Branch : Electronics & Telecommunication Engineering

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Microprocessor

Prepared By Anowar Hossain Molla, Lecturer of MBCIE & T

Group-A

Unit 1 : Introduction to Microprocessor and 8 BIT Microprocessor

1.1 Distinguish between Microprocessor & Microcomputer, Generation and Evolution of Microprocessor.

1.2 Architecture of Intel 8085. Registers, Timing and Control , Add Buffer and Add data, Interrupt Control , Serial Input and Output Control

1.3 Concept of Bus, Bus Organisation of 8085.

1.4 Pin details of 8085 and related signals.

1.5 Demultiplexing of Address and Data bus by ALE signal.

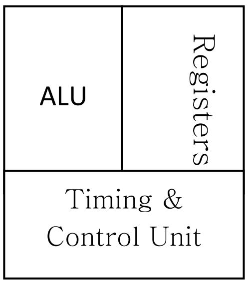
1.1 : Distinguish between Microprocessor & Microcomputer, Generation and Evolution of Microprocessor

Microprocessor :

Microprocessor is a programmable device which consists of (i) Arithmetic Login Unit (ALU), (ii) Registers and (iii) Control Unit. It is an Integrated Circuit (IC) which is manufactured using Large Scale Integration (LSI) or Very Large Scale Integration (VLSI) technique. It is a multipurpose device which is used to execute a sequence of instructions. It is available in a single chip as Dual-In line-Package (DIP). It acts as the Central Processing Unit (CPU) of a microcomputer.

Block diagram of Microprocessor :

A simple block diagram of microprocessor is shown below.



ALU : Arithmetic Login Unit :

This ALU unit is the main part of the microprocessor. This unit consists of a large number of digital gates and digital circuits. This ALU performs arithmetic operations such as addition, subtraction as well as logic operation such as AND , OR and Exclusive OR on binary data.

Registers :

The register is the storing device inside the microprocessor. Register is made of flip-flop. Registers are denoted by the English letters such as A, B, C, D, E, F, H, L etc. Registers are used to store binary data temporarily inside the processor during the execution of a program. The data can be transferred between register and outside memory.

Control Unit :

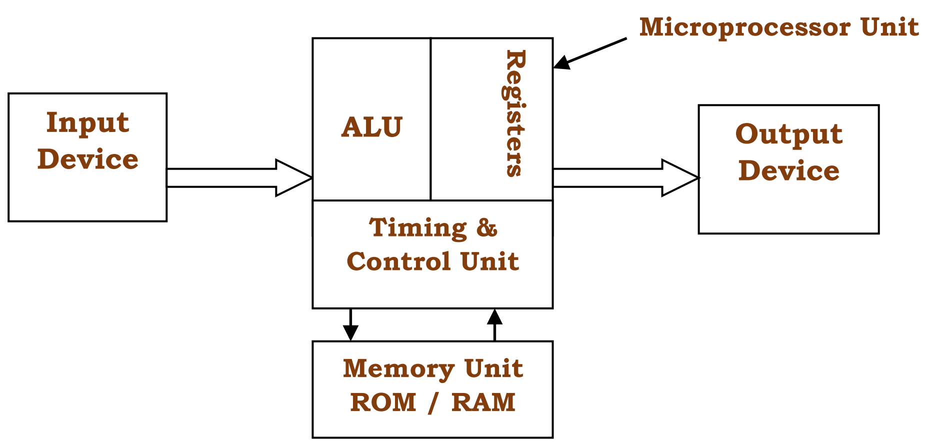
Microprocessor is a clock driven semiconductor device. It needs clock signal during operation. Clock is a series of rectangular pulses of certain frequency. The control unit provides the necessary timing and control signals during data transfer between (i) Register and outside memory devices and (ii) Register and Input-Output devices.

Microcomputer :

Microcomputer is a computer which is designed using a microprocessor as its Central Processing Unit (CPU). Hence, a microcomputer consists of—(i) Microprocessor Chip, (ii) Memory device, (iii) Input device and (iv) Output device. A microcomputer is also called the microprocessor system.

Block diagram of Microcomputer or Microprocessor System :

A simple block diagram of a microcomputer is shown below.



1. Microprocessor is a single chip device which cannot perform any operation alone. It needs some other devices to connect with it for its operation.
2. Microcomputer is a system which consists of peripheral devices to make it suitable for programming. Microprocessor is a part of microcomputer. In the mid-1970s 8—bit, 16—bit microprocessors were available for designing microcomputer.

Nowadays, 32—bit microprocessors and 64—bit microprocessors are available to design large storing capacity and high speed computers with various features in-built. Personal computer (PC), Laptop are the examples of single user microcomputers.

Generation and Evolution of Microprocessor :

In 1971, the Intel Corporation introduced the first 4—bit microprocessor 4004 using LSI technology. Later in 1972, 8—bit microprocessor 8008 was developed. Intel developed first general purpose 8—bit microprocessor 8080 in 1974 and 8—bit microprocessor 8085 in 1976.

Limitations : The limitations of 8—bit microprocessors are : (i) Low operating speed, (ii) Limited memory addressing capability, (iii) Less number of general purpose registers and (iv) Less number of instructions. These limitations are overcome gradually and nowadays advanced microprocessors are developed. The following table shows the development of the microprocessors and their features.

Microprocessor	Year of Development	No. of Transistors in the IC	No. of Pins of IC	Clock Frequency	Data Bus Size	Address Bus Size	Memory Address Size
4004	1971	2300	16	750 KHz	4—bit	10—bit	1 KB
8008	1972	3500	18	500—800 KHz	8—bit	14—bit	16 KB
8080	1974	6000	40	2 MHz	8—bit	16—bit	64 KB
8085	1976	6500	40	3—5 MHz	8—bit	16—bit	64 KB
Initial & Higher Specification Microprocessors							
8086	1978	29000	40	5—10 MHz	16—bit	20—bit	1 MB
80286	1982	1,34,000	68	5—12 MHz	16—bit	24—bit	16 MB
80386	1985	2,75,000	132	20—33 MHz	32—bit	24/32—bit	4 GB
80486	1989	32,00,000	132	25—100 MHz	32—bit	32—bit	4 GB
Advanced Microprocessors							
Pentium	1993	32,00,000	264	60—200 MHz	32—bit	32—bit	4 GB
Pentium Pro	1995	55,00,000	387	150—200 MHz	32—bit	36—bit	64 GB
Pentium II	1997	75,00,000	387	233—400 MHz	32—bit	36—bit	64 GB
Pentium III	1999	95,00,000	387	600—1000 MHz	32—bit	36—bit	64 GB
Pentium 4	2001	550,00,000	478	1.3—2 GHz	32—bit	36—bit	64 GB
Dual-Core	2007	172 Million		2.93 GHz	64—bit	40—bit	1 TB
Core-2 Duo	2008	410 Million	775	3.16 GHz	64—bit	40—bit	1 TB

1.2 : Architecture of Intel 8085, Registers, Timing and Control, Add Buffer, Interrupt Control, Serial Input and Output Control.

Architecture and Features of Intel—8085 :

Intel 8085 µp is a very popular 8—bit microprocessor which was developed by **Intel Corporation**, USA, in 1976. Some important features of Intel—8085 are given below :

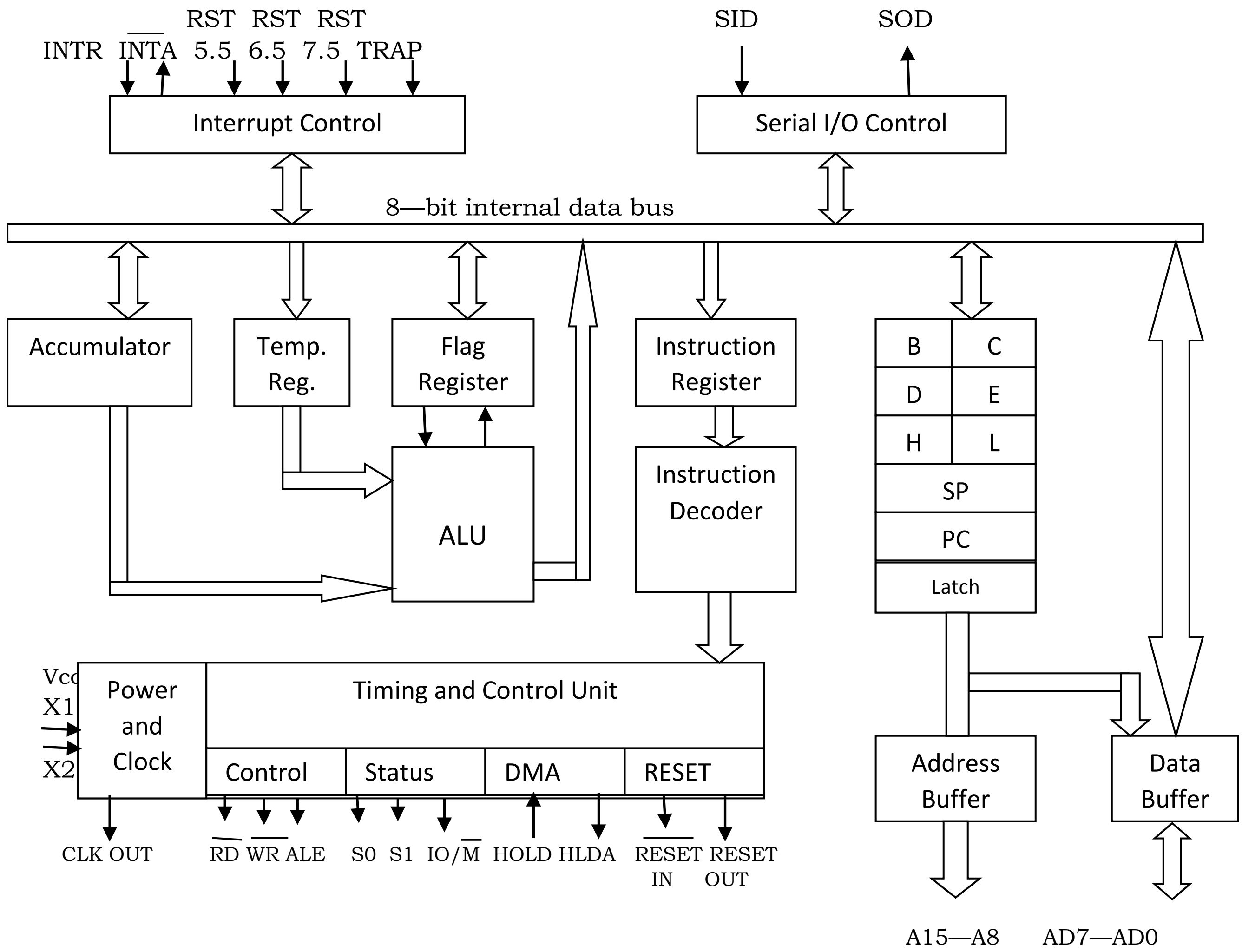
1. Intel 8085 is a semiconductor device containing digital logic circuits.
2. Intel—8085 can process data of size 8—bit at a time, so it is called 8—bit microprocessor.
3. It is a 40-pin digital IC available in Dual In line Package (DIP).
4. It is an LSI Chip, developed using NMOS technology.
5. There are 6500 number of transistors inside the Intel—8085 chip.
6. It needs +5 V dc supply for its operation.
7. Its clock frequency is about 3 MHz so, the crystal frequency is maintained at double value i.e. 6 MHz
8. It has multiplexed address / data bus AD7—AD0 for parallel data transfer. Using ALE signal data bus D7—D0 and address bus A7—A0 are formed for separate use.
9. The 8—bit data bus D7—D0 carry 8—bit data in the range 00 H to FF H
10. The 16—bit address bus A15—A0 to carry 16—bit address in the range 0000 H to FFFF H.
11. Data bus is bi-directional, both Address bus and Control bus are unidirectional.
12. Total memory addressing capacity is $\mathbf{2^{16}}$ Bytes = 64 Kbytes = 64 KB. (1 KB = 1024 Bytes)
13. The 8085 has 8—bit registers as well as 16—bit registers.
14. The 8—bit general purpose registers are : B, C, D, E, H, L.
15. The 16—bit general purpose registers are : BC, DE, HL.
16. The 8—bit Special purpose registers are : A, F. [F is Flag register]
17. The 16—bit Special purpose registers are : PC, SP [PC – Program Counter, SP—Stack Pointer]
18. It has 2—lines SID and SOD for serial data transfer.

Some Additional Features of Intel—8085 Microprocessor:

1. It has 5—number of Hardware Interrupts—TRAP, RST 7.5, RST 6.5, RST 5.5 and INTR.
2. It has 8—number of Software Interrupts—RST 0, RST 1, RST 2, RST 3, RST 4, RST 5, RST 6, RST 7.
3. It has 5—number of Flags—CY, P, AC, Z & S [Carry, Parity, Auxiliary Carry, Zero & Sign]
4. It has 74 basic instructions and 246 codes for assembly language programming.
5. Depending on function, it has 5—types of instructions : (i) Data Transfer, (ii) Arithmetic, (iii) Logical, (iv) Branching & (v) I/O, Machine Control.
6. Depending on Size or Length, it has 3—types of instructions : (i) 1—byte, (ii) 2—byte & (iii) 3—byte.
7. It has 5—types of Addressing Modes : (i) Register, (ii) Direct, (iii) Register Indirect, (iv) Immediate & (v) Implied or Implicit.

Block diagram of Intel—8085 Microprocessor :

Intel 8085 microprocessor consists of three main sections—(i) An Arithmetic and Logic Unit (ALU), (ii) A set of registers and (iii) Timing and Control Unit. The detailed functional block diagram of Intel—8085 shown below.



1. Arithmetic Logic Unit (ALU) :

The arithmetic logic unit performs operations—(i) Addition, (ii) Subtraction, (iii) Logical AND, OR, EX-OR, (iv) Complement, (v) Increment, (vi) Decrement, (vii) Shift left, Shift right etc.

This unit operates with Accumulator, Temporary Register and Flag Register. The contents of Accumulator and Temporary Register are the inputs of ALU. The result of ALU operation is transferred to Accumulator. The content of Flag register changes depending on the result in accumulator.

2. Registers :

The Intel 8085 contains a set of registers for its operations. The registers are :

(i) Six number of general-purpose registers to store 8—bit data, these are B, C, D, E, H and L.
(ii) In pair, BC , DE, HL act as 16—bit general purpose registers.
(iii) One 8—bit accumulator register.
(iv) One 8—bit flag register containing five flag bits- Sign, Carry, Auxiliary Carry, Parity and Zero flag.
(v) One Temporary register.
(vi) One Instruction register.
(vii) One 16—bit Program Counter (PC),
(viii) One 16—bit Stack Pointer (SP)
(ix) Increment / Decrement Latch,
(x) Address Buffer Register
(xi) Data/Address Buffer Register

A user or programmer can use general purpose registers for programming. Accumulator and Stack pointer can also be used by the user. Temporary register holds data for ALU and not accessed by user. Instruction register holds opcode of instruction to be executed. Program Counter holds 16—bit address of the instruction to be executed next time. For stack related operation Stack Pointer register is used by the user. Five number of status flag bits change (Set or Reset) depending on the result of Arithmetic and Logical operations. Buffer is basically register which holds the data until its content is changed.

3. Timing and Control Unit :

This unit generates necessary control signals as given below.

(i) X1 and X2 for crystal connection and clock signal is obtained from CLK OUT.
(ii) $\overline{\text{RD}}$, $\overline{\text{WR}}$ and IO/$\overline{\text{M}}$ are used for memory read, memory write, I/O read and I/O write operations.
(iii) HOLD and HLDA signals are used for Direct Memory Access (DMA) data transfer operation.
(iv) Address Latch Enable (ALE)signal is used for Address/ Data bus demultiplexing
(v) $\overline{\text{RESET IN}}$ and RESET OUT are used to reset the system and peripheral devices respectively.
(vi) S0 and S1 these status signal are used to identify machine cycle.

4. Interrupt Control :

This unit receives interrupt signals from outside to interrupt the microprocessor. These are called hardware interrupts. There are five hardware interrupt signals which are named as—TRAP, RST7.5, RST6.5, RST5.5 and INTR.

5. Serial Input / Output Control :

Microprocessor performs data transfer by the data bus D0—D7 in parallel mode. Serial Input / Output Control unit enables the processor to transfer data serial mode. Data is transferred serially to processor (IN) through SID and data is transferred serially from the microprocessor (OUT) through SOD.

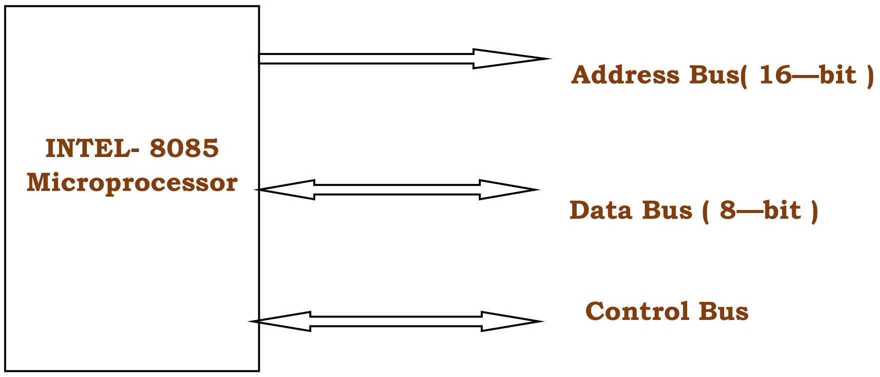
6. Internal Data Bus :

All the blocks are internally connected with the 8—bit wide Internal Data Bus. Bus is a set of wires which carry binary signal. One wire can carry 1—bit data.

1.3 : Concept of Bus , Bus Organisation of 8085.

Concept of Bus :

The 8085 microprocessor communicates with memory and input / output devices using three types of buses, namely, (i) Address Bus, (ii) Data Bus and (iii) Control Bus. These are called the system bus. Bus is a collection of wires which are used to carry binary data. One wire can carry one bit. The microprocessor 8085 and its system buses are shown in the following block diagram.



1. Address Bus :

Address bus is 16—bit wide to carry address of 16—bit in the range 0000 H to FFFF H. Address bus is unidirectional and carry signal from microprocessor to the peripheral devices—memory and input / output devices, interfacing devices etc. The address bus is denoted by A15—A0. Higher order address bus A15—A8 is directly obtained from the 8085 microprocessor. Lower order address bus A7—A0 is obtained from the demultiplexing of Address / Data bus AD7—AD0 by ALE signal.

2. Data Bus :

Data bus is 8—bit wide to carry data of 8—bit in the range 00 H to FF H. Data bus is bidirectional and carry signal between microprocessor and the peripheral devices in both directions. The data bus is denoted by D7—D0. Data bus D7—D0 is obtained from the demultiplexing of Address / Data bus AD7—AD0 by ALE signal.

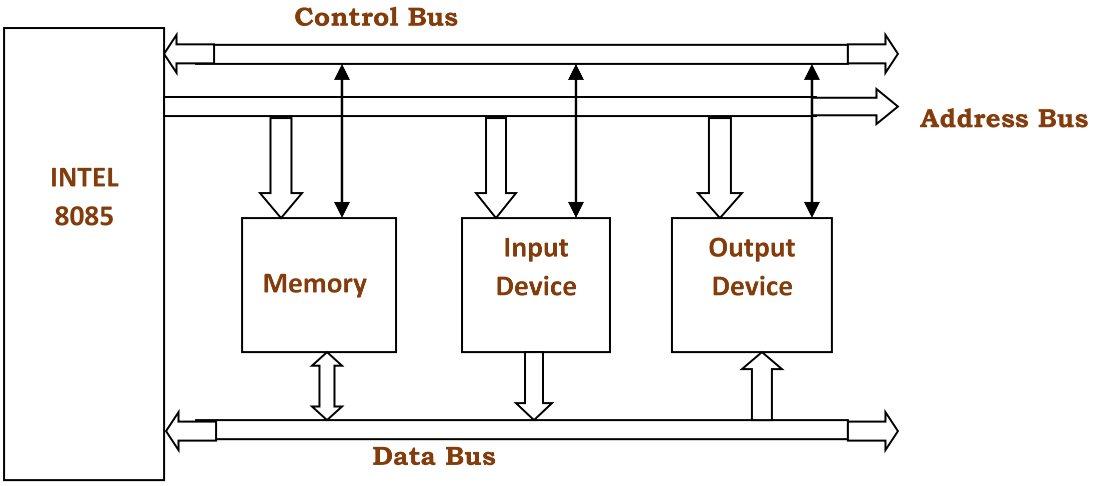
3. Control Bus :

Control bus has various lines to carry different control signals. This bus is hence bidirectional in nature. This bus carries—

(i) Status signals—S0, S1,
(ii) Read/Write control signals— $\overline{RD}$, $\overline{WR}$ and IO/$\overline{M}$
(iii) DMA control signals— HOLD and HLDA
(iv) RESET and READY signals.
(v) Interrupt signals

Bus Organisation of Intel 8085 :

The following block diagram shows how different peripheral devices are connected with the microprocessor by the system bus.



Address bus is unidirectional and sends address to all devices outward from the microprocessor. Address for each device is unique to identify the device.

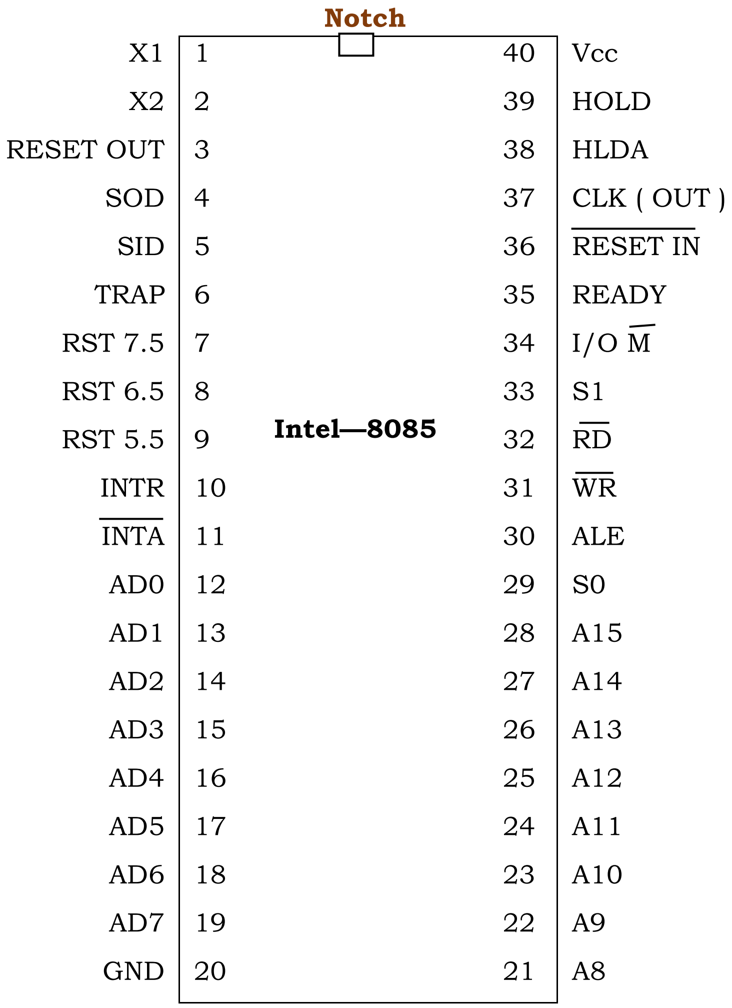
Data bus carries 8—bit data from microprocessor to peripheral devices or vice-versa depending on the control signal. Data bus is connected to each peripheral device.

Control bus carries control signal. Control signal on this bus varies with the type of peripheral device (memory or input device or output device) and the nature of data transfer, i.e. data from microprocessor or to the microprocessor.

1.4 : Pin Details of 8085 and Related Signals

Intel 8085 microprocessor is a digital IC with 40 number of pins attached with the chip having 20 number of pins on each side keeping the notch upward. Each pin is assigned one or more signals to generate or receive.

The detailed pin configuration of Intel 8085 and different signals assigned to the pins are described below.



All the signals can be classified into **six (6) groups** :

- **(i)** **Address Bus Signal**
- **(ii)** **Data Bus Signal**
- **(iii)** **Control and Status Signal**
- **(iv)** **Power Supply and Frequency signals**
- **(v)** **Externally Initiated signals**
- **(vi)** **Serial I/O port signals.**

(i) Address Bus signal :

The Address bus is unidirectional and carry signal from microprocessor to the peripheral devices. Address bus is denoted by A15—A0.Higher order address bus A15—A8 is directly obtained from the 8085 microprocessor. Lower order address bus A7—A0 is obtained from the demultiplexing of Address / Data bus AD7—AD0 by ALE signal.

(ii) Data Bus signal :

Data bus is 8—bit wide to carry data of 8—bit in the range 00 H to FF H. Data bus is bidirectional and carry signal between microprocessor and the peripheral devices in both directions. The data bus is denoted by D7—D0. Data bus D7—D0 is obtained from the demultiplexing of Address / Data bus AD7—AD0 by ALE signal.

(iii) Control Bus signal :

Control bus signals include the following signals

(a) **Status signals**—S0, S1 to identify the machine cycle.

(b) **Read/Write control** signals—
$\overline{\textbf{RD}}$ signal for data transfer from memory and Input device to microprocessor.
$\overline{\textbf{WR}}$ signal for data transfer from microprocessor to memory and output device.
IO/$\overline{\textbf{M}}$signal is used to identify the memory or Input/Output device.

(c) **Address Latch Enable (ALE)** signal is used for demultiplexing of Address / Data bus AD7—AD0 to obtain Lower order address bus A7—A0 and data bus D7—D0 for separate use.

(iv) Power Supply and Frequency signal :

Vcc = + 5 Volt, GND are used for power supply to the processor chip.
X1 , X2 are used for connecting crystal. Form the CLK OUT pin we get the clock signal which is needed for driving the peripheral devices.

(v) Externally Initiated signals :

These signal includes the following signals :

(a) **DMA control** signals— HOLD and HLDA are used in case of direct memory access data transfer scheme between memory and I/O devices with the help of DMA controller chip. In this case microprocessor remains inactive.

(b) **$\overline{\textbf{RESET IN}}$ & RESET OUT :** These signals are used to reset the microprocessor and peripheral device respectively as and when needed.

(c) **READY**: This signal is used for data transfer with slow devices using handshaking signals.

(d) **Interrupt signals—**TRAP, RST 7.5, RST 6.5, RST 5.5, INTR are used to interrupt the microprocessor as and when necessary. These are called hardware interrupts.

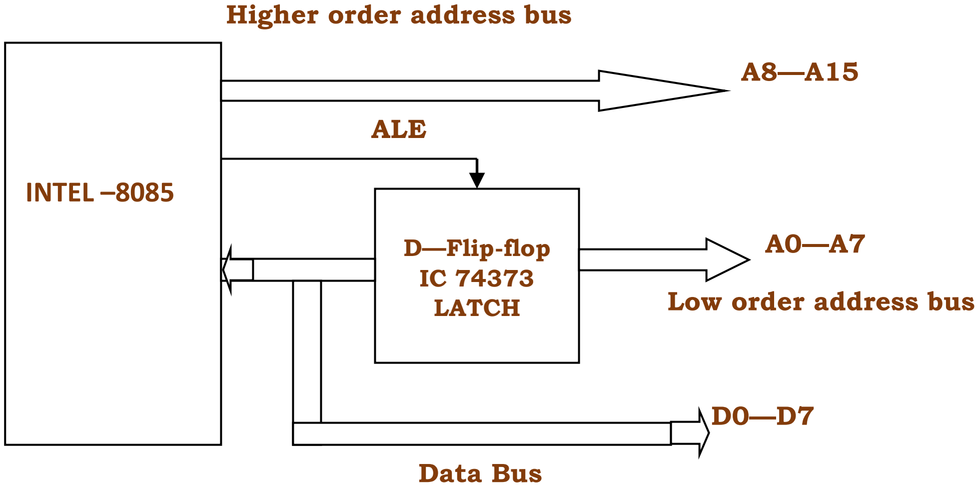
(vi) **Serial I/O Port signal :**

Serial Input Data (SID) and Serial Output Data (SOD) are the two signals for serial port. Data is transferred serially to processor (IN) through SID pin and data is transferred serially from the microprocessor (OUT) through SOD pin.

1.5 :Demultiplexing of Address and Data bus by ALE signal

The Address / Data Bus AD7—AD0 are obtained from the microprocessor chip. So we need to form separate buses A7—A0 for Lower order address and D7—D0 for Data. This is achieved by the technique, called Demultiplexing.

Demultiplexing : The technique by which 8—bit address bus A7—A0 and 8—bit data bus D7—D0 are formed separately from the 8—bit Address / Data Bus AD7—AD0, called demultiplexing. This is basically the time sharing technique. Demultiplexing is done by using Address Latch Enable (ALE) signal and a D—type Latch device (IC 74373). The circuit for demultiplexing is shown below.



Operation :

1. During the first clock cycle T1 of a machine cycle, the content of PC is sent to the address bus A15—A0. The ALE signal is made High, ALE = HIGH, the Low order address on AD7—AD0 passes to A7—A0 and becomes latch for the next cycles.

2. During the next clock cycles T2, T3, the ALE signal is made Low, ALE = LOW, the bus AD7—AD0 acts as the data bus D7—D0.

3. Thus by demultiplexing technique, 8—bit address bus A7—A0 and 8—data bus D7—D0 are obtained for separate use from available 8—bit address/data bus AD7—AD0.