

The
**PROGRAMMER'S
 TECHNICAL
 REFERENCE**
MS - DOS, IBM PC & COMPATIBLES

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reference book for information a book to be consulted

HARDWARE

DAVE WILLIAMS

SIGMA

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

Dave Williams

SIGMA PRESS – Wilmslow, United Kingdom

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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 official 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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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 DOEDIT.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 IBM-BIO.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 80x86 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 first byte 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.

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 further 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		

CPU Ports Assignments, System Memory Data, BIOS Data Area

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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
736k B8000-BBFFF 16k CGA uses | B8 area to the Video Gate Array
756k BC000-BFFFF | and reserved system RAM

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 cartridge
912k E4000-E7FFF | address area
928k E8000-EBFFF

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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 0FFFFFFF are equal to 0FE0000 to 0FFFFFFF. This is necessary due to differences in the memory addressing between Real and Protected Modes.

PC Port Assignment

hexaddress	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 revectorred 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 DOS Compatibility Box if any of the OS/2 COMxx.SYS drivers are loaded.
40:02	word	COM2 port address	
40:04	word	COM3 port address	
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	DMA present
			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

```

CPU Ports Assignments, System Memory Data, BIOS Data Area

```

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

06/01/83	FC	06		7552 'Gearbox'
11/08/82	FD			PCjr
04/24/81	FE			XT, Portable PC, XT/370, 3270PC
10/19/81	FF			PC-0 (16k motherboard)
08/16/82	FF			PC-1 (64k 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 {SU+} specified

Interrupt 04h Divide overflow

(0:0010h)

Generated by INTO instruction if OF flag is set. If flag is not 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. Revectorred 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 SHUT-DOWN 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 60Hz 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.

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    DMA present
      0    DMA present
      1    no DMA (PCjr, some Tandy 1000s, 1400LT)
9,A,B number 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    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
return  DX    comm port (0-3)
       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
       AL        01h      write modem control register
       BL        modem control register
           bits  0        DTR data terminal ready
           bits  1        RTS request to send
           bits  2        out1
           bits  3        out2
           bits  4        loop
           bits  5,6,7    reserved
return  DX        port number (0=COM1, 1=COM2, etc.)
       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
return  DX        port number (NOP if DX=00FFh)
       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)

```

return ES:DI pointer to user buffer
 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 transferred
 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.

The PC ROM BIOS

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 available
	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:DX 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 POSTASK 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
    
```

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

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

- 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)                      |           |
|     | note 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                                                                |           |
|     | note 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

note AL ASCII character  
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

|       |      |       |      |       |     |
|-------|------|-------|------|-------|-----|
| 0000  | 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 hobyte |
|  | 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.

CX:DX nonzero midnight was passed since last read  
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  
return none

CX:DX high word/low word count of timer ticks

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    | \ | each table is 16 bytes long and contains values for 6845 registers |
| table for modes 2 and 3    |   |                                                                    |
| table for modes 4,5, and 6 |   |                                                                    |
| 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 288-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.

# DOS Interrupts and Function Calls

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## 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       | data 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) do not 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 STDPIN                                |
| 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 directory 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, sub-function 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 PC DOS 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.

INT21H 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 STDPN

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

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 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

return AL 00h if the file is found and closed  
 OFFh 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 OFFh. 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  
 OFFh 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 OFFh 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  
 OFFh 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.

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)

return AL        00h        successfully renamed  
                  OFFh       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 1h.  
 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        1    (set)        double sided  
                   1        0    (clear)    not 8 sector  
                           1        1    (set)        8 sector  
                   2        0    (clear)    nonremovable device  
                           1        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



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

- 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 overlay 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

- 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,

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)
 AL 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+)
 AL 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     | 64bytes |  | 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 cluster at which to start search for free space when writing |
| 1Dh | word  |  | unknown                                                                                                                   |
| 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:
- this is not supported under any version of the DOS
  - it usually works under DOS 2, but there may be circumstances when it doesn't (general disclaimer, don't know of a specific circumstance)
  - 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
  - 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)
 AL 01h set character in DL as new switch character
 AL 02h read device availability (as set by function AL=3)
 AL 03h into DL. A 0 means devices that devices must be accessed
 AL 04h in file I/O calls by /dev/device. A non-zero value means
 AL 05h that devices are accessible at every level of the
 AL 06h directory tree (e.g., PRN is the printer and not a file
 AL 07h PRN).
 AL 08h AL=2 to return flag in DL, AL=3 to set from DL (0
 AL 09h = set, 1 = not set).
 AL 10h (DOS 2.x) 03h get device availability, where:
 AL 11h DL 00h means /dev/ must precede device names
 AL 12h DL 01h means /dev/ need not precede device names
return DL switch character (if AL=0 or 1)
 AL 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 ASCII string currency symbol
 03h byte of zeros
 04h ASCII string thousands separator
 05h byte of zeros
 06h ASCII 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         |
|       | 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 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 read/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.  
 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 ASCIIIZ 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 get file attributes  
       00h  
       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  
 return DS:DX pointer to full ASCIIIZ file name  
       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
 6 1 cooked mode - check for control chars
 7 0 EOF - End Of File on input
 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:
 drive number: 0=default, 1=A:, 2=B:, etc.
BL drive number:
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 pointer 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 available 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 available 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 restore 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 subsequent | 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<br>1 byte of 0s. All blanks are moved from<br>the name and extension, and if an<br>extension is present it is preceded by a<br>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 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 calculate 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 0FFFFFFFh |
| 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                                                                                                                                                             |
| bits     | 2                        | subdirectory data                                                                                                                                                    |
| bits     | 3                        | file data                                                                                                                                                            |
| bits     | 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:<br>((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 common set 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



*The Programmer's Technical Reference*

|     |                                                          |
|-----|----------------------------------------------------------|
| 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 ASCIIIZ directory pathname ending with a  
 backslash (\)  
 CX file attribute

return CF clear DS:DX new ASCIIIZ 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 ASCIIIZ pathname  
 CX file attribute

return CF clear AX file handle  
 DS:DX new ASCIIIZ 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/fnl107h.  
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 fnl125h.

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)

03 DS:SI pointer to string buffer  
 Get Printer Control String  
 BX redirection list index  
 ES:DI pointer to string buffer  
 return CX length of setup string (max 64 bytes)  
 successful  
 clear set error  
 AX error code (01h for all listed subfunctions)

return CF clear 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 ASCIIIZ source device name  
 ES:DI pointer to destination ASCIIIZ network path + ASCIIIZ password

04h Cancel Redirection Assignment  
 DS:SI pointer to ASCIIIZ device name or network path to be cancelled

return CF clear set successful 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 ASCIIIZ source string (null terminated)  
 ES:DI pointer to destination 67 byte (?) ASCIIIZ 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 translated 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 OWFO 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 exist
 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



## ***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, STDP RN, 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<br>- 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 (0FFFFh 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
    bit 4 = 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 with 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,	Compag 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 28h 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 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, PC DOS 2.1, PC DOS 3.1, PC DOS 3.2, PC DOS 3.3, PC DOS 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 available 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 placed 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 entry	12h	Multiplex, DOS 3.x Internal Services		
	AH			
	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
 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)
OFFFh 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
      AL    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
      AL    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 ASCIIIZ 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
 2 - Open control file in Log Queue.

file specified in the CX register.
 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

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```

        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 ASCIIIZ path to directory containing
            Resident Manager and CAS software.
            The path must end with a backslash
        70 13 ASCIIIZ name of current phonebook (the
            CAS subdirectory is assumed)
        83 13 AZCIIZ name of current logo file (the
            CAS subdirectory is assumed)
        96 32 ASCIIIZ default sender name
        128 21 ASCIIIZ 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 contains 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 revector 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). Revector to 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 revector 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 through 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 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-4Dh Reserved 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 ASCII string 'REXX'.
                dword  offset in DX to environment name ASCII string
                        note: The environment name will be truncated if longer
                        than 32 characters.
                dword  offset in DX to the file extension ASCII 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
 return DS:SI points to null terminated string to be queued.
 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 REXXIIBMR.

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

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 program. 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 inter-

rupt 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 indicates 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 area 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 receives 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 interrupts do 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 represent 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 environment 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 control 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 are used 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 re-

turn 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 accommodate 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 environment 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 ad-

dress 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 if the first parameter contained an invalid drive specifier,
otherwise AL=00h.
11. All four segment registers contain the segment address of the initial 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.

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 ASCII string giving the name and location of the file. The ASCII string contains an optional drive letter, optional path, mandatory file specification, and a terminal byte of 00h. The following is an example of an ASCII 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 application 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  STDP RN 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 (STDP RN) can be both read from and written to. STDAUX is typically a serial device and STDP RN 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 a sequential 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 constructed 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.

1-8	8 bytes	An 0 is replaced by the actual drive number during open. 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 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.

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	11 bytes		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 is 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 M M M	M M M 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	
		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	FAT size		DIR		total sectors		
				sectors /track	sectors (entries)	DIR sectors	sectors /cluster			
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.						Victor 9000 PC (discont'd)
				Special DSDD drive.						

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) 5¹/₄

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 repartitioning 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 ARLI 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:

$$SPF = \frac{TS - RS - \frac{D * BPD}{BPS}}{CF + \frac{BPS * SPC}{BPC}}$$

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:

$$\text{CYL} = (\text{max clusters} * 8) / (\text{HEADS} * \text{SPT})$$

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)

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

- in the upper 2 bits of register CL.
- 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.
- For hard disks, the upper 2 bits of the 10-bit cylinder number are placed in the upper 2 bits of register CL.
 - 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.
- 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.
 - 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.
 - For hard disks, the upper 2 bits of the 10-bit cylinder number are placed in the upper 2 bits of CL.
 - 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

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:

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-0Fh 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-0Fh 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.

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

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.

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 number of 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 double-word 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	attr.	description
bits	set	
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	0	'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	0	'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 device 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 where '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 | C. not sure |
| B. media changed | 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 from 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, it 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.

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 spe-

cification 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.

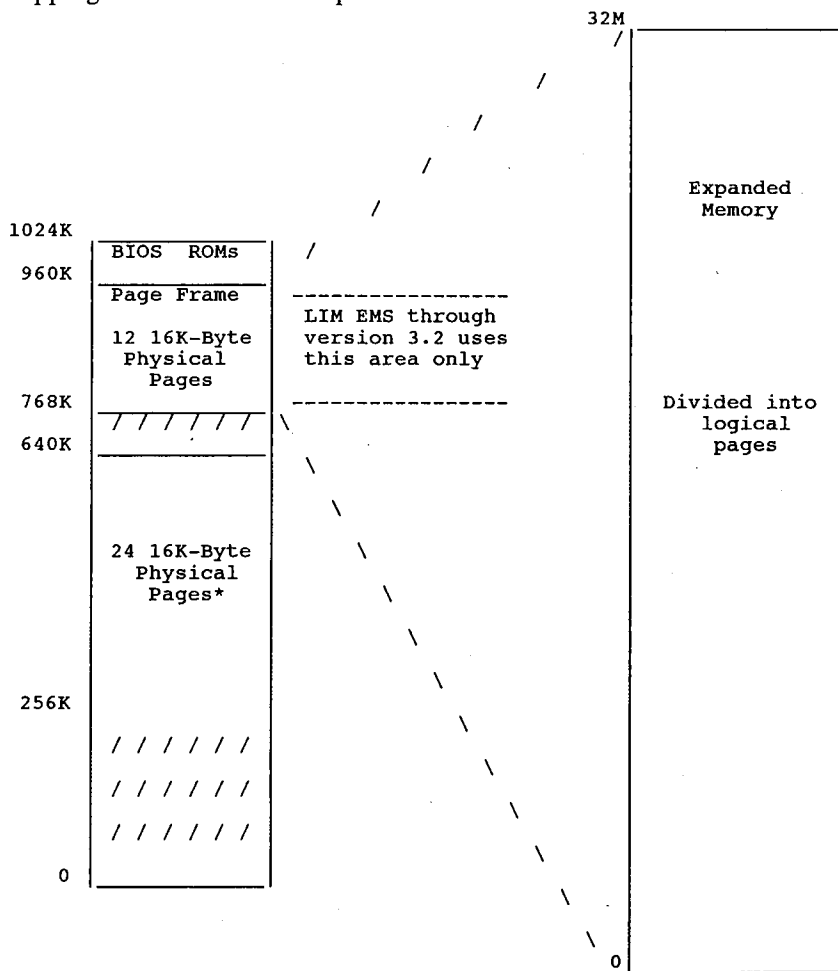
The AQA EEMS permits its pages to be scattered throughout the unused portion of the machine's address space. On August 19, 1987, the new version of the Expanded Memory Specification (EMS) was announced by Lotus, Intel and Microsoft. This new version of the specification includes many features of the 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. (Function 3)
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 megabytes). 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 entries, 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
```

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

- 02h get attribute capability
 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)

return BX,CX access key returned by first invocation
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

note buffer at ES:DI filled
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

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.

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, wParam, lParam):lReply
        FarProc lpPrevWndFunc;
        hWnd    hWnd;
        unsigned wParam;
        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, wIDChangeItem, lpNewItem, wIDNewItem,
        wChange):bChanged
        hMenu    hMenu;
        word    wIDChangeItem;
        lpStr    lpNewItem;
        word    wIDNewItem;
        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 hBitmap 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, wParam, lParam):lReply
        hWnd    hWnd;
        unsigned wParam;
        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
    DestroyMenu(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,
        lpDialogFunc):nResult
        handle hInstance;
        lpStr  lpTemplateName;
        hWnd  hWndParent;
        FarProc lpDialogFunc;
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, lpFacename, lpFontfunc, lpData):nResult
        hDC    hDC;
        lpStr  lpFacename;
        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()

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```

        #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
        GetCurrentPosition(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 wParamFilterMin to wParamFilterMax; stores at
     lParamMsg.
 entry   GetMessage()
         #undef NoMsg
         GetMessage(lParamMsg, hWnd, wParamFilterMin, wParamFilterMax):bContinue
         lParamMsg  lParamMsg;
         hWnd       hWnd;
         unsigned wParamFilterMin;
         unsigned wParamFilterMax;
 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(hModule):nCount
         handle hModule;
 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

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```

        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

```



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        handle hMem;
        dword dwBytes;
        word wFlags;
return handle

GlobalSize
Returns the size, in bytes, of global memory block hMem.
entry GlobalSize()
        #undef NoMemMgr
        GlobalSize(hMem):dwBytes
        handle hMem;
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()
#ifdef 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

LoByte
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()
#ifdef NoMemMgr
LocalAlloc(wFlags, wBytes):hMem
word wFlags;
word wBytes;
return handle

LocalCompact
Compacts local memory to generate wMinFree free bytes.
entry LocalCompact()
#ifdef 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(lInteger):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, wParamFilterMin, wParamFilterMax,
                    bRemoveMsg):bPresent
        lpMsg    lpMsg;
        hWnd    hWnd;
        unsigned wParamFilterMin;
        word    wParamFilterMax;
        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, wParam, lParam):bPosted
        handle  hTask;
        unsigned wParam;
        word    lParam;
        long    lParam;
return  Boolean

PostMessage
        Places message in application queue; returns without waiting for
        processing.
entry   PostMessage()
        #undef  NoWinMessages
        PostMessage(hWnd, wParam, lParam):bPosted
        hWnd     hWnd;
        unsigned wParam;
        word     lParam;
        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, wParam, lParam):lResult
        hWnd    hDlg;
        int     nIDDLgItem;
        unsigned wParam;
        word    wParam;
        long    lParam;
return   long

SendMessage
    Sends a message to a window or windows.
entry    SendMessage()
        #undef NoWinMessages
        SendMessage(hWnd, wParam, lParam):lReply
        hWnd    hWnd;
        unsigned wParam;
        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
                SetScrollRange(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 redisplay 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, nThrowBack)
          lpCatchBuf lpCatchBuf;
          int        nThrowBack;
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, 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

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 ASCII string 'PKT DRV'. 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 DRV' 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	01Fh 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

```

```

return DS:BX pointer to 31-byte ASCIIZ semaphore name
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
return DS:BX   pointer to 31-byte ASCIIZ semaphore name
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
return DS:BX   pointer to 31-byte ASCIIZ semaphore name
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_suspend
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

```


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```

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

return AH 01h Logoff
        DS:DX pointer to superstation ID or nulls (12 bytes)
        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    RTAB 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

```

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if second byte is 00h, first byte is taken as a CB channel number and delivered to all nodes on same channel

return	DS:DX	word	length of data at DX
	CF		pointer to data (max 1024 bytes)
			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/fnl3h.

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-spoiled 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
    
```

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```

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
byte 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, 0FFFFFFFh 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,
0FFFFFFFh reject incoming ALLOCATES
00000000h  queue ALLOCATES

dword     0
dword     pointer to SYSTEM_LOG_EXIT routine, 0FFFFFFFh means
don't log errors

dword     0
byte      maximum TPs
byte      queue depth
dword     pointer to LU_LU_PASSWORD_EXIT routine, 0FFFFFFFh 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

```


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	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:

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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
                0FFFFFFFh reject incoming ALLOCATES
                00000000h queue ALLOCATES
        dword  0
        dword  pointer to SYSTEM_LOG_EXIT routine, 0FFFFFFFh 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, 0FFFFFFFh 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

```

```

return unknown          1      disable

Function 0FBh Convert
entry   AH      0FBh
        DS:DX  pointer to control block
        12 bytes reserved
        word   1A00h
        6 bytes
        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
        AL      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
        AL      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

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                                OFF05h  superstation not available
                                OFF06h  node already logged in
                                OFF07h  login not valid from this node
                                OFF08h  node ID already in use
01h   Logoff
return CX   number of files closed
       AX   status
           0000h  successful
           OFF08h 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
       bit 1   news waiting for you
       bit 2   calendar waiting for you
       bit 3   mail waiting for node
       bit 4   SUBMIT is on
       bit 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
           OFF01h  no response from node
           OFF02h  network error
           OFF04h  no local buffer
           OFF16h  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   RTAB 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
              bit 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)
      AL 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)
return  DS:DX pointer to ASCIIZ pathname
      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)
      AL 01h Set Default Capture Flags)
      AL 02h Get Specific Capture Flags)
      AL 03h Set Specific Print Job Flags)
      AL 04h Get Default Local Printer)
      AL 05h Set Default Local Printer)
      AL 06h Set Capture Print Queue)
      AL 07h Set Capture Print Job)
      AL 08h Get Banner User Name)
      AL 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:DX          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:DX   offset
return AL     error code

Function 0C1h  Novell NetWare 4.6 - Clear Record (FCB)
entry  AH     0C1h
      DS:DX   pointer to FCB
      BX:DX   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  AH     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      0CDh
return 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      0CFh
return 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
        DL          if function 0C6h lock mode 00h:
                    mode
                    00h    no wait
                    01h    wait
                    if function 0C6h lock mode 01h:
                    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 Modesh
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 Copy
entry  AH  0F3h
return  unknown

```

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 the 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 0FFFh 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

ES:BX 0FFFFh unsuccessful
 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)
```

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
0Eh	Diagnostic Status Byte
0Fh	Shutdown Status Byte
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
11h	(AT):Reserved (PS/2):drive type for hard disk C:
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)
6	13h	Reserved
7	14h	Equipment Byte (corresponds to sw. 1 on PC and XT)
7	15h-16h	Base Memory Size (low,high)
7	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 sig-

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	00h	display mode:								
		40x25 B/W text	8x8	CGA	PCjr	MDA	MCGA	EGA	VGA	8514
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					
		80x25 B/W text	8x8	CGA	PCjr			EGA		
16 Colour	02h	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	17h	800x600				Tecmar VGA/AD
		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
		1024x768				Tecmar VGA/AD
16 Colour	19h		132x25	8x14		Tseng Labs EVA
monochrome	1Ah		132x28	8x13		Tseng Labs EVA
monochrome		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)
16 Colour	25h	640x480	80x60	8x8		Tseng Labs EVA
		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
			132x44	8x8		ATI EGA Wonder/ATI VIP
16 Colour	34h	720x348	90x25	8x14		Logitech EGA
monochrome	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
16 Colour	41h	640x200				Tatung VGA
			132x25			AT&T 6300
			132x25			VEGA VGA
			132x25			Tatung VGA
16 Colour	42h	640x400	80x25	8x16		Video7 V-RAM VGA
			132x43			AT&T 6300, AT&T VDC600
16 Colour		640x400	80x25	8x16		VEGA VGA
			132x43			Logitech EGA
			132x43			Tatung VGA
	43h	unsupported 640x200 of 640x400 viewport				Video7 V-RAM VGA
			80x60			AT&T 6300
16 Colour		640x400	80x25	8x16		VEGA VGA
			80x60			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
	51h		80x34			Lava Chrome II EGA
			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
16 Colour			132x43	7x9		Hewlett-Packard D1180A
	55h		132x43	8x14		AT&T VDC600
16 Colour			132x25	8x16		Paradise EGA-480
16 Colour			132x25	7x16		Paradise VGA 256k
			132x25	8x16		Paradise VGA on multisync
			132x25			Taxan 565 EGA
			132x25			AST VGA Plus
16 Colour			132x25	7x16		Hewlett-Packard D1180A
16 Colour			132x25	8x8		AT&T VDC600
			80x66	8x8		ATI VIP 256k
	56h	752x410	94x29	8x14		Lava Chrome II EGA
2 Colour			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

256 Colour		640x480			Hewlett-Packard D1180A
256 Colour		640x480	80x30	8x16	AT&T VDC600 (512K)
	60h	7x400	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)

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 different sizes might be displayed
- Modes 8-10 are available on the PCjr, Tandy 1000, and PS/2
 - IBM claims 100% software and hardware emulation of the CGA with the MCGA chipset. All registers may be read and written as CGA. All characters are 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)
 - 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.
 - 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.
 - 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.
 - The Hercules Graphics Card has 750x348 resolution
 - The Hercules Graphics Card takes 64k beginning at B:000 (same as MDA)
 - The CGA, MCGA, and VGA adapters use hardware address B:800
 - The BIOS clears the screen when the mode is set or reset.
 - For AT&T VDC overlay modes, BL contains the DEB mode, which may be 06h, 40h, or 44h
 - 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.
 - The presence or absence of colour burst is only significant when a composite monitor is being used. For RGB monitors, there is no functional difference between modes 00h and 01h or modes 02h and 03h.
 - On the CGA, two palettes are available in mode 04h and one in mode 05h.
 - 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)

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

- The blinking in text mode is caused by hardware and cannot be turned off, though some kludges can temporarily fake a nonblinking cursor.
- The cursor is automatically turned off in graphics mode.
- 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).
- 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 problem 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

- A separate cursor is maintained for each display page, and each can be set independently with this function regardless of the currently active page.
- 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
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.

- The range of coordinates returned by this function depends on the current display mode.
- 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)

- or a multiple of eight (for 640-by-200 graphics modes).
- 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

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 be 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 be 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
        BL      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 overwriting 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
    BH 01h select register page
       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

```

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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.

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- 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
entry AH
BL

Alternate Select (EGA and after)

```

12h
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 Bit(s)	Feature Control Output Bit	Input Status 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
    
```


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```

return AL      01h    disable greyscale summing
           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)	

```

return ES:DI pointer to 64 byte buffer
       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-OFFh 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

```

```

01h      7      mode 07h supported
        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				

Keyboard Scan Codes

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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

Keyboard Scan Codes

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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	37	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	[	123	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

ASCII Control Codes

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	Ł	224	E0	α
129	81	ü	161	A1	â	193	C1	ł	225	E1	β
130	82	é	162	A2	ó	194	C2	Ť	226	E2	Γ
131	83	â	163	A3	ü	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	â	166	A6	•	198	C6	†	230	E6	μ
135	87	ç	167	A7	•	199	C7	†	231	E7	τ
136	88	ê	168	A8	¿	200	C8	ℓ	232	E8	φ
137	89	è	169	A9	¡	201	C9	ℓ	233	E9	θ
138	8A	è	170	AA	¡	202	CA	ℓ	234	EA	Ω
139	8B	ì	171	AB	¡	203	CB	ℓ	235	EB	δ
140	8C	î	172	AC	¡	204	CC	ℓ	236	EC	ε
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	η
144	90	É	176	B0	⋮	208	D0	⋮	240	F0	μ
145	91	æ	177	B1	⋮	209	D1	⋮	241	F1	†
146	92	Æ	178	B2	⋮	210	D2	⋮	242	F2	‡
147	93	ö	179	B3	⋮	211	D3	⋮	243	F3	Σ
148	94	ö	180	B4	⋮	212	D4	⋮	244	F4	⋮
149	95	ò	181	B5	⋮	213	D5	F	245	F5	⋮
150	96	û	182	B6	⋮	214	D6	π	246	F6	†
151	97	ù	183	B7	⋮	215	D7	†	247	F7	‡
152	98	ÿ	184	B8	⋮	216	D8	†	248	F8	•
153	99	ÿ	185	B9	⋮	217	D9	⋮	249	F9	•
154	9A	Ü	186	BA	⋮	218	DA	⋮	250	FA	•
155	9B	ç	187	BB	⋮	219	DB	⋮	251	FB	√
156	9C	ç	188	BC	⋮	220	DC	⋮	252	FC	η
157	9D	ç	189	BD	⋮	221	DD	⋮	253	FD	•
158	9E	ç	190	BE	⋮	222	DE	⋮	254	FE	•
159	9F	f	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

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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 $1\frac{3}{16}$ 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

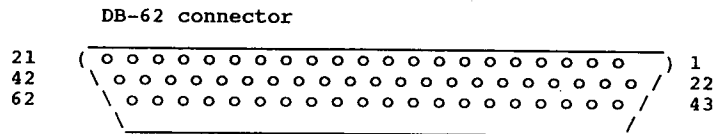
13	+ MFM write data
14	- MFM write data
17	+ MFM read data
18	- MFM read data
2,4,6,11,12,15,16,19,20 ground	
all other pins unused	

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.



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 asynchronous operation of the expansion chassis. IBM uses an amplifier and receiver card to make up for signal losses, with a very short cable it may be possible to 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 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)

pin	use
1	+12vDC
2	ground
3	ground
4	+5vDC

1 / 0 0 0 0 \ 4

4 trace card edge (Sony 3.5 inch)

pin	use
1	+5v
2	gnd (5v)
3	gnd (12v)
4	+12v

Power Supply
PC, XT

	1	power good
	2	+5v
P	3	+12v
8	4	-12v
	5	gnd
	6	gnd
	7	gnd
	8	gnd
P	9	-5
9	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

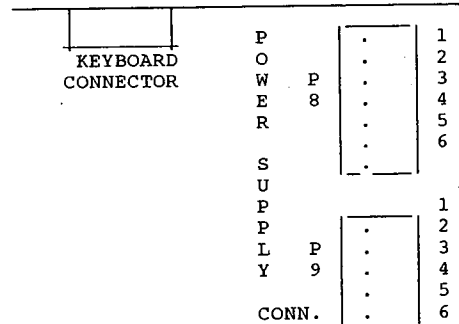
DISKETTE/DISK DRIVE VOLTAGE CHECKS

+4.8	+5.2	2	4
+11.5	+12.6	3	1

TOP OF DISKETTE DRIVE

1 2 3 4

BACK OF SYSTEM BOARD



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)

*pin 10 is not used in card
pin 11 is not used in card*

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 pins into female on card*

1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 13
14 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 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 0 0 0 0 0 1
6 0 0 0 0 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

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

IBM-AT		NEC
DB9	3510/3515	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	

IBM-XT		NEC
DB25	3510/3515	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 Equipment <--> Data Comm. 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 Equipment <--> Data Terminal 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	---	|
8	---	|
1	-----	1

----- 20

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

<i>Short</i>	<i>Long name</i>	<i>Format</i>	<i>Notes</i>
CUP	cursor position	ESC[y;xH	Sets cursor position.
HVP	cursor position	ESC[Y;XH	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;XH	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	

- The first char of the string gives the key to redefine; the rest of the string is the key's new value.
- To specify unprintable chars, give the ASCII value of the character out side of quotes, as a normal parameter.
- 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.

<i>Attrib code</i>	<i>Value</i>
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

<i>metastring</i>	<i>definition special characters</i>
\$B	the '|' character
\$G	the '' character
\$L	the '' character
\$Q	the '=' character
\$\$	the '\$' character
<i>System Information</i>	
\$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)
<i>Cursor Control</i>	
\$H	backspace & erasure of the previous character
\$ _	a carriage return and linefeed sequence (the prompt continues on the beginning of the next screen line).
<i>Other ASCII characters</i>	
\$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[u\$n\$g.

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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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-

tics 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

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Computer Bulletin Board Systems

Various computer bulletin board systems, including

Byte Information Exchange (BIX)

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GEnie IBM RT and Borland RT

GTNet international network

FIDO Net international network

PCanada BBS system, (Toronto, Canada)

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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.
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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]
DIAGNOSE	ARC	14336	1/01/86	memory error codes	possibly David Whitman?
					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.
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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
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DOSINT	ARC	4201	15/03/88	list of DOS 2.0 function calls	John Chapman
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DOSTIPS	ARC	28926	15/03/88	info on DOS	John Chapman
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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
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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
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MSLOOKUP	ARC	58368	25/12/87	interrupt and function listing	Frank Bonita
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PINS	ARC	3072	18/01/88	pinouts of various connectors	[no name]
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RAW_COOK	ARC	2048	15/10/87	info on DOS raw and cooked modes	[no name]
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CED10D		Chris Dunford		CED interrupt calls	
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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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