PIE Tech

POLLACHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by **AICTE** and Affiliated to **Anna University**)

sky is the limit

Department of Mechanical Engineering

Regulation 2021

IV Year – VII Semester

ME3791 MECATRONICS AND IOT

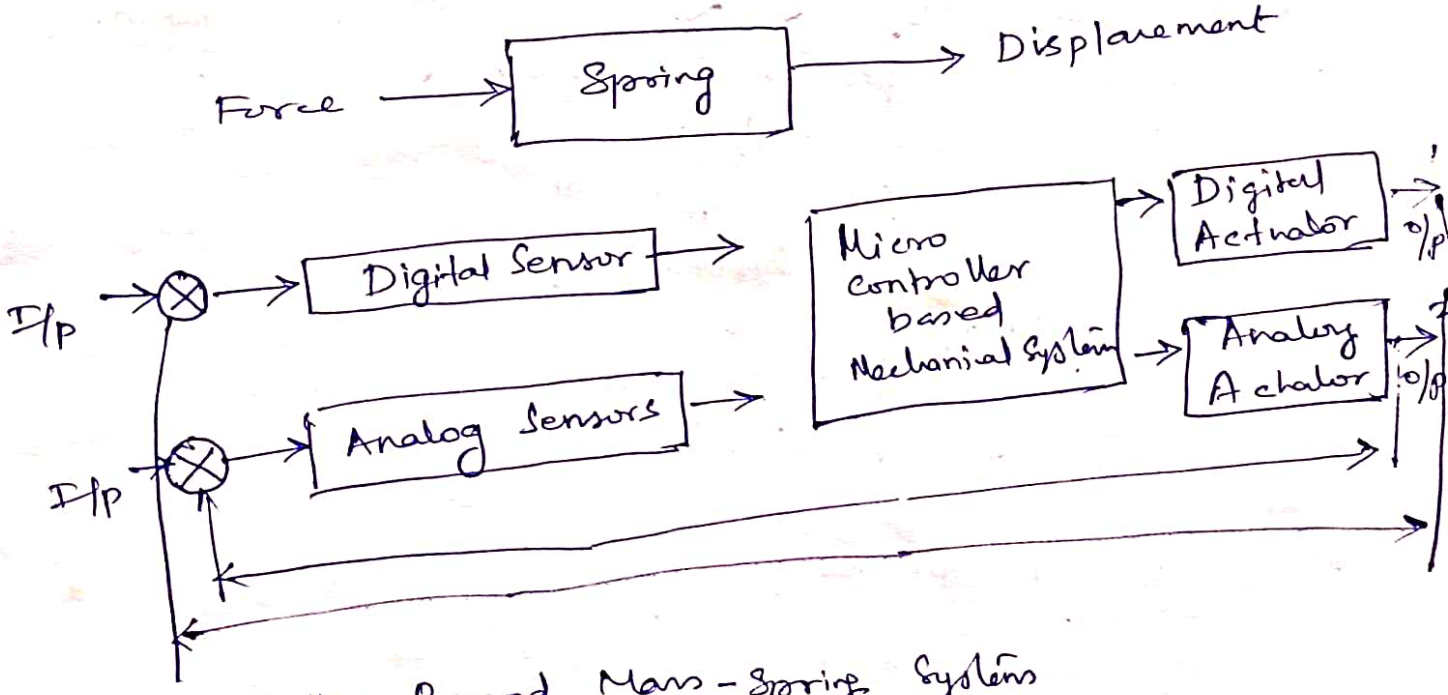
UNIT-1

INTRODUCTION TO MECHATRONICS

Definition:

Mechatronics is the synergistic integration of sensor, actuators, signal conditioning, power electronics, decision and control algorithms and computer hardware and software to manage complexity

- **Mechatronics Systems**



Micro controller Based Mass-Spring Systems

Hydraulic Systems

↓

Actuator

↑

Digital to analog Converter

CPU

Force Sensor/Strain gauge

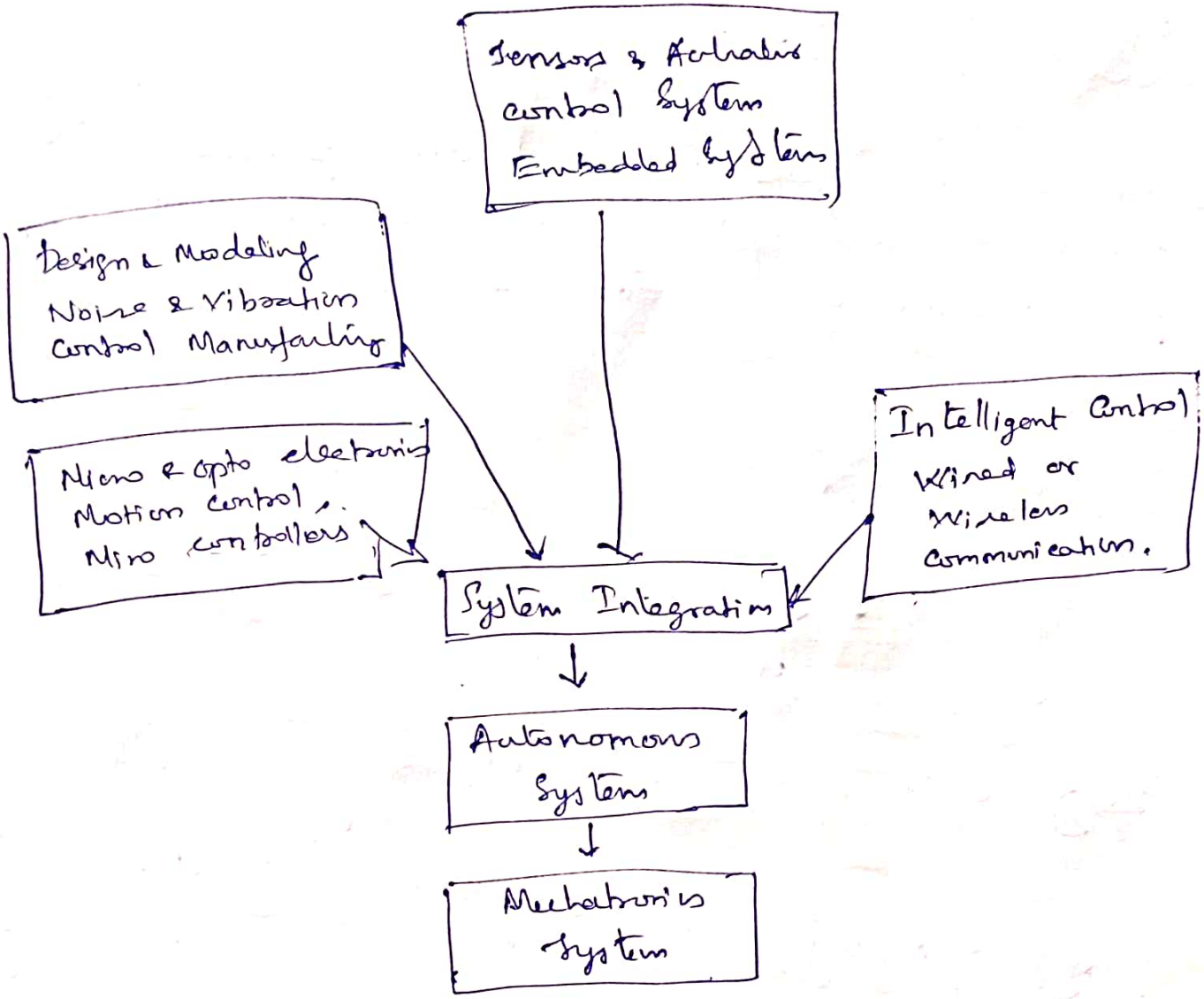
↓

Signal Conditioning Device

↓

Analog to Digital converter

Inter disciplinary Scenario



Need for Mechatronics

- Variety of product range
- Changing market condition
- Good product Quality
- Short production run
- Ease of reconfiguration of the process
- Enhancement in process

Scope of mechatronics.

- Better design of products
- Better process control
- process planning
- Reliable and quality mfg
- Intelligent process

Sensors and Transducers:

Specifications:

- Range
- Span
- Error
- Accuracy
- Sensitivity
- Nonlinearity
- hysteresis
- Resolution
- Stability
- Dead band
- Repeatability
- Response time

classification of Sensors:

- Displacement
- Velocity and motion
- Force - Strain
- Fluid pressure
- Liquid flow
- Liquid level
- Temperature

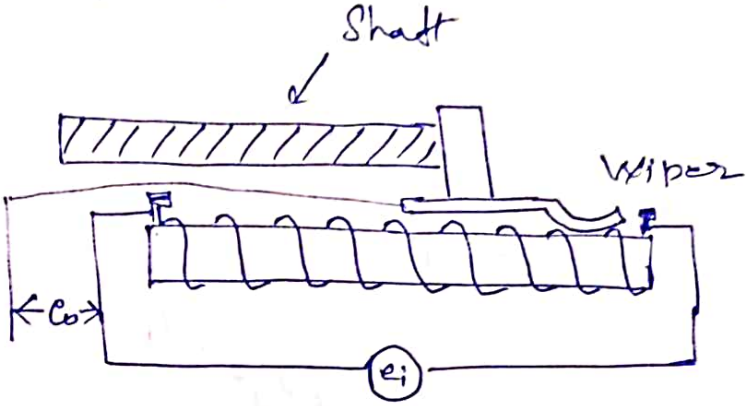
classification of Mechatronics:

- Primary level
- Secondary level
- Tertiary level
- Quaternary level

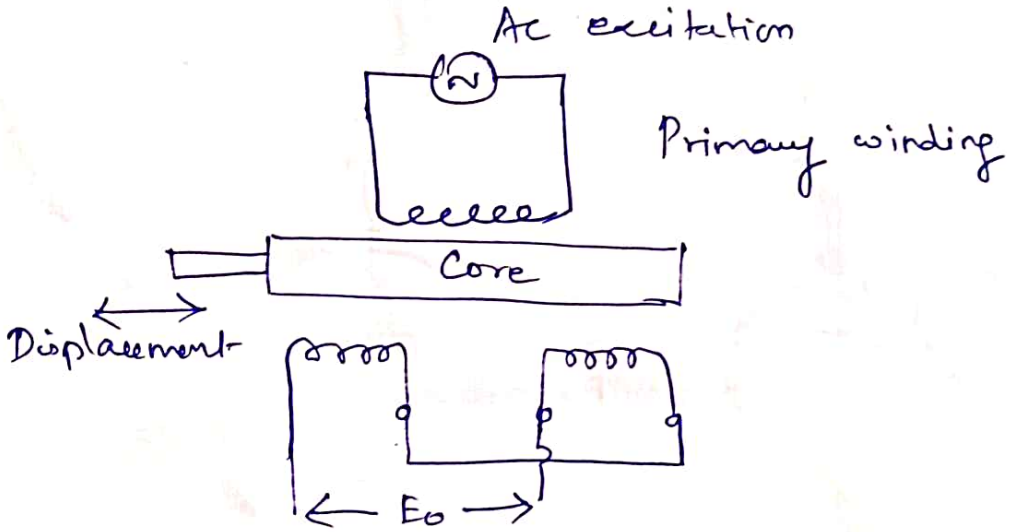
Static and dynamic characteristics of sensors:

- Accuracy
- Precision
- Resolution
- Minimum Detectable Signal
- Threshold
- Sensitivity
- Selectivity and Specificity
- Non linearity
- Hysteresis
- output impedance
- Isolation and groundig

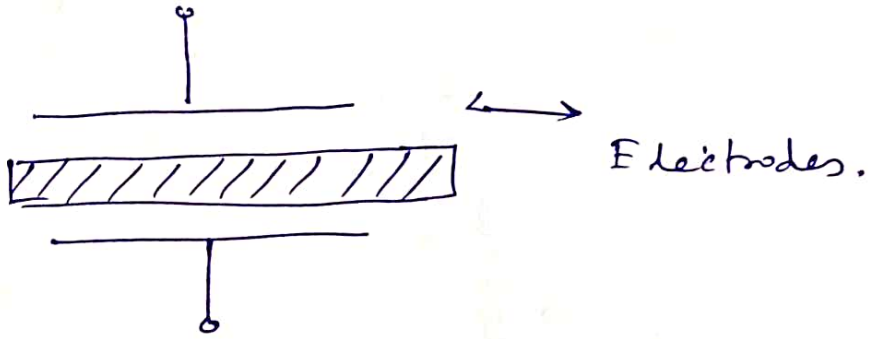
Resistive potentiometer:



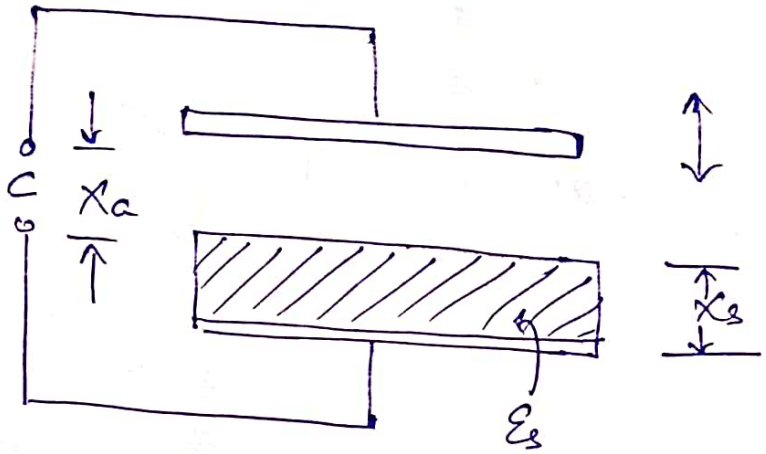
LVDT:



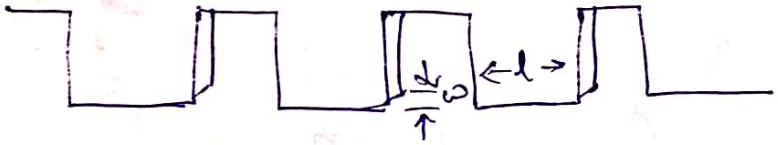
Capacitance Sensors:



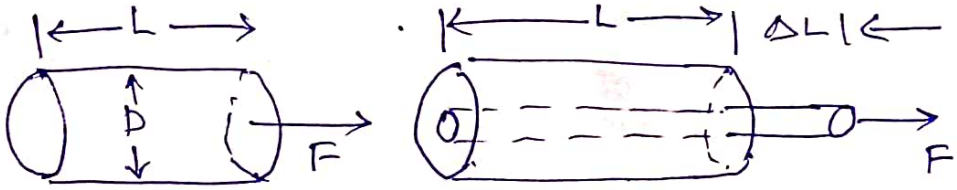
Parallel Plate Capacitive Sensor:



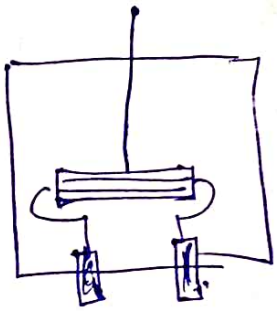
Serrated plate capacitive Sensor:



Strain gauges:

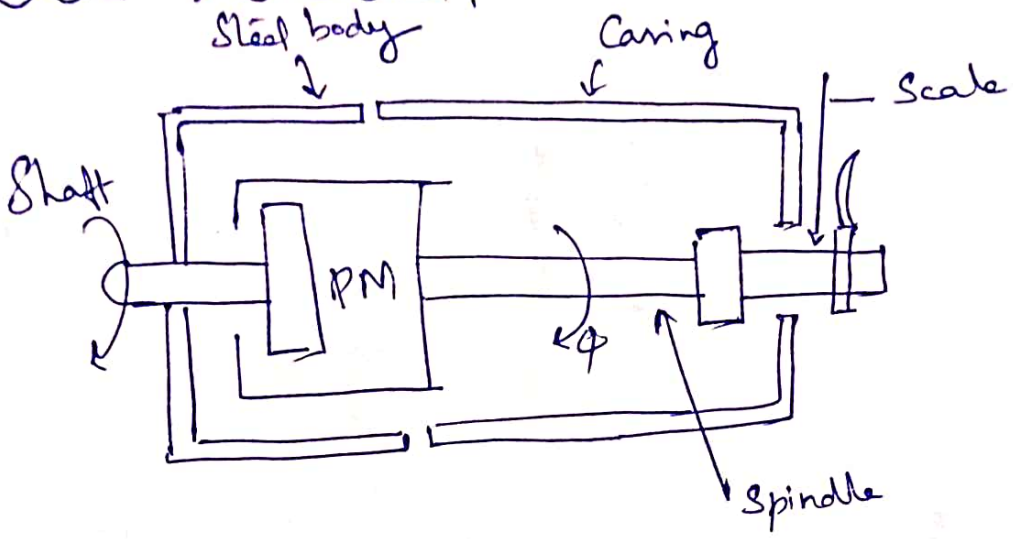


Semi conductor Strain gauges:

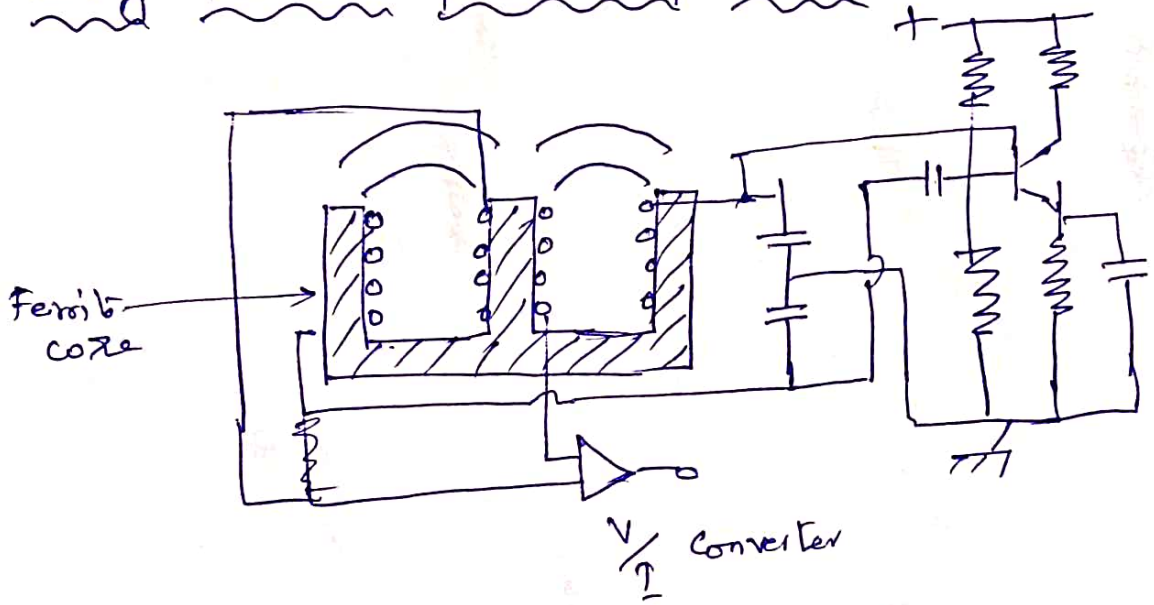


Terminals.

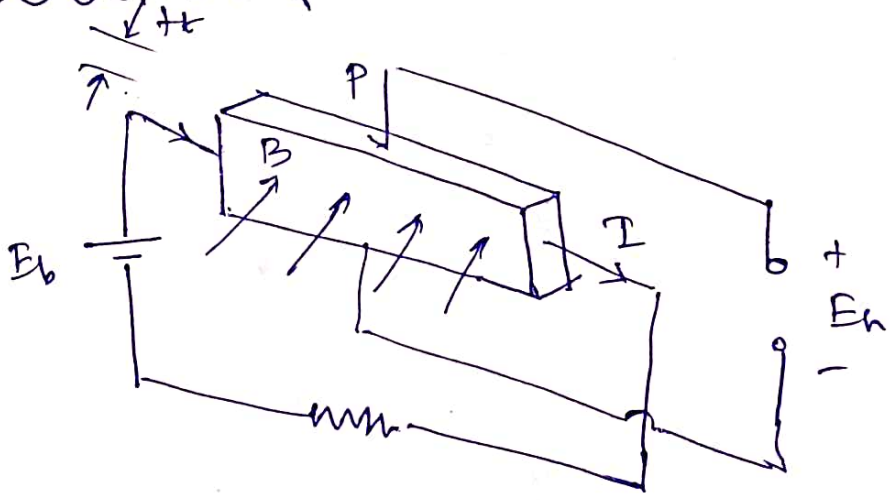
Eddy current Tachometer:



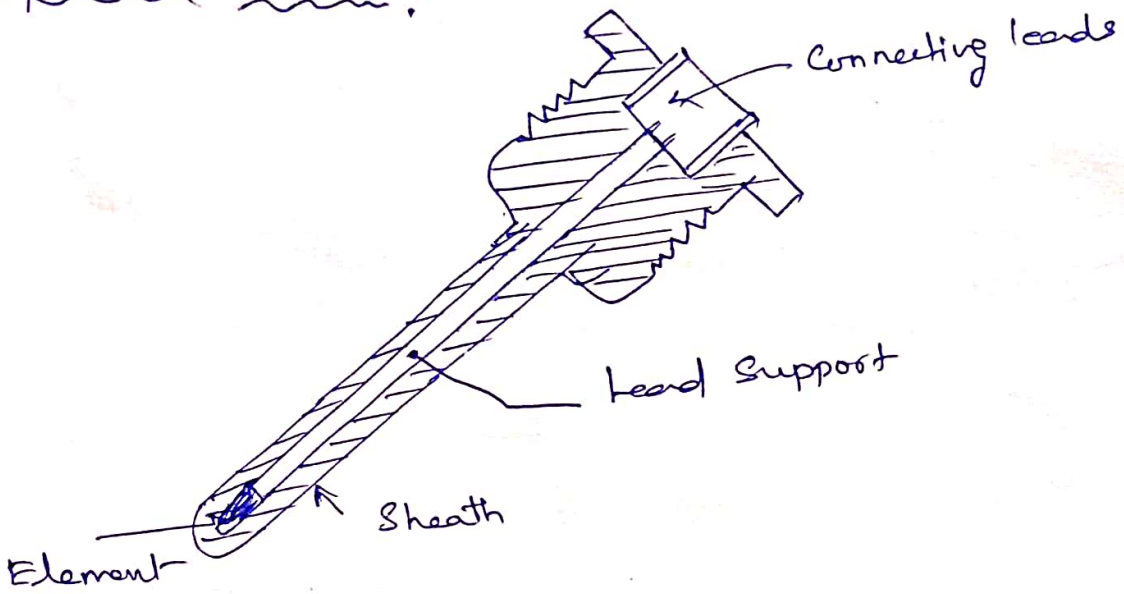
Eddy current proximity Sensor:



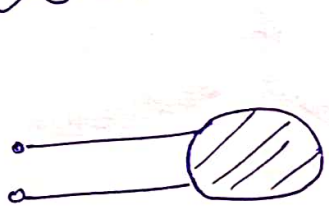
Hall-effect Sensor:



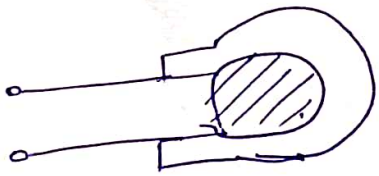
Temperature Sensors:



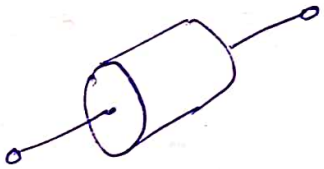
Thermistors:



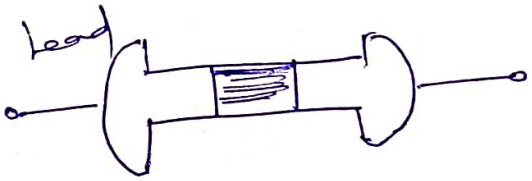
(a) Bead



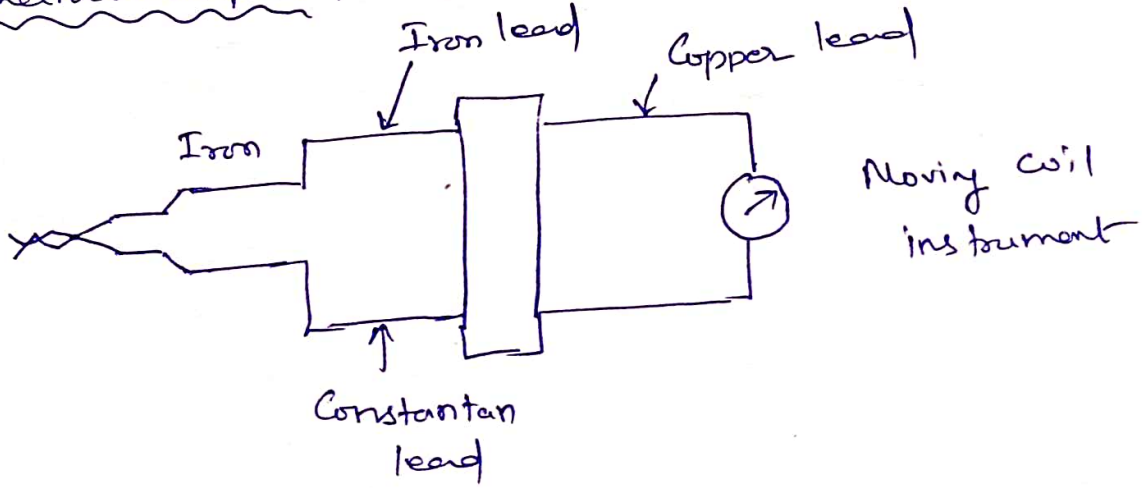
(b) Probe



(c) Disc



Thermocouples:



Light Sensors

- Photoemissive
- Photovoltaic
- Photo resistive

Photoelectric Sensors

- Photovoltaic sensor
- Photo emissive sensors
- Photo transistor
- Photo multiplier
- Photo counter

Photovoltaic Sensors:

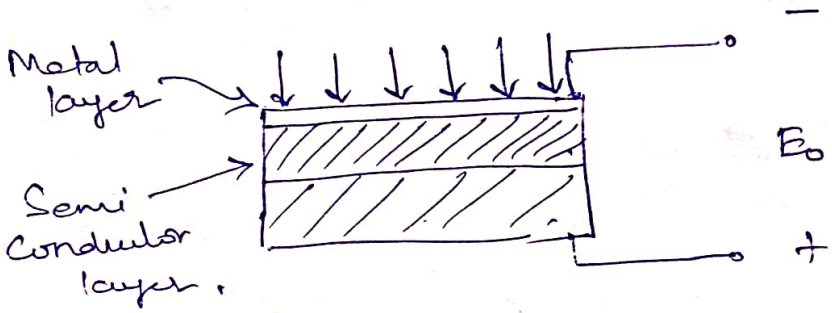


photo emissive Sensors:

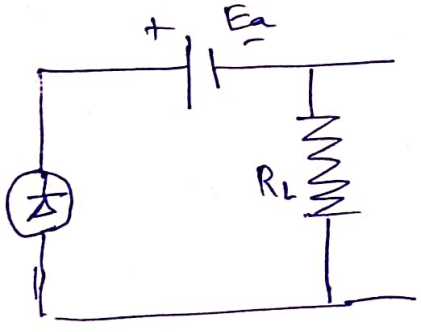


Photo Transistor and its Arrangement:

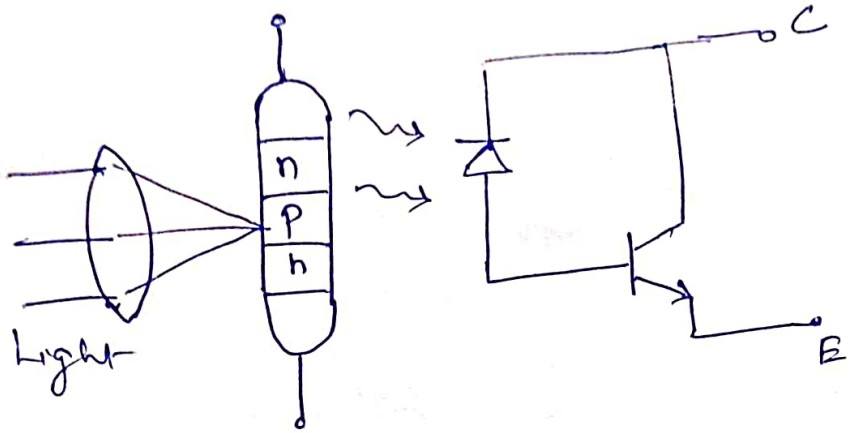
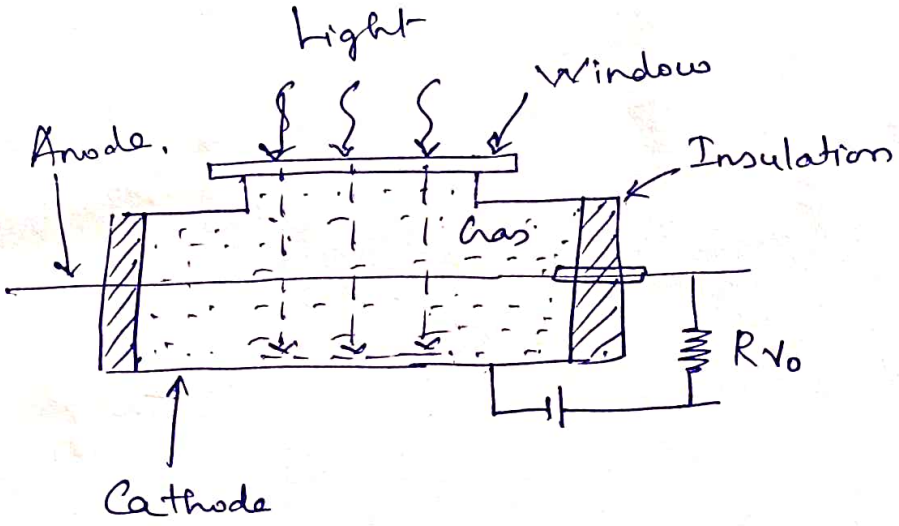


photo Counter:

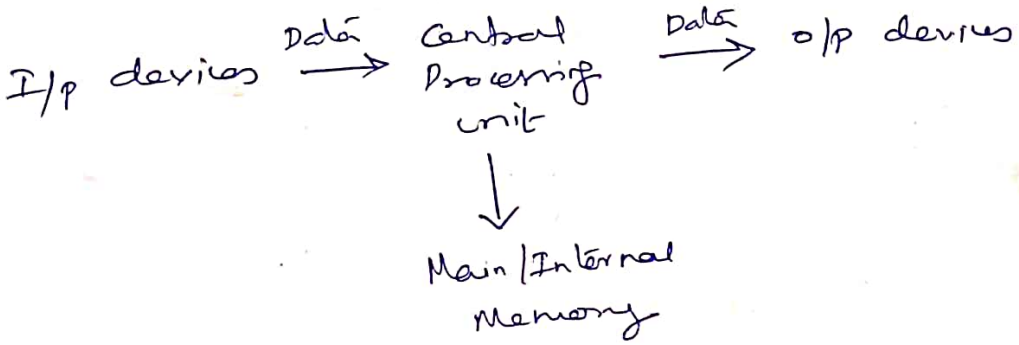


UNIT-II

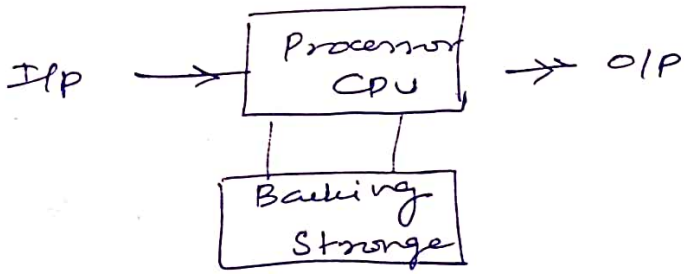
MICROPROCESSOR AND MICROCONTROLLER

8085 MICROPROCESSOR AND 8051 MICROCONTROLLERS

Digital computer :



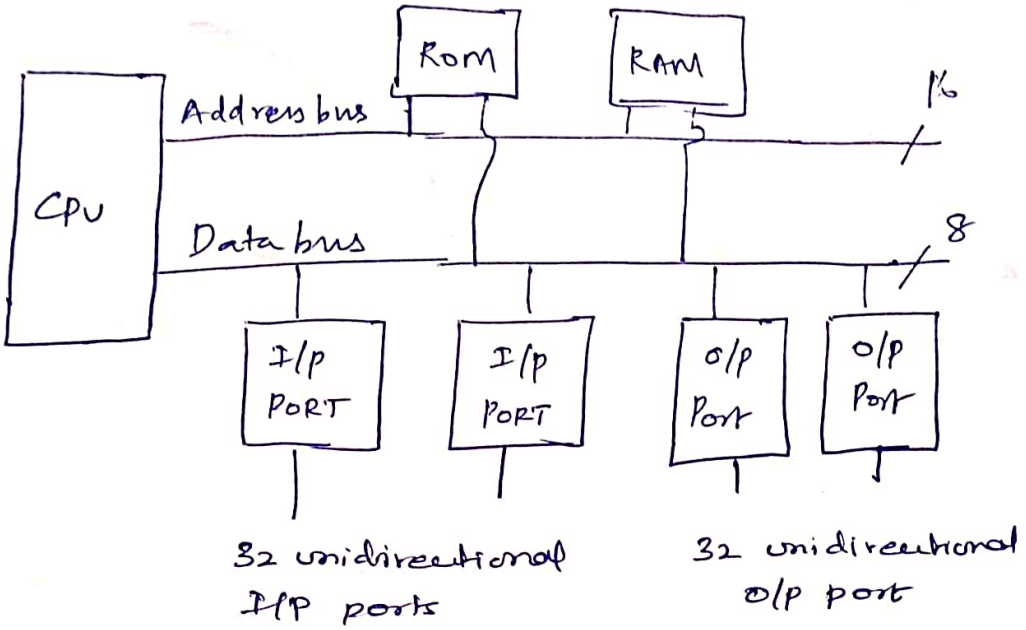
Micro computer :



CPU

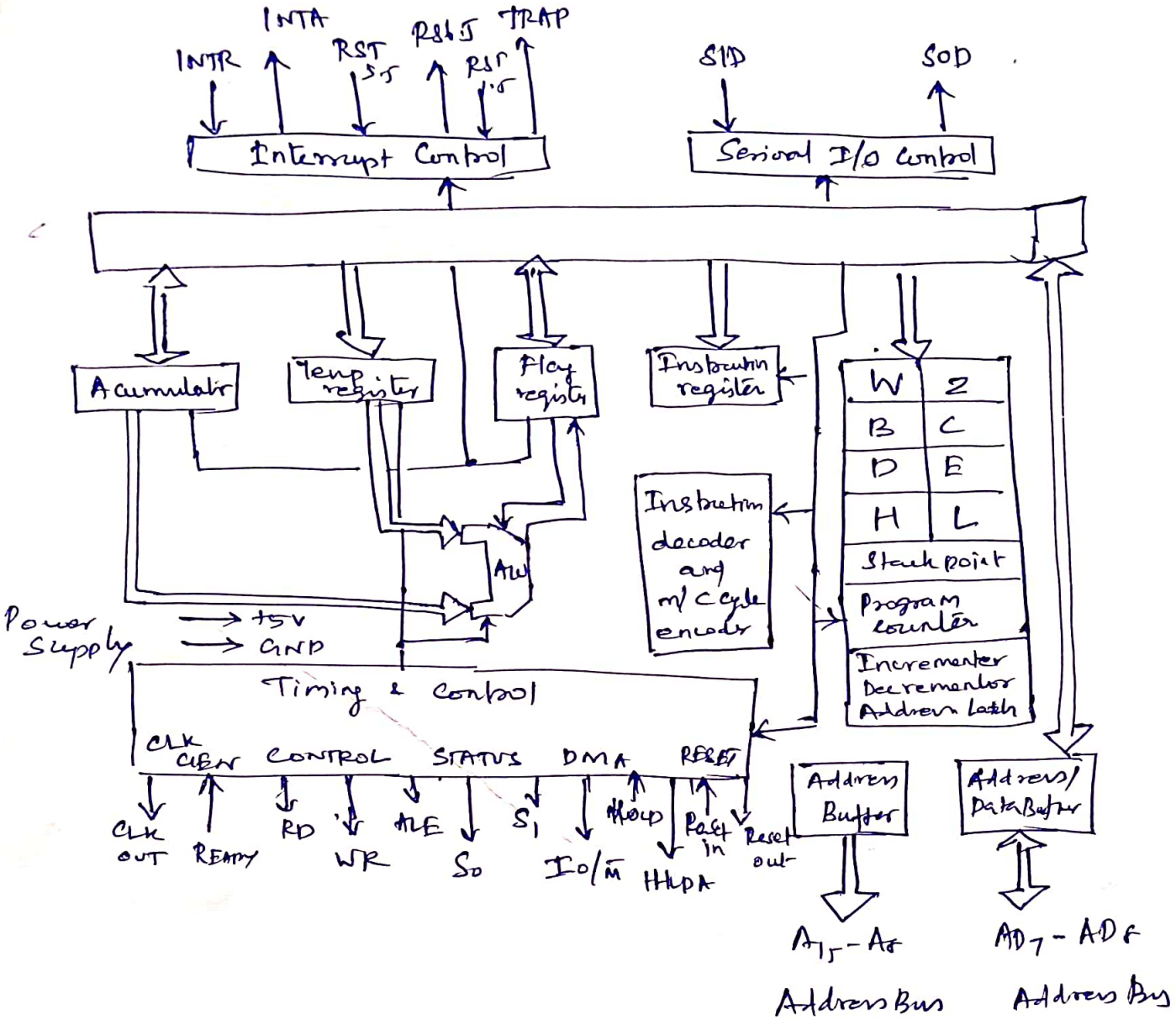
- ALU
- Timing and control unit
- Registers

Schematic Connection of Memory and I/O devices to micro processor:



ARCHITEATURE OF 8085 MICRO PROCESSOR

- Registers
- Arithmatic and logic units
- Instruction decoder, m/c cycle encoder
- Address / Data buffer
- Incrementer / Decrementor Address latch
- Interrupt control
- Serial I/o control
- Timing control circuitry


INTA
INTR
RST 5.5
RST 6.5
RST 7.5
TRAP
Interrupt Control
SID
SOD
Serial I/O control
Accumulator
Temp register
Flag register
Instruction register
W
Z
B
C
D
E
H
L
Stack point
Program counter
Incrementer Decrementer Address latch
Instruction decoder and m/c cycle encoder
ALU
Power Supply
+5V
GND
Timing & Control
CLK
CLEAR
CONTROL
STATUS
DMA
RESET
CLK OUT
READY
RD
WR
ALE
S0
S1
IO/M
HOLD
HLDA
Reset in
Reset out
Address Buffer
Address/ Data Buffer
A15 - A8
AD7 - AD0
Address Bus
Address Bus

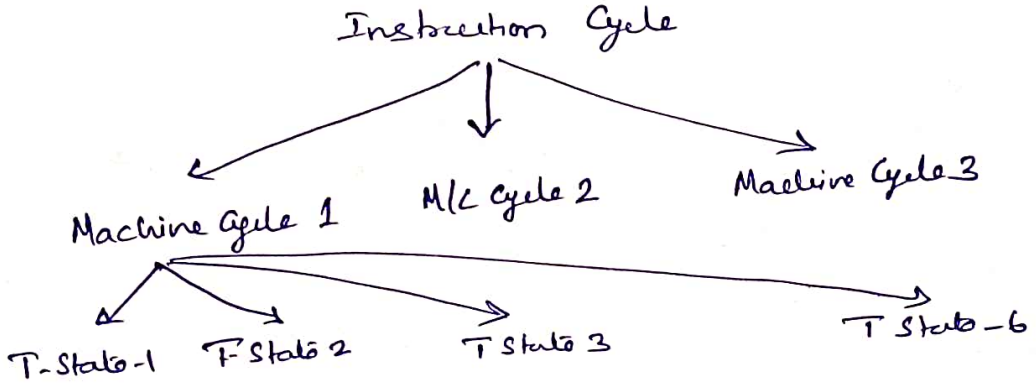
CONFIGURATION OF BUS

- Power and frequency signal
- Data bus and address bus
- Control bus
- Interrupt signal
- Serial I/O signal
- DMA signal
- Reset signals

Addressing modes:

- Immediate addressing
- Direct Addressing
- Register Addressing
- Register Indirect Addressing
- Implied addressing.

Instruction Cycle: (IC)

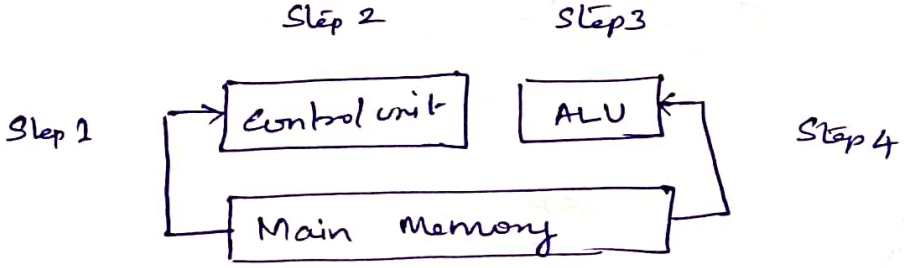


IC = FC + EC

FC - Fetch operation

EC - Execute Operation

Machine Cycle and State:



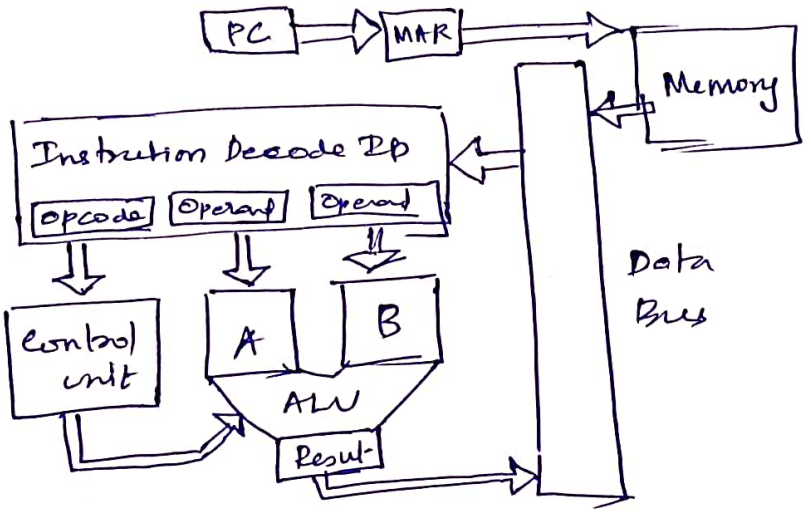
Step - 1 - Fetch Instruction from memory

Step 2 - decode instruction into commands

Step 3 - execute commands

Step 4 - Store result in memory.

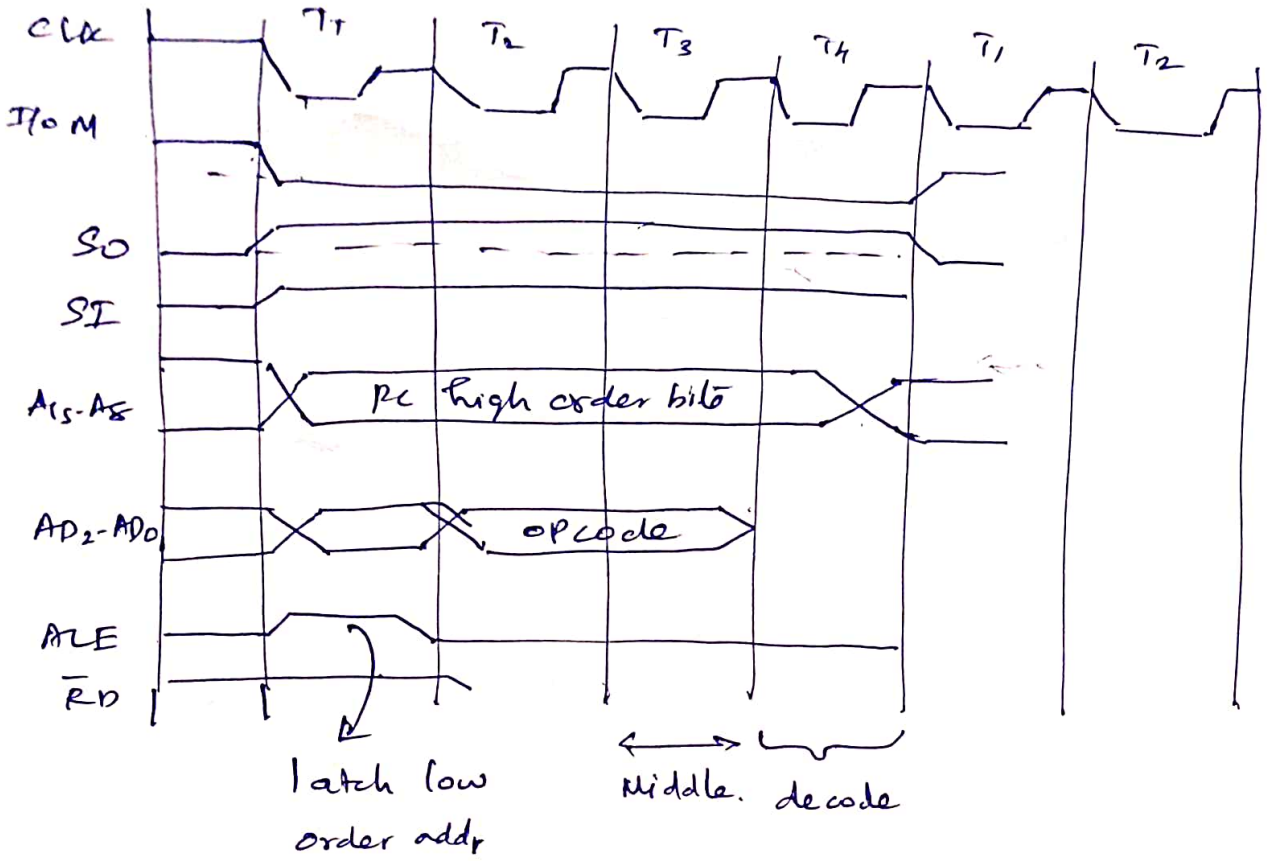
Instruction and Data flow.



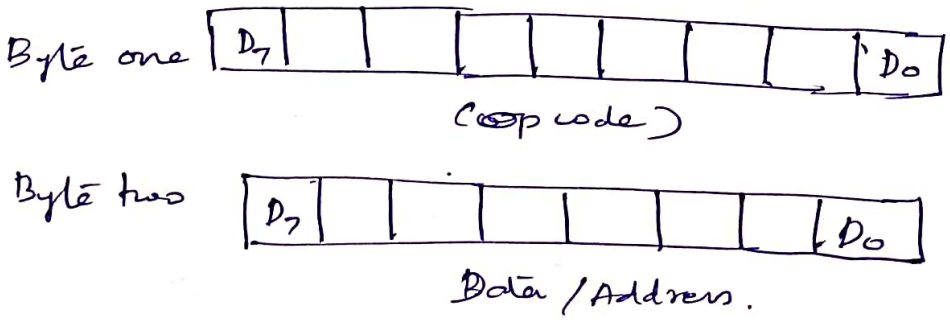
- Timing diagram:

  - Opcode fetch m/c cycle
  - Memory Read m/c cycle
  - Memory write m/c cycle
  - I/O read machine cycle
  - I/O write m/c cycle
  - Interrupt AC knowledge cycle
  - Bus idle.

8085 Timing diagram:



Instruction format:



Instruction Set:

- Data transfer group
- Arithmatic group
- Logic group
- Branch group
- Stack, Input/Output M/c control group

Notation	Meaning
M	- Memory location pointed
r	- 8-Bit register
rp	- 16 Bit register pair
rs	- Source register
rd	- destination register
addr	- 16 bit address.

Data transfer group:

1. MOV rd, rs - Move
2. MOV rd, M - Move from memory
3. MOV M, r - Move to memory
4. MVI r, data(8), MVI - Move immediately
5. MVI M data(8)
6. LXI rp data(16) - load register pair immediate

7- LDA addr - Load accumulator Direct

8 - STA addr - Store accumulator direct

9 - LHLD addr - Load H and L Direct

10 - SHLD addr - Store H and L Direct

11 - LDAX rp - Load accumulator Indirect

12 - STAX rp - Store accumulator Indirect

13 - XCHG - Exchange H and L with Dand E

Arithmatic Instructions:

1 - ADDr - Addition

2 - ADD M - Add memory

3 - ADI data(m) - ADI (Add immediate)

4 - ADC r - Add with carry

5 - ADC M - Add data in memory

6 - ACI data(8) - Add register with carry

7 - SUB r - Subtract

8 - SUB M - Subtract data in memory

9 - SUI data - Subtract immediate

10. SBB r - Subtract register with Borrow

11. SBB m - Subtract memory data and borrow flag from accumulator

12, SBI data(8) - Subtract immediate with borrow

13, INR r — Incremental register

14, INR M — Incremental data in memory

15, DCR r — Decrement

16, DCR M — Decrement data in memory

17, INX rp — Incremental Register pair

18, DCX rp — Decremental register pair

19, DAD rp — Add register pair to H & L

Logical Instruction:

1, ANA r - AND register with accumulator

2, ANA M - AND data in memory with accumulator

3, ANI data(8) - AND Immediate

4, XRA r - Exclusive OR with accumulator

5, XRA M - XOR data in memory with accumulator

6, XRI data - Exclusive OR Immediate

7. ORA r - OR with accumulator

8, ORA M - OR data in memory with accumulator.

9, ORI data - OR immediate

10, CMP r - Compare

11. CMP M - Compare data in memory with accumulator

12. CPI data - Compare immediate

13, RLC - Rotate accumulator left

14, RRC - Rotate accumulator Right

15, RAL - Rotate accumulator left through carry

16, RAR - Rotate accumulator Right through carry

17, CMA - Complement A

18, CMC - Complement carry

19. STC - Set carry

Branch Instructions:

1, JMP addr - Jump

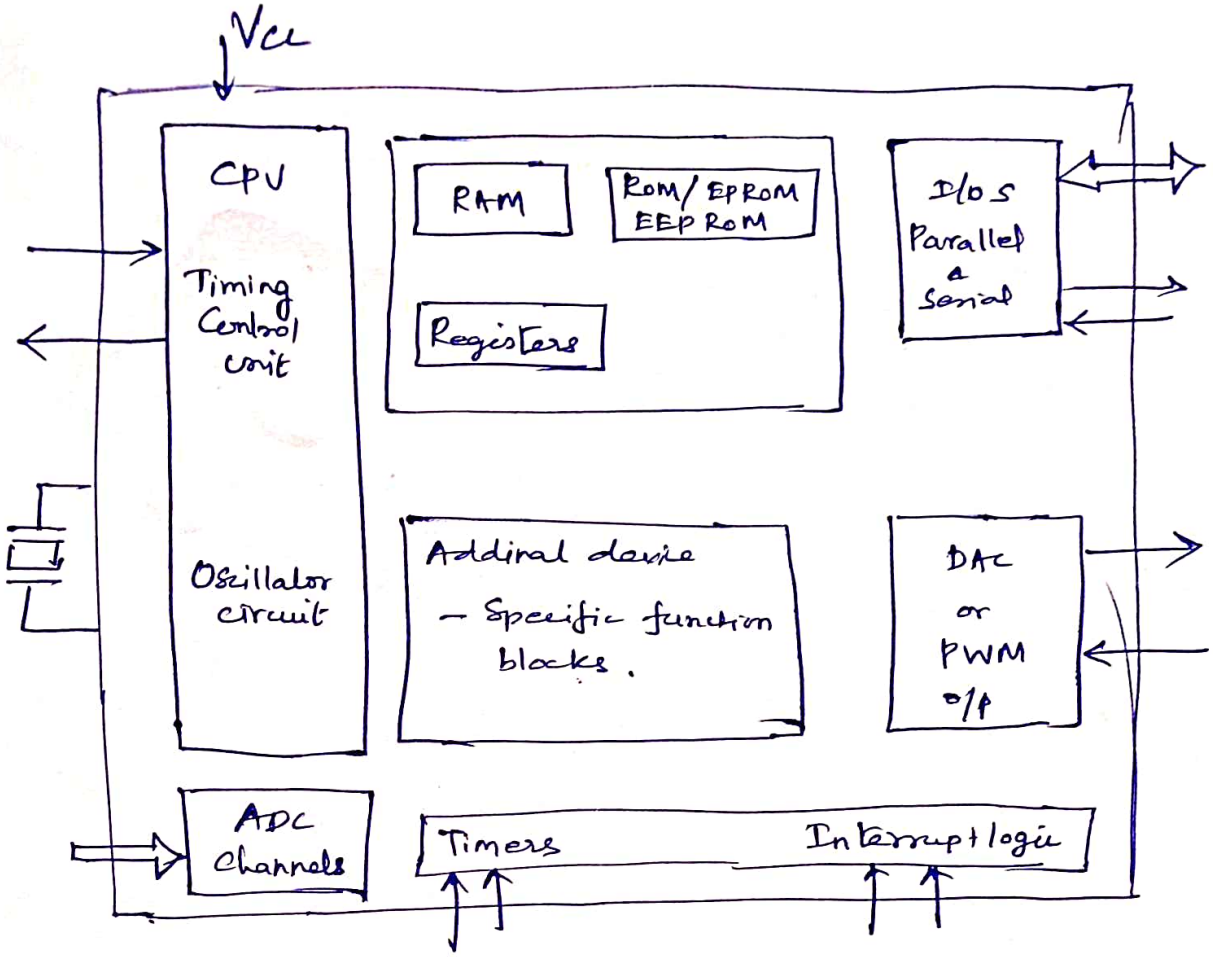
2. J Condition addr - Conditional Jump

3, PCHL - Jump H and L Indirect

Programming of micro processor:

- Assembly language
- high level language

8051 Micro Controllers:



Features of 8051

- 4096 bytes on chip program memory
- 128 bytes on chip memory

Architecture of 8051

- ALU (Arithmetic logic unit)
- PC (Program Counter)
- Registers
- Timers and Counters
- Internal RAm, ROM

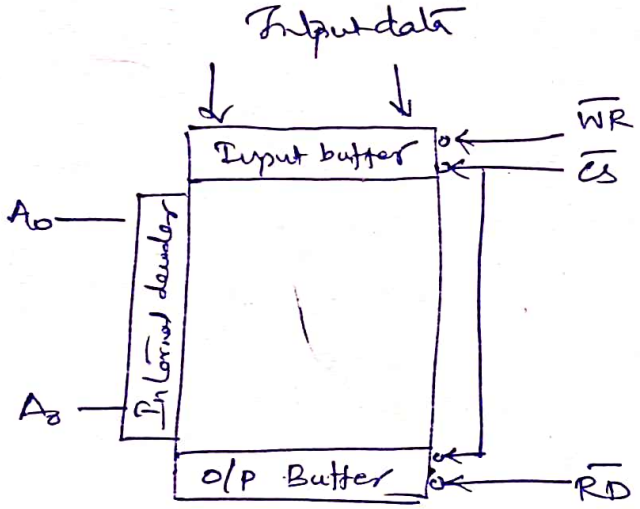
- Four general purpose parallel I/p, o/p ports
- Interrupt control logic with five sources of interrupt
- Serial data communication
- PSW (Program Status word)
- Data pointer (DPTR)
- Stack pointer (SP)
- Data and address bus

PROGRAMMABLE PERIPHERAL INTERFACE

Memory Interfacing:

The micro processor initiates a set of signals when it wants to read from and write in to memory.

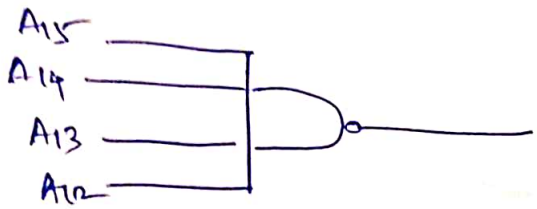
Memory Structure and Requirements:



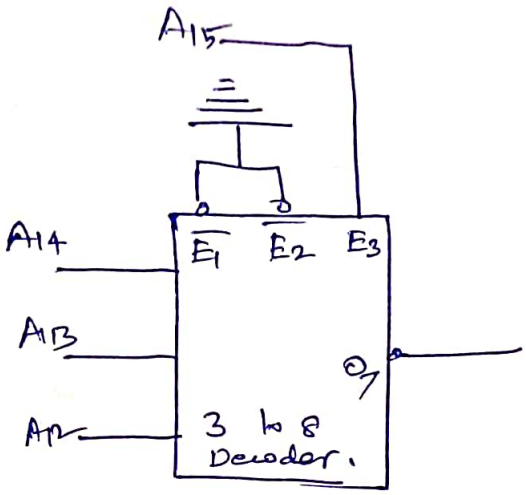
Basic concepts in memory interfacing

- Be able to select chip
- Identify the register
- Enable to appropriate buffer.

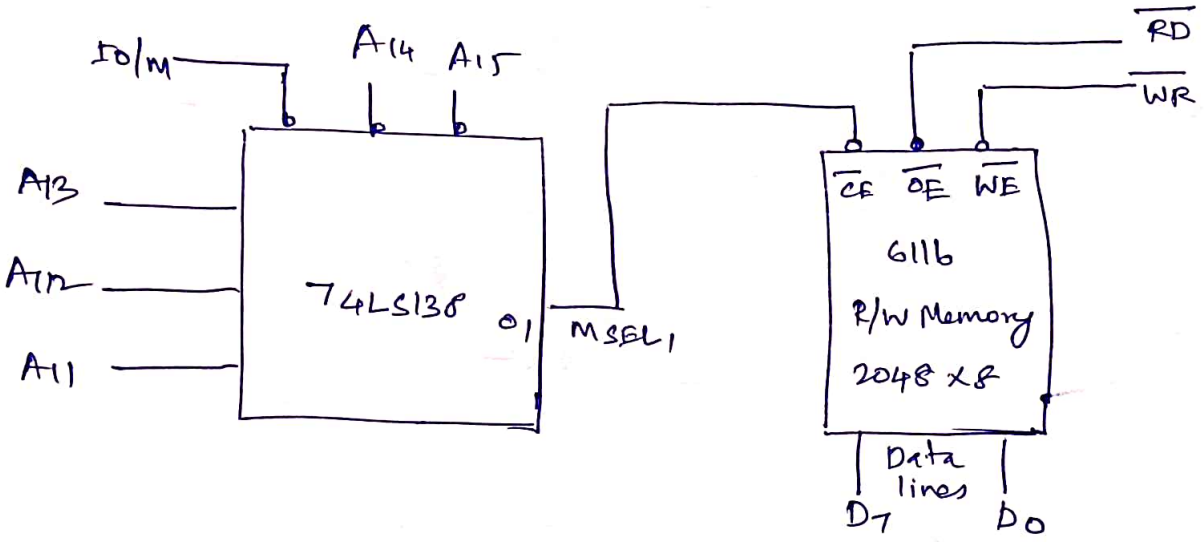
Address decoding



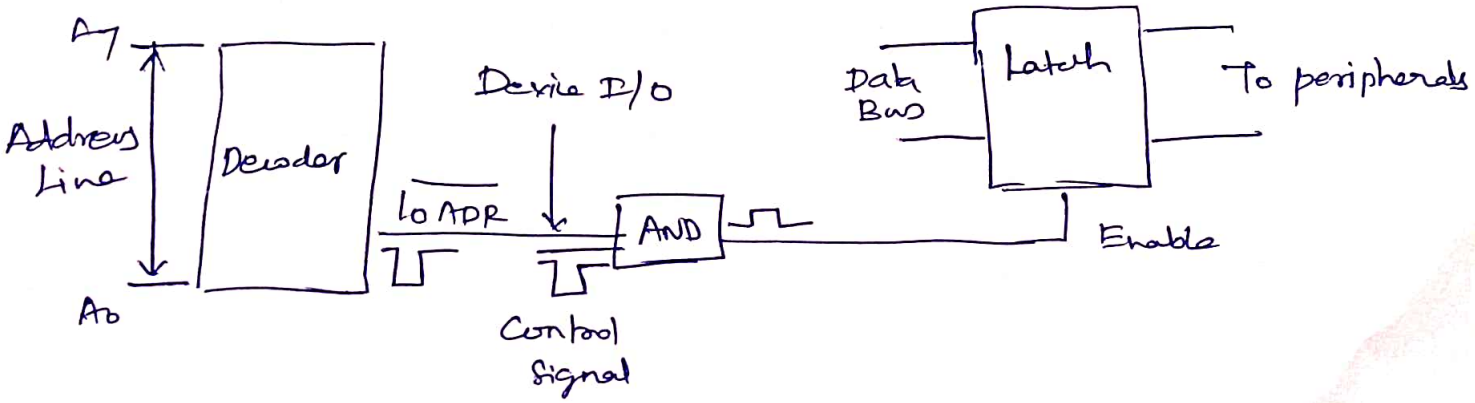
(a)



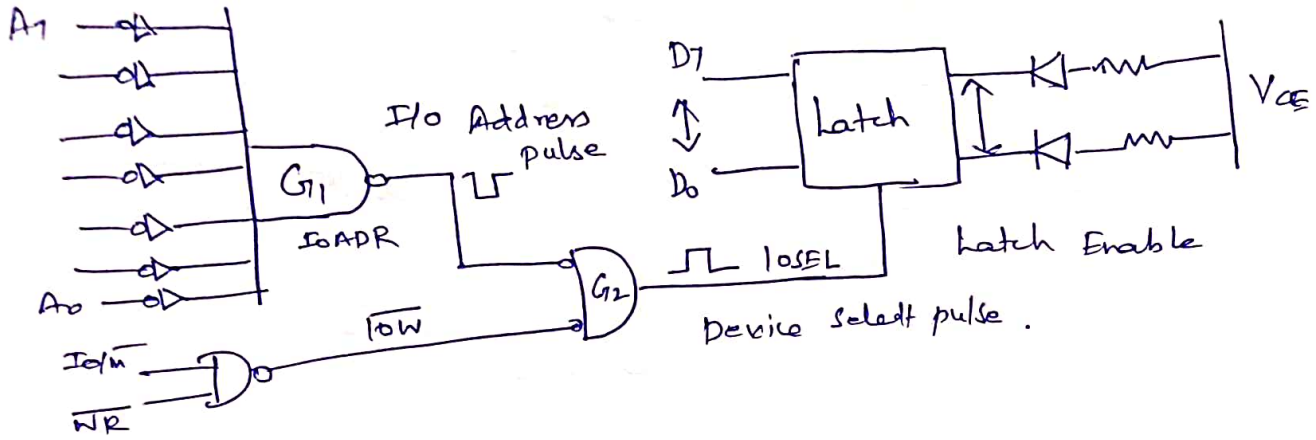
Interfacing R/W memory:



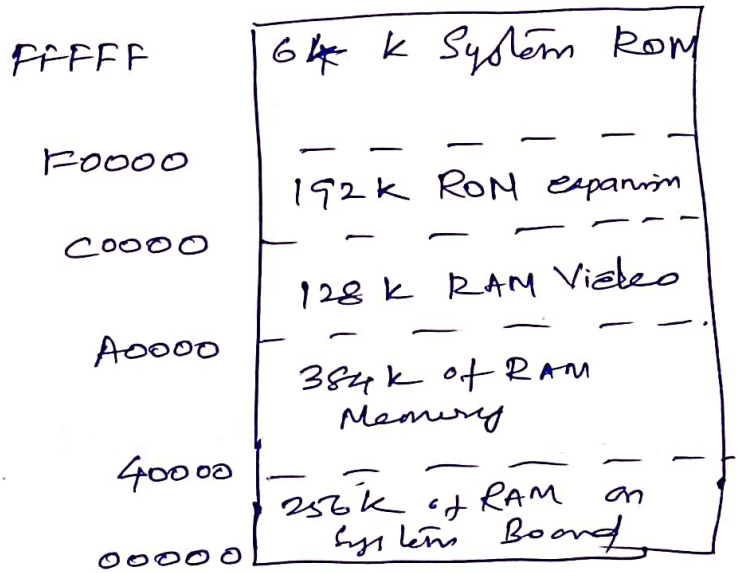
Block diagram of I/O Interface:



Absolute Vs partial decoding:



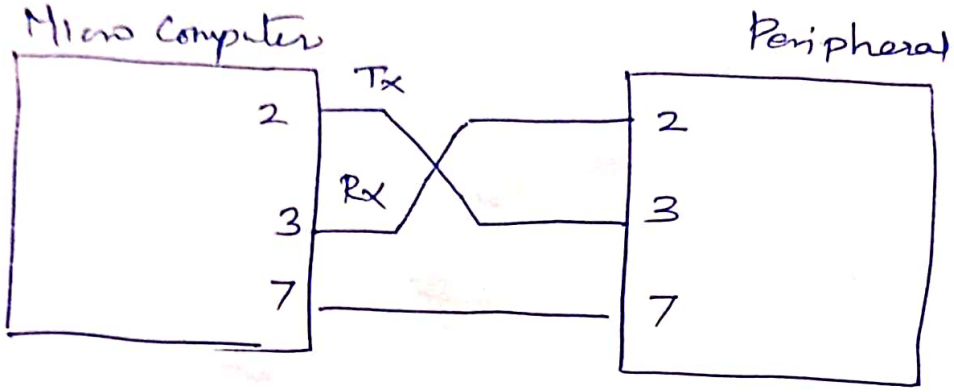
Interfacing Communication:



Serial Communication:

- Baud rate
- Number of bits in the ASCII group
- odd even or no parity
- Number of Stop bits.

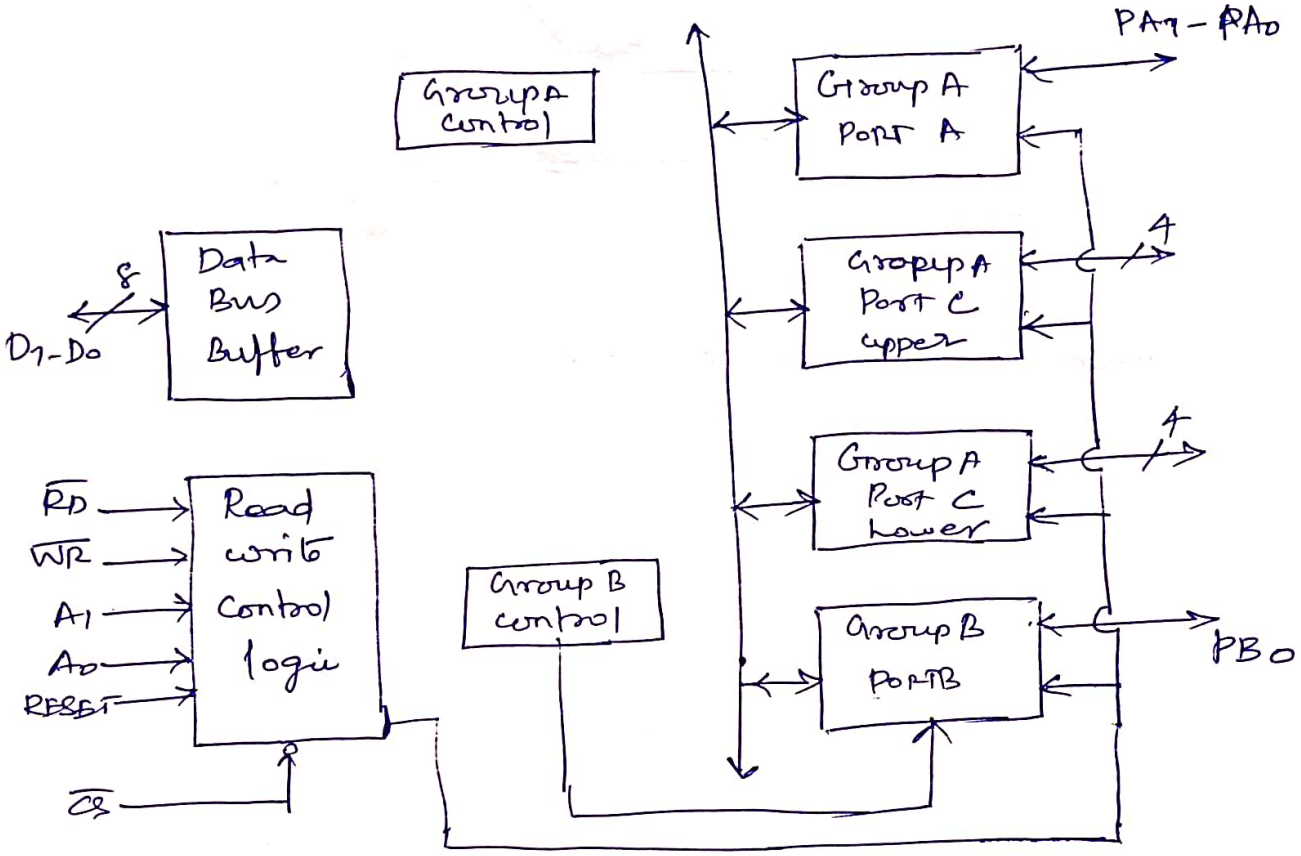
Parallel Communication.



Difference betn Parallel & Serial Communication:

- Data transfer
- Speed
- Connection
- cost and Space

INTEL 8255:



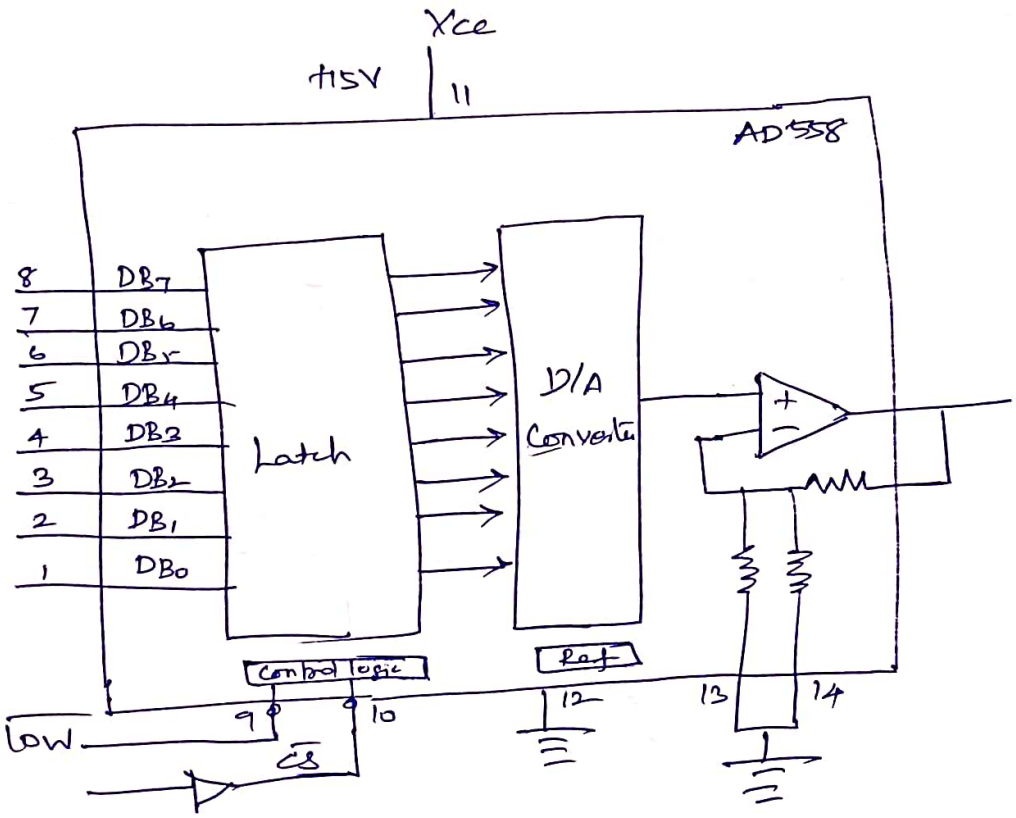
Function Description:

- Data Bus buffer
- Read/write and logic control
- $\overline{CS}$ chip select
- $\overline{WR}$ (write)
- A_1, A_0 port select
- RESET
- PORTS A, B and C
- Group A, Group B Control

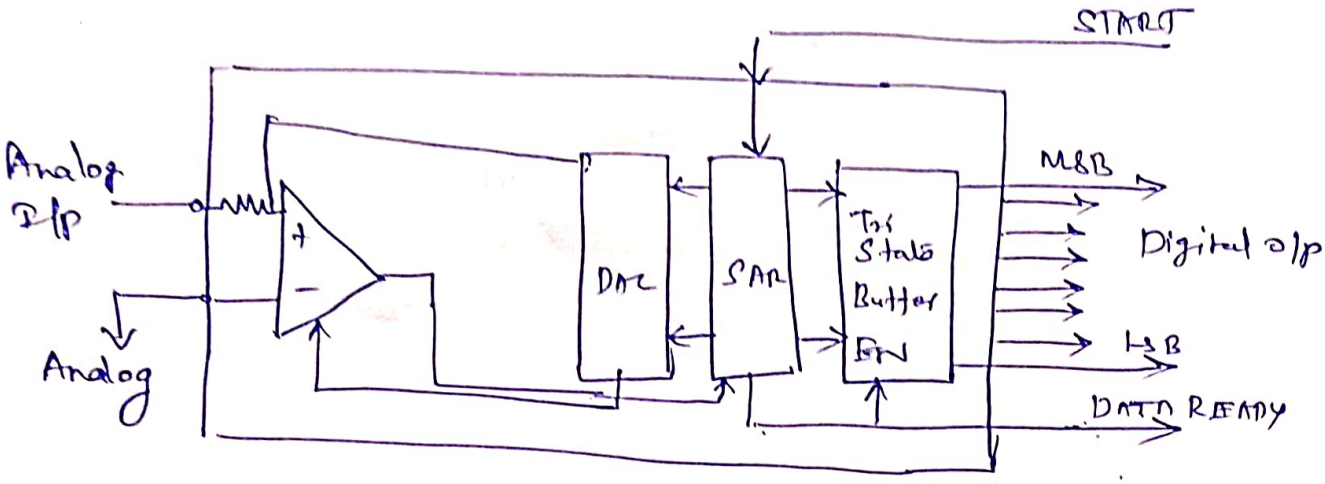
ADC and DAC interfaces

- Digital to Analog converters
  - Current o/p
  - Voltage o/p
  - Multiplying type
- D/A Converters
- D/C Converters

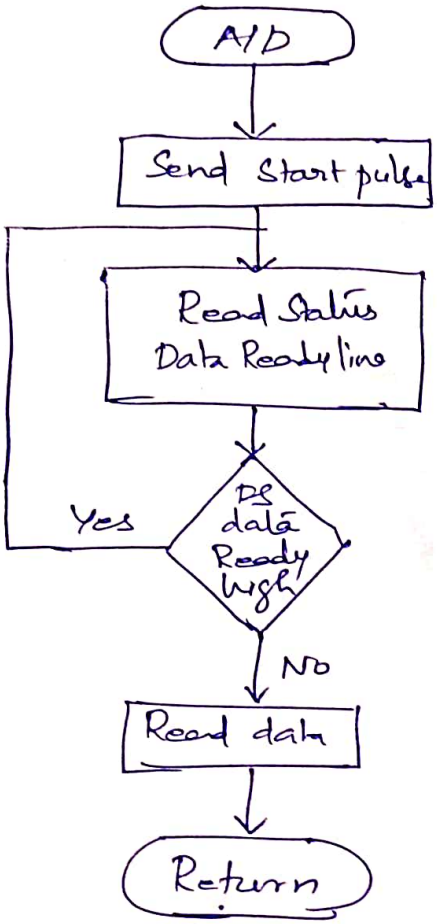
Micro processor - Compatible D/A Converters:



Interfacing 8 bit A/D Converter



Flow chart of A/D Conversion process:



OUT 82H - Start Conversion

TEST IN80H - Read Data Ready Status

RAR - Rotate Do into carry

JC TEST - If Do=1 conversion is not yet complete

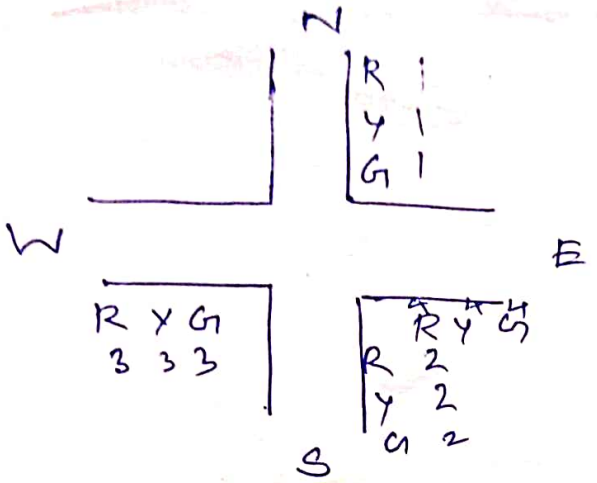
IN 81H - Read o/p and
- Save it an accumulator

RET

TRAFFIC CONTROL INTERFACE:

Sequence:

- Traffic is allowed from West(W), to east(E) and E to W transition for 20 seconds.
- Give transition period of 5 seconds (Yellow)
- Allow traffic from North(N) to south(S) and S to N for 20 seconds
- Give transition period of 5 seconds (Yellow as)
- Repeat the process.



Program for 8085

```
MVI   A, 80H   : Initialize 8255, Port A and
                 port B
OUT   83H (CR) : Input / O/P mode

START MVI   A 09H
OUT   80H (PA) : Send data on PA to glow
                 R1 R2
      MVI   A 24H
OUT   81H (PB) : Send data PB to glow
                 G3 G4
      MVI   C 28H : Load multiplier count (40)10
                    for delay
      CALL  DELAY : Call delay Subroutine
      MVI   A, 12H
OUT   80H PA   : Send data on Port A to
                 glow Y1 and Y2
OUT   81H PB   : Send data on Port B to
                 glow Y3 , Y4
      MVI   C, 0AH : Load multiplier count(10)10
      CALL  DELAY  : Call delay Subroutine.
```

OUT PA : Send data on port A to glow Y_1 and Y_2

OUT PB : Send data on port B to glow Y_3 and Y_4

MVI C,0AH : Load multiplier count (10_{10})

CALL delay : Call delay subroutine.

JMP START

UNIT-IV

PROGRAMMABLE LOGIC CONTROLLER

Characteristics Function of PLCs

- Allows modify programs as per requirements.
- Contain Least logic, timing counting and memory functions
- Determine precisely how the machine
- Checking and diagonitics
- Monitoring capabilities
- with stand the temp, humidity vibration
- Control tasks,

PLC Advantages:

- Flexibility
- Implementing Changes and Correction
- large Quantities of Contacts
- Lower Cost
- Pilot Running
- Visual observation
- Speed of operation
- Ladder or Boolean programe

- Reliability and Maintainability
- Simplicity of ordering Control System
- Documentation
- Security
- Ease of changes by Reprogramming

Dis advantages:

- Newer Technologies
- Fixed Program Applications
- Environmental Considerations
- Fail-Safe operation
- Fixed circuit operation.

Types of PLC:

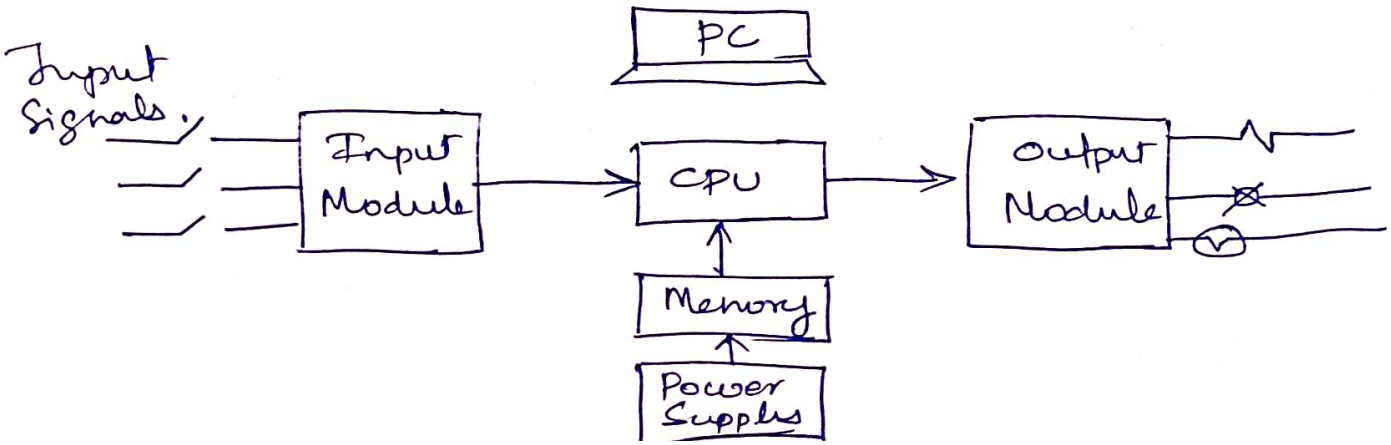
- Unitory PLC
- Modular PLC
- Small PLC
- Medium PLC
- large PLC

Languages:

- Variables
- Online Vs offline
- Flow control
- Functions
- Maintainability
- Speed
- Efficiency
- Ladder Language

Basic Structure:

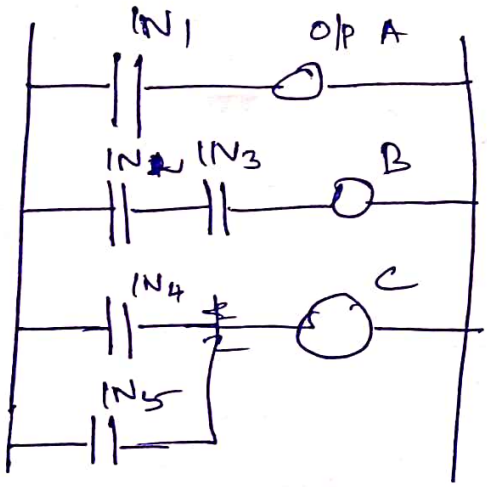
- Sensing input or controlling hardware
- Input section
- CPU
- Hand held programming
- output section
- Output devices.



- Sensing Section
- Input Section
- Controller
- Programmer
- output section
- Field hardware devices.

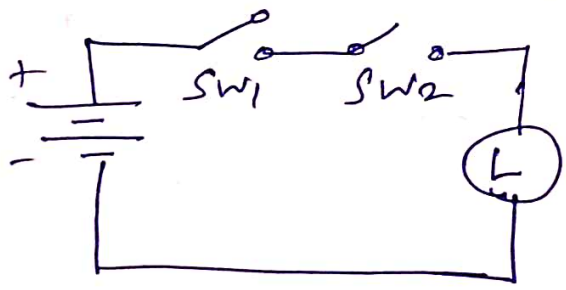
- PLC programming:

Ladder diagram:



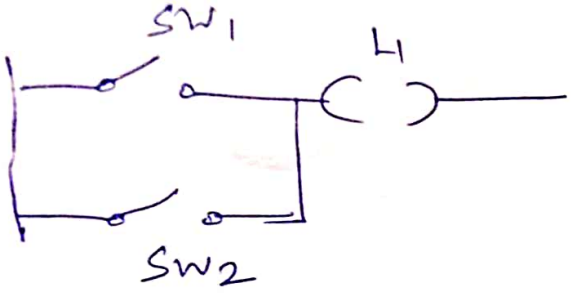
PLC Logic:

AND Logic.



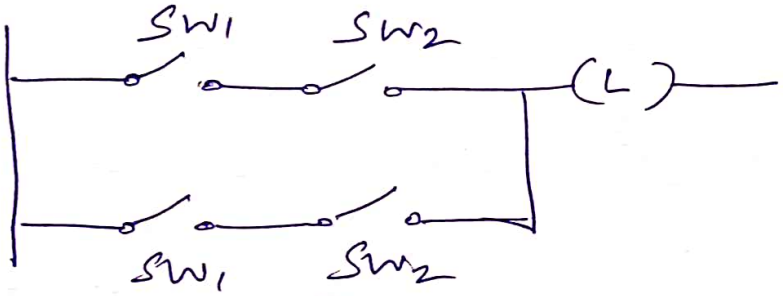
SW_1	SW_2	L_1
0	0	0
0	1	0
1	0	0
1	1	1

OR Logic.



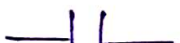
SW_1	SW_2	L_1
0	0	0
0	1	1
1	0	1
1	1	1

Exclusive OR Logic:

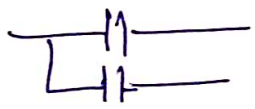


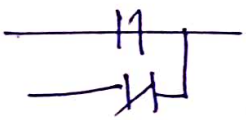
SW_1	SW_2	L_1
0	0	0
0	1	1
1	0	1
1	1	0

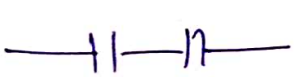
Boolean Instructions and Functions:

-  - Store (STR) - Load (LD)

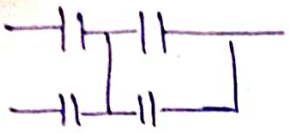
 Store Not (STR NOT) - Load Not (LD NOT)

 OR (OR)

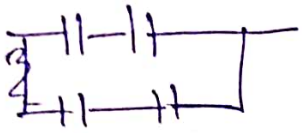
 OR NOT (OR NOT)

 And (AND)

 And Not (AND NOT)



And Store (AND STR) – And Load



Or Store (OR STR) – or Load

—(OUT)— Out (OUT)

—(OROUT) Or out (OR OUT)

Output Not 

PLC Processor:

Steps

Step 1. The inputs are read and stored
2. The ladder it program is starting from rung zero
3. Evaluating the rung,
4. Executing the output instructions
5. one additional rung automatically inserted by the software.
6. automatically inserted by the software "end rung"
7. updating CUP services.

PLC Instructions:

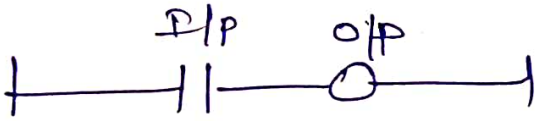
1. output Status file
2. Input Status file
3. Processor Status file
4. Bit file
5. Timer file
6. Counter file
7. Control file
8. Integer file
9. Floating point file
10. Common interface file

PLC Registers:

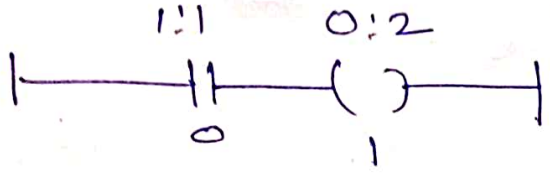
- holding registers
- Single input registers
- Group input registers
- Signal output register
- Group output registers

PLC instruction set:

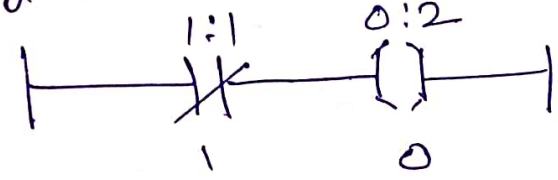
Normally open instructions:



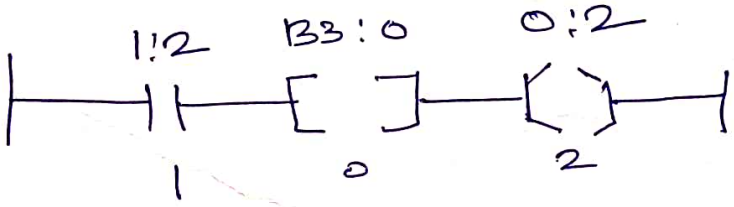
output instruction



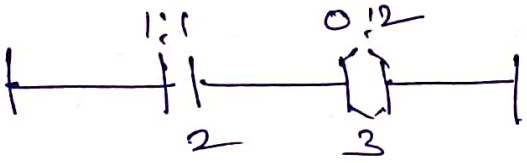
Normally closed Instructions:

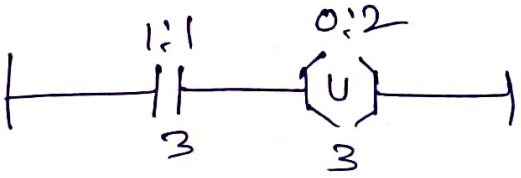


One Shot instruction:

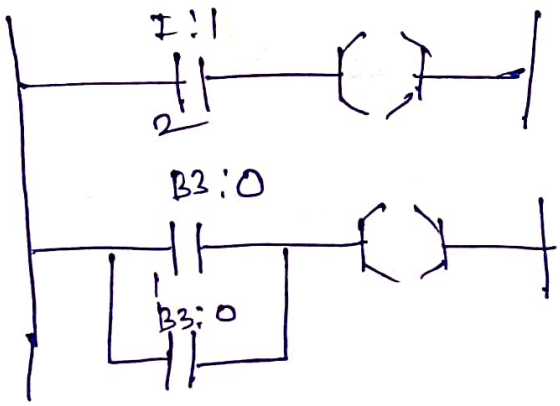


output latching instruction:

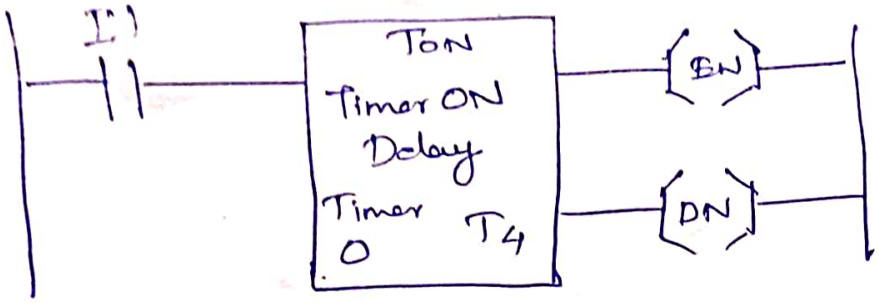




Internal Bit type Instruction:



Timer Instructions:



- on delay
- off delay
- Retentive
- Reset

Timer addressing:

- To address the timer element, the address format is t4:2 where 4 is the timer file 4 and 2 indicates that we are refering to the 2nd timer
- To address timers accumulated value ACC is to be added to the above instruction so as to get T4:2 ACC
- To address its pre set value, PRE is added to the timer instruction as T4:2 PRE

Data Handling Instruction:

- Equal Instruction (EQU)
- Not Equal " (NEQ)
- Less than (LES)
- Less than or equal (LEQ)
- Greater than (GRT)
- Greater than or equal (GEQ)

- Move instruction
- Masked move
- Converting from BCD to integer
- Converting Integer to BCD
- Copy instructions etc

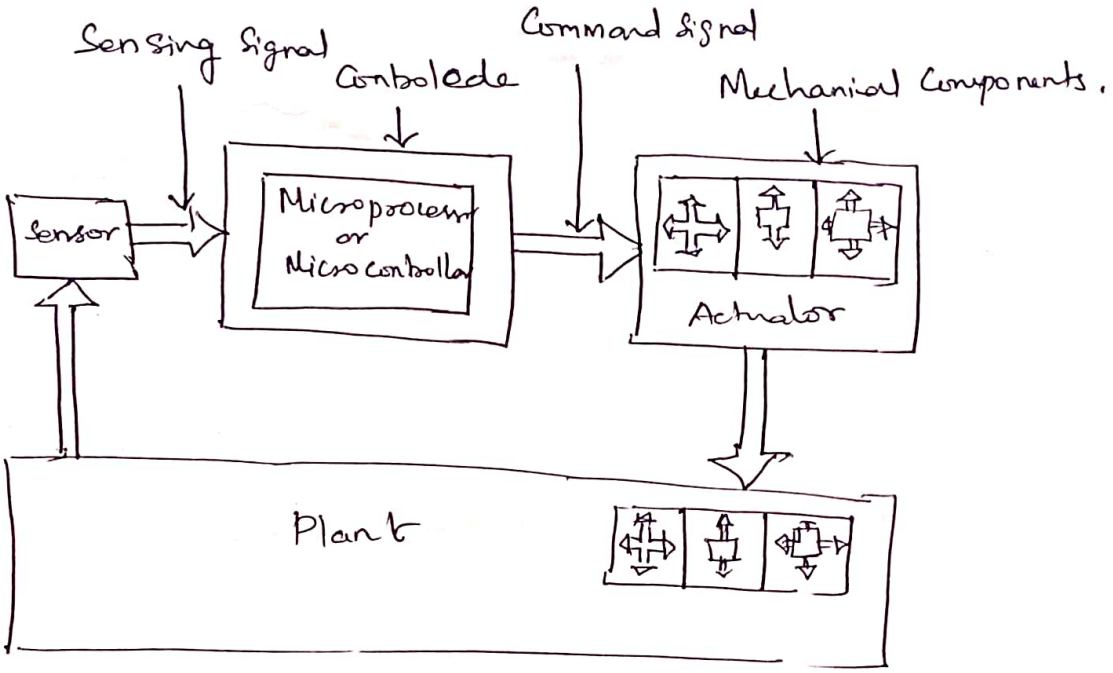
Selection of PLC:

- Cost
- Serviceability / Support
- Flexibility / Expandability
- Training and documentation

UNIT- V

ACTUATORS

Actuators and Mechatronic System:



Actuation is the process of conversion of Energy to Mechanical form.

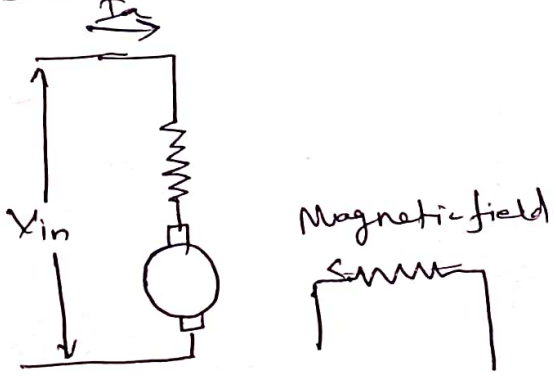
Actuator Types:

- Electro mechanical actuators
- Fluid power actuators
- Active material based actuators.

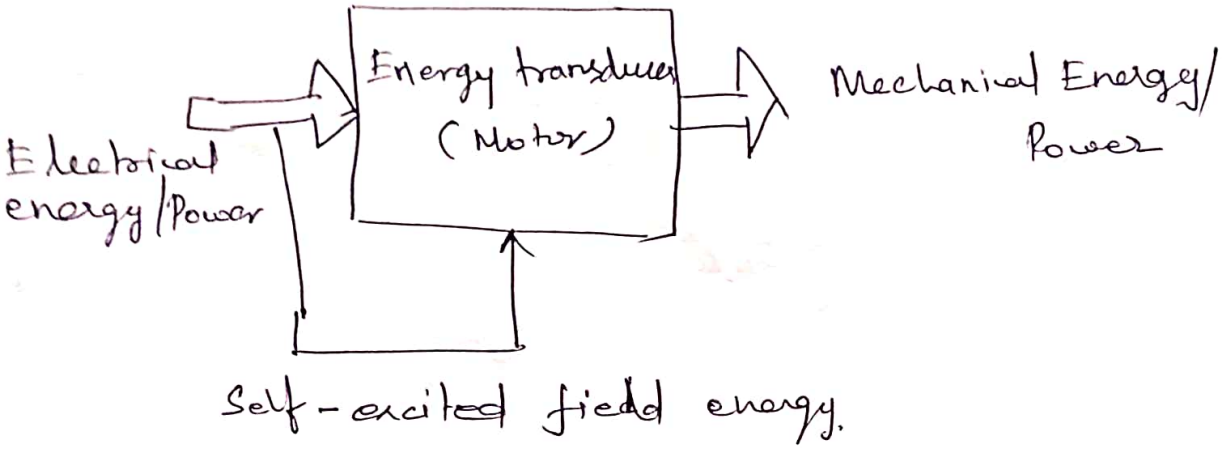
Electric motors for Mechatronics Applications:

1. D.C. Motors
   - Permanent magnet
   - Series wound
   - Shunt wound
   - Compound wound.
2. A.C Motors.
   (i) Single phase
   (or) Induction
   - Squirrel cage
   - wound rotor
   - Synchronous
   - Poly phase
   - Universal motors.

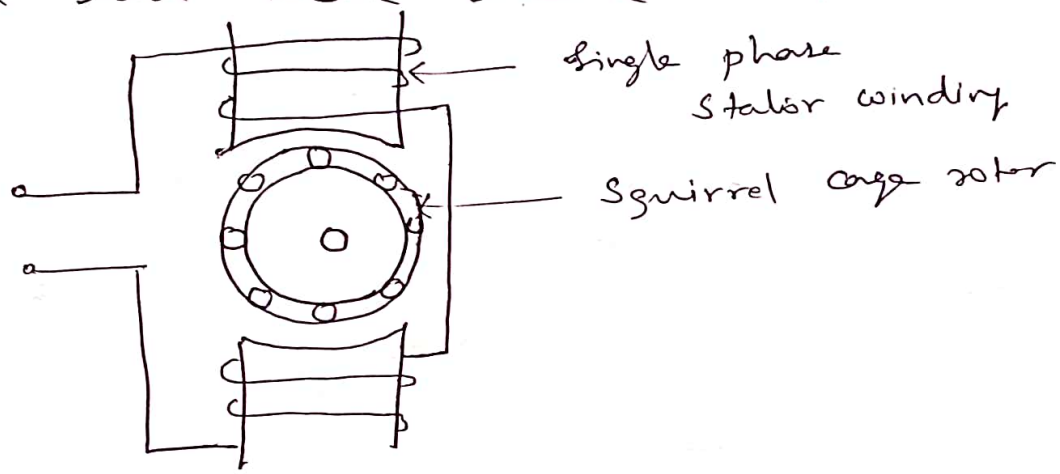
Separately Excited Electromagnetic DC Motor:



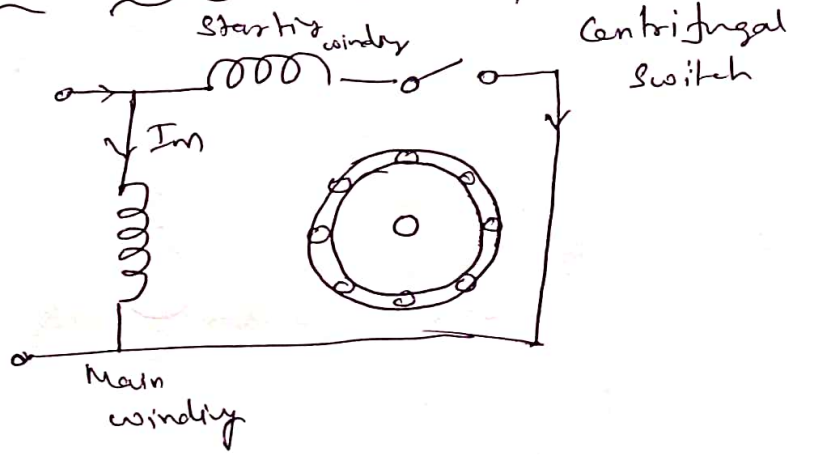
V_m = Input DC Supply
I_a - Armature current
I_f - Field current
R_a - Resistance of armature coil (rotor winding)
R_f - Resistance of Field coil



Two Pole Single Phase Induction Motor:



Split phase Induction motor:



Servomotors:

- Mechanical position
- Time derivatives

Feed back control system:

Requirements:

- high accuracy
- Remote operation
- Fast response
- Unattended control

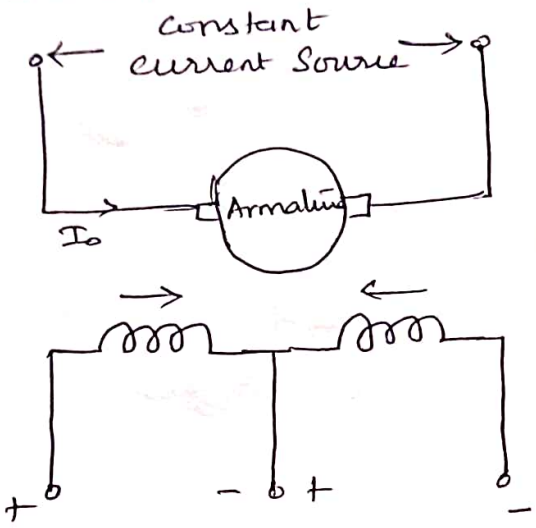
Types of servomotors:

- D.C servo motors
  - Series motors
  - Split series motors
  - Shunt control motors
  - Permanent magnet
- A.C servo motors.
  - Drag-cup rotor servo motor
  - Shaded-pole type servo motor

characteristics of a servo motor

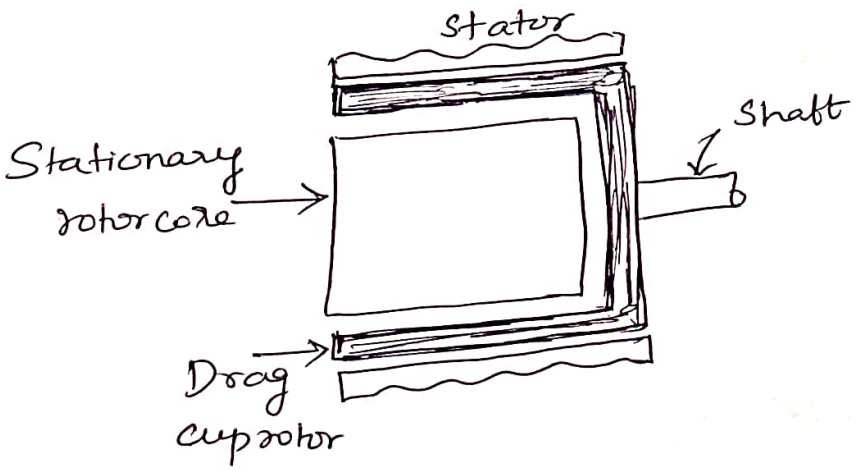
- The output torque of the motor should be proportional to the voltage applied.
- The direction of the torque developed by the servo motor should depend upon the instantaneous polarity of the control voltage.

Series motor:



- High starting torque
- draws large current
- Speed regulation poor

Drag-cup Rotor Servo-Motor:



Two coinding Namely

- Main Winding
- Control Winding

Advantages of Servomotors:

- High Speed operation
- heavy load
- No out-of-Step condition

Disadvantages:

- Higher cost
- Not Suitable for precision control of rotation
- Not Suitable for prevention of vibration

Applications of Servo-Motor:

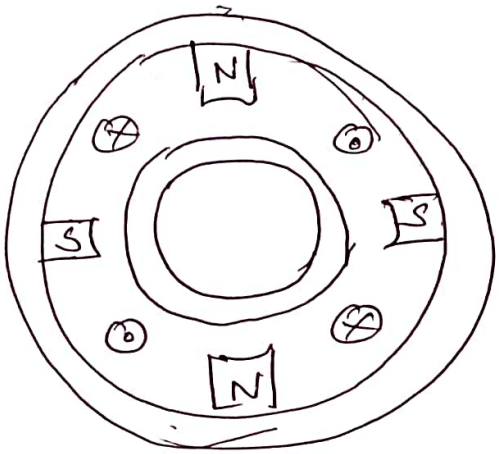
- Requiring rapid variations in speed
- used in machine tool, packing, factory automation, material handling, printing, converting.
- Radio controlled air planes to control the positioning
- Aero space industry
- Auto mobiles to maintain the speed of vehicles
- A.C servo motors, low power applications
- Computer and inertial guidance Systems.

STEPPER MOTOR

Types:

- Permanent magnet Stepper motor
- Variable reluctance Stepper motor
- Hybrid Stepper motor.

Permanent Magnet Stepper motor:

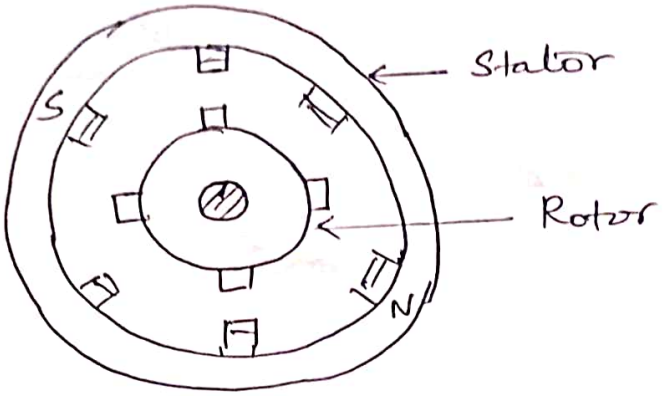


Effective Stator poles Shift Anti clockwise 22.5°

Each phase - 22.5°

Small residual holding torque called detent torque.

Variable Reluctance Stepper motor:

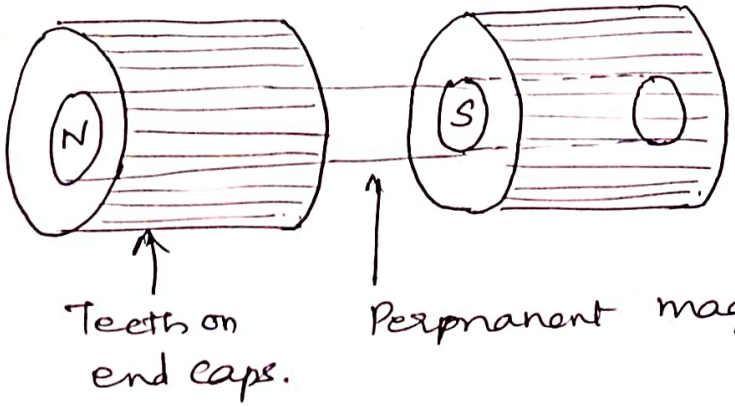


$$\alpha = \frac{360^\circ}{\text{No of phases} \times \text{No of poles}} = \frac{360}{np}$$

This pair of poles energised by current being switched to them and rotor rotates to position.

This pair of poles energised by current being switched to them to give next step

Hybrid Stepper Motor:



Advantages of Stepper motor:

- Compatibility with digital systems
- Angular displacement can be precisely controlled
- No sensors are needed for position and speed sensing
- Readily interfaced with micro controller, micro processor

Dis advantages:

- It cannot be used high speed
- If not properly controlled, resonances can occur
- connected to load in gear box, primary sources for backlash in Mechanical Systems.

Applications of Stepper motor:

- Paper feed motors in type writers
- Positioning of print heads
- Pens in XY Plotters
- Recording heads in computer disc
- Positioning of work tables and tools
- Metering, mixing, cutting, blending, stirring etc.

Design Process:

Need for design

↓

Analysis of problem

↓

Preparation of Specification

↓

Generation of possible solution

↓

Evaluation

↓

Production of detailed design

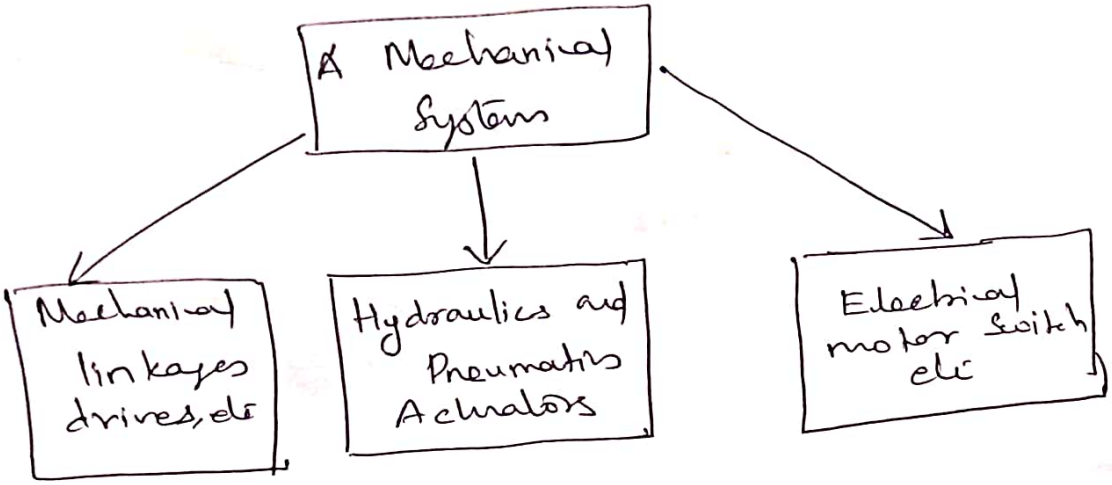
↓

Production of working drawing

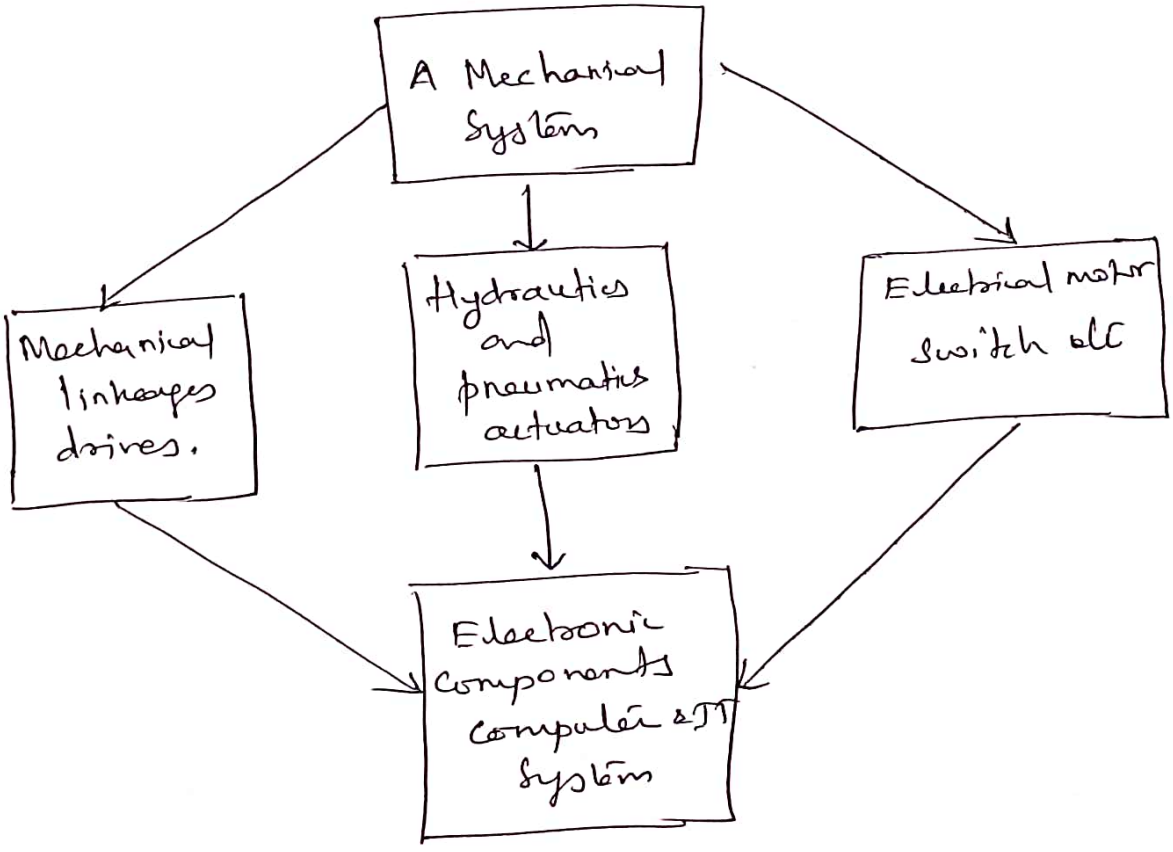
↓

Implementation of design.

Traditional Design Approach:

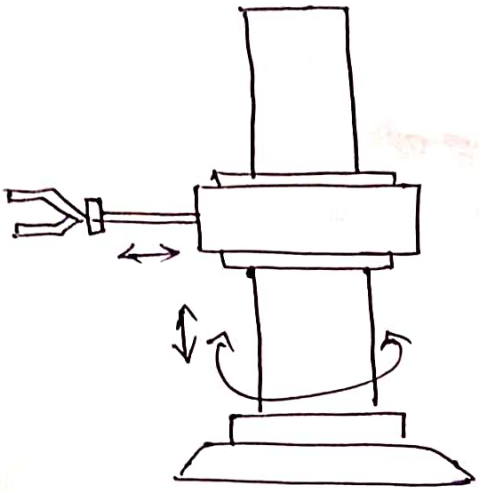


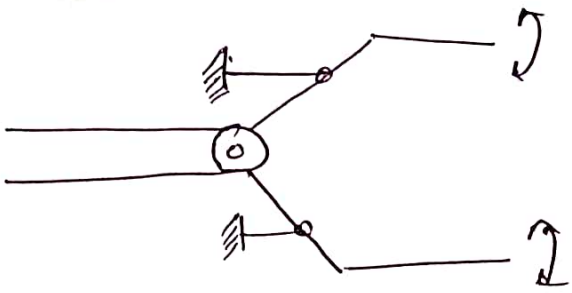
Mechatronic Design Approach:



Case Studies of mechatronic Systems!

Pick and place robot.





Movements :

- Base actuator – cylinder 1
- Arm Extender out – cylinder 2
- Arm up and down – cylinder 3
- Gripper open, close – cylinder 4

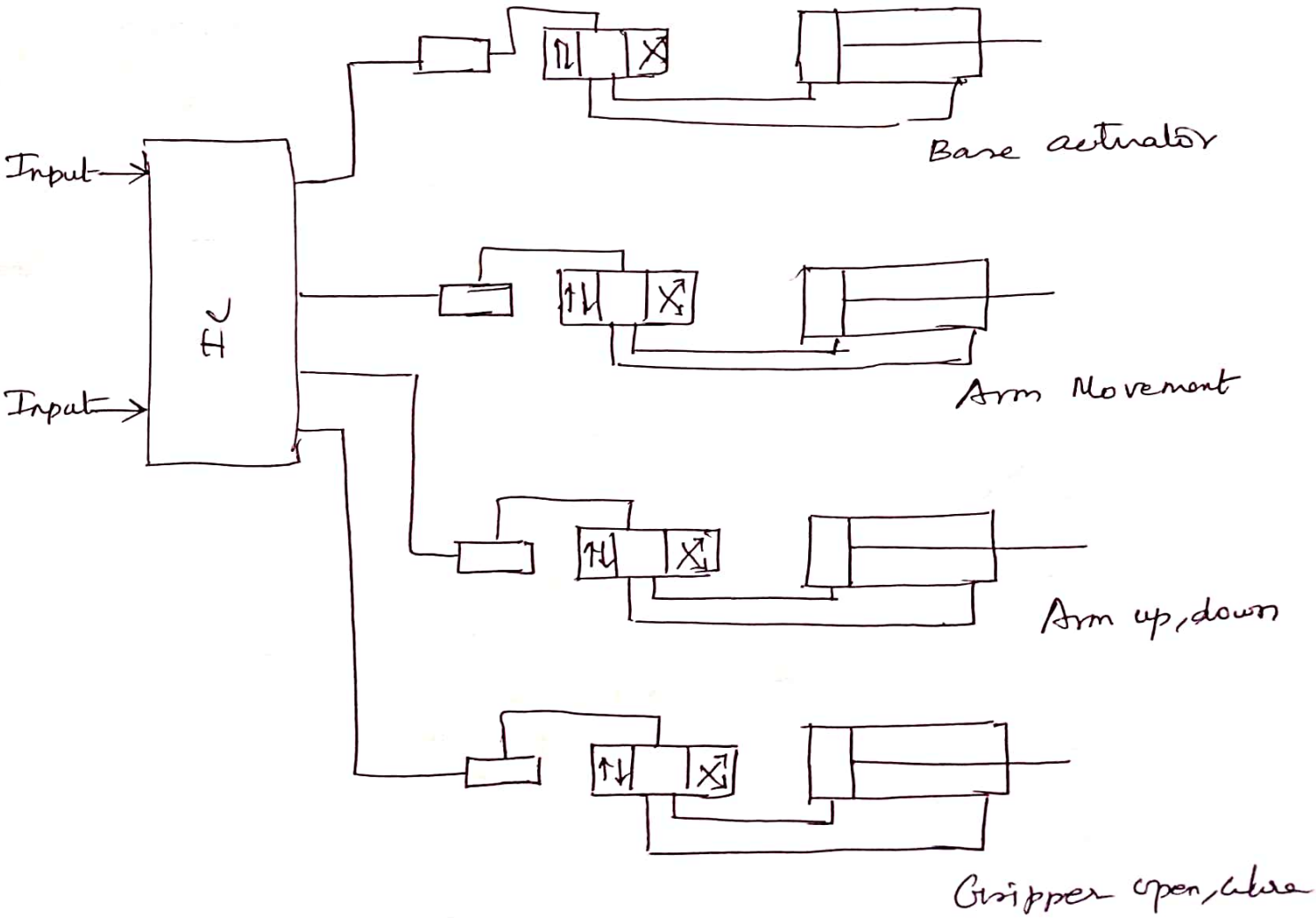
DCV – 1, 2, 3, 4 controlled by Micro process

– LS1, LS2, LS3, LS4 used to Movement control of the robot

– Pressure, Speed regulators ~~and~~ are used the pr, Speed of the arm Movements.

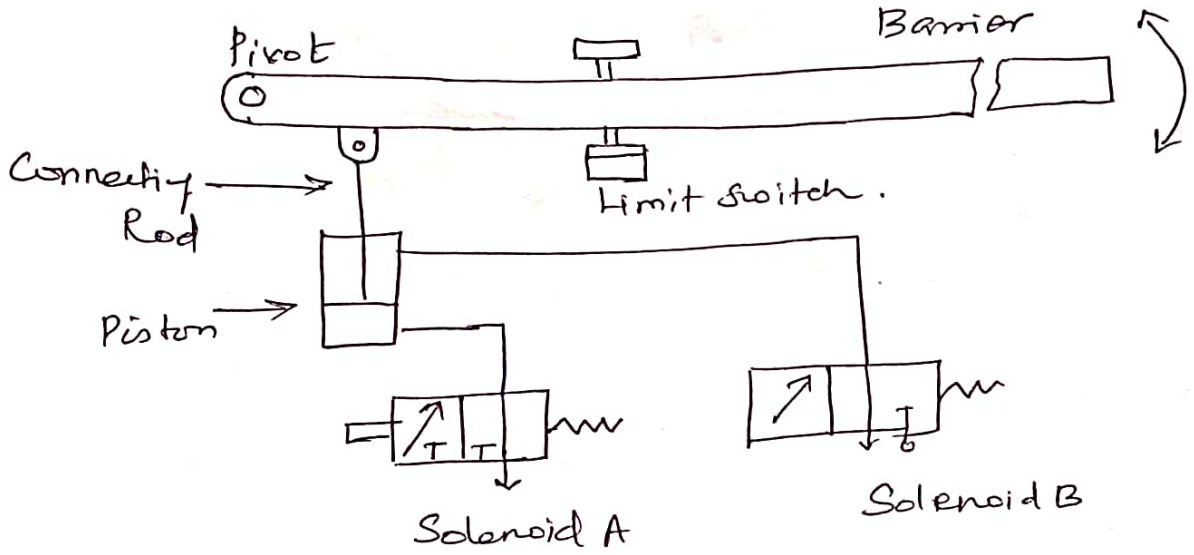
Movements of the robot

- Clockwise and anti-clockwise rotation
- Horizontal linear movement
- up and down movement
- open or close movement

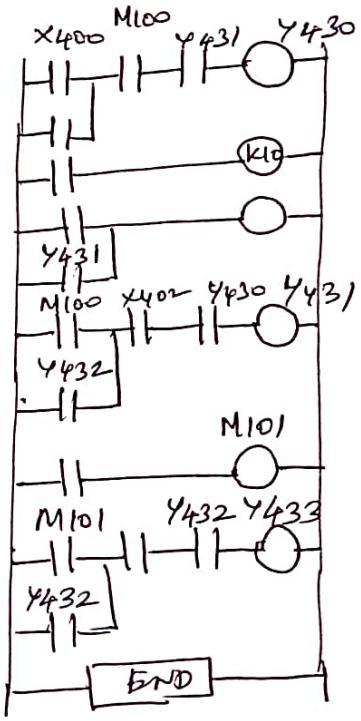


Case Study :

Automatic car park barrier :



Ladder diagram :



- Barrier up, input X401 Start timer
- To lift the entrance barrier coin operated input X400 required, Y430 energies.
- After 10 sec the IR M100 energies
- To start the Solinoid B of entrance barrier
- To lift the exit barrier, can operated input X403,
- when Barrier up input X404 starts.
- After 10S IR M101 starts.

Case Study

Engine Management System :

- Engine Speed Sensor
- Engine temparature sensor
- Hot coize anemometer
- Oxygen Sensor.