data out, 250uA @ .68 or .75vDC

Light Pen Connector

6 pins CGA, Hercules

pin	use
1	+ light pen input
2	not used
3	+ light pen switch
4	ground
5	+ 5v
6	+ 12v

Disk Drive Power Connectors

4 pin special (Shugart standard)

```
1 /‾o   o   o   o‾\ 4
   --------------
```

pin	use
1	+12vDC
2	ground
3	ground
4	+5vDC

4 trace card edge (Sony 3.5 inch)

pin	use
1	+5v
2	gnd (5v)
3	gnd (12v)
4	+12v

Power Supply

PC, XT

P8	1	power good
	2	+5v
	3	+12v
	4	-12v
	5	gnd
	6	gnd
P9	7	gnd
	8	gnd
	9	-5
	10	+5
	11	+5
	12	+5

AT VOLTAGE CHECKS

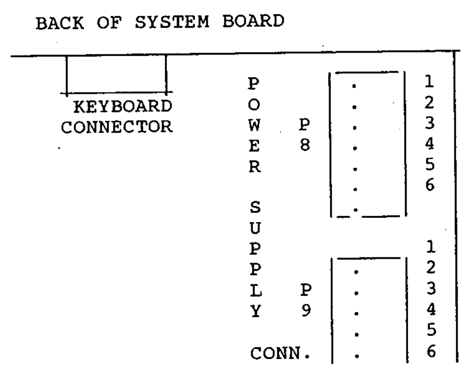
Min Vdc	Max Vdc	- LEAD	+ LEAD
+2.4	+5.2	J8-5	J8-1
+4.8	+5.2	J8-5	J9-4
+4.5	+5.4	J9-3	J8-6
+11.5	+12.6	J9-1	J8-3
+10.8	+12.9	J8-4	J9-2

DISKETTE/DISK DRIVE VOLTAGE CHECKS

+4.8	+5.2	2	4
+11.5	+12.6	3	1

TOP OF DISKETTE DRIVE

. . . .
1 2 3 4



PC/AT power connectors must be terminated with the proper resistor plug if not used, XT power supplies should not be operated without a load.

Parallel Port

DB25 (Amphenol 57-30360)

Female on computer
25 pin male on cable
36 Centronics to printer

1	STROBE (Normal=High, Data read-in when Low)
2	DATA 1
3	DATA 2
4	DATA 3
5	DATA 4
6	DATA 5
7	DATA 6
8	DATA 7
9	DATA 8
10	ACKNLG (5us pulse,low=data rcvd and printer is ready)
11	BUSY
12	PE (high=printer out of paper)
13	SLCT (printer is in the selected state)

14	AUTO FEED XT (low=paper auto. fed one line after printing)
15	N/C
16	0V (logic ground level)
17	chassis ground
18	N/C
19-30	ground
31	INIT (normal=high, low=printer controller reset, buffer cleared)
32	ERROR (low=paper end state, off-line state, or error state)
33	ground
34	N/C
35	+5 VDC through a 4.7K resistor
36	SLCT IN (low=data entry possible)

Serial Port

for PC, XT, PS/2
connector DB-25

plug on computer
25 pin male female on back

```
1 o o o o o o o o o o o o o 13
14  o o o o o o o o o o o o  25
```

1	N/C
2	transmit data
3	receive data
4	RTS (request to send)
5	CTS (clear to send)
6	DSR (data set ready)
7	signal ground
8	CD (carrier detect)
9	+transmit current loop return (20ma)
10	N/C
11	-transmit current loop data (20ma)
12	N/C
13	N/C
14	N/C
15	N/C
16	N/C
17	N/C
18	+receive current loop data (20ma)
19	N/C
20	DTR (data terminal ready)
21	N/C
22	RI (ring indicator)
23	N/C
24	N/C
25	-receive current loop return (20ma)

(RS232C industry standard)

Pin #	code	description	Pin #	code	description
1	AA	ground	13	SCB	sec. clear to send
2	BA	transmitted data	14	SBA	sec. transmitted data
3	BB	received data	15	DB	transmitted signal element timing (DCE)
4	CA	request to send	16	SBB	sec. received data
5	CB	clear to send	17	DD	receiver signal element timing (DCE)
6	CC	data set ready	18	-	unassigned
7	AB	signal ground	19	SCA	sec. request to send
8	CF	received line signal detector	20	CD	data terminal ready
9	-	reserved	21	CG	signal quality detector
10	-	reserved	22	CE	ring indicator
11	-	unassigned	23	CH/CI	data signal rate select
12	SCF	sec. received line signal detector	24	DA	trans. sig. timing (DTE)
			25	-	unassigned

Serial Port

DB9

AT

```
5 o o o o o 1
 6 o o o o 9
```

Pin			Description
1	CD	in	data carrier detect
2	RD	in	serial receive data
3	TD	out	serial transmit data
4	DTR	out	data terminal ready
5	gnd		signal ground
6	DSR	in	data set ready
7	RTS	out	request to send
8	CTS	in	clear to send
9	RI	in	ring indicator

RGB monitor (standard digital)

EIAJ-8 connector

```
1. intensity    5. shield ground                 o   o 1
2. red          6. ground
3. green        7. horiz or composite sync       o   o
4. blue         8. vertical sync                 o   o
                                                 o   o
```

DB9 to EIJ-8 (IBM compatible to Taxan or component TV)

adapter wiring

```
1 == 5 gnd
2 == 6 gnd
3 == 2 red
4 == 3 green
5 == 4 blue
6 == 1 intensity
7 == no connection
8 == 7 horiz sync
9 == 8 vertical sync
```

Note: intensity signals can be either positive or negative!

Sony Multiscan monitor (analog)

Pin	function
1	gnd
2	gnd
3	red
4	grn
5	blu
6	gnd
7	no connection
8	horiz sync
9	vert sync

Various Serial Cable Pin-outs

(like symbols mean connect pins together)

```
IBM-PC        Hayes Modem
 DB-25           DB-25
FGND 1 -------   1 FGND
XMT  2 ------>   2 XMT
RCV  3 <------   3 RCV
RTS  4 ------>   4 RTS
CTS  5 ------>   5 CTS
DSR  6 <------   6 DSR
SGND 7 -------   4 SGND
DCD  8 <------   8 DCD
DTR 20 ------>  20 DTR
RNG 22 <------  22 RNG
```

```
IBM-AT        Hayes Modem
 DB-9            DB-25
DCD  1 <------   8 DCD
RCV  2 <------   3 RCV
XMT  3 ------>   2 XMT
DTR  4 ------>  20 DTR
SGND 5 -------   7 SGND
DSR  6 <-------  6 DSR
RTS  7 ------>   4 RTS
CTS  8 <------   5 CTS
RNG  9 <------  22 RNG
```

```
     Null Modem Cable
IBM PC             IBM PC
 DB-25              DB-25
XMT  2------------ 3 RCV
RCV  3------------ 2 XMT
RTS  4-#         *- 4 RTS
CTS  5-#         *- 5 CTS
DSR  6-+         @- 6 DSR
DCD  8-+         @- 8 DCD
DTR 20-+         @-20 DTR
SGND 7------------ 7 SGND
```

```
     Null Modem Cable
IBM AT             IBM AT
 DB-9               DB-9
RCV  2------------ 3 XMT
XMT  3------------ 2 RCV
RTS  7-#         *- 7 RTS
CTS  8-#         *- 8 CTS
DSR  6-+         @- 6 DSR
DCD  1-+         @- 1 DCD
DTR  4-+         @- 4 DTR
SGND 5------------ 5 SGND
```

```
     Null Modem Cable
IBM PC             IBM AT
 DB-25              DB-9
XMT  2------------ 2 RCV
RCV  3------------ 3 XMT
RTS  4-#         *- 7 RTS
CTS  5-#         *- 8 CTS
DSR  6-+         @- 6 DSR
DCD  8-+         @- 1 DCD
DTR 20-+         @- 4 DTR
SGND 7------------ 5 SGND
```

```
VT 220     Brother M 1509
 DB-9          DB-25
GND  1------- 1 GND
XMT  2------- 3 RCV
RCV  3------- 2 XMT
DSR  6-------20 DTR
SGND 7------- 7 SGND
```

```
P-E 6100    Brother M-1509
 DB-25          DB-25
GND  1------- 1 GND
XMT  2------- 2 RCV
RCV  3------- 3 XMT
RTS  4-------
CTS  5-------
DSR  6-------
SGND 7------- 7 SGND
DCD  8-------
DTR  20-------
```

Various Serial Cable Pinouts

```
                 NEC
IBM-AT        3510/3515
 DB9             DB25
RCV   2------- 2 XMT
XMT   3------- 3 RCV
SGND  5------- 7 SGND
CTS   8-------19 2nd RTS
DCD   1 #    * 4 RTS
DTR   4 #    * 5 CTS
DSR   6 #    + 6 DSR
RTS   7      + 8 DCD
RNG   9      +20 DTR
```

```
                 NEC
IBM-XT        3510/3515
DB25             DB25
XMT  2------- 3 RCV
RCV  3------- 2 XMT
CTS  5-------19 2nd RTS
SGND 7------- 7 SGND
DSR  6 #    * 4 RTS
DCD  8 #    * 5 CTS
DTR 20 #    + 6 DSR
RTS  7      + 8 DCD
RNG  9      +20 DTR
```

```
IBM-AT      NEC 7700 Series
 DB9
DCD  1-+-----20 DTR
DSR  6-+
RCV  2------- 2 XMT
XMT  3------- 3 RCV
DTR  4-----+- 6 DSR
           +- 8 DCD
SGND 5------- 7 SGND
RTS  7------- 5 CTS
CTS  8-------19 2nd RTS
```

```
IBM-AT        HP 7470A
 DB9           DB25
RCV  2------- 2 XMT
XMT  3------- 3 RCV
SGND 5------- 7 SGND
DSR  6-+-----20 DTR
CTS  8-+
```

```
IBM-XT        HP 7470A
DB25          DB25
GND  1------- 1 GND
XMT  2------- 3 RCV
RCV  3------- 2 XMT
CTS  5-+-----20 DTR
DSR  6-+
SGND 7------- 7 SGND
```

```
IBM-AT        HP Laserjet
RCV  2------- 2 XMT
XMT  3------- 3 RCV
SGND 5------- 7 SGND
DSR  6-+-----20 DTR
CTS  8-+
```

```
IBM-XT        HP Laserjet
GND  1------- 1 GND
XMT  2------- 3 RCV
RCV  3------- 2 XMT
CTS  5-+-----20 DTR
DSR  6-+
SGND 7------- 7 SGND
```

```
   IBM-AT Pinout Names
1  DCD  Data Carrier Detect
2  RCV  Receive Data
3  XMT  Transmit Data
4  DTR  Data Terminal Ready
5  SGND Signal Ground
6  DSR  Data Set Ready (In)
7  RTS  Request to Send
8  CTS  Clear to Send
9  RNG  Ring Indicator
```

```
    IBM-XT Pinout Names
1   FGND Frame Ground
2   XMT  Transmit Data
3   RCV  Receive Data
4   RTS  Request to Send
5   CTS  Clear to Send
6   DSR  Data Set Ready
7   SGND Signal Ground
8   DCD  Data Carrier Detect
20  DTR  Data Terminal Ready
22  RNG  Ring Indicator
```

Data Terminal to Data Communications

```
Data Terminal      Data Comm.
 Equipment  <-->  Equipment
   Typical Configuration

 (DTE)              (DCE)
 AT  XT             Modem
      1 FGND-----------  FGND
 3    2 XMT----------->2 XMT
 2    3 RCV<-----------3 RCV
 7    4 RTS----------->4 RTS
 8    5 CTS<-----------5 CTS
 6    6 DSR<-----------6 DSR
 5    7 SGND-----------7 SGND
 1    8 DCD<-----------8 DCD
 4   20 DTR---------->20 DTR
 9   22 RNG<----------22 RNG
```

```
Data Terminal   Data Terminal
 Equipment  <-->  Equipment
   Typical Configuration
 (DTE)              (DTE)
AT  XT             Printer
     1 FGND--------- 1 FGND
3    2 XMT---------> 3 RCV
2    3 RCV<--------- 2 XMT
7    4 RTS<----------5 CTS
8    5 CTS---------> 4 RTS
6    6 DSR<-------- 20 DTR
1    8 DCD<-+
            +-> 6 DSR
4   20 DTR-------+-> 8 DCD
5    7 SGND----------7 SGND
9   22 RNG          22 RNG
```

Null Modem

```
RS-232C Null Modem
Cable Connections
(computer to computer)

2 ----------- 3
3 ----------- 2
4 ----------- 5
5 ----------- 4
6 ----------- 20
7 ----------- 7
20 ---------- 6
```

```
RS-232C Straight
through (computer
to modem)

2 ----------- 2
3 ----------- 3
4 ----------- 4
5 ----------- 5
6 ----------- 6
7 ----------- 7
20 ---------- 20
```

```
RS-232C typical
serial printer

7 ----------- 7
2 ----------- 3
5 ---|
6 ---|------- 20
8 ---|
1 ----------- 1
```

Appendix 6

ANSI.SYS

ANSI.SYS is an installable console (CON) driver which understands ANSI control sequences.

ANSI.SYS replaces CON, since it is named CON and is installed as a device driver. ANSI.SYS watches all output going to the 'CON' file. When it sees its specific 'escape code' (ESC followed by a left bracket '[') it parses the following text until it sees a terminating string. If the escape code is a valid sequence, it will perform the task set by the code and then continue parsing the input stream. Invalid ANSI codes are ignored.

ANSI.SYS contains a buffer of 196 bytes under DOS 2.x or 204 bytes under DOS 3.x. You may use this buffer to store strings which you may assign to any key. The buffer is of fixed size, and so long as you do not overflow it, you may assign any length string to any key. The buffer will only contain the *ANSI.SYS significant* characters ANSI.SYS sees. The assignments to a key may be removed by assigning a NUL string to a key.

When designing ANSI.SYS, IBM selected a set of commands adopted by the American National Standards Institute, or ANSI, hence the driver's name. The driver's incorporation of ANSI standard sequences permits the use of the many programs that are designed with the standards in mind. With the new console device driver installed, the PC can use these programs. ANSI.SYS can also be used to develop programs for the PC or other systems with terminals that meet the standard. It is not necessary to include hardware-specific commands to control the display or cursor location. Program outputs can achieve the same results on any conforming hardware.

ANSI.SYS uses BIOS calls to control the screen. While putting text on the screen, ANSI.SYS watches for valid escape sequences. Such sequences follow the format:

```
                ESC [ param; param; ...; param cmd
        where:
                ESC     is the escape character chr$(27).
                [       is the left bracket character.
                param   is an ASCII decimal number, or a string in quotes.
                cmd     is a case-specific letter identifying the command.
```

Usually, zero, one, or two parameters are given. Spaces are not allowed between parameters. If parameters are omitted, they usually default to 1; however, some commands (KKR) treat the no-parameter case specially. For example, both ESC[1;1H and ESC[H send the cursor to the home position (1,1), which is the upper left.

Either single or double quotes may be used to quote a string. Each character inside a quoted string is equivalent to one numeric parameter. Quoted strings are normally used only for the Keyboard Key Reassignment command.

Control Sequences

The control sequences are valid if you issue them through standard DOS function calls that use standard input, standard output, or standard error output devices. These are the DOS function calls 01h, 02h, 06h, 07h, 09h, 0Ah, and 40h.

The following table lists the sequences understood by ANSI.SYS.

Cursor Positioning

Short	*Long name*	*Format*	*Notes*
CUP	cursor position	ESC[y;xH	Sets cursor position.
HVP	cursor position	ESC[y;xf	Same as CUP; not recommended.
CUU	cursor up	ESC[nA	n = # of lines to move
CUD	cursor down	ESC[nB	
CUF	cursor forward	ESC[nC	n = # of columns to move
CUB	cursor backward	ESC[nD	
DSR	Device Status, Report!	ESC[6n	Find out cursor position.
CPR	Cursor Position report	ESC[y;xR	Response to DSR, as if typed.
SCP	Save Cursor Position	ESC[s	Not nestable.
RCP	Restore Cursor Position	ESC[u	

Editing

ED	Erase in Display	ESC[2J	Clears screen.
EL	Erase in Line	ESC[K	Clears to end of line.

Mode-Setting

SGR	Set Graphics Rendition	ESC[n;n;...nm	See character attribute table.
SM	Set Mode	ESC[=nh	See screen mode table.
RM	Reset Mode	ESC[=nl	See screen mode table.
IBMKKR	Keyboard Key Reass.	ESC['string'p	

1. The first char of the string gives the key to redefine; the restof the string is the key's new value.
2. To specify unprintable chars, give the ASCII value of the character out side of quotes, as a normal parameter.
3. IBM function keys are two byte strings; see Appendix 1. For example, ESC[0;';DIR A:';13;p redefines function key 1 to have the value 'DIR A:' followed by the ENTER key.

Character Attributes

The Set Graphics Rendition command is used to select foreground and background colours or attributes. When you use multiple parameters, they are executed in sequence, and the effects are cumulative.

Attrib code	*Value*
0	All attributes off (normal white on black)
1	Bold
4	Underline
5	Blink
7	Reverse Video
8	Invisible (but why?)
30-37	foregnd blk/red/grn/yel/blu/magenta/cyan/white
40-47	background

Cursor Positioning

To move the cursor to a specified position: ESC [#;#h where the first # is the desired line number and the second the desired column.

To move the cursor up without changing columns: ESC [#a where # specifies the number of lines moved.

To move the cursor to a specified horizontal and vertical position: ESC [#;#f where # means first the line number and secondly the column number.

To get a device status report: ESC [6n.

To get a cursor position report: ESC [#;#r where the first # specifies the current line and the second # specifies the current column.

To move the cursor down: ESC [#b where # specifies the number of lines moved down.

To move the cursor forward: ESC [#C where # specifies the number of columns moved.

To move the cursor backward: ESC [#d where # specifies the number of columns moved.

To save the cursor position: ESC [s and to restore it: ESC [u.

Erasing The Screen

To do a CLS (erase screen move cursor to home position): ESC [2j. To erase from cursor to end of line: ESC [k.

Set Screen/Character Colours

To set the colour/graphics attributes, enter ESC [#;#m where the first # is the desired foreground colour and the second is the desired background colour. Select colours from the list below:

```
30      black foreground
31      red foreground
32      green foreground
33      yellow foreground
34      blue foreground
35      magenta foreground
36      cyan foreground
37      white foreground

40      black background
41      red background
42      green background
43      yellow background
44      blue background
45      magenta background
46      cyan background
47      white background
```

To set additional attributes enter: ESC [#m where # is the number of the desired attribute. Select attributes from the list below:

```
0       all attributes off (white on black)
1       bold (high intensity) on
4       underscore (on monochrome or EGA display)
```

5	blinking
7	reverse video
8	invisible (character and box are set to the same colour)

Using ANSI Codes in the Prompt

PROMPT metastrings

metastring *definition special characters*

```
$B      the '|' character
$G      the '' character
$L      the '' character
$Q      the '=' character
$$      the '$' character
```

System Information

```
$D      the date (14 characters: 3 character day-of-week, blank, 2
        character month, dash, 2 character day, dash, 4 character
        year)
$T      the time (11 characters: 2 digit hour, colon, 2 digit
        minutes, colon, 2 digit seconds, point, 2 digit hundredths-
        of-seconds)
$N      the current default drive (1 character)
$P      the current directory path of the default drive (begins with
        default drive, colon, then a maximum of 63 characters of the
        path from the root to the current directory)
$V      the DOS version number (currently prints 39 characters)
```

Cursor Control

```
$H      backspace & erasure of the previous character
$_      a carriage return and linefeed sequence (the prompt continues
        on the beginning of the next screen line).
```

Other ASCII characters

```
$E      the ASCII ESCape character (alt-27)
$a      a null string  (where 'a' is anything not used above)
```

DOS will not accept any other characters after the $ sign according to the manual, however, $aSTRING is sometimes used to display a string. The PROMPT commands are not case sensitive. ANSI.SYS escape code definitions may be mixed freely with the internal PROMPT commands. For example, PROMPT $e[s$e[1;1H$e[0m$e[K$e[7m $d / $t : $p $e[0m$e[ung.

What this does

```
$e[s          Save current cursor position
$e[1;1H       Move to upper left corner of display
$e[0m         Set normal mode display
$e[K          Erase topmost line of display
$e[7m         Set Reverse Video mode
$d            Display current date
$t            Display current time
$p            Display current drive & path
$e[0m         Set normal mode display
$e[u          Return to original cursor position
$n            Display the current drive
$g            Display the prompt character
```

Bibliography

The information presented here was gathered from megabytes of files found on BBS systems, conversations on a dozen different BBS systems, correspondence, and every reference book I could get my hands on. On occasion, a number of prestigious references didn't agree with each other. Where this has happened, I have used the latest references. There is too much information here for me to verify every fact personally. I have used my own judgement as to the reliability of the sources.

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Microsoft C 4.0 documentation
Borland Turbo Pascal 3.02a and 5.0 documentation, Turbo C 2.0 documentation

Magazines

A large amount of miscellaneous information came from various computer magazines. Documenting what came from where would be an experience all its own. A great deal of information came from articles by Michael Mefford, Charles Petzold, and Neil Rubenking of PC Magazine, and Ray Duncan, who gets around a lot.

Dr. Dobb's Journal (I always thought the old title, *'Doctor Dobbs' Journal of Computer Calisthe-*

nics and Orthodontia - Running Light Without Overbyte' was a killer name, but nobody asked me.)
PC Magazine
PC Resource
PC Tech Journal
Computer Language
Programmer's Journal
Byte Magazine
Computer Shopper

Computer Bulletin Board Systems

Various computer bulletin board systems, including

Byte Information Exchange (BIX)
Compuserve IBM SIG
GEnie IBM RT and Borland RT
GT Net international network
FIDO Net international network
PCanada BBS system, (Toronto, Canada)
Pecan Pi RBBS (404) 454-8756 (Atlanta, GA), Stan Young, sysop (R.I.P).
College Corner BBS (206) 643-0804 (Seattle, WA), Jerry Houston, sysop.
Poverty Rock BBS (206) 232-1763 (Seattle WA), Rick Kunz, sysop.
Night Modulator BBS (408) 728-5598 (San Jose CA), Jim Bready, sysop.

Now that I no longer subscribe to PC-Pursuit, I'm not on any of these boards now, but they're still fine places to call.

Text Files

The text files on the following page were of use. Bear in mind that some of them may be seen under several different names. The author's name is given as it appears in the documentation (if any).

10H-BUG	ASM	4680	29/01/87	bug in 2.x int 21h/fn10h	Ray Duncan
1PT4MB	INF	5120	3/10/87	1.44Mb drives	Clyde Washburn 70305,1211
2EH	ASM	2969	3/03/87	info on undoc'd int 2Eh	David Gwillim
386BUG	ARC	9216	15/10/87	bug in early 80386 chips	Compaq Corp.
8086	3	10572	5/12/88	dump of Fidonet?? 8086 conf??	[no name]
8259	ARC	2826	15/03/88	info on 8259 chip	[no name]
APICALLS	ARC	11481	8/01/88	OS/2 API function call list	Bill Earle
ASM-ADRS	ARC	6144	20/12/87	low memory vectors	Malcolm McCorquodale
ATCMDS	ARC	3072	20/03/88	Hayes 1200 baud command set	[no name]
BIOSDOC	ARC	34816	3/11/87	very good function list	David E. Powell
BIXDOS1	ARC	155648	14/12/87	BIX 'MSDOS Secrets' #1	[no name]
BUG40DOS	ARC	3200	18/08/88	bugs in DOS 4.0	'Doug'
CAS	ARC	33792	27/10/88	Communicating Applications Standard 1.0A	DCA, Intel Corp
DEBUGTUT	ARC	15655	23/04/88	DEBUG tutorial	[no name] possibly David Whitman?
DIAGNOSE	ARC	14336	1/01/86	memory error codes	Jerry Schneider, Arnold Kischi
DISK144	ARC	23086	16/10/88	info on 1.44Mb diskettes	[no name]
DISKTYPE	ARC	5073	14/04/88	IBM floppy formats	[no name]

DOOM	ARC	9216	29/09/88	hard drive information	[no name]
DOS-SIZE	ARC	787	27/03/88	size of DOS files 1.1-3.1	[no name]
DOS32	ARC	17408	31/05/88	command list for DOS 3.2	[no name]
DOS3BUGS	ARC	5639	15/10/87	acknowledged bugs in DOS 3.0 -3.2	IBM Corp.
DOS40	ARC	15625	22/07/88	IBM announcement of DOS 4.0	IBM Corp.
DOS401	ARC	18178	19/10/88	errors in DOS 4.0	IBM Corp.
DOS40B	ARC	27008	26/08/88	Compuserve thread on DOS 4.0	[no name]
DOS40FAT	ARC	1510	11/09/88	DOS 4.0 File Allocation Table	Mike Austin
DOS40FUN	ZOO	3410	31/12/99	DOS 4.0 int 24,25, etc	Pat Myrto
DOS40HLP	ARC	53376	28/08/88	DOS 4.0 command set	[no name]
DOS40TXT	ARC	46169	16/10/88	DOS 4.0 problems & info	[no name]
DOS4TIPS	ARC	1735	19/09/88	problems with DOS 4.0	IBM Corp.
DOSBUG	TXT	1024	15/10/87	info on 2.0 volume label	[no name]
DOSGUIDE	ARC	21344	21/02/88	DOS tutorial	Carrington B. Dixon
DOSINT	ARC	4201	15/03/88	list of DOS 2.0 function calls	John Chapman
DOSNOTES	ARC	5052	15/03/88	info on DOS undoc fns.	[no name]
DOSREF	ARC	9216	21/01/87	partial list of PC BIOS calls	[no name]
DOSREF	ARC	62052	23/08/86	device driver info	'Cracker'
DOSTIPS	ARC	28926	15/03/88	info on DOS	John Chapman
DOSTIPS1	ARC	159657	25/11/85	various DOS info	Dean R. Wood
DOSTIPS3	ARC	59264	25/01/88	various DOS tips (different)	Dean R. Wood
DOSUNDOC	ARC	3840	03/05/86	one of the very first interrupt lists	Spyros Sakellariadis
DRIVPARM	ARC	11264	7/01/88	info on DRIVPARM parameters	Joan Friendman
EGATEK	ARC	8704	15/03/88	IBM EGA registers	Bill Frantz
EMS40BIX	ARC	3802	21/09/87	BIX announcement of EMS 4.0	BIX
ENVIRONM	ARC	4255	18/09/88	info on DOS environment	Jan Fagerholm
ESC_CODE	ARC	3072	3/10/88	Laserjet setup codes	S. Noh
FILEIO	ARC	8192	24/07/88	TSRs and INDOS flag	[no name]
FLOPPIES	ARC	9216	2/11/87	info on floppy media	Ted Jensen
FOSSIL	ARC	9031	15/07/87	list of FOSSIL functions	Vincent Periello
FXN4BH	ASM	4503	1/01/80	odd 4Bh behaviour	Ray Duncan
HAYESET2	ARC	6479	4/09/86	modem commands	Ruth Lubow, Fowler Brown
HD-DATA	ARC	4096	19/07/87	list of hard drives & specs I've seen many similar files. I believe the original was a file or bulletin on Sparta BBS	[no name]
HDINFO	ARC	11264	19/11/87	updated version of above, evidently by someone else	[no name]
HDNOISE	ARC	4159	11/11/87	hard disk information	Clancy Malloy
HDTIPS	ARC	9660	11/10/87	hard disk information	Barry Gordon
IBMTECH	ARC	136064	4/11/88	error codes, other info	IBM Corp.
INT-MDOS	ARC	20682	31/07/85	one of the original INT lists	Ross Greenberg
INTERRUP	ARC	157440	19/09/88	interrupt vector list	Ralf Brown
INTERRPT	ARC	42632	4/04/88	interrupt vector list this is a very nice list and some programming information. If I'd come across it way back then it would have saved a ton of typing (sigh).	Marshall Presnell
JARGON	ARC	49274	16/07/88	dictionary of computer terms	[no name]

LIM-40	ARC	21504	15/10/87	info on LIM 4.0	Stephen Satchell
LISTINTS	ARC	6144	3/12/87	small interrupt list	[no name]
MCB	ARC	5120	24/07/88	info on DOS Memory Control Blocks	David Gwillim
MNP-TEXT	ARC	6144	30/09/88	MNP modem info	Mike Focke
MOUSENG	ARC	10240	13/08/88	Norton Guide file for mouse programming, with C examples	[no name]
MSLOOKUP	ARC	58368	25/12/87	interrupt and function listing	Frank Bonita
MS-OS2	ARC	25600	15/10/87	MS press release on OS/2	Microsoft Corp.
MSINT125	ARC	48128	12/01/88	interrupt vector listing	Ralf Brown
NETBIOS	ARC	17280	29/10/88	NetBIOS tutorial & summary	Tom Thompson
NOVELINT	ARC	4531	18/10/88	NetBIOS calls	Marc Guyot
OCOM_520	ARC	53632	19/08/88	FOSSIL tutorial and functions	Rick Moore
ODDITY	ARC	3072	24/07/88	int 2Eh description	Daniel Briggs
PINS	ARC	3072	18/01/88	pinouts of various connectors	[no name]
QUES40	ARC	9081	1/09/88	info on DOS 4.0	IBM Corp.
RAW_COOK	ARC	2048	15/10/87	info on DOS raw and cooked modes	[no name]
RESETSWT	TXT	3584	23/01/86	add a reset switch to a PC	Don Jenkins
RLLHINTS	ARC	12288	17/10/87	RLL controller into	Steve Sneed
RLLMISC	ARC	5120	17/10/87	info on RLL controllers	Richard Driggers
RLLSTORY	ARC	9718	31/07/88	good info on RLL coding	Pete Holzmann
SEAGATE	ARC	2048	3/03/88	specs for many Seagate drives	Jim McKown
SECRETS2	ARC	179625	17/04/88	BIX 'MS-DOS Secrets' #2	[no name]
SERCBL2	ARC	4372	16/10/88	serial cable pinouts	Lee Zeis
SM2400	ARC	2296	9/08/86	Hayes 2400 baud command set	[no name]
ST225	ARC	11264	7/10/87	optimizing ST225 and WD cont.	Neil Erbe
TANDON	ARC	3612	21/02/88	info on Tandon drives	David Welcher
TECH	ARC	27827	8/05/88	misc tech info - Fidonet?	[no name]
TOS		938	24/03/88	TOS function calls	Mike Crawford
TRYST	ARC	29312	29/10/88	DOS and hard disk info	Amy Goebel
UNDOCINT	21H	7168	14/04/87	undocumented DOS calls	Peter Holzmann
VGAPIN	ARC	1252	24/10/88	VGA pinout	'Mike'
WD-27X	ARC	6144	10/10/87	WD 27X HD controller setup	Steve Shelton
WDCONFIG	ARC	5504	11/10/87	WD-1002 WXS setup	Richard Driggers
WDCONT	ARC	11264	25/12/87	info on WD hard disk controllers	Peter Fales
XEB1210	ARC	7947	18/07/87	Xebec HD controller setup	Richard Driggers
XEBEC	ARC	1036	30/04/88	setup for Xebec HD controller	Richard Driggers
XEBECTEC	ARC	1834	30/04/88	setup for Xebec 1210	[no name]
XMS	ARC	75776	1/08/88	Microsoft Extended Memory Specification 1.0	Microsoft Corporation
XTCHARTS	ARC	12416	4/11/88	ports, charts	[no name]

NBRCV.C	Paul McGinnis	NetBIOS API calls
DESQ10.ASM	James H. LeMay	DesqView API calls
NETTUT.DOC	Charles L. Hedrick	TCP/IP network
CED10D	Chris Dunford	CED interrupt calls
INTER189.ARC	Ralf Brown	interrupt list

LANTSTIC.DOC	LANTastic adware	peer-to-peer LAN calls
GLOSSARY.ARC	no author name	computer terms

And thanks to all the people who have been good enough to furnish information and support (in alphabetical order):

Tommy Apple, Joe Felix, Ron Melson, Denis Murphy, & Ben Sansing, who all loaned me documentation and reference material for so long that some of them have forgotten to ask for their stuff back

Ben Sansing, Little Rock AR: ANSI.SYS information documentation for the NEC V20/30 chips error in register chart in Chapter 4

Pat Myrto, Seattle WA: Compaq DOS 3.31, IBM DOS 4.0 enhanced hard disk support

Mike Crawford, Little Rock AR: Atari ST TOS function calls and information

Alan R. Levinstone, Garland TX: 80286 LOADALL instruction BIOS Data Area floppy control parameters 40:8B, 40:8F, 40:90

Patrick O'Riva, San Jose CA: info on what happens to the interleave when the BIOS is finished

Klaus Overhage, Stuttgart W.Germany: FANSI-CONSOLE system calls

Special thanks to Chris Dunford, who donated his 'CED' program to the public domain. If it wasn't for CED, I would likely have abandoned MSDOS machines entirely and bought a Mac!

Dave Williams
Jacksonville, AR

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