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Model Answer
Winter – 2018 Examinations
Subject & Code: Elements of Industrial Automation (17641)

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

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|		
1	**Attempt any five:**	**20**

1 a) Explain concept of capacitive type proximity switch with neat schematic diagram.

Ans:

Capacitive type proximity switch:

A capacitive proximity switch is device that senses presence of metallic or non-metallic objects. The internal circuit consists of an oscillator, threshold detection stage and an open capacitor formed by two metallic electrodes. The oscillator is inactive when target is away from the switch surface. When target is near to switch surface, change in the net capacitance formed by the switch open capacitor and the target. The circuit begins to oscillate and change in the oscillation amplitude is detected by threshold detection. When target is away from sensing surface, the output switching device is normally open. But when the target comes in close proximity of sensing surface, the change in oscillation amplitude is detected and output switching device is turned on.
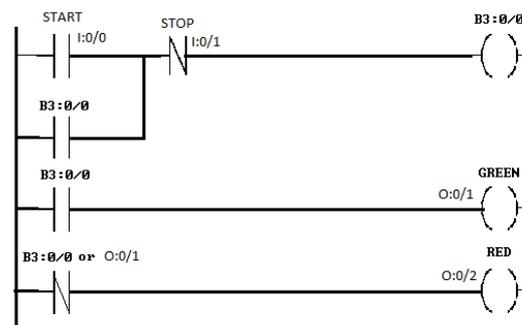
2 marks for description
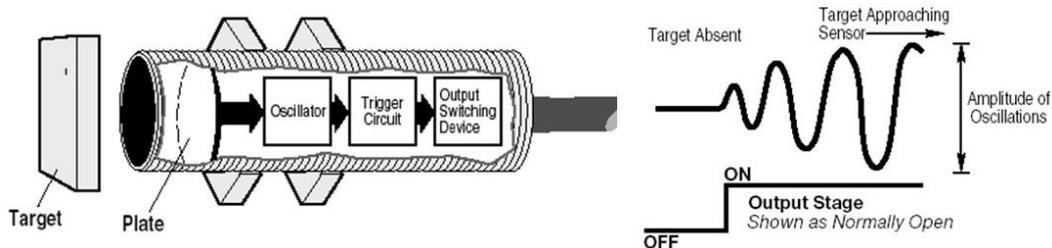
2 marks for diagram

1 b) Draw ladder diagram for following sequence:
   i) When NO START Pushbutton is pressed Green light is on.
   ii) When NC STOP Pushbutton is pressed Red light is on. Green light goes off.

Ans:

Inputs: Start Pushbutton- I:0/0   Stop Pushbutton - I:0/1
Outputs: Green Light - O:0/1   Red Light- O:0/2
Latch: Latch- B3:0/0

1 marks for addressing

3 marks for ladder diagram [1 for each rung]

1 c) List any four applications of servomotor

Ans:

Applications of servomotor:
   i)   Electromechanical actuators
   ii) Aircraft control system
   iii) Robotic controls

4 marks for 4 correct applications

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    iv) Remote positioning systems
    v) Self-balancing recorders
    vi) Tracking and guidance system
    vii) Printers
    viii)Watches
    ix) Process control systems
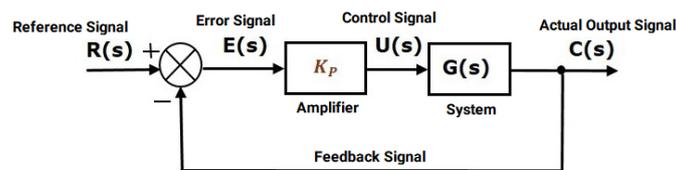
1 d)   Draw block diagram of proportional controller.
       Ans:
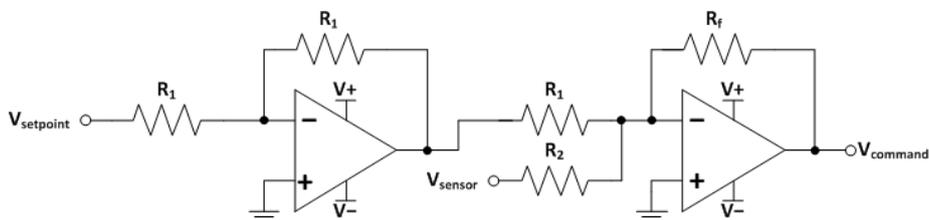   **Block diagram of Proportional Controller:**

OR

OR

$$V_{command} = \frac{R_f}{R_1}\left(V_{setpoint} - V_{sensor}\right) \; if \; R_1 = R_2$$

OR
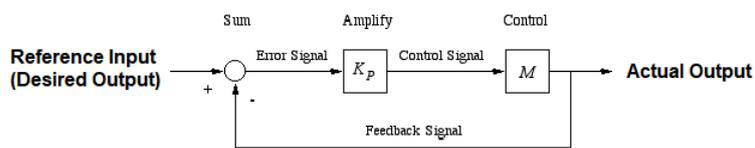
$$Vout = \frac{R2}{R1}Ve + Vo$$

4 marks for any one labeled diagram

2 marks for partially labeled diagram

1 mark for unlabeled diagram
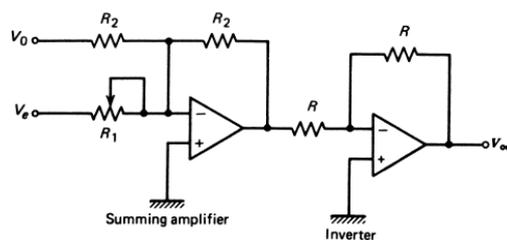
1 e)   List any two ratings of digital input and digital output module each.
       Ans:
       Ratings of Digital Input Module:
       i)   Rated voltage & current: +24V DC at 4mA/120V AC at 6mA/230V AC at 9mA
       ii)   Specified operational voltage range: 0-30V DC/ 264V AC.
       iii) Absolute maximum input voltage: +35V DC for 0.5sec.
       iv) Signal Delay: 5.0 msec for DC/ 15 msec for AC ON to OFF or OFF to ON.

2 marks for input module ratings [any two]

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v)   Logic 1: 15V DC at 2.5mA/ 79V AC at 2.5mA.
vi)   Logic 0: 5V DC at 1mA/ 20V AC at 1mA.
Ratings of Digital Output Module:
i)   Rated voltage: +24V DC/+24VDC or 250V AC relay type/120V/230V AC
ii)   Voltage range: 20.4-28.8V DC/5-30V DC or 5-250VAC relay type/40-264V AC
iii)   Logic 1: 20V DC min./ 24VDC or 250V AC/120V/230V AC
iv)   Logic 0: 0.1V DC max./0 VDC or AC/0VAC
v)   Rated current/point: 0.75A DC/ 2A for relay type/0.5A AC
vi)   Rated current/common: 6A DC/8A for relay type/0.5A AC

2 marks for output module ratings [any two]

1 f)   Explain why derivative action is not used alone.
   Ans:
   Derivative action is not used alone because:
   The equation for derivative 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 K_d% for every 1% per second rate of change of error.

2 marks

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.

1 mark

1 g)   State any two input and output devices of PLC
   Ans:
   Input Devices of PLC:
   i)   Selector switches
   ii)   Push buttons
   iii)   Binary encoders
   iv)   Mechanical/magnetic Limit switches
   v)   Inductive/ capacitive/optical proximity switches
   vi)   Analog transducers/transmitters like flow / level / pressure / temperature / humidity / speed etc.

2 marks for input devices [any two]

   Output Devices of PLC:
   i)   Alarms/Annunciators
   ii)   Buzzers
   iii)   Relays/contactors
   iv)   Indicators/Lamps
   v)   Solenoids
   vi)   Continuous/ discrete valves
   vii)   Analog/digital indicators/recorders etc.
         (Any other valid input/output device shall be considered)

2 marks for output devices [any two]

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2	**Attempt any two:**		**16**

2 a) i) List any four names of optial sensors.

Ans:

Optial sensors:
  i) Photodiodes
  ii) Phototransistors
  iii) LDRs
  iv) Photovoltaic cells
  v) Optical encoder
  vi) Scintillation counter
 vii) Photoionization detector
  viii) Photographic plates

4 marks for any 4 correct names

2 a) ii) Explain role of opto isolator in PLC with neat diagram.

Ans:

Role of optoisolator in PLC:

An optoisolator is a semiconductor device that uses a short optical transmission path to transfer an electrical signal between circuits or elements of a circuit, while keeping them electrically isolated from each other. Optocouplers can be used to isolate low-power circuits from higher power circuits and to remove electrical noise from signals.
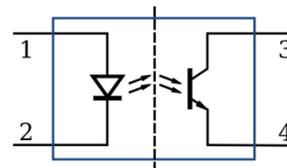
2 marks for diagram

Electronic equipment, as well as signal and power transmission lines, are subject to voltage surges from radio frequency transmissions, lightning strikes and spikes in the power supply. To avoid disruptions, optoisolators offer a safe interface between high-voltage components and low-voltage devices.

2 marks for description

2 b) Draw power and control circuit for definite time-limit starter for slip-ring induction motor. Explain its working.

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 energisation of successive contactors can be obtained by using any of the following types of time-delay elements;
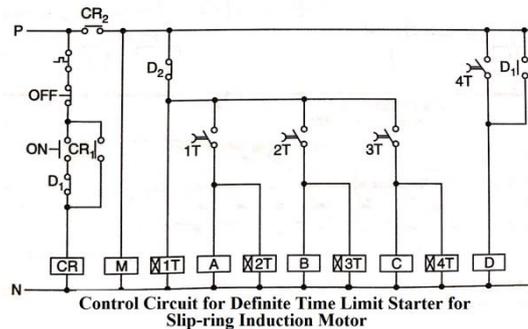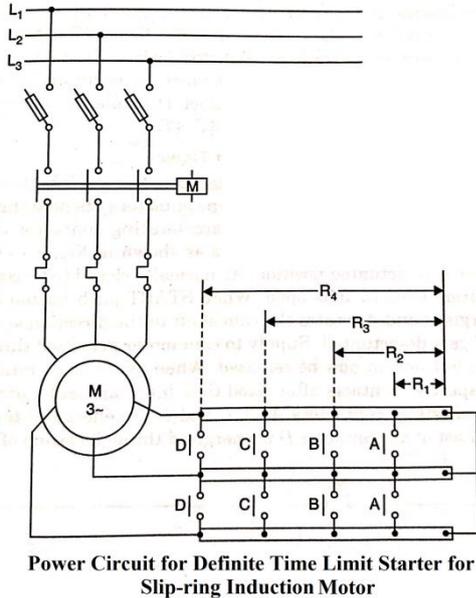
  i) Individual timers
  ii) Motor driven cam timer
  iii) Timer heads mounted on contactors
  iv) Flux decay relays

2 marks for scheme

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 circuit.

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2 marks for power circuit

2 marks for control circuit

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

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 takes place.
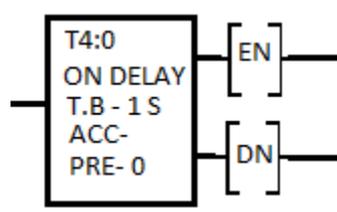
2 marks for working

2 c) Explain ON Delay timer of PLC with suitable example.
Ans:
ON Delay timer of PLC:

An on-delay timer will wait for a set time after a line of ladder logic has been true before turning on, but it will turn off immediately. An ON-delay energize timer (TON) 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.
The control registers and bits used in timers are as follows:

1 mark for description

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	15 14 13	
Word 0	EN TT DN	Internal Use
Word 1	Preset Value	
Word 2	Accumulator Value	

Bits used in timers:

i) T4:0 : This bit indicates timer file4,timer 0 ,it stores timer information

ii) Time base 1.0 : This bit indicates processor increments accumulated values in 1 second intervals.

iii) Preset: It indicates delay for timer

iv) Accumulator value gives current value of the timer as 0 which increases upto the preset value

v) I:010/5 : It is the input to the timer

vi) EN : This bit is set ,when input is true,

vii) TT: This bit is set when timer is running other is reset

viii) DN : This bit is set when accumulator value becomes equal to preset value and then respective output becomes ON

2 marks for control bit description

There are two types of ON Delay timers viz. retentive and non-retentive. A retentive timer will sum all of the on or off time for a timer, even if the timer never finished. A non-retentive timer will start timing the delay from zero each time. The timing diagrams of these timers are as shown below.
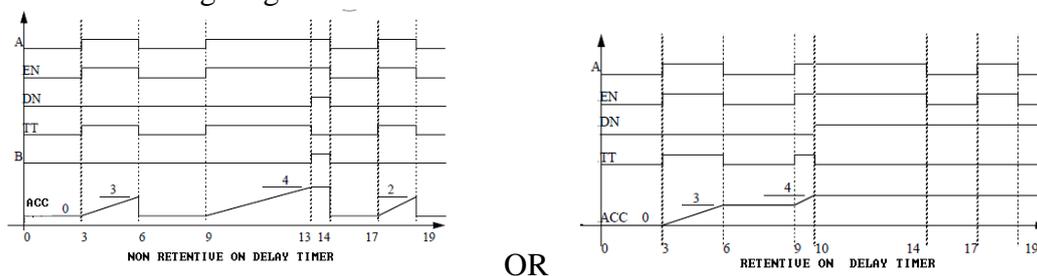
NON RETENTIVE ON DELAY TIMER   OR   RETENTIVE ON DELAY TIMER

1 mark for any one timing diagram

Example: In the following application motor M1 starts as soon as start pushbutton is pressed and motor M2 starts after 10 seconds.

Rung 1: when START Pushbutton is pressed the latch B3:0/0 will be set and will remain set till the circuit is break by pressing STOP pushbutton.

Rung 2: if latch B3:0/0 is set the timer will be enabled. Timer will start to count internal pulses with time base 1 second. The done bit of timer will set after 10 seconds i.e. ACC>=PRE and will remain set till it is reset by RES or if latch is reset.

Rung 3: when latch is set, motor M1 will also set till latch doesn't reset.

Rung 4: The motor M2 will start when latch=1 and timer done bit is set i.e. after completion of delay 10 seconds.

If STOP pushbutton is pressed both motors and timer will turn off.
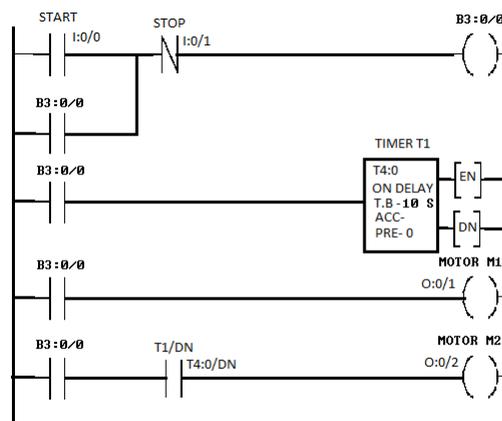
2 marks for description

2 marks for ladder diagram

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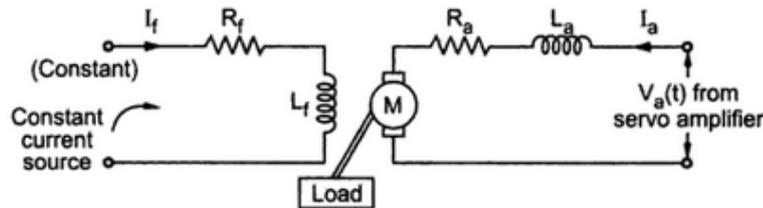**Subject & Code: Elements of Industrial Automation (17641)**

3	Attempt any four:	16

3 a) Draw construction of DC servomotor.
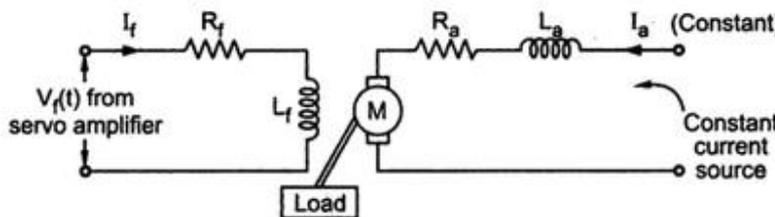**Ans:**
DC servomotor:

Armature controlled d.c. servomotor

OR

Field controlled d.c. servomotor
(Marks may please be awarded for constructional sketch of DC motor)

2 marks for diagram

2 marks for labeling

3 b) Draw and explain PD controller.
Ans:
PD controller:
PD controller has the cascaded proportional and derivative modes. The aim of using P-D controller is to increase the stability of the system by improving control since it has an ability to predict the future error of the system response. In order to avoid effects of the sudden change in the value of the error signal, the derivative is taken from the output response of the system variable instead of the error signal. Therefore, D mode is designed to be proportional to the change of the output variable to prevent the sudden changes occurring in the control output resulting from sudden changes in the error signal. The analytical expression for this mode can be given as
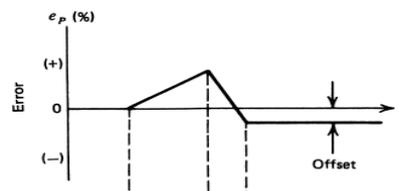
$$p(t) = K_p e_p + K_p K_d \frac{de_p}{dt} + p(o)$$

This mode cannot eliminate the offset of proportional controllers. It can, however, handle fast process load changes as long as the load change offset error is acceptable.
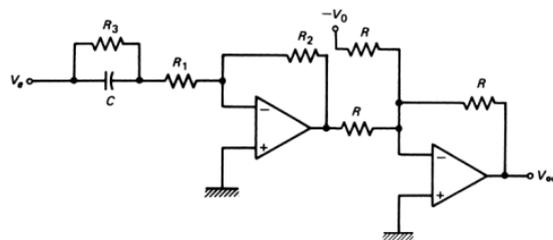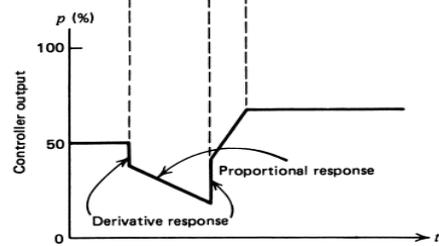

1 mark for circuit diagram

1 mark description

1 mark equation

1 mark graph

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3 c) Explain construction and working of Solenoid valve.
**Ans:**
Solenoid Valve:

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.

Single solenoid spring return valve

2 marks for construction

2 marks for working
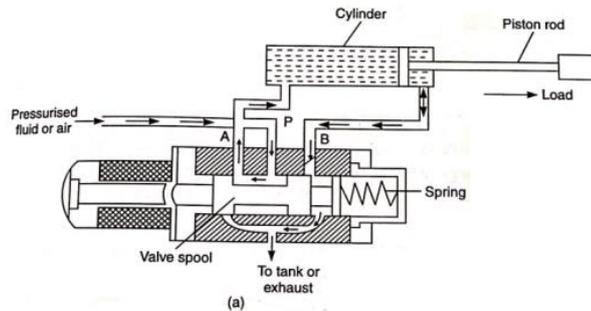
In fig (b) is shown a single solenoid spring return valve in its energized condition. When solenoid coil is energized, plunger is attracted and it pushes the spool against spring pressure. In this position of spool, port A gets connected to tank and port P gets connected to port B. Fluid pressure from 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.
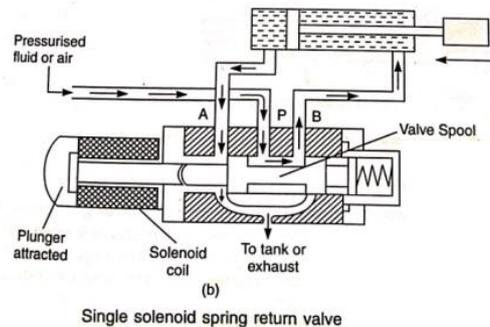
3 d) List types of memory. Explain any one type of memory in brief.
Ans:
Types of Memories in PLC:
  i)   Executive Memory
  ii) Scratch Pad Memory
  iii) Data Table
       a) Input image memory
       b) Output image Memory
       c) Internal bits/ registers/ words
  iv) User Program

2 marks for listing types

Executive Area. The executive is a permanently stored collection of programs that are considered part of the system itself. These supervisory programs direct system activities, such as execution of the control program, communication with

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peripheral devices, and other system housekeeping activities.

OR

Scratch Pad Area. This is a temporary storage area used by the CPU to store a relatively small amount of data for interim calculations and control. The CPU stores data that is needed quickly in this memory area to avoid the longer access time involved with retrieving data from the main memory.

2 marks for description

OR

Data Table Area. This area stores all data associated with the control program, such as timer/counter preset values and other stored constants and variables used by the control program or CPU. The data table also retains the status information of both the system inputs and the system outputs.

OR

User Program Area. This area provides storage for programmed instructions entered by the user. The user program area also stores the control program.

3 e) Differentiate between power and control wiring (any four).
Ans:
Difference between power and control wiring:

|	Power wiring	Control wiring
1	Used for connecting load to main power supply through appropriate switchgear and protecting devices such as overload relay contacts.	Used for connecting control circuit which consists of input devices such as push buttons, selector switches, proximity switches, indicating lamps etc.
2	Power wiring is connected between main supply and load.	Control wiring is connected at the secondary of a control transformer.
3	It is at main supply voltage level (e.g. 440V)	It's a low voltage (e.g. 110VAC)
4	A conductor selections for power wiring is based on rating of load and overload capacity.	A conductor with small current capacity can be used for connecting control circuit as control circuit does not carry higher current.

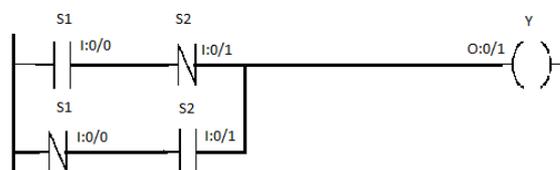1 mark for each difference = 4 marks

3 f) Draw ladder diagram to verify :
   i) AND gate
   ii) EX-OR gate

1 mark for equation
1 mark for ladder
[AND gate]

Ans:
AND Gate: $Y = AB$
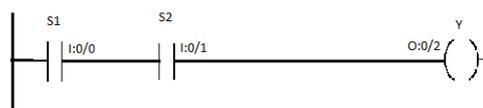
EX-OR Gate: $Y = \bar{A}B + A\bar{B}$

1 mark for equation
1 mark for ladder
[EX-OR gate]

_____

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4	**Attempt any four:**	**16**

4 a) List any two advantages and any two disadvantages of PLC.

Ans:

Advantages of PLC:
   i) Increased productivity
   ii) Increased product quality
   iii) Increased flexibility and convertibility
   iv) Reduced manpower
   v) Reduced cost of product
   vi) Better inventory control
   vii) Increased profit
   viii) Smaller physical size than hard-wire solutions.
   ix) Diagnostics are centrally available
   x) Applications can be duplicated faster and less expensively.
   xi) It is capable to communication with computer in plant.

2 marks for listing 2 correct advantages

Disadvantages of PLC:
   i) PLCs are propitiatory, which means software and parts one manufacturer can't be easily used in combination with part of another manufacturer.
   ii) Need skilled person to handle or program PLC.
   iii) Initial cost is high.
   iv) To maximize PLC performance and Flexibility, a number of Optional Modules must be added
   v) PLCs are not very good at handling large amount of data, or complex data.

2 marks for listing 2 correct disadvantage

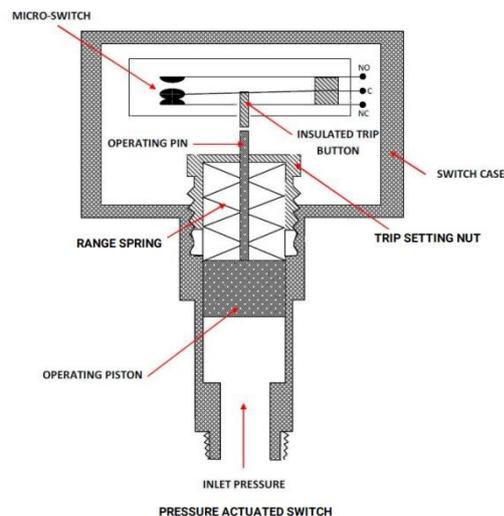4 b) Explain pressure actuated switch with neat constructional diagram.

Ans:

Pressure actuated switch:

A pressure actuated switch is a device designed to monitor a process pressure and provide an output when a set pressure (setpoint) is reached. A pressure actuated switch does this by applying the process pressure to a diaphragm or piston to generate a force which is compared to that of a pre-compressed range spring. A pressure actuated switch is used to detect the presence of fluid pressure. Most pressure switches se diaphragm or below as the sensing element. The movement of this sensing element is used to actuate one or more switch contacts to indicate as alarm or initiate a control action.

The basic parts of a typical pressure actuated switch are shown in the schematic diagram.
   i) Micro-switch

PRESSURE ACTUATED SWITCH

2 marks for constructional diagram

2 marks for explanation

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ii)   Insulated trip button
iii)   Operating pin
iv)   Trip setting nut
v)   Range spring
vi)   Operating piston
vii)   Switch case or housing

Operating Principle:
The inlet pressure is applied to the bottom of the operating piston. This piston is forced upwards by the inlet pressure against the range spring. The tension of the range spring can be adjusted so that it is compressed at a certain pressure or setpoint. When this pressure is reached, the operating pin will hit the trip button on the micro-switch and change it over. The normally open contacts (NO to C) will become closed and the normally closed contacts (NC to O) will open. The pressure at which the micro-switch changes over is set by adjusting the trip setting nut. This nut adjusts the tension of the range spring (e.g. if the nt is turned clockwise the trip pressure will be higher).

4 c)   Develop ladder diagram for star delta (automatic) starter.
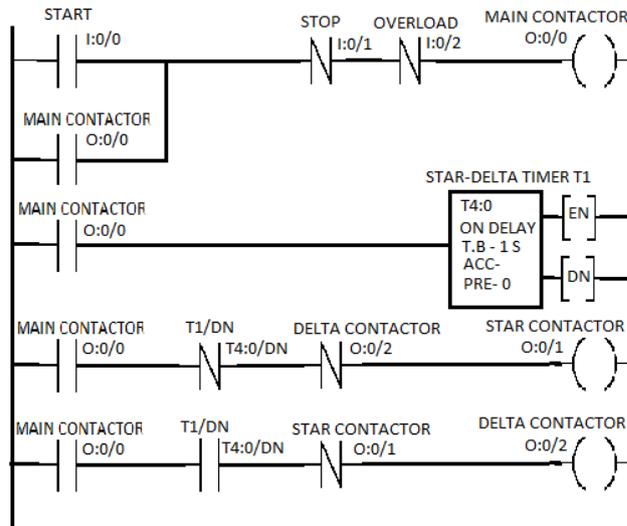
Ans:

Ladder diagram for Automatic star-delta starter:
Inputs: Start switch- I:0/0   Stop Switch- I:0/1   Overload: I:0/2   1 mark for
Outputs: Main Contactor- O:0/0 Start Contactor- O:0/1   Delta Contactor- O:0/2   addressing
Timer: Star-Delta Timer- T4:0 (On Delay)

3 marks for ladder diagram

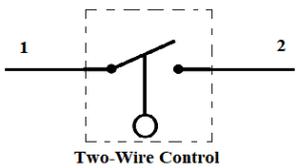4 d)   Differentiate between two-wire and three-wire control (any four points).

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	The control components are usually

	switch, may be automatic such as limit switch, float switch etc.	push-buttons (Start and Stop).	1 mark for each difference = 4 marks
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	Stop / Start / Three-Wire Control	
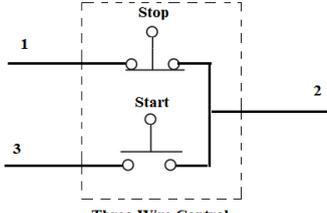
4 e) Explain Integral control action in brief.

Ans:

Integral Control action:

Integral action accumulates error as a function of time. It sums the error over time, multiplies that sum by a gain, and adds the result to the present controller output. If the error makes random excursions above and below zero, the net sum will be zero, so the integral action will not contribute. But if the error becomes positive or negative for an extended period of time, the integral action will begin to accumulate and make changes to the controller output.

The integral action can be represented by equation

$$p(t) = K_i \int_0^t e_p \, dt + p(0)$$

Where; p(0) = controller output when integral action starts

   K_i = integral gain

   e_p = error

   p(t)= integral controller output

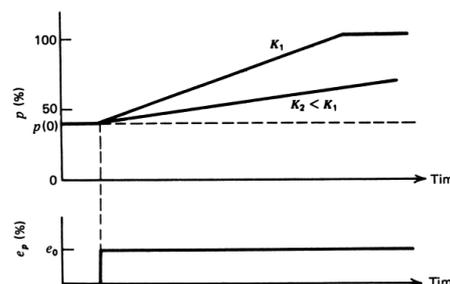we can write the above equation in derivative form as

$$\frac{dp}{dt} = K_i \, e_p$$

This equation shows that when an error occurs, the controller begins to increase or decrease its output at a rate that depends upon the size of the error and the gain. If the error is zero, the controller output is not changed.

Integral action can be summarized as:

1. If the error is zero, the output stays fixed at a value equal to what it was when the error went to zero.

If the error is not zero, the output will begin to increase or decrease at a rate of KI

1 mark description

1 mark equation

1 mark for summary
1 mark for diagram

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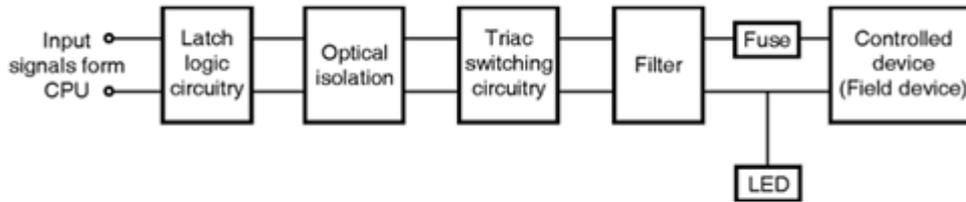**(ISO/IEC-27001-2013 Certified)**
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percent/second for every 1% of error.

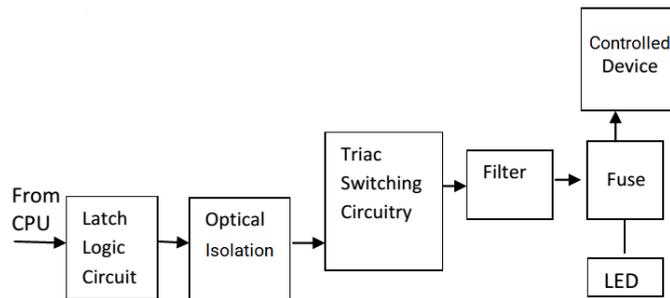4 f) Draw a block diagram of digital output module of PLC.

Ans:

Block diagram of digital output module of PLC:

Block diagram of AC output module

OR

Block diagram of DC output module

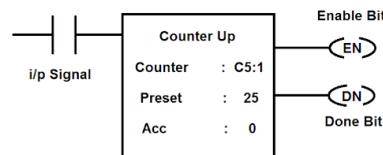|	
	4 marks for labeled diagram
	2 marks for partially labeled diagram

5 **Attempt any two:** **16**

5 a) Explain UP counter instruction of PLC with suitable instruction.

Ans:

The CTU is an instruction that counts false-to-true rung transitions. Rung transitions can be caused by events occurring in the program. When rung conditions for a CTU instruction have made a false-to-true transition, the accumulated value is incremented by one count, provided that the rung containing the CTU instruction is evaluated between these transitions. The accumulated value is retained when the rung conditions again become false. The accumulated count is retained until cleared by a reset (RES) instruction that has the same address as the counter reset. The control word for counter instructions includes six status bits, as indicated below.

1 marks for description

2 marks for control bit description

- **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
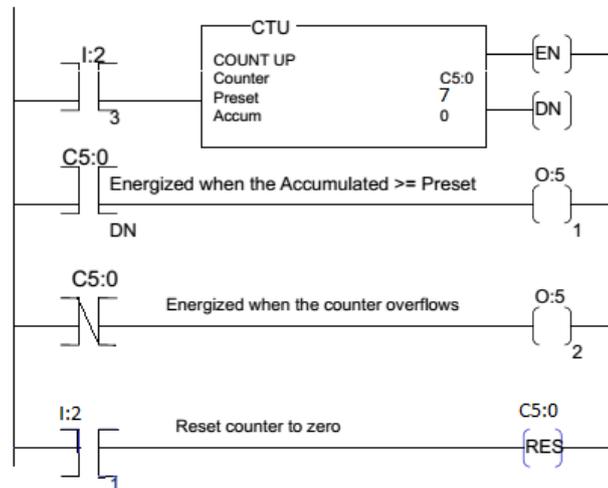
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the present value of the counter.

- **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.
- **Accumulator Value (ACC):** This is the number of false-to-true transitions that have occurred since the counter was last reset.
- **Preset Value (PRE)**: Specifies the value which the counter must reach before the controller sets the done bit.

In the following example count up counter is used to control the Red and Green lamps. Operating pushbutton I:2/3 provides the off-to-on transition pulses that are counted by the counter. The preset value of the counter is set for 7. Each false-to-true transition of rung 1 increases the counter's accumulated value by 1. After 7 pulses, or counts, when the preset counter value equals the accumulated counter value, output DN is energized.

2 marks for ladder diagram

2 marks for description

As a result, rung 2 becomes true and energizes output O:5/1 to switch the red pilot light on. At the same time, rung 3 becomes false and de-energizes output O:5/2 to switch the green pilot light off. The counter is reset by closing pushbutton I:2/1, which makes rung 4 true and resets the accumulated count to zero. Counting can resume when rung 4 goes false again.

(Any other example can also be considered)
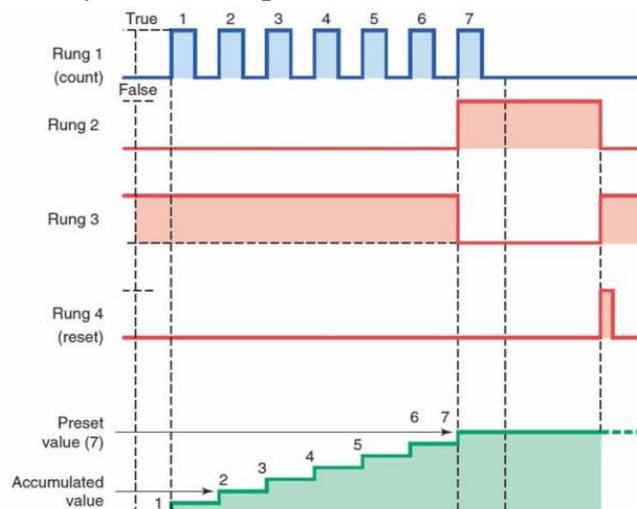
1 mark for timing diagram

5 b)   Draw power and control circuit diagram of automatic type star-delta starter using

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timer for 3ϕ induction motor.

Ans:

4 marks for power circuit diagram
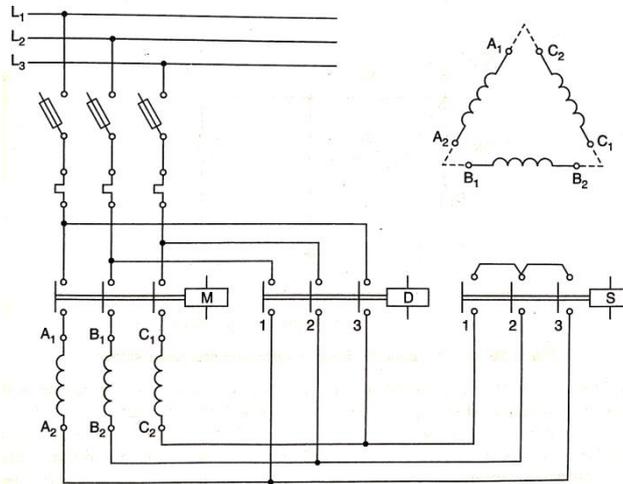
(a) Power circuit diagram for a star-delta starter

4 marks for control circuit diagram
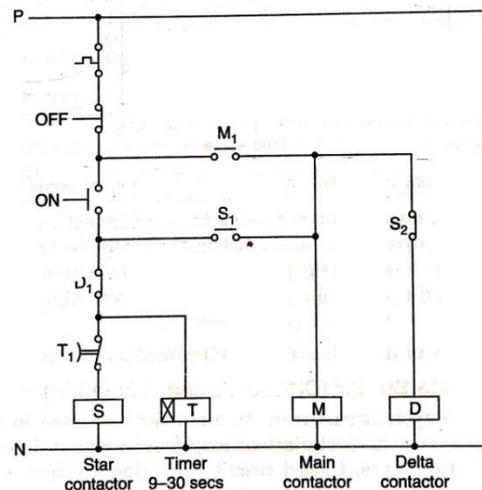
(b) Control circuit for an automatic star-delta starter

5 c) Draw the block diagram of PLC. Explain function of each block in brief.

Ans:

Programmable Logic Controller (PLC):

3 marks for diagram

Block diagram of PLC

Function of CPU:

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CPU or the 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 a computer that executes a program to perf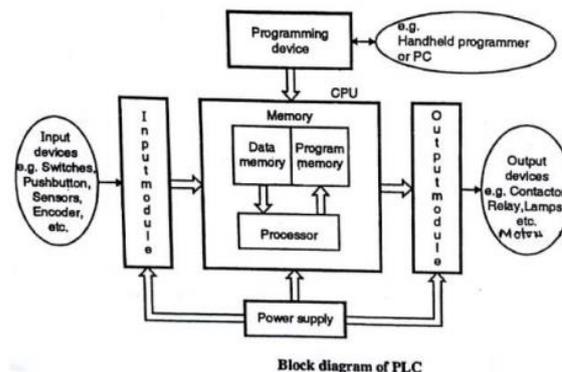orm the operations specified in a ladder diagram or a set of Boolean equations. The processor performs arithmetic and logic operations on input variable data and determines the proper state of the output variables. The processor functions under a permanent supervisory operating system that directs the overall operations from data input and output to execution of user programs.The processor is responsible for the complete program scan in a PLC. During Program scan processor communicate with the memory. 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.

1 mark

Input Modules:
The input module provides the interface between the physical input devices in the real world outside the PLC and the digital arena inside the PLC. The input module has bank of terminals for physically connecting input devices, like push buttons, limit switches etc. The input modules examine the state of physical switches andother input devices and put their state into a form suitable for the processor. The PLC is able to accommodate a number of inputs.

1 mark

Output Modules:
The input module provides the interface between the physical output devices in the real world outside the PLC and the digital arena inside the PLC. The Output module also has bank of terminals that physically connect output devices like solenoids, motor starters, indicating lamps etc. to a PLC. The role of an output module is to translate signals from the PLC's CPU into a form that the output device can use.

1 mark

Programming Unit:
The Programmer is a device used to communicate with the circuits of the PLC. The programming unit allows the user to enter and edit the program to be executed.The programming unit is an external electronic package, may be computer or HHT, is connected to the programmable controller when programming occurs.The unit usually allows input of a program in ladder diagram symbols. The unit then transmits that program into the memory of the programmable controller.

1 mark

Power supply:
Power supply is provided to the processor unit, input and output module unit. Power supply may be integral or separately mounted unit. This module can be built in to the PLC processor module or be an external unit. Common voltage levels required by the PLC are 5Vdc, 24Vdc, 220Vac. The voltage lends are

1 mark

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stabilized and often the PS monitors its own health.

6		**Attempt any four:**	**16**

6 a) Develop ladder diagram for following sequences:
   i) When NO START PB is pressed Motor M_1 starts and after 10 seconds Motor M_2 starts.
   ii) When NC STOP PB is pressed both Motor M_1, M_2 stops immediately.
   Ans:

Inputs: Start switch- I:0/0   Stop Switch- I:0/1

   Outputs: Motor M1 - O:0/1   Motor M2- O:0/2   1 mark for addressing

   Timer: Timer- T4:0 (On Delay)

   Latch: Latch- B3:0/0

3 marks for ladder diagram

6 b) Draw construction of Bimettalic thermal over loaded relay. Explain its working.
   Ans:
   Construction of Bimettalic thermal over loaded relay:

2 marks for diagram

Working of Bimetalic Thermal Over Load Relay:
The relay consists of three bimetallic strips with current coils wound on them as shown in fig. The whole of the assembly is mounted on a bakelite enclosure. Bimetallic strips comprising two dissmilar metals having different thermal coefficients of expansion are used for the three phases. Current flowing through the coils heat the bimetallic strips. Upper ends of the strips are firmly held while lower ends are free to move. When temperature of the strips increases due to

2 marks for working

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current flowing through the coils, the strips bend towards right due to different expansion of metals. When the strips bend towards the right, the tripping mechanism gets actuated and opens the relay contact. More is the current flowing through the coils, faster will be the action of relay.

6 c) Draw block diagram of PID controller
Ans:
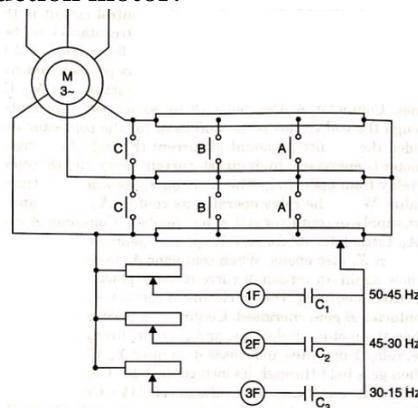**Block diagram of PID Controller:**
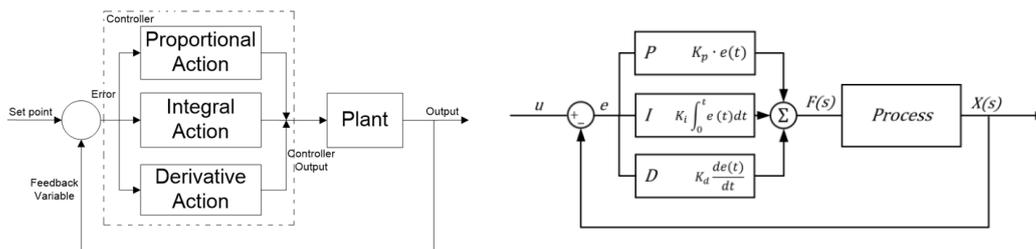
4 marks for any one diagram

OR (Any other equialent block diagram)

6 d) Develop power and control diagram for secondary frequency acceleration starter of slip ring induction motor.
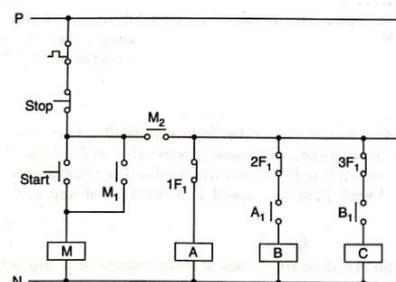**Ans:**
Power and Control Circuit diagram for secondary frequency acceleration starter of slip ring induction motor:

(a) Power circuit diagram for a secondary frequency accelcration starter of slip ring induction motor.

2 marks for power circuit diagram

(b) Control circuit diagram for secondary frequency acceleraton starter of slip ring induction motor.

2 marks for control circuit diagram