PC DOS 7 Technical Update

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Abstract

IBM PC DOS 7 has been designed for all types of users who need an efficient single tasking personal computer operating system. It incorporates many new utilities such as anti-virus software, comprehensive backup programs, PCMCIA support and DOS Pen extensions. Also incorporated are new features to enhance the available memory and disk space.

This book is a technical reference, upgraded from IBM DOS 5.02 and written for DOS programmers, who develop applications for IBM Personal Computers or compatible systems.

The program developer should be competent on the IBM Personal Computer and/or the Personal System/2 and should be familiar with DOS and at least one personal computer programming language.

(381 pages)

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Diskette Contents

At the back of this publication is a diskette which contains the online version of this book. The online book may be viewed with either the PC DOS 7 VIEW or the OS/2 VIEW program.

Preface

This book is written for programmers who develop applications for IBM Personal Computers and PC DOS 7.

The program developer should be competent on the IBM Personal Computer and/or the Personal System/2 and should be familiar with DOS and at least one personal computer programming language.

How This Document is Organized

The document is organized as follows:

- Chapter 1, "Introduction" provides details of the book and its usage.
- Chapter 2, "Accessing Disks" provides the necessary information and system architecture to access disks.
- Chapter 3, "Accessing Files with File Handles" gives information on reading, writing and managing files using file handles.
- Chapter 4, "Accessing Files Using File Control Blocks" gives information on reading, writing and managing files using file control blocks.
- Chapter 5, "Managing Device I/O" provides information on handling device input and output operations, for displays, keyboard and other devices.
- Chapter 6, "Controlling Processes" details the methods used to manage memory and control programs.
- Chapter 7, "Debugging a Program" describes the DEBUG utility program.
- Chapter 8, "Writing an Installable Device Driver" describes the information needed to write device drivers.
- Appendix A, "PC DOS 7 Interrupts" provides information to support the use of the PC DOS 7 interrupts.
- Appendix B, "PC DOS 7 Function Calls" details the INT 21H DOS function calls.
- Appendix C, "I/O Control for Devices (IOCtl)" describes how to set or get device information associated with open device handles.
- Appendix D, "Expanded Memory Support" shows the LIM functions supported by PC DOS 7.
- Appendix E, "DOS Protected Mode Services" describes the supported functions supported by PC DOS 7 DPMS driver.

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- Appendix F, “Task-swapping” details the functions found within the user-shell.
- Appendix G, “PC DOS 7 Viewer” overviews the creation of online viewable documents.
- Appendix H, “Miscellaneous Control Blocks” show some additional control blocks.

Related Publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this document.

- *PC DOS 7 Command Reference and Error Messages*, S83G-9309-00
- *PC DOS 7 Keyboard and Codepage Reference*, S83G-9310-00
- *PC DOS 7 REXX User's Guide and Reference*, S83g-9228-01
- *CID Enablement of DOS Local Area Networks*, SC31-6833
- *OS/2 Warp IPF Programming Guide*, G25H-7110-00
- *Everyday DOS*, ISBN 1-56529-363-0

International Technical Support Organization Publications

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Chapter 1. Introduction

This chapter provides information about this book, including the following:

- Organization of the book for quick information retrieval
- New and enhanced PC DOS 7 services
- Minimum hardware configuration.

This book is organized by logical application program development stages necessary to develop an application program on PC DOS 7.

In addition, the book tells how to make best use of the operating system by writing your own device driver or by using the system extensions.

Each chapter describes a particular subject. You do not need to read the entire book to create programs or solve problems. Key topics also can be found by referring to the index and the table of contents.

The appendixes contain reference information for quick retrieval. They contain the entire numerical list of PC DOS 7 services, including interrupts, function calls and device driver services.

What′s New for PC DOS 7

PC DOS 7 includes the following new features as well as enhancements to features in prior versions of PC DOS:

- The PC DOS Setup program includes enhancements that allow you to:
  - Use a mouse device during installation.
  - Use the DOSKey program immediately after installing DOS, because the DOSKEY command-line statement is now automatically added to your AUTOEXEC.BAT file.
  - View or edit the changes Setup made to your CONFIG.SYS and AUTOEXEC.BAT files prior to system restart. For example, if you use another command retrieval program other than DOSKEY, you can edit the AUTOEXEC.BAT file and delete this command-line statement before the Setup changes become effective.
  - Understand what changes were made to these system files by reviewing comment lines added by Setup. Comment lines describe what was added in these files or what was replaced, updated, or deleted if upgrading your version of DOS.

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See the installation information for a complete list of Setup enhancements.

- RAMBoost more effectively handles multiple configurations now. The most common questions asked about RAMBoost and RAMBoost Setup are now included in a tips and techniques section.
- The E Editor has the following enhancements for PC DOS 7: menu selection, mouse awareness, expanded sort capabilities, deleted record recovery, ability to change E Editor default settings (for color, tab and margin settings, window mode, and a new browse mode for the online F1 help.
- A new program, File Update, watches the files on up to two different two computers to help keep files synchronized (for example, when you work on one computer at home and one at work).
- A new documentation viewer, PC DOS Viewer, is used to read or search online books for PC DOS information. Three online books are included with PC DOS: a Command Reference, a REXX Reference, and Error Messages, which includes the more common error messages.

  This viewer also allows quick access to help for DOS commands, DOS device drivers, and DOS .INI files information. In addition you can get quick help for REXX commands or DOS error messages.
- The enhanced Advanced Power Management driver (POWER.EXE) has added power management events.
- Support is provided for certain docking device drivers. After typing either the DOSDOCK command for DOS or the DDPOPUP command for Windows, these drivers are dynamically loaded when PC DOS senses the appropriate docking devices.
- The amount of conventional memory required by PC DOS has been reduced, allowing more memory for your applications.
- The QCONFIG command now identifies and displays additional machines, adapters and planars.
- The BACKUP command, formally included in DOS versions prior to PC DOS 6, has been returned as a command provided with PC DOS 7.

New, Changed or Removed PC DOS Commands and Device Drivers

The following commands and device drivers are new for PC DOS 7:

ACALC	DPMS.EXE	REMOVDRV	STACHIGH.SYS
BROWSE	DYNALOAD	REPORT	STACKER
CHECK	FILEUP	RESIZE	STACWIN
CNFIGNAM	HCONVERT	REXX	SYSINFO

CONFIG	PASSWD	SCREATE.SYS	TUNER
CRC	PCM	SDEFRAG	UNCOMP
CREATE	PCMDINST	SDIR	UNPACK2
DCONVERT	PCMFDISK	SETUP (Stacker)	VIEW
DDPOPUP	PCMRMAN	SGROUP	XDF
DOSDATA	PCMSETUP	SSETUP	XDFCOPY
DOSDOCK	PCMWIN	STAC	

The following commands and device drivers are enhanced for PC DOS 7:

ANSI.SYS	DOSKEY	HIMEM.SYS	RAMBOOST
BUFFERS	E (E Editor)	INTERLNK	RAMBOOST.EXE
DEFRAG	EMM386.EXE	MSCDEX	RAMDRIVE.SYS
DISKCOPY	FIND	POWER	RAMSETUP
DISPLAY.SYS	HELP	QCONFIG	SETUP
			SMARTDRV.EXE

For further information about new or enhanced DOS commands and device drivers, type help followed by the name of the command or device driver. Note: You must add the extension of the device driver file. For example, you would type HELP ANSI.SYS to get online help about the ANSI.SYS device driver.

The following commands and device drivers are no longer provided with PC DOS 7:

- SuperStor/DS compression commands replaced by Stacker commands.
- PCMCIA Support commands replaced because of the new DOS and Windows full-screen installation interfaces.
- Commands no longer provided by PC DOS.
- Infrequently used commands that are not being provided as part of PC DOS 7:
  - If you have a previous version of DOS installed and are upgrading your system, these commands will not be removed during installation.
  - If you still want to use these commands and have no diskettes from previous versions of DOS, these commands will be provided through electronic delivery, such as bulletin board services.

    If you have a licensed copy of PC DOS 6.3, you are authorized to copy these commands to any system with a licensed copy PC DOS 7.

SuperStor/DS Commands No Longer Provided	PCMCIA Commands No Longer Provided	Removed Commands No Longer Provided	Files Not Provided
DBLSPACE.SYS	PCMFDD.EXE	EXPAND	4201.CPI
MOUNT	PCMINFO	MEUTOINI	4208.CPI
RTOOL	PCMMTD	RECOVER	COMP.COM
SSTOR	PCMMTD.EXE		EDLIN.EXE
SSUNCOMP	WPCMINFO.CPL		EPS.CPI
SSUTIL			EXE2BIN.EXE
UDEOFF			FASTOPEN.EXE
UDEON			GRAPHICS.COM
UNMOUNT			GRAPHICS.PRO
			PPDS.CPI
			PRINTER.SYS

New, Changed or Removed Optional Tools

The new features of, and enhancements to, the optional tools provided with PC DOS 7 include:

- REXX Language Support has been added as the PC DOS programming language tool of choice. REXX for DOS includes utilities and REXX commands that have been designed to work specifically with PC DOS.
- Stacker Compression is now the optional tool that provides data compression for your system. Stacker Compression allows you to:
  - Convert any existing SuperStor/DS, DoubleSpace, or DriveSpace compression during Stacker Setup.
  - Convert any standalone version of Stacker Compression you might already have installed.
  - Make menu selections using either the Stacker DOS Toolbox or the Stacker Windows Toolbox.
  - Use data on compressed diskettes even on a computer that does not have Stacker installed.
  - Guard your data because every time you start up your system Stacker runs AutoProtect to make sure your data is in good condition.
- PCMCIA Support now provides easier Setup procedures because of the new DOS and Windows full-screen interfaces included with PC DOS 7. The PCM.INI file is updated for you as you use the PCMCIA installation program to make selections for the type of PCMCIA support you want.
- Central Point Backup has been enhanced.
- Anti-virus protection provided with PC DOS (AntiVirus or IBM AntiVirus for Windows), has been updated to recognize and fix more viruses. If you are using IBM AntiVirus Services, a full-service, anti-virus protection

offering provided separately by IBM or if you have previously purchased the IBM AntiVirus/DOS product separately, you do not need to install the IBM AntiVirus/DOS optional tool provided with PC DOS. For more information about IBM AntiVirus Services, refer to the coupon provided in the PC DOS 7 coupon booklet.

- IBM DOS Shell is now named the PC DOS Shell.

New, Changed or Removed .INI Files

The following .INI files have been added, changed or are no longer required for PC DOS 7:

New	Changed	Removed
E.INI	RAMBOOST.INI	ADDSTOR.INI
PCM.INI		DBLSPACE.INI
RAMSETUP.INI		
STACKER.INI		

New, Changed or Removed Keyboard Layouts and Code Pages

The following keyboards and code pages have been added or changed for PC DOS 7:

```
452 keyboard
453 keyboard (provides the DIN 2137 German keyboard layout)
865 code page
912 code page
915 code page
```

```
The United Kingdom keyboard 168 has been removed.
```

Type

```
help keyb
```

to see a table that summarizes all the keyboard-layout and country code-page information.

Minimum Hardware Configuration

PC DOS 7 operates on all IBM or IBM-compatible computers with at least 512KB of conventional memory. As a minimum, you must have a computer that has a 1.44MB-capacity, 3.5-inch diskette drive or a 1.2MB-capacity, 5.25-inch diskette drive specified as drive A. Your hard drive should have a minimum of 6.0MB of free space to install only the DOS files and Central Point Backup** for DOS. 18.5MB of free space is needed if you want to install PC DOS plus all the optional tools.

Chapter 2. Accessing Disks

This chapter provides the necessary guide and system architecture information to help you successfully complete the following tasks:

- Accessing the disk
- Requesting drive and disk information
- Reading and writing data to the disk.

The Disk Format

All disks and diskettes formatted by PC DOS 7 are created with a sector size of 512 bytes. PC DOS 7 is formatted on a diskette or on a designated partition of a hard disk in the following order:

PC DOS 7 Component	Size
The boot record	1 sector
The first copy of the File Allocation Table (FAT)	Variable
The second copy of the FAT	Variable
The disk root directory	Variable
The data area	Variable

The Boot Record

The PC DOS 7 FORMAT command creates the boot record. For diskettes, the boot record resides on track 0, sector 1, side 0. For hard disks, it resides at the starting sector of the partition. Accessing any media (diskette or hard disk) that does not have a valid boot record causes an error message.

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The following diagram shows the layout of the DOS boot record, it is placed on all disks to provide an error message if the user trys to start the workstation with a non-system disk in drive A:. If the disk is a system disk the boot record points to the first address of the operating system.

00H	3 bytes	JUMP Instruction to Executable Code
03H	8 bytes	Optional OEM Name and Version
0BH	2 bytes	Bytes Per Sector
0DH	1 byte	Sectors Per Allocation Unit
0EH	2 bytes	Reserved Sectors (Starting at 0)
10H	1 byte	Number of File Allocation Tables
11H	1 byte	Number of Root Directory Entries
13H	2 bytes	Total Number of Sectors (if size is larger than 32MB, this value is 0 and the size is at offset 20H)
15H	1 byte	Media Descriptor
16H	2 byte	Number of Sectors Per FAT
18H	2 bytes	Sectors Per Track
1AH	2 bytes	Number of Heads
1CH	4 bytes	Number of Hidden Sectors
20H	4 bytes	Total Number of Sectors (See offset 13H)
24H	2 bytes	Physical Drive Number
26H	1 byte	Extended Boot Record Signature (29H)
27H	4 bytes	Volume Serial Number
2BH	11 bytes	Volume Label
36H	7 bytes	File System Identifier (FAT12),(FAT16)....

A boot record must be written on the first sector of all hard disks. A partition table is found at the end of the boot record. The table is constructed of 16 byte entires and containing information about the partitions start and end head, sector and cylinder positions. Also in the partition table is an boot indicator which is used to determine if the partition is bootable, in which case it is set to 80H. A system indicator byte is used to show the type of operating system that owns the partition. The following diagram shows the partition table structure and offsets:

Offset from start of Disk	Offset	Size	Description
1BEH	00H	1 byte	Boot Indicator
	01H	1 byte	Beginning Head
	02H	1 byte	Beginning Sector
	03H	1 byte	Beginning Cylinder
	04H	1 byte	System Indicator
	05H	1 byte	Ending Head
	06H	1 byte	Ending Sector
	07H	1 byte	Ending Cylinder
	08H	4 bytes	Relative Starting Sector
	0CH	4 bytes	Number of Sectors
1CEH	00H	1 byte	Boot Indicator
	01H	1 byte	Beginning Head
	02H	1 byte	Beginning Sector
	03H	1 byte	Beginning Cylinder
	04H	1 byte	System Indicator
	05H	1 byte	Ending Head
	06H	1 byte	Ending Sector
	07H	1 byte	Ending Cylinder
	08H	4 bytes	Relative Starting Sector
	0CH	4 bytes	Number of Sectors
1DEH	00H	1 byte	Boot Indicator
	01H	1 byte	Beginning Head
	02H	1 byte	Beginning Sector
	03H	1 byte	Beginning Cylinder
	04H	1 byte	System Indicator
	05H	1 byte	Ending Head
	06H	1 byte	Ending Sector
	07H	1 byte	Ending Cylinder
	08H	4 bytes	Relative Starting Sector
	0CH	4 bytes	Number of Sectors
1EEH	00H	1 byte	Boot Indicator
	01H	1 byte	Beginning Head
	02H	1 byte	Beginning Sector
	03H	1 byte	Beginning Cylinder
	04H	1 byte	System Indicator
	05H	1 byte	Ending Head
	06H	1 byte	Ending Sector
	07H	1 byte	Ending Cylinder
	08H	4 bytes	Relative Starting Sector
	0CH	4 bytes	Number of Sectors
1EFH		2 bytes	55AAH Signature

Figure 1. Partition Table

The Boot Indicator has a value of 80H if the particular partition is bootable or 00H if the partition is not bootable.

The last entry in the partition table is the 55AAH signature and is used to identify a valid boot record.

The following table show some of the system indicators that may be used:

00H	Unknown or no partition defined
01H	DOS 12 bit FAT (under 16MB)
04H	DOS 16 bit FAT (less than 65,536 sectors)
05H	Extended DOS partition
06H	DOS partition (over 32MB)
07H	OS/2 High Performance File System

Note

This table is by no means complete, as other manufactures use different indicators.

The File Allocation Table (FAT)

The File Allocation Table (FAT) occupies the sectors immediately following the boot record. If the FAT is larger than one sector, the sectors occupy consecutive sector numbers.

The FAT keeps track of the physical location of all files on the disk. If the FAT cannot be read because of a disk error, the contents of the files cannot be located. For this reason, two copies of the FAT are written on the disk.

PC DOS 7 uses the FAT to allocate disk space to a file, one cluster at a time. The FAT consists of a 12-bit entry (1.5 bytes) or a 16-bit entry (2 bytes) for each cluster on the disk. On a hard disk, the number of sectors for each cluster are determined by the size of the disk. PC DOS 7 determines whether to create a 12-bit or 16-bit FAT by calculating the number of 8-sector clusters that can occupy the space on the disk. If the number of clusters is less than 4086, a 12-bit FAT is created. If it is greater, a 16-bit FAT is created.

Using the following formula, you can determine the number of sectors on a disk:

TS=SPT * H * C.

TS = the total number of sectors on the disk.
SPT = the number of sectors per track or per cylinder.
H = the number of heads.
C = the number of cylinders.

The number of sectors on a 10MB IBM hard disk, for example, is 20740 (17 * 4 * 305).

The first two entries in the FAT are not used to map data. They indicate the size and format of the disk. The first byte of the FAT designates one of the following:

Hex Value	Meaning
FF	Double-sided, 8 sectors per track diskette
FE	Single-sided, 8 sectors per track diskette
FD	Double-sided, 9 sectors per track diskette
FC	Single-sided, 9 sectors per track diskette
F9	Double-sided, 15 sectors per track diskette (1.2 MB)
F9	Double-sided, 9 sectors per track diskette (720 KB)
F9	Double-sided, eXtended Data Format (1.88 MB)
F8	Hard disk
F0	1.44MB or 2.88MB

The second and third bytes of the FAT contain the value FFH. The fourth byte, used by 16-bit FATs only, contains the value FFH.

The maximum size 16-bit FAT supported by PC DOS 7 for media greater than 32KB is 64KB entries, or 128KB of space on the disk. This is an increase in size from the IBM PC DOS 3.30 limit of 16KB entries.

The Disk Directory

When the FORMAT command is issued, it builds the root directory for all disks. If the disk is formatted with the /S option, the PC DOS 7 system files (IBMBIO.COM, IBMDOS.COM, and COMMAND.COM) are added to the disk. The following eight formats are used for 5.25-inch diskettes and 3.5-inch diskettes:

Sides	Sectors/ Track	FAT Size Sectors	DIR Sectors	DIR Entries	Sectors/ Cluster
1 (5.25)	8	1	4	64	1
2 (5.25)	8	1	7	112	2
1 (5.25)	9	2	4	64	1
2 (5.25)	9	2	7	112	2
2 (5.25)	15	7	14	224	1

Sides	Sectors/ Track	FAT Size Sectors	DIR Sectors	DIR Entries	Sectors/ Cluster
2 (3.5)	9	3	7	112	2
2 (3.5)	18	9	14	224	1
2 (3.5)	36	9	15	240	2

The Data Area

Data files and subdirectories are stored in the last and largest part of a disk. Space is allocated as it is needed, a cluster at a time. This allocation method permits the most efficient use of disk space. As clusters become available, space can be allocated for new files.

Accessing the Disk

Most interrupt 21H functions can be used to access a disk. Five other functions can be used to perform disk-related activity.

Activity	Function Number
Resetting the disk and flushing the file buffer	0DH
Selecting the default disk drive	0EH
Determine the current disk	19H
Determining the boot drive	3305H
Requesting the amount of free space on the disk	36H

Requesting Drive and Disk Information

Information on disks and drives can be requested by using the following INT 21H functions:

Activity	Function Number
Requesting the current drive number	19H
Requesting disk allocation information about the default drive	1BH
Requesting disk allocation information about the specified drive	1CH

Reading and Writing Data Directly to the Disk

PC DOS 7 provides two interrupts, 25H and 26H, to read and write data to a disk.

Activity	**Interrupt Number**
Reading from specified disk sectors	25H
Writing to specified disk sectors	26H

Chapter 3. Accessing Files with File Handles

The information necessary to complete the following tasks is provided in this chapter:

- Reading and writing data to a file
- Requesting and specifying file attributes
- Accessing directories
- Searching for files in directories
- Requesting and specifying National Language Support (NLS)
- Controlling Network Operations.

PC DOS 7 provides nine functions within interrupt 21H to create, open, close and delete a file.

Activity	**Function Number**
Creating a new file or replacing an old file	3CH
Opening a file	3DH
Closing a file handle	3EH
Deleting a file	41H
Renaming a file	56H
Creating a new file with a unique name	5AH
Creating a new file	5BH
Locking and unlocking read/write access to regions of a file	5CH
Creating and opening a file with extended parameters	6CH

Filenames

To name a file, the application program supplies a pointer to an ASCIIZ string giving the name and location of the file. A filename contains an optional drive letter, path, or file specification terminated with a hexadecimal 0 byte. Following is an example of a filename string:

```
'B:\LEVEL1\LEVEL2\FILE1',0
```

The maximum size of a filename is 64 bytes, including the path, name and null terminator. All function calls that accept path names accept a forward slash (/) or backslash (\) as path separator characters.

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File Handles

The open or create function calls return a 16-bit value called a *file handle*. To perform file I/O, a program uses the file handle to reference the file. Once a file is opened, the program no longer needs to maintain the ASCIIZ string pointing to the file. PC DOS 7 keeps track of the location of the file, regardless of which directory is current.

Activity	Function Number
Specifying an additional file handle for a file	45H
Pointing the existing file handle to another file	46H
Specifying the number of open file handles	67H

The number of file handles that can be open at one time by all processes can be specified with the FILES command in CONFIG.SYS. There are 20 default handles available to a single process. All handles inherited by a process can be redirected.

Each open handle is associated with a single file or device, but several handles can reference the same file or device. Thus, the maximum handle limit can exceed the number specified with the FILES command.

Special File Handles

PC DOS 7 provides five special file handles for use by application programs. The handles are:

0000H Standard input device (STDIN)

0001H Standard output device (STDOUT)

0002H Standard error device (STDERR)

0003H Standard auxiliary device (STDAUX)

0004H Standard printer device (STDPRN)

File handles associated with standard devices do not need to be opened by a program, but a program can close them. STDIN should be treated as a read-only file. STDOUT and STDERR should be treated as write-only files. STDIN and STDOUT can be redirected. Function calls 01H through 0CH access the standard devices.

The standard device handles are useful for performing I/O to and from the console device. For example, you can read input from the keyboard using the read function call (3FH) and file handle 0000H (STDIN); you can also write output to the console screen with the write function call (40H) and file handle 0001H (STDOUT).

If you want to prevent redirection of your output to STDOUT, you can send it using file handle 0002H (STDERR). This facility also is useful for error messages or prompts to the user.

Reading and Writing Data to a File

PC DOS 7 provides five functions to allow reading and writing to a file or device, specifying the offset within a file at which the read or write is to occur, and verifying the read-after-write state. The verification operation, however, slows performance.

Activity	Function Number
Reading from a file or device	3FH
Writing to a file or device	40H
Specifying the address (through the pointer) at which a read or write is to occur	42H
Requesting the read-after-write state	54H
Specifying the read-after-write state	2EH

Requesting and Specifying File Attributes

While a file is being created, your program can specify certain attributes; for example, the date and time of creation and level of access.

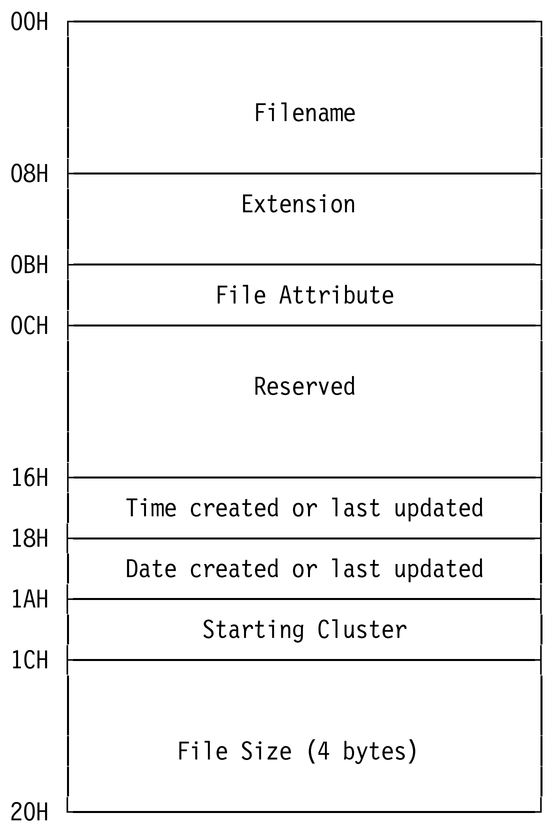
Activity	Function Number
Requesting and specifying a file′s attributes	43H
Requesting and specifying a file′s date and time	57H

Accessing Subdirectories

Subdirectories, that is, directories other than the root directories, are files. There is no limit to the number of subdirectory entries if the physical media can accommodate them. All directory entries are 32 bytes long.

Note: Values are in hexadecimal.

Each entry in the root directory consists of 32 bytes that are described in the figure following:



The Filename

Bytes 0 through 7 represent the filename. The first byte of the filename indicates the status of the filename. The status of a filename can contain the following values:

00H Filename never used. To improve performance, this value is used to limit the length of directory searches.

05H The first character of the filename has an E5H character.

E5H Filename has been used, but the file has been erased.

2EH The 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. (Cluster number 0000H is specified if the parent directory is the root directory.)

Any other character is the first character of a filename.

Note: Byte offsets are in decimal.

.

The Filename Extension

Bytes 8 through 10 indicate the filename extension.

The File Attribute

Byte 11 indicates the file's attribute. The attribute byte is mapped as follows:

01H Indicates a read-only file. An attempt to open the file for output using function call 3DH or 6CH results in an error code being returned.

02H Indicates a hidden file. The file is excluded from normal directory searches.

04H Indicates a system file. The file is excluded from normal directory searches.

08H Indicates the entry contains the volume label in the first 11 bytes. The entry contains no other usable information and may exist only in the root directory.

10H Indicates the entry defines a subdirectory and is excluded from normal directory searches.

20H Indicates an archive bit. The bit is set ON when the file has been written to and closed. It is used by the BACKUP and RESTORE commands for determining whether the file has been changed since it was created or last updated. This bit can be used along with other attribute bits.

All other bits are reserved and must be 0.

The File Creation/Last Changed Time

Bytes 22 and 23 contain the time when the file was created or last updated. The time is mapped in the bits as follows:

```
<         23          > <          22          >
15 14 13 12 11 10 9  8  7  6  5  4  3  2  1  0
h  h  h  h  h  m  m  m  m  m  m  x  x  x  x  x
```

Where:

hh = the binary number of hours (0-23)
mm = the binary number of minutes (0-59)
xx = the binary number of two-second increments

The time is stored with the least significant byte first.

The File Creation Date

Bytes 24 and 25 contain the date when the file was created or last updated. The date (*mm/dd/yy*) is mapped in the bits as follows:

```
<          25           > <            24         >
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:

yy = 0–119 (1980–2099)
mm = 1–12
dd = 1–31

The date is stored with the least significant byte first.

The Starting Cluster Number

Bytes 26 and 27 contain the cluster number of the first cluster in the file. The first cluster for data space on all hard disks and diskettes is cluster 002. The cluster number is stored with the least significant byte first.

```
<          27           > <            26         >
 0  0  0  0  0  0 0  0  0  0  1  0  0  0  0  1
```

The File Size

Bytes 28 through 31 contain 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.

Accessing Directories

PC DOS 7 provides four functions within interrupt 21H to create, identify, change or delete directories.

Activity	Function Number
Removing a subdirectory	3AH
Creating a subdirectory	39H
Changing to another directory	3BH
Identifying the current directory	47H

Finding Files in Directories

PC DOS 7 provides two functions within interrupt 21H to search for the first matching entry and the next matching entry.

Activity	**Function Number**
Searching for the first matching entry	4EH
Searching for the next matching entry	4FH

Requesting and Specifying National Language Support (NLS)

PC DOS 7 provides the following functions for NLS:

Activity	**Function Number**
Specifying the current country	38H
Requesting the country dependent information	38H
Providing double-byte character set (DBCS) support	65H

Controlling Network Operations

Several PC DOS 7 function calls accept a network path as input if the IBM PC Local Area Network support is loaded. If network access is available, further information is noted in the ″Comments″ section under each relevant function call in Appendix B, "PC DOS 7 Function Calls" on page 133.

A network path consists of an ASCII string containing a computer name,a directory path, and an optional filename. The network path cannot contain a drive specifier. The path is terminated by a byte of binary 0′s. Following is an example:

```
SERVER1LEVEL1LEVEL2FILE1
```

Many function calls that accept an ASCIIZ string as input accept a network path. If you want to execute function 5BH (Create a New File), for example, you must have Read/Write/Create or Write/Create access to the directory to be able to create a file. If you have Read Only or Write Only access and no Create access, you cannot create a file in the directory. Two function calls that do not accept a network path as input are Change Current Directory (3BH) and Find First Matching File (4EH).

The following function calls are available to control network operations:

Activity	Function Number
Locking and unlocking read/write access to a region of a file	5CH
Writing all data from a file to a device	68H
Requesting the local computer ID	5E00H
Specifying the printer setup string	5E02H
Requesting the printer setup string	5E03H
Requesting redirection	5F02H
Attaching to a redirect device	5F03H
Canceling redirection	5F04H

Chapter 4. Accessing Files Using File Control Blocks

This chapter provides guide and system architecture information to assist in performing the following tasks:

- Accessing files
- Accessing sequential records
- Accessing random records
- Finding files in directories

The File Control Block (FCB)

With few exceptions, a program should maintain files using File Control Blocks (FCBs) only to run under DOS 1.10. File handles are the recommended method for accessing files.

One FCB maintained by your program and PC DOS 7 is required for each open file. Your program must supply a pointer to the FCB and fill in the appropriate fields required by specific function calls.

A program should not attempt to use the reserved fields in the FCB. Bytes 0 through 15 and 32 through 36 must be set by the user program. Bytes 16 through 31 are set by PC DOS 7 and must not be changed by user programs.

An unopened FCB consists of the FCB prefix (if used), the drive number, the filename, and the extensions appropriately specified. An open FCB is one in which the remaining fields have been specified by the create or open function calls.

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. Figure 2 on page 24 gives further explanation.

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```
 -7  ┌─────────┬───────────────────────────────────────┬─────────┐
     │         │                                       │         │ FCB
     │ hex FF  │                Zeros                  │Attribute│ extension
 0 ┌─┴─────────┼───────────────────────────────────────┴─────────┤
   │           │                                                 │ Standard
   │   Drive   │  Filename (8bytes) or reserved device name      │ FCB
 8 ├───────────┼─────────────────────────┬────────────┬──────────┤
   │           │                         │            │          │
   │           │   Filename extension    │Current block│Record size│
16 ├───────────┴─────┬───────────────────┼────────────┼──────────┤
   │   File size     │    File size      │            │          │
   │   (low part)    │   (high part)     │    Date    │          │
24 ├─────────────────┴───────────────────┴────────────┘          │
   │                                                             │
   │                 Reserved for system use                     │
32 ├───────────┬─────────────────┬─────────────────┬─────────────┘
   │Current    │ Random record   │Random record    │
   │record     │number (low pt)  │number(high pt)  │
   └───────────┴─────────────────┴─────────────────┘
```

Figure 2. The File Control Block

Areas 16 through to 31 are filled in by DOS and must not be modified.

Other areas are filled in by the using program.

Note: Offsets are in decimal.

The FCB is formatted as follows:

Drive Number

Byte 0 represents the drive number. For example, before the file is opened, 0 equals the default drive, 1 equals drive A, and 2 equals drive B. After the file is opened, 0 equals drive A, 1 equals drive A, and 2 equals drive B.

The actual drive number replaces the 0 when a file is opened.

Filename

Bytes 1 through 8 represent the filename, left-justified with trailing blanks. If a reserved device name such as LPT1 is specified here, do not include the colon.

Filename Extension

Bytes 9 through 11 represent the filename extension, left-justified with trailing blanks or all blanks.

Current Block Number

Bytes 12 through 13 represent the current block number relative to the beginning of the file, starting with 0. The 0 is set by the open function call. A block consists of 128 records, each size specified in the logical record size field. The current block number is used with the current record field for sequential reads and writes.

Logical Record Size

Bytes 14 through 15 represent the logical record size in bytes. 80H is set by the open function call. If you want to change the logical record size from 80H, you can reset the value. PC DOS 7 uses the value to determine locations in the file for all disk reads and writes.

File Size

Bytes 16 through 19 represent file size in bytes. In this two-word field, the first word is the low-order part of the size.

File Date

Bytes 20 through 21 represent the date the file was created or last updated. The date (*mm/dd/yy*) is mapped in the bits as follows:

```
<           21          > <           20           >
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:

yy is 0-119 (1980-2099)
mm is 1-12
dd is 1-31

Reserved

Bytes 22 through 31 are reserved.

Record Number in Block

Byte 32 represents the current relative record number (0-127) within the current block. You must set this field before doing sequential read and write operations to the diskette. This field is not initialized by the open function call.

Record Number within File

Bytes 33 through 36 represent the record number relative to the beginning of the file, starting with 0. You must set this field before doing random read and write operations to the diskette. This field is not initialized by the open function call.

If the record size is less than 64 bytes, both words are used. If the record size is more than 64 bytes, only the first 3 bytes are used. Note that if you use the FCB at 5CH in the program segment, the last byte of the FCB overlaps the first byte of the unformatted parameter area.

The Extended FCB

The extended FCB is used to create or search in the disk directory for files with special attributes. The extension adds a 7-byte prefix to the FCB, formatted as follows:

Extended FCB

FCB byte -7 contains FFH to indicate an extended FCB.

Reserved

FCB bytes -6 to -2 are reserved.

File Attribute

FCB byte -1 represents an attribute byte. Function calls 00H through 2EH are valid for both the standard FCB and the 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.

The Disk Transfer Area (DTA)

PC DOS 7 uses a buffer in memory, the Disk Transfer Area (DTA), to hold the data for FCB file reads and writes. The DTA can be at any location within the data area of your program and should be specified by your program.

Only one DTA can be in effect at a time, so your program must tell PC DOS 7 which memory location to use before issuing disk read or write functions. When a program is given control by COMMAND.COM, a default DTA large enough to hold 128 bytes is established at 80H in the program segment prefix.

PC DOS 7 provides the following functions within interrupt 21H to handle DTA activities:

Activity	Function Number
Specifying the buffer address for reading and writing data in the DTA	1AH
Requesting the buffer address for reading and writing data in the DTA	2FH

Accessing Files

An FCB can identify a file on any valid drive, but only in the current directory of the specified drive.

If SHARE has not been loaded, the number of files that can be open at a time (using FCB function calls) is not restricted. When file sharing is loaded, however, the maximum number of FCB opened files is limited by the value specified in the FCBS command in CONFIG.SYS. The *m* value specifies the total number of files that can be opened by FCBS.

When the maximum number of FCB opens is exceeded, PC DOS 7 automatically closes the least recently used file. Any attempt to access such a file results in the interrupt 24H critical error message, "FCB not available." If this situation occurs while a program is running, the value specified for *m* in the FCBS command should be increased.

Do not use the same FCB to open a second file without closing the first open file. If more than one file is to be opened concurrently, use separate FCBs. To avoid potential file sharing problems, close files after I/O is performed. Close the file before trying to delete or rename an open file.

Managing files using the FCBS command can be performed using the following function calls:

Activity	Function Number
Opening a file	0FH
Closing a file	10H
Deleting a file	13H
Creating a file	16H
Renaming a file	17H
Requesting the file size	23H
Separating the filename information into its components (parsing)	29H

Accessing Sequential Records

By using the current block, current record, and record length fields of the FCB, you can perform sequential I/O by using the following sequential read or write function calls within interrupt 21H:

Activity	Function Number
Reading from a record	14H
Writing to a record	15H

Accessing Random Records

Random I/O can be performed by filling in the random record and record length fields in the FCB and issuing the following function calls within interrupt 21H:

Activity	Function Number
Reading from a single record	21H
Writing to a single record	22H
Specifying the random record field in the FCB	24H
Reading from multiple records	27H
Writing to multiple records	28H

Finding Files in Directories

Using the FCB as a source, finding and changing files in directories is performed by the following functions within interrupt 21H:

Activity	Function Number
Searching for the first matching file entry	11H
Searching for the next matching file entry	12H
Deleting a file	13H
Creating a file	16H
Renaming a file	17H
Separating the filename information into its components (parsing)	29H

Chapter 5. Managing Device I/O

This chapter provides guide and system architecture information about the following tasks:

- Managing display I/O
- Managing keyboard I/O
- Managing miscellaneous I/O
- Managing file system activities
- Accessing the system device drivers′ control channel.

Managing Display I/O

PC DOS 7 provides four functions within interrupt 21H that send characters or strings of characters to the screen.

Activity	Function Number
Outputting a character to the screen, with the ability to trigger the control-break interrupt handler	02H
Waiting until a character is input and outputting it to the screen without the ability to trigger the control-break interrupt handler	06H
Outputting a string of characters in memory to the screen	09H
Outputting a string of characters in a buffer to the screen or writing the string to a file device	40H

For further information on specifying character attributes, foreground and background screen colors, and screen size using ANSI.SYS, see the *PC DOS 7 User′s Guide and Reference.*

Managing Keyboard I/O

PC DOS 7 provides a full complement of functions within interrupt 21H that your application program can use to manage keyboard I/O.

Activity	Function Number
Sending input from the keyboard (with echo) to the display	01H
Receiving input directly from the keyboard, or sending output directly to the display	06H
Receiving input directly from the keyboard without echo	07H

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Activity	Function Number
Receiving input from the keyboard without echo to the display with the ability to trigger the control-break interrupt handler	08H
Reading characters from the keyboard to the buffer	0AH
Checking the keyboard buffer status	0BH
Clearing the keyboard buffer; specifying which function to call after clearing the buffer	0CH

For further information on reassigning the keys using ANSI.SYS, see the *PC DOS 7 User's Guide and Reference*.

Managing Miscellaneous I/O

Three functions are available to manage miscellaneous I/O.

Activity	Function Number
Receiving auxiliary input	03H
Sending auxiliary output	04H
Printing output	05H

Managing File System Activities

The following system activities are supported by PC DOS 7:

Activity	Function Number
Requesting the local computer ID	5E00H
Specifying the printer setup string	5E02H
Requesting the printer setup string	5E03H
Requesting redirection list	5F02H
Attaching to a redirect device	5F03H
Canceling redirection	5F04H
Writing all data from a file to a device	68H

Accessing the System Device Drivers′ Control Channel

Function 44H within interrupt 21H is a multi-purpose function for accessing the device drivers′ control channel. Using function 44H, your application program can request the status of a device and read and write to the I/O control channel. The following subfunction values should be passed in AL:

Category	Activity	Subfunction Number
Requesting and specifying device information	Requesting device information	00H
	Specifying device information	01H
Reading and writing data to a character device	Reading from a character device	02H
	Writing to a character device	03H
Reading and writing data to a block device	Reading from a block device	04H
	Writing to a block device	05H
Requesting and specifying device information	Determining whether a device contains removable media	08H
Providing network support for devices	Determining whether a logical device is local or remote	09H
	Determining whether a file handle is local or remote	0AH
	Specifying how many times (and intervals) PC DOS 7 should try to resolve shared file conflicts	0BH
	Controlling I/O for file handles	0CH
	Controlling I/O for block devices	0DH
Requesting and specifying the logical drive	Requesting the logical drive	0EH
	Specifying the logical drive	0FH

Reading and Writing Data in Binary and ASCII Modes

A program can use function 44H to change the mode in which data is read or written to a device. If I/O is performed in binary mode, control values have no meaning. If I/O is performed in ASCII mode, certain control values have meaning. They are shown in the following table:

Control Value	**Keyboard Input**	**Meaning**
03H	^C	Control Break
04H	^D	End of Task
10H	^P	Print Screen
11H	^Q	Scroll restart
13H	^S	Scroll Lock
0AH	^J	Line Feed
0DH	^M	Carriage Return
1AH	^Z	End-Of-File

When a file is read in ASCII mode, it is echoed to the display and tabs are expanded into spaces. They are left as a tab byte (09H) in the input buffer. When a file is written in ASCII mode, tabs are expanded to 8-character boundaries and filled with spaces (20H).

Chapter 6. Controlling Processes

This chapter provides guide and system architecture information about the following activities:

- Allocating memory
- Identifying a program at load time
- Loading and executing overlays
- Terminating a program/subprogram
- Loading an overlay without executing it
- Calling a command processor
- Responding to errors
- Responding to a control-break action
- Requesting and specifying the system date and time
- Requesting and specifying the interrupt vectors.

Allocating Memory

PC DOS 7 keeps track of allocated and available memory blocks and provides three function calls for application programs to communicate their memory requests.

Activity	Function Number
Allocating memory	48H
Freeing allocated memory	49H
Changing the size of blocks of allocated memory	4AH

PC DOS 7 Memory Management

PC DOS 7 manages memory by allocating 16-byte units called *paragraphs* and building a *control block* for each allocated block. Any allocation is 16 bytes larger than the actual request because PC DOS 7 automatically allocates a control block to keep track of each allocated block.

When the user starts the program at the command line, COMMAND.COM loads the executable program module into the largest unused block of available memory and reads the file header. If there is not enough memory available, the system returns an error code and passes control to the program. Your program should use the SETBLOCK function call (4AH) to reduce allocated memory to the size it needs.

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Note: Because it is likely that the default stack supplied by PC DOS 7 lies in the area of memory being freed, a .COM program should remember to set up its own stack before issuing a SETBLOCK. The SETBLOCK call frees unneeded memory which then can be used for loading subsequent programs.

If your program requires additional memory during processing, issue function call 48H within interrupt 21. To free memory, issue function call 49H within interrupt 21.

The PC DOS 7 Memory Map

The following table illustrates the order in which PC DOS 7 components and application programs are located in memory when PC DOS 7 is loaded low and no HMA exists.

Location	Use
0000:0000	Interrupt vector table
0040:0000	ROM communication area
0050:0000	PC DOS 7 communication area
0070:0000	IBMBIO.COM – PC DOS 7 interface to ROM I/O routines
XXXX:0000	IBMDOS.COM – PC DOS 7 interrupt handlers, service routines (INT 21 functions)
XXXX:0000	PC DOS 7 buffers, control areas, and installed device drivers
XXXX:0000	Resident portion of COMMAND.COM – Interrupt handlers for interrupts 22H (terminate), 23H (Ctrl-Break), 24H (critical error), and code to reload the transient portion
XXXX:0000	External command or utility – .COM or .EXE file
XXXX:0000	User stack for .COM files
XXXX:0000	Transient portion of COMMAND.COM

The following table illustrates the order in which the PC DOS 7 components and application programs are located in memory when PC DOS 7 is loaded high.

Location	Use
0000:0000	Interrupt vector table
0040:0000	ROM communication area
0050:0000	PC DOS 7 communication area
0070:0000	Resident BIOS data – also including device driver headers and entry points
XXXX:0000	PC DOS 7 data

Location	Use
XXXX:0000	PC DOS 7 installable device drivers and data structures that are allocated by SYSINIT
FFFF:0010	VDISK header (see note below)
FFFF:0030	IBMBIO
XXXX:XXXX	IBMDOS

Memory map addresses are in segment:offset format. For example, 0070:0000 is absolute address 00700H.

Note: The VDISK header is placed at the start of the HMA as a precaution because most INT 15 allocations respect VDISK headers.

The PC DOS 7 Communication Area is used as follows:

0050:0000 Print screen status flag store

- 0 Print screen not active or successful print screen operation
- 1 Print screen in progress
- 255 Error encountered during print screen operation

0050:0001 Used by BASICA

0050:0004 Single-drive mode status byte

- 0 Diskette for drive A was last used
- 1 Diskette for drive B was last used

0050:0010—0021 Used by BASICA

0050:0022—002F Used by PC DOS 7 for diskette initialization

0050:0030—0033 Used by MODE command.

All other locations within the 256 bytes beginning at 0050:0000 are reserved for PC DOS 7 use.

Identifying a Program at Load Time

PC DOS 7 provides two function calls for application programs to specify and identify themselves at load time:

Activity	**Function Number**
Creating the means for PC DOS 7 to identify a program at load time through the program segment prefix (PSP)	26H
Requesting how PC DOS 7 identified a program at load time	62H

The Program Segment

When you enter an external command or call a program with the EXEC function call (4BH), PC DOS 7 determines the lowest available address in memory and assigns it to the program. That area of memory is called the *program segment*. At offset 0 within the program segment, PC DOS 7 builds a *program segment prefix* control block. When an EXEC is issued, PC DOS 7 loads the program at offset 100H and gives it control. See Figure 3 on page 37 for an illustration of the program segment prefix.

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td colspan="2">INT
20H</td><td colspan="2">Top of
memory</td><td colspan="4">Reserved</td></tr>
<tr><td>8</td><td>9</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td></tr>
<tr><td colspan="2">Reserved</td><td colspan="2">Terminate
address
IP</td><td colspan="2">Terminate
address
CS</td><td colspan="2">Ctrl-break
exit address
IP</td></tr>
<tr><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td></tr>
<tr><td colspan="2">Ctrl-break
exit address
CS</td><td colspan="4">Critical error
exit address
IP CS</td><td colspan="2">Reserved</td></tr>
<tr><td colspan="4">18 to 2B</td><td>2C</td><td>2D</td><td>2E</td><td>2F</td></tr>
<tr><td colspan="4">Reserved</td><td colspan="2">Environment
pointer</td><td colspan="2">Reserved</td></tr>
<tr><td colspan="8">30 to 4F</td></tr>
<tr><td colspan="8">Reserved</td></tr>
<tr><td>50</td><td>51</td><td>52</td><td>53</td><td>54</td><td>55</td><td>56</td><td>57</td></tr>
<tr><td colspan="2">DOS call</td><td colspan="6">Reserved</td></tr>
<tr><td>58</td><td>59</td><td>5A</td><td>5B</td><td>5C</td><td>5D</td><td>5E</td><td>5F</td></tr>
<tr><td colspan="4">Reserved</td><td colspan="4">Unopened Standard FCB1</td></tr>
<tr><td>60</td><td>61</td><td>62</td><td>63</td><td>64</td><td>65</td><td>66</td><td>67</td></tr>
<tr><td colspan="8">Unopened Standard FCB1 (continued)</td></tr>
<tr><td>68</td><td>69</td><td>6A</td><td>6B</td><td>6C</td><td>6D</td><td>6E</td><td>6F</td></tr>
<tr><td colspan="4">Unopened Standard FCB1
(continued)</td><td colspan="4">Unopened Standard FCB2</td></tr>
<tr><td>70</td><td>71</td><td>72</td><td>73</td><td>74</td><td>75</td><td>76</td><td>77</td></tr>
<tr><td colspan="8">Unopened Standard FCB2 (continued)</td></tr>
<tr><td>78</td><td>79</td><td>7A</td><td>7B</td><td>7C</td><td>7D</td><td>7E</td><td>7F</td></tr>
<tr><td colspan="8">Unopened Standard FCB2 (continued)</td></tr>
<tr><td>80</td><td>81</td><td>82</td><td>83</td><td>84</td><td>85</td><td>86</td><td>87</td></tr>
<tr><td>Param
Length</td><td colspan="7">Command parameters
starting with leading blanks</td></tr>
<tr><td>F8</td><td>F9</td><td>FA</td><td>FB</td><td>FC</td><td>FD</td><td>FE</td><td>FF</td></tr>
<tr><td colspan="8">Command parameters</td></tr>
</table>

Figure 3. The Program Segment Prefix

The program segment prefix′s first segment of available memory is in paragraph form; that is, 1000H represents 64KB. The word at offset 6 contains the number of bytes available in the segment.

Offset 2CH contains the environment′s paragraph address.

Offset 50H contains code to invoke the PC DOS 7 function dispatcher. By placing the desired function number in AH, a program can issue a long call to PSP+50H to invoke a PC DOS 7 function rather than issuing an interrupt 21H.

The default disk transfer address is set to 80H.

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 .COM files, offset 6 (one word) contains the number of bytes available in the segment.

Register AX contains the drive specifiers entered with the first two parameters as follows:

AL=FFH if the first parameter contained an invalid drive specifier (otherwise AL=00H).
AH=FFH if the second parameter contained an invalid drive specifier (otherwise AH=00H).

In .EXE programs DS and ES registers are set to point to the program segment and CS, IP, SS, and SP registers are set to the values passed by the Linker.

In .COM programs all four segment registers contain the segment address of the initial allocation block, starting with the program segment prefix control block. The instruction pointer (IP) is set to 100H. 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.

Loading and Executing Overlays

Your program can use the 4BH function call to load optional overlays. Function 4BH, value 0, loads and executes a program with overlays. Function 4BH, value 3, loads an overlay without executing it.

If your program calls an overlay, the EXEC call assumes the calling program has already allocated memory for the overlay. The request to load an overlay does not verify that the calling program owns the memory into which the overlay is to be loaded. An overlay loaded into memory not allocated to it can damage the PC DOS 7 memory management control blocks. This will not be evident until PC DOS 7 needs to use its series of control blocks.

If a memory allocation error is returned, the problem must be corrected and the system restarted. Overlays should not issue SETBLOCK calls because they do not own the memory in which they operate. The memory is controlled by the calling program.

The Parameter Block

When your program calls a subprogram using the EXEC call (4BH), it can pass a parameter block which provides the subprogram with the following:

- The environment string
- A command line which permits it to act like another command processor
- File control blocks at 5C and 6C in the program segment prefix (optional).

The Environment String

The environment passed from the calling program is a copy of its environment. The segment address of the passed environment is contained at offset 2CH in the program segment prefix.

The environment is a series of ASCII strings totaling less than 32KB in the form:

NAME=parameter

Note: NAME= is always in uppercase.

Each string is terminated by a byte of 0′s. The complete series of strings is terminated by another byte of 0′s. Another ASCII string containing the word count and an ASCIIZ string containing the executable program′s drive, path, filename, and extension follow the series of environment strings.

The environment built by the command processor and passed to all called programs contains a COMSPEC= *string*, the last PATH, APPEND and

PROMPT commands issued, and any environment strings specified with the SET command.

The Command Line

Your program must create a command line which will be transferred to the subprogram.

The File Control Blocks

If your program is using files based on file handles, the file control blocks are of no concern. If your program is using file control blocks, and either 5CH or 6CH contain a pathname, the corresponding FCB will contain only a valid drive number. The filename field will not be valid.

Terminating a Program/Subprogram

PC DOS 7 provides four functions and two interrupts to terminate programs. It also provides an interrupt to permit your program to specify where control is to be passed upon termination.

Activity	Function Number
Terminating a program	00H
Terminating a program with a specified portion remaining in memory	31H
Terminating a program and passing control to the calling process	4CH
Determining how a process ended	4DH

Interrupt 20H terminates a program. Interrupt 27H terminates a program with a specified portion remaining in memory. Interrupt 22H specifies where control is to be passed upon program termination.

When a subprogram terminates, control is returned to the calling program. Before terminating, the calling program must return to the system the memory it allocated to the subprogram. When the calling program terminates, control is returned to PC DOS 7. PC DOS 7 does a CHECKSUM to determine if the transient portion of COMMAND.COM has been modified. If it has, PC DOS 7 reloads COMMAND.COM based on the path specified in the environment.

The program returns from executing in one of the following methods:

- By a jump to offset 0 in the program segment prefix
- By issuing an INT 20H
- By issuing an INT 21H with register AH=00H or 4CH

- By calling location 50H in the program segment prefix with AH=00H or 4CH.

Using INT 21H is the preferred method. All programs must ensure that the CS register contains the segment address of the program segment prefix when terminating using any of the preceding methods except call 4CH.

All of the preceding methods return control to the program that issued the EXEC. During the process, interrupt vectors 22H, 23H, and 24H (terminate, Ctrl-Break, and critical error exit addresses) are restored from the values saved in the program segment prefix of the terminating program. Control is then given to the terminating address.

Loading an Overlay without Executing It

If AL=3 is specified within function call 4BH, no program segment prefix is built, and DOS assumes the calling program has allocated memory for the overlay. The calling program should provide memory in one of two ways:

- Provide enough memory for the overlay when it issues the SETBLOCK call (4AH)
- Free adequate memory with the 49H call.

When DOS receives an AL=3 request, the system assumes that the requested memory is owned by the calling program. As in subprograms, an overlay can be loaded into memory not allocated to it and damage the series of DOS memory management control blocks.

Programs loaded with AL=3 should not issue the SETBLOCK call (4AH) because the memory in which they operate is owned by the calling process, not the overlay. Before terminating, the calling program must return to the system the memory it allocated to the overlay. When the calling program terminates, control is returned to DOS.

Calling a Command Processor

To call a command processor, you must do the following:

- Assure that adequate free memory is available to contain the second copy of the command processor and the command it is to execute. Issue function call 4AH to shrink allocated memory to your current requirement. Issue function call 48H with BX=FFFFH. The return is available memory.
- Build a parameter string for the secondary command processor in the form:

1 byte = length of parameter string
xx byte = parameter string
1 byte = 0DH (carriage return)

For example, the following assembly statement builds the string to execute a DISKCOPY command:

```
DB 19, "/C C:DISKCOPY A: B:" , 13
```

- Use the EXEC function call (4BH, function value 0) to execute the secondary copy of the command processor. The COMSPEC = parameter in the environment passed at PSP+2CH identifies the drive, directory, and command processor name. Remember to set offset 2 in the EXEC control block to point to the parameter string.

Responding to Errors

When a PC DOS 7 function cannot be performed (indicating a critical error situation) control is transferred to interrupt 24H. Function 59H provides additional information on the error condition.

Activity	Number
Responding to a critical error situation	Interrupt 24H
Requesting additional error information and suggested action	Function 59H

Handle function calls report an error by setting the carry flag and returning the error code in AX. FCB function calls report an error by returning FFH in AL.

The Extended Error function call (59H) provides a common set of error codes and specific error information such as error classification, location, and recommended action. In most critical cases, applications can analyze the error code and take specific action. Recommended actions are intended for programs that do not understand the error codes. Programs can take advantage of extended error support both from interrupt 24H critical error handlers and after issuing interrupt 21H function calls. Do not code to specific error codes.

Responding to a Control-Break Action

Interrupt 23H is issued if a Ctrl-Break occurs during standard I/O. Function calls 09H and 0AH can be used if there is a ∧C, carriage return and line feed produced as output.

Activity	Function Number
Displaying string	09H
Buffering keyboard input	0AH
Responding to a control-break action	23H

If a Ctrl-Break is entered during standard input, standard output, standard printer, or asynchronous communications adapter operations, an INT 23H is executed. If BREAK is on, INT 23H is checked on most function calls, except 06H and 07H.

The user-written Ctrl-Break routine can use function calls 09H, 0AH, and 0DH to respond to the Ctrl-Break action by having ^C, carriage return, and line feed produced as output. ASCII codes 0DH and 0AH represent carriage return and line feed, respectively. If the Ctrl-Break routine saves all registers, it may end with an IRET (return from interrupt) instruction to continue program execution. If the routine returns with a long return, the carry flag is used to determine whether or not to stop execution. If the carry flag is not set, execution continues, as with an IRET.

There are no restrictions on what the Ctrl-Break handler is allowed to do, providing the registers are unchanged if IRET is used.

Requesting and Specifying the System Date and Time

The following functions get or set the system date and time:

Activity	Function Number
Requesting the system date	2AH
Specifying the system date	2BH
Requesting the system time	2CH
Specifying the system time	2DH

Requesting and Specifying the Interrupt Vectors

A program can create and change the contents of the *interrupt vectors*, the 4-byte addresses of the routines in memory that service hardware and software interrupts. On exit, the program must reset the interrupt vectors to where they were pointing originally.

If you want a program to examine or specify the contents of an interrupt vector, use PC DOS 7 function calls 35H and 25H and avoid referencing the interrupt vector locations directly.

Activity	Function Number
Specifying the interrupt vector value	25H
Requesting the interrupt vector value	35H

Chapter 7. Debugging a Program

This chapter describes how to use the DEBUG.COM program that is shipped as part of PC DOS 7 to identify and fix problems in your programs.

Warning

Use of the DEBUG program should not be undertaken lightly, the utility has the power to alter code, always ensure that you take a backup copy of the code that you will be using debug on.

The DEBUG Utility

DEBUG provides a controlled testing environment that enables you to monitor the execution of a program. You can make changes directly to a .COM or an .EXE file and execute the file immediately to determine whether your changes fixed a problem. You do not need to reassemble source code files first. DEBUG allows you to load, alter, or display any file and to execute object files as well.

Starting the DEBUG.COM Program

To start DEBUG, enter information in the following format:

```
DEBUG [[drive:][path]filename [testfile-parameters]]
```

You can enter just the DEBUG command, or you can include a file specification. The parameters *parm1* and *parm2* represent input and output specifications of the program you are debugging. For example, suppose you wanted to monitor the execution of the PC DOS 7 DISKCOMP utility. You enter:

```
DEBUG DISKCOMP.COM A: B:
```

The DEBUG program loads DISKCOMP into memory and displays the DEBUG prompt:

```
-
```

The hyphen (-) tells you DEBUG is ready to accept commands to alter, display, or execute the contents of the program in memory.

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If you enter just DEBUG without a file specification, you can either work with the present memory contents or you can load a required file into memory using the DEBUG **Name** and **Load** commands.

Entering Commands at the DEBUG Prompt

A DEBUG command consists of a single letter, usually followed by one or more parameters. For example, the **Name** command is entered at the DEBUG prompt as a single letter followed by a file specification:

```
-N MYPROG
```

A command and its parameters can be entered in uppercase, lowercase, or a combination of both. The command and its parameters can be separated by delimiters; however, delimiters are only required between two consecutive hexadecimal values. Thus, the following **Dump** commands are equivalent:

```
dcs:100 110
d cs:100 110
d,cs:100,110
```

A command is activated only after you press the Enter key. If you want to terminate a command and return to the DEBUG prompt, simultaneously press the Ctrl and Break keys.

For commands producing a large amount of output, you can simultaneously press the Ctrl and Num Lock keys (or Pause key if available) to suspend the display and then press any key to restart the display, or you can redirect the command's output to a file.

When DEBUG encounters a syntax error in a line, it displays the line with the error identified as follows:

```
d cs:100 CS:100
               ^error 110
```

In this example, the **Dump** command expects the second address to contain only a hexadecimal offset value. It finds the S, which is not a hexadecimal character.

DEBUG Command Summary

The table below lists the DEBUG commands and describes the debugging operations you can perform with them. Complete format descriptions and examples for each command can be found starting on page 49.

Command	Task Description
A (Assemble)	Assemble IBM Macro Assembler statements directly into memory.
C (Compare)	Compare the contents of two blocks of memory.
D (Dump)	Dump the contents of a portion of memory to the display or redirect it to a file.
E (Enter)	Make changes to bytes in memory.
F (Fill)	Fill a range of memory with byte values.
G (Go)	Execute the program in memory from one address to the breakpoint address and then display the next instruction.
H (Hex)	Add and subtract two hexadecimal values and display the results.
I (Input)	Display the input in the first byte next to the port.
L (Load)	Load the contents of absolute disk sectors or a file specified by the **Name** command into memory.
M (Move)	Copy the contents of a block of memory to another location.
N (Name)	Set up file control blocks and file specification information for **Load** and **Write** commands.
O (Output)	Send a byte to an output port.
P (Proceed)	Execute a subroutine call, loop instruction, interrupt, or repeat string instruction and return control to DEBUG at the next instruction.
Q (Quit)	End the DEBUG session without saving the debugged program.
R (Register)	Display the contents of registers and the settings of flags.
S (Search)	Search a range of memory for characters.
T (Trace)	Execute one or more instructions in your program and display the contents of registers and flags after each instruction.
U (Unassemble)	Translate the contents of memory into Assembler-like statements, displaying their addresses and hexadecimal values.
W (Write)	Write the debugged program to absolute disk sectors or to the original file loaded with DEBUG.
XA (Allocate)	Allocate a specified number of expanded memory pages to an EMS handle.
XD (Deallocate)	Deallocate an EMS handle.
XM (Map)	Map an EMS logical page to an EMS physical page from an EMS handle.
XS (Status)	Display the status of expanded memory.

The DEBUG Work Space

When the DEBUG program starts, the registers and flags are set to the following values for the program being debugged:

- The segment registers (CS, DS, ES, and SS) are set to the bottom of free memory; that is, the first segment after the end of the DEBUG program.
- The Instruction Pointer (IP) is set to hex 0100.
- The Stack Pointer (SP) is set to the end of the segment, or the bottom of the transient portion of the program loader, whichever is lower. The segment size at offset 6 is reduced by hex 100 to allow for a stack that size.
- The remaining registers (AX, BX, CX, DX, BP, SI, and DI) are set to 0. However, if you start the DEBUG program with a file specification, the CX register contains the length of the file in bytes. If the file is greater than 64KB, the length is contained in registers BX and CX (the high portion in BX).
- The initial state of the flags is:

  ```
  NV UP EI PL NZ NA PO NC
  ```

- The default disk transfer address is set to hex 80 in the code segment.

All of available memory is allocated. At this point, the loaded program is unable to allocate memory.

.EXE Files

If a file loaded by DEBUG has an extension of .EXE, DEBUG does the necessary relocation and sets the segment registers, stack pointer, and instruction pointer to the values defined in the file. The DS and ES registers, however, point to the program segment prefix at the lowest available segment. The BX and CX registers contain the size of the program that is smaller than the file size.

The program is loaded at the high end of memory if the appropriate parameter was specified when the linker created the file.

.HEX Files

If a file loaded by DEBUG has an extension of .HEX, the file is assumed to be in INTEL hex format, and is converted to executable form while being loaded.

A (Assemble) Command

Purpose

Assembles macro assembler language statements directly into memory.

Format

A[*address*]

Parameters

address Use any of the following formats:

- A segment register plus an offset, such as CS:0100
- A segment address plus an offset, such as 4BA:0100
- An offset only, such as 100. In this case, the default segment is used.

Comments

All numeric input to the Assemble command is in hexadecimal. The assembly statements you enter are assembled into memory at successive locations, starting with the address specified in *address.* If no address is specified, the statements are assembled into the area at CS:0100, if no previous Assemble command was used, or into the location following the last instruction assembled by a previous Assemble command. After all desired statements have been entered, press the Enter key when you are prompted for the next statement to return to the DEBUG prompt.

DEBUG responds to invalid statements by displaying:

```
^error
```

and re-displaying the current assemble address.

DEBUG supports standard 8086/8088 assembly language syntax (and the 8087 instruction set), with the following rules:

- All numeric values entered are hexadecimal and can be entered as 1 through 4 characters.
- Prefix mnemonics are entered in front of the opcode to which they refer. They can also be entered on a separate line.
- The segment override mnemonics are CS:, DS:, ES:, and SS:.

- String manipulation mnemonics must specify the string size. For example, MOVSW must be used to move word strings and MOVSB must be used to move byte strings.
- The mnemonic for the far return is RETF.
- The assembler will automatically assemble short, near, or far jumps and calls depending on byte displacement to the destination address. These can be overridden with the NEAR or FAR prefix. For example:

  ```
  0100:0500 JMP 502      ; a 2 byte short jump
  0100:0502 JMP NEAR 505 ; a 3 byte near jump
  0100:0505 JMP FAR 50A  ; a 5 byte far jump
  ```

  The NEAR prefix can be abbreviated to NE, but the FAR prefix cannot be abbreviated.
- DEBUG cannot tell whether some operands refer to a word memory location or a byte memory location. In this case, the data type must be explicitly stated with the prefix WORD PTR or BYTE PTR. DEBUG will also accept the abbreviations WO and BY. For example:

  ```
  NEG   BYTE PTR [128]
  DEC   WO [SI]
  ```
- DEBUG also cannot tell whether an operand refers to a memory location or to an immediate operand. DEBUG uses the common convention that operands enclosed in square brackets refer to memory. For example:

  ```
  MOV   AX,21          ; Load AX with 21H
  MOV   AX,[21]          ; Load AX with the contents of memory location 21H
  ```
- Two popular pseudo-instructions have also been included. The DB opcode assembles byte values directly into memory. The DW opcode assembles word values directly into memory. For example:

  ```
  DB   1,2,3,4,"THIS IS AN EXAMPLE"
  DB   'THIS IS A QUOTE: "'
  DB   "THIS IS AN APOSTROPHE:'"

  DW   1000,2000,3000,"BACH:"
  ```
- All forms of the register indirect commands are supported. For example:

  ```
  ADD   BX,34[BP+2][SI-1]
  POP   [BP+DI]
  PUSH  [SI]
  ```
- All opcode synonyms are supported. For example:

```
LOOPZ   100
LOOPE   100

JA      200
JNBE    200
```

- For numeric co-processor opcodes the WAIT or FWAIT prefix must be explicitly specified. For example:

```
FWAIT FADD ST,ST(3)    ;This line will assemble a FWAIT prefix

FLD TBYTE PTR [BX]       ;This line will not
```

Examples

```
C>debug
-a200
08B4:0200 xor ax,ax
08B4:0202 mov [bx],ax
08B4:0204 ret
08B4:0205
```

C (Compare) Command

Purpose

Compares the contents of two blocks of memory.

Format

C *range address*

Parameters

range Either of these two formats:

- An *address* followed by an offset, such as CS:100 110.
- An *address* followed by **L** *value*, where *value* is the number of hexadecimal bytes to be processed. For example, CS:100 L 10.

The limit for *range* is hexadecimal 10000 or decimal 64KB. To specify a range of 64KB within 4 hexadecimal characters, enter 0000 or 0 for *value*.

address Any of these three formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

Comments

The contents of the two blocks of memory are compared; the length of the comparison is determined from the *range*. If unequal bytes are found, their addresses and contents are displayed, in the form:

```
addr1  byte1  byte2  addr2
```

where, the first half (addr1 byte1) refers to the location and contents of the mismatching locations in *range*, and the second half (byte2 addr2) refers to the byte found in *address*.

If you enter only an offset for the beginning address of *range*, the C command assumes the segment contained in the DS register. To specify an ending address for *range*, enter it with only an offset value.

Examples

```
C  100 L20 200
```

The 32 bytes (hex 20) of memory beginning at DS:100 are compared with the 32 bytes beginning at DS:200. L20 is the range.

D (Dump) Command

Purpose

Displays the contents of a portion of memory.

Format

D [*address*]

or

D [*range*]

Parameters

address Any of the following formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

range Either of these two formats:

- An *address* followed by an offset, such as CS:100 110.
- An *address* followed by **L** *value*, where *value* is the number of hexadecimal bytes to be processed. For example, CS:100 L 10.

The limit for *range* is hexadecimal 10000 or decimal 64K bytes. To specify a range of 64K bytes within 4 hexadecimal characters, enter 0000 or 0 for *value*.

Comments

The dump is displayed in two parts:

1. A hexadecimal portion. Each byte is displayed in hexadecimal.
2. An ASCII portion. The bytes are displayed as ASCII characters. Unprintable characters (ASCII 0 to 31 and 127 to 255) are indicated by a period.

With a 40-column system display format, each line begins on an 8-byte boundary and shows 8 bytes.

With an 80-column system display format, each line begins on a 16-byte boundary and shows 16 bytes. There is a hyphen between the 8th and 9th bytes.

Note: The first line may have fewer than 8 or 16 bytes if the starting address of the dump is not on a boundary. In this case, the second line of the dump begins on a boundary.

The Dump command has two format options.

Option 1

Use this option to display the contents of hex 40 bytes (40-column mode) or hex 80 bytes (80-column mode). For example:

```
D address

  or

D
```

The contents are dumped starting with the specified address.

If you do not specify an address, the D command assumes the starting address is the location following the last location displayed by a previous D command. Thus, it is possible to dump consecutive 40-byte or 80-byte areas by entering consecutive D commands without parameters.

If no previous D command was entered, the location is offset hex 100 into the segment originally initialized in the segment registers by DEBUG.

Note: If you enter only an offset for the starting address, the D command assumes the segment contained in the DS register.

Option 2

Use this option to display the contents of the specified address range. For example:

```
D range
```

Note: If you enter only an offset for the starting address, the D command assumes the segment contained in the DS register. If you specify an ending address, enter it with only an offset value.

For example:

```
D cs:100 10C
```

A 40-column display format might look like this:

```
04BA:0100  42 45 52 54 41 20 54 00
                   BERTA T.

04BA:0108  20 42 4F 52 47
                      BORG
```

E (Enter) Command

Purpose

- Replaces the contents of one or more bytes, starting at the specified address, with the values contained in the list (see Option 1).
- Displays and allows modification of bytes in a sequential manner (see Option 2).

Format

E *address* [*list*]

Parameters

address Any of the following formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

list A string of byte values. If you include a character string, enclose the characters in single or double quotation marks. To specify a quotation mark as a character within the string when it is also used to delimit the string, type it twice.

```
"These ""quotes"" are correct."
'This one''s okay, too.'
```

Comments

If you enter only an offset for the address, the E command assumes the segment contained in the DS register.

The Enter command has two format options.

Option 1

Use this option to place the list in memory beginning at the specified address.

```
E  address list
```

For example:

```
E ds:100 F3 "xyz" 8D
```

Memory locations ds:100 through ds:104 are filled with the 5 bytes specified in the list.

Option 2

Use this option to display the address and the byte of a location, then the system waits for your input.

For example:

```
E  address
```

Enter a 1- or 2-character hexadecimal value to replace the contents of the byte; then take any one of the following actions:

1. Press the space bar to advance to the next address. Its contents are displayed. If you want to change the contents take option 1, above.

   To advance to the next byte without changing the current byte, press the space bar again.

2. Enter a hyphen to back up to the preceding address. A new line is displayed with the preceding address and its contents. If you want to change the contents, take option 1, above.

   To back up one more byte without changing the current byte, enter another hyphen.

3. Press the Enter key to end the Enter command.

Note: Display lines can have 4 or 8 bytes of data, depending on whether the system display format is 40- or 80-column. Spacing beyond an 8-byte boundary causes a new display line, with the beginning address, to be started.

For example:

```
E cs:100
```

might cause this display:

```
04BA:0100 EB._
```

To change the contents of 04BA:0100 from hex EB to hex 41, enter 41.

```
04BA:0100 EB.41_
```

To see the contents of the next three locations, press the space bar three times. The screen might look like this:

```
04BA:0100  EB.41  10. 00.  BC._
```

To change the contents of the current location (04BA:0103) from hex BC to hex 42, enter 42.

```
04BA:0100  EB.41  10. 00.  BC.42_
```

Now, suppose you want to back up and change the hex 10 to hex 6F. This is what the screen looks like after entering two hyphens and the replacement byte:

```
04BA:0100 EB.41 10.00.  BC.42-
04BA:0102 00.-
04BA:0101 10.6F_
```

Press the Enter key to end the Enter command. The hyphen prompt will appear.

F (Fill) Command

Purpose

Fills the memory locations in the range with the values in the list.

Format

F *range list*

Parameters

range — Either of these two formats:

- An *address* followed by an offset, such as CS:100 110
- An *address* followed by **L** *value*, where *value* is the number of hexadecimal bytes to be processed. For example, CS:100 L 10.

The limit for *range* is hexadecimal 10000 or decimal 64K bytes. To specify a range of 64K bytes within 4 hexadecimal characters, enter 0000 or 0 for *value*.

list — A string of byte values. If you include a character string, enclose the characters in single or double quotation marks. To specify a quotation mark as a character within the string when it is also used to delimit the string, type it twice.

```
"These ""quotes"" are correct."
'This one''s okay, too.'
```

Comments

If the list contains fewer bytes than the address range, the list is used repeatedly until all the designated memory locations are filled.

If the list contains more bytes than the address range, the extra list items are ignored.

Note: If you enter only an offset for the starting address of the range, the Fill command assumes the segment contained in the DS register.

Examples

```
F 4BA:100 L 5 F3 "XYZ" 8D
```

Memory locations 04BA:100 through 04BA:104 are filled with the 5 bytes specified. Remember that the ASCII values of the list characters are stored. Thus, locations 100-104 will contain F3 58 59 5A 8D.

G (Go) Command

Purpose

Executes the program you are debugging.

Stops the execution when the instruction at a specified address is reached (breakpoint), and displays the registers, flags, and the next instruction to be executed.

Format

G [= *address*] [*address* [*address*...]]

Parameters

address Any of the following formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

Comments

Program execution begins with the current instruction, whose address is determined by the contents of the CS and IP registers, unless overridden by the *=address* parameter (the = must be entered). If *=address* is specified, program execution begins with CS:=*address*.

The Go command has two format options.

Option 1

Use this option to execute the program you are debugging without breakpoints. For example:

```
G [=address]
```

This option is useful when testing program execution with different parameters each time. (Refer to the Name command.) Be certain the CS:IP values are set properly before issuing the G command, if not using *=address*.

Option 2

This option performs the same function as Option 1 but, in addition, allows breakpoints to be set at the specified addresses. For example:

```
G [=address] address
  [address...]
```

This method causes execution to stop at a specified location so the system or program environment can be examined.

You can specify up to ten breakpoints in any order. You may wish to take advantage of this if your program has many paths, and you want to stop the execution no matter which path the program takes.

The DEBUG program replaces the instruction codes at the breakpoint addresses with an interrupt code (hex CC). If *any one* breakpoint is reached during execution, the execution is stopped, the registers and flags are displayed, and all the breakpoint addresses are restored to their original instruction codes. If no breakpoint is reached, the instructions are *not* restored.

Notes:

1. Once a program has reached completion (DEBUG has displayed the "Program terminated normally" message), you must reload the program before it can be executed again.
2. Make sure that the address parameters refer to locations that contain valid 8086/8088 instruction codes. If you specify an address that does not contain valid instruction in the first byte, unpredictable results occur.
3. The stack pointer must be valid and have 6 bytes available for the Go command, otherwise, unpredictable results occur.
4. If only an offset is entered for a breakpoint, the G command assumes the segment contained in the CS register.
5. Do not set breakpoints at instructions in read-only memory (ROM BIOS or ROM BASIC).

   For example:

   ```
   G 102 1EF 208
   ```

Be careful not to set a breakpoint between a segment override indication (such as ES; alone on a line), and the instruction that the override qualifies.

Execution begins with the current instruction, whose address is the current values of CS:IP. The =*address* parameter was not used.

Three breakpoints are specified; assume that the second is reached. Execution stops before the instruction at location CS:1EF is executed, the original instruction codes are restored, all three breakpoints are removed, the display occurs, and the Go command ends.

Refer to the Register command for a description of the display.

H (Hexarithmetic) Command

Purpose

Adds the two hexadecimal values, then subtracts the second from the first. Displays the sum and difference on one line.

Format

H *value value*

Examples

```
H 0F 8
0017 0007
```

The hexadecimal sum of 000F and 0008 is 0017, and their difference is 0007.

I (Input) Command

Purpose

Inputs and displays (in hexadecimal) 1 byte from the specified port.

Format

I *portaddress*

Parameters

portaddress A 1–4 character hexadecimal value specifying an 8- or 16-bit port address.

Examples

```
I 2F8
6B
```

The single hexadecimal byte read from port 02F8 is displayed (6B).

L (Load) Command

Purpose

Loads a file or absolute disk sectors into memory.

Format

L [*address*[*drive sector sector*]]

Parameters

address Any of the following formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

drive A decimal number that indicates a particular drive. For example, drive A is 0, drive B is 1, and so on.

sector 1–3 character hexadecimal values that specify the starting relative sector number and the number of sectors to be loaded or written.

Note: Relative sector numbers are obtained by counting the sectors on the disk surface. The first sector on the disk is at track 0, sector 1, head 0, and is relative sector 0. The numbering continues for each sector on that track and head, then continues with the first sector on the next head of the same track. When all sectors on all heads of the track have been counted, numbering continues with the first sector on head 0 of the next track.

Comments

The maximum number of sectors that can be loaded with a single Load command is hex 80. A sector contains 512 bytes.

Note: DEBUG displays a message if a disk read error occurs. You can retry the read operation by pressing the F3 key to re-display the Load command. Then press the Enter key.

The Load command has two format options.

Option 1

Use this option to load data from the disk specified by *drive* and place the data in memory beginning at the specified *address*. For example:

```
L  address drive sector sector
```

The data is read from the specified starting relative sector (first sector) and continues until the requested number of sectors is read (second sector).

Note: If you only enter an offset for the beginning address, the L command assumes the segment contained in the CS register.

For example, to load data, you might enter:

```
L DS:100 1 0F 6D
```

The data is loaded from the diskette in drive B and placed in memory beginning at DS:100. Consecutive sectors of data are transferred, 6DH (109), starting with relative sector hex 0F (15) (the 16th sector on the diskette).

Note: Option 1 cannot be used if the drive specified is a network drive.

Option 2

When issued without parameters, or with only the address parameter, use this option to load the file whose file specification is at CS:80. For example:

```
L

  or

L address
```

This condition is met by specifying the file name when starting the DEBUG program, or by using the Name command.

Note: If DEBUG was started with a file specification and subsequent Name commands were used, you may need to enter a new Name command for the proper file specification before issuing the Load command.

The file is loaded into memory beginning at CS:100 (or the location specified by *address*), and is read from the drive specified in the file specification, or from the default drive, if none was specified. Note that files with extensions of .COM or .EXE are always loaded at CS:100. If you specified an address, it is ignored.

The BX and CX registers are set to the number of bytes read; however, if the file being loaded has an extension of .EXE, the BX and CX registers are set to the actual program size. The file may be loaded at the high end of memory. Refer to “The DEBUG Work Space” on page 48 for the conditions that are in effect when .EXE or .HEX files are loaded.

For example:

```
DEBUG
-N myprog
-L
-
```

The file named **myprog** is loaded from the default directory and placed in memory beginning at location CS:0100.

M (Move) Command

Purpose

Moves the contents of the memory locations specified by *range* to the locations beginning at the *address* specified.

Format

M *range address*

Parameters

range Either of these two formats:

- An *address* followed by an offset, such as CS:100 110.
- An *address* followed by **L** *value*, where *value* is the number of hexadecimal bytes to be processed. For example, CS:100 L 10.

The limit for *range* is hexadecimal 10000 or decimal 64KB. To specify a range of 64KB within 4 hexadecimal characters, enter 0000 or 0 for *value*.

address Any of the following formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

Comments

Overlapping moves are always performed without loss of data during the transfer. (The source and destination areas share some of the same memory locations.)

The data in the source area remains unchanged unless overwritten by the move.

Notes:

1. If you enter only an offset for the beginning address of the range, the M command assumes the segment contained in the DS register. If you specify an ending address for the range, enter it with only an offset value.
2. If you enter only an offset for the address of the destination area, the M command assumes the segment contained in the DS register.

Examples

```
M CS:100 L10 500
```

The 17 bytes of data from CS:100 through CS:110 are moved to the area of memory beginning at DS:500.

N (Name) Command

Purpose

- Formats file control blocks for the first two file specifications, at CS:5C and CS:6C. (Starting DEBUG with a file specification also formats a file control block at CS:5C.)

  The file control blocks are set up for the Load and Write commands and to supply required file names for the program being debugged.
- All file specifications and other parameters, including delimiters, are placed exactly as entered in a parameter save area at CS:81, with CS:80 containing the number of characters entered. Register AX is set to indicate the validity of the drive specifiers entered with the first two file specifications.

Format

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

Comments

If you start the DEBUG program without a file specification, you must use the Name command before a file can be loaded with the L command.

Examples

```
DEBUG
-N myprog
-L
-
```

To define file specifications or other parameters required by the program being debugged, enter:

```
DEBUG myprog
-N file1 file2
-
```

In this example, DEBUG loads the file **myprog** at CS:100, and leaves the file control block at CS:5C formatted with the same file specification. Then, the Name command formats file control blocks for *file1* and *file2* at CS:5C and CS:6C, respectively. The file control block for **myprog** is overwritten. The parameter area at CS:81 contains all characters entered after the **N**, including all delimiters, and CS:80 contains the count of those characters (hex 0C).

O (Output) Command

Purpose

Sends the *byte* to the specified output port.

Format

O *portaddress byte*

Parameters

portaddress A 1–4 character hexadecimal value specifying an 8- or 16-bit port address.

Examples

To send the byte value 4F to output port 2F8, enter:

```
O 2F8 4F
```

P (Proceed) Command

Purpose

Causes the execution of a subroutine call, a loop instruction, an interrupt, or a repeat string instruction to stop at the next instruction.

Format

P[=address][value]

Parameters

address Any of the following formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

value A 1–4 character hexadecimal value, specifying the number of instructions to execute.

Comments

When at a subroutine call, a loop instruction, an interrupt, or a repeat string instruction, issue the Proceed command to execute the instruction (perform the entire function), and return control at the next instruction. The Proceed command has the same syntax as the Trace command. Specifying P0 is the same as specifying T0.

Examples

If the following instructions are executed:

```
0100    CALL    1000
0103    JC      2000
:
1000    XOR     AX,AX
:
1XXX    RET
```

And if CS:IP was pointing to the CALL 1000 instruction, typing **P** causes the execution of the subroutine and returns control to DEBUG at the JC instruction.

Q (Quit) Command

Purpose

Ends the DEBUG program.

Format

Q

Comments

The file that you are working on in memory is *not* saved by the Quit command. You must use the Write command to save the file.

DEBUG returns to the command processor which then issues the normal command prompt.

Examples

```
-Q
A>
```

R (Register) Command

Purpose

The Register command has the following three functions:

- Displays the hexadecimal contents of a single register with the option of changing those contents
- Displays the hexadecimal contents of all the registers, plus the alphabetic flag settings, and the next instruction to be executed
- Displays the eight 2-letter alphabetic flag settings with the option of changing any or all of them.

Format

R [*registername*]

Parameters

registername The valid names are:

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

IP refers to the instruction pointer, and F refers to the flags register.

Comments

When the DEBUG program starts, the registers and flags are set to certain values for the program being debugged. (Refer to "The DEBUG Work Space" on page 48.)

Display a Single Register

To display the contents of a single register, enter the register name:

```
R AX
```

The system might respond with:

```
AX F1E4
:_
```

Now you can take one of two actions: press the Enter key to leave the contents unchanged, or change the contents of the AX register by entering a 1-4 character hexadecimal value, such as hex FFF.

```
AX F1E4
:FFF_
```

Now, pressing the Enter key changes the contents of the AX register to hex 0FFF.

Display All Registers and Flags

To display the contents of all registers and flags and the next instruction to be executed, type:

```
R
```

The system responds:

```
AX=0E00  BX=00FF  CX=0007  DX=01FF  SP=039D  BP=0000  SI=005C  DI=0000
DS=3D5B  ES=3D5B  SS=3D5B  CS=3D5B  IP=011A   NV UP EI PL NZ NA PO NC
3D5B:011A CD21          INT     21
```

The first four lines display the hexadecimal contents of the registers and the eight alphabetic flag settings. The last line indicates the location of the next instruction to be executed and its hexadecimal and unassembled formats. This is the instruction pointed to by CS:IP.

A system with an 80-column display shows:

1st line - 8 registers
2nd line - 5 registers and 8 flag settings
3rd line - next instruction information

A system with a 40-column display shows:

1st line - 4 registers
2nd line - 4 registers
3rd line - 4 registers
4th line - 1 register and 8 flag settings
5th line - next instruction information

Display All Flags

There are eight flags, each with two-letter codes to indicate either a set condition or a clear condition. The flags appear in displays in the order shown in the following table:

Flag Name	Set	Clear
Overflow (yes/no)	OV	NV
Direction (decrease/increase)	DN	UP
Interrupt (enable/disable)	EI	DI
Sign (negative/positive)	NG	PL
Zero (yes/no)	ZR	NZ
Auxiliary carry (yes/no)	AC	NA
Parity (even/odd)	PE	PO
Carry (yes/no)	CY	NC

To display all flags, enter:

```
R F
```

If all the flags are in a *set* condition, the response is:

```
OV DN EI NG ZR AC PE CY - _
```

Now you can either press the Enter key to leave the settings unchanged or change any or all of the settings.

To change a flag, just enter its opposite code. The opposite codes can be entered in any order with or without intervening spaces. For example, to change the first, third, fifth, and seventh flags, enter:

```
OV DN EI NG ZR AC PE CY - PONZDINV
```

The changes in this example are entered in reverse order.

Press the Enter key and the flags are modified as specified, the prompt appears, and you can enter the next command.

If you want to see if the new codes are in effect, enter:

```
R F
```

The response is:

```
NV DN DI NG NZ AC PO CY - _
```

The first, third, fifth, and seventh flags are changed as requested. The second, fourth, sixth, and eighth flags are unchanged. A single flag can be changed only once for each R F command.

S (Search) Command

Purpose

Searches the *range* for the character(s) in the *list*.

Format

S *range* *list*

range Either of these two formats:

- An *address* followed by an offset, such as CS:100 110.
- An *address* followed by **L** *value*, where *value* is the number of hexadecimal bytes to be processed. For example, CS:100 L 10.

The limit for *range* is hexadecimal 10000 or decimal 64KB. To specify a range of 64KB within 4 hexadecimal characters, enter 0000 or 0 for *value*.

list A string of byte values. If you include a character string, enclose the characters in single or double quotation marks. To specify a quotation mark as a character within the string when it is also used to delimit the string, type it twice.

```
"These ""quotes"" are correct."
'This one''s okay, too.'
```

Comments

All matches are indicated by displaying the addresses where matches are found.

A display of the prompt without an address means that no match was found.

Note: If you enter only an offset for the starting address of the range, the S command assumes the segment contained in the DS register.

Examples

If you want to search the range of addresses from CS:100 through CS:110 for hex 41, type:

```
S CS:100 110 41
```

If two matches are found the response might be:

```
04BA:0104
04BA:010D
```

If you want to search the same range of addresses for a match with the 4-byte list (41 "AB" E), enter:

```
S CS:100 L 11 41 "AB" E
```

The starting addresses of all matches are listed. If no match is found, no address is displayed.

T (Trace) Command

Purpose

Executes one or more instructions starting with the instruction at CS:IP, or at =*address*, if it is specified. The = must be entered. One instruction is assumed, but you can specify more than one with *value*. This command displays the contents of all registers and flags *after each* instruction executes. For a description of the display format, refer to the Register command.

Format

T [= *address*] [*value*]

Parameters

address Any of the following formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

value A 1–4 character hexadecimal value, specifying the number of instructions to execute.

Comments

The display caused by the Trace command continues until *value* instructions are executed. Therefore, when tracing multiple instructions, remember you can suspend the scrolling at any time by pressing the Ctrl and the NumLock keys together, or the Pause key. Resume scrolling by entering any other character.

Notes:

1. The Trace command disables all hardware interrupts before executing the user instruction, and then re-enables the interrupts when the trap interrupt occurs following the execution of the instruction.
2. TRACE should not be used with any steps that change the contents of the 8259 interrupt mask (ports 20 and 21).
3. If you trace an INT3 instruction, the breakpoint is set at the INT3 location.

Examples

```
T
```

If the IP register contains 011A, and that location contains B40E (MOV AH,0EH), this may be displayed:

```
AX=0E00  BX=00FF  CX=0007  DX=01FF  SP=039D  BP=0000  SI=005C  DI=0000
DS=3D5B  ES=3D5B  SS=3D5B  CS=3D5B  IP=011C   NV UP EI PL NZ NA PO NC
3D5B:011C CD21          INT     21
```

This displays the results *after* the instruction at 011A is executed, and indicates the next instruction to be executed is the INT 21 at location 04BA:011C.

```
T 10
```

Sixteen instructions are executed (starting at CS:IP). The contents of all registers and flags are displayed after each instruction. The display stops after the 16th instruction has been executed. Displays may scroll off the screen unless you suspend the display by simultaneously pressing the Ctrl and NumLock keys, or the Pause key.

U (Unassemble) Command

Purpose

Unassembles instructions (that is, translates the contents of memory into assembler-like statements) and displays their addresses and hexadecimal values, together with assembler-like statements. For example, a display might look like this:

```
04BA:0100  206472   AND [SI+72],AH
04BA:0103  FC       CLD
04BA:0104  7665     JBE 016B
```

Format

U [*address*]

or

U [*range*]

Parameters

address Any of the following formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

range Either of these two formats:

- An *address* followed by an offset, such as CS:100 110.
- An *address* followed by **L** *value*, where *value* is the number of hexadecimal bytes to be processed. For example, CS:100 L 10.

The limit for *range* is hexadecimal 10000 or decimal 64KB. To specify a range of 64KB within 4 hexadecimal characters, enter 0000 or 0 for *value*.

Comments

The number of bytes to be unassembled depends on your system display format (40 or 80 columns), and which option you use with the Unassemble command.

Notes:

1. In all cases, the number of bytes unassembled and displayed may be slightly more than either the amount requested or the default amount. This happens because the length of the instructions vary. Therefore, unassembling the last instruction may result in more bytes than expected.
2. Make sure that the address parameters refer to locations containing valid 8086/8088 instruction codes. If you specify an address that does not contain the first byte of a valid instruction, the display will be incorrect.
3. If you enter only an offset for the starting address, the U command assumes the segment contained in the CS register.

The Unassemble command has the following two format options:

Option 1

Use this option to either unassemble instructions without specifying an address, or to unassemble instructions beginning with a specified address. For example:

```
U

  or

U address
```

Sixteen bytes are unassembled with a 40-column display. Thirty-two bytes are unassembled in 80-column mode.

Instructions are unassembled beginning with the specified address.

If you do not specify an address, the U command assumes the starting address is the location following the last instruction unassembled by a previous U command. Thus, it is possible to unassemble consecutive locations, producing continuous unassembled displays, by entering consecutive U commands without parameters.

If no previous U command is entered, the location is offset hex 0100 into the segment originally initialized in the segment registers by DEBUG.

Option 2

Use this option to unassemble instructions in a specified address range. For example:

```
U range
```

All instructions in the specified address range are unassembled, regardless of the system display format.

Note: If you specify an ending address, enter it with only an offset value.

For example:

```
U 04ba:0100 108
```

The display response may be:

```
04BA:0100  206472    AND [SI+72],AH
04BA:0103  FC        CLD
04BA:0104  7665      JBE 016B
04BA:0106  207370    AND [BP+DI+70],DH
```

The same display appears if you enter:

```
U 04BA:100 L 7
```

```
      or
```

```
U 04BA:100 L 8
```

```
      or
```

```
U 04BA:100 L 9
```

W (Write) Command

Purpose

Writes the data being debugged to disk.

Format

W [*address* [*drive sector sector*]]

Parameters

address Any of the following formats:

- A segment register plus an offset, such as CS:0100.
- A segment address plus an offset, such as 4BA:0100.
- An offset only, such as 100. In this case, the default segment is used.

drive A decimal number that indicates a particular drive. For example, drive A is 0, drive B is 1, and so on.

sector 1–3 character hexadecimal values that specify the starting relative sector number and the number of sectors to be loaded or written.

Note: Relative sector numbers are obtained by counting the sectors on the disk surface. The first sector on the disk is at track 0, sector 1, head 0, and is relative sector 0. The numbering continues for each sector on that track and head, then continues with the first sector on the next head of the same track. When all sectors on all heads of the track have been counted, numbering continues with the first sector on head 0 of the next track.

Comments

No more than hex 80 sectors can be written with a single Write command. A sector contains 512 bytes.

DEBUG displays a message if a disk write error occurs. You can retry the write operation by pressing the F3 key to re-display the Write command, then press the Enter key.

The Write command has two format options.

Option 1

Use this option to write data to disk beginning at a specified address. For example:

```
W address drive sector sector
```

The data beginning at the specified address is written to the disk in the indicated drive. The data is written starting at the specified starting relative sector (first sector) and continues until the requested number of sectors are filled (second sector).

Notes:

1. Be extremely careful when you write data to absolute sectors because an erroneous sector specification destroys whatever was on the disk at that location.
2. If only an offset is entered for the beginning address, the W command assumes the segment is contained in the CS register.
3. Remember, the starting sector and the sector count are both specified in *hexadecimal*.
4. Option 1 cannot be used if the specified drive is a network drive.

For example:

```
W 1FD 1 100 A
```

The data beginning at CS:01FD is written to the diskette in drive B, starting at relative sector hex 100 (256) and continuing for hex 0A (10) sectors.

Option 2

This option permits you to use the WRITE command without specifying parameters or specifying only the address parameter. For example:

```
W

  or

W address
```

When issued as shown above, the Write command writes the file (whose file specification is at CS:80) to disk.

This condition is met by specifying the file when starting the DEBUG program, or by using the Name command.

Note: If DEBUG was started with a file specification and subsequent Name commands were used, you may need to enter a new Name command for the proper file specification before issuing the Write command.

In addition, the BX and CX registers must be set to the number of bytes to be written. They may have been set properly by the DEBUG or Load commands, but were changed by a Go or Trace command. You must be certain the BX and CX registers contain the correct values.

The file beginning at CS:100, or at the location specified by *address*, is written to the diskette in the drive included in the file specification or the default drive if no drive was specified.

The debugged file is written over the original file that was loaded into memory, or into a new file if the file name in the FCB didn't previously exist.

Note: An error message is issued if you try to write a file with an extension of .EXE or .HEX. These files are written in a specific format that DEBUG cannot support.

If you find it necessary to modify a file with an extension of .EXE or .HEX, and the exact locations to be modified are known, use the following procedure:

1. RENAME the file to an extension other than .EXE or .HEX.
2. Load the file into memory using the DEBUG or Load command.
3. Modify the file as needed in memory, but do not try to execute it with the Go or Trace commands. Unpredictable results would occur.
4. Write the file back using the Write command.
5. RENAME the file to its correct name.

XA (EMS Allocate) Command

Purpose

Allocates a specified number of expanded memory pages to a handle.

Format

XA *count*

Comments

The *count* indicates the number of 16K pages to allocate. If the amount of expanded memory identified by *count* is available, a message is displayed, indicating that a handle has been created. The XS (EMS Status) command can be used to display the number of expanded memory pages that are available.

Examples

To allocate two EMS pages, enter:

```
XA 2
```

If two pages of memory are available, a message like this is displayed:

```
Handle created = 000E
```

XD (EMS Deallocate) Command

Purpose

Deallocates a handle.

Format

XD *handle*

Comments

The *handle* identifies the number of the handle to be deallocated. If the number is valid, a message is displayed, indicating the handle has been deallocated. The XS (EMS Status) command can be used to display the handles currently being used.

Examples

To deallocate a handle when you have only one allocated, you can enter:

```
XD 000E
```

If the handle deallocation is successful, you receive a message like this:

```
Handle 000E deallocated.
```

XM (EMS Map) Command

Purpose

Maps an EMS logical page to an EMS physical page from an EMS handle.

Format

XM *lpage ppage handle*

Comments

The *lpage* specifies the number of the handle's logical page that is to be mapped. The *ppage* is the number of the physical page to be mapped to. The *handle* is the EMS allocated label used to reference a group of logical pages. If syntax items are valid, a message is displayed indicating that the logical page has been mapped to the physical page.

Examples

To map a logical page to a physical page using handle 0001, you can enter:

```
XM 1 0 1
```

If the mapping is successful, you receive this message:

```
Logical page 01 mapped to physical page 00.
```

XS (EMS Status) Command

Purpose

Displays the status of expanded memory.

Format

XS

Comments

The following expanded memory information is displayed:

```
Handle %1 has %2 pages allocated

:
Physical page %1 = Frame segment %2

:
%1 of a total %2 EMS pages have been allocated
%1 of a total %2 EMS handles have been allocated
```

Examples

A line is displayed for each handle allocated with its associated logical page count.

DEBUG Error Messages

The following error messages are produced by the DEBUG utility:

Access denied	The result of attempting to Write (W) to a read-only file.
Disk error reading drive %1	An invalid parameter was entered on the Load (L) command or an error occurred on issuing the Load (L) command.
Disk error writing drive %1	An invalid parameter was entered on the Write (W) command or an error occurred on issuing the Write (W) command.
EMS hardware/software failure	The result of an EMS command. Tells the user EMS is not functioning properly.
EMS not installed	The result of an EMS command. Tells user EMS is not installed.
^ **Error**	Points to the offending operand in an error condition.
Error in EXE or HEX file	The EXE or HEX file are in error.
EXE and HEX files cannot be written	A file in EXE or HEX format cannot be written to a disk.
EXEC failure	The execution of the requested file failed.
File creation error	The result of attempting to Write (W) to a system or hidden file.
File not found	Issued from the Load (L) command when a file is not found for loading.
Free pages exceeded	The result of an EMS command. Tells the user that the request has exceeded the amount of free EMS pages available.
Handle not found	The result of an EMS command. Tells the user an EMS handle was not found.
Incorrect DOS version	Incorrect version of DEBUG for the DOS version running.

Insufficient memory	Not enough memory to Load (L) the specified file.
Insufficient space on disk	Out of disk space for a Write (W) command.
Invalid drive specification	The drive referenced by the Name (N) and Load (L) command is invalid; that is, it does not exist.
Logical Page out of range	The result of an EMS command. Tells the user that the logical page requested is not in the range of possible pages.
Missing or invalid EMS parameter	The result of an EMS command. Tells the user a missing or invalid parameter was entered.
No free handles	The result of an EMS command. Tells the user that there are no more EMS handles available for allocation.
Parameter error	The result of an EMS command. Tells the user that an EMS parameter is in error.
Physical Page out of range	The result of an EMS command. Tells the user that the physical page requested is not in the range of possible pages.
Program terminated normally	An Interrupt 20H has been encountered, signalling program termination.
Total pages exceeded	The result of an EMS command. Tells the user that the total EMS pages have been exceeded.
Write (W) error, no destination defined	Attempt to Write (W) to a file that has not yet been Named (N).
Write protect error writing drive %1	A Write (W) to a write-protected disk caused an error.
Writing %1 bytes	Reports the number of bytes written to a file when the Write (W) command is issued.

Chapter 8. Writing an Installable Device Driver

This chapter provides guide and system architecture information to support successful creation of an installable device driver.

Types of Device Drivers

A device driver is a memory image file or an .EXE file that contains the code needed to implement a device. DOS allows two types of device drivers to be installed:

- Character device drivers
- Block device drivers.

Character Device Drivers

Character device drivers perform character I/O in a serial manner and have names such as CON, AUX, CLOCK$. You can open handles or FCBs to perform input and output to character devices. Because character device drivers have only one name, they support only one device.

Block Device Drivers

Block device drivers are the hard disk or diskette drives on the system. They perform random I/O in pieces called blocks, which are usually the physical sector size of the disk. Block devices are not named as character devices are and you cannot open them. Instead they are mapped using the drive letters such as A, B, and C.

A single block device driver can be responsible for one or more disk or diskette drives. For example, the first block device driver in the device chain may define four units such as A, B, C, and D. The second device driver may define three units: E, F, and G. The limit is 26 devices with the letters A through Z assigned to drives. The position of the driver in the chain determines the way in which the drive units and drive letters correspond.

How PC DOS 7 Installs Device Drivers

PC DOS 7 installs device drivers at startup time by reading and processing the DEVICE command in CONFIG.SYS. For example, if you have written a device driver called DRIVER1, include the following command in CONFIG.SYS:

```
device=driver1
```

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In PC DOS 7 a new command DYNALOAD has been added to allow you to dynamically load device drivers from the command line. The following is an example of this:

```
C:>DYNALOAD ANSI.SYS
```

The PC DOS 7 device interface links device drivers together in a chain, permitting you to add device drivers for optional devices.

Each device must be initialized. The device driver′s initialization interrupt routine is called once when the device is installed. The initialization routine returns the location in memory of the ending address of the device driver. After setting the ending address field, a character device driver sets the status word and returns.

PC DOS 7 processes installed character device drivers before handling default devices. To have PC DOS 7 install a new CON device (for example, in the device driver header′s Name/Unit field) name the device CON and set the standard input device and standard output device bits in the attribute field. Because PC DOS 7 installs drivers anywhere in memory, care must be taken in any references to locations not in the segment. Your driver will not always be loaded at the same memory location each time.

Block devices are installed in the same manner as character devices, above. Block devices return additional information such as the number of units. This number identifies the devices′ logical names. For example, if the current maximum logical device letter is F at the time of the install call, and the block device driver initialization routine returns three logical units, the logical names of the devices are G, H, and I. The mapping is determined by the position of the driver in the device list and the number of units associated with the device. The number of units returned by INIT overrides the value in the name/unit field of the device header.

A block device also returns a pointer to a BIOS parameter block (BPB) array. This is a pointer to an array of *n* word pointers, where *n* is the number of units defined. If all the units are the same, the array is able to point to the same BIOS parameter block, thus saving space. The array must be protected below the ending address pointer set by the return.

The BPB contains information pertinent to the devices such as the sector size and the number of sectors per allocation unit. The sector size in the BPB cannot be greater than the maximum allowed size set by PC DOS 7 initialization.

A block device returns the media descriptor byte passed to devices to report which parameters PC DOS 7 is using for a particular drive unit.

The Basic Parts of a Device Driver

A device driver is a memory image file or an .EXE file containing the code needed to implement a device. All PC DOS 7 installable device drivers have these things in common:

- A device driver header, which identifies the device to PC DOS 7 and defines the strategy and interrupt entry points. Since a device driver is simply loaded and does not use a program segment prefix, the device header must be located at physical location 0 of the device driver (ORG 0 or no ORG statement).
- A strategy routine, which saves a pointer to the Request Header.
- The interrupt routines, which perform the requested operation.

The Device Driver Header

A device driver requires a device header containing the following:

Field	Length
Pointer to next device header	DWORD
Attribute	WORD
Pointer to device strategy routine	WORD
Pointer to device interrupt routine	WORD
Name/unit field	8 BYTES

Pointer to Next Device Header

The device driver header is a pointer to the device header of the next device driver. It is a doubleword field set by PC DOS 7 at the time the device driver is loaded. The first word is an 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 header field to the offset of the next device driver′s header. Set the device header field of the last device driver to -1.

Attribute Field

The attribute field identifies the device to PC DOS 7.

Bit 15

Bit 15 identifies whether the device is a block device or a character device. If bit 15 is set to 0, this indicates a block device. Setting bit 15 to 1 indicates a character device. Note how the setting of bit 15 affects the interpretation of the setting of the bits below.

Bit 14

Bit 14, for both character and block devices, tells PC DOS 7 whether the device driver can handle control strings through IOCtl 44H, AL=2 through AL=5. Set bit 14 to 1 if control strings can be processed. IOCtl subfunctions permit the device driver to interpret the information passed to it, such as setting a baud rate or changing form lengths, without performing standard reads and writes. Set bit 14 to 0 if control strings cannot be processed. PC DOS 7 will return an error if an IOCtl is issued to send or receive control strings and bit 14 is set to 0.

Bit 13

Bit 13 is used for both block and character devices. For block devices, set bit 13 to 0 if the media is an IBM format. Set bit 13 to 1 if the media is a non-IBM format. For character devices, set bit 13 to 0 if the driver supports output-until-busy. Set bit 13 to 1 if it does not.

With the support of output-until-busy, the device driver will send characters to the device if the device is ready. If the device is not ready, the device driver will immediately return an error.

Bit 12

Bit 12 is reserved.

Bit 11

Set bit 11 if the device driver can handle removable media. This bit is called the open/close removable media bit.

Bits 10 – 8

Bits 10 through 8 are reserved.

Bit 7

For DOS 5.0 and later versions, set bit 7 to 1 to indicate that a device driver supports Query IOCtl. If this bit is set, the driver can be called with function 19H (with a standard Generic IOCtl request packet).

Bit 6

Bit 6 is the generic IOCtl bit for both character and block device drivers. If this bit is set to 1, the device driver supports generic IOCtl function calls. Setting this bit to 1 also indicates support of the Get/Set Logical Drive function for a block device driver.

Bits 5 and 4

Bits 5 and 4 are reserved.

Bit 3

Set bit 3 to 1 if the character device is a clock device; set bit 3 to 0 if it is not.

Bit 2

Set bit 2 to 1 if the character device is the NUL device; set bit 2 to 0 if it is not. Setting the bit tells PC DOS 7 whether the NUL device is being used. The NUL device cannot be reassigned.

Bit 1

If bit 15 is set to 1 for a character device, set bit 1 to 1 to indicate that the character device is the current standard output device. If bit 15 is set to 0 for a block device, set bit 1 to 1 to indicate support for 32-bit sector numbers; otherwise, 16-bit sector number support is assumed.

Bit 0

Set bit 0 to 1 if the character device is the current standard input device; set bit 0 to 0 if it is not the current standard input device.

Pointers to Strategy and Interrupt Routines

When PC DOS 7 passes a request to a device driver, it calls the device driver twice. These two fields point to the first and second entry points: the strategy routine and the interrupt routine. The fields are word values, so they must be in the same segment as the device header.

Name/Unit Field

These 8-byte fields identify a character device by name or a block device by unit. A character device name is left-justified followed by spaces, if necessary. For block devices, although PC DOS 7 automatically fills in this field with the value of number of units returned by INIT call, you may choose to place the number of units in the first place.

The Strategy Routine

PC DOS 7 calls a device driver at the strategy routine at first, passing in a request packet the information describing what PC DOS 7 wants the device driver to do.

The strategy routine does not perform the request but queues the request or saves a pointer to the request packet.

The Interrupt Routine

PC DOS 7 calls the device driver′s interrupt routine with no parameters immediately after the strategy routine returns. An interrupt routine′s function is to perform the operation based on the queued request, process any data in the request packet, and set up information being returned to PC DOS 7.

It is the responsibility of the device driver to preserve the system state. For example, the device driver must save all registers on entry and restore them on exit. The stack maintained by PC DOS 7 is used to save all registers. If more stack space is needed, it is the device driver′s responsibility to allocate and maintain an additional stack.

All calls to device drivers are FAR calls. FAR returns should be executed to return to PC DOS 7.

How PC DOS 7 Passes a Request

PC DOS 7 passes a pointer in ES:BX to the request packet. The packet consists of a request header that contains information common to all requests, followed by data pertinent to the request being made.

The structure of the request header is shown below.

Field	**Length**
Length of the request header and subsequent data	BYTE
Unit code for block devices only	BYTE
Command code	BYTE
Status	WORD
Reserved	8-BYTE
Data	VARIABLE

Length Field

The length field identifies the length of the request header and subsequent data in bytes.

Unit Code Field

The unit code field identifies the requesting unit in a block device driver. If a block device driver has three units defined, for example, the possible values for the unit code field are 0, 1, or 2.

Command Code Field

The command code identifies the request. See “Responding to Requests” on page 92 for a list of command code values and request descriptions.

Status Field

The status word field is zero on entry and is set by the driver interrupt routine on return.

Bit 15

Bit 15 is the error bit. If bit 15 is set to 1, the low order 8 bits of the status word (7-0) indicate the error code.

Bits 14 – 10

Bits 14 through 10 are reserved.

Bit 9

Bit 9 is the busy bit. As a response to status request call, character device drivers can set the busy bit to indicate whether or not a device is ready to perform input and output requests. Block device drivers can set the busy bit to indicate removable or nonremovable media. See “Character Input and Output Status Requests” on page 101 and “Removable Media Request” on page 103 for more information about the calls.

Bit 8

Bit 8 is the done bit. If set, the operation is complete. The driver sets the done bit to 1 when it exits.

Bits 7 – 0

Bits 7 through 0 are the low order 8 bits of the status word. If bit 15 is set, bits 7 through 0 contain the error codes. The error codes and errors are:

Codes	Meaning
00	Write protect violation
01	Unknown unit
02	Device not ready

03	Unknown command
04	CRC error
05	Bad drive request structure length
06	Seek error
07	Unknown media
08	Sector not found
09	Printer out of paper
0A	Write fault
0B	Read fault
0C	General failure
0D	Reserved
0E	Reserved
0F	Invalid disk change

Responding to Requests

Each request packet that is passed to the device driver contains a command code value in the request header to tell the driver which function to perform. The following table contains the PC DOS 7 device interface command code values and the functions to be performed when these values are passed with data. Note that some of these functions are specific to either a block device or a character device.

Following this table are detailed descriptions of request data structures and what the interrupt routines are expected to do. Some of these descriptions pertain to more than one command code.

Command Code	Request Description	Device Type
0	Initialization	Both
1	Media check	Block
2	Build BPB	Block
3	IOCtl input (called only if bit 14 of attribute is set to 1)	Both
4	Input (read)	Both
5	Nondestructive input no wait	Character
6	Input status	Character
7	Input flush	Character
8	Output (write)	Both
9	Output (write with verify)	Block
10 (0AH)	Output status	Character
11 (0BH)	Output flush	Character

Command Code	Request Description	Device Type
12 (0CH)	IOCtl output (called only if bit 14 of attribute is set to 1)	Character
13 (0DH)	Device open (called only if bit 11 of attribute is set to 1)	Both
14 (0EH)	Device close (called only if bit 11 of attribute is set to 1)	Both
15 (0FH)	Removable media (called only if bit 11 of attribute is set to 1)	Block
16 (10H)	Output until busy character	Both
19 (13H)	Generic IOCtl Request (called only if bit 6 of attribute is set to 1)	Block
23 (17H)	Get logical device (called only if bit 6 of attribute is set to 1)	Block
24 (18H)	Set logical device (called only if bit 6 of attribute is set to 1)	Block
25 (19H)	IOCtl Query (called only if bit 7 of attribute is set to 1)	Both

Initialization Request

Command Code = 0

Field	Length
Request header	13 – BYTE
Number of units (not set by character devices)	BYTE
Ending address of resident program code	DWORD
Pointer to BPB array (not set by character devices) pointer to remainder of arguments	DWORD
Drive number	BYTE
CONFIG.SYS Error Message control flag	WORD

The driver must do the following:

- Set the number of units (block devices only).
- Set up the pointer to the BPB array (block devices only).
- Perform any initialization code (to modems, printers, and others).
- Set the ending address of the resident program code.
- Set the status word in the request header.

To obtain information passed from CONFIG.SYS to a device driver at initialization time, the BPB pointer field points to a buffer containing the information passed in CONFIG.SYS following the =. This string may end with either a carriage return (0DH) or a linefeed (0AH). This information is read-only. Only system calls 01H–0CH and 30H can be issued by the initialization 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 and so forth.

If an initialization routine determines that it cannot set up the device and wants to terminate without using any memory, use the following procedure:

- Set the number of units to 0.
- Set the ending address offset to 0.
- Set the ending address segment to the code segment (CS).

For DOS 5.0 support; when loading device drivers into UMBs (Upper Memory Blocks), PC DOS 7 sets the maximum address that is available to the device driver in the INIT request packet. This is stored in the ending address field before the device's INIT function is called. The value is the normalized address of the top of the memory block that is allocated to the driver. This is done before devices complete initialization so memory requirements can be checked against the amount of space available. If there is not enough space for a device's code and data requirements, they will fail to load.

Block device drivers must account for the space needed for a Disk Parameter Block per unit supported. The amount of space needed for a block device driver is:

(end address) - (number of units * DPB size)

If there are multiple device drivers in a single memory image file, the ending address returned by the last initialization called is the one PC DOS 7 uses. IBM recommends that all device drivers in a single memory image file return the same ending address.

If initialization of your device driver fails, and you want the system to display the `Error in Config.Sys line #` error message, set the CONFIG.SYS error message control flag to a non-zero value.

Media Check Request

Command code = 1

Field	Length
Request header	13 – BYTE
Media descriptor from PC DOS 7	BYTE

Field	Length
Return	BYTE
A pointer to the previous volume ID (if bit 11 = 1 and disk change is returned)	DWORD

When the command code field is 1, PC DOS 7 calls Media Check for a drive unit and passes its current Media Descriptor byte. See “Media Descriptor Byte.” Media Check returns one of the following:

- Media not changed
- Media changed
- Not sure
- Error code.

The driver must perform the following:

- Set the status word in the request header.
- Set the return byte to:

  -1 for “media changed”
  0 for “not sure”
  1 for “media not changed.”

The driver uses the following method to determine how to set the return byte:

- If the media is nonremovable (a hard disk), set the return byte to 1.
- If less than 2 seconds since last successful access, set the return byte to 1.
- If changeline not available, set the return byte to 0.
- If changeline is available but not active, set the return byte to 1.
- If the media byte in the new BPB does not match the old media byte, set the return byte to -1.
- If the current volume ID matches the previous volume ID, or if the serial number matches the previous serial number, set the return byte to 0.

Media Descriptor Byte

Currently the media descriptor byte has been defined for some media types. This byte should be identical to the media byte if the device has the non-IBM format bit off. These predefined values are:

```
Media descriptor
    byte —>      1 1 1 1 1 x x x
    bits —>      7 6 5 4 3 2 1 0
```

Bit	Meaning	
0	1=2-sided	0=not 2-sided
1	1=8 sector	0=not 8 sector
2	1=removable	0=not removable
3–7	must be set to 1	

Note: An exception to the above is the media descriptor byte value of F0, which is used to indicate any media types not defined, and F9, which is used for 5.25-inch media with 2 sides and 15 sectors/tracks.

Examples of current PC DOS 7 media descriptor bytes:

Disk Type	# Sides	Sectors/ Track	Media Descriptor
hard disk	--	--	F8H
5.25 inch	2	15	F9H
5.25 inch	1	9	FCH
5.25 inch	2	9	FDH
5.25 inch	1	8	FEH
5.25 inch	2	8	FFH
8 inch	1	26	FEH
8 inch	2	26	FDH
8 inch	2	8	FEH
3.5 inch	2	9	F9H
3.5 inch	2	18	F0H
3.5 inch	2	36	F0H
3.5 inch Read/Write Optical	1	25	F0H

To determine whether you are using a single-sided or a double-sided diskette, attempt to read the second side. If an error occurs, you may assume the diskette is single-sided. Media descriptor F0H may be used for those media types not described earlier. Programs should not use the media descriptor values to distinguish media. PC DOS 7 internal routines use information in the BIOS parameter block (BPB) to determine the media type of IBM-formatted diskettes. These media descriptor bytes do not necessarily indicate a unique media type.

For 8-inch diskettes:

- FEH (IBM 3740 Format) — Single-sided, single-density, 128 bytes per sector, soft-sectored, 4 sectors per allocation unit, 1 reserved sector, 2 FATs, 68 directory entries, 77*26 sectors.
- FDH (IBM 3740 Format) — Double-sided, single-density, 128 bytes per sector, soft-sectored, 4 sectors per allocation unit, 4 reserved sectors, 2 FATs, 68 directory entries, 77*26*2 sectors.
- FEH — Double-sided, double-density, 1024 bytes per sector, soft sectored, 1 sector per allocation unit, 1 reserved sector, 2 FATs, 192 directory entries, 77*8*2 sectors.

Build BPB Request

Command Code = 2

Field	Length
Request header	13 – BYTE
Media descriptor from PC DOS 7	BYTE
Transfer address (buffer address)	DWORD
Pointer to BPB table	DWORD

PC DOS 7 calls Build BPB (BIOS Parameter Block) under the following two conditions:

- If “Media Changed” is returned
- If “Not Sure” is returned, there are no used buffers. Used buffers are buffers with changed data not yet written to the disk.

The driver must do the following:

- Set the pointer to the BPB
- Set the status word in the request header.

The device driver must determine the media type that is in the unit to return the pointer to the BPB table. In previous versions of IBMBIO, the FAT ID byte determined the structure and layout of the media. The FAT ID byte has only eight possible values (F8 through FF), so, as new media types are invented, the available values will soon be exhausted. With the varying media layouts, PC DOS 7 needs to be aware of the location of the FATs and directories before it asks to read them.

The following paragraphs explain the method PC DOS 7 uses to determine the media type.

The information relating to the BPB for a particular media is kept in the boot sector for the media. The following is a summary of the format of the boot sector.

Field	Length
A 2-byte short JMP instruction (EBH), followed by a NOP instruction (90H).	WORD
Product name and version	8 BYTES
Bytes per sector; must be power of 2	WORD
Sectors per allocation unit; must be power of 2	BYTE
Reserved sectors starting at logical sector 0	WORD
Number of FATs	BYTE
Maximum number of root directory entries	WORD
Total number of sectors in media including the boot sector, FAT areas, and directories	WORD
Media descriptor	BYTE
Number of sectors occupied by a FAT	WORD
Sectors per track	WORD
Number of heads	WORD
Number of hidden sectors	WORD

The BPB information contained in the boot sector starts with the Bytes per Sector entry. The last three words are intended to help the device driver identify the media. The number of heads is useful for supporting different multihead drives with the same storage capacity but a different number of surfaces. The number of hidden sectors is useful for supporting drive partitioning schemes.

For drivers that support volume identification and disk change, this call causes a new volume identification to be read from the disk. This call indicates that the disk has changed in a permissible manner.

To handle the partition that is bigger than 32MB, or one that starts beyond or crosses the 32MB boundary, PC DOS 7 defines an extended BPB structure. Depending on the size of the media, you can use either the existing BPB or the extended one, which contains an additional DWORD field to indicate the size of the partition in sectors.

Bit 1 of the attribute field in the block device driver header indicates whether the device can process 32-bit sector numbers. Set bit 1 to indicate 32-bit support.

Field	Length
Bytes per sector	WORD
Sectors per allocation unit	BYTE
Reserved sectors starting at logical sector 0	WORD
Number of FATs — 0 if not a FAT system	BYTE
Maximum number of root directory entries	WORD
Total number of sectors in the media. This field is used to define a partition that is less than 32MB. Setting this field to 0 indicates to use the total (32-bit) number of sectors in the media below.	WORD
Media descriptor	BYTE
Number of sectors occupied by a FAT	WORD
Sectors per track	WORD
Number of heads	WORD
Number of hidden sectors	DWORD
Total (32-bit) number of sectors in the media. This field is used to define a partition that is greater than 32MB, or one that crosses the 32MB boundary.	DWORD

The extended BPB is a superset of the traditional BPB structure. To achieve the maximum compatibility between this structure and that of the traditional BPB, PC DOS 7 uses the following rules:

- If the number of hidden sectors plus the total number of sectors in the media is greater than 64KB, use the 32-bit total number of sectors in the media entry (DWORD).
- Otherwise, use the **Total number of sectors in the media** entry (WORD).

A boot record exists at the beginning of each disk partition and each extended PC DOS 7 partition volume. PC DOS 7 automatically creates the extended boot record. The format of the extended boot record is:

Field	Length
A 2-byte short JMP instruction (EBH) followed by a NOP instruction (90H).	WORD
Product name and version	8 BYTES
Extended BPB	25 BYTES
Physical drive number	BYTE
Reserved	BYTE
Extended boot record signature	BYTE
Volume serial number	DWORD
Volume label	11 BYTES
Reserved	8 BYTES

Note: The value of Extended boot record signature is 29H. The value of the physical drive number is always 0H or 80H.

On all requests to extended drivers with a sector number in their request headers, the sector number is a DWORD. The standard PC DOS 7 block device drivers set the attribute bit 1 for 32-bit support.

For each call to a device driver, PC DOS 7 checks to see if the starting sector number passed in the request can be supported by the device driver. If this value is greater than 64K for an old-style device driver, PC DOS 7 returns an `unknown media` (07H) device driver error.

Input and Output Requests

Command Codes = 3, 4, 8, 9, 12 (0CH)

Field	Length
Request header	13 – BYTE
Media descriptor byte	BYTE
Transfer address (buffer address)	DWORD
Byte/sector count	WORD
Starting sector number (If -1, use DWORD starting sector number. This entry has no meaning for a character device.)	WORD
For DOS 3.0 to PC DOS 7, pointer to the volume identification if error code 0FH is returned	DWORD
Starting 32-bit sector number. (Use this entry to the block device driver with the attribute bit 1 set.)	DWORD

The PC DOS 7 **Input/Output** request structure can process 32-bit sector numbers, providing support for media of more than 4 billion sectors.

The driver must do the following:

- Set the status word in the request header
- Perform the requested function
- Set the actual number of sectors or bytes transferred.

No error checking is performed on an IOCtl call. However, the driver must set the return sector or byte count to the actual number of bytes transferred.

Under certain circumstances the block device driver may be asked to do a WRITE operation of 64KB that seems to be a *wraparound* of the transfer address in the device driver request packet. It will only happen on WRITEs that are within a sector size of 64KB on files that are being extended past the current end of file. The block device driver is allowed to ignore the balance of the WRITE that wraps around. For example, a WRITE of 10000H bytes of sectors with a transfer address of XXXX:1 ignores the last two bytes.

Remember that a program using PC DOS 7 function calls cannot request an input or output operation of more than FFFFH bytes because a wrap around in the transfer buffer segment would occur. Bytes will be ignored that would have wrapped around in the transfer segment.

If the driver returns an error code of 0FH (Invalid Disk Change), it must provide a DWORD pointer to an ASCIIZ string identifying the correct volume ID and the system prompts the user to reinsert the disk.

The reference count of open files on the disk maintained by 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 valid, and error 0FH is not returned. If there are open files (reference count > 0) and the disk has been changed, an error 0FH situation may exist. PC DOS 7 IBMDOS.COM will request an OPEN or CLOSE function only if SHARE is loaded.

Nondestructive Input No Wait Request

Command Code = 5

Field	Length
Request header	13-BYTE
Byte read from device	BYTE

The driver must do the following:

- Return a byte from the device.
- Set the status word in the request header.

If the character device returns busy bit = 0, meaning there are characters in buffer, the next character that would be read is returned. This character is not removed from the input buffer (that is, nondestructive input). This call allows PC DOS 7 to look ahead one input character.

Character Input and Output Status Requests

Command Codes = 6, 10 (0AH)

Field	Length
Request header	13-BYTE

The driver must do the following:

- Perform the requested function.
- Set the busy bit.
- Set the status word in the request header.

The busy bit is set differently for output and input.

Output on Character Devices

If the busy bit is 1 on return, a write request would wait for completion of a current request. If the busy bit is 0, no request is waiting or running. Therefore, a write request would start immediately.

Input on Character Devices with a Buffer

If the busy bit is 1 on return, a read request goes to the physical device. If the busy bit is 0, characters are in the device buffer and a read returns quickly. This also indicates that the user has typed something. PC DOS 7 assumes that all character devices have a type-ahead input buffer. Devices that do not have this buffer should always return busy = 0 so that PC DOS 7 does not loop endlessly, waiting for information to be put in a buffer that does not exist.

Character Input and Output Flush Requests

Command Codes = 7, 11 (0BH)

Field	Length
Request header	13-BYTE

This call tells the driver to flush (terminate) all pending requests of which it has knowledge. 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.

Open and Close Requests

Command Codes = 13 (0DH), 14 (0EH)

Field	Length
Request header	13-BYTE

These calls are designed to give the device information about 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 increases the reference count. Every CLOSE decreases the device reference count. When the reference count is 0, there are no open files on the device. Therefore, the device should flush buffers inside the device to which it has written because the user can change the media on a removable media drive. If the media has been changed, reset the reference count to 0 without flushing the buffers.

These calls are more useful on character devices. The OPEN call can send a device an initialization string. On a printer, the call can send a string to set the font or the page size so the printer is always in a known state at the start of an I/O stream.

Similarly, the CLOSE call can send a post string, such as a form feed, at the end of an I/O stream.

Using IOCtl to set the preliminary and ending strings provides a flexible mechanism for serial I/O device stream control.

Removable Media Request

Command Code = 15 (**0FH**)

Field	**Length**
Request header	13-BYTE

To use this call, set bit 11 of the attribute field to 1. Block devices can use this call only by way of a subfunction of the IOCtl function call (44H).

This call is useful because it notifies a utility if it is dealing with a removable or nonremovable media drive. For example, the FORMAT utility needs to know whether a drive is removable or nonremovable because it displays different versions of some prompts.

The information is returned in the busy bit of the status word. If the busy bit is 1, the media is nonremovable. If the busy bit is 0, the media is removable.

No error bit checking is performed. It is assumed that this call always succeeds.

Output Until Busy

Command Code = 16 (10H)

Field	Length
Request header	13-BYTE
Transfer Address	Dword
Byte Count	Word

The driver must set the status in the request header. The actual bytes are transferred in the byte count word.

This function transfers data from the specified memory buffer to a device until it is busy. It is called only if bit 13 of the device attribute word is set in the device header. This function is not in error if it returns with the number of bytes transferred less than the number of bytes requested.

Generic IOCTL Request

Command Code = 19 (13H)

Field	Length
Request header	13-BYTE
Major function	BYTE
Minor function	BYTE
Contents of SI	WORD
Contents of DI	WORD
Pointer to Generic IOCTL request packet	DWORD

The driver must:

- Support the functions described under Generic IOCtl request
- Maintain its own track table (TrackLayout).

See Appendix C, "I/O Control for Devices (IOCtl)" on page 273 for a description of the functions provided by generic IOCtl requests.

Get Logical Device Request

Command Code = 23 (17H)

Field	Length
Request header length (see note below)	BYTE
Input (unit code)	BYTE

Field	Length
Command code	BYTE
Status	WORD
Reserved	8 BYTES

Upon return, the unit code is the last unit referenced or zero and the status word is updated.

Set Logical Device Request

Command Code = 24 (**18H**)

Field	Length
Request header length (see note below)	BYTE
Input (unit code)	BYTE
Command code	BYTE
Status	WORD
Reserved	8 BYTES

Upon return, the status word is updated.

Note: Length value includes the length byte itself.

IOCtl Query

Command Code = 25 (**19H**)

Field	Length
Request header	13-BYTE
Major function	BYTE
Minor function	BYTE
Contents of SI	WORD
Contents of DI	WORD
Pointer to Generic IOCtl request packet	DWORD

The driver must:

- Support the functions described under Generic IOCtl request
- Maintain its own track table (TrackLayout).

A driver indicates that it supports Query IOCtl by setting bit 7 of the device attribute word. If this bit is set, the driver can be called, with function 19H, with a standard Generic IOCtl request packet. If it is not set, the driver will never receive Query IOCtl calls.

The driver should check the category code and function number in the request packet and return a no error signal if it can handle the call. If the driver cannot handle the call, it should return the Unknown Command error code (error code 3). Usually, a program that wants to use Generic IOCtl calls beyond those in DOS 3.2 will call Query IOCtlHandle or Query IOCtlDevice first. Then it will determine if the particular call is supported, and finally call the actual function.

See Appendix C, "I/O Control for Devices (IOCtl)" on page 273 for a description of the functions provided by generic IOCtl requests.

Appendix A. PC DOS 7 Interrupts

This chapter contains information to support use of the PC DOS 7 interrupts.

PC DOS 7 reserves interrupt types 20H to 3FH for its use. Absolute memory locations 80H to FFH are reserved by PC DOS 7. All interrupt values are in hexadecimal.

Interrupt 20H Program Terminate

Issue interrupt 20H to exit from a program. This vector transfers to the logic in PC DOS 7 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 file buffers are flushed and all handles are closed. You should close all files changed in length (see function call 10H and 3EH) before issuing this interrupt. If the changed file is not closed, its length, date, and time 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 interrupt 20H, and the codes returned by them can be interrogated in batch processing. See function call 4CH for information on the ERRORLEVEL subcommand of batch processing.

Important: Before you issue interrupt 20H, your program must ensure that the CS register contains the segment address of its program segment prefix.

Interrupt 21H Function Request

Refer to each function call issued within 21H in Appendix B, “PC DOS 7 Function Calls” on page 133.

Interrupt 22H Terminate Address

Control transfers to the address at this interrupt location when the program terminates. This address is copied into the program′s Program Segment Prefix at the time the segment is created. You should not issue this interrupt; the EXEC function call does this for you.

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Interrupt 23H Ctrl-Break Exit Address

If the user presses the Ctrl and Break keys during standard input, standard output, standard printer, or asynchronous communications adapter operations, an interrupt 23H is executed. If BREAK is on, the interrupt 23H is checked on most function calls (except calls 06H and 07H). 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 ended. If the carry flag is set, the program is ended, otherwise execution continues (as with a return by IRET).

If the user-written Ctrl-Break interrupt uses function calls 09H or 0AH, then ∧C, carriage-return and linefeed are output. 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 PC DOS 7 was made. There are no restrictions on what the Ctrl-Break handler is allowed to do, including PC DOS 7 function calls, as long as the registers are unchanged if IRET is used.

When the program creates a new segment and loads in a second program it changes the Ctrl-Break address. The termination of the second program and return to the first causes the Ctrl-Break address to be restored to the value it had before execution of the second program. It is restored from the second program′s Program Segment Prefix. You should not issue this interrupt.

Interrupt 24H Critical Error Handler Vector

A critical error is returned when a DOS function cannot be performed. This error is frequently caused by a hardware condition, such as the printer being out of paper, a diskette drive door open, or a diskette out of space. When a critical error occurs within PC DOS 7, control is transferred with an interrupt 24H. On entry to the error handler, AH will have its bit 7=0 (high-order bit) if the error was a disk error (the most common occurrence), bit 7=1 if it was not.

BP:SI contains the address of a Device Header Control Block from which additional information can be retrieved. *See page* 112.

The registers are 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 error codes follow:

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

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

IP	PC DOS 7 registers from issuing INT 24H
CS	
FLAGS	
AX	User registers at time of original
BX	INT 21H request
CX	
DX	
SI	
DI	
BP	
DS	
ES	
IP	From the original interrupt 21H
CS	from the user to PC DOS 7
FLAGS	

The registers are set such that if an IRET is executed, PC DOS 7 responds according to (AL) as follows:

(AL) = 0 ignore the error.
= 1 retry the operation.
= 2 terminate the program through interrupt 22H.
= 3 fail the system call in progress.

Note: Be careful when choosing ignore as a response because this causes PC DOS 7 to believe that an operation has completed successfully when it may not have.

To return control from the critical error handler to a user error routine, the following should occur:

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 receives control, it should push the flag register onto the stack, and then execute a CALL FAR to the original INT 24H vector saved in step 1.
3. PC DOS 7 gives the appropriate prompt, and waits for the user input (Abort, Retry, Fail or Ignore). After the user input, PC DOS 7 returns control to the user error routine at the instruction following the CALL FAR.
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 point.

Disk Errors

If it is a hard error on disk (AH bit 7=0), register AL contains the failing drive number (0 = drive A, and so on). AH bits 0–2 indicate the affected disk area and whether it was a read or write operation, as follows:

```
Bit 0=0 if read operation,
      1 if write operation
Bits 2-1  (affected disk area)
        0 0   PC DOS 7 area
        0 1   file allocation table
        1 0   directory
        1 1   data area
```

AH bits 3–5 indicate which responses are valid. They are:

```
Bit 3=0 if FAIL is not allowed
     =1 if FAIL is allowed
Bit 4=0 if RETRY is not allowed
     =1 if RETRY is allowed
Bit 5=0 if IGNORE is not allowed
```

=1 if IGNORE is allowed

Handling of Invalid Responses

If IGNORE is specified (AL=0) and IGNORE is not allowed (bit 5=0), make the response FAIL (AL=3).

If RETRY is specified (AL=1) and RETRY is not allowed (bit 4=0), make the response FAIL (AL=3).

If FAIL is specified (AL=3) and FAIL is not allowed (bit 3=0), make the response END (AL=2).

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.

Notes:

1. Retry five times before giving this routine control for disk errors. When the errors are in the FAT or a directory, retry three times.
2. For disk errors, this exit is taken only for errors occurring during an interrupt 21H function call. It is not used for errors during an interrupt 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 PC DOS 7 function calls. If necessary, it may use calls 01H through 0CH, 30H, and 59H. Use of any other call destroys the PC DOS 7 stack and leaves PC DOS 7 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 PC DOS 7, 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, PC DOS 7 will be in an unstable state until a function call higher than 0CH is issued; therefore, it is not recommended.

The recommended way to end a critical error is to use FAIL and then test the extended error code of the INT 21H.

8. IGNORE requests (AL=0) are converted to FAIL for critical errors that occur on FAT or DIR sectors.
9. Refer to "Responding to Errors" on page 138 and "Extended Error Codes" on page 138 for information on how to obtain additional error information.
10. For PC DOS 7, IGNORE requests (AL=0) are converted to FAIL requests for certain critical errors (50–79).

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

DWORD Pointer to next device (FFFFH if last device)
WORD Attributes: Bit 15 = 1 if character device = 0 if block 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 14 is the IOCtl bit
WORD pointer to device driver strategy entry point.
WORD pointer to device driver interrupt entry point.
8-BYTE character device named field for block devices. The first byte is the number of units.

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).

If the name of the character device is desired, look at the eight bytes starting at BP:SI+10.

Interrupt 25H/26H Absolute Disk Read/Write

Interrupt vectors 25H and 26H transfer control to the device driver. They have been extended to allow direct access to media greater than 32MB in size. Their use of the CX register is what distinguishes them from the conventional 25H and 26H interrupts. Note that if the conventional format parameters are used in an attempt to access media greater than 32MB, an error code of 0207H is returned in AX.

The request for extended 25H or 26H is:

```
        MOV     AL,DRIVE            ; Drive number to process
                                    ; 0 = A
                                    ; 1 = B
                                    ; 2 = C . . .
        MOV     BX,SEG PACKET       ; Parameter list
        MOV     DS,BX               ;
        MOV     BX,OFFSET PACKET    ;
        MOV     CX,-1               ; Indicates extended format
        INT     25H or 26H          ; Issue request to PC DOS 7
        POP     AX                  ; Discard stack word
        JC      ERROR               ; Error code returned in AX


PACKET  LABEL   BYTE                ; Control packet
        DD      RBA                 ; RBA of first sector
                                    ; (0 origin)
        DW      COUNT               ; Number of sectors to I/O
        DD      BUFFER              ; Data buffer
```

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. Be sure to pop the stack to prevent uncontrolled growth.

Warning: If disk I/O handled by this interrupt exceeds the limit imposed by the 64KB direct memory access boundary, unpredictable results can occur. We recommend you carefully check the sector size and the number of sectors to be read or written to before issuing this call.

The number of sectors specified is transferred between the given drive and the transfer address. *Logical sector numbers* (LSN) 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 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 the disk, because of interleaving. Note that the mapping is different from that used by DOS version 1.10 for double-sided diskettes.

All registers except the segment registers are destroyed by this call. If the transfer was successful, the carry flag (CF) is 0. If the transfer was not successful CF=1 and (AX) indicate the error as follows. (AL) is the PC DOS 7 error code that is the same as the error code returned in the low byte of DI when an interrupt 24H is issued, and (AH) contains:

80H	Attachment failed to respond
40H	SEEK operation failed
08H	Bad CRC on diskette read
04H	Requested sector not found
03H	Write attempt on write-protected diskette
02H	Error other than types listed above

Warning: Before issuing this interrupt to removable media, the media in the drive must be established correctly. This can be accomplished by issuing either an INT 21H Generic IOCTL (AH=44H), with a request to return the BPB that BUILD BPB returns; or an INT 21H Get Current Directory (AH=47H).

Interrupt 27H Terminate but Stay Resident

This vector is used by programs that are to remain resident when COMMAND.COM regains control.

PC DOS 7 function call 31H is the preferred method to cause a program to remain resident, because this allows return information to be passed. It allows a program larger than 64KB to remain resident. 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), and then execute an interrupt 27H. PC DOS 7 then considers the program as an extension of itself, so the program is not overlaid when other programs are executed. This concept is useful for loading programs such as user-written interrupt handlers that must remain resident.

Notes:

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 64KB.
4. Memory can be used more efficiently 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 2C of the PSP, and issuing function call 49H (Free Allocated Memory).
5. PC DOS 7 function call 4CH allows the terminating program to pass a completion (or error) code to PC DOS 7, which can be interpreted within batch processing (see function call 31H).

6. Terminate-but-stay-resident function calls do not automatically close files.

Interrupt 28H–2EH Reserved for PC DOS 7

These interrupts are reserved for PC DOS 7 use.

Interrupt 2FH Multiplex Interrupt

Interrupt 2FH is the multiplex interrupt. A general interface is defined between two processes. The specific application using interrupt 2FH defines specific functions and parameters.

Every multiplex interrupt handler is assigned a specific multiplex number. The multiplex number is specified in the AH register. The specific function that the handler is to perform is specified in the AL register. Other parameters are placed in the other registers, as needed. The handlers are chained into the interrupt 2FH interrupt vector. There is no defined method for assigning a multiplex number to a handler. You must pick one. To avoid a conflict if two applications choose the same multiplex number, the multiplex numbers used by an application should be patchable.

The multiplex numbers AH=00H through BFH are reserved for PC DOS 7. Applications should use multiplex numbers C0H through FFH.

Note: When in the chain for interrupt 2FH, if your code calls PC DOS 7 or if you execute with interrupts enabled, your code must be reentrant and recursive.

Interrupt 2FH Function AH=01H PRINT.COM Function Installed State

The following table contains the function codes that you can specify in AL to request the resident portion of print to perform a specific function:

Function Codes (in AL)	Description
0	Get installed state
1	Submit file
2	Cancel file
3	Cancel all files
4	Status
5	End of status

Print Error Codes

The following table contains the error codes that are returned from the resident portion of print. (Carry flag is set.)

Error Codes (in AX)	Description
1	Invalid function
2	File not found
3	Path not found
4	Too many open files
5	Access denied
6	Queue full
9	Busy
12	Name too long
15	Invalid drive

AL=0 Get Installed State

This call must be defined by all interrupt 2FH handlers. It is used by the caller of the handler to determine if the handler is present. On entry, AL=0, AH=1. On return, AL contains the installed state as follows:

AL=0 Not installed, permissible to install

AL=1 Not installed, not permissible to install

AL=FF Installed

AL=1 Submit File

On entry, AL=1, AH=1, and DS:DX points to the submit packet. A submit packet contains the level (BYTE) and a pointer to the ASCIIZ string (DWORD in offset segment form). The level value for PC DOS 7 is 0. The ASCIIZ string must contain the drive, path, and filename of the file you want to print. The filename cannot contain global filename characters.

AL=2 Cancel File

On entry, AL=2, AH=1, and DS:DX points to the ASCIIZ string for the print file you want to cancel. Global filename characters are allowed in the filename.

AL=3 Cancel all Files

On entry, AL=3 and AH=1.

AL=4 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, AH=1. On return, DX contains the error count. The error count is the number of consecutive failures PRINT had while trying to output the last character. If there are no failures, the number is 0. DS:SI points to the print queue. The print queue 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 a queue entry having a null as the first character.

AL=5 End of Status

Issue this call to release the queue from call 4. On entry, AL=5 and AH=1. On return, AX contains the error codes. For information on the error codes returned, refer to "Print Error Codes" on page 116.

AL=F8 – FF Reserved by PC DOS 7

Interrupt 2FH Function AH=06H Get ASSIGN.COM Installed State

(AL=0) is supported.

Interrupt 2FH Function AH=10H Get SHARE.EXE Installed State

AH=10H is the resident part of SHARE. The Get Installed State function (AL=0) is supported.

Interrupt 2FH Function AX=1680H DOS Idle Call

Many applications execute busy loops. This is usually while the application waits for the user to type something or to respond in some way. Informing the operating system that the application is idle offers some benefits:

- Power-management software can make decisions about how to conserve energy on the system.
- Multitasking software can save time by not giving CPU cycles to tasks that are idle.

This API (applications program interface) should be used by all PC DOS 7 applications to indicate when they are idle. To prevent halting the system, applications should check the Int 2FH vector to see that it is not zero before issuing the first idle call. If the API is supported in the environment you are in, the Int 2FH will return with AL=0; otherwise, it will return with AL unchanged (80H). Applications are not usually interested in the return value.

This API is non blocking. This means an application's execution would continue after issuing this API. Your program should contain an idle loop that re-issues this interrupt if the application stays in the idle state.

DOSDOCK API

In order to provide communication between the PC DOS 7 docking support programs some new multiplex interrupt functions are being defined in PC DOS 7. The following API's are defined and used for docking support in PC DOS 7.

Interrupt 2FH Function 2000H - Check DOSDOCK Installation

This function is being defined to allow a caller to determine if the DOSDOCK program is resident.

```
Called with:
  AX = 2000H

Returns:
  AL = 00H DOSDOCK program not installed
  AL = FFH DOSDOCK program resident
```

Interrupt 2FH Function 2001H - Get Docking Event

This function allows the caller to determine if a docking event has occured. An application can use this interrupt to determine if a docking event has occured rather than poll the PnP Bios. After making this call the event flag is reset to 0.

```
Called with:
  AX = 2001H

Returns:
  AL = 00H No Event
  AL = 01H Docking Event Occured
  AL = 21H Undocking Event Occured
```

Interrupt 2FH Function 2002H - Get Current Dock Status

This function returns the current dock state (docked or undocked). An application can use this interrupt to determine the current dock state of the machine. This flag is modified when a docking event occurs to the new dock state.

```
Called with:
  AX = 2002H

Returns:
  AL = 00H Machine is not Docked
  AL = 01H Machine is Docked
```

Interrupt 2FH Function AX=43E0H DOS Protected Mode Services Check

Please refer to Appendix E, "DOS Protected Mode Services" on page 313 for details of this function call along with the Interrupt 31H calls to the DPMS driver.

Interrupt 2FH Advanced Power Management Driver

All power management functions are accessed through subfunctions of interrupt 2FH, function 54H and 53H. The following table lists the subfunctions. In all calls, undefined bits are reserved and should be set to 0.

The following INT 2Fh APIs (Application Program Interfaces) are defined for DOS APM driver (POWER.EXE) which is APM 1.0 compliant.

INT 2F Function	Description
5400	Detect POWER.EXE
5401	Get or set power status
5402	Get or set idle detection strategy
5403	Get or set power saving level
5481	Get idle statistics
5482	Get or set APM polling frequency

The DOS INT 2Fh APIs for APM driver (POWER.EXE) that is 1.1 compliant do not exist from the APM Committee (Microsoft and Intel). The intent of this document is to propose a standard for APM driver (POWER.EXE 1.01), INT 2Fh APIs that can utilize APM 1.1 BIOS functionality. The following are the DOS INT 2Fh APIs that are proposed as a standard for APM driver.

INT 2F Function	Description
530C	PM Event First Phase Broadcast
5404	Get Device Power State
5405	Set Device Power State
5406	Enable/Disable device power state
5407	Engage/Disengage power management

The intent of these API's is to give POWER.EXE control over specific unit device, thus resulting in a greater savings to the system unit battery life as compared to an application coded to the POWER.EXE 1.0 API's.

Interrupt 2FH Function AX=530BH PM Event Broadcast

```
ENTRY:
          AX    530BH
          BX    0001h      ; System standby request
                0002h      ; System suspend request
                0003h      ; Normal Resume notification
                0004h      ; Critical Resume notification
                0005h      ; Battery low notification
```

```
           *     0006h      ; Power Status Change Notification        (1.1)
           *     0007h      ; Update Time Notification                (1.1)
           *     0008h      ; Critical System Suspend Notification    (1.1)
           *     0009h      ; User System Standby Request Notification (1.1)
           *     000Ah      ; User System Suspend Request Notification (1.1)
           *     000Bh      ; System Standby Resume Notification      (1.1)
EXIT:
           BH    80h     ; An application has rejected the
                           system standby or request.
                 0       ; Otherwise
```

POWER polls the APM firmware periodically for messages. These messages are sent to all applicable APM applications. The broadcasted message is an INT 2FH, function 530BH. When POWER polls the APM firmware and detects a request to switch to the system standby or suspend states, the POWER device driver broadcasts this message and waits for this interrupt to return. Handlers of this interrupt can reject these two request. When a request is rejected by setting BH=80H, POWER sends a state change message to the APM firmware. The APM firmware might still change power states in a critical power situation.

An application that receives a system or standby request might choose to reject it if the application is in a critical section of code. In some other cases, it will prepare for suspend by saving its state and then passing on the request. Any handler of this message must pass it down the INT 2FH chain (even when rejecting the request). This notifies the other handlers of the request. Even when a request has been rejected, APM might still choose to enter the suspend state (particularly in a critical low power situation).

The three notifications (normal resume, critical resume, and battery low) also might cause applications to respond.

All undefined bits are reserved and should be ignored until they are defined.

Note: This interrupt is provided only for passing on information. It is sent during a timer tick. So, processing this interrupt should be as fast as possible. Applications in a critical state should reject this call and should not attempt to do any maintenance work that results in an inordinate delay during the interrupt. Calling DOS or ROM bios functions is not allowed.

Interrupt 2FH Function AH=530CH PM Event First Phase Broadcast (1.1)

```
ENTRY:
          AX    530CH
          BX    0001h      ; System_Standby_OK
                0002h      ; System_Suspend_OK
                0009h      ; User_System_Standby_OK
                000Ah      ; User_System_Suspend_OK
EXIT:
          BH    80h     ; An application has rejected the request
                0       ; Otherwise
```

1.1 compliant:

The PM Event First Phase Broadcast (INT 2Fh, AX = 530Ch) API is defined for POWER.EXE 1.01 that broadcasts first phase PM events for the two phase protocol. The following definition allows consistency to the PM events defined at INT 15h level.

Accessing POWER.EXE Controls

Detect POWER.EXE

```
ENTRY:

        AX      5400H

EXIT:

        AX      5400H             ;If POWER.EXE is not installed
                Version number    ;If POWER.EXE is installed
        BH      50H               ;ASCII "P" character
        BL      4DH               ;ASCII "M" character
```

This call must be made before any calls are made to other APIs. This is done to ensure that calls to POWER are only made when the driver is present.

Get or Set Power Status

```
ENTRY:

        AX      5401H             ;Get or set power status
        BH      0                 ;Get power status
                1                 ;Set power status
        BL      Bit 0             ;POWER.EXE power management
                                  ;switch (0=off, 1=on)
                Bit 1             ;APM firmware power management
                                  ;switch (0=off, 1=on)
```

```
            Bits 2-7          ;Reserved (set to 0)

EXIT:

        AX      0                 ;Operation successful
                02H               ;ERROR_PM_ALREADY_CONNECTED
                03H               ;ERROR_PM_NOT_CONNECTED
                87H               ;ERROR_PM_INVALID_PARAMETER
        BL                        ;Current power status
        BH                        ;Power status before call
```

This function allows selection among any of the combinations of software and hardware power management ON or OFF, as follows:

- POWER=0, APM=0 - Function for all power management is disabled. This is equivalent to POWER OFF.
- POWER=0, APM=1 - Power management at the software level is disabled. Software idle detection and APM event broadcast to applications are disabled. APM firmware power management is enabled. This is equivalent to POWER STD.
- POWER=1, APM=1 - This is true advanced power management. Bidirectional communication between POWER.EXE and the APM firmware is established. POWER.EXE will send CPU_IDLE messages while the APM firmware is posting power events to be read and broadcasted by POWER.EXE. This is equivalent to POWER ADV.

If there is no APM firmware, APM=1 is ignored

Get or Set Idle Detection Strategy

```
ENTRY:

        AX      5402H             ;Get or set idle detection strategy
        BH      0                 ;Get current strategy
                1                 ;Set current strategy
        BL      Bit 0             ;Use INT 16H function 1/11
                                  ;(keyboard idle)
                Bit 1             ;Use INT 28H (DOS idle)
                Bit 2             ;Use INT 2FH function 1680
                                  ;(application)
                Bit 3             ;Use INT 2AH
                Bits 4-7          ;Reserved

EXIT:

        BX                        ;Current savings level (1-8)
```

Interrupt 2FH triggers as soon as it is received. Interrupts 16H and 28H are monitored over a period of time. The interrupt (16H or 28H) that occurs most often is the one used to trigger idles.

An entry value of 0FFH in BL enables all strategies. A value of 0 disables idle detection through these interrupts (but broadcast of PM events is enabled). Use get or set power status to enable or disable power management.

Get or Set POWER Saving Level

```
ENTRY:

        AX      5403H           ;Get or set power saving level
        BX      0               ;Get current saving level
                1-8             ;Set saving level to given number

EXIT:

        AX      0               ;Operation successful
        BX                      ;Current saving level
```

There are 8 different defined power saving levels (1-8). Level 1 is the level where the least power savings are realized. Level 8 is the highest. The default POWER device driver defines ADV:MAX as level 7, ADV:REG as level 6, and ADV:MIN as level 3. This API controls two parameters:

- The BaseLineMax for the INT 16H idle detection
- The spread of INT 16H timings over the current BaseLine (noise)

The following table shows the current assignments for each level:

Level	Base Line %	Noise/spread %
1	222	12.5
2	250	25
3	285	37.5
4	333	50
5	400	62.5
6	500	75
7	750	87.5
8	1000	100

Get Device Power State (1.1)

```
ENTRY:
          AX    5404h
          BX    Power Device ID
                0001h   ; All devices power managed by APM BIOS
                01xxh   ; Display
                02xxh   ; Secondary Storage
                03xxh   ; Parallel Ports
                04xxh   ; Serial Ports
                05xxh   ; Network Adapters
                06xxh   ; PCMCIA Sockets
                E000h - EFFFh
                        ; OEM defined device IDs
                All other values reserved where xxh = unit number (0 based)
EXIT:
          AX    0       ; Operation successful
                03h     ; ERROR_PM_NOT_CONNECTED
          **    04h     ; ERROR_PM_NOT_ENGAGED
          **    05h     ; ERROR_PM_NOT_ENABLED
          **    06h     ; ERROR_PM_INVALID_DEVICE_ID
          CX            ; device power state
```

Note: ** - New error code for POWER.EXE driver.

The following INT 2Fh API returns the power state for the system or device specified in the power device ID. The power state value returned when the power device ID specified indicates ″all devices power managed by the APM BIOS″ or ″all devices in a class″ is defined only when that power device ID has been used in a call to Set Device Power State (INT 2Fh, AX = 5405). In the case where the power device ID has not been used in a call to Set Device Power State, the function will be unsuccessful and will return error code 06 (ERROR_PM_INVALID_DEVICE_ID).

Set Device Power State (1.1)

```
ENTRY:
          AX    5405h
          BX    Power Device ID
                0001h   ; All devices power managed by APM BIOS
                01xxh   ; Display
                02xxh   ; Secondary Storage
                03xxh   ; Parallel Ports
                04xxh   ; Serial Ports
                05xxh   ; Network Adapters
                06xxh   ; PCMCIA Sockets
                E000h - EFFFh
```

```
                ; OEM defined device IDs
        All other values reserved where xxh = unit number (0 based)
     CX Device Power State
        00h     ; APM Enabled
        01h     ; Standby
        02h     ; Suspend
        03h     ; Off
EXIT:
     AX 0       ; Operation successful
        03h     ; ERROR_PM_NOT_CONNECTED
     ** 04h     ; ERROR_PM_NOT_ENGAGED
     ** 05h     ; ERROR_PM_NOT_ENABLED
     ** 06h     ; ERROR_PM_INVALID_DEVICE_ID
        87h     ; ERROR_PM_INVALID_PARAMETER
```

Note: ** - New error code for POWER.EXE driver.

The following INT 2Fh API sets the system or device specified in the power device ID into the requested power state.

Enable/Disable device power state (1.1)

```
ENTRY:
     AX 5406h
     BX Power Device ID
        0001h   ; All devices power managed by APM BIOS
        01xxh   ; Display
        02xxh   ; Secondary Storage
        03xxh   ; Parallel Ports
        04xxh   ; Serial Ports
        05xxh   ; Network Adapters
        06xxh   ; PCMCIA Sockets
        E000h - EFFFh
                ; OEM defined device IDs
        All other values reserved where xxh = unit number (0 based)
     CX 0000h   ; Disable device power state
        0001h   ; Enable device power state
EXIT:
     AX 0       ; Operation successful
        03h     ; ERROR_PM_NOT_CONNECTED
     ** 04h     ; ERROR_PM_NOT_ENGAGED
     ** 05h     ; ERROR_PM_NOT_ENABLED
     ** 06h     ; ERROR_PM_INVALID_DEVICE_ID
        87h     ; ERROR_PM_INVALID_PARAMETER
```

Note: ** - New error code for POWER.EXE driver.

The following INT 2Fh API will enable or disable power management for a specified device. When disabled the APM BIOS does not automatically power manage the device.

Engage/Disengage power management (1.1)

```
ENTRY:
          AX    5407h
          BX    Power Device ID
                0001h   ; All devices power managed by APM BIOS
                01xxh   ; Display
                02xxh   ; Secondary Storage
                03xxh   ; Parallel Ports
                04xxh   ; Serial Ports
                05xxh   ; Network Adapters
                06xxh   ; PCMCIA Sockets
                E000h - EFFFh
                        ; OEM defined device IDs
                All other values reserved where xxh = unit number (0 based)
          CX    0000h   ; Disengage power management
                0001h   ; Engage power management
EXIT:
          AX    0       ; Operation successful
                03h     ; ERROR_PM_NOT_CONNECTED
          **    05h     ; ERROR_PM_NOT_ENABLED
          **    06h     ; ERROR_PM_INVALID_DEVICE_ID
                87h     ; ERROR_PM_INVALID_PARAMETER
```

Note: ** - New error code for POWER.EXE 1.01 driver.

The following INT 2Fh API will engage/disengage power management of the system or device. When disengaged, the APM BIOS automatically power manages the system or device.

Get Statistics

```
ENTRY:

        AX      5481H       ;Get statistics
        DS:SI               ;Point to buffer for statistics
        BX      0           ;Get idle detection statistics
                1           ;Get APM statistics
        CX      1CH         ;Buffer size in bytes

EXIT:

        AX      0           ;Operation successful
```

```
        71H         ;ERROR_PM_BUFFER_TOO_SMALL
        87H         ;ERROR_PM_INVALID_PARAMETER
```

This function returns either a structure detailing the efficiency and strategy of power usage or a count of APM resumes. The following structures are the idle detection and APM statistics blocks.

```
STAT_INFO struc              ;Idle detection statistics
  CPU_ON_TIME         dd ?  ;Total time CPU is active
                            ;(TIMER TICS)
  CPU_IDLE_TIME       dd ?  ;Total time CPU is idle
                            ;(TIMER TICS)
  TOTAL_IDLE_CALLS    dd ?  ;
  TOTAL_APP_IDLE      dd ?  ;Total count DO_IDLE
                            ;executed through INT 2FH
  TOTAL_DOS_YIELD     dd ?  ;Total count DO_IDLE
                            ;executed through INT 28H
  TOTAL_KEY_IDLE      dd ?  ;Total count DO_IDLE
                            ;executed through INT 16H
  TOTAL_DOS_IDLE      dd ?  ;Total count DO_IDLE
                            ;executed through INT 2AH
STAT_INFO ends

APM_STATS struc              ;APM statistics
  RESUME_COUNT        dw ?  ;Total number of resumes
                            ;since last APM_ENABLE
APM_STATS ends
```

The CPU_ON_TIME value does not include timer ticks which occur while idle detection in POWER is disabled.

Get or Set APM Polling Period

ENTRY:

```
    AX      5482H       ;Get or set APM polling period
    BX      0           ;Get APM polling period
            non zero    ;Set APM polling period.  Value
                        ;equals polling period to set
```

EXIT:

```
    AX      0           ;Operation successful

    BX                  ;Current APM polling period
```

This function sets or returns the period at which POWER polls the APM firmware for PM events. The value is the number of timer ticks between polls.

APM Error Return Codes and Descriptions

The error codes that are defined for POWER.EXE device driver for APM 1.0 are as follows.

```
02h     ; ERROR_PM_ALREADY_CONNECTED
03h     ; ERROR_PM_NOT_CONNECTED
71h     ; ERROR_PM_BUFFER_TOO_SMALL
87h     ; ERROR_PM_INVALID_PARAMETER
```

The following new error codes are defined for the POWER.EXE 1.01 device driver to utilize APM 1.1 BIOS functionality.

```
04h     ; ERROR_PM_NOT_ENGAGED
05h     ; ERROR_PM_NOT_ENABLED
06h     ; ERROR_PM_INVALID_DEVICE_ID
07h     ; ERROR_PM_DEVIDNOTSET
```

Interrupt 2FH Function AH=0B7H Get APPEND.EXE Installed State

AH=B7H is the resident part of APPEND. The Get Installed State function (AL=0) is supported.

AL=2 is the Get APPEND version. This call is for distinguishing between the PC LAN APPEND and the DOS APPEND. On return, if AX=FFFFH then the DOS APPEND is loaded.

AL=4 is the Get APPEND Path Pointer (DOS APPEND only). On return ES:DI points to the currently active APPEND path.

AL=6 is the Get APPEND Function State (DOS APPEND only).

BX is returned with bits set indicating if APPEND is currently enabled and what functions are in effect.

Bit	Function in effect if bit is on
0	APPEND enabled
13	/PATH
14	/E
15	/X

Note: The functions in effect do not change whether or not APPEND is disabled.

AL=7 Set function state (DOS APPEND only)

On input BX is the new setting for all functions.
The suggested procedure is to get the current function
state, turn on or turn off the desired bits, then
use this call to set the function state.

AL=11H Set Return Found Name State (DOS APPEND
only)

On request AL=17, a process system state flag is set. If this flag is set, then on the next ASCIIZ 3DH, 43H or 6CH function call within Interrupt 21H that APPEND processes, APPEND returns the name it finds to the application filename buffer. This name may be different from the one the application offered. The application must provide enough space for the found name. After APPEND has processed an Interrupt 21H, it resets the Return Found Name state. The following is an example of this process.

```
        MOV     AH,0B7H         ; Indicate APPEND
        MOV     AL,0            ; Get installed state
        INT     2FH
        CMP     AL,0            ; APPEND installed?
        JE      NOT_INSTALLED

        MOV     AH,0B7H         ; Indicate APPEND
        MOV     AL,2            ; Get APPEND version
        INT     2FH
        CMP     AX,-1           ; DOS version?
                PC_LAN_APPEND   ; AX<> -1 means PC LAN
        JNE     APPEND

; The following functions are valid only if PC DOS 7 APPEND

        MOV     AH,0B7H         ; Indicate APPEND
        MOV     AL,4            ; Get APPEND path pointer
        INT     2FH

                                ; ES:DI = address of APPEND path
                                ; (Buffer is 128 characters long)

        MOV     AH,0B7H         ; Indicate APPEND
        MOV     AL,6            ; Get function state
        INT     2FH
                                ; BX = function state
                                ; 8000H = /X is on
                                ; 4000H = /E is on
                                ; 2000H = /PATH is on
                                ; 0001H = APPEND enabled
                                ; If off, similar to null
```

```
                                ; APPEND path
                                ; Set on by any non-status
                                ; occurrence of APPEND

         MOV     AH,0B7H        ; Indicate APPEND
         MOV     AL,7           ; Set function state
         MOV     BX,state       ; New state
         INT     2FH

         MOV     AH,0B7H        ; Indicate APPEND
         MOV     AL,11H         ; Set Return Found
                                ; Name state
         INT     2FH
```

Example 2FH Handler

```
MYNUM           DB     X ; X = The specific AH
                         ; multiplex number.
INT_2F_NEXT     DD     ? ; Chain location
INT_2F:

ASSUME DS:NOTHING,ES:NOTHING,SS:NOTHING

  CMP     AH,MYNUM
  JE      MINE
  JMP     INT_2F_NEXT   ; Chain to next
                        ; 2FH Handler

MINE:

  CMP     AL,0F8H
  JB      DO_FUNC
  IRET                  ; IRET on reserved
                        ; functions

DO_FUNC:

  OR      AL,AL
  JNE     NON_INSTALL   ; Non Get Installed
                        ; State request
  MOV     AL,0FFH       ; Say I'm here
  IRET                  ; All done

NON_INSTALL:
:
```

Installing the Handler

The following example contains the functions necessary to install a handler:

```
   MOV    AH,MYNUM
   XOR    AL,AL
   INT    2FH                       ; Ask if already
                                    ; installed
   OR     AL,AL
   JZ     OK_INSTALL

BAD_INSTALL:                        ; Handler already  installed



OK_INSTALL:                         ; Install my
                                    ; handler

   MOV    AL,2FH
   MOV    AH,GET_INTERRUPT VECTOR
   INT    21H                        ; Get multiplex
                                     ; vector
   MOV    WORD PTR INT_2F NEXT+2,ES
   MOV    WORD PTR INT_2F_NEXT,BX
   MOV    DX,OFFSET INT_2F
   MOV    AL,2FH
   MOV    AH,SET_INTERRUPT_VECTOR
   INT    21H                        ; Set multiplex
                                     ; vector
⋮
```

Interrupt 30H-3FH Reserved for PC DOS 7

These interrupts are reserved for PC DOS 7 use.

Appendix B. PC DOS 7 Function Calls

Number	Function Name
00H	Program terminate
01H	Console input with echo
02H	Display output
03H	Auxiliary input
04H	Auxiliary output
05H	Printer output
06H	Direct console I/O
07H	Direct console input without echo
08H	Console input without echo
09H	Display string
0AH	Buffered keyboard input
0BH	Check standard input status
0CH	Clear keyboard buffer, invoke a keyboard function
0DH	Disk reset
0EH	Select disk
0FH	Open file
10H	Close file
11H	Search for first entry
12H	Search for next entry
13H	Delete file
14H	Sequential read
15H	Sequential write
16H	Create file
17H	Rename file
18H	Reserved by PC DOS 7
19H	Current disk
1AH	Set disk transfer address
1BH	Allocation table information
1CH	Allocation table information for specific device
1DH	Reserved by PC DOS 7
1EH	Reserved by PC DOS 7
1FH	Get Default Drive Parameter Block
20H	Reserved by PC DOS 7
21H	Random read
22H	Random write
23H	File size
24H	Set relative record field
25H	Set interrupt vector
26H	Create new program segment
27H	Random block read

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28H	Random block write
29H	Parse filename
2AH	Get date
2BH	Set date
2CH	Get time
2DH	Set time
2EH	Set or reset verify switch
2FH	Get disk transfer address
30H	Get PC DOS 7 version number
31H	Terminate process and remain resident
32H	Get Drive Parameter Block
33H	Get or Set system value
34H	Get InDOS Flag Address
35H	Get interrupt vector
36H	Get disk free space
37H	Reserved by PC DOS 7
38H	Get or set country dependent information
39H	Create subdirectory (MKDIR)
3AH	Remove subdirectory (RMDIR)
3BH	Change current directory (CHDIR)
3CH	Create a file (CREAT)
3DH	Open a file
3EH	Close a file handle
3FH	Read from a file or device
40H	Write to a file or device
41H	Delete a file from a specified directory (UNLINK)
42H	Move file read/write pointer (LSEEK)
43H	Change file mode (CHMOD)
44H	I/O control for devices (IOCtl)
45H	Duplicate a file handle (DUP)
46H	Force a duplicate of a file handle (FORCDUP)
47H	Get current directory
48H	Allocate memory
49H	Free allocated memory
4AH	Modify allocated memory blocks (SETBLOCK)
4BH	Load or execute a program (EXEC)
4CH	Terminate a process (EXIT)
4DH	Get return code of a subprocess (WAIT)
4EH	Find first matching file (FIND FIRST)
4FH	Find next matching file (FIND NEXT)
50H	Set Program Segment Prefix Address
51H	Get Program Segment Prefix Address
52H	Reserved by PC DOS 7
53H	Reserved by PC DOS 7

54H	Get verify setting
55H	Reserved by PC DOS 7
56H	Rename a file
57H	Get or set a file′s date and time
5800H	Get Allocation Strategy
5801H	Set Allocation Strategy
5802H	Get Upper-Memory Link
5803H	Set Upper-Memory Link
59H	Get extended error
5AH	Create unique file
5BH	Create new file
5CH	Lock or unlock file access
5D0AH	Set Extended Error
5E00H	Get machine name
5E02H	Set printer setup
5E03H	Get printer setup
5F02H	Get redirection list entry
5F03H	Redirect device
5F04H	Cancel redirection
60H	Reserved by PC DOS 7
61H	Reserved by PC DOS 7
62H	Get PSP address
63H	Reserved by PC DOS 7
64H	Reserved by PC DOS 7
65H	Get extended country information
66H	Get or set global code page
67H	Set handle count
68H	Commit file
69H	Reserved by PC DOS 7
6AH	Reserved by PC DOS 7
6BH	Reserved by PC DOS 7
6CH	Extended open or create

Using PC DOS 7 Function Calls

Most function calls require input to be passed to them in registers. After setting the appropriate register values, issue the function calls in either of the following ways:

- The preferred method is to place the function number in AH and issue interrupt 21H.
- Place the function number in AH and execute a call to offset 50H in your program segment prefix.

Program Code Fragments

In each of the function call descriptions in this chapter, the input, output and method of use are described using a small program code fragment. These fragments are written in IBM PC Assembler Language.

.COM Programs

The descriptions assume that the program is an .EXE, not a .COM program. If a .COM program is desired, do not include either of the following instructions:

```
  MOV ES,SEG —
or
  MOV DS,SEG —
```

Notes:

1. Some FCB function calls do not permit invalid characters (0DH–29H).
2. Device names cannot end in a colon.
3. The contents of the AX register can be altered by any of the function calls. Even though no error code is returned in AX, it is possible that AX has been changed.

PC DOS 7 Registers

PC DOS 7 uses the following registers, pointers, and flags when executing interrupts and function calls:

Register Definition	**General Registers**
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 (8-bit)
DL	Data low-order (8-bit)
Flags	OF,DF,IF,TF,SF,ZF,AF,PF,CF

Register Definition	Pointers
SP	Stack pointer (16-bit)
BP	Base pointer (16-bit)
IP	Instruction pointer (16-bit)

Register Definition	Segment Registers
CS	Code segment (16-bit)
DS	Data segment (16-bit)
SS	Stack segment (16-bit)
ES	Extra segment (16-bit)

Register Definition	Index Registers
DI	Destination index (16-bit)
SI	Source index (16-bit)

Register Numbering Convention

Each register is 16 bits long and is divided into a high and low byte. Each byte is 8 bits long. The bits are numbered from right to left. The low byte contains bits 0 through 7 and the high byte contains bits 8 through 15. The chart below shows the hexadecimal values assigned to each bit.

	High Byte	Low Byte
Bit	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0
Hex value	8 4 2 1 8 4 2 1	8 4 2 1 8 4 2 1

PC DOS 7 Internal Stack

When PC DOS 7 gains control, it switches to an internal stack. User registers are preserved unless information is passed back to the requester as indicated in the specific requests. The user stack needs to be sufficient to accommodate the interrupt system. It is recommended that the user stack be 200H in addition to what the user needs.

Responding to Errors

Handle function calls report an error by setting the carry flag and returning the error code in AX. FCB function calls report an error by returning FFH in AL.

Extended error support (59H) provides a common set of error codes and specific error information such as error classification, location, and recommended action. In most critical cases, applications can analyze the error code and take specific action. Recommended actions are intended for programs that do not understand the error codes. Programs can take advantage of extended error support both from interrupt 24H critical error handlers and after issuing interrupt 21H function calls. Do not code to specific error codes.

Extended Error Codes

Hexadecimal Code	Decimal Code	Meaning
01H	1	Invalid function number
02H	2	File not found
03H	3	Path not found
04H	4	Too many open files (no handles left)
05H	5	Access denied
06H	6	Invalid handle
07H	7	Memory control blocks destroyed
08H	8	Insufficient memory
09H	9	Invalid memory block address
0AH	10	Invalid environment
0BH	11	Invalid format
0CH	12	Invalid access code
0DH	13	Invalid data
0EH	14	Reserved
0FH	15	Invalid drive was specified
10H	16	Attempt to remove the current directory
11H	17	Not same device
12H	18	No more files
13H	19	Attempt to write on write-protected diskette
14H	20	Unknown unit
15H	21	Drive not ready
16H	22	Unknown command
17H	23	Cyclic redundancy check (CRC) — part of diskette is bad
18H	24	Bad request structure length
19H	25	Seek error
1AH	26	Unknown media type
1BH	27	Sector not found
1CH	28	Printer out of paper
1DH	29	Write fault
1EH	30	Read fault
1FH	31	General failure
20H	32	Sharing violation

Hexadecimal Code	Decimal Code	Meaning
21H	33	Lock violation
22H	34	Invalid disk change
23H	35	FCB unavailable
24H	36	Sharing buffer overflow
25H	37	Reserved by PC DOS 7
26H	38	Unable to complete file operation
27H–31H	39–49	Reserved by PC DOS 7
32H	50	Network request not supported
33H	51	Remote computer not listening
34H	52	Duplicate name on network
35H	53	Network path not found
36H	54	Network busy
37H	55	Network device no longer exists
38H	56	NETBIOS command limit exceeded
39H	57	System error; NETBIOS error
3AH	58	Incorrect response from network
3BH	59	Unexpected network error
3CH	60	Incompatible remote adapter
3DH	61	Print queue full
3EH	62	Not enough space for print file
3FH	63	Print file was cancelled
40H	64	Network name was deleted
41H	65	Access denied
42H	66	Network device type incorrect
43H	67	Network name not found
44H	68	Network name limit exceeded
45H	69	NETBIOS session limit exceeded
46H	70	Sharing temporarily paused
47H	71	Network request not accepted
48H	72	Print or disk redirection is paused
49H–4FH	73–79	Reserved
50H	80	File exists
51H	81	Reserved
52H	82	Cannot make directory entry
53H	83	Fail on INT 24
54H	84	Too many redirections
55H	85	Duplicate redirection
56H	86	Invalid password
57H	87	Invalid parameter
58H	88	Network data fault
59H	89	Function not supported by network
5AH	90	Required system component not installed

Error Classes

Hexadecimal Value	Decimal Value	Description
01H	1	**Out of Resource:** Example: out of space or channels.
02H	2	**Temporary Situation:** Something expected to disappear with time. This is not an error condition, but a temporary situation such as a locked file.
03H	3	**Authorization:** Permission problem.

Hexadecimal Value	Decimal Value	Description
04H	4	**Internal:** Internal error in system software. Probable problem with system software rather than a user or system failure.
05H	5	**Hardware Failure:** A serious problem not the fault of user program.
06H	6	**System Failure:** Serious failure of system software not the fault of the user, such as missing or incorrect configuration files.
07H	7	**Application Program Error:** Inconsistent requests.
08H	8	**Not Found:** File or item not found. Inconsistent requests.
09H	9	**Bad Format:** File or value in invalid format or type; unsuitable.
0AH	10	**Locked:** Locked file or item.
0BH	11	**Media:** Media failure such as incorrect disk, CRC error, or defective media.
0CH	12	**Already Exists:** Duplication error, such as declaring a machine name that already exists.
0DH	13	**Unknown:** Classification does not exist or is inappropriate.

Actions

Hexadecimal Code	Decimal Code	Description
01H	1	**Retry:** Retry a few times, then prompt user to determine if the program should continue or be terminated.
02H	2	**Delay Retry:** Retry several times after pause, then prompt user to determine if the program should continue or be terminated.
03H	3	**User:** If the input was entered by a user, advise reentry. The error, however, may have occurred in the program itself, such as a bad drive letter or bad filename specification.
04H	4	**Abort:** Abort application with cleanup. The application cannot proceed, but the system is in an orderly state and it is safe to stop the application.
05H	5	**Immediate Exit:** Stop application immediately without clearing registers. Do not use the application to close files or update indexes, but exit as soon as possible.
06H	6	**Ignore:** Ignore.
07H	7	**Retry After User Intervention:** The user needs to perform some action such as removing a diskette and inserting a different one. Then retry the operation.

Locus (Location)

Hexadecimal Value	Decimal Value	Description
01H	1	**Unknown:** Not specific; not appropriate.
02H	2	**Block Device:** Related to random access mass disk storage.
03H	3	**Net:** Related to the network.
04H	4	**Serial Device:** Related to serial devices.
05H	5	**Memory:** Related to random access memory.

00H — Program Terminate

Purpose

Stops the execution of a program.

Examples

```
        MOV     AH,00H   ; Function Call — Terminate Program
        INT     21H      ; Issue request to DOS
 ; No return
```

Comments

The terminate, Ctrl-Break, and critical error exit addresses are restored to the values they had on entry to the terminating program, from the values saved in the program segment prefix. All file buffers are flushed and the handles opened by the process are closed. Any files that have changed in length and not closed are not recorded properly in the directory. Control transfers to the terminate address. This call performs exactly the same function as interrupt 20H. It is the program's responsibility to ensure that the CS register contains the segment address of its program segment prefix control block before calling this function.

Function 4CH — Terminate a Process is the preferred method for ending a program.

01H — Console Input with Echo

Purpose

Waits for a character to be read at the standard input device (unless one is ready), then echoes the character to the standard output device and returns the character in AL.

Examples

```
        MOV     AH,01H          ; Function Call – keyboard input
        INT     21H             ; Issue request to DOS
        MOV     Char,AL         ; Save character
        CMP     AL,0            ; Extended character ?
        JNE     Normal_Char     ; No!
        MOV     AH,01H          ; Function Call – keyboard input
        INT     21H             ; Issue request to DOS
        MOV     ExtChar,AL      ; Save extended character
Normal_Char:

 -----

 Character      LABEL   WORD    ; Complete character
 Char           DB      ?       ; Character buffer
 ExtChar        DB      ?       ; Character buffer
```

Comments

The character is checked for a Ctrl-Break. If Ctrl-Break is detected, an interrupt 23H is executed.

For function call 01H, extended ASCII codes require two function calls. The first call returns 00H as an indicator that the next call will return an extended code.

02H — Display Output

Purpose

Outputs the character in DL to the standard output device.

Examples

```
    MOV     AH,02H          ; Function Call – Display Output
    MOV     DL,Char         ; Get character to display
    INT     21H             ; Issue request to DOS

-----

CHAR        DB        ?     ; Character buffer
```

Comments

If the character in DL is a backspace (08), the cursor is moved left one position (nondestructive). If a Ctrl-Break is detected after the output, an interrupt 23H is executed.

03H — Auxiliary Input

Purpose

Waits for a character from the standard auxiliary device, then returns that character in AL.

Examples

```
        MOV     AH,03H          ; Function Call — Auxiliary Input
        INT     21H             ; Issue request to DOS
        MOV     Char,AL         ; Save character

-------

CHAR    DB      ?               ; Character buffer
```

Comments

Auxiliary (AUX) support is unbuffered and noninterrupt driven.

At startup, PC DOS 7 initializes the first auxiliary port to 2400 baud, no parity, one-stop bit, and 8-bit word.

The auxiliary function calls (03H and 04H) do not return status or error codes. For greater control, you should use the ROM BIOS routine (interrupt 14H) or write an AUX device driver and use IOCtl.

04H — Auxiliary Output

Purpose

Outputs the character in DL to the standard auxiliary device.

Examples

```
        MOV     AH,04H          ; Function Call — Auxiliary Output

        MOV     DL,Char         ; Get character to output
        INT     21H             ; Issue request to DOS
                                ; Nothing returned

-------

CHAR    DB      ?               ; Character buffer
```

Comments

If the character in DL is a backspace (08), the cursor is moved left one position (nondestructive). If a Ctrl-Break is detected after the output, an interrupt 23H is executed.

05H — Printer Output

Purpose

Outputs the character in DL to the standard printer device.

Examples

```
        MOV     AH,05H          ; Function Call — Printer Output
        MOV     DL,Char         ; Get character to output
        INT     21H             ; Issue request to DOS
                                ; Nothing returned

--------

CHAR    DB       ?              ; Character buffer
```

06H — Direct Console I/O

Purpose

Gets a character from the standard input device if one is ready, or outputs a character to the standard output device.

Examples

```
 In_loop:
   MOV     AH,06H         ; Function Call — Direct Console I/O
   MOV     DL,-1          ; OFFH for input
   INT     21H            ; Issue request to DOS
   JZ      In_loop        ; No character yet on input
   MOV     Char,AL        ; Save character
   CMP     AL,0           ; Extended Character ?
   JNE     Normal_Char    ; No!
   MOV     AH,07H         ; Function Call — Keyboard Input
   INT     21H            ; Issue request to DOS
   MOV     ExtChar,AL     ; Save extended character
Normal_Char:

 or

   MOV     AH,06H         ; Function Call — Direct Console I/O
   MOV     DL,Char        ; Output character to display (not OFFH)
   INT     21H            ; Issue request to DOS

 -----

 Character    LABEL  WORD ; Complete character
 Char          DB      ?  ; Character buffer
 ExtChar       DB      ?  ; Character buffer
```

Comments

If DL is FFH, AL returns with the 0 flag clear and an input character from the standard input device, if one is ready. If a character is not ready, the 0 flag will be set.

If DL is not FFH, DL is assumed to have a valid character that is output to the standard output device. This function does not check for Ctrl-Break, or Ctrl-PrtSc.

For function call 06H, extended ASCII codes require two function calls. The first call returns 00H as an indicator that the next call will return an extended code.

07H — Direct Console Input Without Echo

Purpose

Waits for a character to be read at the standard input device (unless one is ready), then returns the character in AL.

Examples

```
  MOV   AH,07H       ; Function Call — Direct Console Input (no echo)
  INT   21H          ; Issue request to DOS
  MOV   Char,AL      ; Save character
  CMP   AL,0         ; Extended character ?
  JNE   Normal_Char  ; No!
  MOV   AH,07H       ; Function Call — Direct Console Input (no echo)
  INT   21H          ; Issue request to DOS
  MOV   ExtChar,AL   ; Save extended character
Normal_Char:

  -----

  Character     LABEL   WORD    ; Complete character
  Char          DB      ?       ; Character buffer
  ExtChar       DB      ?       ; Character buffer
```

Comments

As with function call 06H, no checks are made on the character.

For function call 07H, extended ASCII codes require two function calls. The first call returns 00H as an indicator that the next call will return an extended code.

08H — Console Input Without Echo

Purpose

Waits for a character to be read at the standard input device (unless one is ready) and returns the character in AL.

Examples

```
 MOV  AH,08H      ; Function Call – Console Input (no echo)
 INT  21H         ; Issue request to DOS
 MOV  Char,AL     ; Save character
 CMP  AL,0        ; Extended character ?
 JNE  Normal_Char; No!
 MOV  AH,08H      ; Function Call – Console Input (no echo)
 INT  21H         ; Issue request to DOS
 MOV  ExtChar,AL ; Save extended character
Normal_Char:
  -----

 Character     LABEL   WORD    ; Complete character
 Char          DB      ?       ; Character buffer
 ExtChar       DB      ?       ; Character buffer
```

Comments

The character is checked for Ctrl-Break. If Ctrl-Break is detected, an interrupt 23H is executed.

For function call 08H, extended ASCII codes require two function calls. The first call returns 00H as an indicator that the next call will return an extended code.

09H — Display String

Purpose

Sends the characters in the string to the standard output device.

Examples

```
MOV  AX,SEG String
MOV  DS,AX             ;Set DS:DX to string
MOV  DX,OFFSET String
MOV  AH,09H            ;Function Call - Display String
INT  21H               ;Issue request to DOS

 -----

 String        DB      "This string ends at the first Dollar"
               DB      0DH,0AH
               DB      "$"
```

Comments

The character string in memory must be terminated by a **$** (24H). Each character in the string is output to the standard output device in the same form as function call 02H.

ASCII codes 0DH and 0AH represent carriage return and line feed, respectively.

0AH — Buffered Keyboard Input

Purpose

Reads characters from the standard input device and places them in the buffer beginning at the third byte.

Examples

```
MOV  AX,SEG Buffer
MOV  DS,AX                ;Set DS:DX to return Buffer
MOV  DX,OFFSET Buffer
MOV  AH,0AH               ;Function Call-Buffered
                          ;Keyboard Input
INT 21H                   ;Issue request to DOS

------

Buffer   DB   128         ; Max length of input
CurLen   DB   ?           ; Number of characters input
                          ; (excludes Return (0DH))
CurText  DB   128 DUP(?)  ; Up to 128 characters allowed
```

Comments

The first byte of the input buffer specifies the number of characters the buffer can hold. This value cannot be 0. Reading the standard input device and filling the buffer continues until Enter is read. If the buffer fills to one less than the maximum number of characters it can hold, each additional character read is ignored and causes the bell to ring, until Enter is read. The second byte of the buffer is set to the number of characters received, excluding the carriage return (0DH), which is always the last character.

0BH — Check Standard Input Status

Purpose

Checks if there is a character available from the standard input device.

Examples

```
In_LOOP:
  MOV     AH,0BH    ; Function Call — Check Input
  INT     21H       ; Issue request to DOS
  CMP     AL,-1     ; 0FFH indicates character available
  JNE     In_LOOP
```

Comments

If a character is available from the STDIN device, AL is FFH. Otherwise, AL is undefined. If a Ctrl-Break is detected, an interrupt 23H is executed.

0CH — Clear Keyboard Buffer and Invoke a Keyboard Function

Purpose

Clears the standard input device of any characters, then executes the function call number in AL.

Examples

```
MOV    AH,0CH          ; Function Call — Clear keyboard &
                       ; Invoke function
MOV    AL,Function     ; Function Call to execute
                       ; (only 01H, 06H, 07H, 08H, and 0AH are allowed).
INT    21H             ; Issue request to DOS
                       ; Output depends on Function Call selected
```

0DH — Disk Reset

Purpose

Writes to the disk file buffers that have been modified. All buffers are then made available for reuse.

Examples

```
MOV     AH,0DH          ; Function Call — Disk Reset
INT     21H             ; Issue request to DOS
                        ; No return
```

Comments

It is necessary to close or commit all open files to correctly update the disk directory.

0EH — Select Disk

Purpose

Selects the drive specified in DL (0=A, 1=B, etc.) (if valid) as the default drive.

Examples

```
MOV     AH,0EH          ; Function Call — Select Disk
MOV     DL,Drive        ; Drive to select       (0=A:, 1=B:, ...)
INT     21H             ; Issue request to DOS
MOV     LastDrive,AL    : Save max drive number (1=A:, 2=B:, ...)
MOV     AH,19H          ; Function Call — Get Current Disk
INT     21H             ; Issue request to DOS
CMP     AL,DL           ; Selected drive = requested
JNE     Error           ; No, Error!

-----

Drive         DB        ; New Drive to select
LastDrive     DB        ; Highest Valid Drive
```

Comments

The total number of unique drive letters, including diskette and hard disk drives, that can be referenced is returned in AL. The value in AL is equal to the value of LASTDRIVE in CONFIG.SYS or the total number of installed devices, whichever is greater. For PC DOS 7 5 is the minimum value returned in AL. If the system has only one diskette drive, it is counted as two to be consistent with the philosophy of thinking of the system as having logical drives A and B.

0FH — Open File

Purpose

Searches the current directory for the named file and AL returns FFH if it is not found. If the named file is found, AL returns 00H and the FCB is filled as described below.

Examples

```
MOV  AX,SEG FCB     ;Address FCB Parameter Block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,0FH         ;Function Call-FCB Open
INT  21H            ;Issue request to DOS

 -----

 FCB           LABEL   BYTE
 Drive         DB      0               ; Drive (0=Current, 1=A, 2=B, ...)
 FName         DB      "FILENAME"      ; File Name      (blank padded)
 Ext           DB      "EXT"           ; File Extension (blank padded)
               DB      25 DUP(0)       ; Filled in by PC DOS 7
```

Comments

AL is 00H if the file is opened.

AL is FFH if the file was not opened.

Use Function Call 59H (Get Extended Error) to determine the actual error condition.

If the drive code was 0 (default drive), it is changed to the actual drive used (1=A, 2=B, and so on). This allows changing the default drive without interfering with subsequent operations on this file. The current block field (FCB bytes C-D) is set to 0. The size of the record to be worked with (FCB bytes E-F) is set to the system default of 80H. The size of the file and the date are set in the FCB from information obtained from the 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 the open, but before any disk operations.

The file is opened in compatibility mode. For information on compatibility mode, refer to function call 3DH.

10H — Close File

Purpose

Closes a file.

Examples

```
MOV  AX,SEG FCB          ; Address FCB Parameter Block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,10H              ; Function Call-FCB Close
INT  21H                 ; Issue request to DOS
CMP  AL,0                ; File Closed?
JNE  Error               ; No, Error!

-----

FCB           LABEL   BYTE
; Contents set by previous operations
```

Comments

AL is 00H if the file is closed.

AL is FFH if the file was not closed.

Use Function Call 59H (Get Extended Error) to determine the actual error condition.

This function call must be executed on open files after file writes, and we highly recommend that it be used on all files. If the file is not found in its correct position in the current directory, it is assumed the disk was changed and AL returns FFH. Otherwise, the directory is updated to reflect the status in the FCB, the buffers for that file are flushed, and AL returns 00H.

11H — Search for First Entry

Purpose

Searches the current directory for the first matching filename.

Examples

```
MOV  AX,SEG DTA    ; Address Buffer for found file
MOV  DS,AX         ; information
MOV  DX,OFFSET DTA
MOV  AH,1AH        ; Function Call-Set DTA address
INT  21H           ; Issue request to DOS
MOV  AX,SEG FCB    ; Address FCB parameter block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,11H        ; Function Call-FCB search first
INT  21H           ; Issue request to DOS
CMP  AL,0          ; File found?
JNE  Error         ; No, Error!

-----

FCB     LABEL   BYTE
Fdrive  DB      0               ; Drive (0=Current, 1=A, 2=B, ...)
Fname   DB      "FILENAME"      ; File name      (blank padded, may use ?)
Fext    DB      "EXT"           ; File extension (blank padded, may use ?)
        DB      25 DUP(0)       ; Filled in by DOS

DTA     LABEL   BYTE
Ddrive  DB      ?               ; Drive
Dname   DB      "????????"      ; File Name      (blank padded)
Dext    DB      "???"           ; File Extension (blank padded)
        DB      25 DUP(0)       ; Filled in by PC DOS 7
```

Comments

AL is 00H if the file is found.

AL is FFH if the file was not found.

Use Function Call 59H (Get Extended Error) to determine the actual error condition.

The current disk directory is searched for the first matching filename. If none is found, AL returns FFH. Global filename characters are allowed in the filename and extension. If a matching filename is found, AL returns 00H and the locations at the disk transfer address are set as follows:

- If the FCB provided for searching was an extended FCB, the first byte at the disk transfer address is set to FFH followed by 5 bytes of 0, 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 extended FCB with the same search attributes as the search FCB.
- 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), and the next 32 bytes contain the matching directory entry. Thus, the disk transfer address contains a valid unopened normal FCB.

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

1. If the attribute is 0, only normal file entries are found. Entries for volume label, sub-directories, hidden and system files, are not returned.
2. If the attribute field is set for hidden or system files, or directory entries, it is 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).
3. If the attribute field is set for the volume label, it is considered an exclusive search, and *only* the volume label entry is returned.

12H — Search for Next Entry

Purpose

Searches the current directory for the next matching filename.

Examples

```
MOV       AX,SEG DTA    ; Address Buffer for found file
MOV       DS,AX         ; Information
MOV       DX,OFFSET DTA
MOV       AH,1AH        ; Function Call-Set DTA address
INT       21H           ; Issue request to DOS
MOV       AX,SEG FCB    ; Address FCB Parameter Block
MOV       DS,AX
MOV       DX,OFFSET FCB
MOV       AH,12H        ; Function Call-FCB Search Next
INT       21H           ; Issue request to DOS
CMP       AL,0          ; File found?
JNE      Error          ; No, Error!

-----

FCB            LABEL   BYTE
; As set by FCB Search First

DTA            LABEL   BYTE
Drive          DB      ?               ; Drive
Fname          DB      "????????"      ; File Name      (blank padded)
Ext            DB      "???"           ; File Extension (blank padded)
               DB      25 DUP(0)       ; Filled in by PC DOS 7
```

Comments

AL is 00H if the file is found. AL is FFH if the file was not found. Use Function Call 59H (Get Extended Error) to determine the actual error condition.

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.

The DTA contains information from the previous Search First or Search Next. 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 if this FCB is between a previous function 11H or 12H call and this one.

13H — Delete File

Purpose

Deletes all current directory entries that match the specified filename. The specified filename cannot be read-only.

Examples

```
MOV  AX,SEG FCB       ;Address FCB Parameter Block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,13H           ;Function Call-FCB Delete File
INT  21H              ;Issue request to DOS
CMP  AL,0             ;File(s) Deleted?
JNE  Error            ;No, Error!

-----

FCB           LABEL   BYTE
Drive         DB      0               ; Drive
FName         DB      Filename        ; File Name      (blank padded, may use ?)
Ext           DB      Ext             ; File Extension (blank padded, may use ?)
              DB      25 DUP(0)       ; Filled in by DOS
```

Comments

AL is 00H if the file is found.

AL is FFH if the file was not found.

Use Function Call 59H (Get Extended Error) to determine the actual error condition.

All matching current directory entries are deleted. The global filename character "?" is allowed in the filename or extension. If no directory entries match, AL returns FFH; otherwise AL returns 00H.

If the file is specified in read-only mode, the file is not deleted.

Note: Close open files before deleting them.

Network Access Rights: Requires Create access rights.

14H — Sequential Read

Purpose

Loads the record addressed by the current block (FCB bytes C-D) and the current record (FCB byte 1F) at the disk transfer address (DTA), then the record address is increased.

Examples

```
MOV  AX,SEG DTA            ;Address Data buffer
MOV  DS,AX
MOV  DX,OFFSET DTA
MOV  AH,1AH                ;Function call Set DTA Address
INT  21H                   ;Issue request to DOS
MOV  AX,SEG FCB            ;Address FCB Parameter Block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,14H                ;Function Call-FCB Sequential Read
INT  21H                   ;Issue request to DOS
CMP  AL,0                  ;Data Read?
JNE  Error                 ;No, Error!

-----

FCB           LABEL   BYTE
; Set by previous open
DTA           LABEL   BYTE
              DB      ?Dup(0)   ;I/O buffer
```

Comments

AL is 00H if the read was successful.

AL is 01H if the file was at End of File (EOF).

AL is 02H if the read would have caused a wrap or overflow because the DTA was too small (the read was not completed).

AL is 03H if EOF (a partial record was read and filled out with 0s).

Use Function Call 59H (Get Extended Error) to determine the actual error condition. The length of the record is determined by the FCB record size field.

Network Access Rights: Requires Read access rights.

15H — Sequential Write

Purpose

Writes the record addressed by the current block and record fields (size determined by the FCB record size field) from the disk transfer address. If records are less than the sector size, the record is buffered for an eventual write when a sector's worth of data is accumulated. Then the record address is increased.

Examples

```
 MOV  AX,SEG DTA           ;Address Data buffer
 MOV  DS,AX
 MOV  DX,OFFSET DTA
 MOV  AH,1AH               ;Function Set DTA Address
 INT  21H                  ;Issue request to DOS
 MOV  AX,SEG FCB           ;Address FCB Parameter Block
 MOV  DS,AX
 MOV  DX,OFFSET FCB
 MOV  AH,15H               ;Function Call-FCB Sequential Write
 INT  21H                  ;Issue request to DOS
 CMP  AL,0                 ;Data Written?
 JNE  Error                ;No, Error!

FCB    LABEL   BYTE
; Set by previous open
DTA    LABEL   BYTE
       DB      ?Dup(0)      ;I/O buffer
```

Comments

AL is 00H if the write was successful.

AL is 01H if the disk or diskette is full (write cancelled).

AL is 02H if the write would have caused a wrap or overflow because the DTA was too small (write cancelled).

Use Function Call 59H (Get Extended Error) to determine the actual error condition. If the file is specified in read-only mode, the sequential write is not performed and 01H is returned in AL.

Network Access Rights: Requires Write access rights.

16H — Create File

Purpose

Creates a new file.

Examples

```
MOV  AX,SEG FCB     ;Address FCB parameter block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,16H         ;Function Call-FCB create file
INT  21H            ;Issue request to DOS
CMP  AL,0           ;File created and opened?
JNE  Error          ;No, Error!

 -----

FCB            LABEL   BYTE
Fdrive         DB      0            ; Drive (0=Current, 1=A, 2=B, ...)
Fname          DB      "FILENAME"   ; File name      (blank padded)
Fext           DB      "EXT"        ; File extension (blank padded)
               DB      25 DUP(0)    ; Filled in by DOS
```

Comments

AL is 00H if the file is created and opened.

AL is FFH if the file was not created (normally a full directory or disk full).

Use Function Call 59H (Get Extended Error) to determine the actual error condition.

If a matching entry is found it is reused. If no match is found, the directory is searched for an empty entry. If a match is found, the entry is initialized to a 0-length file, the file is opened (see function call 0FH), and AL returns 00H.

The file may be marked *hidden* during its creation by using an extended FCB containing the appropriate attribute byte.

Network Access Rights: Requires Create access rights.

17H — Rename File

Purpose

Changes every matching occurrence of the first filename in the current directory of the specified drive to the second, with the restriction that two files cannot have the same name and extension.

Examples

```
MOV  AX,SEG FCB       ;Address FCB Parameter Block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,17H           ;Function Call-FCB Rename File
INT  21H              ;Issue request to DOS
CMP  AL,0             ;File(s) Renamed?
JNE  Error            ;No, Error!

  -----

  FCB      LABEL   BYTE
  Fdrive   DB      0           ; Drive (0=Current, 1=A, 2=B, ...)
  Fname    DB      "FILENAME"  ; File Name          (blank padded, may use ?)
  Fext     DB      "EXT"       ; File Extension     (blank padded, may use ?)
           DB      5 DUP(0)    ; Reserved
  NewName  DB      "FILENAME"  ; New File Name      (blank padded, may use ?)
  NewExt   DB      "EXT"       ; New File Extension (blank padded, may use ?)
           DB      7 DUP(0)    ; Reserved
```

Comments

AL is 00H if the file or files were renamed.

AL is FFH if a file in the current directory did not match or the new name already exists.

Use Function Call 59H (Get Extended Error) to determine the actual error condition. The modified FCB has a drive code and filename in the usual position, and a second filename on the sixth byte after the first (DS:DX+11H) in what is normally a reserved area.

If “?”s appear in the second name, the corresponding positions in the original name are unchanged.

If the file is specified in read-only mode, the file is not renamed.

Network Access Rights: Requires Create access rights.

19H — Current Disk

Purpose

Returns the current default drive.

Examples

```
        MOV     AH,19H   ; Function Call — Get Current Disk
        INT     21H      ; Issue request to DOS
        MOV     Disk,AL  ; Save Current Disk
  ----

  Disk   DB     ?        ; Current Disk code (0=A:, 1=B:, ...)
```

Comments

AL returns with the code of the current default drive (0=A, 1=B, and others).

1AH — Set Disk Transfer Address

Purpose

Sets the disk transfer address to DS:DX.

Examples

```
 MOV  AX,SEG DTA       ;Address Buffer
 MOV  DS,AX
 MOV  DX,OFFSET DTA
 MOV  AH,1AH           ;Function Call-Set DTA address
 INT  21H              ;Issue request to DOS
  -----


DTA    LABEL   BYTE    ; Data Buffer
```

Comments

The area defined by this call is from the address in DS:DX to the end of the segment in DS. PC DOS 7 does not allow disk transfers to wrap around within the segment, or overflow into the next segment. If you do not set the DTA, the default DTA is offset 80H in the program segment prefix. To get the DTA, issue function call 2FH.

1BH — Allocation Table Information

Purpose

Returns information about the allocation table for the default drive.

Examples

```
 MOV  AH,1BH                  ; Function Call — Allocation Table
                              ; Information
 INT  21H                     ; Issue request to DOS
 MOV  NumAllocUnits,DX        ; Save Number of Allocation Units
 MOV  NumSectsAllocUnit,AL    ; Save Number of Sectors/Allocation Unit
 MOV  SectSize,CX             ; Save of Sector Size
 MOV  WORD PTR MediaType@+0,BX; Save Pointer to Media Type Byte
 MOV  WORD PTR MediaType@+2,DS

-----

NumAllocUnits     DW      ?       ; Number of Allocation Units on Current Drive
NumSectsAllocUnit DB      ?       ; Number Sectors in an Allocation Unit
SectSize          DW      ?       ; Sector Size
MediaType@        DD      ?       ; Pointer to Media Type byte
```

Comments

Refer to function call 36H (Get Disk Free Space).

1CH — Allocation Table Information for Specific Device

Purpose

Returns allocation table information for a specific device.

Examples

```
 MOV   AH,1CH                    ; Function Call —
                                 ; Allocation Table Information
 MOV   DL,Drive                  ; Drive requested  (0=current,
                                 ; 1=A:, ...)
 INT   21H                       ; Issue request to DOS
 MOV   NumAllocUnits,DX          ; Save Number of Allocation Units
 MOV   NumSectsAllocUnit,AL      ; Save Number of Sectors/Allocation Unit
 MOV   SectSize,CX               ; Save of Sector Size
 MOV   WORD PTR MediaType@+0,BX ; Save Pointer to Media Type Byte
 MOV   WORD PTR MediaType@+2,DS

-----
Drive             DB             ; drive number to get info for
NumAllocUnits     DW     ?       ; Number of Allocation Units
                                 ; on specified drive
NumSectsAllocUnit DB     ?       ; Number Sectors in an
                                 ; Allocation Unit
SectSize          DW     ?       ; Sector Size
MediaType@        DD     ?       ; Pointer to Media Type byte
```

Comments

This call is the same as call 1BH, except that on entry DL contains the number of the drive that contains the needed information (0 = default, 1 = A, and so forth). For more information on PC DOS 7 disk allocation, refer to “The Disk Directory” on page 11. Also, refer to function call 36H (Get Disk Free Space).

1FH — Get Default Drive Parameter Block

Purpose

Retrieves the drive parameter block for the default drive.

Examples

```
        MOV     AH,1FH   ; Function Call — Get Default DPB
        INT     21H      ; Issue request to DOS

        CMP     AL,0FFH  ;
        JZ      Error    ;

        MOV     WORD PTR [DEFAULT_DPB],BX
        MOV     WORD PTR [DEFAULT_DPB+2],DS
  -----

DPB     STRUCT
  dpbDrive         DB      ?       ; Drive Number (0=A, 1=B...)
  dpbUnit          DB      ?       ; Unit Number for Driver
  dpbSectorSize    DW      ?       ; Sector Size in Bytes
  dpbClusterMask   DB      ?       ; Sectors per Cluster
  dpbClusterShift  DB      ?       ; Sectors per Cluster - power of 2
  dpbFirstFAT      DW      ?       ; First Sector Containing FAT
  dpbFATCount      DB      ?       ; Number of FATs
  dpbRootEntries   DW      ?       ; Number of Root Directory Entries
  dpbFirstSector   DW      ?       ; First Sector of First Cluster
  dpbMaxCluster    DW      ?       ; Number of Clusters on Drive + 1
  dpbFATSize       DW      ?       ; Number of Sectors Occupied by FAT
  dpbDirSector     DW      ?       ; First Sector of Directory
  dpbDriverAddr    DD      ?       ; Address of the Device Driver
  dpbMedia         DB      ?       ; Media Descriptor Byte
  dpbFirstAccess   DB      ?       ; Indicates Access to the Drive
  dpbNextDPB       DD      ?       ; Address of Next Drive Parameter Block
  dpbNextFree      DW      ?       ; Last Allocated Cluster
  dpbFreeCnt       DW      ?       ; Count of Free Clusters
DPB
```

Comments

If AL contains zero then DS:BX (segment/offset registers) point to the DPB structure that will contain the drive parameters. If the default drive is for some reason invalid or a disk error occurs then AL will contain 0FFH.

21H — Random Read

Purpose

Reads the record addressed by the current block and current record fields into memory at the current disk transfer address.

Examples

```
                                 ;Set up FCB
   MOV  AX,SEG DTA               ;Address Data buffer
   MOV  DS,AX
   MOV  DX,OFFSET DTA
   MOV  AH,1AH                   ;Function Set DTA Address
   INT  21H                      ;Issue request to DOS
   MOV  AX,SEG FCB               ;Address FCB Parameter Block
   MOV  DS,AX
   MOV  DX,OFFSET FCB
   MOV  AH,21H                   ;Function Call-FCB Random Read
   INT  21H                      ;Issue request to DOS
   CMP   AL,0                    ;Data Read?
   JNE   Error                   ;No, Error!
  -----
  FCB           LABEL   BYTE
  ; Set by previous open
  ; DTA label byte
```

Comments

AL is 00H if the read was successful.

AL is 01H if the file was at End of File (EOF) (no data read).

AL is 02H if the read would have caused a wrap or overflow because the DTA was too small (the read was not completed).

AL is 03H if EOF (a partial record was read and filled out with 0′s).

Use Function Call 59H (Get Extended Error) to determine the actual error condition. The current block and current record fields are set to agree with the random record field. The record addressed by these fields is read into memory at the current disk transfer address. For information on record size see Chapter 4, “Accessing Files Using File Control Blocks” on page 23.

Note: Function 24H must be called before using this function.

Network Access Rights: Requires Read access rights.

22H — Random Write

Purpose

Writes the record addressed by the current block and current record fields from the current disk transfer address.

Examples

```
;Set up FCB

MOV  AX,SEG FCB       ;Address FCB parameter block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,24H           ;Function Call—FCB Set
                      ;Relative record field
INT  21H              ;Issue request to DOS
MOV  AX,SEG DTA       ;Address data buffer
MOV  DS,AX
MOV  DX,OFFSET DTA
MOV  AH,1AH           ;Function Set DTA address
INT  21H              ;Issue request to DOS
MOV  AX,SEG FCB       ;Address FCB parameter block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,22H           ;Function Call-FCB random writers
INT  21H              ;Issue request to DOS
CMP  AL,0             ;Data written?
JNE  Error            ;No, error!

-----

FCB           LABEL   BYTE
; Set by previous open
DTA           LABEL   BYTE
```

Comments

AL is 00H if the write was successful.

AL is 01H if the write or diskette is full (write cancelled).

AL is 02H if the read would have caused a wrap or overflow because the DTA was too small (write cancelled).

Use Function Call 59H (Get Extended Error) to determine the actual error condition.

The current block and current record fields are set to agree with the random record field. Then the record addressed by these fields is written (or in the case of records not the same as sector sizes — buffered) from the disk transfer address.

If the file is specified in read-only mode, the random write is not performed.

Network Access Rights: Requires Write access rights.

23H — File Size

Purpose

Searches the current directory for an entry that matches the specified file and sets the FCBs random record field to the number of records in the file.

Examples

```
 MOV  AX,SEG FCB      ; Address FCB parameter block
 MOV  DS,AX
 MOV  DX,OFFSET FCB
 MOV  AH,23H          ; Function Call-FCB file size
 INT  21H             ; Issue request to DOS
 CMP  AL,0            ; File found?
 JNE  Error           ; No, error!

-----

FCB          LABEL   BYTE
Drive        DB      0                ; Drive (0=Current, 1=A, 2=B, ...)
Name         DB      "FILENAME"       ; File name      (blank padded)
Ext          DB      "EXT"            ; File extension (blank padded)
             DB      25 DUP(0)        ; Filled in by DOS
```

Comments

AL is 00H if the file exists.

AL is FFH if the file was not created (normally a full directory or disk full).

Use Function Call 59H (Get Extended Error) to determine the actual error condition.

The 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 (in terms of the record size field rounded up). If no matching entry is found, AL returns FFH.

Note: If you do not set the FCB record size field before using this function, incorrect information is returned.

24H — Set Relative Record Field

Purpose

Sets the random record field to the same file address as the current block and record fields.

Examples

```
MOV  AX,SEG FCB    ;Address FCB parameter block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,24H        ;Function Call—FCB set
                   ;Relative record field
INT  21H           ;Issue request to DOS

-----

FCB           LABEL   BYTE
; Set by previous open
```

Comments

You must call this function before you perform random reads and writes, and random block reads and writes.

25H — Set Interrupt Vector

Purpose

Sets the interrupt vector table for the interrupt number.

Examples

```
MOV  AX,SEG Handler    ;Address new handler
MOV  DS,AX
MOV  DX,OFFSET Handler
MOV  AH,25H            ;Function Call — Set Interrupt
                       ;Vector
MOV  AL,Vector
INT  21H               ;Issue request to DOS

-----

Vector     DB     ?    ;Number of vector to be replaced
Handler:               ;Code to process interrupt
```

Comments

The interrupt vector table for the interrupt number specified in AL is set to address contained in DS:DX. Use function call 35H (Get Interrupt Vector) to obtain the contents of the interrupt vector.

26H — Create New Program Segment

Purpose

Creates a new program segment.

Examples

```
 MOV     AH,26H               ; Function Call — Create Program
                              ; Segment
 MOV     DX,SEG PSP           ; Segment address to create new PSP
 INT     21H                  ; Issue request to DOS

-----

PSP          LABEL   BYTE     ; Area to fill in
             DB      100H DUP(0)
```

Comments

The entire 100H area at location 0 in the current program segment is copied into location 0 in the new program segment. The memory size information at location 6 in the new segment is updated and the current termination, Ctrl-Break exit and critical error addresses from interrupt vector table entries for interrupts 22H, 23H, and 24H are saved in the new program segment starting at 0AH. They are restored from this area when the program ends.

Note: The EXEC function call 4BH provides a more complete service. Therefore, you should use the EXEC 4BH and avoid using this call.

27H — Random Block Read

Purpose

Reads the specified number of records (in terms of the record size field) from the file address specified by the random record field into the disk transfer address.

Examples

```
                            ;Set up disk transfer address

MOV  AX,SEG DTA             ;Address data buffer
MOV  DS,AX
MOV  DX,OFFSET DTA
MOV  AH,1AH                 ;Function set DTA address
INT  21H                    ;Issue request to DOS

MOV  AX,SEG FCB             ;Address FCB parameter block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,24H                 ;Function Call — FCB Set
                            ;Relative Record Field
INT  21H                    ;Issue request to DOS
MOV  AX,SEG FCB             ;Address FCB parameter block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  CX,Records_to_read     ;number of records to read
MOV  AH,27H                 ;Function Call — FCB random block read
INT  21H                    ;Issue request to DOS
CMP  AL,0                   ;Data read?
JNE  Error                  ;No, error!

 -----

 FCB              LABEL   BYTE
 ; Set by previous open
 DTA              LABEL   BYTE
                  DB      ?Dup(0)    ;I/O buffer
 Records_to_read  DW     ?
```

Comments

AL is 00H if the read was successful.

AL is 01H if the file was at End of File (EOF) (no data read).

AL is 02H if the read would have caused a wrap or overflow because the DTA was too small (the read was not completed).

AL is 03H if EOF (a partial record was read and filled out with zeros).

Use Function Call 59H (Get Extended Error) to determine the actual error condition.

The random record field and the current block/record fields are set to address the next record (the first record not read).

Note: Function 24H must be called before using this function.

Network Access Rights: Requires Read access rights.

28H — Random Block Write

Purpose

Writes the specified number of records from the disk transfer address into the file address specified by the random record field.

Examples

```
                             ;Set up disk transfer address
MOV  AX,SEG DTA              ;Address data buffer
MOV  DS,AX
MOV  DX,OFFSET DTA
MOV  AH,1AH                  ;Function set DTA address
INT  21H                     ;Issue request to DOS

MOV  AX,SEG FCB              ;Address FCB parameter block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  AH,24H                  ;Function Call—FCB set
                             ;Relative record field
INT  21H                     ;Issue request to DOS


MOV  AX,SEG FCB              ;Address FCB parameter block
MOV  DS,AX
MOV  DX,OFFSET FCB
MOV  CX,Records_to_write     ;Number of records to write
MOV  AH,28H                  ;Function Call — FCB Random Block write
INT  21H                     ;Issue request to DOS
CMP  AL,0                    ;Data written?
JNE  Error                   ;No, error!

  -----

DTA     LABEL     BYTE

        DB        ?DUP(0)     ; I/O Buffer
```

Comments

AL is 00H if the write was successful.

AL is 01H if the disk or diskette is full (write cancelled).

AL is 02H if the write would have caused a wrap or overflow because the DTA was too small (write cancelled).

Use Function Call 59H (Get Extended Error) to determine the actual error condition.

If there is insufficient space on the disk, AL returns 01H and no records are written. If CX is 0 upon entry, no records are written, but the file is set to the length specified by the random record field, whether longer or shorter than the current file size. (Allocation units are released or allocated as appropriate.)

Note: Function call 24H must be called before using this function.

Network Access Rights: Requires Write access rights.

29H — Parse Filename

Purpose

Parses the specified filename.

Examples

```
MOV   AX,SEG CmdBuf
MOV   DS,AX            ;Address command string
MOV   SI,OFFSET CmdBuf
MOV   AX,SEG FCB
MOV   ES,AX            ;Address FCB Parameter Block
MOV   DI,OFFSET FCB
MOV   AH,29H           ;Function Call - FCB Parse Filename
MOV   AL,OPTIONS       ;Set desired action
INT   21H              ;Issue request to DOS

CMP   AL,-1            ;Drive valid?
JE    Error            ;No, Error!
-----

CmdBuf      LABEL    BYTE
            DB       " a:file.ext      ",0DH

FCB         LABEL    BYTE
; Created in a pre-open state based on input found.
  Options   DB   ?   ;parsing options
```

Comments

The contents of AL are used to determine the action to take, as shown below:

```
     <must = 0>
bit:  7   6   5   4   3   2   1   0
```

If bit 0 = 1, leading separators are scanned off the command line at DS:SI. Otherwise, no scan-off of leading separators takes place.

If bit 1 = 1, the drive ID byte in the FCB will be set (changed) *only* if a drive was specified in the command line being parsed.

If bit 2 = 1, the filename in the FCB will be changed only if the command line contains a filename.

If bit 3 = 1, the filename extension in the FCB will be changed only if the command line contains a filename extension.

Filename separators include the following characters:

: . : , = + along with TAB and SPACE. Filename terminators include all of these characters plus ,<, >, |, /, ″, [,], and any control characters.

Output:

AL is 00H if no global characters (? or *) were found in the Command String.

AL is 01H if global characters (? or *) were found in the Command String.

AL is FFH if the drive specified is invalid.

The command line is parsed for a filename of the form *d*:*filename.ext*, and if found, a corresponding unopened FCB is created at ES:DI. If no drive specifier is present, it is assumed to be all blanks. If the character * appears in the filename or extension, it and all remaining characters in the name or extension are set to ?.

DS:SI returns pointing to the first character after the filename and ES:DI points to the first byte of the formatted FCB. If no valid filename is present, ES:DI+1 contains a blank.

2AH — Get Date

Purpose

Returns the day of the week, the year, month and date.

Examples

```
        MOV     AH,2AH          ; Function Call — Get Date
        INT     21H             ; Issue request to DOS
        MOV     DayofWeek,AL    ; Save Day of the Week
        MOV     Year,CX         ; Save Year
        MOV     Month,DH        ; Save Month
        MOV     Day,DL          ; Save Day

  -----

  DayofWeek     DB      ?       ; 0=Sunday, ... 6=Saturday
  Year          DW      ?       ; 1980 to 2099
  Month         DB      ?       ; 1 to 12
  Day           DB      ?       ; 1 to 31
```

Comments

If the time-of-day clock rolls over to the next day, the date is adjusted accordingly, taking into account the number of days in each month and leap years.

2BH — Set Date

Purpose

Sets the date (also sets CMOS clock, if present).

Examples

```
        MOV     AH,2BH          ; Function Call — Set Date
        MOV     CX,Year         ; Set Year
        MOV     DH,Month        ; Set Month
        MOV     DL,Day          ; Set Day
        INT     21H             ; Issue request to DOS
        CMP     AL,0            ; Valid Date?
        JNE     Error           ; No!
  -----

  Year          DW      ?       ; 1980 to 2099
  Month         DB      ?       ; 1 to 12
  Day           DB      ?       ; 1 to 31
```

Comments

AL is 00H if the date is valid and the operation is successful.

AL is FFH if the date is not valid.

On entry, CX:DX must have a valid date in the same format as returned by function call 2AH.

On return, AL returns 00H if the date is valid and the set operation is successful. AL returns FFH if the date is not valid.

2CH — Get Time

Purpose

Returns the time; hours, minutes, seconds and hundredths of seconds.

Examples

```
        MOV     AH,2CH          ; Function Call  —
                                ; Get Time
        INT     21H             ; Issue request to DOS
        MOV     Hour,CH         ; Save Hour
        MOV     Minute,CL       ; Save Minute
        MOV     Second,DH       ; Save Second
        MOV     Hundredth,DL    ; Save Partial Second

  -----

  Hour          DB      ?       ; 0 to 23
  Minute        DB      ?       ; 0 to 59
  Second        DB      ?       ; 0 to 59
  Hundredth     DB      ?       ; 0 to 99
```

Comments

On entry, AH contains 2CH. On return, CX:DX contains the time-of-day. Time is actually represented as four 8-bit binary quantities as follows:

CH Hours (0–23)
CL Minutes (0–59)
DH Seconds (0–59)
DL 1/100 seconds (0–99).

This format is readily converted to a printable form yet can also be used for calculations, such as subtracting one time value from another.

2DH — Set Time

Purpose

Sets the time (also sets the CMOS clock, if present).

Examples

```
          MOV     AH,2DH          ; Function Call — Set Time
          MOV     CH,Hour         ; Set Hour
          MOV     CL,Minute       ; Set Minute
          MOV     DH,Second       ; Set Second
          MOV     DL,Hundredth    ; Set Partial Second
          INT     21H             ; Issue request to DOS
          CMP     AL,0            ; Valid Time?
          JNE     Error           ; No!

    -----

    Hour          DB      ?       ; 0 to 23
    Minute        DB      ?       ; 0 to 59
    Second        DB      ?       ; 0 to 59
    Hundredth     DB      ?       ; 0 to 99
```

Comments

AL is 00H if the time is valid.

AL is FFH if the time is not valid.

On entry, CX:DX has time in the same format as returned by function 2CH. On return, if any component of the time is not valid, the set operation is cancelled and AL returns FFH. If the time is valid, AL returns 00H.

If your system has a CMOS realtime clock, it will be set.

2EH — Set/Reset Verify Switch

Purpose

Sets the verify switch.

Examples

```
; To set VERIFY=OFF

     MOV     AH,2EH          ; Function Call — Set
                             ; VERIFY
     MOV     AL,0            ; Set OFF
     INT     21H             ; Issue request to DOS

; To set VERIFY=ON

     MOV     AH,2EH          ; Function Call — Set
                             ; VERIFY
     MOV     AL,1            ; Set ON
     INT     21H             ; Issue request to DOS
```

Comments

On entry, AL must contain 01H to turn verify on, or 00H to turn verify off. When verify is on, PC DOS 7 performs a verify operation each time it performs a disk write to assure proper data recording. Although disk recording errors are very rare, this function has been provided for applications in which you may wish to verify the proper recording of critical data. You can obtain the current setting of the verify switch through function call 54H.

Note: Verification is not supported on data written to a network disk.

2FH — Get Disk Transfer Address (DTA)

Purpose

Returns the current disk transfer address.

Examples

```
        MOV     AH,2FH              ; Function Call — Get
                                    ; DTA Address
        INT     21H                 ; Issue request to DOS
        MOV     WORD PTR DTA@+0,BX  ; Save Address
        MOV     WORD PTR DTA@+2,ES

  -----

  DTA@          DD      ?           ; DTA Buffer
```

Comments

On entry, AH contains 2FH. On return, ES:BX contains the current Disk Transfer Address. You can set the DTA using function call 1AH.

30H — Get DOS Version Number

Purpose

Returns the DOS version number.

Examples

```
        PUSH    CX                  ; CX destroyed in call
        PUSH    BX
        MOV     AH,30H              ; Function Call — Get PC DOS 7
                                    ; Version
        INT     21H                 ; Issue request to DOS
        MOV     MajorVersion,AL     ; Save Version
        MOV     MinorVersion,AH
        MOV     DOS_Running_From,BH ;
        POP     BX
        POP     CX

  -----
MajorVersion     DB      ?       ; X of X.YY
MinorVersion     DB      ?       ; YY of X.YY
DOS_Running_From DB      ?       ; 0 = DOS not running in ROM
DOS_Running_From DB      ?       ; 8 = DOS running in ROM
```

Comments

On entry, AH contains 30H. On return, CX is set to 0. AL contains the major version number. AH contains the minor version number. BH contains 8 or 0 for DOS running or not running in ROM.

If AL returns a major version number of 0, you can assume that the DOS version is pre-DOS 2.00.

Use function call 33H AL=6 (Get or Set System Value) to get the true version number.

31H — Terminate Process and Remain Resident

Purpose

Terminates the current process and attempts to set the initial allocation block to the memory size in paragraphs.

Examples

```
        MOV     AH,31H          ; Function Call — Terminate
                                ; and Keep Process
        MOV     AL,RetCode      ; Set value of ERRORLEVEL
        MOV     DX,MySize       ; Set my program and data size
        INT     21H             ; Issue request to DOS
        INT     20H             ; Be safe if on DOS Version 1.X

  -----

  RetCode       DB      ?       ; Value to return to my EXEC'er
  MySize        DW      ?       ; Size of my code and data
                                ; (in paragraphs)
```

Comments

On entry, AL contains a binary return code. DX contains the memory size value in paragraphs. This function call does not free up any other allocation blocks belonging to that process. Files opened by the process are not closed when the call is executed. The return code passed in AL is retrievable by the parent through Wait (function call 4DH) and can be tested through the ERRORLEVEL batch subcommands.

Memory is used efficiently 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 2C of the PSP, and issuing function call 49H (Free Allocated Memory). The five standard handles, 0000 through 0004, should be closed before exiting.

32H — Get Drive Parameter Block

Purpose

Retrieves the drive parameter block for the specified drive.

Examples

```
        MOV     DL,DRIVE_NUM ; Drive Number (0=Default, 1=A, 2=B...)
        MOV     AH,32H       ; Function Call – Get DPB
        INT     21H          ; Issue request to DOS

        CMP     AL,0FFH  ;
        JZ      Error    ;

        MOV     WORD PTR [SPECIFIED_DPB],BX
        MOV     WORD PTR [SPECIFIED_DPB+2],DS


  -----
DPB     STRUCT
  dpbDrive         DB      ?       ; Drive Number (0=A, 1=B...)
  dpbUnit          DB      ?       ; Unit Number for Driver
  dpbSectorSize    DW      ?       ; Sector Size in Bytes
  dpbClusterMask   DB      ?       ; Sectors per Cluster
  dpbClusterShift  DB      ?       ; Sectors per Cluster - power of 2
  dpbFirstFAT      DW      ?       ; First Sector Containing FAT
  dpbFATCount      DB      ?       ; Number of FATs
  dpbRootEntries   DW      ?       ; Number of Root Directory Entries
  dpbFirstSector   DW      ?       ; First Sector of First Cluster
  dpbMaxCluster    DW      ?       ; Number of Clusters on Drive + 1
  dpbFATSize       DW      ?       ; Number of Sectors Occupied by FAT
  dpbDirSector     DW      ?       ; First Sector of Directory
  dpbDriverAddr    DD      ?       ; Address of the Device Driver
  dpbMedia         DB      ?       ; Media Descriptor Byte
  dpbFirstAccess   DB      ?       ; Indicates Access to the Drive
  dpbNextDPB       DD      ?       ; Address of Next Drive Parameter Block
  dpbNextFree      DW      ?       ; Last Allocated Cluster
  dpbFreeCnt       DW      ?       ; Count of Free Clusters
DPB
```

Comments

If AL contains zero then DS:BX (segment/offset registers) point to the DPB structure that will contain the drive parameters. If the specified drive is for some reason invalid or a disk error occurs then AL will contain 0FFH.

33H — Get or Set System Value

Purpose

Set or get the state of System Values such as BREAK (Ctrl-Break checking).

Examples

```
; To check BREAK state

      MOV     AH,33H          ; Function Call — Get/Set
                              ; System value
      MOV     AL,0            ; Do Get BREAK
      INT     21H             ; Issue request to DOS
      MOV     BREAK,DL        ; Save state (00=OFF, 01H=ON)

; To set BREAK=OFF

      MOV     AH,33H          ; Function Call — Get/Set
                              ; System value
      MOV     AL,1            ; Do Set BREAK
      MOV     DL,0            ; Set OFF
      INT     21H             ; Issue request to DOS

; To set BREAK=ON

      MOV     AH,33H          ; Function Call — Get/Set
                              ; System Value
      MOV     AL,1            ; Do Set BREAK
      MOV     DL,1            ; Set ON
      INT     21H             ; Issue request to DOS

; To get the Boot Drive

      MOV     AH,33H          ; Function Call — Get/Set
                              ; System Value
      MOV     AL,5            ; Do Get Boot Drive
      INT     21H             ; Issue request to DOS
      MOV     Drive,DL        ; Save boot drive

; To get the True Version Number

      MOV     AH,33H          ; Function Call — Get/Set
                              ; System Value
      MOV     AL,6            ; Get True Version
      INT     21H             ; Issue request to DOS
      MOV     MajorVersion,BL
```

```
      MOV     MinorVersion,BH
      MOV     Rev_Level,DL
      MOV     DOS_Flags,DH

----

BREAK         DB      ?       ; Current BREAK state (0=OFF, 1=ON)
Drive         DB      ?       ; PC DOS 7 boot drive (1=A, 2=B, ...)
MajorVersion  DB      ?       ; True Version X of X.YY
MinorVersion  DB      ?       ; YY of X.YY
Rev_Level     DB      ?       ; The lower three bits indicates the
                              ; revision number.  All other bits
                              ; are reserved and set to 0.
DOS_Flags     DB      ?       ; Bits 0 - 2  Reserved.
                              ; Bit 3       When set to 1, DOS is
                              ;             running from ROM.
                              ; Bit 4       When set to 1, DOS is
                              ;             running from HMA.
                              ; Bits 5 - 7  Reserved.
```

34H — Get InDOS Flag Address

Purpose

Returns the address of the PC DOS 7 InDOS flag. The InDOS flag shows the current state of Interrupt 21H processing.

Examples

```
MOV     AH,34H        ; Function Call — Get InDOS Flag Address
INT     21H           ; Issue request to DOS

MOV     InDOS,BYTE PTR ES:[BX]
```

Comments

While PC DOS 7 is processing one of the Interrupt 21H functions, the value of the InDOS flag will be nonzero.

The ES:BX (segment/offset) register pair will contain the InDOS flag address.

35H — Get Interrupt Vector

Purpose

To obtain the address in an interrupt vector.

Examples

```
        MOV   AH,35H                  ; Function Call –
                                      ; Set Interrupt Vector
        MOV   AL,Vector               ; Vector to get (0 to 255)
        INT   21H                     ; Issue request to DOS
        MOV   WORD PTR OldVect+0,BX
        MOV   WORD PTR OldVect+2,ES

  -----

  OldVect      DD      ?              ; Previous vector contents
  Vector       DB      ?              ; Vector number to get
```

Comments

On return, ES:BX contains the CS:IP interrupt vector for the specified interrupt. Use function call 25H (Set Interrupt Vector) to set the interrupt vectors.

36H — Get Disk Free Space

Purpose

Returns the disk free space (available clusters, clusters/drive, bytes/sector).

Examples

```
          MOV     AH,36H                     ; Function Call —
                                             ; Get disk free space
          MOV     DL,Drive                   ; Drive to query
                                             ; (0=current, 1=A:,
                                             ; 2=B:, ...)
          INT     21H                        ; Issue request to DOS
          CMP     AX,-1                      ; Error?
          JE      Error                      ; Yes
          MOV     SectAU,AX                  ; Save allocation unit
                                             ; Size
          MOV     AvailAU,BX                 ; Save free allocation
                                             ;  Units
          MOV     SectSize,CX                ; Save sector size
          MOV     TotalAU,DX                 ; Save disk size

          MOV     AX,SectSize                ; Calculate allocation
                                             ; Unit size
          MUL     SectAU
          MOV     CX,AX                      ; CX = bytes/AU
          MOV     AX,TotalAU                 ; Calculate total space
          MUL     CX
          MOV     WORD PTR TotalBytes+0,AX ; Save it
          MOV     WORD PTR TotalBytes+2,DX
          MOV     AX,AvailAU                 ; Calculate free space
          MUL     CX
          MOV     WORD PTR FreeBytes+0,AX  ; Save it
          MOV     WORD PTR FreeBytes+2,DX

    -----

    SectAU        DW      ?                  ; Sectors in an
                                             ; Allocation unit
    AvailAU       DW      ?                  ; Free allocation units
    SectSize      DW      ?                  ; Bytes in a sector
    TotalAU       DW      ?                  ; Number of allocation
                                             ; Units on DL disk
    TotalBytes    DD      ?                  ; Disk size in bytes
    FreeBytes     DD      ?                  ; Free space in bytes
    Drive         DD      ?                  ; Drive number to get info for
```

Comments

If the drive number in DL was valid, BX contains the number of available allocation units, DX contains the total number of allocation units on the drive, CX contains the number of bytes per sector, and AX contains the number of sectors for each allocation unit.

38H — Get or Set Country Dependent Information

Purpose

Sets the Active Country or returns country dependent information.

Examples

```
; To set the Current Country

      MOV     AH,38H          ; Function Call — Get/Set
                              ; Country Information
      MOV     AL,CountryID    ; Country ID (-1 if >= 255)
      MOV     BX,CountryIDX   ; Country ID (if AL=-1)
      MOV     DX,-1           ; Indicate set country code
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX

; To get Country Information

      MOV     AX,SEG Buffer
      MOV     DS,AX
      MOV     DX,OFFSET Buffer
      MOV     AH,38H
      MOV     AL,CountryID    ; Country ID (-1 if >= 255)
                              ; (0 to get current country)
      MOV     BX,CountryIDX   ; Country ID (if AL=-1)

      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX
      MOV     CountryCode,BX  ; Save current Country Code

----

CountryCode   DW      ?       ; Current country code

CountryIDX    DW      ?       ; Extended country code for input

Buffer        LABEL   WORD    ; Country information (see format below)
CountryID     DB      ?       ; Country code for input
```

Country Information

```
DateFormat    DW    ?          ; Date Format:
                               ;   0 = m d y order
                               ;   1 = d m y order
                               ;   2 = y m d order
$Symbol       DB    "????",0   ; Currency Symbol
                               ;   example: "DM",0,?,?
Sep1000       DB    "?",0      ; Thousands Separator
                               ;   example: ",",0
Sep1          DB    "?",0      ; Fractions Separator
                               ;   example: ".",0
SepDate       DB    "?",0      ; Date Separator
                               ;   example: "/",0
SepTime       DB    "?",0      ; Time Separator
                               ;   example: ":",0
$Format       DB    ?          ; Currency Format:
                               ;   0 = currency symbol, value
                               ;   1 = value, currency symbol
                               ;   2 = currency symbol, space, value
                               ;   3 = value, space, currency symbol
                               ;   4 = currency symbol is decimal separator
SigDigits     DB    ?          ; Number of Significant Digits in Currency
TimeFormat    DB    ?          ; Time Format:
                               ;   0 = 12 hour clock
                               ;   1 = 24 hour clock
UpperCaseAL@  DD    ?          ; Address of Routine to Upper Case AL
                               ;   Only for values >=80H
SepData       DB    "?",0      ; Data List Separator
                               ;   example: ",",0
Reserved      DW    5 DUP(?)   ; Reserved for future
```

Comments

The date format has the following values and meaning:

Code	**Date**
0=USA	m d y
1=Europe	d m y
2=Japan	y m d

Case Map Call Address: The register contents for the case map call are:

On Entry	Register Contents
AL	ASCII code of character to be converted to uppercase

On Return	Register Contents
AL	ASCII code of the uppercase input character

The case map call address is in a form suitable for a FAR call indirect.

Results

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Function Call 65H (Get Extended Country Information) returns more country information and is preferred.

Setting the Current County Code by using this function call is not recommended. The user can set it by placing a COUNTRY command in the CONFIG.SYS file. The Country Code set by the user should not be changed. The NLSFUNC PC DOS 7 extension must be installed to change the Current Country.

39H — Create Subdirectory (MKDIR)

Purpose

Creates the specified directory.

Examples

```
MOV  AX,SEG    DName  ;Directory Name
MOV  DS,AX
MOV  DX,OFFSET DName
MOV  AH,39H           ;Function-Make a directory
INT  21H              ;Issue request to DOS
JC   Error

 ----

DName          DB     "?? .. ??",0  ; ASCIIZ Name
                                    ; Example:
                                    ; "c:\dir",0
```

Comments

On entry, DS:DX contains the address of an ASCIIZ string with drive and directory path names. All directory levels other than the last one in the name must exist before using this function. Only one directory level at a time can be created with this function. The maximum length of the ASCIIZ string is 64 characters.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

Network Access Rights: Requires Create access rights.

3AH — Remove Subdirectory (RMDIR)

Purpose

Removes the specified directory.

Examples

```
MOV  AX,SEG DName             ;Directory name
MOV  DS,AX
MOV  DX,OFFSET DName
MOV  AH,3AH                   ;Function-Remove directory
INT  21H                      ;Issue request to DOS
JC   Error

 ----

DName          DB      "?? .. ??",0  ; ASCIIZ Name
                                     ;   example: "c:\dir",0
```

Comments

On entry, DS:DX contains the address of an ASCIIZ string with the drive and directory path names. The specified directory is removed from the structure. The current directory or a directory with files in it cannot be removed.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

Network Access Rights: Requires Create access rights.

3BH — Change the Current Directory (CHDIR)

Purpose

Changes the current directory to the specified directory.

Examples

```
MOV  AX,SEG DName             ;Directory name
MOV  DS,AX
MOV  DX,OFFSET DName
MOV  AH,3BH                   ;Function — Change directory
INT  21H                      ;Issue request to DOS
JC   Error

 ----

DName          DB      "?? .. ??",0  ; ASCIIZ Name
                                     ;   example: "c:\dir",0
```

Comments

On entry, DS:DX contains the address of an ASCIIZ string with drive and directory path names. The string is limited to 64 characters and cannot contain a network path. If any member of the directory path does not exist, the directory path is not changed. Otherwise, the current directory is set to the ASCIIZ string.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

3CH — Create a File

Purpose

Creates a new file or shortens an old file to 0 length in preparation for writing.

Examples

```
          MOV     AX,SEG FName          ;File name
          MOV     DS,AX
          MOV     DX,OFFSET FName
          MOV     AH,3CH                ;Function — Create a File
          MOV     CX,Attribute          ; Attribute of the file
                                        ; Allowed values
                                        ;  0001H=Read only
                                        ;  0002H=Hidden
                                        ;  0004H=System
                                        ;  0008H=Volume label
          INT     21H                   ; Issue request to DOS
          JC      Error                 ; Error code in AX
          MOV     Handle,AX             ; Save file handle for

  ----

  FName           DB      "?? .. ??",0  ; ASCIIZ Name
                                        ;   example: "c:\dir\file.ext",0
  Handle          DW      ?             ; File handle
  Attribute       DW      ?             ; Attributes for directory entry
```

Comments

If the file did not exist, the file is created in the appropriate directory and the file is given the read/write access code. The file is opened for read/write, the read/write pointer is set to the first byte of the file and the handle is returned in AX. Note that function call 43H (Change File Mode) can be used later to change the attribute of the file.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

This function does not replace an existing volume label. You must delete the existing volume label before issuing this call.

Network Access Rights: Requires Create access rights.

3DH — Open a File

Purpose

Opens the specified file.

Examples

```
MOV  AX,SEG FName          ; File name
MOV  DS,AX
MOV  DX,OFFSET FName
MOV  AH,3DH                ; Function — Open a File
MOV  AL,OpenMode
INT  21H                   ; Issue request to DOS
JC   Error                 ; Error code in AX
MOV  Handle,AX             ; Save file handle for following operations

 ----

 FName         DB      "?? .. ??",0  ; ASCIIZ Name
                                     ;   example: "c:\dir\file.ext",0
 Handle        DW      ?             ; File Handle
 OpenMode      DB      ?             ; Open mode
```

Comments

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 with function call 42H. The returned file handle must be used for subsequent input and output to the file. The file's date and time can be obtained or set through call 57H, and its attribute can be obtained through call 43H.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

Notes:

1. This call opens any normal or hidden file whose name matches the name specified.
2. Device names cannot end in a colon.
3. When a file is closed, any sharing restrictions placed on it by the open are canceled.
4. File sharing must be loaded, or the file must be a network file for the sharing modes to function. Refer to the SHARE command.

5. The file read-only attribute can be set when creating the file using extended FCBs or specifying the appropriate attribute in CX and using the CHMOD interrupt 21H function call or the PC DOS 7 ATTRIB command.
6. If the file is inherited by the subordinate process, all sharing and access restrictions are also inherited.
7. If an open file handle is duplicated by either of the DUP function calls, all sharing and access restrictions are also duplicated.

Open Mode

The open mode is defined in AL and consists of four bit-oriented fields:

Inheritance flag	Specifies if the opened file is inherited by a subordinate process.
Sharing mode field	Defines which operations other processes can perform on the file.
Reserved field	
Access field	Defines which operations the current process can perform on the file.

Bit Fields

The bit fields are mapped as follows:

```
                 <I> < S > <R> < A >
 Open Mode bits   7  6 5 4  3  2 1 0
```

I Inheritance flag

If I = 0; File is inherited by subordinate processes.
If I = 1; File is private to the current process.

S Sharing Mode

The file is opened as follows:

S = 000 — Compatibility mode
S = 001 — DenyRead/Write mode (exclusive)
S = 010 — DenyWrite mode
S = 011 — DenyRead mode
S = 100 — DenyNone mode

Any other combinations are invalid.

When opening a file, you must inform PC DOS 7 which operations any other processes, in sharing mode, can perform on the file.

The default, compatibility mode, denies all other computers in a network access to the file. If other processes can continue to read the file while your process is operating on it, specify DenyWrite. DenyWrite prohibits writing by other processes, but allows reading.

Similarly, you must specify which operations, or access modes, your process can perform. The default access mode, ReadWrite, causes the open request to fail if another process on the computer or any other computer on a network has the file opened with any sharing mode other than DenyNone. If you intend to read from the file only, your Open will succeed unless all other processes have specified DenyNone or DenyWrite. File sharing requires cooperation of both sharing processes.

R Reserved (set this bit field to 0).

A Access

The file access is assigned as follows:

If A = 000; Read access
If A = 001; Write access
If A = 010; Read/Write access

Any other combinations are invalid.

Network Access Rights: If the Access field (A) of the Open mode field (AL) is equal to:

000 Requires Read access rights

001 Requires Write access rights

010 Requires Read/Write access rights

Compatibility Mode

A file is considered to be in compatibility mode if the file is opened by:

- Any of the CREATE function calls
- An FCB function call
- A handle function call with compatibility mode specified.

A file can be opened any number of times in compatibility mode by a single process, provided that the file is not currently open under one of the other four sharing modes. If the file is marked read-only, and is open in DenyWrite sharing mode with Read Access, the file may be opened in Compatibility Mode with Read Access. If the file was successfully opened in one of the other sharing modes and an attempt is made to open the file again in Compatibility Mode, an interrupt 24H is generated to signal this error. The base interrupt 24H error indicates `Drive not ready`, and the extended error indicates a `Sharing violation`.

Sharing Modes

The sharing modes for a file opened in compatibility mode are changed by PC DOS 7 depending on the read-only attribute of the file. This allows sharing of read-only files.

File Opened By	Read-Only Access	Sharing Mode
FCB	Read-Only	DenyWrite
Handle Read	Read-Only	DenyWrite
Handle Write	Error	-----
Handle Read or Write	Error	-----

File Opened By	Not Read-Only Access	Sharing Mode
FCB	Read/Write	Compatibility
Handle Read	Read	Compatibility
Handle Write	Write	Compatibility
Handle Read or Write	Read or Write	Compatibility

DenyRead/Write Mode (Exclusive)

If a file is successfully opened in DenyRead/Write mode, access to the file is exclusive. A file currently open in this mode cannot be opened again in any sharing mode by any process (including the current process) until the file is closed.

DenyWrite Mode

A file successfully opened in DenyWrite sharing mode prevents any other write access opens to the file (A = 001 or 010) until the file is closed. An attempt to open a file in DenyWrite mode is unsuccessful if the file is open with a write access.

DenyRead Mode

A file successfully opened in DenyRead sharing mode prevents any other read sharing access opens to the file (A = 000 or 010) until the file is closed. An attempt to open a file in DenyRead sharing mode is unsuccessful if the file is open in Compatibility mode or with a read access.

DenyNone Mode

A file successfully opened in DenyNone mode places no restrictions on the read/write accessibility of the file. An attempt to open a file in DenyNone mode is unsuccessful if the file is open in Compatibility mode.

When accessing files that reside on a network disk, no local buffering is done when files are opened in any of the following sharing modes:

- DenyRead
- DenyNone.

Therefore, in a network environment, DenyRead/Write sharing mode, Compatibility sharing mode, and DenyWrite mode opens are buffered locally.

The following sharing matrix shows the results of opening, and subsequently attempting to reopen the same file using all combinations of access and sharing modes:

		DRW			DW			DR			ALL		
		I	IO	O	I	IO	O	I	IO	O	I	IO	O
DRW	I	N	N	N	N	N	N	N	N	N	N	N	N
	IO	N	N	N	N	N	N	N	N	N	N	N	N
	O	N	N	N	N	N	N	N	N	N	N	N	N
DW	I	N	N	N	Y	N	N	N	N	N	Y	N	N
	IO	N	N	N	N	N	N	N	N	N	Y	N	N
	O	N	N	N	N	N	N	Y	N	N	Y	N	N
DR	I	N	N	N	N	N	N	N	N	N	N	N	Y
	IO	N	N	N	N	N	N	N	N	N	N	N	Y
	O	N	N	N	N	N	N	N	N	Y	N	N	Y
ALL	I	N	N	N	Y	Y	Y	N	N	N	Y	Y	Y
	IO	N	N	N	N	N	N	N	N	N	Y	Y	Y
	O	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y

Y	:2nd,3rd,...open is allowed
N	:2nd,3rd,...open is denied
DRW	:DenyRead/Write Mode (Exclusive)
DW	:DenyWrite Mode
DR	:DenyRead Mode
ALL	:Read/Write Mode
I	:Read Only Access
O	:Write Only Access
IO	:Read/Write Access

3EH — Close a File Handle

Purpose

Closes the specified file handle.

Examples

```
        MOV     AH,3EH          ; Function Call –
                                ; Close a Handle
        MOV     BX,Handle
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX

  ----

  Handle        DW      ?       ; File Handle (from Open / Create)
```

Comments

On entry, BX contains the file handle that was returned by Open or Create. On return, the file is closed, the directory is updated, and all internal buffers for that file are flushed.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

3FH — Read from a File or Device

Purpose

Transfers the specified number of bytes from a file into a buffer location.

Examples

```
MOV  AX,SEG Buffer           ; Address data buffer
MOV  DS,AX
MOV  DX,OFFSET Buffer
MOV  AH,3FH                  ; Function — Read from a file
MOV  BX,Handle
MOV  CX,BufSize              ; Buffer size
INT  21H                     ; Issue request to DOS
JC   Error                   ; Error code in AX
CMP  AX,0                    ; At End Of File?
JE   EOF                     ; Yes!
MOV  SizeRead,AX             ; Save Amount Read

 ----
 N             EQU   512       ; Typical buffer size
 Handle        DW    ?         ; File Handle (from Open /Create)
 BufSize       DW    N         ; Buffer Size, N is
 Buffer        DB    N DUP(?)  ; Data Buffer
 SizeRead      DW    ?         ; Amount of Data in Buffer
```

Comments

On entry, BX contains the file handle. CX contains the number of bytes to read. DS:DX contains the buffer address. On return, AX contains the number of bytes read.

This function call attempts to transfer (CX) bytes from a file into a buffer location. It is not guaranteed that all bytes will be read. For example, when PC DOS 7 reads from the keyboard, at most one line of text is transferred. If this read is performed from the standard input device, the input can be redirected. If the value in AX is 0, then the program has tried to read from the end of file.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

Network Access Rights: Requires Read access rights.

40H — Write to a File or Device

Purpose

Transfers the specified number of bytes from a buffer into a specified file.

Examples

```
MOV  AX,SEG Buffer       ;Data Buffer
MOV  DS,AX
MOV  DX,OFFSET Buffer
MOV  CX,BufSize
MOV  AH,40H              ;Function-Write to a File
MOV  BX,Handle
MOV  DX,OFFSET Buffer
INT  21H                 ; Issue request to DOS
JC   Error               ; Error code in AX
CMP  AX,CX               ; Disk Full?
JB   FullDisk            ; Yes!

 ----
 N            EQU    512      ; Typical buffer size
 Handle       DW     ?        ; File Handle (from Open / Create)
 BufSize      DW     N        ; Buffer Size
 Buffer       DB     N DUP(?) ; Data Buffer
```

Comments

On entry, BX contains the file handle. CX contains the number of bytes to write. DS:DX contains the address of the data to write.

This function call attempts to transfer (CX) bytes from a buffer into a file. AX returns the number of bytes actually written. If the carry flag is not set and this value is not the same as the number requested (in CX), it should be considered an error. Although no error code is returned, your program can compare these values. Normally, the reason for the error is a full disk. If this write is performed to the standard output device, the output can be redirected.

To truncate a file at the current position of the file pointer, set the number of bytes (CX) to 0 before issuing the interrupt 21H. The file pointer can be moved to the desired position by reading, writing, and performing function call 42H, (Move File Read/Write Pointer.)

If the file is read-only, the write to the file or device is not performed.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

Network Access Rights: Requires Write access rights.

41H — Delete a File from a Specified Directory (UNLINK)

Purpose

Removes a directory entry associated with a filename.

Examples

```
        MOV  AX,SEG FName        ; File Name
        MOV  DS,AX
        MOV  DX,OFFSET FName
        MOV  AH,41H              ; Function-Delete a File
        INT  21H                 ; Issue request to DOS
        JC   Error               ; Error code in AX

  ----

 FName       DB    ″?? .. ??″,0  ; ASCIIZ Name
                                 ;   example: ″c:\dir\File.ext″,0
```

Comments

Global filename characters are not allowed in any part of the ASCIIZ string. Read-only files cannot be deleted by this call. To delete a read-only file, you can first use call 43H to change the file′s read-only attribute to 0, then delete the file.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

Network Access Rights: Requires Create access rights.

42H — Move File Read/Write Pointer (LSEEK)

Purpose

Moves the read/write pointer according to the method specified.

Examples

```
          MOV     AH,42H                  ; Function Call —
                                          ; Move Read/Write Pointer
          MOV     AL,Method               ; Method of Positioning:
                                          ;   0 = From Beginning of File
                                          ;       (BOF)
                                          ;   1 = From Current Position
                                          ;   2 = From End of File (EOF)
          MOV     BX,Handle               ; Select File
          MOV     DX,WORD PTR Position+0  ; New Position = Position + METHOD
          MOV     CX,WORD PTR Position+2
          INT     21H                     ; Issue request to DOS
          JC      Error                   ; Error code in AX
          MOV     WORD PTR Position+0,AX  ; Set new File Position
          MOV     WORD PTR Position+2,DX

  ----

  Handle          DW      ?               ; File Handle (from Open /
                                          ; Create)
  Position        DD      ?               ; File Offset (may be
                                          ; negative)
  Method          DB      ?
```

Comments

On entry, AL contains a method value. BX contains the file handle. CX:DX contains the desired offset in bytes with CX containing the most significant part. On return, DX:AX contains the new location of the pointer with DX containing the most significant part if the carry flag is not set.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

This function call moves the read/write pointer according to the following methods:

AL	Description
0	The pointer is moved CX:DX bytes (offset) from the beginning of the file.
1	The pointer is moved to the current location plus offset.
2	The pointer is moved to the end-of-file plus offset. This method can be used to determine file′s size.

Note: If an LSEEK operation is performed on a file that resides on a network disk that is open in either DenyRead or DenyNone sharing mode, the read/write pointer information is adjusted on the computer where the file actually exists. If the file is opened in any other sharing mode, the read/write pointer information is kept on the remote computer.

43H — Change File Mode (CHMOD)

Purpose

Changes the file mode of the specified file.

Examples

```
; To Get Attributes

      MOV     AX,SEG FName          ;File Name
      MOV     DS,AX
      MOV     DX,OFFSET FName       ;DS:DX points to ASCIIZ path name
      MOV     AL,0                  ;Indicate get
      MOV     AH,43H                ;Function-Change File Mode
      INT     21H                   ;Issue request to DOS
      JC      Error                 ;Error code in AX
      MOV     Attribute,CX          ;Save Attribute

; To Set Attributes

      MOV     AX,SEG FName          ;File Name
      MOV     DS,AX
      MOV     DX,OFFSET FName       ;DS:DX points to ASCIIZ path name
      MOV     AL,1                  ;Indicate set
      MOV     AH,43H                ;Function-Change File Mode
      MOV     CX,Attribute          ;Set Attribute
      INT     21H                   ;Issue request to DOS
      JC      Error                 ;Error code in AX

----

Fname         DB      64 Dup (0)    ;ASCIIZ Name
                                    ;  example: "c:\dir\File.ext",0
Attribute     DW      ?             ;File Attribute
                                    ;  example: 0001H to set Read-Only
```

Comments

On entry, AL contains a function code, and DS:DX contains the address of an ASCIIZ string with the drive, path, and filename.

If AL contains 01H, the file′s attribute is set to the attribute in CX. See "The Disk Directory" on page 11 for the attribute byte description. If AL is 00H the file′s current attribute is returned in CX.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

Note: Only the Archive (20H), Read-Only (01H), System (04H) and Hidden (02H) bits can be changed. All other bits of CX must be 0, otherwise, an error may be indicated.

Network Access Rights: To change the archive bit (AL=20H), no access rights are required. To change any other bit, Create access rights are required.

44H — I/O Control for Devices

Purpose

Sets or gets device information associated with open device handles, or sends control strings to the device handle or receives control strings from the device handle.

See Appendix C, "I/O Control for Devices (IOCtl)" on page 273 for full details on this function call.

AL = 00H	Get device information (returned in DX).
AL = 01H	Set device information (determined by DX). DH must be 0 for this call.
AL = 02H	Read from character device
AL = 03H	Write to character device
AL = 04H	Read from block device
AL = 05H	Write to block device
AL = 06H	Get input status
AL = 07H	Get output status
AL = 08H	Determine if a particular block device is removable
AL = 09H	Determine if a logical device is local or remote
AL = 0AH	Determine if a handle is local or remote
AL = 0BH	Change sharing retry count
AL = 0CH	Issue handle generic IOCtl request
AL = 0DH	Issue block device generic IOCtl request
AL = 0EH	Get logical drive
AL = 0FH	Set logical drive
AL = 10H	QueryIOCtlHandle
AL = 11H	QueryIOCtlDevice

45H — Duplicate a File Handle (DUP)

Purpose

Returns a new file handle for an open file that refers to the same file at the same position.

Examples

```
        MOV     AH,45H          ; Function Call —
                                ; Duplicate a Handle
        MOV     BX,Handle       ; Select File
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        MOV     NewHandle,AX    ; Save New Handle

  ----

  Handle        DW      ?       ; File Handle (from Open / Create)
  NewHandle     DW      ?       ; File Handle that duplicates Handle
```

Comments

On entry, BX contains the file handle. On return, AX contains the returned file handle.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

Note: If you move the read/write pointer of either handle by a read, write, or LSEEK function call, the pointer for the other handle is also changed.

46H — Force a Duplicate of a Handle (FORCDUP)

Purpose

Forces the handle in CX to refer to the same file at the same position as the handle in BX.

Examples

```
        MOV     AH,46H          ; Function Call –
                                ; Force Duplicate a Handle
        MOV     BX,Handle       ; Select file
        MOV     CX,NewHandle    ; Select new definition of File
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX

  ----

  Handle        DW      ?       ; File Handle (from Open/Create)
  NewHandle     DW      ?       ; File Handle that duplicates Handle
```

Comments

On entry, BX contains the file handle. CX contains a second file handle. On return, the CX file handle refers to the same file at the same position as the BX file handle. If the CX file handle was an open file, it is closed first. If you move the read/write pointer of either handle, the pointer for the other handle is also changed.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

47H — Get Current Directory

Purpose

Places the full path name (starting from the root directory) of the current directory for the specified drive in the area pointed to by DS:SI.

Examples

```
 MOV     AX,SEG DName     ; Directory Name Buffer
 MOV     DS,AX
 MOV     SI,OFFSET DName  ; OS:SI points to buffer
 MOV     DL,Drive         ; Select Drive
 MOV     AH,47H           ; Function-Get Current Dir
 INT     21H              ; Issue request to DOS
 JC      Error            ; Error code in AX

----

Drive    DB  ?            ; Drive (0=current, 1=A:, 2=b:, ...)
DName    DB  64 DUP(?)    ; ASCIIZ Directory Name Returned
                          ;   example: "dir1\dir2",0
```

Comments

The drive letter is not part of the returned string. The string does not begin with a backslash and is terminated by a byte containing 00H.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

48H — Allocate Memory

Allocates the requested number of paragraphs of memory.

Examples

```
        MOV     AH,48H          ; Function Call –
                                ; Allocate Memory
        MOV     BX,Paragraphs   ; Paragraphs Desired
        INT     21H             ; Issue request to DOS
        JNC     Done
        MOV     AH,48H          ; Function Call –
                                ; Allocate memory
                                ; BX set to largest available memory
        INT     21H             ; Issue request to DOS
Done:
        MOV     BlockSeg,AX     ; Save BlockSeg of memory
        MOV     Paragraphs,BX

----

Paragraphs      DW      ?       ; Size requested in paragraphs
                                ; (Bytes allocated is 16 * Paragraphs)
BlockSeg        DW      ?       ; BlockSeg address of allocated memory
```

Comments

On entry, BX contains the number of paragraphs requested. On return, AX:0 points to the allocated memory block. If the allocation fails, BX returns the size of the largest block of memory available in paragraphs.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

49H — Free Allocated Memory

Purpose

Frees the specified allocated memory.

Examples

```
        MOV     AH,49H          ; Function Call – Free Memory
        MOV     ES,BlockSeg     ; Set address to free
        INT     21H             ; Issue request to DOS
        JC      Error

 ----

 BlockSeg       DW      ?       ; BlockSeg address of allocated memory
```

Comments

On entry, ES contains the segment of the block to be returned to the system pool. On return, the block of memory is returned to the system pool.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

4AH — Modify Allocated Memory Blocks (SETBLOCK)

Purpose

Modifies allocated memory blocks to contain the new specified block size.

Examples

```
      MOV     AH,4AH           ; Function Call –
                               ; Modify Allocated Memory; allocate memory
      MOV     ES,BlockSeg      ; Set address to free
      MOV     BX,BlockSize     ; New size (may be larger or smaller)
      INT     21H              ; Issue request to DOS
      JNC     Done
      MOV     AH,4AH           ; Function Call –
                               ; Allocate memory
                               ; BX set to largest available Size
      INT     21H              ; Issue request to DOS
Done:
      MOV     Size,BX

----

BlockSeg      DW      ?        ; Segment address of allocated memory
BlockSize     DW      ?        ; Size requested in paragraphs
                               ; (Bytes allocated is 16 * Size)
```

Comments

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

Note: This call is often used to set the size of a program before using function call 31H (Terminate Process and Remain Resident). Use the program segment prefix. This value can be obtained using function call 62H (Get Program Segment Prefix Address). Another use is to release memory to prepare for using function call 4BH (Load or Execute a Program).

4BH — Load or Execute a Program (EXEC)

Purpose

Allows a program to load another program into memory and may choose to begin execution of it.

Examples

```
; To Execute a Program

 MOV  AH,4BH                  ; Function Call — Execute a Program
 MOV  AL,0                    ; Indicate execute program
 MOV  CX,SEG Parms            ; Program parameters
 MOV  ES,CX
 MOV  BX,OFFSET Parms         : ES:BX points to parameter block
 MOV  CX,SEG PName            ; Program name
 MOV  DS,CX
 MOV  DX,OFFSET PName         ; DS:DX points to program name
 MOV  WORD PTR StackSave+0,SP ; Save stack pointer
 MOV  WORD PTR StackSave+2,SS
 INT  21H                     ; Issue request to DOS
 JC   Error                   ; Error code in AX
; Note:  All Registers (except CS:IP) Destroyed

; Program Runs here

 CLI                          ; Protect from stack usage
 MOV  SS,WORD PTR StackSave+2 ; Restore stack pointer
 MOV  SP,WORD PTR StackSave+0
 STI                          ; Enable interrupts
 MOV  AH,4DH                  ; Function Call — Get Return Code
 INT  21H                     ; Issue request to DOS
 MOV  RetCode,AX              ; Save return code

; To Load an Overlay
 MOV  AH,4BH                  ; Function Call — Execute a Program
 MOV  AL,3                    ; Indicate load overlay
 MOV  CX,SEG OParms           ; Overlay parameters
 MOV  ES,CX
 MOV  BX,OFFSET OParms        ; ES:BX points to parameter block
 MOV  CX,SEG PName            ; Overlay name
 MOV  DS,CX
 MOV  DX,OFFSET PName         ; DS:DX points to overlay filename
 INT  21H                     ; Issue request to DOS
 JC   Error                   ; Error code in AX
```

```
----
PName      DB    64 Dup (0)   ; ASCIIZ Name
                              ;   example: "c:\dir\File.ext",0
Parms      LABEL WORD         ; Program parameters
Env@       DW    ?            ; Environment segment address
                              ;   Value of 0000H indicates copy EXEC'ers
                              ;   Environment
Cmd@       DD    ?            ; Command line address
FCB1@      DD    ?            ; FCB Image to set to New PSP+5CH
FCB2@      DD    ?            ; FCB Image to set to New PSP+6CH

StackSave  DD    ?            ; Stack pointer save area
RetCode    DW    ?            ; Program return code
                              ; (see function code 4DH for more information)
OParms     LABEL WORD         ; Overlay parameters
Load@      DW    ?            ; Overlay load segment address
RelocFactor DW   ?            ; Relocation factor to apply (for .EXE files)
```

Comments

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to "Responding to Errors" on page 138 and "Extended Error Codes" on page 138 for more information on the codes returned from function call 59H.

The following function values are allowed in AL:

Function Value	Description
00H	Load and execute the program. A program segment prefix is established for the program; terminate and Ctrl-Break addresses are set to the instruction after the EXEC system call. **Note:** When control is returned, all registers are changed, including the stack. You must restore SS, SP, and any other required registers before proceeding.
03H	Load, do not create the program segment prefix, and do not begin execution. This is useful in loading program overlays.

Only the first 20 file handles are duplicated in the newly created process after an EXEC, unless the file was opened with the inheritance bit set to 1. This means that the parent process has control over the meanings of standard input, output, auxiliary, and printer devices. The parent could, for example, write a series of records to a file, open the file as standard input, open a listing file as standard output, and then execute a sort program that takes its input from standard input and writes to standard output.

Also inherited (or copied from the parent) is an “environment.” This is a block of text strings (less than 32KB total) that conveys various configuration parameters. The following is the format of the environment (always on a paragraph boundary):

Byte ASCIIZ string 1
Byte ASCIIZ string 2
...
Byte ASCIIZ string n
Byte of 0

Typically the environment strings have the form:

parameter = *value*

Following the byte of 0 in the environment is a WORD that indicates the number of other strings following. Following this is a copy of the DS:DX filename passed to the child process. For example, the string VERIFY=ON could be passed. A 0 value of the environment address causes the newly created process to inherit the original environment unchanged. The segment address of the environment is placed at offset 2CH of the program segment prefix for the program being invoked.

Errors codes are returned in AX. Refer to “Responding to Errors” on page 138 and “Extended Error Codes” on page 138 for more information on the codes returned.

Note: When your program received control, all available memory was allocated to it. You must free some memory (see call 4AH) before EXEC can load the program you are invoking. Normally, you would shrink down to the minimum amount of memory you need, and free the rest.

4CH — Terminate a Process (EXIT)

Purpose

Terminates the current process and transfers control to the invoking process.

Examples

```
        MOV     AH,4CH          ; Function Call — Terminate a Process
        MOV     AL,ErrorCode    ; Set ERRORLEVEL
        INT     21H             ; Issue request to DOS
        INT     20H             ; Be safe if running on PC/DOS 1.1

  ----

  ErrorCode     DB      ?       ; Error Code (sets ERRORLEVEL if EXEC'ed
                                ; by COMMAND.COM)
```

Comments

In addition, a return code can be sent. The return code can be interrogated by the batch subcommands IF and ERRORLEVEL and by the wait function call 4DH. All files opened by this process are closed.

4DH — Get Return Code of a Subprocess (WAIT)

Purpose

Gets the return code specified by another process either through function call 4CH or function call 31H. It returns the Exit code only once.

Examples

```
        MOV     AH,4DH          ; Function Call — Get Return Code
        INT     21H             ; Issue request to DOS
        MOV     RetCode,AX      ; Save return code

  RetCode       LABEL   WORD    ; Program return code
  ExitCode      DB      ?       ; ERRORLEVEL value
  ExitType      DB      ?       ; Method used to exit (AH):
                                ;   00H — for normal termination
                                ;   01H — for termination by Ctrl-Break
                                ;   02H — for termination as a result
                                ;          of a critical device error
                                ;   03H — for termination by call 31H
```

Comments

The low byte of the exit code contains the information sent by the exiting routine.

4EH — Find First Matching File (FIND FIRST)

Purpose

Finds the first filename that matches the specified file specification.

Examples

```
        MOV     AH,1AH          ; Function Call — Set DTA Address
        MOV     CX,SEG DTA      ; Address buffer for found file
        MOV     DS,CX
        MOV     DX,OFFSET DTA
        INT     21H             ; Issue request to DOS
        MOV     AH,4EH          ; Function Call — ASCIIZ Find First
        MOV     CX,SEG FName    ; Directory or filename
        MOV     DS,CX
        MOV     DX,OFFSET FName ; DS:DX points to ASCII filename
        MOV     CX,Attribute    ; Set Match Attribute
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX


----

DTA             LABEL   BYTE              ; Find return information
                DB      21 DUP(0)         ; Reserved for PC DOS 7 to continue find
FileAttr        DB      ?                 ; Matched files attribute low byte
FileTime        DW      ?                 ; File time
FileDate        DW      ?                 ; File date
FileSize        DD      ?                 ; File size
FileNameExt     DB      "????????.???",0  ; Filename and extension

FName           DB      64 DUP (0)        ; ASCIIZ Name
                                          ;   example: "c:\dir\*.*",0
Attribute       DW      ?                 ; Select files attribute
                                          ; Combination of following:
                                          ;  0001H=Read only
                                          ;  0002H=Hidden
                                          ;  0004H=System
                                          ;  0008H=Volume label
                                          ;  0010H=Directory
                                          ;  0040H=Reserved
                                          ;  0080H=Reserved
```

Notes:

1. If the attribute is 0, only normal file entries are found. Entries for volume label, subdirectories, hidden files, and system files are not returned.
2. If the attribute field is set for hidden files, or system files, or directory entries, it is to be considered as an inclusive search. All normal file entries plus all entries matching the specified attributes are returned. To look at all directory entries except the volume label, the attribute byte may be set to hidden + system + directory (all 3 bits on).

Comments

The filename in DS:DX can contain global filename characters. The ASCIIZ string cannot contain a network path. See function call 11H (Search for First Entry) for a description of how the attribute bits are used for searches.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to "Responding to Errors" on page 138 and "Extended Error Codes" on page 138 for more information on the codes returned from function call 59H.

Note: The name and extension of file found is returned as an ASCIIZ string. All blanks are removed from the name and extension, and, if an extension is present, it is preceded by a period.

4FH — Find Next Matching File (FIND NEXT)

Purpose

Finds the next directory entry matching the name that was specified on the previous Find First or Find Next function call.

Examples

```
        MOV     AH,1AH          ; Function Call — Set DTA Address
        MOV     CX,SEG DTA      ; Address buffer for found file
        MOV     DS,CX
        MOV     DX,OFFSET DTA
        INT     21H             ; Issue request to DOS
        MOV     AH,4FH          ; Function Call — Find next
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
```

```
  ----

  DTA           LABEL   BYTE          ″  ; Find Return Information
                DB      21 DUP(0)     ″  ; Reserved for DOS to Continue Find
                                      ″  ; Set by Find First or Previous Find Next
  FileAttr      DB      ?             ″  ; Matched Files Attribute Low Byte
  FileTime      DW      ?             ″  ; File Time
  FileDate      DW      ?             ″  ; File Date
  FileSize      DD      ?             ″  ; File Size
  FileNameExt   DB      ″????????.???″,0 ; File Name and Extension
```

Comments

If a matching file is found, the DTA is set as described in call 4EH (Find First Matching File (FIND FIRST)). If no more matching files are found, an error code is returned.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location.

50H — Set Program Segment Prefix Address

Purpose

Sets the segment address of the current programs, program segment prefix.

Examples

```
        MOV     BX,SEGMENT_PSP  ; Segment Address of New PSP
        MOV     AH,50H          ; Function Call — Set PSP Address
        INT     21H             ; Issue request to DOS
                                ; No Return
    ----
    SEGMENT_PSP      DW      ?  ; Segment Address of PSP
```

51H — Get Program Segment Prefix Address

Purpose

Returns the segment address of the currently executing programs, program segment prefix.

Examples

```
        MOV     AH,51H        ; Function Call — Get PSP Address
        INT     21H           ; Issue request to DOS
        JC      Error         ; Error Code in AX

        MOV     SEGMENT_PSP,BX  ; Save PSP Address
    ----
    SEGMENT_PSP      DW      ?  ; Segment Address of PSP
```

Comments

This function is identical to Interrupt 21H function 62H.

54H — Get Verify Setting

Purpose

Returns the value of the verify flag.

Examples

```
       MOV     AH,54H          ; Function Call — Get VERIFY Setting
       INT     21H             ; Issue request to DOS
       MOV     VERIFY,AL       ; Save VERIFY State
 -----

VERIFY         DB      ?       ; VERIFY State:
                               ; 0 = OFF
                               ; 1 = ON
```

Comments

On return, AL returns 00H if verify is OFF, 01H if verify is ON. Note that the verify switch can be set through call 2EH (Set/Reset Verify Switch).

56H — Rename a File

Purpose

Renames the specified file.

Examples

```
        MOV     AH,56H              ; Function Call – ASCIIZ Rename File
        MOV     CX,SEG FName        ; File Name
        MOV     DS,CX
        MOV     DX,OFFSET FName     ; DS:DX points to original name
        MOV     CX,SEG NewName      ; New File Name
        MOV     ES,CX
        MOV     DI,OFFSET NewName   ; ES:DI points to rename
        INT     21H                 ; Issue request to DOS
        JC      Error               ; Error code in AX

  ----

  FName         DB      64 DUP (0)    ; ASCIIZ Name
                                      ;   example: "c:\dir\abc.lst",0
  NewName       DB      64 DUP (0)    ; ASCIIZ Name
                                      ;   example: "\dir\xyz.lst",0
```

Comments

If a drive is used in the NewName string, it must be the same as the drive specified or implied in the Name string. The directory paths need not be the same, allowing a file to be moved to another directory and renamed in the process. Directory names can be changed but not moved. Global filename characters are not allowed in the filename.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to "Responding to Errors" on page 138 and "Extended Error Codes" on page 138 for more information on the codes returned from function call 59H.

Network Access Rights: Requires Create access rights.

57H — Get/Set File′s Date and Time

Purpose

Gets or sets a file′s date and time.

Examples

```
 ; To Get a File′s Date and Time

      MOV     AH,57H          ; Function Call — Get/Set Date and Time
      MOV     AL,0            ; Indicate get
      MOV     BX,Handle       ; Select file
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX
      MOV     FileTime,CX     ; Save Time
      MOV     FileDate,DX     ; Save Date

; To Set a File′s Date and Time

      MOV     AH,57H          ; Function Call — Get/Set Date and Time
      MOV     AL,1            ; Indicate Set
      MOV     BX,Handle       ; Select file+
      MOV     CX,FileTime     ; Set Time
      MOV     DX,FileDate     ; Set Date
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX

----

Handle        DW      ?       ; File Handle (from Open / Create)
FileTime      DW      ?       ; File Time
FileDate      DW      ?       ; File Date
```

Comments

The date and time formats are the same as those for the directory entry described in Chapter 5 of this book.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to “Responding to Errors” on page 138 and “Extended Error Codes” on page 138 for more information on the codes returned from function call 59H.

5800H — Get Allocation Strategy

Purpose

Returns the scheme in which PC DOS 7 uses to allocate memory.

Examples

```
        MOV     AH,5800H     ; Function Call — Get Allocation Strategy
        INT     21H          ; Issue request to DOS

        JC      Error
        MOV     STRATEGY,AX  ; Save Allocation Strategy
    ----
    STRATEGY      DW      ?  ; Allocation Strategy
```

Comments

The following table describes the allocation strategies returned values:

Table 1 (Page 1 of 2). Allocation Strategies

Value		Description
FIRST_FIT_LOW	0000H	Search conventional memory for an available block having the lowest address. This is also the default strategy.
BEST_FIT_LOW	0001H	Search conventional memory for an available block that closely matches the requested size.
LAST_FIT_LOW	0002H	Search conventional memory for an available block at the highest address.
FIRST_FIT_HIGH	0080H	Search the upper-memory area for an available block at the lowest address. If no block is found then the search continues in the conventional memory.
BEST_FIT_HIGH	0081H	Search the upper-memory area for an available block that closely matches the requested size. If no block is found then the search continues in the conventional memory.
LAST_FIT_HIGH	0082H	Search the upper-memory area for an available block at the highest address. If no block is found then the search continues in the conventional memory.

Table 1 (Page 2 of 2). Allocation Strategies		
Value		**Description**
FIRST_FIT_HIGHONLY	0040H	Search the upper-memory area for an available block at the lowest address.
BEST_FIT_HIGHONLY	0041H	Search the upper-memory area for an available block that closely matches the requested size.
LAST_FIT_HIGHONLY	0042H	Search the upper-memory area for an available block at the highest address.

5801H — Set Allocation Strategy

Purpose

Sets the scheme by which PC DOS 7 uses to allocate memory.

Examples

```
        MOV     BX,STRATEGY  ; Allocation Strategy
        MOV     AH,5801H     ; Function Call — Set Allocation Strategy
        INT     21H          ; Issue request to DOS

        JC      Error
    ----
    STRATEGY      DW      ?  ; Allocation Strategy
```

Comments

The strategy used is the same as described in the table on Table 1 on page 243.

After the function is called the carry flag will be clear if it has been successfull. If the carry flag is set the AX register contains an error, which could be 0001H, indicating that the strategy is not one of the ones specified.

5802H — Get Upper-Memory Link

Purpose

Specifies whether programs can allocate memory from the upper-memory area.

Examples

```
        MOV     AH,5802H     ; Function Call — Get Upper-Mem Link
        INT     21H          ; Issue request to DOS

        MOV     UM_LINK,AX  ; Save Upper-Memory Link Information
    ----
    UM_LINK       DB      ?  ; Upper-Memory Linked
                                ; 1 = Linked
                                ; 0 = Not Linked
```

Comments

5803H — Set Upper-Memory Link

Purpose

Allows you to link or unlink the upper-memory area. If linked, a program may allocate memory from the upper-memory area.

Examples

```
        MOV     BX,UM_LINK      ; Set Upper-Memory Link Information
        MOV     AH,5802H      ; Function Call — Set Upper-Mem Link
        INT     21H           ; Issue request to DOS
        JC      Error         ; AX contains the error value
                              ; 0001H ERROR_INVALID_FUNCTION
                              ; 0007H ERROR_ARENA_TRASHED

    ----
    UM_LINK       DB      ?   ; Upper-Memory Linked
                                 ; 1 = Link Upper-Memory Area
                                 ; 0 = Unlink Upper-Memory Area
```

Comments

The return of the 0001H error (ERROR_INVALID_FUNCTION) could indicate that PC DOS 7 has been loaded without DOS=UMB being specified in the CONFIG.SYS file.

59H — Get Extended Error

Purpose

Returns additional error information, such as the error class, location, and recommended action.

Examples

```
        PUSH    DX              ; Save Registers
        PUSH    SI
        PUSH    DI
        PUSH    ES
        PUSH    DS
        MOV     AH,59H          ; Function Call — Get Extended Error
        MOV     BX,0            ; Version 0 information
        INT     21H             ; Issue request to DOS
        POP     DS              ; Restore registers
        POP     ES
        POP     DI
        POP     SI
        POP     DX
        MOV     ExtError,AX     ; Save error code
        MOV     ErrorClass,BH   ; Save error class
        MOV     ErrorAction,BL  ; Save error action
        MOV     ErrorLocation,CH; Save error location

  ----

  ExtError      DW      ?       ; DOS extended error
  ErrorClass    DB      ?       ; Class of error
  ErrorAction   DB      ?       ; Suggested action
  ErrorLocation DB      ?       ; System area effected
```

Comments

This function call returns the error class, location, and recommended action, in addition to the return code. Use this function call from:

- Interrupt 24H error handlers
- Interrupt 21H function calls that return an error in the carry bit
- FCB function calls that return FFH.

On return, the registers contents of DX, SI, DI, ES, CL, and DS are destroyed.

Error Return in Carry Bit

For function calls that indicate an error by setting the carry flag, the correct method for performing function call 59H is:

- Load registers.
- Issue interrupt 21H.
- Continue operation, if carry not set.
- Disregard the error code and issue function call 59H to obtain additional information.
- Use the value in BL to determine the suggested action to take.

Error Status in AL

For function calls that indicate an error by setting AL to FFH, the correct method for performing function call 59H is:

- Load registers.
- Issue interrupt 21H.
- Continue operation, if error is not reported in AL.
- Disregard the error code and issue function call 59H to obtain additional information.
- Use the value in BL to determine the suggested action to take.

5AH — Create Unique File

Purpose

Generates a unique filename, and creates that file in the specified directory.

Examples

```
        MOV     AH,5AH                  ; Function Call — Create a
                                        ; Unique File
        MOV     CX,SEG DirName          ; Directory name
        MOV     DS,CX
        MOV     DX,OFFSET DirName
        MOV     CX,Attribute            ; File attribute
        INT     21H                     ; Issue request to DOS
        JC      Error                   ; Error code in AX
        MOV     Handle,AX               ; Save file handle for following
                                        ; Operations

  ----

  DirName       DB      "?? .. ??\",0   ; ASCIIZ name
                DB      "????????.???"
                                        ;   example in : "c:\dir\",0
                                        ;   example out: "c:\dir\file",0
  Handle        DW      ?               ; File handle
  Attribute     DW      ?               ; Select file's attribute
```

Comments

On entry, AH contains 5AH. If no error has occurred, the file is opened in compatibility mode with Read/Write access. The read/write pointer is set at the first byte of the file and AX contains the file handle and the filename is appended to the path specified in DS:DX.

This function call generates a unique name and attempts to create a new file in the specified directory. If the file already exists in the directory, then another unique name is generated and the process is repeated. Programs that need temporary files should use this function call to generate unique filenames.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to "Responding to Errors" on page 138 and "Extended Error

Codes" on page 138 for more information on the codes returned from function call 59H.

Note: The file created using this function call is not automatically deleted at program termination.

Network Access Rights: Requires Create access rights.

5BH — Create New File

Purpose

Creates a new file.

Examples

```
        MOV     AH,5BH          ; Function Call — Create a New File
        MOV     CX,SEG FName    ; File Name
        MOV     DS,CX
        MOV     DX,OFFSET FName
        MOV     CX,Attribute
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        MOV     Handle,AX       ; Save File Handle for following operations

  ----

  FName         DB      64 DUP (0)    ; ASCIIZ Name
                                      ;   example: ″c:\dir\file″,0
  Handle        DW      ?             ; File Handle
  Attribute     DW      ?             ; Select File′s Attribute
```

Comments

This function call is the same as function call 3CH (Create), except it will fail if the filename already exists. The file is created in compatibility mode for reading and writing and the read/write pointer is set at the first byte of the file.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to “Responding to Errors” on page 138 and “Extended Error Codes” on page 138 for more information on the codes returned from function call 59H.

Network Access Rights: Requires Create access rights.

5CH — Lock/Unlock File Access

Purpose

Locks or unlocks a single range of bytes in an opened file. This function call provides database services that are useful in maintaining database integrity in a network environment.

Examples

```
; To Lock a Single Range

      MOV     AH,5CH                  ; Function Call —
                                      ; Access Lock/Unlock File
      MOV     AL,0                    ; Indicate lock
      MOV     BX,Handle               ; Select file
      MOV     DX,WORD PTR Position+0  ; Set position
      MOV     CX,WORD PTR Position+2
      MOV     DI,WORD PTR Llength+0   ; Set length
      MOV     SI,WORD PTR Llength+2
      INT     21H                     ; Issue request to DOS
      JC      Error                   ; Error code in AX

; To Unlock a Single Range

      MOV     AH,5CH                  ; Function Call —
                                      ; Lock/Unlock File Access
      MOV     AL,1                    ; Indicate unlock
      MOV     BX,Handle               ; Select file
      MOV     DX,WORD PTR Position+0  ; Set position
      MOV     CX,WORD PTR Position+2
      MOV     DI,WORD PTR Llength+0   ; Set length
      MOV     SI,WORD PTR Llength+2
      INT     21H                     ; Issue request to DOS
      JC      Error                   ; Error code in AX

----

Handle        DW      ?               ; File Handle
Position      DD      ?               ; Start of Range
Llength       DD      ?               ; Length of Range
```

Comments

The Lock/Unlock function calls should only be used when a file is opened using the DenyRead or DenyNone sharing modes. These modes do no local buffering of data when accessing files on a network disk.

AL = 00H Lock
Lock provides a simple mechanism for excluding other processes′ read/write access to regions of the file. If another process attempts to read or write in such a region, its system call is retried the number of times specified with the system retry count set by IOCTL. If, after those retries, no success occurs, a general failure error is generated, signaling the condition. The number of retries, as well as the length of time between retries, can be changed using function call 440BH (IOCTL Change Sharing Retry Count).

The recommended action is to issue function call 59H (Get Extended Error) to get the error code, in addition to the error class, location, and recommended action. The locked regions can be anywhere in the logical file. Locking beyond end-of-file is not an error. It is expected that the time in which regions are locked will be short. Duplicating the handle duplicates access to the locked regions. Access to the locked regions is not duplicated across the EXEC system call. Exiting with a file open and having issued locks on that file has undefined results.

Programs that may be cancelled using INT 23H or INT 24H should trap these interrupts and release the locks before exiting from the program. The proper method for using locks is not to rely on being denied read or write access, but to attempt to lock the region desired and examining the error code.

AL = 01H Unlock
Unlock releases the lock issued in the lock system call. The region specified must be exactly the same as the region specified in the previous lock. Closing a file with locks still in force has undefined results. Exiting with a file open and having issued locks on that file has undefined results.

Programs that may be abended using INT 23H or INT 24H should trap these interrupts and release the lock before exiting from the program. The proper method for using locks is not to rely on being denied read or write access but rather attempting to lock the region desired and examining the error code.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to “Responding to Errors” on page 138 and “Extended Error Codes” on page 138 for more information on the codes returned from function call 59H.

5D0AH — Set Extended Error

Purpose

This function sets the error class, location suggested action and other information that will be returned by the next call to function 59H Get Extended Error.

Examples

```
        MOV     DX, SEG ERROR_INFO
        MOV     DS,DX
        MOV     DX, OFFSET ERROR_INFO

        MOV     AH,5D0AH     ; Function Call – Set Extended Error
        INT     21H          ; Issue request to DOS
   ----
ERROR_INFO  STRUC
        ExtendedErr DW    ?    ; Extended Error Code
        ErrorClass  DB    ?    ; Error Class
        ErrorAction DB    ?    ; Suggested Action
        ErrorLoc    DB    ?    ; Location of Error
        errCL       DB    ?    ; CL Register
        errDX       DW    ?    ; DX Register
        errSI       DW    ?    ; SI Register
        errDI       DW    ?    ; DI Register
        errDS       DW    ?    ; DS Register
        errES       DW    ?    ; ES Register
        errReserved DW    ?    ; Reserved Word
        errUID      DW    ?    ; USER ID
        errPID      DW    ?    ; Program ID
```

Comments

Please refer to "Responding to Errors" on page 138 for details of the possible values that may be used in the ERROR_INFO structure.

5E00H — Get Machine Name

Purpose

Returns the character identifier of the local computer.

Examples

```
MOV    AX,SEG CNAME      ; Name buffer
MOV    DS,AX
MOV    DX OFFSET CNAME
MOV    AX,5E00H          ; Function Call –
                         ; Get Machine Name
INT    21H               ; Issue request to DOS
JC     Error             ; Error code in AX
MOV    NameFlag,CH       ; Save name number indicator
MOV    NameID,CL         ; Save NETBIOS name number

  ----

CName          DB     "???????????????",0     ; ASCIIZ computer name
NameFlag       DB     ?                       ; 0 = Name is not set
                                              ; 1 = Name is set
NameID         DB     ?                       ; NETBIOS name number
```

Comments

Get Machine Name returns the text of the current computer name to the caller. The computer name is a 15-character byte string padded with spaces and followed by a 00H byte. If the computer name was never set, register CH is returned with 00H and the value in the CL register is invalid. The IBM PC Local Area Network Services program must be loaded for the function call to execute properly.

5E02H — Set Printer Setup

Purpose

Specifies an initial string for printer files.

Examples

```
        MOV     AX,5E02H        ; Function Call –
                                ; Set Printer Setup
        MOV     BX,Index        ; Redirection List Index
        MOV     CX,size         ; String size
        MOV     SI,SEG String   ; String Buffer
        MOV     DS,SI
        MOV     SI,OFFSET String
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX

  ----

  Index         DW      ?       ; Redirection List Index
  Size          DW      N       ; String size (Maximum 64)
  String        DB      N DUP(?) ; Printer Setup String
```

Comments

The string specified is put in front of all files destined for a particular network printer. Set Printer Setup allows multiple users of a single printer to specify their own mode of operation for the printer. BX is set to the same index that is used in function call 5F02H (Get Redirection List Entry). An error code is returned if print redirection is paused or if the IBM PC Local Area Network Services program is not loaded.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to "Responding to Errors" on page 138 and "Extended Error Codes" on page 138 for more information on the codes returned from function call 59H. **IMPORTANT:** The redirection index value may change if function call 5F03H (Redirect Device) or function call 5F04H (Cancel Redirection) is issued between the time the redirection list is scanned and the function call 5E02H (Set Printer Setup) is issued. Therefore, we recommend that you issue Set Printer Setup immediately after you issue "Get Redirection List ."

5E03H — Get Printer Setup

Purpose

Returns the printer setup string for printer files.

Examples

```
      MOV     AX,5E03H        ; Function Call —
                              ; Get Printer Setup
      MOV     BX,Index        ; Redirection List Index
      MOV     CX,SEG String   ; String Buffer
      MOV     ES,CX
      MOV     DI,OFFSET String
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX
      MOV     Ssize, CX       ; Save String size

----

Index         DW    ?         ; Redirection List Index
Ssize         DW    ?         ; String size
String        DB    64 DUP(?) ; Printer Setup String
```

Comments

This function call returns the printer setup string which was specified using the function call 5E02H (Set Printer Setup). The setup string is attached to all files destined for a particular printer. The value in BX is set to the same index issued in function call 5F02H (Get Redirection List). Error code 1 (invalid function number) is returned if the IBM PC Local Area Network Services is not loaded.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to “Responding to Errors” on page 138 and “Extended Error Codes” on page 138 for more information on the codes returned from function call 59H.

IMPORTANT: The redirection index value may change if function call 5F03H (Redirect Device) or function call 5F04H (Cancel Redirection) is issued between the time the redirection list is scanned and the function call 5E03H (Get Printer Setup) is issued. Therefore, we recommend that you issue “Get Printer Setup” immediately after you issue “Get Redirection List.”

5F02H — Get Redirection List Entry

Purpose

Returns nonlocal network assignments.

Examples

```
     MOV      BX,0                ; Start at beginning of list
Get_Loop:                         ; Get next entry
     MOV      Index,BX            ; Redirection list index
     MOV      AX,5F02H            ; Function Call —
                                  ; Get redirection list entry
     MOV      SI,SEG device       ; ″PRN″ is possible
     MOV      DS,SI
     MOV      SI,OFFSET device    ; DS:SI points to local name
     MOV      DI,SEG info
     MOV      ES,DI
     MOV      DI,OFFSET inf       ; ES:DI points to buffer address of network name
     PUSH     BX
     PUSH     DX                  ; Save registers
     PUSH     BP
     INT      21H                 ; Issue request to DOS
     POP      BP                  ; Restore registers
     POP      DX
     JC       CheckEnd            ; Error code in AX
     MOV      Status,BH           ; Save status
     MOV      Type,BL             ; Save type
     MOV      UserParm,CX         ; Save user parameter
     POP      BX
     INC      BX                  ; Set to next entry
     JMP      Get_Loop


CheckEnd:
      POP     BX                  ; Balance state
      CMP     AX,18               ; End of list?
      JNE     Error               ; No!

----

Index       DW      ?               ; Redirection list index (0 based)
Device      DB      128 DUP(?)      ; ASCIIZ device name
                                    ;  example: ″LPT1″,0
                                    ;               ″A:″,0
Status      DB      ?               ; Device status
                                    ; Bit 0=0 : Device is OK
```

```
                                        ; Bit 0=1 : Device in Error
                                        ; Bit 7-1 reserved
UserParm    DW      ?                   ; User parameter
Type        DB      ?                   ; Device type
                                        ; 3 = NET USE device
                                        ; 4 = NET USE drive
Info        DB      128 DUP(?)          ; NET USE network path
                                        ;   example: "\\MYNODE\CDRIVE",0
```

Comments

The Get Redirection List Entry function call returns the list of network redirections that were created through function call 5F03H (Redirect Device). Each call returns one redirection, so BX should be increased by one each time to step through the list. The contents of the list may change between calls. The end-of-list is detected by error code 18 (no more files). Error code 1 (invalid function number) is returned if the IBM PC Local Area Network Services program and IFSFUNC are not loaded.

If either disk or print redirection is paused, the function is not effected.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to "Responding to Errors" on page 138 and "Extended Error Codes" on page 138 for more information on the codes returned from function call 59H.

5F03H — Redirect Device

Purpose

Causes a Redirector/Server connection to be made.

Examples

```
        MOV     AX,5F03H              ; Function Call –
                                      ; Redirect Device
        MOV     SI,SEG Device         ; Device Buffer
        MOV     DS,SI
        MOV     SI,OFFSET Device
        MOV     DI,SEG Net Path info  ; Information Buffer
        MOV     ES,DI
        MOV     DI,OFFSET Net Path
        MOV     BL,Type               ; Set Type
        MOV     CX,UserParm           ; Set User Parameter
        INT     21H                   ; Issue request to DOS
        JC      Error                 ; Error code in AX
----

Device        DB      "....",0        ; ASCIIZ Device Name
                                      ;  example: "LPT1",0
                                      ;               "A:",0
UserParm      DW      ?               ; User Parameter
Type          DB      ?               ; Device Type
                                      ; 3 = NET USE Device
                                      ; 4 = NET USE Drive
Net Path      DB     128 DUP(0)
```

Comments

This call defines the current directories for the network and defines redirection of network printers.

- If BL = 03, the source specifies a printer, the destination specifies a network path, and the CX register has a word that PC DOS 7 maintains for the programmer. For compatibility with the IBM PC Local Area Network Services program, CX should be set to 0. Values other than 0 are reserved for the IBM PC Local Area Network Services program. This word may be retrieved through function call 5F02H (Get Redirection List). All output destined for the specified printer is buffered and sent to the remote printer spool for that device. The printers are redirected at the INT 17H level.

The source string must be **PRN** , **LPT1**, **LPT2**, or **LPT3** each ended with a 00H. The destination string must point to a network name string of the following form:

[*computername*{*shortname*∨*printdevice*}]

The destination string must be ended with a 00H.

The ASCIIZ password (0 to 8 characters) for access to the remote device should immediately follow the network string. The password must end with a 00H. A null (0 length) password is considered to be no password.

- If BL = 4, the source specifies a drive letter and colon ending with 00H, the destination specifies a network path ending with 00H, and the CX register has a word that DOS maintains for the programmer. For compatibility with the IBM PC Local Area Network Services program, CX should be set to 00H. Values other than 00H are reserved for the IBM PC Local Area Network Services program. The value may be retrieved through function call 5F02H (Get Redirection List). If the source was a drive letter, the association is made between the drive letter and the network path. All subsequent references to the drive letter are translated to references to the network path. If the source is an empty string, the system attempts to grant access to the destination with the specified password without redirecting any device.

  The ASCIIZ password for access to the remote path should immediately follow the network string. A null (0 length) password ended with 00H is considered to be no password.

  Error codes are returned in AX. Issue function call 59H for additional information about the error class, suggested action, and location. Refer to "Responding to Errors" on page 138 and "Extended Error Codes" on page 138 for more information on the codes returned from function call 59H (Get Extended Error) .

Notes:

1. Devices redirected through this function call are not displayed by the NET USE command.
2. An error is returned if you try to redirect a drive while disk redirection is paused, or if you try to redirect a printer while print redirection is paused.

5F04H — Cancel Redirection

Purpose

Cancels a previous redirection.

Examples

```
        MOV     AX,5F04H        ; Function Call —
                                ; Cancel redirection
        MOV     SI,SEG Device   ; Device buffer
        MOV     DS,SI
        MOV     SI,OFFSET Device
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX

  ----

  Device        DB      "....",0        ; ASCIIZ Device Name
                                        ;  example: "LPT1",0
                                        ;               "A:",0
                                        ;               "\\Computer\Path",0
```

Comments

The redirection created by the Redirect Device function call (5F03H) is removed through the Cancel Redirection call. If the buffer points to a drive letter and the drive is associated with a network name, the association is ended and the drive is restored to its physical meaning. If the buffer points to PRN, LPT1, LPT2, or LPT3, and the device has an association with a network device, the association is terminated and the device is restored to its physical meaning. If the buffer points to a network path ending with 00H and a password ending with 00H, the association between the local machine and the network directory is terminated.

An error is returned if you try to cancel a redirected file device while disk redirection is paused, or if you try to cancel a redirected printer while print redirection is paused. Error code 1 (invalid function number) is returned if the IBM PC Local Area Network Services program is not loaded.

Error codes are returned in AX. Issue function call 59H (Get Extended Error) for additional information about the error class, suggested action, and location. Refer to "Responding to Errors" on page 138 and "Extended Error Codes" on page 138 for more information on the codes returned from function call 59H.

62H — Get Program Segment Prefix Address

Purpose

Returns the program prefix address.

Examples

```
        MOV     AH,62H          ; Function Call –
                                ; Get Program Segment Prefix Address
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        MOV     PSPSeg,BX       ; Save PSP address

  ----

  PSPSeg        DW      ?       ; Segment address of my PSP
```

Comments

The internal PSP address for the currently executing process is returned in BX.

65H — Get Extended Country Information

Purpose

Returns extended country information.

Examples

```
; To get information

      MOV     AH,65H          ; Function Call —
                              ; Get extended country information
      MOV     AL,InfoID       ; Data/function requested
                              ; (1, 2, 4, 6 or 7).
      MOV     BX,CodePage     ; Set desired code page
                              ; (-1=current, Set by function call 6602H).
      MOV     CX,SizeBuffer   ; Maximum data to return
                              ; (must be >= 5)
      MOV     DX,CountryID    ; Set desired Country ID
                              ; (-1=current, set by function call 38H).
      MOV     DI,SEG Buffer   ; Information return buffer
      MOV     ES,DI
      MOV     DI,OFFSET Buffer
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX
-----

Buffer        LABEL   BYTE
; Format depends on AL value
; AL=1 : Extended Country Information

InfoID        DB      ?       ; Type of info to get
CIinfoSize    DW      ?       ; amount of data that follows
                              ; (limited by CX input)
CountryID     DW      ?       ; Selected CountryID
CodePage      DW      ?       ; Selected Code Page
; See function call 38H, Country Information, for the format of the
    remainder of this buffer

-----

; AL=2 : Upper Case Table
              DB      2               ; Indicates Upper Case Table
UpperCase@    DD      ?               ; Address of Upper Case Table

; AL=4 : File Upper Case Table
```

```
              DB      4               ; Indicates File Upper Case Table
UpperCase@    DD      ?               ; Address of File Upper Case Table

; AL=6 : Collating Table
              DB      6               ; Indicates Collate Table
Collate@      DD      ?               ; Address of Collate Table

; AL=7 : DBCS Vector Table
              DB      7               ; Indicates DBCS Vector Table
DBCS@         DD      ?               ; Address of DBCS Vector Table
```

Comments

On entry, DX contains the ID of the country for which the extended information is needed. AL contains the ID value for the country.

- If the country code and code page do not match, or if either one or both are invalid, an error code of 2 (file not found) is returned in AX.
- The size requested in CX must be 5 or greater. If it is less than 5, an error code of 1 is returned in AX.
- If the amount of information returned is greater than the size requested in CX, it is ended and no error is returned in AX.

Note: For further information on the country information, see function call 38H (Get or Set Country Dependent Information).

The NLSFUNC DOS extension must be installed to get information for countries other than the Current Country.

The uppercase table and the filename uppercase tables are 130 bytes long, consisting of a length field (2 bytes), followed by 128 uppercase values for the upper 128 ASCII characters. They have the following layout:

```
Tsize         DW      128             ; Table Size
Table         DB      128 DUP(?)      ; Upper case versions of 80H to FFH
```

The following formula can be used to determine the address of an uppercase equivalent for a lowercase character (ASCII_in) in the uppercase table or the filename uppercase table.

Examples

```
ASCII_in -(256-table_len)+table_start= address of ASCII_out
```

Where

```
ASCII_in    = character to be generated

table_len   = length of list of uppercase
values (2 bytes)

table_start = starting address of uppercase
table (4 bytes)

ASCII_out   = uppercase value for ASCII_in
```

If the value of ASCII_in is equal to or greater than (256-table_len), there is an uppercase equivalent for ASCII_in in the table. If it is lower than (256-table_len), no uppercase equivalent exists in the table.

The collate table is 258 bytes long, consisting of a length field (2 bytes) followed by 256 ASCII values, in the appropriate order. It has the following layout:

```
Tsize         DW      256             ; Table Size
Table         DB      256 DUP(?)      ; Sort Weights for 00H to FFH
```

The DBCS vector is variable in length, consisting of a length field (two bytes) followed by one or more pairs of bytes in ascending order. It has the following layout:

```
Tsize   DW    Nx2          ;List size
1       DB    Start,end    ;DBCS vector 1
2       DB    Start,end    ;DBCS vector 2
:
N       DB    Start,end    ;DBCS vector n
        DB    0,0          ;End marker
```

66H — Get/Set Global Code Page

Purpose

This function gets or sets the code page for the current country.

```
        MOV     AX,6601H        ; Function Call —
                                ; Get Global Code Page
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        MOV     GlobalCP,BX     ; Save Global Code Page
        MOV     SystemCP,DX     ; Save DOS System Code Page

      or

        MOV     AX,6602H        ; Function Call —
                                ; Set Global Code Page
        MOV     BX,GlobalCP     ; New Global Code Page
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX

  ----

  GlobalCP      DW      ?       ; Current Code Page of DOS Country Information
  SystemCP      DW      ?       ; Code Page of DOS messages
                                ; Often the default Code Page for the
                                ; current country
```

Comments

PC DOS 7 moves the new code page data from the COUNTRY.SYS file to a resident country buffer area. PC DOS 7 uses the new code page to perform a Select to all attached devices that are set up for code page switching, (that is, have a code page switching device driver specified in CONFIG.SYS). If any device fails to be selected, an error code of 65 is returned in AX. The code page must be recognizable by the current country, and PC DOS 7 must be able to open and read from the country information file. Otherwise, the carry flag will be set on return and AX will contain 02 (file not found).

Note: NLSFUNC must be installed to use this function call, and all the devices must be prepared in order for the Select function to be successful.

67H — Set Handle Count

Purpose

Permits more than 20 open files per process.

Examples

```
EntryPoint:
        MOV     AH,62H          ; Function Call —
                                ; Get PSP Address
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        MOV     ES,BX           ; Set Segment
        MOV     AH,4AH          ; Function Call —
                                ; Set Memory Block Size
        MOV     BX,paragraphs   ; Set Size
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        MOV     AH,67H          ; Function Call - Set Handle Count
        MOV     BX,NewHandles   ; Set new handle count
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX

  ----

NewHandles      DW     ?                              ; Number of Handles needed
                                                      ; by this PC DOS 7 process
ListSize        EQU    (Endofprogram - EntryPoint)    ; Number of bytes
Paragraphs      EQU    (ListSize / 10H)               ; Number of paragraphs
End_of_program  LABEL  BYTE                           ; Last used position for
                                                      ;  this program
```

Comments

The maximum number of file handles allowed for this interrupt is 64KB. If the the specified number of allowable handles is less than the current number allowed, the specified number will become current only after all the handles above the specified number have been closed. If the specified number is less than 20, the number is assumed to be 20. Data base applications can use this function to reduce the need to swap handles.

You must release memory for PC DOS 7 to contain the extended handle list. You can do this by using the SET BLOCK (4AH) function call.

68H — Commit File

Purpose

Causes all buffered data for a file to be written to the device. This function can be used instead of a close-open sequence.

Examples

```
        MOV     AH,68H          ; Function Call — Commit File
        MOV     BX,Handle       ; Select file
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX

  ----

  Handle        DW      ?       ; Handle from previous Open or Create
```

Comments

Commit File provides a faster and more secure method of committing data in multi-user environments such as the IBM PC Local Area Network Services.

6CH — Extended Open/Create

Purpose

Optionally opens and creates a file.

Examples

```
 MOV     AH,6CH              ; Extended open
 MOV     AL,0                ; Reserved
 MOV     BX,MODE             ; Open mode
                             ; Format : 0WF00000ISSS0AAA
                             ; AAA=Access code 0=Read
                             ;                 1=Write
                             ;                 2=Read/Write
                             ; SSS=Sharing mode 0=Compatibility
                             ;                  1=DenyRead/Write
                             ;                  2=DenyWrite
                             ;                  3=DenyRead
                             ;                  4=DenyNone
                             ; I 0=Pass handle to child, 1=No inherit
                             ; F 0=INT 24H, 1=Return error
                             ;  on this open and any I/O to this handle
                             ; W 0=No commit, 1=Auto-Commit on write
 MOV     CX,ATTR             ; Create attribute (ignored if open)
 MOV     DX,FLAG             ; Function control, Format=00000000NNNNEEEE
                             ; NNNN=Does not exist action
                             ;   0=Fail, 1=Create
                             ; EEEE=Exists action
                             ;   0=Fail, 1=Open, 2=Replace/Open

 MOV     SI,SEG file_name    ; Name to open or create
 MOV     DS,SI
 MOV     SI,OFFSET file_name
 INT     21H
 JC      ERROR
                             ; AX=Handle
                             ; CX=Action taken code
                             ; 1=File Opened
                             ; 2=File Created/Opened
                             ; 3=File Replaced/Opened
----
Mode     DW        ?         ; Open mode bit
                             ; Definitions
Attr     DW        ?         ; File attributes
Flag     DW        ?         ; Function definition
File_name    64 DUP (0)
```

Comments

Function 6CH combines the functions currently available with OPEN, CREATE and a CREATE NEW.

If F is 1, the critical error handler (Interrupt 24) is disabled for the handle returned by Extended Open. Any I/O issued to this handle will never generate the critical error but only the extended error.

If F is 0, no actions are taken.

If W is 1, any disk write using the handle returned by Extended Open will accompany with a commit call (see Interrupt 21H (AL=68H)).

If W is 0, no actions are taken.

Appendix C. I/O Control for Devices (IOCtl)

Purpose

Sets or gets device information associated with open device handles, or sends control strings to the device handle or receives control strings from the device handle.

Comments

The following function values are allowed in AL:

AL = 00H	Get device information (returned in DX).
AL = 01H	Set device information (determined by DX). DH must be 0 for this call.
AL = 02H	Read from character device
AL = 03H	Write to character device
AL = 04H	Read from block device
AL = 05H	Write to block device
AL = 06H	Get input status
AL = 07H	Get output status
AL = 08H	Determine if a particular block device is removable
AL = 09H	Determine if a logical device is local or remote
AL = 0AH	Determine if a handle is local or remote
AL = 0BH	Change sharing retry count
AL = 0CH	Issue handle generic IOCtl request
AL = 0DH	Issue block device generic IOCtl request
AL = 0EH	Get logical drive
AL = 0FH	Set logical drive
AL = 10H	QueryIOCtlHandle
AL = 11H	QueryIOCtlDevice

IOCtl can be used to get information about devices. You can make calls on regular files, but only function values 00H, 06H, and 07H are defined in that case. All other calls return an `Invalid Function` error.

Function values 00H to 08H are not supported on network devices. Function value 0BH requires the file sharing command to be loaded (SHARE).

Many of the function calls return the carry flag clear if the operation was successful. If an error condition was encountered, the carry flag is set; AX contains an extended error code. (See "Extended Error Codes" on page 138 in *Appendix B* for an explanation). An explanation of the error codes for call 440CH can be located beginning on page 284 in this chapter. Information

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about the error, such as the *error class*, *location*, and recommended *action*, is obtained by issuing the 59H (Get Extended Error) function call.

44H — I/O Control for Devices (IOCtl)

Calls AL=00H and AL=01H

Purpose

These two calls set or get device information.

Examples

```
; To Get Device Information

      MOV     AH,44H          ; Function Call –  IOCtl
      MOV     AL,0            ; Indicate get device information
      MOV     BX,Handle       ; Select device
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX
      MOV     DevInfo,DX      ; Save device information

; To Set Device Information

      MOV     AH,44H          ; Function Call – IOCtl
      MOV     AL,1            ; Indicate set device information
      MOV     BX,Handle       ; Select device
      MOV     DX,DevInfo      ; Device information to set
      XOR     DH,DH           ; All DH bits must be off
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX

-----

DevInfo       DW      ?       ; Device information
Handle        DW      ?       ; Handle to open device
```

Comments

The bits of DevInfo are defined as follows:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RES	CTRL	Reserved						ISDEV	EOF	BINARY	RES	ISCLK	ISNUL	ISCOT	ISCIN

ISDEV = 1 if this channel is a device.

= 0 if this channel is a disk file (bits 8 through 15 are 0 in this case).

Bits 8 through 15 of DX correspond to the upper 8 bits of the device driver attribute word.

If ISDEV = 1

EOF = 0 if end-of-file on input.

BINARY = 1 if operating in binary mode (no checks for Ctrl-Z).

= 0 if operating in ASCII mode

(checking for Ctrl-Z as

end-of-file).

ISCLK = 1 if this device is the clock device.

ISNUL = 1 if this device is the null device.

ISCOT = 1 if this device is the console output.

ISCIN = 1 if this device is the console input.

CTRL = 0 if this device cannot process control strings via calls AL=02H, AL=03H, AL=04H, and AL=05H.

CTRL = 1 if this device can process control strings via calls AL=02H and AL=03H. Note that this bit cannot be set by function call 44H.

If ISDEV = 0

EOF = 0 if channel has been written. Bits 0-5 are the block device number for the channel (0 = A, 1 = B, ...). Bits 15, 8-13, 4 are reserved and should not be altered.

Note: DH must be 0 for call AL=01H.

Calls AL=02H, AL=03H

Purpose

These two calls allow control strings to be sent or received from a character device.

Examples

```
; To Read a Control String from a Character Device

     MOV     AH,44H           ; Function Call — IOCtl
     MOV     AL,2             ; Indicate IOCtl read
     MOV     BX,Handle        ; Select device
     MOV     CX,SIZE Buffer   ; Set size to read
     MOV     DI,SEG Buffer    ; Address I/O buffer
     MOV     DS,DI
     MOV     DX,OFFSET Buffer ; DS:DX points to I/O buffer
     INT     21H              ; Issue request to DOS
     JC      Error            ; Error code in AX
     MOV     Count,AX         ; Save data read count

; To Write a Control String to a Character Device

     MOV     AH,44H           ; Function Call — IOCtl
     MOV     AL,3             ; Indicate IOCtl write
     MOV     BX,Handle        ; Select device
     MOV     CX,SIZE Buffer   ; Set size to write
     MOV     DI,SEG Buffer    ; Address I/O buffer
     MOV     DS,DI
     MOV     DX,OFFSET Buffer ; DS:DX points to I/O buffer
     INT     21H              ; Issue request to DOS
     JC      Error            ; Error code in AX
     MOV     Count,A X        ; Save data written count

-----

Handle  DW    ?               ; Handle to open device
Buffer  DB    N DUP(?)        ; I/O buffer
Count   DW    ?               ; Actual I/O data transfer count
```

Comments

These are the Read and Write calls for a character device. An Invalid Function error is returned if the CTRL bit is 0.

Calls AL=04H, AL=05H

Purpose

These two calls allow arbitrary control strings to be sent or received from a block device.

Examples

```
; To Read a Control String from a Block Device

      MOV     AH,44H           ; Function Call – IOCtl
      MOV     AL,4             ; Indicate IOCtl read
      MOV     BL,Drive         ; Select drive
      MOV     CX,SIZE Buffer   ; Set Size to read
      MOV     DI,SEG Buffer    ; Address I/O buffer
      MOV     DS,DI
      MOV     DX,OFFSET Buffer ; DS:DX points to I/O buffer
      INT     21H              ; Issue request to DOS
      JC      Error            ; Error code in AX
      MOV     Count,AX         ; Save data read count

; To Write a Control String to a Block Device

      MOV     AH,44H           ; Function Call – IOCtl
      MOV     AL,5             ; Indicate IOCtl write
      MOV     BL,Drive         ; Select drive
      MOV     CX,SIZE Buffer   ; Set Size to write
      MOV     DI,SEG Buffer    ; Address I/O buffer
      MOV     DS,DI
      MOV     DX,OFFSET Buffer ; DS:DX points to I/O buffer
      INT     21H              ; Issue request to DOS
      JC      Error            ; Error code in AX
      MOV     Count,AX         ; Save data written count

-----

Drive         DB   ?           ; Drive (0=current, 1=A:, 2=B:, ...)
Buffer        DB   N DUP(?)    ; I/O buffer
Count         DW   ?           ; Actual I/O data transfer count
```

Comments

These are the Read and Write calls for a block device. The drive number is in BL for these calls. An `Invalid Function` error is returned if the CTRL bit is 0. An “Access-Denied” code is returned if the drive is invalid. The following control strings are defined for block device drivers that support media lock or unlock, and eject:

```
; Buffer to read drive status (use with IOCtl Read AL=04)

   LockStatus   STRUC
    Status_Read      db   6  ;Status Read Control block code
    Status_Bits      dd   ?  ;Drive status
   LockStatus   ENDS

 The Status_Bits on return, are interrupted as follows:

    Bit 0       0     Door closed
                1     Door open
    Bit 1       0     Door locked
                1     Door unlocked
    Bits 2-31   0     Reserved (all zeros)

 ; Buffer to lock or unlock drive (use with IOCtl Write AL=05H)

    LockCommand  STRUC
     Lock_Unlock     db   1  ;Lock or unlock Control Block Code
     Cmd_Code        db   ?  ;0 for unlock, 1 for lock
    LockCommand  ENDS

 ; Buffer to eject media (use with IOCtl Write AL=05H)

    EjectCommand STRUC
     Eject           db   0  ;Eject Control Block Code
    EjectCommand Ends
```

Calls AL=06H and AL=07H

Purpose

These calls allow you to check if a handle is ready for input or output.

Examples

```
; To Get Input Device Status

      MOV     AH,44H          ; Function Call — IOCtl
      MOV     AL,6            ; Indicate IOCtl input status
      MOV     BX,Handle       ; Select device
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX
      MOV     Status,AL       ; Save status

; To Get Output Device Status

      MOV     AH,44H          ; Function Call — IOCtl
      MOV     AL,7            ; Indicate IOCtl output status
      MOV     BX,Handle       ; Select device
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX
      MOV     Status,AL       ; Save status

-----

Handle        DW      ?       ; Handle to open device
Status        DB      ?       ; Status
                              ; for a file:
                              ;   00H = At End of File
                              ;   FFH = Not at End of File
                              ; for a device:
                              ;   00H = Not ready
                              ;   FFH = Ready
```

Comments

If used for a file, AL always returns F2H until end-of-file is reached, then always returns 00H unless the current file position is changed through call 42H. When used for a device, AL returns FFH for ready or 0 for not ready.

Call AL=08H

Purpose

This call allows you to determine if a device can support removable media.

Examples

```
        MOV     AH,44H          ; Function Call – IOCtl
        MOV     AL,8            ; Indicate IOCtl is removable
        MOV     BL,Drive        ; Select drive
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        MOV     Dtype,AX        ; Save type

  -----

  Drive         DB      ?       ; Drive (0=current, 1=A:, 2=B:, ...)
  Dtype         DW      ?       ; Drive type
                                ;   0 = Drive is removable
                                ;   1 = Drive is fixed
                                ; 0FH = Drive not valid
```

Comments

If the value returned in AX is 0, the device is removable. If the value is 1, the device is fixed. The drive number should be placed in BL. If the value in BL is invalid, an ″Access-Denied″ is returned. For network devices, the error `Invalid Function` is returned.

Call AL=09H

Purpose

This call allows you to determine if a logical device is associated with a network directory.

Examples

```
        MOV     AH,44H          ; Function Call – IOCtl
        MOV     AL,9            ; Indicate IOCtl is remote drive
        MOV     BL,Drive        ; Select drive
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        TEST    DX,1000H        ; See if local/remote
        JNZ     Is_Remote       ; Drive is remote

  -----

  Drive         DB      ?       ; Drive (0=current, 1=A:, 2=B:, ...)
```

Comments

On entry, BL contains the drive number of the block device you want to check (0=default, 1=A, 2=B, and so forth). The value returned in DX indicates whether the device is local or remote. Bit 12 is set for remote devices (1000H). Bit 12 is not set for local devices. The other bits in DX are reserved. If disk redirection is paused, the function returns with bit 12 not set.

Call AL=0AH

Purpose

This call allows you to determine if a handle is for a local device or a remote device across the network.

Examples

```
        MOV     AH,44H          ; Function Call — IOCtl
        MOV     AL,0AH          ; Indicate IOCtl is remote handle
        MOV     BX,Handle       ; Select device/file
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        TEST    DX,8000H        ; See if local/remote
        JNZ     Is_Remote       ; Drive is remote

  -----

  Handle        DW      ?       ; Handle to open file or device
```

Comments

For remote devices, bit 15 is set (8000H). The handle should be placed in BX. Bit 15 is not set for local devices.

Call AL=0BH

Purpose

This call controls retries on sharing and lock resource conflicts.

Examples

```
        MOV     AH,44H          ; Function Call – IOCtl
        MOV     AL,0BH          ; Indicate IOCtl set retry counts
        MOV     CX,NumLoops     ; Set number of loops
        MOV     DX,NumRetries   ; Set number of retries
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX

  -----

  NumLoops      DW      ?       ; Number of times to execute loop below
  NumRetries    DW      ?       ; Number of times to retry on error
```

Comments

All sharing and lock conflicts are automatically retried a number of times before they are returned as a PC DOS 7 error or critical error. You can select the number of retries and the delay time between retries. On input, CX contains the number of times to execute a delay loop, and DX contains the number of retries. The delay loop consists of the following sequence:

```
XOR     CX,CX
LOOP    $         ;spin 64K times
```

If this call is not issued, PC DOS 7 uses delay=1 and retries=3 as the defaults for CX and DX. If you expect your application to cause sharing or lock conflicts on locks that are in effect for a short period of time, you may want to increase the values for CX and DX to minimize the number of errors actually returned to your application.

Call AL = 0CH

Purpose

This generic IOCtl function uses an open device handle to request a device driver to perform code page switching or to get/set device information.

Examples

```
        MOV     AH,44H          ; Function Call – IOCtl
        MOV     AL,0CH          ; Indicate file handle generic IOCtl request
        MOV     BX,Handle       ; Select device/file
        MOV     CH,Category     ; Set device type
        MOV     CL,Function     ; Set function
        MOV     DI,SEG Packet   ; Address subfunction parameter packet
```

```
      MOV     DS,DI
      MOV     DX,OFFSET Packet ; DS:DX points to parameter packet
      INT     21H              ; Issue request to DOS
      JC      Error            ; Error code in AX

-----

Handle        DW      ?        ; Handle to open file or device
Category      DB      ?        ; Type of Device
                               ; 0 - Unknown (if device type not known)
                               ; 1 - a COMx device
                               ; 3 - CON
                               ; 5 - a LPTx device
Function      DB      ?        ; Function within category
                               ; For category 3 & 5:
                               ;   4CH = Prepare start
                               ;   4DH = Prepare end
                               ;   4AH = Select (Set)  code page
                               ;   6AH = Query  (Get) selected code page
                               ;   6BH = Query prepare list
                               ; For Category 3:
                               ;   5FH = Set display information
                               ;   7FH = Get display information
```

Prepare Start: When CL=4CH, the parameter block, pointed to by DS:DX, has the following layout:

```
Packet          Label            Word
  PS_PACKET     STRUC          ; Prepare start packet
  PS_FLAGS      DW      0      ; Control flags
                                     ; Bit 0 = 0 : Download prepare
                                     ; BIT 0 = 1 : Cartridge prepare
                                     ; Others reserved (set to 0)
  PS_LENGTH     DW      (n+1)*2 ; Length of rest of packet in bytes
  PS_NUMCP      DW      n      ; Number of code pages
  PS_CP1        DW      ?      ; Code page 1
                    .
                    .
                    .
                    .
  PS_CPn        DW      ?      ; Code page n
  PS_PACKET     ENDS
```

Notes:

1. Setting any PS_CPn to -1 tells the device driver not to change the code page value for that position. Any other value is a code page to be prepared.
2. n is the number of additional code pages specified in the DEVICE= command in CONFIG.SYS. The value for n can be up to 12.
3. For cartridge-prepares set the PS_FLAGS field to 1.

A Prepare Start request begins the preparation of a code page. It is followed by writing data defining the code page font to the device driver using one or more IOCtl write control string calls (AX=4403H). It is assumed that this information will be downloaded to the device. The stream is ended by a Prepare End. The format of the stream is device dependent.

If the information is lost (due to a system failure or power-off), you do not have to rewrite the prepared code page. Requesting a ″refresh″ operation by issuing a Prepare Start to the device driver with all code page values (PS_CPn) set to a negative one (-1), restores the most recently prepared code page information to the device. You must follow this operation immediately with a Prepare End.

If no data is written for a prepare operation, the driver interprets the newly prepared code page(s) as a hardware code page. This allows devices that support user changeable hardware fonts (usually in cartridges) to be supported.

No prepare is needed for hardware-defined code pages.

Prepare Start Error Codes

Code	Meaning
01	Invalid function number
22	Unknown command
27	Code page conflict (used for KEYBxx mismatch)
29	Device error
31	Device driver does not have copy of code page to download to device

Write Error Codes

Code	Meaning
27	Device not found in file, or code page not found in file
29	Device error
31	File contents not a font file, or file contents structure damaged

Prepare End: When CL=4DH the parameter block, pointed to by DS:DX, has the following layout:

```
Packet          Label        Word
  PE_PACKET     STRUC           ; Prepare end packet
  PE_LENGTH     DW      2       ; Length of packet in bytes
  PE_RESV1      DW      0       ; (Reserved, must be 0)
  PE_PACKET     ENDS
```

Prepare End Error Codes

Code	Meaning
19	Bad data read from font file
31	No prepare start

Select/Query Selected Code Page: When CL=4AH or 6AH the parameter block, pointed to by DS:DX, has the following layout:

```
PACKET LABEL WORD
 CP_PACKET     STRUC                  ; Select/Query Selected packet
 CP_LENGTH     DW      2+(n+1)*2     ; Length of packet in bytes
 CP_CPID       DW      ?              ; Code page ID
 CP_VECTOR1    DB      ?,?            ; DBCS vector1
                             .
                             .
                             .
CP_VECTORn     DB      ?,?            ; DBCS Vectorn
                              DB      0,0          ; End marker
CP_PACKET      ENDS
```

Select/Query Selected Code Page also includes the DBCS environment vector. Some device drivers may support only the code page value. As a result, you must check the returned length when using this call to determine if the DBCS information is present. Only the drivers supplied with the Asian version of PC DOS 7 provide this support.

Select Code Page Error Codes

Code	Meaning
26	Code page not prepared
27	Current keyboard does not support this code page
29	Device error

Query Selected Code Page Error Codes

Code	Meaning
26	No code page has been selected
27	Device error

Query Prepared List: When CL=6BH, the parameter block, pointed to by DS:DX, has the following layout:

```
PACKET              LABEL              WORD
  QL_PACKET     STRUC                ; Query list packet
  QL_LENGTH     DW((m+1)+(n+1))*2    ; Length of packet in bytes
  QL_NUMHWCP    DW      n            ; Number of hardware code pages
  QL_HWCP1      DW      ?            ; Hardware code page 1
                    .
                    .
                    .
                    .
  QL_HWCPn      DW      ?            ; Hardware code page n
  QL_NUMCP      DW      n            ; Number of prepared code pages
  QL_CP1        DW      ?            ; Prepared code page 1
                    .
                    .
                    .
                    .
  QL_CPm        DW      ?            ; Prepared code page n
  QL_PACKET     ENDS
```

Note: The device driver may return up to 12 code page values for each type of code page (hardware or prepared) so n can be up to 12, and m can be up to 12.

Query Prepared List Error Codes

Code	Meaning
26	No code pages have been selected
29	Device error

Get/Set Display Information: When CL=5FH or 7FH, the parameter block, pointed to by DS:DX, has the following layout:

```
  VP_PACKET     STRUC           ; Video parameters packet
  VP_LEVEL      DB      0       ; Requested info level (set to 0 before IOCtl
                                              ; Call)
  VP_RESV1      DB      0       ; (Reserved, must be 0)
  VP_LENGTH     DW      14      ; Length of rest of packet in bytes
  VP_FLAGS      DW      0       ; Control flags
                                ; Bit 0 = 0 : Intense colors
                                ; Bit 0 = 1 : Blink
                                ; Others reserved (set to 0)
  VP_MODE       DB      ?       ; Video mode
                                ; 1 = Text
                                ; 2 = APA
                                ; Others reserved
  VP_RESV2      DB      0       ; (Reserved. must be 0)
```

```
VP_COLORS     DW      ?       ; Number of colors (Mono=0)
VP_WIDTH      DW      ?       ; Display width in pixels (APA mode only)
VP_LENGTH     DW      ?       ; Display length in pixels (APA mode only)
VP_COLS       DW      ?       ; Display width in characters
VP_ROWS       DW      ?       ; Display length in characters

VP_PACKET     ENDS
```

Call AL = 0DH

Purpose

This generic IOCtl function requests a block device driver to perform one of the following subfunctions:

- Get device parameters
- Set device parameters
- Read track on logical device
- Write track on logical device
- Format and verify track on logical device
- Verify track on logical device
- Get access flag status
- Set access flag status.

Examples

```
      MOV     AH,44H          ; Function Call – IOCtl
      MOV     AL,0DH          ; Indicate Block Device Generic IOCtl
      MOV     BL,Drive        ; Select Device/File
      MOV     CH,Category     ; Set Device Type
      MOV     CL,Function     ; Set Function
      MOV     DS,SEG Packet   ; Address Subfunction Parameter Packet
      MOV     DX,OFFSET Packet
      INT     21H             ; Issue request to DOS
      JC      Error           ; Error code in AX
-----

Drive         DB      ?       ; Drive (0=current, 1=A:, 2=B:, ...)
Category      DB      ?       ; Type of Device
                              ; 8 - Block Device
Function      DB      ?       ; Function within Category
                              ; For Category 8:
                              ;   40H = Set device parameters
                              ;   60H = Get device parameters
                              ;   41H = Write track on logical device
                              ;   61H = Read track on logical device
```

```
                                        ;   42H = Format and verify track on
                                        ;         logical device
                                        ;   62H = Verify track on logical device
                                        ;   47H = Set access flag
                                        ;   67H = Get access flag
                                        ;   68H = Get media type
```

Note: Functions 43H through 46H and functions 63H through 66H are reserved for the system.

Comments

CH contains the major code (08H for all functions) and CL contains the minor code (function).

Get or Set Device Parameters

To Get Device Parameters, set CL = 60H.

To Set Device Parameters, set CL = 40H.

When CL = 60H or CL = 40H, the parameter block has the following field layout:

```
Packet                    Label       Byte
 A_deviceParameters       STRUC
 SpecialFunctions         DB      ?
 DeviceType               DB      ?
 DeviceAttributes         DW      ?
 NumberOfCylinders        DW      ?
 MediaType                DB      ?
 DeviceBPB                a_BPB   <>
 TrackLayout              a_TrackLayout <>
 A_deviceParameters       ends
```

An explanation of each field in the parameter block is given in the pages that follow.

SpecialFunctions Field

This 1-byte field is used to further define the Get and Set Device Parameters functions.

For the Get Device Parameters function, bit 0 of the **SpecialFunctions** field has the following meaning:

Bit 0 =1 Return the BPB that BUILD BPB would return.
=0 Return the default BPB for the device.

Note: All other bits must be off.

For the Set Device Parameters function bits 0, 1, and 2 of the **SpecialFunctions** field are used.

These bits have the following meanings when CL = 40H.

Bit 0	=1 All subsequent BUILD BPB requests return **DeviceBPB**. If another Set Device request is received with bit 0 reset, BUILD BPB returns the actual media BPB. =0 Indicates that the **DeviceBPB** field contains the new default BPB for this device. If a previous Set Device request set this bit on, the actual media BPB is returned. Otherwise, the default BPB for the device is returned by BUILD BPB.
Bit 1	=1 Ignore all fields in the Parameter Block except the **TrackLayout** field. =0 Read all fields of the parameter block.
Bit 2	=1 Indicates that all sectors in the track are the same size and all sector numbers are between 1 and *n* (where *n* is the number of sectors in the track.) =0 Indicates that all sectors in the track may not be the same size.

Notes:

1. All other bits must be reset.
2. Set bit 2 for normal track layouts. Format Track can be more efficient if bit 2 is set.
3. Setting bits 0 and 1 at the same time is invalid and should be considered an error.

DeviceType Field

This 1-byte field describes the physical device type. Device type is not set by IOCtl but is received from the device.

The values in this field have the following meanings:

0 = 320/360 KB 5.25 inch
1 = 5.25 inch, 1.2 MB
2 = 3.5 inch, 720 KB
3 = 8-inch single-density
4 = 8-inch double-density
5 = Hard disk
6 = Tape drive
7 = 3.5 inch, 1.44 MB
8 = Read/Write Optical devices
9 = 3.5 inch, 2.88 MB

DeviceAttributes Field

A 1-word field that describes the physical attributes of the device. Device attributes are not set by IOCtl but are received from the device driver.

Only bits 0 and 1 of this field are used. They have the following meanings:

Bit 0	=1 media is not removable.
	=0 media is removable.
Bit 1	=1 diskette changeline is supported.
	=0 diskette changeline is not supported.

Bits 2 – 15 are reserved.

NumberOfCylinders Field

This field indicates the maximum number of cylinders supported on the physical device, independent of the media type. The information in this field is not set by IOCtl, but is received from the device driver.

MediaType Field

For multimedia drives, this field indicates which media is expected to be in the drive. This field is only meaningful for Set Device Parameters (CL = 40H) subfunction.

The **MediaType** field is used only when the actual media in the drive cannot otherwise be determined. Media type is dependent on device type.

Regardless of the device type, a value of 0 represents the default. For example, a 5.25-inch 1.2MB diskette drive is a multimedia drive. The media type is defined as follows:

0 = Quad density 1.2 MB (96 tpi) diskette

1 = Double density 320/360KB (48 tpi) diskette

The default media type for a 1.2MB drive is a quad density 1.2 MB diskette.

DeviceBPB Field

For the Get Device Parameters function:

- If bit 0 of the **SpecialFunctions** field is set, the device driver returns the BPB that BUILD BPB would return.
- If bit 0 of the **SpecialFunctions** field is not set, the device driver returns the default BPB for the device.

For the Set Device Parameters function:

- If bit 0 of the **SpecialFunctions** field is set, the device driver is requested to return the BPB from this field for all subsequent BUILD BPB requests until a Set Device Parameters request is received with bit 0 in the **SpecialFunctions** field reset.
- If bit 0 is not set, the BPB contained in this field becomes the new default BPB for the device.

The **DeviceBPB** field has the following format:

```
a_BPB              STRUC
BytesPerSector     DW      ?
SectorsPerCluster  DB      ?
ReservedSectors    DW      ?
NumberOfFATs       DB      ?
RootEntries        DW      ?
TotalSectors       DW      ?
MediaDescriptor    DB      ?
SectorsPerFAT      DW      ?
;
SectorsPerTrack    DW      ?
Heads              DW      ?
HiddenSectors      DD      ?
BigTotalSectors    DD      ?
Reserved           DB      6 Dup (0)
a_BPB              ENDS
```

TrackLayout Field

This is a variable length table indicating the expected layout of sectors on the media track.

PC DOS 7 device drivers do not keep a track layout table for each logical device. The global track table must be updated (by the Set Device Parameters subfunction) when the attributes of the media change.

Note: The Set Device Parameters subfunction (CL=40H) modifies the track table regardless of how bit 1 of the **SpecialFunctions** field is set.

For Get Device Parameters, this field is not used. The track layout is used by subsequent Read/Write Track, Format/Verify Track and Verify Track functions.

The following example shows how this field is formatted:

```
 Total sectors-------|SectorCount      DW  n

 Sector  1-----------|SectorNumber_1   DW  1H
                     |SectorSize_1     DW  200H

 Sector  2-----------|SectorNumber_2   DW  2H
                     |SectorSize_2     DW  200H

 Sector  3-----------|SectorNumber_3   DW  3H
                     |SectorSize_3     DW  200H

 Sector  4-----------|SectorNumber_4   DW  4H
                     |SectorSize_4     DW  200H
                             |
                             |
                             |
 Sector  n-----------|SectorNumber_n   DW  n
                     |SectorSize_n     DW  200H
```

Note: All values are in hexadecimal.

The total number of sectors is indicated by the **SectorCount** field. Each sector number must be unique and in a range between 1 and n (sector count). As shown in the example above, the first sector number is 1 and the last sector number is equal to the sector count (n). If bit 2 of the **SpecialFunctions** field is set, all sector sizes, which are measured in bytes, must be the same. See the description of bit 2 under the **SpecialFunction** field.

Note: The **DeviceType**, **DeviceAttributes**, and **NumberOfSectors** fields should be changed only if the physical device has been changed.

Read/Write Track on Logical Device

To read a track on a logical device, set CL = 61H.

To write a track on a logical device, set CL = 41H.

The parameter block has the following layout when reading or writing a track on a logical device.

```
Packet                   LABEL   BYTE
 a_ReadWriteTrackPacket  STRUC
 SpecialFunctions        DB      ?
 Head                    DW      ?
 Cylinder                DW      ?
 FirstSector             DW      ?
 NumberOfSectors         DW      ?
 TransferAddress         DD      ?
```

```
 A_ReadWriteTrackPacket  ENDS
```

Notes:

1. All bits in the **SpecialFunctions** field must be reset.
2. The value in the **FirstSector** field and the **NumberOfCylinders** field is 0-based. For example, to indicate sector 9, set the value to 8.

Format/Verify Track on Logical Drive (IOCtl Write)

To format and verify a track, set CL = 42H.

To verify a track, set CL = 62H.

The parameter block has the following layout when formatting a track or verifying a track on a logical drive.

```
PACKET                    LABEL   BYTE
 A_FormatPacket           STRUC
 SpecialFunctions         DB      ?
 Head                     DW      ?
 Cylinder                 DW      ?
 A_FormatPacket           ENDS
```

On entry, bit 0 of the SpecialFunctions field has the following meanings:

Bit 0 = 1 Format status check call to determine if a
        combination of number-of-tracks and
        sectors-per-track is supported.

    = 0 Format /Verify track call.

To determine if a combination of number-of-tracks and sectors- per-track is supported, a Set Device Parameters call must be issued with the correct BPB for that combination before issuing the Format Status call. The device driver can then return the correct code to indicate what is supported. The value returned in the SpecialFunctions field for a Format Status Check call are:

0 = This function is supported by the ROM BIOS. The specified combination of number-of-tracks and sectors-per-track is allowed for the diskette drive.

1 = This function is not supported by the ROM BIOS.

2 = This function is supported by the ROM BIOS. The specified combination of number-of-tracks and sectors-per-track is not allowed for the diskette drive.

3 = This function is supported by the ROM BIOS, but ROM BIOS cannot determine if the numbers-of-tracks and sectors-per-track are allowed because the diskette drive is empty.

To format a track:

1. Issue the Set Device Parameters function call.
2. Issue the Format Status Check function call to validate the number-of-tracks and sectors-per-track combination. Ignore the result if the value returned is 1, because the ROM BIOS does not support this function.
3. Issue the Format/Verify Track function call with the SpecialFunctions bit 0 reset for each track on the medium.

Get/Set AccessFlag Status

To get the access flag status of a hard disk, set CL=67H.

To set the access flag status of a hard disk, set CL=47H.

The parameter block has the following layout when getting or setting the access flag status of a hard disk:

```
PACKET                    LABEL          BYTE
a_DiskAccess_Control      STRUC
SpecialFunctions          DB     0
DiskAccess_Flag           DB     ?       ; 0 = Disallow disk access
                                         ; Other value = allow disk access
a_DiskAccess_Control      ENDS
```

If the media has not been formatted or has an invalid boot record, the system will not allow disk I/O for the media. This ensures data integrity of fixed media. Since formatting a media is a special activity, and is needed to perform disk I/O for unformatted media, additional functions to control the disk access flag are necessary. A format utility should issue "Set the access flag status (CL=47H)" with DiskAccess_Flag = non-zero value to access the unformatted media. When every format operation is a success, leave the access flag status as it is to allow further disk I/O from general users. If format fails, issue ″Set the access flag status (CL = 47H)″ with DiskAccess_Flag = zero in order to block further media access. To get the current status of the system disk access flag, issue ″Get the access flag status (CL = 67H)″. If DiskAccess_Flag = zero, disk I/O is not allowed for the media.

Get/Set Media ID

To get the media ID, set CL=66H.

To set the media ID, set CL=46H.

The parameter block has the following layout when getting and setting the media ID:

```
PACKET              LABEL   BYTE
Media_ID_Packet     STRUC
Info_Level          DW      0               ; Information level,
                                            ; currently always 0
Serial              DD      ?               ; Volume serial number
Label               DB      11 dup (′ ′)    ; Volume label from
                                            ; boot record
File_Sys_Type       DB      8 dup (′ ′)     ; File system type
Media_ID_Packet     ENDS
```

Get Media ID copies the information from the boot record into the Media_ID_Packet. Set Media ID copies the information from the Media_ID_Packet to the boot record. If the disk does not contain a valid BPB, or the signature field is missing, then no action is taken, and both functions return Unknown Media (error code 7).

Get Media Type (PC DOS 7)

To get the media type, set CL=68H.

The parameter block has the following layout:

```
PACKET                  LABEL   BYTE
 Media_Type_Packet      STRUC
 Default                 DB      ?    ; 1 if media is equal or equivalent
                                      ; to the capacity of the drive.
                                      ; 0 if media is less than
                                      ; the capacity of the drive.
 Media_Type              DB      ?    ; Media Type:
                                      ; 2 for 720KB 3.5-inch 80-track floppy
                                      ; 7 for 1.44MB 3.5-inch 80-track floppy
                                      ; 9 for 2.88MB 3.5-inch 80-track floppy
 Reserved_1              DB      ?    ; Reserved
 Reserved_2              DD      ?    ; Reserved
```

```
Media_Type_Packet       ENDS    ?
```

Comments

If carry is set, then the error return code is in AX. Otherwise, carry is cleared.

Call AL = 0EH   Get Logical Drive Map

Purpose

This call allows the device driver to determine if more than one logical drive is assigned to a block device. When this call is issued, a drive number is passed in BL on input.

Examples

```
        MOV     AH,44H          ; Function Call – IOCtl
        MOV     AL,0EH          ; Indicate Logical Drive Check
        MOV     BL,Drive        ; Select Drive
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        CMP     AL,0            ; Only one drive letter for this device?
        JE      Single_Drive    ; Yes!
        MOV     ActiveDrive,AL  ; Save Active Drive info


  -----

  Drive         DB      ?       ; Drive (0=current, 1=A:, 2=B:, ...)
  ActiveDrive   DB      ?       ; Current drive letter for this device
                                ; (1=A:, 2=B:, ...)
```

Comments

If the block device has more than one logical drive letter assigned to it, on output a drive number corresponding to the last drive letter that was used to reference the device is returned in AL. If only one drive letter is assigned to the device, 0 is returned in AL by this call.

Call AL = 0FH   Set Logical Drive Map

Purpose

This call requests the device driver to change the next logical drive letter that will be used to reference a block device.

Examples

```
        MOV     AH,44H          ; Function Call — IOCtl
        MOV     AL,0FH          ; Indicate Set Logical Drive
        MOV     BL,Drive        ; Set Drive
        INT     21H             ; Issue request to DOS
        JC      Error           ; Error code in AX
        CMP     AL,0            ; Only one drive letter for this device?
        JE      Single_Drive    ; Yes!
        MOV     ActiveDrive,AL  ; Save Active Drive info
                                ; (should be the same as BL in)

  -----

  Drive         DB      ?       ; Drive (0=current, 1=A:, 2=B:, ...)
  ActiveDrive   DB      ?       ; Current drive letter for this device
                                ; (1=A:, 2=B:, ...)
```

Comments

When copying diskettes on a drive whose physical drive number has more than one logical drive letter assigned to it (for example, copying on a single drive system), PC DOS 7 issues diskette swap prompts to tell you which logical drive letter is currently referencing the physical drive number. As the drive changes from source to target, PC DOS 7 issues the message: `Insert diskette for drive X: and strike any key when ready.`

It is possible to avoid this message by issuing call AL = 0FH (Set Logical Drive).

To avoid the PC DOS 7 diskette swap message, set BL to the drive number that corresponds to the drive letter that will be referenced in the next I/O request.

Note: You can determine the last logical drive letter assigned to the physical drive number by issuing call AL = 0EH.

Because any block device can have logical drives, this call should be issued before all I/O operations involving more than one drive letter; otherwise, the PC DOS 7 message may be issued.

Call AL = 10H   Query IOCTL Handle

Purpose

QueryIOCtlHandle accepts a device handle and determines whether a specific IOCtl capability is supported by the device.

Examples

```
MOV     AH,44H          ; Function Call – IOCtl
MOV     AL,10H          ;
MOV     BX,handle       ; Select device/file
MOV     CH,category     ; Category function
MOV     CL,function     ; Packet filled in for function
                        ; to be tested
MOV     DX,offset packet
INT     21H             ; Issue request to DOS
JC      Error           ; Error code in AX
```

Comments

Category, function, and parameter block are filled in as they would be for the function whose presence is being checked for.

Upon exit, if carry is set, the error code in AL will be 1 for “Function not supported.” If carry is not set, then AX = 0.

This function call is supported by DOS 5.0 device drivers.

Call AL = 11H   Query IOCTL Device

Purpose

QueryIOCtlDevice accepts a drive number and determines whether a specific IOCtl capability is supported by the drive.

Examples

```
MOV     AH,44H          ; Function Call – IOCtl
MOV     AL,11H          ;
MOV     BL,drive        ; Select drive
MOV     CH,category     ; Category function
MOV     CL,function     ; Packet filled in for function
                        ; to be tested
MOV     DX,offset packet
INT     21H             ; Issue request to DOS
JC      Error           ; Error code in AX
```

Comments

Category, function, and parameter block are filled in as they would be for the function whose presence is being checked for.

Upon exit, if carry is set, the error code in AL will be 1 for “Function not supported.” If carry is not set, then AX = 0.

This function call is supported by DOS 5.0 device drivers.

Appendix D. Expanded Memory Support

Expanded memory is memory addressable through a combination of an Expanded Memory Specification (EMS) device driver and an EMS-capable hardware adapter or via a 386 memory manager.

The table below lists the *Lotus/Intel/Microsoft (LIM) Expanded Memory Manager Specification Version 4.0* functions.

LIM Function	INT 67H	Interface	Description
1	AH = 40H	Basic	Get status
2	AH = 41H	Basic	Get page frame address
3	AH = 42H	Basic	Get unallocated page count
4	AH = 43H	Basic	Allocate pages
5	AH = 44H	Basic	Map/unmap handle page
6	AH = 45H	Basic	Deallocate pages
7	AH = 46H	Basic	Get EMM version
8	AH = 47H	Advanced	Save page map
9	AH = 48H	Advanced	Restore page map
10			Reserved
11			Reserved
12	AH = 4BH	Advanced	Get EMM Handle count
13	AH = 4CH	Advanced	Get EMM Handle pages
14	AH = 4DH	Advanced	Get all EMM handle pages
15	AH = 4EH	Advanced	Get/Set page map
16	AH = 4FH	Advanced	Get/Set partial page map
17	AH = 50H	Advanced	Map/Unmap multiple handle pages
18	AH = 51H	Advanced	Reallocate pages
19	AH = 52H	Advanced	Get/Set handle attributes
20	AH = 53H	Advanced	Get/Set handle name
21	AH = 54H	Advanced	Get handle directory
22	AH = 55H	Advanced	Alter page map and jump
23	AH = 56H	Advanced	Alter page map and call
24	AH = 57H	Advanced	Move/Exchange memory region
25	AH = 58H	Advanced	Get mappable physical address array
26	AH = 59H	Advanced	Get expanded memory hardware information
27	AH = 5AH	Advanced	Allocate new pages
28	AH = 5BH	Advanced	Alternate page map register set
29	AH = 5CH	Advanced	Prepare expanded memory hardware for warm boot
30	AH = 5DH	Advanced	Enable/Disable Operating System Environment function set

The following pages only outline the basic functions of the Expanded Memory Specification, these functions being the ones useful to application developers.

For information on the advanced functions, more detailed information and guidelines on the use of these calls, refer to the Expanded Memory Specification published by Lotus/Intel/Microsoft.

Function 1 — Get Status

Purpose

This function returns the status that tells you whether the EMM386 is present and if the hardware is working correctly. This function does not require a previously opened EMM handle.

Examples

```
     MOV       AH, 40H              ; Function to Get Status
     INT       67H                  ; Call Interrupt 67H
     OR        AH, AH
     JNZ       error_handler
   ----
```

Comments

A return code of 0 in the AH register is for a successful call. The following is a list of other possible codes.

AH	Description
00H	The memory manager is loaded and the hardware is working.
80H	The manager detected a problem in the EMM software.
81H	The manager detected a problem in the expanded memory hardware.
84H	The function code passed to the EMM is not defined.

Function 2 — Get Page Frame Address

Purpose

This function informs your program where the page frame is located. It returns the segment portion of the page frame address in the BX register. This function does not require a previously opened EMM handle.

Examples

```
  MOV       AH, 41H             ; Get Page Frame Address function
  INT       67H                 ; Call interrupt 67H
  OR        AH, AH
  JNZ       error_handler

  MOV       Page_Segment, BX
----
  Page_Segment     DW     ?     ; Page Segment Address
```

Comments

A return code of 0 in the AH register is for a successful call. The following is a list of other possible codes.

AH	Description
00H	The memory manager is loaded and the hardware is working.
80H	The manager detected a problem in the EMM software.
81H	The manager detected a problem in the expanded memory hardware.
84H	The function code passed to the EMM is not defined.

The BX register contains the segment address of the page frame. The value in BX has no significance if AH is not equal to 0.

Function 3 — Get Unallocated Page Count

Purpose

This function informs your program the number of unallocated pages and the total number of pages in expanded memory. This function does not require a previously opened EMM handle.

Examples

```
MOV       AH,42H              ; Get Unallocated Page count
INT       67h                 ; Call Interrupt 67H
OR        AH,AH
JNZ       error_handler

MOV       UNAllocated_Pages,BX  ; Store UnAllocated pages
MOV       Total_Pages,DX      ; Store Total Pages
----
UnAllocated_Pages     DW   ?  ; Number of Unallocated Pages
Total_Pages           DW   ?  ; Total Number of Pages
```

Comments

A return code of 0 in the AH register is for a successful call. The following is a list of other possible codes.

AH	Description
00H	The memory manager is loaded and the hardware is working.
80H	The manager detected a problem in the EMM software.
81H	The manager detected a problem in the expanded memory hardware.
84H	The function code passed to the EMM is not defined.

The BX register has the following meaning:

BX	Description
00H	All pages in expanded memory have already been allocated. None are currently available for expanded memory.
< > 00H	The number of pages that are currently available.

The DX register if not equal to 0 contains the total number of pages in expanded memory.

Function 4 — Allocate Pages

Purpose

This function allocates the number of pages your program requests and assigns a unique EMM handle to these pages. The EMM handle ″owns″ these pages until your program later deallocates them.

Examples

```
  MOV       AH,43H               ; Allocated Pages Function
  MOV       BX,Number_Pages      ; Number of Pages to Allocate
  INT       67H                  ; Call Interrupt 67H
  OR        AH,AH
  JNZ       error_handler

  MOV       EMM_Handle, DX       ; Store EMM Handle
----
  Number_Pages  DW      ?        ; Number of Pages to Allocate
  EMM_Handle    DW      ?        ; EMM Handle
```

Comments

The status is returned in register AH and has the following meanings:

AH	Description
00H	The manager has allocated the pages to an assigned EMM handle.
80H	The manager detected a problem in the EMM software.
81H	The manager detected a problem in the expanded memory hardware.
84H	The function code passed to the EMM is not defined.
85H	All of the EMM handles are being used.
87H	There is not enough expanded memory pages to satisfy your program′s request.
88H	There is not enough unallocated pages to satisfy your program′s request.
89H	Can not allocate zero pages.

The DX register contains a unique EMM handle. The program must use this EMM handle (as a parameter) in any subsequent function calls that map or deallocate expanded memory.

Function 5 — Map Handle Page

Purpose

This function lets your program access the information stored in a logical page at a physical page within the page frame.

Examples

```
MOV     DX,EMM_Handle      ; Previously Opened EMM Handle
                           ; (Function 4 - Allocate Pages)
MOV     BX,Logical_Page    ; Logical Page in the Physical
                           ; Page Within the Page Frame
                           ; Range is 0 to total pages
                           ; allocated to a Handle -1

MOV     AL,Physical_Page   ; Range is 0 to 3
MOV     AH,44H             ; function to Map Handle Page
INT     67H                ; Call Interrupt 67H
OR      AH, AH
JNZ     error_handler
```

Comments

The function returns one of the following status codes:

AH	Description
00H	The manager has mapped the page. The page is now ready to be accessed.
80H	The manager detected a problem in the EMM software.
81H	The manager detected a problem in the expanded memory hardware.
83H	Invalid EMM handle specified.
84H	The function code passed to the EMM is not defined.
8AH	The logical page is out of range of the logical pages which are allocated to this EMM handle.
8BH	The physical page at which the logical page was supposed to be mapped is out of the range of physical pages.

Function 6 — Deallocate Pages

Purpose

This function deallocates the pages currently allocated to an EMM handle. After your program invokes this function, other application programs can use these pages.

Warning

Your program should invoke this function before it exits to DOS. If it does not, other programs may not use these pages or their handle.

Examples

```
MOV     DX, EMM_handle     ; Previously Opened EMM Handle
                           ; (Function 4 - Allocate Pages)
MOV     AH, 45h            ; Deallocate Pages Function
INT     67h                ; Call Interrupt 67H
OR      AH, AH
JNZ     error_handler
```

Comments

The following status is returned in the AH register:

AH	Description
00H	The manager has deallocated the pages previously allocated to the EMM handle.
80H	The manager detected a problem in the EMM software.
81H	The manager detected a problem in the expanded memory hardware.
83H	Invalid EMM handle specified.
84H	The function code passed to the EMM is not defined.
86H	The EMM detected a ″save″ or ″restore″ page mapping context error (FUNCTION 8 or 9). There is a page mapping register state in the ″save area″ for the EMM handle specified. Save Page Map (FUNCTION 8) placed it there and it has not been removed by a subsequent Restore Page Map (FUNCTION 9). You need to restore the contents of the page mapping register before you deallocate the EMM handle′s page(s).

Function 7 — Get EMM Version

Purpose

This function returns the version number of the Expanded Memory Manager software.

Examples

```
MOV     AH,46H
INT     67H
OR      AH,AH
JNZ     error_handler

MOV     EMM_Version,AL      ; Store Version Information
```

Comments

The function returns one of the following status values:

AH	Description
00H	The manager is present in the system and the hardware is working correctly.
80H	The manager detected a problem in the EMM software.
81H	The manager detected a problem in the expanded memory hardware.
84H	The function code passed to the EMM is not defined.

The AL register contains the Expanded Memory Manager's version number in Binary Coded Decimal. The upper four bits in the AL register contain the integer digit (3.x) of the version number. The lower four bits in the AL register contain the fractional digit of (x.2) version number. The value contained in AL has no importance if AH is not equal to 0.

Detecting the Expanded Memory Manager

In this brief section we show an example of how you may detect the presence of an installed Expanded Memory Manager. The first method uses the DOS INT 21H function 3DH (Open a File), which is used to open a file or device.

The EMM driver is opened using its name EMMXXXX0, if the open is successful, it means that either an EMM driver is installed or that a file named EMMXXXX0 exists on the default drive and directory. The latter case is unlikely, but you should check for the possibility. This is done by using DOS INT 21H function 44H, subfunction 07H (IOCtl, Get Output Status). The handle returned from the Open File function is used with the IOCtl, Get Output Status - this subfunction checks the output status of a device that is associated with a handle. If the return of this subfunction is 00H, then the device is actually a disk file and EMM is not installed or available. If the return is FFH then the opened handle is associated with a Expanded Memory Manager.

The following is an example of using the above technique:

Examples

```
EMM_Device_Name DB  "EMMXXXX0"
-----

  PUSH      DS
  PUSH      CS
  POP       DS
  MOV       AH,3DH              ; Open File Function Call
  MOV       DX,EMM_Device_Name  ; Set ASCII Name in DX
  MOV       AL, 0H              ; Open file in read only mode
  INT       21H                 ; Call Interrupt 21H
  JC        Open_Device_Error

  MOV       EMM_Handle,AX    ; Save file handle

  MOV       DX, Buffer          ;
  MOV       BX, EMM_Handle
  MOV       CX, 0H              ;
  MOV       AX,44H              ; IOCtl function 44H
  MOV       AL,07H              ; Subfunction 07 Get Output Status
  INT       21H                 ; Call Interrupt 21H

  MOV       Status,AX

  MOV       BX,EMM_Handle    ;
```

```
MOV      AH,3EH             ; Close File Handle
INT      21H                ; Call Interrupt 21H
```

The second method of detecting the Expanded Memory Manager is by using the address that may be found in the 67H interrupt vector. The 67H interrupt is of course the one used by the EMM driver, this interrupt 67H vector contains the address location of the driver. By normal convention the memory location at an offset of 0AH in the EMM drivers code segment contains the device driver name, EMMXXXX0 (in our case). If the name is present at the location specified then the EMM driver is installed.

The following is an example of using the above technique:

Examples

```
 EMM_Device_name DB     "EMMXXXX0"
----

  MOV      AH,35H             ; Get Interrupt vector
  MOV      AL,67H             ; EMM Interrupt number
  INT      21H                ; Call Interrupt 21H

  MOV      DI,0AH             ; Segment is in ES, set the
                              ; offset in DI
  LEA      SI, EMM_Device_Name
                              ; Offset of EMM name in SI
  MOV      CX,08              ; EMM String Name size in CX
  CLD                         ; Compare the names for a match
  REPE
  CMPSB
  JNE      Error_Exit
```

Appendix E. DOS Protected Mode Services

The following section describes the DOS Protected Mode Services (DPMS) driver that is provided along with PC DOS 7. The driver is written by Novell** and is used by the Stacker** compression driver.

Interrupt	Function	Description
2FH	AX=43E0H	DPMS Installation Check
31H	AX=0100H	Call Protected-Mode Procedure
31H	AX=0101H	Call Real-Mode Procedure (RETF)
31H	AX=0102H	Call Real-Mode Procedure (IRET)
31H	AX=0103H	Call Real-Mode Interrupt Handler
31H	AX=0200H	Allocate Descriptors
31H	AX=0201H	Free a Descriptor
31H	AX=0202H	Create Alias Descriptor
31H	AX=0203H	Build Alias to Real-Mode Segment
31H	AX=0204H	Set Descriptor Base
31H	AX=0205H	Set Descriptor Limit
31H	AX=0206H	Set Descriptor Type/Attribute
31H	AX=0207H	Get Descriptor Base
31H	AX=0300H	Get Size of Largest Free Block of Memory
31H	AX=0301H	Allocate Block of Extended Memory
31H	AX=0302H	Free Block of Extended Memory
31H	AX=0303H	Map Linear Memory
31H	AX=0304H	Unmap Linear Memory
31H	AX=0400H	Relocate Segment to Extended Memory

The DPMS driver makes its services available to DPMS clients via interrupts 2FH and 31H. In this section are briefly described the 2FH Multiplex Interrupt call that are provided if the DPMS driver is installed and the Interrupt 31H calls.

For more detailed information please refer to the DOS Protected Mode Services specifications from Novell.

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Interrupt 2FH Function AX=43E0H DPMS Installation Check

Purpose

This call is used to determine if the DPMS driver is installed and returns information about the driver.

```
        MOV     AX,43E0H        ; DPMS Installation Check
        INT     2FH             ; Call DOS 2F Interrupt
      ----
On Exit         AX = 0000h if installed
                ES:BX -> Registration Structure
```

Format of registration structure:

```
 Offset  Size    Description
  00h    DWORD   real-mode API entry point
  04h    DWORD   16-bit protected-mode API entry point
  08h  8 BYTEs   reserved (0)
  10h  8 BYTEs   blank-padded server OEM name
  18h    WORD    flags
                 bit 0: fast processor reset available (286 only)
                 bits 1-15 reserved (undefined)
  1Ah  2 BYTEs   DPMS version (major,minor)
  1Ch    BYTE    CPU type (02h = 286, 03h = 386 or higher)
```

Interrupt 31H Function AX=0100H Call Proteted-Mode Procedure

```
        AX = 0100h call protected-mode procedure
        CX = number of words of stack to copy
        ES:DI -> callup/down register structure

Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See “Callup/Down Register Structure” on page 323 for details of the callup/down structure.

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0101H Call Real-Mode Procedure (RETF)

```
AX = 0101h call real-mode procedure (RETF return)
CX = number of words of stack to copy
ES:DI -> callup/down register structure
```

```
Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See “Callup/Down Register Structure” on page 323 for details of the callup/down structure.

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0102H Call Real-Mode Procedure (IRET)

```
AX = 0102h call real-mode procedure (IRET return)
CX = number of words of stack to copy
ES:DI -> callup/down register structure
```

```
Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See “Callup/Down Register Structure” on page 323 for details of the callup/down structure.

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0103H Call Real-Mode Interrupt Handler

Purpose

This function call transfers control to the address specified by the real-mode interrupt vector.

```
        AX = 0103h call real-mode interrupt handler
        BL = interrupt number
        CX = number of words of stack to copy
        ES:DI -> callup/down register structure

Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See "Callup/Down Register Structure" on page 323 for details of the callup/down structure.

See "Interrupt 31H DPMS Error Return Codes" on page 323 for possible error return codes.

Interrupt 31H Function AX=0200H Allocate Descriptors

Purpose

This function allocates one or more descriptors in the task's local descriptor table. The descriptors allocated must be initialized by the application.

```
        AX = 0200h allocate descriptors
        CX = number of descriptors to allocate

Return
        CF clear if successful
           AX = first descriptor allocated
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0201H Free a Descriptor

Purpose

Frees a previously allocated descriptor.

```
        AX = 0201h free a descriptor
        BX = descriptor

Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0202H Create Alias Descriptor

Purpose

Creates a new descriptor that has the same base and limit as the specified descriptor.

```
        AX = 0202h create alias descriptor
        BX = descriptor

Return
        CF clear if successful
           AX = alias descriptor
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0203H Build Alias to Real-Mode Segment

Purpose

```
        AX = 0203h build alias to real-mode segment
        BX = descriptor
        CX = real-mode segment

Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0204H Set Descriptor Base

```
        AX = 0204h set descriptor base
        BX = descriptor
        CX:DX = base address

Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0205H Set Descriptor Limit

```
        AX = 0205h set descriptor limit
        BX = descriptor
        CX = limit

Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0206H Set Descriptor Type/Attribute

```
        AX = 0206h set descriptor type/attribute
        BX = descriptor
        CL = type
        CH = attribute

Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0207H Get Descriptor Base

```
        AX = 0207h get descriptor base
        BX = descriptor

Return
        CF clear if successful
        CX:DX = base address
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0300H Get Size of Largest Free Block of Memory

```
        AX = 0300h get size of largest free block of memory

Return
        CF clear if successful
           BX:CX = size
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0301H Allocate Block of Extended Memory

```
        AX = 0301h allocate block of extended memory
        BX:CX = size

Return
        CF clear if successful
           BX:CX = base address
           SI:DI = handle
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0302H Free Block of Extended Memory

```
        AX = 0302h free block of extended memory
        SI:DI = handle

Return
        CF clear if successful
        CF set on error
```

```
AX = error code (see below)
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0303H Map Linear Memory

```
        AX = 0303h map linear memory
        ES:[DI] = DDS

Return
        CF clear if successful
           BX:CX = base address
           SI:DI = handle
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0304H Unmap Linear Memory

```
        AX = 0304h unmap linear memory
        SI:DI = handle

Return
        CF clear if successful
        CF set on error
           AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H Function AX=0400H Relocate Segment to Extended Memory

```
          AX = 0400h relocate segment to extended memory
          ES:SI = base address
          CX = limit
          BL = type
          BH = attribute
          DX = selector or 0000h

  Return: CF clear if successful
             AX = selector
             BX:CX = new base address
             SI:DI = handle
          CF set on error
             AX = error code
```

Comments

See “Interrupt 31H DPMS Error Return Codes” on page 323 for possible error return codes.

Interrupt 31H DPMS Error Return Codes

Table 2. DPMS Error Return Codes

AX	Description
8000H	General error
8001H	Unsupported function
8011H	Descriptor unavailable
8012H	Linear memory unavailable
8013H	Physical memory unavailable
8021H	Invalid value
8022h	Invalid selector
8023H	Invalid handle

Callup/Down Register Structure

The following is the format for the callup/down register structure that is used with interrupt 31H, function calls 0100H, 0101H, 0102H and 0103H.

```
Offset  Size     Description
 00H     DWORD   EDI
 04H     DWORD   ESI
 08H     DWORD   EBP
 0CH   4 BYTEs   Reserved (0)
 10H     DWORD   EBX
 14H     DWORD   EDX
 18H     DWORD   ECX
 20H     DWORD   EAX
 24H     DWORD   EIP
 28H     WORD    CS
 2AH   2 BYTEs   Reserved (0)
 2CH     DWORD   EFLAGS
 30H     DWORD   ESP
 34H     WORD    SS
 36H   2 BYTEs   Reserved (0)
 38H     WORD    ES
 3AH   2 BYTEs   Reserved (0)
 3CH     WORD    DS
 3EH   2 BYTEs   Reserved (0)
 40H     WORD    FS
 42H   2 BYTEs   Reserved (0)
 44H     WORD    GS
 46H   2 BYTEs   Reserved (0)
```

Appendix F. Task-swapping

The user-shell introduced with DOS 5.0 provides a task-swapper function. With it the user can switch from one application to another without terminating either application. When a user starts a new program, the task-swapper suspends the currently-active program (in this case, the session-manager program) saves the contents of all registers, and writes the contents of the program memory to disk or to where “SET TEMP=” is specified. A new session is then created by the loading and executing of the new program. (A session is a program that is executed directly by the task-swapper and runs independently of other sessions.) The task-swapper remains active, normally monitoring the keyboard for a predefined key sequence. When the user presses the key sequence, the task-swapper suspends and saves the current session and transfers control to the formerly suspended session. It reads the memory contents of another suspended session into system memory, sets up the registers with the saved values, and transfers control to the formerly suspended session.

Most application programs can be suspended without problems. Because they execute synchronously, they can be interrupted in mid-execution and restarted (if the task-swapper properly saves and restores the state of the system that was in effect when it suspended the program). Some types of programs cannot operate safely with a task-swapper. For example:

- Some terminate-stay-resident (TSR) programs. (These are memory-resident programs that are executed asynchronously.) That is, they execute and take control of the system independently of the foreground program, the main program in control of the system. A network utility which performs tasks ″in the background″ while the foreground application is inactive is an example of this type of program. If a program with an outstanding network read request is suspended and replaced with another program, the network utility can copy the requested data into the second program′s context. This data can overwrite code or data used by the second program, causing a system malfunction.
- Some types of mainframe communications software. Mainframe communication software is normally communicating with software on another system.
- Software that maintains separate data for each process running on the system (a process is any program running within a session). One example of this type of software is a network redirector which traps DOS function calls to provide access to a simulated drive, but which does not use internal data structures maintained by DOS. While a task-swapper

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might adjust these data structures during a session switch, a redirector which does not rely on these tables must be able to maintain this information by itself. Consequently, the redirector must be notified of a session switch and must be able to prevent or delay the switch until it can handle the switch properly.

The DOS task-swapping protocol gives this type of software the ability to coexist with task-swappers that conform to the protocol. The protocol specifies a standard method of communication between the task-swapper and other software on the system, and gives software that would be adversely affected by a session switch the opportunity to control the timing of a switch or to prevent it altogether. Finally, the protocol provides a standard method for task-swappers to cooperate with each other, minimizing the problems that would result when competing task-swappers exist on the system simultaneously. Programs which conform to the DOS Task-swapping Protocol can coexist safely with the task-swappers incorporated in DOS 5.0 and later, and in future versions of Windows** running in real and standard modes.

Windows running in 386 enhanced mode is a preemptive, multitasking system. For this reason, it has a different set of requirements than swappers that do not support multitasking.

To be ″safe″ in both task-swapping and multitasking environments, clients and task-swappers must support both types of environments. This appendix describes the requirements for safe operation in a task-swapping environment. However, programs that are to run safely in a multitasking environment must also use the Windows 386 enhanced mode Int 2FH interface and are likely to require a specialized Windows 386 enhanced mode virtual device. These programs may need also to maintain separate instance data for task-swapper sessions and for virtual devices.

For more information on the Windows 386 enhanced mode virtual devices and the Int 2FH interface, see the *Microsoft Windows Device Driver Kit Virtual Device Adaptation Guide*.

The DOS task-swapping protocol specifies a standard method for task-swappers and other programs so they can cooperate with each other. Task-swappers and other types of programs exist in a client/server relationship in which the task-swapper is the server and other programs act as clients. This chapter uses the term client to refer to a program that conforms to this protocol and is not a task-swapper. As noted above, most

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task-swappers work by suspending one session, moving that session to a disk or to extended or expanded memory, and then loading another application in the same address space. However, in most systems there are other areas of memory, such as memory occupied by DOS, device drivers, and TSR utilities that are not swapped. In nearly every case, the programs that occupy this memory were started before the task-swapper, and are running and accessible regardless of which application the task-swapper has loaded into system memory. These type programs are referred to as global software. Memory that remains unchanged through task switches is called global memory. Local memory, on the other hand, is memory associated with a session spawned by the task-swapper. When the task-swapper swaps the session, this memory is swapped to disk or to extended or expanded memory.

Client Initialization

One of the first responsibilities of the task-swapper is to add itself to the chain of Int 2FH handlers by calling the Get Interrupt Vector Int 21H function (AH = 35H) and the Set Interrupt Vector Int 21H function (AH = 25H). After a client program has installed itself in the interrupt chain, it must determine whether a task-swapper is already present by calling the Detect swapper Int 2FH call-in function. If a task-swapper is present, the function returns with the call-in address of the task-swapper in ES:DI. Using the call-in address in ES:DI, the client must call the Hook Call-Out call-in function to allow the task-swapper to add the client′s call-out function handler address to the chain of call-out handlers it is maintaining for the session in which the client is running.

The Client Int 2FH Handler

The task-swapper issues an Int 2FH to call two client functions, the Build Call-Out Chain function and the Identify Instance Data function. Both of these functions are called by the task-swapper to build a linked list of data structures. Depending on the function, each structure identifies a particular client′s call-out function handler address or a client′s instance data. In general, the client Int 2FH handler performs the following tasks to add its structure to the list:

1. The Int 2FH handler determines whether AX contains a value identifying a task-swapper call-out function. If not, it transfers control to the previous Int 2FH handler with a far jump.

2. If AX identifies a task-swapper call-out function, the Int 2FH handler pushes the flags and makes a far call to the previous Int 2FH handler.

3. When the call returns, the Int 2FH handler places the value in ES:BX (the address of the previous handler′s data structure) in the appropriate field of the client′s data structure.
4. The Int 2FH handler places the address of the client′s own data structure in ES:BX and returns from the interrupt. The specific actions taken by the Int 2FH handler and the data structure used depends on the particular Int 2FH call-out function.

Responding to a Pending Session Switch

Most clients must be able to prevent a session switch from occurring when the client or other software is in an unstable state during which a session switch could result in the loss or corruption of data.

A task-swapper calls two call-out functions before performing a session switch. The Query Suspend function provides notification to affected clients that the task-swapper is preparing to suspend the currently active session. When a client receives a call to this function, it can either perform whatever operations are required and then allow the session switch to proceed, or it can prevent the session switch altogether.

The task-swapper calls the Suspend Session call-out function of each client if no client fails the Query Suspend call. Since interrupts were enabled while the task-swapper was making the Query Suspend call, the system state could have changed after a given client had received the call. The Suspend Session call provides clients one last opportunity to prevent the session switch. Since the task-swapper calls this function with interrupts disabled, the system state is guaranteed not to change following the Suspend Session call until the session switch takes place. For this reason interrupts must remain disabled until all clients have returned from the call. Also, a client must not issue software interrupts or use calls that might enable interrupts. The client can only return zero in AX to permit the session switch or one to prevent the session switch. All other registers must be preserved.

A client must not fail a Query Suspend or Suspend Session call because an asynchronous API is being executed without first determining that the applications program interface (API) is not being handled by more competent software. The client determines this by calling the Query API Support call-in function.

If any client fails the Query Suspend or Suspend Session calls, all clients in the entry-point chain called by the task-swapper may receive a Session Active call for the session that was to be suspended. For this reason it is possible to receive a Session Active call for a session that has not been suspended or activated. Clients can safely ignore these calls.

If no client fails the Suspend Session call, the task-swapper replaces the current interrupt vector table with a saved copy before enabling interrupts. The saved copy represents the global state present when the task-swapper was first started. This guarantees that interrupt handlers local to the session being suspended are not called until the session is resumed.

Between the Suspend Session call and the next Activate Session call interrupts are enabled intermittently and global software can receive interrupts during this time. Global clients must not assume the contents of any nonglobal memory between Suspend Session and Activate Session calls.

The task-swapper calls the Activate Session call-out function of affected clients to notify them that a task is about to be resumed. It then calls the Session Active function when the previously suspended session has been loaded into memory (including its local memory and interrupt vector table) and interrupts have been enabled.

Responding to the Pending Creation of a New Session

Just as a client can prevent a session switch, a client also can prevent the task-swapper from creating a new session. Before creating the new session, the task-swapper calls the Create Session call-out function. A client can take the appropriate action to prepare for the new session (for example, allocating additional memory to hold information for the session) and then permit the task-swapper to create the new session. Or the client can fail the Create Session call to block the new session from being created. A client would prevent a new session from being created, for example, if it maintained session-data in a fixed-length buffer that was too full to accommodate another session.

If any client fails the Create Session call, the task-swapper calls the Destroy Session function of some or all clients. The Destroy Session function notifies client programs that the session ID passed with the Create Session call is no longer valid. Since the task-swapper may call all clients or only those clients that had received the Create Session call, it is possible to receive a Destroy Session call for a session that has not been created or activated. Clients can safely ignore this Destroy Session call.

If no client fails the Create Session call, the task-swapper usually suspends the current session and then calls the Activate Session function by using a flag set to notify clients that the new session is about to take control. This gives clients the opportunity to take whatever action is required to prepare for the new session. The task-swapper then calls the Session Active (again with a flag set) to notify clients that the new session has been started. However, because some session managers (such as Windows) permit the user to start a session in an inactive state, the Activate Session and Session Active calls might not occur immediately after the Create Session call. Other sessions might also be activated and suspended before the newly created session becomes active for the first time, if at all.

Client Termination

Before terminating, a client must perform two tasks:

- It must call the Unhook Call-Out call-in function. This removes its call-out function handler from the chain of local call-out handlers maintained by the task-swapper.
- The client must remove its Int 2FH handler from the chain of Int 2FH handlers by calling the Set Interrupt Vector Int 21H function (AH = 25H), replacing the Int 2FH interrupt vector with the address of the previous Int 2FH handler (saved when the client was initialized).

The Switch_Call_Back_Info Data Structure

Every client must maintain a Switch_Call_Back_Info (SCBI) data structure. The client supplies this structure to the task-swapper when calling or responding to several different functions. The SCBI structure contains information about the entry point of the client's call-out function handler and a pointer to a list of API_Info_Struc data structures. These structures specify the types of asynchronous API which the client supports and the level of support it is able to provide. The Switch_Call_Back_Info data structure is defined as follows:

```
Switch_Call_Back_Info STRUC
SCBI_Next              dd  ?   ; address of next structure in chain
SCBI_Entry_Pt          dd  ?   ; address of notification function handler
SCBI_Reserved          dd  ?
SCBI_API_Ptr           dd  ?

Switch_Call_Back_Info ENDS
```

The Switch_Call_Back_Info structure contains the following fields:

- SCBI_Next – This 32-bit value contains a pointer to the next structure in the client chain. A task-swapper calls the Build Call-Out Chain Int 2FH call-out function to build this chain.
- SCBI_Entry_Pt – This 32-bit value contains a pointer to the entry point of the client's call-out function handler.
- SCBI_Reserved – This 32-bit value is reserved for use by the task-swapper.

- SCBI_API_Ptr – This 32-bit value contains a segment:offset pointer to a zero-terminated list of API_Info_Struc data structures. These structures specify the type of support the client provides for various asynchronous APIs.

The API_Info_Struc Data Structure

The API_Info_Struc (AIS) data structure contains information about the level of support that a client provides to a particular type of asynchronous API. The API_Info_Struc structure is defined as follows:

```
API_Info_Struc STRUC

AIS_Length          dw 10
AIS_API             dw ?
AIS_Major_Ver       dw ?
AIS_Minor_Ver       dw ?
AIS_Support_Level   dw ?

API_Info_Struc ENDS
```

The API_Info_Struc data structure contains the following fields:

1. AIS_Length – This 16-bit value specifies the length of the AIS data structure.

2. AIS_API – This 16-bit value specifies the ID of the asynchronous API supported by the client. The following values are defined:

```
API_NETBIOS     equ 1   ; NETBIOS

API_8022        equ 2   ; 802.2

API_TCPIP       equ 3   ; TCP/IP

API_LANMAN      equ 4   ; LAN Manager named pipes

API_IPX         equ 5   ; NetWare IPX
```

- AIS_Major_Ver – This 16-bit value specifies the highest major version of the API for which the client provides the level of support specified by the AIS_Support_Level field. For example, if the highest version of the API supported by the client at the specified level is 3.10, this field would be set to 3h.

- AIS_Minor_Ver – This 16-bit value specifies the highest minor version of the API for which the client provides the specified level of support. For example, if the highest version of the API supported by the client at the specified level is 3.10, this field would be set to Ah.

- AIS_Support_Level – This 16-bit value specifies the level of support provided by the client for the particular version of the API. The range and significance of values in this field depends upon the particular API. The following definitions are used for NETBIOS:
  - Minimal support. The client prevents a session switch after the application has executed any asynchronous API, even after the request has been completed.
  - API-level support. The client tracks asynchronous requests that are outstanding and prevents task switches at those times. The client allows task switches after all outstanding asynchronous requests have completed.
  - swapper compatibility. The API provider allows switches to occur even when asynchronous requests are outstanding. However, this might be limited by such factors as buffer size, and some requests might fail.
  - Seamless compatibility. The API provider always allows session switches to occur, and this never causes loss of data.

The Win386_Startup_Info_Struc Data Structure

The Win386_Startup_Info_Struc data structure is defined as follows:

```
Win386_Startup_Info_Struc      STRUC

SIS_Version                       db  3,0 ; ignored
SIS_Next_Dev_Ptr                  dd  ?   ; Ptr to previous handler's
                                          ; Win386_Startup_Info_Struc
SIS_Virt_Dev_File_Ptr             dd  0   ; ignored
SIS_Reference_Data                dd  ?   ; ignored
SIS_Instance_Data_Ptr             dd  ?   ; Ptr to IIS structures

Win386_Startup_Info_Struc ENDS
```

The Win386_Startup_Info_Struc is the same structure used to respond to the Microsoft Windows startup Int 2FH function. However, the DOS task-swapper uses only the SIS_Next_Dev_File_Ptr and SIS_Instance_Data_Ptr fields. (For information on the other fields, see the *Microsoft Windows Device Driver Kit Virtual Device Adaptation Guide*.)

The Win386_Startup_Info_Struc data structure contains the following fields:

- SIS_Version – This two-byte field is not used.

- SIS_Next_Dev_Ptr – This 32-bit value contains a segment:offset pointer to the next structure in the client chain. See below for more information about how this chain is constructed.
- SIS_Virt_Dev_File_Ptr – This 32-bit field is not used.
- SIS_Reference_Data – This 32-bit field is not used.
- SIS_Instance_Data_Ptr – This 32-bit value contains a segment:offset pointer to a list of Instance_Item_Struc data structures. Each structure describes one contiguous block of instance data. The list is terminated by a 32-bit zero value.

The Instance_Item_Struc Data Structure

The Instance_Item_Struc data structure is defined as follows:

```
Instance_Item_Struc STRUC

IIS_Ptr           dd  ?
IIS_Size          dw  ?

Instance_Item_Struc ENDS
```

The Instance_Item_Struc structure contains the following fields:

- IIS_Ptr – This 32-bit value contains a segment:offset pointer to the first byte of the block of instance data. IIS_Size – This 16-bit value specifies the size, in bytes, of the block of instance data.

The Swapper_Ver_Structure

The following shows the definition of the Swapper_Ver_Struc data structure:

```
Swapper_Ver_Struc   STRUC

SVS_API_Major            dw  ?
SVS_API_Minor            dw  ?
SVS_Product_Major        dw  ?
SVS_Product_Minor        dw  ?
SVS_swapper_ID           dw  ?
SVS_Flags                dw  ?
SVS_Name_Ptr             dd  ?
SVS_Prev_Swapper         dd  ?

Swapper_Ver_Struc   ENDS
```

The Swapper_Ver_Struc contains the following fields:

- SVS_API_Major – This 16-bit value specifies the highest major version of the Task-swapping Protocol that the swapper supports. For example, if the highest version of the protocol supported by the client at the specified level is 3.10, this field would be set to AH. The current version is 1.0.
- SVS_API_Minor – This 16-bit value specifies the highest minor version of the Task-swapping Protocol that the swapper supports. For example, if the highest version of the protocol supported by the task-swapper is 3.10, this field would be set to AH. The current version is 1.0.
- SVS_Product_Major – This 16-bit value specifies the major version of the task-swapper, in the same format as SVS_API_Major.
- SVS_Product_Minor – This 16-bit value specifies the minor version of the task-swapper, in the same format as SVS_API_Minor.
- SVS_Swapper_ID – This 16-bit field specifies, in its low-order four bits, the swapper ID value obtained from the Allocate swapper ID function.
- SVS_Flags – This 16-bit field contains a bit-array of 16 bits used as flags. In this version of the Task-swapping Protocol, only bit 0 is used. If the swapper is currently disabled, bit 0 is set. Otherwise, bit 0 is clear.
- SVS_Name_Ptr – This 32-bit value contains a segment:offset pointer to a zero-terminated ASCII string that identifies the task-swapper (for example, ″DOS Shell Task-swapper″).
- SVS_Prev_Swapper – This 32-bit value contains the address (in segment:offset form) of the previously loaded swapper′s call-out function entry point that is returned by the Detect swapper Int 2FH task-swapper function.

Function Descriptions

This section describes the Int 2FH handler functions, task-swapper call-out functions, and task-swapper call-in functions that comprise the DOS Task-swapping Protocol. The function descriptions are grouped according to these categories. Within each category the function descriptions are described in numeric order. Each function description is headed by the name of the function followed by a brief description of the function and the required conditions at the entry and exit of the function. Optional comments appear following the entry and exit information.

Note: All registers not used by these functions must be preserved.

Task-swapper Int 2FH Handler Functions

Currently there is one Int 2FH function for the task-swapper. It is specified below:

Detect Swapper (Function 4B02H)

A client calls the Detect Swapper Int 2FH function to determine if a task-swapper is currently running and to obtain the address of its call-in (to the task-swapper) function entry point.

```
Example:

        MOV  AX,04B02H          ;Detect presence of a task-swapper
        XOR  BX,BX              ;Required for future extensibility
        XOR  DI,DI
        MOV  ES,DI
        INT  2FH
             ;
             ;Save call-out address to the current task-swapper
             ;
        MOV  WORD PTR OUT_TO_SWAPPER+0, DI
        MOV  WORD PTR OUT_TO_SWAPPER+2, ES

--------

OUT_TO_SWAPPER DD   0    ; Call-out address to the current
task-swapper

All other registers are preserved.
```

Comments

A non-NULL pointer returned in ES:DI indicates the presence of a task-swapper. AX is returned with zero for future extensibility and the carry flag is clear.

Clients call this function during initialization and take the appropriate action if a swapper is detected.

Client Int 2FH Handler Functions

A client that is in full compliance with this protocol must contain an Int 2FH handler that can properly respond to the Build Call-Out Chain function (4B01H) from the task-swapper. In addition, it must also respond to the Identify Instance Data function (4B05H) if the client maintains data for each session. The following sections describe these functions.

Build Call-out Chain

This Client Int 2FH Handler function links a client′s call-out function entry point to a chain of client call-out entry points on the swapper.

```
On Entry:
        ; Respond to Call_Out function from task-swapper

        cmp     ax,04b01h               ;Build Chain Call-in function?
        jnz     Pass_Function_On
        test    Bit_flag,00000001b
        jnz     Pass_Function_On
          ;
          ;ES:BX = 0:0 for future extensibility
          ;CX:DX = call-in address of the calling task-swapper
          ;
        pushf
        call    far Prev_Int2f_Handler
          ;ES:BX = 0:0 if the first client loaded in memory

          ;
        mov     offset SCBI_Next,bx
        mov     offset SCBI_Next+2,es

Back_to_swapper:

         or     Bit_flag,1           ;We′ve been here
        mov     bx,offset Swap_Call_Back_Info
        mov     es,cs
          ;
          ;All other registers must be preserved.
          ;
        iret


Pass_Function_On:
          ;
        jmp     far Prev_Int2f_Handler

--------

Bit_flag        db      0               ; bit 1 = 0 if not called by swapper
                                        ;       = 1 if called by the swapper
```

Comments

ES:BX = 0:0 if you are first client loaded in-memory

A task-swapper calls this function to create a linked list of the call-out function entry points of all global clients, clients running in the current session, and of information about the asynchronous APIs supported by each client. When the function returns, ES:BX contains a pointer to the client′s SCBI data structure containing this information.

```
Swap_Call_Back_Info STRUC

        SCBI_Next          dd  ?       ;pointer to next structure in list
        SCBI_Entry_Pt      dd  ?       ;CS:IP of entry point procedure
        SCBI_Reserved      dd  ?       ;used by the swapper
        SCBI_API_Ptr       dd  ?       ;pointer to list of API structures

Swap_Call_Back_Info ENDS
```

For a description of the SCBI data structure, see “The Switch_Call_Back_Info Data Structure” on page 330 in this manual for a description of this structure.

When a client receives an Int 2FH, it checks AX to determine whether the Int 2FH is calling a Client Int 2FH Handler function. If not, the client passes control to the previous Int 2FH handler using a far jump. If it is, the Client Int 2FH Handler routine immediately pushes the flags and call the previous Int 2FH vector using a far call. It does not modify any registers before making the call.

When the call returns, ES:BX will contain the address of the previous client′s SCBI data structure (or 0:0 if the current client was the first loaded into memory). Whether or not ES:BX is 0:0, the value in ES:BX is placed in the SCBI_Next field of the client′s SCBI data structure. The client then places the address of its SCBI data structure into ES:BX and then returns from the interrupt.

When the call returns to the calling task-swapper, ES:BX points to the SCBI data structure of the last client loaded into memory. As a result, the SCBI data structures of the most recently loaded clients appear near the head of the chain. Consequently, the most recently loaded clients will be called before clients that were loaded earlier. This would allow, for example, an application with outstanding asynchronous requests to cancel the request when a session swap is about to occur before the network is queried. If the calls were to occur in the reverse order, the network might block the session swap because of the outstanding asynchronous requests.

At the entry to the Build Call-in Chain function, CX:DX contains the call-in function entry point of the calling task-swapper. A client can call this routine, with arguments specifying the function to be performed, while it is handling the Int 2FH call. However, the address passed in the Int 2FH call may not be the same address made available in later call-out function calls.

Identify Instance Data

This Client Int 2FH Handler function identifies instance data maintained by the client. For example:

```
On Entry:
         ; Respond to Call_Out function from task-swapper for Instance Data

        cmp     ax,04b05h               ;Build Chain Call-in function?
        jnz     Pass_Function_On
          ;
          ;ES:BX = 0:0 for future extensibility
          ;CX:DX = call-in address of the calling task-swapper
          ;Calls to DOS can be made

          ;Make call to previous client's Win386_Startup_Info_Struc
          ; data structure
          ;
        pushf
        call    far Prev_Int2f_Handler

        mov     offset SIS_Next_Dev_Ptr,BX
        mov     offset SIS_Next_Dev_Ptr+2,ES

Back_to_swapper:
          ;
          ;Provide Win386_Startup_Info_Struc data structure address
          ;
        mov     bx,offset Win386_Startup_Info_Struc
        push    cs
        pop
        iret                            ;All other registers must be preserved

Pass_Function_On:
        jmp     far Prev_Int2f_Handler  ;to previous Int 2FH handler

--------


Win386_Startup_Info_Struc      STRUC

SIS_Version                    db  3,0 ; ignored
SIS_Next_Dev_Ptr               dd  ?   ; Ptr to previous handler's
                                       ;   Win386_Startup_Info_Struc
SIS_Virt_Dev_File_Ptr          dd  0   ; ignored
```

```
SIS_Reference_Data            dd  ?   ; ignored
SIS_Instance_Data_Ptr         dd  ?   ; Ptr to IIS structures

Win386_Startup_Info_Struc ENDS
```

Comments

A task-swapper calls this function to create a linked list of instance data blocks of all clients running on the system.

When a client receives an Int 2FH, it checks AX to determine whether the Int 2FH is calling a Client Int 2FH Handler function. If it is not, the client passes control to the previous Int 2FH handler by using a far jump. If it is, the client Int 2FH handler routine immediately pushes the flags and call the previous Int 2FH vector using a far call. It does not modify any registers before making the call.

When the call returns, ES:BX will contain the address of the previous client's Win386_Startup_Info_Struc data structure (or 0:0 if the current client was the first loaded into memory). Whether or not ES:BX is 0:0, the value in ES:BX is placed in the SIS_Next_Dev_Ptr field of the client's Win386_Startup_Info_Struc data structure. The client then places the address of its Win386_Startup_Info_Struc data structure into ES:BX and returns from the interrupt.

When the call returns to the calling task-swapper, ES:BX points to the Win386_Startup_Info_Struc data structure of the last client loaded into memory.

Task-swapper Call-In Functions

The DOS task-swapper is in full compliance with this protocol and contains a call-in function entry point that can properly respond to the following seven functions:

- Get Version (Function 0H)
- Test Memory Region (Function 1H)
- Hook Call-out (Function 4H)
- Unhook Call-out (Function 5H)
- Query API Support (Function 6H)

The following sections describe these functions.

Note: All task-swapper call-in functions return with the carry flag clear. If a call-in function returns with the carry flag set, the function is not implemented by the receiving task-swapper.

Get Version

This task-swapper call-in function identifies the current task-swapper, its version number, and the level of the task-swapping Protocol that it supports.

```
For Example:

        MOV     AX,0            ;Get Version call to the task-swapper
        CLI                     ;Interrupts disabled
        CALL    OUT_TO_SWAPPER  ;From Detect swapper Int 2FH, AX=4b02h
                                ;
                                ;AX = 0 for future extensibility
                                ;All other registers are preserved.
                                ;
                                ;Save address of the swapper's Version
                                ;  Data structure
                                ;
        MOV     SWAPPER_VER_STRUC_PTR+0,BX
        MOV     SWAPPER_VER_STRUC_PTR+2,ES

--------

SWAPPER_VER_STRUC_PTR  DD      0
```

Comments

The following shows the definition of the Swapper_Ver_Struc data structure.

```
Swapper_Ver_Struc   STRUC

SVS_API_Major            dw  ?
SVS_API_Minor            dw  ?
SVS_Product_Major        dw  ?
SVS_Product_Minor        dw  ?
SVS_Swapper_ID           dw  ?
SVS_Flags                dw  ?
SVS_Name_Ptr             dd  ?
SVS_Prev_Swapper         dd  ?

Swapper_Ver_Struc   ENDS
```

For a description of the Swapper_Ver_Struc data structure, see "The Swapper_Ver_Structure" on page 333 in this manual.

Test Memory Region

This task-swapper call-in function is used to identify global or local memory locations to the current session. Memory that is global is not replaced when a task-swap occurs.

For Example:

```
        MOV     AX,1                    ;Test memory region call-out to the
                                        ;  task-swapper
        MOV     DI,OFFSET BUFFER        ;Address of buffer to be tested
        MOV     ES,SEG_BUFFER           ;ES is the buffer's segment address
        MOV     CX,BUFFER_LENGTH        ;Length of buffer in bytes (0 to 65535)
                                        ;  where 0 indicates 64K bytes (65536)
        CLI                             ;Interrupts disabled
        CALL    OUT_TO_SWAPPER          ;Obtained from Detect Swapper
                                        ;  Int 2FH, AX=4b02h
                                        ;
                                        ;Carry flag is clear
        MOV     REGION_LOCATION,AX
                                        ;AX = 0, Buffer is in global memory
                                        ;AX = 1, Buffer is partially in global
                                        ;         and partially in local memory
                                        ;AX = 2, Buffer is in local memory
                                        ;
                                        ;All other bits are reserved and must be 0
                                        ;All other registers are preserved.
```

Comments

If the buffer to be tested is longer than 64K bytes, more than one call is required to test the entire region. The determination whether memory is global or local is performed by the current task-swapper. Clients check the status of memory following each Query Suspend or Session Active call to determine whether the memory is global or local to the task-swapper performing the session swap.

Global software can use this function to identify asynchronous calls coming from another layer of global software. In these cases, the global software would not have to take special action when a session swap occurs because the calling application's buffer and callback address would be accessible regardless of which session is currently running.

A memory-resident utility also could use this function to determine whether it is running locally within a session. For example, a communication application could temporarily shut down before being suspended. If the application were running globally, however, that action that would not be necessary because the application would not be affected by a session swap.

Hook Call-out

This call-in function adds the address of the calling client's call-out function handler to the task-swapper's call-out chain.

For Example:

```
        MOV     AX,4                    ;Call-out to swapper to add this client's
                                        ; Call-out address

        MOV     DI,OFFSET SWAP_CALL_BACK_INFO
                                        ;
        MOV     ES,CS                   ;Swap_Call_Back_Info (SCBI)
                                        ;  data structure
                                        ;Interrupts are enabled.
                                        ;Calls to DOS can be made.
        CALL    OUT_TO_SWAPPER         ;Obtained from Detect swapper
                                        ;  Int 2FH, AX=4b02h
                                        ;
                                        ;Carry flag is clear.
                                        ;
                                        ;AX = 0 for future extensibility
                                        ;
                                        ;All other registers are preserved
```

Note: The client is not expected to fill in the SCBI_Next field for this structure. See "The Switch_Call_Back_Info Data Structure" on page 330 in this manual for more information.

Comments

During initialization a client calls the Detect swapper task-swapper Int 2FH function. If this call indicates that a task-swapper is running, the client calls the Hook Call-out call-in function of the task-swapper to add its own call-out handler to the task-swapper's call-out chain. Although some task-swappers create a call-out chain before every task-swapper event by calling the Build Call-out Chain Int 2FH function, other task-swappers generate this list only when initializing. These task-swappers keep a separate chain for each session. Each time the task-swapper creates a new session, it gives the session a copy of the global chain that was generated when the task-swapper initialized. (Alternatively, the task-swapper can keep a single global chain and a separate local chain for each session.) After the session is created, a client that runs locally within that session must explicitly add its call-out handler address to the local chain by calling the Hook Call-out call-in function.

A client must explicitly unhook itself from the call-out chain before terminating. The Unhook Call-out task-swapper call-in function unhooks a client from the task-swapper's call-out chain.

Unhook Call-out

This call-in function removes the address of the calling client's call-out function handler from the task-swapper's call-out chain.

For Example:

```
        MOV     AX,5                    ;Call-in to swapper to remove
                                        ;  this client's call-out address
                                        ;
        MOV     DI,OFFSET SWAP_CALL_BACK_INFO
        MOV     ES,CS                   ;Swap_Call_Back_Info (SCBI)
                                        ;  data structure
                                        ;Interrupts are enabled.
                                        ;Calls to DOS can be made.
        CALL    OUT_TO_SWAPPER          ;Obtained from Detect swapper
                                        ;Int 2FH, AX=4b02h
                                        ;
                                        ;Carry flag is clear.
                                        ;
                                        ;AX = 0 for future extensibility
                                        ;
                                        ;All other registers are preserved
```

See "The Switch_Call_Back_Info Data Structure" on page 330 in this manual for more information.

Comments

During initialization, a client calls the Detect swapper task-swapper Int 2FH function. If this call indicates that a task-swapper is running, the client calls the Hook Call-out call-in function of the task-swapper to add its own call-out handler to the task-swapper's call-out chain. Then, before terminating, a client must explicitly call the Unhook Call-out function to remove itself from the call-out chain.

Query API Support

This call-out function tells a client if it should control session swapping to handle a particular asynchronous API.

```
For Example:

        MOV     AX,6                    ;Call-out to swapper for most capable
                                        ;  API handler
        MOV     BX,ID                   ;ID value of the asynchronous API
                                        ;API_NETBIOS     equ 1
                                        ;API_8022        equ 2
                                        ;API_TCPIP       equ 3
                                        ;API_LANMAN      equ 4
                                        ;API_IPX         equ 5
        CALL    OUT_TO_SWAPPER          ;Obtained from Detect swapper Int 2FH,
                                        ;  AX=4b02h

        MOV     BEST_API_SUPPORTER+0,BX
        MOV     BEST_API_SUPPORTER+2,ES

                                        ;Carry flag is clear.
                                        ;AX = 0 for future extensibility
                                        ;All other registers are preserved

--------

API_Info_Struc STRUC

AIS_Length        dw    ?               ;length of the structure
AIS_API           dw    ?               ;the API ID value
AIS_Major_Ver     dw    ?               ;major version of API spec
AIS_Minor_Ver     dw    ?               ;minor version of the API spec
AIS_Support_Level dw    ?               ;support level

API_Info_Struc ENDS


Note:  See "The API_Info_Struc Data Structure" on page 331 in this manual
       for more information and the description of the AIS_API field.
```

Comments

This function determines which client will control session swapping (with regard to a particular asynchronous API). When a client is processing a Query Suspend or a Suspend Session call-out function, but before it prevents the session swap because of the state of an asynchronous API, it must first call the Query API Support call-in function to determine if it is the most competent client to handle the API. If it is, it prevents the session swap. If it is not the most competent client it does not prevent the session swap, relying instead on the more competent client to prevent the session swap, if necessary.

Every asynchronous API is assigned an ID value. Several levels of support are defined and indicated by a numeric value. Clients that can allow session swapping under more circumstances have a higher level of support than other clients.

Client programs maintain information about the asynchronous APIs they support and the level of support provided to each. It is in a list of API_Info_Struc data structures. A client provides a pointer to the beginning of this list in its Swap_Call_Back_Info (SCBI) data structure. See "The API_Info_Struc Data Structure" on page 331 in this manual for a full description of the API_Info_Struc structure. See "The Switch_Call_Back_Info Data Structure" on page 330 in this manual for more information on the SCBI data structure.

This function identifies the client most competent to support a specific API by returning the address of the API_Info_Struc data structure of the most competent client. The most competent client is the client that supports the highest version of the API. If two or more clients support the same highest version, the most competent client is the one that provides the highest level of support for that version.

If the calling client determines that the API_Info_Struc address returned by this function is the same as its own API_Info_Struc, the client prevents the session swap.

Task-swapper Call-in Functions

A client that is in compliance with this protocol contains a call-out function entry point that can properly respond to any of eight functions:

- Init swapper (Function 0)
- Query Suspend (Function 1)
- Suspend Session (Function 2)
- Activate Session (Function 3)
- Session Active (Function 4)
- Create Session (Function 5)

- Destroy Session (Function 6)
- Swapper Exit (Function 7)

A client is not required to implement any particular function and can respond to any of these function calls by returning control to the calling task-swapper. The following sections describe these functions.

Init swapper

This task-swapper call-out function notifies client programs that a new task-swapper is being initialized.

For Example:

```
        CMP     AX,0       ;Init swapper call?
                           ;ES:DI = the call-out address to the
                           ;  calling task-swapper.
                           ;Interrupts are enabled.
                           ;Calls to DOS can be made.

                           ;The task-swapper can safely load, nonzero value
                           ;  indicates that the task-swapper should not load.

        MOV     AX,OKAY_TO_SWAP

        RET                ;Return to task-swapper

--------

OKAY_TO_SWAP    DB    0    ;Flag to indicate if its okay to swap away
```

Comments

Because it is not necessarily the task-swapper that calls this function, clients should not assume that the call-out address passed in ES:DI will be the same address passed with subsequent call-in functions. This address can be NULL.

A session-manager application or environment that supports session swapping must call this function when it is initialized. A global client that needs to take special action to coexist with a task-swapper does so when it receives this call. The call-in entry point provided in ES:DI must be able to respond to the Get Version call-in function.

Typically, an application that invokes and controls the task-swapper calls the Init swapper call-out function (rather than the task-swapper itself). For example, the DOS 5.0 Shell calls the Init swapper call-out function during its initialization, before it starts the DOS task-swapper that actually performs the session swapping. If any client fails the Init swapper call (that is, returns with a nonzero value in AX), the Shell disables its task-swapping option. Other task-swapping applications may terminate if a client fails this function. If any client fails the Init swapper call-out function call, all clients may receive a call to the swapper Exit call-out function, including the client that failed the Init swapper call. As a result clients can receive a swapper Exit call without first receiving a corresponding swapper Init call. Clients can ignore this swapper Exit call.

Query Suspend

This call-out function to client programs notifies them that the task-swapper is preparing to perform a session swap.

For Example:

```
        CMP     AX,1                ;Query Suspend check from the task-swapper
        JA      CHECK_NEXT_FUNCTION
        CMP     BX,OUR_SESSION_ID   ;BX has the current session ID

          ;Interrupts are enabled
          ;Calls to DOS can be made
          ;ES:DI = The call-out address of the calling task-swapper


        MOV     AX,SWAP_FLAG
        CMP     AX,0
        JE      RETURN_TO_CALLER

          ;Determine that the API is not being handled by another,
          ;  more competent client


        MOV     AX,6                ;Call-out to swapper for most capable
                                    ;  API handler
        MOV     BX,ID               ;ID value of the asynchronous API
        CALL    OUT_TO_SWAPPER

          ;Does the most capable client have the same address as this client?


        CMP     OFFSET API_INFO_STRUC,BX

        JNE     OTHER_CLIENT_TO_HANDLE
        MOV     AX,1
        JMP     RETURN_TO_CALLER

OTHER_CLIENT_TO_HANDLE:
```

```
        XOR     AX,AX

RETURN_TO_CALLER:
        RET

--------

SWAP_FLAG     DB      0         ;0 if a session swap can be performed safely
                                ;1 if the client cannot safely handle a session
                                ;  swap.  All other values are reserved
                                ;
                                ;All other registers must be preserved.
CHECK_NEXT_FUNCTION:
```

Comments

A task-swapper calls this function when a session swap has been requested. The client can prevent the session swap, or it can perform any operation needed to allow the swap before returning.

A global client can use the current session ID to identify the session that will be suspended when the session swap occurs. It can use this ID to maintain information about the session when it is suspended and to restore the information when the session is resumed. The session ID is an arbitrary value provided by the task-swapper; the values are not necessarily sequential and values may be reused after a session is destroyed. A client can call the Test Memory Region task-swapper function to determine whether specific code or data in memory will be affected by the session swap and determine whether to allow the session swap. For example, a network redirector could run through a chain of outstanding request descriptors and, using the Test Memory Region function, check to see if any of the buffers or call-back addresses are located in local memory. If any are in local memory, the redirector could prevent the session swap or invoke special code to handle the case.

Before a client prevents a session swap because of the state of an asynchronous API, it calls the Query API Support call-in function to ensure that the API is not being handled by another, more competent client. If any client fails the Query Suspend function call, all clients may receive a call to the Session Active call-out function, including the client that failed the Query Suspend call. As a result, clients can receive a Session Active call without first receiving a corresponding Query Suspend or Suspend Session call. Clients can ignore this Session Active call.

Suspend Session

This call-out function notifies clients that a session swap is about to take place. This is the last opportunity provided to a client to prevent the session swap.

For Example:

```
        CMP     AX,2                ;Suspend Session notification?
        JA      CHECK_NEXT_FUNCTION ;
        CMP     BX,OUR_SESSION_ID   ;BX has the current session ID

           ;ES:DI = The call-out address of the calling task-swapper
           ;Interrupts are disabled


        MOV     AX,SWAP_FLAG
        CMP     AX,0
        JE      RETURN_TO_CALLER

          ;Determine that the API is not being handled by another,
          ;  more competent client

        MOV     AX,6                ;Call-out to swapper
        MOV     BX,ID               ;ID value of the asynchronous API
        CALL    OUT_TO_SWAPPER
        CMP     OFFSET API_INFO_STRUC,BX


          ;Does the most capable client have the same address as this client?

        JNE     OTHER_CLIENT_TO_HANDLE
        MOV     AX,1
        JMP     RETURN_TO_CALLER

OTHER_CLIENT_TO_HANDLE:
        XOR     AX,AX

RETURN_TO_CALLER:
        RET


SWAP_FLAG  DB   0        ;Equals 0 if a session swap can be performed safely
                         ;Equals 1 if the client cannot safely handle a session
                         ;  swap.  All other values are reserved
                         ;
                         ;All other registers must be preserved.
CHECK_NEXT_FUNCTION:
```

Comments

If no client fails the Query Suspend function call, the task-swapper disables interrupts and calls the Suspend Session call-out function. This provides clients with a final chance to prevent the session swap. Clients cannot issue any software interrupts or make any calls that might enable interrupts.

If all clients return with zero in AX, the task-swapper replaces the current interrupt vector table with a saved copy before enabling interrupts. The saved copy represents the global state present when the task-swapper first started. This guarantees that interrupt handlers local to the session being suspended will not be called after the Suspend Session call returns to the task-swapper and before the next session is activated. Local software cannot receive interrupts between the Suspend Session call and the Activate Session call. This ensures that local software cannot gain control on a hardware interrupt and make a call into global software before the global software receives the ID of the resumed session. However, global clients can receive interrupts after the Suspend Session call and before the next Activate Session call. During this period, global software should not assume the contents of nonglobal memory. The Test Memory Region task-swapper call-out function tests a block of memory to determine whether it is local or global.

Before a client prevents a session swap because of the state of an asynchronous API, it calls the Query API Support call-out function to ensure that the API is not being handled by another, more competent client. If any client fails the Suspend Session call-in function call, all clients may receive a call to the Session Active call-in function, including the client that failed the Suspend Session call. As a result clients can receive a Session Active call without first receiving a corresponding Query Suspend or Suspend Session call. Clients can ignore this Session Active call.

Activate Session

This call-out function notifies clients that a session is about to become active. If the session is a previously-suspended session, it has been reinstalled in memory and includes its local memory and interrupt-vector table. However, interrupts are disabled and must remain disabled.

For Example:

```
        CMP     AX,3               ;Activate Session call-in

          ;Interrupts are disabled and must remain disabled.
          ;Calls to DOS cannot be made

        JA      CHECK_NEXT_FUNCTION
```

```
        TEST    CX,0              ;If Bit 0 is set, indicates a new session
                                  ;  if not set, session was previously
                                  ;  suspended and is now being resumed.

        JNZ     TRACK_SESSION_IDS ;If global client update list

          ;ES:DI = The call-out address of the calling task-swapper.

        XOR     AX,AX             ;for future extensibility

        RET                       ;All other registers are preserved.

TRACK_SESSION_IDS:
        MOV     [LIST_INDEX],BX   ;BX = ID of session being activated
        INC     LIST_INDEX
        INC     LIST_INDEX
        RET

CHECK_NEXT_FUNCTION:
```

Comments

Although interrupts may have been enabled at times while the session memory was being swapped (and global software may have continued to receive interrupts), no interrupts could have been received by local software. However, after the interrupt-vector table of the new session has been loaded it is possible that a hardware interrupt will occur as soon as interrupts are enabled. If interrupts were not disabled when the call is made, local software could receive the interrupt and make a call to global software. However, that software might not be able to handle it correctly because it had not received the new session ID. If this is a newly-created session being activated for the first time, the Activate Session call will be preceded by a Create Session call-out function call.

Session Active

This call-out function notifies clients that a session has become active. If the session is a previously-suspended session, it has been reinstalled in memory and includes its local memory and interrupt vector table.

For Example:

```
        CMP     AX,4              ;Session Active call-in function
                                  ;Interrupts are enabled
                                  ;Calls to DOS can be made
        JA      CHECK_NEXT_FUNCTION
```

```
          ;ES:DI = call-out address of the calling task-swapper.

        TEST    CX,0              ;If Bit 0 is set, indicates a new session
                                  ;  if not set, session was previously
                                  ;  suspended and is now being resumed.
        JNZ     TRACK_SESSION_IDS ;If global client update list

        XOR     AX,AX             ;for future extensibility

        RET                       ;All other registers are preserved.


TRACK_SESSION_IDS:
        MOV     [LIST_INDEX],BX   ;BX = ID of session being activated
        INC     LIST_INDEX
        INC     LIST_INDEX
        XOR     AX,AX             ;for future extensibility
        RET

CHECK_NEXT_FUNCTION:
```

Comments

If any client fails a Query Suspend or Suspend Session call-out function call, all clients may receive a call to the Session Active call-out function, including the client that failed the Suspend Session call. As a result clients can receive a Session Active call without first receiving a corresponding Query Suspend or Suspend Session call. Clients can ignore this Session Active call.

Create Session

This call-out function notifies clients that the task-swapper is about to create a new session.

For Example:

```
        CMP     AX,5            ;Create Session call-in function
                                ;Interrupts are enabled
                                ;Calls to DOS can be made
        JA      CHECK_NEXT_FUNCTION

          ;ES:DI = call-out address of the calling task-swapper.
          ;BX = The session ID of the new session.

        MOV     AX,CREATE_SESSION_FLAG
        RET
```

```
--------

CREATE_SESSION_FLAG   DB   0    ;=0 New Session can be created
                                ;=1 Client cannot handle a new session
                                ;     All other values are reserved
```

Comments

When a new session is going to be created the task-swapper issues the Create Session function enabling a client to prevent the session from being created. For example, global software that keeps information for each session in a fixed-length data structure can fail the call if the structure does not have enough room for another session. The newly-created session may not be activated immediately, and other sessions can be created, destroyed and swapped before the new session becomes active. If any client fails the Create Session call-in function call, all clients may receive a call to the Destroy Session call-in function, including the client that failed the Create Session call. As a result, clients can receive a Destroy Session call without first receiving a corresponding Create Session call. Clients can ignore this Destroy Session call.

Destroy Session

This function notifies clients that the task-swapper is destroying a session.

```
For Example:

        CMP     AX,6            ;Destroy Session call-in function?
                                ;Interrupts are enabled
                                ;Calls to DOS can be made
        JA      CHECK_NEXT_FUNCTION

          ;ES:DI = call-out address of the calling task-swapper
          ;BX = The session ID of the session being destroyed

        XOR     AX,AX           ;For future extensibility
        RET

                                ;All other registers are preserved.
```

Comments

A task-swapper calls the Destroy Session call-out function when a session is being destroyed. Typically this will occur when the application in the current session exits. However, the session manager that controls the task-swapper also can provide a way for the user to terminate a session while the application is still running or is suspended. As a result, the session being destroyed is not necessarily the current session. If any client fails the Create Session call-in function call, all clients may receive a call to the Destroy Session call-in function, including the client that failed the Create Session call. As a result, clients can receive a Destroy Session call without first receiving a corresponding Create Session call. Clients can ignore this Destroy Session call.

Swapper Exit

This call-in function notifies global clients that the task-swapper is no longer active.

For Example:

```
        CMP     AX,7            ;Notification task-swapper no longer active?
                                ;Interrupts are enabled
                                ;Calls to DOS can be made
        JA      OUT_OF_FUNCTIONS

          ;ES:DI = The call-out address of the calling task-swapper.


        TEST    OTHER_SWAPPER_PRESENT,BX           ;Other swapper present?
        XOR     AX,AX                              ;AX = 0 for future extensibility
        RET

OTHER_SWAPPER_PRESENT  EQU     00000001B

          ; Bit 1 is set if no other active swappers
          ; Bit 1 is not set if at least one task-swapper
          ;  remains after the calling task-swapper exits
          ;All other bits are reserved and must be 0

OUT_OF_FUNCTIONS:
```

Comments

A task-swapper calls this function when it is no longer active as a task-swapper. This allows global software that performs extra processing to disable that processing and to coexist with the task-swapper.

This function can be called by software that invokes the actual task-swapper rather than by the task-swapper itself. For this reason the call-in address specified in ES:DI may differ from addresses passed with other call-out functions and may be NULL.

Appendix G. PC DOS 7 Viewer

The PC DOS Viewer that is included in PC DOS 7 is an online publication viewer facility. It allows the user to search for, view and print information in online books created by the IBM OS/2 Information Presentation Facility Compiler (IPFC). The books must have an extension of .INF and be in the IPF format. The PC DOS viewer supports a subset of the OS/2 IPF tags.

There are online books supplied with PC DOS 7, they are:

- PC DOS Command Reference (CMDREF.INF)
- REXX Information (DOSREXX.INF)
- PC DOS Error Message (DOSERROR.INF)

Invoking the Viewer

The PC DOS Viewer is invoked in one of two ways:

1. Command Line

   VIEW

   Launches the Viewer. A list of .INF files found in the same directory as VIEW.EXE is displayed for the user to choose a book.

   VIEW BOOKNAME

   Launches the Viewer and opens the specified book at the Table of Contents.

   Note: If the specified book is not in either the current directory or the same directory VIEW.EXE is in, a path must be specified.

2. PC DOS 7.0 Tools Group in Windows

   Double click on the desired book icon to launch the Viewer and open the desired book at the Table of Contents.

Uses of Online Documents

The uses of online document′s are many and various. For the application developer, the use of online documents is a boost in productivity, no longer does the developer need to create code to display the help text or the links from subject to subject or even the string search utilities - this all becomes part of the online document structure once it has been compiled. The final result becomes searchable via the PC DOS viewer and allows for instant

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access from the search results to the referenced page. All of this provides a more consistent way of viewing help to the end-user.

As another example of the online document's use, an administrator may provide the user with reference manuals for their particular company - this results in portable and quicker access to information.

The high use of online information is very true for the OS/2 world, where most products shipped also have some form of online help or information with them - this provided via the use of the Information Presentation Facility.

Creating Online Documents

The information that you wish to view via the PC DOS viewer must be prepared and compiled. The Information Presentation Facility compiler is supplied with the OS/2 developers tool kit and only runs under OS/2. For additional information regarding the IPF compiler please refer to the OS/2 Tool kit documentation. The current OS/2 IPF manual is *OS/2 Warp IPF Programming Guide*, this is referenced in the preface section of this book.

To prepare your source files so that they may be recognized by the IPF compiler, requires certain tags to be coded into the source file. The following briefly describes the process of creating a viewable online document.

The following is a simple example of using a single source file, that uses a limited number of tags, which will produce a usable online document:

```
:userdoc.
:docprof.
:title.Online Example
:h1.Introduction
:p.This is the introduction chapter to the rest of the document.
:euserdoc.
```

The :userdoc. tag is always the first item in the source file. It identifies the beginning of the IPF file. This tag is a signal to the IPF compiler to begin translating the tagged file. The :euserdoc. is used to signal the end of the tagged document.

Place the :docprof. (document profile) tag at the beginning of your source file after the :userdoc. tag and before any heading definitions. Use the toc (table of contents) attribute on the :docprof. tag to control the heading levels displayed in the Content window. For example, if you want only heading levels 1 and 2 to appear, the tagging is:

```
:docprof toc=12.
```

If no toc= value is specified, heading level 1 through 3 appear in the Contents window.

Not to be confused with window titles, the text string specified with a :title. tag is placed into the title bar of an on-line document. When the online document is displayed, the title appears on the title line of the main window. The tagging looks like this:

```
:title.Endangered Mammals
```

The maximum length of a title string specified with a :title. tag is 47 characters, including spaces and blanks.

The title tag provides a name for the online document, but is also used for titles of Help windows. The title appears in the title bar of the main window. You usually place the title tag after the :docprof. tag.

Every file must start with a :h1. (chapter heading) tag. Heading level sequences must not skip a level in the heading hierarchy. For example, you cannot have a heading level 1 tag (:h1.) followed by a heading level 3 tag (:h3.).

You must have at least one paragraph tag (:p.) and associated text to display a window. The following shows an IPF example source file:

```
.*
:userdoc.
:title.Endangered Mammals
:h1 res=001.The Manatee
.*
:p.
The manatee has a broad flat tail and two flipper
like forelegs.  There are no back legs.
The manatee's large upper lip is split in two and
can be used like fingers to place food into the
mouth.  Bristly hair protrudes from its lips,
and almost buried in its hide are small eyes, with
which it can barely see.
.*
:euserdoc.
```

It is a good idea to give your source file the extension of IPF, so that it may be distinguished from other files. The IPF compiler however, will append this extension if you do not specify a file extension when compiling. The following is the syntax that the IPF compiler will accept:

```
IPFC filename [/INF] [/S] [/X] [/W] [> messageoutputfilename]
```

where:

filename Specifies the name of your IPF source file or base file. If you do not give a file-name extension, the IPF compiler uses .IPF by default. If your file has a file-name extension other than IPF, include that file-name extension in the command line.

/INF Compiles the source file as an online document. If this parameter is not included, the default is to compile the source file as a help library, whose extension is .HLP.

/S Suppresses the performance of the Search function. This parameter increases compression of compiled data by about 10% to further reduce the storage it requires.

/X Generates and displays a cross-reference list.

/Wn Generates and displays a list of error messages. The n indicates the level of error messages you want to receive. Values you can specify for n are 1, 2, or 3. For more information, see Interpreting IPFC Error Messages, that is supplied with the OS/2 tool kit.

messageoutputfilename Specifies the name of the file where error and cross reference messages are sent. If you do not specify this parameter, messages generated by /X and /Wn are sent to the display screen.

The IPF compiler is run from an OS/2 command line, as in the following example:

```
C:>IPFC MYFILE.IPF /INF
```

Files that may be viewed with either the PC DOS viewer or the OS/2 viewer, need to have the /INF option specified. This file is portable across both operating systems but, the following section describes functions and tags which should not be used if the online document is to be used with the PC DOS viewer.

IBM OS/2 Functions and Tags not Supported by DOS

The following major functions are not currently supported by the PC DOS Viewer:

- Bookmarks
- Viewed Pages
- Libraries

- Graphics and hypergraphics
- Hyperlinks between books
- Launching of tutorials/applications
- Customized windows/controls

All tags and all tag options may not be supported by the PC DOS Viewer. The following table describes the tags supported by DOS and any limitations, if applicable.

Tag	End Tag	Exceptions (if any)
.br		
.*		
.im		
:caution.	:ecaution.	
:cgraphic.	:ecgraphic.	
:color.		
:dl.	:edl.	
:docprof.		Only the toc= attribute is supported
:fig.	:efig.	
:figcap.		
:fn.	:efn.	
:h1. - :h6.		Only the following attributes are supported: res=, id=, name=, toc=, nosearch and hide
:hp1. - :hp9.	:ehp1. - :ehp9.	hpx, where x = 1, 2, 3, 5, 6 or 7 will result in the string being displayed in the default font. Italicized strings will be enclosed in quotation marks.
:i1. - :i2.		Only the following attributes are supported: id=, roots=, sortkey= and refid=
:isyn.		
:li.		
:link.	:elink.	Only the following attributes are supported: reftype= and reftype=fn
:ln		
:lp		
:note.		
:nt.	:ent.	

Tag	End Tag	Exceptions (if any)
:ol.	:eol.	
:p.		
:parml.	:eparml.	
:pd.		
:pt.		
:rm.		
:sl.	:esl.	
:table.	:etable.	
:title.		
:ul.	:eul.	
:userdoc.	:euserdoc.	
:warning.	:ewarning.	
:xmp.	:exmp.	

Again, please be aware that additional information may be found in the OS/2 tool kit publications.

Appendix H. Miscellaneous Control Blocks

This section identifies the structure and content of some control blocks referenced throughout this document.

DPB - Disk Parameter Block Definition

DPB structure:

```
dpb     STRUC
    dpb_drive           DB      ?           ; Logical drive # assoc with DPB (A=0,B=1,...)
    dpb_UNIT            DB      ?           ; Driver unit number of DPB
    dpb_sector_size     DW      ?           ; Size of physical sector in bytes
    dpb_cluster_mask    DB      ?           ; Sectors/cluster - 1
    dpb_cluster_shift   DB      ?           ; Log2 of sectors/cluster
    dpb_first_FAT       DW      ?           ; Starting record of FATs
    dpb_FAT_count       DB      ?           ; Number of FATs for this drive
    dpb_root_entries    DW      ?           ; Number of directory entries
    dpb_first_sector    DW      ?           ; First sector of first cluster
    dpb_max_cluster     DW      ?           ; Number of clusters on drive + 1
    dpb_FAT_size        DW      ?           ; Number of records occupied by FAT
    dpb_dir_sector      DW      ?           ; Starting record of directory
    dpb_driver_addr     DD      ?           ; Pointer to driver
    dpb_media           DB      ?           ; Media byte
    dpb_first_access    DB      ?           ; This is initialized to -1 to force a media
                                            ; check the first time this DPB is used
    dpb_next_dpb        DD      ?           ; Pointer to next Drive parameter block
    dpb_next_free       DW      ?           ; Cluster # of last allocated cluster
    dpb_free_cnt        DW      ?           ; Count of free clusters, -1 if unknown
dpb     ENDS

    DPBSIZ  EQU     SIZE dpb                ; Size of the structure in bytes

    DSKSIZ  =       dpb_max_cluster         ; Size of disk (temp used during init only)
```

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BPB - BIOS Parameter Block Definition

This structure is used to build a full DPB.

```
BPBLOCK STRUC
    BPSECSZ DW      ?                    ; SIZE IN BYTES OF PHYSICAL SECTOR
    BPCLUS  DB      ?                    ; SECTORS/ALLOC UNIT
    BPRES   DW      ?                    ; NUMBER OF RESERVED SECTORS
    BPFTCNT DB      ?                    ; NUMBER OF FATS
    BPDRCNT DW      ?                    ; NUMBER OF DIRECTORY ENTRIES
    BPSCCNT DW      ?                    ; TOTAL NUMBER OF SECTORS
    BPMEDIA DB      ?                    ; MEDIA DESCRIPTOR BYTE
    BPFTSEC DW      ?                    ; NUMBER OF SECTORS TAKEN UP BY ONE FAT
BPBLOCK ENDS

A_BPB                   STRUC
    BPB_BYTESPERSECTOR      DW      ?
    BPB_SECTORSPERCLUSTER   DB      ?
    BPB_RESERVEDSECTORS     DW      ?
    BPB_NUMBEROFFATS        DB      ?
    BPB_ROOTENTRIES         DW      ?
    BPB_TOTALSECTORS        DW      ?
    BPB_MEDIADESCRIPTOR     DB      ?
    BPB_SECTORSPERFAT       DW      ?
    BPB_SECTORSPERTRACK     DW      ?
    BPB_HEADS               DW      ?
    BPB_HIDDENSECTORS       DW      ?
                            DW      ?
    BPB_BIGTOTALSECTORS     DW      ?
                            DW      ?
                            DB      6 DUP(?)
A_BPB                   ENDS
```

CDS - Current Directory Structure

CDS items are used by the internal routines to store cluster numbers and network identifiers for each logical drive. The ID field is used dually, both as net ID and for a cluster number for local devices. In the case of local devices, the cluster number will be -1 if there is a potential of the disk being changed or if the path must be recracked. The END field is the location of the end of the definition.

```
    DIRSTRLEN       EQU     64+3            ; Max length in bytes of directory strings
    TEMPLEN         EQU     DIRSTRLEN*2

curdir_list     STRUC
    curdir_text     DB      DIRSTRLEN DUP (?)   ; text of assignment and curdir
    curdir_flags    DW      ?               ; various flags
    curdir_devptr   DD      ?               ; local pointer to DPB or net device
    curdir_ID       DW      ?               ; cluster of current dir (net ID)
                    DW      ?
    curdir_user_word DW     ?
    curdir_end      DW      ?               ; end of assignment
    curdir_type     DB      ?               ; IFS drive (2=ifs, 4=netuse)
    curdir_ifs_hdr  DD      ?               ; Ptr to File System Header
    curdir_fsda     DB      2 DUP (?)       ; File System Dependent Data Area
curdir_list     ENDS

    curdirLen       EQU     Size curdir_list        ; Needed for
                                                ; ASM87 which doesn't allow
                                                ; Size directive as a macro
                                                ; argument
    curdir_netID    EQU     DWORD PTR curdir_ID

 ;Flag word masks
    curdir_isnet    EQU     1000000000000000B
    curdir_isifs    EQU     1000000000000000B       ; DOS 4.0
    curdir_inuse    EQU     0100000000000000B
    curdir_splice   EQU     0010000000000000B
    curdir_local    EQU     0001000000000000B
```

Purpose:

Maps drive letter to physical device and provide a way to keep track of each directory for each drive.

SFT - System File Table

System File Table structures:

```
SF              STRUC
    SFLink          DD      ?
    SFCount         DW      ?               ; number of entries
    SFTable         DW      ?               ; beginning of array of the following
SF              ENDS

 ; system file table entry
sf_entry        STRUC
    sf_ref_count    DW      ?               ; number of processes sharing entry
                                            ;   if FCB then ref count
    sf_mode         DW      ?               ; mode of access or high bit on if FCB
    sf_attr         DB      ?               ; attribute of file
    sf_flags        DW      ?               ;Bits 8-15
                                            ; Bit 15 = 1 if remote file
                                            ;        = 0 if local file or device
                                            ; Bit 14 = 1 if date/time is not to be
                                            ;   set from clock at CLOSE.  Set by
                                            ;   FILETIMES and FCB_CLOSE.  Reset by
                                            ;   other reseters of the dirty bit
                                            ;   (WRITE)
                                            ; Bit 13 = Pipe bit (reserved)
                                            ; Bits 0-7 (old FCB_devid bits)
                                            ; If remote file or local file, bit
                                            ; 6=0 if dirty Device ID number, bits
                                            ; 0-5 if local file.
                                            ; bit 7=0 for local file, bit 7
                                            ;      =1 for local I/O device
                                            ; If local I/O device, bit 6=0 if EOF (input)
                                            ;              Bit 5=1 if Raw mode
                                            ;              Bit 0=1 if console input device
                                            ;              Bit 1=1 if console output device
                                            ;              Bit 2=1 if null device
                                            ;              Bit 3=1 if clock device
    sf_devptr       DD      ?               ; Points to DPB if local file, points
                                            ; to device header if local device,
                                            ; points to net device header if remote
    sf_firclus      DW      ?               ; First cluster of file (bit 15 = 0)
    sf_time         DW      ?               ; Time associated with file
    sf_date         DW      ?               ; Date associated with file
    sf_size         DD      ?               ; Size associated with file
    sf_position     DD      ?               ; Read/Write pointer or LRU count for FCBs
 ; Starting here, the next 7 bytes may be used by the file system to store an ID
    sf_cluspos      DW      ?               ; Position of last cluster accessed
    sf_dirsec       DD      ?               ; Sector number of directory sector for this fil
    sf_dirpos       DB      ?               ; Offset of this entry in the above
 ; End of 7 bytes of file-system specific info.
    sf_name         DB      11 DUP (?)      ; 11 character name that is in the
                                            ; directory entry.  This is used by
                                            ; close to detect file deleted and
                                            ; disk changed errors.
```

```
 ; SHARING INFO
    sf_chain       DD      ?              ; link to next SF
    sf_UID         DW      ?
    sf_PID         DW      ?
    sf_MFT         DW      ?
    sf_lstclus     DW      ?              ; Last cluster accessed
    sf_IFS_HDR     DD      ?
sf_entry       ENDS
    sf_fsda        EQU     BYTE PTR sf_cluspos          ;DOS 4.0
    sf_serial_ID   EQU     WORD PTR sf_firclus          ;DOS 4.0
    sf_netid       EQU     BYTE PTR sf_cluspos
    sf_OpenAge     EQU     WORD PTR sf_position+2
    sf_LRU         EQU     WORD PTR sf_position
    sf_default_number   EQU     5h
 ; Note that we need to mark an SFT as being busy for OPEN/CREATE.  This is
 ; because an INT 24 may prevent us from 'freeing' it.  We mark this as such
 ; by placing a -1 in the ref_count field.
    sf_busy EQU -1
 ; mode mask for FCB detection
    sf_isfcb               EQU     1000000000000000B
 ; Flag word masks
    sf_isnet               EQU     1000000000000000B
    sf_close_nodate        EQU     0100000000000000B
    sf_pipe                EQU     0010000000000000B
    sf_no_inherit          EQU     0001000000000000B
    sf_net_spool           EQU     0000100000000000B
    Handle_Fail_I24        EQU     0000000100000000B  ;BIT 8 - DISK FULL I24 ERROR
 ; Local file/device flag masks
    devid_file_clean       EQU     40h     ; true if file and not written
    devid_file_mask_drive  EQU     3Fh     ; mask for drive number
    devid_device           EQU     80h     ; true if a device
    devid_device_EOF       EQU     40h     ; true if end of file reached
    devid_device_raw       EQU     20h     ; true if in raw mode
    devid_device_special   EQU     10h     ; true if special device
    devid_device_clock     EQU     08h     ; true if clock device
    devid_device_null      EQU     04h     ; true if null device
    devid_device_con_out   EQU     02h     ; true if console output
    devid_device_con_in    EQU     01h     ; true if consle input
```

```
; structure of devid field as returned by IOCTL is:
;       BIT     7   6   5   4   3   2   1   0
;             |---|---|---|---|---|---|---|---|
;             | I | E | R | S | I | I | I | I |
;             | S | O | A | P | S | S | S | S |
;             | D | F | W | E | C | N | C | C |
;             | E |   |   | C | L | U | O | I |
;             | V |   |   | L | K | L | T | N |
;             |---|---|---|---|---|---|---|---|
;       ISDEV = 1 if this channel is a device
;             = 0 if this channel is a disk file
;       If ISDEV = 1
;             EOF = 0 if End Of File on input
;             RAW = 1 if this device is in Raw mode
;                 = 0 if this device is cooked
;             ISCLK = 1 if this device is the clock device
;             ISNUL = 1 if this device is the null device
;             ISCOT = 1 if this device is the console output
;             ISCIN = 1 if this device is the console input
;       If ISDEV = 0
;             EOF = 0 if channel has been written
;             Bits 0-5  are  the  block  device  number  for
;                 the channel (0 = A, 1 = B, ...)
  devid_ISDEV     EQU     80h
  devid_EOF       EQU     40h
  devid_RAW       EQU     20h
  devid_SPECIAL   EQU     10H
  devid_ISCLK     EQU     08h
  devid_ISNUL     EQU     04h
  devid_ISCOT     EQU     02h
  devid_ISCIN     EQU     01h
  devid_block_dev EQU     1Fh             ; mask for block device number
```

Buffer Header - Disk I/O Buffer Header

Field definition for I/O buffer information:

```
BUFFINFO        STRUC
    buf_next        DW      ?               ; Pointer to next buffer in list
    buf_prev        DW      ?               ; Pointer to prev buffer in list
    buf_ID          DB      ?               ; Drive of buffer (bit 7 = 0)
                                            ; SFT table index (bit 7 = 1)
                                            ; = FFH if buffer free
    buf_flags       DB      ?               ; Bit 7 = 1 if Remote file buffer
                                            ;       = 0 if Local device buffer
                                            ; Bit 6 = 1 if buffer dirty
                                            ; Bit 5 = Reserved
                                            ; Bit 4 = Search bit (bit 7 = 1)
                                            ; Bit 3 = 1 if buffer is DATA
                                            ; Bit 2 = 1 if buffer is DIR
                                            ; Bit 1 = 1 if buffer is FAT
                                            ; Bit 0 = Reserved
    buf_sector      DD      ?               ; Sector number of buffer (bit 7 = 0)
 ; The next two items are often refed as a word (bit 7 = 0)
    buf_wrtcnt      DB      ?               ; For FAT sectors, # times sector written out
    buf_wrtcntinc   DW      ?               ; "   "     "   , # sectors between each write
    buf_DPB         DD      ?               ; Pointer to drive parameters
    buf_fill        DW      ?               ; How full buffer is (bit 7 = 1)
    buf_reserved    DB      ?               ; make DWORD boundary for 386
BUFFINFO        ENDS

    buf_offset      EQU     DWORD PTR buf_sector
                                            ;For bit 7 = 1, this is the byte
                                            ;offset of the start of the buffer in
                                            ;the file pointed to by buf_ID.  Thus
                                            ;the buffer starts at location
                                            ;buf_offset in the file and contains
                                            ;buf_fill bytes.

    BUFINSIZ        EQU     SIZE BUFFINFO
                                        ; Size of structure in bytes

    buf_Free        EQU     0FFh            ; buf_id of free buffer

 ;Flag byte masks
    buf_isnet       EQU     10000000B
    buf_dirty       EQU     01000000B
 ;***
    buf_visit       EQU     00100000B
 ;***
    buf_snbuf       EQU     00010000B

    buf_isDATA      EQU     00001000B
    buf_isDIR       EQU     00000100B
    buf_isFAT       EQU     00000010B
    buf_type_0      EQU     11110001B       ; AND sets type to "none"

    buf_NetID       EQU     BUFINSIZ

 ;
 ; Buffer Hash Entry Structure
 ;
    BUFFER_HASH_ENTRY       STRUC           ; DOS 4.0
    EMS_PAGE_NUM    DW      -1              ; logical page number for EMS handle
```

```
BUFFER_BUCKET   DD       ?              ; pointer to buffers
DIRTY_COUNT     DB       0              ; number of dirty buffers
BUFFER_RESERVED DB       0              ; reserved
BUFFER_HASH_ENTRY       ENDS

MaxBuffinBucket EQU     15              ; Max number of buffers per bucket
MaxBucketinPage EQU      2              ; Max number of buckets per 16kb page
```

Storage Header - Memory arena structure

```
 ; arena item
 ;
arena   STRUC
    arena_signature     DB  ?              ; 4D for valid item, 5A for last item
    arena_owner         DW  ?              ; owner of arena item
    arena_size          DW  ?              ; size in paragraphs of item
    arena_reserved      DB  3 DUP(?)       ; reserved
    arena_name          DB  8 DUP(?)       ; owner file name
arena   ENDS

    arena_owner_system      EQU 0          ; free block indication
    arena_signature_normal  EQU 4Dh        ; valid signature, not end of arena
    arena_signature_end     EQU 5Ah        ; valid signature, last block in arena
```

Index

Special Characters

Numerics

A

B

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