Interrupt 21H (33) Function 3FH (63)

2.0 and later

Read File or Device

Function 3FH reads from the file or device referenced by a handle.

To Call

AH	= 3FH
BX	= handle number
CX	= number of bytes to read
DS:DX	= segment:offset of data buffer

Returns

If function is successful:

Carry flag is clear.

AX	= number of bytes read from file
DS:DX	= segment:offset of data read from file

If function is not successful:

Carry flag is set.

AX = error code:

05H	access denied
06H	invalid handle

Programmer's Notes

- Data is read from the file beginning at the current location of the file pointer. After a successful read, the file pointer is updated to point to the byte following the last byte read.
- If Function 3FH returns 00H in the AX register, the function attempted to read when the file pointer was at the end of the file. If AX is less than CX, a partial record at the end of the file was read.
- Function 3FH can be used with all handles, including standard input (normally the keyboard). When reading from standard input, this function normally reads characters only to the first carriage-return character. Thus, the number of bytes read in AX will not necessarily match the length requested in CX.
- On networks running under MS-DOS version 3.1 or later, the user must have Read access to the directory and file containing the information to be read.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

40H (Write File or Device)
42H (Move File Pointer)
59H (Get Extended Error Information)

Example

```
        ;************************************************************;
        ;                                                            ;
        ;           Function 3FH: Read File or Device                ;
        ;                                                            ;
        ;           int read(handle,pbuffer,nbytes)                  ;
        ;               int handle,nbytes;                           ;
        ;               char *pbuffer;                               ;
        ;                                                            ;
        ;           Returns -1 if there was a read error,            ;
        ;           otherwise returns number of bytes read.          ;
        ;                                                            ;
        ;************************************************************;

cProc   read,PUBLIC,ds
parmW   handle
parmDP  pbuffer
parmW   nbytes
cBegin
        mov     bx,handle       ; Get handle.
        loadDP  ds,dx,pbuffer   ; Get pointer to buffer.
        mov     cx,nbytes       ; Get number of bytes to read.
        mov     ah,3fh          ; Set function code.
        int     21h             ; Ask MS-DOS to read CX bytes.
        jnb     rd_ok           ; Branch if read worked.
        mov     ax,-1           ; Else return -1.
rd_ok:
cEnd
```

Interrupt 21H (33) Function 40H (64)

2.0 and later

Write File or Device

Function 40H writes the specified number of bytes to a file or device referenced by a handle.

To Call

AH	= 40H
BX	= handle
CX	= number of bytes to write
DS:DX	= segment:offset of data buffer

Returns

If function is successful:

Carry flag is clear.

AX = number of bytes written to file or device

If function is not successful:

Carry flag is set.

AX = error code:

05H	access denied
06H	invalid handle

Programmer's Notes

- Data is written to the file or device beginning at the current location of the file pointer. After writing the specified data, Function 40H updates the position of the file pointer and returns the actual number of bytes written in AX.
- Function 40H returns error code 05H (access denied) if the file was opened as read-only with Function 3CH (Create File with Handle), 3DH (Open File with Handle), 5AH (Create Temporary File), or 5BH (Create New File). On networks running under MS-DOS version 3.1 or later, access is also denied if the file or record has been locked by another process.
- The handle number in BX must be one of the predefined device handles (0 through 4) or a handle obtained through a previous call to open or create a file (such as Function 3CH, 3DH, 5AH, or 5BH).
- If CX = 0, the file is truncated or extended to the current file pointer location. Clusters are allocated or released in the file allocation table (FAT) as required to fulfill the request.

- If the handle parameter for Function 40H refers to a disk file and the number of bytes written (returned in AX) is less than the number requested in CX, the destination disk is full. The carry flag is *not* set in this situation.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

3FH (Read File or Device)
42H (Move File Pointer)

Example

```
        ;***********************************************************;
        ;                                                           ;
        ;          Function 40H: Write File or Device               ;
        ;                                                           ;
        ;          int write(handle,pbuffer,nbytes)                 ;
        ;              int handle,nbytes;                           ;
        ;              char *pbuffer;                               ;
        ;                                                           ;
        ;          Returns -1 if there was a write error,           ;
        ;          otherwise returns number of bytes written.       ;
        ;                                                           ;
        ;***********************************************************;

cProc   write,PUBLIC,ds
parmW   handle
parmDP  pbuffer
parmW   nbytes
cBegin
        mov     bx,handle       ; Get handle.
        loadDP  ds,dx,pbuffer   ; Get pointer to buffer.
        mov     cx,nbytes       ; Get number of bytes to write.
        mov     ah,40h          ; Set function code.
        int     21h             ; Ask MS-DOS to write CX bytes.
        jnb     wr_ok           ; Branch if write successful.
        mov     ax,-1           ; Else return -1.
wr_ok:
cEnd
```

Interrupt 21H (33) Function 41H (65)

2.0 and later

Delete File

Function 41H deletes the directory entry of the specified file.

To Call

AH	= 41H
DS:DX	= segment:offset of ASCIIZ pathname

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code:

02H	file not found
03H	path not found
05H	access denied

Programmer's Notes

- The pathname must be a null-terminated ASCII string (ASCIIZ). Unlike Function 13H (Delete File), Function 41H does not allow wildcard characters in the pathname.
- Because Function 41H supports the use of full pathnames, it is preferable to Function 13H.
- Function 41H returns error code 05H (access denied) and fails if the file has either a directory or volume attribute or if it is a read-only file.

  A directory can be deleted (if it is empty) with Function 3AH (Remove Directory). A read-only file can be deleted if its attribute is changed to normal with Function 43H (Get/Set File Attributes) before Function 41H is called.
- On networks running under MS-DOS version 3.1 or later, the user must have Create access to the directory containing the file to be deleted.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

3AH (Remove Directory)
43H (Get/Set File Attributes)

Example

```
        ;************************************************************;
        ;                                                            ;
        ;                Function 41H: Delete File                   ;
        ;                                                            ;
        ;                int delete(pfilepath)                       ;
        ;                    char *pfilepath;                        ;
        ;                                                            ;
        ;                Returns 0 if file deleted,                  ;
        ;                otherwise returns error code.               ;
        ;                                                            ;
        ;************************************************************;

cProc   delete,PUBLIC,ds
parmDP  pfilepath
cBegin
        loadDP  ds,dx,pfilepath ; Get pointer to pathname.
        mov     ah,41h          ; Set function code.
        int     21h             ; Ask MS-DOS to delete file.
        jb      dl_err          ; Branch if MS-DOS could not delete
                                ; file.
        xor     ax,ax           ; Else return 0.
dl_err:
cEnd
```

Interrupt 21H (33) Function 42H (66)

2.0 and later

Move File Pointer

Function 42H sets the position of the file pointer (for the next read/write operation) for the file associated with the specified handle.

To Call

AH	= 42H	
AL	= method code:	
	00H	byte offset from beginning of file
	01H	byte offset from current location of file pointer
	02H	byte offset from end of file
BX	= handle number	
CX:DX	= offset value to move pointer:	
	CX	most significant half of a doubleword value
	DX	least significant half of a doubleword value

Returns

If function is successful:

Carry flag is clear.

DX:AX = new file pointer position (absolute byte offset from beginning of file)

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function (AL not 00H, 01H, or 02H)
	06H	invalid handle

Programmer's Notes

- The value in CX:DX is an offset specifying how far the file pointer is to be moved. With method code 00H, the value in CX:DX is always interpreted as a positive 32-bit integer, meaning the file pointer is always set relative to the beginning of the file.

  With method codes 01H and 02H, the value in CX:DX can be either a positive or negative 32-bit integer. Thus, method 1 can move the file pointer either forward or backward from its current position; method 2 can move the file pointer either forward or backward from the end of the file.

- Specifying method code 00H with an offset of 0 positions the file pointer at the beginning of the file. Similarly, specifying method code 02H with an offset of 0 conveniently positions the file pointer at the end of the file. With method code 02H offset 0, the size of the file can also be determined by examining the pointer position returned by the function.
- Depending on the offset specified in CX:DX, methods 1 and 2 may move the file pointer to a position before the start of the file. Function 42H does not return an error code if this happens, but later attempts to read from or write to the file will produce unexpected errors.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

3FH (Read File or Device)
40H (Write File or Device)

Example

```
        ;************************************************************;
        ;                                                            ;
        ;           Function 42H: Move File Pointer                  ;
        ;                                                            ;
        ;           long seek(handle,distance,mode)                  ;
        ;                int handle,mode;                            ;
        ;                long distance;                              ;
        ;                                                            ;
        ;           Modes:                                           ;
        ;                   0: from beginning of file                ;
        ;                   1: from the current position             ;
        ;                   2: from the end of the file              ;
        ;                                                            ;
        ;           Returns -1 if there was a seek error,            ;
        ;           otherwise returns long pointer position.         ;
        ;                                                            ;
        ;************************************************************;

cProc   seek,PUBLIC
parmW   handle
parmD   distance
parmB   mode
cBegin
        mov     bx,handle       ; Get handle.
        les     dx,distance     ; Get distance into ES:DX.
        mov     cx,es           ; Put high word of distance into CX.
        mov     al,mode         ; Get move method code.
        mov     ah,42h          ; Set function code.
```

(more)

```
        int     21h             ; Ask MS-DOS to move file pointer.
        jnb     sk_ok           ; Branch if seek successful.
        mov     ax,-1           ; Else return -1.
        cwd
sk_ok:
cEnd
```

Interrupt 21H (33) Function 43H (67)

2.0 and later

Get/Set File Attributes

Function 43H gets or sets the attributes of the specified file.

To Call

AH = 43H

To get file attributes:

AL = 00H
DS:DX = segment:offset of ASCIIZ pathname

To set file attributes:

AL = 01H
CX = attributes to set:

Bit	Attribute
0	Read-only file
1	Hidden file
2	System file
5	Archive

DS:DX = segment:offset of ASCIIZ pathname

Returns

If function is successful:

Carry flag is clear.

CX = attribute

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid function (AL not 00H or 01H)
02H	file not found
03H	path not found
05H	access denied

Programmer's Notes

- The pathname must be a null-terminated ASCII string (ASCIIZ).
- Function 43H cannot be used to set or change either a volume-label or directory attribute (bits 3 and 4 of the attribute byte). With MS-DOS versions 3.x, Function 43H can be used to make a directory hidden or read-only.
- On networks running under MS-DOS version 3.1 or later, the user must have Create access to the directory containing the file in order to change the read-only, hidden, or system attribute. The archive bit, however, can be changed regardless of access rights.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

```
        ;***********************************************************;
        ;                                                           ;
        ;           Function 43H: Get/Set File Attributes           ;
        ;                                                           ;
        ;           int file_attr(pfilepath,func,attr)              ;
        ;               char *pfilepath;                            ;
        ;               int func,attr;                              ;
        ;                                                           ;
        ;           Returns -1 for all errors,                      ;
        ;           otherwise returns file attribute.               ;
        ;                                                           ;
        ;***********************************************************;

cProc   file_attr,PUBLIC,ds
parmDP  pfilepath
parmB   func
parmW   attr
cBegin
        loadDP  ds,dx,pfilepath ; Get pointer to pathname.
        mov     al,func         ; Get/set flag into AL.
        mov     cx,attr         ; Get new attr (if present).
        mov     ah,43h          ; Set code function.
        int     21h             ; Call MS-DOS.
        jnb     fa_ok           ; Branch if no error.
        mov     cx,-1           ; Else return -1.
fa_ok:
        mov     ax,cx           ; Return this value.

cEnd
```

Interrupt 21H (33) Function 44H (68)

2.0 and later

IOCTL

Function 44H is a collection of subfunctions that provide a process a direct path of communication with a device driver. As such, this function is the most flexible means of gaining access to the full capabilities of an installed device.

An IOCTL subfunction is called with 44H in AH and the value for the subfunction in AL. If a subfunction has minor functions, those values are specified in CL. Otherwise, the BX, CX, and DX registers are used for such information as handles, drive identifiers, buffer addresses, and so on.

The subfunctions and the versions of MS-DOS with which they are available are

Subfunction	Name	MS-DOS Versions
00H	Get Device Data	2.0 and later
01H	Set Device Data	2.0 and later
02H	Receive Control Data from Character Device	2.0 and later
03H	Send Control Data to Character Device	2.0 and later
04H	Receive Control Data from Block Device	2.0 and later
05H	Send Control Data to Block Device	2.0 and later
06H	Check Input Status	2.0 and later
07H	Check Output Status	2.0 and later
08H	Check If Block Device Is Removable	3.0 and later
09H	Check If Block Device Is Remote	3.1 and later
0AH	Check If Handle Is Remote	3.1 and later
0BH	Change Sharing Retry Count	3.1 and later
0CH	Generic I/O Control for Handles	3.2
	Minor Code 45H: Set Iteration Count	
	Minor Code 65H: Get Iteration Count	
0DH	Generic I/O Control for Block Devices	3.2
	Minor Code 40H: Set Device Parameters	
	Minor Code 60H: Get Device Parameters	
	Minor Code 41H: Write Track on Logical Drive	
	Minor Code 61H: Read Track on Logical Drive	
	Minor Code 42H: Format and Verify Track on Logical Drive	
	Minor Code 62H: Verify Track on Logical Drive	

(more)

Subfunction	Name	MS-DOS Versions
0EH	Get Logical Drive Map	3.2
0FH	Set Logical Drive Map	3.2

These subfunctions are documented, either individually or in related pairs, in the entries that follow.

Interrupt 21H (33) Function 44H (68) Subfunction 00H

2.0 and later

IOCTL: Get Device Data

Function 44H Subfunction 00H gets information about a character device or file referenced by a handle.

To Call

AH = 44H
AL = 00H
BX = handle number

Returns

If function is successful:

Carry flag is clear.

DX contains information on file or device:

Bit	Value	Meaning
For a file (bit 7 = 0):		
8–15	0	Reserved.
7	0	Handle refers to a file.
6	0	File has been written.
0–5		Drive number (0 = A, 1 = B, 2 = C, and so on).
For a device (bit 7 = 1):		
15	0	Reserved.
14	1	Processes control strings transferred by IOCTL Subfunctions 02H (Receive Control Data from Character Device) and 03H (Send Control Data to Character Device), set by MS-DOS.
8–13	0	Reserved.
7	1	Handle refers to a device.
6	0	End of file on input.
5	0	Checks for control characters (cooked mode).
	1	Does not check for control characters (raw mode).

(more)

Bit	Value	Meaning
4	0	Reserved.
3	1	Clock device.
2	1	Null device.
1	1	Standard output device.
0	1	Standard input device.

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid IOCTL subfunction
05H	access denied
06H	invalid handle

Programmer's Notes

- Bits 8–15 of DX correspond to the upper 8 bits of the device-driver attribute word.
- The handle in BX must reference an open device or file.
- Bit 5 of the device data word for character-device handles defines whether that handle is in raw mode or cooked mode. In cooked mode, MS-DOS checks for Control-C, Control-P, Control-S, and Control-Z characters and transfers control to the Control-C exception handler (whose address is saved in the vector for Interrupt 23H) when a Control-C is detected. In raw mode, MS-DOS does not check for such characters when I/O is performed to the handle; however, it will still check for a Control-C entered at the keyboard on other function calls unless such checking has been turned off with Function 33H, the BREAK=OFF directive in CONFIG.SYS, or a BREAK OFF command at the MS-DOS prompt.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

33H (Get/Set Control-C Check Flag)
3CH (Create File with Handle)
3DH (Open File with Handle)

Example

```
;************************************************************;
;                                                            ;
;        Function 44H, Subfunctions 00H,01H:                 ;
;                      Get/Set IOCTL Device Data             ;
;                                                            ;
;        int ioctl_char_flags(setflag,handle,newflags)       ;
;            int setflag;                                    ;
;            int handle;                                     ;
;            int newflags;                                   ;
;                                                            ;
;        Set setflag = 0 to get flags, 1 to set flags.       ;
;                                                            ;
;        Returns -1 for error, else returns flags.           ;
;                                                            ;
;************************************************************;

cProc   ioctl_char_flags,PUBLIC
parmB   setflag
parmW   handle
parmW   newflags
cBegin
        mov     al,setflag      ; Get setflag.
        and     al,1            ; Save only lsb.
        mov     bx,handle       ; Get handle to character device.
        mov     dx,newflags     ; Get new flags (they are used only
                                ; by "set" option).
        mov     ah,44h          ; Set function code.
        int     21h             ; Call MS-DOS.
        mov     ax,dx           ; Assume success - prepare to return
                                ; flags.
        jnc     iocfx           ; Branch if no error.
        mov     ax,-1           ; Else return error flag.
iocfx:
cEnd
```

Interrupt 21H (33) Function 44H (68) Subfunction 01H

2.0 and later

IOCTL: Set Device Data

Function 44H Subfunction 01H, the complement of IOCTL Subfunction 00H, sets information about a character device—but not a file—referenced by a handle.

To Call

AH = 44H
AL = 01H
BX = handle number
DX = device data word:

Bit	Value	Meaning
8–15	0	Reserved.
7	1	Handle refers to a device.
6	0	End of file on input.
5	0	Check for control characters (cooked mode).
	1	Do not check for control characters (raw mode).
4	0	Reserved.
3	1	Clock device.
2	1	Null device.
1	1	Standard output device.
0	1	Standard input device.

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid IOCTL subfunction
05H	access denied
06H	invalid handle

Programmer's Notes

- The handle in BX must reference an open device.
- DH must be 00H. If it is not, the carry flag is set and error code 01H (invalid function) is returned.
- Bit 5 of the device data word for character-device handles selects raw mode or cooked mode for the handle. In cooked mode, MS-DOS checks for Control-C, Control-P, Control-S, and Control-Z characters and transfers control to the Control-C exception handler (whose address is saved in the vector for Interrupt 23H) when a Control-C is detected. In raw mode, MS-DOS does not check for such characters when I/O is performed to the handle; however, it will still check for a Control-C entered at the keyboard on other function calls unless such checking has been turned off with Function 33H, the BREAK=OFF directive in CONFIG.SYS, or a BREAK OFF command at the MS-DOS prompt.
- Function 59H (Get Extended Error Information) provides further information on any error—in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

33H (Get/Set Control-C Check Flag)
3CH (Create File with Handle)
3DH (Open File with Handle)

Example

See SYSTEM CALLS: INTERRUPT 21H: Function 44H Subfunction 00H.

Interrupt 21H (33) Function 44H (68) Subfunctions 02H and 03H

2.0 and later

IOCTL: Receive Control Data from Character Device; Send Control Data to Character Device

Function 44H Subfunctions 02H and 03H respectively receive and send control strings from and to a character-oriented device driver.

To Call

AH	= 44H	
AL	= 02H	receive control strings
	03H	send control strings
BX	= handle number	
CX	= number of bytes to transfer	
DS:DX	= segment:offset of data buffer	

Returns

If function is successful:

Carry flag is clear.

AX	= number of bytes transferred

If AL was 02H on call:

Buffer at DS:DX contains data read from device driver.

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function
	05H	access denied
	06H	invalid handle
	0DH	invalid data (bad control string)

Programmer's Notes

- Subfunctions 02H and 03H provide a means of transferring control information of any type or length between an application program and a character-device driver. They do not necessarily result in any input to or output from the physical device itself.
- Subfunction 02H can be used to read control information about such features as device status, availability, and current output location. Subfunction 03H is often used to configure the driver or device for subsequent I/O; for example, it may be used to set the baud rate, word length, and parity for a serial communications adapter or to initialize a printer for a specific font, page length, and so on. The format of the control data passed by these subfunctions is driver specific and does not follow any standard.

- Character-device drivers are not required to support IOCTL Subfunctions 02H and 03H. Therefore, Subfunction 00H (Get Device Data) should be called before either Subfunction 02H or 03H to determine whether a device can process control strings. If bit 14 of the device data word returned by Subfunction 00H is set, the device driver supports IOCTL Subfunctions 02H and 03H.
- Function 59H (Get Extended Error Information) provides further information on any error—in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

44H Subfunction 00H (Get Device Data)
44H Subfunction 04H (Receive Control Data from Block Device)
44H Subfunction 05H (Send Control Data to Block Device)

Example

```
        ;**********************************************************;
        ;                                                          ;
        ;     Function 44H, Subfunctions 02H,03H:                  ;
        ;                    IOCTL Character Device Control        ;
        ;                                                          ;
        ;     int ioctl_char_ctrl(recvflag,handle,pbuffer,nbytes)  ;
        ;         int   recvflag;                                  ;
        ;         int   handle;                                    ;
        ;         char *pbuffer;                                   ;
        ;         int   nbytes;                                    ;
        ;                                                          ;
        ;     Set recvflag = 0 to receive info, 1 to send.         ;
        ;                                                          ;
        ;     Returns -1 for error, otherwise returns number of    ;
        ;     bytes sent or received.                              ;
        ;                                                          ;
        ;**********************************************************;

cProc   ioctl_char_ctrl,PUBLIC,<ds>
parmB   recvflag
parmW   handle
parmDP  pbuffer
parmW   nbytes
cBegin
        mov     al,recvflag     ; Get recvflag.
        and     al,1            ; Keep only lsb.
        add     al,2            ; AL = 02H for receive, 03H for send.
        mov     bx,handle       ; Get character-device handle.
        mov     cx,nbytes       ; Get number of bytes to receive/send.
        loadDP  ds,dx,pbuffer   ; Get pointer to buffer.
        mov     ah,44h          ; Set function code.
        int     21h             ; Call MS-DOS.
        jnc     iccx            ; Branch if no error.
        mov     ax,-1           ; Return -1 for all errors.
iccx:
cEnd
```

Interrupt 21H (33) Function 44H (68) Subfunctions 04H and 05H

2.0 and later

IOCTL: Receive Control Data from Block Device; Send Control Data to Block Device

Function 44H Subfunctions 04H and 05H respectively receive and send control strings from and to a block-oriented device driver.

To Call

AH	= 44H	
AL	= 04H	receive block-device data
	05H	send block-device data
BL	= drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)	
CX	= number of bytes to transfer	
DS:DX	= segment:offset of data buffer	

Returns

If function is successful:

Carry flag is clear.

AX = number of bytes transferred

If AL was 04H on call:

Buffer at DS:DX contains control data read from device driver.

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function
	05H	access denied
	06H	invalid handle
	0DH	invalid data (bad control string)

Programmer's Notes

- Subfunctions 04H and 05H provide a means of transferring control information of any type or length between an application program and a block-device driver. They do not necessarily result in any input to or output from the physical device itself.
- Control strings can be used to request driver operations that are not file oriented, such as tape rewind or disk eject (if hardware supported). The contents of such control strings are specific to individual device drivers and do not follow any standard format.

- Subfunction 04H can be used to obtain a code from the driver indicating device availability or status. Block devices that might use this subfunction include magnetic tape or tape cassette, CD ROM, and Small Computer Standard Interface (SCSI) devices.
- Block-device drivers are not required to support IOCTL Subfunctions 04H and 05H. If the driver does not support these subfunctions, error code 01H (Invalid Function) is returned.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

44H Subfunction 00H (Get Device Data)
44H Subfunction 02H (Receive Control Data from Character Device)
44H Subfunction 03H (Send Control Data to Character Device)

Example

```
        ;************************************************************;
        ;                                                            ;
        ;   Function 44H, Subfunctions 04H,05H:                      ;
        ;                IOCTL Block Device Control                  ;
        ;                                                            ;
        ;   int ioctl_block_ctrl(recvflag,drive_ltr,pbuffer,nbytes)  ;
        ;       int   recvflag;                                      ;
        ;       int   drive_ltr;                                     ;
        ;       char *pbuffer;                                       ;
        ;       int   nbytes;                                        ;
        ;                                                            ;
        ;   Set recvflag = 0 to receive info, 1 to send.             ;
        ;                                                            ;
        ;   Returns -1 for error, otherwise returns number of        ;
        ;   bytes sent or received.                                  ;
        ;                                                            ;
        ;************************************************************;

cProc   ioctl_block_ctrl,PUBLIC,<ds>
parmB   recvflag
parmB   drive_ltr
parmDP  pbuffer
parmW   nbytes
cBegin
        mov     al,recvflag     ; Get recvflag.
        and     al,1            ; Keep only lsb.
        add     al,4            ; AL = 04H for receive, 05H for send.
        mov     bl,drive_ltr    ; Get drive letter.
        or      bl,bl           ; Leave 0 alone.
        jz      ibc
        and     bl,not 20h      ; Convert letter to uppercase.
        sub     bl,'A'-1        ; Convert to drive number: 'A' = 1,
                                ; 'B' = 2, etc.
```

(more)

```
ibc:
        mov     cx,nbytes       ; Get number of bytes to receive/send.
        loadDP  ds,dx,pbuffer   ; Get pointer to buffer.
        mov     ah,44h          ; Set function code.
        int     21h             ; Call MS-DOS.
        jnc     ibcx            ; Branch if no error.
        mov     ax,-1           ; Return -1 for all errors.
ibcx:
cEnd
```

Interrupt 21H (33) Function 44H (68) Subfunctions 06H and 07H

2.0 and later

IOCTL: Check Input Status; Check Output Status

Function 44H Subfunctions 06H and 07H respectively determine whether a device or file associated with a handle is ready for input or output.

To Call

AH	= 44H	
AL	= 06H	get input status
	07H	get output status
BX	= handle number	

Returns

If function is successful:

Carry flag is clear.

AL = input or output status:

00H	not ready
FFH	ready

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid function
05H	access denied
06H	invalid handle
0DH	invalid data (bad control string)

Programmer's Notes

- The status returned in AL has the following meanings:

Status	Device	Input File	Output File
00H	Not ready	Pointer at EOF	Ready
0FFH	Ready	Ready	Ready

- Output files always return a ready condition, even if the disk is full or no disk is in the drive.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

```
        ;**************************************************************;
        ;                                                              ;
        ;   Function 44H, Subfunctions 06H,07H:                        ;
        ;                 IOCTL Input/Output Status                    ;
        ;                                                              ;
        ;   int ioctl_char_status(outputflag,handle)                   ;
        ;       int outputflag;                                        ;
        ;       int handle;                                            ;
        ;                                                              ;
        ;   Set outputflag = 0 for input status, 1 for output status. ;
        ;                                                              ;
        ;   Returns -1 for all errors, 0 for not ready,                ;
        ;   and 1 for ready.                                           ;
        ;                                                              ;
        ;**************************************************************;

cProc   ioctl_char_status,PUBLIC
parmB   outputflag
parmW   handle
cBegin
        mov     al,outputflag    ; Get outputflag.
        and     al,1             ; Keep only lsb.
        add     al,6             ; AL = 06H for input status, 07H for output
                                 ; status.
        mov     bx,handle        ; Get handle.
        mov     ah,44h           ; Set function code.
        int     21h              ; Call MS-DOS.
        jnc     isnoerr          ; Branch if no error.
        mov     ax,-1            ; Return error code.
        jmp     short isx
isnoerr:
        and     ax,1             ; Keep only lsb for return value.
isx:
cEnd
```

Interrupt 21H (33) Function 44H (68) Subfunction 08H

3.0 and later

IOCTL: Check If Block Device Is Removable

Function 44H Subfunction 08H checks whether the specified block device contains a removable storage medium, such as a floppy disk.

To Call

AH = 44H
AL = 08H
BL = drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)

Returns

If function is successful:

Carry flag is clear.

AX = 00H storage medium removable
01H storage medium not removable

If function is not successful:

Carry flag is set.

AX = error code:
01H invalid function
0FH invalid drive

Programmer's Notes

- This subfunction exists to allow an application to check for a removable disk so that the user can be prompted to change disks if a required file is not found.
- When the carry flag is set, error code 01H normally means that MS-DOS did not recognize the function call. However, this error can also mean that the device driver does not support Subfunction 08H. In this case, MS-DOS assumes that the storage medium is not removable.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

```
            ;*************************************************************;
            ;                                                             ;
            ;      Function 44H, Subfunction 08H:                         ;
            ;                    IOCTL Removable Block Device Query       ;
            ;                                                             ;
            ;      int ioctl_block_fixed(drive_ltr)                       ;
            ;          int drive_ltr;                                     ;
            ;                                                             ;
            ;      Returns -1 for all errors, 1 if disk is fixed (not     ;
            ;      removable), 0 if disk is not fixed.                    ;
            ;                                                             ;
            ;*************************************************************;

    cProc   ioctl_block_fixed,PUBLIC
    parmB   drive_ltr
    cBegin
            mov     bl,drive_ltr    ; Get drive letter.
            or      bl,bl           ; Leave 0 alone.
            jz      ibch
            and     bl,not 20h      ; Convert letter to uppercase.
            sub     bl,'A'-1        ; Convert to drive number: 'A' = 1,
                                    ; 'B' = 2, etc.
    ibch:
            mov     ax,4408h        ; Set function code, Subfunction 08H.
            int     21h             ; Call MS-DOS.
            jnc     ibchx           ; Branch if no error, AX = 0 or 1.
            cmp     ax,1            ; Treat error code of 1 as "disk is
                                    ; fixed."
            je      ibchx
            mov     ax,-1           ; Return -1 for other errors.
    ibchx:
    cEnd
```

Interrupt 21H (33) Function 44H (68) Subfunction 09H

3.1 and later

IOCTL: Check If Block Device Is Remote

Function 44H Subfunction 09H checks whether the specified block device is local (attached to the computer running the program) or remote (redirected to a network server).

To Call

AH = 44H
AL = 09H
BL = drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)

Returns

If function is successful:

Carry flag is clear.

DX = device attribute word:

bit 12 = 1	drive is remote
bit 12 = 0	drive is local

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid function
0FH	invalid drive

Programmer's Notes

- This subfunction should be avoided. Application programs should not distinguish between files on local and remote devices.
- When the carry flag is set, error code 01H can mean either that the function number is invalid or that the network has not been started.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

```
;************************************************************;
;                                                            ;
;        Function 44H, Subfunction 09H:                      ;
;                     IOCTL Remote Block Device Query        ;
;                                                            ;
;        int ioctl_block_redir(drive_ltr)                    ;
;            int drive_ltr;                                  ;
;                                                            ;
;        Returns -1 for all errors, 1 if disk is remote      ;
;        (redirected), 0 if disk is local.                   ;
;                                                            ;
;************************************************************;

cProc   ioctl_block_redir,PUBLIC
parmB   drive_ltr
cBegin
        mov     bl,drive_ltr    ; Get drive letter.
        or      bl,bl           ; Leave 0 alone.
        jz      ibr
        and     bl,not 20h      ; Convert letter to uppercase.
        sub     bl,'A'-1        ; Convert to drive number: 'A' = 1,
                                ; 'B' = 2, etc.
ibr:
        mov     ax,4409h        ; Set function code, Subfunction 09H.
        int     21h             ; Call MS-DOS.
        mov     ax,-1           ; Assume error.
        jc      ibrx            ; Branch if error, returning -1.
        inc     ax              ; Set AX = 0.
        test    dh,10h          ; Is bit 12 set?
        jz      ibrx            ; If not, disk is local: Return 0.
        inc     ax              ; Return 1 for remote disk.
ibrx:
cEnd
```

Interrupt 21H (33)
Function 44H (68) Subfunction 0AH

3.1 and later

IOCTL: Check If Handle Is Remote

Function 44H Subfunction 0AH checks whether the handle in BX refers to a file or device that is local (on the computer running the program) or remote (redirected to a network server).

To Call

AH = 44H
AL = 0AH
BX = handle

Returns

If function is successful:

Carry flag is clear.

DX = attribute word for file or device:

bit 15 = 1	remote
bit 15 = 0	local

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid function
06H	invalid handle

Programmer's Notes

- Application programs should not distinguish between files on local and remote devices.
- When the carry flag is set, error code 01H can mean either that the function number is invalid or that the network has not been started.

Related Functions

None

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;    Function 44H, Subfunction 0AH:                           ;
        ;                  IOCTL Remote Handle Query                  ;
        ;                                                             ;
        ;    int ioctl_char_redir(handle)                             ;
        ;        int handle;                                          ;
        ;                                                             ;
        ;    Returns -1 for all errors, 1 if device/file is remote    ;
        ;    (redirected), 0 if it is local.                          ;
        ;                                                             ;
        ;*************************************************************;

cProc   ioctl_char_redir,PUBLIC
parmW   handle
cBegin
        mov     bx,handle       ; Get handle.
        mov     ax,440ah        ; Set function code, Subfunction 0AH.
        int     21h             ; Call MS-DOS.
        mov     ax,-1           ; Assume error.
        jc      icrx            ; Branch on error, returning -1.
        inc     ax              ; Set AX = 0.
        test    dh,80h          ; Is bit 15 set?
        jz      icrx            ; If not, device/file is local:
                                ; Return 0.
        inc     ax              ; Return 1 for remote.
icrx:
cEnd
```

Interrupt 21H (33)
Function 44H (68) Subfunction 0BH

3.1 and later

IOCTL: Change Sharing Retry Count

Function 44H Subfunction 0BH sets the number of times MS-DOS retries a disk operation after a failure caused by a file-sharing violation before it returns an error to the requesting process.

To Call

AH = 44H
AL = 0BH
CX = pause between retries
DX = number of retries

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid function

Programmer's Notes

- The pause between retries is a machine-dependent value determined by the CPU and CPU clock speed. MS-DOS performs a delay loop that consists of 65,536 machine instructions for each iteration specified by the value in CX. The actual code is as follows:

  ```
  xor    cx,cx
  loop   $
  ```

  The default number of retries is 3, with a pause of one loop between retries—equivalent to calling this subfunction with DX = 3 and CX = 1.
- When the carry flag is set, error code 01H indicates either that the function code is invalid or that file sharing (SHARE.EXE) is not loaded.
- Subfunction 0BH can be used to tune the system if file-contention problems are likely to arise with shared files but are expected to last only a short while.
- If file contention is expected and if some applications will lock regions of the file for an appreciable period of time, the user may need to be informed. The best procedure is to set an initial small number of retries with a short pause period. After notifying the user, the application can wait a reasonable amount of time for file access by adjusting the retry or pause-period values.

- If a process uses this subfunction, it should restore the original default values for the pause and number of retries before terminating, to avoid unwanted effects on the behavior of subsequent processes.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

```
        ;**************************************************************;
        ;                                                              ;
        ;     Function 44H, Subfunction 0BH:                           ;
        ;                   IOCTL Change Sharing Retry Count           ;
        ;                                                              ;
        ;     int ioctl_set_retry(num_retries,wait_time)               ;
        ;         int num_retries;                                     ;
        ;         int wait_time;                                       ;
        ;                                                              ;
        ;     Returns 0 for success, otherwise returns error code.     ;
        ;                                                              ;
        ;**************************************************************;

cProc   ioctl_set_retry,PUBLIC,<ds,si>
parmW   num_retries
parmW   wait_time
cBegin
        mov     dx,num_retries  ; Get parameters.
        mov     cx,wait_time
        mov     ax,440bh        ; Set function code, Subfunction 0BH.
        int     21h             ; Call MS-DOS.
        jc      isrx            ; Branch on error.
        xor     ax,ax
isrx:
cEnd
```

Interrupt 21H (33) Function 44H (68) Subfunction 0CH

3.2

IOCTL: Generic I/O Control for Handles

Function 44H Subfunction 0CH sets or gets the output iteration count for character-oriented devices. *See also* APPENDIX A: MS-DOS Version 3.3.

To Call

AH	= 44H	
AL	= 0CH	
BX	= handle	
CH	= category code:	
	05H	printer
CL	= function (minor) code:	
	45H	set iteration count
	65H	get iteration count
DS:DX	= segment:offset of 2-byte buffer receiving or containing iteration-count word	

Returns

If function is successful:

Carry flag is clear.

If CL was 65H on call:

DS:DX = segment:offset of iteration-count word

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function
	06H	invalid handle

Programmer's Notes

- The iteration count controls the number of times the device driver tries to send output to the printer before assuming that the device is busy.
- With MS-DOS version 3.2, only category code 05H (printer) is supported by this subfunction.
- Function 59H (Get Extended Error Information) provides further information on any error—in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;   Function 44H, Subfunction 0CH:                            ;
        ;                 Generic IOCTL for Handles                   ;
        ;                                                             ;
        ;   int ioctl_char_generic(handle,category,function,pbuffer)  ;
        ;       int   handle;                                         ;
        ;       int   category;                                       ;
        ;       int   function;                                       ;
        ;       int  *pbuffer;                                        ;
        ;                                                             ;
        ;   Returns 0 for success, otherwise returns error code.      ;
        ;                                                             ;
        ;*************************************************************;

cProc   ioctl_char_generic,PUBLIC,<ds>
parmW   handle
parmB   category
parmB   function
parmDP  pbuffer
cBegin
        mov     bx,handle       ; Get device handle.
        mov     ch,category     ; Get category
        mov     cl,function     ; and function.
        loadDP  ds,dx,pbuffer   ; Get pointer to data buffer.
        mov     ax,440ch        ; Set function code, Subfunction 0CH.
        int     21h             ; Call MS-DOS.
        jc      icgx            ; Branch on error.
        xor     ax,ax
icgx:
cEnd
```

Interrupt 21H (33)
Function 44H (68) Subfunction 0DH

3.2

IOCTL: Generic I/O Control for Block Devices

Function 44H Subfunction 0DH includes six input/output tasks, or minor functions, related to block-oriented devices. The tasks perform the following operations: set or get device parameters; write, read, format and verify, or verify tracks on a logical drive.

This entry covers general information on Subfunction 0DH. Details on each minor code are presented in subsequent entries.

To Call

AH	= 44H	
AL	= 0DH	
BL	= drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)	
CH	= category code:	
	08H	disk drive
CL	= function (minor) code:	
	40H	set parameters for block device
	41H	write track on logical drive
	42H	format and verify track on logical drive
	60H	get parameters for block device
	61H	read track on logical drive
	62H	verify track on logical drive
DS:DX	= segment:offset of parameter block	

Returns

If function is successful:

Carry flag is clear.

If CL was 60H or 61H on call:

DS:DX	= segment:offset of parameter block

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function
	02H	invalid drive

Programmer's Notes

- Set Device Parameters (minor code 40H) must be used before an attempt to write, read, format, or verify a track on a logical drive. In general, the following sequence applies to any of these operations:

1. Get the current parameters (minor code 60H). Examine and save them.
2. Set the new parameters (minor code 40H).
3. Perform the task.
4. Retrieve the original parameters and restore them (minor code 40H).

- With version 3.2 of MS-DOS, only category code 08H is supported by this subfunction.
- Parameter blocks in the data buffer vary with the task being performed.

Related Functions

None

Example

```
        ;**************************************************************;
        ;                                                              ;
        ;    Function 44H, Subfunction 0DH:                            ;
        ;                  Generic IOCTL for Block Devices             ;
        ;                                                              ;
        ;    int ioctl_block_generic(drv_ltr,category,func,pbuffer)    ;
        ;        int   drv_ltr;                                        ;
        ;        int   category;                                       ;
        ;        int   func;                                           ;
        ;        char *pbuffer;                                        ;
        ;                                                              ;
        ;    Returns 0 for success, otherwise returns error code.      ;
        ;                                                              ;
        ;**************************************************************;

cProc   ioctl_block_generic,PUBLIC,<ds>
parmB   drv_ltr
parmB   category
parmB   func
parmDP  pbuffer
cBegin
        mov     bl,drv_ltr      ; Get drive letter.
        or      bl,bl           ; Leave 0 alone.
        jz      ibg
        and     bl,not 20h      ; Convert letter to uppercase.
        sub     bl,'A'-1        ; Convert to drive number: 'A' = 1,
                                ; 'B' = 2, etc.
ibg:
        mov     ch,category     ; Get category
        mov     cl,func         ; and function.
        loadDP  ds,dx,pbuffer   ; Get pointer to data buffer.
        mov     ax,440dh        ; Set function code, Subfunction 0DH.
        int     21h             ; Call MS-DOS.
        jc      ibgx            ; Branch on error.
        xor     ax,ax
ibgx:
cEnd
```

Interrupt 21H (33)
Function 44H (68) Subfunction 0DH
Minor Code 40H

IOCTL: Generic I/O Control for Block Devices: Set Device Parameters

Function 44H Subfunction 0DH minor code 40H sets device parameters in the parameter block pointed to by DS:DX.

To Call

AH	= 44H
AL	= 0DH
BL	= drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)
CH	= category code: 08H disk drive
CL	= 40H
DS:DX	= segment:offset of parameter block

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function
	02H	invalid drive

Programmer's Notes

- The parameter block is formatted as follows:

Special-functions field: offset 00H, length 1 byte

Bit	Value	Meaning
0	0	Device BIOS parameter block (BPB) field contains a new default BPB.
	1	Use current BPB.
1	0	Use all fields in parameter block.
	1	Use track layout field only.

(more)

Special-functions field: offset 00H, length 1 byte *(continued)*

Bit	Value	Meaning
2	0	Sectors in track may be different sizes. (This setting should not be used.)
	1	Sectors in track are all same size; sector numbers range from 1 to the total number of sectors in the track. (This setting should always be used.)
3–7	0	Reserved.

Device type field: offset 01H, length 1 byte

Value	Meaning
00H	320/360 KB 5.25-inch disk
01H	1.2 MB 5.25-inch disk
02H	720 KB 3.5-inch disk
03H	Single-density 8-inch disk
04H	Double-density 8-inch disk
05H	Fixed disk
06H	Tape drive
07H	Other type of block device

Device attributes field: offset 02H, length 1 word

Bit	Value	Meaning
0	0	Removable storage medium
	1	Nonremovable storage medium
1	0	Door lock not supported
	1	Door lock supported
2–15	0	Reserved

Number of cylinders field: offset 04H, length 1 word

Meaning: Maximum number of cylinders supported; set by device driver

Media type field: offset 06H, length 1 byte

Value	Meaning
00H (default)	1.2 MB 5.25-inch disk
01H	320/360 KB 5.25-inch disk

Device BPB field: offset 07H, length 31 bytes.

Meaning: *See* Programmer's Note below.

If bit 0 = 0 in special-functions field, this field contains the new default BPB for the device.

If bit 0 = 1 in special-functions field, BPB in this field is returned by the device driver in response to subsequent Build BPB requests.

Track layout field: offset 26H, variable-length table

Length	**Meaning**
Word	Number of sectors in track
Word	Number of first sector in track*
Word	Size of first sector in track*
	•
	•
	•
Word	Number of last sector in track
Word	Size of last sector in track

*Sector number and sector size fields are repeated for each sector on the track. If bit 2 of the special-functions field is set, all sector sizes in the track layout field must be the same.

- The device BPB field is a 31-byte data structure. Information contained in the device BPB field describes the current disk and disk control areas. The device BPB field is formatted as follows:

Byte	**Meaning**
00–01H	Number of bytes per sector
02H	Number of sectors per allocation unit
03–04H	Number of sectors reserved, beginning at sector 0
05H	Number of file allocation tables (FATs)
06–07H	Maximum number of root-directory entries
08–09H	Total number of sectors
0AH	Media descriptor
0B–0CH	Number of sectors per FAT
0D–0EH	Number of sectors per track
0F–10H	Number of heads
11–14H	Number of hidden sectors
15–1FH	Reserved

- When Set Device Parameters (minor code 40H) is used, the number of cylinders should not be reset — some or all of the volume may become inaccessible.
- Subfunction 0DH minor code 60H performs the complementary action, Get Device Parameters.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

None

Interrupt 21H (33)
Function 44H (68) Subfunction 0DH
Minor Code 60H

IOCTL: Generic I/O Control for Block Devices: Get Device Parameters

Function 44H Subfunction 0DH minor code 60H gets device parameters in the parameter block pointed to by DS:DX.

To Call

AH	= 44H	
AL	= 0DH	
BL	= drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)	
CH	= category code:	
	08H	disk drive
CL	= 60H	
DS:DX	= segment:offset of parameter block	

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function
	02H	invalid drive

Programmer's Notes

- The parameter block is formatted as follows:

Special-functions field: offset 00H, length 1 byte

Bit	Value	Meaning
0	0	Returns default BIOS parameter block (BPB) for the device.
	1	Returns BPB that the Build BPB device driver call would return.
1–7	0	Reserved (must be zero).

Device type field: offset 01H, length 1 byte

Value	Meaning
00H	320/360 KB 5.25-inch disk
01H	1.2 MB 5.25-inch disk
02H	720 KB 3.5-inch disk
03H	Single-density 8-inch disk
04H	Double-density 8-inch disk
05H	Fixed disk
06H	Tape drive
07H	Other type of block device

Device attributes field: offset 02H, length 1 word

Bit	Value	Meaning
0	0	Removable storage medium
	1	Nonremovable storage medium
1	0	Door lock not supported
	1	Door lock supported
2–15	0	Reserved

Number of cylinders field: offset 04H, length 1 word

Meaning: Maximum number of cylinders supported; set by device driver

Media type field: offset 06H, length 1 byte

Value	Meaning
00H (default)	1.2 MB 5.25-inch disk
01H	320/360 KB 5.25-inch disk

Device BPB field: offset 07H, length 31 bytes

Meaning: *See* Programmer's Note below.

If bit 0 = 0 in special-functions field, this field contains the new default BPB for the device.

If bit 0 = 1 in special-functions field, BPB in this field is returned by the device driver in response to subsequent Build BPB requests.

Track layout field: offset 26H
Unused

- The device BPB field is a 31-byte data structure. Information contained in the device BPB field describes the current disk and disk control areas. The device BPB field is formatted as follows:

Byte	**Meaning**
00–01H	Number of bytes per sector
02H	Number of sectors per allocation unit
03–04H	Number of sectors reserved, beginning at sector 0
05H	Number of file allocation tables (FATs)
06–07H	Maximum number of root-directory entries
08–09H	Total number of sectors
0AH	Media descriptor
0B–0CH	Number of sectors per FAT
0D–0EH	Number of sectors per track
0F–10H	Number of heads
11–14H	Number of hidden sectors
15–1FH	Reserved

- Subfunction 0DH minor code 40H performs the complementary action, Set Device Parameters.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

None

Interrupt 21H (33)
Function 44H (68) Subfunction 0DH
Minor Codes 41H and 61H

IOCTL: Generic I/O Control for Block Devices: Write Track on Logical Drive; Read Track on Logical Drive

Function 44H Subfunction 0DH minor code 41H writes a track on the logical drive specified in BL and minor code 61H reads a track on the logical drive specified in BL, using information in the parameter block pointed to by DS:DX.

To Call

AH	= 44H	
AL	= 0DH	
BL	= drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)	
CH	= category code:	
	08H	disk drive
CL	= function (minor) code:	
	41H	write a track
	61H	read a track
DS:DX	= segment:offset of parameter block	

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function
	02H	invalid drive

Programmer's Notes

- The parameter block is formatted as follows:

Offset	Size	Meaning
00H	Byte	Special-functions field; must be 0.
01H	Word	Head field; contains number of disk head used for read/write.
03H	Word	Cylinder field; contains number of disk cylinder used for read/ write.
05H	Word	First-sector field; contains number of first sector to read or write (first sector on track = sector 0).
07H	Word	Number-of-sectors field; contains number of sectors to transfer.
09H	Dword	Transfer address field; contains address of buffer to use for data transfer.

- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

None

Interrupt 21H (33)
Function 44H (68) Subfunction 0DH
Minor Codes 42H and 62H

IOCTL: Generic I/O Control for Block Devices: Format and Verify Track on Logical Drive; Verify Track on Logical Drive

Function 44H Subfunction 0DH minor code 42H formats and verifies a track on the specified logical drive and minor code 62H verifies a track on the specified logical drive, using information in the parameter block pointed to by DS:DX.

To Call

```
AH       = 44H
AL       = 0DH
BL       = drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)
CH       = category code:
           08H      disk drive
CL       = function (minor) code:
           42H      format and verify
           62H      verify
DS:DX    = segment:offset of parameter block
```

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

```
AX       = error code:
           01H      invalid function
           02H      invalid drive
```

Programmer's Notes

- The parameter block is formatted as follows:

Offset	Size	Meaning
00H	Byte	Special-functions field; must be 0.
01H	Word	Head field; contains number of disk head used for format/verify.
03H	Word	Cylinder field; contains number of cylinder used for format/verify.

- This driver subfunction allows the writing of generic formatting programs that are minimally hardware dependent.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

None

Interrupt 21H (33) 3.2
Function 44H (68) Subfunctions 0EH and 0FH

IOCTL: Get Logical Drive Map; Set Logical Drive Map

Function 44H Subfunction 0EH allows a process to determine whether more than one logical drive is assigned to a block device. Subfunction 0FH sets the next logical drive number that will be used to reference a block device.

To Call

AH	= 44H	
AL	= 0EH	get logical drive map
	0FH	set logical drive map
BL	= drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)	

Returns

If function is successful:

Carry flag is clear.

AL = mapping code:

00H	only one letter assigned to the block device
01–1AH	logical drive letter (A through Z) mapped to block device

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid function
0FH	invalid drive

Programmer's Notes

- If a drive has not been assigned a logical mapping with Function 44H Subfunction 0FH, the logical and physical drive references are the same. (The default is that logical drive A and physical drive A both refer to physical drive A.)
- If this function is used to map logical drives to physical drives, the result is similar to MS-DOS's treatment of a single physical drive as both A and B on a system with one floppy-disk drive. With MS-DOS version 3.2, however, the installable device driver DRIVER.SYS extends this type of physical/logical referencing to other drives. Therefore, processes can prompt for disks themselves, instead of using the prompt provided by MS-DOS.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;       Function 44H, Subfunctions 0EH, 0FH:                  ;
        ;                     IOCTL Get/Set Logical Drive Map         ;
        ;                                                             ;
        ;       int ioctl_drive_owner(setflag, drv_ltr)               ;
        ;           int setflag;                                      ;
        ;           int drv_ltr;                                      ;
        ;                                                             ;
        ;       Set setflag = 1 to change drive’s map, 0 to get       ;
        ;       current map.                                          ;
        ;                                                             ;
        ;       Returns -1 for all errors, otherwise returns          ;
        ;       the block device’s current logical drive letter.      ;
        ;                                                             ;
        ;*************************************************************;

cProc   ioctl_drive_owner,PUBLIC
parmB   setflag
parmB   drv_ltr
cBegin
        mov     al,setflag      ; Load setflag.
        and     al,1            ; Keep only lsb.
        add     al,0eh          ; AL = 0EH for get, 0FH for set.
        mov     bl,drv_ltr      ; Get drive letter.
        or      bl,bl           ; Leave 0 alone.
        jz      ido
        and     bl,not 20h      ; Convert letter to uppercase.
        sub     bl,'A'-1        ; Convert to drive number: 'A' = 1,
                                ; 'B' = 2, etc.
ido:
        mov     bh,0
        mov     ah,44h          ; Set function code.
        int     21h             ; Call MS-DOS.
        mov     ah,0            ; Clear high byte.
        jnc     idox            ; Branch if no error.
        mov     ax,-1-'A'       ; Return -1 for errors.
idox:
        add     ax,'A'          ; Return drive letter.
cEnd
```

Interrupt 21H (33) Function 45H (69)

2.0 and later

Duplicate File Handle

Function 45H obtains an additional handle for a currently open file or device.

To Call

AH = 45H
BX = handle for open file or device

Returns

If function is successful:

Carry flag is clear.

AX = new handle number

If function is not successful:

Carry flag is set.

AX = error code:

04H	too many open files
06H	invalid handle

Programmer's Notes

- The file pointer for the new handle is set to the same position as the pointer for the original handle. Any subsequent changes to the file are reflected in both handles. Thus, using either handle for a read or write operation moves the file pointer associated with both.
- Function 45H is often used to duplicate the handle assigned to standard input (0) or standard output (1) before a call to Function 46H (Force Duplicate File Handle). The handle forced by Function 46H can then be used for redirected input or output from or to a file or device.
- Another use for Function 45H is to keep a file open while its directory entry is being updated to reflect a change in length. If a new handle is obtained with Function 45H and then closed with Function 3EH (Close File), the directory and FAT entries for the file are updated. At the same time, because the original handle remains open, the file need not be reopened for additional read or write operations.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Function

46H (Force Duplicate File Handle)

Example

```
          ;************************************************************;
          ;                                                            ;
          ;              Function 45H: Duplicate File Handle           ;
          ;                                                            ;
          ;              int dup_handle(handle)                        ;
          ;                  int handle;                               ;
          ;                                                            ;
          ;              Returns -1 for errors,                        ;
          ;              otherwise returns new handle.                 ;
          ;                                                            ;
          ;************************************************************;

cProc   dup_handle,PUBLIC
parmW   handle
cBegin
        mov     bx,handle       ; Get handle to copy.
        mov     ah,45h          ; Set function code.
        int     21h             ; Ask MS-DOS to duplicate handle.
        jnb     dup_ok          ; Branch if copy was successful.
        mov     ax,-1           ; Else return -1.
dup_ok:
cEnd
```

Interrupt 21H (33) Function 46H (70)

2.0 and later

Force Duplicate File Handle

Function 46H forces the open handle specified in CX to track the same file or device specified by the handle in BX.

To Call

AH = 46H
BX = open handle to be duplicated
CX = open handle to be forced

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code:

04H	too many open files
06H	invalid handle

Programmer's Notes

- The handle in BX must refer either to an open file or to any of the five standard handles reserved by MS-DOS: standard input, standard output, standard error, standard auxiliary, or standard printer.
- If the handle in CX refers to an open file, the file is closed.
- The file pointer for the duplicate handle is set to the same position as the pointer for the original handle. Changing the position of either file pointer moves the pointer associated with the other handle as well.
- When used with Function 45H (Duplicate File Handle), Function 46H can be used to redirect input and output as follows:

  1. Duplicate the handle from which input or output will be redirected with Function 45H (Duplicate File Handle). Save the duplicated handle for later reference (Step 3).
  2. Call Function 46H, with the handle to be redirected from in the CX register and the handle to be redirected to in the BX register.
  3. To restore I/O redirection to its original state, call Function 46H again, with the redirected file handle from Step 2 in the CX register and the duplicated file handle from Step 1 in the BX register.

This procedure is normally used to redirect a standard device, but it can redirect any device referenced by handles.

- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Function

45H (Duplicate File Handle)

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;         Function 46H: Force Duplicate File Handle           ;
        ;                                                             ;
        ;         int dup_handle2(existhandle,newhandle)              ;
        ;             int existhandle,newhandle;                      ;
        ;                                                             ;
        ;         Returns -1 for errors,                              ;
        ;         otherwise returns newhandle unchanged.              ;
        ;                                                             ;
        ;*************************************************************;

cProc   dup_handle2,PUBLIC
parmW   existhandle
parmW   newhandle
cBegin
        mov     bx,existhandle  ; Get handle of existing file.
        mov     cx,newhandle    ; Get handle to copy into.
        mov     ah,46h          ; Close handle CX and then
        int     21h             ; duplicate BX's handle into CX.
        mov     ax,newhandle    ; Prepare return value.
        jnb     dup2_ok         ; Branch if close/copy was successful.
        mov     ax,-1           ; Else return -1.
dup2_ok:
cEnd
```

Interrupt 21H (33) Function 47H (71)

2.0 and later

Get Current Directory

Function 47H returns the path, excluding the drive and leading backslash, of the current directory for the specified drive.

To Call

AH	= 47H
DL	= drive number (0 = default drive, 1 = drive A, 2 = drive B, and so on)
DS:SI	= segment:offset of 64-byte buffer

Returns

If function is successful:

Carry flag is clear.

Buffer is filled in with ASCIIZ pathname.

If function is not successful:

Carry flag is set.

AX = error code:

0FH	invalid drive

Programmer's Notes

- The string representing the pathname is returned as a null-terminated ASCII string (ASCIIZ).
- This function does not return an error if the buffer is too small or is incorrectly identified. MS-DOS pathnames can be as long as 64 characters; if the buffer is less than 64 bytes, MS-DOS can overwrite sections of memory outside the buffer.
- The path returned by Function 47H starts at the root directory and fully specifies the path to the current directory but does not include a drive code or a leading backslash (\) character.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Function

3BH (Change Current Directory)

Example

```
          ;**********************************************************;
          ;                                                          ;
          ;           Function 47H: Get Current Directory            ;
          ;                                                          ;
          ;           int get_dir(drive_ltr,pbuffer)                 ;
          ;               int drive_ltr;                             ;
          ;               char *pbuffer;                             ;
          ;                                                          ;
          ;           Returns -1 for bad drive,                      ;
          ;           otherwise returns pointer to pbuffer.          ;
          ;                                                          ;
          ;**********************************************************;

cProc   get_dir,PUBLIC,<ds,si>
parmB   drive_ltr
parmDP  pbuffer
cBegin
        loadDP  ds,si,pbuffer   ; Get pointer to buffer.
        mov     dl,drive_ltr    ; Get drive number.
        or      dl,dl           ; Leave 0 alone.
        jz      gdir
        and     dl,not 20h      ; Convert letter to uppercase
        sub     dl,'A'-1        ; Convert to drive number: 'A' = 1,
                                ; 'B' = 2, etc.
gdir:
        mov     ah,47h          ; Set function code.
        int     21h             ; Call MS-DOS.
        mov     ax,si           ; Return pointer to buffer ...
        jnb     gd_ok
        mov     ax,-1           ; ... unless an error occurred.
gd_ok:
cEnd
```

Interrupt 21H (33) Function 48H (72)

2.0 and later

Allocate Memory Block

Function 48H allocates a block of memory, in paragraphs (1 paragraph = 16 bytes), to the requesting process.

To Call

AH = 48H
BX = number of paragraphs to allocate

Returns

If function is successful:

Carry flag is clear.

AX = segment address of base of allocated block

If function is not successful:

Carry flag is set.

AX = error code:

07H	memory control blocks damaged
08H	insufficient memory to allocate as requested

BX = size of largest available block (paragraphs)

Programmer's Notes

- If the allocation succeeds, the address returned in AX is the segment of the base of the block. This address would be copied to a segment register (usually DS or ES) to access the memory within the block.
- If the amount of memory requested is greater than the amount in any available contiguous block of memory, the number of paragraphs in the largest available memory block is returned in the BX register.
- The default memory-management strategy in MS-DOS is to choose the first contiguous block of memory that fits the request, no matter how good the fit. With MS-DOS versions 3.0 and later, however, the memory-management strategy can be altered with Function 58H (Get/Set Allocation Strategy).
- If a process actively allocates and frees blocks of memory, the transient program area (TPA) can become fragmented — that is, small blocks of memory can be orphaned because the memory-management strategy seeks contiguous blocks of memory.
- If a process writes to memory outside the limits of the allocated block, it can destroy control structures for other memory blocks. This could result in failure of subsequent memory-management functions, and it will cause MS-DOS to print an error message and halt when the process terminates.

- Initially, the MS-DOS loader allocates all available memory to .COM programs. Function 4AH (Resize Memory Block) can free memory for dynamic reallocation by a process or by its children.
- Function 59H (Get Extended Error Information) provides further information on any error—in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

49H (Free Memory Block)
4AH (Resize Memory Block)
58H (Get/Set Allocation Strategy)

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;         Function 48H: Allocate Memory Block                 ;
        ;                                                             ;
        ;         int get_block(nparas,pblocksegp,pmaxparas)          ;
        ;             int nparas,*pblockseg,*pmaxparas;               ;
        ;                                                             ;
        ;         Returns 0 if nparas are allocated OK and            ;
        ;         pblockseg has segment address of block,             ;
        ;         otherwise returns error code with pmaxparas         ;
        ;         set to maximum block size available.                ;
        ;                                                             ;
        ;*************************************************************;

cProc   get_block,PUBLIC,ds
parmW   nparas
parmDP  pblockseg
parmDP  pmaxparas
cBegin
        mov     bx,nparas       ; Get size request.
        mov     ah,48h          ; Set function code.
        int     21h             ; Ask MS-DOS for memory.
        mov     cx,bx           ; Save BX.
        loadDP  ds,bx,pmaxparas
        mov     [bx],cx         ; Return result, assuming failure.
        jb      gb_err          ; Exit if error, leaving error code
                                ; in AX.
        loadDP  ds,bx,pblockseg
        mov     [bx],ax         ; No error, so store address of block.
        xor     ax,ax           ; Return 0.
gb_err:
cEnd
```

Interrupt 21H (33)
Function 49H (73)

2.0 and later

Free Memory Block

Function 49H releases a block of memory previously allocated with Function 48H (Allocate Memory Block).

To Call

AH = 49H
ES = segment address of memory block to release

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code:

07H	memory control blocks damaged
09H	incorrect memory segment specified

Programmer's Notes

- The memory segment pointed to by ES:0000H must have been allocated by Function 48H (Allocate Memory Block).
- If a program has inadvertently damaged any of the system's memory control blocks by writing outside an allocated block, an attempt to free allocated memory results in error code 07H (memory control blocks damaged).
- Function 59H (Get Extended Error Information) provides further information on any error—in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

48H (Allocate Memory Block)
4AH (Resize Memory Block)
58H (Get/Set Allocation Strategy)

Example

```
        ;**********************************************************;
        ;                                                          ;
        ;               Function 49H: Free Memory Block            ;
        ;                                                          ;
        ;               int free_block(blockseg)                   ;
        ;                   int blockseg;                          ;
        ;                                                          ;
        ;               Returns 0 if block freed OK,               ;
        ;               otherwise returns error code.              ;
        ;                                                          ;
        ;**********************************************************;

cProc   free_block,PUBLIC
parmW   blockseg
cBegin
        mov     es,blockseg     ; Get block address.
        mov     ah,49h          ; Set function code.
        int     21h             ; Ask MS-DOS to free memory.
        jb      fb_err          ; Branch on error.
        xor     ax,ax           ; Return 0 if successful.
fb_err:
cEnd
```

Interrupt 21H (33) Function 4AH (74)

2.0 and later

Resize Memory Block

Function 4AH adjusts the size of a previously allocated block of memory.

To Call

AH = 4AH
BX = new size of memory block, in paragraphs
ES = segment address of previously allocated memory block

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code:

07H	memory control blocks damaged
08H	insufficient memory to allocate as requested
09H	incorrect memory segment specified

BX = maximum number of paragraphs available (if an increase was requested)

Programmer's Notes

- Function 4AH can be used to change the size of a memory block previously allocated with Function 48H (Allocate Memory Block) or to modify the amount of memory originally allocated to a process by MS-DOS.
- If a process is denied an increase in the amount of memory it has been allocated, MS-DOS places the size of the largest contiguous block available in the BX register. The process can then notify the user of the problem and exit, or it can continue to operate in a reduced memory environment.
- Because the MS-DOS loader allocates all available memory to .COM programs, such a program should use Function 4AH immediately (with the segment address of its program segment prefix, or PSP) to release any memory that is not needed. This is mandatory if the .COM program will either allocate memory dynamically or use Function 4BH (Load and Execute Program) to load a child process or overlay.

  In addition, if Function 4AH is used to adjust the amount of memory allocated to a .COM program, the stack pointer must be adjusted so that it is within the limits of the program's revised memory allocation.

- If this function is used to shrink an allocated block, any memory above the new limit is not owned by the process and should never be used. If this function is used to expand an allocated block, the contents of memory above the old boundary are unpredictable and the memory should be initialized before use.
- Although it is not possible to predict how much memory-resident software and how many installable device drivers will be used on a computer system, Function 4AH can reliably determine the amount of memory available to an application.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

48H (Allocate Memory Block)
49H (Free Memory Block)
58H (Get/Set Allocation Strategy)

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;         Function 4AH: Resize Memory Block                   ;
        ;                                                             ;
        ;         int modify_block(nparas,blockseg,pmaxparas)         ;
        ;             int nparas,blockseg,*pmaxparas;                 ;
        ;                                                             ;
        ;         Returns 0 if modification was a success,            ;
        ;         otherwise returns error code with pmaxparas         ;
        ;         set to max number of paragraphs available.          ;
        ;                                                             ;
        ;*************************************************************;

cProc   modify_block,PUBLIC,ds
parmW   nparas
parmW   blockseg
parmDP  pmaxparas
cBegin
        mov     es,blockseg     ; Get block address.
        mov     bx,nparas       ; Get nparas.
        mov     ah,4ah          ; Set function code.
        int     21h             ; Ask MS-DOS to change block size.
        mov     cx,bx           ; Save BX.
        loadDP  ds,bx,pmaxparas
        mov     [bx],cx         ; Set pmaxparas, assuming failure.
        jb      mb_exit         ; Branch if size change error.
        xor     ax,ax           ; Return 0 if successful.
mb_exit:
cEnd
```

Interrupt 21H (33) Function 4BH (75)

2.0 and later

Load and Execute Program (EXEC)

Function 4BH, often called EXEC, loads a program file into memory and, optionally, executes the program. This function can also be used to load a program overlay.

To Call

AH	= 4BH	
AL	= 00H	load and execute program
	03H	load overlay
DS:DX	= segment:offset of ASCIIZ pathname for an executable program file	
ES:BX	= segment:offset of parameter block	

Returns

If function is successful:

Carry flag is clear.

With MS-DOS versions 2.x, all registers except CS and IP can be destroyed; with MS-DOS versions 3.x, registers are preserved.

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function (AL did not contain 00H or 03H)
	02H	file not found
	03H	path not found
	05H	access denied
	08H	insufficient memory
	0AH	bad environment
	0BH	bad format (AL = 00H only)

Programmer's Notes

- The pathname must be a null-terminated ASCII string (ASCIIZ).
- The handles for any files opened by the parent process before the call to Function 4BH are inherited by the child process, unless the parent specified otherwise in calling Function 3DH (Open File with Handle).

  All standard devices also remain open and available to the child process. Thus, the parent process can control the files used by the child process and control redirection for the child process.

- If AL = 00H, the parameter block is 14 bytes long and formatted in four parts, as follows:

Offset	Length	Meaning
00H	Word	Segment address of environment to be passed; 00H indicates child program inherits environment of the current process.
02H	Dword	Segment:offset address of command tail for the new program segment prefix (PSP). Command tail must be 128 bytes or fewer and formatted as a count byte followed by an ASCII string and terminated by a carriage return, as follows: `db      7,'a:mydoc',0Dh` The carriage return is not included in the count; the command tail is placed at offset 80H in the new process's PSP.
06H	Dword	Segment:offset address of an FCB to be copied to the default FCB position at offset 5CH in the new process's PSP.
0AH	Dword	Segment:offset address of an FCB to be copied to the default FCB position at offset 6CH in the new process's PSP.

If AL = 03H, the parameter block is 4 bytes long and formatted in two parts, as follows:

Offset	Length	Meaning
00H	Word	Segment address where the overlay is to be loaded.
02H	Word	Relocation factor to be applied to the code image (.EXE files only); not needed if the file is a .COM program or is data.

- The first 2 bytes of the parameter block for Function 4BH Subfunction 00H contain either the segment address for an environment block to be passed to the new process or zero. If the value is zero, the child process inherits an exact copy of the parent process's environment.

  The environment block must be aligned on a paragraph boundary (a multiple of 16 bytes). It can be as large as 32 KB, and it consists of a block of ASCIIZ strings, each in the following form:

parameter=value

For example:

```
db      'VERIFY=ON',0
```

The final string in the environment block is followed by a second zero byte. With MS-DOS versions 3.0 and later, the second zero is followed by a word containing a count and an ASCIIZ string containing the drive and pathname of the program file.

The environment passed to the child process allows the parent process to send it messages regarding the system state or control parameters. The pathname included with MS-DOS versions 3.0 and later enables the child process to determine where it was loaded from.

- If AL = 00H, MS-DOS creates a PSP for the new process and sets the terminate and Control-C addresses to the instruction in the parent process that follows the call to Function 4BH. If AL = 03H, no PSP is created.
- Before AL = 00H is used to load and execute a process, the system must contain enough free memory to accommodate the new process. Function 4AH (Resize Memory Block) should be used, if necessary, to reduce the amount of memory allocated to the parent process. If the parent is a .COM program, allocated memory *must* be reduced, because a .COM program is given ownership of all available memory when it is executed.

  If Function 4BH is called with AL = 03H, free memory is not a factor, because MS-DOS assumes the new process is being loaded into the calling process's own address space.
- If Function 4BH is called with AL = 00H, the child process remains in control until it executes an exit request, such as Function 4CH (Terminate Process with Return Code), or until Control-C or Control-Break is received or a critical error occurs and the user responds *Abort* to the *Abort, Retry, Ignore?* message.
- With MS-DOS versions 2.x, SS and SP must be saved in the current code segment before Function 4BH is invoked with AL = 00H. When the parent process regains control, all registers other than CS:IP and the stack will most likely have been changed by loading and executing the child process.
- Function 4BH with AL = 03H is useful for loading program overlays or for loading data to be used by the parent process (if that data requires relocation).
- If the child process that is executed attempts to remain resident through either Interrupt 27H or Interrupt 21H Function 31H (Terminate and Stay Resident), system memory becomes permanently fragmented and subsequent processes can fail because of lack of memory.
- The EXEC function (with AL = 00H) is commonly used to load a new copy of COMMAND.COM and then execute an MS-DOS command from within another program.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

31H (Terminate and Stay Resident)
4CH (Terminate Process with Return Code)
4DH (Get Return Code of Child Process)

Examples

```
        ;*************************************************************;
        ;                                                             ;
        ;          Function 4BH: Load and Execute Program             ;
        ;                                                             ;
        ;          int execute(pprogname,pcmdtail)                    ;
        ;              char *pprogname,*pcmdtail;                     ;
        ;                                                             ;
        ;          Returns 0 if program loaded, ran, and              ;
        ;          terminated successfully, otherwise returns         ;
        ;          error code.                                        ;
        ;                                                             ;
        ;*************************************************************;

sBegin  data
$cmdlen =       126
$cmd    db      $cmdlen+2 dup (?) ; Make space for command line, plus
                                ; 2 extra bytes for length and
                                ; carriage return.

$fcb    db      0               ; Make dummy FCB.
        db      'dummy   fcb'
        db      0,0,0,0

                                ; Here’s the EXEC parameter block:
$epb    dw      0               ; 0 means inherit environment.
        dw      dataOFFSET $cmd ; Pointer to cmd line.
        dw      seg dgroup
        dw      dataOFFSET $fcb ; Pointer to FCB #1.
        dw      seg dgroup
        dw      dataOFFSET $fcb ; Pointer to FCB #2.
        dw      seg dgroup
sEnd    data
sBegin  code

$sp     dw      ?               ; Allocate space in code seg
$ss     dw      ?               ; for saving SS and SP.

Assumes ES,dgroup

cProc   execute,PUBLIC,<ds,si,di>
parmDP  pprogname
parmDP  pcmdtail
cBegin
        mov     cx,$cmdlen      ; Allow command line this long.
        loadDP  ds,si,pcmdtail  ; DS:SI = pointer to cmdtail string.
```

(more)

```
        mov     ax,seg dgroup:$cmd    ; Set ES = data segment.
        mov     es,ax
        mov     di,dataOFFSET $cmd+1  ; ES:DI = pointer to 2nd byte of
                                      ; our command-line buffer.
copycmd:
        lodsb                   ; Get next character.
        or      al,al           ; Found end of command tail?
        jz      endcopy         ; Exit loop if so.
        stosb                   ; Copy to command buffer.
        loop    copycmd
endcopy:
        mov     al,13
        stosb                   ; Store carriage return at
                                ; end of command.

        neg     cl
        add     cl,$cmdlen      ; CL = length of command tail.
        mov     es:$cmd,cl      ; Store length in command-tail buffer.

        loadDP  ds,dx,pprogname ; DS:DX = pointer to program name.
        mov     bx,dataOFFSET $epb ; ES:BX = pointer to parameter
                                   ; block.

        mov     cs:$ss,ss       ; Save current stack SS:SP (because
        mov     cs:$sp,sp       ; EXEC function destroys stack).
        mov     ax,4b00h        ; Set function code.
        int     21h             ; Ask MS-DOS to load and execute
                                ; program.
        cli                     ; Disable interrupts.
        mov     ss,cs:$ss       ; Restore stack.
        mov     sp,cs:$sp
        sti                     ; Enable interrupts.
        jb      ex_err          ; Branch on error.
        xor     ax,ax           ; Return 0 if no error.
ex_err:
cEnd
sEnd    code


        ;*************************************************************;
        ;                                                             ;
        ;   Function 4BH: Load an Overlay Program                     ;
        ;                                                             ;
        ;   int load_overlay(pfilename,loadseg)                       ;
        ;       char *pfilename;                                      ;
        ;       int  loadseg;                                         ;
        ;                                                             ;
        ;   Returns 0 if program has been loaded OK,                  ;
        ;   otherwise returns error code.                             ;
        ;                                                             ;
        ;   To call an overlay function after it has been             ;
        ;   loaded by load_overlay(), you can use                     ;
        ;   a far indirect call:                                      ;
```

(more)

```
        ;                                                               ;
        ;    1. FTYPE (far *ovlptr)();                                  ;
        ;    2. *((unsigned *)&ovlptr + 1) = loadseg;                   ;
        ;    3. *((unsigned *)&ovlptr) = offset;                        ;
        ;    4. (*ovlptr)(arg1,arg2,arg3,...);                          ;
        ;                                                               ;
        ;    Line 1 declares a far pointer to a                         ;
        ;    function with return type FTYPE.                           ;
        ;                                                               ;
        ;    Line 2 stores loadseg into the segment                     ;
        ;    portion (high word) of the far pointer.                    ;
        ;                                                               ;
        ;    Line 3 stores offset into the offset                       ;
        ;    portion (low word) of the far pointer.                     ;
        ;                                                               ;
        ;    Line 4 does a far call to offset                           ;
        ;    bytes into the segment loadseg                             ;
        ;    passing the arguments listed.                              ;
        ;                                                               ;
        ;    To return correctly, the overlay  must end with a far      ;
        ;    return instruction.  If the overlay is                     ;
        ;    written in Microsoft C, this can be done by                ;
        ;    declaring the overlay function with the                    ;
        ;    keyword "far".                                             ;
        ;                                                               ;
        ;***************************************************************;

sBegin  data
                                ; The overlay parameter block:
$lob    dw      ?               ; space for load segment;
        dw      ?               ; space for fixup segment.
sEnd    data

sBegin  code

cProc   load_overlay,PUBLIC,<ds,si,di>
parmDP  pfilename
parmW   loadseg
cBegin
        loadDP  ds,dx,pfilename ; DS:DX = pointer to program name.
        mov     ax,seg dgroup:$lob ; Set ES = data segment.
        mov     es,ax
        mov     bx,dataOFFSET $lob ; ES:BX = pointer to parameter
                                   ; block.
        mov     ax,loadseg      ; Get load segment parameter.
        mov     es:[bx],ax      ; Set both the load and fixup
        mov     es:[bx+2],ax    ; segments to that segment.

        mov     cs:$ss,ss       ; Save current stack SS:SP (because
        mov     cs:$sp,sp       ; EXEC function destroys stack).
        mov     ax,4b03h        ; Set function code.
        int     21h             ; Ask MS-DOS to load the overlay.
        cli                     ; Disable interrupts.
```

(more)

```
        mov     ss,cs:$ss       ; Restore stack.
        mov     sp,cs:$sp
        sti                     ; Enable interrupts.
        jb      lo_err          ; Branch on error.
        xor     ax,ax           ; Return 0 if no error.
lo_err:
cEnd
sEnd    code
```

Interrupt 21H (33) Function 4CH (76)

2.0 and later

Terminate Process with Return Code

Function 4CH terminates the current process with a return code and returns control to the calling (parent) process.

To Call

AH = 4CH
AL = return code

Returns

Nothing

Programmer's Notes

- When a process is terminated with Function 4CH, MS-DOS restores the termination-handler (Interrupt 22H), Control-C handler (Interrupt 23H), and critical error handler (Interrupt 24H) addresses from the program segment prefix, or PSP (offsets 0AH, 0EH, and 12H). MS-DOS also flushes the file buffers to disk, updates the disk directory, closes all files with open handles belonging to the terminated process, and then transfers control to the termination-handler address.
- On termination with Function 4CH, all memory owned by the process is freed.
- Function 4CH is the recommended method for terminating all processes — particularly sizable .EXE files — that do not stay resident. This function should be used in preference to the other termination methods (Interrupt 20H, Interrupt 21H Function 00H, near RET for .COM files, or a jump to PSP:0000H). Memory-resident programs should be terminated with Function 31H (Terminate and Stay Resident).
- A return code of 00H is customarily used to indicate that the process executed successfully; a nonzero return code is used to indicate that the process terminated because of an error or lack of resources — for example, the file could not be opened, the process could not be allocated sufficient memory, and so on.
- If the terminated process was invoked by a command line or batch file, control returns to COMMAND.COM and the transient portion of the command interpreter is reloaded, if necessary. If a batch file was in progress, execution continues with the next line of the file and the return code can be tested with an IF ERRORLEVEL statement. Otherwise, the command prompt is issued.

  If the terminated process was loaded by a process other than COMMAND.COM, the parent process can retrieve the child's return code with Function 4DH (Get Return Code of Child Process).
- In a networking environment running under MS-DOS version 3.1 or later, all file locks should be removed by the process before it calls Function 4CH to terminate.

Related Functions

00H (Terminate Process)
31H (Terminate and Stay Resident)
4DH (Get Return Code of Child Process)

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;       Function 4CH: Terminate Process with Return Code      ;
        ;                                                             ;
        ;       int terminate(returncode)                             ;
        ;           int returncode;                                   ;
        ;                                                             ;
        ;       Does NOT return at all!                               ;
        ;                                                             ;
        ;*************************************************************;

cProc   terminate,PUBLIC
parmB   returncode
cBegin
        mov     al,returncode   ; Set return code.
        mov     ah,4ch          ; Set function code.
        int     21h             ; Call MS-DOS to terminate process.
cEnd
```

Interrupt 21H (33) Function 4DH (77)

2.0 and later

Get Return Code of Child Process

Function 4DH retrieves the return code of a child process that was invoked with Function 4BH (Load and Execute Program) and terminated with either Function 31H (Terminate and Stay Resident) or Function 4CH (Terminate Process with Return Code).

To Call

AH = 4DH

Returns

AH = termination method:

00H	normal termination (Interrupt 20H, or Interrupt 21H Function 00H or Function 4CH)
01H	terminated by entry of Control-C
02H	terminated by critical error handler (for example, user responded *Abort* to *Abort, Retry, Ignore?* prompt)
03H	terminated and stayed resident (Interrupt 27H or Interrupt 21H Function 31H)

AL = return code passed by child process

If terminated with Interrupt 20H, Interrupt 21H Function 00H, or Interrupt 27H:

AL = 00H

Programmer's Notes

- Function 4DH can be used only once to retrieve the return code of a terminated process. Subsequent calls do not yield meaningful results.
- Function 4DH does not set the carry flag to indicate an error. If no previous child process exists, the information returned in AH and AL is undefined.

Related Functions

31H (Terminate and Stay Resident)
4CH (Terminate Process with Return Code)

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;        Function 4DH: Get Return Code of Child Process       ;
        ;                                                             ;
        ;        int child_ret_code()                                 ;
        ;                                                             ;
        ;        Returns the return code of the last                  ;
        ;        child process.                                       ;
        ;                                                             ;
        ;*************************************************************;

cProc   child_ret_code,PUBLIC
cBegin
        mov     ah,4dh          ; Set function code.
        int     21h             ; Ask MS-DOS to return code.
        cbw                     ; Convert AL to a word.
cEnd
```

Interrupt 21H (33) Function 4EH (78)

2.0 and later

Find First File

Function 4EH searches the specified directory for the first matching entry.

To Call

AH	= 4EH
CX	= attribute word
DS:DX	= segment:offset of ASCIIZ pathname

Returns

If function is successful:

Carry flag is clear.

Current disk transfer area (DTA) contains the following information about the file:

Offset	Length (bytes)	Value
00H	21	Reserved for use by MS-DOS in subsequent call to Function 4FH (Find Next File)
15H	1	File attribute
16H	2	Time of last write
18H	2	Date of last write
1AH	2	Low word of file size
1CH	2	High word of file size
1EH	13	Filename and extension in ASCIIZ form with blanks removed and period inserted between filename and extension

If function is not successful:

Carry flag is set.

AX = error code:

02H	file not found
03H	path not found
12H	no more files; no match found

Programmer's Notes

- The pathname must be a null-terminated ASCII string (ASCIIZ).

- The filename and extension portions of the pathname can contain the MS-DOS wildcards ? (match any character) and * (match all remaining characters).
- The DTA should be set with Function 1AH (Set DTA Address) before Function 4EH is called. If no DTA address is set, MS-DOS uses a default 128-byte buffer at offset 80H in the program segment prefix (PSP).
- The attribute word in CX controls the search as follows:
  - If the attribute word is 00H, only normal files are included in the search.
  - If the attribute word has any combination of bits 1, 2, and 4 (hidden, system, and subdirectory bits) set, the search includes normal files as well as files with any of the attributes specified.
  - If the attribute word has bit 3 set (volume-label bit), only a matching volume label is returned.
  - Bits 0 and 5 (read-only and archive bits) are ignored by Function 4EH.
- If Function 4FH (Find Next File) is used in conjunction with Function 4EH, the DTA must be preserved, because the first 21 bytes contain information needed by Function 4FH.
- The time at which the file was last written is returned as a binary value in a word formatted as follows:

Bits	Meaning
0–4	Number of seconds divided by 2
5–10	Minutes (0 through 59)
11–15	Hours, based on a 24-hour clock (0 through 23).

- The date on which the file was last written is returned as a binary value in a word formatted as follows:

Bits	Meaning
0–4	Day of the month
5–8	Month (1 = January, 2 = February, 3 = March, and so on)
9–15	Number of the year minus 1980

- Function 4EH is preferred to Function 11H (Find First File) because it fully supports pathnames.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

11H (Find First File)
12H (Find Next File)
1AH (Set DTA Address)
4FH (Find Next File)

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;               Function 4EH: Find First File                 ;
        ;                                                             ;
        ;               int find_first(ppathname,attr)                ;
        ;                   char *ppathname;                          ;
        ;                   int  attr;                                ;
        ;                                                             ;
        ;               Returns 0 if a match was found,               ;
        ;               otherwise returns error code.                 ;
        ;                                                             ;
        ;*************************************************************;

cProc   find_first,PUBLIC,ds
parmDP  ppathname
parmW   attr
cBegin
        loadDP  ds,dx,ppathname ; Get pointer to pathname.
        mov     cx,attr         ; Get search attributes.
        mov     ah,4eh          ; Set function code.
        int     21h             ; Ask MS-DOS to look for a match.
        jb      ff_err          ; Branch on error.
        xor     ax,ax           ; Return 0 if no error.
ff_err:
cEnd
```

Interrupt 21H (33)
Function 4FH (79)

2.0 and later

Find Next File

Function 4FH continues a search initiated by a previously successful call to Function 4EH (Find First File). The search is based on the pathname and attributes specified in the call to Function 4EH and uses information left in the current disk transfer area (DTA) by the call to Function 4EH or by a preceding call to Function 4FH.

To Call

AH = 4FH

DTA contains information from prior search with Function 4EH or Function 4FH.

Returns

If function is successful:

Carry flag is clear.

DTA is filled in as for a call to Function 4EH:

Offset	Length (bytes)	Value
00H	21	Reserved for use by MS-DOS in subsequent call to Function 4FH
15H	1	File attribute
16H	2	Time of last write
18H	2	Date of last write
1AH	2	Low word of file size
1CH	2	High word of file size
1EH	13	Filename and extension in ASCIIZ form with blanks removed and period inserted between filename and extension

If function is not successful:

Carry flag is set.

AX = error code:

12H	no more files, no match found, or no previous call to Function 4EH

Programmer's Notes

- If multiple calls to Function 4FH are used to find more than one matching file, the DTA setting (Function 1AH) and contents must be preserved because they provide information needed for continuing the search.
- The time at which the file was last written is returned as a binary value in a word formatted as follows:

Bits	Meaning
0–4	Number of seconds divided by 2
5–10	Minutes (0 through 59)
11–15	Hours, based on a 24-hour clock (0 through 23).

- The date on which the file was last written is returned as a binary value in a word formatted as follows:

Bits	Meaning
0–4	Day of the month
5–8	Month (1 = January, 2 = February, 3 = March, and so on)
9–15	Number of the year minus 1980

- Function 4FH is preferred to Function 12H (Find Next File) because it fully supports pathnames.
- Function 59H (Get Extended Error Information) provides further information on any error—in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

11H (Find First File)
12H (Find Next File)
1AH (Set DTA Address)
4EH (Find First File)

Example

```
;*************************************************************;
;                                                             ;
;               Function 4FH: Find Next File                  ;
;                                                             ;
;               int find_next()                               ;
;                                                             ;
;               Returns 0 if a match was found,               ;
;               otherwise returns error code.                 ;
;                                                             ;
;*************************************************************;
```

(more)

```
cProc   find_next,PUBLIC
cBegin
        mov     ah,4fh          ; Set function code.
        int     21h             ; Ask MS-DOS to look for the next
                                ; matching file.
        jb      fn_err          ; Branch on error.
        xor     ax,ax           ; Return 0 if no error.
fn_err:
cEnd
```

Interrupt 21H (33) Function 54H (84)

2.0 and later

Get Verify Flag

Function 54H returns the current value of the MS-DOS verify flag.

To Call

AH = 54H

Returns

AL = verify flag:

00H	verify off; no read after write operation
01H	verify on; read after write operation

Programmer's Notes

- The default state of the verify flag is 00H (off).
- The state of the verify flag can be changed either through a call to Function 2EH (Set/Reset Verify Flag) or by the user with the VERIFY ON and VERIFY OFF commands.

Related Function

Function 2EH (Set/Reset Verify Flag)

Example

```
        ;************************************************************;
        ;                                                            ;
        ;            Function 54H: Get Verify Flag                   ;
        ;                                                            ;
        ;            int get_verify()                                ;
        ;                                                            ;
        ;            Returns current value of verify flag.           ;
        ;                                                            ;
        ;************************************************************;

cProc   get_verify,PUBLIC
cBegin
        mov     ah,54h          ; Set function code.
        int     21h             ; Read flag from MS-DOS.
        cbw                     ; Clear high byte of return value.

cEnd
```

Interrupt 21H (33)
Function 56H (86)

2.0 and later

Rename File

Function 56H renames a file and/or moves it to a new location in the hierarchical directory structure.

To Call

AH	= 56H
DS:DX	= segment:offset of existing ASCIIZ pathname for file
ES:DI	= segment:offset of new ASCIIZ pathname for file

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code:

02H	file not found
03H	path not found
05H	access denied
11H	not the same device

Programmer's Notes

- The pathnames must be null-terminated ASCII strings (ASCIIZ).
- The directory paths specified in DS:DX and ES:DI need not be identical. Thus, specifying different directory paths effectively moves a file from one directory to another.
- Function 56H cannot be used to move a file to a different drive. Both the existing pathname and the new one must either contain the same drive identifier or default to the same drive.
- If Function 56H returns error code 05H, the cause can be any of the following:
  - The new pathname would move the file to the root directory, but the root directory is full.
  - A file with the new pathname already exists.
  - The user is on a network and has insufficient access to either the existing file or the new subdirectory.
- Unlike Function 17H (Rename File), Function 56H does not support the use of MS-DOS wildcard characters (? and *).

- Function 56H should not be used to rename open files. An open file should be closed with Function 10H (Close File with FCB) or 3EH (Close File) before Function 56H is called to rename it.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Function

17H (Rename File)

Example

```
        ;************************************************************;
        ;                                                            ;
        ;                Function 56H: Rename File                   ;
        ;                                                            ;
        ;                int rename(poldpath,pnewpath)               ;
        ;                    char *poldpath,*pnewpath;               ;
        ;                                                            ;
        ;                Returns 0 if file moved OK,                 ;
        ;                otherwise returns error code.               ;
        ;                                                            ;
        ;************************************************************;

cProc   rename,PUBLIC,<ds,di>
parmDP  poldpath
parmDP  pnewpath
cBegin
        loadDP  es,di,pnewpath  ; ES:DI = pointer to newpath.
        loadDP  ds,dx,poldpath  ; DS:DX = pointer to oldpath.
        mov     ah,56h          ; Set function code.
        int     21h             ; Ask MS-DOS to rename file.
        jb      rn_err          ; Branch on error.
        xor     ax,ax           ; Return 0 if no error.
rn_err:
cEnd
```

Interrupt 21H (33) Function 57H (87)

2.0 and later

Get/Set Date/Time of File

Function 57H retrieves or sets the date and time of a file's directory entry.

To Call

AH = 57H
AL = 00H get date and time
01H set date and time
BX = handle number

If AL = 01H:

CX = time; binary value formatted as follows:

Bits	Meaning
0–4	Number of seconds divided by 2
5–10	Minutes (0 through 59)
11–15	Hours, based on a 24-hour clock (0 through 23)

DX = date; binary value formatted as follows:

Bits	Meaning
0–4	Day of the month (1 through 31)
5–8	Month (1 = January, 2 = February, 3 = March, and so on)
9–15	Year minus 1980

Returns

If function is successful:

Carry flag is clear.

If AL was 00H on call:

CX = time file was last modified; format as described above
DX = date file was last modified; format as described above

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid function (AL not 00H or 01H)
06H	invalid handle

Programmer's Notes

- Before the date and time in a file's directory entry can be retrieved or changed with Function 57H, a handle must be obtained by opening or creating the file using one of the following functions:
  - 3CH (Create File with Handle)
  - 3DH (Open File with Handle)
  - 5AH (Create Temporary File)
  - 5BH (Create New File)
- Use of Function 57H to retrieve the date and time of a file is preferable to examining the fields of an open FCB directly.
- Function 59H (Get Extended Error Information) provides further information on any error—in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

2AH (Get Date)
2BH (Set Date)
2CH (Get Time)
2DH (Set Time)

Example

```
        ;************************************************************;
        ;                                                            ;
        ;       Function 57H: Get/Set Date/Time of File              ;
        ;                                                            ;
        ;       long file_date_time(handle,func,packdate,packtime)   ;
        ;            int handle,func,packdate,packtime;              ;
        ;                                                            ;
        ;       Returns a long -1 for all errors, otherwise packs    ;
        ;       date and time into a long integer,                   ;
        ;       date in high word, time in low word.                 ;
        ;                                                            ;
        ;************************************************************;

cProc   file_date_time,PUBLIC
parmW   handle
parmB   func
parmW   packdate
parmW   packtime
cBegin
        mov     bx,handle       ; Get handle.
        mov     al,func         ; Get function: 0 = read, 1 = write.
        mov     dx,packdate     ; Get date (if present).
        mov     cx,packtime     ; Get time (if present).
        mov     ah,57h          ; Set function code.
        int     21h             ; Call MS-DOS.
```

(more)

```
        mov     ax,cx           ; Set DX:AX = date/time, assuming no
                                ; error.
        jnb     dt_ok           ; Branch if no error.
        mov     ax,-1           ; Return -1 for errors.
        cwd                     ; Extend the -1 into DX.
dt_ok:
cEnd
```

Interrupt 21H (33) Function 58H (88)

3.0 and later

Get/Set Allocation Strategy

Function 58H retrieves or sets the method MS-DOS uses to allocate memory blocks for a process that issues a memory-allocation request.

To Call

AH	= 58H	
AL	= 00H	get allocation strategy
	01H	set allocation strategy

If AL = 01H:

BX = allocation strategy:

00H	use first (lowest available) block that fits
01H	use block that fits best
02H	use last (highest available) block that fits

Returns

If function is successful:

Carry flag is clear.

If AL was 00H on call:

AX = allocation-strategy code:

00H	first fit
01H	best fit
02H	last fit

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid function (AL not 00H or 01H)

Programmer's Notes

- Allocation strategies determine how MS-DOS finds and allocates a block of memory to an application that issues a memory-allocation request with either Function 48H (Allocate Memory Block) or Function 4AH (Resize Memory Block).

  The three strategies are carried out as follows:

  – First fit (the default): MS-DOS works upward from the lowest available block and allocates the first block it encounters that is large enough to satisfy the request for memory. This strategy is followed consistently, even if the block allocated is much larger than required.

  - Best fit: MS-DOS searches all available memory blocks and then allocates the smallest block that satisfies the request, regardless of its location in the empty-block chain. This strategy maximizes the use of dynamically allocated memory at a slight cost in speed of allocation.
  - Last fit (the reverse of first fit): MS-DOS works downward from the highest available block and allocates the first block it encounters that is large enough to satisfy the request for memory. This strategy is followed consistently, even if the block allocated is much larger than required.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

48H (Allocate Memory Block)
4AH (Resize Memory Block)

Example

```
        ;***********************************************************;
        ;                                                           ;
        ;         Function 58H: Get/Set Allocation Strategy         ;
        ;                                                           ;
        ;         int alloc_strategy(func,strategy)                 ;
        ;             int func,strategy;                            ;
        ;                                                           ;
        ;         Strategies:                                       ;
        ;                 0:.First fit                              ;
        ;                 1: Best fit                               ;
        ;                 2: Last fit                               ;
        ;                                                           ;
        ;         Returns -1 for all errors, otherwise              ;
        ;         returns the current strategy.                     ;
        ;                                                           ;
        ;***********************************************************;

cProc   alloc_strategy,PUBLIC
parmB   func
parmW   strategy
cBegin
        mov     al,func         ; AL = get/set selector.
        mov     bx,strategy     ; BX = new strategy (for AL = 01H).
        mov     ah,58h          ; Set function code.
        int     21h             ; Call MS-DOS.
        jnb     no_err          ; Branch if no error.
        mov     ax,-1           ; Return -1 for all errors.
no_err:
cEnd
```

Interrupt 21H (33)
Function 59H (89)

3.0 and later

Get Extended Error Information

Function 59H returns extended error information, including a suggested response, for the function call immediately preceding it.

To Call

AH = 59H
BX = 00H

Returns

AX = extended error code:

00H	no error encountered
01H	invalid function number
02H	file not found
03H	path not found
04H	too many files open; no handles available
05H	access denied
06H	invalid handle
07H	memory control blocks destroyed
08H	insufficient memory
09H	invalid memory-block address
0AH	invalid environment
0BH	invalid format
0CH	invalid access code
0DH	invalid data
0EH	reserved
0FH	invalid disk drive
10H	attempt to remove current directory
11H	device not the same
12H	no more files
13H	write-protected disk
14H	unknown unit
15H	drive not ready
16H	invalid command
17H	data error based on cyclic redundancy check (CRC)
18H	length of request structure invalid
19H	seek error
1AH	non-MS-DOS disk
1BH	sector not found

1CH	printer out of paper
1DH	write fault
1EH	read fault
1FH	general failure
20H	sharing violation
21H	lock violation
22H	invalid disk change
23H	FCB unavailable
24H	sharing buffer exceeded
25–31H	reserved
32H	unsupported network request
33H	remote machine not listening
34H	duplicate name on network
35H	network name not found
36H	network busy
37H	device no longer exists on network
38H	net BIOS command limit exceeded
39H	error in network adapter hardware
3AH	incorrect response from network
3BH	unexpected network error
3CH	remote adapt incompatible
3DH	print queue full
3EH	queue not full
3FH	not enough room for print file
40H	network name deleted
41H	access denied
42H	incorrect network device type
43H	network name not found
44H	network name limit exceeded
45H	net BIOS session limit exceeded
46H	temporary pause
47H	network request not accepted
48H	print or disk redirection paused
49–4FH	reserved
50H	file already exists
51H	reserved
52H	cannot make directory
53H	failure on Interrupt 24H (critical error)
54H	out of structures
55H	already assigned
56H	invalid password
57H	invalid parameter
58H	net write fault

BH = error class:

01H	out of resource (such as storage)
02H	temporary situation, expected to end; not an error
03H	authorization problem
04H	internal error in system software
05H	hardware failure
06H	system-software failure, such as missing or incorrect configuration files; not the fault of the active process
07H	application-program error
08H	file or item not found
09H	file or item of invalid format or type or otherwise unsuitable
0AH	file or item interlocked
0BH	drive contains wrong disk, disk has bad spot, or other problem with storage medium
0CH	already exists
0DH	unknown

BL = suggested action:

01H	perform a reasonable number of retries before prompting user to choose Abort or Ignore in response to error message
02H	perform a reasonable number of retries, with pauses between, before prompting user to choose Abort or Ignore in response to error message
03H	prompt user to enter corrected information, such as drive letter or filename
04H	clean up and exit application
05H	exit immediately without cleanup
06H	ignore; informational error
07H	prompt user to remove cause of error (for example, change disks) and then retry

CH = location of error:

01H	unknown
02H	block device
03H	network
04H	serial device
05H	memory related

Programmer's Notes

- The extended error codes returned by Function 59H correspond to the error values returned in AX by functions in MS-DOS versions 2.0 and later that set the carry flag on error. Versions 2.x of MS-DOS, however, provide a smaller set of error codes (01H through 12H) than do later versions.

  Thus, although Function 59H itself is not available in versions of MS-DOS earlier than 3.0, the matching of error codes to earlier versions helps ensure downward compatibility. Function 59H was also designed to be open-ended so that additional error codes could be incorporated as needed. As a result, processes should remain flexible in their use of this function and should not rely on a fixed set of code numbers for error detection.

- Function 59H is useful in the following situations:
  - When MS-DOS encounters a hardware-related error condition and shifts control to an Interrupt 24H handler that has been created by the programmer
  - When a handle-related function sets the carry flag to indicate an error or when an FCB-related function indicates an error by returning 0FFH in the AL register
- If a function call results in an error, Function 59H returns meaningful information only if it is the next call to MS-DOS. An intervening call to another MS-DOS function, whether explicit or indirect, causes the error value for the unsuccessful function to be lost.
- Unlike most MS-DOS functions, Function 59H alters some registers that are not used to return results: CL, DX, SI, DI, ES, and DS. These registers must be preserved before a call to Function 59H if their contents are needed later.

Related Functions

None

Example

```
        ;************************************************************;
        ;                                                            ;
        ;          Function 59H: Get Extended Error Information      ;
        ;                                                            ;
        ;          int extended_error(err,class,action,locus)        ;
        ;              int *err;                                     ;
        ;              char *class,*action,*locus;                   ;
        ;                                                            ;
        ;          Return value is same as err.                      ;
        ;                                                            ;
        ;************************************************************;

cProc   extended_error,PUBLIC,<ds,si,di>
parmDP  perr
parmDP  pclass
parmDP  paction
parmDP  plocus
cBegin
        push    ds              ; Save DS.
        xor     bx,bx
        mov     ah,59h          ; Set function code.
        int     21h             ; Request error info from MS-DOS.
        pop     ds              ; Restore DS.
        loadDP  ds,si,perr      ; Get pointer to err.
        mov     [si],ax         ; Store err.
        loadDP  ds,si,pclass    ; Get pointer to class.
        mov     [si],bh         ; Store class.
        loadDP  ds,si,paction   ; Get pointer to action.
        mov     [si],bl         ; Store action.
        loadDP  ds,si,plocus    ; Get pointer to locus.
        mov     [si],ch         ; Store locus.
cEnd
```

Interrupt 21H (33)
Function 5AH (90)

3.0 and later

Create Temporary File

Function 5AH uses the system clock to create a unique filename, appends the filename to the specified path, opens the temporary file, and returns a file handle that can be used for subsequent file operations.

To Call

AH	= 5AH	
CX	= file attribute:	
	00H	normal file
	01H	read-only file
	02H	hidden file
	04H	system file
DS:DX	= segment:offset of ASCIIZ path, ending with a backslash character (\) and followed by 13 bytes of memory (to receive the generated filename)	

Returns

If function is successful:

Carry flag is clear.

AX	= handle
DS:DX	= segment:offset of full pathname for temporary file

If function is not successful:

Carry flag is set.

AX	= error code:	
	03H	path not found
	04H	too many open files; no handle available
	05H	access denied

Programmer's Notes

- Only the drive and path to use for the new file should be specified in the buffer pointed to by DS:DX. The function appends an eight-character filename that is generated from the system time.
- Function 5AH is valuable in such situations as print spooling on a network, where temporary files are created by many users.
- The input string representing the path for the temporary file must be a null-terminated ASCII string (ASCIIZ).
- In networking environments running under MS-DOS version 3.1 or later, MS-DOS opens the temporary file in compatibility mode.

- MS-DOS does not delete temporary files; applications must do this for themselves.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

16H (Create File with FCB)
3CH (Create File with Handle)
5BH (Create New File)

Example

```
          ;************************************************************;
          ;                                                            ;
          ;             Function 5AH: Create Temporary File            ;
          ;                                                            ;
          ;             int create_temp(ppathname,attr)                ;
          ;                 char *ppathname;                           ;
          ;                 int attr;                                  ;
          ;                                                            ;
          ;             Returns -1 if file was not created,            ;
          ;             otherwise returns file handle.                 ;
          ;                                                            ;
          ;************************************************************;

cProc   create_temp,PUBLIC,ds
parmDP  ppathname
parmW   attr
cBegin
        loadDP  ds,dx,ppathname ; Get pointer to pathname.
        mov     cx,attr         ; Set function code.
        mov     ah,5ah          ; Ask MS-DOS to make a new file with
                                ; a unique name.
        int     21h             ; Ask MS-DOS to make a tmp file.
        jnb     ct_ok           ; Branch if MS-DOS returned handle.
        mov     ax,-1           ; Else return -1.
ct_ok:
cEnd
```

Interrupt 21H (33)
Function 5BH (91)

3.0 and later

Create New File

Function 5BH creates a new file with the specified pathname. This function operates like Function 3CH (Create File with Handle) but fails if the pathname references a file that already exists.

To Call

AH	= 5BH	
CX	= file attribute:	
	00H	normal file
	01H	read-only file
	02H	hidden file
	04H	system file
DS:DX	= segment:offset of ASCIIZ pathname	

Returns

If function is successful:

Carry flag is clear.

AX	= handle

If function is not successful:

Carry flag is set.

AX	= error code:	
	03H	path not found
	04H	too many open files; no handle available
	05H	access denied
	50H	file already exists

Programmer's Notes

- The pathname must be a null-terminated ASCII string (ASCIIZ).
- In networking environments running under MS-DOS version 3.1 or later, the file is opened in compatibility mode. Function 5BH fails, however, if the user does not have Create access to the directory that is to contain the file.
- Function 5BH can be used to implement semaphores in the form of files across a local area network or in a multitasking environment. If the function succeeds, the semaphore has been acquired. To release the semaphore, the application simply deletes the file.

- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

16H (Create File with FCB)
3CH (Create File with Handle)
5AH (Create Temporary File)

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;          Function 5BH: Create New File                      ;
        ;                                                             ;
        ;          int create_new(ppathname,attr)                     ;
        ;              char *ppathname;                               ;
        ;              int attr;                                      ;
        ;                                                             ;
        ;          Returns -2 if file already exists,                 ;
        ;                  -1 for all other errors,                   ;
        ;                  otherwise returns file handle.             ;
        ;                                                             ;
        ;*************************************************************;

cProc   create_new,PUBLIC,ds
parmDP  ppathname
parmW   attr
cBegin
        loadDP  ds,dx,ppathname ; Get pointer to pathname.
        mov     cx,attr         ; Get new file's attribute.
        mov     ah,5bh          ; Set function code.
        int     21h             ; Ask MS-DOS to make a new file.
        jnb     cn_ok           ; Branch if MS-DOS returned handle.
        mov     bx,-2
        cmp     al,80           ; Did file already exist?
        jz      ae_err          ; Branch if so.
        inc     bx              ; Change -2 to -1.
ae_err:
        mov     ax,bx           ; Return error code.
cn_ok:
cEnd
```

Interrupt 21H (33) Function 5CH (92)

3.0 and later

Lock/Unlock File Region

Function 5CH enables a process running in a networking or multitasking environment to lock or unlock a range of bytes in an open file.

To Call

AH	= 5CH	
AL	= 00H	lock region
	01H	unlock region
BX	= handle	
CX:DX	= 4-byte integer specifying beginning of region to be locked or unlocked (offset in bytes from beginning of file)	
SI:DI	= 4-byte integer specifying length of region (measured in bytes)	

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function (AL not 00H or 01H or file sharing not loaded)
	06H	invalid handle
	21H	lock violation
	24H	sharing buffer exceeded

Programmer's Notes

- A process that either closes a file containing a locked region or terminates with the file open leaves the file in an undefined state. Under either condition, MS-DOS might handle the file erratically. If the process can be terminated by Interrupt 23H (Control-C) or 24H (critical error), these interrupts should be trapped so that any locked regions in files can be unlocked before the process terminates.
- Locking a portion of a file with Function 5CH denies all other processes both read and write access to the specified region of the file. This restriction also applies when open file handles are passed to a child process with Function 4BH (Load and Execute Program). Duplicate file handles created with Function 45H (Duplicate File Handle) and 46H (Force Duplicate File Handle), however, are allowed access to locked regions of a file within the current process.
- Locking a region that goes beyond the end of a file does not cause an error.

- Function 5CH is useful primarily in ensuring that competing programs or processes do not interfere while a record is being updated. Locking at the file level is provided by the sharing parameter in Function 3DH (Open File with Handle).
- Function 5CH can also be used to check the lock status of a file. If an attempt to lock a needed portion of a file fails and error code 21H is returned in the AX register, the region is already locked by another process.
- Any region locked with a call to Function 5CH must also be unlocked, and the same 4-byte integer values must be used for each operation. Two adjacent regions of a file cannot be locked separately and then be unlocked with a single unlock call. If the region to unlock does not correspond exactly to a locked region, Function 5CH returns error code 21H.
- The length of time needed to hold locks can be minimized with the transaction-oriented programming model. This concept requires defining and performing an update in a uniform manner: Assert lock, read data, change data, remove lock.
- If file sharing is not loaded, an application receives a 01H (function number invalid) error status when it attempts to lock a file. An immediate call to Function 59H returns the error locus as an unknown or a serial device.
- Function 59H (Get Extended Error Information) provides further information on any error—in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

45H (Duplicate File Handle)
46H (Force Duplicate File Handle)
4BH (Load and Execute Program) [EXEC]

Example

```
        ;************************************************************;
        ;                                                            ;
        ;           Function 5CH: Lock/Unlock File Region            ;
        ;                                                            ;
        ;           int locks(handle,onoff,start,length)             ;
        ;               int handle,onoff;                            ;
        ;               long start,length;                           ;
        ;                                                            ;
        ;           Returns 0 if operation was successful,           ;
        ;           otherwise returns error code.                    ;
        ;                                                            ;
        ;************************************************************;

cProc   locks,PUBLIC,<si,di>
parmW   handle
parmB   onoff
parmD   start
parmD   length
```

(more)

```
cBegin
        mov     al,onoff        ; Get lock/unlock flag.
        mov     bx,handle       ; Get file handle.
        les     dx,start        ; Get low word of start.
        mov     cx,es           ; Get high word of start.
        les     di,length       ; Get low word of length.
        mov     si,es           ; Get high word of length.
        mov     ah,5ch          ; Set function code.
        int     21h             ; Make lock/unlock request.
        jb      lk_err          ; Branch on error.
        xor     ax,ax           ; Return 0 if no error.
lk_err:
cEnd
```

Interrupt 21H (33) Function 5EH (94) Subfunction 00H

3.1 and later

Network Machine Name/Printer Setup: Get Machine Name

If Microsoft Networks is running, Function 5EH Subfunction 00H retrieves the network name of the local computer.

To Call

AH	= 5EH
AL	= 00H
DS:DX	= segment:offset of 16-byte buffer

Returns

If function is successful:

Carry flag is clear.

CH	= validity of machine name:	
	00H	invalid
	nonzero	valid
CL	= NETBIOS number assigned to machine name	
DS:DX	= segment:offset of ASCIIZ machine name	

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function; Microsoft Networks not running

Programmer's Notes

- The NETBIOS number in CL and the name at DS:DX are valid only if the value returned in CH is nonzero.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Function

5FH (Get/Make Assign List Entry)

Example

None

Interrupt 21H (33) Function 5EH (94) Subfunctions 02H and 03H

3.1 and later

Network Machine Name/Printer Setup: Set Printer Setup;
Get Printer Setup

Function 5EH Subfunctions 02H and 03H respectively set and get the setup string that MS-DOS adds to the beginning of a file sent to a network printer.

To Call

AH	= 5EH	
AL	= 02H	set printer setup string
	03H	get printer setup string
BX	= assign-list index number (obtained with Function 5FH Subfunction 02H)	

If AL = 02H:

CX	= length of setup string in bytes (64 bytes maximum)
DS:SI	= segment:offset of ASCII setup string

If AL = 03H:

ES:DI	= segment:offset of 64-byte buffer to receive string

Returns

If function is successful:

Carry flag is clear.

If AL was 03H on call:

CX	= length of printer setup string in bytes
ES:DI	= segment:offset of ASCII printer setup string

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid subfunction

Programmer's Notes

- Function 5EH Subfunctions 02H and 03H enable multiple users on a network to configure a shared printer as required. The assign-list number is an index to a table that identifies the printer as a device on the network. A process can determine the assign-list number for the printer by using Function 5FH Subfunction 02H (Get Assign-List Entry).
- Error code 01H in the AX register may indicate either that Microsoft Networks is not running or that an invalid subfunction was selected.

- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Function

5FH (Get/Make Assign-List Entry)

Example

```
        ;**************************************************************;
        ;                                                              ;
        ;       Function 5EH Subfunction 02H:                          ;
        ;                     Set Printer Setup                        ;
        ;                                                              ;
        ;       int printer_setup(index,pstring,len)                   ;
        ;           int   index;                                       ;
        ;           char *pstring;                                     ;
        ;           int   len;                                         ;
        ;                                                              ;
        ;       Returns 0, otherwise returns -1 for all errors.        ;
        ;                                                              ;
        ;**************************************************************;

cProc   printer_setup,PUBLIC,<ds,si>
parmW   index
parmDP  pstring
parmW   len
cBegin
        mov     bx,index        ; BX = index of a net printer.
        loadDP  ds,si,pstring   ; DS:SI = pointer to string.
        mov     cx,len          ; CX = length of string.
        mov     ax,5e02h        ; Set function code.
        int     21h             ; Set printer prefix string.
        mov     al,0            ; Assume no error.
        jnb     ps_ok           ; Branch if no error,
        mov     al,-1           ; Else return -1.
ps_ok:
        cbw
cEnd
```

Interrupt 21H (33) Function 5FH (95) Subfunction 02H

3.1 and later

Get/Make Assign-List Entry: Get Assign-List Entry

Function 5FH Subfunction 02H obtains the local and remote (network) names of a device. To find the names, MS-DOS uses the device's user-assigned index number (set with Function 5FH Subfunction 03H) to search a table of redirected devices on the network. Microsoft Networks must be running with file sharing loaded for this subfunction to operate successfully.

To Call

AH	= 5FH
AL	= 02H
BX	= assign-list index number
DS:SI	= segment:offset of 16-byte buffer for local (device) name
ES:DI	= segment:offset of 128-byte buffer to receive remote (network) name

Returns

If function is successful:

Carry flag is clear.

BH	= device status:	
	00H	valid device
	01H	invalid device
BL	= device type:	
	03H	printer
	04H	drive
CX	= user data	
DS:SI	= segment:offset of ASCIIZ string representing local device name	
ES:DI	= segment:offset of ASCIIZ string representing network name	

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function or Microsoft Networks not running
	12H	no more files

Programmer's Notes

- All strings returned by this subfunction are null-terminated ASCII strings (ASCIIZ).
- A successful call to this subfunction destroys the contents of the DX and BP registers.

- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Function

5EH Subfunction 00H (Get Machine Name)

Example

```
        ;************************************************************;
        ;                                                            ;
        ;    Function 5FH Subfunction 02H:                           ;
        ;                   Get Assign-List Entry                    ;
        ;                                                            ;
        ;    int get_alist_entry(index,                              ;
        ;           plocalname,premotename,                          ;
        ;           puservalue,ptype)                                ;
        ;        int  index;                                         ;
        ;        char *plocalname;                                   ;
        ;        char *premotename;                                  ;
        ;        int  *puservalue;                                   ;
        ;        int  *ptype;                                        ;
        ;                                                            ;
        ;    Returns 0 if the requested assign-list entry is found,  ;
        ;    otherwise returns error code.                           ;
        ;                                                            ;
        ;************************************************************;

cProc   get_alist_entry,PUBLIC,<ds,si,di>
parmW   index
parmDP  plocalname
parmDP  premotename
parmDP  puservalue
parmDP  ptype
cBegin
        mov     bx,index        ; Get list index.
        loadDP  ds,si,plocalname  ; DS:SI = pointer to local name
                                  ; buffer.
        loadDP  es,di,premotename ; ES:DI = pointer to remote name
                                  ; buffer.
        mov     ax,5f02h        ; Set function code.
        int     21h             ; Get assign-list entry.
        jb      ga_err          ; Exit on error.
        xor     ax,ax           ; Else return 0.
        loadDP  ds,si,puservalue ; Get address of uservalue.
        mov     [si],cx         ; Store user value.
        loadDP  ds,si,ptype     ; Get address of type.
        mov     bh,0
        mov     [si],bx         ; Store device type to type.
ga_err:
cEnd
```

Interrupt 21H (33) Function 5FH (95) Subfunction 03H

3.1 and later

Get/Make Assign-List Entry: Make Assign-List Entry

Function 5FH Subfunction 03H redirects a local printer or disk drive to a network device and establishes an assign-list index number for the redirected device. Microsoft Networks must be running with file sharing loaded for this subfunction to operate successfully.

To Call

AH	= 5FH	
AL	= 03H	
BL	= device type:	
	03H	printer
	04H	drive
CX	= user data	
DS:SI	= segment:offset of 16-byte ASCIIZ local device name	
ES:DI	= segment:offset of 128-byte ASCIIZ remote (network) device name and password in the form	

machine name\pathname, null, password, null

For example:

```
string  db      '\\mymach\wp',0,'blibbet',0
```

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function or Microsoft Networks not running
	03H	path not found
	05H	access denied
	08H	insufficient memory
	0FH	redirection paused on server
	12H	no more files

Programmer's Notes

- The strings used by this subfunction must be null-terminated ASCII strings (ASCIIZ). The ASCIIZ string pointed to by ES:DI (the destination, or remote, device) cannot be more than 128 bytes including the password, which can be a maximum of 8 characters. If the password is omitted, the pathname must be followed by 2 null bytes.

- If BL = 03H, the string pointed to by DS:SI must be one of the following printer names: PRN, LPT1, LPT2, or LPT3. If the call is successful, output is redirected to a network print spooler, which must be named in the destination string. For printer redirection, MS-NET intercepts Interrupt 17H (BIOS Printer I/O). When redirection for a printer is canceled, all printing is sent to the first local printer (LPT1).

  If BL = 04H, the string pointed to by DS:SI can be a drive letter followed by a colon, such as E:, or it can be a null string. If the string represents a valid drive, a successful call redirects drive requests to the network directory named in the destination string. If DS:SI points to a null string, MS-DOS attempts to provide access to the network directory named in the destination string without redirecting any device.
- Only printer and disk devices are supported in MS-DOS versions 3.1 and later. COM1 and COM2 are not supported for network redirection, nor are the standard output or standard error devices supported.
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Function

5EH Subfunction 00H (Get Machine Name)

Example

```
        ;************************************************************;
        ;                                                            ;
        ;    Function 5FH Subfunction 03H:                           ;
        ;                 Make Assign-List Entry                     ;
        ;    int add_alist_entry(psrcname,pdestname,uservalue,type)  ;
        ;        char *psrcname,*pdestname;                          ;
        ;        int  uservalue,type;                                ;
        ;                                                            ;
        ;    Returns 0 if new assign-list entry is made, otherwise   ;
        ;    returns error code.                                     ;
        ;                                                            ;
        ;************************************************************;

cProc   add_alist_entry,PUBLIC,<ds,si,di>
parmDP  psrcname
parmDP  pdestname
parmW   uservalue
parmW   type
cBegin
        mov     bx,type         ; Get device type.
        mov     cx,uservalue    ; Get uservalue.
        loadDP  ds,si,psrcname  ; DS:SI = pointer to source name.
        loadDP  es,di,pdestname ; ES:DI = pointer to destination name.
        mov     ax,5f03h        ; Set function code.
        int     21h             ; Make assign-list entry.
        jb      aa_err          ; Exit if there was some error.
        xor     ax,ax           ; Else return 0.
aa_err:
cEnd
```

Int 21H (33) Function 5FH (95) Subfunction 04H

3.1 and later

Get/Make Assign-List Entry: Cancel Assign-List Entry

Function 5FH Subfunction 04H cancels the redirection of a local device to a network device previously established with Function 5FH Subfunction 03H (Make Assign-List Entry). Microsoft Networks must be running with file sharing loaded for this subfunction to operate successfully.

To Call

AH	= 5FH
AL	= 04H
DS:SI	= segment:offset of ASCIIZ device name or path

Returns

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code:

01H	invalid function or Microsoft Networks not running
03H	path not found
05H	access denied
08H	insufficient memory
0FH	redirection paused on server
12H	no more files

Programmer's Notes

- The string pointed to by DS:SI must be a null-terminated ASCII string (ASCIIZ). This string can be any one of the following:
  - The letter, followed by a colon, of a redirected local drive. This function restores the drive letter to its original, physical meaning.
  - The name of a redirected printer: PRN, LPT1, LPT2, LPT3, or its machine-specific equivalent. This function restores the printer name to its original, physical meaning at the local workstation.
  - A string, beginning with two backslashes (\\) followed by the name of a network directory. This function terminates the connection between the local workstation and the directory specified in the string.

- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Function

5EH Subfunction 00H (Get Machine Name)

Example

```
        ;*************************************************************;
        ;                                                             ;
        ;    Function 5FH Subfunction 04H:                            ;
        ;                  Cancel Assign-List Entry                   ;
        ;                                                             ;
        ;    int cancel_alist_entry(psrcname)                         ;
        ;        char *psrcname;                                      ;
        ;                                                             ;
        ;    Returns 0 if assignment is canceled, otherwise returns   ;
        ;    error code.                                              ;
        ;                                                             ;
        ;*************************************************************;

cProc   cancel_alist_entry,PUBLIC,<ds,si>
parmDP  psrcname
cBegin
        loadDP  ds,si,psrcname  ; DS:SI = pointer to source name.
        mov     ax,5f04h        ; Set function code.
        int     21h             ; Cancel assign-list entry.
        jb      ca_err          ; Exit on error.
        xor     ax,ax           ; Else return 0.
ca_err:
cEnd
```

Interrupt 21H (33) Function 62H (98)

3.0 and later

Get Program Segment Prefix Address

Function 62H gets the segment address of the program segment prefix (PSP) for the current process.

To Call

AH = 62H

Returns

BX = segment address of PSP for current process

Programmer's Notes

- The PSP is constructed by MS-DOS at the base of the memory allocated for a .COM or .EXE program being loaded into memory by the EXEC function, 4BH (Load and Execute Program). The PSP is 100H bytes and contains information useful to an executing program, including
  - The command tail
  - Default file control blocks (FCBs)
  - A pointer to the program's environment block
  - Previous addresses for MS-DOS Control-C, critical error, and terminate handlers
- Function 59H (Get Extended Error Information) provides further information on any error — in particular, the code, class, recommended corrective action, and locus of the error.

Related Functions

None

Example

```
;*************************************************************;
;                                                             ;
;       Function 62H: Get Program Segment Prefix Address      ;
;                                                             ;
;       int get_psp()                                         ;
;                                                             ;
;       Returns PSP segment.                                  ;
;                                                             ;
;*************************************************************;
```

(more)

```
cProc   get_psp,PUBLIC
cBegin
        mov     ah,62h          ; Set function code.
        int     21h             ; Get PSP address.
        mov     ax,bx           ; Return it in AX.
cEnd
```

Interrupt 21H (33) Function 63H (99)

2.25

Get Lead Byte Table

Function 63H, available only in MS-DOS version 2.25, includes three subfunctions that support 2-byte-per-character alphabets such as Kanji and Hangeul (Japanese and Korean characters sets). Subfunction 00H obtains the address of the legal lead byte ranges for the character sets; Subfunctions 01H and 02H set or obtain the value of the interim console flag, which determines whether interim characters are returned by certain console system calls.

To Call

AH	= 63H	
AL	= 00H	get lead byte table address
	01H	set or clear interim console flag
	02H	get interim console flag

If AL = 01H:

DL	= interim console flag:	
	00H	clear
	01H	set

Returns

If function is successful:

Carry flag is clear.

If AL was 00H on call:

DS:SI = segment:offset of lead byte table

If AL was 02H on call:

DL = value of interim console flag

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function

Programmer's Notes

- Function 63H does not necessarily preserve any registers other than SS:SP, so register values should be saved before a call to this function. To avoid saving registers repeatedly, a process can either copy the table or save the pointer to the table for later use.

- The lead byte table contains pairs of bytes that represent the inclusive boundary values for the lead bytes of the specified alphabet. Because of the way bytes are ordered by the 8086 microprocessor family, the values must be read as byte values, not as word values.
- If the interim console flag is set (DL = 01H) by a program through a call to Function 63H, the following functions return interim character information on request:
  - 07H (Character Input Without Echo)
  - 08H (Unfiltered Character Input Without Echo)
  - 0BH (Check Keyboard Status)
  - 0CH (Flush Buffer, Read Keyboard), if Function 07H or 08H is requested in AL

Related Functions

None

Example

```
        ;************************************************************;
        ;                                                            ;
        ;   Function 63H: Get Lead Byte Table                        ;
        ;                                                            ;
        ;   char far *get_lead_byte_table()                          ;
        ;                                                            ;
        ;   Returns far pointer to table of lead bytes for multibyte ;
        ;   characters.  Will work only in MS-DOS 2.25!              ;
        ;                                                            ;
        ;************************************************************;

cProc   get_lead_byte_table,PUBLIC,<ds,si>
cBegin
        mov     ax,6300h        ; Set function code.
        int     21h             ; Get lead byte table.
        mov     dx,ds           ; Return far pointer in DX:AX.
        mov     ax,si
cEnd
```

Interrupt 22H (34)

1.0 and later

Terminate Routine Address

The machine interrupt vector for Interrupt 22H (memory locations 0000:0088H through 0000:008BH) contains the address of the routine that receives control when the currently executing program terminates by means of Interrupt 20H, Interrupt 27H, or Interrupt 21H Function 00H, 31H, or 4CH.

To Call

This interrupt should never be issued directly.

Returns

Nothing

Programmer's Note

- The address in this vector is copied into offsets 0AH through 0DH of the program segment prefix (PSP) when a program is loaded but before it begins executing. The address is restored from the PSP (in case it was modified by the application) as part of MS-DOS's termination handling.

Example

None

Interrupt 23H (35)

1.0 and later

Control-C Handler Address

The machine interrupt vector for Interrupt 23H (memory locations 0000:008CH through 0000:008FH) contains the address of the routine that receives control when a Control-C (also Control-Break on IBM PC compatibles) is detected during any character I/O function and, if the Break flag is on, during most other MS-DOS function calls.

To Call

This interrupt should never be issued directly.

Returns

Nothing

Programmer's Notes

- The address in this vector is copied into offsets 0EH through 11H of the program segment prefix (PSP) when a program is loaded but before it begins executing. The address is restored from the PSP (in case it was modified by the application) as part of MS-DOS's termination handling.
- The initialization code for an application can use Interrupt 21H Function 25H (Set Interrupt Vector) to reset the Interrupt 23H vector to point to its own routine for Control-C handling. By installing its own Control-C handler, the program can avoid being terminated as a result of keyboard entry of a Control-C or Control-Break.
- When a Control-C is detected and the program's Interrupt 23H handler receives control, MS-DOS sets all registers to the original values they had when the function call that is being interrupted was made. The program's interrupt handler can then do any of the following:
  - Set a local flag for later inspection by the application (or take any other appropriate action) and then perform a return from interrupt (IRET) to return control to MS-DOS. (All registers must be preserved.) The MS-DOS function in progress is then restarted and proceeds to completion, and control finally returns to the application in the normal manner.
  - Take appropriate action and then perform a far return (RET FAR) to give control back to MS-DOS. MS-DOS uses the state of the carry flag to determine what action to take: If the carry flag is set, the application is terminated; if the carry flag is clear, the application continues in the normal manner.
  - Retain control by transferring to an error-handling routine within the application and then resume execution or take other appropriate action, never performing a RET FAR or IRET to end the interrupt-handling sequence. This option causes no harm to the system.
- Any MS-DOS function call can be used within the body of an Interrupt 23H handler.

Example

None

Interrupt 24H (36)

1.0 and later

Critical Error Handler Address

The machine interrupt vector for Interrupt 24H (memory locations 0000:0090H through 0000:0093H) contains the address of the routine that receives control when a critical error (usually a hardware error) is detected.

To Call

This interrupt should never be issued directly.

Returns

Nothing

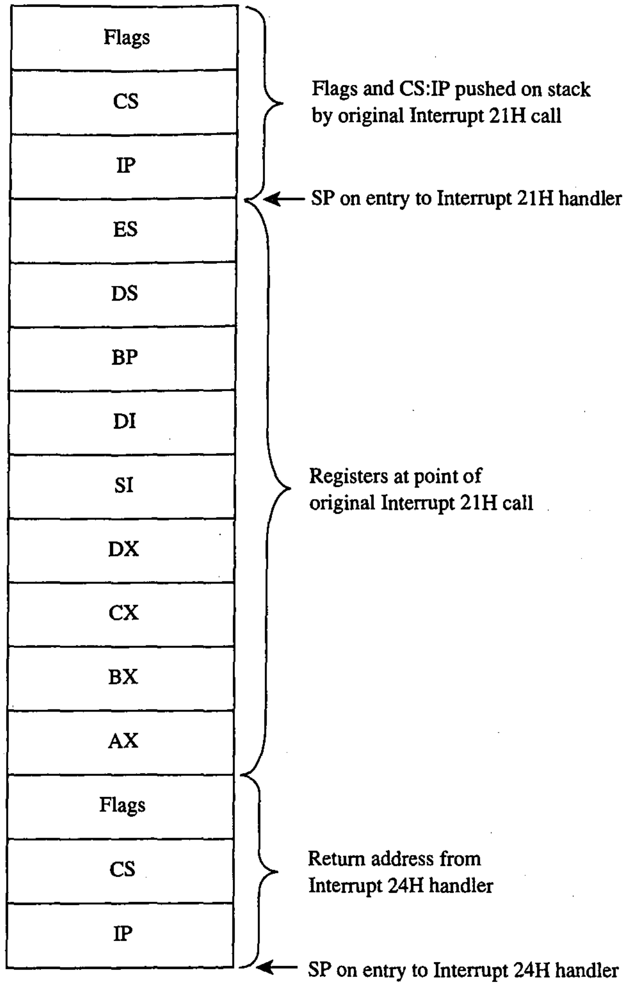
Programmer's Notes

- The address of this vector is copied into offsets 12H through 15H of the program segment prefix (PSP) when a program is loaded but before it begins executing. The address is restored from the PSP (in case it was modified by the application) as part of MS-DOS's termination handling.
- On entry to the critical error interrupt handler, bit 7 of register AH is clear (0) if the error was a disk I/O error; otherwise, it is set (1). BP:SI contains the address of a device-header control block from which additional information can be obtained. Interrupts are disabled. MS-DOS sets up the registers for a retry operation and one of the following error codes is in the lower byte of the DI register (the upper byte is undefined):

Code	Meaning
00H	Write-protect error
01H	Unknown unit
02H	Drive not ready
03H	Unknown command
04H	Data error (bad CRC)
05H	Bad request structure length
06H	Seek error
07H	Unknown media type
08H	Sector not found
09H	Printer out of paper
0AH	Write fault
0BH	Read fault
0CH	General failure
0FH	Invalid disk change

These are the same error codes returned by the device drivers in the request header.

- On a disk error, MS-DOS retries the operation three times before transferring to the Interrupt 24H handler.
- On entry to the Interrupt 24H handler, the stack is set up as follows:


Flags
CS
IP
ES
DS
BP
DI
SI
DX
CX
BX
AX
Flags
CS
IP
Flags and CS:IP pushed on stack by original Interrupt 21H call
SP on entry to Interrupt 21H handler
Registers at point of original Interrupt 21H call
Return address from Interrupt 24H handler
SP on entry to Interrupt 24H handler

- Interrupt 24H handlers must preserve the SS, SP, DS, ES, BX, CX, and DX registers. Only Interrupt 21H Functions 01H through 0CH, 30H, and 59H can be used by an Interrupt 24H handler; other calls will destroy the MS-DOS stack and its ability to retry or ignore an error.

- Before issuing a RETURN FROM INTERRUPT (IRET), the Interrupt 24H handler should place an action code in AL that will be interpreted by MS-DOS as follows:

Code	Meaning
00H	Ignore error.
01H	Retry operation.
02H	Terminate program through Interrupt 23H.
03H	Fail system call in progress (versions 3.1 and later).

- If an Interrupt 24H routine returns to the user program rather than to MS-DOS, it must restore the user program's registers, removing all but the last three words from the stack, and issue an IRET. Control returns to the instruction immediately following the Interrupt 21H function call that resulted in an error. This leaves MS-DOS in an unstable state until a call is made to an Interrupt 21H function higher than 0CH.

Example

None

Interrupt 25H (37)

1.0 and later

Absolute Disk Read

Interrupt 25H provides direct linkage to the MS-DOS BIOS module to read data from a logical disk sector into a specified memory location.

To Call

AL	= drive number (0 = drive A, 1 = drive B, and so on)
CX	= number of sectors to read
DX	= starting relative (logical) sector number
DS:BX	= segment:offset of disk transfer area (DTA)

Returns

If operation is successful:

Carry flag is clear.

If operation is not successful:

Carry flag is set.

AX	= error code

Programmer's Notes

- Interrupt 25H might destroy all registers except the segment registers.
- When Interrupt 25H returns, the CPU flags originally pushed onto the stack by the INT 25H instruction are still on the stack. The stack must be cleared by a POPF or ADD SP,2 instruction to prevent uncontrolled stack growth and to make accessible any other values that were pushed onto the stack before the call to Interrupt 25H.
- Logical sector numbers are zero based and are obtained by numbering each disk sector sequentially from track 0, head 0, sector 1 and continuing until the last sector on the disk is counted. The head number is incremented before the track number. Because of interleaving, logically adjacent sectors might not be physically adjacent for some types of disks.
- The lower byte of the error code (AL) is the same error code that is returned in the lower byte of DI when an Interrupt 24H is issued. The upper byte (AH) contains one of the following codes:

Code	Meaning
80H	Device failed to respond
40H	Seek operation failure
20H	Controller failure

(more)

Code	Meaning
10H	Data error (bad CRC)
08H	Direct memory access (DMA) failure
04H	Requested sector not found
03H	Write-protect fault
02H	Bad address mark
01H	Bad command

- ***Warning:*** Interrupt 25H bypasses the MS-DOS file system. This function must be used with caution to avoid damaging the disk structure.

Example

```
;****************************************************************;
;                                                                ;
;      Interrupt 25H: Absolute Disk Read                         ;
;                                                                ;
;      Read logical sector 1 of drive A into the memory area     ;
;      named buff. (On most MS-DOS floppy disks, this sector     ;
;      contains the beginning of the file allocation table.)     ;
;                                                                ;
;****************************************************************;

        mov     al,0            ; Drive A.
        mov     cx,1            ; Number of sectors.
        mov     dx,1            ; Beginning sector number.
        mov     bx,seg buff     ; Address of buffer.
        mov     ds,bx
        mov     bx,offset buff
        int     25h             ; Request disk read.
        jc      error           ; Jump if read failed.
        add     sp, 2           ; Clear stack.
        .
        .
        .
error:                          ; Error routine goes here.
        .
        .
        .
buff    db      512 dup (?)
```

Interrupt 26H (38)

1.0 and later

Absolute Disk Write

Interrupt 26H provides direct linkage to the MS-DOS BIOS module to write data from a specified memory buffer to a logical disk sector.

To Call

AL	= drive number (0 = drive A, 1 = drive B, and so on)
CX	= number of sectors to write
DX	= starting relative (logical) sector number
DS:BX	= segment:offset of disk transfer area (DTA)

Returns

If operation is successful:

Carry flag is clear.

If operation is not successful:

Carry flag is set.

AX	= error code

Programmer's Notes

- When Interrupt 26H returns, the CPU flags originally pushed onto the stack by the INT 26H instruction are still on the stack. The stack must be cleared by a POPF or ADD SP,2 instruction to prevent uncontrolled stack growth and to make accessible any other values that were pushed on the stack before the call to Interrupt 26H.
- Logical sector numbers are zero based and are obtained by numbering each disk sector sequentially from track 0, head 0, sector 1 and continuing until the last sector on the disk is counted. The head number is incremented before the track number. Because of interleaving, logically adjacent sectors might not be physically adjacent for some types of disks.
- The lower byte of the error code (AL) is the same error code that is returned in the lower byte of DI when an Interrupt 24H is issued. The upper byte (AH) contains one of the following codes:

Code	Meaning
80H	Device failed to respond
40H	Seek operation failure
20H	Controller failure
10H	Data error (bad CRC)

(more)

Code	Meaning
08H	Direct memory access (DMA) failure
04H	Requested sector not found
03H	Write-protect fault
02H	Bad address mark
01H	Bad command

- ***Warning:*** Interrupt 26H bypasses the MS-DOS file system. This function must be used with caution to avoid damaging the disk structure.

Example

```
;************************************************************;
;                                                            ;
;       Interrupt 26H: Absolute Disk Write                   ;
;                                                            ;
;       Write the contents of the memory area named buff     ;
;       into logical sector 3 of drive C.                    ;
;                                                            ;
;       WARNING: Verbatim use of this code could damage      ;
;       the file structure of the fixed disk. It is meant    ;
;       only as a general guide. There is, unfortunately,    ;
;       no way to give a really safe example of this interrupt.  ;
;                                                            ;
;************************************************************;

        mov     al,2            ; Drive C.
        mov     cx,1            ; Number of sectors.
        mov     dx,3            ; Beginning sector number.
        mov     bx,seg buff     ; Address of buffer.
        mov     ds,bx
        mov     bx,offset buff
        int     26h             ; Request disk write.
        jc      error           ; Jump if write failed.
        add     sp,2            ; Clear stack.
        .
        .
        .
error:                          ; Error routine goes here.
        .
        .
        .
buff    db      512 dup (?)     ; Data to be written to disk.
```

Interrupt 27H (39)

1.0 and later

Terminate and Stay Resident

Interrupt 27H terminates execution of the currently executing program but reserves part or all of its memory so that it will not be overlaid by the next transient program to be loaded.

To Call

DX = offset of last byte plus 1 (relative to the program segment prefix, or PSP) of program to be protected
CS = segment address of PSP

Returns

Nothing

Programmer's Notes

- In response to an Interrupt 27H call, MS-DOS takes the following actions:
  - Restores the termination vector (Interrupt 22H) from PSP:000AH.
  - Restores the Control-C vector (Interrupt 23H) from PSP:000EH.
  - With MS-DOS versions 2.0 and later, restores the critical error handler vector (Interrupt 24H) from PSP:0012H.
  - Transfers to the termination handler address.
- If the program is returning to COMMAND.COM rather than to another program, control transfers first to COMMAND.COM's resident portion, which reloads COMMAND.COM's transient portion (if necessary) and passes it control. If a batch file is in progress, the next line of the file is then fetched and interpreted; otherwise, a prompt is issued for the next user command.
- This interrupt is typically used to allow user-written drivers or interrupt handlers to be loaded as ordinary .COM or .EXE programs and then remain resident. Subsequent entrance to the code is by means of a hardware or software interrupt.
- The maximum amount of memory that can be reserved with this interrupt is 64 KB. Therefore, Interrupt 27H should be used only for applications that must run under MS-DOS versions 1.x.

  With versions 2.0 and later, the preferred method to terminate and stay resident is to use Interrupt 21H Function 31H, which allows the program to reserve more than 64 KB of memory and does not require CS to contain the PSP address.
- Interrupt 27H should not be called by .EXE programs that are loaded into the high end of memory (that is, linked with the /HIGH switch), because this would reserve the memory that is ordinarily used by the transient portion of COMMAND.COM. If COMMAND.COM cannot be reloaded, the system will fail.

- Because execution of Interrupt 27H results in the restoration of the terminate routine (Interrupt 22H), Control-C (Interrupt 23H), and critical error (Interrupt 24H) vectors, it cannot be used to permanently install a user-written critical error handler.
- Interrupt 27H does not work correctly when DX contains values in the range FFF1H through FFFFH. In this case, MS-DOS discards the high bit of the contents of DX, resulting in 32 KB less resident memory than was actually requested by the program.

Example

```
;****************************************************************;
;                                                                ;
;       Interrupt 27H: Terminate and Stay Resident               ;
;                                                                ;
;       Exit and stay resident, reserving enough memory          ;
;       to protect the program's code and data.                  ;
;                                                                ;
;****************************************************************;

Start:    .
          .
          .
          mov     dx,offset pgm_end  ; DX = bytes to reserve.
          int     27h                ; Terminate, stay resident.
          .
          .
          .
pgm_end   equ     $
          end     start
```

Interrupt 2FH (47)

2.0 and later

Multiplex Interrupt

Interrupt 2FH with AH = 01H submits a file to the print spooler, removes a file from the print spooler's queue of pending files, or obtains the status of the printer. Other values for AH are used by various MS-DOS extensions, such as APPEND.

To Call

AH	= 01H	print spooler call
AL	= 00H	get installed status
	01H	submit file to be printed
	02H	remove file from print queue
	03H	cancel all files in queue
	04H	hold print jobs for status read
	05H	end hold for status read

If AL is 01H:

DS:DX = segment:offset of packet address

If AL is 02H:

DS:DX = segment:offset of ASCIIZ file specification

Returns

If operation is successful:

Carry flag is clear.

If AL was 00H on call:

AL	= status:	
	00H	not installed, OK to install
	01H	not installed, not OK to install
	FFH	installed

If AL was 04H on call:

DX	= error count
DS:SI	= segment:offset of print queue

If operation is not successful:

Carry flag is set.

AX	= error code:	
	01H	function invalid
	02H	file not found
	03H	path not found

(more)

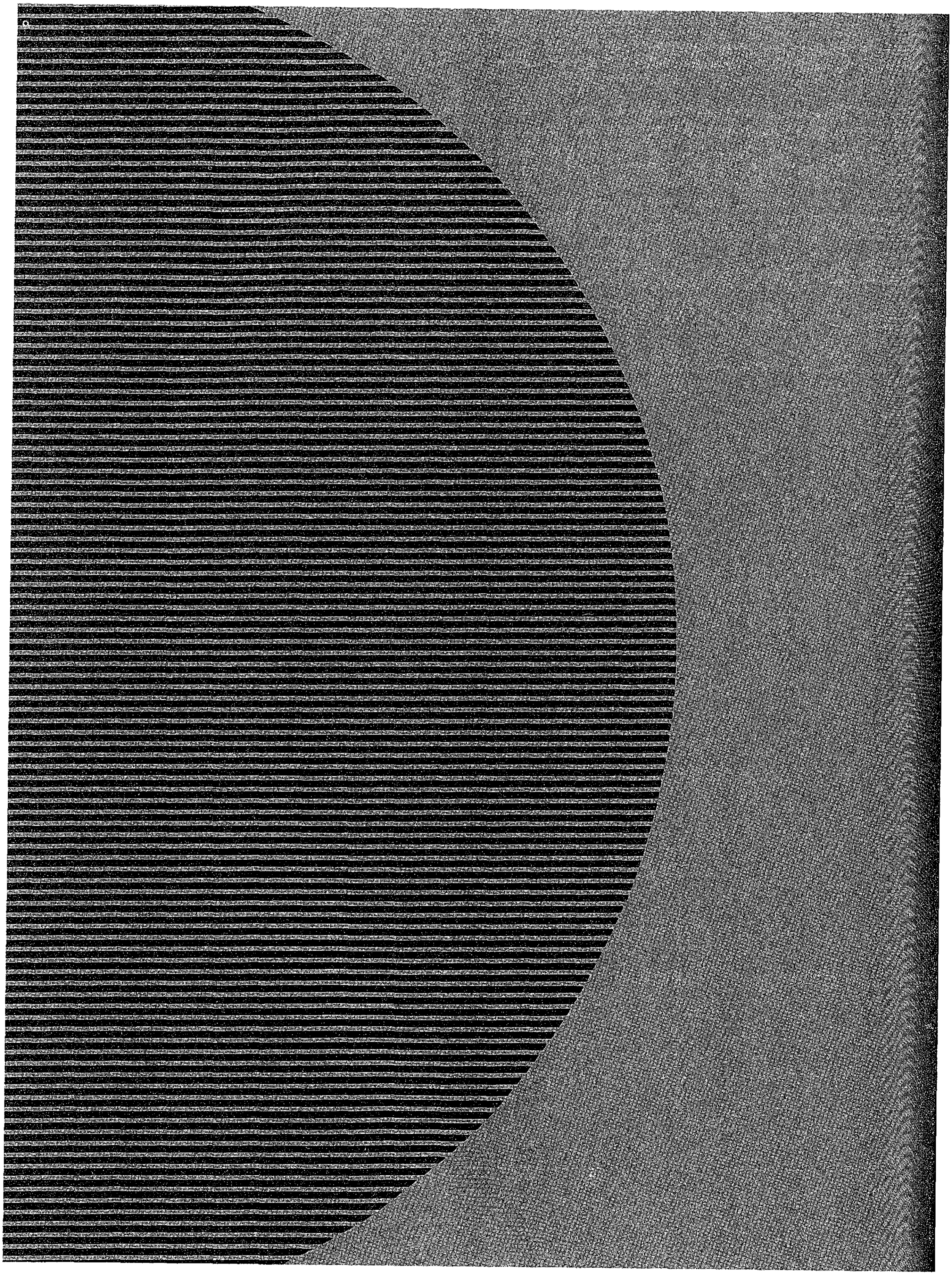
04H	too many open files
05H	access denied
08H	queue full
09H	spooler busy
0CH	name too long
0FH	drive invalid

Programmer's Notes

- For Subfunction 01H, the packet consists of 5 bytes. The first byte contains the level (must be zero), the next 4 bytes contain the doubleword address (segment and offset) of an ASCIIZ file specification. (The filename cannot contain wildcard characters.) If the file exists, it is added to the end of the print queue.
- For Subfunction 02H, wildcard characters (*and ?) are allowed in the file specification, making it possible to delete multiple files from the print queue with one call.
- For Subfunction 04H, the address returned for the print queue points to a series of filename entries. Each entry in the queue is 64 bytes and contains an ASCIIZ file specification. The first file specification in the queue is the one currently being printed. The last slot in the queue has a null (zero) in the first byte.

Example

None



Appendixes

Appendix A
MS-DOS Version 3.3

For the MS-DOS user, version 3.3 incorporates some long-awaited capabilities, runs faster in places, and requires about 9 KB more memory than version 3.2. Its most apparent changes, however, relate to a new, more flexible method of supporting different national languages. For the MS-DOS programmer, version 3.3 offers several enhancements in the areas of file management and internationalization support. This appendix offers an overview of these new features.

Version 3.3 User Considerations

MS-DOS version 3.3 has introduced several changes at the user level. A new external command, FASTOPEN, speeds up the filing system by keeping file locations in memory. A new batch command, CALL, lets a batch file call another batch file and, when that file terminates, continue execution with the next command in the original batch file rather than return to MS-DOS as in previous versions. Two commands previously present only in PC-DOS, COMP and SELECT, have been added to MS-DOS. Five commands have additional capabilities: APPEND, ATTRIB, BACKUP, FDISK, and MODE. In addition, the TIME and DATE commands automatically set the CMOS clock-calendar on the IBM PC/AT and PS/2 machines, making use of the separate SETUP program unnecessary for these functions. Changes to the national language support involve four new commands, three new options to the MODE command, two new or modified system information files, and two new device drivers. Each of these new or modified commands is discussed individually below.

The FASTOPEN command

When MS-DOS searches for a program file, it searches each directory specified in the PATH search path. A lengthy path that has to search many levels of a directory structure can make this a slow process. The FASTOPEN command loads a terminate-and-stay-resident (TSR) program that caches the locations of the most recently accessed directories and files on one or more fixed disks in the system. The number of files and directories to be cached is under the user's control; the default is 10. When it needs a file, MS-DOS looks first in the FASTOPEN list; if the file is found in the list, MS-DOS can bypass inspection of the search path specified by PATH. When the FASTOPEN list is filled and a new file is opened, the new file replaces the least recently used file on the FASTOPEN list.

The improvement in file-system performance depends on the number of open files and the frequency of file access. The FASTOPEN command can be entered only once during a session and, if desired, can be placed in the AUTOEXEC.BAT file.

The FASTOPEN command has two parameters:

FASTOPEN *drive*:[=*entries*][...]

The *drive* parameter is the drive letter, followed by a colon, of a fixed disk for which FASTOPEN is to keep track of the most recently accessed directories and files. More than one drive can be specified by separating the drive identifiers with spaces; the maximum is four drives. A drive associated with a JOIN, SUBST, or ASSIGN command cannot be specified, nor can a drive assigned to a network.

The optional *entries* parameter is the number of directory entries FASTOPEN is to keep in memory. The value of *entries* can be from 10 through 999; the default is 34. If more than one *entries* value is specified, their sum cannot exceed 999. Each entry subtracts 40 bytes from the RAM normally available to run application programs.

Examples: The following command tells MS-DOS to keep track of the last 50 directories and files on drive C:

```
C>FASTOPEN C:=50  <Enter>
```

The next command tells MS-DOS to keep track of the last 34 files on drives C and D:

```
C>FASTOPEN C: D:  <Enter>
```

Changes to batch-file processing

Batch-file processing also gains power in MS-DOS version 3.3. The user can now suppress the echo of all batch commands and call one batch file from another without terminating the first batch file.

@

With MS-DOS version 3.3, any line in a batch file preceded by @ is not echoed to the screen when the batch file is executed.

CALL

A batch file no longer needs to load an additional copy of COMMAND.COM in order to execute another batch file and return control to the calling batch file. The CALL command executes a batch file and returns to the next command in the calling batch file.

CALL commands can be nested. If an exit condition is provided, a batch file can even call itself; however, the input or output of a called batch file cannot be redirected or piped.

The CALL command has two parameters:

CALL *batch-file* [*parameters*]

The *batch-file* parameter is the name of the batch file to be executed. The file must be in the current drive and directory or in a drive and/or directory specified in the command path.

The optional *parameters* parameter represents any parameters that may be required by *batch-file.*

Example: Suppose the batch file SORTFILE.BAT accepts one parameter. The following command calls SORTFILE.BAT, specifying NAMES.TXT as the parameter:

```
CALL SORTFILE NAMES.TXT
```

If NAMES.TXT was specified as a command-line parameter to the *calling* batch file, the CALL command could be

```
CALL SORTFILE %1
```

Commands from PC-DOS

Two commands have been added to MS-DOS from earlier versions of PC-DOS: COMP, present in PC-DOS version 1.0, and SELECT, present in PC-DOS version 2.0.

COMP

The COMP command compares two files or sets of files and reports any differences encountered. FC, a similar file-comparison command present in MS-DOS versions 2.0 and later, is still included with MS-DOS 3.3. *See* USER COMMANDS: COMP; FC.

Syntax for the COMP command is

COMP [*drive*:][*filename1*] [*drive*:][*filename2*]

The optional *drive* parameter is the drive letter, followed by a colon, of the drive containing the file to be compared. The *filename1* parameter is the name and location of the file to compare to *filename2*; *filename2* is the name and location of the file to be compared against. Both filenames can be preceded by a path; wildcard characters are permitted in either filename.

Example: The following command tells MS-DOS to compare the file NEWFILE.TXT in the current drive and directory to the file OLDFILE.TXT in the \ARCHIVE directory on drive D and report any differences encountered:

```
C>COMP NEWFILE.TXT D:\ARCHIVE\OLDFILE.TXT  <Enter>
```

SELECT

The SELECT command creates a system disk with the time format, date format, and keyboard layout configured for a selected country. The syntax for SELECT is

SELECT [[*drive1*:] [*drive2*:][*path*]] [*country*][*keyboard*]

The optional *drive1* parameter is the drive containing a disk with the MS-DOS operating-system files, the FORMAT program, and the country configuration files. The *drive2* parameter is the drive containing the disk to be formatted with the country-specific information; this drive specifier can be followed by a path. The *country* parameter is a code that selects the date and time format; the information is taken from the COUNTRY.SYS system file. The *keyboard* parameter is a code that selects the desired keyboard layout. *See* KEYB below.

The SELECT command

- Formats the target disk.
- Creates CONFIG.SYS and AUTOEXEC.BAT files on the target disk.
- Copies the contents of the source disk to the destination disk.

Example: The following command, which assumes drive A contains a valid system disk and drive B contains the disk to be formatted, creates a bootable system disk that includes country-specific information and keyboard layout for Germany:

```
C>SELECT A: B: 049 GR  <Enter>
```

Enhanced commands

Several existing MS-DOS user commands have been given expanded capabilities in version 3.3. These are presented alphabetically in the next few pages. *See* USER COMMANDS: APPEND; ATTRIB; BACKUP; FDISK; MODE.

APPEND

The APPEND command specifies a search path for data files — files whose extensions are neither .COM, .EXE, nor .BAT — similar to the command path specified by the PATH command, which searches only for executable files *with* those extensions. APPEND has three forms, depending on whether it is being entered for the first time. When it is entered the first time, the APPEND command now has two optional switches:

APPEND [/E] [/X]

The /E switch makes the data path part of the environment, like the command path. The data path can then be displayed or changed with both the SET and APPEND commands and is inherited by child processes. (However, any changes made to the data path by the child process are lost when the child returns to its parent process.)

The /X switch causes calls to the Find First File functions (Interrupt 21H Functions 11H and 4EH) and the EXEC function (Interrupt 21H Function 4BH) to search the data path. If /X is not specified, only Interrupt 21H Function 0FH (Open File with FCB), Interrupt 21H Function 23H (Get File Size), and Interrupt 21H Function 3DH (Open File with Handle) system calls search the data path.

If either /X or /E is specified the first time APPEND is entered, a pathname cannot be included.

Subsequent uses of the command must take the form

APPEND [[*drive*:]*path*] [;[*drive*:]*path* ...]

or

APPEND ;

The *path* parameter is the name of a directory that is to be made part of the data path. The user can specify as many directory names as will fit in the 128 characters of the command line. Entries must be separated by semicolons. If APPEND is followed only by a semicolon, any previous APPEND paths are deleted.

Example: The following two APPEND commands make the data path part of the environment and put the directories C:\WORD\PROPOSAL, C:\WORD\REPORTS, and C:\123\BUDGET in the data path:

```
C>APPEND /E  <Enter>
C>APPEND C:\WORD\PROPOSAL;C:\WORD\REPORTS;C:\123\BUDGET  <Enter>
```

Because the data path usually involves frequently used directories, the APPEND command ordinarily is placed in the AUTOEXEC.BAT file.

Note: APPEND is a new command in PC-DOS version 3.3.

ATTRIB

The /S switch has been added to the ATTRIB command so that any attribute changes can be applied to all files in subdirectories contained in the specified directory.

Example: The following command sets the read-only attribute of all files in the directory C:\DOS and in all its subdirectories:

```
C>ATTRIB +R C:/DOS /S  <Enter>
```

BACKUP

A formatting parameter has been added to the BACKUP command in MS-DOS version 3.3. The /F switch tells MS-DOS to format the backup diskette if it hasn't been formatted. The /F switch formats the backup diskette to the maximum capacity of the backup drive, so a disk of lower capacity, such as a 360 KB diskette in a 1.2M drive, should not be used. If this switch is used, FORMAT.COM must be available in the current drive and directory or in one of the directories named in the environment's PATH string.

Performance of the BACKUP command has also been improved. Instead of storing each file separately on the backup disk, BACKUP stores only two files: BACKUP.*nnn*, which contains all the backed-up files, and CONTROL.*nnn*, which contains the pathnames of the backed-up files.

FDISK

FDISK can now create a new type of MS-DOS partition called an extended partition on a fixed disk. An extended partition can contain multiple logical drives and allows the use of very large fixed disks. Each logical drive is still limited to 32 MB.

An extended partition is not bootable. In order for the fixed disk to be bootable, it must also contain a primary MS-DOS partition that has been formatted using the FORMAT command with the /S switch so that it contains a system boot record and the operating-system files.

MODE

The MODE command now supports two additional serial ports (COM3 and COM4) and increases the maximum serial transmission rate to 19,200 baud.

Some additional options have been added to MODE to support code-page switching. *See* MODE Command Changes below.

New national language support

The new national language support in MS-DOS version 3.3 replaces the methods used in previous versions to change the keyboard layout and the display and printer character sets so that more than one language could be used. These changes are extensive: four new or modified system files, three new commands, four new options for the MODE command, a new parameter for the GRAFTABL command, and a new parameter for the COUNTRY and DEVICE configuration commands.

Code pages and code-page switching

The key element of the new national language support is the code page, a table of 256 character correspondence codes. MS-DOS recognizes both a hardware code page, which is the character correspondence table built into a device, and a prepared code page, which is an alternate character correspondence table available through MS-DOS. The current code page is the code page most recently selected.

The hardware code page for a device is determined by the country for which the device was manufactured. The user selects a prepared code page, from a list of five included with MS-DOS version 3.3, by using the new CP PREPARE option of the MODE command. *See* MODE Command Changes below.

The new national language support is often referred to as code-page switching because, after the devices and code pages required by the system have been defined, the only commands the user must deal with simply switch from one code page to another. In order to use the new national language support, device drivers must support code-page switching and the devices must be able to display the full character sets.

Code pages are numbered. The identifying numbers have no relationship to the country code introduced with previous versions of MS-DOS and used by the COUNTRY configuration command. Five code pages are included with version 3.3:

Page Number	Configuration
437	United States
850	Multilingual
860	Portugal
863	Canadian French
865	Norway/Denmark

Code page 437 is the character correspondence table used in previous versions of MS-DOS. Its character set supports United States English and includes many accented characters used in other languages. It is the hardware code page for most countries.

Code page 850 replaces two of the four box-drawing sets and some of the mathematical symbols in code page 437 with additional accented characters. It supports English and most Latin-based European languages.

Code page 860 is for Portuguese, code page 863 is for Canadian French, and code page 865 is for Norwegian/Danish. These pages are the hardware code pages for the specified countries.

Setting up the system for code-page switching

Although several commands are required to manage national language support, the process is fairly straightforward. Setting up the system requires the following:

- A DEVICE configuration command in CONFIG.SYS to load a driver for each device that supports code-page switching.
- An NLSFUNC command in AUTOEXEC.BAT to load the memory-resident national language support functions.
- A MODE CP PREPARE command in AUTOEXEC.BAT to prepare code pages for each device that supports code-page switching.
- A CHCP command in AUTOEXEC.BAT to select the initial code page.
- Optionally, a KEYB command in AUTOEXEC.BAT to select the initial keyboard layout.

After starting the system with these commands in CONFIG.SYS and AUTOEXEC.BAT, only a MODE CP SELECT command is required to change to a different language during an MS-DOS session.

The COUNTRY configuration command is still used to control country-specific characteristics such as the time and date format and currency symbol. An added parameter in the COUNTRY command lets the user also specify a code page. *See* Modified National Language Support Commands below.

The system files

MS-DOS version 3.3 includes four system files that support the national language functions: two device drivers and two system information files.

The device drivers are PRINTER.SYS and DISPLAY.SYS. These drivers implement code-page switching for the IBM Proprinter Model 4201 and Quietwriter III Model 5202 printers and for the EGA, PC Convertible LCD, and PS/2 display adapters. They also support all display adapters compatible with the EGA.

The information files are COUNTRY.SYS, which contains information such as time and date formats and currency symbols, and KEYBOARD.SYS, which contains the scan-code-to-ASCII translation tables for the various keyboard layouts.

The new support commands

The new national language support in MS-DOS version 3.3 adds three MS-DOS commands: Change Code Page (CHCP), Keyboard (KEYB), and National Language Support Functions (NLSFUNC).

CHCP

The Change Code Page (CHCP) command tells MS-DOS which code page to use for all devices that support code-page switching.

The NLSFUNC command must be executed before the CHCP command can be used.

CHCP is a system-wide command: It specifies the code page used by MS-DOS and each device attached to the system that supports code-page switching. The CP SELECT option of the MODE command, on the other hand, specifies the code page for a single device.

If the code page specified with CHCP is not compatible with a device, CHCP responds

```
Code page nnn not prepared for all devices
```

If the code page specified with CHCP was not first identified with the CP PREPARE option of the MODE command, CHCP responds

```
Code page nnn not prepared for system
```

The CHCP command has one optional parameter:

CHCP [*code-page*]

The *code-page* parameter is the three-digit number that specifies the code page MS-DOS is to use. If *code-page* is omitted, CHCP displays the current MS-DOS code page.

Examples: The following command changes the system code page to 850:

```
C>CHCP 850  <Enter>
```

If the current code page is 850 and CHCP is entered without parameters, MS-DOS responds:

```
Active code page: 850
```

KEYB

The Keyboard (KEYB) command selects a keyboard layout by changing the scan-code-to-ASCII translation table used by the keyboard driver. It replaces the KEYBxx commands used in earlier versions of MS-DOS to select keyboard layouts.

The first time KEYB is executed, it loads the memory-resident keyboard driver and the translation table, thereby increasing the size of MS-DOS by slightly more than 7 KB. Subsequent executions simply load a different translation table, which replaces the previously loaded translation table and accommodates a different country-specific keyboard layout.

The KEYB command has three optional parameters:

KEYB [*country*[,[*code-page*],*kbdfile*]]

The *country* parameter is one of the following two-character country codes:

Country	Code	Country	Code
Australia	US	Netherlands	NL
Belgium	BE	Norway	NO
Canada		Portugal	PO
English	US	Spain	SP
French	CF	Sweden	SV
Denmark	DK	Switzerland	
Finland	SU	French	SF
France	FR	German	SG
Germany	GR	United Kingdom	UK
Italy	IT	United States	US
Latin America	LA		

The *code-page* parameter is the three-digit number that specifies the code page defining the character set that MS-DOS is to use.

If the specified country code and code page aren't compatible, KEYB responds:

```
Code page requested nnn is not valid for given keyboard code
```

If KEYB is entered with no parameters, MS-DOS displays the currently active keyboard country code, keyboard code page, and console device code page.

Examples: The following command selects the French keyboard layout, code page 850, and the keyboard definition file named C:\DOS\KEYBOARD.SYS:

```
C>KEYB FR,850,C:\DOS\KEYBOARD.SYS  <Enter>
```

If the code page is omitted but the keyboard definition file is specified, the comma must be included to show the missing parameter:

```
C>KEYB FR,,C:\DOS\KEYBOARD.SYS  <Enter>
```

NLSFUNC

The National Language Support Function (NLSFUNC) command loads a memory-resident program that implements code-page switching. It also allows the user to name the file that contains country-specific information — such as date format, time format, and currency symbol — if there is no COUNTRY configuration command in CONFIG.SYS. NLSFUNC must be used before the Change Code Page (CHCP) command.

If national language support is needed for every session, NLSFUNC should be placed in the AUTOEXEC.BAT file.

The NLSFUNC command has one optional parameter:

NLSFUNC [*country-file*]

The *country-file* parameter is the name of the country information file (in most implementations of MS-DOS, COUNTRY.SYS). If *country-file* is omitted, MS-DOS defaults to the name of the country information file specified in the COUNTRY configuration command in CONFIG.SYS; if there is no COUNTRY configuration command in CONFIG.SYS, MS-DOS looks for a file named COUNTRY.SYS in the root directory of the current drive.

Example: The following command loads the NLSFUNC program and specifies C:\DOS\COUNTRY.SYS as the country information file:

```
C>NLSFUNC C:\DOS\COUNTRY.SYS  <Enter>
```

The modified support commands

The new national language support changes two configuration commands — COUNTRY and DEVICE — and two general MS-DOS commands — GRAFTABL and MODE.

COUNTRY

The COUNTRY configuration command now has three parameters:

COUNTRY=*country-code*,[*code-page*],[*country-file*]

The *country-code* parameter is one of the following three-digit country codes (identical to the specified country's international telephone prefix):

Country	Code	Country	Code
Arabia	785	Latin America	003
Australia	061	Netherlands	031
Belgium	032	Norway	047
Canada		Portugal	351
English	001	Spain	034
French	002	Sweden	046
Denmark	045	Switzerland	
Finland	358	French	041
France	033	German	041
Germany	049	United Kingdom	044
Israel	972	United States	001
Italy	039		

The *code-page* parameter is the three-digit number that specifies the code page defining the character set that MS-DOS is to use.

The *country-file* parameter is the name of the file that contains the country-specific information; the name of the file can be preceded by a drive and/or path. If *country-file* is omitted, MS-DOS defaults to the file COUNTRY.SYS, which it looks for in the root directory of the current drive.

The COUNTRY command is not required; if it is not included in CONFIG.SYS, MS-DOS defaults to country 001 (US), code page 437, and country information file COUNTRY.SYS in the root directory of the current drive.

Example: The following CONFIG.SYS command specifies the French country code, code page 850, and C:\DOS\COUNTRY.SYS as the country information file:

```
COUNTRY=033,850,C:\DOS\COUNTRY.SYS
```

DEVICE

Two options have been added to the DEVICE configuration command that allow the user to specify the display and printer drivers that support code-page switching.

The display driver that supports code-page switching is DISPLAY.SYS. It supports the IBM Enhanced Graphics Adapter (EGA), the IBM Personal System/2 display adapter, and all display adapters compatible with either of these. The Monochrome Display Adapter (MDA) and the Color/Graphics Adapter (CGA) do not support code-page switching.

If the ANSI.SYS display driver is also used, the DEVICE command that defines it must precede the DEVICE command that defines DISPLAY.SYS.

When used to specify the display driver, the DEVICE command has five parameters:

DEVICE=*driver* CON=(*type*[,[*hwcp*][,*prepcp*[,*sub-fonts*]]])

The *driver* parameter is the name of the file that contains the display driver; the filename can be preceded by a drive and/or path. If *driver* is omitted, MS-DOS defaults to the file DISPLAY.SYS, which it looks for in the root directory of the current drive.

The *type* parameter defines the type of display adapter attached to the system. It must be one of the following:

Code	Adapter
MONO	Monochrome display/printer adapter
CGA	Color/graphics adapter
EGA	Enhanced graphics adapter or IBM Personal System/2 display adapter
LCD	IBM PC Convertible liquid crystal display

The *hwcp* parameter is the three-digit number that specifies the hardware code page supported by the display adapter:

Code	Configuration
437	United States (default)
850	Multilingual
860	Portugal
863	Canadian French
865	Norway/Denmark

The *prepcp* parameter is the number of additional code pages the display can support. These are referred to as prepared code pages and must be defined by the CP PREPARE option of the MODE command. If *type* is either MONO or CGA, *prepcp* must be 0; the default is 0. If *type* is either EGA or LCD, *prepcp* can be any value from 1 through 12; the default is 1. If *hwcp* is 437, *prepcp* should be allowed to default to 1; if *hwcp* is not 437, *prepcp* should be set to 2.

The *sub-fonts* parameter is the number of subfonts supported for each code page. If *type* is either MONO or CGA, *sub-fonts* must be 0; the default is 0. If *type* is EGA, *sub-fonts* can be 1 or 2; the default is 2. If *type* is LCD, *sub-fonts* can be 1 or 2; the default is 1.

Example: The following CONFIG.SYS command specifies C:\DOS\DISPLAY.SYS as the display driver for an EGA whose hardware code page is 437. The parameter for prepared code pages is allowed to default to 1 and the parameter for subfonts is allowed to default to 2.

```
DEVICE=C:\DOS\DISPLAY.SYS CON=(EGA,437)
```

The printer driver that supports code-page switching is PRINTER.SYS. It supports the IBM Proprinter Model 4201, the IBM Quietwriter III Printer Model 5202, and all printers compatible with either of these.

When used to specify the printer driver, the DEVICE configuration command has five parameters:

DEVICE=*driver port*=(*type*[,[*hwcp*][,*prepcp*]])

The *driver* parameter is the name of the file that contains the printer driver; the filename can be preceded by a drive and/or path. If *driver* is omitted, MS-DOS defaults to the file PRINTER.SYS, which it looks for in the root directory of the current drive.

The *port* parameter is the MS-DOS device name of the printer port being defined: LPT1 (or PRN), LPT2, or LPT3. A different set of *type*, *hwcp*, and *prepcp* parameters can be specified for each of the three printer ports.

The *type* parameter defines the type of printer attached to the printer port. It must be one of the following:

Code	Printer
4201	IBM Proprinter Model 4201
5202	IBM Quietwriter III Printer Model 5202

The *hwcp* parameter is a three-digit number that specifies the hardware code page supported by the hardware:

Code	Configuration
437	United States (default)
850	Multilingual
860	Portugal
863	Canadian French
865	Norway/Denmark

If *type* is 5202, two hardware code-page numbers can be specified, enclosed in parentheses and separated by a comma. If two hardware code pages are specified, *prepcp* must be 0.

The *prepcp* parameter is the number of additional code pages (referred to as prepared code pages) for which MS-DOS must reserve buffer space; its value can be from 0 through 12. These additional code pages must be defined by the CP PREPARE option of the MODE command. If *hwcp* is 437, *prepcp* should be set to 1; if *hwcp* is not 437 and only one *hwcp* value is specified, *prepcp* should be set to 2.

Examples: The following CONFIG.SYS command defines C:\DOS\PRINTER.SYS as the printer driver for the PRN device. The printer is an IBM Proprinter Model 4201 whose hardware code page is 437, and MS-DOS is instructed to allow for one prepared code page:

```
DEVICE=C:\DOS\PRINTER.SYS PRN=(4201,437,1)
```

The next CONFIG.SYS command defines C:\DOS\PRINTER.SYS as the printer driver for ports LPT1 and LPT2. The printer attached to LPT1 is the same as in the previous command; the printer attached to LPT2 is an IBM Quietwriter III Printer Model 5202 with two hardware code pages (437 and 850). For the second printer, MS-DOS is instructed to allow for no prepared code pages.

```
DEVICE=C:\DOS\PRINTER.SYS LPT1=(4201,437,1) LPT2=(5202,(437,850),0)
```

GRAFTABL

The GRAFTABL command now has two forms:

GRAFTABL [*code-page*]

or

GRAFTABL /STATUS

The first form of the command loads a code page for the color/graphics adapter (CGA) so that its character set matches that used by MS-DOS and other devices when displaying the upper 128 characters. The *code-page* parameter is the three-digit number that specifies the code page defining the character set that GRAFTABL is to use.

The /STATUS switch causes GRAFTABL to display the name of the graphics character set table currently in use.

MODE

National language support adds four options to the MODE command:

Option	Action
CODEPAGE	Displays the code pages available and active.
CODEPAGE PREPARE	Defines the code pages selected for use.
CODEPAGE REFRESH	Restores code-page contents damaged by hardware error or other causes.
CODEPAGE SELECT	Selects a code page for a particular device.

(CODEPAGE can be abbreviated to CP in the command line.)

When used to display the status of the code pages, the MODE command has one parameter:

MODE *device* CP

The *device* parameter is the name of the device whose code-page status is to be displayed. It can be CON, PRN, LPT1, LPT2, or LPT3.

Example: The following command displays the status of the console device:

```
C>MODE CON CP  <Enter>
```

When used to define the code page or pages to be used with a device, the MODE command has three parameters:

MODE *device* CP PREPARE=(*code-page font-file*)

The *device* parameter is the name of the device for which the code page or pages are to be prepared. It can be CON, PRN, LPT1, LPT2, or LPT3.

The *code-page* parameter is one or more of the three-digit numbers, enclosed in parentheses, that specify the code page to be used with *device.* If more than one code-page number is specified, the numbers must be separated with spaces.

The *font-file* parameter is the name of the code-page file that contains the font information for *device.* The files provided for IBM devices include

File	Device
EGA.CPI	IBM Enhanced Graphics Adapter (EGA) and EGA-compatible display adapters
4201.CPI	IBM Proprinter Model 4201
5202.CPI	IBM Quietwriter III Printer Model 5202
LCD.CPI	IBM Convertible liquid crystal display

Example: Assume the display is attached to an EGA. The following command prepares code pages 437 and 850 for the console, specifying C:\DOS\EGA.CPI as the code-page information file:

```
C>MODE CON CP PREPARE=((437 850) C:\DOS\EGA.CPI)  <Enter>
```

When used to select a code page for a device, the MODE command has two parameters:

MODE *device* CP SELECT=*code-page*

The *device* parameter is the name of the device for which the code page is to be selected. Permissible values are CON, PRN, LPT1, LPT2, and LPT3.

The *code-page* parameter is the three-digit number that specifies the code page to be used with *device.*

Example: The following command selects code page 850 for the console:

```
C>MODE CON CP SELECT=850  <Enter>
```

Setting up code-page switching for an EGA-only system

Figure A-1 shows the commands required to implement the new national language support for a system that includes only a display attached to an EGA or EGA-compatible adapter. The hardware code page of the EGA is 437 (United States English) and the system is set up to handle code pages 437 and 850. All MS-DOS files are assumed to be in the directory \DOS on the disk in drive C. If the ANSI.SYS driver is not used, the configuration command DEVICE=C:\DOS\ANSI.SYS should be omitted from CONFIG.SYS; if ANSI.SYS is used, however, the DEVICE configuration command that defines it must precede the DEVICE configuration command that defines DISPLAY.SYS.

Commands in CONFIG.SYS:

```
COUNTRY=001,437,C:\DOS\COUNTRY.SYS
DEVICE=C:\DOS\ANSI.SYS
DEVICE=C:\DISPLAY.SYS CON=(EGA,437,1)
```

Commands in AUTOEXEC.BAT:

```
NLSFUNC C:\DOS\COUNTRY.SYS
MODE CON CP PREPARE=((437 850) C:\DOS\EGA.CPI)
MODE CON CP SELECT=437
KEYB US,437,C:\DOS\KEYBOARD.SYS
```

Figure A-1. Setup commands for a system with an EGA only.

When the system is started, code page 437 is selected for MS-DOS, the display, and the keyboard. To change to code page 850 during the session, simply type

```
C>CHCP 850  <Enter>
```

Setting up code-page switching for a PS/2 and printer

Figure A-2 shows the commands required to implement the new national language support for an IBM Personal System/2 or compatible system that includes both a PS/2, EGA, or EGA-compatible display adapter and an IBM Proprinter Model 4201. The hardware code page of both devices is 437 (United States English) and the system is set up to handle code pages 437 and 850.

Commands in CONFIG.SYS:

```
COUNTRY=001,437,C:\DOS\COUNTRY.SYS
DEVICE=C:\DOS\ANSI.SYS
DEVICE=C:\DISPLAY.SYS CON=(EGA,437,1)
DEVICE=C:\DOS\PRINTER.SYS PRN=(4201,437,1)
```

Commands in AUTOEXEC.BAT:

```
NLSFUNC C:\DOS\COUNTRY.SYS
MODE CON CP PREPARE=((437 850) C:\DOS\EGA.CPI)
MODE PRN CP PREPARE=((437 850) C:\DOS\4202.CPI)
MODE CON CP SELECT=850
MODE PRN CP SELECT=850
KEYB US,850,C:\DOS\KEYBOARD.SYS
```

Figure A-2. Setup commands for a PS/2 with display and printer.

Again, all MS-DOS files are assumed to be in the directory \DOS on the disk in drive C. If the ANSI.SYS driver is not used, the configuration command DEVICE=C:\DOS\ANSI.SYS should be omitted from CONFIG.SYS; if ANSI.SYS is used, however, the DEVICE configuration command that defines it must precede the DEVICE configuration command that defines DISPLAY.SYS.

Version 3.3 Programming Considerations

The changes introduced in MS-DOS version 3.3 that are of primary interest to the programmer include

- New Interrupt 21H function calls for file management and internationalization support
- An extension to the definition of the MS-DOS IOCTL function for code-page switching, plus the addition of the underlying device-driver support
- Support for extended MS-DOS partitions on fixed disks

Each of these areas is discussed in detail below.

New file-management functions

MS-DOS version 3.3 includes two new Interrupt 21H file-management functions: Set Handle Count (Function 67H) and Commit File (Function 68H).

Set Handle Count

The Set Handle Count function (Interrupt 21H Function 67H) allows a single process to have more than 20 handles for files or devices open simultaneously. Function 67H is invoked by issuing a software Interrupt 21H with

AH = 67H
BX = number of desired handles

On return,

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code

For each process, the operating system maintains a table that relates handle numbers for the process to MS-DOS's internal global table for all open files in the system. In MS-DOS versions 3.0 and later, the per-process table is ordinarily stored within the reserved area of the program segment prefix (PSP) and has only enough room for 20 handle entries. If 20 or fewer handles are requested in register BX, Function 67H takes no action and returns a success signal. If more than 20 handles are requested, however, Function 67H allocates on behalf of the calling program a new block of memory that is large enough to hold the expanded table of handle numbers and then copies the process's old handle table to the new table. Because the function will fail if the system does not have sufficient free memory to allocate the new block, most programs need to make a call to Interrupt 21H Function 4AH (Resize Memory Block) to "shrink" their initial memory block allocations before calling Function 67H.

Function 67H does not fail if the number requested is larger than the available entries in the system's global table for file and device handles. However, a subsequent attempt to open a file or device or to create a new file will fail if all the entries in the system's global file table are in use, even if the requesting process has not used up all its own handles. (The size of the global table is controlled by the FILES entry in the CONFIG.SYS file. *See* USER COMMANDS: CONFIG.SYS: FILES; PROGRAMMING IN THE MS-DOS ENVIRONMENT: PROGRAMMING FOR MS-DOS: File and Record Management.)

Example: Set the maximum handle count for the current process to 30, so that the process can have as many as 25 files or devices open simultaneously (5 of the handles are already expended by the MS-DOS standard devices when the process starts up). Note that a FILES=30 (or greater value) entry in the CONFIG.SYS file also is required for the process to successfully open 30 files or devices.

```
        .
        .
        .
        mov     ah,67h          ; Function 67H = set handle count.
        mov     bx,30           ; Maximum number of handles.
        int     21h             ; Transfer to MS-DOS.
        jc      error           ; Jump if function failed.
        .
        .
        .
```

Commit File

The Commit File function (Interrupt 21H Function 68H) forces all data in MS-DOS's internal buffers that is associated with a given handle to be written to disk and forces the corresponding disk directory and file allocation table (FAT) information to be updated. By calling this function at appropriate points within its execution, a program can ensure that newly entered data will not be lost if there is a power failure, if the program crashes, or if the user fails to terminate the program properly before turning off the machine. Function 68H is called by issuing a software Interrupt 21H with

AH = 68H
BX = handle for previously opened file.

On return,

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX = error code

The effect of Function 68H is equivalent to closing and reopening the file or to duplicating a file handle with Interrupt 21H Function 45H (Duplicate File Handle) and then closing the duplicate. *See* PROGRAMMING IN THE MS-DOS ENVIRONMENT: PROGRAMMING FOR MS-DOS: File and Record Management. However, Function 68H has the advantages that the application will not lose control of the file (as could happen with the close-open sequence in a networking environment) and that it will not fail because of a lack of handles (as the duplicate handle method might).

Note: Function 68H operations requested on a handle associated with a character device return a success flag but have no effect.

Example: Assume that the file MYFILE.DAT has been opened previously and that the handle for the file is stored in the variable *fhandle*. Call Function 68H to ensure that any data in MS-DOS's internal buffers associated with the handle is written out to disk and that the directory and FAT are up-to-date.

```
fname   db      'MYFILE.DAT',0  ; ASCIIZ filename.
fhandle dw      ?               ; Handle from Open operation.
        .
        .
        .
        mov     ah,68h          ; Function 68H = commit file.
        mov     bx,fhandle      ; Handle from previous open.
        int     21h             ; Transfer to MS-DOS.
        jc      error           ; Jump if function failed.
        .
        .
        .
```

New internationalization support functions

MS-DOS version 3.3 includes two new Interrupt 21H internationalization support functions: Get Extended Country Information (Function 65H) and Select Code Page (Function 66H).

Get Extended Country Information

The Get Extended Country Information function (Interrupt 21H Function 65H) returns a superset of the internationalization information obtained with Interrupt 21H Function 38H (Get/Set Current Country). Function 65H is called by issuing a software Interrupt 21H with

AH	= 65H	
AL	= information ID code:	
	01H	get general internationalization information
	02H	get pointer to uppercase table
	04H	get pointer to filename uppercase table
	06H	get pointer to collating sequence table
BX	= code page of interest (active CON device = –1)	
CX	= length of buffer to receive information (error returned if less than 5)	
DX	= country ID (default = –1)	
ES:DI	= address of buffer to receive information	

On return,

If function is successful:

Carry flag is clear.

Requested data is in calling program's buffer.

If function is not successful:

Carry flag is set.

AX = error code

Function 65H may fail if either the country code or the code-page number is invalid or if the code page does not match the country code. If the buffer to receive the information is at least 5 bytes but is too short for the requested information, the data is truncated and no error is returned.

The format of the data returned by Subfunction 01H in the calling program's buffer is

Field	Size
Information ID code (01H)	Byte
Length of following buffer (38 or less)	Word
Country ID	Word
Code-page number	Word
Date format	Word
Currency symbol	5 bytes
Thousands separator	Word
Decimal separator	Word
Date separator	Word
Time separator	Word
Currency format flags	Byte
Digits in currency	Byte
Time format	Byte
Monocase routine entry point	Doubleword
Data list separator	Word
Reserved	10 bytes

See SYSTEM CALLS: INTERRUPT 21H: Function 38H.

The format of the data returned by Subfunctions 02H, 04H, and 06H is

Field	Size
Information ID code (02H, 04H, or 06H)	Byte
Pointer to table	Doubleword

The uppercase and filename uppercase tables are 130 bytes. The first 2 bytes contain the size of the table; the subsequent 128 bytes contain the uppercase equivalents, if any, for character codes 80H through 0FFH. The main use of these tables is to map accented or otherwise modified vowels to their plain vowel equivalents. Text translated using these tables can be sent to devices that do not support the IBM graphics character set or can be used to create filenames that do not require a special keyboard configuration for entry.

The collating table is 258 bytes. The first 2 bytes contain the table length and the next 256 bytes contain the values to be used for the corresponding character codes (0–0FFH) during a sort operation. Among other things, this table maps uppercase and lowercase ASCII characters to the same collating codes (so that sorts will be case insensitive) and maps accented vowels to their plain vowel equivalents.

Note: In some cases, a truncated translation table might be presented to the program by MS-DOS. Applications should always check the length specified at the beginning of the table to be sure the table contains a translation code for the character of interest.

Example: Obtain the extended country information associated with the default country and code page 437.

```
buffer  db      41 dup (0)        ; Receives country information.
        .
        .
        .
        mov     ax,6501h          ; Function = get extended info.
        mov     bx,437            ; Code page.
        mov     cx,41             ; Length of buffer.
        mov     dx,-1             ; Default country.
        mov     di,seg buffer     ; ES:DI = buffer address.
        mov     es,di
        mov     di,offset buffer
        int     21h               ; Transfer to MS-DOS.
        jc      error             ; Jump if function failed.
        .
        .
        .
```

In this case, MS-DOS fills the following extended country information into the buffer:

```
buffer  db      1                 ; Information ID code
        dw      38                ; Length of following buffer
        dw      1                 ; Country ID (USA)
        dw      437               ; Code-page number
        dw      0                 ; Date format
        db      '$',0,0,0,0       ; Currency symbol
        db      ',',0             ; Thousands separator
        db      '.',0             ; Decimal separator
        db      '-',0             ; Date separator
        db      ':',0             ; Time separator
        db      0                 ; Currency format flags
        db      2                 ; Digits in currency
        db      0                 ; Time format
        dd      026ah:176ch       ; Monocase routine entry point
        db      ',',0             ; Data list separator
        db      10 dup (0)        ; Reserved
```

Example: Obtain the pointer to the uppercase table associated with the default country and code page 437.

```
buffer  db      5 dup (0)         ; Receives pointer information.
        .
        .
        .
        mov     ax,6502h          ; Function = get pointer to
                                  ; uppercase table.
```

(more)

```
        mov     bx,437          ; Code page.
        mov     cx,5            ; Length of buffer.
        mov     dx,-1           ; Default country.
        mov     di,seg buffer   ; ES:DI = buffer address.
        mov     es,di
        mov     di,offset buffer
        int     21h             ; Transfer to MS-DOS.
        jc      error           ; Jump if function failed.
        .
        .
        .
```

In this case, MS-DOS fills the following values into the buffer:

```
buffer  db      2               ; Information ID code
        dw      0204h           ; Offset of uppercase table
        dw      1140h           ; Segment of uppercase table
```

The table at 1140:0204H contains the following data:

```
            0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F  0123456789ABCDEF
1140:0200               80 00 80 9A 45 41 8E 41 8F 80 45 45      ....EA.A..EE
1140:0210  45 49 49 49 8E 8F 90 92 92 4F 99 4F 55 55 59 99  EIII.....O.OUUY.
1140:0220  9A 9B 9C 9D 9E 9F 41 49 4F 55 A5 A5 A6 A7 A8 A9  ......AIOU......
1140:0230  AA AB AC AD AE AF B0 B1 B2 B3 B4 B5 B6 B7 B8 B9  ................
1140:0240  BA BB BC BD BE BF C0 C1 C2 C3 C4 C5 C6 C7 C8 C9  ................
1140:0250  CA CB CC CD CE CF D0 D1 D2 D3 D4 D5 D6 D7 D8 D9  ................
1140:0260  DA DB DC DD DE DF E0 E1 E2 E3 E4 E5 E6 E7 E8 E9  ................
1140:0270  EA EB EC ED EE EF F0 F1 F2 F3 F4 F5 F6 F7 F8 F9  ................
1140:0280  FA FB FC FD FE FF                                ......
```

Select Code Page

The Select Code Page function (Interrupt 21H Function 66H) queries or selects the current code page. Function 66H is called by issuing a software Interrupt 21H with

AH = 66H
AL = subfunction:
    01H   get code page
    02H   select code page
BX = code page to select if AL = 02H

On return,

If function is successful:

Carry flag is clear.

If AL was 01H on call:

BX = active code page
DX = default code page

If function is not successful:

Carry flag is set.

AX = error code

When Subfunction 02H is used, MS-DOS gets the new code page from the COUNTRY.SYS file. The device must be previously prepared for code-page switching by including the appropriate DEVICE command in the CONFIG.SYS file and by issuing the NLSFUNC and MODE CP PREPARE commands (usually by placing them in the AUTOEXEC.BAT file).

Example: Force the active code page to be the same as the system's default code page—that is, return to the code page that was active when the system was first booted.

```
        .
        .
        .
        mov     ax,6601h        ; Function = get code page.
        int     21h             ; Transfer to MS-DOS.
        jc      error           ; Jump if function failed.

        mov     bx,dx           ; Force active page = default.

        mov     ax,6602h        ; Function = set code page.
        int     21h             ; Transfer to MS-DOS.
        jc      error           ; Jump if function failed.
        .
        .
        .
```

Extension of IOCTL

The MS-DOS IOCTL service (Interrupt 21H Function 44H) and its device-driver underpinnings have been extended to support code-page switching by the interactive CHCP and MODE commands or by application programs. The relevant IOCTL subfunction is 0CH (Generic IOCTL for Handles). An MS-DOS utility or application program gains access to this subfunction by executing a software Interrupt 21H with

AH = 44H
AL = 0CH
BX = handle for character device
CH = category code:

00H	unknown
01H	COM1, COM2, COM3, or COM4
03H	CON (keyboard and video display)
05H	LPT1, LPT2, or LPT3

(more)

CL	= function (minor) code:	
	4AH	select code page
	4CH	start code-page preparation
	4DH	end code-page preparation
	6AH	query selected code page
	6BH	query prepare list
DS:DX	= pointer to Generic IOCTL parameter block	

On return,

If function is successful:

Carry flag is clear.

If function is not successful:

Carry flag is set.

AX	= error code:	
	01H	invalid function number
	19H	bad data read from font file
	22H	unknown command
	26H	code page not prepared or selected
	27H	code page conflict or device or code page not found in file
	29H	device error
	31H	file contents not a valid font or no previous "start code-page preparation" call

Additional information about the cause of the error can be obtained with a call to Interrupt 21H Function 59H (Get Extended Error Information).

The parameter blocks for minor codes 4AH, 4DH, and 6AH have the following format:

Field	**Size**
Length of following data	Word
Code page ID	Word

The parameter block for minor code 4CH has the following format:

Field	**Size**
Flags	Word
Length of remainder of parameter block (2[*n*+1])	Word
Number of code pages in the following list (*n*)	Word

(more)

Field	Size
Code page 1	Word
Code page 2	Word
.	
.	
.	
Code page n	Word

The parameter block for minor code 6BH has the following format, assuming n hardware code pages and m prepared code pages (n <= 12, m <= 12):

Field	Size
Length of following data (2[n+m+2])	Word
Number of hardware code pages (n)	Word
Hardware code page 1	Word
Hardware code page 2	Word
.	
.	
.	
Hardware code page n	Word
Number of prepared code pages (m)	Word
Prepared code page 1	Word
Prepared code page 2	Word
.	
.	
.	
Prepared code page m	Word

After a Start Code-Page Preparation (minor code 4CH) call, the program must write the data defining the code-page font to the driver using one or more IOCTL Send Control Data to Character Device (Interrupt 21H Function 44H Subfunction 03H) calls. The format of the data is both device-specific and driver-specific. After the font data has been written to the driver, the program must issue an End Code-Page Preparation (minor code 4DH) call. If no data is written to the driver between the start and end calls, the driver interprets the newly prepared code pages as hardware code pages.

A special variation of Start Code-Page Preparation, called "refresh," is required to actually load the peripheral device with the prepared code pages. The refresh operation is obtained by calling minor code 4CH with each code-page position in the parameter block set to –1 and then immediately calling minor code 4DH.

The device-driver support that corresponds to IOCTL Subfunction 0CH is invoked by the MS-DOS kernel via the Generic IOCTL function (driver command code 19). The category (major) and function (minor) codes described above, along with a pointer to the parameter block, are passed to the driver in the request header. *See* PROGRAMMING IN THE MS-DOS ENVIRONMENT: CUSTOMIZING MS-DOS: Installable Device Drivers.

Extended MS-DOS partitions

An extended MS-DOS partition is indicated by a system indicator byte value of 05 in the partition table of the fixed disk's master boot record. *See* PROGRAMMING IN THE MS-DOS ENVIRONMENT: STRUCTURE OF MS-DOS: MS-DOS Storage Devices. An extended partition is not bootable and can be created on a bootable fixed-disk drive only if that drive already contains a primary MS-DOS partition (system indicator type 01 or 04). Fixed disks that are not bootable can contain an extended partition without a primary partition.

An extended partition is subdivided into extended logical disk volumes, each consisting of an extended boot record and a logical block device. The extended boot record is analogous in structure to the partition table for the fixed disk as a whole; it contains a logical drive table describing the volume and a pointer to the next extended logical volume. The logical block device is an image of a normal MS-DOS disk, including a master block (logical sector 0 containing the BPB describing the device), root directory, FAT, and files area. Each extended volume must start and end on a cylinder boundary.

Van Wolverton
Ray Duncan

Appendix B
Critical Error Codes

Critical errors are returned via Interrupt 24H. If register AL bit 7 is 0, then the error was a disk error; if register AL bit 7 is 1, then the error was a nondisk error. The upper half of DI is undefined; the lower half of DI contains one of the following error-condition codes:

Code	Description
00H	Attempt to write on write-protected disk
01H	Unknown drive or unit
02H	Drive not ready
03H	Invalid command
04H	Data error (CRC failed)
05H	Bad request structure length
06H	Seek error
07H	Unknown media type
08H	Sector not found
09H	Printer out of paper
0AH	Write fault
0BH	Read fault
0CH	General failure
0FH	Invalid disk change

Appendix C
Extended Error Codes

The extended error codes used by Interrupt 21H functions consist of four separate codes in the AX, BH, BL, and CH registers. These codes give as much detail as possible about the error and suggest how the issuing program should respond.

AX — Extended Error Code

If an error condition occurs in response to an Interrupt 21H function call, the carry flag is set and one of the following error codes is returned in AX:

Error	Description	Error	Description
01H	Invalid function code	16H	Invalid disk command
02H	File not found	17H	CRC error
03H	Path not found	18H	Invalid length (disk operation)
04H	Too many open files (no handles left)	19H	Seek error
		1AH	Not an MS-DOS disk
05H	Access denied	1BH	Sector not found
06H	Invalid handle	1CH	Out of paper
07H	Memory control blocks destroyed	1DH	Write fault
		1EH	Read fault
08H	Insufficient memory	1FH	General failure
09H	Invalid memory block address	20H	Sharing violation
0AH	Invalid environment	21H	Lock violation
0BH	Invalid format	22H	Wrong disk
0CH	Invalid access code	23H	FCB unavailable
0DH	Invalid data	24H	Sharing buffer overflow
0EH	Reserved	25–31H	Reserved
0FH	Invalid drive	32H	Network request not supported
10H	Attempt to remove the current directory	33H	Remote computer not listening
		34H	Duplicate name on network
11H	Not same device	35H	Network path not found
12H	No more files	36H	Network busy
13H	Disk is write-protected	37H	Network device no longer exists
14H	Bad disk unit	38H	Net BIOS command limit exceeded
15H	Drive not ready		

(more)

Error	Description	Error	Description
39H	Network adapter hardware error	45H	Net BIOS session limit exceeded
3AH	Incorrect response from network	46H	Sharing temporarily paused
		47H	Network request not accepted
3BH	Unexpected network error	48H	Print or disk redirection paused
3CH	Incompatible remote adapter	49-4FH	Reserved
3DH	Print queue full	50H	File exists
3EH	Print queue not full	51H	Reserved
3FH	Print file was canceled (not enough space)	52H	Cannot make directory entry
		53H	Fail on Interrupt 24H
40H	Network name was deleted	54H	Out of network structures
41H	Access denied	55H	Device already assigned
42H	Network device type incorrect	56H	Invalid password
43H	Network name not found	57H	Invalid parameter
44H	Network name limit exceeded	58H	Network data fault

BH — Error Class

BH returns a code that describes the class of error that occurred:

Class	Description
01H	Out of a resource, such as storage or channels
02H	Not an error, but a temporary situation (such as a locked region in a file) that can be expected to end
03H	Authorization problem
04H	An internal error in system software
05H	Hardware failure
06H	A system software failure not the fault of the active process (could be caused by missing or incorrect configuration files, for example)
07H	Application program error
08H	File or item not found
09H	File or item of invalid format or type or otherwise invalid or unsuitable
0AH	File or item interlocked
0BH	Wrong disk in drive, bad spot on disk, or other problem with storage medium
0CH	Other error

BL — Suggested Action

BL returns a code that suggests how the program should respond to the error:

Action	Description
01H	Retry, then prompt user.
02H	Retry after a pause.
03H	If the user entered data such as a drive letter or filename, prompt for it again.
04H	Terminate with cleanup.
05H	Terminate immediately. The system is so unhealthy that the program should exit as soon as possible without taking the time to close files and update indexes.
06H	Error is informational.
07H	Prompt the user to perform some action, such as changing disks, then retry the operation.

CH — Locus

CH returns a code that provides additional information to help locate the area involved in the failure. This code is particularly useful for hardware failures (BH = 05H).

Locus	Description
01H	Unknown
02H	Related to random-access block devices, such as a disk drive
03H	Related to network
04H	Related to serial-access character devices, such as a printer
05H	Related to random-access memory

Procedure

Programs should handle errors by noting the error returned in AX from the original system call and then invoking Interrupt 21H Function 59H to get the extended error information. If no extended error information is provided, the program should respond to the original error code.

The Function 59H system call is available during Interrupt 24H.

Appendix D
ASCII Character Set and IBM Extended Character Set

Char	Number		Control	Char	Number		Control
	Dec	Hex			Dec	Hex	
	0	00	NUL (Null)	#	35	23	
☺	1	01	SOH (Start of heading)	$	36	24	
☻	2	02	STX (Start of text)	%	37	25	
♥	3	03	ETX (End of text)	&	38	26	
♦	4	04	EOT (End of	’	39	27	
			transmission)	(	40	28	
♣	5	05	ENQ (Enquiry)	)	41	29	
♠	6	06	ACK (Acknowledge)	*	42	2A	
•	7	07	BEL (Bell)	+	43	2B	
◘	8	08	BS (Backspace)	,	44	2C	
○	9	09	HT (Horizontal tab)	-	45	2D	
◙	10	0A	LF (Linefeed)	.	46	2E	
♂	11	0B	VT (Vertical tab)	/	47	2F	
♀	12	0C	FF (Formfeed)	0	48	30	
♪	13	0D	CR (Carriage return)	1	49	31	
♫	14	0E	SO (Shift out)	2	50	32	
☼	15	0F	SI (Shift in)	3	51	33	
►	16	10	DLE (Data link escape)	4	52	34	
◄	17	11	DC1 (Device control 1)	5	53	35	
↕	18	12	DC2 (Device control 2)	6	54	36	
‼	19	13	DC3 (Device control 3)	7	55	37	
¶	20	14	DC4 (Device control 4)	8	56	38	
§	21	15	NAK (Negative	9	57	39	
			acknowledge)	:	58	3A	
▬	22	16	SYN (Synchronous idle)	;	59	3B	
↨	23	17	ETB (End transmission	<	60	3C	
			block)	=	61	3D	
↑	24	18	CAN (Cancel)	>	62	3E	
↓	25	19	EM (End of medium)	?	63	3F	
→	26	1A	SUB (Substitute)	@	64	40	
←	27	1B	ESC (Escape)	A	65	41	
∟	28	1C	FS (File separator)	B	66	42	
↔	29	1D	GS (Group separator)	C	67	43	
▲	30	1E	RS (Record separator)	D	68	44	
▼	31	1F	US (Unit separator)	E	69	45	
<space>	32	20		F	70	46	
!	33	21		G	71	47	
”	34	22		H	72	48	

(more)

	Number			Number				Number	
Char	**Dec**	**Hex**	**Char**	**Dec**	**Hex**	**Control**	**Char**	**Dec**	**Hex**
I	73	49	z	122	7A		½	171	AB
J	74	4A	{	123	7B		¼	172	AC
K	75	4B	¦	124	7C		¡	173	AD
L	76	4C	}	125	7D		«	174	AE
M	77	4D	~	126	7E		»	175	AF
N	78	4E	Δ	127	7F	DEL	░	176	B0
O	79	4F	Ç	128	80		▒	177	B1
P	80	50	ü	129	81		▓	178	B2
Q	81	51	é	130	82		│	179	B3
R	82	52	â	131	83		┤	180	B4
S	83	53	ä	132	84		╡	181	B5
T	84	54	à	133	85		╢	182	B6
U	85	55	å	134	86		╖	183	B7
V	86	56	ç	135	87		╕	184	B8
W	87	57	ê	136	88		╣	185	B9
X	88	58	ë	137	89		║	186	BA
Y	89	59	è	138	8A		╗	187	BB
Z	90	5A	ï	139	8B		╝	188	BC
[	91	5B	î	140	8C		╜	189	BD
\	92	5C	ì	141	8D		╛	190	BE
]	93	5D	Ä	142	8E		┐	191	BF
^	94	5E	Å	143	8F		└	192	C0
_	95	5F	É	144	90		┴	193	C1
`	96	60	æ	145	91		┬	194	C2
a	97	61	Æ	146	92		├	195	C3
b	98	62	ô	147	93		─	196	C4
c	99	63	ö	148	94		┼	197	C5
d	100	64	ò	149	95		╞	198	C6
e	101	65	û	150	96		╟	199	C7
f	102	66	ù	151	97		╚	200	C8
g	103	67	ÿ	151	98		╔	201	C9
h	104	68	Ö	152	99		╩	202	CA
i	105	69	Ü	154	9A		╦	203	CB
j	106	6A	¢	155	9B		╠	204	CC
k	107	6B	£	156	9C		═	205	CD
l	108	6C	¥	157	9D		╬	206	CE
m	109	6D	₧	158	9E		╧	207	CF
n	110	6E	ƒ	159	9F		╨	208	D0
o	111	6F	á	160	A0		╤	209	D1
p	112	70	í	161	A1		╥	210	D2
q	113	71	ó	162	A2		╙	211	D3
r	114	72	ú	163	A3		╘	212	D4
s	115	73	ñ	164	A4		╒	213	D5
t	116	74	Ñ	165	A5		╓	214	D6
u	117	75	ª	166	A6		╫	215	D7
v	118	76	º	167	A7		╪	216	D8
w	119	77	¿	168	A8		┘	217	D9
x	120	78	⌐	169	A9		┌	218	DA
y	121	79	¬	170	AA		█	219	DB

(more)

	Number			Number			Number	
Char	**Dec**	**Hex**	**Char**	**Dec**	**Hex**	**Char**	**Dec**	**Hex**
▄	220	DC	Φ	232	E8	⌠	244	F4
▌	221	DD	Θ	233	E9	⌡	245	F5
▐	222	DE	Ω	234	EA	÷	246	F6
▀	223	DF	δ	235	EB	≈	247	F7
α	224	E0	∞	236	EC	°	248	F8
β	225	E1	φ	237	ED	•	249	F9
Γ	226	E2	ε	238	EE	·	250	FA
π	227	E3	∩	239	EF	√	251	FB
Σ	228	E4	≡	240	F0	ⁿ	252	FC
σ	229	E5	±	241	F1	²	253	FD
μ	230	E6	≥	242	F2	■	254	FE
τ	231	E7	≤	243	F3		255	FF

Appendix E
EBCDIC Character Set

	Number			Number			Number	
Char	**Dec**	**Hex**	**Char**	**Dec**	**Hex**	**Char**	**Dec**	**Hex**
NUL	0	00		41	29		82	52
SOH	1	01	SM	42	2A		83	53
STX	2	02	CU2	43	2B		84	54
ETX	3	03		44	2C		85	55
PF	4	04	ENQ	45	2D		86	56
HT	5	05	ACK	46	2E		87	57
LC	6	06	BEL	47	2F		88	58
DEL	7	07		48	30		89	59
GE	8	08		49	31	!	90	5A
RLF	9	09	SYN	50	32	$	91	5B
SMM	10	0A		51	33	*	92	5C
VT	11	0B	PN	52	34	)	93	5D
FF	12	0C	RS	53	35	;	94	5E
CR	13	0D	UC	54	36	¬	95	5F
SO	14	0E	EOT	55	37	-	96	60
SI	15	0F		56	38	/	97	61
DLE	16	10		57	39		98	62
DC1	17	11		58	3A		99	63
DC2	18	12	CU3	59	3B		100	64
TM	19	13	DC4	60	3C		101	65
RES	20	14	NAK	61	3D		102	66
NL	21	15		62	3E		103	67
BS	22	16	SUB	63	3F		104	68
IL	23	17	Sp	64	40		105	69
CAN	24	18		65	41	¦	106	6A
EM	25	19		66	42	,	107	6B
CC	26	1A		67	43	%	108	6C
CU1	27	1B		68	44	_	109	6D
IFS	28	1C		69	45	>	110	6E
IGS	29	1D		70	46	?	111	6F
IRS	30	1E		71	47		112	70
IUS	31	IF		72	48		113	71
DS	32	20		73	49		114	72
SOS	33	21	¢	74	4A		115	73
FS	34	22	.	75	4B		116	74
	35	23	<	76	4C		117	75
BYP	36	24	(	77	4D		118	76
LF	37	25	+	78	4E		119	77
ETB	38	26	|	79	4F		120	78
ESC	39	27	&	80	50		121	79
	40	28		81	51		122	7A

	Number			Number			Number	
Char	**Dec**	**Hex**	**Char**	**Dec**	**Hex**	**Char**	**Dec**	**Hex**
#	123	7B	y	168	A8	N	213	D5
@	124	7C	z	169	A9	O	214	D6
'	125	7D		170	AA	P	215	D7
=	126	7E		171	AB	Q	216	D8
"	127	7F		172	AC	R	217	D9
	128	80		173	AD		218	DA
a	129	81		174	AE		219	DB
b	130	82		175	AF		220	DC
c	131	83		176	B0		221	DD
d	132	84		177	B1		222	DE
e	133	85		178	B2		223	DF
f	134	86		179	B3	\	224	E0
g	135	87		180	B4		225	E1
h	136	88		181	B5	S	226	E2
i	137	89		182	B6	T	227	E3
	138	8A		183	B7	U	228	E4
	139	8B		184	B8	V	229	E5
	140	8C		185	B9	W	230	E6
	141	8D		186	BA	X	231	E7
	142	8E		187	BB	Y	232	E8
	143	8F		188	BC	Z	233	E9
	144	90		189	BD		234	EA
j	145	91		190	BE		235	EB
k	146	92		191	BF	⑁	236	EC
l	147	93	{	192	C0		237	ED
m	148	94	A	193	C1		238	EE
n	149	95	B	194	C2		239	EF
o	150	96	C	195	C3	0	240	F0
p	151	97	D	196	C4	1	241	F1
q	152	98	E	197	C5	2	242	F2
r	153	99	F	198	C6	3	243	F3
	154	9A	G	199	C7	4	244	F4
	155	9B	H	200	C8	5	245	F5
	156	9C	I	201	C9	6	246	F6
	157	9D		202	CA	7	247	F7
	158	9E		203	CB	8	248	F8
	159	9F	⑀	204	CC	9	249	F9
	160	A0		205	CD	|	250	FA
~	161	A1	⑂	206	CE		251	FB
s	162	A2		207	CF		252	FC
t	163	A3	}	208	D0		253	FD
u	164	A4	J	209	D1		254	FE
v	165	A5	K	210	D2	EO	255	FF
w	166	A6	L	211	D3			
x	167	A7	M	212	D4			

Appendix F
ANSI.SYS Key and Extended Key Codes

The following escape sequence allows redefinition of keyboard keys to a specified *string*:

ESC[*code*;*string*;. . . p

where:

string is either the ASCII code for a single character or a string contained in quotation marks. For example, both 65 and "A" can be used to represent an uppercase A.

code is one or more of the following values that represent keyboard keys. Semicolons shown in this table must be entered in addition to the required semicolons in the command line.

Key	**Code**			
	Alone	**Shift-**	**Ctrl-**	**Alt-**
F1	0;59	0;84	0;94	0;104
F2	0;60	0;85	0;95	0;105
F3	0;61	0;86	0;96	0;106
F4	0;62	0;87	0;97	0;107
F5	0;63	0;88	0;98	0;108
F6	0;64	0;89	0;99	0;109
F7	0;65	0;90	0;100	0;110
F8	0;66	0;91	0;101	0;111
F9	0;67	0;92	0;102	0;112
F10	0;68	0;93	0;103	0;113
Home	0;71	55	0;119	–
Up Arrow	0;72	56	–	–
Pg Up	0;73	57	0;132	–
Left Arrow	0;75	52	0;115	–
Down Arrow	0;77	54	0;116	–
End	0;79	49	0;117	–
Down Arrow	0;80	50	–	–
Pg Dn	0;81	51	0;118	–
Ins	0;82	48	–	–
Del	0;83	46	–	–
PrtSc	–	–	0;114	–
A	97	65	1	0;30

(more)

Key	**Code**			
	Alone	**Shift-**	**Ctrl-**	**Alt-**
B	98	66	2	0;48
C	99	67	3	0;46
D	100	68	4	0;32
E	101	69	5	0;18
F	102	70	6	0;33
G	103	71	7	0;34
H	104	72	8	0;35
I	105	73	9	0;23
J	106	74	10	0;36
K	107	75	11	0;37
L	108	76	12	0;38
M	109	77	13	0;50
N	110	78	14	0;49
O	111	79	15	0;24
P	112	80	16	0;25
Q	113	81	17	0;16
R	114	82	18	0;19
S	115	83	19	0;31
T	116	84	20	0;20
U	117	85	21	0;22
V	118	86	22	0;47
W	119	87	23	0;17
X	120	88	24	0;45
Y	121	89	25	0;21
Z	122	90	26	0;44
1	49	33	–	0;120
2	50	64	–	0;121
3	51	35	–	0;122
4	52	36	–	0;123
5	53	37	–	0;124
6	54	94	–	0;125
7	55	38	–	0;126
8	56	42	–	0;127
9	57	40	–	0;128
0	48	41	–	0;129
–	45	95	–	0;130
=	61	43	–	0;131
Tab	9	0;15	–	–
Null	0;3	–	–	–

Appendix G
File Control Block (FCB) Structure

Figures G-1 and G-2 (memory block diagrams) and Tables G-1 and G-2 describe the structure of normal and extended file control blocks (FCBs).

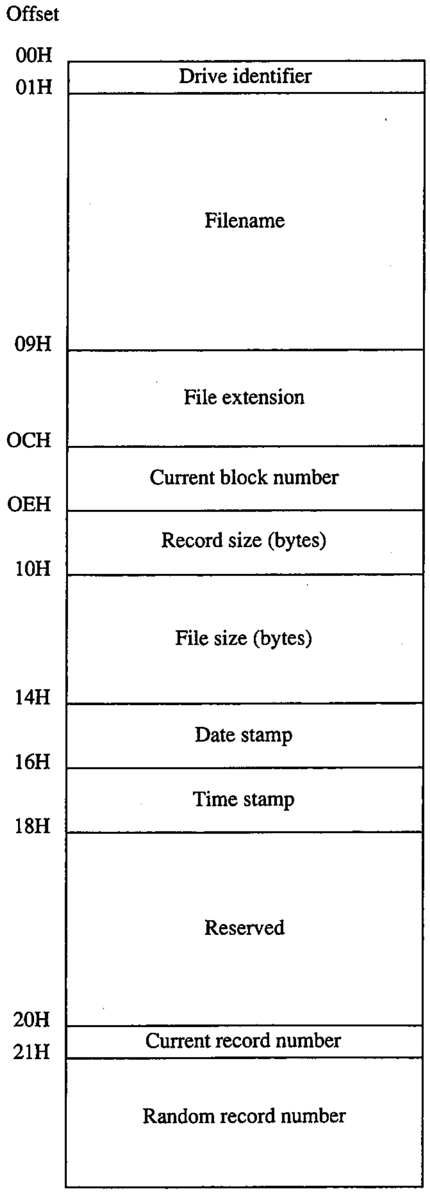


Figure G-1. Structure of a normal file control block.

Table G-1. Elements of a Normal File Control Block.

Element	Maintained by	Comments
Drive identifier	Program	Designates the drive on which the file to be opened or created resides (0 = default drive, 1 = drive A, 2 = drive B, and so on). If the application supplies a zero in this byte, MS-DOS alters the byte during the open or create operation to reflect the actual drive used.
Filename	Program	Standard eight-character filename; must be left justified and must be padded with blanks if fewer than eight characters. A device name (for example, PRN) can be used; there is no colon after a device name.
File extension	Program	Three-character file extension; must be left justified and must be padded with blanks if fewer than three characters.
Current block number	Program	Zero when the file is opened; the current block number and the current record number combined make up the record pointer during sequential file access.
Record size	Program	Set to 128 when the file is opened or created; the program can modify the field afterward to any desired record size.*
File size	MS-DOS	The size of the file in bytes; the first 2 bytes of this 4-byte field are the least significant bytes of the file size.
Date stamp	MS-DOS	The date of the last write operation on the file; follows the same format used by Interrupt 21H file handle Function 57H (Get/Set Time and Date): **Bits** **Contents** 9–15 Year (relative to 1980) 5–8 Month (1–12) 0–4 Day of month (1–31)
Time stamp	MS-DOS	The time of the last write operation on the file; follows the same format used by Interrupt 21H file handle Function 57H (Get/Set Time and Date): **Bits** **Contents** 11–15 Hours (0–23) 5–10 Minutes (0–59) 0–4 Number of 2-second increments (0–29)

(more)

Table G-1. *Continued.*

Element	Maintained by	Comments
Current record number	Program	Limited to the range 0 through 127; there are 128 records per block. The beginning of a file is record 0 of block 0. Together with the current block number, this field constitutes the record pointer used during sequential read and write operations. MS-DOS does not automatically initialize this field when a file is opened.
Random record pointer	Program	Identifies the record to be transferred by the Interrupt 21H random record functions 21H, 22H, 27H, and 28H; if the record size is 64 bytes or larger, only the first 3 bytes of this field are used. MS-DOS updates this field after random block reads and writes (Functions 27H and 28H) but not after random record reads and writes (Functions 21H and 22H).

* If the record size is made larger than 128 bytes, the default data transfer area (DTA) in the program segment prefix (PSP) cannot be used because it will collide with the program's own code or data.

Table G-2. Additional Elements of an Extended File Control Block.

Element	Maintained by	Comments
Extended FCB flag	Program	0FFH tells MS-DOS this is an extended (44-byte) FCB.
File attribute byte	Program	Must be initialized by the application when an extended FCB is used to open or create a file. The bits of this field have the following significance: **Bit** **Meaning** 0 Read-only 1 Hidden 2 System 3 Volume label 4 Directory 5 Archive 6 Reserved 7 Reserved

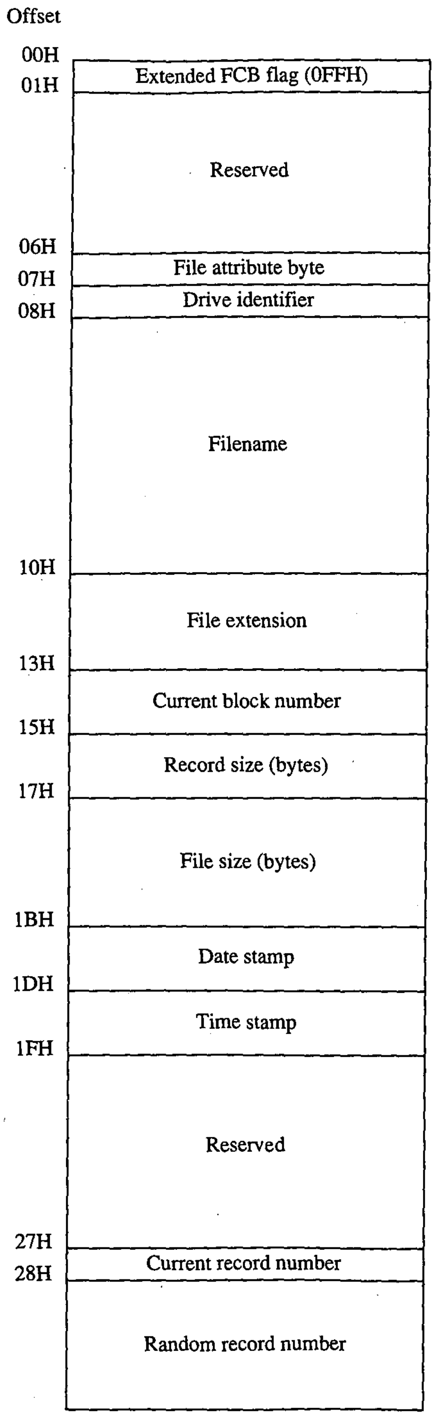
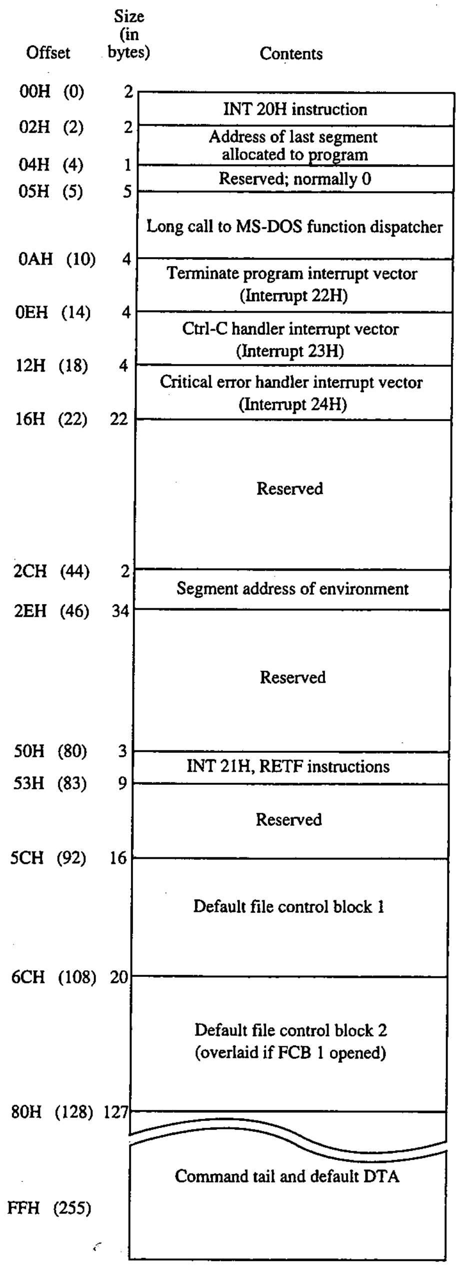


Figure G-2. Structure of an extended file control block.

Appendix H
Program Segment Prefix (PSP) Structure



Offset	Size (in bytes)	Contents
00H (0)	2	INT 20H instruction
02H (2)	2	Address of last segment allocated to program
04H (4)	1	Reserved; normally 0
05H (5)	5	Long call to MS-DOS function dispatcher
0AH (10)	4	Terminate program interrupt vector (Interrupt 22H)
0EH (14)	4	Ctrl-C handler interrupt vector (Interrupt 23H)
12H (18)	4	Critical error handler interrupt vector (Interrupt 24H)
16H (22)	22	Reserved
2CH (44)	2	Segment address of environment
2EH (46)	34	Reserved
50H (80)	3	INT 21H, RETF instructions
53H (83)	9	Reserved
5CH (92)	16	Default file control block 1
6CH (108)	20	Default file control block 2 (overlaid if FCB 1 opened)
80H (128)	127	Command tail and default DTA
FFH (255)		

Figure H-1 (memory block diagram) illustrates the structure of the program segment prefix (PSP).

Figure H-1. Structure of the program segment prefix.

Appendix I
8086/8088/80286/80386 Instruction Sets

The 8086/8088 Instruction Set

Mnemonic	Description	Mnemonic	Description
AAA	ASCII adjust after addition	JB	Jump on below
AAD	ASCII adjust before division	JBE	Jump on below or equal
AAM	ASCII adjust after multiplication	JC	Jump on carry
AAS	ASCII adjust after subtraction	JCXZ	Jump on CX zero
ADC	Add with carry	JE	Jump on equal
ADD	Add	JG	Jump on greater
AND	Logical AND	JGE	Jump on greater or equal
CALL	Call procedure	JL	Jump on less than
CBW	Convert byte to word	JLE	Jump on less than or equal
CLC	Clear carry flag	JMP	Jump unconditionally
CLD	Clear direction flag	JNA	Jump on not above
CLI	Clear interrupt flag	JNAE	Jump on not above or equal
CMC	Complement carry flag	JNB	Jump on not below
CMP	Compare	JNBE	Jump on not below or equal
CMPS	Compare string	JNC	Jump on no carry
CMPSB	Compare byte string	JNE	Jump on not equal
CMPSW	Compare word string	JNG	Jump on not greater
CWD	Convert word to doubleword	JNGE	Jump on not greater or equal
DAA	Decimal adjust for addition	JNL	Jump on not less than
DAS	Decimal adjust for subtraction	JNLE	Jump on not less than or equal
DEC	Decrement by 1	JNO	Jump on not overflow
DIV	Unsigned divide	JNP	Jump on not parity
ESC	Escape	JNS	Jump on not sign
HLT	Halt	JNZ	Jump on not zero
IDIV	Integer divide	JO	Jump on overflow
IMUL	Integer multiply	JP	Jump on parity
IN	Input from port	JPE	Jump on parity even
INC	Increment by 1	JPO	Jump on parity odd
INT	Call to interrupt procedure	JS	Jump on sign
INTO	Interrupt on overflow	JZ	Jump on zero
IRET	Interrupt on return	LAHF	Load AH with flags
JA	Jump on above	LDS	Load pointer into DS
JAE	Jump on above or equal	LEA	Load effective address

(more)

Mnemonic	Description	Mnemonic	Description
LES	Load pointer into ES	REPNE	Repeat while not equal
LOCK	Lock the bus	REPNZ	Repeat while not zero
LODS	Load string	REPZ	Repeat while zero
LODSB	Load byte (string)	RET	Return
LODSW	Load word (string)	ROL	Rotate left
LOOP	Loop	ROR	Rotate right
LOOPE	Loop while equal	SAHF	Store AH into flags
LOOPNE	Loop while not equal	SAL	Shift arithmetic left
LOOPNZ	Loop while not zero	SAR	Shift arithmetic right
LOOPZ	Loop while zero	SBB	Subtract with borrow
MOV	Move data	SCAS	Scan string
MOVS	Move data from string to string	SCASB	Scan byte (string)
MOVSB	Move byte (string)	SCASW	Scan word (string)
MOVSW	Move word (string)	SHL	Shift logical left
MUL	Multiply	SHR	Shift logical right
NEG	Negate	STC	Set carry flag
NOP	No operation	STD	Set direction flag
NOT	Logical NOT	STI	Set interrupt flag
OR	Logical OR	STOS	Store string
OUT	Output to port	STOSB	Store byte (string)
POP	Pop top of stack	STOSW	Store word (string)
POPF	Pop stack into flags	SUB	Subtract
PUSH	Push onto stack	TEST	Logical compare
PUSHF	Push flags onto stack	WAIT	Enter wait state
RCL	Rotate through carry left	XCHG	Exchange
RCR	Rotate through carry right	XLAT	Translate
REP	Repeat	XOR	Exclusive OR
REPE	Repeat while equal		

The 80286 Instruction Set

Mnemonic	Description	Mnemonic	Description
AAA	ASCII adjust after addition	AND	Logical AND
AAD	ASCII adjust before division	ARPL	Adjust RPL field of selector
AAM	ASCII adjust after multiplication	BOUND	Check array index against bounds
AAS	ASCII adjust after subtraction	CALL	Call procedure
ADC	Add with carry	CBW	Convert byte to word
ADD	Add	CLC	Clear carry flag

(more)

Mnemonic	Description	Mnemonic	Description
CLD	Clear direction flag	JNE	Jump on not equal
CLI	Clear interrupt flag	JNG	Jump on not greater
CLTS	Clear task switched flag	JNGE	Jump on not greater or equal
CMC	Complement carry flag	JNL	Jump on not less than
CMP	Compare	JNLE	Jump on not less than or equal
CMPS	Compare string	JNO	Jump on not overflow
CMPSB	Compare byte string	JNP	Jump on not parity
CMPSW	Compare word string	JNS	Jump on not sign
CWD	Convert word to doubleword	JNZ	Jump on not zero
DAA	Decimal adjust for addition	JO	Jump on overflow
DAS	Decimal adjust for subtraction	JP	Jump on parity
DEC	Decrement by 1	JPE	Jump on parity even
DIV	Unsigned divide	JPO	Jump on parity odd
ENTER	Make stack frame (for procedure parameters)	JS	Jump on sign
		JZ	Jump on zero
ESC	Escape	LAHF	Load AH with flags
HLT	Halt	LAR	Load access-rights byte
IDIV	Integer divide	LDS	Load pointer into DS
IMUL	Integer multiply	LEA	Load effective address
IN	Input from port	LEAVE	High-level procedure exit
INC	Increment by 1	LES	Load pointer into ES
INS	Input string from port	LGDT	Load global descriptor table
INT	Call to interrupt procedure	LIDT	Load interrupt descriptor table
INTO	Interrupt on overflow	LLDT	Load local descriptor table
IRET	Interrupt on return	LMSW	Load machine status word
JA	Jump on above	LOCK	Lock the bus
JAE	Jump on above or equal	LODS	Load string
JB	Jump on below	LODSB	Load byte (string)
JBE	Jump on below or equal	LODSW	Load word (string)
JC	Jump on carry	LOOP	Loop
JCXZ	Jump on CX zero	LOOPE	Loop while equal
JE	Jump on equal	LOOPNE	Loop while not equal
JG	Jump on greater	LOOPNZ	Loop while not zero
JGE	Jump on greater or equal	LOOPZ	Loop while zero
JL	Jump on less than	LSL	Load segment limit
JLE	Jump on less than or equal	LTR	Load task register
JMP	Jump unconditionally	MOV	Move data
JNA	Jump on not above	MOVS	Move data from string to string
JNAE	Jump on not above or equal	MOVSB	Move byte (string)
JNB	Jump on not below	MOVSW	Move word (string)
JNBE	Jump on not below or equal	MUL	Multiply
JNC	Jump on no carry	NEG	Negate

(more)

Mnemonic	Description	Mnemonic	Description
NOP	No operation	SCAS	Scan string
NOT	Logical NOT	SCASB	Scan byte (string)
OR	Logical OR	SCASW	Scan word (string)
OUT	Output to port	SGDT	Store global descriptor table
OUTS	Output string to port	SHL	Shift logical left
POP	Pop top of stack	SHR	Shift logical right
POPA	Pop eight 16-bit registers	SIDT	Store interrupt descriptor table
POPF	Pop stack into flags	SLDT	Store local descriptor table
PUSH	Push onto stack	SMSW	Store machine status word
PUSHA	Push eight 16-bit registers	STC	Set carry flag
PUSHF	Push flags onto stack	STD	Set direction flag
RCL	Rotate through carry left	STI	Set interrupt flag
RCR	Rotate through carry right	STOS	Store string
REP	Repeat	STOSB	Store byte (string)
REPE	Repeat while equal	STOSW	Store word (string)
REPNE	Repeat while not equal	STR	Store task register
REPNZ	Repeat while not zero	SUB	Subtract
REPZ	Repeat while zero	TEST	Logical compare
RET	Return	VERR	Verify a segment for reading
ROL	Rotate left	VERW	Verify a segment for writing
ROR	Rotate right	WAIT	Enter wait state
SAHF	Store AH into flags	XCHG	Exchange
SAL	Shift arithmetic left	XLAT	Translate
SAR	Shift arithmetic right	XOR	Exclusive OR
SBB	Subtract with borrow		

The 80386 Instruction Set

Mnemonic	Description	Mnemonic	Description
AAA	ASCII adjust after addition	BSF	Bit scan forward
AAD	ASCII adjust before division	BSR	Bit scan reverse
AAM	ASCII adjust after multiplication	BT	Bit test
AAS	ASCII adjust after subtraction	BTC	Bit test and complement
ADC	Add with carry	BTR	Bit test and reset
ADD	Add	BTS	Bit test and set
AND	Logical AND	CALL	Call procedure
ARPL	Adjust RPL field of selector	CBW	Convert byte to word
BOUND	Check array index against bounds	CDQ	Convert doubleword to quad word

(more)

Mnemonic	Description	Mnemonic	Description
CLC	Clear carry flag	JMP	Jump unconditionally
CLD	Clear direction flag	JNA	Jump on not above
CLI	Clear interrupt flag	JNAE	Jump on not above or equal
CLTS	Clear task switched flag	JNB	Jump on not below
CMC	Complement carry flag	JNBE	Jump on not below or equal
CMP	Compare	JNC	Jump on no carry
CMPS	Compare string	JNE	Jump on not equal
CMPSB	Compare byte string	JNG	Jump on not greater
CMPSD	Compare doubleword string	JNGE	Jump on not greater or equal
CMPSW	Compare word string	JNL	Jump on not less than
CWD	Convert word to doubleword	JNLE	Jump on not less than or equal
DAA	Decimal adjust for addition	JNO	Jump on not overflow
DAS	Decimal adjust for subtraction	JNP	Jump on not parity
DEC	Decrement by 1	JNS	Jump on not sign
DIV	Unsigned divide	JNZ	Jump on not zero
ENTER	Make stack frame	JO	Jump on overflow
	(for procedure parameters)	JP	Jump on parity
ESC	Escape	JPE	Jump on parity even
HLT	Halt	JPO	Jump on parity odd
IDIV	Integer divide	JS	Jump on sign
IMUL	Integer multiply	JZ	Jump on zero
IN	Input from port	LAHF	Load AH with flags
INC	Increment by 1	LAR	Load access-rights byte
INS	Input string from port	LDS	Load pointer into DS
INSD	Input doubleword from port	LEA	Load effective address
INT	Call to interrupt procedure	LEAVE	High-level procedure exit
INTO	Interrupt on overflow	LES	Load pointer into ES
IRET	Interrupt on return	LFS	Load pointer into FS
IRETD	Interrupt return to	LGDT	Load global descriptor table
	virtual 8086 mode	LGS	Load pointer into GS
JA	Jump on above	LIDT	Load interrupt descriptor table
JAE	Jump on above or equal	LLDT	Load local descriptor table
JB	Jump on below	LMSW	Load machine status word
JBE	Jump on below or equal	LOCK	Lock the bus
JC	Jump on carry	LODS	Load string
JCXZ	Jump on CX zero	LODSB	Load byte (string)
JE	Jump on equal	LODSD	Load doubleword (string)
JECXZ	Jump on ECX zero	LODSW	Load word (string)
JG	Jump on greater	LOOP	Loop
JGE	Jump on greater or equal	LOOPE	Loop while equal
JL	Jump on less than	LOOPNE	Loop while not equal
JLE	Jump on less than or equal	LOOPNZ	Loop while not zero

(more)

Mnemonic	Description	Mnemonic	Description
LOOPZ	Loop while zero	ROL	Rotate left
LSL	Load segment limit	ROR	Rotate right
LSS	Load pointer into SS	SAHF	Store AH into flags
LTR	Load task register	SAL	Shift arithmetic left
MOV	Move data	SAR	Shift arithmetic right
MOVS	Move data from string to string	SBB	Subtract with borrow
MOVSB	Move byte (string)	SCAS	Scan string
MOVSD	Move doubleword (string)	SCASB	Scan byte (string)
MOVSW	Move word (string)	SCASD	Scan doubleword (string)
MOVSX	Move with sign extend	SCASW	Scan word (string)
MOVZX	Move with zero extend	SET	Byte set on condition
MUL	Multiply	SGDT	Store global descriptor table
NEG	Negate	SHL	Shift logical left
NOP	No operation	SHLD	Double precision shift left
NOT	Logical NOT	SHR	Shift logical right
OR	Logical OR	SHRD	Double precision shift right
OUT	Output to port	SIDT	Store interrupt descriptor table
OUTS	Output string to port	SLDT	Store local descriptor table
POP	Pop top of stack	SMSW	Store machine status word
POPA	Pop eight 16-bit registers	STC	Set carry flag
POPAD	Pop eight 32-bit registers	STD	Set direction flag
POPF	Pop stack into flags	STI	Set interrupt flag
POPFD	Loads doubleword into EFLAGS	STOS	Store string
PUSH	Push onto stack	STOSB	Store byte (string)
PUSHA	Push eight 16-bit registers	STOSD	Store doubleword (string)
PUSHAD	Push eight 32-bit registers	STOSW	Store word (string)
PUSHED	Push EFLAGS	STR	Store task register
PUSHF	Push flags onto stack	SUB	Subtract
RCL	Rotate through carry left	TEST	Logical compare
RCR	Rotate through carry right	VERR	Verify a segment for reading
REP	Repeat	VERW	Verify a segment for writing
REPE	Repeat while equal	WAIT	Enter wait state
REPNE	Repeat while not equal	XCHG	Exchange
REPNZ	Repeat while not zero	XLAT	Translate
REPZ	Repeat while zero	XOR	Exclusive OR
RET	Return		

Appendix J
Common MS-DOS Filename Extensions

The Microsoft systems programs and language products commonly use the following filename extensions:

Extension	Program/System	Description
.@@@	MS-DOS	Backup ID file
.$$$	EDLIN	Backup filename if out of disk space; error condition
.ASC	Generic	ASCII text file
.ASM	MASM	Assembly-language source code
.BAK	Generic	Backup file
.BAS	BASIC	BASIC language source code
.BAT	MS-DOS	Batch file (contains MS-DOS command lines)
.BIN	Generic	Binary file
.C	C	C language source code
.CAL	Windows	Calendar file
.COB	COBOL	COBOL language source code
.COD	Generic	Object listing file
.COM	MS-DOS	Executable program file
.CRD	Windows	Cardfile file
.CRF	MASM	Cross-reference file
.DAT	Generic	Data file
.DBG	COBOL	Debug file
.DEF	Windows	Module definition file
.DOC	Generic	Documentation or document file
.DRV	Generic	Driver file
.ERR	Generic	Error file
.EXE	MS-DOS	Executable program file
.FNT	Generic	Font file
.FON	Generic	Font file
.FOR	FORTRAN	FORTRAN language source code
.GRB	Windows	Grab file (snapshot)
.H	C	Include file
.HEX	MS-DOS	INTEL hexadecimal format file
.HLP	Generic	Help file
.INC	Generic	Include file
.INI	Windows	Initialization file

(more)

Extension	Program/System	Description
.INT	COBOL	Object file
.LIB	Generic	Library file
.LST	Generic	List file
.MAP	Generic	Address map file
.MOD	Generic	Module file
.MSG	COBOL	Message file
.MSP	Windows	Windows Paint file
.OBJ	Generic	Relocatable object module
.OVL	Generic	Overlay file
.OVR	COBOL	Compiler overlay file
.PAS	PASCAL	PASCAL language source code
.PIF	Windows	Program information file
.QLB	Generic	Library file for Microsoft's Quick products
.RC	Windows	Resource script file
.REF	CREF	Cross-reference listing file
.RES	Windows	Compiled resource file
.SCR	Generic	Script file
.SYM	Generic	Symbol file
.SYS	Generic	System file or device driver
.TMP	Generic	Temporary file
.TRM	Windows	Terminal file
.TXT	Generic	Text file or Windows Notepad file
.WRI	Windows	Write file

Appendix K
Segmented (New) .EXE File Header Format

Microsoft Windows requires much more information about a program than is available in the format of the .EXE executable file supported by MS-DOS. For example, Windows needs to identify the various segments of a program as code segments or data segments, to identify exported and imported functions, and to store the program's resources (such as icons, cursors, menus, and dialog-box templates). Windows must also support dynamically linkable library modules containing routines that programs and other library modules can call. For this reason, Windows programs use an expanded .EXE header format called the New Executable file header format. This format is used for Windows programs, Windows library modules, and resource-only files such as the Windows font resource files.

The Old Executable Header

The New Executable file header format incorporates the existing MS-DOS executable file header format. In fact, the beginning of a New Executable file is simply a normal MS-DOS .EXE header. The 4 bytes at offset 3CH are a pointer to the beginning of the New Executable header. (Offsets are from the beginning of the Old Executable header.)

Offset	Length (bytes)	Contents
00H	1	Signature byte *M*
01H	1	Signature byte *Z*
3CH	4	Offset of New Executable header from beginning of file

This normal MS-DOS .EXE header can contain size and relocation information for a non-Windows MS-DOS program that is contained within the .EXE file along with the Windows program. This program is run when the .EXE file is executed from the MS-DOS command line. Most Windows programmers use a standard program that simply prints the message *This program requires Microsoft Windows.*

The New Executable Header

The beginning of the New Executable file header contains information about the location and size of various tables within the header. (Offsets are from the beginning of the New Executable header.)

Offset	Length (bytes)	Contents
00H	1	Signature byte *N*
01H	1	Signature byte *E*
02H	1	LINK version number
03H	1	LINK revision number
04H	2	Offset of beginning of entry table relative to beginning of New Executable header
06H	2	Length of entry table
08H	4	32-bit checksum of entire contents of file, using zero for these 4 bytes
0CH	2	Module flag word (*see* below)
0EH	2	Segment number of automatic data segment (0 if neither SINGLEDATA nor MULTIPLEDATA flag is set in flag word)
10H	2	Initial size of local heap to be added to automatic data segment (0 if there is no local heap)
12H	2	Initial size of stack to be added to automatic data segment (0 for library modules)
14H	2	Initial value of instruction pointer (IP) register on entry to program
16H	2	Initial segment number for setting code segment (CS) register on entry to program
18H	2	Initial value of stack pointer (SP) register on entry to program (0 if stack segment is automatic data segment; stack should be set above static data area and below local heap in automatic data segment)

(more)

Offset	Length (bytes)	Contents
1AH	2	Segment number for setting stack segment (SS) register on entry to program (0 for library modules)
1CH	2	Number of entries in segment table
1EH	2	Number of entries in module reference table
20H	2	Number of bytes in nonresident names table
22H	2	Offset of beginning of segment table relative to beginning of New Executable header
24H	2	Offset of beginning of resource table relative to beginning of New Executable header
26H	2	Offset of beginning of resident names table relative to beginning of New Executable header
28H	2	Offset of beginning of module reference table relative to beginning of New Executable header
2AH	2	Offset of beginning of imported names table relative to beginning of New Executable header
2CH	4	Offset of nonresident names table relative to beginning of file
30H	2	Number of movable entry points listed in entry table
32H	2	Alignment shift count (0 is equivalent to 9)
34H	12	Reserved for expansion

The module flag word at offset 0CH in the New Executable header is defined as shown in Figure K-1.

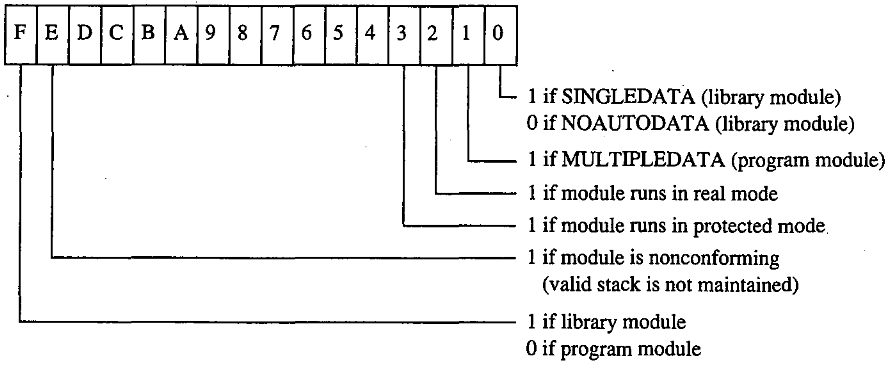

F
E
D
C
B
A
9
8
7
6
5
4
3
2
1
0
1 if SINGLEDATA (library module)
0 if NOAUTODATA (library module)
1 if MULTIPLEDATA (program module)
1 if module runs in real mode
1 if module runs in protected mode
1 if module is nonconforming
(valid stack is not maintained)
1 if library module
0 if program module

Figure K-1. The module flag word.

The segment table

This table contains one 8-byte record for every code and data segment in the program or library module. Each segment has an ordinal number associated with it. For example, the first segment has an ordinal number of 1. These segment numbers are used to reference the segments in other sections of the New Executable file. (Offsets are from the beginning of the record.)

Offset	Length (bytes)	Contents
00H	2	Offset of segment relative to beginning of file after shifting value left by alignment shift count
02H	2	Length of segment (0000H for segment of 65536 bytes)
04H	2	Segment flag word (*see* below)
06H	2	Minimum allocation size for segment; that is, amount of space Windows reserves in memory for segment (0000H for minimum allocation size of 65536 bytes)

The segment flag word is defined as shown in Figure K-2.

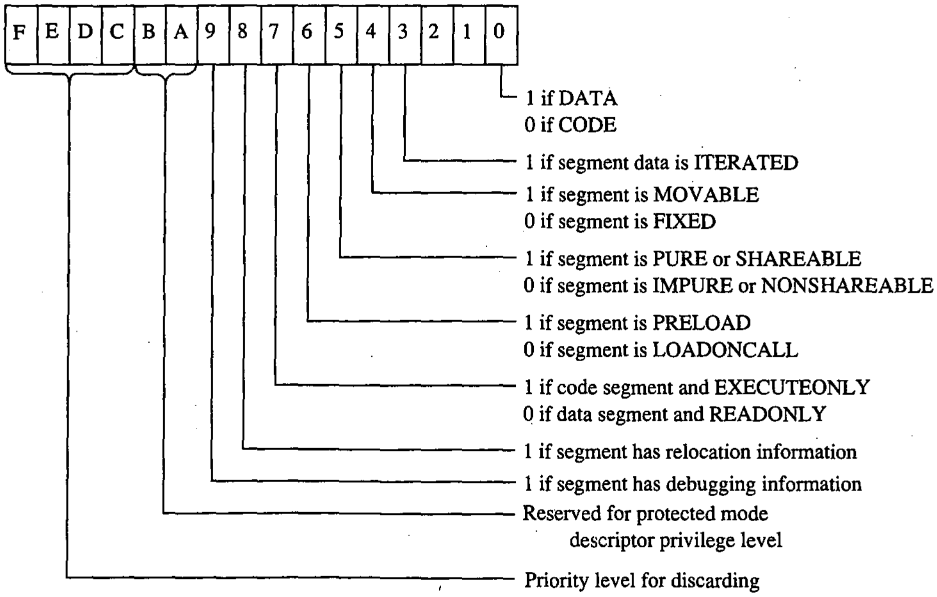

F
E
D
C
B
A
9
8
7
6
5
4
3
2
1
0
1 if DATA
0 if CODE
1 if segment data is ITERATED
1 if segment is MOVABLE
0 if segment is FIXED
1 if segment is PURE or SHAREABLE
0 if segment is IMPURE or NONSHAREABLE
1 if segment is PRELOAD
0 if segment is LOADONCALL
1 if code segment and EXECUTEONLY
0 if data segment and READONLY
1 if segment has relocation information
1 if segment has debugging information
Reserved for protected mode descriptor privilege level
Priority level for discarding

Figure K-2. The segment flag word.

The resource table

Resources are segments that contain data but are not included in a program's normal data segments. Resources are commonly used in Windows programs to store menus, dialog-box templates, icons, cursors, and text strings, but they can also be used for any type of read-only data. Each resource has a type and a name, both of which can be represented by either a number or an ASCII name.

The resource table begins with a resource shift count used for adjusting other values in the table. (Offsets are from the beginning of the table.)

Offset	Length (bytes)	Contents
00H	2	Resource shift count

This is followed by one or more resource groups, each defining one or more resources. (Offsets are from the beginning of the group.)

Offset	Length (bytes)	Contents
00H	2	Resource type (0 if end of table) If high bit set, type represented by predetermined number (high bit not shown): 1 Cursor 2 Bitmap 3 Icon 4 Menu template 5 Dialog-box template 6 String table 7 Font directory 8 Font 9 Keyboard-accelerator table If high bit not set, type is ASCII text string and this value is offset from beginning of resource table, pointing to 1-byte value with number of bytes in string followed by string itself.
02H	2	Number of resources of this type
04H	4	Reserved for run-time use
08H	12 each	Resource description

Each resource description requires 12 bytes. (Offsets are from the beginning of the description.)

Offset	Length (bytes)	Contents
00H	2	Offset of resource relative to beginning of file after shifting left by resource shift count
02H	2	Length of resource after shifting left by resource shift count
04H	2	Resource flag word (*see* below)
06H	2	Resource name If high bit set, represented by a number; otherwise, type is ASCII text string and this value is offset from beginning of resource table, pointing to 1-byte value with number of bytes in string followed by string itself.
08H	4	Reserved for run-time use

The resource flag word is defined as shown in Figure K-3.

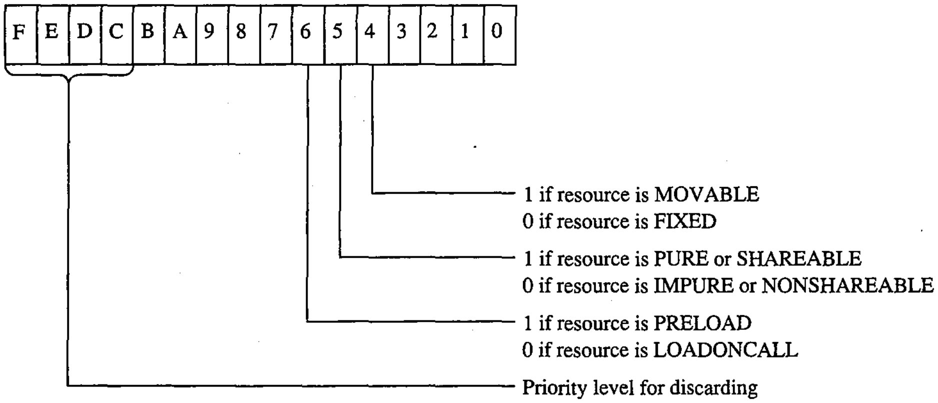

F E D C B A 9 8 7 6 5 4 3 2 1 0
1 if resource is MOVABLE
0 if resource is FIXED
1 if resource is PURE or SHAREABLE
0 if resource is IMPURE or NONSHAREABLE
1 if resource is PRELOAD
0 if resource is LOADONCALL
Priority level for discarding

Figure K-3. The resource flag word.

The resident names table

This table contains a list of ASCII strings. The first string is the module name given in the module definition file. The other strings are the names of all exported functions listed in the module definition file that were not given explicit ordinal numbers or that were explicitly specified in the file as resident names. (Exported functions with explicit ordinal numbers in the module definition file are listed in the nonresident names table.)

Each string is prefaced by a single byte indicating the number of characters in the string and is followed by a word (2 bytes) referencing an element in the entry table, beginning at 1. The word that follows the module name is 0. (Offsets are from the beginning of the record.)

Offset	Length (bytes)	Contents
00H	1	Number of bytes in string (0 if end of table)
01H	*n*	ASCII string, not null-terminated
n+1	2	Index into entry table

The module reference table

The module reference table contains 2 bytes for every external module the program uses. These 2 bytes are an offset into the imported names table.

The imported names table

The imported names table contains a list of ASCII strings. These strings are the names of all other modules that are referenced through imported functions. The strings are prefaced with a single byte indicating the length of the string.

For most Windows programs, the imported names table includes KERNEL, USER, and GDI, but it can also include names of other modules, such as KEYBOARD and SOUND. (Offsets are from the beginning of the record.)

Offset	Length (bytes)	Contents
00H	1	Number of bytes in name string
01H	*n*	ASCII name string, not null-terminated

These strings do not necessarily start at the beginning of the imported names table; the names are referenced by offsets specified in the module reference table.

The entry table

This table contains one member for every entry point in the program or library module. (Every public FAR function or procedure in a module is an entry point.) The members in the entry table have ordinal numbers beginning at 1. These ordinal numbers are referenced by the resident names table and the nonresident names table.

LINK versions 4.0 and later bundle the members of the entry table. Each bundle begins with the following information. (Offsets are from the beginning of the bundle.)

Offset	Length (bytes)	Contents
00H	1	Number of entry points in bundle (0 if end of table)
01H	1	Segment number of entry points if entry points in bundle are in single fixed segment; 0FFH if entry points in bundle are in movable segments

For a bundle containing entry points in fixed segments, each entry point requires 3 bytes. (Offsets are from the beginning of the entry description.)

Offset	Length (bytes)	Contents
00H	1	Entry-point flag byte (*see* below)
01H	2	Offset of entry point in segment

For bundles containing entry points in movable segments, each entry point requires 6 bytes. (Offsets are from the beginning of the entry description.)

Offset	Length (bytes)	Contents
00H	1	Entry-point flag byte (*see* below)
01H	2	Interrupt 3FH instruction: CDH 3FH
03H	1	Segment number of entry point
04H	2	Offset of entry-point segment

The entry-point flag byte is defined as shown in Figure K-4.

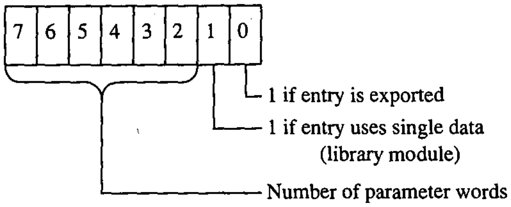

7
6
5
4
3
2
1
0
1 if entry is exported
1 if entry uses single data (library module)
Number of parameter words

Figure K-4. The entry-point flag.

The nonresident names table

This table contains a list of ASCII strings. The first string is the module description from the module definition file. The other strings are the names of all exported functions listed in the module definition file that have ordinal numbers associated with them. (Exported functions without ordinal numbers in the module definition file are listed in the resident names table.)

Each string is prefaced by a single byte indicating the number of characters in the string and is followed by a word (2 bytes) referencing a member of the entry table, beginning at 1. The word that follows the module description string is 0. (Offsets are from the beginning of the table.)

Offset	Length (bytes)	Contents
00H	1	Number of bytes in string (0 if end of table)
01H	*n*	ASCII string, not null-terminated
n+1	2	Index into entry table

The code and data segment

Following the various tables in the New Executable file header are the code and data segments of the program or library module.

If the code or data segment is flagged in the segment flag word as ITERATED, the segment is organized as follows. (Offsets are from the beginning of the segment.)

Offset	Length (bytes)	Contents
00H	2	Number of iterations of data
02H	2	Number of bytes of data
04H	*n*	Data

Otherwise, the size of the segment data is given by the length of the segment field in the segment table.

If the segment is flagged in the segment flag word as containing relocation information, then the relocation table begins immediately after the segment data. Windows uses the relocation table to resolve references within the segments to functions in other segments in the same module and to imported functions in other modules. (Offsets are from the beginning of the table.)

Offset	Length (bytes)	Contents
00H	2	Number of relocation items

Each relocation item requires 8 bytes. (Offsets are from the beginning of the relocation item.)

Offset	Length (bytes)	Contents
00H	1	Type of address to insert in segment: 01H Offset only 02H Segment only 03H Segment and offset

(more)

Offset	Length (bytes)	Contents
01H	1	Relocation type: 00H Internal reference 01H Imported ordinal 02H Imported name If bit 2 set, relocation type is additive (*see* below)
02H	2	Offset of relocation item within segment

The next 4 bytes depend on the relocation type. If the relocation type is an internal reference to a segment in the same module, these bytes are defined as follows. (Offsets are from the beginning of the relocation item.)

Offset	Length (bytes)	Contents
04H	1	Segment number for fixed segment; 0FFH for movable segment
05H	1	0
06H	2	If MOVABLE segment, ordinal number referenced in entry table; if FIXED segment, offset into segment

If the relocation type is an imported ordinal to another module, then these bytes are defined as follows. (Offsets are from the beginning of the relocation item.)

Offset	Length (bytes)	Contents
04H	2	Index into module reference table
06H	2	Function ordinal number

Finally, if the relocation type is an imported name of a function in another module, these bytes are defined as follows. (Offsets are from the beginning of the relocation item.)

Offset	Length (bytes)	Contents
04H	2	Index into module reference table
06H	2	Offset within imported names table to name of imported function

If the ADDITIVE flag of the relocation type is set, the address of the external function is added to the contents of the address in the target segment. If the ADDITIVE flag is not set, then the target contains an offset to another target within the same segment that requires the same relocation address. This defines a chain of target addresses that get the same address. The chain is terminated with a –1 entry.

Charles Petzold

Appendix L
Intel Hexadecimal Object File Format

The MCS-86 hexadecimal object file format provides a means of recording a program's binary (compiled or assembled) image in a text-only (printable) file format. This format makes it easy to transfer the program between computers over telephone lines without using special communications software. More important, it provides a ready means of transferring programs between computers and the various types of laboratory equipment typically used during the development of specialized programs.

The MCS-86 hexadecimal file format is a superset of Intel's older Intellec-8 hexadecimal object file format. Intel originally designed the Intellec-8 format for use with its 8-bit microprocessor line. The format rapidly gained acceptance among other microprocessor manufacturers. When Intel subsequently developed the MCS-86 microprocessor family, it also expanded the Intellec-8 hexadecimal file format into the MCS-86 hexadecimal file format to support the new microprocessors' extended addressing capabilities.

The MCS-86 hexadecimal object file format should not be confused with the object (.OBJ) files produced by the Microsoft Macro Assembler (MASM) and language compilers. The MCS-86 hexadecimal object file format is referred to as an *absolute* object file format because the code contained within the file has been completely linked and all address references have already been resolved. The object modules produced by the assembler and compilers (.OBJ files) are referred to as *relocatable* object modules because they contain the information necessary to relocate the enclosed code to any memory address for execution.

The MCS-86 hexadecimal object file format consists of four types of ASCII text records:

- Data record
- End-of-file record
- Extended-address record
- Start-address record

All records begin with a *record mark* consisting of a single ASCII colon character (:). The remainder of the record consists of a variable number of ASCII hexadecimal digit pairs (00–0FH), each representing an unsigned byte value (0–255 decimal). The first digit represents the value of the high nibble (bits 7–4) of the byte; the second digit represents the value of the low nibble (bits 3–0). These digit pairs begin immediately after the record mark and continue through the end of the record without any separation between them.

All records have the following fields, in the order listed:

- A fixed-length *record length* field
- A fixed-length *address* field (optional)
- A fixed-length *record type* field

- A fixed-length or variable-length *data* field
- A fixed-length *checksum* field

The fixed-length *record length* field consists of the first digit pair following the record mark and gives the length of the record-type-dependent variable-length data field.

The optional fixed-length *address* field consists of the second and third digit pairs following the record mark. The first digit pair of this field (second digit pair of the record) gives the high byte of a word address value (bits 15–8); the second digit pair (third digit pair of the record) gives the low byte of a word address value (bits 7–0). If the record type does not use the address field, then the field contains a fill-in value consisting of the four-character ASCII string *0000.*

The fixed-length *record type* field consists of the fourth digit pair of the record and indicates the type of data the record contains. The valid record-type values are

Value	Type
00H	Data record
01H	End-of-file record
02H	Extended-address record
03H	Start-address record

All records end with a fixed-length *checksum* field. This field contains the negative of the sum of all byte values represented by the digit pairs in the record, from the record length field through the last digit pair before the checksum field. The checksum field is used to determine whether an error occurred during the transmission of a record between computers or other pieces of equipment.

(The receiving equipment can easily perform this error checking as each record is received. It only has to add all digit pairs of the record, including the checksum, and ignore any overflow beyond 8 bits. The total should be 00H, because the checksum is the negative of the summation of all preceding digit pairs.)

The variable-length *data* field of the data record contains the actual data bytes of the program's image. In data records, the record length field indicates the number of bytes, each represented as a digit pair, contained within the data field; the address field gives the offset within the current memory segment at which to load the record's data into memory.

The fixed-length data field of the extended-address record establishes the memory segment into which subsequent data records are to be loaded. In extended-address records, the data field consists of a single field identical to the address field. The address field of an extended-address record always contains the ASCII 0000 filler, and the record length field always contains ASCII 02, which reflects the fixed length of the data field. The memory segment (also known as the memory frame) established by an extended-address record remains in effect until the next extended-address record is encountered; thus, all data records following the most recent extended-address record are loaded in the established memory segment. *See* PROGRAMMING IN MS-DOS: PROGRAMMING TOOLS: The Microsoft Object Linker.

Figures L-1 and L-2 show how the extended-address record and the data record combine to load the byte values 0FDH, 0B9H, 75H, 31H, 0ECH, 0A8H, 64H, and 20H into memory starting at address 9A6EH:429FH.

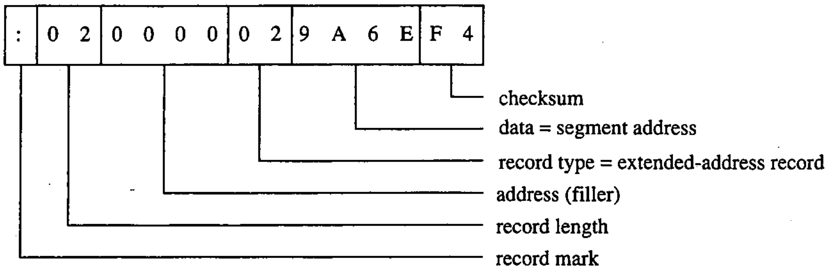

: | 0 2 | 0 0 0 0 | 0 2 | 9 A 6 E | F 4
checksum
data = segment address
record type = extended-address record
address (filler)
record length
record mark

Figure L-1. The extended-address record.

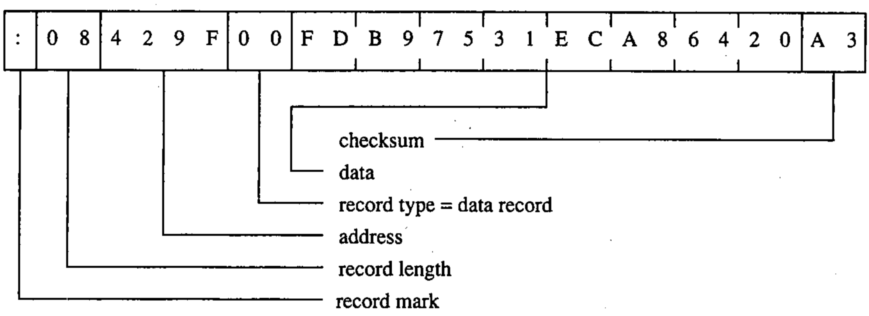

: | 0 8 | 4 2 9 F | 0 0 | F D B 9 7 5 3 1 E C A 8 6 4 2 0 | A 3
checksum
data
record type = data record
address
record length
record mark

Figure L-2. The data record.

The start-address record provides the CS and IP register values at which program execution begins. This record contains the register values within the fixed-length data field. The address field of a start-address record always contains the ASCII 0000 filler, and the record length field always contains ASCII 04, which reflects the fixed length of the data field. The example in Figure L-3 shows a CS:IP setting (program entry point) of F924H:E69AH.

The end-of-file record marks the end of an MCS-86 hexadecimal file. Under the MCS-86 hexadecimal file definition, the end-of-file record does not contain any variable-value fields; the record always appears as shown in Figure L-4.

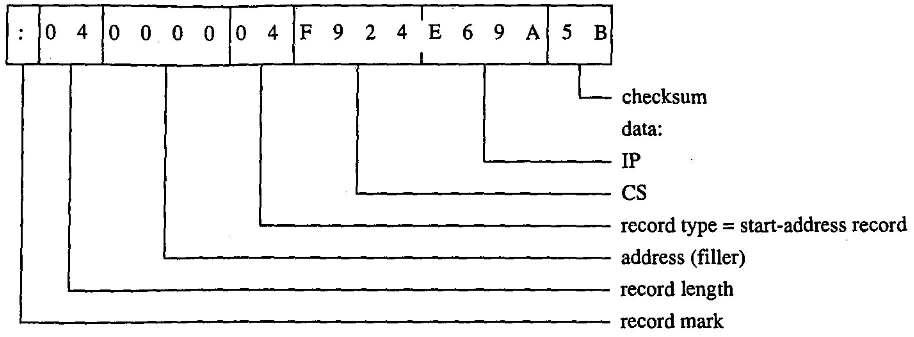

: 0 4 0 0 0 0 0 4 F 9 2 4 E 6 9 A 5 B
checksum
data:
IP
CS
record type = start-address record
address (filler)
record length
record mark

Figure L-3. The start-address record.

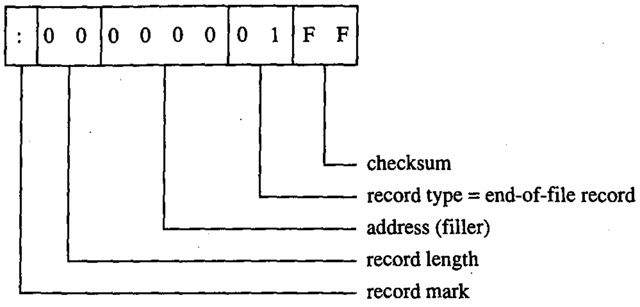


Figure L-4. The end-of-file record.

Traditionally, development equipment and programs that accept the MCS-86 hexadecimal file format as input also recognize an alternate end-of-file record. The alternate record consists of a data record that contains no data; therefore, its record length field contains 00. Figure L-5 shows this alternate end-of-file record.

DEBUG is the only program supplied with MS-DOS that accepts the MCS-86 hexadecimal file format. Even then, DEBUG only loads hexadecimal files into memory; it does not save a program back to disk as a hexadecimal file. (The same applies for SYMDEB and for CodeView.)

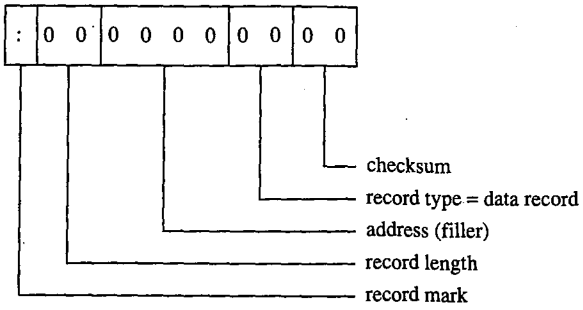


Figure L-5. The alternate end-of-file record.

While loading a hexadecimal file, DEBUG actually processes only data records and end-of-file records; it ignores both start-address records and any extended-address records. Thus, DEBUG actually supports only the older Intellec-8 hexadecimal file format but will not reject the file if it also contains the newer MCS-86 hexadecimal file records.

DEBUG does not support MCS-86 records because it must operate within the MS-DOS environment and MS-DOS does not support the loading of programs into absolute memory locations — a restriction imposed by most general-purpose operating systems. Because DEBUG cannot load the data records into the absolute segments indicated by the extended-address records, it simply loads the program image contained within the data records in a manner similar to that in which a .COM program is loaded. *See* PROGRAMMING IN THE MS-DOS ENVIRONMENT: PROGRAMMING FOR MS-DOS: Structure of an Application Program. DEBUG uses the address field for the data records as the offset into the .COM program segment at which to load the contents of the records.

The sample QuickBASIC (versions 3.0 and later) program shown in Figure L-6 converts binary files, including .COM files, into limited MCS-86 hexadecimal files that DEBUG can load. Examining this program can provide additional understanding of the structure of Intel hexadecimal files.

```
'Binary-to-Hex file conversion utility.
'Requires Microsoft QuickBASIC version 3.0 or later.

DEFINT A-Z                                     ' All variables are integers
                                               ' unless otherwise declared.
CONST FALSE = 0                                ' Value of logical FALSE.
CONST TRUE = NOT FALSE                         ' Value of logical TRUE.

DEF FNHXB$(X) = RIGHT$(HEX$(&H100 + X), 2)     ' Return 2-digit hex value for X.
DEF FNHXW$(X!) = RIGHT$("000" + HEX$(X!), 4)   ' Return 4-digit hex value for X!.
DEF FNMOD(X, Y) = X! - INT(X!/Y) * Y           ' X! MOD Y (the MOD operation is
                                               ' only for integers).
CONST SRCCNL = 1                               ' Source (.BIN) file channel.
CONST TGTCNL = 2                               ' Target (.HEX) file channel.

LINE INPUT "Enter full name of source .BIN file         :  ";SRCFIL$
OPEN SCRCFIL$ FOR INPUT AS SRCCNL              ' Test for source (.BIN) file.
SRCSIZ! = LOF(SRCCNL)                          ' Save file's size.
CLOSE SRCCNL
IF (SRCSIZ! > 65536) THEN                      ' Reject if file exceeds 64 KB.
    PRINT "Cannot convert file larger than 64 KB."
    END
END IF

LINE INPUT "Enter full name of target .HEX file         :  ";TGTFIL$
OPEN TGTFIL$ FOR OUTPUT AS TGTCNL              ' Test target (.HEX) filename.
CLOSE TGTCNL
```

Figure L-6. QuickBASIC binary-to-hexadecimal file conversion utility. *(more)*

```
DO
    LINE INPUT "Enter starting address of .BIN file in HEX :  ";L$
    ADRBGN! = VAL("&H" + L$)                  ' Convert ASCII HEX address value
                                              ' to binary value.
    IF (ADRBGN! < 0) THEN                     ' HEX values 8000-FFFFH convert
     ADRBGN! = 65536 + ADRBGN!                ' to negative values.
    END IF
    ADREND! = ADRBGN! + SRCSIZ! - 1           ' Calculate resulting end address.
    IF (ADREND! > 65535) THEN                 ' Reject if address exceeds FFFFH.
     PRINT "Entered start address causes end address to exceed FFFFH."
    END IF
LOOP UNTIL (ADRFLD! >= 0) AND (ADRFLD! <= 65535) AND (ADREND! <= 65535)

DO
    LINE INPUT "Enter byte count for each record in HEX    :  ";L$
    SRCRLN = VAL("&H" + L$)                   ' Convert ASCII HEX max record
                                              ' length value to binary value.
    IF (SRCRLN < 0) THEN                      ' HEX values 8000-FFFFH convert
     SRCRLN = 65536 + SRCRLN                  ' to negative values.
    END IF
LOOP UNTIL (SRCRLN > 0) AND (SRCRLN < 256)    ' Ask again if not 1-255.

OPEN SRCFIL$ AS SRCCNL LEN = SRCRLN           ' Reopen source for block I/O.
FIELD#SRCCNL,SRCRLN AS SRCBLK$
OPEN TGTFIL$ FOR OUTPUT AS TGTCNL             ' Reopen target for text output.
SRCREC = 0                                    ' Starting source block # minus 1.

FOR ADRFLD! = ADRBGN! TO ADREND! STEP SRCRLN  ' Convert one block per loop.
    SRCREC = SRCREC + 1                       ' Next source block.
    GET SRCCNL,SRCREC                         ' Read the source block.
    IF (ADRFLD! + SRCRLN > ADREND!) THEN      ' If last block less than full
     BLK$=LEFT$(SRCBLK$,ADREND!-ADRFLD!+1)    ' size:  trim it.
    ELSE                                      ' Else:
        BLK$ = SRCBLK$                        ' Use full block.
    END IF

    PRINT#TGTCNL, ":";                        ' Write record mark.

    PRINT#TGTCNL, FNHXB$(LEN(BLK$));          ' Write data field size.
    CHKSUM = LEN(BLK$)                        ' Initialize checksum accumulate
                                              ' with first value.
    PRINT#TGTCNL,FNHXW$(ADRFLD!);             ' Write record's load address.

' The following "AND &HFF" operations limit CHKSUM to a byte value.
    CHKSUM = CHKSUM + INT(ADRFLD!/256) AND &HFF   ' Add hi byte of adrs to csum.
    CHKSUM = CHKSUM + FNMOD(ADRFLD!,256) AND &HFF ' Add lo byte of adrs to csum.

    PRINT#TGTCNL,FNHXB$(0);                   ' Write record type.
```

Figure L-6. Continued. *(more)*

```
' Don't bother to add record type byte to checksum since it's 0.
    FOR IDX = 1 TO LEN(BLK$)                  ' Write all bytes.
     PRINT#TGTCNL,FNHXB$(ASC(MID$(BLK$,IDX,1)));      ' Write next byte.
     CHKSUM = CHKSUM + ASC(MID$(BLK$,IDX,1)) AND &HFF ' Incl byte in csum.
    NEXT IDX

    CHKSUM = 0 - CHKSUM AND &HFF              ' Negate checksum then limit
                                              ' to byte value.
    PRINT #TGTCNL,FNHXB$(CHKSUM)              ' End record with checksum.

NEXT ADRFLD!

PRINT#TGTCNL, ":00000001FF"                   ' Write end-of-file record.

CLOSE TGTCNL                                  ' Close target file.
CLOSE SRCCNL                                  ' Close source file.

END
```

Figure L-6. Continued.

Keith Burgoyne

Appendix M
8086/8088 Software Compatibility Issues

In general, the Intel 80286 microprocessor running in real mode executes 8086/8088 software correctly. The following is a list of the actions to take to compensate for the minor differences between the 8086/8088 and real mode of the 80286.

- *Do not rely on 8086/8088 instruction clock counts.* The 80286 takes fewer clocks for most instructions than the 8086/8088. The areas to look into are delays between I/O operations and assumed delays when the 8086/8088 is operating in parallel with an 8087 coprocessor.
- *Note that divide exceptions point to the DIV instruction.* Any interrupt on the 80286 always leaves the saved CS:IP value pointing to the instruction that failed. On the 8086/8088, the CS:IP value saved for a divide exception points to the next instruction.
- *Set up numeric exception handlers to allow prefixes.* The saved CS:IP value in the NPX environment save area points to any ESC instruction prefixes. On 8086/8088 systems, this value points only to the ESC instruction.
- *Do not attempt undefined 8086/8088 operations.* 8086/8088 instructions like POP CS or MOV CS,op either invoke exception 06H (Invalid Opcode) or perform a protection setup operation like LIDT on the 80286. Undefined bit encodings for bits 5–3 of the second byte of POP MEM or PUSH MEM invoke exception 13H on the 80286.
- *Do not rely on the value written by PUSH SP.* The 80286 pushes a different value on the stack for PUSH SP than does the 8086/8088. If the value pushed is important, replace PUSH SP instructions with the following instructions:

  ```
  PUSH      BP
  MOV       BP,SP
  XCHG      BP,[BP]
  ```

  This code functions like the 8086/8088 PUSH SP instruction on the 80286.
- *Do not shift or rotate by more than 31 bits.* The 80286 masks all SHIFT/ROTATE counts to the low 5 bits. This MOD 32 operation limits the count to a maximum of 31 bits. With this change, the longest SHIFT/ROTATE instruction is 39 clocks. Without this change, the longest SHIFT/ROTATE instruction is 264 clocks, which delays interrupt response until the instruction completes execution.
- *Do not duplicate prefixes.* The 80286 sets an instruction-length limit of 10 bytes. The only way to exceed this limit is to include the same prefix two or more times before an instruction. Exception 06H occurs if the instruction-length limit is violated. The 8086/8088 has no instruction-length limit.
- *Do not rely on odd 8086/8088 LOCK characteristics.* The LOCK prefix and its corresponding output signal should be used only to prevent other bus masters from interrupting a data movement operation. The 80286 always asserts LOCK during an XCHG instruction with memory (even if the LOCK prefix was not used). LOCK should be

used only with the XCHG, MOV, MOVS, INS, and OUTS instructions. The 80286 LOCK signal will *not* go active during an instruction prefetch.

- *Do not rely on IDIV exceptions for quotients of 80H or 8000H.* The 80286 can generate the largest negative number as a quotient for IDIV instructions. The 8086/8088 generates exception 00H (Divide by Zero) instead.
- *Do not rely on address space wraparound.*
- *Do not use I/O ports 0F8–0FFH.* These are reserved for controlling the 80287 and future microprocessor extensions.

Appendix N
An Object Module Dump Utility

The program OBJDUMP.C displays the contents of an object file as individual object records. It can be used to study the structure of object modules as well as to verify the output of a language translator. The program recognizes all of the object record types discussed in PROGRAMMING IN THE MS-DOS ENVIRONMENT: PROGRAMMING TOOLS: Object Modules.

OBJDUMP.C should be executed with the following syntax:

OBJDUMP *filename*

where *filename* is a complete filename specification. For example, to dump the contents of the object file MYPROG.OBJ, the user would type

```
C>OBJDUMP MYPROG.OBJ  <Enter>
```

The following is a typical object record as displayed by OBJDUMP:

```
Record 9:  96h LNAMES
96 002Eh 00 06 44 47 52 4F 55 50 05 5F 54 45 58 54 04 43   ..DGROUP._TEXT.C
         4F 44 45 05 5F 44 41 54 41 04 44 41 54 41 05 43   ODE._DATA.DATA.C
         4F 4E 53 54 04 5F 42 53 53 03 42 53 53 3F         ONST._BSS.BSS?
```

This sample LNAMES record defines a null name and eight names used in subsequent SEGDEF and GRPDEF records. The first 3 bytes of the record (the identifying byte and the 2-byte record length) are displayed to the left of the hexadecimal and ASCII listings of the contents of the record.

```
/*****************************************************************************
*                                                                            *
* OBJDUMP.C -- display contents of an object file                            *
*                                                                            *
*                                                                            *
*     Compile:  msc objdump;    (Microsoft C version 4.0 or later)           *
*     Link:     link objdump;                                                *
*     Execute:  objdump <filename>                                           *
*                                                                            *
*****************************************************************************/

#include        <fcntl.h>

#define         TRUE    1
#define         FALSE   0
```

(more)

```
main( argc, argv )
int        argc;
char       **argv;
{
        unsigned char        CurrentByte;
        int     ObjFileHandle;
        int     CurrentLineLength;                 /* length of output line */
        int     ObjRecordNumber = 0;
        int     ObjRecordLength;
        int     ObjRecordOffset = 0;   /* offset into current object record */
        char    ASCIIEquiv[17];
        char    FormatString[24];
        char    *ObjRecordName();
        char    *memset();


/* open the object file */

        ObjFileHandle = open( argv[1],O_BINARY );

        if( ObjFileHandle == -1 )
        {
          printf( "\nCan't open object file\n" );
          exit( 1 );
        }

/* process the object file character by character */

        while( read( ObjFileHandle, &CurrentByte, 1 ) )
        {
          switch( ObjRecordOffset ) /* action depends on offset into record */
          {
            case(0):                              /* start of object record */
              printf( "\n\nRecord %d:  %02Xh %s",
                ++ObjRecordNumber, CurrentByte, ObjRecordName(CurrentByte) );
              printf( "\n%02X ", CurrentByte );
              ++ObjRecordOffset;
              break;

            case(1):                          /* first byte of length field */
              ObjRecordLength = CurrentByte;
              ++ObjRecordOffset;
              break;

            case(2):                         /* second byte of length field */
              ObjRecordLength += CurrentByte << 8; /* compute record length */
              printf( "%04Xh ", ObjRecordLength );           /* show length */
              CurrentLineLength = 0;
              memset( ASCIIEquiv, '\0' , 17 );          /* zero this string */
              ++ObjRecordOffset;
              break;
```

(more)

```
            default:                     /* remaining bytes in object record */
              printf( "%02X ", CurrentByte );                         /* hex */

              if( CurrentByte < 0x20 || CurrentByte > 0x7F )        /* ASCII */
                CurrentByte = '.';
              ASCIIEquiv[CurrentLineLength++] = CurrentByte;

              if( CurrentLineLength == 16 ||  /* if end of output line ... */
                 ObjRecordOffset == ObjRecordLength+2 )
              {                                          /* ... display it */
                sprintf( FormatString, "%%%ds%%s\n         ",
                  3*(16-CurrentLineLength)+2 );
                printf( FormatString, " ", ASCIIEquiv );
                memset( ASCIIEquiv, '\0', 17 );
                CurrentLineLength = 0;
              }

              if( ++ObjRecordOffset == ObjRecordLength+3 )   /* if done ... */
                ObjRecordOffset = 0;          /* ... process another record */
              break;
          }
        }

        if( CurrentLineLength )    /* display remainder of last output line */
          printf( "  %s", ASCIIEquiv );

        close( ObjFileHandle );

        printf( "\n%d object records\n", ObjRecordNumber );

        return( 0 );
}


char *ObjRecordName( n )                        /* return object record name */
int         n;                                            /* n = record type */
{
        int         i;

        static      struct
        {
          int         RecordNumber;
          char        *RecordName;
        }               RecordStruct[] =
                         {
                          0x80,"THEADR",
                          0x88,"COMENT",
                          0x8A,"MODEND",
                          0x8C,"EXTDEF",
                          0x8E,"TYPDEF",
                          0x90,"PUBDEF",
```

(more)

```
                          0x94,"LINNUM",
                          0x96,"LNAMES",
                          0x98,"SEGDEF",
                          0x9A,"GRPDEF",
                          0x9C,"FIXUPP",
                          0xA0,"LEDATA",
                          0xA2,"LIDATA",
                          0xB0,"COMDEF",
                          0x00,"******"
                         };

        int      RecordTableSize = sizeof(RecordStruct)/sizeof(RecordStruct[0]);


        for( i=0; i<RecordTableSize-1; i++ )        /* scan table for name */
          if ( RecordStruct[i].RecordNumber == n )
            break;

        return( RecordStruct[i].RecordName );
}
```

Richard Wilton

Appendix O
IBM PC ROM BIOS Calls

To invoke an IBM PC BIOS routine, set register AH to the desired function and execute the software interrupt (INT) for the desired routine.

Graphics pixel coordinates and cursor row and column coordinates are always zero based.

Interrupt 10H: Video Services

Function 00H: Set Video Mode

To call:

AH	= 00H				
AL	= mode:				
		00H	16-shade gray text EGA: 64-color	40 by 25	B000:8000H
		01H	16/8-color text EGA: 64-color	40 by 25	B000:8000H
		02H	16-shade gray text EGA: 64-color	80 by 25	B000:8000H
		03H	16/8-color text EGA: 64-color	80 by 25	B000:8000H
		04H	4-color graphics	320 by 200	B000:8000H
		05H	4-shade gray graphics	320 by 200	B000:8000H
		06H	2-shade gray graphics	640 by 200	B000:8000H
		07H	monochrome text	80 by 25	B000:0000H
		08H	16-color graphics	160 by 200	B000:0000H
		09H	16-color graphics	320 by 200	B000:0000H
		0AH	4-color graphics	640 by 200	B000:0000H
		0BH	Reserved		
		0CH	Reserved		
		0DH	16-color graphics	320 by 200	A000:0000H
		0EH	16-color graphics	640 by 200	A000:0000H
		0FH	monochrome graphics	640 by 350	A000:0000H
		10H	16/64-color graphics	640 by 350	A000:0000H

Returns:

Nothing

Function 01H: Set Cursor Size and Shape

To call:

AH	= 01H
CH	= starting scan line
CL	= ending scan line

Note: CH < CL gives normal one-part cursor; CH > CL gives two-part cursor; CH = 20H gives no cursor.

Returns:

Nothing

Function 02H: Set Cursor Position

To call:

AH	= 02H
BH	= display page (0 in graphics)
DH	= row number
DL	= line number

Returns:

Nothing

Function 03H: Read Cursor Position, Size, and Shape

To call:

AH	= 03H
BH	= display page

Returns:

CH	= starting scan line
CL	= ending scan line
DH	= row number
DL	= column number

Function 04H: Read Light-Pen Position

To call:

AH	= 04H

Returns:

AH	= status:	
	01H	pen triggered
	00H	not triggered
BX	= pixel column number	
CH	= pixel line number	
CX	= pixel line number for some EGA modes	
DH	= character row number	
DL	= character column number	

Function 05H: Select Active Page

To call:

AH	= 05H	
AL	= page number:	
	00–07H	40-column text modes
	00–03H	80-column text modes
	varies	EGA graphics modes

Note: Each page = 2 KB in 40-column text mode, 4 KB in 80-column text mode.

Returns:

Nothing

Function 06H: Scroll Window Up
Function 07H: Scroll Window Down

To call:

AH	= 06H	scroll up
	= 07H	scroll down
AL	= number of lines to scroll (00H blanks screen)	
BH	= display attributes for blank lines	
CH	= row number of upper left corner	
CL	= column number of upper left corner	
DH	= row number of lower right corner	
DL	= column number of lower right corner	

Returns:

Nothing

Function 08H: Read Character and Attribute at Cursor

To call:

AH	= 08H
BH	= display page (for text mode only)

Returns:

If text mode:

AH	= color attributes of character
AL	= ASCII character from current location

If graphics mode:

AL	= ASCII character (00H if unmatched)

Function 09H: Write Character and Attribute

To call:

AH	= 09H
AL	= ASCII character to write
BH	= display page
BL	= text attribute or graphics foreground color
CX	= number of times to write character (must be > 0)

Returns:

Nothing

Note: Cursor position unchanged.

Function 0AH: Write Character Only

To call:

AH	= 0AH
AL	= ASCII character to write
BH	= display page
BL	= graphics foreground color (unused in text modes)
CX	= number of times to write character (must be > 0)

Returns:

Nothing

Note: Cursor position unchanged.

Function 0BH: Select Color Palette

To call:

AH	= 0BH
BH	= palette color ID
BL	= color or palette value

Returns:

Nothing

Function 0CH: Write Pixel Dot

To call:

AH	= 0CH
AL	= color attribute of pixel
CX	= pixel column number
DX	= pixel raster line number

Returns:

Nothing

Function 0DH: Read Pixel Dot

To call:

AH	= 0DH
CX	= pixel column number (0-based)
DX	= pixel raster line number (0-based)

Returns:

AL	= pixel color attribute

Function 0EH: Write Character as TTY

To call:

AH	= 0EH
AL	= ASCII character
BH	= display page
BL	= foreground color of character (unused in text mode)

Returns:

Nothing

Note: Cursor position advanced; beep, backspace, linefeed, and carriage return active; all other characters displayed.

Function 0FH: Get Current Video Mode

To call:

AH	= 0FH

Returns:

AH	= characters per line (20, 40, or 80)
AL	= current video mode (*see* Interrupt 10H Function 00H)
BH	= active display page

Function 13H: Write Character String

To call:

AH = 13H
AL = subfunction number:

- 00H string shares attribute in BL, cursor unchanged
- 01H string shares attribute in BL, cursor advanced
- 02H each character has attribute, cursor unchanged
- 03H each character has attribute, cursor advanced

BH = active display page
BL = string attribute (for AL = 00H or 01H only)
CX = length of character string
DH = starting row number
DL = starting column number
ES:BP = address of string to be displayed

Note: For AL = 00H or 01H, string = (*char*, *char*, *char*, ...). For AL = 02H or 03H, string = (*char*, *attr*, *char*, *attr*, ...).

Returns:

Nothing

Note: For AL = 01H or 03H, cursor position set to location following last character output.

Interrupt 11H: Get Peripheral Equipment List

Returns:

AX = equipment list code word (bit settings PPMURRRUFFVVUUCI):

- PP number of printers installed
- M 1 if internal modem installed
- RRR number of RS-232 ports installed
- U unused
- FF number of floppy-disk drives minus 1 (0 = one drive)
- VV initial video mode:
  - 00 = reserved
  - 01 = 40-by-25 color
  - 10 = 80-by-25 color
  - 11 = 80-by-25 monochrome
- U unused
- C 1 if math coprocessor installed
- I 1 if IPL (Initial Program Load) diskette installed

Interrupt 12H: Get Usable Memory Size (KB)

Returns:

AX	= available memory size in KB

Interrupt 13H: Disk Services

Function 00H: Reset Disk System

To call:

AH	= 00H	
AL	= drive number:	
	00–7FH	floppy disk
	80–FFH	fixed disk

Returns:

CF	= 0	no error
	1	error
AH	= error code (*see* Interrupt 13H Function 01H)	

Function 01H: Get Disk Status

To call:

AH	= 01H

Returns:

AH	= 00H	
AL	= disk status of previous disk operation:	
	00H	no error
	01H	invalid command
	02H	address mark not found
	03H	write attempt on write-protected disk (F)
	04H	sector not found
	05H	reset failed (H)
	06H	floppy disk removed (F)
	07H	bad parameter table (H)
	08H	DMA overflow (F)
	09H	DMA crossed 64 KB boundary
	0AH	bad sector flag (H)
	10H	uncorrectable CRC or ECC data error
	11H	ECC corrected data error (H)
	20H	controller failed

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40H	seek failed
80H	time out
AAH	drive not ready (H)
BBH	undefined error (H)
CCH	write fault (H)
E0H	status error (H)

Note: H = fixed disk only, F = floppy disk only.

Function 02H: Read Disk Sectors
Function 03H: Write Disk Sectors
Function 04H: Verify Disk Sectors
Function 05H: Format Disk Tracks

To call:

AH	= 02H	read disk sectors
	03H	write disk sectors
	04H	verify disk sectors
	05H	format disk track
AL	= number of sectors	
CH	= cylinder number	
CL	= sector number (unused if AH = 05H)	
DH	= head number	
DL	= drive number	
ES:BX	= buffer address (unused if AH = 04H)	

Returns:

CF	= 0	no error
	1	error
AH	= error code (*see* Interrupt 13H Function 01H)	

If AH was 05H on call:

ES:BX	= 4-byte address field entries, 1 per sector:		
	byte 0	cylinder number	
	byte 1	head number	
	byte 2	sector number	
	byte 3	sector-size code:	
		00H	128 bytes per sector
		01H	256 bytes per sector
		02H	512 bytes per sector (standard)
		03H	1024 bytes per sector

Function 08H: Get Current Drive Parameters

To call:

AH	= 08H
DL	= drive number

Returns:

AX	= 00H
BH	= 00H
BL	= drive type
CH	= low-order 8 bits of 10-bit maximum number of cylinders
CL	= bits 7 and 6 high-order 2 bits of 10-bit maximum number of cylinders bits 5–0 maximum number of sectors/track
DH	= maximum head number
DL	= number of drives installed
ES:DI	= address of floppy-disk-drive parameter table

Function 09H: Initialize Hard-Disk Parameter Table

To call:

AH	= 09H

Returns:

Nothing

Function 0AH: Read Long

Reads 512-byte sector plus 4-byte ECC code.

To call:

See Interrupt 13H Function 02H.

Returns:

See Interrupt 13H Function 02H.

Function 0BH: Write Long

Writes 512-byte sector plus 4-byte ECC code.

To call:

See Interrupt 13H Function 03H.

Returns:

See Interrupt 13H Function 03H.

Function 0CH: Seek to Head

Positions head but does not transfer data.

To call:

See Interrupt 13H Functions 02H and 03H.

Returns:

See Interrupt 13H Functions 02H and 03H.

Function 0DH: Alternate Disk Reset

To call:

AH	= 0DH
DL	= drive number

Returns:

Nothing

Function 10H: Test for Drive Ready

To call:

AH	= 10H
DL	= drive number

Returns:

AH	= status

Function 11H: Recalibrate Drive

To call:

AH	= 11H
DL	= drive number

Returns:

AH	= status

Function 14H: Controller Diagnostic

To call:

AH	= 14H

Returns:

AH	= status

Function 15H: Get Disk Type

To call:

AH	= 15H
DL	= drive number

Returns:

AH = drive type code:

00H	no drive present
01H	cannot sense when floppy disk is changed

(more)

02H	can sense when floppy disk is changed
03H	fixed disk

If AH = 03H:

CX:DX	= number of sectors

Function 16H: Check for Change of Floppy Disk Status

To call:

AH	= 16H
DL	= drive number to check

Returns:

AH	= 00H	no change
	06H	floppy-disk change

Function 17H: Set Disk Type

To call:

AH	= 17H
DL	= drive number
AL	= floppy-disk type code

Returns:

Nothing

Interrupt 14H: Serial Port Services

Function 00H: Initialize Port Parameters

To call:

AH	= 00H
AL	= serial port parameters (bit settings BBBPPSCC):

BBB	baud rate:	
	000	110 baud
	001	150 baud
	010	300 baud
	011	600 baud
	100	1200 baud
	101	2400 baud
	110	4800 baud
	111	9600 baud

(more)

PP parity code:
00 none
01 odd
10 none
11 even
S number of stop bits code:
0 one stop bit
1 two stop bits
CC character size:
00 unused
01 unused
10 7-bit character size
11 8-bit character size

DX = serial port number (0 = first port)

Returns:

Nothing

Function 01H: Send One Character

To call:

AH = 01H
AL = character to send
DX = serial port number (0 = first port)

Returns:

AH = error status (*see* Interrupt 14H Function 03H):
00H no error

Function 02H: Receive One Character

To call:

AH = 02H
DX = serial port number (0 = first port)

Returns:

AL = character received
AH = error status (*see* Interrupt 14H Function 03H):
00H no error

Function 03H: Get Port Status

To call:

AH = 03H
DX = serial port number (0 = first port)

Returns:

AX = serial port status:

8000H	time out
4000H	transfer shift register empty
2000H	transfer holding register empty
1000H	break detect
0800H	framing error
0400H	parity error
0200H	overrun error
0100H	data ready
0080H	received line signal detect
0040H	ring indicator
0020H	data set ready
0010H	clear to send
0008H	delta receive line signal detect
0004H	trailing edge ring detector
0002H	delta data set ready
0001H	delta clear to send

Note: Multiple conditions can be active simultaneously.

Interrupt 15H: Miscellaneous System Services

Function 00H: Turn On Cassette Motor
Function 01H: Turn Off Cassette Motor

To call:

AH	= 00H	turn on cassette motor
	01H	turn off cassette motor

Returns:

Nothing

Function 02H: Read Data from Cassette

To call:

AH	= 02H
CX	= number of bytes to read
ES:BX	= buffer address

Returns:

CF	= 0	no error
	1	error
AH	= error status (if needed):	
	01H	CRC error
	02H	bit signals scrambled
	03H	no data found
DX	= number of bytes read	
ES:BX	= location following last byte read	

Function 03H: Write Data to Cassette

To call:

AH	= 03H
CX	= number of bytes to write
ES:BX	= buffer address

Note: Blocking factor = 256 bytes/block.

Returns:

CX	= 00H
ES:BX	= location following last byte written

Interrupt 16H: Keyboard Services

Function 00H: Read Next Character

To call:

AH	= 00H

Returns:

If ASCII characters:

AH	= standard PC keyboard scan code
AL	= ASCII character

If extended ASCII codes:

AH	= extended ASCII code
AL	= 00H

Note: Does not return until character is read; removes character from keyboard buffer.

Function 01H: Report If Character Ready

To call:

AH	= 01H .

Returns:

ZF	= 0	character ready
	1	character not ready
AH	= *see* Interrupt 16H Function 00H	
AL	= *see* Interrupt 16H Function 00H	

Note: Returns immediately; does not remove character from keyboard buffer.

Function 02H: Get Shift Status

To call:

AH	= 02H

Returns:

AL	= shift status:	
	01H	right shift active
	02H	left shift active
	04H	Ctrl active
	08H	Alt active
	10H	Scroll Lock active
	20H	Num Lock active
	40H	Caps Lock active
	80H	insert state active

Note: Multiple states can be active simultaneously.

Interrupt 17H: Printer Services

Function 00H: Send Byte to Printer

To call:

AH	= 00H
AL	= character to be printed
DX	= printer number

Returns:

AH	= status (*see* Interrupt 17H Function 02H)

Function 01H: Initialize Printer

To call:

AH	= 01H
DX	= printer number

Returns:

AH	= status (*see* Interrupt 17H Function 02H)

Function 02H: Get Printer Status

To call:

AH	= 02H
DX	= printer number

Returns:

AH	= status:	
	01H	time out
	02H	unused
	04H	unused
	08H	I/O error
	10H	printer selected
	20H	out of paper
	40H	printer acknowledgment
	80H	printer not busy (bit off, 0, = busy)

Note: Multiple states can be active simultaneously.

Interrupt 18H: Transfer Control to ROM-BASIC

Interrupt 19H: Reboot Computer (Warm Start)

Interrupt 1AH: Get/Set Time/Date

Function 00H: Read Current Clock Count

To call:

AH	= 00H

Returns:

AL	= midnight signal
CX	= high-order word of tick count
DX	= low-order word of tick count

Function 01H: Set Current Clock Count

To call:

AH	= 01H
CX	= high-order word of tick count
DX	= low-order word of tick count

Returns:

Nothing

Function 02H: Read Real-Time Clock

To call:

AH	= 02H

Returns:

CF	= 0	clock running
	1	clock stopped
CH	= hours in BCD	
CL	= minutes in BCD	
DH	= seconds in BCD	

Function 03H: Set Real-Time Clock

To call:

AH	= 03H	
CH	= hours in BCD	
CL	= minutes in BCD	
DH	= seconds in BCD	
DL	= 00H	standard time
	01H	daylight saving time

Returns:

Nothing

Function 04H: Read Date from Real-Time Clock

To call:

AH	= 04H

Returns:

CF	= 0	clock running
	1	clock stopped
CH	= century in BCD (19 or 20)	
CL	= year in BCD	
DH	= month in BCD	
DL	= day in BCD	

Function 05H: Set Date in Real-Time Clock

To call:

AH	= 05H
CH	= century in BCD (19 or 20)
CL	= year in BCD
DH	= month in BCD
DL	= day in BCD

Returns:

Nothing

Function 06H: Set Alarm

To call:

AH	= 06H
CH	= hours in BCD
CL	= minutes in BCD
DH	= seconds in BCD

Returns:

CF	= status:	
	0	operation successful
	1	alarm already set or clock stopped

Function 07H: Reset Alarm (Turn Alarm Off)

To call:

AH	= 07H

Returns:

Nothing

Indexes

Subject

Commands and System Calls

This index lists only primary command and system call entries. Please use the Subject Index for related entries.

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