CHAPTER

2

8085 Architecture

2.1 Introduction

- A microprocessor is a semiconductor chip that implements the central processor of computer. The microprocessor works as a brain of a computer. It consists of arithmetic and logic unit (ALU) and a control unit.
- The microprocessors are usually characterised by speed, word length, architectu and instruction set.
- This central processing unit built into single chip is called as ***Microprocessor***.

In this chapter we will study features of 8085, detailed architecture of Intel's 80 microprocessor and pin configuration.

2.2 8085 Features

The features of a processor can be divided into three broad groups viz. ba features, special features and miscellaneous features.

2.2.1 Basic Features of 8085

Q. How many memory locations can be addressed by 8085 microprocessor ? Can i addressing capability be increased ? if yes, explain how.

- Processor size
- Speed of processor
- Address bus size for memory
- Address bus size for I/O

1. 8085 is a 8-bit microprocessor. This implies that :
   a) It has 8-bit ALU that can perform 8-bit operations simultaneously.
   b) It has 8-bit internal data bus and registers.
   c) It has 8-bit external data bus.
2. It has three versions based on frequency of operation.
   a) 8085 → 3 MHz b) 8085-2 → 5 MHz c) 8085-1 → 6 MHz
3. 8085 has 16-bit address bus to access memory, hence it can access $2^{16} = 2^6 \times$ = 64 × 1K = 64 KB memory locations. The addressing capability of 8085 can increased by using status pins S_1, S_0 as address pins. Hence the new address capability is upto 256 KB.

4. It has 8-bit address bus to access I/O locations, hence it can access $2^8 = 256$ I/O locations.

2.2.2 Special Features of 8085

- Single + 5V power supply
- On-chip clock generator
- Duplex serial port

1. 8085 was the first processor that required only single +5V power supply.
2. 8085 has a duplex serial port with 2 pins to receive and transmit serial data.
3. It has an on-chip clock generator. Hence there is no need for external clock generators, instead only a crystal is to be connected to 8085.

2.2.3 Miscellaneous Features of 8085

- Interrupts
- Instruction set
- Registers
- Data types for ALU.

1. 8085 has 5 hardware interrupts and 8 software interrupts. Software interrupts are vectored. Out of the 5 hardware interrupts four are vectored, while one is non-vectored. Also four of the hardware interrupts are maskable and one is non-maskable interrupt.

Hardware interrupt name	Vectored/Non-vectored	Maskable/Non-maskable
Trap	Vectored	Non-maskable
RST 7.5	Vectored	Maskable
RST 6.5	Vectored	Maskable
RST 5.5	Vectored	Maskable
INTR	Non- Vectored	Maskable

2. 8085 has following registers
   a. 8-bit accumulator
   b. Six 8-bit general purpose registers named as B, C, D, E, H and L.
   c. Flag register
   d. 16-bit program counter and
   e. 16-bit stack pointer
3. 8085 has a powerful instruction set that can do various arithmetic operations like 8-bit addition, 16-bit addition, 8-bit subtraction, increment and decrement of 8 bit as well as 16 bit. Also it can perform logical operations like AND, OR, EXOR and NOT.
4. 8085 can perform operations on bit, byte and some word (16-bit) data. It can work with binary as well as decimal data.

2.3 8085 Microprocessor Architecture (Functional Block Diagram)

Q. 1 Explain the architecture of 8085 microprocessor with functional block diagram.
Q. 2 Discuss 8085 microprocessor architecture.
Q. 3 Explain the architecture of 8085 in detail, including flag register.

Fig. 2.3.1 shows the architecture of 8085.

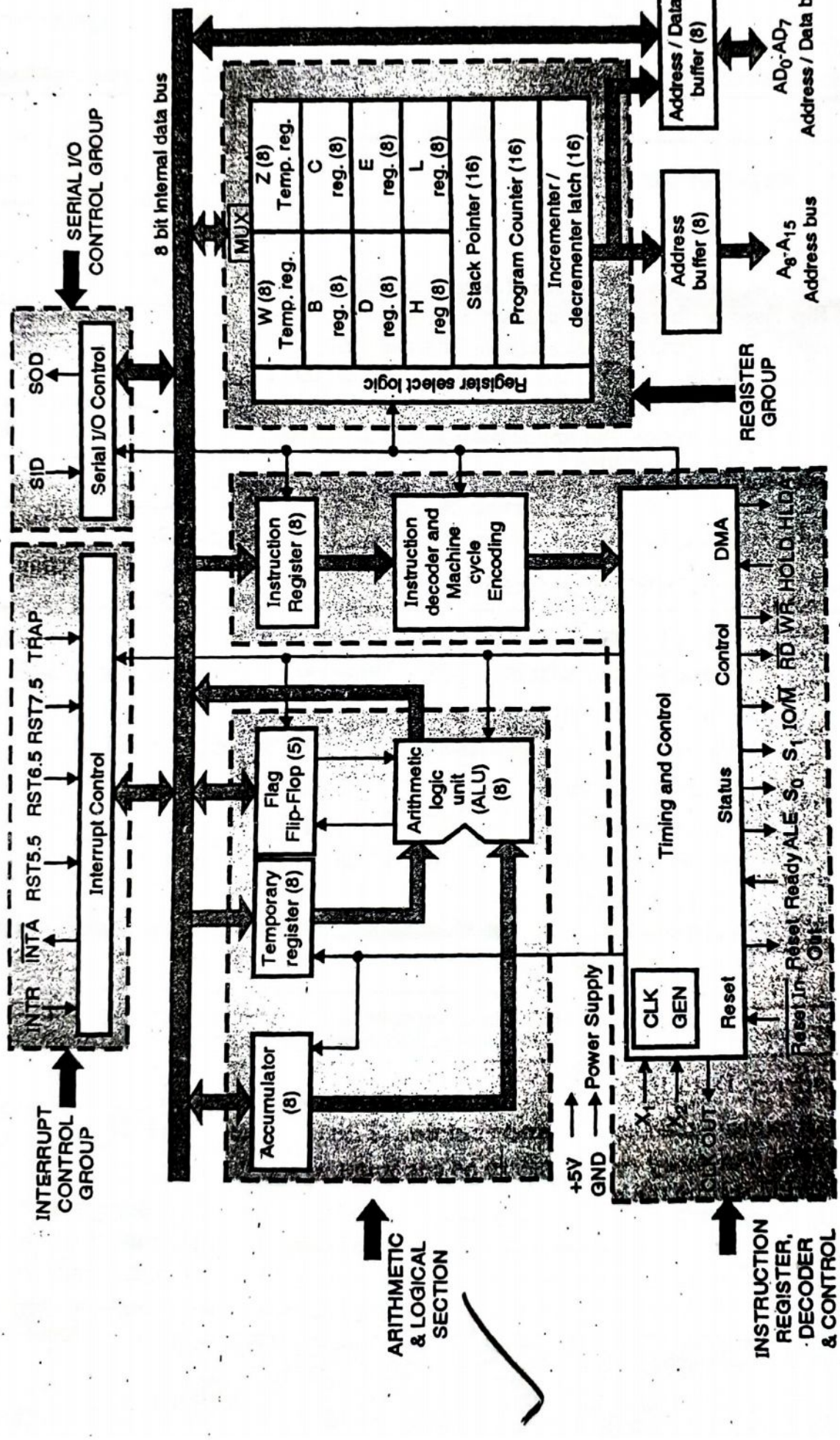

Fig. 2.3.1 : 8085 architecture

This architecture is divided in following groups :

- Register group
- Arithmetic and logical section
- Instruction register, decoder and control group.
- Address and Address/ Data Buffers
- Interrupt control group
- Serial I/O control group.

Q. What are the different registers of 8085 ? Discuss their functions.

2.3.1 Register Section

- It consists of PIPO (Parallel in parallel out) registers.
- The register contains a set of binary storage cells / flip flops with reading and writing facilities. It is used for temporary storage of instructions and data/address. Hence, the number of bits in a register is equal to data or address or instruction size depending on the application Fig. 2.3.2 shows register section of 8085.

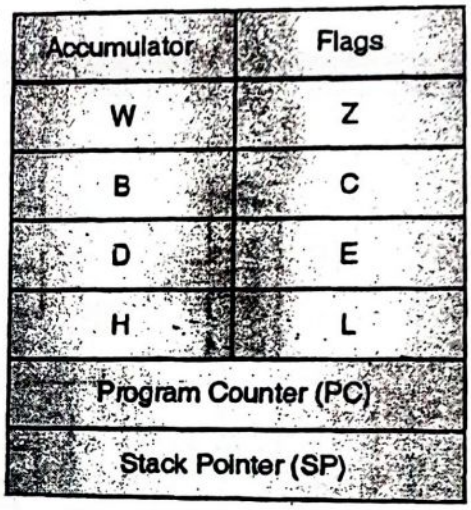

Fig. 2.3.2 : Register section of 8085

The architecture of 8085 consists of following registers :

(a) Temporary registers
  (i) Temporary data register (ii) Temporary registers W and Z (8-bit each)
(b) General purpose register
  (i) Six general purpose registers viz. B, C, D, E, H and L.
(c) Special purpose register
  (i) 8-bit accumulator (ii) Flag register
  (iii) Instruction register (iv) 16-bit program counter
  (v) 16-bit stack pointer

2.3.1(A) Temporary Registers

Q. What do you mean by temporary registers and general purpose registers ?

1) Temporary Data Register

- It is also called as **operand register** (8 Bit). It provides operands to the ALU.
- The temporary register serve as one input to the ALU. The other input to the ALU is from the accumulator. It is not available to user.
- **Example :** ADD B instruction adds A register and B register contents, the result is stored in A register. In this case one data is available in A register. The other data is available in B register. The data from B register is transferred to temporary register. Contents of A register and temporary register will be added up by ALU and the result is stored in Accumulator.

2) Temporary Registers (W and Z)

Q. Explain any two instructions in which 8085 processor uses the registers W and Z

- These registers are not available to the user. They are internally used by microprocessor.
- These registers are used by control section to hold the data during arithmetic or logical operation.
- These registers hold 8 bit data each.

W and Z registers are used by 8085 for swaps instructions. For e.g.

(i) XCHG (exchange)
This instruction swaps the contents of H and L registers with that of D and Hence W and Z register are used as temporary storage while swapping.

(ii) XTHL (exchange top of stack with registers H and L)
This instruction swaps the contents of H and L registers with that of the two st top locations. Hence again W and Z registers are used as temporary storage wh swapping.

2.3.1(B) General Purpose Registers

Q. Which registers are called programmable in 8085 ?

- The 8085 contains 6 general purpose registers of 8 bits each, named as B, C, D, E and L.
- B, C, D, E, H and L can be used to store 8 bits of data or can be used to for register pair to store 16 bit of data. ***The valid register pairs available are DE and HL .The user cannot form a register pair of his/her choice..***
- These registers are called programmable because : (i) These registers are avail to the user. (ii) They are used to hold data, results of arithmetic and lo operations and address of data memory.
- The HL register pair functions as default data pointer. If used as memory point holds the address of a 16 bit address of a memory location. The L register store lower byte of address and the H register stores the higher byte of address. He the HL register pair is also called as **memory or data pointer.**

Use of General Purpose Registers and How do they Increase the speed of Operation

- The main use is to hold data which is frequently used.
- It increases the speed of program execution. The main reason is as follows. The in microprocessor can be stored in memory or general purpose registers. If the is present in memory the microprocessor has to perform an operation of me read. This data is taken by microprocessor, the required operation is performed result is stored back to memory. To store result in memory the microprocessor h perform one more operation of memory write. Thus there are two operat involved in using memory to hold data.
- But if the data is present in general purpose register there is no operation invol As the general purpose registers are part of microprocessor architecture, microprocessor doesn't have to perform any external memory read and w operation. Thus the time required to execute program using general pur registers is very less as compared to program using memory.

2.3.1(C) Special Purpose Registers

Q. What are the different special purpose register used in 8085 architecture.

These registers are used for special use. The special purpose registers are :

- Accumulator
- Flag Register
- Instruction register
- Program counter
- Stack pointer

1) Accumulator

- It is an 8 bit general purpose registers of 8085.
- It also has some special functions and hence is also a special register.
- Accumulator has following special function.
  (i) It has to private one of the operand for any ALU operations.
  (ii) It has to accumulate (hence the name accumulator) the result of ALU operations.
  (iii) It also works as a via register for I/O accesses i.e. whenever a data is read from input devices, it comes in accumulator and similarly output device gets data from accumulator.

2) Status or Flag Register

Q. 1 Explain the flag register of 8085.
Q. 2 What is the use of flag register of 8085 ?
Q. 3 Explain the role of sign flag of 8085.
Q. 4 How many flags are present the flag register of 8085 ? Show the position of each flag in flag register. Explain the necessity of each flag giving proper example.

- A flag is a flip flop. It indicates some condition produced by the execution of an instruction. For example, the zero flag (ZF) will set if the result of execution of an instruction is zero.
- The flag register of 8085 microprocessor consists of five flags. The flag register is connected to ALU.
- When an operation is performed by ALU the result is transferred on internal data bus and status of result will be stored in flip flops.
- The different flags and their positions in flag register are as shown in Fig. 2.3.3.

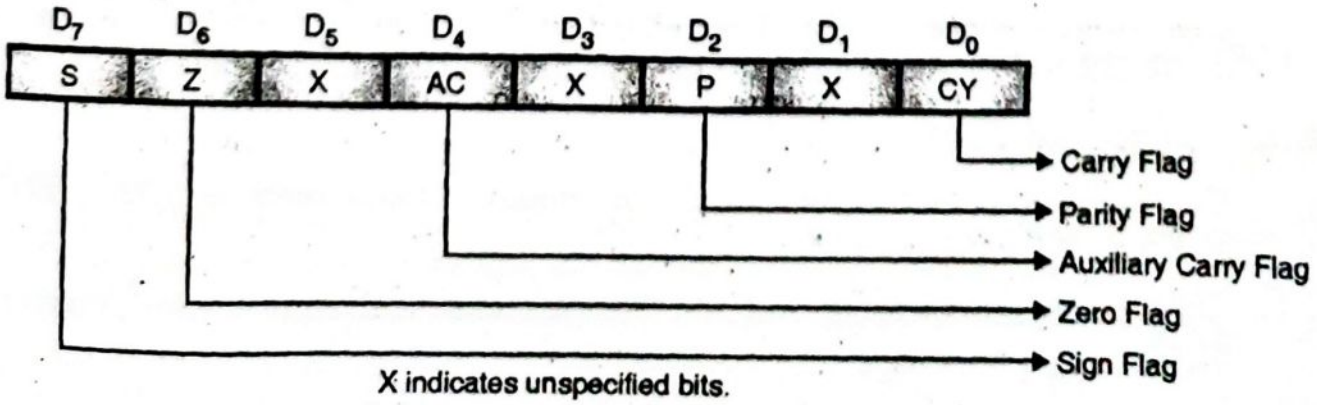

Fig. 2.3.3 : 8085 flag register

a. The carry flag (CF)

(i) This flag is set whenever there has been a carry out of, or a borrow into, the higher order bit of the result (8 or 16 bit).

(ii) The flag is used by the instructions that add and subtract multibyte numbers.

(iii) Rotate instructions can also isolate a bit in memory or a register by placing it in the carry flag.

1 - there is a carry out from the most significant bit
0 - no carry out from msb

b. The parity flag (PF)

(i) This flag is set when the result has even parity, an even number of 1 bits.

(ii) If parity is odd, PF is resetted.

(iii) This flag is normally used to check for data transmission errors.

1- low byte has an even number of 1 bits *0 - low byte has odd parity*

c. The auxiliary carry flag (AF)

(i) This flag is set, whenever there has been a carry out of the lower nibble into the higher nibble or a borrow from higher nibble into the lower nibble of an 8 bit quantity, else AF is reset.

(ii) This flag is used by decimal arithmetic instructions.

1 - carry out from bit 3 on addition or borrow into bit 3 on addition
0 - otherwise

d. The zero flag (ZF)

This flag is set, when the result of operation is zero, else it is reset.

1 - zero result *0 - non-zero result*

e. The sign flag (SF)

(i) This flag is set, when MSB (Most Significant Bit) of the result is 1.

(ii) Since negative binary numbers are represented in the 8085 CPU in standard two's complement notation, SF indicates sign of the result.

1 - msb is 1 (negative) *0 - msb is 0 (positive)*

3) Instruction Register

- This register is not accessible to the user.
- The instruction register holds the opcode of the instruction that is decoded and executed.
- This opcode is further sent to the instruction decoder to select one of the 256 alternatives (operations). The contents of the instruction decoder are in the form of 0's and 1's.

4) Program Counter (PC)

- It is used to hold the address of program memory.
- When reset is activated, the program counter is set to 0000H i.e. the address of the first instruction to be fetched and executed.
- It always points to the next instruction to be fetched i.e. it holds the memory address of the next instruction to be executed.

- During instruction fetch operation, the microprocessor places contents of program counter (PC) on the address bus and fetches first byte of the instruction from that memory location. Then the microprocessor increments program counter to point to the next byte of the instruction.
- The size of program counter depends upon the numbers of address bits. Hence for 8085 it is 16 bit.
- Incase of jump and call instructions, the address followed by the jump and call instructions is placed in the program counter .If the condition is satisfied then the 8085 fetches the next instruction from the new address specified by JUMP or CALL instruction otherwise the 8085 continues with the next instruction after CALL or JUMP instruction.

5) Stack Pointer (SP)

- Stack is a reserved portion of memory where information can be stored or taken back under software control. This memory area is referred to as ***stack area***.
- SP is a 16 bit register used to define the stack starting address. It always points at top of the stack.
- It is used to keep track of data stored on stack.
- The stack pointer is decremented after each stack write operation and incremented after each stack read operation.
- The stack pointer is loaded with an initial value by means of a transfer type instruction. This initial value must be the highest address of an assigned stack in memory.

Note : The instruction register and temporary registers cannot be accessed by the programmer. The ALU and control section use these registers for temporary storage.

6) Program Status Word

Q. Write short note on Program status word with reference to 8085 microprocessor.

- Program status word refers to the accumulator and flag register where accumulator is the high order register and flag register is the lower order register.
- In stack related instructions the instruction PUSH PSW can be used to save the contents of flag register onto the stack so that processor can switch to some service routine. PUSH PSW will store the contents of accumulator and flag register onto the stack.

2.3.2 Arithmetic and Logical Section

Q. What is the function of ALU in 8085 microprocessor architecture ?

This section processes data i.e. it perform arithmetic and logical operations.

- It performs arithmetic operations like addition, subtraction and logical operations like ANDing, ORing, EX-ORing, etc.

- The ALU is not available to the user. Its word length depends upon the width of internal data bus i.e. 8 bit.
- The ALU is always controlled by timing and control circuits.
- It accepts operands from accumulator and temporary register. It stores result arithmetic and logic operations in accumulator.
- It provides status of result to the flag register.
- It looks after the branching decisions.

2.3.3 Instruction Decoder and Machine Cycle Encoder

Q. How instruction register, decoder and timing control unit performs in control section of architecture ?

- This accepts a bit pattern (OPCODE) from instruction register, decodes it and gives the decoded information to control logic. It is a 8:256 decoder.
- The information includes what operation is to be performed, who is going to perform it, how many operand bytes the instruction contains, etc. It means that it will understand the instruction in this block.
- The decoded information is given to the timing and control unit that provides control signals.
- The 8085 executes seven types of machine cycles. The status signals give information about which machine cycle is currently being executed.

2.3.4 Address Buffer

- This is an 8 bit unidirectional buffer used for address lines.
- A buffer is used to isolate the microprocessor from getting loaded due to high current in the other peripherals connected to the microprocessor.
- These are used to drive the higher order address bus.
- When they are not in use or under certain conditions such as reset, hold, halt; the buffer is used to tri-state the address lines.

2.3.5 Address/data Buffer

- This is an 8 bit bidirectional buffer used for address and data.
- It is used to drive the lower order address and data bus.
- Under certain condition such as reset, hold, halt this buffer is used to tri-state the address/data lines.

2.3.6 Incrementer / decrementer Address Latch

This 16 bit register is used to increment or decrement address i.e. the contents of PC, HL, BC, DE and SP registers. They are also used to latch the address.

2.3.7 Interrupt Control

- This block accepts different interrupt request inputs such as TRAP, RST 7.5, RST 6.5, RST 5.5 and INTR.
- $\overline{\text{INTA}}$ is an acknowledgement pin for maskable and non-vectored interrupt i.e. INTR.

- When a valid interrupt request is present it informs control logic to take action in response to each signal .In such a case the processor has to be interrupted in order to service the interrupt.
- The interrupt control units job is to service the interrupt and after completing the interrupt service routine return back the control to the main program where it was interrupted.

2.3.8 Serial I/O Control Group

- The data transferred on to data bus is parallel data, but under certain condition it is advantageous to use serial data transfer. 8085 implements this by using SID and SOD signals.
- The data on these lines is accepted or transferred under software control by serial I/O control block.
- In 8085 to perform serial data transfer there are two special instructions RIM and SIM.

2.3.9 Timing and Control

- This is a control section of 8085 made up of synchronous sequential logic circuit.
- It controls all internal and external circuits in the microprocessor system.
- It operates with reference to clock signal.
- It accepts information from instruction decoder and generates microsteps to perform it. In addition to this, the block accepts clock inputs, performs sequencing and synchronising operations. The synchronization is required for communication between microprocessor and peripheral devices. To implement this it uses different status and control signals.
- Fig. 2.3.4 shows the control section of microprocessor.
- The contents of the instruction register are in the form of 0's and 1's. They are converted to meaningful form by the decoding network called matrices. The control matrix provides internal signals for controlling operation and data between registers.
- The control unit also generates timing signals essential for microprocessor to operate.

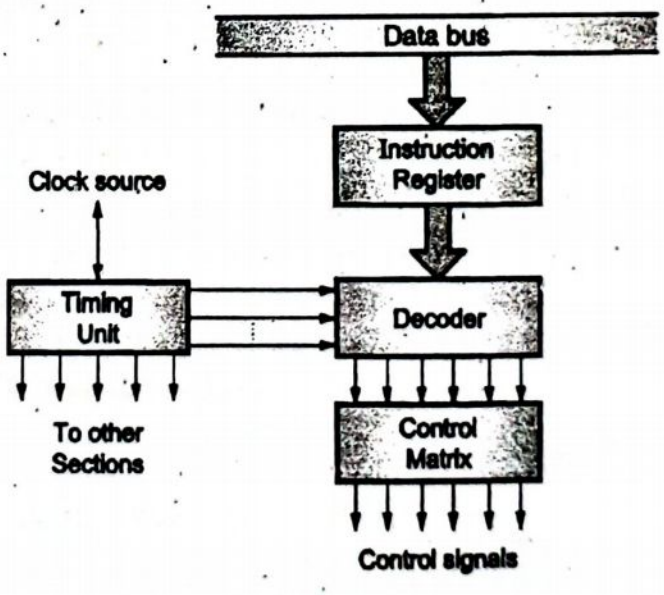

Fig. 2.3.4 : Control section of microprocessor

- The microprocessor uses a quartz crystal (LC or RC circuit) to determine the clock frequency, so that other timing and control signals are developed.
- The speed of microprocessor is directly proportional to the speed of the crystal. The clock speed and access time must be compatible for maximum performance.