STELLA MARY'S COLLEGE OF ENGINEERING

(Accredited by NAAC, Approved by AICTE - New Delhi, Affiliated to Anna University Chennai)

Aruthenganvilai, Azhikal Post, Kanyalumari District, Tamilnadu - 629202.

ME8791 MECHATRONICS

(Anna University: R2017)

Prepared By

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DEPARTMENT OF MECHANICAL ENGINEERING

2021-2022 (ODD)

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DEPARTMENT OF MECHANICAL ENGINEERING

COURSE MATERIAL

REGULATION	**2017**
YEAR	**IV**
SEMESTER	**07**
COURSE NAME	**Mechatronics**
COURSE CODE	**ME8791**
NAME OF THE COURSE INSTRUCTOR	**Dr. F. MICHAEL RAJ**

SYLLABUS:

UNIT I INTRODUCTION 9

Introduction to Mechatronics – Systems – Concepts of Mechatronics approach – Need for Mechatronics – Emerging areas of Mechatronics – Classification of Mechatronics. Sensors and Transducers**:** Static and dynamic Characteristics of Sensor, Potentiometers – LVDT – Capacitance sensors – Strain gauges – Eddy current sensor – Hall effect sensor – Temperature sensors – Light sensors

UNIT II MICROPROCESSOR AND MICROCONTROLLER 9

Introduction – Architecture of 8085 – Pin Configuration – Addressing Modes –Instruction set, Timing diagram of 8085 – Concepts of 8051 microcontroller – Block diagram,.

UNIT III PROGRAMMABLE PERIPHERAL INTERFACE 9

Introduction – Architecture of 8255, Keyboard interfacing, LED display –interfacing, ADC and DAC interface, Temperature Control – Stepper Motor Control – Traffic Control interface.

UNIT IV PROGRAMMABLE LOGIC CONTROLLER 9

Introduction – Basic structure – Input and output processing – Programming – Mnemonics – Timers, counters and internal relays – Data handling – Selection of PLC.

UNIT V ACTUATORS AND MECHATRONIC SYSTEM DESIGN 9

Types of Stepper and Servo motors – Construction – Working Principle – Advantages and Disadvantages. Design process-stages of design process – Traditional and Mechatronics design concepts – Case studies of Mechatronics systems – Pick and place Robot – Engine Management system – Automatic car park barrier.

TEXT BOOKS :

1. Bolton, "Mechatronics", Prentice Hall, 2008
2. Ramesh S Gaonkar, "Microprocessor Architecture, Programming, and Applications with the 8085", 5th Edition, Prentice Hall, 2008.

REFERENCES:

1. Bradley D.A, Dawson D, Buru N.C and Loader A.J, "Mechatronics", Chapman and Hall, 1993.
2. Clarence W, de Silva, "Mechatronics" CRC Press, First Indian Re-print, 2013
3. Devadas Shetty and Richard A. Kolk, "Mechatronics Systems Design", PWS publishing company, 2007.
4. Krishna Kant, "Microprocessors & Microcontrollers", Prentice Hall of India, 2007.
5. Michael B.Histand and Davis G.Alciatore, "Introduction to Mechatronics and Measurement systems", McGraw Hill International edition, 2007.

Course Outcome Articulation Matrix

	Program Outcome												*PSO*		
Course Code / CO No	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***1***	***2***	***3***
ME8791 / C403.1	3	2	1	2	2	2	1	0	0	2	0	3	1	1	2
ME8791 / C403.2	3	2	1	2	2	2	1	0	0	1	0	3	1	1	2
ME8791 / C403.3	3	2	1	2	2	2	1	0	3	1	0	3	1	1	2
ME8791 / C403.4	3	2	1	2	2	1	1	0	1	1	1	3	1	1	2
ME8791 / C403.5	3	2	1	2	2	1	1	0	0	1	1	3	2	1	2
Average	3	2	1	2	2	2	1	0	0	2	0	3	1	1	2

UNIT-I [INTRODUCTION]

(L1)

Introduction to Mechatronics

* Mechatronics is a word originated in Japan in 1980s to denote the combination of technologies which go together to produce industrial robots.

* The word, mechatronics is composed of "mecha" from mechanism and the "tronics" from electronics.

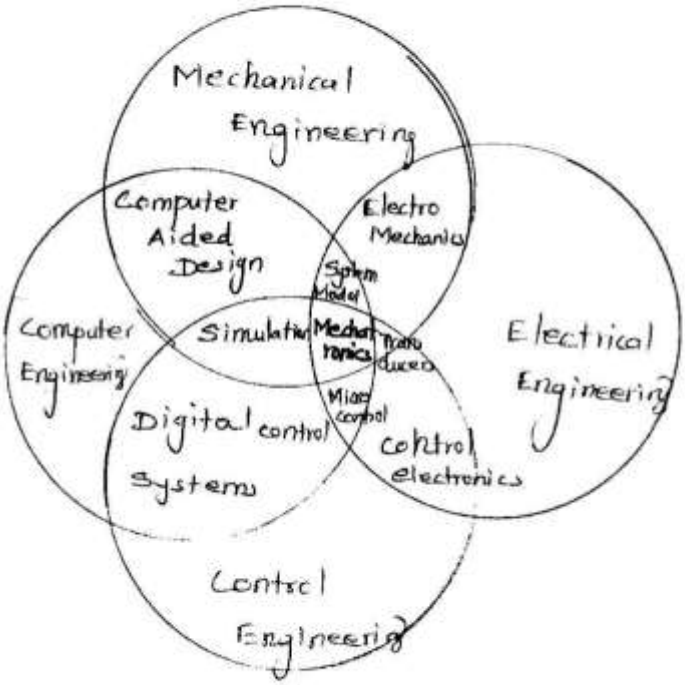
* According to the Mechatronics from UK a formal definition of Mechatronics is "the synergeistic integration of Mechanics and Mechanical Engineering, Electronics, Computer technology, and IT to produce or enhance products and systems".

* W. Bolton defines mechatronics as "A mechatronic system is not just a marriage of electrical and mechanical systems and is more than just a control system; it is a complete integration of all of them".

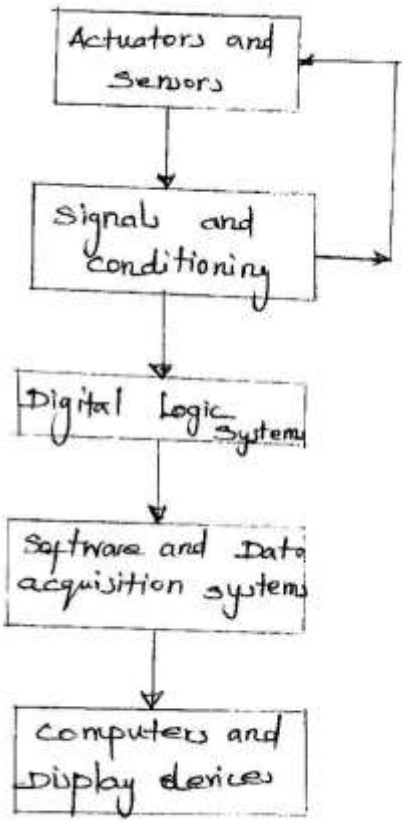
* In other words, technologies and developed products will be incorporating electronics more and more mechanisms intimately and organically and making it impossible to tell where one ends and other begins.

(* Mechatronics brings together the areas of technology involving sensors and measurement systems, drive and actuation system, analysis of behaviour of the system, control system and microprocessor system)

Graphical representation of Mechatronics



Elements of Mechatronics Systems:



i. Actuators and Sensors:

* Sensors and actuators mostly come under mechanical systems. The actuators produce motion. The sensors detect the state of the system parameters, inputs and outputs.

ii. Signals and conditioning:

* The mechatronic systems deal with two types of signals and conditioning: (Input and output)

(a) Input. Input devices reciere the input signals from the mechatronic systems and then send to the control circuits for processing. Ex: Analog to digital convertors, [D to D]

(b) Output. The output signals from the system are sent to output/display devices. Ex: Analog convertors, Display decoders, amplifiers

iii. Digital logic systems:

* Digital logic devices control overall system operation. The various digital logic systems are micro controllers, Programmable logic controllers (PLC) sequencing and timing controls, 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...

* Software is used to control the acquisition of data through 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.

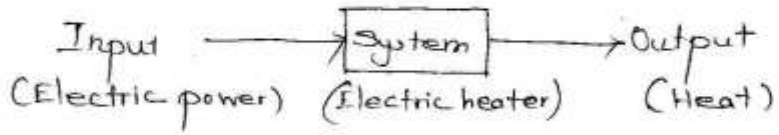
LED, CRT, LCD etc...

Question:

1. Define mechatronics. (2) [Nov/Dec 2004]
2. Sketch the graphical representation of mechatronic systems. (2) [Apr/May 2005]
3. What are the elements in typical mechatronic systems? (2)
4. Explain the various elements of mechatronics systems. (8)

System

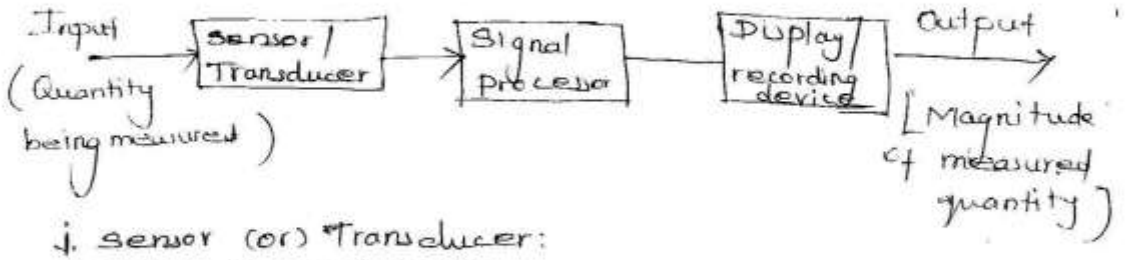
* The word system in mechatronics refers to a group of physical components connected or related in such a manner as to form an entire unit for performing a specific task.



Measurement Systems:

* A measurement system involves the precise measurement and display/recording of physical, chemical, mechanical, electrical & optical parameters. It provides a means of describing natural phenomena in quantitative terms.

Basic elements of the measurement system



i. Sensor (or) Transducer:

* Sensor (or) transducer is a device which converts a physical quantity, property

ii Signal processor:

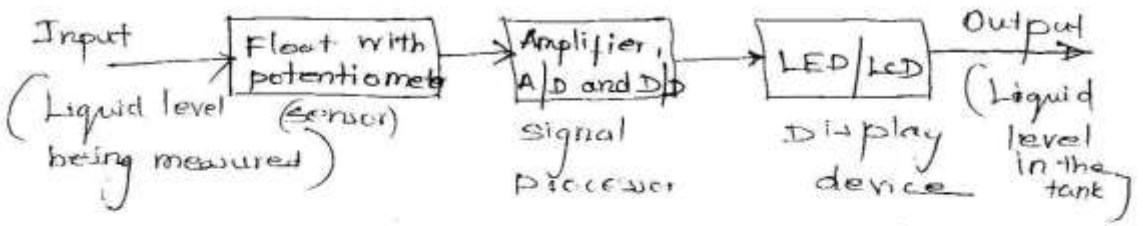
* Signal processor (or) conditioner recieves output signal from sensor (or) transducer and manipulates into a suitable input signal to control system. Ex: Amplifier

iii Display (or) recording device:

* Recorder records the output from signal conditioner and display device gives the measured variable in visual.

Ex: LED, CRT, LCD

Example of Measurement system: [Digital liquid level measuring system in a tank]



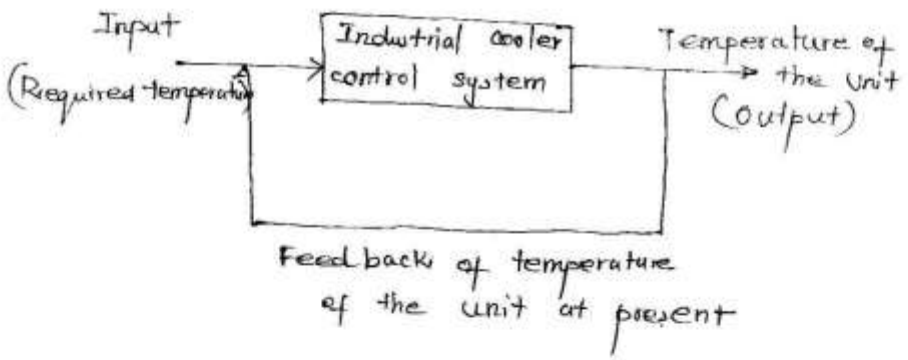
* This system incorporates float with resistive potentiometer as a sensor which gives electrical voltage as output depending upon the liquid level in the tank.

Control System:

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

(* The physical components may be of electrical, mechanical, hydraulic, pneumatic, thermal or chemical)

Cooling level control system



* Consider an industrial cooler in a food processing unit which is required to maintain the temperature of unit at particular predefined level.

* In this control system, the input is the temperature of the unit at present which is recieved from temperature sensor and the output is the particular predefined temperature of the unit.

Elements of the Control System

* Reference Variable (or) Input : to a control system from an external source excitation applied
* Output : The actual response obtained from the system.
* Feedback : The portion of the output of a system that is returned to modify the input
* Error → Error = Input stimulus − Output response
* Disturbance : Any other signal which affect the system performance
* Actuating signal : Feedback signal − reference signal
* Control (or) feed forward elements
* Controlled output
* Feedback elements.

Questions:

1. What is meant by a system in mechatronics? (2)
2. What is meant by measurement system in mechatronics? (8)
3. What are the basic elements of the measurement system and sketch its blocks diagram? (2)
   [Apr/May 2005]
4. What is meant by control system in mechatronics? (2)
5. What are the elements of the control system? (2)

Concepts of Mechatronics Approach (13)

Functions of control systems

* To minimize the error between the actual and the desired output
* To minimize the time response to load changes in the system.

Some applications of control system:

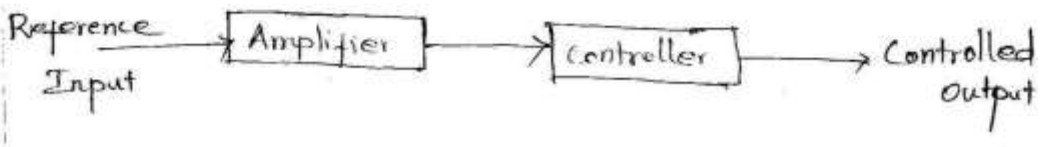
* Print Wheel control system of a printer
* Temperature control of an electric furnace(or) oven
* Sun tracking control of solar collector
* Idle speed control system of an automobile.

Open loop control system:

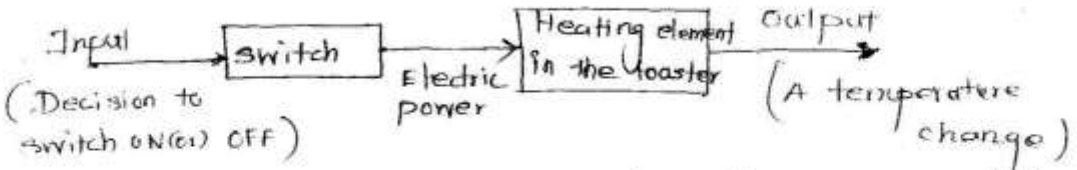
* Open loop systems are systems in which the output of a system is not used as a variable to control the system.
* In other words, open loop systems are systems in which input to the system is not controlled by the present output.

Ex: Electric fire alarm system, Bread toaster, chemical addition pump.

Basic elements of open loop c/s



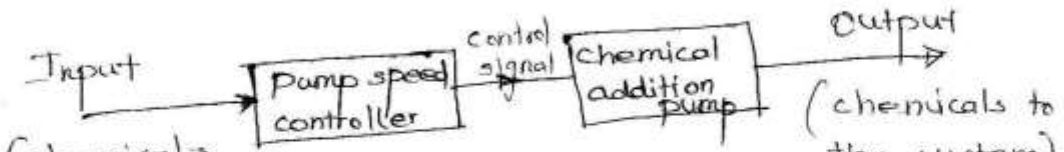
Bread toaster (open loop) control system



* In this system, when the system is switched ON, the heating element in the toaster heat the bread for particular time and then automatically it get switched OFF and ejects the bread.

* Here there is no feedback of data of whether the bread is toasted properly (or) not.

Chemical addition pump (open loop) cls



Advantages

* Simple and cost effective construction.
* Easy maintenance
* Good stability
* Good reliability

Disadvantages:

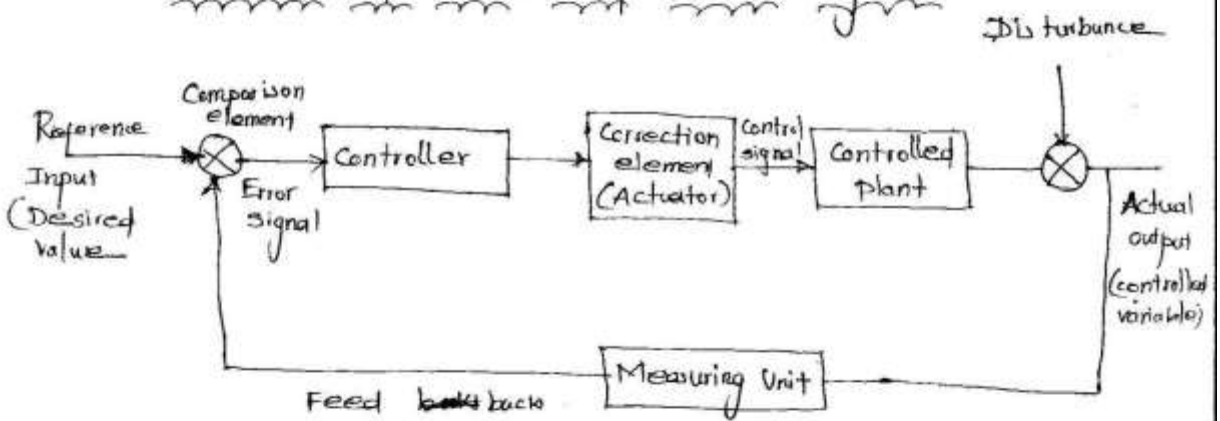
* Less accurate
* slow because of manual control.
* optimisation in control not possible.
* System is affected by internal and external disturbances.

Closed - loop control systems

* closed-loop system uses on a feedback 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 drives the plant in such a way as to obtained the desired output.

Ex: Automatic tank level control system, Automatic shaft speed control system.

Elements of closed - loop control system



Measuring Unit: Sensors, estimators, and signal conditioners are the part of measuring unit.

Control elements: control elements are needed to generate the appropriate control signal applied to the plant. These elements are also called the controller.

Comparison element (or Error junction:

* Where the desired system outputs and the measured outputs are compared to generate the error signal / measured value

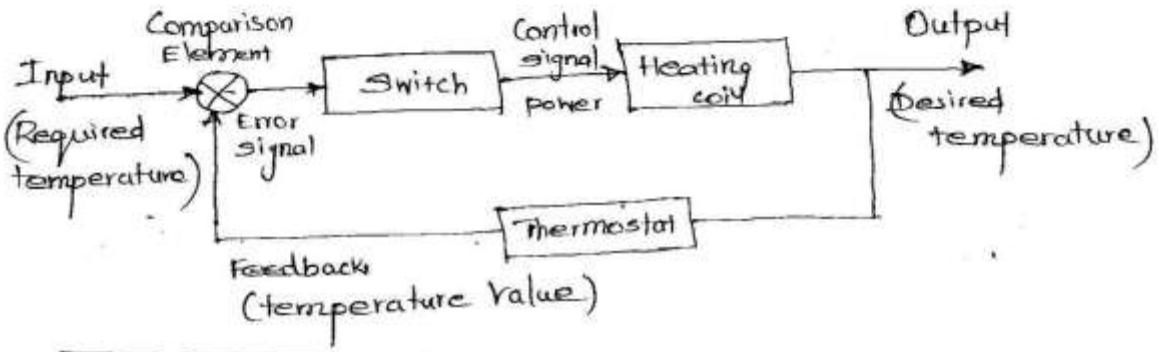
Error signal = Difference b/w the reference value and the

Correction element or Actuator:

* Produces a change in the plant (or) process to correct the controlled plant.

Feedback elements: * The feedback elements are components needed to identify the functional relationship between the feedback signal and the controlled output.

Room heating (closed-loop) control system



Questions:

1. Draw the basic feedback system and indicate various terms associated with this block diagram. (8) [Apr/May 2006]
2. Distinguish between open-loop and closed loop control systems. (8) [Nov/Dec 2007]
3. Explain open loop and closed loop control system with neat sketches. (16) [Apr/May 2005]

* Sensors are devices which produce a proportional output signal (mechanical, electrical, magnetic, etc.) when exposed to a physical phenomenon (pressure, temperature, displacement, force, etc.)

* Sensor is a device which detects (or) measures a physical property and records, indicates, (or) otherwise responds to it

* Transducers are devices which converts an input of one form of energy into an output of another form of energy.

Classification of sensors:

* Based on its power requirement

i. Passive sensor: * passive sensors require external power source. [Ex: differential transformers, strain gauge, resistance thermometers, etc.]

* Passive sensors work based on one of the following principles: resistance, inductance, and capacitance.

ii. Active sensor: * In active sensors, the power required to produce the output is provided by the sensed physical phenomenon itself.

[Ex: thermocouples, thermometer, piezoelectric transducers]

* The active sensors are also called as "self-generating transducers.

* Based on the type of output signal

i. Analog sensors: [Ex: potentiometers, LVDT]

Primary Sensor:

* Primary sensors produce the output which is the direct measure of the input phenomenon.

Secondary sensor:

* Secondary sensors on the other hand produce output which is not the direct representation of the physical phenomenon.

Active → Primary Sensor

Passive → Secondary sensor

Performance Terminology:

1- Static characteristics:

Range:

* Every sensor is designed to work a specified range. (or) certain maximum and minimum value.

Ex: Thermocouple range of −100 to 1260°C

Span:

* It is the difference between maximum and minimum values of the quantity to be measured.

Span = Maximum Value of the input − Minimum Value of the input

Error:

Error = Measured value − True input value.

Accuracy:

* The accuracy of a sensor is inversly proportional

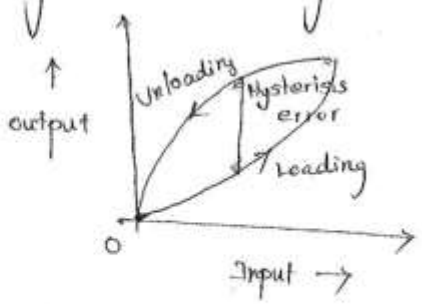
Sensitivity:

$$\text{Sensitivity} = \frac{\text{change in output}}{\text{change in input}} = \frac{\Delta \theta_o}{\Delta \theta_i}$$

Hysteresis:

* Hysteresis is defined as the maximum differences in output for a given input when this value is approached from the opposite direction.

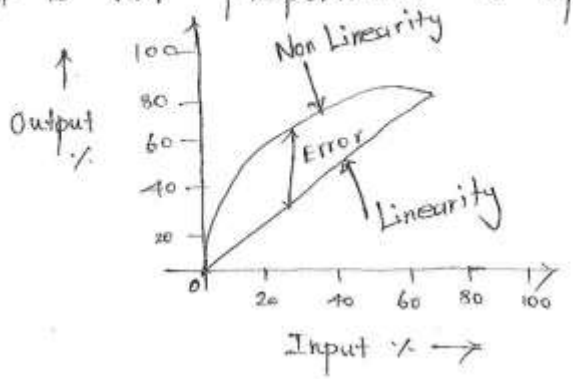
* It is a phenomenon which shows different outputs when loading and unloading.



Linearity: * Linearity of a sensor refers to the output that is directly proportional to input over its entire range.

Non Linearity:

* Non linearity of a sensor refers to the output that is not proportional to input over its entire range.

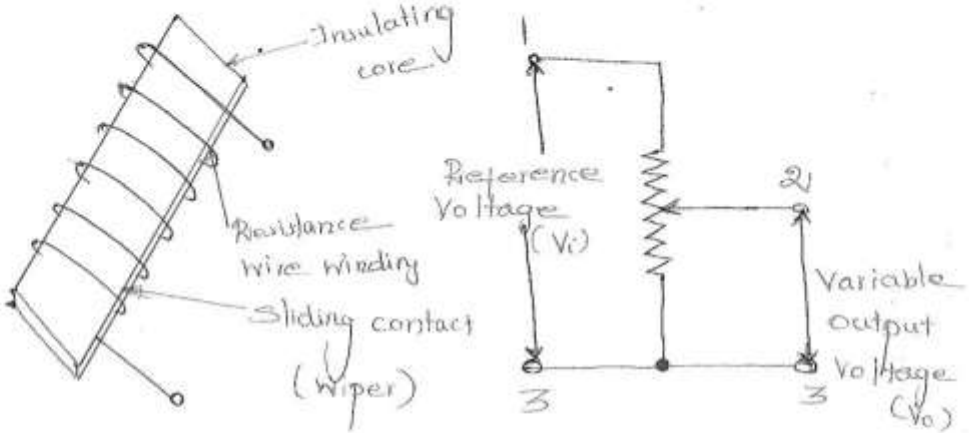


* Displacement sensors are those sensors which measures the variation of position of a body.

* The various displacement sensors are
  * Potentiometer
  * strain gauge
  * Capacitance
  * LVDT

Potentiometer :

* Potentiometer is a primary sensor which converts the linear motion or the angular motion of a shaft into changes in resistance - It is a type of resistive displacement sensor.



Linear Potentiometer

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

* The linear potentiometer employ an electrically conductive linear slide member (wiper)

conducted to a variable wire wound resistor (winding) that changes resistance to be equated to the linear position of the device that is monitored.

* As the sliding contact moves along the winding, the resistance changes in linear relationship with the distance from one end of the potentiometer.

* To measure displacement, a potentiometer is typically wired as a "voltage divider" so that the output voltage is proportional to the distance traveled by the wiper.

Advantages:

* Easy to use
* Low cost
* High amplitude output signal

Disadvantages:

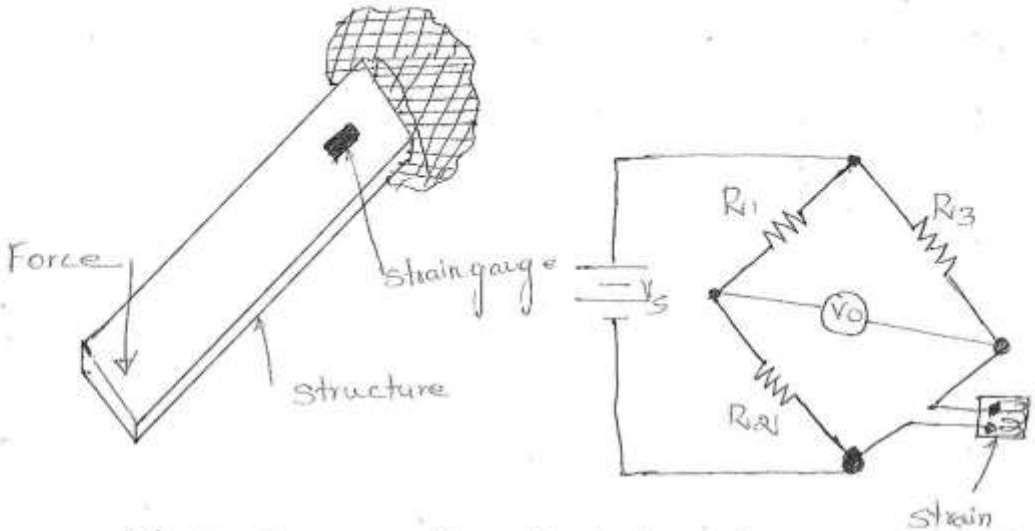
* Limited bang width
* Frictional loading
* Limited life due to wear

Strain gauge

* strain gauge is attached to the object by a suitable adhesive. As the member is stressed, the resulting strain deforms the strain gauge attached with the structure.

* Strain gauge displacement sensor consists of a structure attached with the strain gauge that elastically deforms when subjected to a displacement.

* The change of resistance is very small and is usually measured using a Wheatstone bridge circuit where the strain gauge is connected into the circuit. This causes an increase in resistivity of the



Strain gauge with wheatstone bridge circuit

* The change in the resistance of a bonded strain gauge is usually less than 0.5 %. | change is res per unit res is proportional to the strain. ε

$$\frac{\Delta R}{R} = G \times \varepsilon$$

$G \rightarrow$ gauge factor

$R \rightarrow$ Resistance

$\Delta R \rightarrow$ change in resistance

$\varepsilon \rightarrow$ strain.

Questions:

1. Describe with neat sketch of potentiometer displacement sensors. (8)

2. Explain the working of strain gauge with neat sketch. (8)

Applications:

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

Advantages: * High sensitivity

* Excellent linearity over entire dynamic range when area is changed.

* High accuracy and resolution.

* Fractional change in capacitance can be made large.

Disadvantages: * The performance of these sensors is likely affected due to the environment.

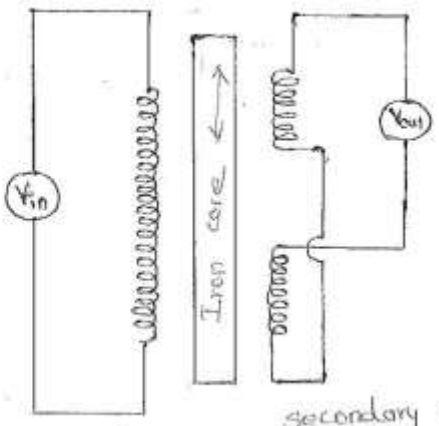
* The metallic parts of the capacitor must be insulated from each other.

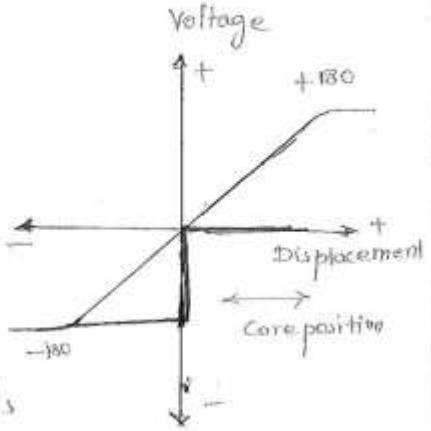
LVDT [Linear Variable Differential Transformer]

* It is a passive type sensor. It is an electro mechanical device designed to produce an AC voltage output proportional to the relative displacement of the transformer and the ferromagnetic core.

* One of the three coils is the primary coil (or) excitation coil and the other two are secondary coils (or) pick up coils.

* An AC current is passed through the primary coil and an AC voltage is induced in the secondary coils. The magnetic core inside the coil winding assembly provides





Application: * LVDT can be used to measure the displacement, deflection, position and profile of a workpiece.

Advantages: * Relative low cost due to its popularity.
* Solid and robust, capable of working in a wide variety of environments.
* Negligible hysteresis.
* High sensitivity.
* Less power consumption.

Disadvantages: * The performance of the sensors is affected by vibration.
* Not suitable for fast dynamic measurements.

Questions:

1. Explain capacitive push-pull sensor. (8) [Apr/May 2008]
2. Explain the working principle of LVDT, sensor with neat sketch. (8) [Nov Apr/May 2006]

(Null position)

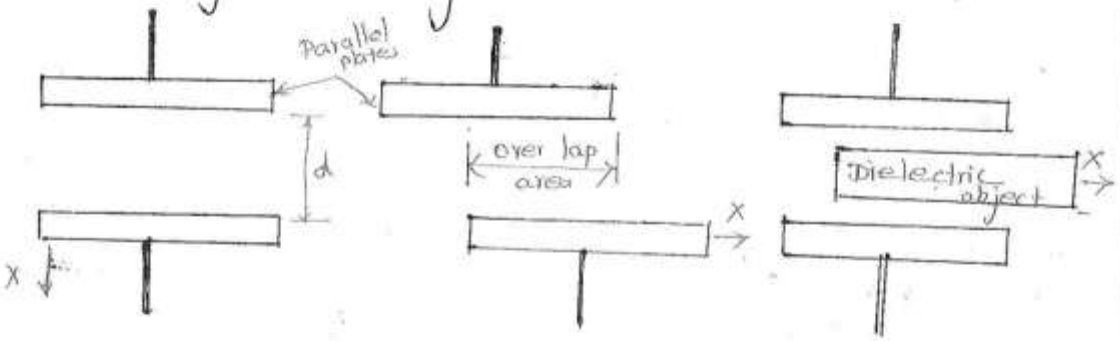
* When the magnetic core is at the centre position the output voltage is zero.

* When the core is displaced from the null position, an electromagnetic imbalance occurs. This imbalance generates a differential AC output voltage across the secondary coil which

* A transducer that uses capacitance variation can be used to measure displacement.

* The capacitive sensor senses very small deflections accurately.

* Capacitive sensors can directly sense a variety of things such as motion, chemical composition, electric field and indirectly sense many other variables



* A capacitance sensor consists of two metal plates seperated by an air gap. The capacitance C between terminals is given by the expression:

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

C → Capacitance in Farads (F)

ε_r → Relative dielectric constant of the insulator

ε_0 → Dielectric constant

A → Overlapping area for the two plates

h → thickness of the gap b/w two plates

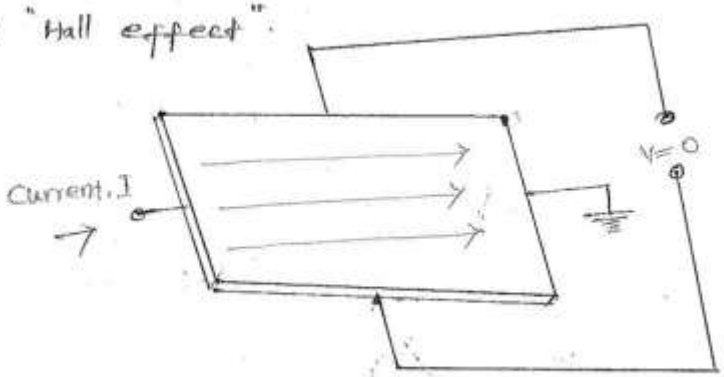
* The operating principle is based on either the geometry or capacitance variations in the presence of conductive (or) dielectric materials.

* As the dielectric object moves between the plates, ... changes linearly with motion.

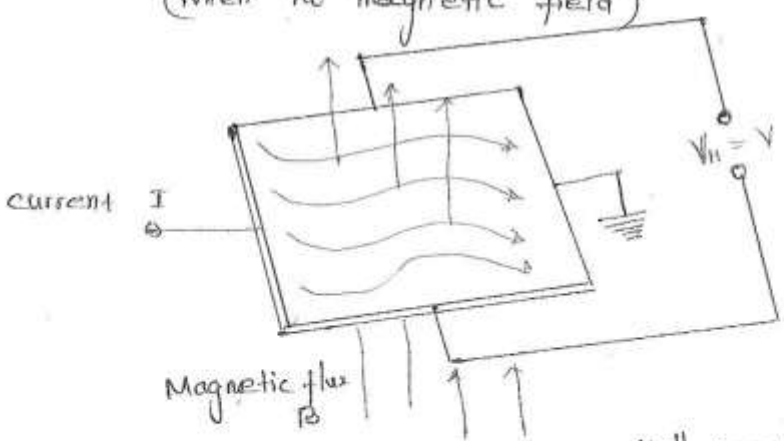
* Hall effect sensor is a type of magnetic sensor. A hall effect sensor is a transducer that varies its output voltage in response to changes in magnetic field.

* When a conductor (or) semiconductor with current flowing in one direction was introduced perpendicular to a magnetic field a voltage could be measured at right angles to the current path

* When a current carrying conductor is placed into a magnetic field, a voltage will be generated perpendicular to both the current and the field. This principle is known as "Hall effect".



(When no magnetic field)



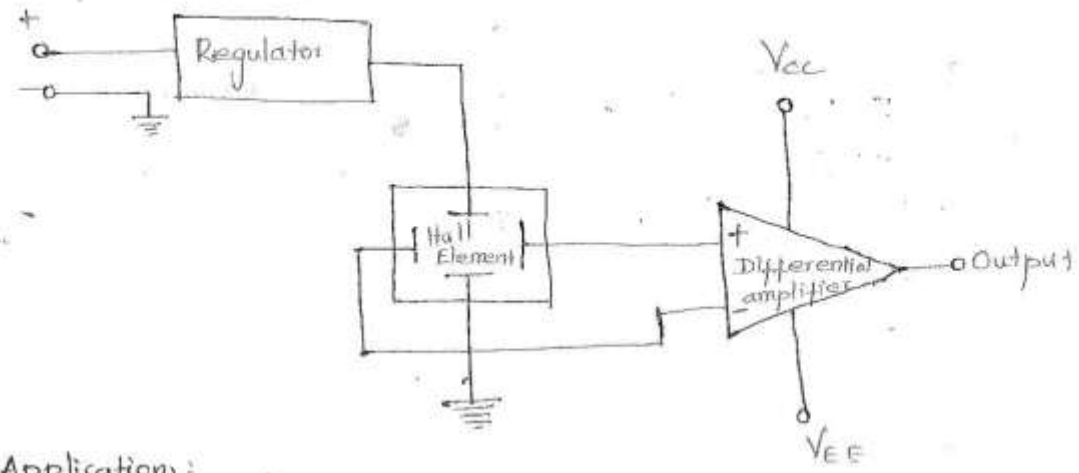
(When magnetic field present)

$V_H \propto I B$

$V_H = K_H \frac{IB}{t}$

$K_H \rightarrow$ Hall coefficient

$t \rightarrow$ Thickness of the Hall element



Applications:

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

* Hall sensors are commonly wed to time the speed of wheels and shafts.

Advantages: * Relative low cost compared to electromagnetic switches.

* High frequency operation is possible.

* No contact bounce problem.

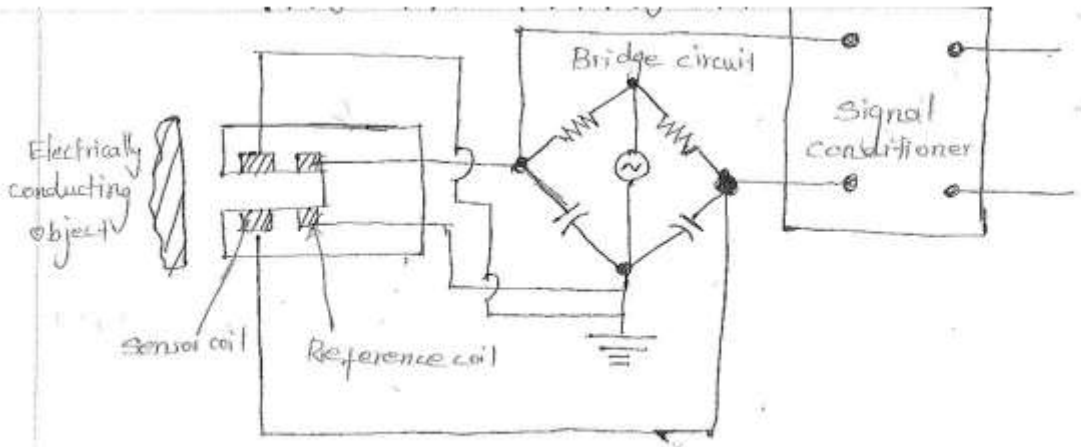
Disadvantages:

* Sensor becomes weak during offset effects caused by misalignment of contact in Hall element and piezo-resistive effects.

Eddy current sensors

* Proximity sensors are wed to determine the presence of nearby objects.

* Eddy current proximity sensors 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]



* They can be used as proximity sensors to detect presence of a target, or can be configured to measure the position or displacement of a target.

* The eddy currents are confined to shallow depths near the conductive target surface. Their effective depth is given by $\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$

$f \rightarrow$ Excitation frequency of the circuit.

$\mu \rightarrow$ Magnetic permeability of the target material

$\sigma \rightarrow$ Conductivity of the target material

Advantages:

* Compact in size.
* Low cost.
* High reliability.
* High sensitivity for small displacement

Questions:

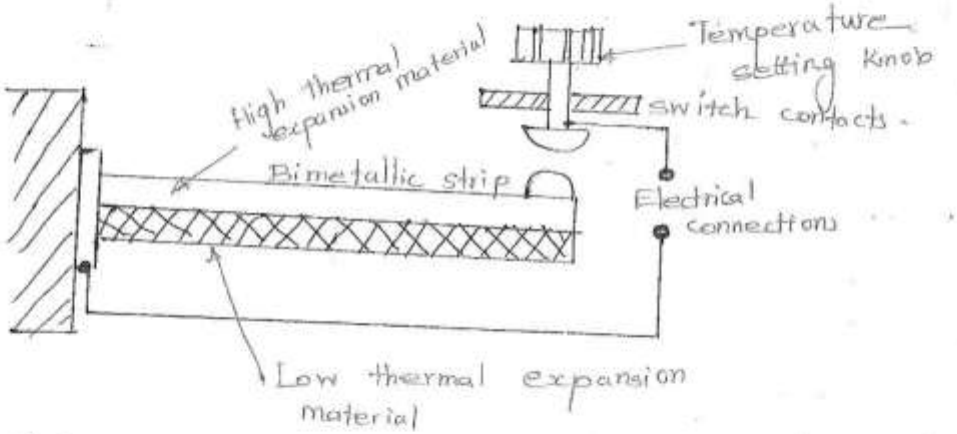
1. Define Hall effect. (2)
2. What are the advantages and disadvantages of Hall Effect sensors? (2)
3. Explain the working principle of Hall effect sensor with neat sketches. (8)

* Temperature measurements are most widely monitored parameter in science and industry.

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. A bimetallic strip is used to convert a temperature change into mechanical displacement.



Advantages:

* Power source not required.
* Low cost.
* Robust construction
* Easy to use and can be used upto 500°C

High thermal expansion material — steel (Cu)
Low — Invar

Disadvantages:

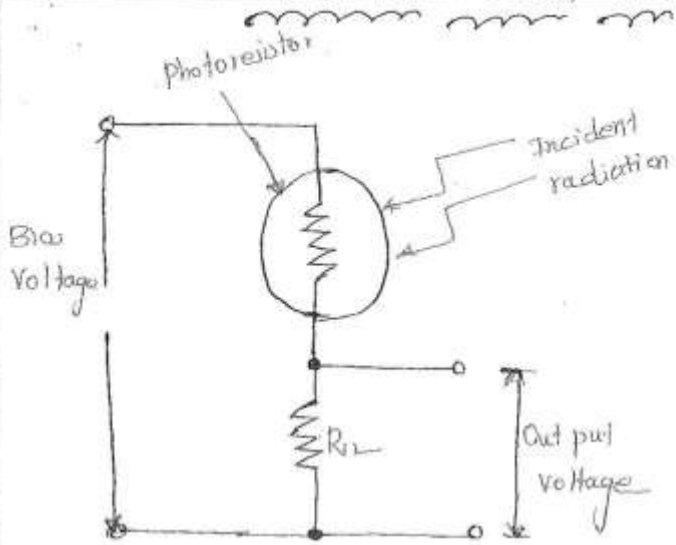
* Less accurate
* Limited to applications
* Not suitable for very low temperatures.

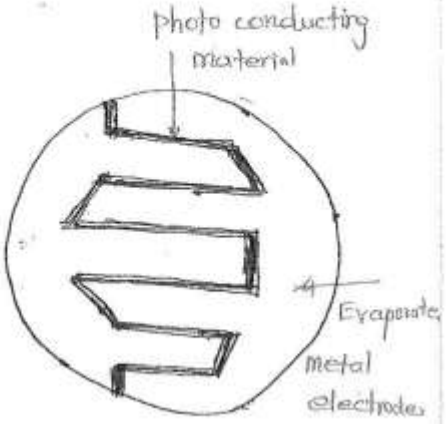
Light Sensors:

* A light sensor or detector converts the radiant power it absorbs into a change of a device parameter such as resistance, surface charge, current (or) voltage.

Photoresistor:

* A photo resistor consists of a slab of semiconductor material on the faces of which electrodes are deposited to allow the resistance to be monitored.
* The increase in conductivity, caused by the absorption of photons increasing electrons and holes is the basis for the operation of the photoresistive detector.
* Photoconductive devices used for the detection of long wavelength infrared radiation should be cooled because of the noise caused by fluctuations in the thermal generation of charge.





* A simple light detector circuit employing a photoresistor, an increase in light illumination cause the resistance of the photoresistor to decrease and the output voltage to increase.

* The photon-induced current is proportional to the length of the electrodes and inversely proportional to their separation.

Questions:

1. Explain the working principle of temperature sensor. (3) [Nov/Dec 2004]
2. What are the materials used for photoresistor? (2)
3. Explain the working principle of thermocouple with neat sketches (3) [Apr/May 2006]

UNIT-II

8085-MICROPROCESSOR & 8051-MICROCONTROLLER

1 (L1)

Introduction:

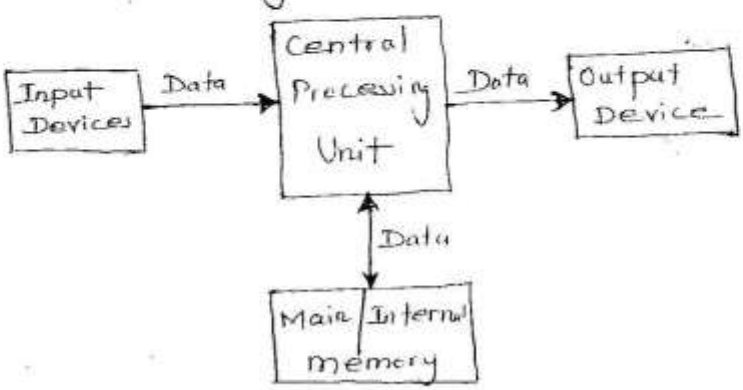
* The microprocessor is one of the most important components of a digital computer. It acts as the brain of a computer system.

* Computers are two types: Digital computer and analog computers.

* A digital computer makes processing of numbers. An analog computer processes analog signals An analog signal is a continuous quantity.

* Now a days computers which are commonly used are digital computers. A digital computer is a programmable machine. Its main components are: CPU (central Processing Unit), memory, input device and output devices.

Digital computer

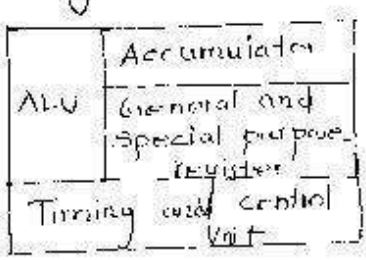


CPU (Central Processing Unit)

* The CPU is the brain of a computer. It executes user programs and controls memory and input/output devices users program is stored in the memory.

* The CPU fetches instructions of a program from the memory sequentially. CPU of a micro-computer is a microprocessor the major components of a CPU are

i. ALU (Arithmetic and Logic Unit)
ii. Timing and control Unit
iii. Registers



ALU: (Arithmetic and Logic Unit)

* ALU performs arithmetic and logical operations performed are addition, subtraction, multiplication and division. In addition to rotate left and right, increment and decrements a number.

Timing and control unit:

* Actually it acts as brain of computer. It controls all the operation of the CPU. It also controls input, output and all other devices connected to CPU.

Registers:

* Registers include accumulator, general purpose register and special purpose registers. The accumulator is a register which contain one of the operands of an instruction to be executed.

Memory:

* It is essential components of digital computer. It is needed to store programs data and results. Its access time is about 10ns it uses static RAMS.

Input devices:

* The CPU receives data and instruction through input devices converts instructions input data and data signals to proper binary form suitable for computer.

Output devices:

* It sends result to output devices. an output devices may store, display or send electrical signal to control certain equipment

Ex:- LED, CRT

(1&2)

Architecture of 8085 Microprocessor

Intel 8085

* The microprocessor is the central processing Unit of a computer. The 8085 also provided some additions features over and above the 8080.

Features of 8085:

* The features of 8085 include.
* It is an 8-bit MP.
* It operates on a signal +5V power supply connected at Vcc.
* It operates on clock cycles with 50% dutycycle
* It has 16 Address Line, hence it can access (2^16) 64 kbytes of memory.

Architecture of 8085 Microprocessor:

* It consists of various function blocks as listed below

1. Registers: * It has 8 addressable 8-bit registers. A, B, C, D, E, H, L, F and two 16 bit registers PC and SP. These registers are classified as:
   i. General purpose register
   ii. Temporary Registers --> (a) Temporary data register (b) W & Z registers
   iii. Special purpose register
      (a) Accumulator (b) flag Registers (c) Stack pointer (SP)

II. Arithmetic and Logic Unit : (ALU)

* The 8085's ALU perform arithmetic and logical function on bit variables. The arithmetic unit performs bitwise fundamental arithmetic operation such as addition, subtraction.

* The logic unit performs logical operations such as complement, AND, OR and EX-OR.

III. Instruction Decoder

* As the 8085 executes seven different type of machine cycles. It gives the information about which machine cycle is currently executing in the encoded from on the S_0 S, IO/$\overline{M}$ lines. This task is done by machine cycle encoder.

IV Address Data Buffer

* This is an 8-bit directional buffer. It is used to drive multiplexed Address/data bus (AD) low order address bus ($A_7 - A_0$) and data bus ($D_7 - D_0$)

* The address and data buffers are used to drive external address and data buses respectively.

V. Address Buffer :

* This is 8-bit unidirectional buffer. It is used to drive external high order address bus ($A_{15} - A_8$). It is also used to tri-state the high order address bus under certain conditions such as reset, hold halt and when address lines are not in use

VI. Incrementer / Decremented Address Latch:

* 16 bit register is used to increment or decrement the content of Program Counter (or) Stack pointer as a part of execution of instruction related to them.

VII. Interrupt control

* The processor fetches, decodes and executes instruction in sequence the occurrence of this special condition is referred as interrupt the interrupt control blocks has five interrupt inputs RST 5.5, RST 6.5, RST 7.5, TRAP and INTR and acknowledge signal $\overline{INTA}$.

VIII. Serial I/o control: * In serial communication one bit is transferred at a time over a signal line.

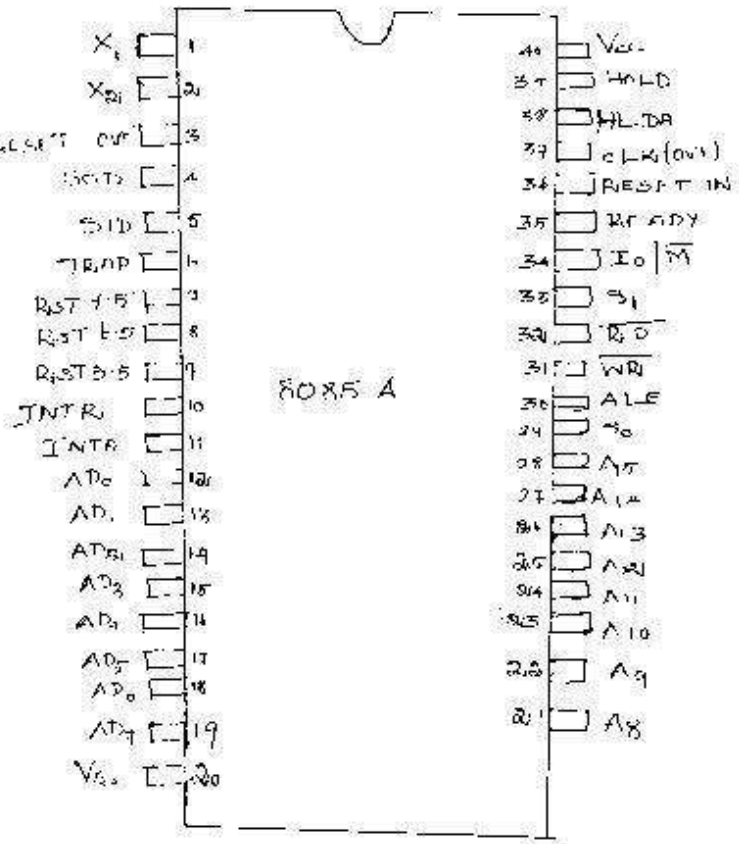
IX. Timing & Control Unit: * The control circuitry in processor 8085 is responsible for all the operation

---

Question.

1. Write the features of 8085 microprocessor. (7)
2. Why data bus is bidirectional & address bus is unidirectional (2)
3. What is flag and list of flag in 8085? (3)
4. Explain the architecture of 8085 microprocessor with neat sketch. (16)

Pin Configuration of 8085 :



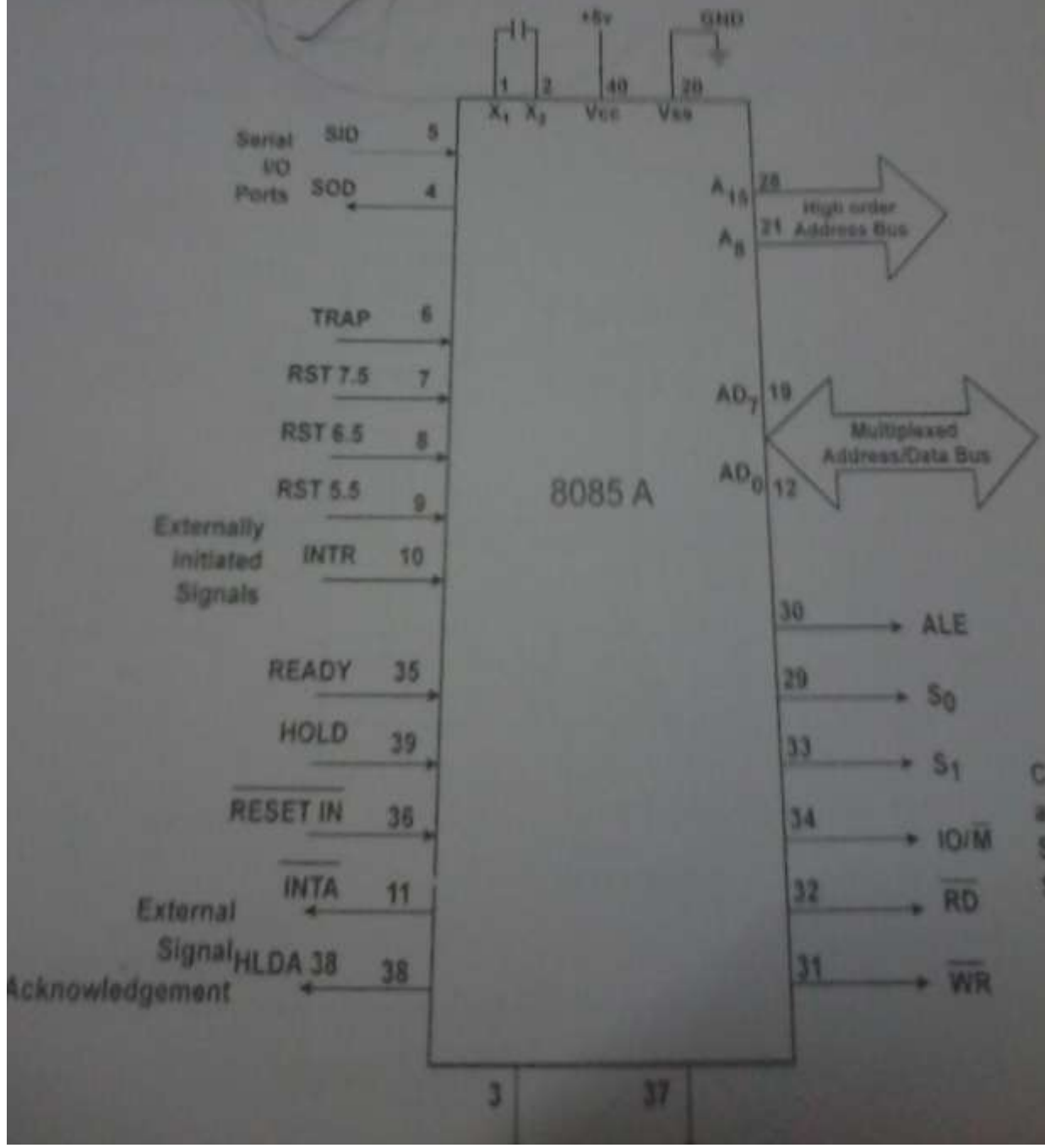
* The signals of 8085 can be classified into seven groups according to their function :

1 Power supply and frequency signals :

* V_{CC} - It requires a signal +5V power supply
* V_{SS} — Ground reference
* X1 and X2 - A tuned circuit like RLC or crystal is connected at these two pins
* CLK OUT — This signal is used as a system clock for other devices. Its frequency is half the oscillator frequency.

(3) Control and Status signals.
(4) Power supply and frequency signals.
(5) Externally initiated signals.
(6) Serial I/O ports.

2.3.1. ADDRESS BUS



ii. Data bus and Address bus

* AD_0 to AD_7 : * The data Bus (D_0 - D_7) is multiplexed with the lower half (A_0 - A_7) of the machine cycle (T_1).

* A_8 to A_{15} :

* The upper half of the 16 bit address appears on the address line A_8 to A_{15}.

iii. Control and status signals

* ALE (Address Latch Enable) * AD_0 - AD_7 line are multiplexed and the lower half of address (A_0 - A_7) is available only during T_1 of the machine cycle.

* $\overline{RD}$ and $\overline{WR}$:

* These signals are basically used to control the direction of the data flow between processor and memory or I/O device/port.

* IO/$\overline{M}$: * Indicator whether I/O operation or memory operation is being carried out. So it indicates the type of machine cycle in process.

iv. Interrupt signals

* The 8085 has five hardware input signals : RST 5.5, RST 6.5, TRAP and INTR.

* The $\overline{INTA}$ (Interrupt Acknowledge) signal is used to indicate that the processor has acknowledged an INTR interrupt.

v Serial I/o signals:

* SID (serial I/p Data): * This input signal is used to accept serial data bit by bit from the external device.

* SOD: (serial o/p data): * this is an output signal which enables the transmission of serial data bit by bit to the external device.

vi DMA Signals:

* HOLD: * this signal indicates that another master is requesting for the use of address bus, data bus and control bus.

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

vii Reset Signals:

* RESET IN: * A low on this pin

* RESET OUT: * this active high signal indicates that process is being reset.

Questions:

1. Define machine cycle, T states and Instruction cycle(s)
2. Mention the various registers in 8085 along with its size. (8)
3. What is ALE? (3)
4. Explain briefly about the pin configuration of 8085. (16)

Addressing Modes

* Every instruction of a program has to operate on a data. The method of specifying the data to be operated by the instruction is called "Addressing". The 8085 supports the following five addressing modes.

i. Immediate Addressing
ii. Direct Addressing
iii. Register Addressing
iv. Register Indirect Addressing
v. Implied Addressing

Immediate Addressing:

* In immediate addressing mode, the data is specified in the instruction itself. The data will be a part of the program instruction.

Example: MVI B, $3E_4$ - Move the data $3E_4$ given in the instruction to B-register.

Direct addressing:

* In direct addressing mode, the address of the data is specified in the instruction.
* The data will be in memory. In this addressing mode the program instruction and data can be stored in different memory blocks.

Ex: LDA 1050_H - Load the data available in memory location 1050_H in accumulator.

Register Addressing:

* In register Addressing mode, the instruction specifies name of the register in which the data is available.

Ex: MOV A, B - Move the content of B-register to A-register.

Register Indirect Addressing:

* In register Indirect, Addressing mode the instruction specified the name of the register in which the address of the data is available.

* Here the data will be in memory and the address will the address will be in a register pair.

Ex: MOV A, M -- The memory data addressed by HL pair is moved to A-register.

Timing diagram of 8085

* The necessary steps which are carried out in a machine cycle can be represented graphically such a graphical representation is called "timing diagram"

* The timing diagram of 8085 micro processor are:

1. Opcode Fetch Machine Cycle: (OF)

* The Opcode fetch cycle, fetches the instructions from memory and delivery it to the instruction register of the microprocessor. For any instruction cycle, Opcode fetch is the first machine cycle.

* The purpose of an OF is to read the contents of a memory location containing the opcode addressed by the program counter and to place it in the instruction register.

2. Memory Read Machine cycle:

* It requires 3 states T_1 to T_3, the purpose of the memory READ operation is to read the contents of a memory location addressed by a and place the data in a µp register by a

register pair, the source of address issued during T_{2s} is not always the program counter but may be any one of the several other register pairs in the µp depending on the particular instruction of which the machine cycle is a part.

iii. Memory Write Machine Cycle:

* It also requires only T_1 to T_3 states

The purpose of memory write is to store the contents of any of the 8085 reg. such as the accumulator into a memory location addressed by a register pair such as HL.

* The 8085 µp made $IO/\overline{M}$ in the beginning of T_2 state to indicate memory reference operation then it puts $S_0 = 1$, $S_1 = 0$ indicates a memory write operation.

iv. Input/Output Read Machine Cycle:

* It is used to fetch one byte from an IO port. It requires 3 T-states.

* During T2, ALE goes low, WR (bar) goes low and data appears on AD0 - AD7 to write data into IO device.

* During T3, Data remains on AD0 - AD7 till WR (bar) is low.

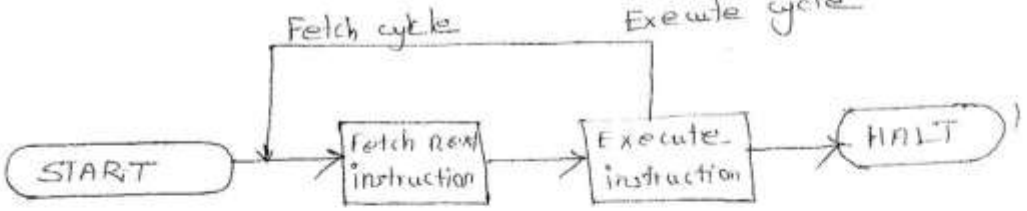
Questions:

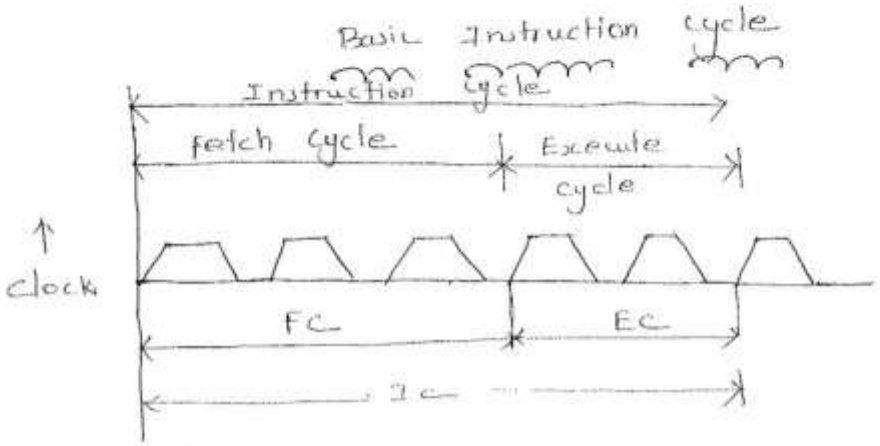
1. What is the need for timing diagram? (2)
2. What operation is performed during first T state of every machine cycle of 8085? (2)
3. Explain briefly about the timing diagram of 8085. (16)

Execute operation:

* The opcode fetched from memory goes to the data register, data/address buffer and then to instruction register (IR).

* From the instruction register it goes to the the decode circuitry which decode the instruction the decode circuit is within the microprocessor.

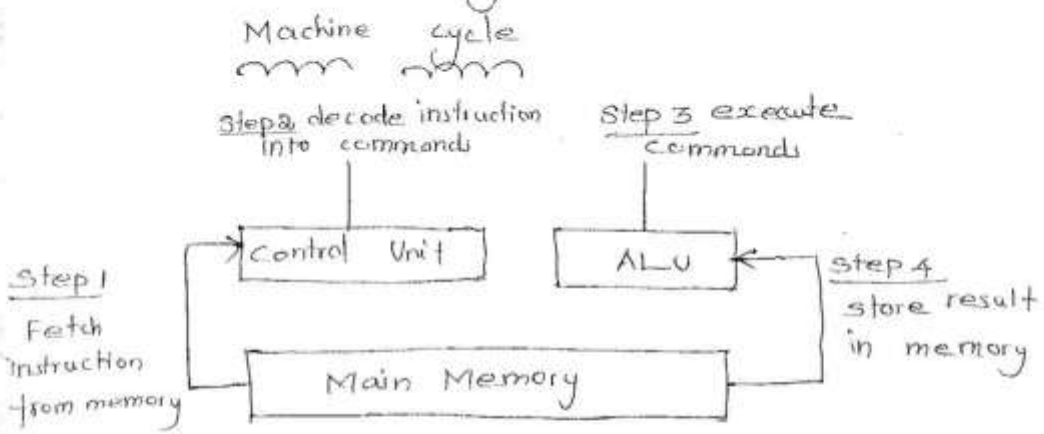




Machine cycle and state:

* The necessary steps carried out to perform the operation of accessing either memory or I/o device, constitute a machine cycle. In order other words necessary steps carried out to

perform a fetch, a read or a write operation constitute a machine cycle.



* In a machine cycle, one basic operation such as opcode fetch, memory read memory write, I/o read, I/o write is performed. An instruction cycle consists of several machine cycles. The opcode of an instruction is fetched in the first machine cycle of an instruction cycle.

Questions:

1. Define machine cycle, T states and Instruction cycle. (8)
2. List the steps involved in the instruction execution. (8)
3. Explain the following in detail (16)
   i. Instruction cycle
   ii. Machine cycle

* During T2, ALE goes low, WR (bar) goes low and data appears on AD0 - AD7 to write data into IO device.

* During T3, Data remains on AD0 - AD7 till WR (bar) is low.

Questions:

1. What is the need for timing diagram? (2)
2. What operation is performed during first T state of every machine cycle of 8085? (2)
3. Explain briefly about the timing diagram of 8085. (16)

Example of Program

1. Statement : Store the data byte 32H into memory location 4000H.

Program 1:

```
MVIA, 32H   : store 32H in the accumulator
STA 4000H   : Copy accumulator contents at
              address 4000H
HLT         : Terminate program execution
```

Program 2:

```
LXI H, 4000 : Load HL with 4000H
MVI M       : store 32H in memory location
              pointed by HL register pair
              (4000H)
HLT         : Terminate program execution
```

---

2. Statement : Exchange the contents of memory locations 2000H and 4000H

```
LDA 2000H   : Get the contents of memory
              location 2000H into accumulator.
MOV B, A    : Save the contents into B
              register.
```

Program:

LDA 4000 H : Get the contents of memory location 4000H into accumulator.

STA 2000 H : store the contents of accumulator at address 2000H

MOV A, B : Get the saved contents back into A register.

STA 4000 H : store the contents of accumulator at address 4000H

---

3. Write an assembly language program for addition of Two 8-bit Numbers.

Algorithm:

step 1 : Intialize the carry as "zero"

step 2 : Load the first 8 bit data into the accumulator.

step 3 : Copy the contents of accumulator into the register "B"

step 4 : Load the second 8 bit data into the accumulator.

step 5 : Add the 2-8 bit datas and check for carry.

step 6 : Jump on if no carry

step 7 : Increment carry if there is

step 8 : store the added request in accumulator

Step 9 : More the carry value to accumulator

step 10 : store the carry value in accumulator

step 11 : stop the program execution.

Program :

MVI C, 100 : Initialize the carry as zero

LDA 4300 : Load the first 8 bit data.

MOV, B, A : Copy the value of 8 bit data into register B

LDA 4301 : Load the second 8 bit data into the accumulator.

ADD B : Add the values

JNC : Jump on if no carry

INR C : If carry is there increment it by one.

STA 4302 : store the added value in the accumulator.

MOV A, C : More the value of carry to the accumulator from register C

HLT : Stop the program execution.

UNIT – III

(L1)

Programmable Peripheral Interface

Introduction:

* Memory is a storage device and it is an important role in any microcomputer system. This chapter focus how to interface a memory chip with microprocessor.

* Memory has certain signal requirements to write into and read from its register. Similarly, the microprocessor initiates a set of signals when it wants to read from and write into memory.

Memory Structure and its Requirements:

* The primary function of memory interfacing is that the microprocessor should be able to read from and write into a given register of a memory chip. To perform these operations, the microprocessor should.

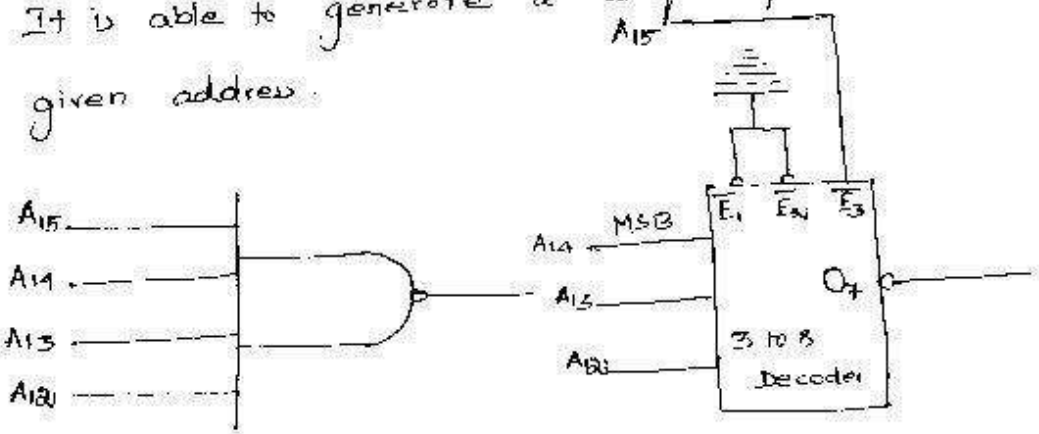
i. Be able to select the chip

ii. Identify the register

iii. Enable the appropriate buffer

Address Decoding:

* The process of address decoding should result in identifying a register for a given address. It is able to generate a unique pulse for a given address.



Address Decoding Using NAND Gate and 3-to-8 Decoder

Step 1 * The 8085 address lines A_{11} - A_6 are connected to pins A_{11} - A_6 of the memory chip to address 4096 registers.

Step 2. * The decoder is used to decode four address lines A_{15} - A_{12}. The output O_0 of the decoder is connected to chip Enable ($\overline{CE}$). The $\overline{CE}$ is asserted only when the address on A_{15} - A_{12} is 0000.

Step 3: * For this EPROM, one control signal is : Memory read ($\overline{MEMR}$), active low. The $\overline{MEMR}$ is connected to $\overline{OE}$ to enable the output buffer, $\overline{OE}$ is the same as $\overline{RD}$.

Address decoding and memory addresses:

* The address range of this memory chip is obtained by analyzing the possible logic level on the 16 address lines.

* The logic levels on the address lines A_{15} - A_{12} must be 0000 to assert the chip Enable, and the address lines A_{11} – A_0 can assume any combinations from all 0's to all 1's.

* Thus, the address OFFFH selects the register. When the 8085 asserts the $\overline{RD}$ signal, the output buffer is enabled and the contents of the register OFFFH are placed on the data bus for the processor to read.

Questions.

1. What is the need of port? (2)
2. Define port. (2)
3. Why interfacing is added for I/o devices? (2)
4. Define PPI. (8)

Architecture of 8255

INTEL 8255

* The 8255 is a general purpose programmable I/o device designed for use with Intel microprocessors. It consists of three 8-bit bidirectional I/o ports (24 I/o lines) that can be configured to meet different system I/o needs.

* The three ports are PORT A, PORT B, PORT C. PORT A contains one 8-bit output latch/buffer and one 8-bit input buffer. PORT B is same as PORT A. PORT C can be split into two parts PORT C lower ($PC_0 - PC_3$) and PORT C upper ($PC_7 - PC_4$) by the control word.

Function Description:

* This support chip is a general purpose I/o component to interface peripheral equipment to the microcomputer system. It is programmed by the system software so that normally no external logic is necessary to interface peripheral devices (or) structures.

Data bus buffer:

* It is a tri-state 8-bit buffer used to interface the chip to the system data bus. Data is transmitted (or) received by the buffer upon execution of input (or) output instructions by the CPU.

Port B: It has an 8-Bit data I/O latch/buffer and an 8-bit data input buffer. It can be programmed in Mode 0 and Mode 1.

Port C: It has one 8-Bit unlatched input buffer and an 8-bit output latch/buffer. Port C can be separated into two ports and each can be used as control signals for port A and B in the handshake mode. It can be programmed for bit set/reset operation.

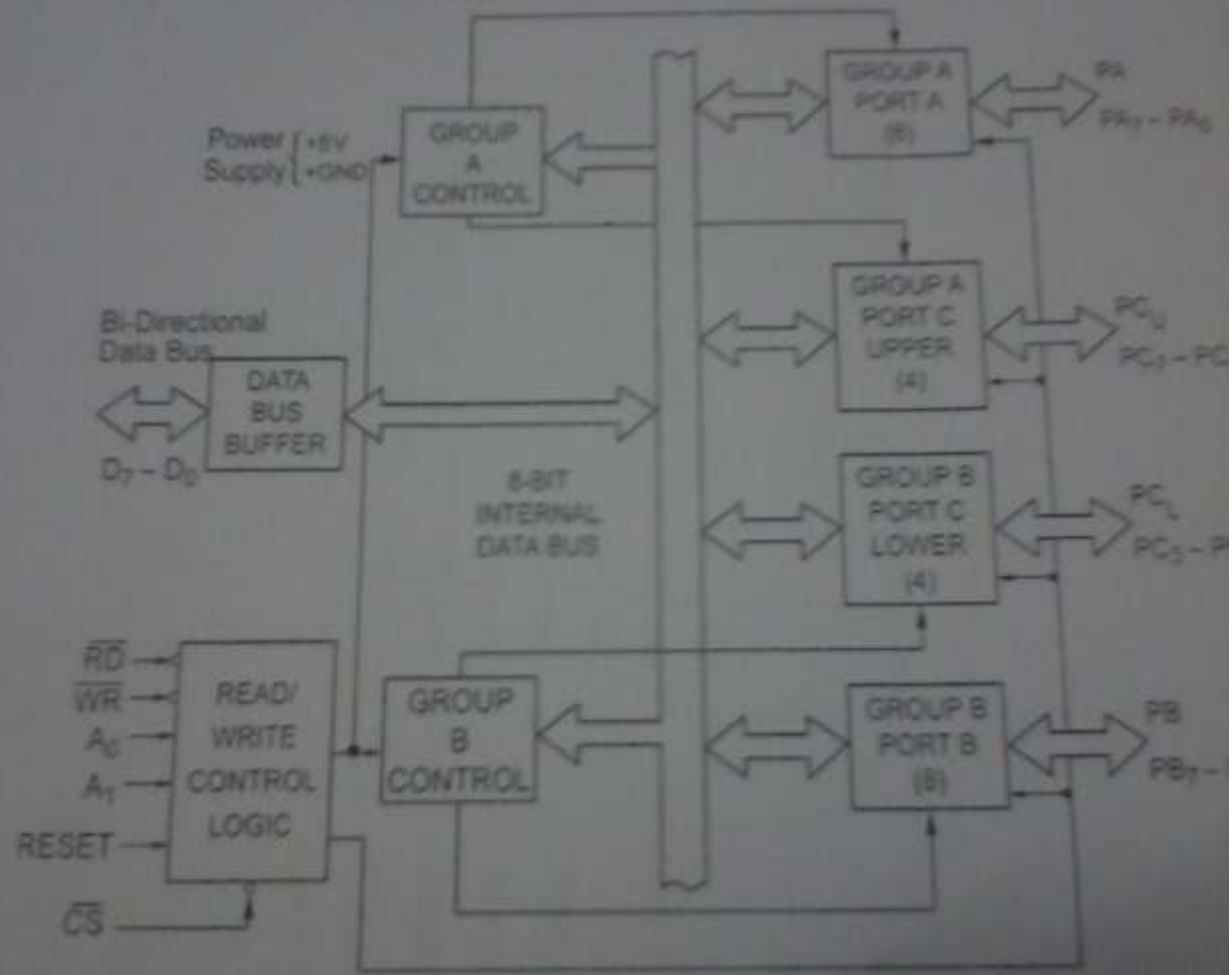


Figure 3.3 Block Diagram of 8255

ta Bus Buffer

- It is a tri-state bi-directional buffer used to interface the internal da 8255 to the system data bus.
- The instruction executed by the microprocessor can read the data

* Control words and status information are also transferred through the data bus buffer. The data lines are connected to BDB of microprocessor.

Read/write and logic control:

* The function of this blocks is to control the internal operation of the device and to control the transfer of data and control (or) status words. It accepts inputs from the CPU address and control buses and in turn issues command to both the control groups.

$\overline{CS}$ chip select:

* A low on this input selects the chip and enables the communication between the 8255 A & the CPU. It is connected to the output of address decode circuitry to select the device when it

$\overline{RD}$ (Read):

A low on this input enables the 8255 to send the data (or) status information to the CPU on the data bus.

$\overline{WR}$ (WRITE)

* A low on this input pin enable the CPU to write data (or) control words into the 8255 A.

RESET:

* A high on this input pin clears the control register and all ports (A, B, C) are initialized to input mode. This is connected to RESET OUT of 8255. This is done to prevent destruction of circuitry connected to port lines.

PORT A: * One 8-bit data output latch/buffer and one 8-bit data input latch.

PORT B: * One 8-bit data output latch/buffer and one 8-bit data input buffer.

PORT C:

* This port can be divided into two 4-bit ports under the mode control. Each 4-bit port contains a 4-bit latch and it can be used for the control signal outputs and status signals inputs in conjunction with ports A and B.

Questions:

1. What are the operating modes in 8255? (2)
2. Why 8255 IC is called programmable device? (3)
3. With a neat block diagram, explain in detail the internal architecture of 8255. (16)

Keyboard Interfacing

* The 8279 is a hardware approach to interfacing a matrix keyboard and a multiplexed display. The software approach to interfacing a matrix keyboard and a multiplexed display of seven-segment LEDs.

* The keyboard segment can be connected to a 64-contact key matrix. Keyboard entries are debounced and stored in the internal Fifo (First-in-First-Out) memory which is an Interrupt signal is generated with each entry.

* The display segment can provide a 16-character scanned display interface with such devices as LEDs. This segment has 16 x 8 R/W memory (RAM), which can be used to read/write information for display purpose. The display can be set up in either right-entry or left-entry format.

* Four major sections of 8279. They are as follows;

i. Keyboard section
ii. Scan section
iii. Display section
iv. MPU Interface section

Keyboard Section:

* This section has eight lines ($RL_0 - RL_7$) that can be connected to eight columns of a keyboard, plus two additional lines: shift and CNTL/STB (control/strobe). The status of the SHIFT key and the control key can be stored along with a key closure.

* The key board section also includes 8x8 FIFO RAM. The FIFO RAM consists of eight registers that can store eight keyboard entries; each is then read in the order of the entries. The status logic keeps track of the number of entries and provides an IRQ (Interrupt Request) signal when the FIFO is not empty.

Scan Section:

* The scan section has a scan counter and four scan lines ($SL_0 - SL_3$). These four scan lines can be decoded using a 4-to-16 decoder to generate 16 lines for scanning. These lines can be connected to the rows of a matrix keyboard and the digit drivers of a multiplexed display.

Display Section:

* The display section has eight output lines divided into two groups $A_0 - A_3$ and $B_0 - B_3$. These lines can be used, either as a group of eight lines or as two groups of four, in conjunction with the scan lines for a multiplexed display.

* The display can be blanked by using the blank line. This section includes 16×8 display RAM. The MUP can read from or write into any of these registers.

MPU Interface Section:

* This section includes eight bidirectional data lines ($DB_0 - DB_7$), one interrupt request line (IRQ), and six line for interfacing including the buffer address line (A_0)

* When A_0 is high, signals are interpreted as control words or status. When A_0 is low signals are interpreted as data. The IRQ line goes high whenever data entries are stored in the FIFO. This signal is used to interrupt the MPU to indicate the availability of data.

Questions:

1. What are the difference between Synchronous serial and asynchronous data transmission? (2)
2. What are the tasks involved in keyboard interface? (2)
3. What is multiplexed display? (2)
4. Explain briefly about the architecture of 8279. (6)

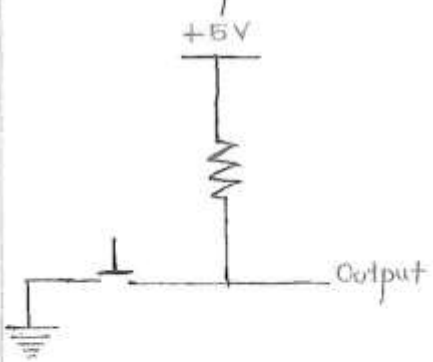
Keyboard :

* In keyboard, the keys $K_7 - K_0$ are tied high through to K_Ω resistor, and when a key is pressed, the corresponding line is grounded. When all keys are open and if the 8085 reads port A, the reading on the gate bus will be FFH.

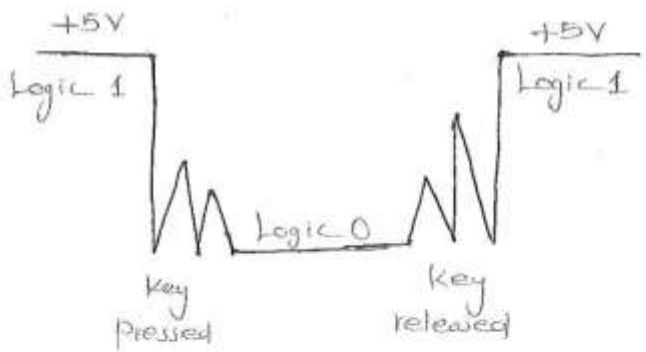
* When any key is pressed, the reading will be less then FFH. If K_7 is pressed, the output of port A will be 01111111 (7FH).

Key Debounce :

* When a mechanical pushbutton key is pressed or released, the metal contacts of the key momentarily bounce before given a steady state reading. Therefore if is necessary that the bouncing of the key should not read as input.



Push button key Bounce



Push Button Key Debounce

* The microprocessor sends a start of conversion (SOC) signal to the A/D converter through port C lower of 8255.

* When A/D converter computer conversion, it sends as End of conversion (EOC) signal to the microprocessor.

* Having received as EOC signal from A/D converter, the microprocessor reads the output of an A/D converter which is a digital quantity proportional to the temperature to be measured.

* If there is no error, then no process has to be done and again the sensing activity has to be done repeatedly for continuous temperature maintenance.

Questions:

1. What is resolution in DAC? (2)
2. What are the internal devices of a typical DAC? (2)
3. Explain the working of 8085 based temperature control. (16)

* The three-bit D/A converter has eight possible combinations. If a converter has "n" input lines, it can have 2^n input combinations.

* If the full-scale analog voltage is 1V, the smallest unit or the LSB (001_2) is equivalent to $1/2^n$ of 1V. This is defined as resolution.

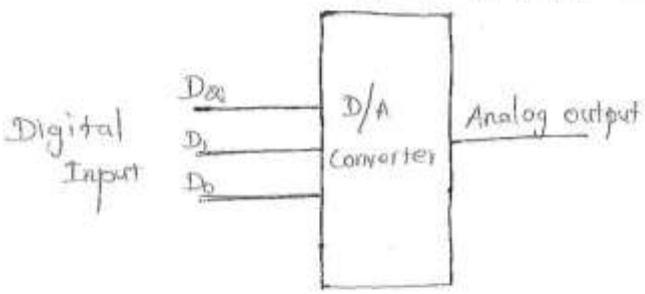
* The MSB represents half of the full-scale value.

* For the maximum input signal (111_2), the output signal is equal to the value of the full-scale input signal minus the value of the 1 LSB input signal.

D/A Converter Circuit:

* Input signals representing appropriate binary values can be simulated by operation amplifier with a summing network.

A 3-Bit D/A converter



* The input resistors R_1, R_2 and R_3 are selected in binary weighted proportion; each has double the value of the previous resistor. If all three input are 1V. The total output current is

Digital - to Analog (D/A) Converters: [DAC]

* Digital - to - Analog converters can be broadly classified in there categories;

i. Current output
ii. Voltage output
iii. Multiplying type

* The current output DAC provides current as the output signal. The voltage output DAC internally converts the current signal into the voltage signal. The voltage output DAC is slower than the current output DAC because of the delay in converting the current signal in the voltage signal.

Concept of D/A converters:

* A three-bit D/A converter has three digital input lines ($D_2 - D_1$, D_0) and one output line for the analog signal. The thee lines can assume eight (2^3=8) input combinations from 000 to 111, D_2 being the most signification bit (MSB) and D_0 being the least significatin bit (LSB).

* The following are the features of a D/A converter

* Various standards have been drawn up to define the protocol for the transmission of binary data from within the microcomputer bus structure to external microcomputer devices such as display monitors, printers and other peripheral equipment.

Serial Communication:

* Serial communication is the most common method used for the interconnection of a microcomputer to the relatively slow peripheral hardware, or between two computers, when transferring a low volume of information.

* The three main connections are "transmitted data" (pin 2), 'received data' (pin 3) and 'signal ground or common return' (pin 7). These would normally be connected. For communication in both directions, (ie) full duplex, the two handshaking control lines - 'request to send' (pin 4) and 'clear to send' (pin 5) are also required.

* It should be noted that while the voltages and signal connections for the plug are defined in the standard, the data protocol is not identified. This must be known for the devices which are to be connected and can be set accordingly by software. The requirements are:

* Baud rate;
* Number of bits in the ASCII group defining the character being transmitted;
* Odd, even or no parity;

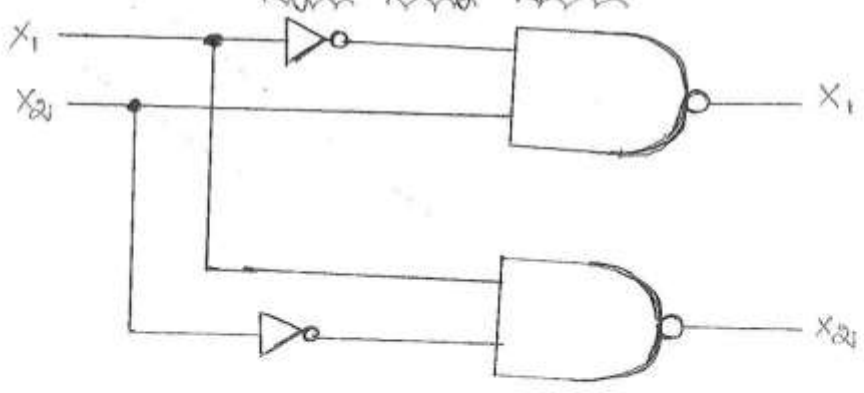
* A stepper motor is a digital motor. If had been driven by digital signal. A typical two phase motor interfaced wing 8255.

* Motor shown in the circuit has two phases, With center-tap winding. The center taps of these windings are connected to the 12V supply. Due to this motor can be excited by grounding four terminals of the two windings.

* Motor can be rotated in steps by giving proper excitation sequence to these windings. The lower nibble of port A of the 8255 is wed to generate excitation signal in the proper sequence.

* The given excitation sequence rotates the motor in clockwise direction. To rotate motor in anti-clockwise direction, we have to excite motor in a reverse sequence.

Digital Locking System



* The excitation sequence for stepper motor may change due to change in winding connections. However, it is not desirable to excite

* Due to this motor can be excited by grounding four terminals of the two windings.

* Motor can be rotated in steps by giving proper excitation sequence to these winding.

* The lower nibble of port A of the 8255 is wed to generate excitation signals in the proper sequence. These excitation signal are buffered wing driver transistors.

* The transistors are selected such that they can source rated current for the windings. Motor is rotated by 1.8° per excitation.

Stepping rate:

* A stepper motor is stepped from one position to the next by changing the currents through the fields in the motor. The winding inductance opposes the change in current and this puts limit on the stepping rate.

Isolation: * For higher current motor, it is not desirable to have a common power circuit ground and control circuit ground.

Questions:

1. What is Debouncing? (2)
2. Explain the interfacing of stepper motor with 8255 with relevant diagram. (16)

* Temperature control using 8085 microprocessor.

The following elements are used in 8085 microprocessor.

Transducer:

* For the measurement of physical quantities transducers are used. They convert them to electrical quantities. Here, for measuring temperature, sensor like thermocouple, thermistor, sensitor can be used.

Amplifier:

* If the electrical signal from transducer is small, it can not be visualised (or) processed. Hence it is amplified using amplifiers.

ADC:

* The electrical signal from transducer is an analog signal which a microprocessor cannot process. Hence an analog to digital converter is used.

DAC:

* The signal from microprocessor will be digital signal which is going to control the analog elements like heater, cooler etc. For the digital signal from the microprocessor has to be converted to analog by a DAC.

Working:

* The plant may be an equipment (or) a furnace for which the temperature has to be monitored and maintained

Data Transfer:

* A serial communication device transfers data in bits in the same direction. A parallel communication device sends data in multiple bits to the same direction. In serial communication a word of eight bits in length is sent sequentially.

* In parallel communication the eight bits are transferred in corresponding 8 channels, every channel transmits a bit, and a byte of data is received simultaneously.

Speed:

* A parallel communication devices are faster than their serial counterparts. A serial communication device sends data in bits, and at the end the bits harmonize to form a byte of data.

Connection: * Serial communication uses fewer connections and cables than parallel communication. The use of fewer wires in serial communication makes its signals clearer.

Cost: * Serial communication has a single port with a connector while a parallel port is usually connected to eight wires.

Questions:

1. What are the difference between parallel and serial communication ? (2)

2. Explain briefly about the interfacing communication in detail. (10)

* The traffic light control using 8085/8086 is given as follows. The traffic light arrangement and traffic should be controlled in the following sequence.

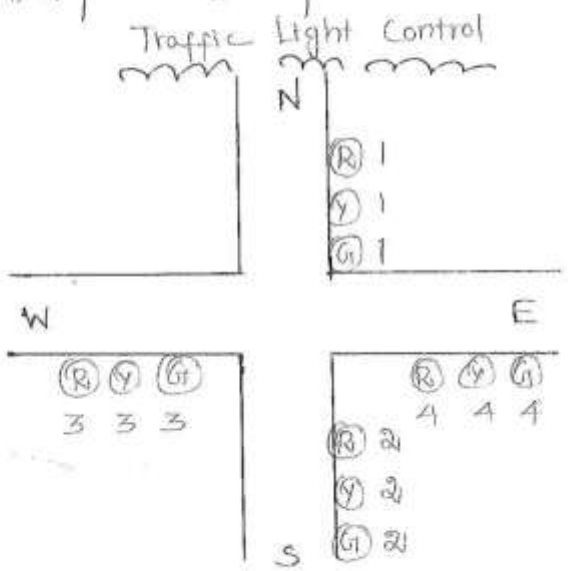
i. Traffic is allowed from west (W) to east (E) and E to W transition for 20 seconds.

ii. Give transition period of 5 seconds (yellow bulbs ON)

iii. Allow traffic from North (N) to south (S) and S to N for 20 seconds.

iv. Give transition period of 5 seconds (yellow bulbs ON)

v. Repeat the process.



Digital - to Analog (D/A) Converters: [DAC]

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* The following are the features of a D/A converter

of the same winding simultaneously. This cancels the flux and motor winding may get damaged. To avoid this, digital locking system must be designed.

* Only one output is activated (made low) when properly excited, otherwise output is disabled. (made high).

* Stepper motor is stepped from one position to the next by changing the currents through the fields in the motor. The winding inductance opposes the change in current and this puts limit on the stepping rate.

* For higher stepping rates and more torque it is necessary to use a higher voltage source and current limiting resistors.

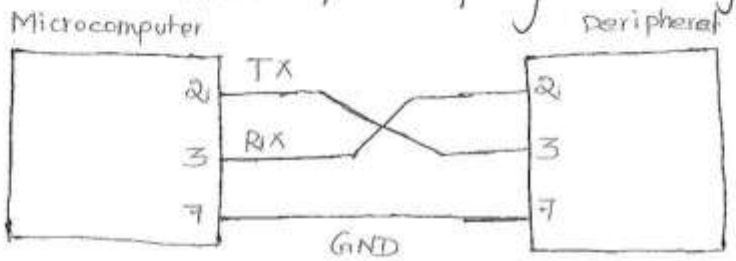
* By adding series resistance we decrease L/R time constant, which allows the current to change more rapidly in the windings. There is a power loss across series resistor, but designer has to compromise between power and speed.

Hardware:

* Interface of stepper motor to 8086 micro processor system using 8255. In the circuit has two phase,

Parallel Communication:

* The RS232 serial standard for communication was developed essentially for the connection of microcomputers via a telephone links. The parallel standard emerged from the need to establish a means of interfacing a variety of instruments



Pin connection of Information Transfer

* The most common standard for the integration of automated test systems, developed by Hewlett-Packard, is referred to as the IEEE-488 interface bus, and has achieved wide recognition among instrument manufacturers since the start of the 1980s.

* The bus consists of 24 lines, accommodated within standard type connectors. The eight bit-directional data lines carry informations as 7-bit ASCII codes between the microcomputer (controller), and an instrument (listener) on the bus.

* The roles may be reversed when data are being logged. To process the information on the data bus, up to eight control and status signals are available.

* Interfacing a pushbutton keyboard and a seven segment LED display wing 8255A may emphasis to integrate hardware and software.

* When a key is pressed, the binary reading of the key has almost no relationship to what is represent. Similarly, to display a number at a seven-segment LED, the binary value of number need to be converted into the seven-segment code, which is primarily decided by the hardware consideration.

* Let us consider a pushbutton keyboard is connected to port A and a seven-segment LED is connected to PORTB of the 8255A.

* Consider an example of writing a program to monitor the keyboard to sense a key pressed and display the number of the key of the seven-segment LED. When the key K7 is pressed, the digit 7 should be display at PORT B.

* The programming of this problem can be divided into the categories as follows

i. Checks a key is pressed

ii. Debounce the key

iii. Identify and encode the key in appropriate binary format.

iv. Obtains the seven-segment code and display it.

Seven-Segment Display:

* Seven segment LED is connected to PORTB through the driver 74LS244. The driver is necessary to increase the current capacity of portB; each LED segment requires 15-20 mA of current.

* The driver 74LS244 is an octal non-inverting drive with tri-state output and current sinking capacity of 24mA. It has active low enable lines ($1\overline{G}$ and $2\overline{G}$) and the driver is permanently enable by grounding these line.

DISPLAY: This routine takes the binary number and converts.

```
; into its common-anode seven-segment LED code.
; The codes are stored in memory sequentially,
; Starting from the address CACODE
; Input : Binary number in accumulator
; Output : None
; Modifies contents of HL and A
```

Questions:

1. What is multiplexed display? (2)
2. What is scanning in display and scan time? (2)
3. What is the disadvantages in 7-segment LED interfacing using ports? (2)
4. Explain briefly LED display-interfacing. (16)

* The three-bit D/A converter has eight possible combinations. If a converter has "n" input lines, it can have 2^n input combinations.

* If the full-scale analog voltage is 1V, the smallest unit or the LSB (001_2) is equivalent to $1/2^n$ of 1V. This is defined as resolution.

* The MSB represents half of the full-scale value.

* For the maximum input signal (111_2), the output signal is equal to the value of the full-scale input signal minus the value of the 1 LSB input signal.

D/A Converter Circuits:

* Input signals representing appropriate binary values can be simulated by operation amplifier with a summing network.

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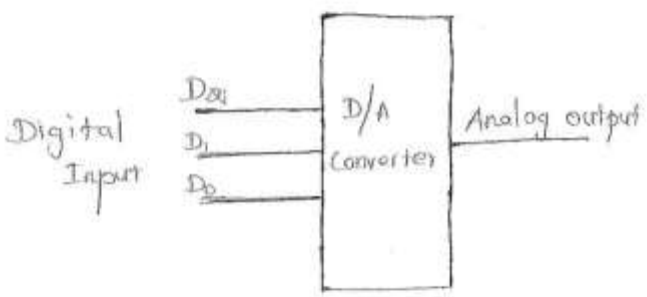


* The input resistors R_1, R_{2i} and R_3 are selected in binary weighted proportion; each has double the value of the previous resistor. If all three input are 1V. The total output current is

Control word

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

Consider the operating frequency of 8085 = 2 MHz

$$\text{Time for 1 T-State} = \frac{1}{2\text{MHz}} = 0.5\ \mu\text{sec}$$

$$\text{Count} = \frac{\text{Required delay}}{\text{Time required for 1 loop}}$$

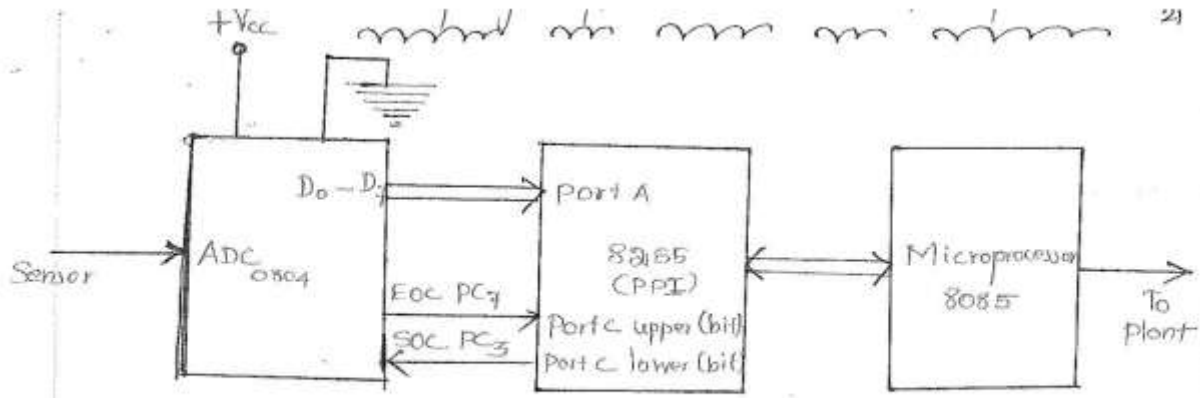
If time required for count initialization instruction is neglected.

$$\text{Count} = \frac{0.5\ \text{sec}}{0.5\mu\text{sec} \times 24} = \text{A2C.2H}$$

(∵ 1 loop is required 24 T-states)

Question:

1. With a relevant diagram explain the interfacing of traffic light control system with 8255. (16)



* The transducer measures current temperature and it is amplified by the amplifier which gets converted to hexadecimal digital value in ADC.

* This value is compared with the already set desired value in the microprocessor and the result of the comparison is an error signal (or) null. The error may be positive meaning the temperature has to be increased by a heater arrangement.

* It may be negative meaning the temperature has to be reduced by some coding setup.

* If there is no error, then no process has to be done and again the sensing activity has to be done repeatedly for continuous temperature maintenance.

* For interfacing temperature control system with microprocessor, 8255(PPI) and suitable ADC are connected between microprocessor and sensor output.

$$I_o = I_T = I_1 + I_2 + I_3$$

$$= \frac{V_{in}}{R_1} + \frac{V_{in}}{R_2} + \frac{V_{in}}{R_3}$$

$$= \frac{V_{in}}{1K}\left[\frac{1}{2} + \frac{1}{4} + \frac{1}{8}\right]$$

$$= 0.875\ mA$$

The output voltage $V_o = -R_f I_T$

$$= -(1\ K)(0.875\ mA)$$

$$= 0.875\ V$$

Where input voltage Vin is replaced by V_{REF}, which can be turned on (or) off by the switches. The output current I_o can be generalize for any number of bits as

$$I_o = \frac{V_{Ref}}{R_1}\left(\frac{A_1}{2} + \frac{A_2}{4} + \cdots \frac{A_n}{2^n}\right)$$

Where A_1 to $A_n = 0$ (or) 1

Questions:

1. What are the different types of ADC? (2)
2. What is settling (or) conversion time in DAC? (2)
3. What are the internal devices of a typical DAC? (2)
4. With relevant diagram explain the interfacing of digital to analog converter with 8085. (16)

Seven-Segment Display:

* Seven segment LED is connected to PORT B through the driver 74 LS 244. The driver is necessary to increase the current capacity of port B; each LED segment requires 15-20 mA of current.

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Questions:

1. What is multiplexed display? (2)
2. What is scanning in display and scan time? (2)
3. What is the disadvantages in 7-segment LED interfacing using ports? (2)
4. Explain briefly LED display-interfacing. (16)

* The interface diagram to control 12 electric bulbs are used. Port A is used to control lights on N-S road and port B is used to control lights on W-E road.

* The electric bulbs are controlled by relays. The 8255 pins are used to control relay on-off action with the help of relay driver circuits. The driver circuit include 12 transistor to drive 12 relays.

Pin connection

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

* The I/o mapping and the control word for the initialization of 8255. The data bytes to be send for specific combination is shown in table.

Software:

Control Word: For initialization of 8255.

Keyboard :

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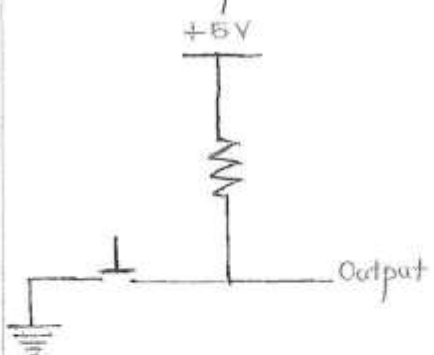
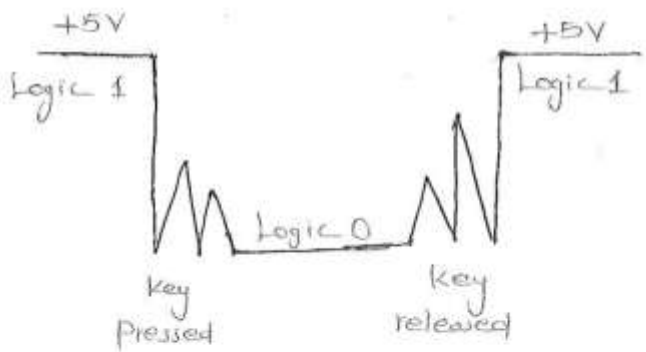


Push button key Bounce



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iv. Obtains the seven-segment code and display it.

UNIT-IV [Programmable Logic Controller] (L1)

Introduction

* A programmable logic controller is a solid state digital electronic device, designed for use in an industrial environment.

* It is a microprocessor based specialized computer that carries out control functions of many types and levels of complexity. Its purpose is to monitor crucial process parameters and adjusts process operations accordingly.

* The programmable logic controllers find fast applications in the control and operation of automated manufacturing process equipment and machinery, conveyors systems etc.. most of the industrial setting PLCs are used to automate manufacturing and assembly processes.

PLC

* A programmable logic controller is a microprocessor based controller that uses a programmable memory to store instructions and to implement functions such as logic,

Sequencing, timing, counting and arithmetic inorder to control machines and process.

Basic structure:

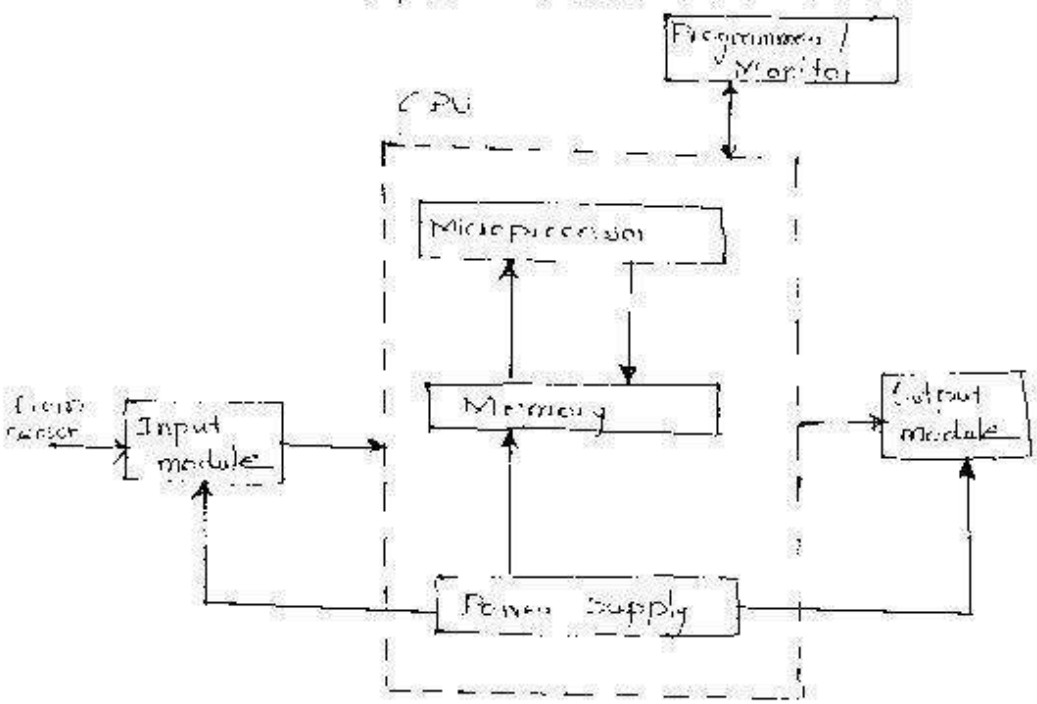
* Three major parts of PLC are

i. Central processing Unit

ii. Programmer/Monitor and

iii. Input/Output modules

Block diagram of PLC



Central Processing Unit (CPU)

* The "brain" of the system which has three sub-parts

I. Microprocessor:

* Microprocessor carries out mathematic and logical operations.

II. Memory:

* The area of the CPU in which data and information is stored and retrieved. It holds the system software and user program.

III. Power supply:

* The electrical supply that converts Alternating Current (AC) line voltage to various operational DC values.

Programmer/Monitor:

* The programmer/Monitor (PM) is a device used to communicate with the circuits of the PLC. Handheld terminals, industrial terminals and the personal computer exist as PM devices.

* In a hand-held unit, input takes place through a membrane keypad and the display is usually a Liquid Crystal Display (LCD).

Input/output Modules:

* The input module has terminals into which outside process electrical signals, generated by sensors (or) transducers are entered. The output module has terminals to which output signals are sent to activate relays, solenoids, various solid state switching devices, motors and displays.

Questions:

1. Define PLC (2)
2. What are the components of a PLC? (2)
3. Draw the blocks diagram of PLC. (8) [Nov/Dec 2004]
4. Explain the basic functions of the major parts of PLC. (8) [Nov/Dec 2004, May 2005, Apr/May 2007]

Input/Output Processing

* From the input/output module, we get information in and out of the PLC. The input module terminals receive signals from wires connected to input sensors and transducers. The output module terminals provide output voltages to energize actuators and indicating device.

* In smaller systems, the input and output terminals may be included on the same frame as the CPU. In other, larger PLC systems, the input and output modules are separate units.

* Some PLC systems the programming instead of switches to configure Input/Output module settings. Some small systems require no address setting on the Input/Output modules.

* A most important consideration for an Input/Output module is the module's voltage and current rating. Both voltage and current must match the electrical requirements of the system to which the module is connected.

Input Modules (Interfaces)

* The input module performs four tasks electronically,

i. It senses the presence (or) absence of an input signal at each of its input terminals. The input signals tells what switch, sensor (or) other signals is ON or OFF in the process being controlled.

ii. It converts the input signals for high or ON state, to a DC level usable by the modules electronic circuit.

iii. The input module carries out electronic isolation by electronically isolating the input module output from its input.

iv. Finally, its electronic circuit must produce an output, via output logic, to be sensed by C.P.U. (PLC). For a low or OFF, input signals, no signal is converted, indicating OFF

Output Modules (Interfaces)

* The output module operates in the opposite manner from the input module as seen in the block diagram. A DC signal from

the CPU is converted through each module section to a usable output voltage, either AC (or) DC.

* A signal from the CPU is recieved by the output module logic, once for each scan. If the CPU signal code matches the assigned number of the module, the module section is turned ON. The identification numbers of the module are again determined by the setting of the module DIP switches.

* The matching CPU signals, if received goes through an isolation stage. Again isolation is necessary so that any erratic voltage surge from the output device does not get back into the CPU and cause damage.

Questions:

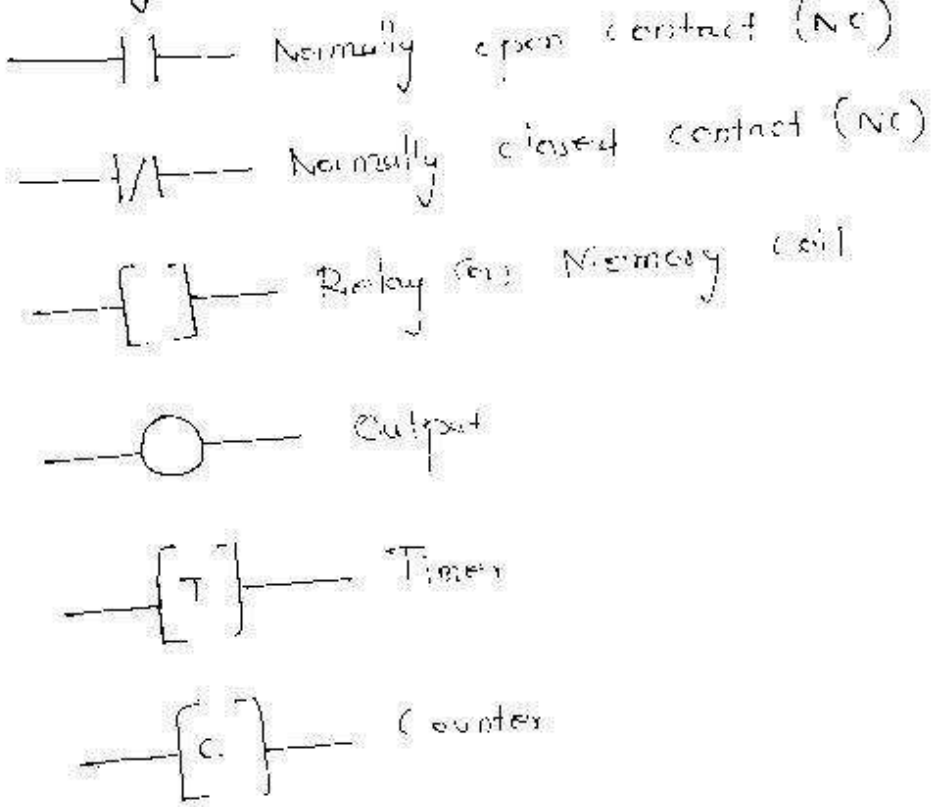
1. What is the function of programming devices? (2)
2. List out the various programming device. (2)
3. Explain the input and modules. (16)

Programming

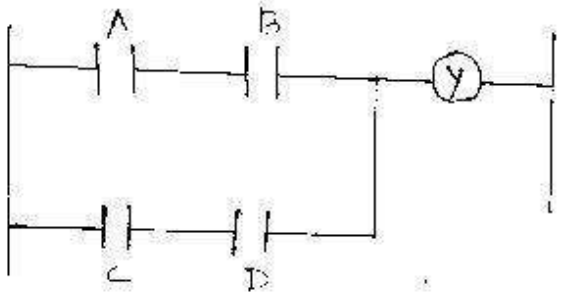
* Ladder diagrams is most commonly used programming method evolved from electrical relay circuits and is in the form of graphical language.

* In its simple form, ladder diagram is a network of contacts and coils are arranged on rungs between two vertical lines called rails used.

* Followings are the symbols used in the ladder diagram.



Proper Construction of PLC ladder Diagrams



* No Vertical contacts are allowed.

* A coil must be inserted at the end of the rung.

* All contacts must run horizontally.

* Only one output may be connected to a group of contacts.

* Flow must be from left to right.

Proces scanning Considerations:

* PLC function by scanning their operational programs. Each PLC operational cycle is made up of three separate parts

i. Input Scan

ii. Program Scan and

iii. Output Scan

* The total time for one complete program Scan is a function of processor speed and length of user program.

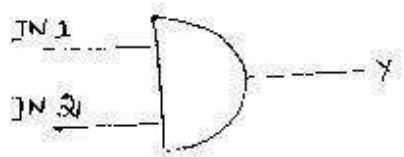
* During the input scan, input terminals are read and the input status table is updated accordingly

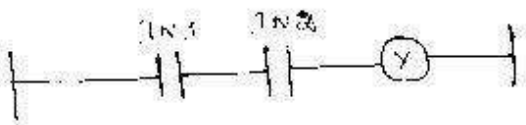
* During the program scan, data in the input status table is applied to the user program, the program is executed, and the the output status table is updated.

* During the output scan, data associated with the output status table is transferred to output terminals.

Logic function:

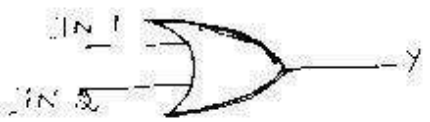
i. AND Gate:

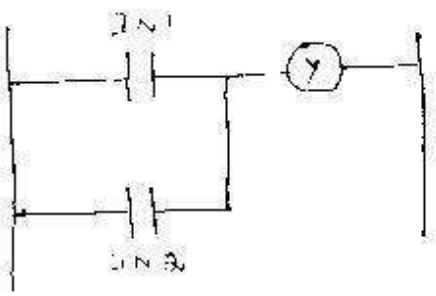




* IN 1 and IN 2 are the inputs. When the two inputs are energized, we get high output (Y). If any one input is not energise then the output (Y) is low or OFF

ii. OR Gate:





Shift Register:

* shift registers can be used where sequence of operations is required (or) movement (or) tracks the flow of parts and information. It essentially consists of number of internal relays grouped together that allows the shifting of bits serially (from bit to bit) through an array in an orderly fashion.

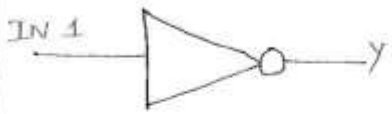
* Common applications for shift registers include the following:

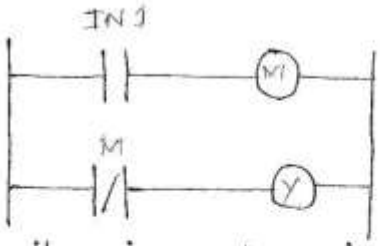
i. Tracking parts through an assembly line
ii. Controlling machine (or) process operations
iii. Inventory counter
iv. System diagnostics

Questions:

1. What is the need of a counter? (2) [Apr/May 2006]
2. How PLC differ from relay logic? (2) [Apr/May 2005]
3. What is meant by Internal relays? Explain. (6) [Apr/May 2008]

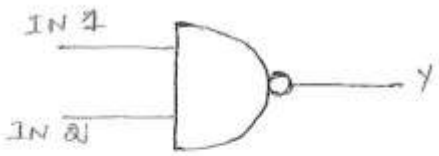
iii. NOT logic:

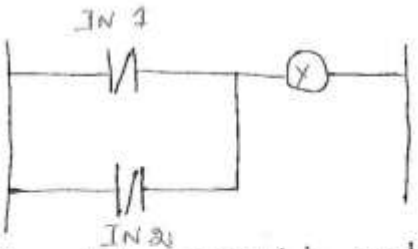




* IN 1 is the input. If the input IN 1 is energized the output y is in OFF state. If the input IN 1 is not energized then the output y is in ON state.

iv. NAND Logic:





* An AND gate with an inverted output is called NAND gate.

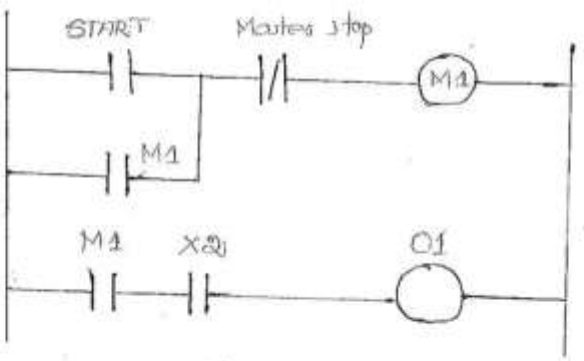
Questions:

1. Draw the ladder diagram of NAND gate. (2)
2. Explain the ladder logic program in PLC. (8)

[Nov/Dec 2004]

Master Control:

* It is often necessary to provide means of executing sections of the control logic when certain criteria are realized.



M1 → Memory coil

X2 → Input to energise the motor

O1 → Motor

* When master start button is ON, the memory coil (M1) relay is ON and being latched and thus output act according to their rung logic as usually followed in normal case.

* X2 is the input (separate) for motor and there is a master stop watch is stopping the entire process.

* The following factors to be considered for selecting PLC

i. System definition
ii. choosing the input and output hardware
iii. Analog Input/output module
iv. Input and Output timing consideration
v. Conversion speed
vi. Analog closed control,
vii. Communications and choose the correct processor.

General applications of PLCs for control:

* Control of a process motor, vibrating machine
* Control of a two pneumatic pistons.
* Detection, sorting and packaging unit

Various Input and Output devices:

* Commonly used input devices are

Digital/Discrete Input devices:

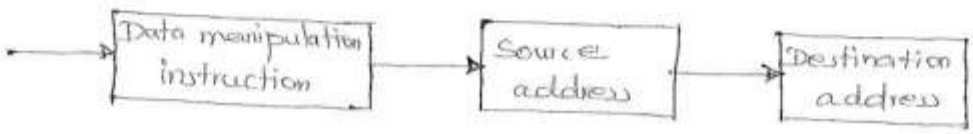
i. Mechanical switches
ii. Proximity switches

* Data manipulation instructions enable the PLCs to take on additional characteristics that are beyond the conventional relay equivalent instruction. It all the movement, manipulation (or) storage of data in either single (or) multi-word from one data memory area of the PLC to another.

* Data manipulation can be divided into many categories

i. Data transfer

ii: Data comparison



Data Transfer operations:

i. GET/PUT data transfer rung:

* This is common data transfer instruction. GET instructions instruct the processor to get a value stored in some word. PUT instructions tell the processor where

* Most PLCs are having 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 for only internal purpose.

* Such internal relay does not exist as real world switching devices are merely bits in the storage memory.

* An internal relay output is represented using the symbol of an output device with an address to indicate an internal relay.

* In many PLC, the symbol M or relay is used for indicating the internal relay and the internal relay outputs is represented as M or relay 1 etc.

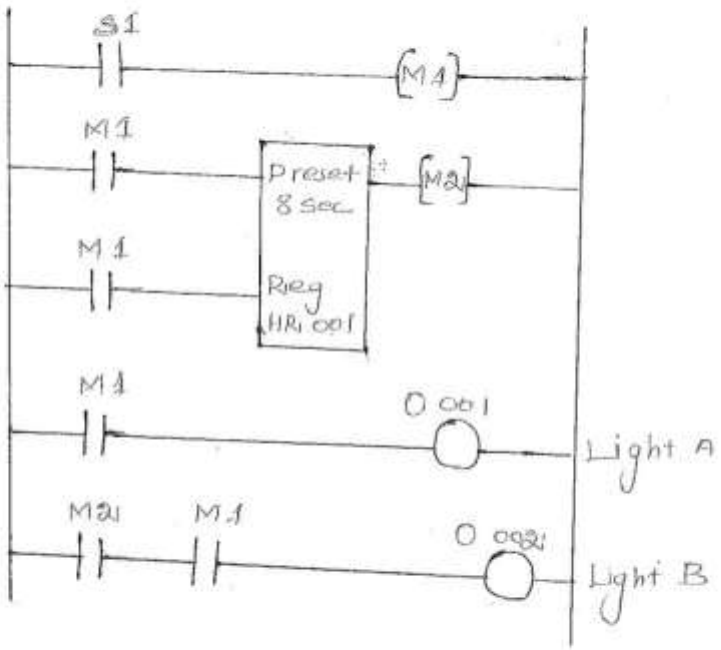
* The internal relays are used in programmes for many purposes as follows;

i. Resetting a latch circuit

ii. Push button used as the input

iii. Master Controls.

PLC Ladder Diagram



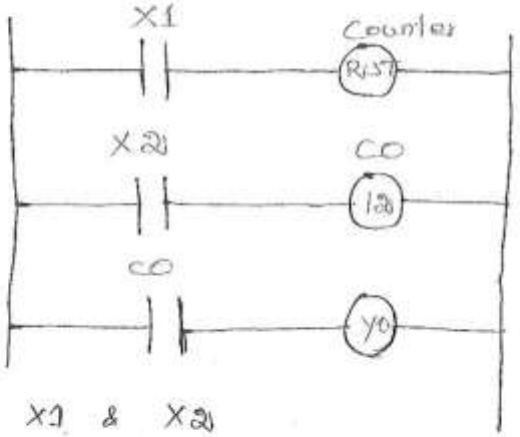
Question:

1. What are the input/output devices used? (2)
2. What are the factors to be considered for selecting PLC? (2) [Nov/Dec 2004, Nov/Dec 2007]
3. List down general applications of PLCs for control. (2) [Nov/Dec 2004]

* Conventional counters replaced by the PLC counter function include mechanical, electrical and electronic types.

* Most PLCs contain both up and down counter which function similarly some PLC also include a combination up/down counter in one function.

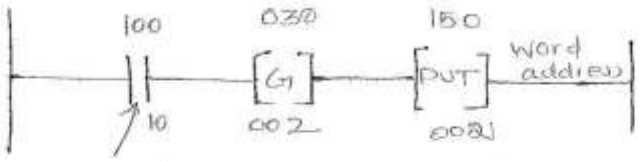
* The up counter counts from 0 upto a preset count, where some indicating action takes place. The down counter starts from the preset value and counts down to 0, where the indicating action takes place.



Inputs → X1 & X2

X1 for reset the counter

X2 is to energise the counter



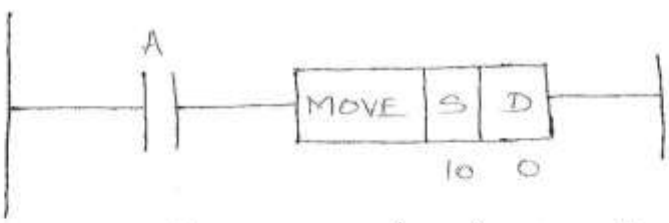
contact

* GET/PUT instruction tells the processor to get the numeric value 0021 stored in word 030 when input 100/10 is true.

* This word is now transferred to put into word 150. Note that the PUT instructions must be preceded by GET instruction.

ii. MOVE instruction:

* MOVE instruction is commonly used to copy the value from one address to another address. The instruction should specify from source address and destination address.

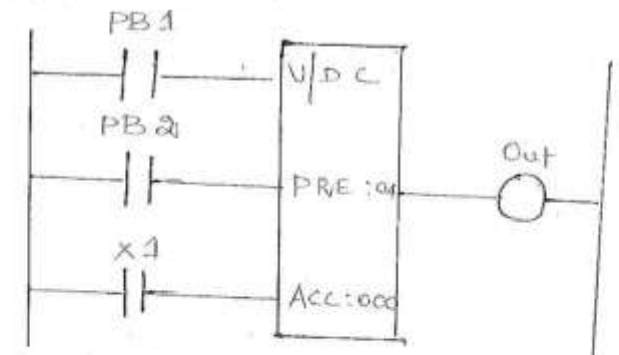


* When the rung is true, the value stored in source address 10 is copied to destination address 0.

Counters:

* Counters allow a number of occurrences of input signals to count (or) record the number of times some event occurs. PLC includes some form of counting element and are set to some preset number value.

Up and Down Counters:



Up and Down counter

* A up and down counter is shown in Fig. Separate count up and count down inputs are provided.

* The preset value of the counter and accumulated count are designated as 4 and 0. The counter accepts the input pulses 4 or more than 4 from PB1 and switch the output from OFF to ON.

iv. Encoders

v. Temperature switches

vi. Pressure switches

Analog Input devices:

i. Potentiometer

ii. Linear variable differential transformer

iii. strain gauges

iv. Temperature sensors.

v. Pressure sensors

vi. Level detector

vii. Flow measurement devices

The output devices normally wed are:

i. Contactors

ii. Directional control valves

iii. Motors and

iv. stepper motors.

Problem: 1

Develop a PLC ladder logic for following segments

i. When switch S1 is turned ON, light A goes ON

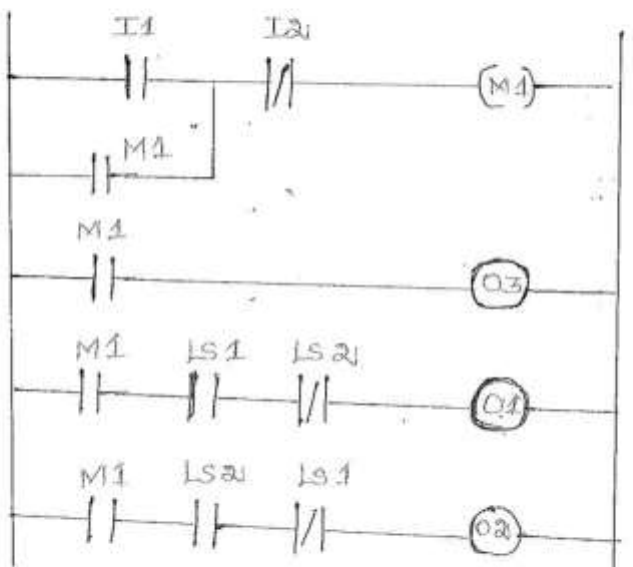
ii. 8 secs after A light, light B also goes ON

iii. Both lights goes OFF whenever switch 1 is open.

Problem: 2

A workpiece is loaded on a conveyor belt and operates between two limits of travel A and B. When limit switch at station A is activated, the conveyor moves forward. When limit switch at station B is activated, the conveyor changes direction. Pressing the start button causes the motor to run in the forward direction, and pressing the stop button the motor. Create a ladder logic diagram.

Ladder logic diagram



LS1 → Limit switch A

Ls 2 → Limit switch B

Q1 → Conveyor moves forward

Q3 → Motor run

I1 → start button

I2 → stop button

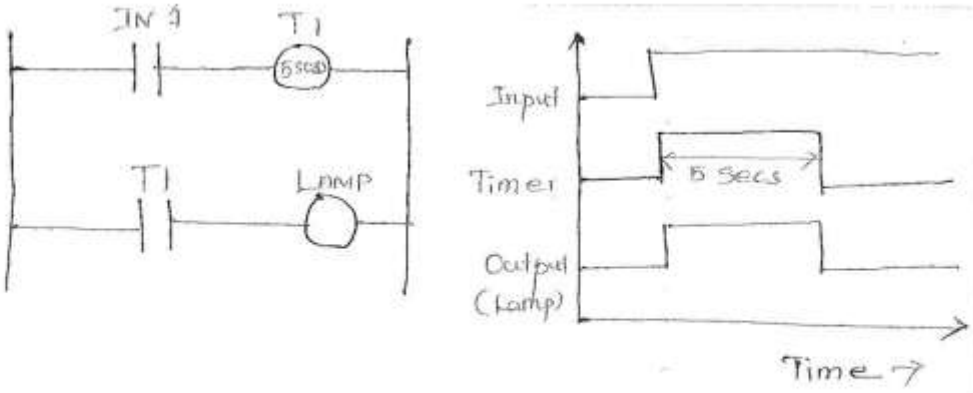
* The counter keeps track of number of counts received above the preset value. If the count down input (PB2) is now pulsed number of times such that the difference in accumulated value and number pulses reduced by PB2 is less than preset count, then the output switches from ON to OFF. X1 is the input to reset the counter.

Types of Counters:

i. Down counters
ii. Up Counters

Questions:

1. What are counters? (2)
2. Write down the variow types of counters. (2)
3. Write a short notes on counters. (8) [Nov/Dec 2004]



* When the contact IN 1 is closed, the contact will energize the timer T1 and holds the output lamp ON for specified set value of 10 sec. The action of an OFF delay timer is to delay setting the lamp OFF.

Questions:

1. List out the different types of timers. (2)
2. What is meant by retentive timer? (2)
3. Write a short notes on timers. (8) [Nov/Dec 2004]
4. Explain the functioning of cascaded timer, on-off cyclic timers, and delay-off timers with ladder diagrams. (16) [Apr/May 2006]

Data compare Instructions:

* Data compare instructions are input instructions and it gets the PLC to compare two data values. The compare instructions have many uses and can be used when data needs to be compared before next part of a process can takes place.

* Normally, PLCs can make comparison for each of the following conditions.

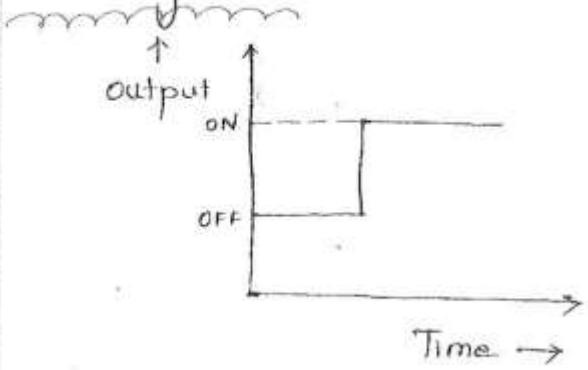
Name	symbols
Less	$<$
Equal to	$=$
Greater	$>$
Less than or equal to	$\leq$
Greater than or equal to	$\geq$

(Logic for compare instruction)

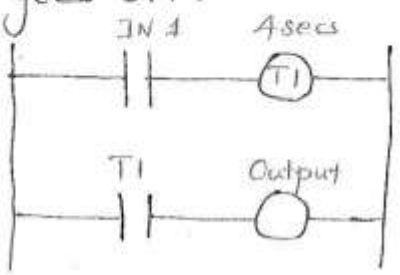
Questions:

1. Explain Latching with ladder diagram. (8)
2. Briefly explain how data handling is carried out in PLC. (16) [Apr/May 2008]

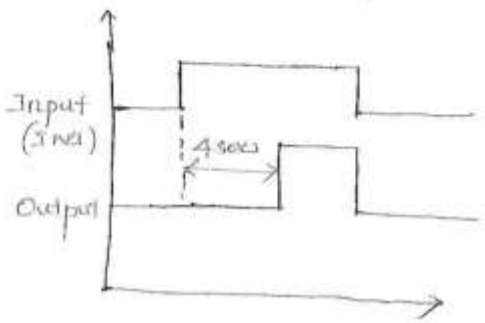
ON Delay Timer:



* The timer is energized when the input IN 1 becomes energized. The timer starts running, after some preset time the timer closes the timer contact on rung 2. The timer is reset when the input IN 1 goes OFF.

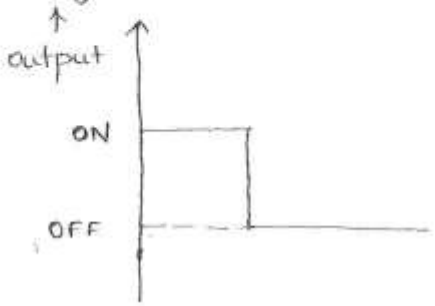


Ladder logic



Timing diagram

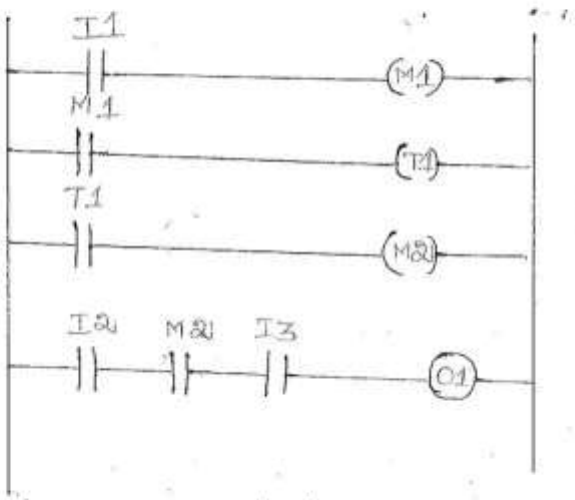
OFF delay timer:



Problem: 3

Device a system, wing a PLC that could be wed with a conveyor belt which is wed to move an item to work station. The presence of the item at the work station is detected by means of breaking a contact activated by a beam of light to a photo-sensor. There it stops for 100 sec for an operation to be carried out and then starts moving. The motor for the belt is started by a normally open start switch and stopped by a normally closed switch.

Ladder Logic Diagram

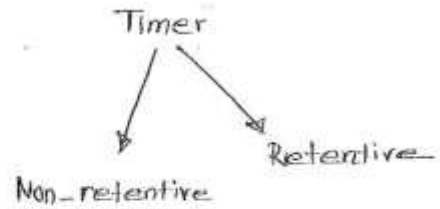


I1 → photosensor output

I2 → start button for motor for the belt

I3 → stop button

M1, M2 → Memory coil

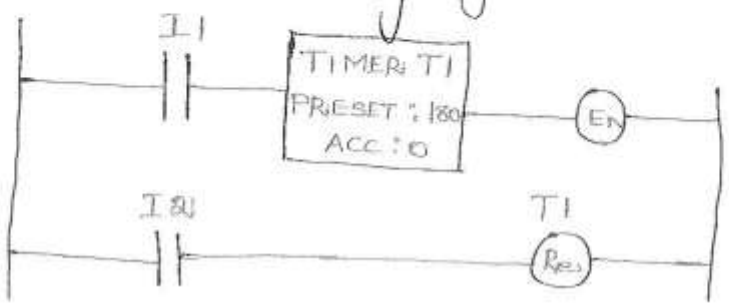


* A single input timer called a "non-retentive timer is wed in some PLCs.

* Energizing IN 1 causes the timer to run for 3 seconds. At the end of 4 seconds the output goes ON. When the input is deenergised the output goes OFF and the timer resets to 0.

Retentive timer :

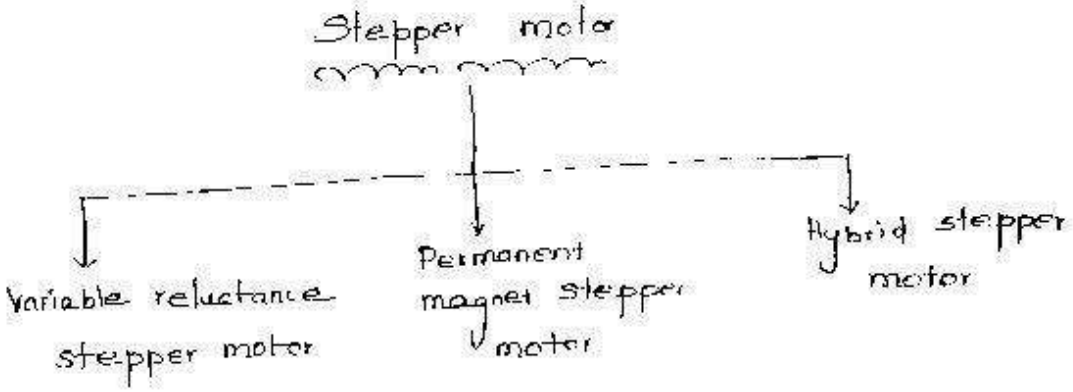
* Retentive on delay timer (RTO) will hold its accumulated value when the timer rung goes false and will continue timing where it left OFF when the timer rung goes true again.



Stepper Motors

* The stepper motor is a device that produces rotation through equal angles when digital pulses are supplied as input.

* In other words, the stepper motor transforms the electrical pulses in to equal increments of rotary shaft motion.

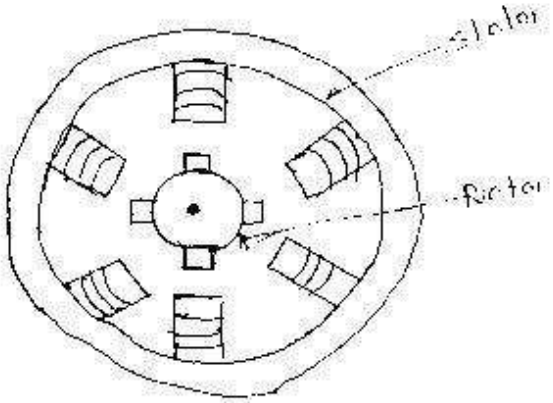


Types of Stepper Motor

1. Variable Reluctance Stepper Motor

Construction

* The rotor is made up of soft steel and it is cylindrical in shape with four poles.



* Usualy the number of poles on the robot is less than number of poles on the stator. The stator poles have windings and it is switched by means of electronic switching device.

* The function of the switching device is to switch the control windings in the stator of stepper motor.

Working:

* When current is switched to a pair of windings in stator, a magnetic field is produced. The lines of force pass from stator poles to nearest set of poles on the rotor.

Applications :

* High accuracy positioning applications.

Ex : Computer hard disc drive.

Advantages.

* These stepper motors combine the features of both variable reluctance and permanent magnet motors.
* Minimum step angle can be achieved.

Disadvantages :

* When it is connected with microprocessor output port, it is must to include protection to avoid damage to microprocessor.

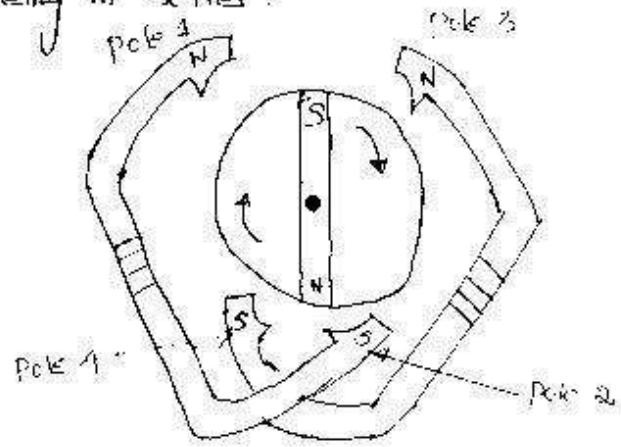
Question :

1. What is a stepper motor? (2.)
2. What are the advantages and disadvantages of stepper motor? (2).

Permanent Magnet Stepper Motor:

Construction:

* The stator has four poles. Each pole is wound with a field winding. the coils on opposite pair of poles being in series.



* The rotor is a permanent magnet and when current is switched to a pair of stator poles, the rotor will move to lineup with it.

Working:

* Thus for the currents given in the rotor moves to 45° position.

* If the current is switched so that the polarities are reversed, the rotor will move a further 45° in order to line up again.

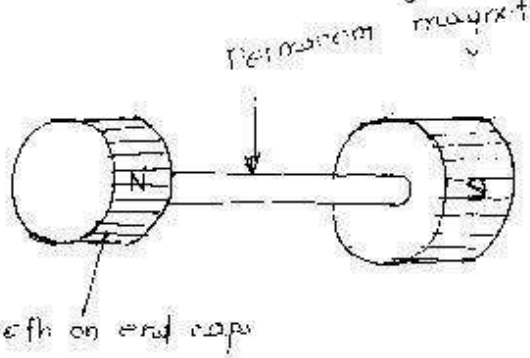
* Thus by switching currents through the coils, the rotor rotates by 45° steps.

* With this type of motor, step angle of 1.8°, 7.5°, 15°, 30°, 34° or 90° can be achieved.

III Hybrid Stepper Motor

* It combines the features of both the variable reluctance and permanent magnet motors.

Construction:



* The permanent magnet is encased in iron caps which are cut to have teeth.

Working:

* The rotor sets itself in minimum reluctance position if a pair of stator coils is energized.

* In this stepper motor, step angles of 0.9° and 1.8° are achieved.

Applications:

* High accuracy positioning applications.

Example: computer hard disc drives.

Advantages:

* These stepper motors combine the features of both variable reluctance and permanent magnet motors.

* Minimum step angle can be achieved.

Disadvantages:

* When it is connected with microprocessor output port, it is must to include protection to avoid damage to microprocessor

Stepper Motor Specifications:

* Phase
* Step angle
* Holding torque
* Pull in torque
* Pull out torque
* Pull in rate
* Pull out rate
* Slew range

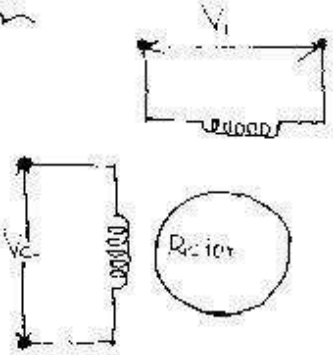
Questions:

1. List out the specifications of stepper motor. (2)
2. Explain the working principle of various stepper motors. (16) [Apr/May 2005]

AC Servometers:

* Basically an AC servomotor is a two phase induction motor

Construction:



V_r → Reference winding
V_c → Control winding

* It consists of two stator windings namely reference winding and control winding.
* These two windings are placed at 90° and excited by AC voltage.
* The reference winding is excited by a fixed voltage V_r and control winding voltage V_c is 90° phase shifted with respect to the reference voltage V_r.
* The rotor is squirrel cage or drag-cup type having small diameter in order to reduce the inertia.

Operation:

* The two windings are excited by voltage of magnitude and 90° phase shift.
* It develops a magnetic field of constant magnitude rotating at synchronous speed.

* The direction of rotation depends upon the phase relationship between V_r and V_c.

* The rotating magnetic field interacts with the currents and produces torque in the direction of rotation.

Advantages:

* Drift-free AC amplifier
* Low rotor inertia
* Rugged construction
* Rotor withstand at higher temperature.

Disadvantages:

* More expensive
* Cannot work at open loop
* Required more maintenance.

Control scheme for an AC servomotor:

* The reference winding is excited by a reference voltage source.
* The control winding is supplied by a Zener amplifier having variable magnitude and polarity.

Speed can be controlled by varying any one of the following:

* Flux/pole (flux control)
* Voltage control
* Rheostatic control

Dc servomotors

* Dc motors which are used in servo systems are called "Dc servomotors".

* In Dc servomotors, field windings may be connected either in series with the armature (or) separate from the armature.

* This motor provides high starting torque due to low inertia.

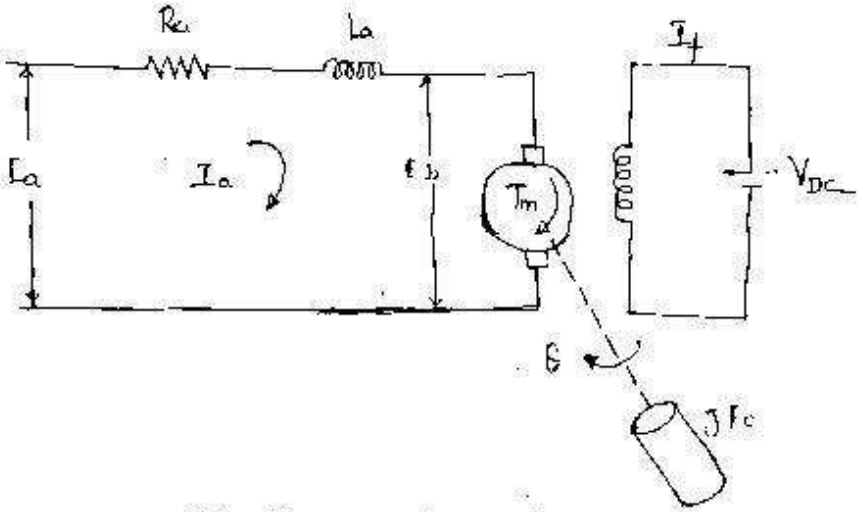
* This low inertia can be achieved by reducing armature diameter with increasing armature length so that desired output power can be achieved.

Two different control modes:

i. Armature control mode.

ii. Field control mode.

i. Armature control of Dc servomotor:



* In which the speed of the Dc servomotor is controlled by armature current with field current constant.

$R_a \rightarrow$ Armature resistance (Ω)

$L_a \rightarrow$ Armature winding inductance (H)

$I_a \rightarrow$ Armature current (A)

$I_f \rightarrow$ Field current (A)

$E_a \rightarrow$ Applied Voltage (V)

$E_b \rightarrow$ Back emf (V)

$\theta \rightarrow$ Angular displacement

$T_m \rightarrow$ Motor torque (Nm)

$F_c \rightarrow$ Viscous friction coefficient ($Nm\,rad^{-1}$)

$J \rightarrow$ Moment of inertia ($kg\text{-}m^2$)

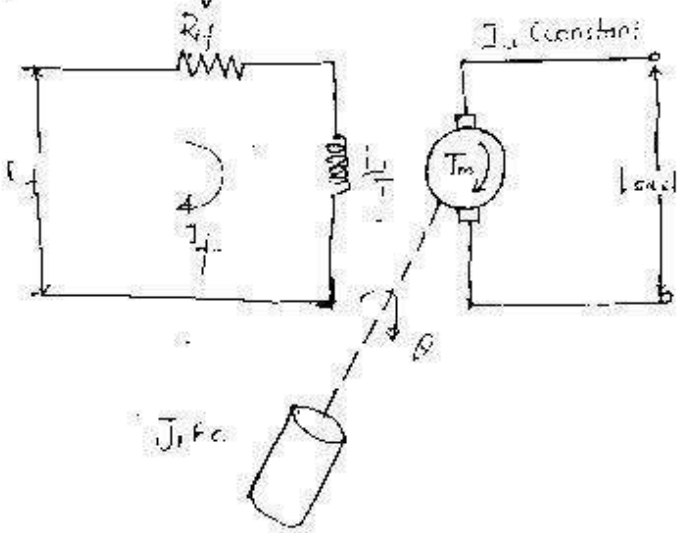
The flux ϕ is proportional to the field current I_f

$$\phi \propto I_f$$

$$\boxed{\phi = K_f I_f} \quad (K_f \rightarrow \text{constant})$$

ii Field control of DC servomotor:

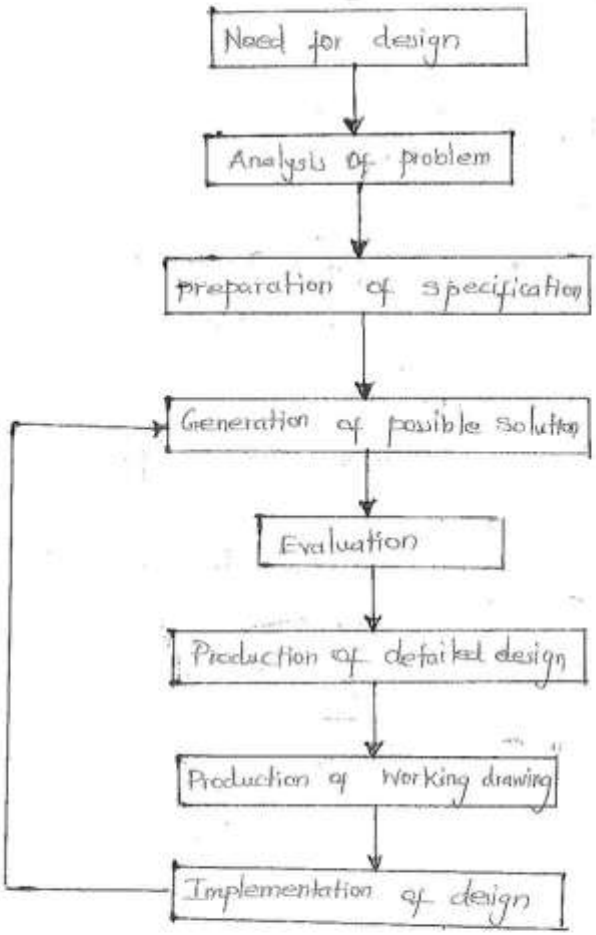
* In which the armature current is maintained constant and speed of the DC servomotor is controlled by field voltage.



Design Process

* The design process of mechatronic system consists of the following stages.

Stages in designing mechatronics systems



Stage 1: [Need for design]

* The design process begins with a need. Needs are usually arise from dissatisfaction with an existing situation.

* Needs may come from inputs of operating of service personal or from a customer through sales or

Stage 2: [Analysis of problem]

* Probably the most critial step in a design process is the analysis of the problem (N) to find out the true nature of the problem.

* The true problem is not always what it seems to be at the first glance.

Stage 3: [Preparation of specification]

* The design must meet the required performance specifications. Therefore specification of the requirements needs to be prepared first. The following are some of the specification

* Mass and dimensions of design
* Type and range of motion required.
* Accuracy of the element.
* Input and output requirements of elements.
* operating environments.

Stage 4: [Generation of possible solution]

* This stage is often known as "conceptualisation stage". The conceptulisation step is to determine the elements, mechanisms, materials, process of configuration that in some combination or other result in a design that satisfies the need.

* This is the key step for employing inventiveness and creativity. A virtual aspect of this step is synthesis.

Stage 5: [selection of suitable solution (or) Evaluation]

* This stage involves a through analysis of the design.
* The evaluation stage involves detailed calculation, often computer calculation of the performance of the design by using an analytical model.

Stage 6: [Production of detailed design]

* The detail of selected design has to be worked out.
* It might have required the extensive simulated service testing of an experimental model.

Stage 7: [Production of working drawing]

* The finalised drawing must be properly communicated to the person who is going to manufacture.
* The communication may be oral presentation or a design report.

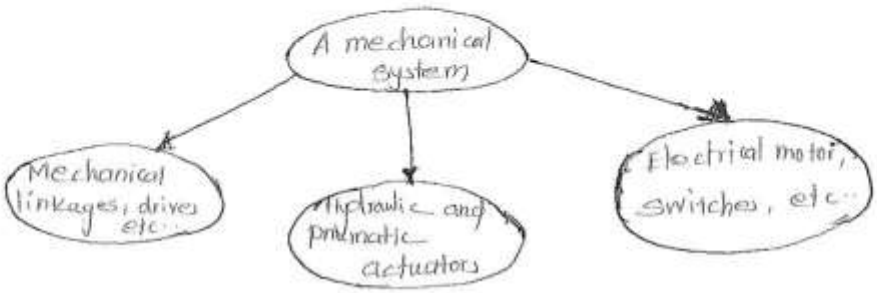
Stage 8: [Implementation of design]

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

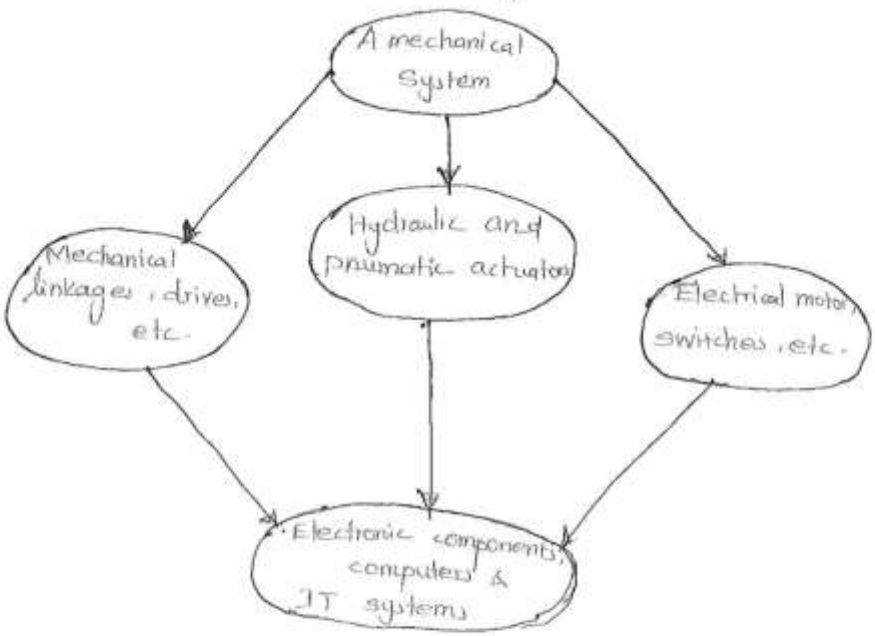
Questions:

1. Mention the stages in designing a mechatronic system. (2) [Nov/Dec 2004, Apr/May 2006]
2. Mention any four statements about the problem definition. (2)
3. Explain the various stages in designing a mechatronic system. (16) [Nov/Dec 2005]

Traditional design approach



Mechatronics design approach



* The same system can be modified by a mechatronics approach. This system uses a microprocessor controlled thermo couple as the sensor.

* Such a system has many advantages over a traditional

* The bimetallic thermostat is less sensitive compared to the thermodiode. Therefore, the temperature is not accurately controlled. Also it is not suitable for having a different temperature at a different time of the day because it is very difficult to achieve.

* But the microprocessor controlled thermodiode system can overcome that difficulties and is giving precision and programmed control.

* This system is much more flexible. This improvement in flexibility is a common characteristic of the mechatronics system when compared with a traditional system.

Questions:

1. Distinguish between traditional design approach and Mechatronics approach. (8) [Apr/May 2005, Apr/May 2008]
2. List the advantages of mechatronics design over traditional design. (2) [Nov/Dec 2008]
3. Briefly explain traditional and mechatronics designs. (16)

Pick and place robot

* The pick and place robot has three axes about which motion can occur. The following movements are required for this robot.

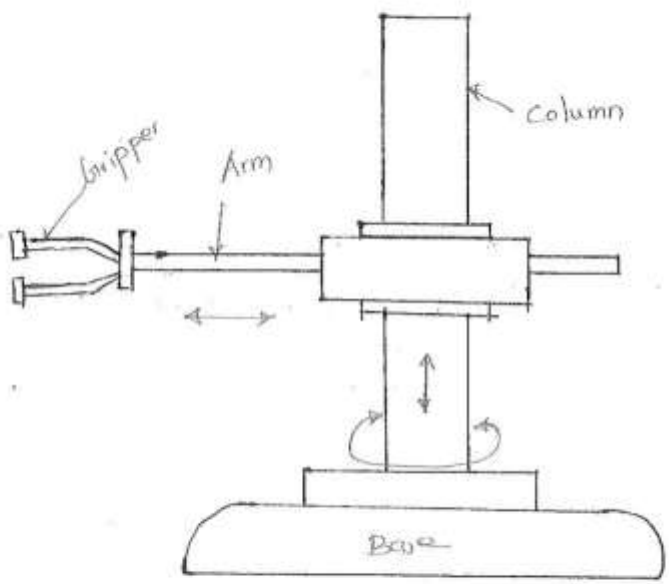
i. clockswise and anticlockswise rotation of the robot unit on its base.

ii. Linear movement of the arm horizontally (ie) extension (or) contraction of arm.

iii. Up and down movement of the arm

iv. Open and close movement of the gripper.

Pick and place robot



* The foresaid movements can be obtained by pneumatic cylinders which are operated by solenoid valves with limit switches. Limit switches are used to indicate when a motion is completed.

movement of the piston in the cylinder. Figure 5.29 shows a mechanism used for this purpose.

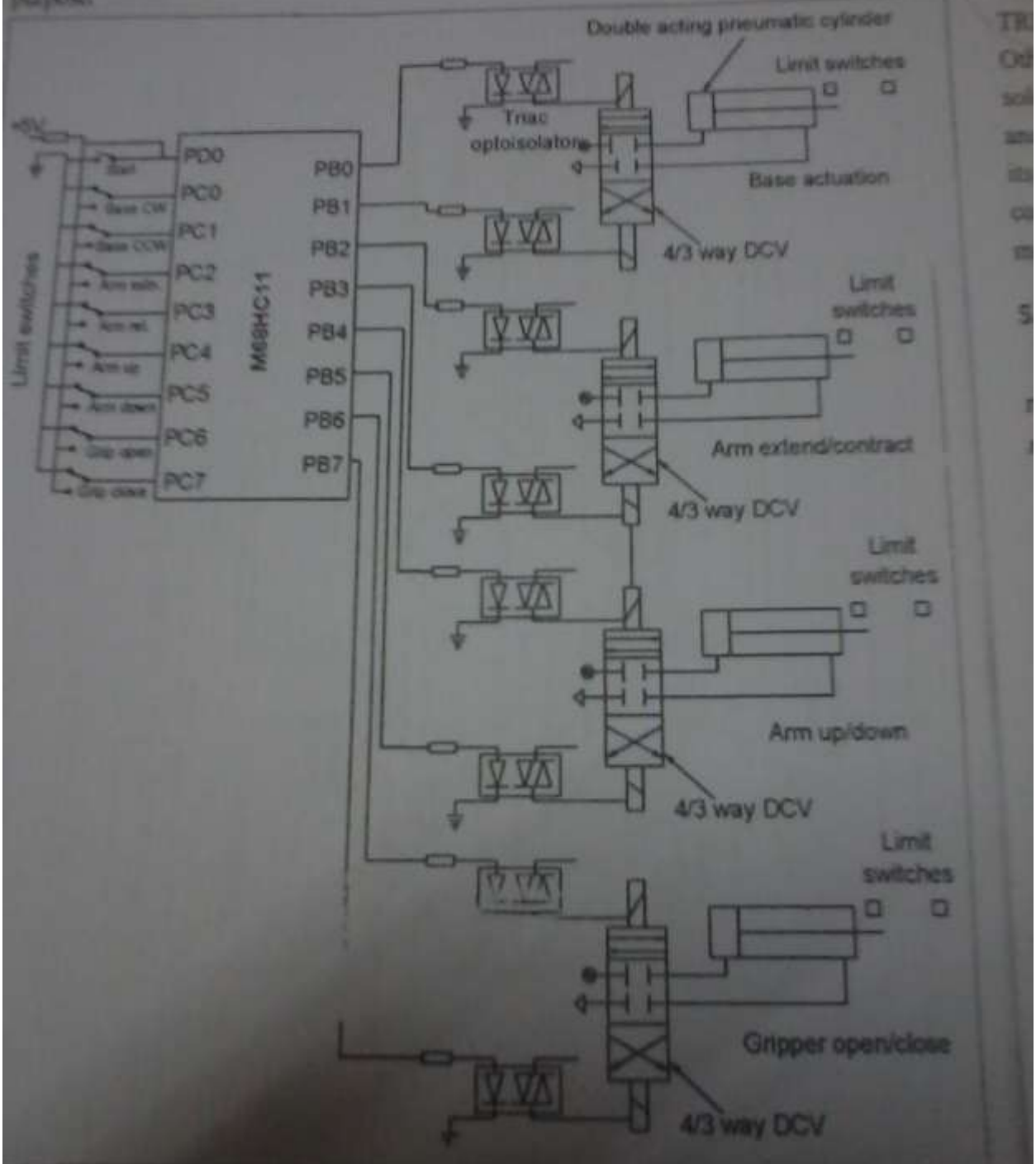


Figure 5.30 Microcontroller circuit for pick and place robot

* The clockwise rotation of the robot unit on its base can be obtained from a piston and cylinder arrangement during pistons forward movement. Similarly counter clockwise rotation can be obtained during backward movement of the piston in cylinder.

* The upword movement of the arm can result from forward movement of the piston in a cylinder whereas downward movement from its retardation.

* The gripper can also be operated in a similar way (ie) gripper is opened during forward movement of the piston and closed during backward movement of the piston in the cylinder.

* A microcontroller used to control the solenoid valves of various cylinders. The micro controller used of this purpose is M68HC11 type. A software program is used to control the robot.

* TRIAC optoisolator consists of LED and TRIAC. If the input of the LED is 1, it glows and activates the TRIAC to conduct the current to the solenoid valve otherwise TRIAC will not conduct the current to the solenoid valve.

Questions:

1. What are the various movements of robots? (2)
2. Design a pick and place robot using mechatronics elements and explain about the robot control. (16) [Nov/Dec 2008]

* An electronic engine management system is made up of sensors, actuators and related wiring that is tied into a central processor called microprocessor (or) microcomputer.

* The various components in the typical engine management system are:

i. Electronic Control Unit (ECU)

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

ii. Fuel delivery system:

* This system consist 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. The fuel line connects to a fuel rail that feeds each of the injectors. At the end of the rail is a fuel pressure regulator, with surplus fuel heading back to the tank in the return line.

iii. Ignition System:

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

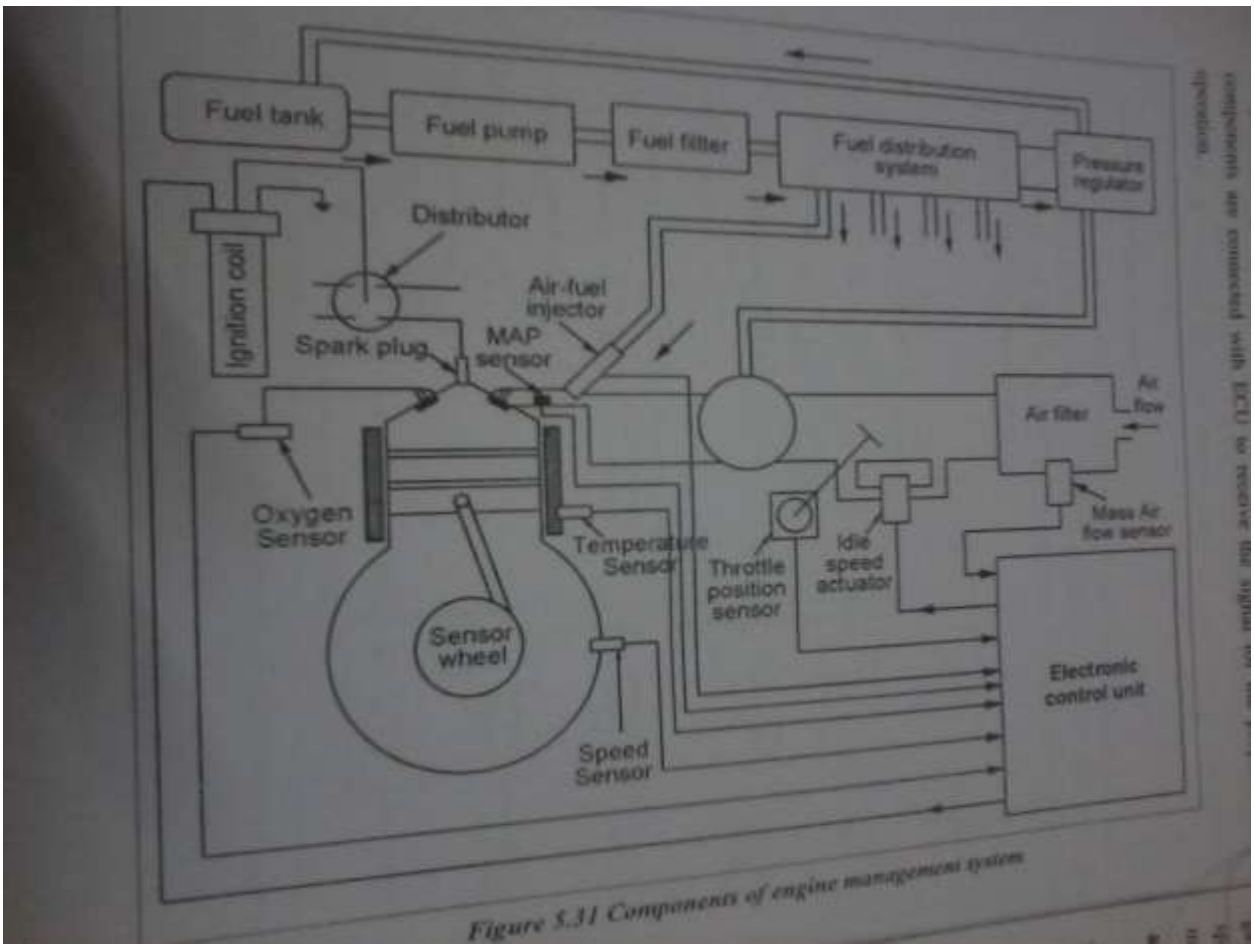


Figure 5.31 Components of engine management system

IV. Various Sensors:

Throttle - Position sensors:

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

Exhaust Gas Oxygen (EGO) sensors:

* Exhaust gas Oxygen sensors are placed within the engine's exhaust system. The amount of oxygen in the exhaust gas indicates whether or not the ECU has directed the fuel delivery system to provide the proper air-fuel ratio.

Manifold Absolute Pressure (MAP) sensors:

* MAP sensors measure the degree of vacuum in the engine's intake manifold.

Temperature sensors:

* Temperature sensors are used to report the engine temperature to the ECU to activate / deactivate the cooling system.

Engine speed sensors: * speed / timing sensors provide information to the ECU regarding engine speed and the crank position.

Knock Sensor: * It is used to identify the sounds of knocking and sends signal to ECU to avoid knocking.

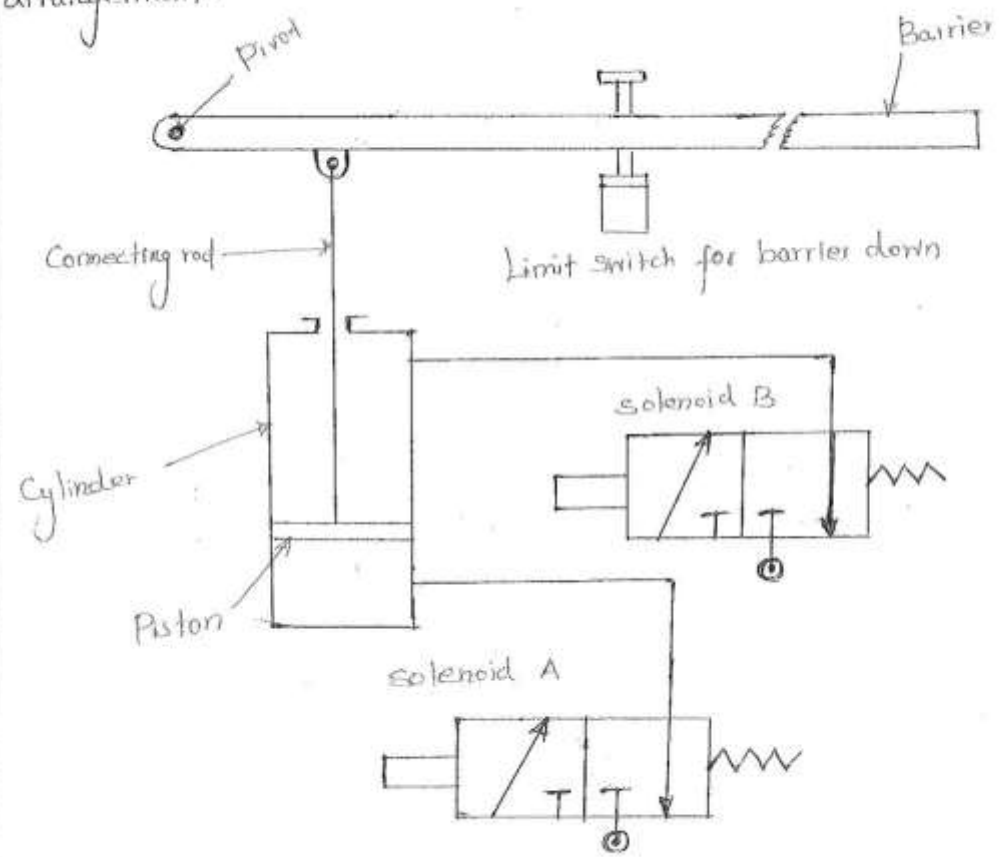
Questions:

1. What is an electronic engine management? (2)
2. List out the various sensors used in engine management system. (2)
3. Explain the engine management system. (16) [Apr/May 2006,

* Consider an automatic car park barriers operated by coin inserts. The system wes a PLC for its operation. There are two barriers wed named in barrier and out barrier.

* In barrier is wed 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 pivoted at one end, two solenoid valves A and B and a piston cylinder arrangement.



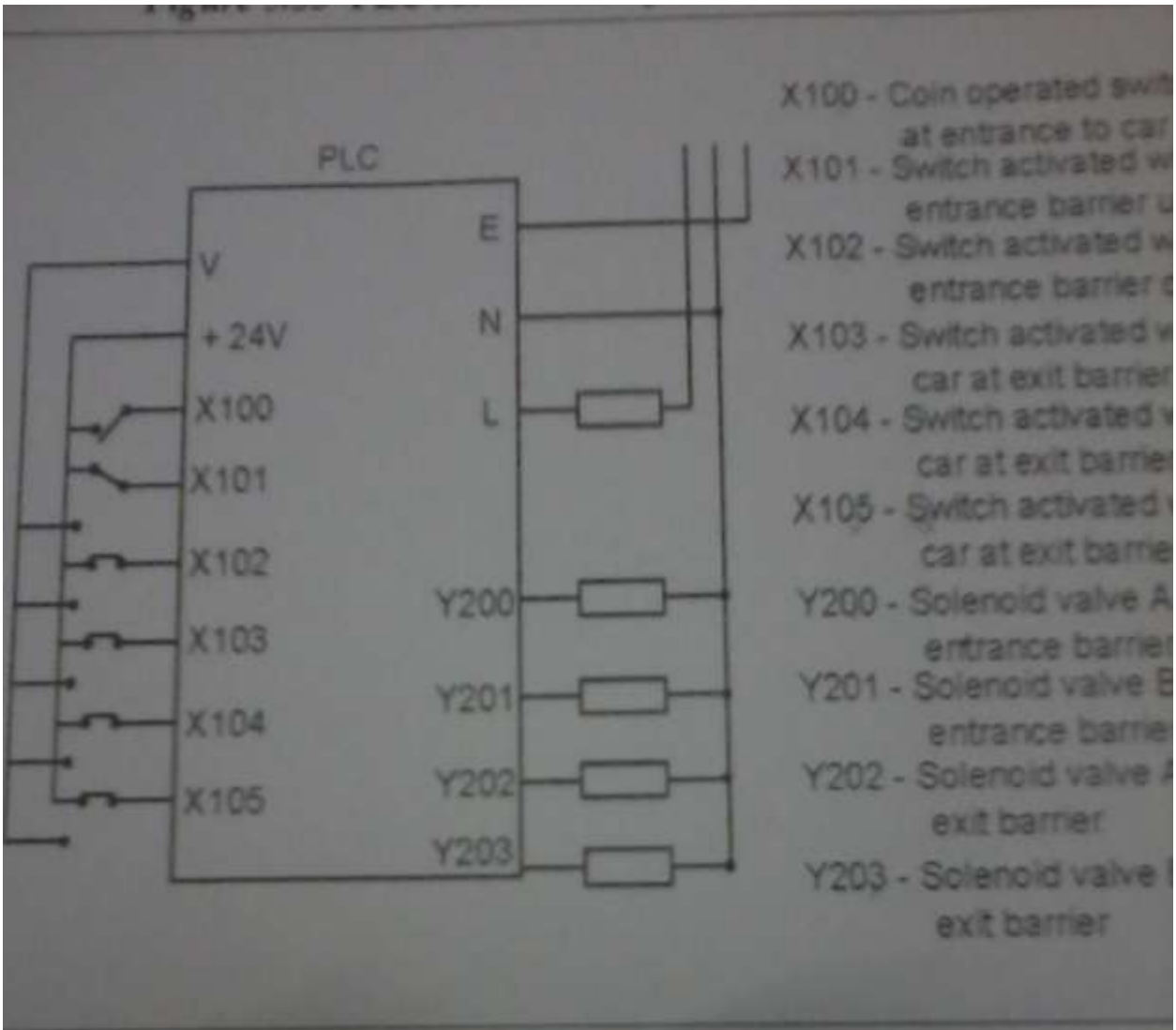


Figure 5.34 PLC arrangement for operating barrier

* A connecting rod connects piston and barrier as shown in Fig. Solenoid Valves are used to control the movement of the piston.

* Solenoid A is used to move the piston upward in turn barrier whereas solenoid B is used to move the piston downward.

* Limit switches are used to detect the foremost position of the barrier. When current flows through solenoid A, the piston in the cylinder moves upward and causes the barrier to rotate about its pivot and rises to let a car through.

* When the barrier hits the limit switch, it will turns on the timer to give a required time delay. After that time delay, the solenoid B is activated which brings the barrier downward by an operating piston in the cylinder.

* This principle is used for both the barriers.