Popular 500

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Table of Contents

Chapter 1
Getting Started

The first thing to learn about your computer is the different configurations that made up a complete system. This chapter is all about these configurations and a brief description on their functions.

Every complete computer system consists of:

1.1 The System Unit

The system unit is the personal computer itself and it comes in the form of an attractively designed box measuring about 400 x 120 X 380 mm. Housed inside are the different vital parts that make the system unit function. These include the Central Processing Unit (CPU) which is also referred to as the heart of the computer, the power supply, fan, motherboard, peripheral interfaces and circuitries, etc.

1.2 The Real Panel

Important features on the rear panel like the power switch, sockets and connectors provide convenience for connecting peripherals like the keyboard, printer and monitor to the system unit.

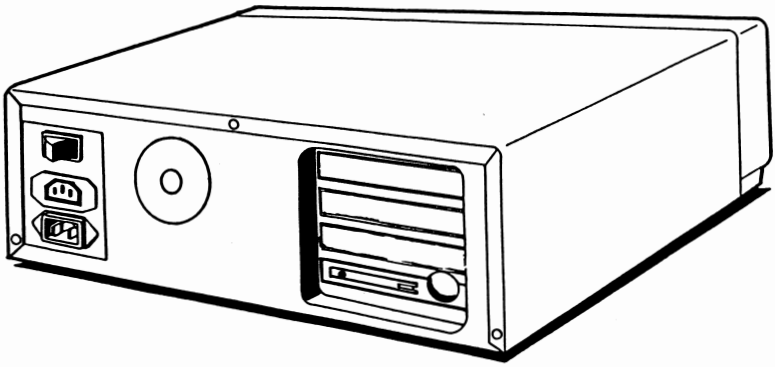


Fig. 1-1 The Rear Panel

1.3 The Keyboard

Provided with the system is a 84-key typewriter style keyboard. The keys are low profile, full travel, sculptured type. In additional to the standard typewriter keys, there are the function keys, cursor control keys and numeric keypad for user convenience.

The keyboard can also be inclined for typing comfort. To tilt the keyboard, pull out the two pivotal legs at the bottom. Refer to Chapter Four for details on keyboard usage.

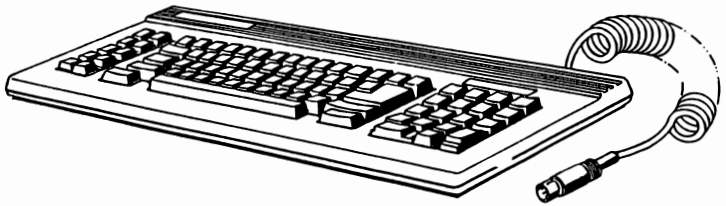


Fig. 1-2 Keyboard

1.4 The Rear Panel Connectors and Switches

The power switch, peripheral sockets and connectors are located at the rear panel of the system unit as shown in Fig. 1-3. The corresponding peripherals that can be attached are also shown.

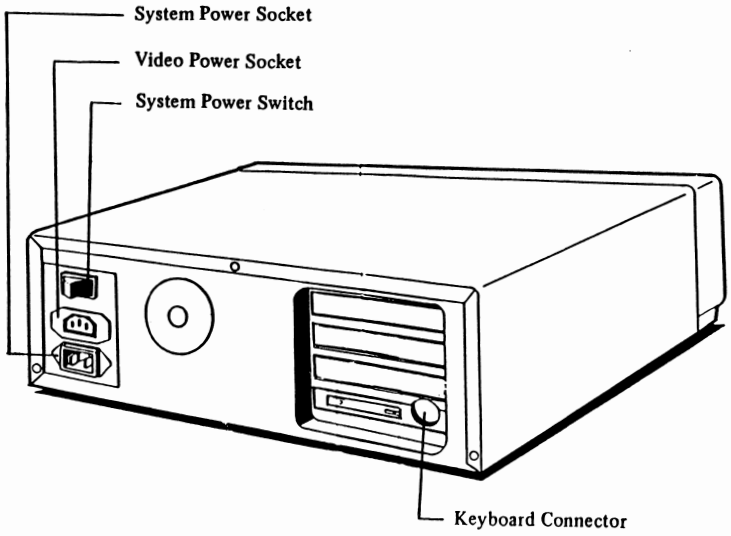


Fig. 1-3 The Rear Panel

1.5 The System Power Socket

Power is supplied to the system unit by means of a power cable. The three-prong male socket from the cable should be plugged to the system power socket in the rear panel as shown in Fig. 1-4. The other end of the cable is plugged to the power source.

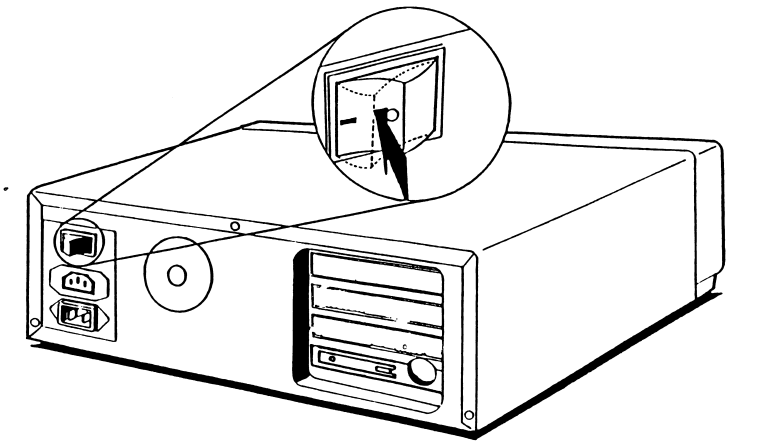


Fig. 1-4 System Power Socket

1.6 The System Unit Power Switch

The power switch is located at the upper left corner of the rear panel. The power to the system is turned on and off using this switch.

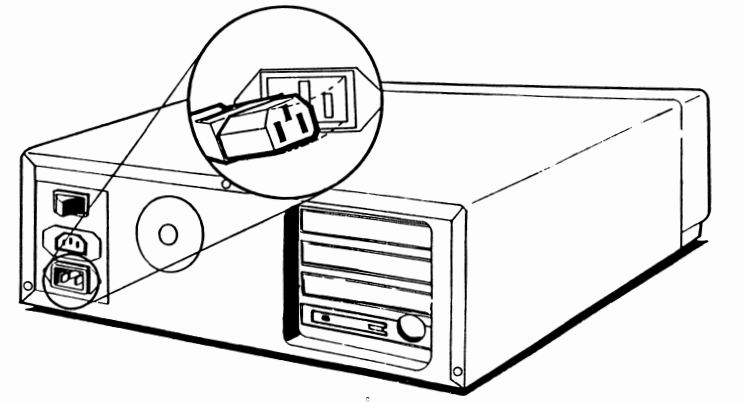


Fig. 1-5 System Unit Power Switch

1.7 The Video Monitor Power Socket

For monochrome monitors, the monitor power cable should be connected to the video monitor power socket located below the system power switch. Color monitors are usually plugged directly to the power outlet.

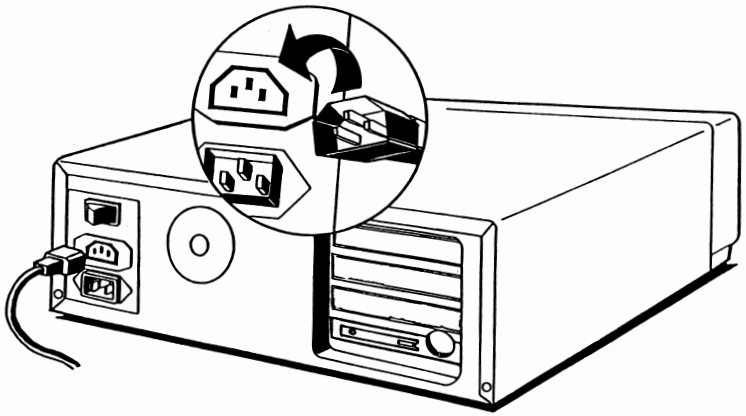


Fig. 1-6 Video Monitor Power Socket

1.8 The Keyboard Connectors

The keyboard connector (Fig. 1-7) provides the interface between the system unit and the keyboard.

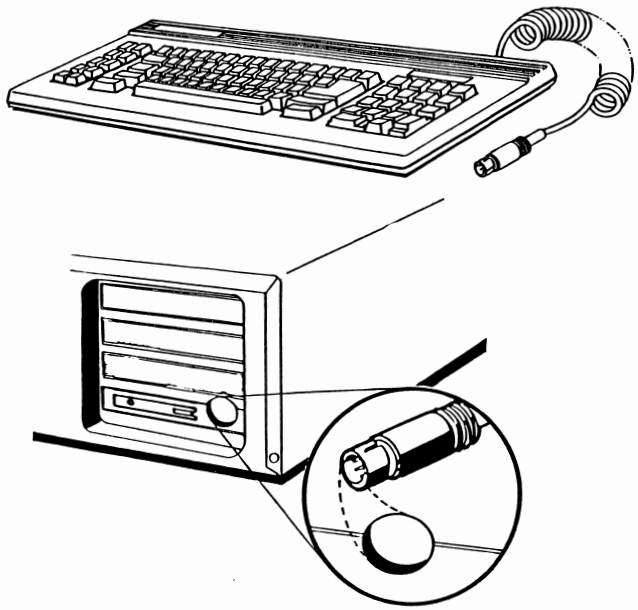


Fig. 1-7 The Keyboard Connector

1.9 Expansion Slots

Inside the system unit is a vertical motherboard that supports four horizontal expansion slots. Add-on cards are inserted horizontally into these slots as against the conventional vertical insertion.

The CPU card is inserted in the lowest slot while the IO board occupies the next-to-lowest slot.

A display card may or may not be added into one of the two upper slots depending on your model. For details on how to install a card into the slot, refer to Chapter 4.

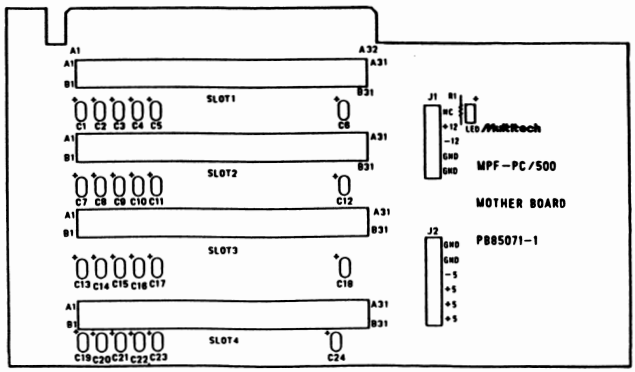


Fig. 1-8 The MotherBoard and the Expansion Slots

1.10 The CPU Card

On the CPU card are:

A. The 8088 CPU working at 4.77 MHz without coprocessor 8087.

B. ROM: 8K bytes for BIOS (U36)

C. RAM: up to 512K bytes of memory can be installed on board without parity check.

D. DMA (8237): working at 4.77 MHz

E. WAIT: I/O RW Wait 1 clock for 4.77 MHz

F. Keyboard Interface: Compatible with IBM-PC keyboard.

* The total memory can be expanded to 640KB (512KB on board and 128KB on the expansion card) by using an expansion card - the MEB-500. For details on how to use the MEB-500, please refer to Appendix I.

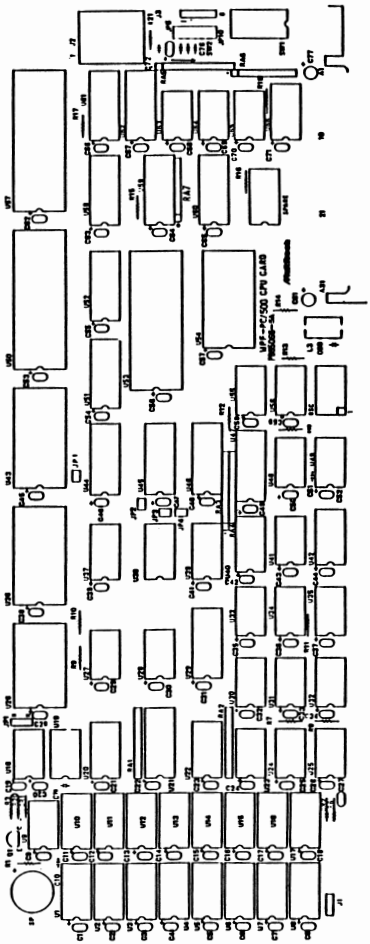


Fig. 1-9 CPU Card Block Diagram

Chapter 2
Keyboard Usage

The keyboard serves one of the most important functions in a computer system. Without the device, direct communications between the computer and the user will be impossible.

By using the keyboard, the user can key in commands directly and store them in the diskette, or simply "echo" data entered on the screen.

There are 84 keys on the keyboard. These keys are divided into three groups: 1) the main keyboard, 2) the numeric key pad, and 3) the function keys.

2.1 The Main Keyboard

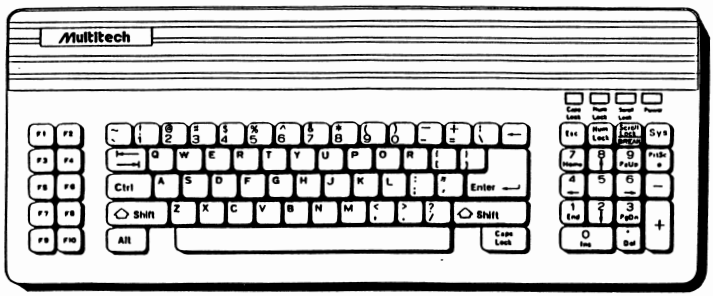


Fig. 2-1 The Main Keyboard

The main keyboard is similar to an ordinary typewriter keyboard. It is used mainly to enter alphabets from A to Z, numeric digits from 0 to 9, special signs, and punctuation marks such as:

```
! @ # $ % ^ & * ( ) _ - + =
[ ] { } : ; ' " ~ `
| \ < > , . ? /
```

Once a key is pressed, its corresponding character will be displayed on your video monitor. In this case, we say the pressed key is "echoed" on the screen in computer terminology.

2.1.1 The Shift Key

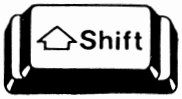


Fig. 2-2 The Shift Key

The main keyboard may be used to enter both upper and lower case characters. On an ordinary typewriter keyboard, pressing the Shift key and any key will produce an upper case character of that key. By the same token, to type an upper case character using this keyboard, press the desired key while holding down the Shift key. The Shift key is always used together with another key.

2.1.2 The Ctrl (Control) Key

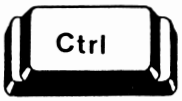


Fig. 2-3 The Ctrl Key

The control key, which is marked "Ctrl", is another kind of shift key. Normally, it is used together with other keys to generate an internal code for a special function that the system understands.

2.1.3 The Alt (Alternate) Key

Fig. 2-4 The Alt Key

The Alt key is a third kind of shift key that is used in conjunction with other keys to perform a special function.

2.1.4 The Caps Lock Key

Fig. 2-5 The Caps Lock Key

This key is located on the lower right corner of the main keyboard. This key functions as an on/off (toggle) switch for shifting from capital letters to small letters.

Pressing this key once will lock your keyboard to the capital-letter-only mode. After locking the keyboard to the capital-letter-only mode, all the keys pressed will be echoed in upper case letters on the video monitor. Pressing it again will return your keyboard to the lower case mode.

2.1.5 The Enter Key

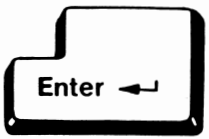


Fig. 2-6 The Enter Key

This is the Enter key. It is equivalent to the typewriter's carriage return. When the Enter key is pressed, the cursor will move to the beginning of the next line.

2.1.6 The Backspace Key

Fig. 2-7 The Backspace Key

Pressing the Backspace key will move the cursor one character to the left of its current position, at the same time deleting the character from the position it has moved from.

2.1.7 The Tab Key

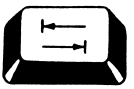


Fig. 2-8 The Tab Key

The Tab key shifts the cursor eight spaces to the right at each press. However, it cannot cause the cursor to tab to the left.

2.1.8 The Space Bar

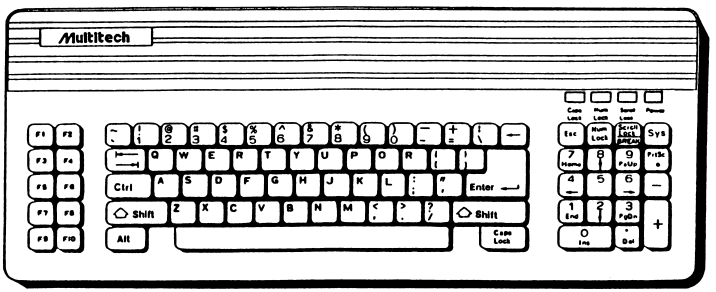


Fig. 2-9 The space Bar

The Space bar is located at the bottom of the main keyboard. This key is used for producing spaces.

2.2 The Numeric Keypad

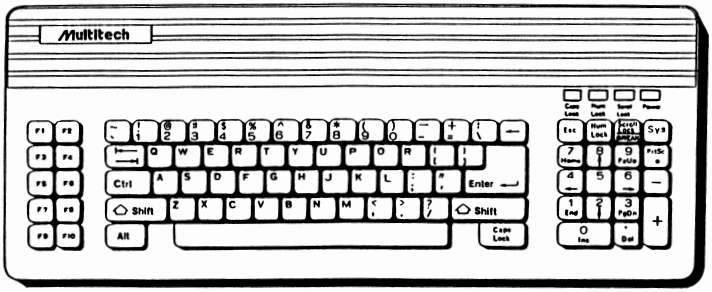


Fig. 2-10 The Numeric Keypad

On the right side of the keyboard is the numeric keypad as shown by the shaded keys in Fig. 2-10. These keys have two specific functions, including the numeric or cursor-control modes.

When serving as the numeric mode, the keys in this area are used for entering numerals. This is rather convenient for entering long string of numeric data.

The default is cursor-control mode. This means that upon power on, the keys on the numeric keypad will be used to shift the cursor one space to any of the four directions as indicated by the respective keys.

To enter the numeric mode, press the Num Lock key once. Pressing the "Num Lock" key for a second time disables the numeric mode.

The usage of each key in the numeric keypad depends on different software. A detailed explanation of the operation of some special keys in this area are as follows:

Pressing this key once will print an asterisk (*) on the screen. When this key is used together with the "Shift" key, all the data on the screen wil be printed on the printer. When used with the "Ctrl" key, each line of data will be printed as they are entered from the keyboard.

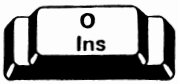
This key is defined differently by different application softwares. Please refer to the manual pertaining to operating system or application programs for the key's usage.

This key is used to determine the movements of the text on the screen when the cursor reaches the top line of the screen or the bottom of the screen. Pressing it once will cause the LED labelled "Scroll Lock" to light up. Pressing it again will turn off the LED.

When this key is locked on, the cursor-up and the cursor-down keys move the text on the screen up or down one line without changing the cursor position.

There is also another function for this key. The "Break" key is used together with the "Ctrl" key to terminate the execution of a program or command.

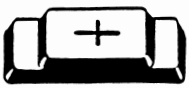
This key is a function key whose usage depends on your own application programs or operating system.



This key is used to insert character(s) in a line. When a character is inserted, all the data to the right of the cursor moves one position to the right. Under certain application software, pressing this key once will cause the screen to stay in the "Insert On" mode.

This key is used to erase the character where the cursor is positioned. When a character is deleted from a line, all the data to the right of the cursor moves one position to the left.

This key is used to enter the minus symbol.



This key is used to enter the plus symbol.

Cursor Control Keys in the Numeric Keypad

This key is called the "cursor-up" key whose function is to move the cursor up one line at a time.

This key is called the "Cursor-down" key whose function is to move the cursor down one line at a time.

This key is called the "cursor-right" key which moves the cursor one position to the right at a time.

This is the "cursor-left" key which moves the cursor one position to the left at a time.

This key is called the "Home" key which moves the cursor to the top left corner of your screen.

This is the "End" key whose function depends on the definition of different application software.

This key is called the "Page-Up" key which moves the cursor up by one screen. The length of one screen depends on the definition of different application software.

This key is called the "Page-Down" key which moves the cursor down by one screen. The length of one screen depends on the definition of different application software.

2.3 The Function Keys Under the MS-DOS

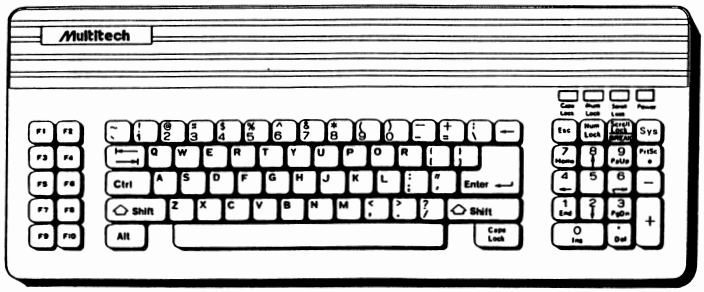


Fig. 2-11 The Function Keys

Under MS-DOS, the first five function keys are used mainly for editing. Their functions are:

2.3.1 F1

F1 is used for displaying one character from the template each time you enter this key. The same results can be achieved by using the right direction arrow key ("6" on the numeric keypad).

For example, type "Personal Computer" from the keyboard and hit F5 to enter the characters into the template. Press the F1 key 17 times and all the characters, one character at a time from left to right, will be displayed.

2.3.2 F2

Pressing F2 and a character will display all the characters preceding that character from the template. The specified character and the succeeding characters will not be displayed.

For example, pressing F2 and then "C" will immediately display "Personal" on the screen.

2.3.3 F3

Pressing F3 will copy all the characters from the template to the screen.

2.3.4 F4

This key will delete all the characters preceding a specified character.

Let's continue with the above example. Enter "Personal Computer" and press F5. Press F4 and "C". Nothing seems to have happened. Don't worry. Now press F3 and "Computer" will be shown on the screen. The characters preceeding the "C" in "Computer" has been deleted.

2.3.5 F5

Pressing F5 will send all the keyed in characters to the template without sending them to the computer for processing.

For example, after the MS-DOS prompt > appears, enter "Multitech Personal Computer" and press F5, a "@" will be displayed at the end of the line and the cursor will move to the beginning of the next line. Now enter the key F3, all the characters that you just typed into the template will be displayed.

2.4 Other Editing Keys

Aside from the five function keys, there are three more keys that are used for MS-DOS editing. They are the "Del", "Ins" and "Esc" keys on the numeric keypad.

2.4.1 Ins

Ins will insert characters anywhere in the line. The "Ins" key is located at the bottom of the numeric keypad.

For example, key in "Personal Computer". Press F5 to enter these characters into the template. Press F1 until "Personal" is displayed on the screen. Press "Ins" key once and key in "micro". Now press the "Ins" key again to exit from the insert mode. Press F3 and "Personal microcomputer" will be shown on the screen.

2.4.2 Del

The Del key deletes characters (to the right of the cursor position) from the template without moving the cursor position on the screen. It is located at the bottom of the numeric keypad.

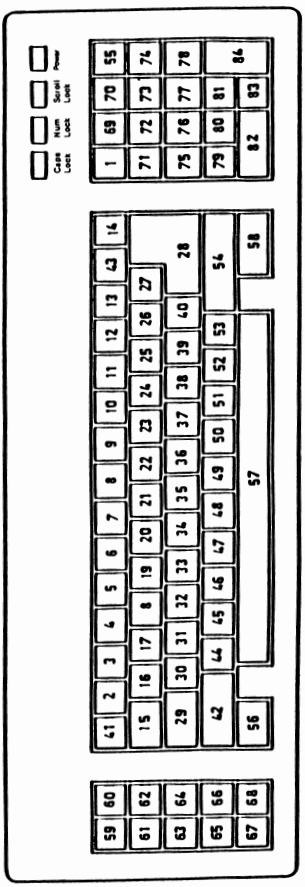
Using the above example, press F1 until "Personal" appears on the screen. Press the Del key five times (to delete "micro") before pressing F3. Now "Personal computer" will be shown on the screen.

2.4.3 Esc

The Esc key will cancel the current line on the screen. However, the characters in the template remain unchanged.

While "Personal computer" is being displayed, press the "Esc" key. The cursor will move to the next line. You can either enter new data and press the Return key to remove the previous data from the template, or you can press F3 to re-display "Personal computer".

2.5 Key Positions



2.5 Key Positions

2.6 Key Scan Codes (For PC Mode)

LEGEND	KEY POSITION	MAKE CODE	BREAK CODE
Esc	1	Ø1	81
!1	2	Ø2	82
@2	3	Ø3	83
#3	4	Ø4	84
$4	5	Ø5	85
%5	6	Ø6	86
^6	7	Ø7	87
&7	8	Ø8	88
*8	9	Ø9	89
(9	1Ø	ØA	8A
)Ø	11	ØB	8B
_-	12	ØC	8C
+=	13	ØD	8D
Back Space	14	ØE	8E
⟵⟶	15	ØF	8F

LEGEND	KEY POSITION	MAKE CODE	BREAK CODE
Q	16	1Ø	9Ø
W	17	11	91
E	18	12	92
R	19	13	93
T	2Ø	14	94
Y	21	15	95
U	22	16	96
I	23	17	97
O	24	18	98
P	25	19	99
{[	26	1A	9A
}]	27	1B	9B
←┘	28	1C	9C
Ctrl	29	1D	9D
A	3Ø	1E	9E
S	31	1F	9F
D	32	2Ø	AØ
F	33	21	A1

LEGEND	KEY POSITION	MAKE CODE	BREAK CODE
G	34	22	A2
H	35	23	A3
J	36	24	A4
K	37	25	A5
L	38	26	A6
:;	39	27	A7
",	4Ø	28	A8
~`	41	Ø1	81
⇧ Shift	42	2A	AA
| \	43	2B	AB
Z	44	2C	AC
X	45	2D	AD
C	46	2E	AE
V	47	2F	AF
B	48	3Ø	BØ
N	49	31	B1
M	5Ø	32	B2
<,	51	33	B3
>.	52	34	B4

LEGEND	KEY POSITION	MAKE CODE	BREAK CODE
?/	53	35	B5
⇧ Shift	54	36	B6
Sys Req	55		
Alt	56	38	B8
Sp	57	39	B9
Caps Lock	58	3A	BA
F1	59	3B	BB
F2	60	3C	BC
F3	61	3D	BD
F4	62	3E	BE
F5	63	3F	BF
F6	64	40	C0
F7	65	41	C1
F8	66	42	C2
F9	67	43	C3
F10	68	44	C4
Num Lock	69	45	C5

LEGEND	KEY POSITION	MAKE CODE	BREAK CODE
Scroll Lock	70	46	C6
7 Home	71	47	C7
8 ↑	72	48	C8
9 Pg Up	73	49	C9
PrtSc *	74	37	B7
4 <-	75	4B	CB
5	76	4C	CC
6 ->	77	4D	CD
-	78	4A	CA
1 End	79	4F	CF
2 ↓	80	50	DO
3 Pg Dn	81	51	Dl
0 Ins	82	52	D2
. Del	83	53	D3
+	84	4E	CE

Chapter 3

On-board Switch Setting

3.1 Configuration Switch Settings

There is a DIP (Dual In-Line Package) switch on the CPU card designated as SW1. On this switch are eight slide switches that can be set to "ON" or "OFF" by using a pin or toothpick.

The switch is adjusted so that the microprocessor can access the devices connected directly or indirectly to it, e.g., the RAM (Random Access Memory) and peripheral devices that are connected to or installed in your system unit.

3.2 The Location of the DIP Switch

The switch is positioned conveniently in the rear panel in such a way that it can be accessed without having to remove the housing from the system unit.

Remove the metal strip on the CPU Board by loosening the screw as shown in Fig. 3-1. The DIP switch is then visible.

The locations of the two switches are shown in the following illustration:

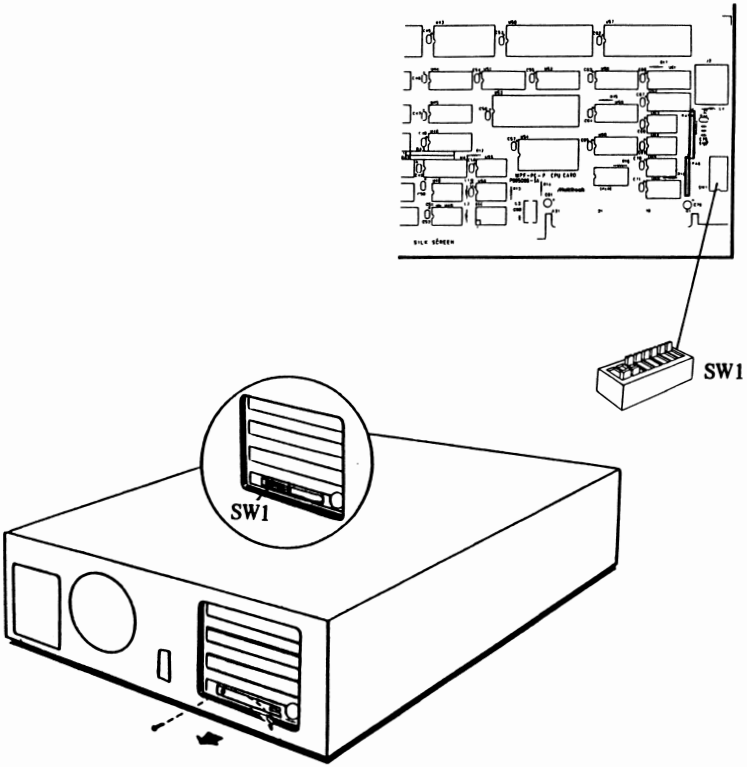


Fig. 3-1 Location of the DIP Switch

To operate your system properly, SW1 should be set properly. The following is a summary of the function of each slide switch. The summary provides you with an overview of the functions of the two configuration switches.

3.3 Descriptions of the DIP Switches

3.3.1 SW1 — DIP Switch One

Switch No.	Function
SW1-1	Enables disk drive.
SW1-2	Unused
SW1-3 SW1-4	SW1-3 and SW1-4 determine the amount of RAM installed on the system board.
SW1-5	Determines the number of display columns.
SW1-6	Determines display type.
SW1-7 SW1-8	SW1-7 and SW1-8 determine the number of disk drive(s) installed in the system unit.

3.4 Default Switch Settings

3.4.1 SW1 — DIP Switch One

Switch No.	Default Setting	
SW1-1	OFF	Disk drive enabled.
SW1-2	*	Unused
SW1-3 SW1-4	OFF OFF	Default Memory Size is 256K

SW1-5	ON	Default display type is CGA and display is 80 characters by 25 lines.
SW1-6	OFF	
SW1-7	ON	Default number of drives is 1
SW1-8	ON	

3.5 How to Set the Switches

We strongly recommend that all switch positions be noted down before attempting to adjust any of the switches (so that you can reset them to their original positions if necessary).

3.5.1 Switch No. 1 - SW1

SW1-1 The normal position of this slide switch is OFF. This will load the operating system from the floppy disk drive to the system memory upon system power on. If it is ON, the diskette drive(s) will be deactivated, and the system cannot be booted even if you have diskette drive(s) installed and operating system program inserted in your diskette drive.

SW1-5 The video display type is determined by SW1-5 and SW1-6. Be forewarned that setting the slide switches for the display monitor differently from those given in this manual may damage your display. For monochrome display monitor, this slide switch should be set to OFF. For color display monitor having 40 characters per line, it should also be set to OFF. Refer to the following figures for the correct switch settings. Set this switch to ON if the Enhanced Graphics Adapter is installed.

SW1-6 This slide switch should be set to OFF for monochrome display. For color monitor with 40 characters mode, it should be ON. Refer to the following figures for the correct switch settings. Set this switch to ON if the Enhanced Graphics Adapter is installed.

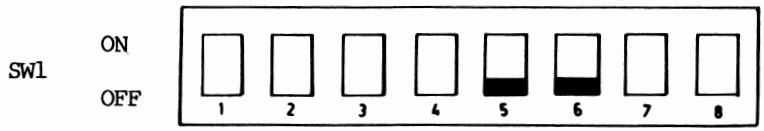


Fig. 3-2 Switch Setting for Monochrome Display 80 x 25

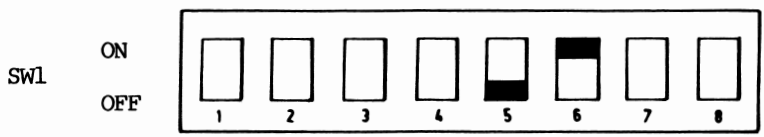


Fig. 3-3 Switch Setting for Color Card 40 x 25

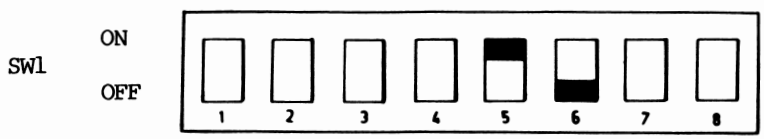
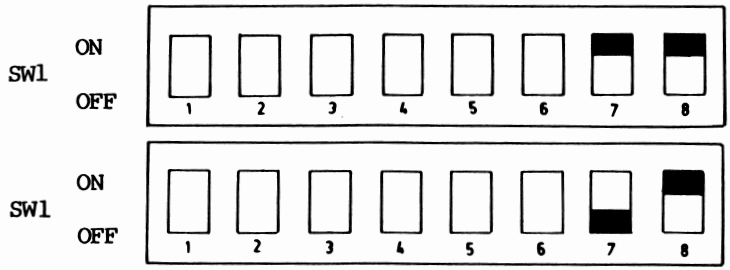


Fig. 3-4 Switch Setting for Color Card 80 x 25

SW1-7 The number of disk drives is determined by switches SW1-7 and SW1-8.

SW1-8 In combination with SW1-7 the purpose of this slide switch is to determine the number of diskette drives in the system unit.



3.6 RAM Space Allocation and Switch Settings

1. 512K

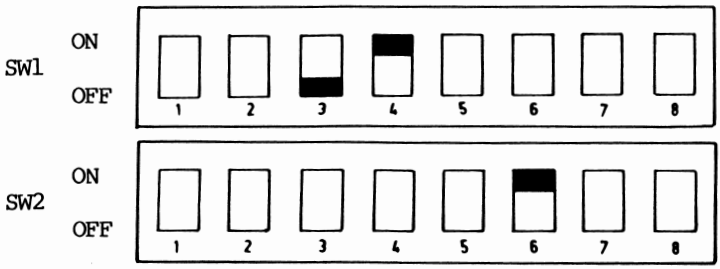


Fig. 3-6 Switch Setting for 512K

BANK NO.	CHIP TYPE	MEMORY INCREMENT
Ø	41256	256K
1	41256	512K (256 + 256)

Table 3-1 RAM Space Allocation for 512K

2. 256K

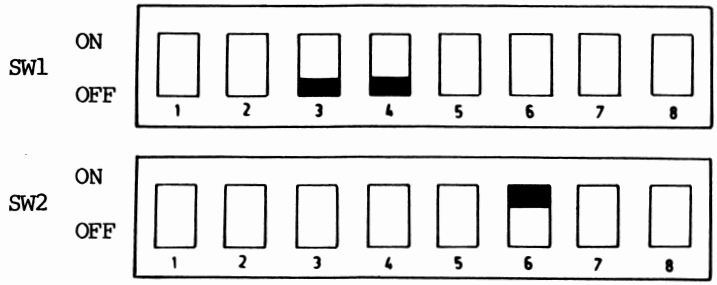


Fig. 3-7 Switch Setting for 256K

BANK NO.	CHIP TYPE	MEMORY INCREMENT
Ø	41256	256K
1		

Table 3-2 RAM Space Allocation for 256K

3.7 Quick Reference for Switch Settings Involved with the Memory Size

SW2-6 ON - indicates that 41256 RAM chips should be inserted in Bank Ø.
OFF - indicates that 4164 RAM chips should be inserted in Bank 1.

SW2-6	SW1-3	SW1-4	Enabled Bank	41256
ON	OFF	OFF	1	256K
ON	OFF	oFF	1,2	512K

Chapter 4

How to Install the Expansion Board

To install an expansion board into the system, simply follow the following steps:

1) Turn off the power switch on the rear panel of the system unit.

2) Turn off all external power switches (such as Monitor, Printer, etc.).

3) Disconnect all cables from the rear panel of the system unit, remembering distinctly where each cable was attached.

4) Place the system unit in a convenient position to allow easy access to the rear panel.

5) Remove the three screws from the cover with a flat screwdriver by turning them counter-clockwise as shown below. (Save the screws for re-installation of the cover.)

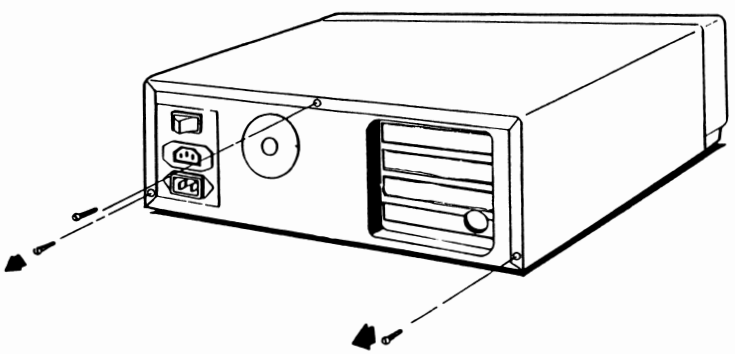


Fig. 4-1 Removing the Screws

6) Carefully slide the system unit's cover a few inches toward the rear as shown below, then pull both sides a little bit sideways.

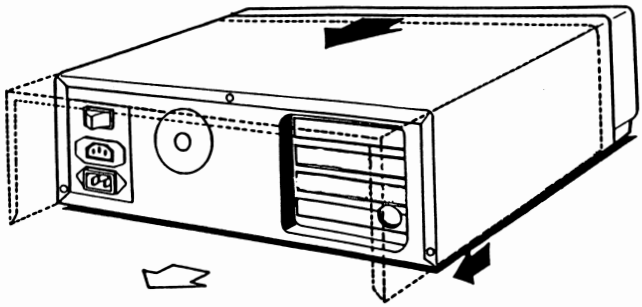


Fig. 4-2 Openning the Top Cover

7) Raise the cover upwards and pull backwards. Set the cover aside.

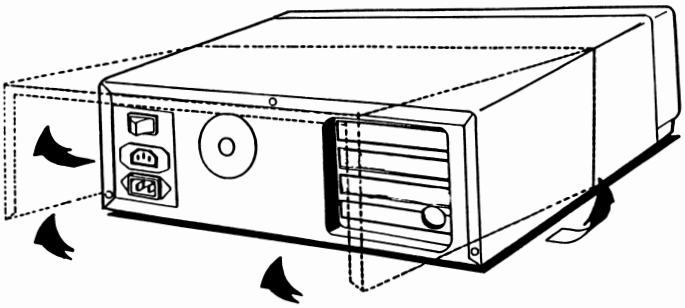


Fig. 4-3 Removing the Cover

8) There are four expansion slots on the mother board. You can insert the expansion board in the unused slot.

9) Remove the metal strip that corresponds to the expansion slot by turning the screw counter-clockwise (save the screw for the re-installation of the expansion board).

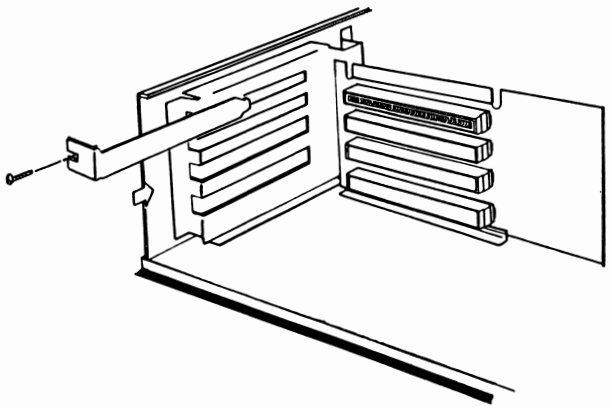


Fig. 4-4 Removing the Metal Strip

10) Remove the screw on the board stopper and pull forward until it becomes horizontal. Insert the board horizontally. Make sure the board slides into the plastic groove on the right side.

Chapter 5

How to Install the Floppy Disk Drive on the System Unit

There is only one built-in floppy disk drive in our system but two floppy disk interfaces are supported by the FDI on the I/O board. For users who wish to expand their system by adding another disk drive, just follow these steps:

1. Place the system unit on a work table. Remove the housing from the system unit by removing the three screws from the rear panel.

2. The disk drives are housed inside the floppy drive unit inside the system unit. The built-in disk drive occupies the upper bunk; while the lower bunk is reserved for a second drive.

3. Remove the four screws from the floppy drive unit, refer to Fig. 5-1. Save the screws for reinstallation.

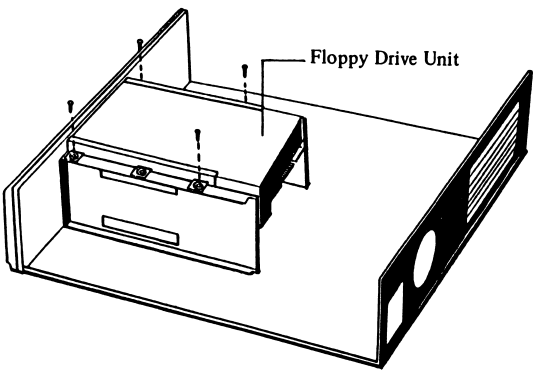


Fig. 5-1 Removing the Screws from the Floppy Drive Unit

4. Slide the floppy drive unit towards the rear of the system unit until the lever of the built-in floppy disk drive is beyond the top of the front panel. Remove the floppy drive unit by lifting it upwards, then place it on the work table. See Fig. 5-2.

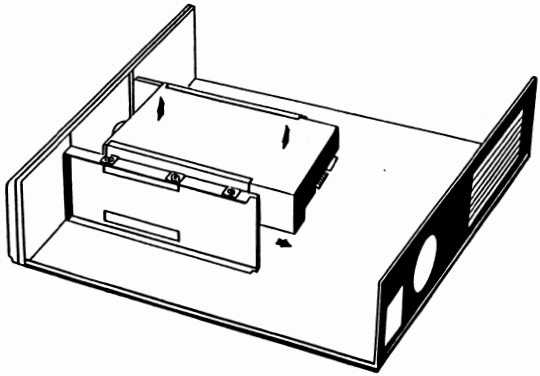


Fig. 5-2 Removing the Floppy Drive Unit

5. A plastic board covers the empty lower bunk to prevent dust and other foreign materials from getting inside the system unit. Remove the plastic board by removing the two screws that attach it to the floppy drive unit as shown in Fig. 5-3.

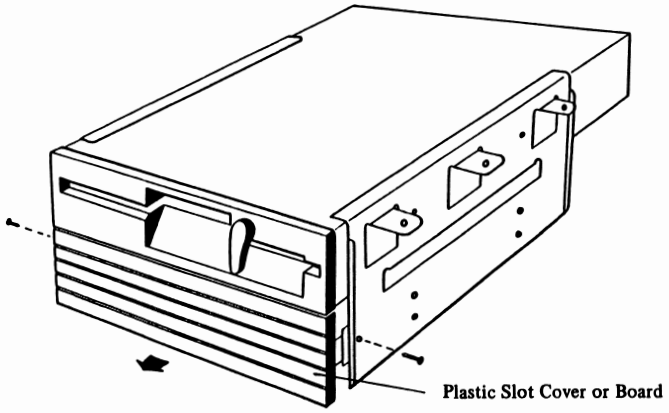


Fig. 5-3 Removing the plastic board from the Empty Lower Bunk

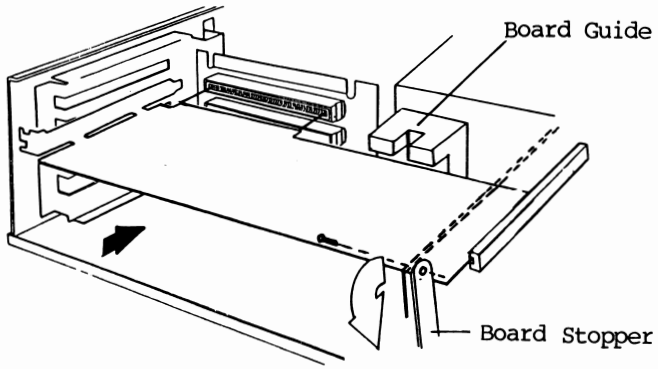


Fig. 4-5 Inserting the Card

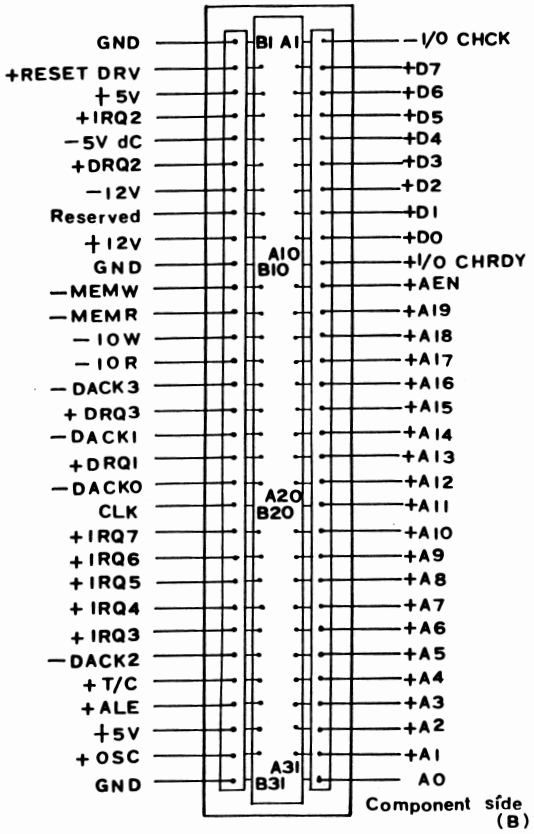
11) Note that the board should be inserted between two notches in the board guide. Screw the board in place. Return the card stopper to its original position and screw it in place.

12) Read the instructions for the option card and make the necessary connections if any.

13) Replace the cover and reinstall the screws.

Appendix

A. I/O Channel Pin Assignment

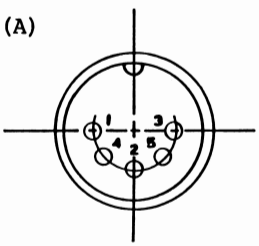


B. Keyboard Connector Pin Assignment

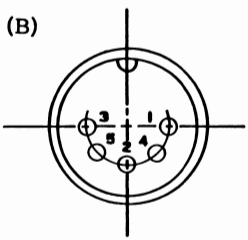
The keyboard is connected to the system through a cable attached with a 5-pin DIN connector. The following table lists the pin assignment of the connector and their corresponding signals.

Pin No.	Signal
1	Clock
2	Data
3	Reserved
4	Ground
5	+5 Vdc

(A)



(B)

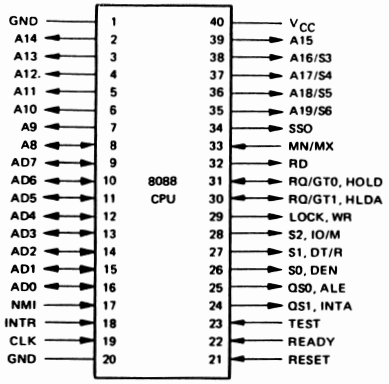


Note:

(A): System Board 5-Pin Connector

(B): Keyboard 5-Pin Connector

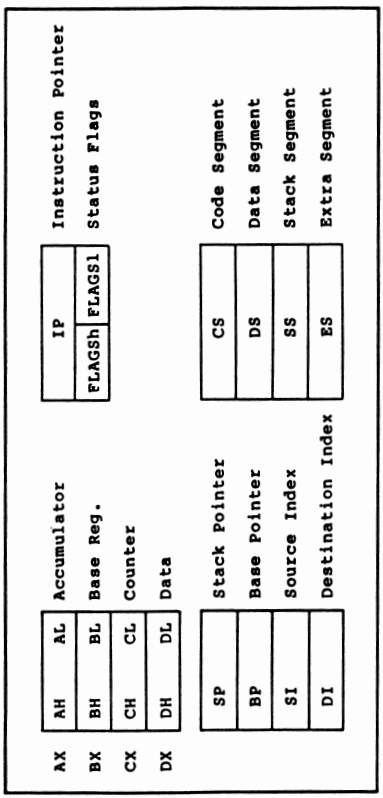
C. CPU Pin Assignment



Pin Name	Description	Type
AD0-AD7	Address/Data Bus	Bidirectional, tristate
A8-A15	Address Bus	Output, tristate
A16/S3, A17/S4	Address/Segment identifier	Output, trisate
A18/S5	Address/Interrupt enable status	Output, tristate
A19/S6	Address/status	Output, tristate
SSO	Status output	Output, tristate
RD	Read control	Output, tristate
READY	Wait state request	Input
TEST	Wait for test control	Input
INTR	Interrupt request	Input
NIMI	Non-maskable interrupt request	Input
RESET	System Reset	Input
CLK	System Clock	Input
MN/MX	= GND for a maximum system	
S0, S1, S2	Machine cycle status	Output, tristate
RQ/GT0, RQ/G11	Local bus priority control	Bidirectional
QS0, QS1	Instruction queue status	Output
LOCK	Bus hold control	Output, tristate
MN/MX	= V_{CC} for a minimum system	
IO/M	Memory or I/O access	Output, tristate
WR	Write control	Output, tristate
ALE	Address Latch enable	Output
DT/R	Data transmit/receive	Output, tristate
DEN	Data enable	Output, tristate
INTA	Interrupt acknowledge	Output, tristate
HOLD	Hold request	Input
HLDA	Hold acknowledge	Output
V_{CC}. GND	Power, ground	
Maximum System Signals		Minimum System Signals

8088 Pins and Signal Assignments

D. 8080 Registers



E. 8086/8088 Instruction Set — Listed Alphabetically

Instruction		Object Code	Bytes	Clock Periods
AAA		37	1	4
AAD		D5 0A	2	60
AAM		D4 0A	2	83
AAS		3F	1	4
ADC	ac,data	0001010w kk [jj]	2 or 3	4
ADC	mem/reg$_1$,data	100000sw mod 010 r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg: 4 mem: 17 + EA
ADC	mem/reg$_1$mem/reg$_2$	00100dw mod rrr r/m [DISP] [DISP]	2, 3 or 4	reg to reg: 3 mem to reg: 9 + EA reg to mem: 16 + EA
ADD	ac,data	0000010w kk [jj]	2 or 3	4
ADD	mem/reg,data	100000sw mod 000 r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg: 4 mem: 17 + EA
ADD	mem/reg$_1$,mem/reg$_2$	000000dw mod rrr r/m [DISP] [DISP]	2, 3 or 4	reg to reg: 3 mem to reg: 9 + EA reg to mem: 16 + EA
AND	ac,data	0010010w kk [jj]	2 or 3	4
AND	mem/reg,data	1000000w mod 100 r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg: 4 mem: 17 + EA
AND	mem/reg$_1$,mem/reg$_2$	001000dw mod rrr r/m [DISP] [DISP]	2, 3 or 4	reg to reg: 3 mem to reg: 9 + EA reg to mem: 16 + EA
CALL	addr	9A kk jj hh gg	5	28
CALL	disp16	E8 kk jj	3	19
CALL	mem	FF mod 011 r/m [DISP] [DISP]	2, 3 or 4	32-bit mem pointer: 37 + EA
CALL	mem/reg	FF mod 010 r/m [DISP] [DISP]	2, 3, or 4	16-bit reg pointer: 16 16-bit mem pointer: 21 + EA

Instruction		Object Code	Bytes	Clock Periods
CBW		98	1	2
CLC		F8	1	2
CLD		FC	1	2
CLI		FA	1	2
CMC		F5	1	2
CMP	ac,data	0011110w kk [jj]	2 or 3	4
CMP	mem/reg,data	100000sw mod 111 r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg: 4 mem: 10 + EA
CMP	mem/reg_1,mem/reg_2	001110dw mod rrr r/m [DISP] [DISP]	2, 3 or 4	reg to reg: 3 mem to reg: 9 + EA reg to mem: 9 + EA
CMPS		1010011w	1	22 9 + 22/repetition*
CWD		99	1	5
DAA		27	1	4
DAS		2F	1	4
DEC	mem/reg	1111111w mod 001 r/m [DISP] [DISP]	2, 3 or 4	reg: 3 mem: 15 + EA
DEC	16-bit reg	01001rrr	1	2
DIV	mem/reg	1111011w mod 110 r/m [DISP] [DISP]	2, 3 or 4	8-bit reg: 80 → 90 16-bit reg: 144 → 162 8-bit mem: (86 → 96) + EA 16-bit mem: (150 → 168) + EA
ESC	mem/reg	11011xxx mod xxx r/m [DISP] [DISP]	2, 3 or 4	mem: 8 + EA reg: 2
HLT		F4	1	2
IDIV	mem/reg	1111011w mod 111 r/m [DISP] [DISP]	2, 3 or 4	8-bit reg: 101 → 112 16-bit reg: 165 → 184 8-bit mem: (107 → 118) + EA 16-bit mem: (171 → 190) + EA
IMUL	mem/reg	1111011w mod 101 r/m [DISP] [DISP]	2, 3 or 4	8-bit reg: 80 → 98 16-bit reg: 128 → 154 8-bit mem: (86 → 104) + EA 16-bit mem: (134 → 160) + EA
IN	ac, DX	1110110w	1	8
IN	ac, port	1110010w	2	10

* When preceded by REP prefix

Instruction		Object Code	Bytes	Clock Periods
INC	mem/reg	1111111w mod 000 r/m [DISP] [DISP]	2, 3 or 4	reg: 3 mem: 15 + EA
INC	16-bit reg	01000rrr	1	2
INT		11001100*	1	52
		11001101 type	2	51
INTO		CE	1	interrupt: 53 no interrupt: 4
IRET		CF	1	24
JA	disp	77	2	4/No Branch
JNBE		disp		16/Branch
JAE	disp	73	2	4/No Branch
JNB		disp		16/Branch
JB	disp	72	2	4/No Branch
JNAE		disp		8/Branch
JBE	disp	76	2	4/No Branch
JNA		disp		16/Branch
JCXZ	disp	E3	2	6/No Branch
		disp		18/Branch
JE	disp	74	2	4/No Branch
JZ		disp		16/Branch
JG	disp	7F	2	4/No Branch
JNLE		disp		16/Branch
JGE	disp	7D	2	4/No Branch
JNL		disp		16/Branch
JL	disp	7C	2	4/No Branch
JNGE		disp		16/Branch
JLE	disp	7E	2	4/No Branch
JNG		disp		16/Branch
JMP	addr	EA kk jj hh gg	5	15
JMP	disp	EB disp	2	15
JMP	disp16	E9 kk jj	3	15
JMP	mem	FF [DISP] [DISP]	2, 3 or 4	mem ptr 32
JMP	mem/reg	FF [DISP] [DISP]	2, 3 or 4	reg ptr 16: 11 18 + EA
JNE	disp	75	2	4/No Branch
JNZ		disp		16/Branch
JNO	disp	71	2	4/No Branch
		disp		16/Branch
JNP	disp	7B	2	4/No Branch
JPO		disp		16/Branch
JNS	disp	79	2	4/No Branch
		disp		16/Branch
JO	disp	70	2	4/No Branch
		disp		16/Branch

* Implied type = 3

Instruction		Object Code	Bytes	Clock Periods
JP	disp	7A	2	4/No Branch
JPE		disp		16/Branch
JS	disp	78	2	4/No Branch
		disp		16/Branch
LAHF		9F	1	4
LDS	reg,mem	C5	2, 3 or 4	16 + EA
		mod rrr r/m		
		[DISP]		
		[DISP]		
LEA	reg,mem	8D	2, 3 or 4	2 + EA
		mod rrr r/m		
		[DISP]		
		[DISP]		
LES	reg,mem	C4	2, 3 or 4	16 + EA
		mod rrr r/m		
		[DISP]		
		[DISP]		
LOCK		F0	1	2
LODS		1010110w	1	12
				9 + 13/repetition*
LOOP	disp	E2	2	5/No Branch
		disp		17/Branch
LOOPE	disp	E1	2	6/No Branch
LOOPZ		disp		18/Branch
LOOPNE	disp	E0	2	5/No Branch
LOOPNZ		disp		19/Branch
MOV	mem/reg_1,mem/reg_2	100010dw	2, 3 or 4	reg to reg: 2
		mod rrr r/m		reg to mem: 8 + EA
		[DISP]		mem to reg: 9 + EA
		[DISP]		
MOV	reg,data	1011wrrr	2 or 3	4
		kk		
		[jj]		
MOV	ac,mem	1010000w	3	10
		kk		
		jj		
MOV	mem,ac	1010001w	3	10
		kk		
		jj		
MOV	segreg,mem/reg	8E	2, 3 or 4	reg to reg: 2
		mod 0rr r/m		mem to reg: 8 + EA
		[DISP]		
		[DISP]		
MOV	mem/reg,segreg	8C	2, 3 or 4	reg to reg: 2
		mod 0rr r/m		reg to mem: 9 + EA
		[DISP]		
		[DISP]		
MOV	mem/reg,data	1100011w	3, 4, 5 or 6	reg/mem: 10 + EA
		mod 000 r/m		
		[DISP]		
		[DISP]		
		kk		
		[jj]		
MOVS		1010010w	1	18
				9 + 17/repetition*

* When preceded by REP prefix

Instruction		Object Code	Bytes	Clock Periods
MUL	mem/reg	1111011w mod 100 r/m [DISP] [DISP]	2, 3 or 4	8-bit reg: 70 → 77 16-bit reg: 118 → 133 8-bit mem: (76 → 83) + EA 16-bit mem: (124 → 139) + EA
NEG	mem/reg	1111011w mod 011 r/m [DISP] [DISP]	2, 3 or 4	reg: 3 mem: 16 + EA
NOP		90	1	3
NOT	mem/reg	1111011w mod 010 r/m [DISP] [DISP]	2, 3 or 4	reg: 3 mem: 16 + EA
OR	ac,data	0000110w kk [jj]	2 or 3	4
OR	mem/reg,data	1000000w mod 001 r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg: 4 mem: 17 + EA
OR	mem/reg_1,mem/reg_2	000010dw mod rrr r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg to reg: 3 mem to reg: 9 + EA
OUT	DX,ac	1110111w	1	8
OUT	port,ac	1110011w yy	2	10
POP	mem/reg	8F mod 000 r/m [DISP] [DISP]	2, 3 or 4	reg: 8 mem: 17 + EA
POP	reg	01011rrr	1	8
POP	segreg	000ss111	1	8
POPF		9D	1	8
PUSH	mem/reg	FF mod 110 r/m [DISP] [DISP]	2, 3 or 4	reg: 11 mem: 16 + EA
PUSH	reg	01010rrr	1	10
PUSH	segreg	000ss110	1	10
PUSHF		9C	1	10
RCL	mem/reg,count	110100cw mod 010 r/m [DISP] [DISP]	2, 3 or 4	count = 1 reg: 2 mem: 15 + EA count: [CL] reg: 8 + (4*N) mem: 20 + EA + (4*N)

N = count value in CL

Instruction		Object Code	Bytes	Clock Periods
RCR	mem/reg,count	110100cw mod 011 r/m [DISP] [DISP]	2, 3 or 4	count = 1 reg: 2 mem: 15 + EA count: [CL] reg: 8 + (4*N) mem: 20 + EA + (4*N)
REP	/REPE/REPNE	1111011z	1	2
RET	(Inter-segment)	CB	1	18
RET	(Intra-segment)	C3	1	8
RET	disp 16 (Inter-segment)	CA kk jj	3	17
RET	disp 16 (Intra-segment)	C2 kk jj	3	12
ROL	mem/reg,count	110100cw mod 000 r/m [DISP] [DISP]	2, 3 or 4	count = 1 reg: 2 mem: 15 + EA count = [CL] reg: 8 + (4*N) mem: 20 + EA + (4*N)
ROR	mem/reg,count	110100cw mod 001 r/m [DISP] [DISP]	2, 3 or 4	count = 1 reg: 2 mem: 15 + EA count: [CL] reg: 8 + (4*N) mem: 20 + EA + (4*N)
SAHF		9E	1	4
SAR	mem/reg,count	110100cw mod 111 r/m [DISP] [DISP]	2, 3 or 4	count = 1 reg: 2 mem: 15 + EA count = [CL] reg: 8 + (4*N) mem: 20 + EA + (4*N)
SBB	ac,data	0001110w kk [jj]	2 or 3	4
SBB	mem/reg,data	100000sw mod 011 r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg: 4 mem: 17 + EA
SBB	mem/reg_1,mem/reg_2	000110dw mod rrr r/m [DISP] [DISP]	2, 3 or 4	reg from reg: 3 mem from reg: 9 + EA reg from mem: 16 + EA
SCAS		1010111w	1	15 9 + 16/repetition*
SEG	segreg	001ss110	1	2
SHL SAL	mem/reg,count	110100cw mod 100 r/m [DISP] [DISP]	2, 3 or 4	count = 1 reg: 2 mem: 15 + EA count: [CL] reg: 8 + (4*N) mem: 20 + EA + (4*N)

* When preceded by REP prefix
N = count value in CL

Instruction		Object Code	Bytes	Clock Periods
SHR	mem/reg,count	110100cw mod 101 r/m [DISP] [DISP]	2, 3 or 4	count = 1 reg: 2 mem: 15 + EA count = [CL] reg: 8 + (4*N) mem: 20 + EA + (4*N)
STC		F9	1	2
STD		FD	1	2
STI		FB	1	2
STOS		1010101w	1	11 9 + 10/repetition*
SUB	ac,data	0010110w kk [jj]	2 or 4	4
SUB	mem/reg,data	100000sw mod 101 r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg: 4 mem: 17 + EA
SUB	mem/reg_1,mem/reg_2	001010dw mod rrr r/m [DISP] [DISP]	2, 3 or 4	reg from reg: 3 mem from reg: 9 + EA reg from mem: 16 + EA
TEST	ac,data	1010100w kk [jj]	2 or 3	4
TEST	mem/reg,data	1111011w mod 000 r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg: 5 mem: 11 + EA
TEST	reg,mem/reg	1000010w mod rrr r/m [DISP] [DISP]	2, 3 or 4	reg with reg: 3 reg with mem: 9 + EA
WAIT		9B	1	3(mm) + 5n
XCHG	reg,ac	10010rrr	1	3
XCHG	reg.mem/reg	1000011w [DISP] [DISP]	2, 3 or 4	reg with reg: 4 reg with mem: 17 + EA
XLAT		D7	1	11
XOR	ac,data	0011010w kk [jj]	2 or 3	4
XOR	mem/reg,data	1000000w mod 110 r/m [DISP] [DISP] kk [jj]	3, 4, 5 or 6	reg: 4 mem: 17 + EA
XOR	mem/reg_1,mem/reg_2	001100dw mod rrr r/m [DISP] [DISP]	2, 3 or 4	reg with reg: 3 mem with reg: 9 + EA reg with mem: 16 + EA

* When preceded by REP prefix

N = clocks per samples of the TEST input

F. 8086/8088 Instruction Set — Object Codes in Ascending Numeric Sequence

Object Code			Mnemonic
Byte # 0	Byte # 1	Succeeding Bytes	
00	mod reg r/m	[disp][disp]	ADD mem/reg,reg (byte)
01	mod reg r/m	[disp][disp]	ADD mem/reg,reg (word)
02	mod reg r/m	[disp][disp]	ADD reg, mem/reg (byte)
03	mod reg r/m	[disp][disp]	ADD reg, mem/reg (word)
04	kk		ADD AL,kk
05	kk	jj	ADD AX, jjkk
06			PUSH ES
07			POP ES
08	mod reg r/m	[disp][disp]	OR mem/reg,reg (byte)
09	mod reg r/m	[disp][disp]	OR mem/reg,reg (word)
0A	mod reg r/m	[disp][disp]	OR reg,mem/reg (byte)
0B	mod reg r/m	[disp][disp]	OR reg,mem/reg (word)
0C	kk		OR AL,kk
0D	kk	jj	OR AL,jjkk
0E			PUSH CS
0F			Not used
10	mod reg r/m	[disp][disp]	ADC mem/reg,reg (byte)
11	mod reg r/m	[disp][disp]	ADC mem/reg,reg (word)
12	mod reg r/m	[disp][disp]	ADC reg,mem/reg (byte)
13	mod reg r/m	[disp][disp]	ADC reg,mem/reg (word)
14	kk		ADC AL,kk
15	kk	jj	ADC AX,jjkk
16			PUSH SS
17			POP SS
18	mod reg r/m	[disp][disp]	SBB mem/reg,reg (byte)
19	mod reg r/m	[disp][disp]	SBB mem/reg,reg (word)
1A	mod reg r/m	[disp][disp]	SBB reg,mem/reg (byte)
1B	mod reg r/m	[disp][disp]	SBB reg,mem/reg (word)
1C	kk		SBB AL,kk
1D	kk	jj	SBB AX,jjkk
1E			PUSH DS
1F			POP DS
20	mod reg r/m	[disp][disp]	AND mem/reg,reg (byte)
21	mod reg r/m	[disp][disp]	AND mem/reg,reg (word)
22	mod reg r/m	[disp][disp]	AND reg,mem/reg (byte)
23	mod reg r/m	[disp][disp]	AND reg,mem/reg (word)
24	kk		AND AL,kk
25	kk	jj	AND AX,jjkk
26			SEG ES
27			DAA
28	mod reg r/m	[disp][disp]	SUB mem/reg,reg (byte)
29	mod reg r/m	[disp][disp]	SUB mem/reg,reg (word)
2A	mod reg r/m	[disp][disp]	SUB reg,mem/reg (byte)
2B	mod reg r/m	[disp][disp]	SUB reg,mem/reg (word)
2C	kk		SUB AL,kk
2D	kk	jj	SUB AX,jjkk
2E			SEG CS
2F			DAS

Object Code			Mnemonic
Byte # 0	Byte # 1	Succeeding Bytes	
30	mod reg r/m	[disp][disp]	XOR mem/reg,reg (byte)
31	mod reg r/m	[disp][disp]	XOR mem/reg,reg (word)
32	mod reg r/m	[disp][disp]	XOR reg,mem/reg (byte)
33	mod reg r/m	[disp][disp]	XOR reg,mem/reg (word)
34	kk		XOR AL,kk
35	kk	jj	XOR AX,jjkk
36			SEG SS
37			AAA
38	mod reg r/m	[disp][disp]	CMP mem/reg,reg (byte)
39	mod reg r/m	[disp][disp]	CMP mem/reg,reg (word)
3A	mod reg r/m	[disp][disp]	CMP reg,mem/reg (byte)
3B	mod reg r/m	[disp][disp]	CMP reg,mem/reg (word)
3C	kk		CMP AL,kk
3D	kk	jj	CMP AX,jjkk
3E			SEG DS
3F			AAS
40			INC AX
41			INC CX
42			INC DX
43			INC BX
44			INC SP
45			INC BP
46			INC SI
47			INC DI
48			DEC AX
49			DEC CX
4A			DEC DX
4B			DEX BX
4C			DEC SP
4D			DEC BP
4E			DEC SI
4F			DEC DI
50			PUSH AX
51			PUSH CX
52			PUSH DX
53			PUSH BX
54			PUSH SP
55			PUSH BP
56			PUSH SI
57			PUSH DI
58			POP AX
59			POP CX
5A			POP DX
5B			POP BX
5C			POP SP
5D			POP BP
5E			POP SI
5F			POP DI
60-6F			Not used

Object Code			Mnemonic
Byte # 0	Byte # 1	Succeeding Bytes	
70	disp		JO disp
71	disp		JNO disp
72	disp		JB or JNAE or JC disp
73	disp		JNB or JAE or JNC disp
74	disp		JE or JZ disp
75	disp		JNE or JNZ disp
76	disp		JBE or JNA disp
77	disp		JNBE or JA disp
78	disp		JS disp
79	disp		JNS disp
7A	disp		JP or JPE disp
7B	disp		JNP or JPO disp
7C	disp		JL or JNGE disp
7D	disp		JNL or JGE disp
7E	disp		JLE or JNG disp
7F	disp		JNLE or JG disp
80	mod 000 r/m	[disp][disp] kk	ADD mem/reg,kk
80	mod 001 r/m	[disp][disp] kk	OR mem/reg,kk
80	mod 010 r/m	[disp][disp] kk	ADC mem/reg,kk
80	mod 011 r/m	[disp][disp] kk	SBB mem/reg,kk
80	mod 100 r/m	[disp][disp] kk	AND mem/reg,kk
80	mod 101 r/m	[disp][disp] kk	SUB mem/reg,kk
80	mod 110 r/m	[disp][disp] kk	XOR mem/reg,kk
80	mod 111 r/m	[disp][disp] kk	CMP mem/reg,kk
81	mod 000 r/m	[disp][disp] kkjj	ADD mem/reg,jjkk
81	mod 001 r/m	[disp][disp] kkjj	OR mem/reg,jjkk
81	mod 010 r/m	[disp][disp] kkjj	ADC mem/reg,jjkk
81	mod 011 r/m	[disp][disp] kkjj	SBB mem/reg,jjkk
81	mod 100 r/m	[disp][disp] kkjj	AND mem/reg,jjkk
81	mod 101 r/m	[disp][disp] kkjj	SUB mem/reg,jjkk
81	mod 110 r/m	[disp][disp] kkjj	XOR mem/reg,jjkk
81	mod 111 r/m	[disp][disp] kkjj	CMP mem/reg,jjkk
82	mod 000 r/m	[disp][disp] kk	ADD mem/reg,kk (byte)
82	xx 001 xxx		Not used
82	mod 010 r/m	[disp][disp] kk	ADC mem/reg,kk (byte)
82	mod 011 r/m	[disp][disp] kk	SBB mem/reg,kk (byte)
82	xx 100 xxx		Not used
82	mod 101 r/m	[disp][disp] kk	SUB mem/reg,kk (byte)
82	xx 110 xxx		Not used
82	mod 111 r/m	[disp][disp] kk	CMP mem/reg,kk (byte)
83	mod 000 r/m	[disp][disp] kk	ADD mem/reg,jjkk (word-sign extended)
83	xx 001 xxx		Not used
83	mod 010 r/m	[disp][disp] kk	ADC mem/reg,jjkk (word-sign extended)
83	mod 011 r/m	[disp][disp] kk	SBB mem/reg,jjkk (word-sign extended)
83	xx 100 r/m		Not used
83	mod 101 r/m	[disp][disp] kk	SUB mem/reg,jjkk (word-sign extended)
83	xx 110 xxx		Not used
83	mod 111 r/m	[disp][disp] kk	CMP mem/reg,jjkk (word-sign extended)
84	mod reg r/m	[disp][disp]	TEST mem/reg,reg (byte)
85	mod reg r/m	[disp][disp]	TEST mem/reg,reg (word)
86	mod reg r/m	[disp][disp]	XCHG reg,mem/reg (byte)
87	mod reg r/m	[disp][disp]	XCHG reg,mem/reg (word)
88	mod reg r/m	[disp][disp]	MOV mem/reg,reg (byte)
89	mod reg r/m	[disp][disp]	MOV mem/reg,reg (word)

Object Code			Mnemonic
Byte # 0	Byte # 1	Succeeding Bytes	
8A	mod reg r/m	[disp][disp]	MOV reg,mem/reg (byte)
8B	mod reg r/m	[disp][disp]	MOV reg,mem/reg (word)
8C	mod 0ss r/m	[disp][disp]	MOV mem/reg,segreg
8C	x 1 xxxxx		Not used
8D	mod reg r/m	[disp][disp]	LEA reg,addr
8E	mod 0ss r/m	[disp][disp]	MOV segreg, mem/reg
8E	xx 1 xxxxx		Not used
8F	mod 000 r/m	[disp][disp]	POP mem/reg
8F	xx 001 xxx		Not used
8F	xx 010 xxx		Not used
8F	xx 011 xxx		Not used
8F	xx 100 xxx		Not used
8F	xx 101 xxx		Not used
8F	xx 110 xxx		Not used
8F	xx 111 xxx		Not used
			Not used
90			NOP
91			XCHG AX,CX
92			XCHG AX,DX
93			XCHG AX,BX
94			XCHG AX,SP
95			XCHG AX,BP
96			XCHG AX,SI
97			XCHG AX,DI
98			CBW
99			CWD
9A	kk	jj hh gg	CALL addr
9B			WAIT
9C			PUSHF
9D			POPF
9E			SAHF
9F			LAHF
A0	qq	pp	MOV AL,addr
A1	qq	pp	MOV AX,addr
A2	qq	pp	MOV addr,AL
A3	qq	pp	MOV addr,AX
A4			MOVS BYTE
A5			MOVS WORD
A6			CMPS BYTE
A7			CMPS WORD
A8	kk		TEST, AL,kk
A9	kk	jj	TEST AX,jjkk
AA			STOS BYTE
AB			STOS WORD
AC			LODS BYTE
AD			LODS WORD
AE			SCAS BYTE
AF			SCAS WORD

Object Code			Mnemonic
Byte # 0	Byte # 1	Succeeding Bytes	
B0	kk		MOV AL,kk
B1	kk		MOV CL,kk
B2	kk		MOV DL,kk
B3	kk		MOV BL,kk
B4	kk		MOV AH,kk
B5	kk		MOV CH,kk
B6	kk		MOV DH,kk
B7	kk		MOV BH,kk
B8	kk	jj	MOV AX,jjkk
B9	kk	jj	MOV CX,jjkk
BA	kk	jj	MOV DX,jjkk
BB	kk	jj	MOV BX,jjkk
BC	kk	jj	MOV SP,jjkk
BD	kk	jj	MOV BP,jjkk
BE	kk	jj	MOV SI,jjkk
BF	kk	jj	MOV DI,jjkk
C0			Not used
C1			Not used
C2	kk	jj	RET jjkk
C3			RET
C4	mod reg r/m	[disp][disp]	LES reg,addr
C5	mod reg r/m	[disp][disp]	LDS reg,addr
C6	mod 000 r/m	[disp][disp] kk	MOV mem,kk
C6	xx 001 xxx		Not used
C6	xx 010 xxx		Not used
C6	xx 011 xxx		Not used
C6	xx 100 xxx		Not used
C6	xx 101 xxx		Not used
C6	xx 110 xxx		Not used
C6	xx 111 xxx		Not used
C7	mod 000 r/m	[disp][disp] kkjj	MOV mem,jjkk
C7	xx 001 xxx		Not used
C7	xx 010 xxx		Not used
C7	xx 011 xxx		Not used
C7	xx 100 xxx		Not used
C7	xx 101 xxx		Not used
C7	xx 110 xxx		Not used
C7	xx 111 xxx		Not used
C8			Not used
C9			Not used
CA	kk	jj	RET jjkk
CB			RET
CC			INT 3
CD	type		INT Type
CE			INTO
CF			IRET

Object Code			Mnemonic
Byte # 0	Byte # 1	Succeeding Bytes	
D0	mod 000 r/m	[disp][disp]	ROL mem/reg,1 (byte)
D0	mod 001 r/m	[disp][disp]	ROR mem/reg,1 (byte)
D0	mod 010 r/m	[disp][disp]	RCL mem/reg,1 (byte)
D0	mod 011 r/m	[disp][disp]	RCR mem/reg,1 (byte)
D0	mod 100 r/m	[disp][disp]	SAL or SHL mem/reg,1 (byte)
D0	mod 101 r/m	[disp][disp]	SHR mem/reg,1 (byte)
D0	xx 110 xxx		Not used
D0	mod 111 r/m	[disp][disp]	SAR mem/reg,1 (byte)
D1	mod 000 r/m	[disp][disp]	ROL mem/reg,1 (word)
D1	mod 001 r/m	[disp][disp]	ROR mem/reg,1 (word)
D1	mod 010 r/m	[disp][disp]	RCL mem/reg,1 (word)
D1	mod 011 r/m	[disp][disp]	RCR mem/reg,1 (word)
D1	mod 100 r/m	[disp][disp]	SAL or SHL mem/reg,1 (word)
D1	mod 101 r/m	[disp][disp]	SHR mem/reg,1 (word)
D1	xx 110 xxx		Not used
D1	mod 111 r/m	[disp][disp]	SAR mem/reg,1 (word)
D2	mod 000 r/m	[disp][disp]	ROL mem/reg,CL (byte)
D2	mod 001 r/m	[disp][disp]	ROR mem/reg,CL (byte)
D2	mod 010 r/m	[disp][disp]	RCL mem/reg,CL (byte)
D2	mod 011 r/m	[disp][disp]	RCR mem/reg,CL (byte)
D2	mod 100 r/m	[disp][disp]	SAL or SHL mem/reg,CL (byte)
D2	mod 101 r/m	[disp][disp]	SHR mem/reg,CL (byte)
D2	xx 110 xxx		Not used
D2	mod 111 r/m	[disp][disp]	SAR mem/reg,CL (byte)
D3	mod 000 r/m	[disp][disp]	ROL mem/reg,CL (word)
D3	mod 001 r/m	[disp][disp]	ROR mem/reg,CL (word)
D3	mod 010 r/m	[disp][disp]	RCL mem/reg,CL (word)
D3	mod 011 r/m	[disp][disp]	RCR mem/reg,CL (word)
D3	mod 100 r/m	[disp][disp]	SAL or SHL mem/reg,CL (word)
D3	mod 101 r/m	[disp][disp]	SHR mem/reg,CL (word)
D3	xx 110 xxx		Not used
D3	mod 111 r/m	[disp][disp]	SAR mem/reg,CL (word)
D4	0A		AAM
D5	0A		AAD
D6			Not used
D7			XLAT
D8	mod xxx r/m	[disp][disp]	ESC mem/reg
D9	mod xxx r/m	[disp][disp]	ESC mem/reg
DA	mod xxx r/m	[disp][disp]	ESC mem/reg
DB	mod xxx r/m	[disp][disp]	ESC mem/reg
DC	mod xxx r/m	[disp][disp]	ESC mem/reg
DD	mod xxx r/m	[disp][disp]	ESC mem/reg
DE	mod xxx r/m	[disp][disp]	ESC mem/reg
DF	mod xxx r/m	[disp][disp]	ESC mem/reg
E0	disp		LOOPNE/LOOPNZ disp
E1	disp		LOOPE/LOOPZ disp
E2	disp		LOOP disp
E3	disp		JCXZ disp
E4	kk		IN AL,kk
E5	kk		IN AX,kk
E6	kk		OUT kk,AL
E7	kk		OUT kk,AX
E8	disp	disp	CALL disp16
E9	disp	disp	JMP disp16

Object Code			Mnemonic
Byte # 0	Byte # 1	Succeeding Bytes	
EA	kk	jj hh gg	JMP addr
EB	disp		JMP disp
EC			IN AL,DX
ED			IN AX,DX
EE			OUT DX,AL
EF			OUT DX,AX
F0			LOCK
F1			Not used
F2			REPNE or REPNZ
F3			REP or REPE or REPZ
F4			HLT
F5			CMC
F6	mod 000 r/m	[disp][disp] kk	TEST mem/reg,kk
F6	xx 001 xxx		Not used
F6	mod 010 r/m	[disp][disp]	NOT mem/reg (byte)
F6	mod 011 r/m	[disp][disp]	NEG mem/reg (byte)
F6	mod 100 r/m	[disp][disp]	MUL mem/reg (byte)
F6	mod 101 r/m	[disp][disp]	IMUL mem/reg (byte)
F6	mod 110 r/m	[disp][disp]	DIV mem/reg (byte)
F6	mod 111 r/m	[disp][disp]	IDIV mem/reg (byte)
F7	mod 000 r/m	[disp][disp] kkjj	TEST mem/reg,jjkk
F7	xx 001 xxx		Not used
F7	mod 010 r/m	[disp][disp]	NOT mem/reg (word)
F7	mod 011 r/m	[disp][disp]	NEG mem/reg (word)
F7	mod 100 r/m	[disp][disp]	MUL mem/reg (word)
F7	mod 101 r/m	[disp][disp]	IMUL mem/reg (word)
F7	mod 110 r/m	[disp][disp]	DIV mem/reg (word)
F7	mod 111 r/m	[disp][disp]	IDIV mem/reg (word)
F8			CLC
F9			STC
FA			CLI
FB			STI
FC			CLD
FD			STD
FE	mod 000 r/m	[disp][disp]	INC mem/reg (byte)
FE	mod 001 r/m	[disp][disp]	DEC mem/reg (byte)
FE	xx 010 xxx		Not used
FE	xx 011 xxx		Not used
FE	xx 100 xxx		Not used
FE	xx 101 xxx		Not used
FE	xx 110 xxx		Not used
FE	xx 111 xxx		Not used
FF	mod 000 r/m	[disp][disp]	INC mem/reg (word)
FF	mod 001 r/m	[disp][disp]	DEC mem/reg (word)
FF	mod 010 r/m	[disp][disp]	CALL mem/reg
FF	mod 011 r/m	[disp][disp]	CALL mem
FF	mod 100 r/m	[disp][disp]	JMP mem/reg
FF	mod 101 r/m	[disp][disp]	JMP mem
FF	mod 110 r/m	[disp][disp]	PUSH mem
FF	xx 111 xxx		Not used

G. BIOS Error Messages

When you power on the system unit, the firmware will perform a series of self-tests. The results of these tests are displayed on the screen. Note that the video display will remain blank for a few seconds after power up.

After powering on your system unit, you will hear a long beep generated by the built-in speaker unless an error occurs.

The possible errors are:

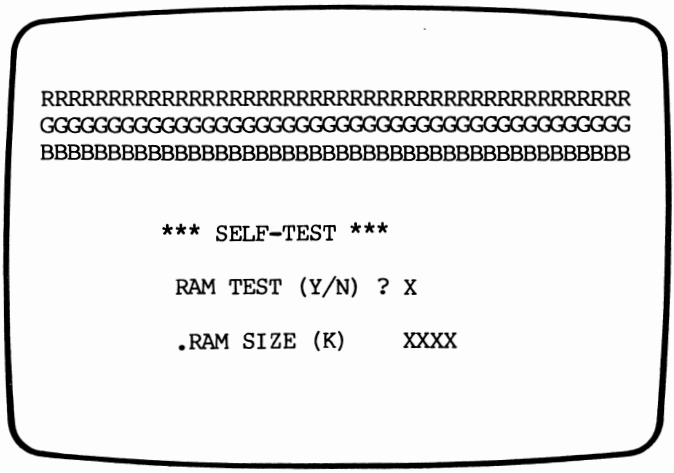
1. System halt!

   DMA Register R/W error.

2. The system halts after generating a long beep, when an R/W or parity error has occurred in the memory range from Ø through ØFFFFH on the system board.

3. The system generates two short beeps after a long beep. This error occurs when R/W error is detected on the color/graphic adapter.

   The first screen shows the results of the self-test:



NOTES:

A. The DIP switches on the system board are set for actual RAM size. If you have inserted additional RAMs on the system board, the DIP switches will have to be adjusted accordingly, else the screen message will not echo the correct RAM size.

B. The top three rows of the self-test messages are used to show whether the color signals are transferred normally between the sytem unit and the video display.

   If you use a monochrome video display connected to the system via a Monochrome Display and printer Adapter, the top three rows of the self-test will not be shown.

   But if you use a color monitor, the "R" line is red, the "G" line green and the "B" line blue.

4. .8259 Error!

This means 8259A PIC error.

5. .8253 Error!

   Represents 8253 Timer error.

6. PR.P.Err

   Printer Port Error.

7. K_B Error!

   Keyboard not connected or out of order.

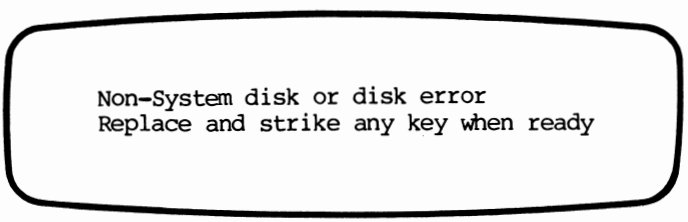
8. .BAD FDC!

   Disk controller error.

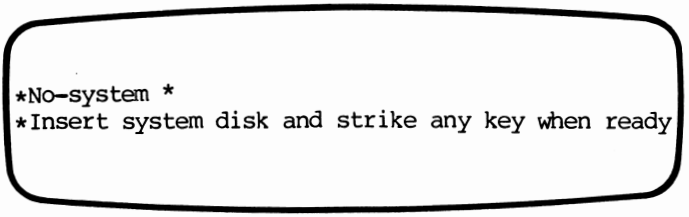
9. Warning RAM Error!

   Indicates that there is an error in one of the memory banks, the location of which is currently shown on the screen.

After the Self-test, the operating system will be booted into the system. At this point, if a non-system diskette is inserted in the default drive, the screen will display the following error message:



Or, if no system diskette is inserted in the default drive, this error message will be displayed:



H. U43 Memory Mapping

A 32K ROM space (F6000 ~ FDFFF) is available at U43 and if you insert a 27256 chip in that location, the memory space should be mapped as follows:

27256 Chip	Memory Address
1st 8K bytes	F8000 ~ F9FFF
2nd 8K bytes	FA000 ~ FBFFF
3rd 8K bytes	FC000 ~ FDFFF
4th 8K bytes	F6000 ~ F7FFF

For your convenience, below is a cross reference:

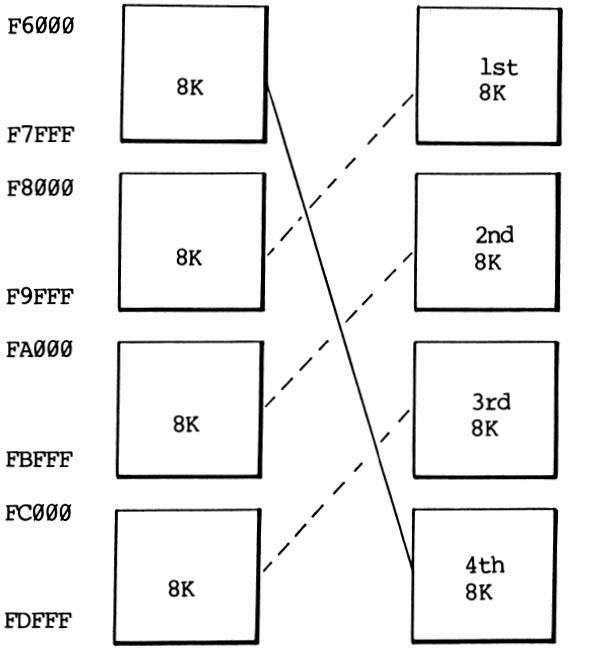


Fig. H-1 U43 Memory Mapping

I. MEM-500 Installation Guide

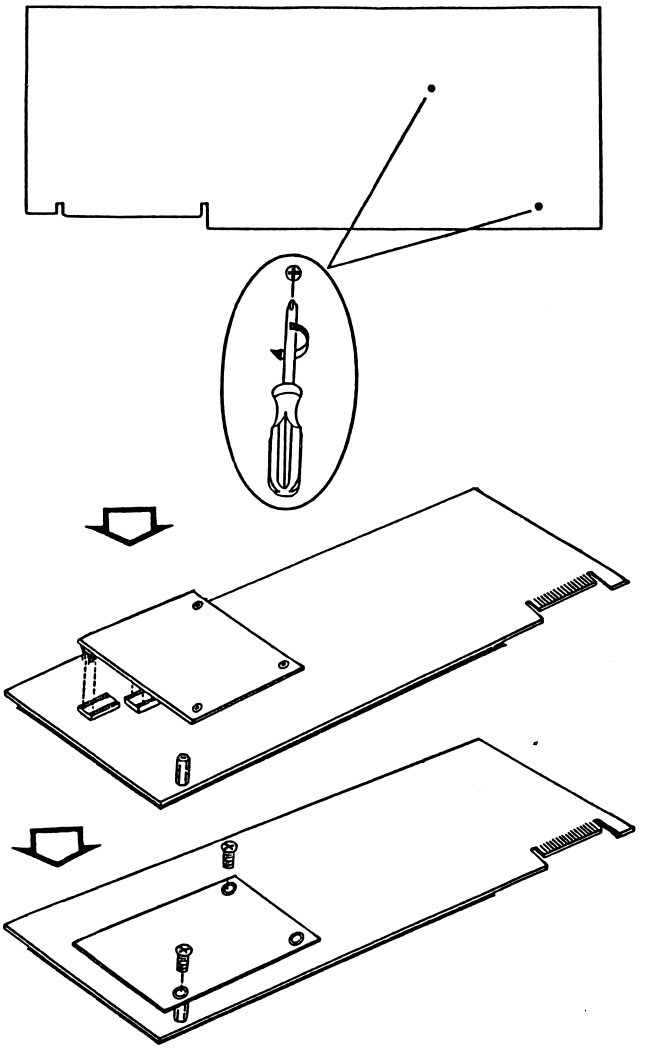
The memory expansion board MEB-500 is a small printed circuit borad on which 128KB of RAM is installed. This expansion board could be installed to the CPU card to expand the system RAM of the Popular 500 from 512KB to 640KB.

NOTE: If your CPU board is not installed with 512KB, you should first expand its memory to 512KB before installing the MEB-500.

The MEB-500 card is shipped to you with two copper bolts and four screws, which are used for attaching the MEB-500 to the CPU card.

On the component side of the MEB-500, you can see three locations markded with U12, U21, and U29. There are three connectors with round pins soldered to the three locations and with the round pins extending on the other side of the MEB-500.

After unpacking, you should check whether the round pins on the three connectors are straight. If they are bent, straighten them. Then, fasten the two copper bolts to the CPU card as illustrated below:



To install the MEB-500 to the CPU card, you must insert the round pins to three sockets on the CPU card. The three sockets are also marked with the same numbers - U12, U21 and U29.

While inserting the round pins to their sockets on the CPU card, be cautious that each pin is aligned properly so that they will fit into the right holes on the sockets. Don't exert excessive force while making the connection. If a pin bends twice or three times, it may be broken.

Since some of the CPU card is built with ICs inserted on the locations U12, U21 and U29. You must first extract the ICs on the two locations and then solder the round-pin sockets to these locations. Then, you can attach the MEB-500 to the CPU card following the steps mentioned above.

After installing the MEB-500 to the CPU card, you must fasten the remaining two screws to the copper bolts.

If you want to change the system back to 512KB model, make sure U12 is installed with 41256, U21, 74LS245; and U29, 20L10.

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