

CHAPTER 1

INTRODUCTION

1.1 TERMS USED IN MICROPROCESSOR LITERATURE

- Bit** : A digit of the binary number or code is called a bit.
- Nibble** : The 4-bit (4-digit) binary number or code is called a nibble.
- Byte** : The 8-bit (8-digit) binary number or code is called a byte.
- Word** : The 16-bit (16-digit) binary number or code is called a word.
- Double Word** : The 32-bit (32-digit) binary number or code is called a double word.
- Multiple Word** : The 64, 128, ... bit/digit binary numbers or codes are called multiple words.
- Data** : The quantity (binary number/code) operated by an instruction of a program is used data. The size of data is specified as bit, byte, word, etc.
- Address** : Address is an identification number (in binary) for memory locations. The 8086 processor uses a 20-bit address for memory.
- Memory Word Size (or Addressability)** : The memory word size or addressability is the size of binary information that can be stored in a memory location. The memory word size for an 8086 processor-based system is 8-bit.

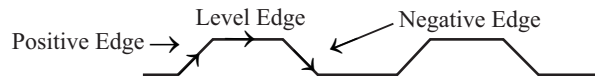
[Address and program codes in a microprocessor system are given in binary (i.e., as a combination of "0" and "1"). With n -bit binary we can generate 2^n different binary codes or addresses.]

- Microprocessor** : The microprocessor is a program-controlled semiconductor device (IC), which fetches data (from memory), decodes and executes instructions. It is used as a CPU (Central Processing Unit) in computers. The basic functional blocks of a microprocessor are ALU (Arithmetic Logic Unit), an array of registers and a control unit. The microprocessor is identified with the size of data the ALU of the processor can work with at a time. The 8086 processor has a 16-bit ALU; hence, it is called a 16-bit processor. The 80486 processor has a 32-bit ALU; hence, it is called a 32-bit processor.
- Bus** : A bus is a group of conducting lines that carries data, address and control signals. Buses can be classified into Data bus, Address bus and Control bus.
- The group of conducting lines that carries data is called a data bus.
- The group of conducting lines that carries address is called an address bus.
- The group of conducting lines that carries control signals is called a control bus.

- CPU Bus** : The group of conducting lines that are directly connected to the microprocessor is called a CPU bus. In a CPU bus, the signals are multiplexed, i.e., more than one signal is passed through the same line but at different timings.
- System Bus** : The group of conducting lines that carries data, address and control signals in a microcomputer system is called System bus. Multiplexing is not allowed in a system bus.

[In microprocessor-based systems, each bit of information (data/address/control signal) is sent through a separate conducting line. Due to practical limitations, the manufacturers of microprocessors may provide multiplexed pins, i.e., one pin is used for more than one purpose. This leads to a multiplexed CPU bus. For example, in an 8086 processor, the address and data are sent through the same pins but at different timings. But when the system is formed, the multiplexed bus lines should be demultiplexed by using latches, ports, transceivers, etc. The demultiplexed bus lines are called system bus. In a system bus, separate conducting lines will be provided for each bit of data, address and control signals.]

- Clock** : A clock is a square wave used to synchronize various devices in the microprocessor and in the system. Every microprocessor system requires a clock for its functioning. The time taken for the microprocessor and the system to execute an instruction or program are measured only in terms of the time period of its clock.



A clock has three edges: rising edge (positive edge), level edge and falling edge (negative edge). The device is made sensitive to any one of the edges for better functioning (it means that the device will recognize the clock only when the edge is asserted or arrived).

- Tristate Logic** : Almost all the devices used in a microprocessor-based system use tristate logic. In devices with tristate logic, three logic levels will be available: **High** state, **Low** state and **High impedance** state.

The **high** and **low** level states are normal logic levels for data, address or control signals. The **high impedance** state is an electrical open-circuit condition. The **high impedance** state is provided to keep the device electrically isolated from the system. The tristate devices will normally remain in the **high impedance** state and their pins are physically connected in the system bus but electrically isolated. In the **high impedance** state, they cannot receive or send any signal or information. These devices are provided with chip enable/chip select pins. When the signal at this pin is asserted to the right level, they come out from the **high impedance** state to normal levels.

1.2 EVOLUTION OF MICROPROCESSORS

History tells us that it was the ancient Babylonians who first began using the abacus (a primitive calculator made of beads) in about 500 BC. This simple calculating machine eventually sparked the human mind into the development of calculating machines that use gears and wheels (Blaise Pascal in 1642). The giant computing machines of the 1940s and 1950s were constructed with relays and vacuum tubes. Next, the transistor and solid-state electronics were used to build the mighty computers of the 1960s. Finally, the advent of the Integrated Circuit (IC) led to the development of the microprocessor and microprocessor-based computer systems.

In 1971, INTEL Corporation released the world's first microprocessor the INTEL 4004, a 4-bit microprocessor. It addresses 4096 memory locations of 4-bit word size. The instruction set consists of 45 different instructions. It is a monolithic IC employing large-scale integration in PMOS technology. The INTEL 4004 was soon followed by a variety of microprocessors, with most of the major semiconductor manufacturers producing one or more types.

First-Generation Microprocessors

The microprocessors introduced between 1971 and 1973 were the first-generation processors. They were designed using PMOS technology. This technology provided low cost, slow speed and low output currents and was not compatible with TTL (Transistor Transistor Logic) levels.

The first-generation processors required a lot of additional support ICs to form a system, sometimes as high as 30 ICs. The 4-bit processors are provided with only 16 pins, but 8-bit and 16-bit processors are provided with 40 pins. Due to limitations of pins, the signals are multiplexed. A list of first-generation microprocessors are as follows:

- | | | |
|-------------------------------|---|-------------------|
| 1. INTEL 4004 | } | 4-bit processors |
| 2. INTEL 4040 | | |
| 3. FAIR CHILD PPS - 25 | | |
| 4. NATIONAL IMP - 4 | | |
| 5. ROCKWELL PPP - 4 | | |
| 6. MICRO SYSTEMS INTL. MC - 1 | } | 8-bit processors |
| 7. INTEL 8008 | | |
| 8. NATIONAL IMP - 8 | | |
| 9. ROCKWELL PPS - 8 | } | 16-bit processors |
| 10. AMI 7200 | | |
| 11. MOSTEK 5065 | | |
| 12. NATIONAL IMP/16 | | |
| 13. NATIONAL PACE | | |

Second-Generation Microprocessors

The second-generation microprocessors appeared in 1973 and were manufactured using the NMOS technology. The NMOS technology offers faster speed and higher density than PMOS and it is TTL compatible. Some of the second-generation processors are as follows:

1. INTEL 8080	}	8-bit processors
2. INTEL 8085		
3. FAIRCHILD F - 8		
4. MOTOROLA M6800		
5. MOTOROLA M6809		
6. NATIONAL CMP -8		
7. RCA COSMAC		
8. MOS TECH. 6500		
9. SIGNETICS 2650	}	12-bit processors
10. ZILOG Z80		
11. INTERSIL 6100	}	16-bit processors
12. TOSHIBA TLCS - 12		
13. TI TMS 9900		
14. DEC - W.D. MCP - 1600		
15. GENERAL INSTRUMENT CP 1600		
16. DATA GENERAL μ N601		

Characteristics of Second-Generation Microprocessors

1. Larger chip size (170×200 mil). [1mil = 10^{-3} inch]
2. 40 pins.
3. More numbers of on-chip decoded timing signals.
4. The ability to address large memory spaces.
5. The ability to address more IO ports.
6. Faster operation.
7. More powerful instruction set.
8. A greater number of levels of subroutine nesting.
9. Better interrupt-handling capabilities.

Third-Generation Microprocessors

After 1978, the third-generation microprocessors were introduced. These are 16-bit processors and designed using HMOS (High density MOS) technology. Some of the third-generation microprocessor are given below:

- | | | |
|----------------|-------------------|--------------------------------|
| 1. INTEL 8086 | 4. INTEL 80286 | 7. ZILOG Z8000 |
| 2. INTEL 8088 | 5. MOTOROLA 68000 | 8. NATIONAL NS 16016 |
| 3. INTEL 80186 | 6. MOTOROLA 68010 | 9. TEXAS INSTRUMENTS TMS 99000 |

The HMOS technology offers better Speed Power Product (SPP) and higher packing density than NMOS.

Speed Power Product (SPP) = Speed $\times$ Power

Unit of SPP = Nanoseconds $\times$ Milliwatts

= Picojoules

1. Speed Power Product of HMOS is four times better than NMOS.
 SPP of NMOS = 4 picojoules (pJ)
 SPP of HMOS = 1 picojoules (pJ)
2. Circuit densities provided by HMOS are approximately twice those of NMOS.
 Packing density of NMOS = 1852.5 gates/mm²
 Packing density of HMOS = 4128 gates/mm² (1 mm = 10^{-6} metre)

Characteristics of Third-Generation Microprocessors

- Provided with 40/48/64 pins.
- High speed and very strong processing capability.
- Easier to program.
- Allow for dynamically relocatable programs.
- Size of internal registers are 8/16/32 bits.
- The processor has multiply/divide arithmetic hardware.
- Physical memory space is from 1 to 16 megabytes.
- The processor has segmented addresses and virtual memory features.
- More powerful interrupt-handling capabilities.
- Flexible IO port addressing.
- Different modes of operations (e.g., user and supervisor modes of M68000).

Fourth-Generation Microprocessors

The fourth-generation microprocessors were introduced in the year 1980. These generation processors are 32-bit processors and are fabricated using the low-power version of the HMOS technology called HCMOS. These 32-bit microprocessors have increased sophistications that compete strongly with mainframes. Some of the fourth-generation microprocessors are given below:

- | | | |
|---------------------|--------------------|---------------------|
| 1. INTEL 80386 | 4. MOTOROLA M68020 | 7. MOTOROLA MC88100 |
| 2. INTEL 80486 | 5. BELLMAC - 32 | |
| 3. NATIONAL NS16032 | 6. MOTOROLA M68030 | |

Characteristics of Fourth-Generation Microprocessors

1. Physical memory space of 2^{24} bytes = 16 MB (megabytes).
2. Virtual memory space of 2^{40} bytes = 1 TB (terabytes).
3. Floating-point hardware is incorporated.
4. Supports increased number of addressing modes.

Fifth-Generation Microprocessors

In microprocessor technology, INTEL has taken a leading edge and is developing more and more new processors. The latest processor by INTEL is the **pentium** which is considered a fifth-generation processor. The pentium is a 32-bit processor with 64-bit data bus and is available in a wide range of clock speeds from 60 MHz to 3.2 GHz. With improvement in semiconductor technology, the processing speed of microprocessors has increased tremendously. The 8085 released in the year 1976 executes 0.5 Million Instructions Per Second (0.5 MIPS). The 80486 executes 54 Million Instructions Per Second. The pentium is optimized to execute two instructions in one clock period. Therefore, a pentium processor working at 1 GHz clock can execute 2000 Million Instructions Per Second (2000 MIPS). The various processors released by INTEL are listed in Appendix I.

1.3 BASIC FUNCTIONAL BLOCKS OF A MICROPROCESSOR

A microprocessor is a programmable IC which is capable of performing arithmetic and logical operations. The basic functional block diagram of a microprocessor is shown in Fig. 1.1.

The basic functional blocks of a microprocessor are ALU, Flag register, Register array, Program Counter (PC)/Instruction Pointer (IP), Instruction decoding unit, and the Timing and Control unit.

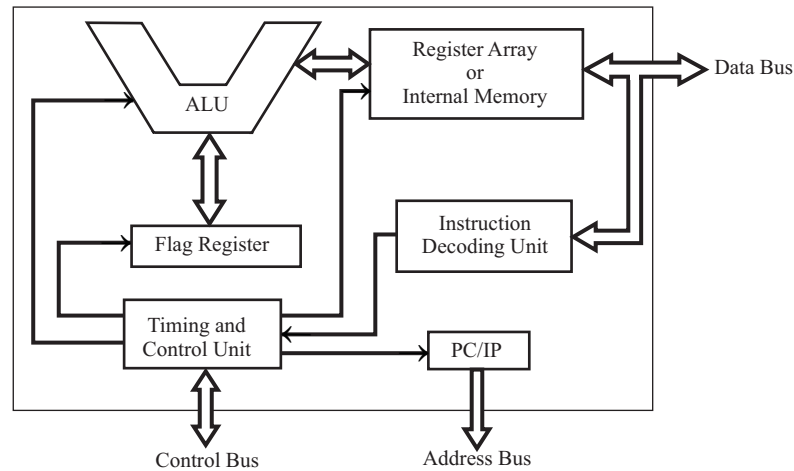


Fig. 1.1: Block diagram showing basic functional blocks of a microprocessor.

ALU is the computational unit of the microprocessor which performs arithmetic and logical operations on binary data. The various conditions of the result are stored as status bits called flags in the flag register. For example, consider sign flag. One of the bit positions of the flag register is called sign flag and it is used to store the status of the sign of the result of the ALU operation (output data of ALU). If the result is negative then “1” is stored in the sign flag and if the result is positive then “0” is stored in the sign flag.

The register array is the internal storage device and so it is also called internal memory. The input data for ALU, the output data of ALU (result of computations) and any other binary information needed for processing are stored in the register array.

For any microprocessor, there will be a set of instructions given by its manufacturer. For doing any useful work with the microprocessor, we have to first write a program using these instructions, and store them in a memory device external to the microprocessor.

The instruction pointer generates the address of the instructions to be fetched from the memory and sends it through the address bus to the memory. The memory will send the instruction codes and data through the data bus. The instruction codes are decoded by the decoding unit and it sends information to the timing and control unit. The data is stored in the register array for processing by the ALU.

The control unit will generate the necessary control signals for internal and external operations of the microprocessor.

1.4 MICROPROCESSOR-BASED SYSTEMS (ORGANIZATION OF A MICROCOMPUTER)

A microprocessor is a semiconductor device (or Integrated Circuit) manufactured by the VLSI (Very Large Scale Integration) technique. It includes the ALU, register arrays and control circuit on a single chip. To perform a function or useful task, we have to form a system by using the microprocessor as a CPU (Central Processing Unit) and interfacing memory, the input and output devices to it. A system designed using a microprocessor as its CPU is called a microcomputer or single-board microcomputer. A microprocessor-based system consists of a microprocessor as the CPU, semiconductor memories like EPROM and RAM, an input device, an output device and interfacing devices. The memories, input device, output device and interfacing devices are called peripherals.

The commonly used EPROM and static RAM ion microcomputers are given below :

EPROM

INTEL 2708 (1kB)
INTEL 2716 (2kB)
INTEL 2732 (4kB)
INTEL 2764 (8kB)

Static RAM

MOTORROLA 6208 (1kB)
MOTORROLA 6216 (2kB)
MOTORROLA 6232 (4kB)
MOTORROLA 6264 (8kB)

Note : kB refer to kilobytes.

The popular input devices are the keyboard, floppy disk, etc., and the output devices are printer, LED/LCD displays, CRT monitor, etc.

The block diagram of an 8086 microprocessor-based system bus structure is shown in Fig. 1.2. In this system, the microprocessor is the master and all other peripherals are slaves. The master controls all the peripherals and initiates all the operations.

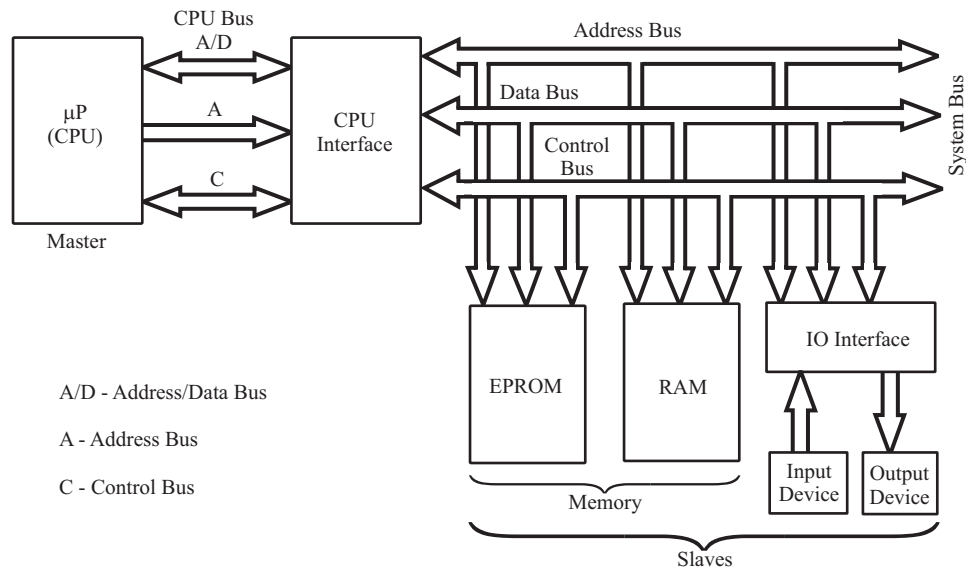


Fig. 1.2: Microprocessor-based system (organization of microcomputer).

Buses are a group of lines that carry data, address and control signals. The CPU bus has multiplexed lines, i.e., the same line is used to carry different signals. The CPU interface is provided to demultiplex the multiplexed lines, to generate chip select signals and additional control signals. The system bus has separate lines for each signal.

All the slaves in the system are connected to the same system bus. At any time, instant communication takes place between the master and one of the slaves. All the slaves have tristate logic and hence normally remain in a **high impedance** state. The processor selects a slave by sending an address. When a slave is selected, it comes to the normal logic and communicates with the processor.

The EPROM memory is used to store permanent programs and data. The RAM memory is used to store temporary programs and data. The input device is used to enter the program, data and to operate the system. The output device is used for examining the results. Since the speed of IO devices does not match with the speed of the microprocessor, an interface device is provided between the system bus and the IO devices. Generally, IO devices are slow devices.

1.4.1 WORKING OF 8086 MICROPROCESSOR-BASED SYSTEM

The work done by the processor can be classified into the following three groups:

1. Work done internal to the processor.
2. Work done external to the processor.
3. Operations initiated by the slaves or peripherals.

The works done internal to the processor are addition, subtraction, logical operations, data transfer within registers, etc. The works done external to the processor are reading/writing the memory and reading/writing the IO devices or the peripherals. If the peripheral requires the attention of the master then it can interrupt the master and initiate an operation.

The microprocessor is the master which controls all the activities of the system. To perform a specific job or task, the microprocessor has to execute a program stored in the memory. The program consists of a set of instructions stored in consecutive memory locations. In order to execute the program, the microprocessor issues address and control signals to fetch the instruction and data from memory one by one. After fetching each instruction, the processor decodes the instruction and carries out the task specified by the instruction.

1.4.2 CONCEPT OF MULTIPLEXING IN A MICROPROCESSOR

Multiplexing is transferring different information at different well-defined times through the same lines. A group of such lines is called a **multiplexed bus**. The result of multiplexing is that fewer pins are required for microprocessors to communicate with the outside world.

Due to pin-number limitations, most microprocessors cannot provide simultaneously similar lines (such as address, data, status signals, etc.). Hence multiplexing of one or more of these buses is performed. Most often data lines are multiplexed with some or all address lines to form an address/data bus (e.g., in 8086, the lower 16-address lines are multiplexed with data lines). The status signals emitted by the microprocessor are sometimes multiplexed either with the data lines (as done in INTEL 8080A) or with some of the address lines (as done in INTEL 8086).

Whenever multiplexing is used, the CPU interface of the system must include the necessary hardware to demultiplex those lines to produce separate address, data and control buses required for the system. Demultiplexing of a multiplexed bus can be handled either at the CPU interface or locally at appropriate points in the system. Besides a slower system operation, a multiplexed bus also results in additional interface hardware requirements.

1.4.3 DEMULTIPLEXING OF ADDRESS/DATA LINES IN AN 8086 PROCESSOR

In order to demultiplex the address/data lines (of the processor), the processor provides a signal called ALE (Address Latch Enable). The ALE is asserted **high** and then **low** by the processor at the beginning of every bus cycle. At the same time, the address is given out through AD_0 - AD_{15} lines and A_{16} - A_{19} /status lines. Demultiplexing of address/data lines and address/status lines using 8-bit D-latch 74LS373 is shown in Fig. 1.3.

The ALE is connected to the **Enable Pin (EN)** of the external 8-bit latches. When ALE is asserted **high** and then **low**, the addresses are latched into the output lines of the latch. It holds the address until the next bus cycle. After latching the address, the AD_0 - AD_{15} lines are free for data transfer and A_{16} - A_{19} /status lines are free for carrying status information. The first T-state of every bus cycle is used for address latching in 8086 and the remaining T-states are used for reading or writing operation.

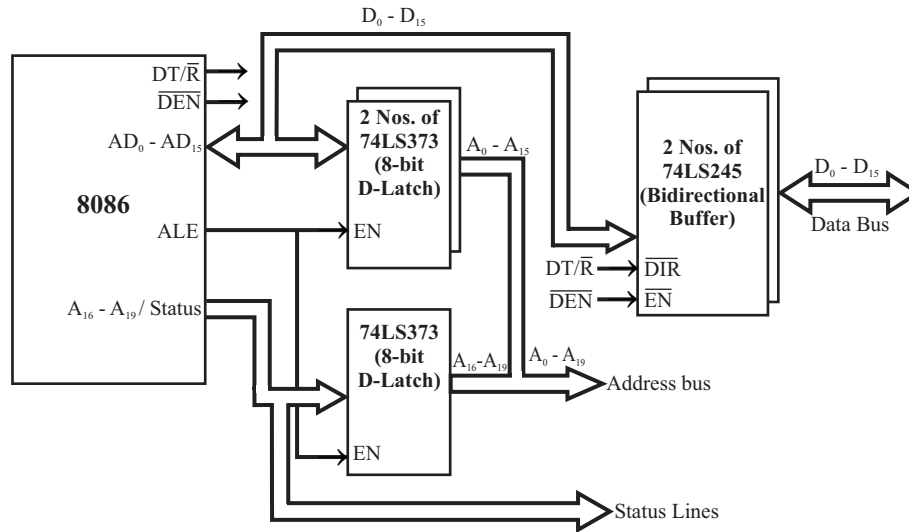


Fig. 1.3: Demultiplexing of address and data lines in an 8086 processor.

The data bus is provided with a bidirectional buffer in order to drive the data to a longer distance in the bus. The 8086 provides two control signals, $\overline{DT/R}$ and $\overline{DEN}$, for controlling the data buffers. $\overline{DT/R}$ is used to decide the direction of data flow and $\overline{DEN}$ is used to enable the data buffer.

1.5 SHORT-ANSWER QUESTIONS

Q1.1 What is a microprocessor ?

A microprocessor is a program controlled semiconductor device (IC), which fetches, decodes and executes instructions.

Q1.2 What are the basic functional blocks of a microprocessor ?

The basic functional blocks of a microprocessor are ALU, an array of registers and control unit .

Q1.3 What is a bus ?

A bus is a group of conducting lines that carries data, address and control signals.

Q1.4 Define bit, byte and word.

A digit of the binary number or code is called bit. The bit is also the fundamental storage unit of computer memory.

The 8-bit (8-digit) binary number or code is called byte and 16-bit binary number or code is called word. (Some microprocessor manufacturers refer to the basic data size operated by the processor as word.)

Q1.5 State the relation between the number of address pins and physical memory space?

The size of the binary number used to address the memory decides the physical memory space. If a microprocessor has n-address pins then it can directly address 2^n memory locations. (The memory locations that are directly addressed by the processor are called physical memory space.)

Q1.6 Why is data bus bidirectional?

The microprocessor has to fetch (read) the data from the memory or input device for processing and after processing it has to store (write) the data in the memory or output device. Hence, the data bus is bidirectional.

Q1.7 Why is address bus unidirectional?

The address is an identification number used by the microprocessor to identify or access a memory location or IO device. It is an output signal from the processor. Hence, the address bus is unidirectional.

Q1.8 State the difference between CPU and ALU.

ALU is the unit that performs arithmetic or logical operations. CPU is the unit that includes ALU and control unit. Apart from processing the data, the CPU controls the functioning of the entire system. Usually, a microprocessor will be the CPU of a system and it is called the brain of the computer.

Q1.9 What is tristate logic? Why is it needed in a microprocessor system?

In tristate logic, three logic levels are used: **high**, **low** and **high impedance** state. The **high** and **low** are normal logic levels and **high impedance** state is an electrical open circuit condition.

In a microprocessor system, all the peripheral/slave devices are connected to a common bus. But communication (data transfer) takes place between the master (microprocessor) and one slave (peripheral) at any time instant. During this time instant, all other devices should be isolated from the bus. Therefore, normally all the slaves (peripherals) will remain in **high impedance** state (i.e., in electrical isolation). The master will select a slave by sending the address and chip select signal. When the slave is selected, it comes to normal logic and it communicates with the master.

Q1.10 What is HMOS and HCMOS?

HMOS is High density n-type Metal Oxide Silicon field effect transistor. The third-generation microprocessors are fabricated using HMOS transistors.

HCMOS is High density n-type Complementary Metal Oxide Silicon field effect transistor. It is a low power version of HMOS and the fourth-generation microprocessors are fabricated using HCMOS transistors.

Q1.11 What are the drawbacks of first generation microprocessors?

First generation processors are fabricated using PMOS technology and they have drawbacks like slow speed, low output currents and are not compatible with TTL logic levels.

Q1.12 What is microcomputer? Explain the difference between a microprocessor and a microcomputer.

A system designed using a microprocessor as its CPU is called a microcomputer. The term microcomputer refers to the whole system, whereas a microprocessor is the CPU of a system.

Q1.13 What is the function of a microprocessor in a system?

A microprocessor is the master of a system, which controls all the activities of the system. It issues address and control signals and fetches the instruction and data from the memory. It also executes the instructions to take appropriate action.

Q1.14 List the components of a microprocessor-based (single board microcomputer) system.

A microprocessor-based system consists of a microprocessor as the CPU, semiconductor memories like EPROM and RAM, input device, output device and interfacing devices.

Q1.15 Why is interfacing needed for IO devices?

Generally, IO devices are slow devices. Therefore, the speed of IO devices do not match with the speed of the microprocessors. Therefore, an interface is provided between the system bus and IO devices.

Q1.16 What is the difference between CPU bus and system bus?

The CPU bus has multiplexed lines but the system bus has separate lines for each signal. (The multiplexed CPU lines are demultiplexed by the CPU interface circuit to form the system bus.)

Q1.17 What is multiplexing and what is its advantage?

Multiplexing is transferring of different information at different well-defined times through the same lines. A group of such lines is called a multiplexed bus. The advantage of multiplexing is that fewer pins are required for microprocessors to communicate with the outside world.

1.6 EXERCISES**I. Fill in the blanks with appropriate words**

1. A digit of the binary number or code is called _____.
2. The group of conducting lines that carry control signals is called _____ bus.
3. The _____ state is used to keep the device electrically isolated from the system.
4. The third generation microprocessors were designed using _____ technology.
5. Transferring different information at different well defined times through the same lines is called _____.
6. 1 mil is equivalent to _____ inch.
7. The _____ is an identification number (in binary) for memory locations.
8. The _____ is the size of binary information that can be stored in a memory location.
9. The group of conducting lines that are directly connected to the microprocessor is called _____.
10. The group of conducting lines that carries data, address and control signals in a microcomputer system is called _____.
11. A microprocessor is a _____ which is capable of performing arithmetic and logical operations.
12. The register array is also called as _____.
13. The CPU bus has _____ lines that is the same line is used to carry different lines.
14. The _____ memory is used to store permanent programs and data.
15. The ALE is connected to the _____ pin of the external 8-bit latches.

Answers

- | | | |
|---------------------------|---------------------|---------------------|
| 1. bit | 6. 10^{-3} | 11. Programmable IC |
| 2. control | 7. Address | 12. Internal memory |
| 3. High impedance | 8. Memory word size | 13. Multiplexed |
| 4. High density MOS(HMOS) | 9. CPU bus | 14. EPROM |
| 5. Multiplexing | 10. System bus | 15. Enable(EN) |

II. State whether the following statements are True/False.

1. The address bus is bidirectional.
2. The CPU bus is directly connected to the microprocessor.
3. The high impedance state is an electrical open-circuit condition .
4. The NMOS technology offers faster speed and higher density than HMOS technology.
5. Registers can be read/written faster than memory chips.
6. The microprocessor is a program-controlled semiconductor device (IC) which fetches data,decodes and executes instruction.
7. The 8086 processor has a 16-bit ALU, hence it is called a 16-bit processor.
8. The group of conducting lines that carries data is called a data bus.
9. The group of conducting lines that carries control signals is called an address bus .
10. A clock is a square wave used to synchronize various devices in the microprocessor.
11. The NMOS technology offers lowest speed and higher density than PMOS.
12. The third-generation microprocessors are 16-bit processors and designed using NMOS technology.
13. The HMOS technology offers better speed power product and higher density than NMOS.

Answers

- | | | |
|----------|----------|-----------|
| 1. False | 6. True | 11. False |
| 2. True | 7. True | 12. False |
| 3. True | 8. True | 13. True |
| 4. False | 9. False | |
| 5. True | 10. True | |

III. Choose the right answer for the following questions

1. *Microprocessors are intended to be a _____ computer.*
 - a) general-purpose
 - b) special purpose
 - c) hybrid
 - d) analog
2. *Group of 4-bits is called*
 - a) byte
 - b) nibble
 - c) word
 - d) double word

3. *What would be the total memory capacity of a microprocessor with 10 address lines*
 - a) 1 MB
 - b) 1 GB
 - c) 1 KB
 - d) 512 MB
4. *Which of the following is used to store temporary programs and data?*
 - a) EPROM
 - b) ROM
 - c) RAM
 - d) all the three
5. *The 1-bit register provided to store the results of certain program instructions is*
 - a) status register
 - b) instruction register
 - c) program counter
 - d) flag
6. *Which of the following signals is used to demultiplex the address/data lines in 8085 and 8086 processors?*
 - a) $\overline{DT}/\overline{R}$
 - b) ALE
 - c) SOD
 - d) READY
7. *The group of conducting lines that carries data is called _____ .*
 - a) Data bus
 - b) Address bus
 - c) Control bus
 - d) neither a nor b
8. *Which state is an electrical open-circuit condition.*
 - a) High
 - b) Low
 - c) High impedance
 - d) neither a nor b

9. The second - generation microprocessors has a large-chip size as.
- 170×200 mil
 - 150×180 mil
 - both a and b
 - neither a nor b
10. In fourth - generation microprocessor, the physical memory space of 2^{24} byte are.
- 24 MB
 - 16 MB
 - 1 MB
 - 10 MB
11. In fourth - generation microprocessor, the virtual memory space of 2^{40} bytes are.
- 16 TB
 - 1 TB
 - both a and b
 - neither a nor b

<u>Answers</u>		
1. a	5. d	9. a
2. b	6. b	10. b
3. c	7. a	11. b
4. c	8. c	

IV. Answer the following questions.

- E1.1** What is meant by addressability of a microprocessor?
- E1.2** State the significance of clock pulse in microprocessor based system.
- E1.3** Define the term speed power product(SPP).
- E1.4** Mention the packing density of NMOS and HMOS technology
- E1.5** Define the term MIPS.
- E1.6** Draw the basic functional blocks of a microprocessor.
- E1.7** When power on, how does the CPU know the starting address of the first instruction it has to execute?
What is that first instruction? why?
- E1.8** How many bus cycles are required for accessing a word which is stored at memory location 20013_H?
Which (higher or lower) data lines are used for placing lower byte and higher byte?
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