3 INTRODUCTION TO INTEL X-86 FAMILY

16 BIT MICROPROCESSOR

16-bit microprocessors families are used in micro computers and are oriented towards high level languages. They have powerful instruction set and are capable of addressing megabytes of memory.

Examples:

1) 8086/8088
2) 80186/80286
3) Motorola 68000 and NS 16000

Apart from the design concept and instruction set, one of the critical factors that decide capability of microprocessor is the no. of pins available.

Primary objectives of these X-86 family:-

1. Increase memory addressing capacity.
2. Increase execution speed.
3. Provide a powerful instruction set.
4. Facilitating programming in high level languages.
5. Function in multiprocessor environment.

These objectives can be met by using various design concepts.

FEATURES OF INTEL 8086/8088

1. It is a 16-bit microprocessor
2. It consists of 40 pin DIP (Dual Inline package). Where DIP is an integrated circuit package with two rows of pins.
3. It is capable of addressing 1MB of memory.
4. Clock frequencies from 5MHz to 10MHz .
5. 8-Bit external data bus.
6. 20-Bit address bus (220 =1MB).
7. Operates in minimum addressing mode and maximum addressing mode.
8. 8086 and 8088 are identical in internal architecture, only difference is in external design.
9. Power and clock are identical to that of the 8085 microprocessor.
10. Signals for multiprocessor environment.
11. Data bus and status signals are multiplexed with the address bus.
12. 16 Data lines (AD0-AD15) are multiplexed.
13. The cost of 8085 microprocessor is high.

INTEL 8086 ARCHITECTURE

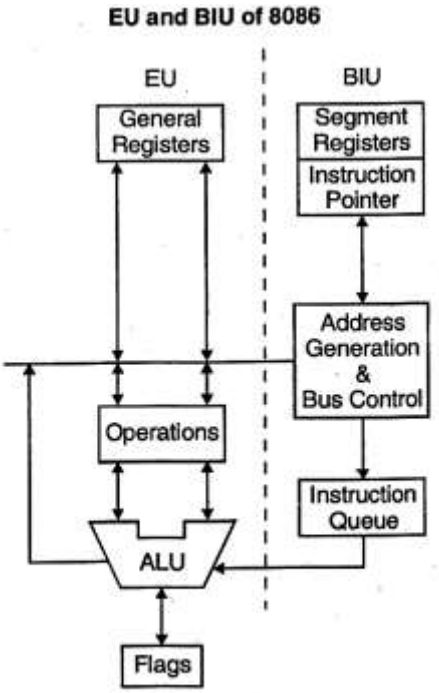


Fig. Block Diagram of 8086

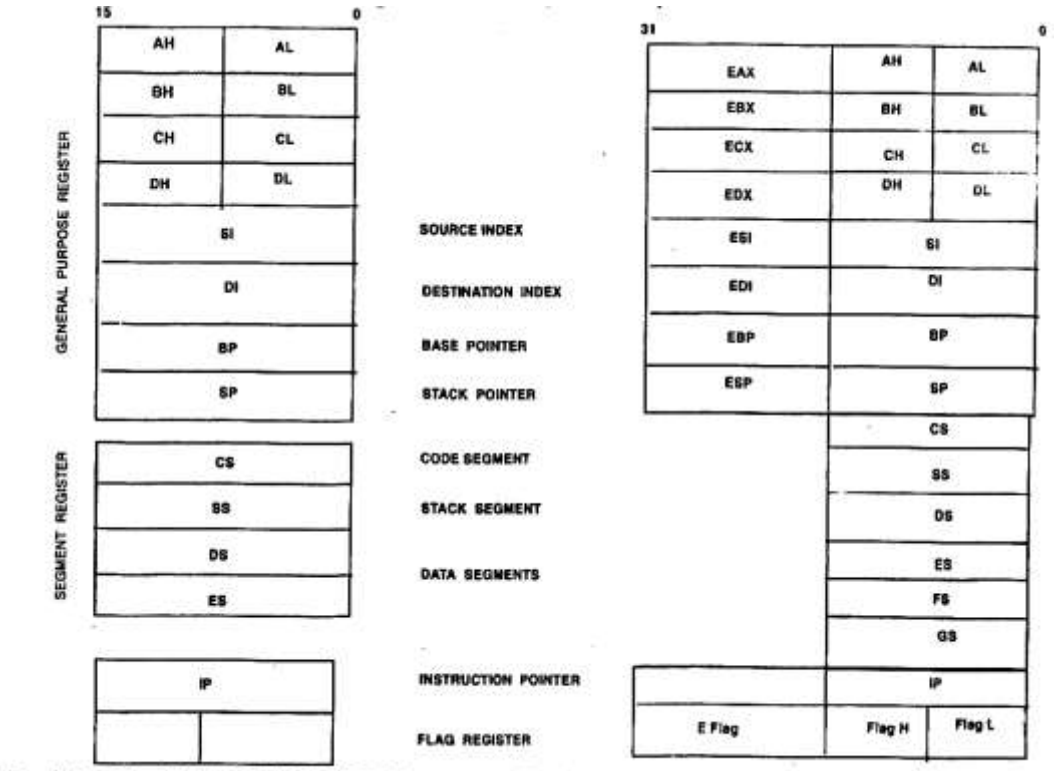
The above figure shows an architecture of 8086 with two main processing units. i.e. EU(Execution Unit) and BIU(Bus Interface Unit). When 8085 microprocessor fetches and executes the instruction, the buses are occupied for the fetch operation but remain idle during internal execution of an instruction. To speed up the execution, 8086 processor includes two processing units called execution unit(EU) and Bus interface unit(BIU). The concept of dividing work between two units and processing it simultaneously speeds up the execution.

The BIU fetches the instruction and places them in instruction queue. An instruction pointer is same as program counter of 8085 which stores address of next instruction to be executed.

EU continuously executes them until the instruction queue becomes empty. Such a processing is known as parallel processing.

A segment register provides a base address and other register supplies offset address to increase memory addressing capacity.

PROGRAMMING MODEL OF 8086



Register Model of 8088/8086/80286 **Register Model of 32-bit µp386/486/pentium**

AX	Accumulator
BX	base register
CX	Counter
DX	to hold i/o address during certain i/o operations.

Register	Full Name
CS	Code Segment Register
DS	Data Segment Register
SS	Stack Segment Register
ES	Extra Segment Register

I) General Purpose Register (16-bit)

There are 8 general purpose registers as follows:

1. Accumulator Register (AX): It is used in arithmetic operations. It performs mathematical and logical operations on data and stores the result.
2. Counter Register (CX): Used in shift or rotate instructions and loop where the condition is checked again and again until it becomes false and the loop terminates.
3. Base Register (BX): It is used as a pointer to data which is located in the segment register DS
4. Data Register (DX): It is used in arithmetic operation and I/O operation. Register stores data during I/O operation and arithmetic operations.
   The 8086 processor has 4 16-bit general purpose registers: AX,BX,CX and DX. They are equivalent to 4 accumulators. Each register can be used as 8-bit register and are compatible with 8085 registers. Example: H-L register pair in 8085 is same as BX register.
5. Source Index Register (SI): It is used as a pointer to source in string operations. Source means the starting of data.
6. Destination Index Register (DI): It is used as a pointer to destination of a string operation string (string is a group of words or characters on which operations are performed) is a series of words or data byte available in the memory at consecutive locations. String operations like repeat, move, string compare etc can be performed in 8086 microprocessor.
7. Stack Pointer Register (SP): Pointer to the top of stack.
8. Stack Base Pointer Register (BP): It is used to point to the base of the stack.

II) Segment Registers:

There are 4 segment registers in 16-bit register model of 8086 microprocessor

1. Stack Segment (SS): Pointer to the stack. Points to starting memory location of stack where the stack starts.
2. Code Segment (CS): Pointer to the code. It stores executable program.
3. Data Segment (DS): Pointer to the data. It points to that segment where data is stored.
4. Extra Data Segment (ES): Pointer to extra data segment. ES,FS,GS,HS are used when extra memory is needed then these additional segment registers are used. Segments are used in alphabetical order.

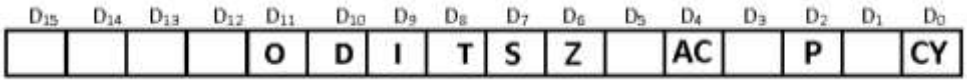
III) FLAG REGISTER OF 8086

A flag register includes 9 flags. These flags are divided into two groups:

1. 6-bit data flags
2. 3-bit control flags

The first 5 flags or the first 5 bits are identical to 8085.

The flag register is a 16-bit register in the Intel 8086 microprocessor that contains information about the state of the processor after executing an instruction. It is sometimes referred to as the status register because it contains various status flags that reflect the outcome of the last operation executed by the processor.



Different flag registers of 8086

1. Carry flag (CY): Carry is generated when performing n bit operations and the result is more than n bits, then this flag becomes set i.e. 1, otherwise, it becomes reset i.e. 0. During subtraction (A-B), if A>B it becomes reset, and if (A<B) it becomes set. Carry flag is also called the borrow flag. 1-carry out from MSB bit on addition or borrow into MSB bit on subtraction 0-no carry out or borrow into MSB bit.
2. Parity flag (P): If after any arithmetic or logical operation the result has even parity, an even number of 1 bit, the parity register becomes set i.e. 1, otherwise it becomes reset i.e. 0. 1-accumulator has an even number of 1 bits 0-accumulator has odd parity.
3. Auxiliary carry (AC): This flag is used in the BCD number system(0-9). If after any arithmetic or logical operation D(3) generates any carry and passes it on to D(4) this flag becomes set i.e. 1, otherwise, it becomes reset i.e. 0.
4. Zero flag(Z): After any arithmetical or logical operation if the result is 0 (00)H, the zero flag becomes set i.e. 1, otherwise it becomes reset i.e. 0. 00H zero flags is 1. from 01H to FFH zero flag is 0 1- zero-result 0- non-zero result
5. Sign flag(S): After any operation if the MSB (B(7)) of the result is 1, it indicates the number is negative and the sign flag becomes set, i.e. 1. If the MSB is 0, it indicates the number is positive and the sign flag becomes reset i.e. 0. from 00H to 7F, sign flag is 0 from 80H to FF, sign flag is 1 1- MSB is 1 (negative) 0- MSB is 0 (positive)

   Example:

   MVI A 30 (load 30H in register A) MVI B 40 (load 40H in register B) SUB B (A = A – B) These set of instructions will set the sign flag to 1 as 30 – 40 is a negative number. MVI A 40 (load 40H in register A) MVI B 30 (load 30H in register B) SUB B (A = A – B) These set of instructions will reset the sign flag to 0 as 40 – 30 is a positive number.
6. Overflow flag(OF): This flag will be set (1) if the result of a signed operation is to large to fit in the number of bits available to represent it, otherwise reset (0).
7. Direction flag(DF): Direction flag is used to control the direction (increment/decrement) of an operation. This flag is specifically used in string instructions. If directional flag is set (1), then access the string data from higher memory location towards lower memory location. If directional flag is reset (0), then access the string data from lower memory location towards higher memory location.
8. Trap flag(TF): This flag is used when processor is performing step by step debugging.
9. Interrupt flag(IF): This flag is enabled when an interrupt occurs. If trap flag is set (1), the CPU automatically generates an internal interrupt after each instruction, allowing a program to be inspected as it executes instruction by instruction. If trap flag is reset (0), no function is performed.

IV) Instruction Pointer (IP): To access instructions 8086 uses registers i.e. code segment and instruction pointer. The code segment register contains the segment number of the next instruction and instruction pointer contains offset. Instruction pointer is updated each time an instruction is executed so that it will point to the next instruction.

Difference between 8085 AND 8086

8085 Microprocessor	8086 Microprocessor
It is a 8-bit microprocessor	It is a 16-bit microprocessor
The address bus is 16-bit hence it accesses 64KB memory.	The address bus is 20-bit hence it accesses 1MB of memory.
It has 8-bit registers like A,B,C and so on.	It has 16-bit registers like AX, BX,CX and so on.
8-bits of address bus (AD0-AD7) is multiplexed.	16-bits of address bus (AD0-AD15) is multiplexed.
There are 5 flag registers in 8085 microprocessor. Each of 8-bit.	There are 9 flag registers in 8086 microprocessor. Each of 16-bit.
Operated only in one mode.	There are 2 operating modes.

FEATURES OF 80286

1. It is a 16–bit Microprocessor extended version of 8086.
2. 68 pin DIP package
3. Capable of addressing 16 MB of memory its address bus is 24 bit (2^{24} = 16 MB)
4. Clock frequencies from 6 MHz. to 20 MHz.
5. It can support a memory management unit, through it can address 1 GB memory known as virtual memory.
6. This processor includes various built in mechanisms that can protect system software from user programs and restrict access to some regions of memory.
7. It is designed for multiuser system.

FEATURES OF 80386

1. It is a 32–bit Microprocessor extended version of 80286
2. 132 pin grid array package
3. Capable of addressing 4GB of memory its address bus is 32 bit (2^{32} = 4GB)
4. Clock frequencies from 16 MHz to MHz.
5. 80386 has 32 bit registers and compatible with 8086
6. Execution of instructions is highly pipelined and the processor is designed to operate in a multiuser and multitasking environment.

FEATURES OF 80486

1. Upgraded, faster version of 80386.
2. DX type version is a 32–bit processor housed in a 168–pin grid array package and can operate with clock frequencies from 25 MHz. to 66 MHz.
3. Design is based on 1.2 million transistors compared to 300 thousand transistors of 386 processor.
4. Important concepts that are built in to 486 other than 386 are:
   (a) Built–in math–co–processor
   (In 386 math–co–processor is external)
   ∴ Math instructions in 486 systems are executed three times faster than in 386.
   (b) 8 Kbyte of code and data cache memory on chip.
   (c) Highly pipelined execution unit.
   ∴ The execution time for many instructions is 1 clock period.
5. Generally used for high–end μcomputers and new environment.
6. Designed to facilitate the execution of high–level languages and are suited for multiuser and multiprocessing systems.

COMPARISON OF MAJOR FEATURES OF X-86 FAMILY

Microprocessor	8086	80286	80386	80486	Pentium
Data bus (bits)	16	16	32	32	64
Address Bus (bits)	20	24	32	32	32
Operating speed MHz	5 – 10	6 – 20	16 – 33	25 – 50	50 – 100
Memory capacity	1 MB	16 MB	4 GB	4 GB	4 GB
Memory management	External	External	External	Internal	Internal
PC Type (IBM)	PC–XT	PC–AT	PC–AT	PC–AT	PC–AT
Math Co–processor	External	External	External	Internal	Internal
Introduction	1978	1982	1985	1989	1993

FEATURES OF INTEL PENTIUM PROCESSOR

1. Pentium processor has 32-bit address bus and 64-bit data bus and is designed to operate from 60MHZ to 233MHZ.
2. Upward software compatibility with the previous line of Intel microprocessors.
3. It includes many features normally available in mainframe computers.
4. The processor is ideally suited for high-end desktop PCs.
5. It can run advanced operating systems like UNIX.
6. The data bus is 64-bit which increases the processing speed.
7. Suited for multiprocessing applications.
8. Maintains data integrity in multiple processors.

Advanced Features of Pentium:

1. **Dual Pipelining Architecture:** It has two execution units with dual pipelined architecture able to execute two instructions simultaneously per clock cycle and achieve a high level of performance.
2. On chip cache memory for instruction and data.
3. Branch prediction: Most likely set of instructions are predetermined. It makes intelligent guess of the next conditional instruction.
4. Performance monitoring: It enables user to monitor the performance of the processor.
5. 64-bit data bus: 64-bit data bus which performs high speed data transfer.

Exercise

Select the correct alternative and rewrite the following:

1. Which of the following microprocessors does not use multiplexed data/address bus ……..
(i) 8085 (iii) 80386 (iii) 80386 (iv) 80186
1. (iii) 80386

2. Pentium processor has bit ……. data bus and ..... bit address bus.
(i) 64,32 (ii) 32, 64 (iii) 32, 32 (iv) 16,32
2. (i) 64,32

3. The 8086 allows us to set …… of memory as stack.
(i) 4 GB (ii) 64 kB (iii) 1 Mb (iv) 16 MB
3. (ii) 64 kB

4. The maximum physical memory can be addressed by 286 is ……
(i) 640 kB (ii) 1 MB (iii) 16 MB (iv) None of these
4. (iii) 16 MB

5. 80386 is a.....
(i) 8 bit microprocessor (ii) 16 bit microprocessor
(iii) 32 bit microprocessor (iii) 32 bit microprocessor
5. (iii) 32 bit microprocessor

6. The Intel 80286 is a …… microprocessor.
(i) 16 bit (ii) 8 bit (iii) 32 bit (iv) None of these
6. (i) 16 bit

7. The main difference between the older and newer versions of the aX86 and advanced microprocessor is that the general purpose register in the newer processor are
(i) 4-bit (ii) 8-bit (iii) 16-bit (iv) 32–bit (v) 64-bit
7. (iv) 32 bit

8. You will find data segment registers called the FS and the GS registers on the ….. microprocessors.
(i) 8088 (ii) 8086 (iii) 286 (iv) 386 (v) all of the above
8. (iv) 386

9. The length of the 8088 instruction pointer is.
(i) 4-bit (ii) 8bit (iii) 16 bit (iv) 32 bit
9. (iii) 16 bit

10. A separate ALU is used with the ……..registers to perform memory location calculations.
(i) Segment (ii) Flag (iii) 16-Instruction pointer
(iv) General purpose (v) All of the above
10. (i) Segment

11. A perfect queue or code cache first appeared on the.
(i) 8088 (ii) 8086 (iii) 286 (iv) 386SX
(v) 386DX (vi) 486SX (vii) 486DX (viii) All of the above
11. (i) 8088

12. Some of the newer version of the X86 processor have an on-board memory which is used to store data as well as prefetched instructions. This is called
(i) An on-chip floating pointer (ii) Virtual memory capability
(iii) Cache memory (iv) Any of the above

12. (iii) Cache memory

13. Logic which analyzes the instruction held in the code cache to anticipate what code will be needed after a branch was introduced with the.
(i) 8088 (ii) 8086 (iii) 286 (iv) 386SX
(v) 386DX (vi) 486SX (vii) 486DX (viii) Pentium
13. (viii) Pentium

14. Internally, the X86 family of advanced microprocessors has a(n) ……..architecture.
(i) 4-bit (ii) 8-bit (iii) 16-bit (iv) 32-bit
(v) 64-bit (vi) 4-bit or 8-bit (vii) 8-bit or 16-bit (viii) 16-bit or 32-bit
14. (viii) 16 bit or 32 bit

15. The first microprocessor in the X86 family to support an on-chip instruction cache is
(i) 8088 (ii) 8086 (iii) 286 (iv) 386SX
(v) 386DX (vi) 486SX (vii) 486DX (viii) Pentium
15. (i) 8088

16. The maximum physical memory space which can be addressed by the 286 is
(i) 640 kbytes (ii) 1 Mbytes (iii) 16 Mbytes (iv) 4 Gbytes
(v) All of the above
16. (iii) 16 Mbytes

17. An internal memory management unit (MMU) first appeared on the
(i) 8088 (ii) 8086 (iii) 286 (iv) 386SX
(v) 386DX (vi) 486SX (vii) 486DX (viii) Pentium
17. (iii) 286

18. On-chip floating pointer arithmetic units first appeared on the
(i) 8088 (ii) 8086 (iii) 286 (iv) 386
(v) 486 (vi) Pentium
18. (v) 486

19. If the processor you are using does not have enough physical memory for the program that is being used, you can use …… to make the program believe that the processor has enough main memory for the program.
(i) An on chip floating point processor (ii) Virtual memory capability
(iii) Cache memory (iv) Any of the above
19. (ii) Virtual memory capability

20. The first X86 advanced microprocessor to use full 32-bit data words was the
(i) 8088 (ii) 386 (iii) 8086 (iv) 486
(v) 286 (vi) Pentium
20. (iv) 486

21. The Intel 80286 is a …… microprocessor.
(i) 16 bit (ii) 8 bit (iii) 32 bit (iv) None of these
21. (i) 16 bit

22. ……..is a 32 bit microprocessor.
(i) 8086 (ii) 80386 (iii) Intel Pentium (iv) M68000
22. (ii) 80386

23. The Processor 80386 falls in …….. generation of MPU.
(i) First (ii) Second (iii) Third (iv) Fourth
23. (iv) Fourth

24. Data bus of 80286 MPU is of size ……
(i) 8 bit (ii) 16 bit (iii) 32 bit (iv) 64 bit
24. (ii)

25. The maximum physical memory can be addressed by 80286 microprocessor is ……..
(i) 640 KB (ii) 1 MB (iii) 16 MB (iv) 4 KB
25. (iii) 16 MB

26. The duty 32-byte Microprocessor from the following is ……
(i) 8086 (ii) 8085 (iii) 80386 (iv) 80586
26. (iii) 80386

27. Intel 80586 was introduced in ……..
(i) 1978 (ii) 1993 (iii) 1996 (iv) 1984
27. (ii) 1993

❑ ❑ ❑ ❑ ❑ ❑