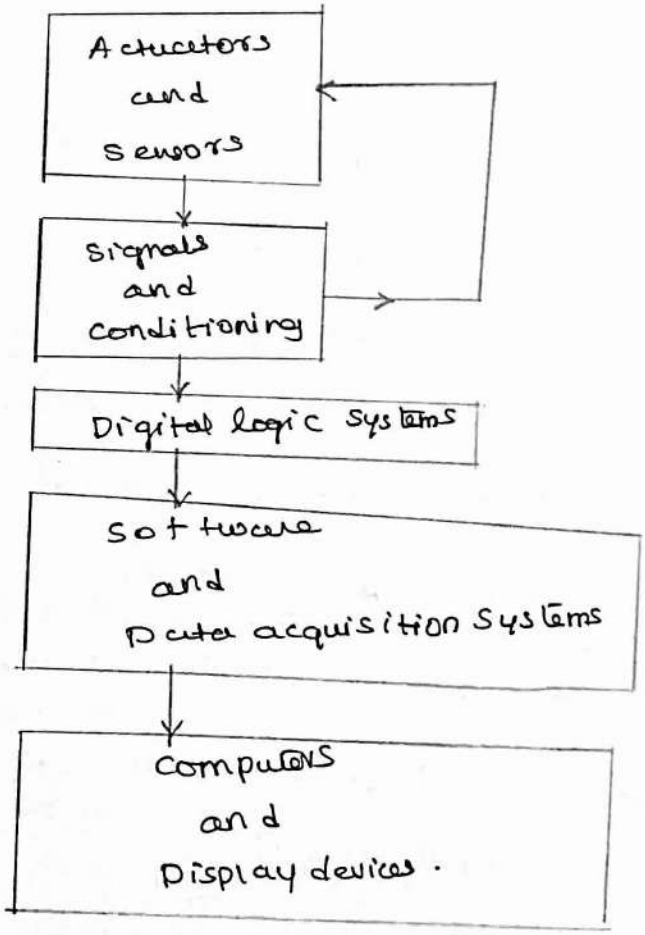
Mechatronics
Unit-1

Introduction :-

1.1 Introduction

Mechatronics is the synergistic integration of Mechanics and Mechanical Engineering, Electronics, Computer technology and IT to produce or enhance products and systems.

Elements of Mechatronics systems



(i) Actuators and sensors

(ii) Signals and Conditioning

(iii) Digital logic systems

(iv) Software and data acquisition systems

V Computer and display devices

(i) sensors and actuators :-

* sensors and actuators mostly come under mechanical systems. The actuators produce motion or cause some action.

* The various actuators used in Mechatronic System are pneumatic and hydraulic actuators, electro-mechanical actuators, electrical motors such as Dc motors, Ac motors, stepper motors, servomotors and piezo electric actuators.

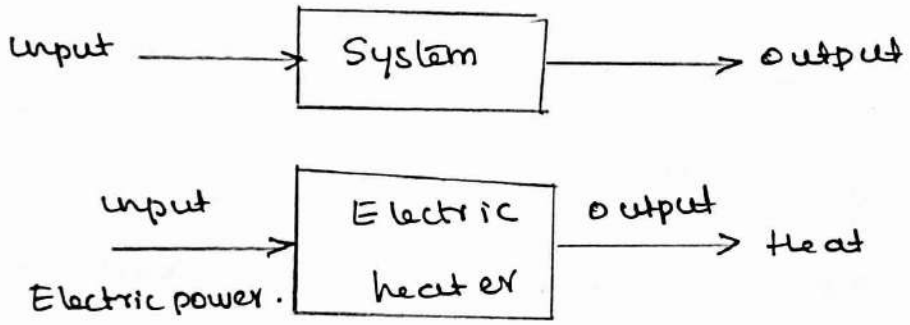
(ii) Signals and Conditioning

* The mechatronic systems deal with two types of signals and Conditioning such as input and output.

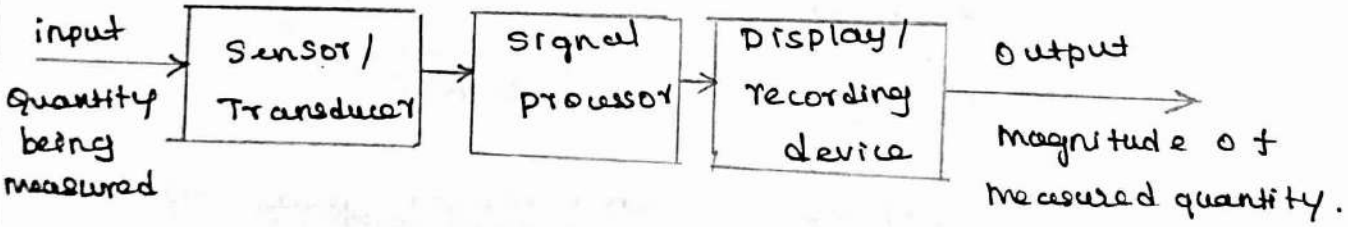
* The various input signal Conditioning devices used in mechatronic system are discrete circuits, amplifiers, Analog to Digital (A/D) converters, Digital to Digital (D/D) converters.

1.2 Systems :-

* The word system in mechatronics refers to a group of physical component connected or related in such a manner to form the entire unit for performing a specific task.



Measurement systems :-



* All mechatronic devices consist of various systems in which some input data are given to get specified output

* A system can be treated as a black box having an input and output

Advantages of Mechatronics Systems

* It is cost effective and it can produce high quality products.

* Production of parts and products of international standards gives better reputation and return

* It serves effectively for high dimensional accuracy requirements.

* It provides high degree of flexibility to modify or redesign the systems

Disadvantages :-

* The initial cost is high.

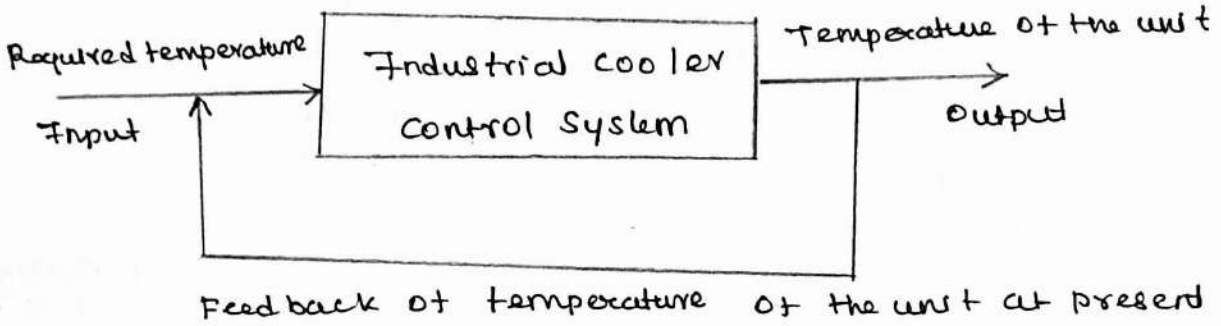
* maintenance and repair may workout costly

* Multi-disciplinary engineering background is required to design and implementation

* It needs highly trained workers to operate

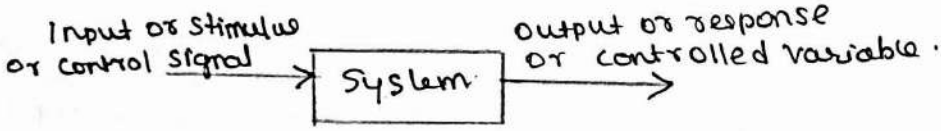
* Techno-economic estimation has to be done carefully in the selection of mechatronic system.

Control systems :-



* A control system in Mechatronics refers to a group of physical component connected or related in such a manner to command or direct or regulate itself or another system.

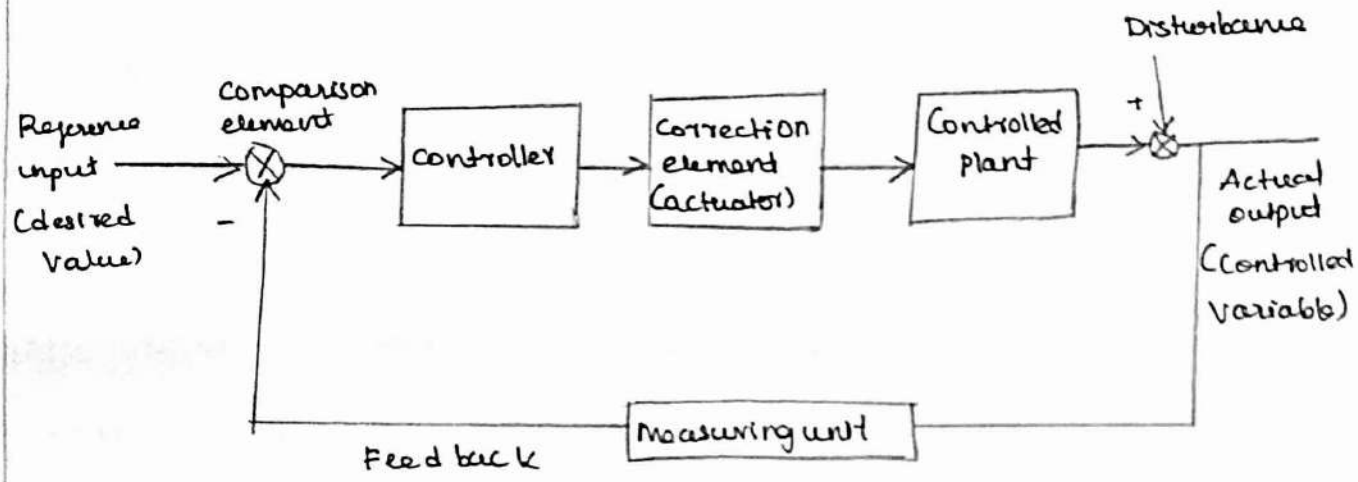
Open-loop control systems



* Open loop systems are systems in which the output of a system is not used as a variable to control the system.

* In an open-loop system, the output of this system is not fed back as input to the system for control or operation

Closed - loop control systems :-



* closed - loop system uses on a feed back loop to control the operation of the system.

* In closed loop or feedback control, the controller notices what actually takes place at the output end and it drives the plant in such a way as to obtain the desired output.

Advantages :-

* It will also give much better repeatability.
* Good reliability can be achieved
* Optimisation in control is possible.

Disadvantages :-

* Generally, closed - loop control systems are complicated in construction.
* The cost of the system is higher.
* Sometimes, closed loop control systems may become unstable.

Examples of mechatronics Systems :-

* Numerical control (NC) and Computer Numerical Control (CNC) Machine tools, variable speed drives, flexible manufacturing systems (FMS) and automated manufacturing systems (AMS), automated guided vehicles, rapid prototyping and robots.

* computers disk drives

* photocopiers, laser printers and Fax machines

* VCR/DVD drives

* Automatic washing machines, dish washer, rice cooker, automatic oven and Modern sewing machines.

* Coin Counter

* Automatic / digital camera and digital watch

* Automobile applications include electronic engine management system, collision detection, global positioning system, antilock brake system.

* Automatic sliding door, vending machines and garage door openers.

(iii) Digital logic systems:-

* Digital logic devices control overall system operation. the various digital logic systems used in mechatronic system are logic circuits, microcontrollers, programmable logic controllers, sequencing and timing controls and control algorithms.

(iv) Software and data acquisition systems

* Data acquisition system acquires the output signals from sensors in the form of voltage, frequency resistance, etc,

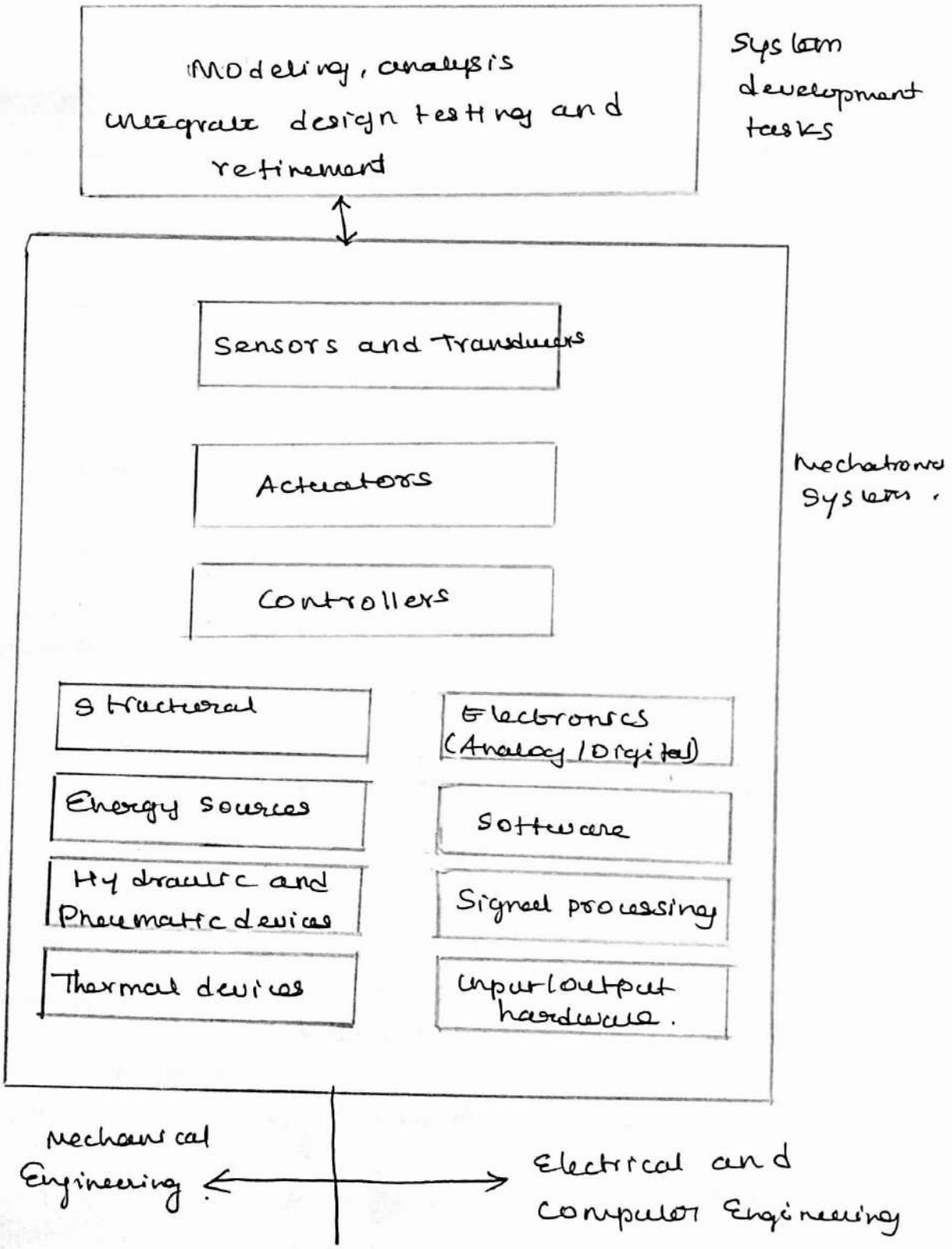
* The data acquisition system consists of multiplexer amplifier, register and control circuitry and DAC board.

v computers and display devices.

* computers are used to store large number of data and process further through software.

* Display devices are used to give visual feedback to the user. the various display devices used in mechatronic system are LEDS, CRT, LCD, digital displays etc

1.3 Concepts of Mechatronics:-



* Mechatronics is a multidisciplinary engineering field which involves a synergistic integration of several areas such as mechanical engineering.

* In the traditional development of an electromechanical system, the mechanical components and electrical components are designed or selected separately and then integrated possibly with other components and hardware and software.

* Generally, a product based on mechatronic approach will be more efficient and cost effective

* A Mechatronics approach can greatly benefit the design and development of complex electromechanical system.

* For example, an actuator itself may represent a mechatronic device within a larger Mechatronic system such as an automobile or a robot. Such an integrated and "concurrent" design will call for a fresh look at the design process.

1.4. Need for Mechatronics :-

* Smart becomes smarter when mechanical, electronic, computer and software engineering integrate to design and manufacture products and processes.

(a) Dynamic market Condition :-

* the market scenario in the 21st century is so volatile that often products become obsolete very fast because of the changing perceptions of consumers.

(b) producing next generation products :-

* mechatronic is needed to design and manufacture the "next generation" advanced machines. It is due to the fact that those trained in mechatronics technologies have the ability to work across disciplines, combining appropriate technologies to create cost-effective, reliable solution and devices.

(c) Integration of modern technologies in products.

* The market condition is presently characterized by customer expectations being at an all-time high.

d) variety in product ranges :-

Variations in size, shape, colour, texture, performance and aesthetics are governed by customer likes, dislikes and needs. Therefore, manufacturers are in a situation to produce variety of product in wide range.

e) Batch production runs

* Batch production in an industry producing products of diversified specifications is not avoidable.

* The adaption of mechatronics is the only possible solution here.

f) Product quality and consistency :-

* For any industry, maintaining product quality and producing consistently the same quality product are very essential for a better reputation, surviving the competition and better export turnovers.

g) Ease of reconfiguration of the process :-

* The processing flexibility inherent in a system is decided by the ease with which the facility can be reconfigured between runs.

* Resorting to mechatronics can suitably favour the reconfiguration of the process carried out on the machine.

1.5 Emerging Areas of Mechatronics:

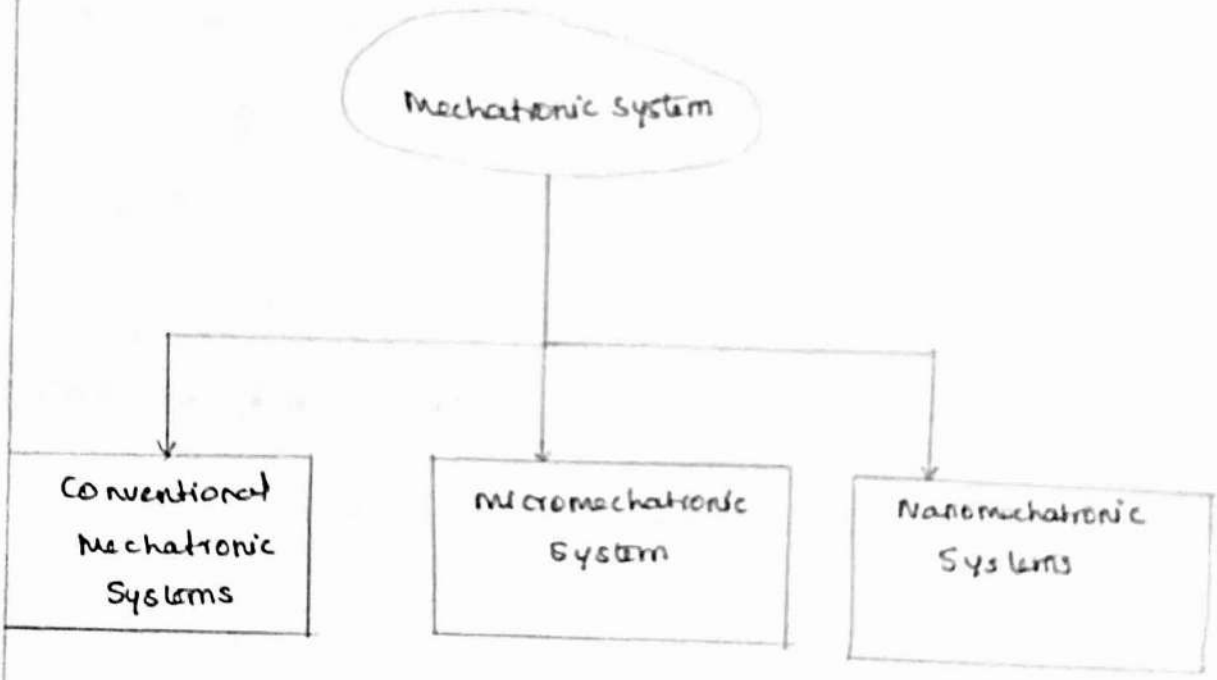
Mechatronics is an emerging field and it presents flexible opportunities with diverse engineering backgrounds

* machine vision
* Automation and robotics
* Development of Unmanned Vehicles.
* Design of subsystems for automotive engineering
* Sensing and control systems
* operations and maintenance of CNC machines
* Expert systems and Artificial intelligence
* Industrial electronics and consumer products
* medical Mechatronics and medical imaging systems
* Structural dynamic systems.
* Transportation and vehicular systems
* computer integrated Manufacturing (CIM)
* Human-Machine interface.
* Mechatronics applications in cyber-physical systems.

1.6 Classification of Mechatronics

* Based on the application of basic theories used, mechatronic systems are classified as follows

1. Conventional mechatronic Systems
2. Microelectromechanicals - Micro mechatronic systems (MEMS)
3. Nano electromechanical - Nano mechatronic system (NEMS)



* The operational principles and basic foundations of Conventional Mechatronic Systems and MEMS are the same while NEMS can be studied using different concept and theories.

* In particular, the designer applies classical mechanics and electromagnetics to study conventional mechatronic systems and MEMS.

* MEMS products not only contain micro machined components but they typically include electronic signal conditioning circuits, self testing and calibration.

(i) class I

* primarily mechanical products with electronics are incorporated to enhance functionality

Examples :- NC machine tools and variable speed drives in manufacturing machines.

(ii) class II

* Traditional mechanical systems with significantly updated internal devices are incorporating electronics. The external user interface are unaltered.

Examples :- modern sewing machine and automated manufacturing systems

(iii) class III

System are the retain the functionality of the traditional mechanical system but the internal mechanisms are replaced by electronics

~~Examples~~ Example : digital watch, automatic cameras.

(iv) class IV

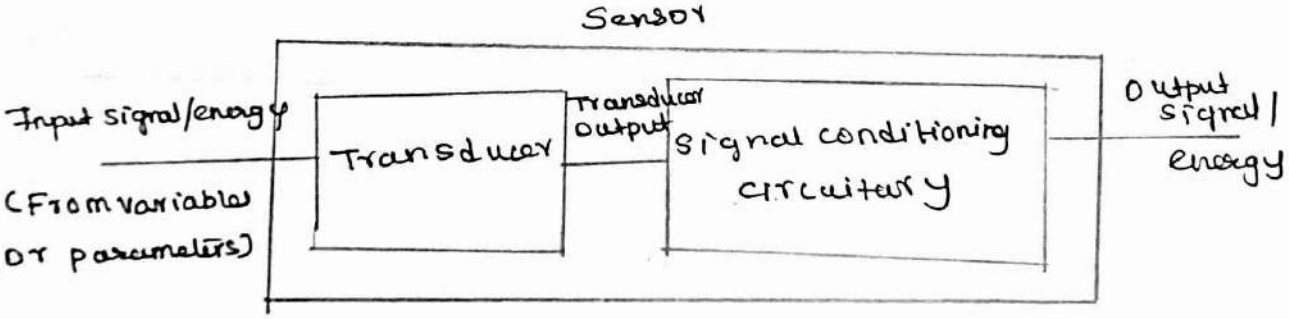
products are designed with mechanical and electronic technologies through synergistic integration

Examples :- photocopiers, intelligent, washers and dryers, rice cookers.

1.7 Sensors and Transducers:

* Sensors are devices which produce a proportional output signal (mechanical, electrical, magnetic, etc) when exposed to a physical phenomenon (pressure, temperature, displacement, force etc), many devices require sensors for the accurate measurement of pressure, position, speed, acceleration or volume.

* Transducers are devices which converts an input of one form of energy into an output of another form of energy. The term transducer is often used synonymously with sensors.



* Sensors are transducers when they sense one form of energy input and output in a different form of energy. For example, a thermocouple responds to a temperature change (thermal energy) and outputs a proportional change in electromotive force (electrical energy). Therefore, a thermocouple can be called sensor or transducer.

Classification of sensors

(i) Active sensor

- Active sensors, the power required to produce the output is provided by the sensed physical phenomenon itself. Examples:- thermocouples, photovoltaic cells, piezoelectric transducers, thermometer etc.

(ii) passive sensor:-

- The passive sensors require external power source. Examples:- resistance, thermometers, potentiometric devices.

(iii) Analog sensor

- Analog sensor produce continuous signals that are proportional to the sensed parameters. These sensors generally require analog to digital conversion before sending output signal to digital Controller. Examples:- potentiometers, linear.

(iv) Digital sensor.

- Digital sensor on the other hand produce digital outputs that can be directly interfaced with the digital controller. Examples:- incremental encoder, photovoltaic cells.

classification of Transducers:-

1. Electrical (Resistive, capacitive, inductive, thermo electric, resonant etc)

2. Solid state (magnetic, thermal, mechanical, chemical etc)

3. optical (Radian energy, photo detector, vision system, laser, Scanning, fiber opic etc)

4. piezo-electric (Accelerometer, humidity meter, light modulators, actuators acoustic devices etc.).

5 ultrosonic (Flow measurement, distance, velocity ultrasonic imaging etc.).

1.8. Static Characteristics of sensors:-

1. Range:-

* Every sensor is designed to work over a specified range i.e. certain maximum and minimum value. For example, a thermocouple may have a range of −100 to 1260° C.

2. span:-

* It represents the highest possible input value which can be applied to the sensor without causing unacceptably a large inaccuracy.

3. Error

* Error is the difference between measured value and true input value.

Error = Measured value - True input value.

4. Accuracy:-

* A very important characteristic of a sensor is accuracy which really means inaccuracy.

* Inaccuracy is measured as a ratio of the highest deviation of a value represented by the sensor to the ideal value.

5. precision:-

* precision is the estimate which signifies the number of decimal places to which a property can be reliably measured

6. Resolution:-

* Resolution is defined as the smallest change that can be detected by a sensor. it can also be defined as the minimum value of the input required to cause an appreciable change or an increment in the output

7. Repeatability

* Repeatability may be defined as the ability of the sensor to give the same output reading for same applied input value repeatedly under the same operating conditions

1.9 Dynamic characteristics of sensors:

1. Response time:

* The time taken by a sensor to approach its true output when subjected to a step input is referred as response time.

2. Time constant:

* It is the time taken by the system to reach 63.2% of its final output signal amplitude 62.3% of response time.

3. Rise time:

* Rise time is the length of time taken for the output to reach 90% of full response i.e steady-state output when a step pulse is applied to input

4. setting time

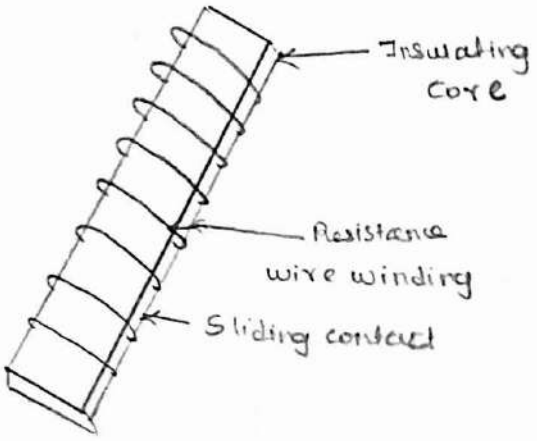
* It is the time taken by a sensor to be within a close range of its steady-state value.

5. Frequency response:

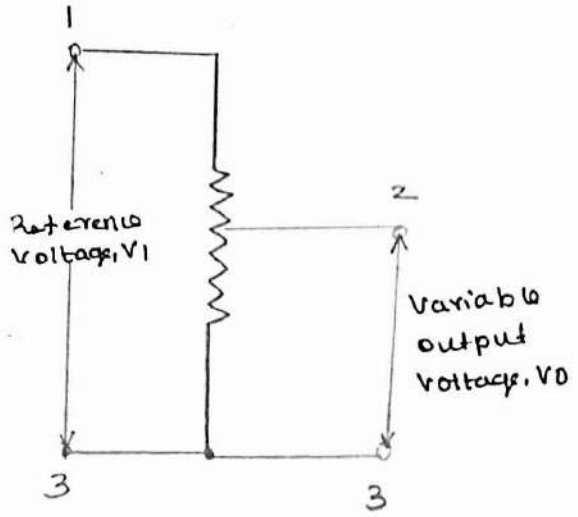
Frequency response describes how the ratio of output and input changes with the sinusoidal input frequency.

1.10 potentiometers :-

* The potentiometer is also called linear position sensors or resistors ruler and it is one of the most commonly used devise for measuring the displacement



(a) principle of operation



(b) Circuit diagram

* Linear potentiometers are sensors that produce a resistance output proportional to the linear displacement or position.

* Linear potentiometers are essentially variable resistors whose resistance is varied by the movement of a slider over a resistance element.

* The linear potentiometer employs an electrically conductive linear slide member connected to a variable wire wound resistor that changes resistance to be equated to the linear position of the device which is monitored

The following factors are to be considered while selecting the potentiometers:

(i) operating temperature

(ii) Shock and vibration

(iii) Humidity

(iv) contamination and seals

(v) Life cycle

(vi) Dither

Applications

(i) Linear displacement measurement

(ii) Rotary displacement measurement

(iii) volume control

(iv) Brightness control

(v) Liquid level measurements using float.

Advantages:

(i) It is easy to use

(ii) The cost is low

(iii) It has high-amplitude output signal

(iv) It is a proven technology

(v) It has rugged construction

Disadvantages:

(i) It has limited band width

(ii) Frictional loading is more

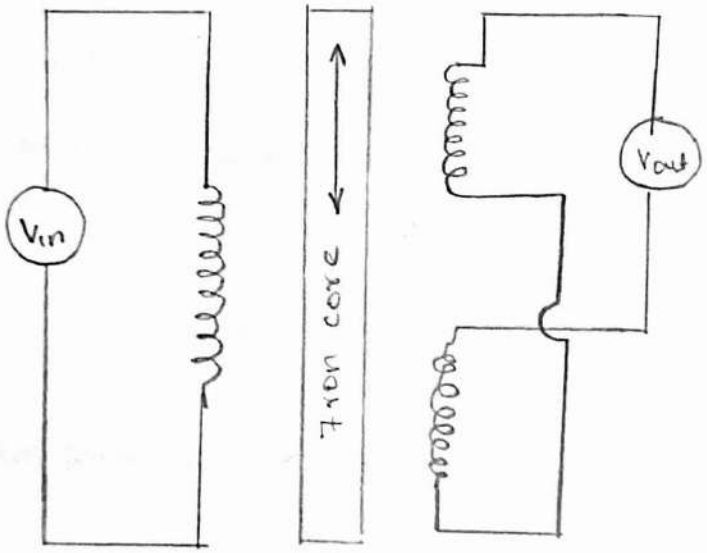
(iii) It has limited operating cycle.

(iv) Inertial loading is more

(v) It has limited life due to wear.

1.11. Linear Variable Differential Transformer (LVDT)

* The most widely used variable - inductance displacement transducer in industry is Linear Variable Differential Transformer (LVDT). It is a passive type sensor



* When the magnetic core is at the centre position or null position, the output voltage are being equal and opposite in polarity and therefore, the output voltage zero

* The Null position of an LVDT is extremely stable and repeatable. When magnetic core is displaced from the Null position.

* The output voltage to displacement plot is a straight line within a specified range

Applications :-

LVDT can be used to measure the displacement, deflection, position and profile of a work piece.

Advantages :-

* It is relatively low cost due to its popularity
* It is solid and robust capable of working in a wide variety of environments
* It has negligible hysteresis
* It can operate over a temperature range of $-265^{\circ}C$ to $600^{\circ}C$
* It is has high sensitivity up to 40V/mm

Disadvantages :-

* The performance of these sensors is likely affected by vibration
* Relatively large displacement are required for appreciable output.
* It is inherently low in power output.

1.12 capacitance sensors:

* A transducer that uses capacitance variation is known as capacitance sensors.

* The elastic deflection of a membrane due to the applied force is detected by a capacitance variation.

* A highly sensitive displacement and proximity transducers can be constructed because the capacitive transducer senses very small deflections accurately.

$$C = \frac{\varepsilon_0 \varepsilon_r A}{h}$$

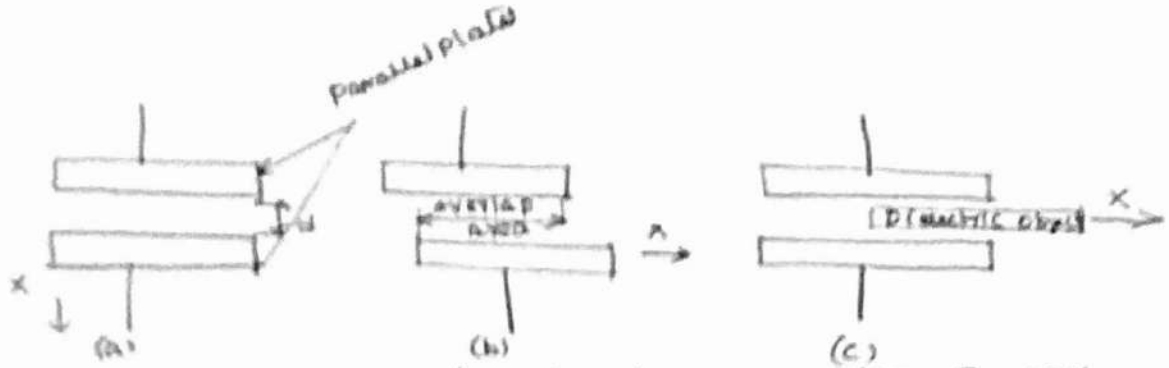
C = capacitance in farads (F)

ε_r = Relative dielectric constant of the insulator

ε_0 = Dielectric constant of free space

A = overlapping area for the two plates

h = thickness of the gap between two plates



Different forms of capacitive Sensor.

* Different forms of capacitive sensor are shown in figure where one plate of the capacitor is placed inside a probe which is sealed in an insulator and the external target object forms the other plate of the capacitor.

* Distance variation of parallel plates is often used for proximity or motion detection if the distance change(d) is less than the plate size

* Transverse displacement is easily detected by overlap or under lap areas of the parallel plates

* Capacitive Sensors can detect metallic or nonmetallic objects, liquids or any object with a dielectric constant greater than air

$$C_1 = \frac{\varepsilon_0 \varepsilon_r A}{d + x}$$

$$C_2 = \frac{\varepsilon_0 \varepsilon_r A}{d - x}$$

ε_r = Relative permittivity of the dielectric between the plates

ε_0 = Dielectric constant of free space

x = Displacement of central plate

A = the area of overlap between the two plates

d = Distance of the plate separation.

Applications :-

* This type of sensor can be employed for measuring position, displacement gauging or any other similar parameter in a machine tool

Advantages :-

* Excellent linearity over entire dynamic range when area is changed

* It has high sensitivity

* Capacitive displacement detectors can detect 10^{-4} m displacement with good stability, high speed and wide extremes of environment

* The system responds to an average displacement of a large area of a moving

* It has freedom of electrode (plate) materials and geometry for demanding environments and applications.

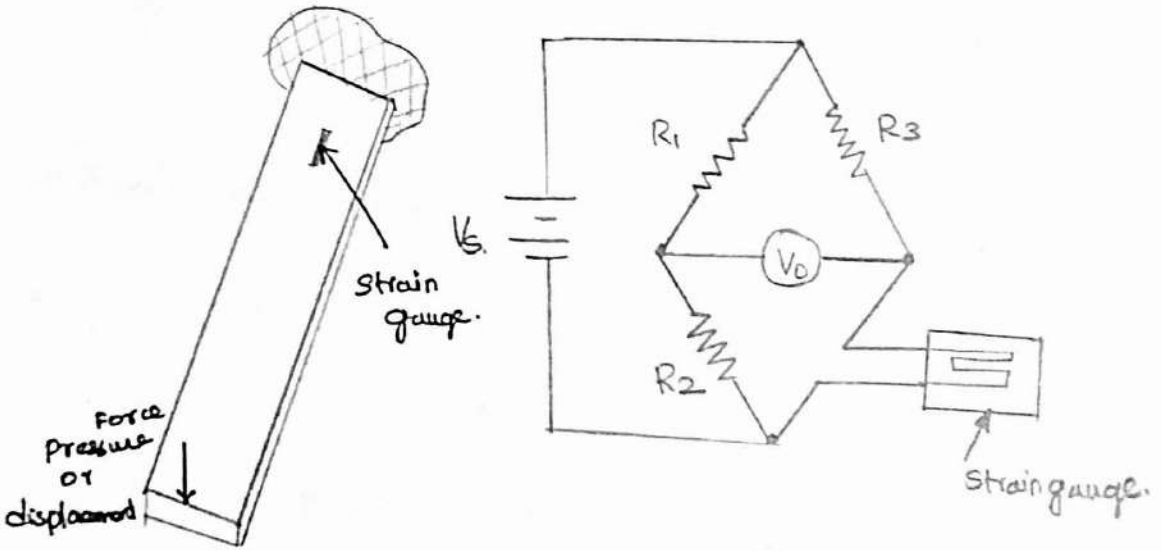
Disadvantages :-

* The performance of these sensors is likely affected due to the environmental conditions such as dust, moisture, vibration etc

1.13 Strain gauges:

* A strain gauges is an example of passive transducer that converts a mechanical displacement into a change of resistance.

* It is a thin, water-like device which can be attached to a variety of materials by a suitable adhesive to measure the applied strain.

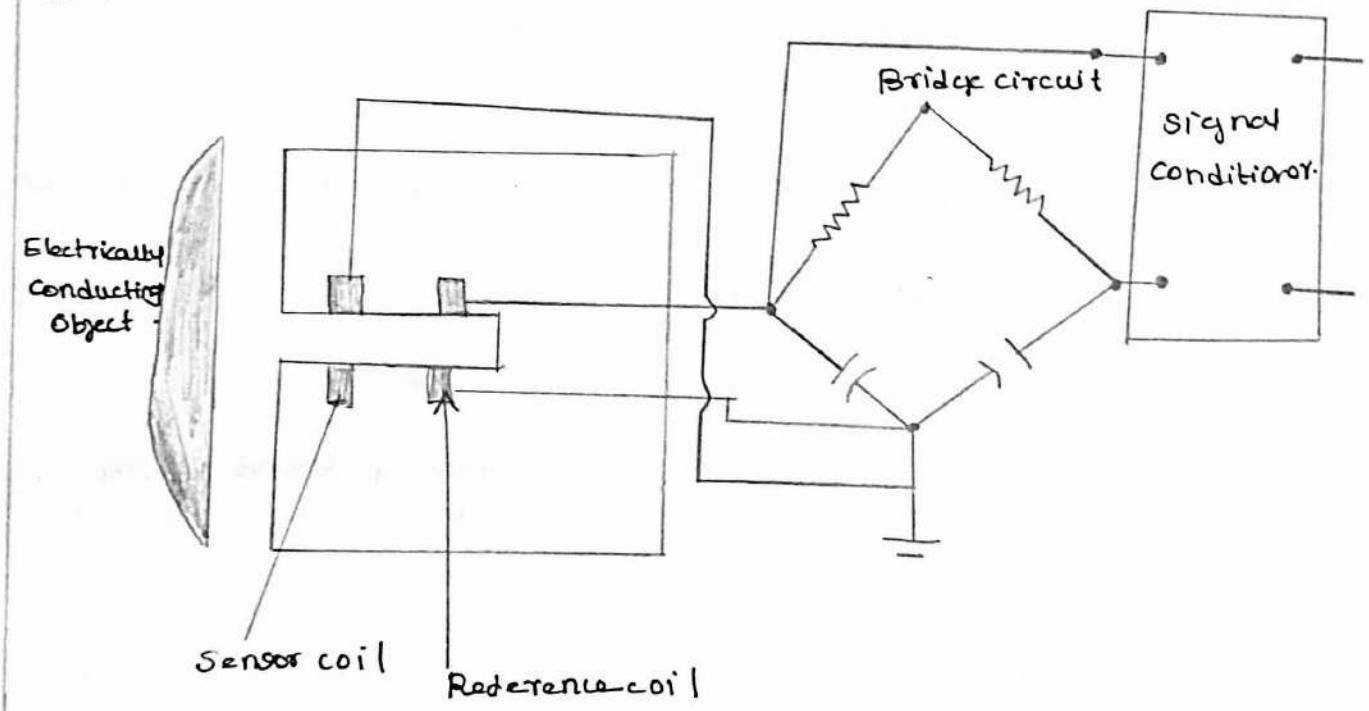


* The change of resistance is very small and it is usually measured using a Wheatstone bridge circuit where a strain gauge is connected into the circuit with a combination of four active gauges for full bridge.

1.14 EDDY current sensor :-

* Eddy current sensor detect the proximity or presence of a target by sensing the magnetic fields generated by a reference coil.

* Eddy current sensors detect ferrous and non-ferrous metals.



* An eddy current is a local electric current induced in a conductive material due the magnetic field produced by the sensor or active coil.

* It is sensed by a reference coil to create an output signal.

Applications:

* Strain measurement
* Residual stress measurement
* Vibration measurement
* Torque measurement
* Bending and deflection measurement
* Compression and tension measurement

Advantages:

* There is no moving part and hence no wear
* Strain gauge are very precise
* It is small and inexpensive
* It has a high frequency bandwidth.

Disadvantages:

* It is non-linear.
* It is very sensitive to temperature
* It needs to be calibrated regularly
* Strain gauges have to be applied manually. putting them in their place is time consuming and costly. It is one of their biggest disadvantages.

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

f = is the excitation frequency of the circuit

μ = is the magnetic permeability of the target material

σ = is the conductivity of the target material.

Application

* position measurement
* Vibrating motion measurement.

Advantages:

* It is compact in size
* cost is low
* Reliability is high.
* It produces high frequency response
* sensitivity for small displacement is high
* it is insensitive to material in the gap between transducer and Conductor.

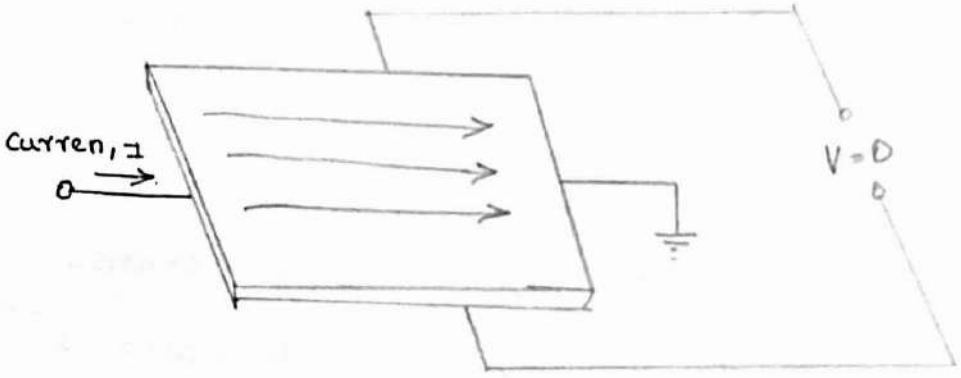
Disadvantages:

* The result will be precise only if the gap between transducer and Conductor small
* The device cannot be used for finding the position of non-conducting materials.

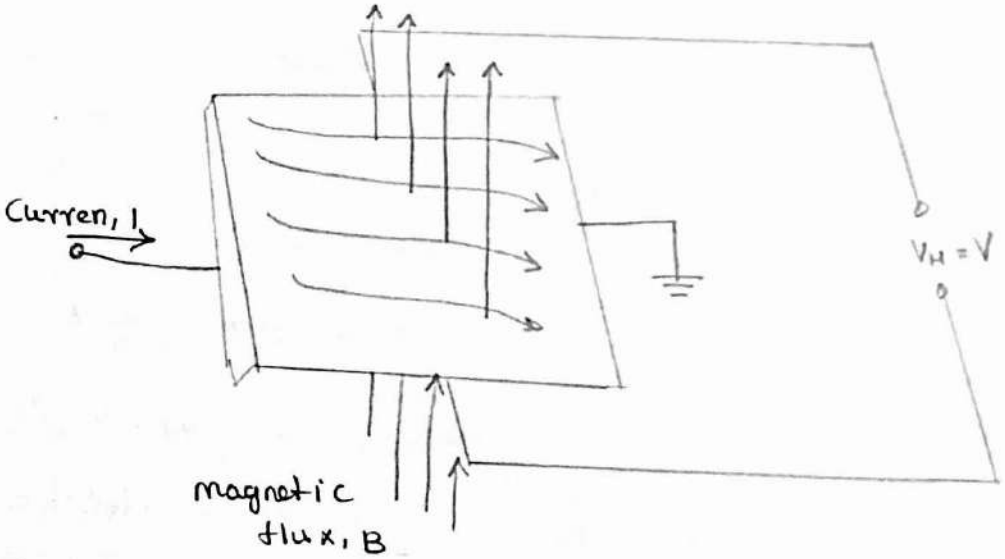
1.15. Hall effect Sensor :-

* Hall effect sensor is a type of magnetic sensor. A Hall effect sensor is a transducer that varies its output voltage in response to changes in magnetic field.

* When a current - carrying conductor is placed in a magnetic field, a voltage will be generated perpendicular to both the current and the field.



(a) When no magnetic field



(b) When magnetic field present.

* the output connections are perpendicular to the direction of current.

* when the magnetic field is present in figure. the current distribution is uniform and no potential difference is seen across the output

$$V_H \propto I B$$

$$V_H = K_H \frac{I B}{t}$$

K_H is the Hall co-efficient

t is the thickness of the Hall element.

* The Hall element is the basic magnetic field sensor. It requires the signal conditioning to make the output usable for most applications

Applications

* Hall sensors are used for proximity switching, positioning, speed detection and current sensing applications.

* Hall sensors are commonly used to time the speed of wheels and shafts such as for internal combustion engine timing

Advantages:

* It is relative low cost compared to electromagnetic switches

* High frequency operation is possible.

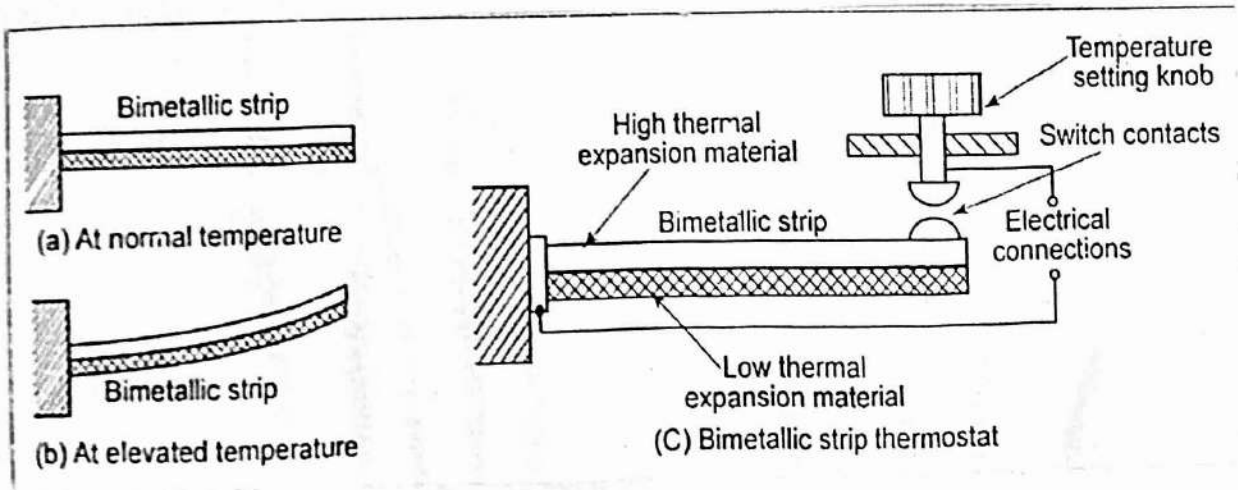
1.16 Temperature Sensors:

* Temperature measurements are most widely monitored parameter in science and industry. Temperature is defined as the average kinetic energy of individual molecules that comprise the system.

* The following are the common methods used to measure the temperature which and described in detail

1. Bimetallic strips.
2. Resistance temperature detectors (RTDS)
3. Thermistors
4. Thermocouples.
5. Thermo diodes and transistors.

Bimetallic strips:-



* Bimetallic strip thermometers are mechanical thermometers. They are widely used in industry for temperature control because of their robustness,

temperature range and simplicity

* It consists of a bimetallic strip which is made of two dissimilar metals bonded together with one end fixed and the other free.

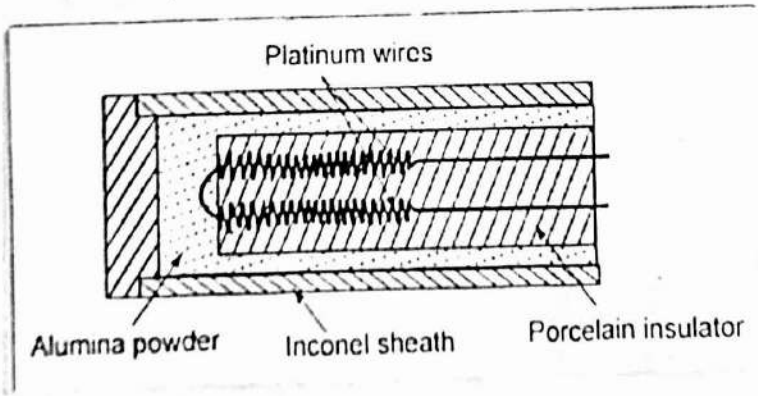
Advantages

* power source is not required
* cost is low.
* It is robust construction.

Disadvantages:-

* It is less accurate
* It is limited to applications where manual reading is acceptable.

Resistance temperature Detectors:-



* when a metal wire is heated the resistance increases, so, a temperature can be measured using the resistance of a wire.

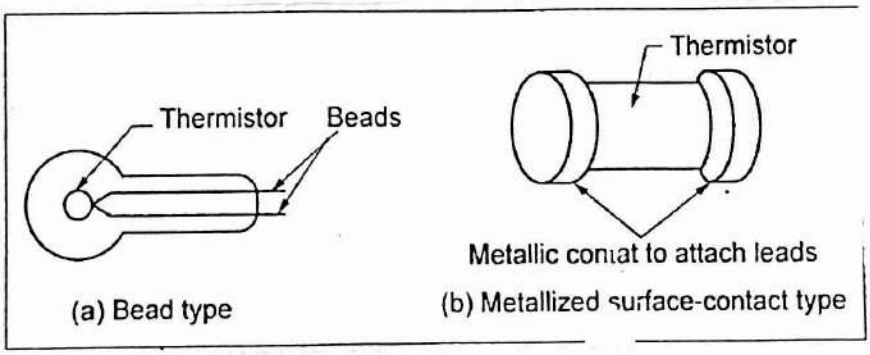
Advantages of RTDs

* It is suitable for measuring high temperatures
* It has high degree of accuracy
* It ensures good stability and repeatability.

Disadvantages of RTDS.

* Size is more than the thermocouple
* power supply is required
* It needs auxiliary apparatus to get required form of output.

Thermistors :-



* Thermistor is a word formed by combining thermal with resistor.

* Thermistors are small and inexpensive devices which are most commonly made of metal oxides such as those of chromium, nickel, manganese and cobalt.

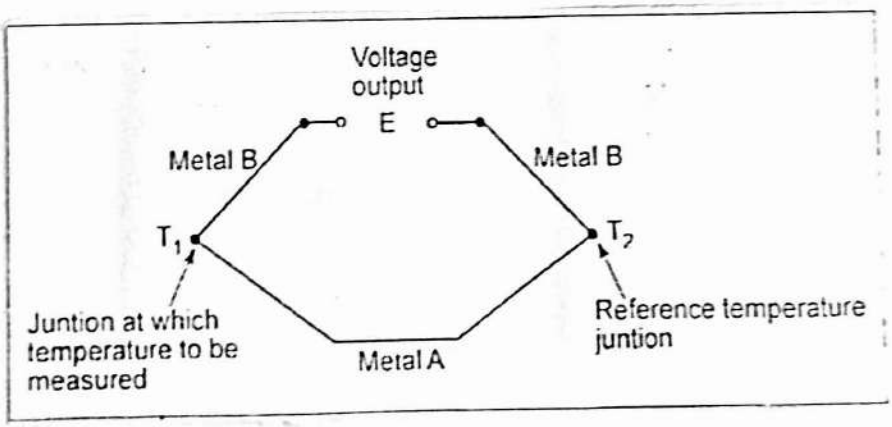
Advantages of thermistors :-

* It produces more accurate output and fast
* It is suitable for the usage in romote location
* It can be manufactured in almost any shape and size

Disadvantages of thermistors

* It produces highly non-linear behaviour over its range of operation
* It has a limited measuring range.
* Self-heating may occur.

Thermocouple.



* The thermocouple is a device that converts thermal energy into electrical energy.
* Thermocouples are very simple and durable temperature sensors.

Advantages of thermocouples :-

* It is simple in construction
* It is inexpensive
* It is rugged in construction
* It has wide variety to choose for particular applications.

* Disadvantages of thermocouples :-

* It is highly non-linear behavior over its range of operation
* It is capable of generating low voltage.
* It has low stability

Thermodiodes and transistors :-

1. Thermodiode :-

* A junction semiconductor diode is widely used in temperature - measuring instruments.
* The mobility of semiconductor diode will change whenever the temperature changes.
* The difference in voltage and current through the junction is a function of a temperature

2 Thermal transistor :-

* The base-to-emitter voltage drop of a transistor operating at a constant current is a simple function of absolute temperature.

* It means that very useful for measuring one junction of the thermocouple and most ambient temperature measurements

Advantages :-

* It produces almost linear output

* It is responsive

* It is compact in size

Disadvantages :-

* It is applicable for the measurement of less than 150°C.

* power supply is required

* It produces slow output

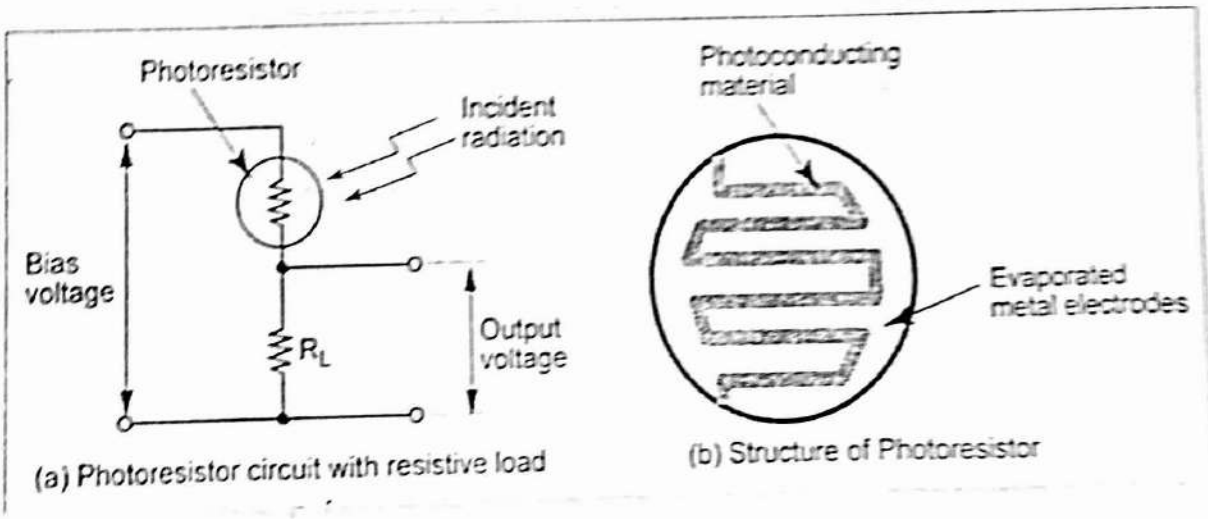
* It has the problem of self-heating.

1.17 Light sensors :-

* A light sensor or detector converts that radiant power. It absorbs into a change of a desire parameter such as resistance, electric charge, current or voltage.

* It may be integrated into the detector or require external components. There are several types of light sensors in common use.

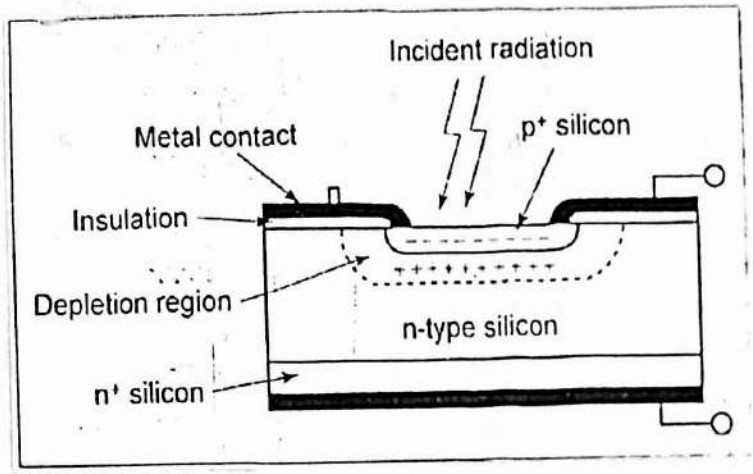
1. Photo Resistor :-



* A photo resister consists of a slab of semiconductor material on the faces of electrodes.

* They are deposited to allow the resistance to be monitored. The increase in conductivity is caused by the absorption of photons increasing electrons and holes are the basis for the operation of the photo resistive detector.

2. photodiode



* In photo resistors, the rate of generation of electrons and holes pairs by the absorption of radiation results the increase in free charge and therefore, electrical conductivity will also increase.

* the seperation of electrons and holes takes place in the electric field associated with a p-n junction fabricated in a semiconductor material which is usually silicon.

* The basic structure of a typical silicon photodiode is illustrated in figure. The substrate material is lightly doped n-type silicon.

* the p-type region is made thin to allow photons to penetrate into the depletion region.

UNIT - II.

Introduction:-

A digital computer in its simplest form is a fast electronic machine that accepts digitilized information & provides information to the user. The computer s/m basically needs following units.

- → I/P units
- → CPU
- → Memory storage
- → O/P unit.

Features of - 8085 Processors:-

(i) It is an 8-bit microprocessor
(ii) operating voltage -15 V
(iii) It operates on clock cycle with 50% duty cycle
(iv) It can operates in 3MHz freq
(v) It supports 74 instructions with following addressing modes

(a) immediate
(b) register
(c) Direct
(d) Indirect
(e) Implied addressing.

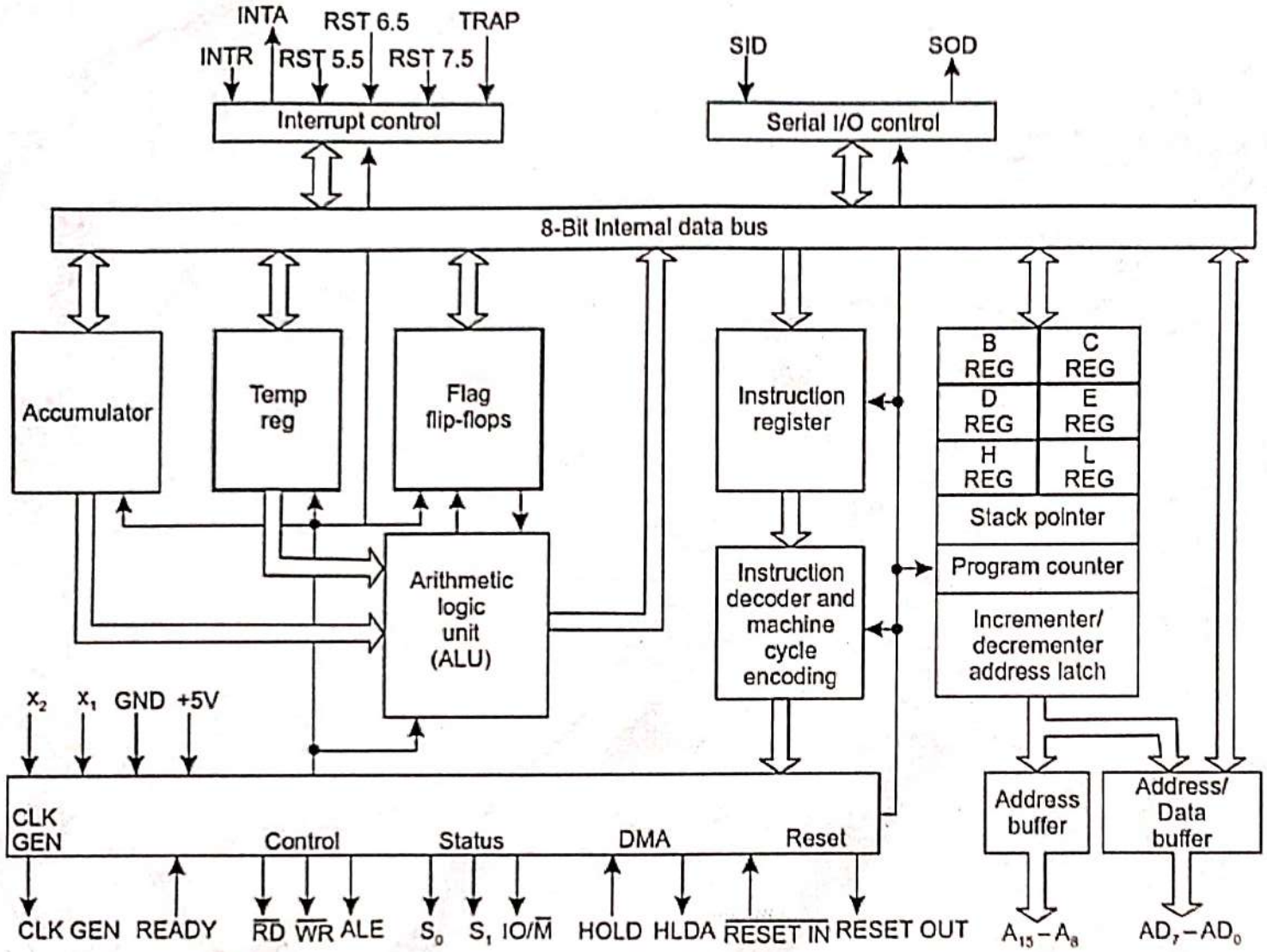


Fig 1.1 Hardware Architecture of 8085

S - Sing flag:-

After the execution of the ALU if the bit D_7 of the result is 1 the sign flag is set.

Z - zero flag: The zero flag is set if the result of operation of ALU is 5 zero.

AC Auxillary Carry flag:-

This flag is set if there is an over flow of bit 3 (ie) the lower ripple to liger ripple.

P - Parity flag:-

It is the number of ones present in A register after the arithematic a logical operation.

Cy - Carry flag:-

The flag is set there is an overflow bit of 7.

Program Counter:-

Program counter is a 16 bit register. It stores the address the next instruction to be executed.

ALU: (Arithematic Logic Unit)

The 8085 ALU peforms arithematic &

It consists of various functional blocks listed below.

Registers.

→ Arithmatic logic unit

→ Instruction decoder & machine cycle encoder

→ Address buffer

→ Incrementor (or) Decrementor

→ Intrupt control

→ Serial I/O control

→ Timing & ctrl circuitary.

* General purpose Registers

B, C, D, E, H, L are the 8 bit general purpose registers as 16 bits pairs BC, DE, HL,

* Special Function Registers.

It is a tristate 8-bit register. It is extensively used in arithmatic logic, load & store operations.

Flag Registers:-

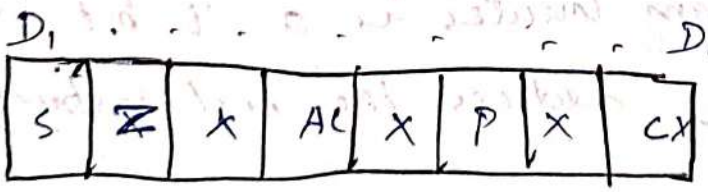


Fig: Flag registers.

& logical functions on 8-bit variables. The arithmatic unit performs fundamental arithmatic operations such as addition, subtraction, multiplication division and logical functions such as OR, EX-OR etc.

Instruction Decoder:-

The processor first fetches the opcode of instruction from memory & stores this opcode in the instruction register.

The instruction decodes it & accordingly gives timing & control signals.

Address Buffer:-

This is an 8-bit unidirectional buffer. It is used to drive external higher order buses.

Intrupt Control :-

The processor fetches decodes & executes instructions in a sequence. The interrupt control block has five interrupt i/p. RST 5.5, RST 6.5 & RST 7.5, TRAP & INTR & one acknowledge $\overline{INTD}$

Serial i/p Control :-

In serial communication one bit is transferred at a time over a single line. The 8085 has serial

i/o control. It provides two lines SOD, SID. The SOD is used to send data serially. &

Timing & Control Circuitry :-

The control circuitry in the processor 8085 is responsible for all operations. The control circuitry fetching decode & execution also generates signals.

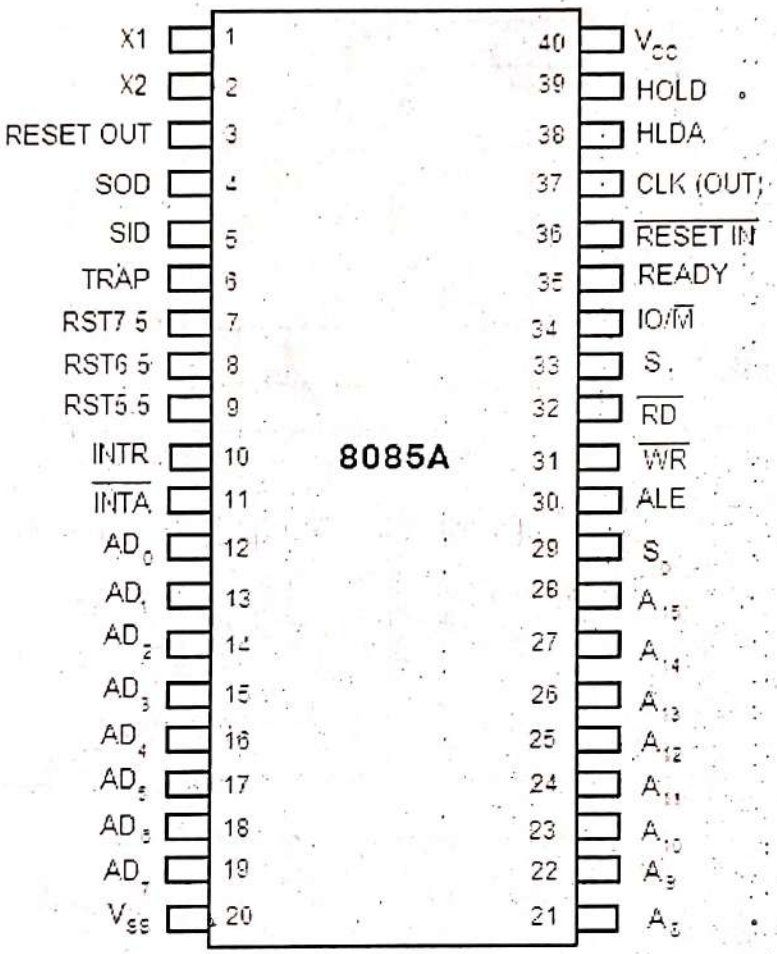


Fig: Pin diagram of 8085

The signals of 8085 can be classified into seven groups accordingly to its functions.

(a) Power supply & frequency signals.
(b) Data bus & address bus
(c) Control bus
(d) Interrupt signals.
(e) Serial i/p signals.
(f) DMA signals.
(g) Reset signals.

Power supply & frequency Signals :-

(i) V_{CC} -> It requires single +5 v power supply
(ii) V_{SS} -, Ground reference
(iii) X_1 & X_2 : A tuned circuit like LC & RC or Crystal is connected at these two pins.

The internal clock generator divides oscillator frequency clock generator divides oscillator frequency by 2.

(iv) Clk out :-

This signal is used as a s/m clock for other devices. Its frequency is half the oscillator frequency.

Data Buses & Address Buses:-

(A) $AD0 - AD7$: The 8 bit data bus $D_0 - D_7$ is multiplexed with the lower half of 16 bit address bus $A_0 - A_7$.

(B) $A_8 - A_{15}$: The upper half of the 16-bit address appears on the address lines as $A_8 - A_{15}$.

Control Bus:-

(A) ALEC Address Latch Enable:-

The latching of lower half of an address is done by using external latch & ALE from 8085

(B) $\overline{RD}$ & $\overline{WR}$: These signals are basically used to control the instruction direction of the data flow between processor & memory (or) I/O port. A low $\overline{RD}$ instruct indicates that the dat must be read from the selected memory location. A low or $\overline{WR}$ indicates that the dat must be written into the selected memory or I/O port.

(C) I/O $\overline{M}$, S_0 & S_1:

I/O $\overline{M}$ indicates whether I/O operation or memory operation being carried out. S_1 & S_2 indicates the types of machine cycle is progress.

(D) Ready: It is used to synchronize slower peripherials to the microprocessor.

Interrupt Signals:-

The 8085 has five hardware interrupt signals: RST 5.5, RST 6.5, RST 7.5, TRAP & INTR, INTA signal is used to indicate that the processor has acknowledge & INTR interrupt.

SID: SID is used to accept serial data bit by bit from the external device.

SOD: This is an o/p signal enables the transmission of serial data bit to external device.

DMA signal:

HOLD: This signal indicates the another master is requesting for the use of address bus & control bus.

HLDA: This active high is used to acknowledge HOLD request.

Reset signal:-

Reset IN: A low on this Pin.

Reset out: This active signal indicates that process is being reset.

Addressing Modes of 8085 :-

The different ways that the microprocessor access the data can be referred as the addressing modes. The 8085 has 5 addressing modes. They are

- → Immediate
- → Register
- → Direct
- → Indirect
- → Implied.

(i) Immediate Addressing Mode :-

In this addressing mode 8 or 16 bit data can be specified as the part of the instruction.

Eg: MVI A, 20H

↳ MOV 8 bit data 20H to Acc

(ii) Register Addressing Mode :-

This addressing mode specifies the source operand & the destination operand both to be contained in 8085 registers.

Eg: MOV A, B.

↳ Moves the content of A to B.

③ Direct ✱

This type of mode specifies the 16 bit address of the operand within the instruction itself.

Eg: LDA 2000H : Load 8 bit contents of memory location.

④ Indirect Addressing mode.

In this addressing mode, the memory address where the operand location specified by the content of the register pair.

Eg: MOV M, A :

↳ stores the contents of the Acc to the memory location pointed by HL pair.

Implied Addressing Mode :-

In this type of mode, the operand specifies the address of operand.

Eg: CMA : Complement the content of Accumulator,

Instruction Set of 8085 :-

The instruction form all groups are explained with the help of the following examples.

(i) Data transfer group :-

This type of instruction used to transfer the data from the source to destination.

Eg : MVI B, 60H → load 60H to B register.

MVI M, 40H → Load 40H to memory

MOV r_d, r_s → Move the content of r_s to r_d

(ii) Logical Group :-

This type of instruction is used to perform logical operation.

Eg: ANA r → And operation with register.

XRA r → Ex-or operation with register.

ORA r → OR operation with register

CMP r → Compare register pair.

(iii) Arithematic Group :

This type of instruction is used to perform arithematic operations like addition, subtraction

Xication & division.

Eg: ADD r → add the content to the content of ALU

ADD c → Add the content of C reg to the content of accumulator.

Sub r → This instruction subtracts the content of accumulator & stores the result in register.

(iv) Branch Group:-

JMP addr : Loads the PC with given within the instruction & resumes the program execution from this location.

CALL Addr : CALL

RET : Returns the main instruction

v) Machine Control Group:-

NOP : No operation is performed

HLT : This instruction halt the program.

SIM : This instruction masks the interrupts as desired.

RIM : The instruction copies the states of the interrupts into the accumulator.

Timing Diagram of 8085 :-

Timing diagram is a graphical representation of execution time taken by each instruction in a graphical format.

Instruction cycle :- Time required to execute an instruction.

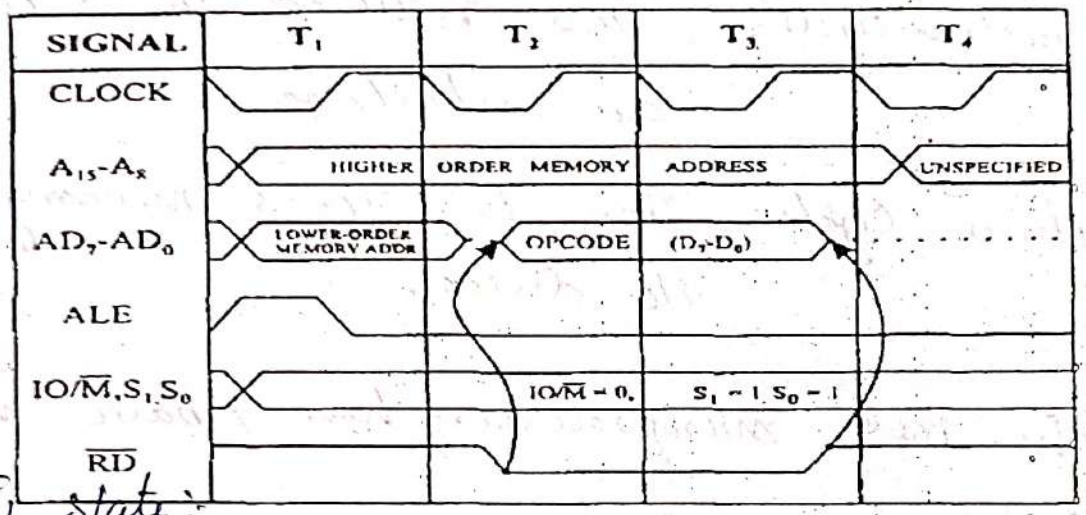
Machine Cycle : Time to access memory or i/o device.

The 8085 microprocessors has 7 basic machine cycle.

1. Op-code fetch cycle (4T or 6T)
2. Memory read cycle
3. Memory write cycle
4. I/O read cycle
5. I/o write cycle
6. Inetrrupt Ack cycle
7. Bus idle cycle.

Opcode Fetch Cycle (Diagram)

1. Opcode fetch cycle (4T or 6T)



T1 state :-

During the T_1 state, the contents of the program counter are placed on the 16 bit address bus.

* ALE signal goes high. At the middle of the T state.

T2 state :-

* $\overline{RD}$ signal goes low which enables memory.

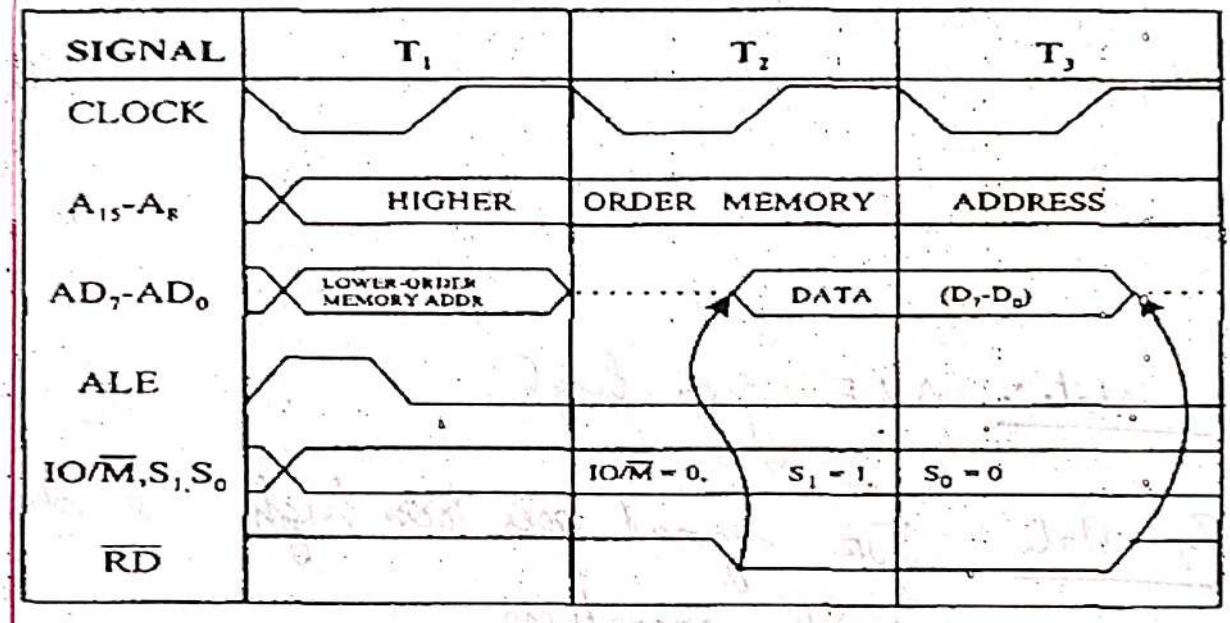
T3 state :-

* $\overline{RD}$ goes high, disables the memory from A/D.

T_4 → The opcode was fetched from memory decoded.

Memory Read Cycle :- (Diagram).

2. Memory read cycle (3T)



T_1 State :- ALE goes high. $F_0/F_1 = 0$, $S_1, 0$; $S_1 = 0$

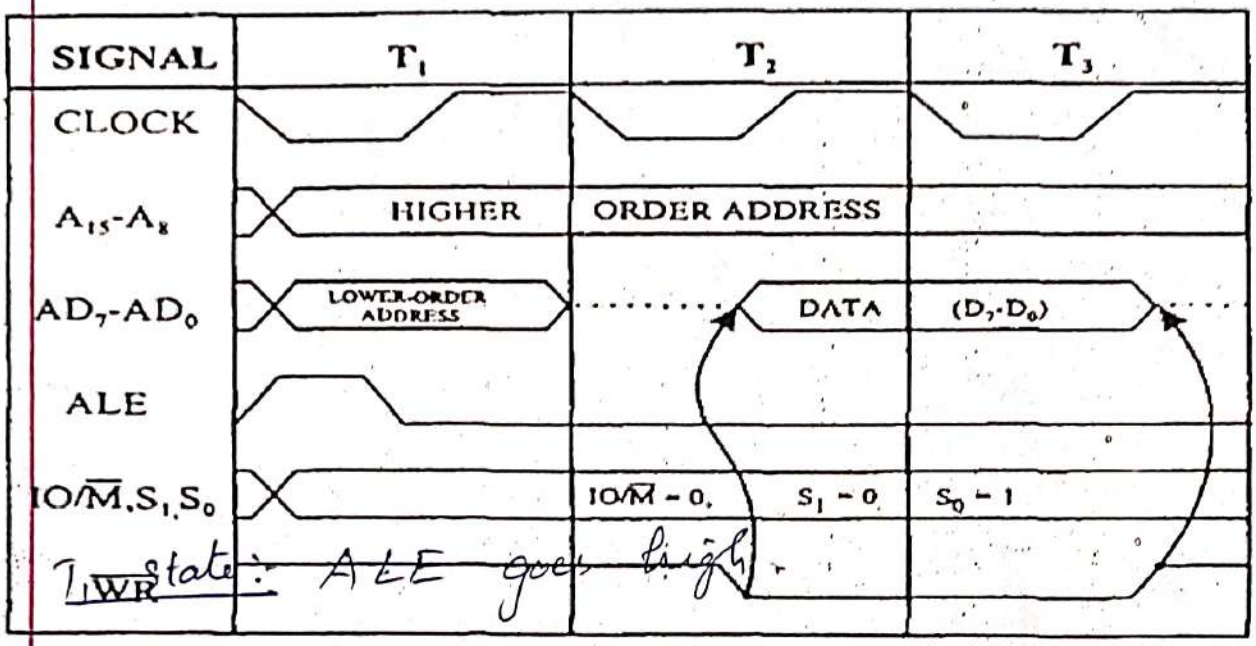
T_2 state :- $\overline{RD}$ goes low

T_3 State :- $\overline{RD}$ goes high & disable memory operation.

Memory Write Cycle :-

Diagram.

3. Memory write cycle (3T)



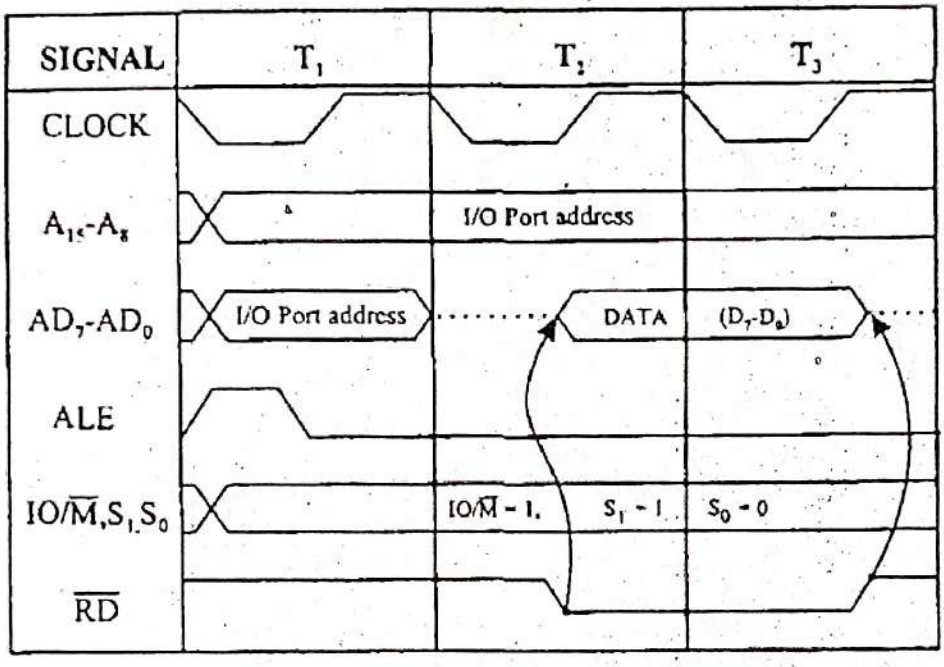
T_1 state :- ALE goes high.

T_2 state :- $\overline{WR}$ signal goes high & disable write operation.

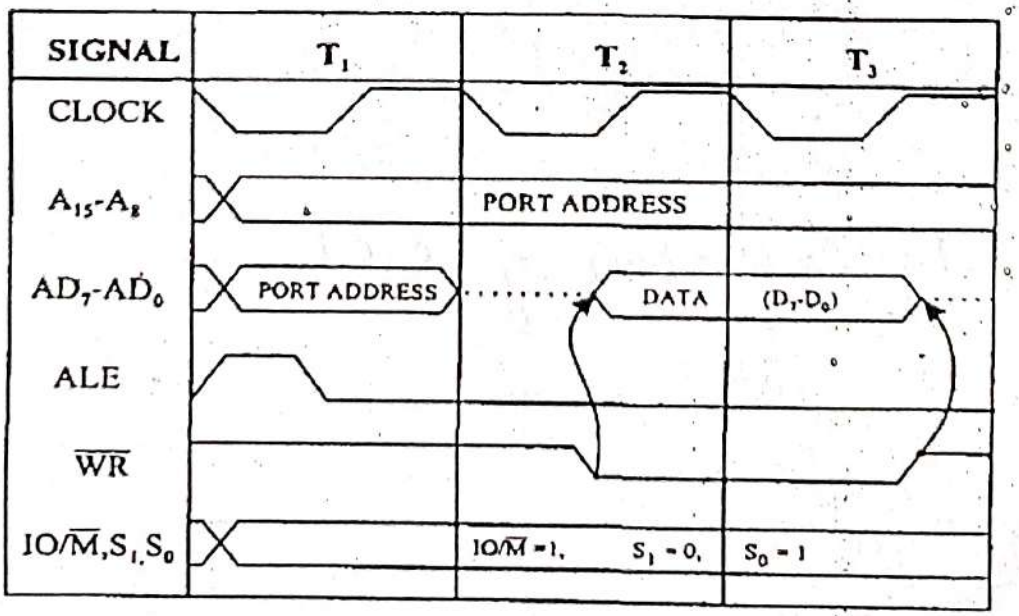
T_3 state :- $\overline{WR}$ goes high and enables the memory operation.

I/O Read Cycle :-

4.I/O read cycle(3T)



5.I/O write cycle(3T)



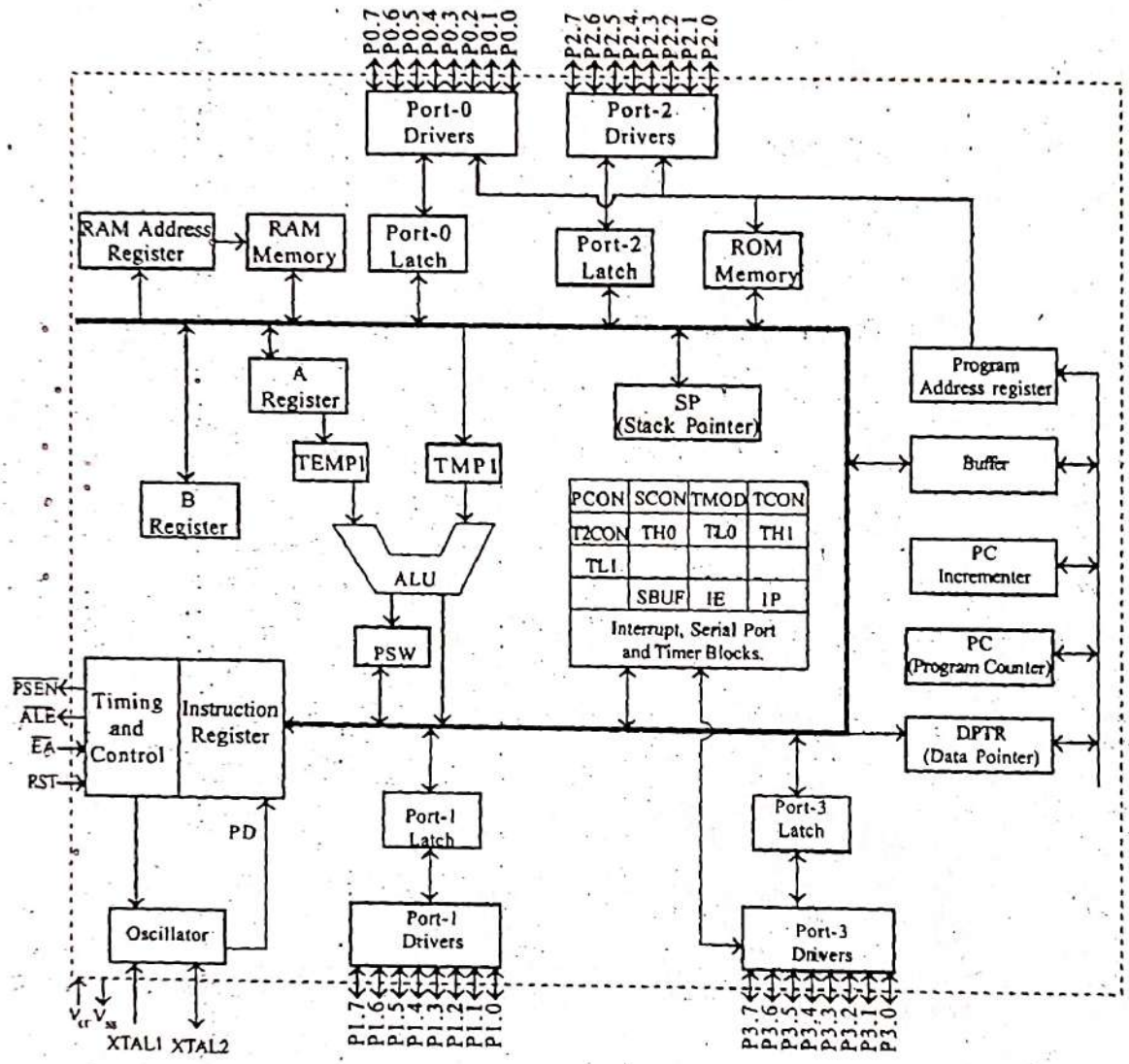


Fig: Architecture of 8051.

Features of 8051 Microcontrollers:-

1. 4096 bytes on - chip program memory
2. 128 bytes on chip data memory.
3. Four register banks.
4. 128 user defined flags
5. Multiple mode, high speed programmable serial port.
6. Two multiple mode 16 bit timer/control.

Register Set of 8051:

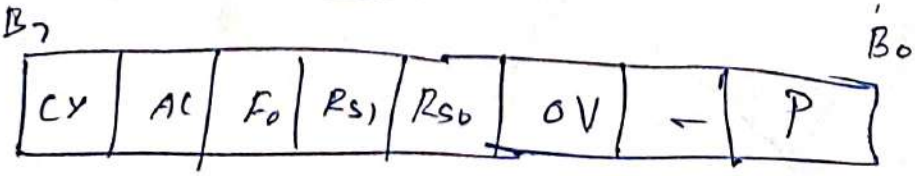
Register A (Accumulator)

It is an 8-bit register. It holds the source operand and receives the results of the arithmetic instruction, & also logic instruction.

Register B:-

B register is available as the general purpose register. It is not being used for hardware multiply or divide operation.

Program Status Word:-



CY -> Carry flag.
AC -> Auxillary carry flag.
OV -> over flow flag.
P -> Parity flag.

Stacks Pointer :-

The stack pointer is used by the 8051 hold ant internal RAM address that is called by top of stack.

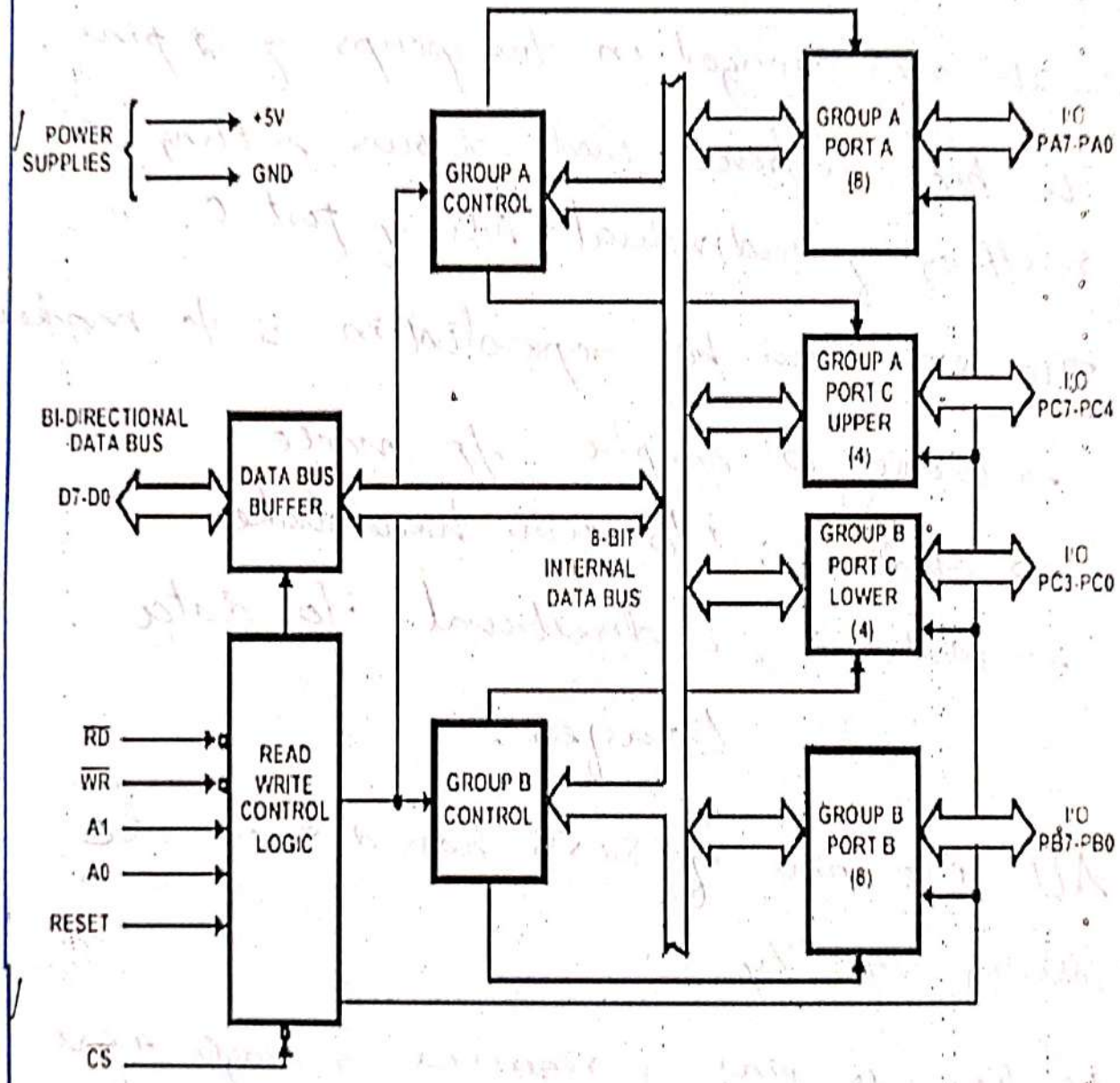
Data Pointer :-

The data pointer consists of high byte & a low byte. Its function is to hold a 16 bit address.

Program Counter :- Program counter stores the address of next instruction to exceed.

UNIT - III

Architecture of 8255 :-



Feature of 8255 :-

The 8255 is widely used in programmable parallel i/o device.

* It is compactable will all intel & most other microprocessors.
* It is completely TTL compactable.
* It has three 8 bit ports : Port A, B & C. which are arranged in two groups of 12 pins.
* its bit set/reset mode allows setting & resetting of individual bits of port C.
* The 8255 can be operated in 3 i/o modes.
  - → Mode 0 : Simple i/p mode
  - → Mode 1 : i/o with handshake
  - → Mode 2 : Bi directional i/o data transfer.
* All i/p pins of 8255 has 2.5 mA dc driving capacity.
* It has 40 pins & requires a single +5V supply.
* The intel 8255 is a device used to parallel data transfer between microprocessor & slow peripheral device like ADC, DAC, keyboard & 7-segment display.

Group A (12 bits) : It consists of port A (8-bits) & port B upper (4-bits).

Group B (12-bits) : It consists of port C (8-bits) & port B, lower (4-bits).

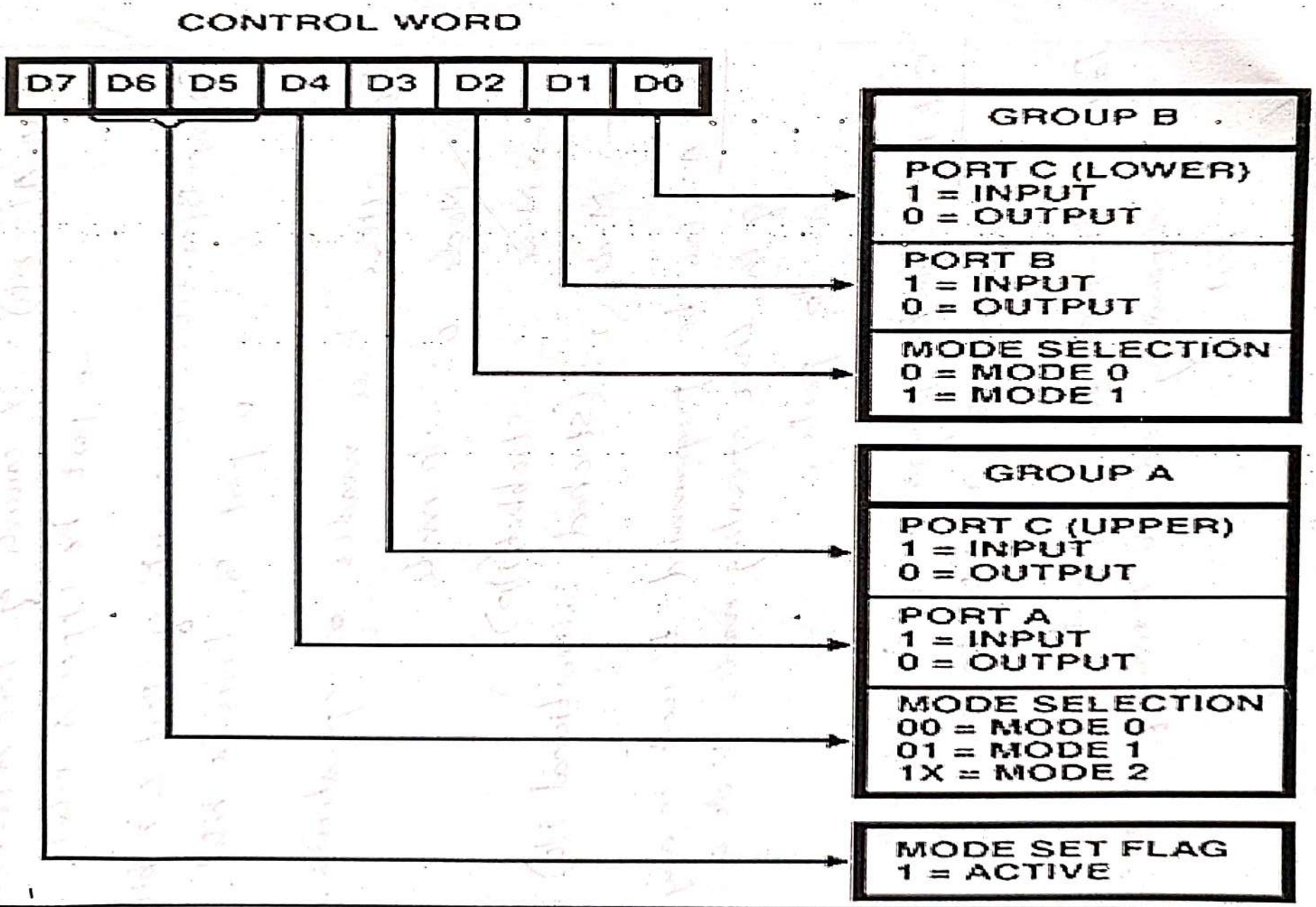
It offers three modes of operations.

→ Mode 0 : - i/p mode
→ Mode 1 : strobbed (i/p)
→ Mode 2 : (strobed bidirectional i/o)

Port A : Can be programmed to work in any one of the three operating modes Mode 0, 1, & 2 as i/p ports.

Port B : Can be programmed to work either in Mode 0, 1, 2 as i/o port.

Port C : (8-pins) has different assignments depending on the mode of Port A & port B.


CONTROL WORD
D7
D6
D5
D4
D3
D2
D1
D0
GROUP B
PORT C (LOWER)
1 = INPUT
0 = OUTPUT
PORT B
1 = INPUT
0 = OUTPUT
MODE SELECTION
0 = MODE 0
1 = MODE 1
GROUP A
PORT C (UPPER)
1 = INPUT
0 = OUTPUT
PORT A
1 = INPUT
0 = OUTPUT
MODE SELECTION
00 = MODE 0
01 = MODE 1
1X = MODE 2
MODE SET FLAG
1 = ACTIVE

Operation Modes:-

Bit set/Reset mode:-

The port can be set or reset by sending out instruction to the control registers.

I/O Modes:-

→ In this mode, port A, port B & port C is used as individually

Features:-

→ I/O are latched, i/p are buffered not latched

→ Ports do not have handshake or interrupt capability.

Mode 2: Bidirectional I/O data transfer:.

→ This mode allows bidirectional data transfer over a single 8-bit data bus using hand shake signals.

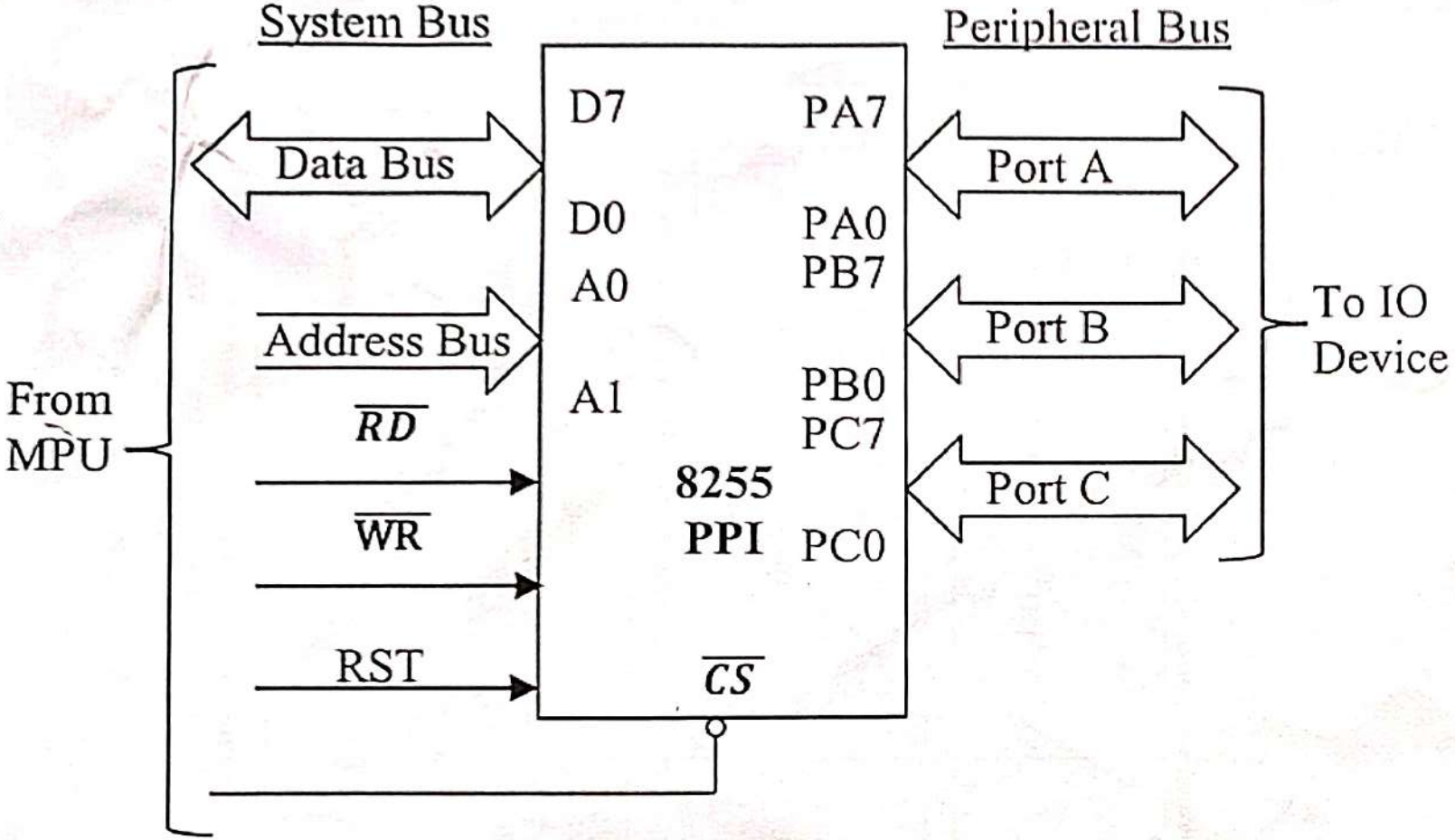
→ This feature is possible only by group A.

→ Port A is working as 8-bit bidirectional.

Key board Interfacing :-

The data from keyboard is similar in which data is received from the switching activity of a circuit. Here an integerated circuit is presented to understand the data reception from the switch pattern to i/p port of 8255 & o/p to LED arrangement.

Interfacing of keyboard with 8522 :-


System Bus
Peripheral Bus
Data Bus
Address Bus
From MPU
RD
WR
RST
D7
D0
A0
A1
8255 PPI
CS
PA7
PA0
PB7
PB0
PC7
PC0
Port A
Port B
Port C
To IO Device

LED Program:-

```
MVI   A, 90H
out   ABH
IN    ADH
cmi   A1H
MVI   A, 90H
out   CE
IN    PA
RAR
JC LOOP
MVI A, 04H
Out PC
CALL DELAY
MVI A, 05H
OUT PC
CALL Delay
JMP LOOP )
DELAY : LX IB, count
        DC X, B
        MOV A, B
        OR A, C.
        JN Z LOOP 2
        RET.
```

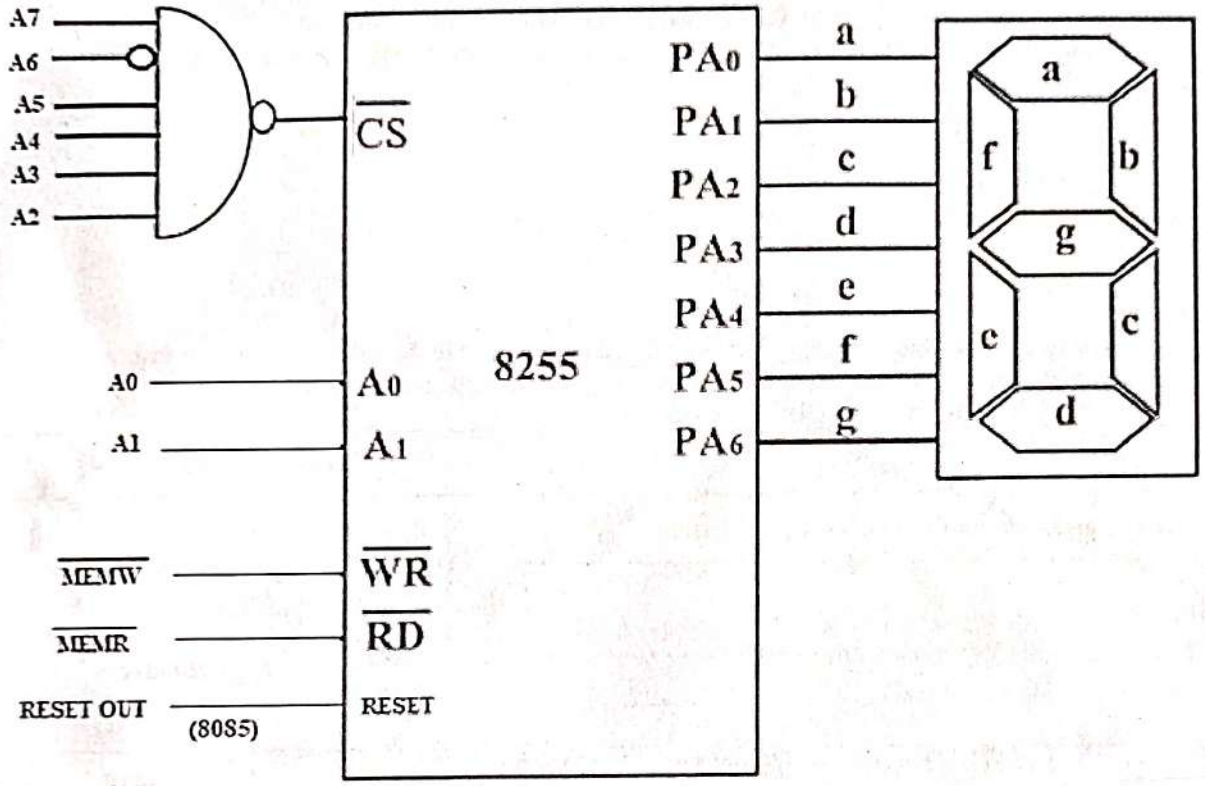
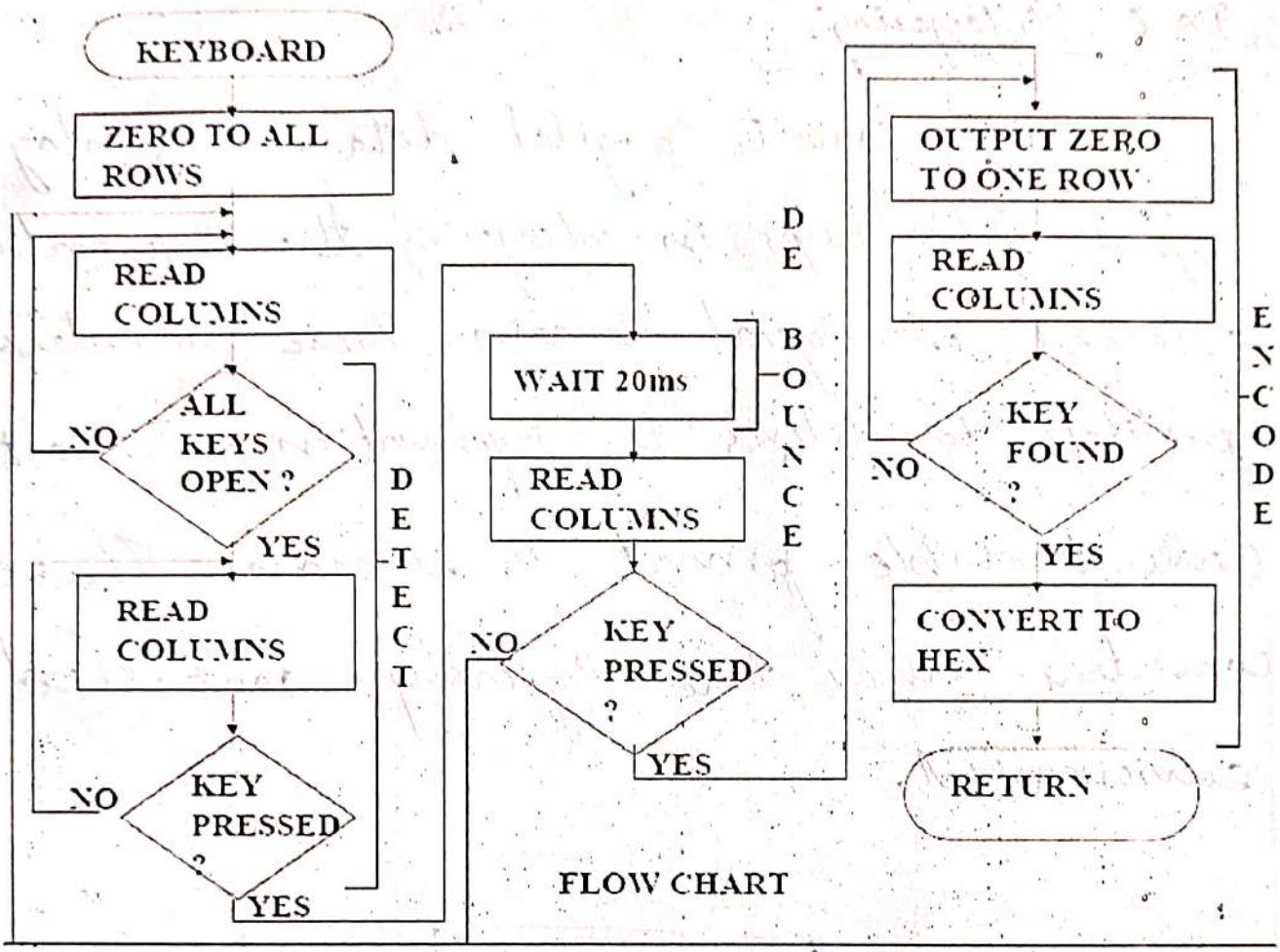


Fig Q3(b)

Fig: LED Interfacing with 8085.


KEYBOARD
ZERO TO ALL ROWS
READ COLUMNS
ALL KEYS OPEN ?
NO
YES
READ COLUMNS
KEY PRESSED ?
NO
YES
DETECT
WAIT 20ms
READ COLUMNS
KEY PRESSED ?
NO
YES
DEBOUNCE
OUTPUT ZERO TO ONE ROW
READ COLUMNS
KEY FOUND ?
NO
YES
CONVERT TO HEX
RETURN
ENCODE

FLOW CHART

DAC & ADC interface:

DAC interfacing:

DAC converts digital data into analog signal. This helps in interfacing the information processed in digital domain. These converters facilitate to deliver the information in most understandable format to humans. These converters ensure the digitally controlled environment.

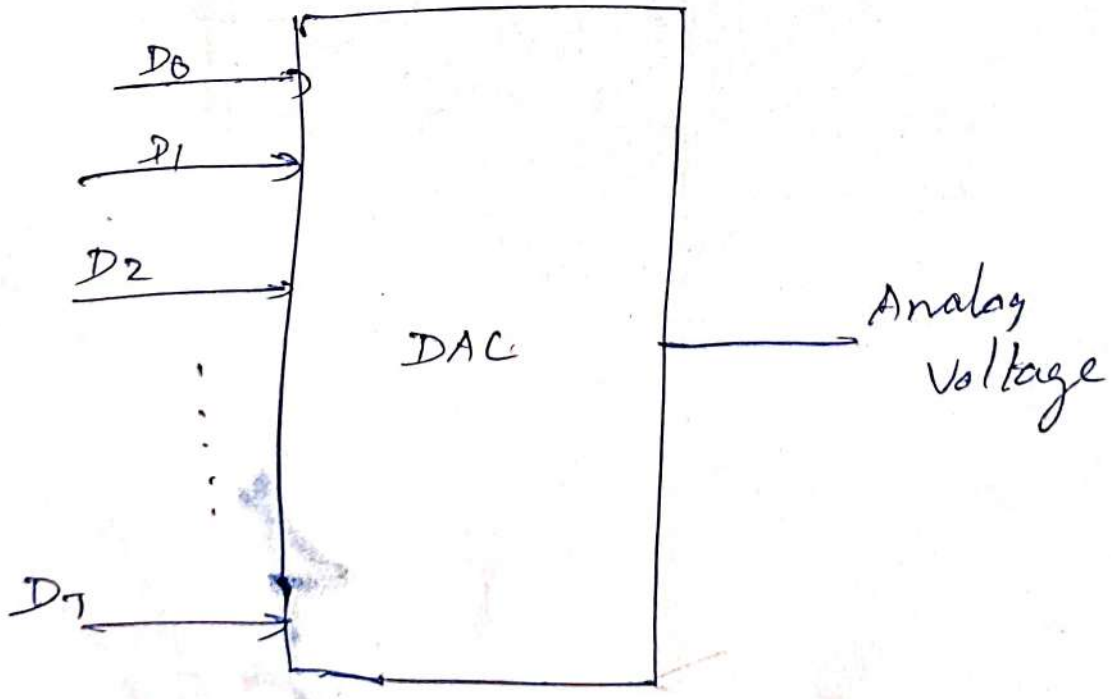


Fig: DAC i/p o/p.

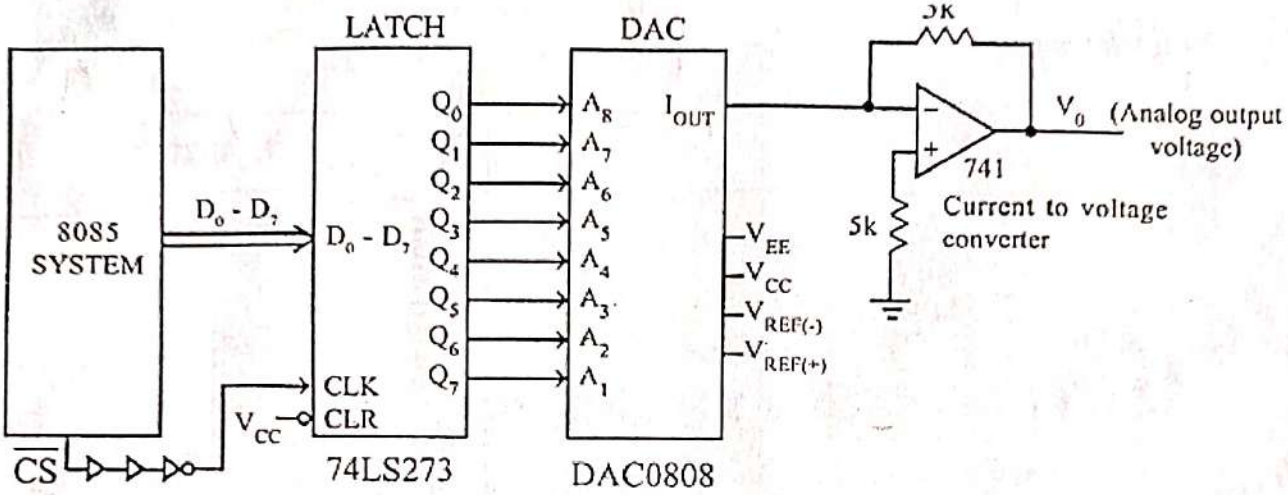


Fig 7.11 : Interfacing DAC0808 to 8085 microprocessor system

Program :-

```
        MVI   A, 80H
        OUT
        CONTROL - REG
        MVA, 00H
LOOP :  OUT   PORT A.
        CALL  DELAY
        MVR   A
        JMP   LOOP

DELAY   MVI   B, COUNT
        DCR   B
        JNZ   R'P T.
        RET,
```

ADC Interfacing :-

The start of analog to digital is done by SOC, which is a pulse of specific duration. The time taken from the active edge of SOC to the active edge of ADC is known as conversion delay.

The generic procedure for ADC is

-> Checking the stability of analog I/P
-> Initializing ADC with SOC
-> Reading EOC
-> Receiving o/p of ADC an equivalent digital data for applied analog input.

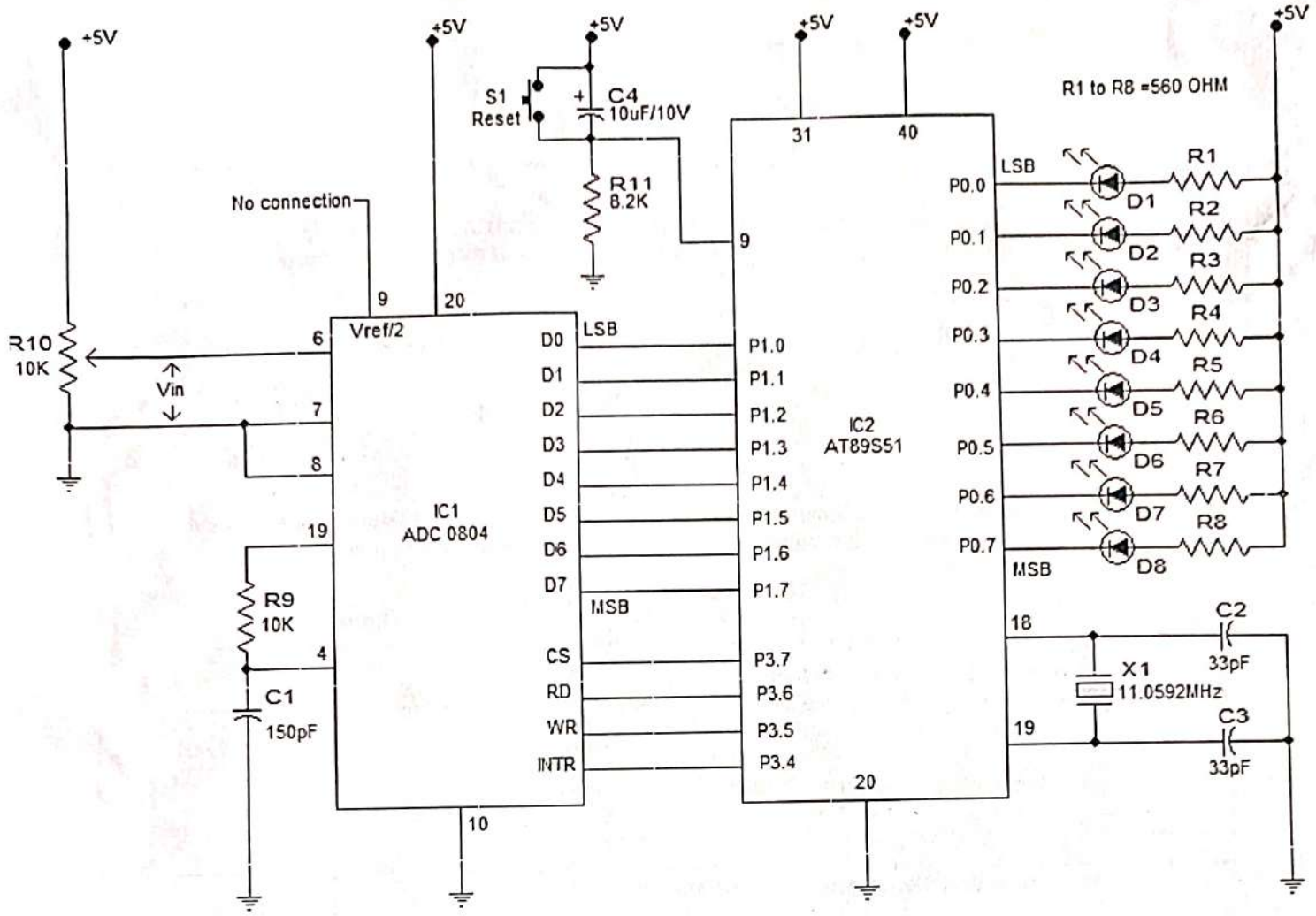


fig:-

1 Program :

```
MVI   A, 83H
OUT   CONTROL-REG
LDA   C11 - NUM
ANI   0F H

DCR   B

OUT   PORT A

NOP
NOP
```

```
MVI  B, 00H
ORL  B
OUT  PART A
IN   PORT C
RAR
JNC  CHECK
LDA  CH - NUM
MVI  B, 20H
ORL  B
OUT  PORT A
IN   PORT A
IN   PORT B
STA  ADC - RES
RET.
```

Traffic Light Interfacing :-

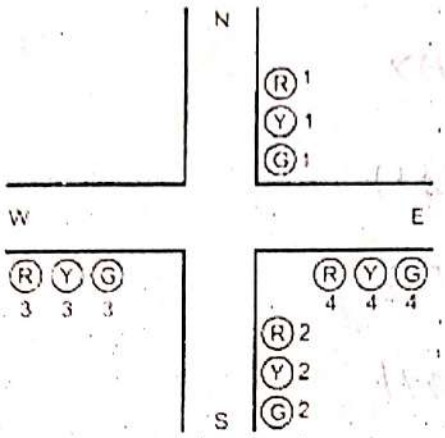


Fig: Logic.

Pins	Light	Pins	Light
PA_0	R_1	PB_0	R_3
PA_1	Y_1	PB_1	Y_3
PA_2	G_1	PB_2	G_3
PA_3	R_2	PB_3	R_4
PA_4	Y_2	PB_4	Y_4
PA_5	G_2	PB_5	G_4

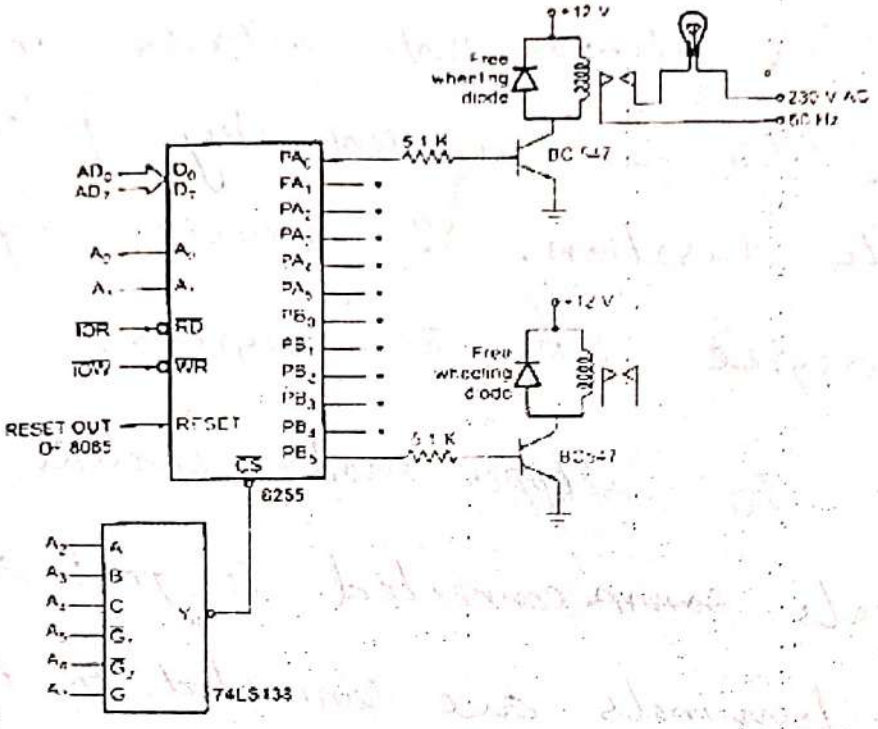
Table: PIN Assignment.

Program :-

```
MVI  A, 80H
OUT  83H
MVI  A, 09H
OUT  80H
MVI  A, 24H
OUT  81H
CALL DELAX
MVI  A, 12H
OUT  81H
OUT  81H
```

```
MVI C, 0AH
CALL DELAY
MVI A, 24H
OUT 80H PA
MVI A, 09H
OUT 81H
MVI C, 28H
CALL DELAY
MVI A, 12H
OUT PA
OUT PB
MVI C, 0A1H
CALL DELAY
JMP START.
DELAY:
    LXI D, COUNT
    DCX, D
    MOV A, D
    ORA, E
    JNZ BACK
    DCR C
    JNZ DELAY
    RET.
```

INTERFACING DIAGRAM



I/O MAP:

Ports / Control Register	Address lines A_7 A_6 A_5 A_4 A_3 A_2 A_1 A_0	Address
Port A	1 0 0 0 0 0 0 0	80H
Port B	1 0 0 0 0 0 0 1	81H
Port C	1 0 0 0 0 0 1 0	82H
Control Register	1 0 0 0 0 0 1 1	83H

Table 2

SOFTWARE FOR TRAFFIC LIGHT CONTROL

Control word – for initialization of 8255.

BSR/IO	MODE A	P_A	PC_H	MODE B	P_B	PC_L	= 80H
1	0 0	0	X	0	0	X	

Fig. Control word

Table shows the data bytes to be sent for specific combinations

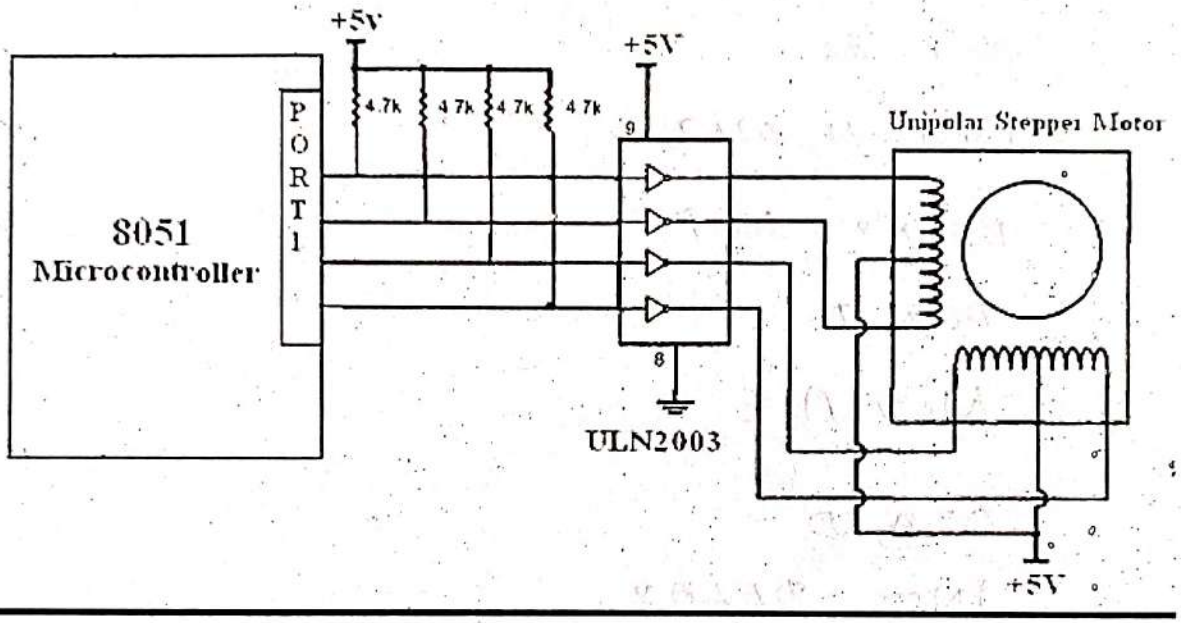
To glow	PB_7 PB_6 PB_5 PB_4 PB_3 PB_2 PB_1 PB_0	PA_7 PA_6 PA_5 PA_4 PA_3 PA_2 PA_1 PA_0	Port B (Output)	Port A (Output)
R, R_2, G, and G_2	X X 1 0 0 1 0 0	X X 0 0 1 0 0 1	24H	09H
Y, Y_2, G, and G_2	X X 0 1 0 0 1 0	X X 0 0 0 0 1 0	12H	12H
R, R_2, G, and G_2	X X 0 0 1 0 0 1	X X 1 0 0 1 0 0	09H	24H

Stepper Motor Interfacing :-

A stepper motor rotates in incremental steps. This is executed by pulses of definite duration. The generic step size is from 1 degree to 30 degrees.

The stepper motor consists of four terminals ~~connected~~ connected to port A of 8255. These terminals are connected to the lines of 8255 through the transistor Q_1, Q_2, Q_3 & Q_4.

Two types of execution is possible for four phase motor. They are one phase & two phase excitation. The program for driving stepper motor should be written to procedure the signals in program to program to port A of 8255.



Half step sequence

Half Mode Sequence

Step	A	B	A\	B\
0	1	1	0	0
1	0	1	0	0
2	0	1	1	0
3	0	0	1	0
4	0	0	1	1
5	0	0	0	1
6	1	0	0	1
7	1	0	0	0

Program :-

```
MVI A, 80
OUT d3
START LXI H, 9200
MVI B, 04
REPEAT: MOV A, M
OUT 20
LXI H, 0202
DELAY : NOP
DCX D
MOV A, E
ORA, D
JNZ DELAY
INX H
DCR B
JNZ REPEAT
JNZ START.
```

DATA : 9200, 03, 06, 0C, 09.

Unit - 4

Programmable Logic Controller :-

4.1 Introduction :-

* A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of typically industrial electromechanical processes. such as control of machinery on factory assembly lines amusement rides or light fixtures.

* The PLCs has following features and specific which distinguish from Computers.

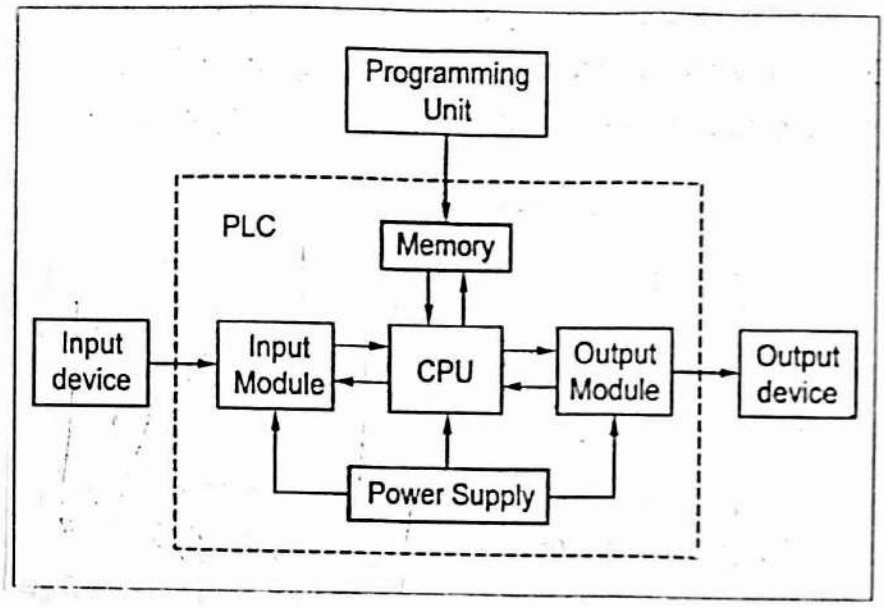
* They are rugged and designed to withstand vibrations, temperature, humidity and noise

* The interfacing for inputs and outputs is inside the controller

* They are easily programmed and have an easily understood programming language.

* they can be designed with Communication capabilities that allow them to interface with a Computer

4.2. Basic structure.



* the PLC is designed as a replacement for the hardwired relay and timer logic. where PLC provides ease and flexibility of control based on programming and executing logical instructions.

A typical PLC can be divided into four parts

(i) input/output module (I/O)

(ii) central processing unit (CPU)

(iii) Memory

(iv) programming Unit

(i) input/output Module :-

Input/output module are used to transfer data between external device and CPU.

The input and output modules are normally incorporated into PLC in two ways.

* Fixed I/O — It is a small unit that comes in one piece with processor i.e., the I/O terminals cannot be changed in Fixed I/O

* Modular I/O - It is packed together i.e. there are several compartments of I/O modules are plugged together.

(ii) Central processing Unit (CPU) :-

* The CPU is the brain of the PLC, consisting of a microprocessor which interprets the input signals and carries out the control actions according to the program stored in the memory.

* The CPU scans the total information package stored in the memory and the input and output devices continuously

(iii) Memory unit :-

* The memory unit is where the program is stored that is to be used for the control actions to be exercised by the microprocessor.

and the data stored from input for processing and for the output.

The memory used in PLC is

(i) Non- volatile memory - The memory may retain the information even the power is turned off

(ii) volatile memory - The memory may lose the information when the electrical power is turned off.

IV Programming Unit :.

* The programming unit is used to enter the required program into the memory of the processor.

* the program is developed in the device and then transferred to the memory unit of the PLC

* programming device also enters the required program using ladder logic into the memory of the processor.

4.3. Input / output processing :-

* processing of Input/output is through the programming the PLC. The basic form of programming commonly used with PLCs in "Ladder programming"

* Ladder programming involved each program task being specified as though a Rung (A cross piece forming a step of ladder) of a ladder.

The programming sequence followed by a PLC are

Step 1:- Scan the inputs associated with one Rung of the ladder program.

Step 2:- Solve the logic operation involving these inputs.

Step : 3: Set / reset the outputs for the Rung

Step : 4 : Move on to the next Rung and repeat operations in Step 1, 2 and 3.

Step : 5. Move on to the next Rung and repeat operations in step 1, 2 and 3.

There are two methods that can be used for input/output processing

(i) continuous updating

(ii) mass input/output copying

(i) continuous updating

* continuous updating involves the cpu scanning the input channels as they occur in the program instructions.

* here each input point is scanned individually and its effect on the program is determined

(ii) mass input/output copying

* In continuous updating, there has to be a 3ms delay on each input, the time take to examine several hundred input/output points can become comparatively long time.

* To avoid such a delay, the input/output is processing in a mass input/output copying method for a more rapid execution of a program.

1.4. Programming:-

* The programming of PLC is based on the "Ladder diagram". Ladder diagram involves writing a program in a similar manner to drawing a switching circuit.

Ladder Symbol	Description
	input as contacts but not closed until input
	input as contacts which are closed until input
	output
	Special instruction.

* The Ladder diagram consists of two vertical lines representing the power rails and circuits are connected as horizontal lines.

* In drawing the circuit line for a rung, input must always proceed output and there must be at least one output on each line.

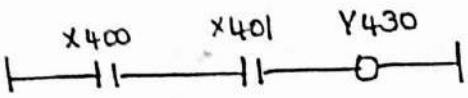
4.5 Mnemonics.

* Each horizontal rung on the ladder in a ladder program represented a line in the program and the entire ladder gives the complete program in "Ladder language."

List of mnemonics used for the mitsubishi F Series PLC.

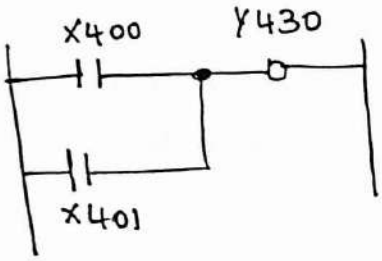
Mnemonics	Comment
LD	Start a rung with an open circuit
OUT	An output
AND	A series element and so an AND logic instruction.
OR	parallel elements and so an OR logic
ORI	An OR NOT logic function
ANI	An AND NOT logic function
RST	Reset shift register
K.	Insert a constant
END	END ladder

i) AND Logic



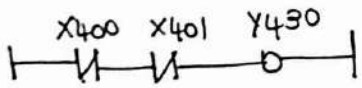
Step	Instruction	Comment.
0	LD X400	Load input at address X400
1	AND X401	AND input X400 at address X401
2	OUT Y430	Output stored to address Y430

ii) OR Logic



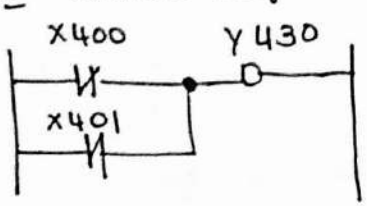
Step	Instruction	Comment
0	LD X400	Load input at address X400
1	OR X401	OR input X400 at address X401
2	OUT Y430	Output stored to address Y430.

iii) NOR Logic



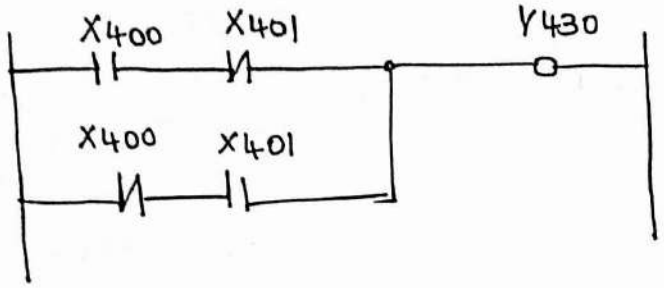
Step	Instruction	Comment.
0	LDI X400	Load closed contact input at address X400
1	ANI X401	AND NOT Logic input at address X401
2	OUT Y430	Output stored to address Y430

IV NAND Logic



Step	Instruction	Comment
0	LDI X400	load closed contact input at address X400
1	ORI X401	OR NOT Logic input at address X401
2	OUT Y430	Output stored to address Y430

V EX-OR (XOR) Logic



Step	Instruction	Comment
0	LD X400	Load open contact input at address X400
1	AN I X401	AND NOT input at address X401
2.	LD I X400	Load closed contact input at address X400
3.	AND X401	AND input at address X401
4.	ORB	OR used with two sub circuits
5.	OUT Y430	Output stored at address Y430

4.6 Timers, Internal Relays and counters:-

* The tasks requiring the series and parallel connections of input contacts.

* However, there are tasks can involve time delays and event counting.

Example: For the Mitsubishi F series, the numbers used are.

Timers 450—457, 8 points, delays - on period 0.1-999S

T 550-557, 8 points, delays on period 0.1-999S

Internal relay or 100-107, 170-177, 200-207

marker

M 12-8 points

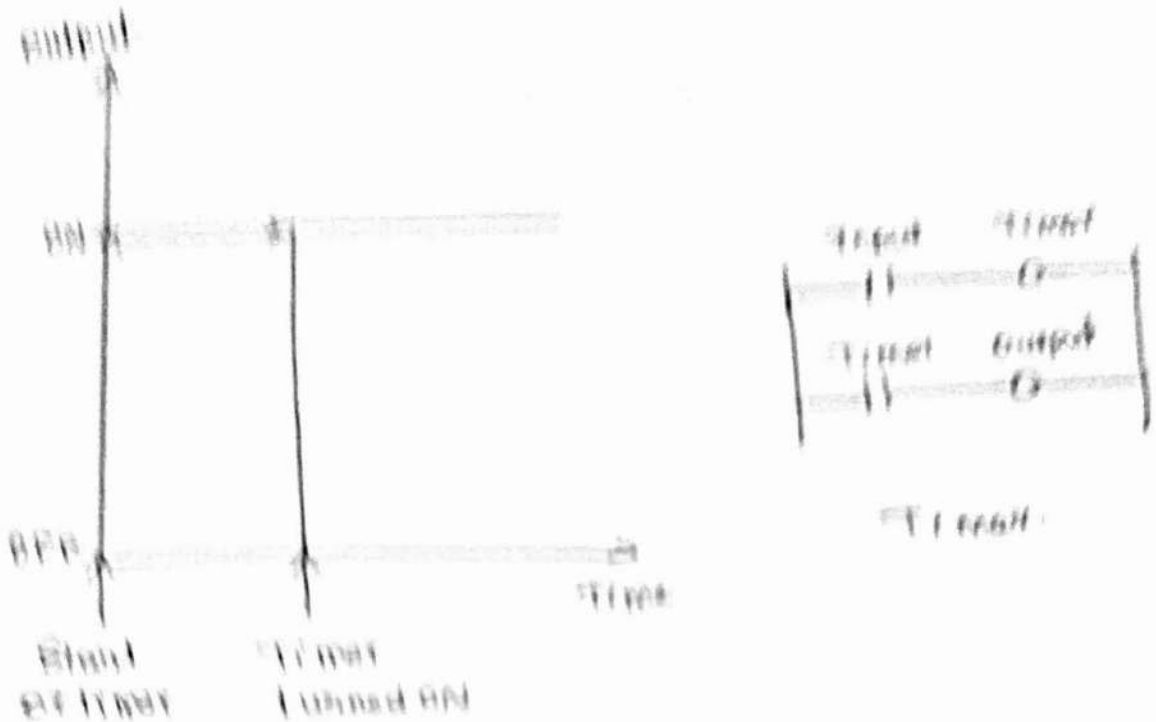
300-307, 370-377, battery backed, 64 points

or counter 460-467, 8 points, 1 to 999

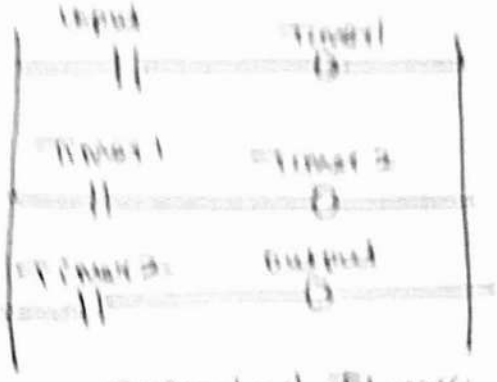
C 560-567, 8 points, 1 to 999.

Timers:-

* A Timer circuit is specified by starting the interval to be timed and the conditions or events that are to start and/or stop the timer



Retentive On Timer



Cascaded Timer

* Whenever there is an input, the timer is energized and starts timing.

* After some preset time the contacts associated with the timer closes and the output occurs.

Internal Relay (Marker)

* Most PLCs have an area of the memory allocated for internal storage that are used to hold data, which behave like relays, being able to be switched ON or OFF but only for internal purposes.

* Internal relays are often used when there are programs with multiple input conditions

* Internal relays can be very useful aids in the implementation of switching sequences.

* Internal relay are also used for the Starting of multiple outputs

* An internal relay can be used to switch between groups of outputs to give the form of control for pneumatic cylinders which is termed cascade control.

Counters :-

Counters are used when there is a need to count a specified number of contact operations.

Example :-

* where items pass along a conveyor into boxes, and when the specified number of items has passed into a box and next item is divided into another box

* Counters allow a number of occurrences of input signals to count or record the number of times some event occurs.

* In most cases, the counter operates as a down - counter. This means that the counter counts down from the present values to zero i.e, events are subtracted from the set value. When zero is reached the counter's contact changes state.

4.7. Data Handling :-

Data handling instructions enable the PLC's to have on additional characteristics that are beyond the conventional relay equivalent instruction.

* Moving data
* comparison of magnitudes of data i.e greater than, equal to, or less than
* Arithmetic operations such as addition and subtraction
* Conversions between binary coded decimal (BCD), binary and octal.

Data Registers :-

* It is a register where the data instructions in the PLC are stored. The data instruction required memory addresses and the location in the PLC memory.

4.8. selection of PLC

* In general, PLC are considering the size and type required for particular tasks or tasks criteria that need to be considered are.

* Input/output capacity required
* Types of input/output required
* Size of memory required
* Speed and power of CPU.

1. System definition.

* A technique of functional decomposition can be applied to define the whole system, with hardware and software, as it is defining the program alone.

2. Choosing the I/O hardware:-

* Various types of input and output modules are available, based on the type and speed of operation.

3. I/O timing Consideration:-

* It is most important to determine how fast (Speed of operation) the sub-system of input program and output must react to changing input conditions.

4. Analog I/O module:-

* There are many terms used to set out to select analog modules for describing performance.

5. Conversion speed:-

* The choice of conversion speed basically depends on the number of readings per second we need to capture. There are two types of A/D converters.

6. Analog closed control:-

* Analog inputs sometimes are used as feedback to control a process by controlling relay outputs or varying an analog output.

7. Counders, encoders and positioning:

* In order to select the PLC hardware, we need to consider (a) the sped

b) the total number of pulses to be counted

c) the positioning accuracy

8) Communications

* When we are selecting a PLC, we need to evaluate the communication facility is adequate for the application.

a). selecting Suppliers:-

* Functionality and features.

* customer support.

* customer acceptability

* User knowledge

* cost.

Unit-5

Actuators and mechatronic system Design:-

5.1. Actuators:-

* One of the important components of mechatronic Control System is the actuator. Actuators are the devices that accept a control command and produce a change in the physical system by generating force, motion, heat, flow, etc.

Primary functions of mechanical actuation systems:-

* Transformation of a rotary motion into a translating motion as in the case of a cam and follower mechanism.

* Transformation of rotary motion for a medium distance without slipping which is not possible by using belt drives, as in the case of belt drives.

5.2. Electrical Motors :-

& The electric motors are used as the power source in a variety of mechatronic applications. Therefore, electric motors often feature as the prime mover in a variety of driven systems.

The common classification of electric motors is as follows.

(i) Dc motors :-

1) permanent magnet type

2) Electromagnet type

a) shunt wound

b) series wound

c) Compound wound

d) Seperate wound

(ii) Ac motors

1) Single – phase

a) induction

b) synchronous.

2) poly phase

a) induction

b) synchronous.

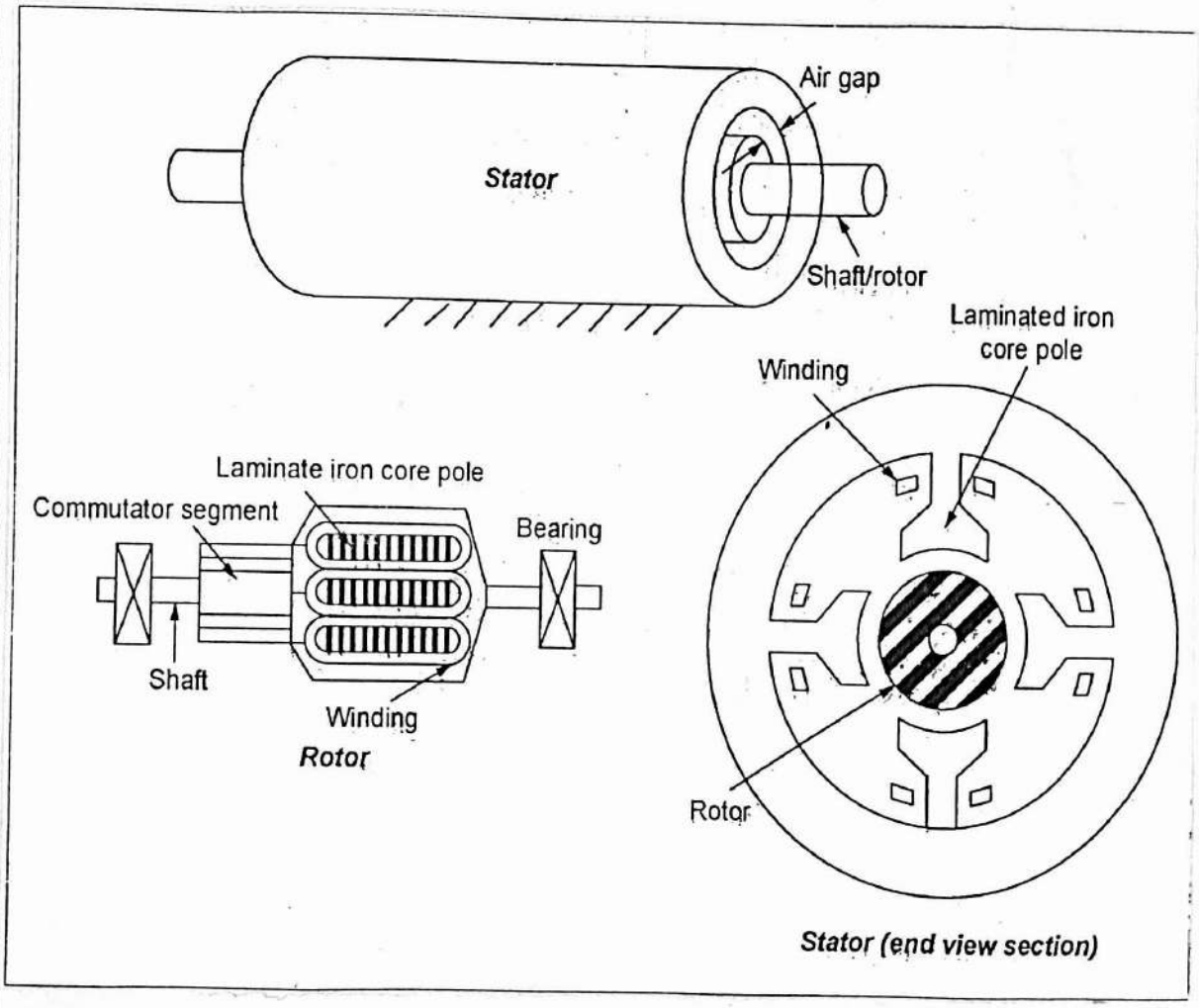
3) universal

(iii) stepper motors.

1) permanent magnet type

2) Variable reluctance

3) Hybrid



* Rotor is the rotating part of the motor. Depending on the construction, it can be a permanent magnet or a ferromagnetic core with coil windings (armature)

* field coil (system) is the portion of the stator that is responsible for generating the stator magnetic flux.

* Commutator is the part of a DC motor rotor that is in contact with brushes and it is used for controlling the armature current direction.

5.2 Stepper motors :-

* stepper motor is a special type of DC motor having a permanent magnet or variable reluctance DC motor.

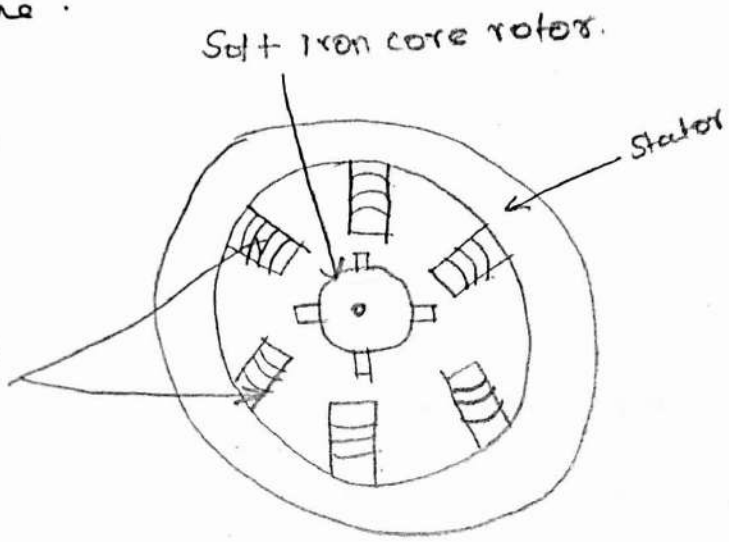
Types of stepper motor

1. Variable reluctance stepper motor
2. permanent magnet stepper motor
3. Hybrid stepper motor

* A stepper motor is a motor controlled by a series of electromagnetic coils. The center shaft has a series of magnets mounted on it and the coils surrounding the shafts.

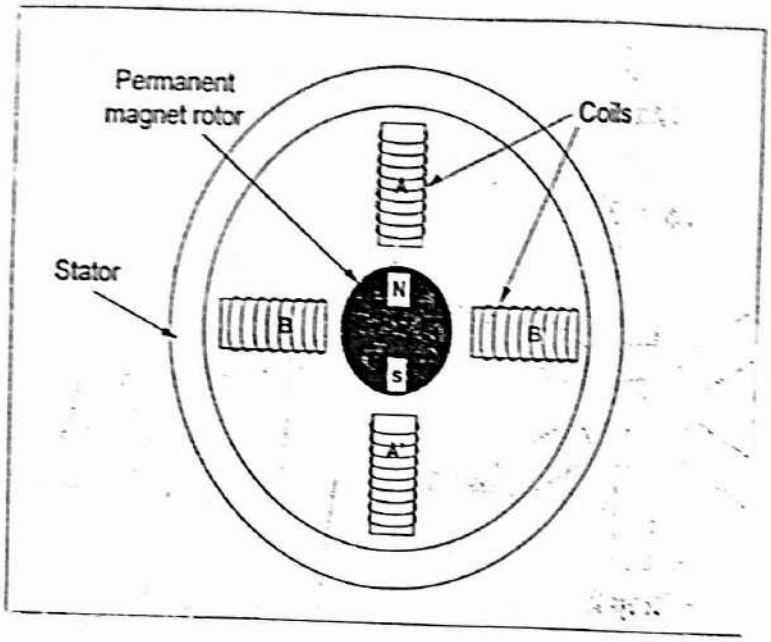
1. Variable reluctance stepper motor

* The variable reluctance stepper has a multi-toothed non-magnetic soft iron rotor with a wound stator. in figure.



* If only two phases are used in the stator, there will be ambiguity regarding the direction of rotation.
* Hence at least, three phases would be required for this two-pole rotor geometry shown in figure.
* In the case of half-stepping, however, two phases have to be energized simultaneously during some steps.
* In this case, the minimum reluctance position is halfway between corresponding pole pairs.

2. permanent magnet Stepper motor :-



* The permanent magnet motor is often referred to a 'tin can' or 'cantack' motor.

* The rotor and stator poles of a permanent magnet stepper are not teethed

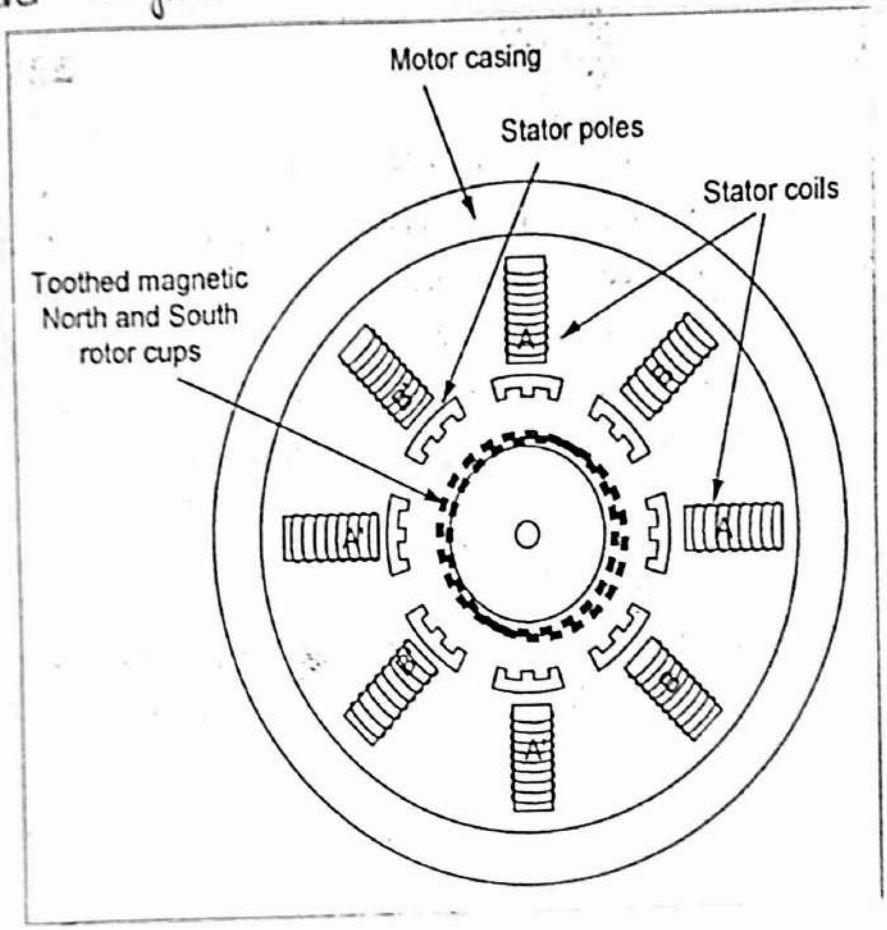
* The step angle for this motor is 45°. At the end of each step, the rotor assumes the minimum reluctance position.

* Applying current to each phase in sequence, the rotor is caused to rotate by adjusting to the changing magnetic fields

* Although it is operated at fairly low speed. the PM motor has a relatively high torque characteristic.

3. Hybrid Stepper Motor:

* A hybrid stepper is a combination of both permanent magnet and variable reluctance.



* A hybrid stepper is a combination of both. permanent magnet and variable reluctance.
* Hence, it combines the best features of both permanent magnet and variable reluctance type. Stepper motors.
* The magnetic rotor has two cups. one cup is for north poles and second cup is for south poles.

Advantages :- of stepper motors

* The rotation angle of the motor is proportional to the input pulse.
* The motor has full torque at stand - still
* It has excellent response to starting / stopping / reversing.

Disadvantages of stepper motors :

* Resonances can occur if not properly controlled
* It is not easy to operate at extremely high speeds

Applications :-

* Floppy disc head drives.
* printer carriage drive.
* positioning of print heads and pens in x-y plotters
* NC and CNC machine tool slide drive.
* Automatic teller machine (ATM).
* Recording heads in computer disc drives.

5.3 Servomotors:-

* There are some special types of application of electrical motor where the rotation of the motor is required for just a certain angle not continuously for a long period.

The important characteristics of servomotor are as follows:-

* Fast response
* High accuracy
* Fast and accurate speed
* Very high starting torque
* Unattended control
* Direction control
* Remote operation.

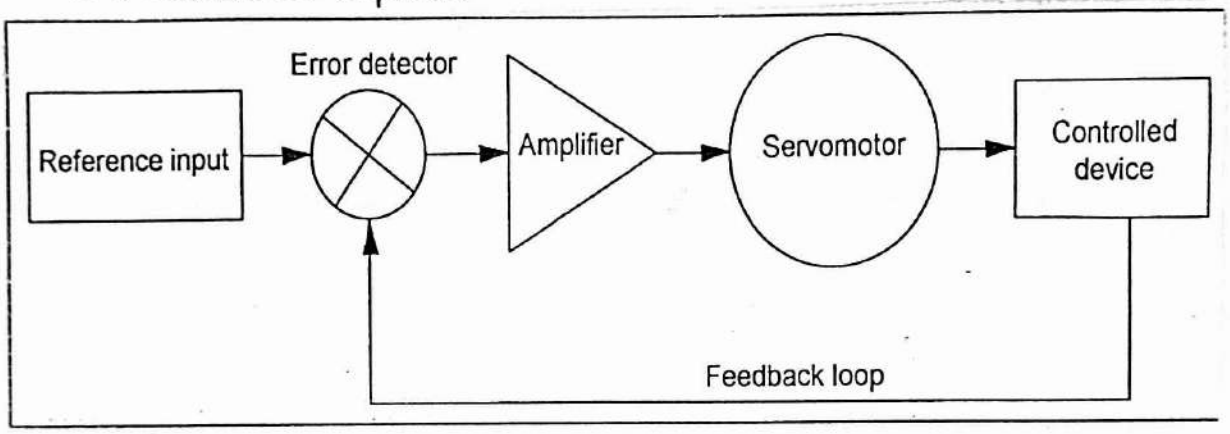
* Due to these features, they are being used in many applications such as toy car for controlling direction of motion, Rc helicopters and planes, Robotics, CD/DVD player, CNC machine etc.

* A servomotor is a simple electric motor combined with a position sensing device (e.g a digital decoder) and controlled for specific angular rotation with the help of servomechanism.

Construction and working principle of servomotor.

A servo system mainly consists of the following three basic components.

* Controlled device
* Output sensor
* feedback system.



* The servomotors used in industry today are automatic closed-loop servo system where it uses the positive feedback system to control motion and final position of the shaft.
* A servo unit consists of a small DC motor, potentiometer, gear arrangement and control circuit.
* Therefore, a gear mechanism is used in servo units. It reduces the speed of the motor and it increases the torque.

Types of servomotor :-

There are mainly two types of Servo-motors used

* Ac servomotors
* Dc servomotors

1. Ac servomotors :-

* This type of motor is basically a two-phase induction motor which is capable of reverse operation.
* To achieve the dynamic requirements of a servo system, the servomotor must have a small diameter.
* In many cases, the design of Ac servomotor offers only reasonable efficiency at the sacrifice of high starting

2. Dc servomotors :-

* Unlike large industrial motors, Dc servomotors are not used for continuous energy conversion.
* Design, construction and mode of operation are different. The rotors of this kind of motor are designed with long rotor lengths and smaller diameters.

Applications of Servomotor :-

* For very high voltage power systems, DC motors are preferred because they operate more efficiently than comparable AC servomotor.
* It has also found its application in inkjet printers and RC helicopters.
* It is also used in a solar tracking system.

Advantages of servomotor :-

* It provides high output power relative to motor size and weight.
* Encoder determines accuracy and resolution
* It has high speed torque.
* It has audibly quiet at high speeds

Disadvantage :- of servomotor

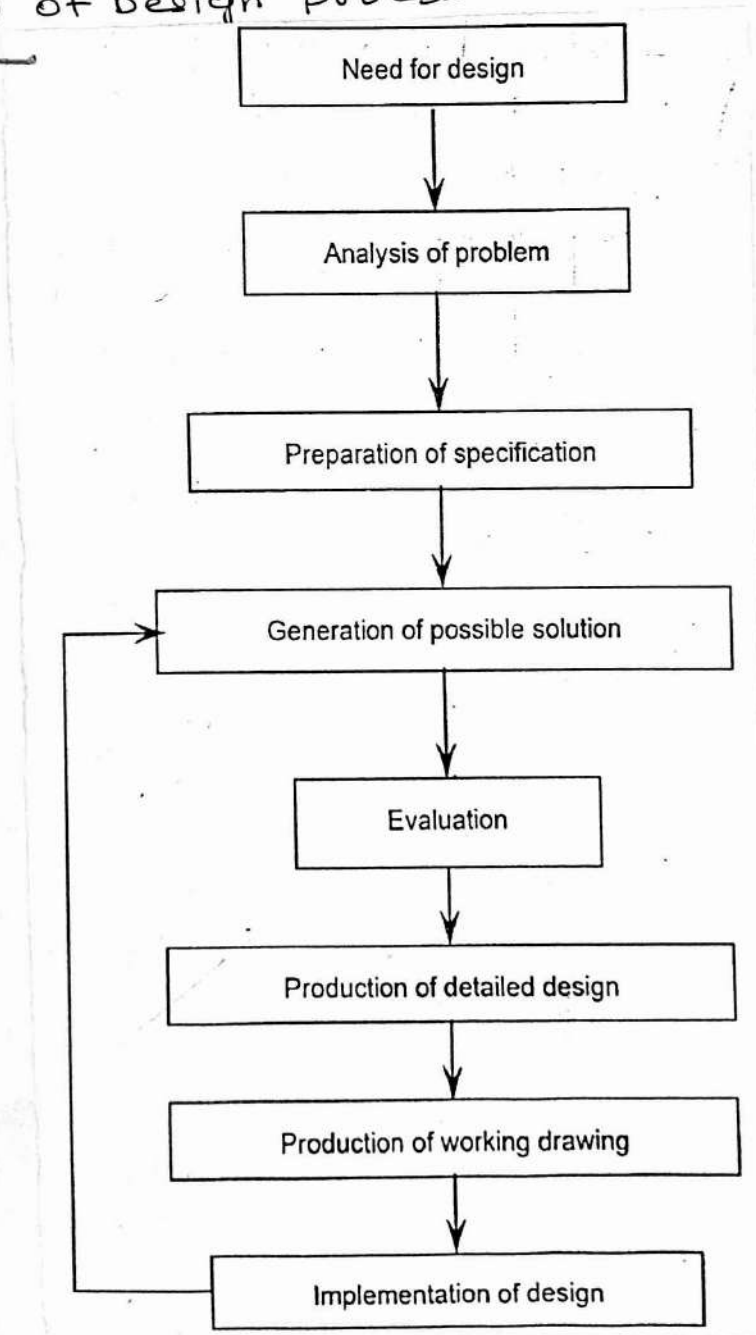
* motor develops peak power at higher speeds. Gearing often required.
* poor motor cooling
* Design is complex.
* motor can be damaged by sustained overload.

5.4 Design process :-

* The engineering design process is a series of steps that engineers follow to come up with a solution to a problem.

*. The design process varies between different projects and design fields.

Stages of design process :-



Stage 1 :- Need for design

* The design process begin with a need. the needs usually arise from dissatisfaction with an existing situation

* the needs may come from inputs of operating or service personal or from a customer through sales or marketing representatives.

Stage 2 :- Analysis problem

* probably the most critical step in a design process is the analysis of the problem. to find out the true nature of the problem

* if the problem is not accurately defined, it will lead to a waste of time on designs and it will not fulfill the need.

Stage :- 3 preparation of specification

* The design must meet the required performance specifications

* the following are some of the statements about the problem

* mass and dimensions of design
* Type and range of motion required
* Accuracy of the element

Stage 4:- Generation of Possible solution:-

* This stage is often known as Conceptualization Stage. The Conceptualization step is to determine the elements
* A vital aspect of this step is synthesis.

Stage 5:- Selection of Suitable Solution

* This stage involves a through analysis of the design. The evaluation stage involves detailed calculation.
* The various solutions obtained in Stage 4 are critically and the most suitable one is selected.

Stage 6:- production of detailed design:-

* The details of selected design have to be worked out. It might have required the extensive simulated service testing of an experimental model or a full size prototype in order to determine the optimum details of design.

Step 7:- Production of working drawings :-

* The finalized drawings must be properly communicated to the person who is going to manufacture

Step :8 Implementation of design

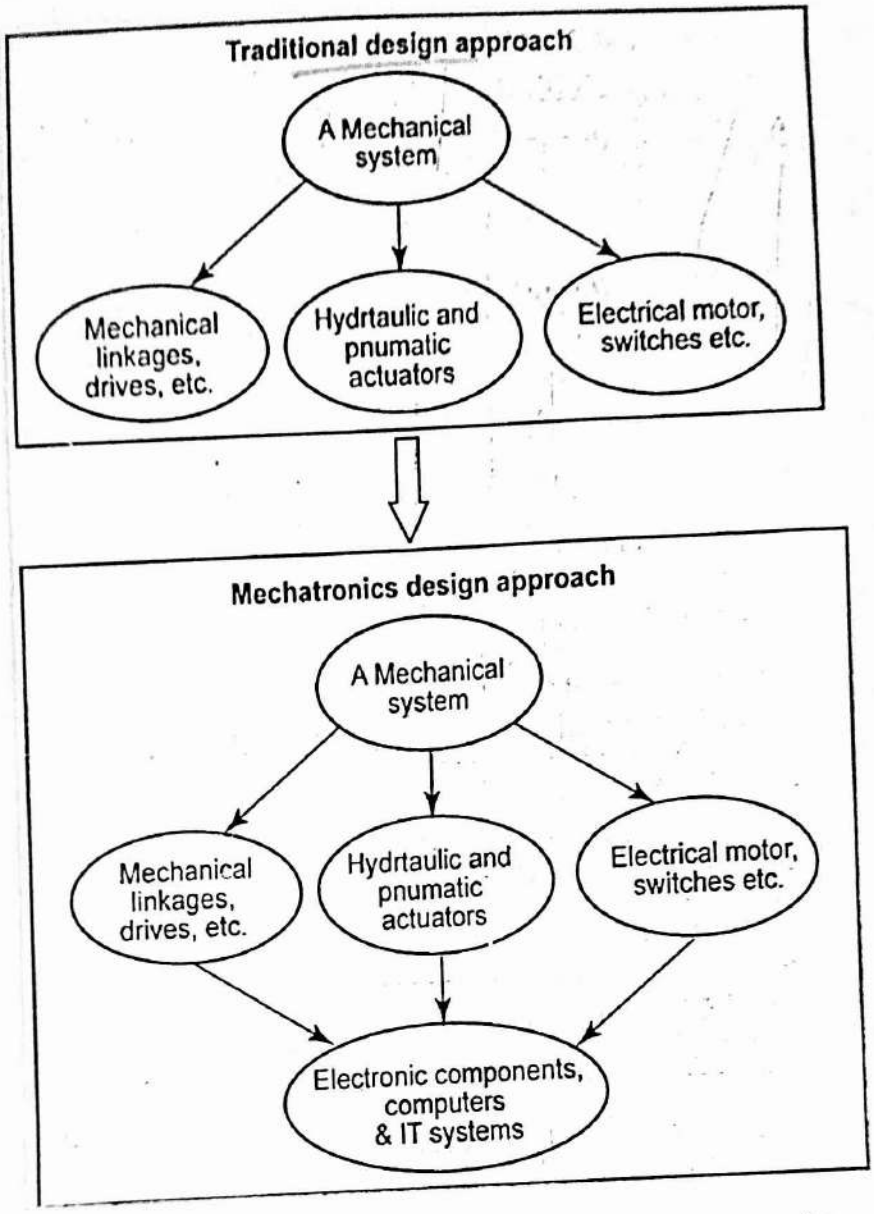
* The components as per the drawings are manufactured and assembled as a whole system.

5.5. Traditional and Mechatronics Design Concepts :-

* Engineering design is a compex process which involves interaction between many skills and disciplins.

* In traditional design, the components are designed through mechanical, hydraulic or pneumatic components and principles.

* For example, the design of a weighing scale might be considered only in terms of the compression of springs and a mechanism is used to convert the motion of spring.



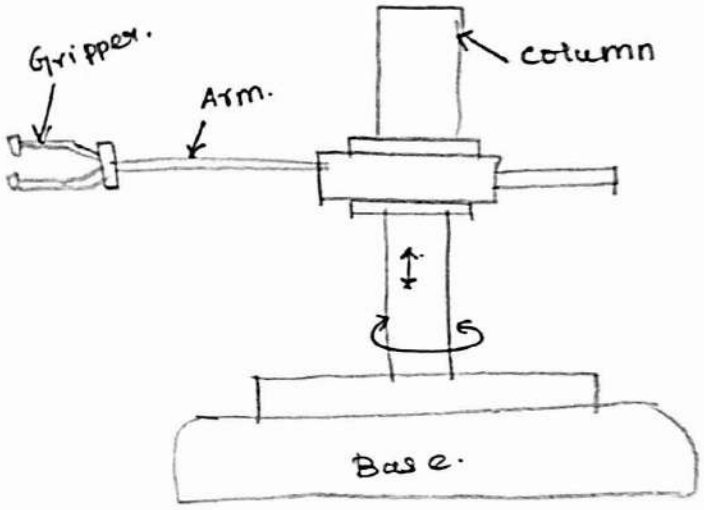
* Similarly, the traditional design of the temperature control for a central AC system involves a bimetallic thermostat in a closed loop control system.

* This system uses a microprocessor controlled thermo couple as the sensor. Such a system has many advantages over a traditional system

* The improvement in flexibility is a common characteristics of the mechatronics system when compared with a traditional system.

5.6. Case studies of mechatronics system :-

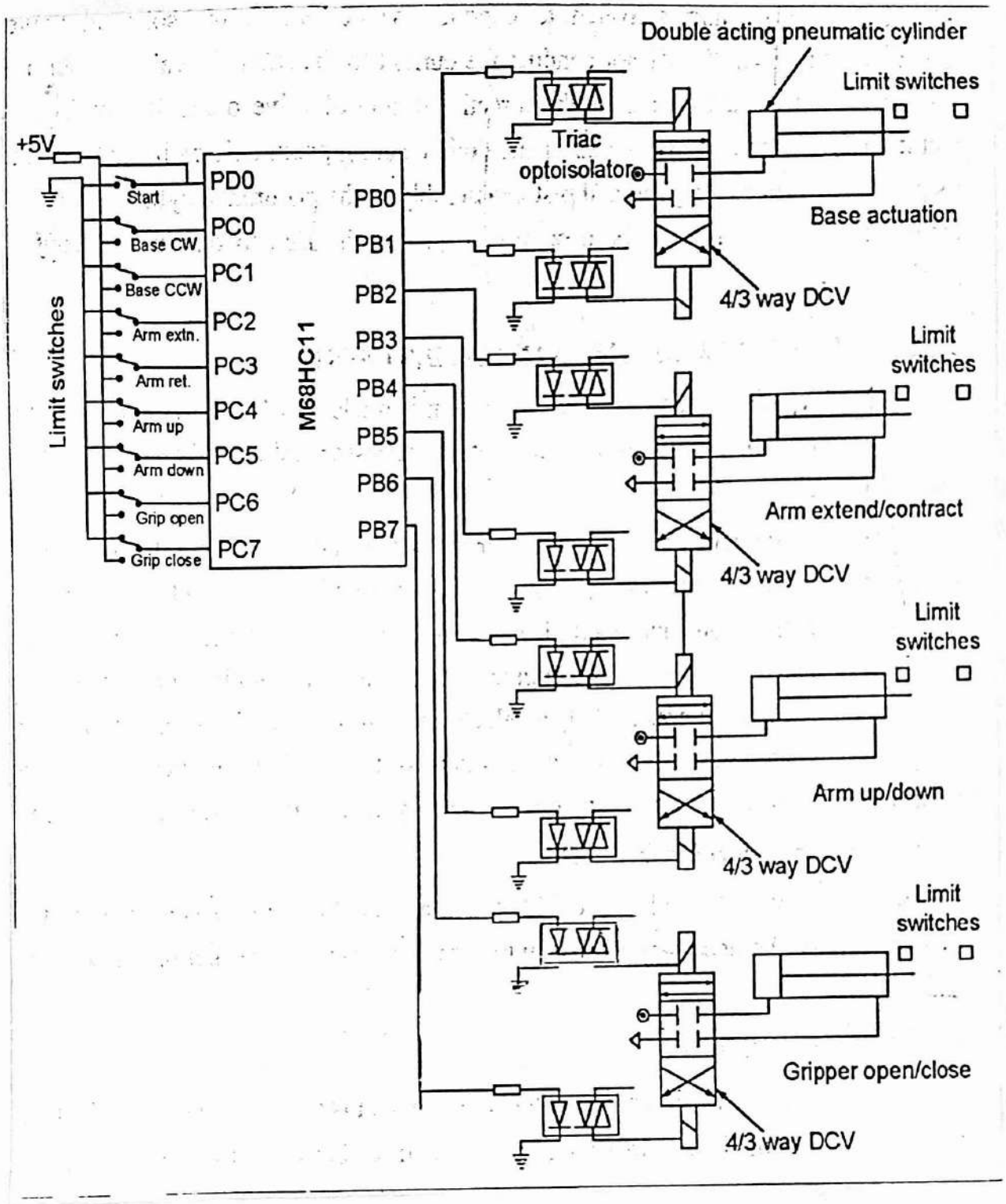
Case study : 1 : Pick and Place Robot.



The following movements are required for this robot.

* Clockwise and anticlockwise rotation of the robot unit on its base
* Linear movement of the arm horizontally i.e extension or contraction
* Up and down movement of the arm.
* Open and close movement of the gripper.

The clockwise rotation of the robot unit on its base can be obtained from a piston and cylinder arrangement during piston forward movement.



* A microcontroller used to control the solenoid valves of various cylinders is shown in figure.

* The microcontroller used of this purpose is m68HC11 type.

Case Study 2 :- Engine management system.

* An electronic engine management system is made up of sensors, actuators and related wiring which is tied into a central processor called Microprocessor.

* Electronic management systems monitor and gather data from a number of sensors in the engine and continuously adjust the fuel supply and injection timing.

1. Electronic Control unit (ECU)

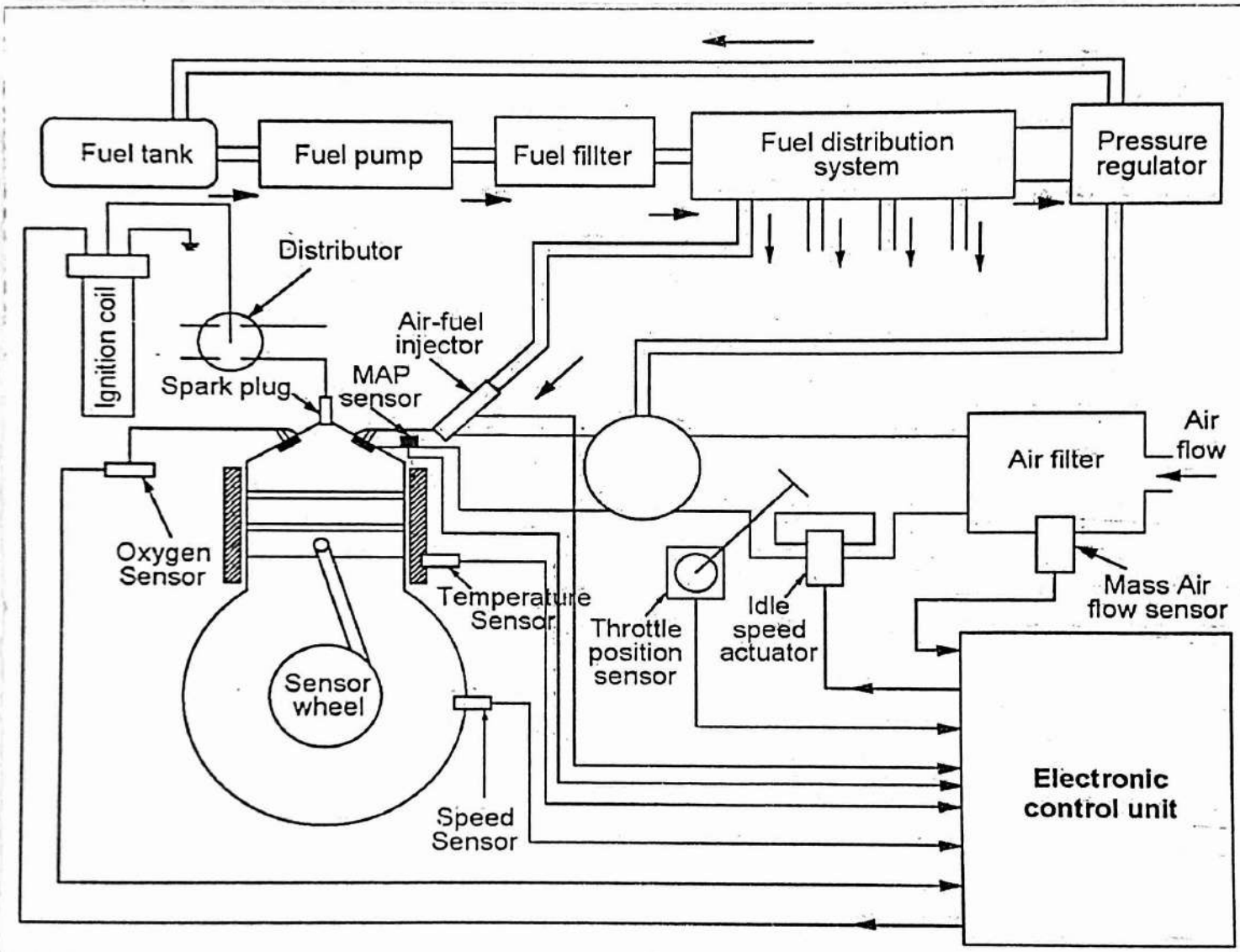
* The sensors provide feedback to ECU to indicate how the engine is running so that ECU can make the necessary adjustments to the operation of the fuel delivery and/or ignition system.

2. Fuel delivery system :-

* This system consists high pressure fuel pump which is mounted in or near the tank. The fuel line from the pump passes through a filter before it runs forward to the engine bay.

3. Ignition System:-

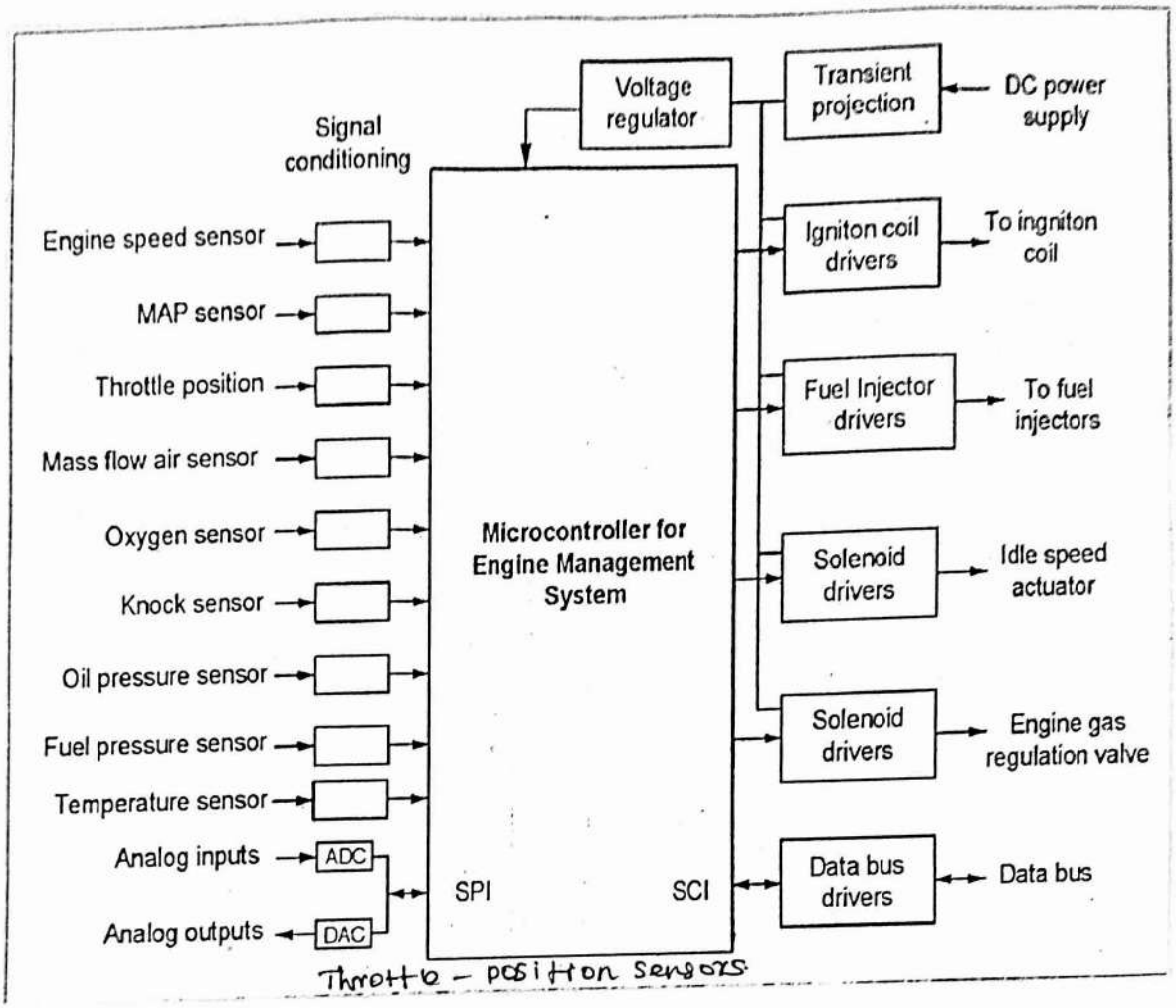
* Ignition system consists of ignition coil, distributor and spark plug. These components are connected with ECU to receive the signal for the proper timed operation.



* Ignition System consists of ignition coil, distributor and spark plug.

* These components are connected with ECU to receive the signal for the proper timed operation.

4. Various sensors used in engine management system :-

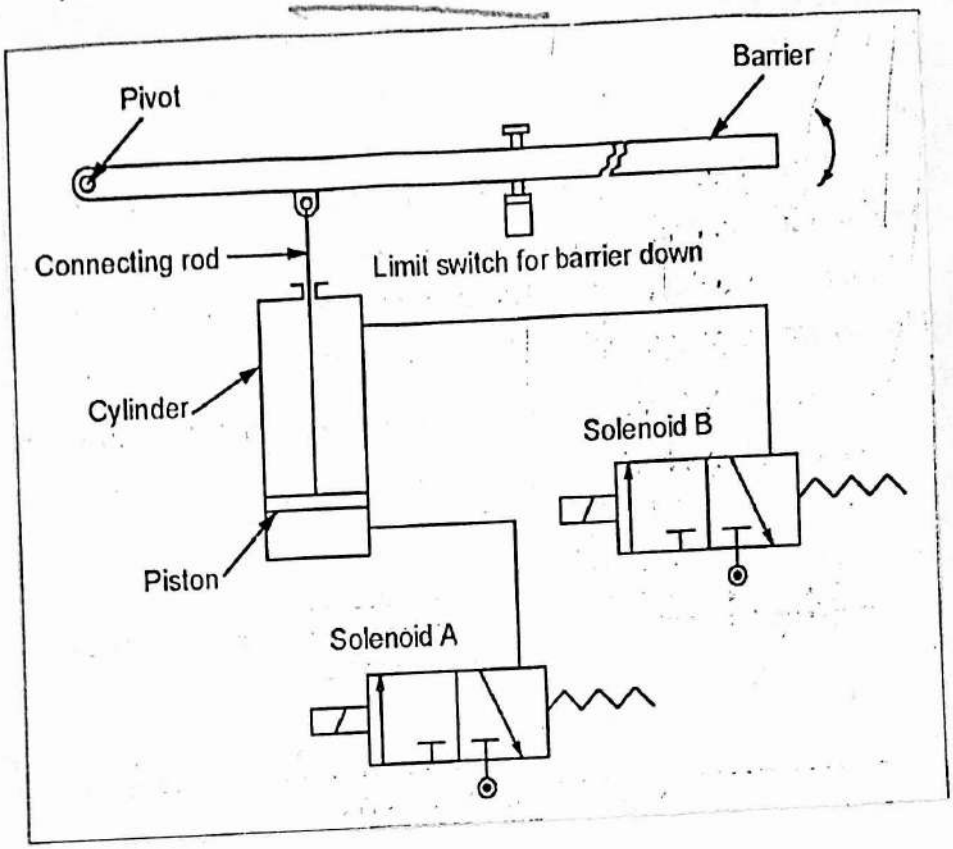


* Engine sensors fall into five broad categories :- Throttle position sensors, exhaust gas oxygen sensors, manifold absolute pressure sensors, temperature sensors and speed / timing sensors.

*. A throttle - position sensor sends the signal to ECU about the throttle opening and the force applied by the driver.

* Then the ECU controls the fuel delivery and spark timing based on the throttle position

Case Study 3 :- Automatic car park Barrier :-



* consider an automatic car park barriers operated by coin inserts. The system uses a PLC for its operation. There are two barriers used namely, in barrier and out barrier.

* In barrier is used to open when the correct money is inserted while out barrier opens. When a car is detected in front of it.

* It consists of a barrier which is pivoted at one end, two solenoid actuated 3/2 way directional control valves (DCVs) A and B and a piston cylinder arrangement.

Advantages of mechatronics systems over traditional systems

* Mechatronics system serves the purpose effectively with high dimensional accuracy requirements
* It provides increased productivity in the industry
* It facilitates in the manufacturing is reduced which results in lowering the production cost specially in mass production

Disadvantages :-

* Improper application and underutilization of the system can result losses.
* Maintenance and repair of systems may be costly affair.
* Initial cost and installation cost are high.
* A proper selection of mechatronics system is difficult and it needs a careful study of technology and cost
* It needs the work force of multi-disciplinary knowledge such as precision mechanics and integrated electronics