Summer – 2018 Examinations
Model Answer **Subject Code: 17641 (EIA)**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner should assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner should give credit for any equivalent figure/figures drawn.
5) Credits to be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer (as long as the assumptions are not incorrect).
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept

1 Attempt any FIVE of the following: **20**

1 a) Explain the concept of NO / NC contacts.

Ans:

An electromechanical relay is generally having the two contacts named as normally open (NO) and normally closed (NC). A NO contact is one that is open when the relay coil is not energized and closes when the relay is energized. Conversely, the NC contact is closed when the relay coil is not energized and opens when the relay is energized. When a set of contacts closes, it provides power flow, or continuity, in the circuit where it is used.

2 marks for description

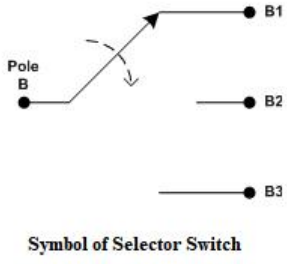
2 marks for diagram

1 b) Define and draw the symbols of the following:

a) Selector switch
b) Limit switch

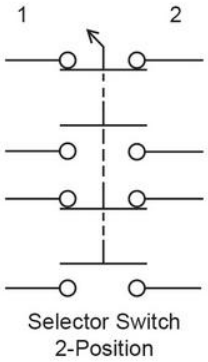
Ans:

a) Selector Switch:



Symbol of Selector Switch

OR



Selector Switch
2-Position

1 mark for symbol

(Any other valid symbol may please be considered)

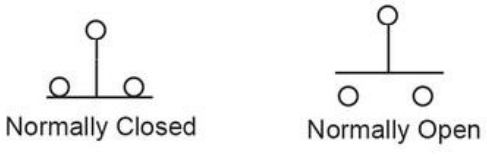
Definition: Selector switch is a manually operated multi-position switch, which is usually adjusted by a knob or handle and may have detents to hold in a given position. It is used for making or breaking or changing the connections in a circuit or to select among alternatives.

1 mark for definition

b) Limit Switch:

LIMIT SWITCHES	
Normally Open	Normally Closed
	
 Held Closed	 Held Open

OR



Limit Switch

1 mark for symbol

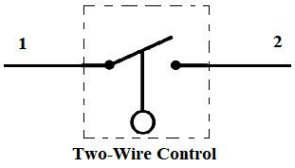
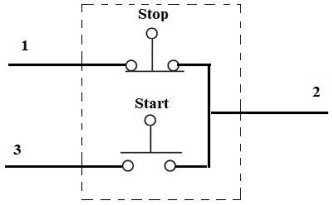
Definition: Limit switch is a switch that operates as an automatic control to prevent a mechanism or process from going beyond a prescribed limit. It is a switch operated by the motion of a machine part or the presence of an object, for controlling machinery as a part of the control system, as a safety interlocks or to count objects passing a point.

1 mark for definition

1 c) State difference between two-wire and three-wire control.

Ans:

Difference between Two-wire and Three-wire control:

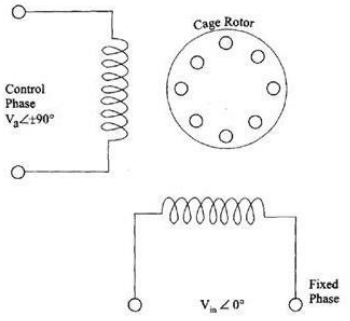
	Two-Wire Control	Three-Wire Control
1	The control component offers only two-wires for its connection in control circuit.	The control components offer three-wires for their connection in control circuit.
2	The control device is usually a switch, may be automatic such as limit switch, float switch etc.	The control components are usually push-buttons (Start and Stop).
3	On supply failure, the motor stops, but when it restores, the motor restarts automatically without starter and may get damaged. Thus motor is not protected from No-volt condition.	On supply failure, the motor stops and when it restores, the motor can not start automatically. The operator need to start the motor using starter. The safe starting ensures the No-volt protection.
4	 Two-Wire Control	 Three-Wire Control

1 mark for each difference = 4 marks

1 d) Explain AC servomotor and give its application.

Ans:

AC servo motor:



1 mark for diagram

There are some special applications of electrical motor where rotation of the motor is required for just a certain angle and not continuously for long period of time. For these applications some special types of motor are required with some special arrangement which makes the motor to rotate a certain angle for a given electrical input (signal). Such motors can be ac or dc motors. These motors are used for position control or in servo mechanisms, hence are termed as servomotors. The AC servomotor consists of main and control winding and squirrel cage / drag cup type rotors. V_r is the voltage applied to the main or reference winding while V_c is that applied to control winding which controls the torque-speed characteristics. The 90° space displacement of the two coils/windings and the 90° phase difference between the voltages applied to them result in production of rotating magnetic field in the air gap, due to which the

2 marks for explanation

force or torque is exerted on rotor and is set in motion.

Applications :

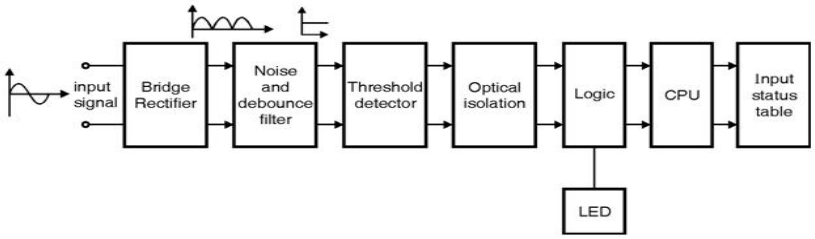
1. Process control equipment.
2. Machine tools.
3. Robotics.
4. Process Controllers.
5. AC position control applications.
6. Portable drilling machine.
7. Sewing machine.

1 mark for any two applications

1 e) Draw and explain digital input module.

Ans:

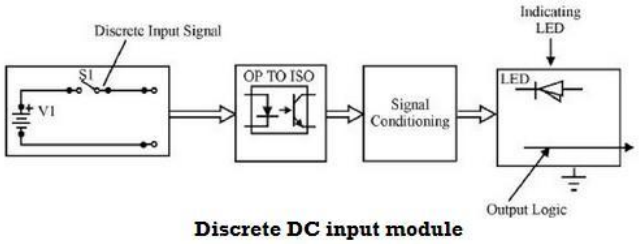
Digital input module:



Block diagram of AC input module

2 marks for diagram

OR



Discrete DC input module

Explanation:

Power conversion: The power conversion section usually consists of resistors and bridge rectifier. The bridge rectifier converts the incoming AC signal to a pulsating DC level. The DC level is passed through filters and other logic circuits in order to deliver a clean, de-bounced, DC input signal. The filtered DC signal goes on to the threshold detector.

Threshold detection: Threshold detection circuitry detects if the incoming signal has reached or exceeded a predetermined value for a predetermine time, and whether it should be classified as valid ON or OFF signal.

Isolation: Isolation section of the input circuit is usually made up of an optical isolator, or opto-coupler. In a 120VAC input module, isolation separates the high voltage, 120VAC input signal from the CPUs low voltage control logic.

Logic section: DC signal from the opto-coupler are used by the logic section to pass the input signal to the module's input address LED and the CPU and then on to the input status file.

2 marks for description

1 f) Give the advantages of PLC (any four).

Ans:

Advantages of PLC:

1. Increased productivity.

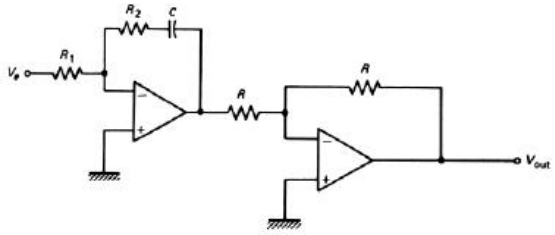
2. Improved product quality.
3. Increased accuracy.
4. Reduced manpower.
5. Reduction in personal injury or accidents.
6. Reduction in the cost of product due mass production.
7. Increased profit.
8. Achieves consistency in the manufacturing.
9. Centralized control of plant is possible.

1 mark for each of any 4 advantages = 4 marks

1 g) Explain PI controller in brief.

Ans:

PI Controller:



1 mark for diagram

This is a control mode that results from a combination of the proportional mode and the integral mode. The characteristics of the PI mode are:

1. When the error is zero, the controller output is fixed at the value that the integral term had when the error went to zero. This output is given by in equation, $$m = K_c e + \frac{K_c}{\tau_I}\int e\,dt + m(0)$$

1 mark for equation

2. If the error is not zero, the proportional term contributes a correction, and the integral term begins to increase or decrease the accumulated value [initially $V_{out}(0)$], depending on the sign of the error and the direct or reverse action.

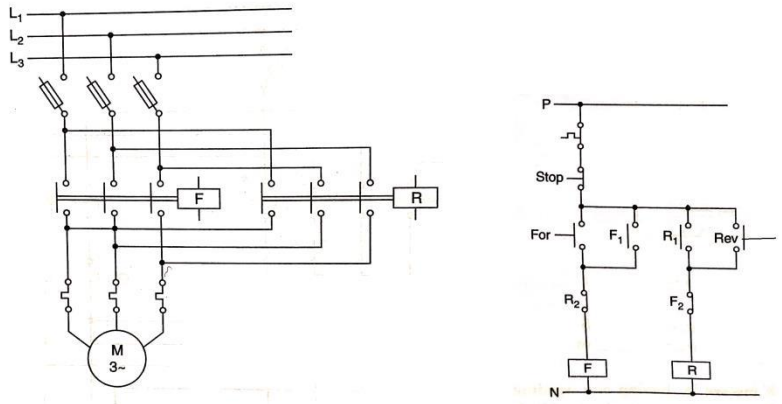
2 marks for explanation

2 Attempt any TWO of the following: 16

2 a) Draw and explain the power and control circuit diagram of forward-stop-reverse type DOL starter for 3-phase Induction Motor.

Ans:

Forward-Stop-Reverse type DOL starter for 3-phase Induction Motor:



(a) Power Circuit for Forward-Stop-Reverse Control (b) Control Circit for Forward-Stop-Reverse Control

2 marks for power circuit

2 marks for control circuit

The power and control circuit of DOL starter with Forward-Stop-Reverse control are shown in figures (a) and (b) above respectively. In power circuit, two contactors (F and R) are used to provide electric supply with opposite phase sequence to motor. When contactor F is ON, the three-phase supply

with phase sequence L_1-L_2-L_3 is provided to motor and it runs in Forward direction. However, when contactor R is ON, the three-phase supply with reversed phase sequence L_1-L_3-L_2 is provided to motor and it runs in Reverse direction. 4 marks for explanation

In control circuit, when push-button 'For' is pressed, the contactor coil 'F' get energized through 'Stop' push-button, pressed 'For' push-button and R_2 NC contact. Therefore, the contactor 'F' get closed and in power circuit, the three phase supply with phase sequence L_1-L_2-L_3 is provided to motor and it runs in Forward direction. The operation of contactor 'F' causes closing of NO contact 'F_1' and opening of NC contact 'F_2'. The contact F_1 being connected in parallel with push-button 'For', it holds ON the contactor 'F' after releasing push-button 'For'. Now even if somebody presses push-button 'Rev', the contactor 'R' cannot be energized as the NC contact F_2 is open. So if we wish to reverse the direction of rotation, we need to press 'Stop' push-button first to stop the motor. Pressing of 'Stop' push-button causes interruption of current of forward contactor coil 'F'. Therefore, the contactor 'F' gets de-energized and NC contact F_2 regains its original closed state.

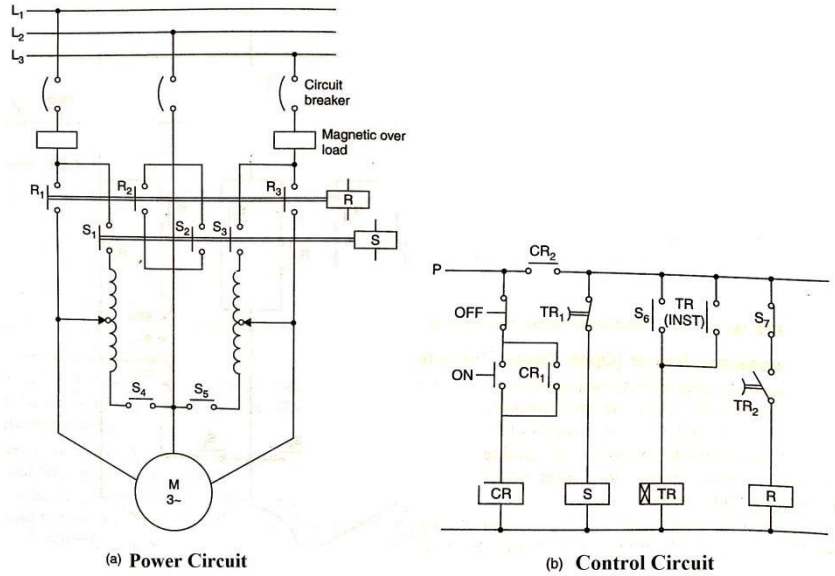
Then only the direction of rotation can be reversed by pressing push-button 'Rev'. It causes the current to flow through contactor coil 'R', energizing contactor 'R' and closing its NO contacts. In power circuit, the contactor R get closed providing three-phase supply with reversed phase sequence L_1-L_3-L_2 to motor and it runs in Reverse direction.

Thus during transition from Forward to Reverse or vice-versa, we need to Stop the motor, hence this control is referred as 'Forward-Stop-Reverse' control.

2 b) Draw and explain the power and control circuit diagram of 3-[illegible]nduction Motor using autotransformer type starters.

Ans:

Autotransformer type starter for 3-[illegible]nduction Motor:



(a) Power Circuit (b) Control Circuit

2 marks for power circuit

2 marks for control circuit

The power and control circuit for autotransformer starter with open-circuit transition are shown in figures (a) and (b) above. Four main contacts of Start

contactor (S) are used to connect the auto-transformer windings in open-delta, as shown in power circuit. The interlock is such that only one contactor (Start S or Run R) is ON at a time. When Start contactor S is ON, the contacts S_1 to S_5 are closed, the motor gets reduced voltage supply from open-delta connected auto-transformer and it starts. When Run contactor R is ON, the contacts R_1 to R_3 are closed and full line voltage is supplied to motor. The motor then continues to run with full rated supply voltage. 4 marks for explanation

Referring to control circuit, when the ON push-button is pressed, the control relay CR is energized through normally-closed OFF push-button, pressed ON push-button and hold ON through contact CR_1. On energizing control relay CR, the contact CR_2 gets closed and the Start contactor coil S is energized through delay-in –opening type timer contact TR_1. The closing of contact S_6 energizes the timer TR. The instantaneous contact TR(INST) holds on the timer. The contactor S connects the motor to supply through open-delta connected auto-transformer. Thus motor is started with reduced voltage and accelerated. The operating time of timer TR decides the accelerating time for the motor.

After preset time delay, contact TR_1 get opened, de-energizing the Start contactor S. Therefore, the contact S_7 regains its original closed state. The delay-in-closing type timer contact TR_2 also get closed and therefore the Run contactor R get energized. Thus the motor get connected to rated supply voltage through the contacts R_1 to R_3. The motor continues to run with full supply voltage.

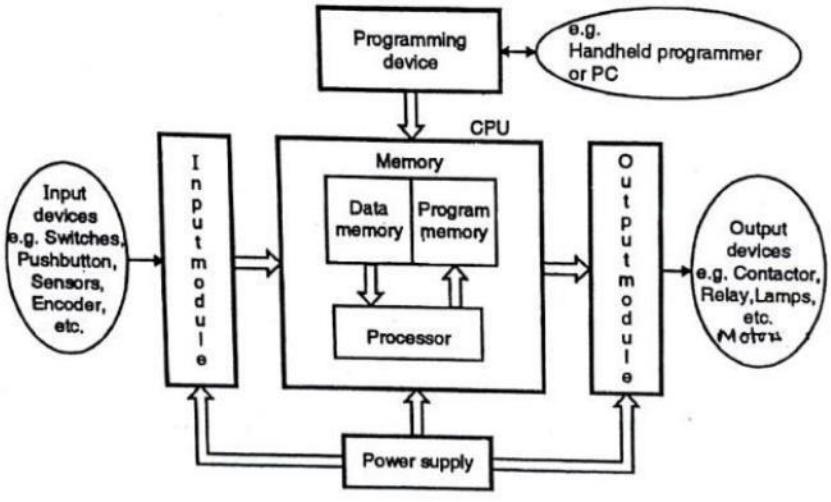
In this scheme, during transition from Start to Run, the Star contactor is de-energized first thereby disconnecting (open circuiting) the motor from supply and then Run contactor is energized thereby re-connecting motor to supply. Therefore, it is called as open circuit transition.

(NOTE: Any other valid scheme of Autotransformer starter, such as Closed-circuit transition, may please be considered for allotment of marks)

2 c) Draw and explain the block diagram of PLC.

Ans:

Programmable Logic Controller (PLC):



Block diagram of PLC

4 marks diagram

CPU: Central processing unit is the main part of any PLC. The CPU solves the user program logic by using real time input status from input module and

updates the status of output module. The CPU consists of – (i) Processor, (ii) Memory.

The processor is responsible for the complete program scan in a PLC. During Program scan processor communicate with the memory. 4 marks description

Memory is used in CPU are of two types RAM and ROM. RAM memory is used to store the data related to input status, output status, timers, counters, internal bit relay, numerical values etc. ROM memory is to store system program and user program.

Input Modules: The input modules examine the state of physical switches and other input devices and put their state into a form suitable for the processor. The PLC is able to accommodate a number of inputs.

Output Modules: The objective of the output module is ultimately to supply power to an external device such as a motor, light, solenoid, and so on, as required by the ladder diagram.

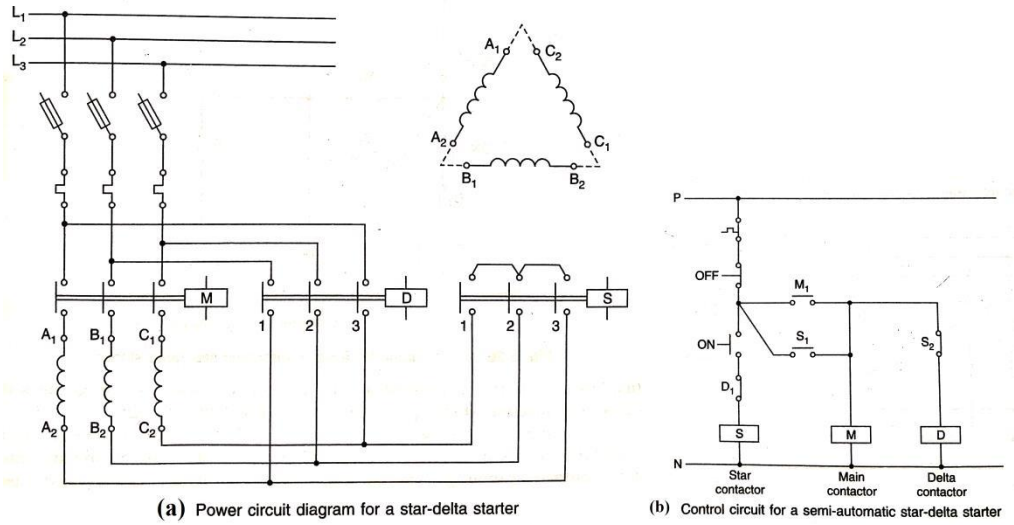
Programming Unit: The programming unit is an external electronic package that is connected to the programmable controller when programming occurs. The unit usually allows input a program in ladder diagram symbols. The unit then transmits that program into the memory of the programmable controller. The programming unit may be a PC or Handheld Terminal.

3 Attempt any <u>FOUR</u> of the following: 16

3 a) Draw Star/Delta starter circuit for 3-[illegible] M. semiautomatic type & explain.

Ans:

Semiautomatic Star-Delta Starter for 3-[illegible]nduction Motor:



(a) Power circuit diagram for a star-delta starter

(b) Control circuit for a semi-automatic star-delta starter

1 mark for power circuit

1 mark for control circuit

The power and control circuit of Semiautomatic Star-Delta starter for 3-[illegible] induction motor is shown in the figure (a) and (b) respectively. In power circuit, three contactors are required to connect motor to supply and to connect its windings first in Star and then in delta. 2 marks for explanation

Referring to the control circuit, the motor is operated in following sequence:

i) When ON push-button is pressed, the Star-contactor coil S is energized through normally-closed OFF push-button, pressed ON push-button and NC contact D_1. Therefore, Star contactor S is opearted and motor windings are connected in star.

ii) After energizing Star-contactor S, the NO contact S_1 get closed and the Main-contactor M get energized. In power circuit, the closing of M contactor connects the motor to supply and it is started as star-connected motor. The M-contactor is held ON through the closed NO contact M_1.

iii) The motor continues to run in star-connection as long as ON push-button is kept pressed.

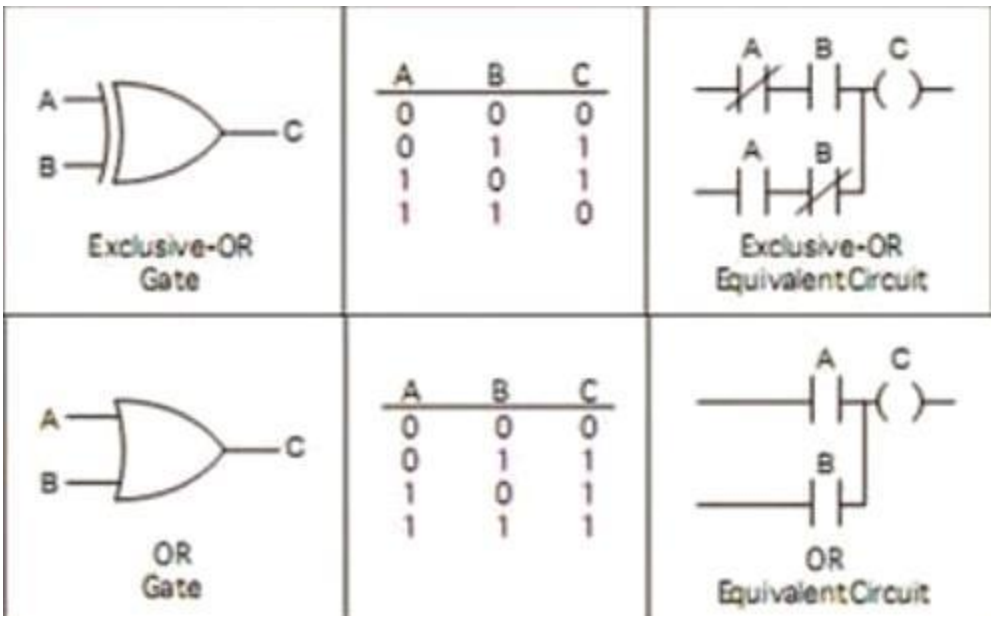
iv) When it is ensured that the motor has picked up 75% of its rated speed, the pressed ON push-button is released. The opening of ON push-button causes interruption of current in coil S and Star-contactor is de-energized. Therefore, the contact S_1 is opened, however contactor M is held ON through closed NO contact M_1.

v) After de-energizing Star-contactor S, the motor winding is disconnected from star-connection and due to closing of NC contact S_2, the Delta-contactor D is energized.

vi) On energizing contactor D, the motor is reconnected in delta-connection. Thus motor then continues to run as delta-connected motor.

3 b) Draw the ladder diagram along with the truth table of XOR and OR gate.

Ans:



2 marks truth table

(Symbols are optional: No marks)

2 marks ladder diagram

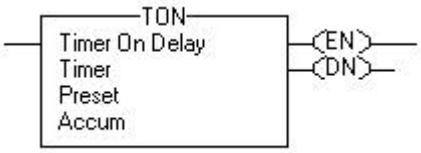
3 c) Explain ON-Delay timer operation.

Ans:

ON-Delay Timer (ODT):

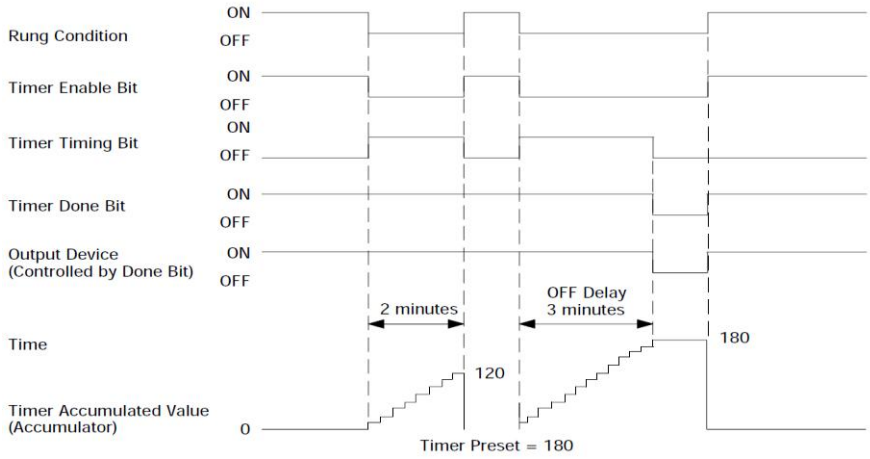
An ON-delay timer (TON) output instruction either provides time delayed action or measures the duration for which some event occurs. Once the rung has continuity, the timer begins counting time-based intervals and counts down until the accumulated time equals the preset time. When these two values are equal, the timer energizes the output and closes the timed out contact associated with the output. The timed contact can be used throughout the program as either a normally open or normally closed contact. If logic continuity is lost before the timer times out, the timer resets the accumulated register to zero.

1½ marks description



1) T4:0 : This bit indicates timer file4,timer 0, it stores timer information
2) Time base 1.0 : This bit indicates processor increments accumulated values in 1 second intervals.
3) Preset: It indicates delay for timer
4) Accumulator value gives current value of the timer as 0 which increases upto the preset value
6) EN : This bit is set ,when input is true,
7) TT: This bit is set when timer is running other is reset
8) DN : This bit is set when accumulator value becomes equal to preset value and then respective output becomes ON

1½ marks for bit's status



1 mark timing diagram

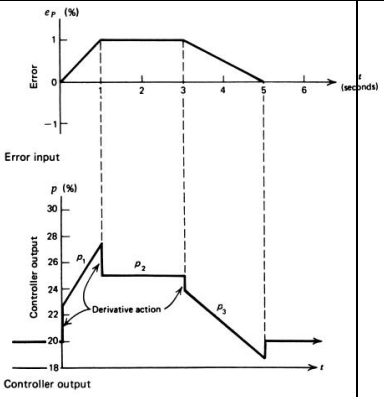
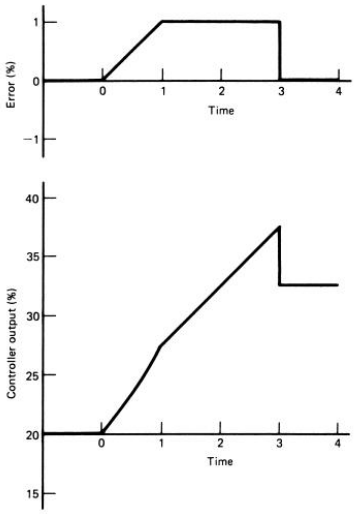
3 d) Compare P+D and PI controller (any for points).

Ans:

Comparison Between P+D and PI controllers:

Parameter	PD	PI
Action	Proportional action cascaded with derivative action.	Proportional action cascaded with integral action.
equation	$p = K_P e_p + K_P K_D \frac{de_p}{dt} + p_0$	$p = K_P e_p + K_P K_I \int_0^t e_p \, dt + p_I(0)$
Characte-ristic	Controller output will be zero if i) error Ep is zero and ii) if error is constant.	When the error is zero, the controller output is fixed at the value that the integral term had when the error went to zero. If the error is not zero, the proportional term contributes a correction, and the integral term begins to increase or decrease the accumulated

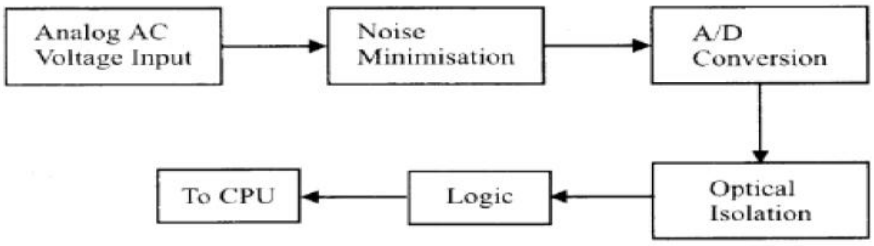
4 marks for any 4 correct points

		value depending on the sign of the error and the direct or reverse action.
Output		
Application	Fast process load changes as long as the load change offset error is acceptable	Systems with frequent or large load changes

3 e) Explain with the block diagram the analog module of PLC.

Ans:

Analog Input Module:



2 marks for diagram

Description-

Analog input module interfaces a PLC to analog input signals. It gives ability to PLC to monitor a continuously changing input signals such as pressure, temperature, flow etc. The module converts analog input signals to 16 bit binary values storage in the processor's input status table. Analog modules are designed to accept current and voltage signals such as 0-10 Vdc, ±10 Vdc, 0-5Vdc and 0-20mA, 4-20mA etc. When signal reaches an input module, it is rich in different noise signals.

2 marks for description

Noise minimization:-The signal is freed from noise through noise minimization circuit. The signal is then digitized and sent to logic section through an isolation circuit.

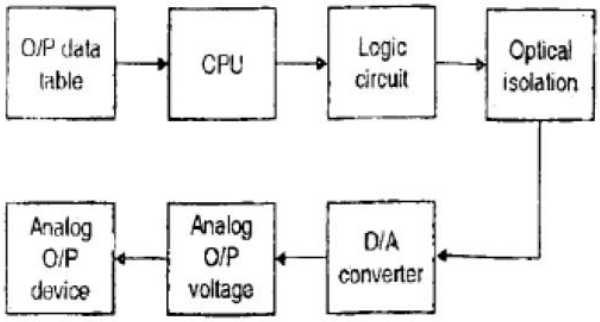
A/D Conversion:- It convert analog to digital signal required for further process.

Optical Isolation: It is used to protect CPU from high voltage coming from fault in the input section.

Logic section:-The logic section allows the digitized signal to go to the CPU following the predetermined logic.

OR

Block diagram of Analog output module :



2 marks for diagram

Explanation:-

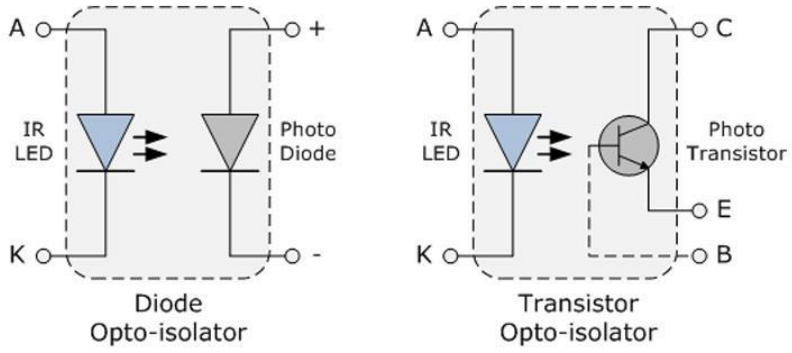
- CPU sends data to output module through different blocks. Optical isolation blocks isolate.
- CPU circuit from high voltage o/p devices.
- Isolation section of the input circuit. Is usually made up of an optical isolator, or opt coupler. In a 120VAC input module, isolation separates the high voltage, 120VAC input signal from the CPUs low voltage control logic.
- DC signal from the opto coupler are used by the logic section to pass the input signal to the module's input address LED and the CPU and then on to the input status file.
- This module accepts 16 bit status word, convert it into analog value using DAC.
- Analog signals are 0 to 10Vdc, -10Vdc to +10Vdc, 0 to 5Vdc 0 to 20mA, -20 to +20mA, 4mA to 20mA.etc.
- These modules are selected to send output either a varying current or voltage signal, each represent particular operation.

2 marks for description

3 f) Draw and explain the function of optoisolator .

Ans:

Optoisolator:



1 mark for any one diagram

Opto-coupler or Opto-isolator is a safety component that transfers electrical signals between two isolated circuits by using light signal. A common type of opto-isolator consists of an LED and a phototransistor in the same package. Opto-coupler are mainly used in delicate system like between sensor and PLC. Opto-coupler functions as a galvanic isolation component, it maintains the connection between two devices or component without any direct conduction. An opto-isolator connects input and output sides with a beam of light modulated

3 marks for description

by input current. It transforms useful input signal into light, sends it across the dielectric channel, captures light on the output side and transforms it back into electric signal.

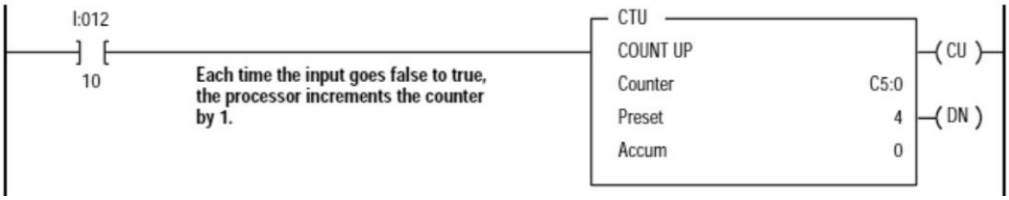
Opto-isolators can pass DC or slow-moving signals and do not require matching impedance between input and output sides. The main function of an opto-isolator is to block high voltages and voltage transients, so that a surge in one part of the system will not disrupt or destroy the other parts. In a 120VAC input module, isolation separates the high voltage, 120VAC input signal from the CPUs low voltage control logic.

4 Attempt any <u>TWO</u> of the following: 16

4 a) Explain in detail the up and down counter of PLC.

Ans:

Up counter:



1 mark for up counter symbol

The up counter counts upward over a range of -32768 to +32767. Each time the rung goes from false to true, the up counter increments accumulated value by one count. When accumulated value equals or exceeds preset value the up counter sets a done bit (DN). The accumulated value is retentive; count is retained until reset by reset instruction.

2 marks for description

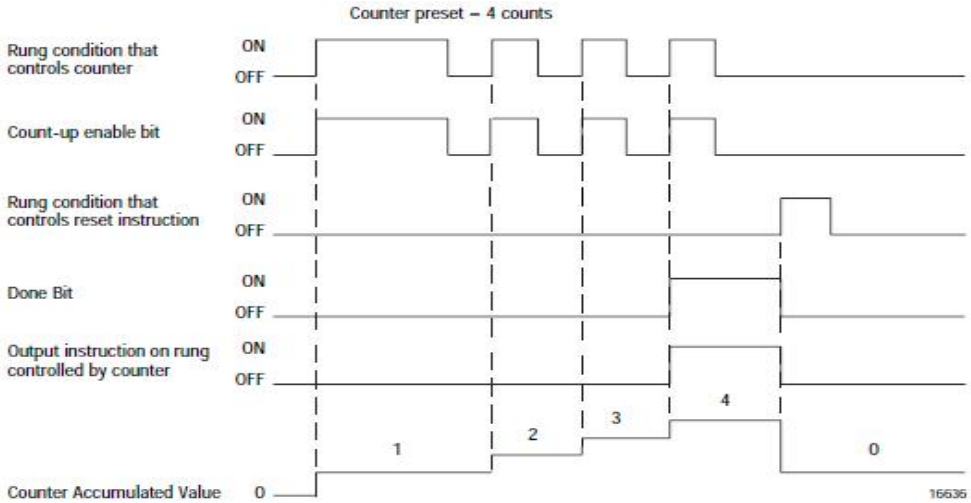
Status Bits:

CU Bit: This status bit is true when UP counter instruction is true.

DN bit: This bit is true when accumulated value is equal to or greater than the present value of the counter.

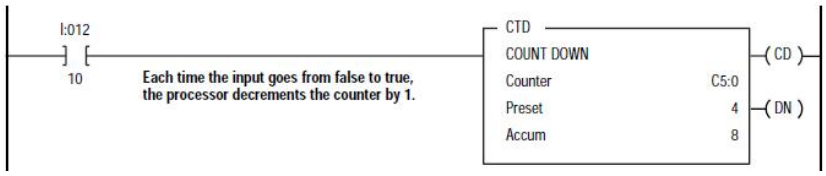
OV(Overflow) bit: when counter count value exceeds 32,767,this bit becomes true.

UN(Underflow): It will go true when counter counts below -32,768.



1 mark for waveforms

Down counter:



1 mark for down counter symbol

The up counter counts downward over a range of +32767 to -32768. Each time the rung goes from false to true, the up counter decrements accumulated value by one count. The DN bit is set as long as accumulated value is greater than or equal to preset value. When accumulated value is less than preset value the down counter resets a done bit (DN). The accumulated value is retentive; count is retained until reset by reset instruction.

2 marks for description

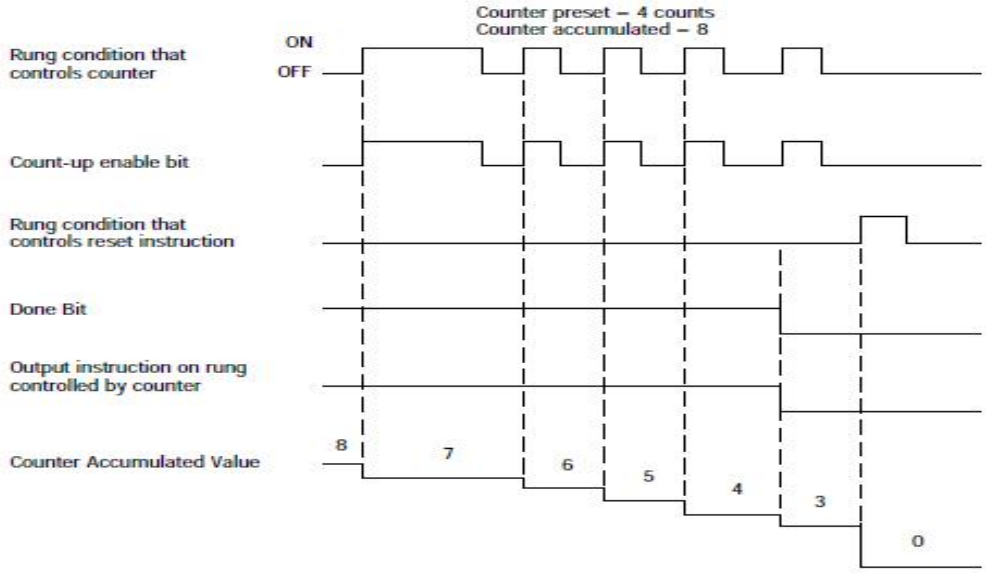
Status Bits:

CD Bit: This status bit is true when DOWN counter instruction is true.

DN bit: This bit is true when accumulated value is equal to or greater than the present value of the counter.

OV(Overflow) bit: when counter count value exceeds 32,767,this bit becomes true.

UN(Underflow):It will go true when counter counts below -32,768.



1 mark for waveforms

4 b) Develop ladder diagram for following sequence of operation:

i) When start button is ON, the system starts.
ii) Lamp L_1 start when the system is ON
iii) Lamp L_2 starts 10 sec, after L_1 is ON
iv) When stop button is ON, lamp L_1 and L_2 are OFF.

Ans:

Input Addresses:
START Button: I:0/0 STOP Button: I:0/1
Output Addresses:
Lamp L1: O:0/0 Lamp L2: O:0/1
Timer address:
ON Delay Timer T1: T4:0

Description:

Rung0: start button and stop button is used in series and output CR is used in parallel with start button. This logic acts like latch it stores status of start button and stop button. When start is pressed latch CR will be turned ON and remain ON irrespective of start. Similarly, when stop is pressed latch CR will be turned OFF and remain OFF irrespective of stop.

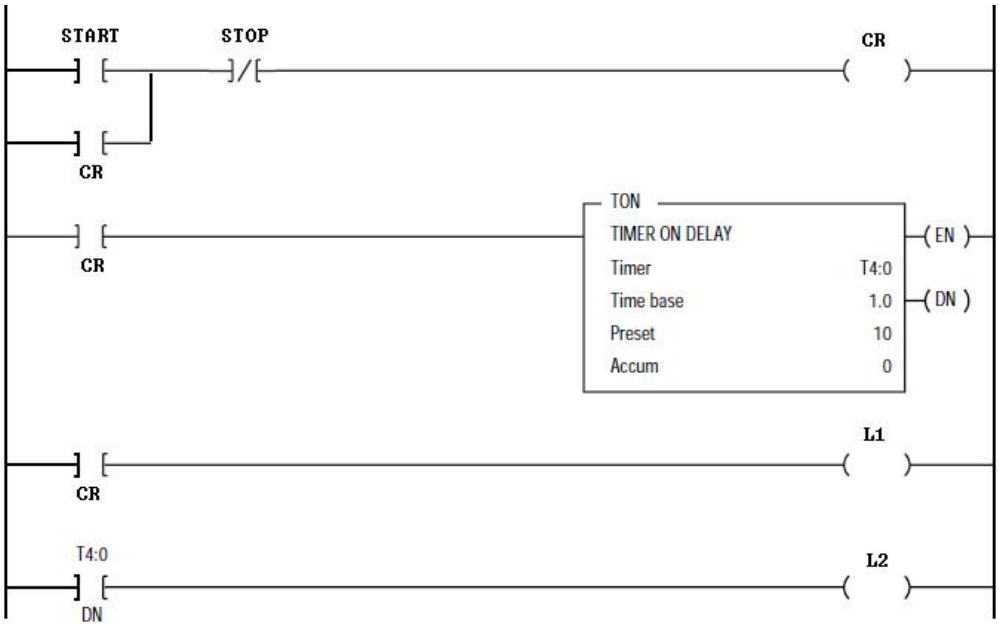
Rung1: when latch CR turn ON, it enables timer T1. Timer T1 starts counting internal pulses by incrementing accumulator. When accumulator value is greater than or equal to preset value i.e. after 10 sec. done bit will set.

Rung2: When latch CR turn ON, Lamp L1 will turn ON.

Rung3: when rung condition i.e. T4:0/DN is true Lamp L2 will turn ON i.e. after 10secc. of Lamp L1.

CR will be turned OFF if stop button is pressed hence Lamp L1 and L2.

4 marks for description



4 marks for ladder program

4 c) Draw and explain power and control circuit for definite time-limit starter for slip-ring induction motor.

Ans:

Definite Time-limit Starter for Slip-ring Induction Motor:

This starter is used for automatic control of acceleration of slip-ring induction motor at the time of starting. In this starter, the accelerating contactors close after pre-set time delays determined by the timers. The time periods are so adjusted that when a resistance step is cut off, the resulting current peaks remain within limits. The time delay between energization of successive contactors can be obtained by using any of the following types of time-delay elements;

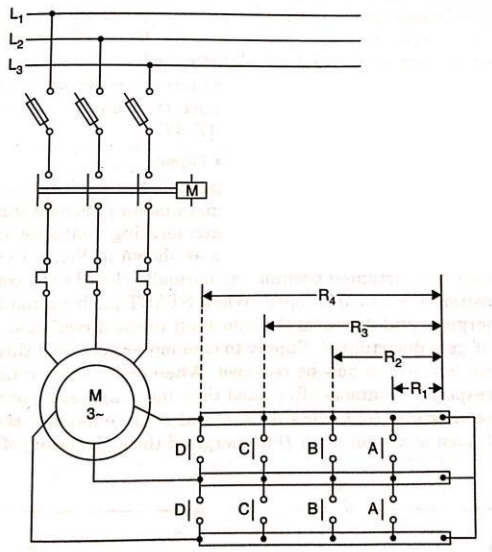
i) Individual timers
ii) Motor driven cam timer
iii) Timer heads mounted on contactors
iv) Flux decay relays

1 mark for explanation of power circuit

The power circuit is as shown below. The slip-ring induction motor is started by rotor resistance starter having resistance steps R_1, R_2, R_3 and R_4. At the time of

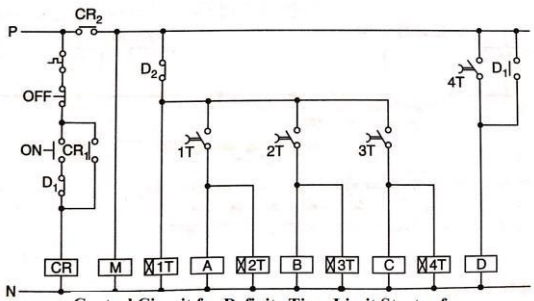
starting, full resistance R_4 is inserted in each rotor phase. With preset time delays, the contactors are operated in sequence A-B-C-D and resistance is cut in steps as R_1-R_2-R_3-R_4 during starting and finally total resistance is cut-out from the rotor circit.

2 marks for power circuit diagram



Power Circuit for Definite Time Limit Starter for Slip-ring Induction Motor

2 marks for control circuit diagram **(Any one control circuit of other types please be considered for allotment of marks)**



Control Circuit for Definite Time Limit Starter for Slip-ring Induction Motor

The control circuit using individual timers is as shown in figure above. Pressing of ON-pushbutton energizes control relay CR. Contactor M and 1T also get energized as contact CR_2 closes. Contactor M starts the motor with full resistance R4 in the rotor circuit. When timer 1T times out, its delayed contact 1T closes to energize contactor A and timer 2T. Energization of contactor A causes cutting off of resistance R_1 from the three rotor phases and motor accelerates. When timer 2T times out, its contact 2T closes to energize contactor B and timer 3T. The closing of contactor B shorts second step of resistance i.e R_2 and the motor accelerates further. In this way, the contactors C and D are closed with time delay determined by timers 3T and 4T respectively and the resistance is cut-off in steps for further acceleration of motor. Finally, when contactor D is closed, the full resistance R_4 is cut off from each phase, shorting the rotor winding terminals and final acceleration of the motor.

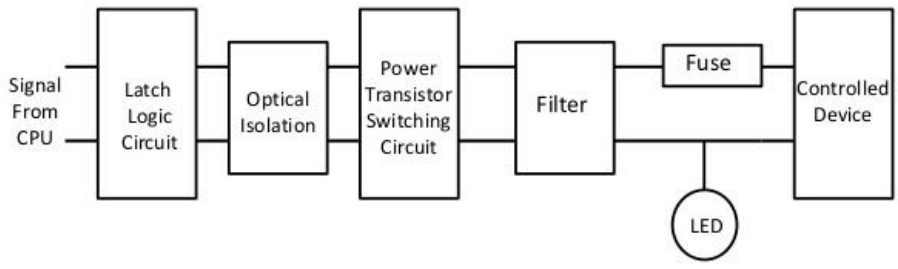
3 marks for explanation of control circuit

5 Attempt any <u>TWO</u> of the following: 16

5 a) Draw the block diagram of digital output module and explain its working.

Ans:

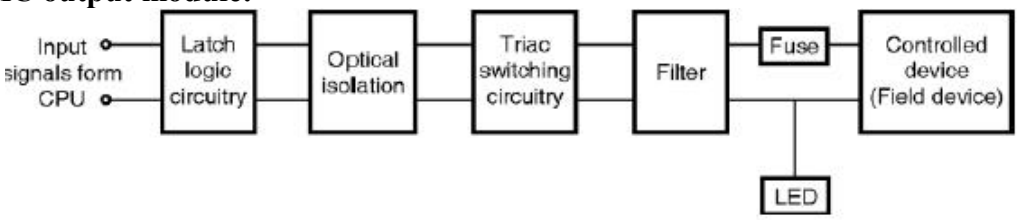
DC output module:



4 marks for diagram

OR

AC output module:



Latch logic circuit and optical isolation circuit:

i) If the status of output terminal is one and if CPU sends low voltage signal (12-18 V DC) to the latching circuit.
ii) Latching circuit will latch that logic signal as a ON state and then send it to the optical isolation circuitry.
iii) Same operation is performed for status is zero.
iv) Optical isolation circuit will isolate low voltage signal of CPU and high voltage operating field devices.

4 marks for description

Switching and filtering circuitry:

i) In this block, power transistor/TRIAC is a solid state switching device used to provide high voltage operating signal to output field devices.
ii) Power transistor /TRIACs are switched ON or OFF by the signal from optical isolation circuit.
iii) DC/AC signals switched by power transistor/TRIAC are filtered to a safe level by filtering circuitry.
iv) To indicate the status of the output LED is provided on output module.
v) In some output module circuit, fuse is provided to protect the circuit from drawing higher current.

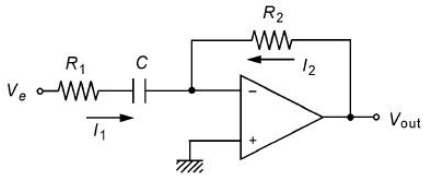
Controlled device(Load):

i) Controlled device are the field output devices may operate from different voltages.
ii) When the status of output is one in output data table then controlled device turns ON and when status is zero, then device turns OFF.

5 b) Explain the working of Derivative controller. And explain why derivative mode is not used alone.

Ans:

Derivative controller:



2 marks for diagram

The equation for D controller is:

1 mark for equation

$$p(t) = K_d \frac{de(t)}{dt}$$

For a given rate of change of error signal, there is a unique value of the controller output. When the error is zero, the controller output is zero. When the error is constant i.e. rate of change of error is zero, the controller output is zero. When the error is changing, the controller output changes by Kd % for even 1 % per second rate of *change of error.*

3 marks for description

When the error is zero or a constant, the derivative controller output is zero. Hence, it is never used alone. Its gain should be small because faster rate of change of error can cause very large sudden change of controller output. This may lead to instability of the system.

2 marks for reason

5 c) i) Explain the OFF-Delay Timer of PLC with neat diagram.

Ans:

OFF-Delay Timer of PLC:

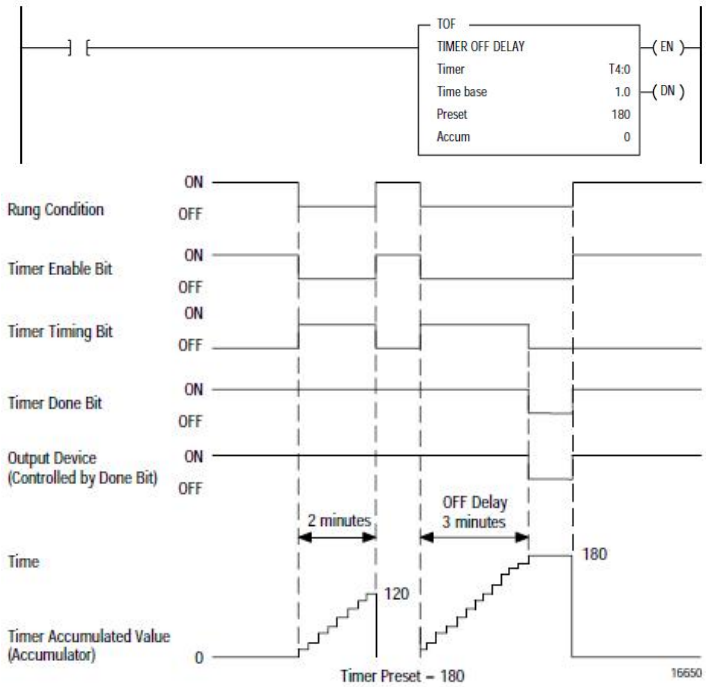
The OFF delay timer is used to turn on/off an output after its rung condition has been off for preset time interval. It starts accumulating the time when the rung goes false and continues timing until one of the following condition occurs:

i. accumulated value equals its preset value
ii. a rung goes true
iii. a reset instruction resets timer

2 marks for description

There are 3 memory words reserved for every timer for status, accumulator and preset.

1) T4:0 : This bit indicates timer file4, timer 0, it stores timer information
2) Time base 1.0: This bit indicates processor increments accumulated values in 1 second intervals.
3) Preset: It indicates delay for timer
4) Accumulator value gives current value of the timer as 0 which increases upto the preset value.
5) EN : This bit is set ,when input is true,
6) TT: This bit is set when rung condition fails and turns off
7) TT: This bit is set when timer is running other is reset
8) DN : This bit is set when accumulator value becomes equal to preset value and then respective output becomes ON. This bit is initially set when rung is true and turns off when accumulator value becomes equal to preset.

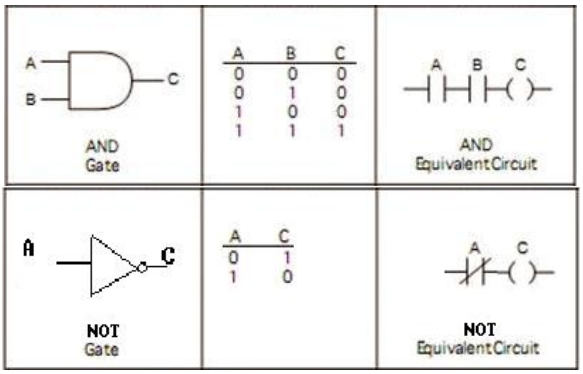


1 mark for symbol

1 mark for waveform

5 c) ii) Draw the ladder diagram for (i) AND gate (ii) NOT gate.

Ans:



2 marks for truth-tables

(Symbols of gates are optional: NO marks)

2 marks for ladder diagrams

6 Attempt any FOUR of the following: 16

6 a) List any four input and output of PLC.

Ans:

Inputs:	Outputs:
1. Pushbutton	1. Lamp
2. SPDT switch	2. Motor
3. Limit switch	3. solenoid
4. Proximity switch	4. Relay
5. Pressure switch	5. Actuator
6. Temperature switch	6. Alarm
7. Level switch	
8. Flow switch	
9. Encoder	

½ mark for each of any four inputs = 2 marks

½ mark for each of any four outputs = 2 marks

OR Any other relevant answer.

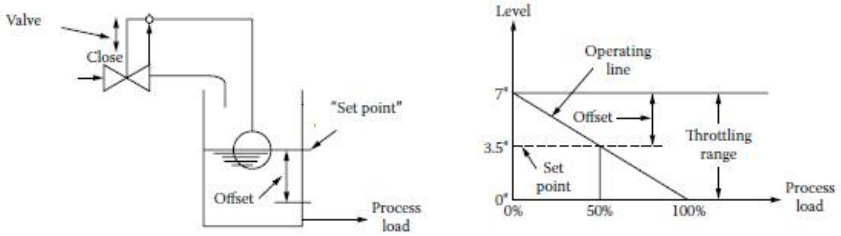
6 b) Explain the offset in proportional controller.

Ans:

The main limitation of plain proportional control is that it cannot keep the controlled variable on set point. The proportional controller produces a permanent residual error in the controlled variable, when a change in load occurs. This is referred to as offset.

3 marks for explanation

Let us consider the level control system shown in Figure. The float-type proportional controller can only respond to a load change (change in the outflow of water) because it must experience a change in level before it can respond. Therefore, the only condition when this process will be on set point is when the load is 50%. In all other cases the level will have to travel up or down on its "operating line" as a function of the load. The difference between the actual value of the level and set point is called the offset, because this is the amount by which the process is off set point.



1 mark for diagram

6 c) Describe the operation of pneumatic cylinder.

Ans:

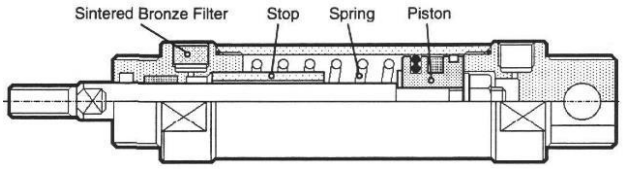
Pneumatic Cylinder:

Pneumatic cylinders are one of the most common pneumatic actuators used in many industrial applications that require linear motion. A pneumatic Cylinder is an actuator that uses the energy of compressed air to convert it in mechanical energy, in the form of a linear movement.

1. Single-acting cylinders with one air inlet to produce a power stroke in one direction.
2. Double acting cylinders with two air inlets to produce extending and retracting power strokes.

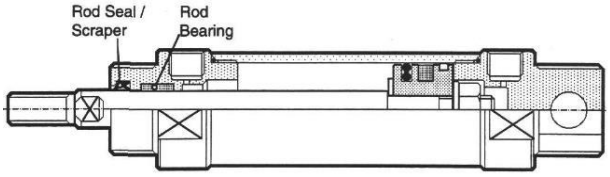
2 marks for description

Single-acting Cylinder: A single acting cylinder develops thrust in one direction only. The piston rod is returned by a fitted spring or by external force from the load or spring. They have a somewhat lower air consumption compared with the equivalent size of double acting cylinder. However there is a reduction in thrust due to the opposing spring force, and so a larger bore may be require.



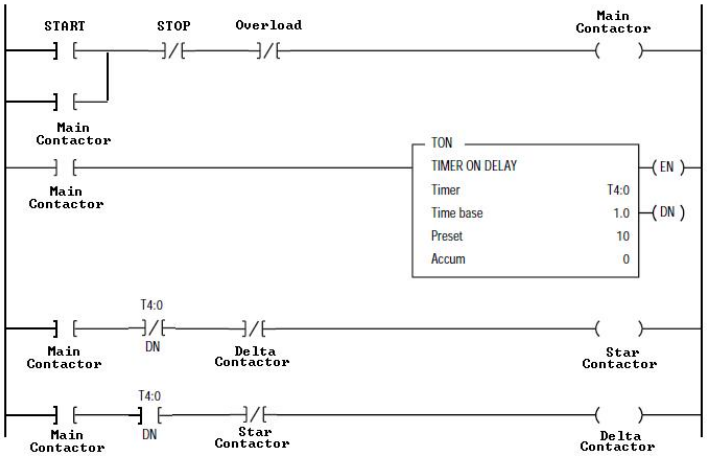
2 marks for diagram

Double acting cylinder: With this actuator, thrust is developed in both extending and retracting directions as air pressure is applied alternately to opposite sides of a piston. The thrust available on the retracting stroke is reduced due to the smaller effective piston area, but is only a consideration if the cylinder is to 'pull' the same load in both directions.



6 d) Draw the ladder diagram for star delta starter.

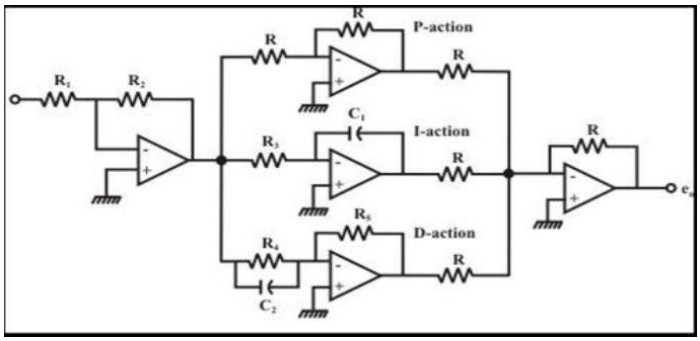
Ans:



4 marks for correct ladder diagram

6 e) Draw the block diagram of PID controller and explain its working.

Ans:



1 mark for diagram

Output Equation:

$$P_O = K_P E_P + K_P K_I \int E_P \, dt + K_P K_d \frac{dE_P}{dt} + P_I(0)$$

1 mark for equation

Explanation:

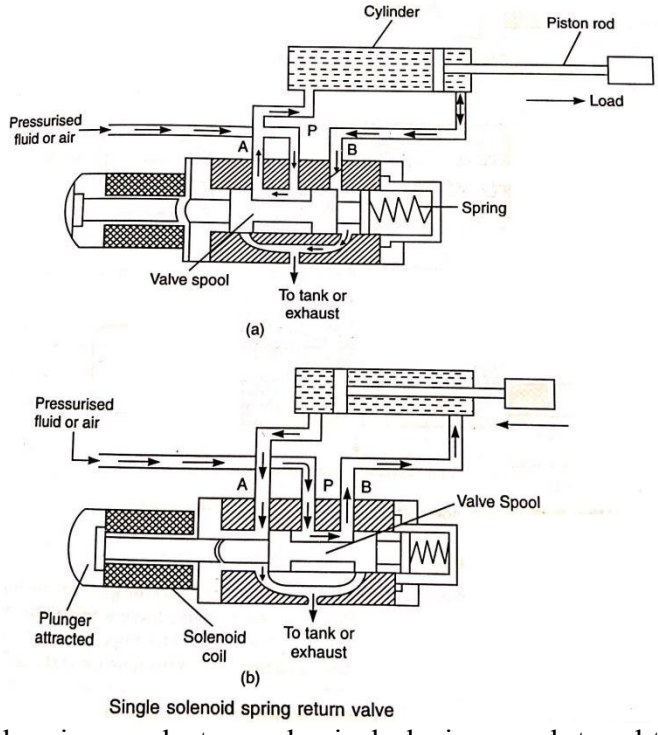
PID is combination of 3 control action- proportional + integral + derivative. The proportional corrects instances of error, the integral corrects accumulation of error, and the derivative takes the corrective action in anticipation. The effect of the derivative is to counteract the overshoot caused by P and I. When the error is large, the 'P' and the 'I' will push the controller output. This controller response makes error change quickly, which in turn causes the derivative to more aggressively counteract the P and the I.

2 marks for explanation

6 f) Explain ~~its~~ working of Solenoid valves with the help of neat diagram.

Ans:

Solenoid valves:



Single solenoid spring return valve

2 marks for diagram

A solenoid valve is an electromechanical device used to obtain mechanical movement in machinery by utilizing fluid or air pressure. The fluid or air pressure

is applied to the cylinder piston through a valve operated by a cylindrical electrical coil. The electrical coil along with its frame and plunger is known as the solenoid and the assembly of solenoid and mechanical valve is known as solenoid valve.

In fig (a) is shown a single solenoid spring return valve in its de-energized condition. In this condition the plunger and valve spool position are as shown, port P is connected to port A and port B is connected to tank or exhaust, if air is used. The spring(S) pressure keeps the spool in this condition as long as the coil is de-energized. Fluid pressure from port P through port A is applied to the left side of the cylinder piston. Thus the cylinder piston moves in the right direction.

2 marks for explanation

In fig (b) is shown a single solenoid spring return valve in its energized condition. When solenoid coil is energized, plunger is attracted and it pushes the spool against spring pressure. In this position of spool, port A gets connected to tank and port P gets connected to port B . Fluid pressure from port P through port B is applied to the right side of the cylinder piston. Thus the cylinder piston moves in the left direction. At the same time fluid in the other side is drained out to the tank.