UNIT – 1

Evolution of Microprocessors

Transistor was invented in 1948 (23 December 1947 in Bell lab). IC was invented in 1958 (Fair Child Semiconductors) By Texas Instruments J Kilby. The first microprocessor was invented by INTEL (INTegrated ELectronics)

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A. Size of the microprocessor – 4 bit

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
INTEL 4004/4040	1971 by Ted Hoff and Stanley Mazor	740 kHz	2300	60,000

B. Size of the **microprocessor –** 8 bit

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
8008	1972	500 kHz	3500	50,000
8080	1974	2 MHz	6000	10 times faster than 8008
8085	1976 (16-bit address bus)	3 MHz	6500	769230

C. Size of the microprocessor – 16 bit

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
8086	1978 (multiply and divide instruction, 16-bit data bus and 20-bit address bus)	4.77 MHz, 8 MHz, 10 MHz	29000	2.5 Million

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
8088	1979 (cheaper version of 8086 and 8-bit external bus)			2.5 Million
80186/80188	1982 (80188 cheaper version of 80186, and additional components like interrupt controller, clock generator, local bus controller, counters)	6 MHz		
80286	1982 (data bus 16bit and address bus 24 bit)	8 MHz	134000	4 Million

D. Size of the microprocessor – 32 bit

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
INTEL 80386	1986 (other versions 80386DX, 80386SX, 80386SL , and data bus 32-bit address bus 32 bit)	16 MHz – 33 MHz	275000	
INTEL 80486	1986 (other versions 80486DX, 80486SX, 80486DX2, 80486DX4)	16 MHz – 100 MHz	1.2 Million transistors	8 KB of cache memory
PENTIUM	1993	66 MHz		Cache memory 8 bit for instructions 8 bit for data

E. **Size of the microprocessor –** 64 bit

Name	Year of Invention	Clock speed	Number of transistors	Inst. per sec
INTEL core 2	2006 (other versions core2 duo, core2 quad, core2 extreme)	1.2 GHz to 3 GHz	291 Million transistors	64 KB of L1 cache per core 4 MB of L2 cache
i3, i5, i7	2007, 2009, 2010	2.2GHz – 3.3GHz, 2.4GHz – 3.6GHz, 2.93GHz – 3.33GHz		

Generations of microprocessors:

1. **First-generation –**
   From 1971 to 1972 the era of the first generation came which brought microprocessors like INTEL 4004 Rockwell international PPS-4 INTEL 8008 etc.

2. **Second generation –**
   The second generation marked the development of 8-bit microprocessors from 1973 to 1978. Processors like INTEL 8085 Motorola 6800 and 6801 etc came into existence.

3. **Third generation –**
   The third generation brought forward the 16-bit processors like INTEL 8086/80186/80286 Motorola 68000 68010 etc. From 1979 to 1980 this generation used the HMOS technology.

4. **Fourth generation –**
   The fourth-generation came into existence from 1981 to 1995. The 32-bit processors using HMOS fabrication came into existence. INTEL 80386 and Motorola 68020 are some of the popular processors of this generation.

5. **Fifth-generation –**
   From 1995 till now we are in the fifth generation. 64-bit processors like PENTIUM, Celeron, dual, quad, and octa-core processors came into existence.

Types of microprocessors :

- **Complex instruction set microprocessor –**
  The processors are designed to minimize the number of instructions per program and ignore the number of cycles per instruction. The compiler is used to translate a high-level language to assembly-level language because the length of code is relatively short and an extra RAM is used to store the instructions. These processors can do tasks like downloading, uploading, and recalling data from memory. Apart from these tasks, this microprocessor can perform complex mathematical calculations in a single command.
  Example: IBM 370/168, VAX 11/780

- **Reduced instruction set microprocessor –**
  These processors are made according to function. They are designed to reduce the execution time by using the simplified instruction set. They can carry out small things in specific commands. These processors complete commands at a faster rate. They require only one clock cycle to implement a result at uniform execution time. There is a number of registers and less number of transistors. To access the memory location LOAD and STORE instructions are used.
  Example: Power PC 601, 604, 615, 620

- **Superscalar microprocessor –**
  These processors can perform many tasks at a time. They can be used for ALUs and multiplier-like arrays. They have multiple operation units and perform tasks by executing multiple commands.

- **Application-specific integrated circuit –**
  These processors are application-specific like personal digital assistant computers. They are designed according to proper specifications.

- **Digital signal multiprocessor –**
  These processors are used to convert signals like analog to digital or digital to analog. The chips of these processors are used in many devices such as RADAR SONAR home theatres etc.

MOTOROLA 6800 SERIES

- Motorola 6800 is a 8-bit microprocessor which was released at about the same time as Intel 8080. The 6800 had 16-bit address bus and could address up to 64 KB of memory. From common registers the CPU had only two accumulators and one index register. The 6800 didn't have I/O instructions and therefore 6800-based systems had to use memory-mapped I/O for input/output capabilities. Motorola 6800 started the big family of 680x microcontrolers and microprocessors, some of which are still produced today.

- 6800 major features and related families:

Previous Generation		Related Family	Next Generation
	6800 • » 8-bit microprocessor • » Up to 2 MHz • » 64 KB RAM • » No I/O ports • 40-pin DIP	680x • » 8-bit microcontroller • » On-chip ROM / RAM • » On-chip peripherals 650x • » 256 bytes stack 8080 • » Up to 4 MHz • » 256 I/O ports	6809 • » 8-bit CPU • » UP to 2 MHz • » 64 KB RAM • » No I/O ports • » New registers, instructions and addressing modes 68000 • » 32-bit CPU • » 16-bit data bus • » Up to 20 MHz • » 16 MB RAM • » No I/O ports

Microprocessor - 8085 Architecture

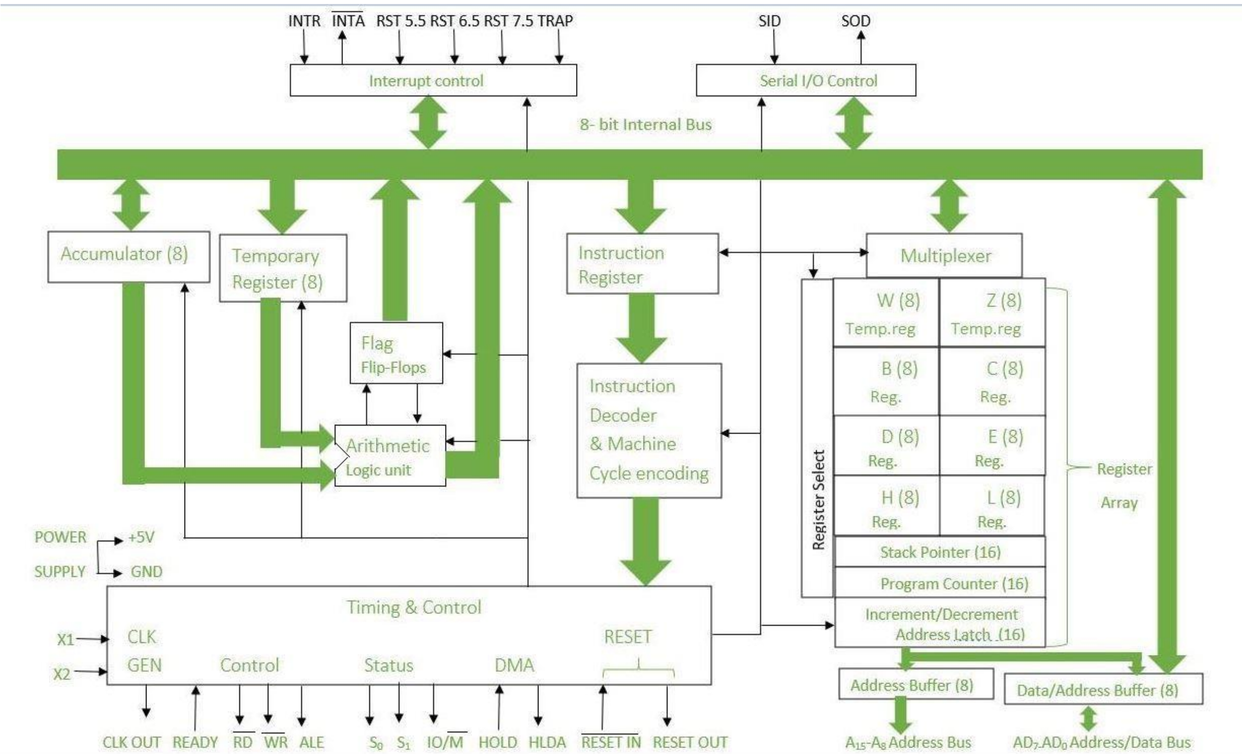
8085 is pronounced as "eighty-eighty-five" microprocessor. It is an 8-bit microprocessor designedby Intel in 1977 using NMOS technology.

It has the following configuration −

- 8-bit data bus
- 16-bit address bus, which can address
- upto 64KBA 16-bit program counter
- A 16-bit stack pointer
- Six 8-bit registers arranged in pairs: BC, DE, HL
- Requires +5V supply to operate at 3.2 MHZ single phase clock

It is used in washing machines, microwave ovens, mobile phones, etc.

8085 is an 8-bit, general-purpose microprocessor. It consists of the following functional units:



Arithmetic and Logic Unit (ALU):

It is used to perform mathematical operations like addition, multiplication, subtraction, division, decrement, increment, etc. Different operations are carried out in ALU: ***Logical operations, Bit-Shifting Operations, and Arithmetic Operations.***

Flag Register:

It is an 8-bit register that stores either 0 or 1 depending upon which value is stored in the accumulator. Flag Register contains 8-bit out of which 5-bits are important and the rest of 3-bits are “don’t Care conditions”. The flag register is a dynamic register because after each operation to check whether the result is zero, positive or negative, whether there is any overflow occurred or not, or for comparison of two 8-bit numbers carry flag is checked. So for numerous operations to check the contents of the accumulator and from that contents if we want to check the behavior of given result then we can use Flag register to verify and check. So we can say that the **flag register is a status register and it is used to check the status of the current operation which is being carried out by ALU.**
Different Fields of Flag Register:

1. **Carry Flag**
2. **Parity Flag**
3. **Auxiliary Carry Flag**
4. **Zero Flag**
5. **Sign Flag**

Accumulator:

Accumulator is used to perform I/O, arithmetic, and logical operations. It is connected to ALU and the internal data bus. The accumulator is the heart of the microprocessor because for all arithmetic operations Accumulator’s 8-bit pin will always there be connected with ALU and in most-off times all the operations carried by different instructions will be stored in the accumulator after operation performance.

General Purpose Registers:

There are six general-purpose registers. These registers can hold 8-bit values. These 8-bit registers are B, C, D, E, H, L. These registers work as 16-bit registers when they work in pairs like B-C, D-E, and H-L. Here registers W and Z are reserved registers. We can’t use these registers in arithmetic operations. It is reserved for microprocessors for internal operations like swapping two 16-bit numbers. We know that to swap two numbers we need a third variable hence here W-Z register pair works as temporary registers and we can swap two 16-bit numbers using this pair.

Program Counter:

Program Counter holds the address value of the memory to the next instruction that is to be executed. It is a 16-bit register.

For Example: *Suppose current value of Program Counter : [PC] = 4000H*
(It means that next executing instruction is at location 4000H.After fetching, program Counter (PC) always increments
by +1 for fetching of next instruction.)

Stack Pointer:

It works like a stack. In stack, the content of the register is stored that is later used in the program. It is a 16-bit special register. The stack pointer is part of memory but it is part of Stack operations, unlike random memory access. Stack pointer works in a continuous and contiguous part of the memory. whereas Program Counter(PC) works in random memory locations. This pointer is very useful in stack-related operations like ***PUSH, POP, and nested CALL requests*** initiated by Microprocessor. *It reserves the address of the most recent stack entry.*

Temporary Register:

It is an 8-bit register that holds data values during arithmetic and logical operations.

Instruction register and decoder:

It is an 8-bit register that holds the instruction code that is being decoded. The instruction is fetched from the memory.

Timing and control unit:

The timing and control unit comes under the CPU section, and it controls the flow of data from the CPU to other devices. It is also used to control the operations performed by the microprocessor and the devices connected to it. There are certain timing and control signals like Control signals, DMA Signals, RESET signals and Status signals.

Interrupt control:

Whenever a microprocessor is executing the main program and if suddenly an interrupt occurs, the microprocessor shifts the control from the main program to process the incoming request. After the request is completed, the control goes back to the main program. There are 5 interrupt signals in 8085 microprocessors: INTR, TRAP, RST 7.5, RST 6.5, and RST 5.5.

Priorities of Interrupts: TRAP > RST 7.5 > RST 6.5 > RST 5.5 > INTR

Address bus and data bus:

The data bus is bidirectional and carries the data which is to be stored. The address bus is unidirectional and carries the location where data is to be stored.

In the 8085 microprocessor, the address bus and data bus are two separate buses that are used for communication between the microprocessor and external devices.

The Address bus is used to transfer the memory address of the data that needs to be read or written. The address bus is a 16-bit bus, allowing the 8085 to access up to 65,536 memory locations.

The Data bus is used to transfer data between the microprocessor and external devices such as memory and I/O devices. The data bus is an 8-bit bus, allowing the 8085 to transfer 8-bit data at a time. The data bus can also be used for instruction fetch operations, where the microprocessor fetches the instruction code from memory and decodes it.

The combination of the address bus and data bus allows the 8085 to communicate with and control external devices, allowing it to execute its program and perform various operations.

Serial Input/output control:

It controls the serial data communication by using Serial input data and Serial output data.

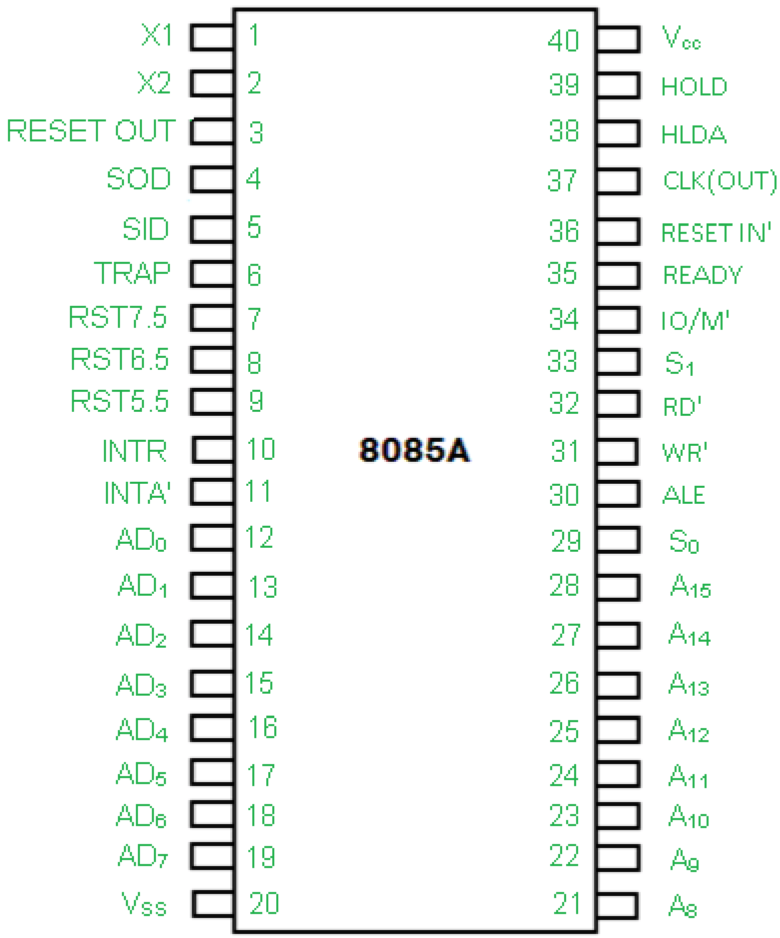
Serial Input/Output control in the 8085 microprocessor refers to the communication of data between the microprocessor and external devices in a serial manner, i.e., one bit at a time. The 8085 has a serial I/O port (SID/SOD) for serial communication. The SID pin is used for serial input and the SOD pin is used for serial output. The timing and control of serial communication is managed by the 8085's internal circuitry. The 8085 also has two special purpose registers, the Serial Control Register (SC) and the Serial Shift Register (SS), which are used to control and monitor the serial communication.

The flow of an Instruction Cycle in 8085 Architecture :

1. Execution starts with Program Counter. It starts program execution with the next address field. it fetches an instruction from the memory location pointed by Program Counter.
2. For address fetching from the memory, multiplexed address/data bus acts as an address bus and after fetching instruction this address bus will now acts as a data bus and extract data from the specified memory location and send this data on an 8-bit internal bus. For multiplexed address/data bus Address Latch Enable(ALE) Pin is used. If ***ALE = 1 (Multiplexed bus is Address Bus otherwise it acts as Data Bus).***
3. After data fetching data will go into the Instruction Register it will store data fetched from memory and now data is ready for decoding so for this Instruction decoder register is used.
4. After that timing and control signal circuit comes into the picture. *It sends control signals all over the microprocessor to tell the microprocessor whether the given instruction is for READ/WRITE and whether it is for MEMORY/I-O Device activity.*
5. Hence according to timing and control signal pins, logical and arithmetic operations are performed and according to that data fetching from the different registers is done by a microprocessor, and mathematical operation is carried out by ALU. And according to operations Flag register changes dynamically.
6. With the help of Serial I/O data pin(SID or SOD Pins) we can send or receive input/output to external devices .in this way execution cycle is carried out.
7. ***While execution is going on if there is any interrupt detected then it will stop execution of the current process and Invoke Interrupt Service Routine (ISR)*** Function. Which will stop the current execution and do execution of the current occurred interrupt after that normal execution will be performed.

Pin diagram of 8085 microprocessor

Pin diagram of 8085 microprocessor is as given below:



1. Address Bus and Data Bus:
The address bus is a group of sixteen lines i.e A0-A15. The address bus is unidirectional, i.e., bits flow in one direction from the microprocessor unit to the peripheral devices and uses the high order address bus.
2. Control and Status Signals:

- **ALE –** It is an Address Latch Enable signal. It goes high during first T state of a machine cycle and enables the lower 8-bits of the address, if its value is 1 otherwise data bus is activated.

- **IO/M' –** It is a status signal which determines whether the address is for input-output or memory. When it is high(1) the address on the address bus is for input-output devices. When it is low(0) the address on the address bus is for the memory.

- **SO, S1 –** These are status signals. They distinguish the various types of operations such as halt, reading, instruction fetching or writing.

IO/M'	S1	S0	Data Bus Status
0	1	1	Opcode fetch
0	1	0	Memory read
0	0	1	Memory write
1	1	0	I/O read
1	0	1	I/O write
1	1	1	Interrupt acknowledge
0	0	0	Halt

-
- **RD' –** It is a signal to control READ operation. When it is low the selected memory or input-output device is read.

- **WR' –** It is a signal to control WRITE operation. When it goes low the data on the data bus is written into the selected memory or I/O location.

- **READY –** It senses whether a peripheral is ready to transfer data or not. If READY is high (1) the peripheral is ready. If it is low (0) the microprocessor waits till it goes high. It is useful for interfacing low speed devices.

3. Power Supply and Clock Frequency:

- **Vcc –** +5v power supply
- **Vss –** Ground Reference
- **XI, X2 –** A crystal is connected at these two pins. The frequency is internally divided by two, therefore, to operate a system at 3MHZ the crystal should have frequency of 6MHZ.
- **CLK (OUT) –** This signal can be used as the system clock for other devices.

4. Interrupts and Peripheral Initiated Signals:

The 8085 has five interrupt signals that can be used to interrupt a program execution.
(i) INTR
(ii) RST 7.5
(iii) RST 6.5
(iv) RST 5.5
(v) TRAP

The microprocessor acknowledges Interrupt Request by INTA' signal. In addition to Interrupts, there are three externally initiated signals namely RESET, HOLD and READY. To respond to HOLD request, it has one signal called HLDA.

- **INTR –** It is an interrupt request signal.
- **INTA' –** It is an interrupt acknowledgement sent by the microprocessor after INTR is received.

5. Reset Signals:

- **RESET IN' –** When the signal on this pin is low(0), the program-counter is set to zero, the buses are tristated and the microprocessor unit is reset.
- **RESET OUT –** This signal indicates that the MPU is being reset. The signal can be used to reset other devices.

6. DMA Signals:

- **HOLD –** It indicates that another device is requesting the use of the address and data bus. Having received HOLD request the microprocessor relinquishes the use of the buses as soon as the current machine cycle is completed. Internal processing may continue. After the removal of the HOLD signal the processor regains the bus.

- **HLDA –** It is a signal which indicates that the hold request has been received after the removal of a HOLD request, the HLDA goes low.

7. Serial I/O Ports:

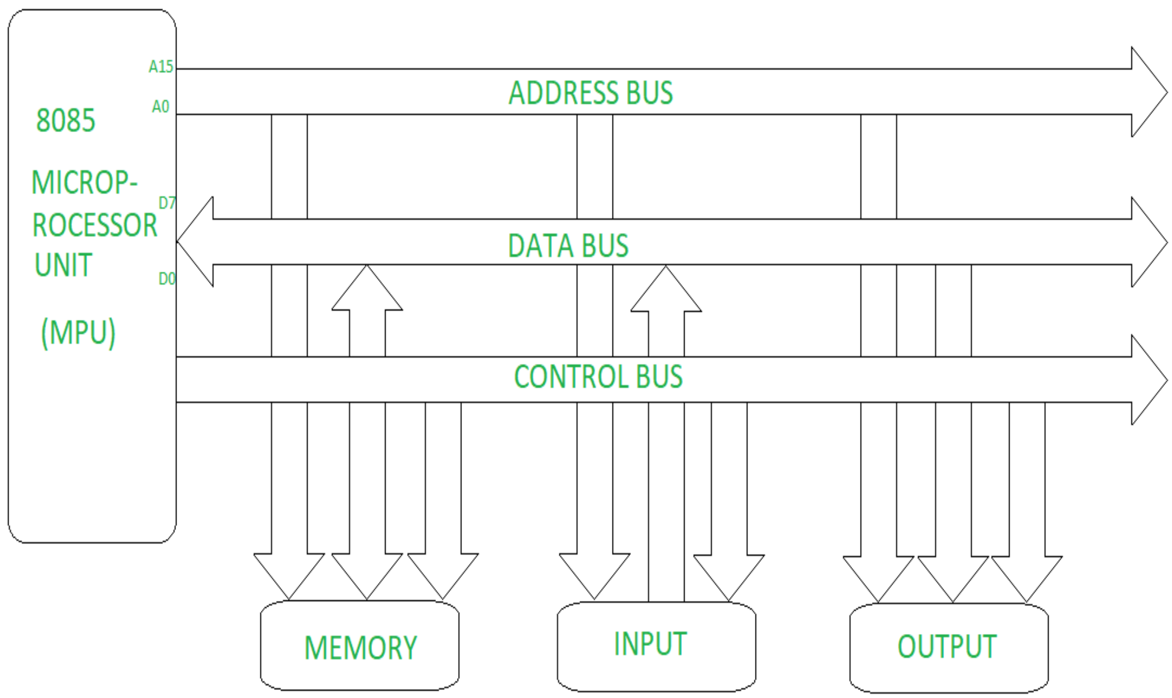
Serial transmission in 8085 is implemented by the two signals,

- **SID and SOD –** SID is a data line for serial input where as SOD is a data line for serial output.

Bus organization of 8085 microprocessor

Bus is a group of conducting wires which carries information, all the peripherals are connected to microprocessor through Bus.

Diagram to represent bus organization system of 8085 Microprocessor.



Bus organization system of 8085 Microprocessor

There are three types of buses.

1. **Address bus –**
   It is a group of conducting wires which carries address only.Address bus is unidirectional because data flow in one direction, from microprocessor to memory or from microprocessor to Input/output devices (That is, Out of Microprocessor).
   Length of Address Bus of 8085 microprocessor is 16 Bit (That is, Four Hexadecimal Digits), ranging from 0000 H to FFFF H, (H denotes Hexadecimal). The microprocessor 8085 can transfer maximum 16 bit address which means it can address 65, 536 different memory location.

   The Length of the address bus determines the amount of memory a system can address.Such as a system with a 32-bit address bus can address 2^32 memory locations.If each memory location holds one byte, the addressable memory space is 4 GB.However, the actual amount of memory that can be accessed is usually much less than this theoretical limit due to chipset and motherboard limitations.

2. **Data bus –**
   It is a group of conducting wires which carries Data only.Data bus is bidirectional because data flow in both directions, from microprocessor to memory or Input/Output devices and from memory or Input/Output devices to microprocessor.
   Length of Data Bus of 8085 microprocessor is 8 Bit (That is, two Hexadecimal Digits), ranging from 00 H to FF H. (H denotes Hexadecimal).

   When it is write operation, the processor will put the data (to be written) on the data bus, when it is read operation, the memory controller will get the data from specific memory block and put it into the data bus.

   The width of the data bus is directly related to the largest number that the bus can carry, such as an 8 bit bus can represent 2 to the power of 8 unique values, this equates to the number 0 to 255.A 16 bit bus can carry 0 to 65535.

3. **Control bus –**
   It is a group of conducting wires, which is used to generate timing and control signals to control all the associated peripherals, microprocessor uses control bus to process data, that is what to do with selected memory location. Some control signals are:
   - Memory read
   - Memory write
   - I/O read
   - I/O Write
   - Opcode fetch

   If one line of control bus may be the read/write line.If the wire is low (no electricity flowing) then the memory is read, if the wire is high (electricity is flowing) then the memory is written.