The x86 PC

assembly language, design, and interfacing

fifth edition

Prentice Hall

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Keyboard and Mouse Programming

The x86 PC

assembly language, design, and interfacing

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OBJECTIVES

this chapter enables the student to:

- Code Assembly language instructions using INT 16H to get and check the keyboard input buffer and status bytes.
- Code Assembly language instructions for key press and detection.
- Use INT 33H to control mouse functions in text and graphics modes.
- Code Assembly language instructions to initialize the mouse and to set or get the mouse cursor position.

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OBJECTIVES
this chapter enables the student to: (*cont*)

- Use INT 33H functions to retrieve mouse button press or release information.
- Limit mouse cursor postions by setting boundaries or defining exclusion areas.

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5.1: INT 16H KEYBOARD PROGRAMMING

- The original IBM PC keyboard had 83 keys, in three major groupings:
  - 1. The standard typewriter keys.
  - 2. Ten function keys, F1 to F10.
  - 3. 15-key keypad.
- In later years, 101 key *enhanced keyboards* have become popular.

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5.1: INT 16H KEYBOARD PROGRAMMING
keyboard scan codes

- Each key is associated with a *scan code*.

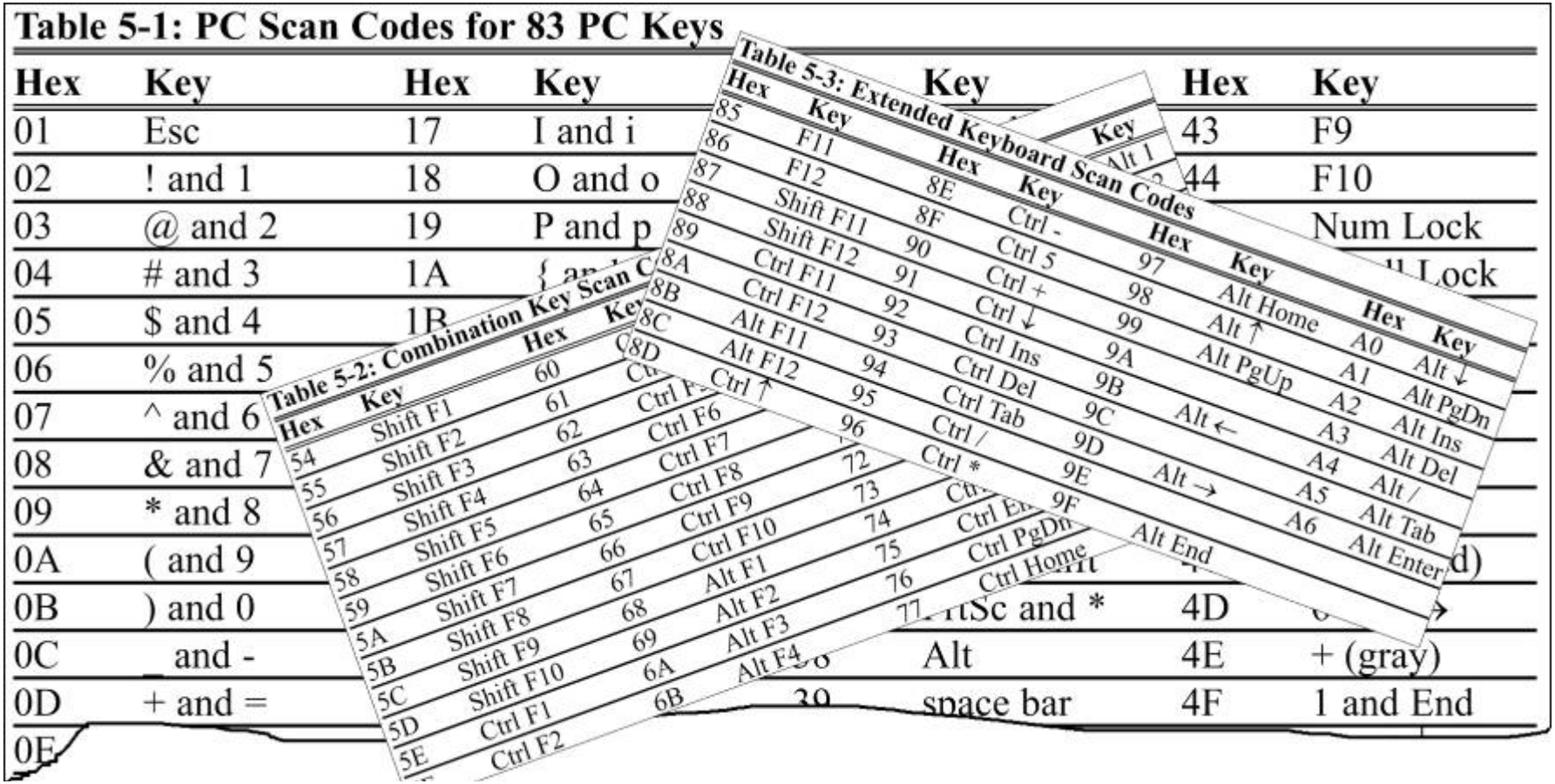

Table 5-1: PC Scan Codes for 83 PC Keys

Hex	Key	Hex	Key	Hex	Key
01	Esc	17	I and i	43	F9
02	! and 1	18	O and o	44	F10
03	@ and 2	19	P and p		Num Lock
04	# and 3	1A	{ and [		Lock
05	$ and 4	1B			
06	% and 5				
07	^ and 6				
08	& and 7				
09	* and 8				
0A	(and 9				d)
0B	) and 0			4D	→
0C	_ and -		Alt	4E	+ (gray)
0D	+ and =		space bar	4F	1 and End
0E					

Table 5-2: Combination Key Scan Codes

Hex	Key
54	Shift F1
55	Shift F2
56	Shift F3
57	Shift F4
58	Shift F5
59	Shift F6
5A	Shift F7
5B	Shift F8
5C	Shift F9
5D	Shift F10
5E	Ctrl F1
5F	Ctrl F2
60	Ctrl F3
61	Ctrl F4
62	Ctrl F5
63	Ctrl F6
64	Ctrl F7
65	Ctrl F8
66	Ctrl F9
67	Ctrl F10
68	Alt F1
69	Alt F2
6A	Alt F3
6B	Alt F4
8D	Ctrl ↑
91	Ctrl ↓
73	Ctrl ←
74	Ctrl →
75	Ctrl End
76	Ctrl PgDn
77	Ctrl Home

Table 5-3: Extended Keyboard Scan Codes

Hex	Key
85	F11
86	F12
87	Shift F11
88	Shift F12
89	Ctrl F11
8A	Ctrl F12
8B	Alt F11
8C	Alt F12
8D	Ctrl ↑
8E	Ctrl -
8F	Ctrl 5
90	Ctrl +
91	Ctrl ↓
92	Ctrl Ins
93	Ctrl Del
94	Ctrl Tab
95	Ctrl /
96	Ctrl *
97	Alt Home
98	Alt ↑
99	Alt PgUp
9A	Alt ←
9B	Alt →
9C	Alt End
9D	Alt ↓
9E	Alt PgDn
9F	Alt Ins
A0	Alt Del
A1	Alt /
A2	Alt Tab
A3	Alt Enter

See the scan code tables on pages 162 - 163 of your textbook.

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5.1: INT 16H KEYBOARD PROGRAMMING

- The same scan code is used for a given lowercase letter and its capital, and all keys with dual labels.
  - The keyboard shift status byte distinguishes the keys.
    - Some INT 16H function calls provide the status byte in AL.
  - For keyboard-motherboard, interaction IBM has provided INT 16H.

When a key is pressed, the OS stores its scan code in memory locations called a *keyboard buffer*, located in the BIOS data area.

Table 5-4: Keyboard Status Byte

Bit	If = 1	Mask Code (OR)
0	Right shift pressed	FEH
1	Left shift pressed	FDH
2	Ctrl pressed	FBH
3	Alt pressed	F7H
4	Scroll Lock toggled	EFH
5	NumLock toggled	DFH
6	CapsLock toggled	BFH
7	Ins toggled	7FH

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5.1: INT 16H KEYBOARD PROGRAMMING
checking a key press

- For a program to run tasks continuously while checking for a keypress requires use of INT 16H.
  - A BIOS interrupt used exclusively for the keyboard.
- To check a keypress, use INT 16H function AH = 01.

```
MOV AH,0          ;get key pressed
INT 16H           ;using INT 16H
```

  - If ZF = 0, there is a key press.
  - If ZF = 1, there is no key press.
- This function does not wait for the user to press a key—it simply checks to see *if* there is a key press.
  - If a character is available, it returns the scan code in AH, and the ASCII code in AL.

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5.1: INT 16H KEYBOARD PROGRAMMING
checking a key press

- Program 5-1 sends the ASCII bell character, 07 hex to the screen continuously.

```
        .MODEL SMALL
        .STACK
        .DATA
MESSAGE   DB 'TO STOP THE BELL SOUND PRESS ANY KEY$'
        .CODE
MAIN    PROC
        MOV    AX,@DATA
        MOV    DS,AX
        MOV    AH,09
        MOV    DX,OFFSET MESSAGE ;DISPLAY THE MESSAGE
        INT    21H
AGAIN:  MOV    AH,02     ;SENDING TO MONITOR A SINGLE CHAR
        MOV    DL,07     ;SEND OUT THE BELL CHAR
        INT    21H
        MOV    AH,01     ;CHECK THE KEY PRESS
        INT    16H       ;USING INT 16H
        JZ     AGAIN     ;IF NO KEY PRESS STAY IN THE LOOP
        MOV    AH,4CH    ;IF ANY KEY PRESSED GO BACK TO DOS
        INT    21H
MAIN    ENDP
        END
```

To stop the bell sound, the user must press any key.

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5.1: INT 16H KEYBOARD PROGRAMMING
which key is pressed?

- INT 16H AH = 0 determines the key pressed.
  - This function must be used *immediately after* AH = 01.

```
MOV AH,0          ;get key pressed
INT 16H           ;using INT 16H
```

  - AH = 0 doesn't return until a key is pressed.
    - AH = 1 comes back whether or not a key has been pressed.
  - AL contains the ASCII character of the pressed key.
    - The scan key is in AH.
  - For characters such as F1–F10 for which there is no ASCII code, the scan code is in AH and AL = 0.
    - Thus, if AL = 0, a special function key was pressed.

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5.1: INT 16H KEYBOARD PROGRAMMING
which key is pressed?

```
        .MODEL SMALL
        .STACK
        .DATA
MESSAGE DB 'TO STOP THE BELL SOUND PRESS Q (or q) KEY$'
        .CODE
MAIN    PROC
        MOV    AX,@DATA
        MOV    DS,AX
        MOV    AH,09
        MOV    DX,OFFSET MESSAGE ;DISPLAY THE MESSAGE
        INT    21H
AGAIN:MOV      AH,02
        MOV    DL,07     ;SOUND THE BELL BY SENDING OUT BELL CHAR
        INT    21H
        MOV    AH,01     ;CHECK FOR KEY PRESS
        INT    16H       ;USING INT 16H
        JZ     AGAIN     ;IF NO KEY PRESS KEEP SOUNDING THE BELL
        MOV    AH,0      ;TO GET THE CHARACTER
        INT    16H       ;WE MUST USE INT 16H ONE MORE TIME
        CMP    AL,'Q'    ;IS IT 'Q'?
        JE     EXIT      ;IF YES EXIT
        CMP    AL,'q'    ;IS IT 'q'
        JE     EXIT      ;IF YES EXIT
        JMP    AGAIN     ;NO. KEEP SOUNDING THE BELL
EXIT:   MOV    AH,4CH    ;GO BACK TO DOS
        INT    21H
MAIN    ENDP
        END
```

To stop the bell sound, the user must press a specific key.

Test for the correct keypress to stop the bell

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5.1: INT 16H KEYBOARD PROGRAMMING
other INT 16H functions

- **INT 16H, AH = 10H**
  (read a character) - the same as AH = 0, except that it also accepts the additional keys on the IBM extended (enhanced) keyboard.
- **INT 16H, AH = 11H**
  (find if a character is available) - the same as AH = 1, except that it also accepts the additional keys on the IBM extended (enhanced) keyboard.

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5.2: MOUSE PROGRAMMING WITH INT 33H
detecting the presence of a mouse

- Because the original IBM PC & DOS did not provide support for the mouse, interrupt INT 33H is not part of BIOS or DOS.
  - INT 33H is part of the mouse driver software installed when the PC is booted.
- The first task of any INT 33H program should be to verify the presence of a mouse and the number of buttons it supports, using INT 33H function AX = 0.
  - On return from INT 33H, if AX = 0, no mouse is supported.
  - If AX = FFFFH, the mouse is supported and the number of mouse buttons will be contained in register BX.

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5.2: MOUSE PROGRAMMING WITH INT 33H
detecting the presence of a mouse

- Although most mice have two buttons, right and left, there are some with middle buttons as well.

```
    MOV    AX,0          ;mouse initialization option
    INT    33H
    CMP    AX,0          ;check AX contents after INT 33H
    JE     EXIT          ;exit if AX=0 since no mouse available
    MOV    M_BUTTON,BX   ;mouse is there,save number of buttons
    ...
EXIT:
```

  - In INT 21H & INT 10H, register AH is used to select functions — not the case in INT 33H.
    - AL is used to select various functions and AH is set to 0.
    - The reason for "**MOV AX,0**".

Do not forget the "H", indicating hex.

If absent, the compiler assumes it is decimal & executes INT 21H.

(33 decimal = 21H)

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5.2: MOUSE PROGRAMMING WITH INT 33H
some mouse terminology

- The mouse *pointer* (or cursor) is the pointer on the screen indicating where the mouse is pointing at a given time.
  - In graphics mode it is an arrow.
  - In text mode, a flashing block.
- As the mouse is moved, the mouse cursor is moved.

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5.2: MOUSE PROGRAMMING WITH INT 33H
some mouse terminology

- While movement of the mouse is measured in inches (or centimeters), movement of the mouse cursor on the screen is measured in units called *mickeys*.
  - Mickey units indicate mouse sensitivity.
- A mouse that can move the cursor 200 units for every inch of mouse movement has a sensitivity of 200 mickeys.
  - In this case, one mickey represents 1/200 of an inch on the screen.
  - Some mice have a sensitivity of 400 mickeys in contrast to the commonly used 200 mickeys.

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5.2: MOUSE PROGRAMMING WITH INT 33H
displaying and hiding the mouse cursor

- The AX = 01 function of INT 33H is used to display the mouse cursor.

```
MOV    AX,01
INT    33H
```

  - If the video mode is graphics, the mouse arrow is visible.
  - If the video mode is text, a rectangular block representing the mouse cursor becomes visible.
    - The color of the mouse cursor block is the opposite of the background color in order to be visible.
- To hide the mouse cursor after making it visible, execute option AX = 02 of INT 33H.

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5.2: MOUSE PROGRAMMING WITH INT 33H
video resolution vs. mouse resolution

- When the video mode is set to text mode, the mouse will automatically adopt the same resolution of 640 × 200 for its horizontal/vertical coordinates.
  - When a program gets the mouse cursor position, values are provided in pixels and must be divided by 8.
    - To get position in terms of character locations 0 to 79 (horizontal) and 0 to 24 (vertical) on the screen.

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5.2: MOUSE PROGRAMMING WITH INT 33H
video resolution vs. mouse resolution

- In graphics modes, resolution is 640 × 200, 640 × 350 and 640 × 480.

Table 5-5: Video and Mouse Resolution for Some Video Modes

Video Mode	Video Resolution	Type	Mouse Resolution	Characters per Screen
AL = 03	640 × 200	Text	640 × 200	80 × 25
AL = 0EH	640 × 200	Graphics	640 × 200	80 × 25
AL = 0FH	640 × 350	Graphics	640 × 350	80 × 44
AL = 10H	640 × 350	Graphics	640 × 350	80 × 44
AL = 11H	640 × 480	Graphics	640 × 480	80 × 60
AL = 12H	640 × 480	Graphics	640 × 480	80 × 60

The mouse also adopts these graphics resolutions.

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5.2: MOUSE PROGRAMMING WITH INT 33H
getting the current mouse cursor position

- Option AX = 03 of INT 33H gets the current position of the mouse cursor.
  - On return, the X & Y coordinates are in registers CX (horizontal) and DX (vertical).
- BX contains the button status, 1 if *down*, 0 if *up*.
  - D0 = left button; D1 = right button; D2 = center button.
- The cursor position is given in pixels.
  - To get the mouse cursor character position, divide the horizontal and vertical values of CX & DX by 8.
- See Programs 5-3 & 5-4 on pages 168 - 171 of your textbook.

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5.2: MOUSE PROGRAMMING WITH INT 33H
setting the mouse pointer position

- INT 33H option AX = 04 allows a program to set the mouse pointer to a new location anywhere on the screen.
  - Coordinates for the new location must be placed in CX for the horizontal (x coordinate) and DX for the vertical (y coordinate).
- Values must be in pixels.
  - In the range of 0–639 & 0–199 for 640 × 200 resolution.
    - Coordinate (0,0) is the upper left corner of the screen.

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5.2: MOUSE PROGRAMMING WITH INT 33H
getting mouse button press information

- INT 33H option AX = 05 is used to get information about specific button presses since the last call to this function.

AX = 05
BX = 0 for left button; 1 for right button; 2 for center button
Upon return:
AX = button status where
D0 = Left button, if 1 it is down and if 0 it is up
D1 = Right button, if 1 it is down and if 0 it is up
D2 = Center button, if 1 it is down and if 0 it is up
BX = button press count
CX = *x*-coordinate at the last button press in pixels (horizontal)
DX = *y*-coordinate at the last button press in pixels (vertical)

Program 5-4 on pages 170 - 171 of your textbook shows one way to use this function.

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5.2: MOUSE PROGRAMMING WITH INT 33H
the button press count program

- Program 5-5 on pages 172 - 173 uses the AX = 05 function to monitor the number of times the left button is pressed and then displays the count.
  - It prompts the user to press the left button a number of times.
    - When the user is ready to see how many times the button was pressed, any key can be pressed.

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