Chapter 3
Organization of the IBM Personal Computers

Learning Outcome

- Takes a closer look at the IBM personal computers.
  - Intel 8086 family.
- Introduces the registers and mention some of their special functions.
- Ideas of segmented memory is discussed.
- Overall structure of the IBM PC is explored.
  - Memory organization, I/O parts, and the DOS and BIOS routines.

The Intel 8086 Family of Microprocessors

- Family consists of the IBM PC, PC XT, PC AT, PS/l, and PS/2 models.
  - Based on the Intel 8o86 family
- Includes the 8086, 8088, 80186, 80188, 80286, 80386, 80386SX, 80486, and 80486SX.

Family	Use for IBM PCs
8088	PC and PC XT
80286	PC AT and PS/1
80186	PC-compatible laptop models
8086, 80286, 80386, or 80486	PS/2 models

8086 and 8088 Microprocessors

8086

- Intel introduced in 1978
- It has a 16-bit data bus
- It has a faster clock rate, and thus has better performance.

8088

- Intel introduced in 1979
- It has a 8-bit data bus
- It was less expensive to build a computer

80186 and 80188 Microprocessors

- 80186 and 80188 are enhanced versions of the 8086 and 8088, respectively.
- Incorporate all the functions of the 8086 and 8088 microprocessors
- Execute some new instructions called the extended iiistruction set.
- These processors offered no significant advantage over the 8086 and 8088 and hence develop the 80286.

80286 Microprocessor

- Introduced in 1981 and is also 16 bit microprocessor.
- Offers the following important advances over its predecessors
  - Two modes of operations
    - Real address mode and protected virtual address mode
  - More addressable memory.
    - In protected mode can address 16 megabytes of physical memory (as opposed to 1 megabyte for the 8086 and 8088)
  - Virtual memory in protected mode.
    - Treat external storage (that is, a disk) as if it were physical memory, and therefore execute programs that are too large to be contained in physical memory.

80386 and 80386SX Microprocessors

- First 32-bit microprocessor,
- The 80386 (or 386) introduced in 1985.
- Much faster than the 80286
- Address 4 gigabytes of physical memory, and **64 terabyte** (2^{46} bytes) of virtual memory.
- 386SX has essentially the same internal structure as the 386, but it has only a 16-bit data bus.

80486 and 80486SX Microprocessors

- Another 32-bit microprocessor.
- Introduced in 1989.
- Fastest and most powerful processor in the family.
- Performs floating-point number operations, and an 8-KB cache memory that serves as a fast memory area to buffer data coming from the slower memory unit.
- 486SX is similar to the 486 but without the floating-point processor.

Organization of the 8086/8088 Microprocessors

- Registers
  - Information inside the microprocessor is stored in registers.
  - Classify according to the functions they perform.
    - Data registers hold data for an operation.
    - Address resisters hold the address of an instruction or data.
    - A status registers keeps the current status of the processor.
  - There are fourteen 16-bit registers.

Data Registers

Address Registers

Status Registers

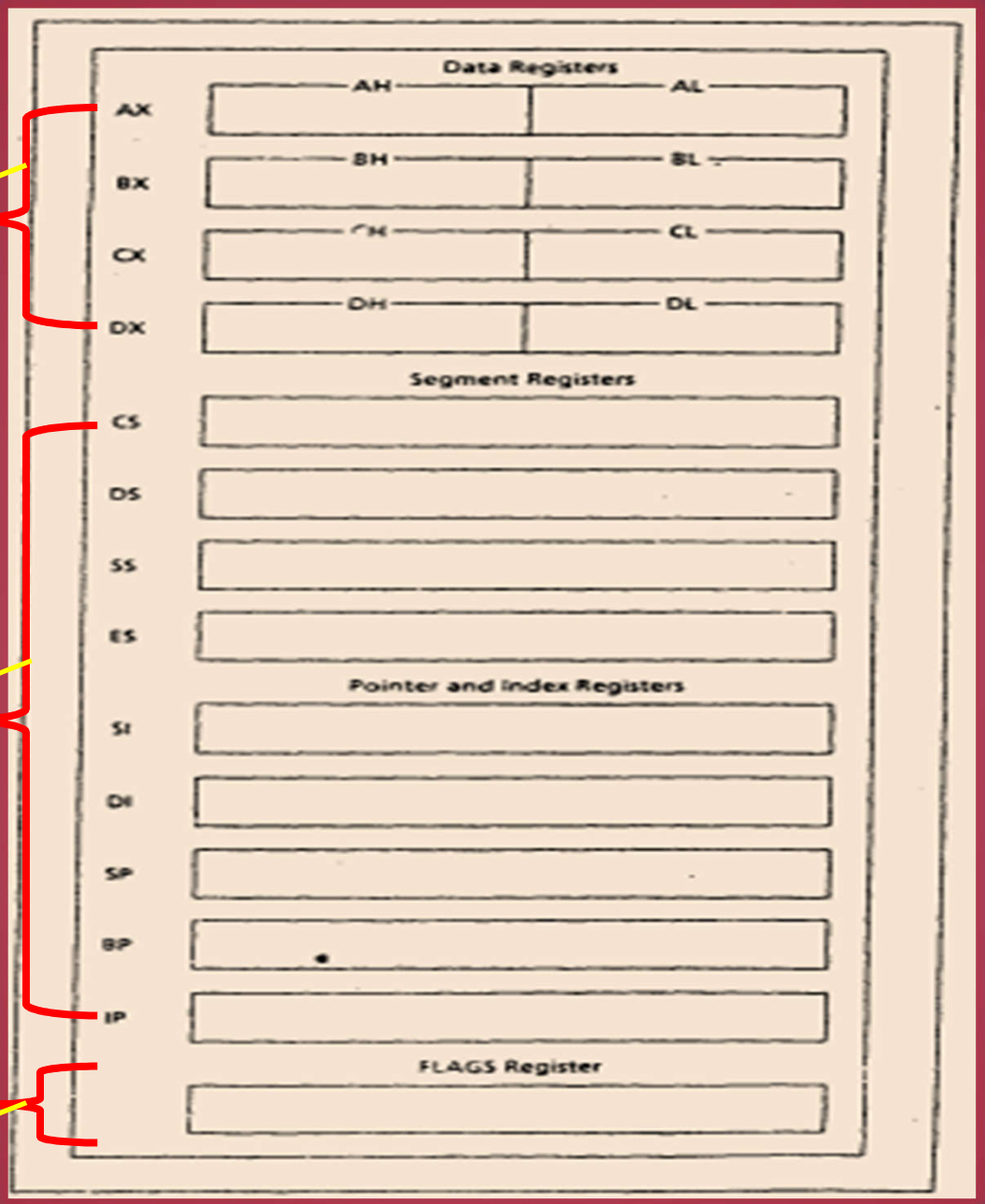


Figure: 8086 Registers

Data Registers: AX, BX, CX,DX

- Available to the programmer for general data manipulation.
- Instruction is faster (requires fewer clock cycles) if the data are stored in registers.
  - Modern processors
- High and low bytes of the data registers can be accessed separately.
- These four registers are to being general-purpose registers.

Data Registers: AX, BX, CX,DX (2)

- AX (Accumulator Register)
  - Prefers to use in arithmetic, logic, and transfer instructions
  - In multiplication and division operations, one of the numbers involved must be in AX or AL.
  - Input and output operations also require the use of AL and AX.

Data Registers: AX, BX, CX,DX (3)

- BX (Base Register)
  - Serves as an address register; an example is a table look-up . Instruction called XLAT (translate).
  - Locates a byte entry in a table in memory, using the contents of the AL register as a table index,
  - Copies the contents of the table entry back into the AL register.

Data Registers: AX, BX, CX,DX (4)

- CX (Count Register)
  - Program loop constructions are facilitated.
  - Serves as a loop counter.
  - Controls a special class of instructions called *string operations*.
    - Shift and rotate bits.
- *DX (Data Register)*
  - DX is used in multiplication and division. It is also used in I/O operations.

Segment Registers: CS, DS, SS, ES

- Address registers store addresses of instructions and data in memory.
- Memory is a collection of bytes. Each memory byte has an address, starting with 0.
- 8086 processor assigns a 20-bit physical address to its memory locations.
  - It is possible to address 2^{20} = 1,048,576 bytes (one megabyte) of memory.
- Introduce the idea of memory segments.
  - A direct consequence of using a 20-bit address in a 16-bit processor.

Segment Registers: CS, DS, SS, ES (2)

- *Memory Segment*
  - A block of 2^{16} (or 64 K) consecutive memory bytes.
  - A segment number is 16 bits, so the highest segment number is FFFFh.
  - A memory location is specified by giving an offset.
    - The number of bytes from the beginning of the segment.
    - The first byte in a segment has offset 0 and the last offset in a segment is FFFFh

Segment Registers: CS, DS, SS, ES (3)

- Segment: Offset Address
  - *A memory location may be specified by providing a segment number* and an *offset*
    - the form *of segment:offset* that is known as *a logical address*.
  - For example, A4FB:4872h means offset 4872h within segment A4FBh.
  - To obtain a 20-bit physical address.
  - The 8086 microprocessor first shifts the segment address 4 bits to the left *(this is equivalent to multiplying by 10h)*, and then adds the offset.

Segment Registers: CS, DS, SS, ES (4)

- Thus the physical address for A4FB:4872 is

```
A4FB0h
+ 4872h
-------
A9822h   (20-bit physical address)
```

- Find the 20 bit physical address for B5EC:3654

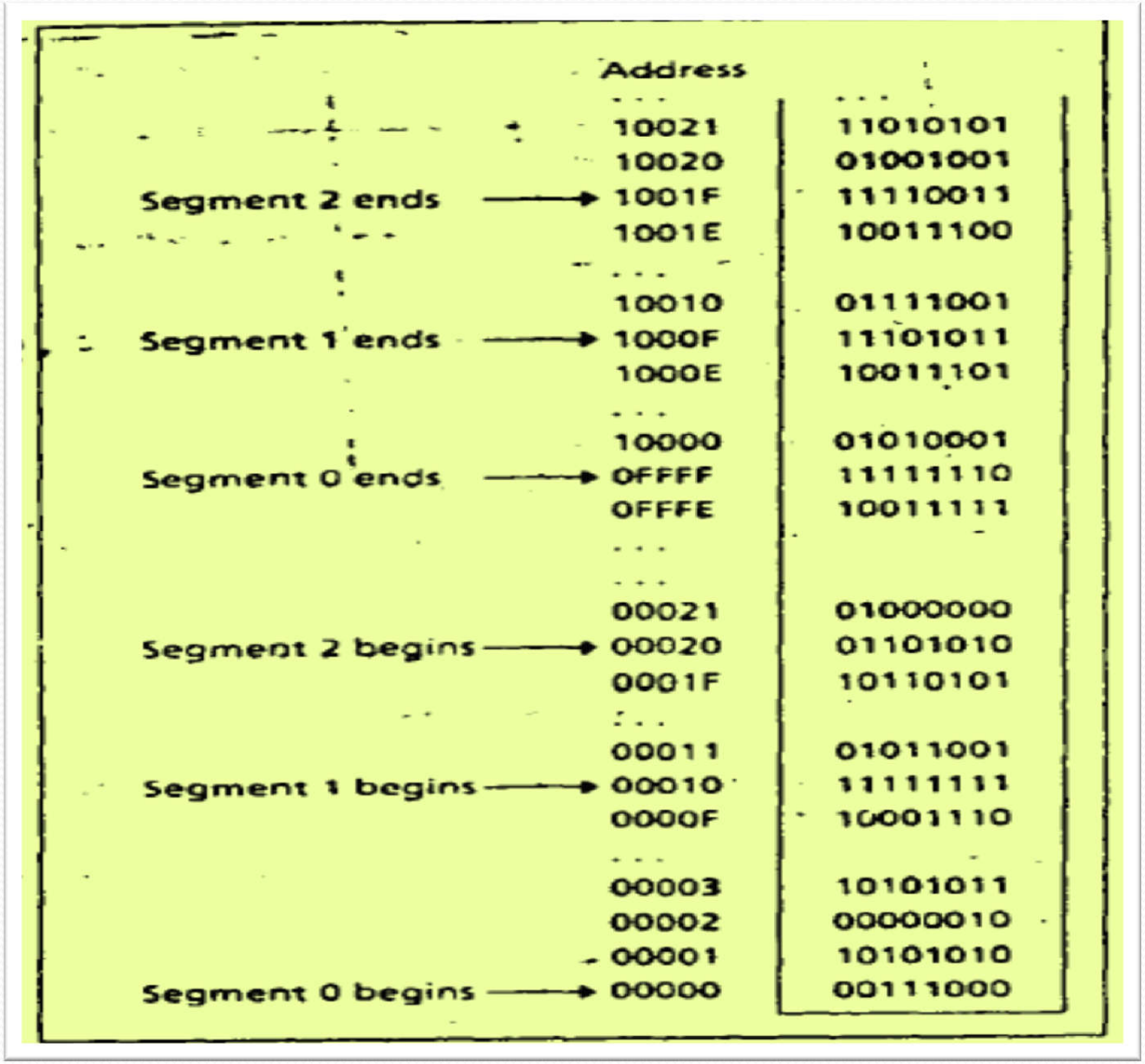
- THE ANSWER IS: B9514

Segment Registers: CS, DS, SS, ES (4)

- *Location -of Segments*
  - the layout of the segments in memory.
  - segment 0 start at address 0000:0000 = 00000h and ends at 0000: FFFF = 0FFFFh
  - Segment 1 starts at address 0001:0000 = 00010h and ends at 0001 : FFFF =1000Fh

Location of Memory Segments

The segments start every 10h= 16 bytes and the starting address of a segment always ends with a hex digit 0



Segment Registers: CS, DS, SS, ES (5)

- Example: For the memory location whose physical address is specified by 1256Ah, give the address in segment:offset form for segments 1256h and 1240h.

Solution: Let X be the offset in segment 1256h and Y the offset in segment 1240h. We have

$$1256Ah = 12560h + X \text{ and } 1256Ah = 12400h + Y$$

and so

$$X = 1256Ah - 12560h = Ah \text{ and } Y = 1256Ah - 12400h = 16Ah$$

thus

$$1256Ah = 1256:000A = 1240:016A$$

Segment Registers: CS, DS, SS, ES (6)

- Example: A memory location has physical address 80FD2h. In what segment does it have offset BFD2h?

Solution: We know that

$$\text{physical address} = \text{segment} \times 10\text{h} + \text{offset}$$

Thus

$$\text{segment} \times 10\text{h} = \text{physical address} - \text{offset}$$

in this example

$$\begin{array}{l} \text{physical address} = 80\text{FD2h} \\ \underline{-\ \text{offset} = \ \text{BFD2h}} \\ \text{segment} \times 10\text{h} = 75000\text{h} \end{array}$$

So the segment must be 7500h.

Pointer and Index Registers:
SP, BP SI, *DI*

- SP, BP, SI, and DI normally point to (contain the offset addresses of) memory locations.
- Use in arithmetic and other operation.
- *SP (Stack Pointer)*
  - The SP (stack pointer) register is used in conjunction with SS for accessing the stack segment.
- *BP (Base Pointer)*
  - The BP (base pointer) register is used primarily to access data on the stack.
  - Unlike SP

Pointer and Index Registers: SP, BP SI, DI (2)

- *SI (Source Index)*
  - The SI (source index) register is used to point to memory locations in the data segment addressed by DS.
- *DI (Destination Index)*
  - The DI (destination index) register performs the same functions as SI.
- *Instruction Pointer: IP*
  - To access the instructions, the 8086 uses the registers CS and IP
  - CS register contains the segment number of the next instruction, and the IP contains the offset.

Pointer and Index Registers: SP, BP SI, DI (3)

- *FLAGS Register*
  - To indicate the status of the microprocessor.
  - There are two kinds of flags:
    - Status flags
    - Control flags
  - Reflects the result of an instruction executed by the processor, for instance, Zero Flag
  - Enable or disable certain operations of the processor, for instance, interrupt flag

Organization of the PC

- The Operating System
  - The most important piece of software for a computer is the operating system.
  - To coordinate the operations of all the devices that make up the computer system.
  - Some of the operating system functions are:
    - Reading and executing the commands typed by the user
    - Performing I/o operations.
    - Generating error messages ·
    - Managing **memory** and other resources.
  - DOS

Organization of the PC (2)

- There are several versions of DOS, with each new version having more capabilities.
- DOS is not just one program; it consists of a number of service routines.
- supports a Graphical User Interface (GUI), allowing the use of a mouse.
- There are two types of user commands, internal and external
  - Routines loaded into memory
  - Routines that not loaded into memory

BIOS

- System routines stored in ROM that are not destroyed when the power is off.
  - BIOS (Basic Input/Output System) routines
- Performs I/O operations for the PC
- Routines are machine specific.
  - Different hardware configuration has it own BIOS routines