



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 may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more 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 may give credit for anyequivalent figure drawn.
- 5) Credits may 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.
- 6) In case of some questions credit may be given by judgement 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.

Q1. (A) Attempt any three :	12
<p>(i) Define the following</p> <p>(a) Push button</p> <p>(b) Selector switch</p> <p>(c) Proximity switch</p> <p>(d) Limit switch</p> <p>Push Button: It is a manually operated input device which gets activated when pressed and deactivated when released.</p> <p>Selector Switch: It is a manually operated input device which selects one input out of many inputs as per handle position.</p> <p>Proximity switch: It is an input device which detects presence of an object within its sensing distance.</p> <p>Limit switch: It is an input device which detects presence of an object when it comes in contact.</p>	04
<p>(ii) Draw diagram of DOL starter power and control circuit for 3-phase induction motor for forward stop-reverse operation. Explain its working.</p> <div data-bbox="470 1218 1006 1680"> </div> <p>C1 and C2 are forward and reverse contactors. Pressing P1 turns ON C1 and runs the motor in forward direction. When C1 is ON C2 remains OFF because of C1 NC auxiliary contact. To run the motor in reverse direction, P3 must be pressed. When P3 is pressed, C1 is OFF. Now pressing P2 turns ON C2 and motor runs in reverse direction. Motor STOP is a must before changing direction of rotation of the motor.</p>	2+2



(iii) State advantages of PLC. (Any four)

- 1) Flexibility.
- 2) Implementing changes & correcting errors.
- 3) Speed of operation.
- 4) Reliability & maintainability.
- 5) PLCs are smaller in size & can operate Number of devices at a time.
- 6) Logic change can be very easily done by just adjusting the ladder logic.
- 7) Operation of PLC can be displayed on CRT or LCD screen.
- 8) Error occurred in operation can be very easily observed and diagnosed.

4

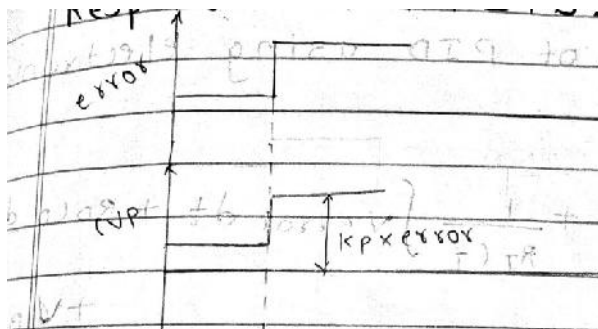
(iv) Explain proportional controller process control action.

Proportional controller action output is directly proportional to error over a range of errors. The range of error is called as proportional band (PB). The proportional gain (K_p) is reciprocal of proportional band.

$$PB = 100/K_p$$

$$CO(t) = K_p e(t) + CO(0)$$

$CO(t)$ is the controller output. $CO(0)$ is the zero error controller output. K_p is the proportional gain and $e(t)$ is instantaneous error.



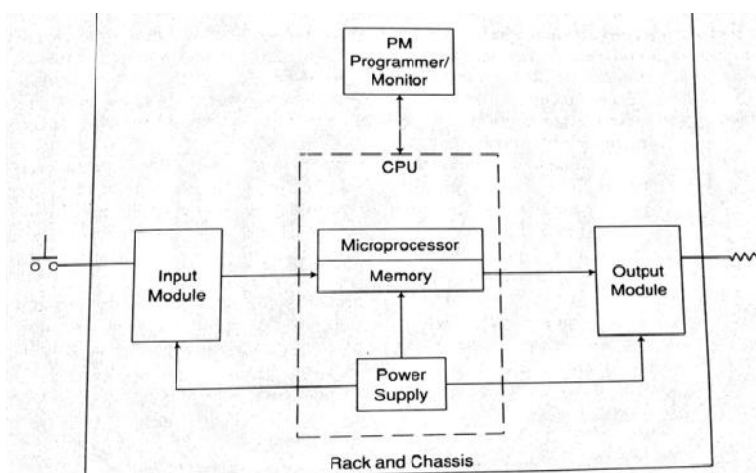
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(B) Attempt any ONE

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(i) Draw block diagram of PLC. State functions Of its component

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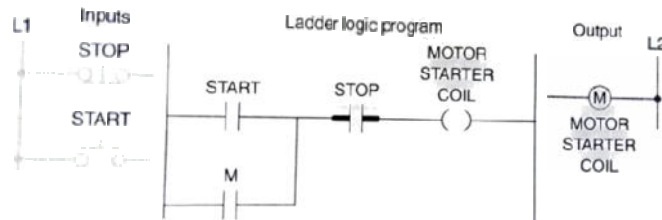




The main parts of a PLC are,

- 1) **Central Processing Unit** consisting of a microprocessor, and memory unit. A microprocessor is essentially a logic solver. Memory unit is used to store operating system of PLC, user program and temporary data.
- 2) **Power supply:** A switched mode power supply is used which generates the required dc levels to power the internal circuit
- 3) **Programmer/ Monitor:** Programmer/monitor is device used to load program into PLC from a hand held terminal or a PC
- 4) **I/O modules:** The IO modules are for connecting outside world digital/analog input/output devices to PLC.

- (ii) Draw ladder diagram for 3 phase induction motor start/stop operation. Explain its working. Enlist PLC Input/Outputs in them.

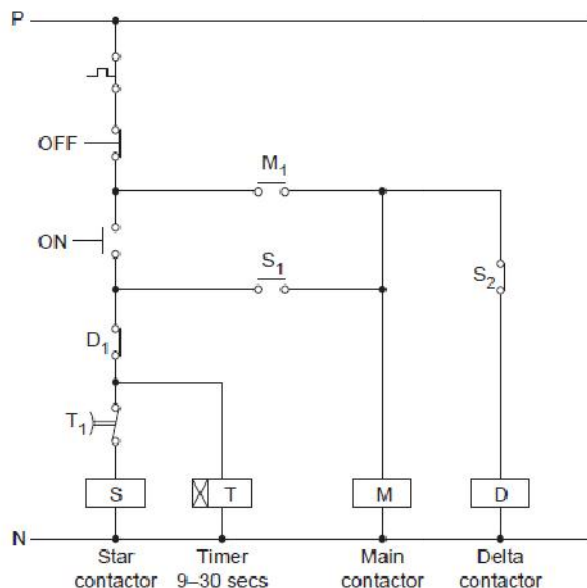


PLC inputs: 1) STOP Push button 2) START Push button

PLC outputs: Motor starter coil

Q2. Attempt any FOUR

- (a) Draw Star/Delta starter circuit diagram for 3-phase induction motor using timer. Explain its working.



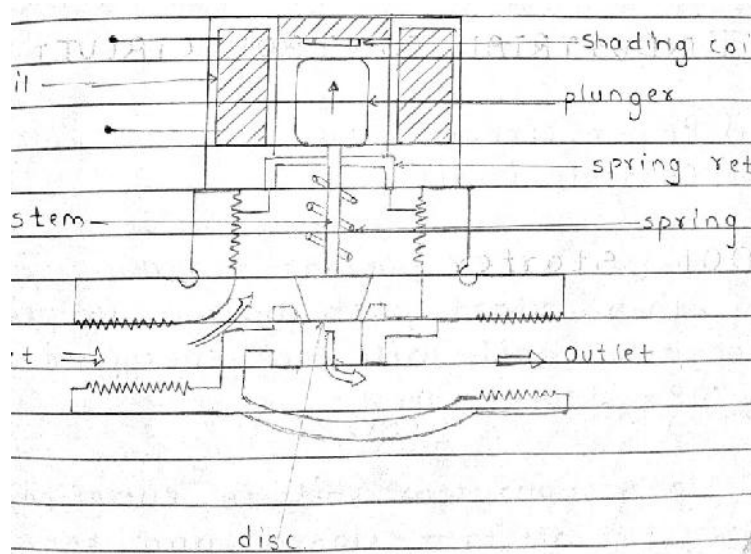


When ON push button is pressed star contactor and main contactor get energized. Timer starts counting. When preset time is over, NC contact T1 gets opened and STAT contactor is deenergised. S2 gets closed as it is NC contact of S. Now Delta contactor D gets energized and the motor runs in delta. STOP push button will de-energise M and motor will stop.

(b) Describe operation of solenoid valve with neat diagram

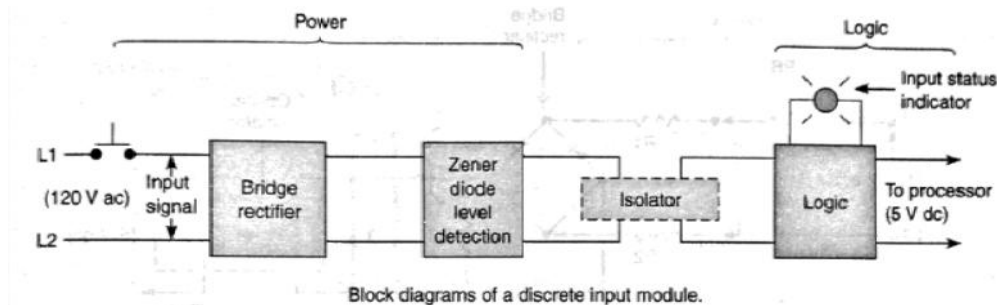
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Solenoid valve is an electromagnetic valve used to control flow of fluid such as air or oil. It consists of a solenoid assembly and valve assembly. When current passes through solenoid, the plunger is lifted upwards and the valve is opened. In normal state, because of return spring force, the valve remains closed. Solenoid valves are used in hydraulic and pneumatic circuits to regulate air/oil flow.



(c) Draw the block diagram of digital input module of PLC. State function of its blocks.

4



The digital input module consists of rectifier which converts AC into DC. The DC signal passes through zener diode based level detection. The output of level detection stage passes to logic stage through optical isolation. The logic section output goes to PLC CPU

(d) Compare between P-controller and Pi-controller control action (four points).

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P controller	PI controller
P stands for Proportional control action	PI stands for Proportional+Integral control action

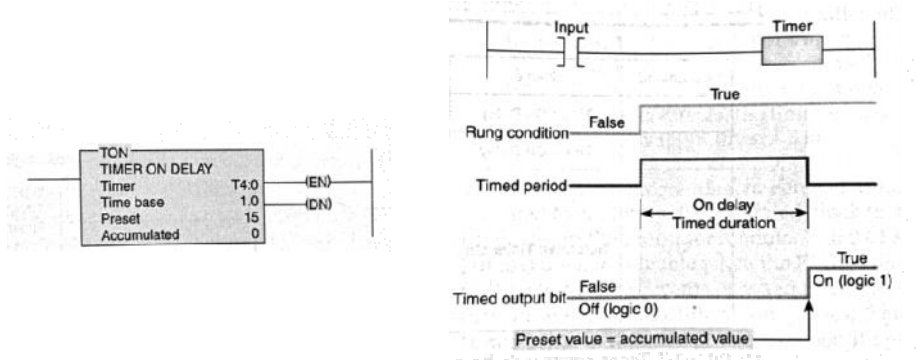


The controller output is directly proportional to error	The integral action output is added to proportional controller action output	
Controller output is constant for constant error	Controller output increases with constant error.	
Proportional control action produce offset error	PI controller removes offset error.	
Proportional control action do not affect steady state response	PI action improves steady state response	

(e) Explain on delay timer operation with diagram.

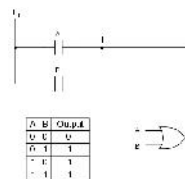
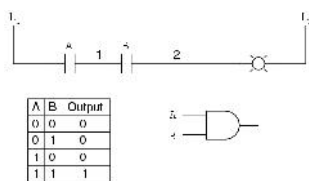
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On delay timer operates such that when rung containing timer is true, the timer starts counting time ticks. At the end of timer preset time period, output is made active.



(f) Develop ladder diagram for (i) AND gate (ii) OR gate.

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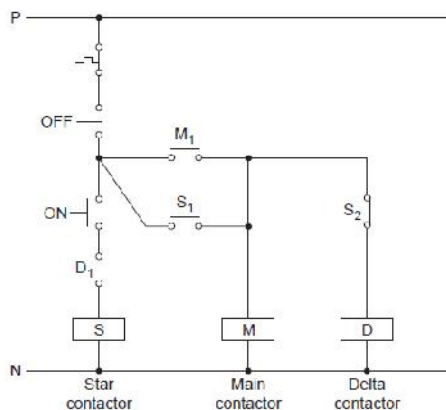


Q3. Attempt any FOUR

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(a) Draw Star/Delta starter circuit diagram for 3-phase Induction Motor semi automatic type. Explain its working.

4



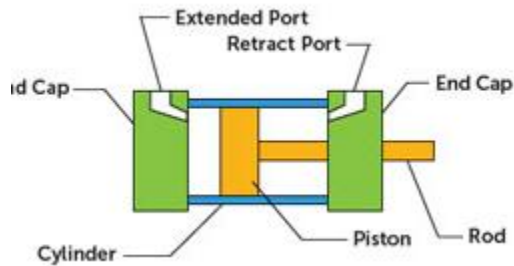


When ON push button is pressed, Motor starts running in STAR connection, When ON push button is released motor runs in DELTA.

(b) Describe operation of pneumatic cylinder with neat diagram

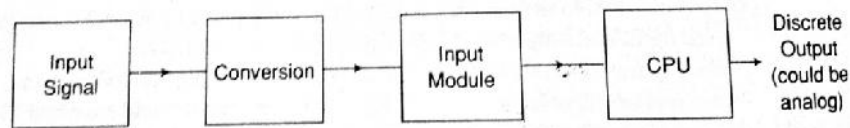
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Pneumatic cylinders are mechanical devices which use the power of compressed gas to produce force in linear motion. They can be single or double acting . There is a piston inside cylinder. There is pressure gas inlet. When gas(such as air) enters into inlet, the piston expands or retracts.



(c) Draw block diagram of analog input module of PLC. State function of its blocks.

4



The analog input signals are interfaced to PLC through analog Input module. The analog signal is converted to binary by analog-to-digital converter. Suitable multiplexing arrangement is provided for number of input analog channels. The binary output of particular analog channel is read by CPU of PLC

(d) Define derivative controller. State their advantages.

4

For derivative control action, the controller output depends upon rate of change of error i.e. time derivative of error. The basic equation of derivative control action is

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

K_d (sec) is called as derivative gain.

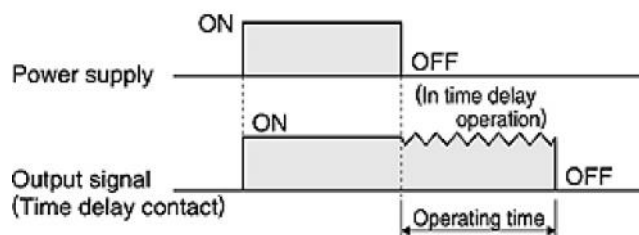
When the error is constant w.r.t. time, the derivative controller output is zero. This is the reason why derivative controller can't be used alone. It is always combined with basic proportional control to improve dynamic response of the control system. The derivative action is effective whenever there are sudden changes in error because of rapid changes in set point or load disturbance. However, derivative action adds to noise sensitivity.

(e) Explain off delay timer operation with neat diagram.

4

The off-delay operation is an operation to turn OFF output when preset time expires after a predetermined input is given to the power supply circuit or input circuit, and at the same time output signal is given and predetermined input is turned OFF.

Example of power supply off-delay operation





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Model Answer

Summe 2016 EXAMINATION

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**(f) Describe working of PID controller.**

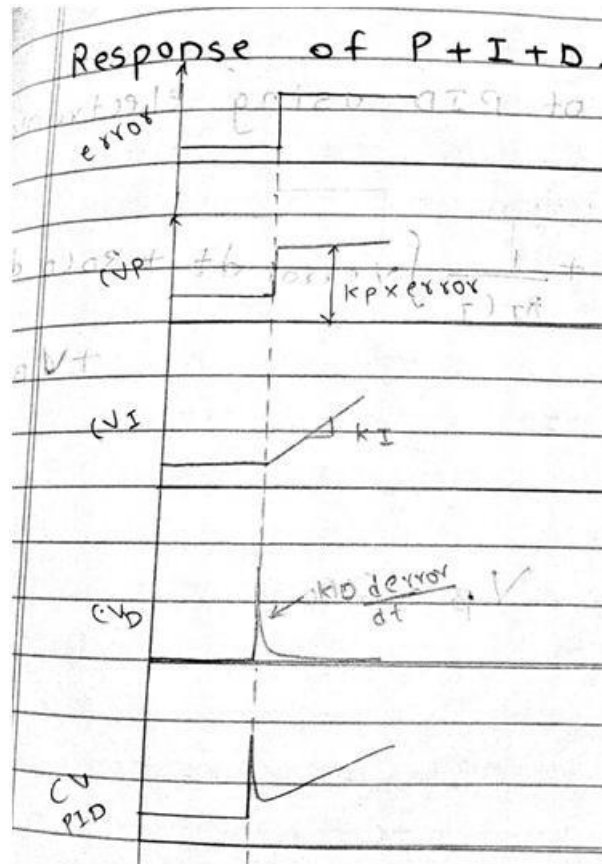
Proportional controller action produces one-to-one relationship between error and controller output within proportional band. K_p is the proportional gain and proportional band $PB = 100/K_p$. Proportional band is the range of error for which controller output is directly proportional to error.

Integral action produces output depending upon time accumulation of error. Integral control action removes any steady state error or offset error in the controlled variable

Derivative action responds to rate of change of error. Derivative action is effective in case of sudden disturbances in the setpoint or process load.

PID controller equation is given by

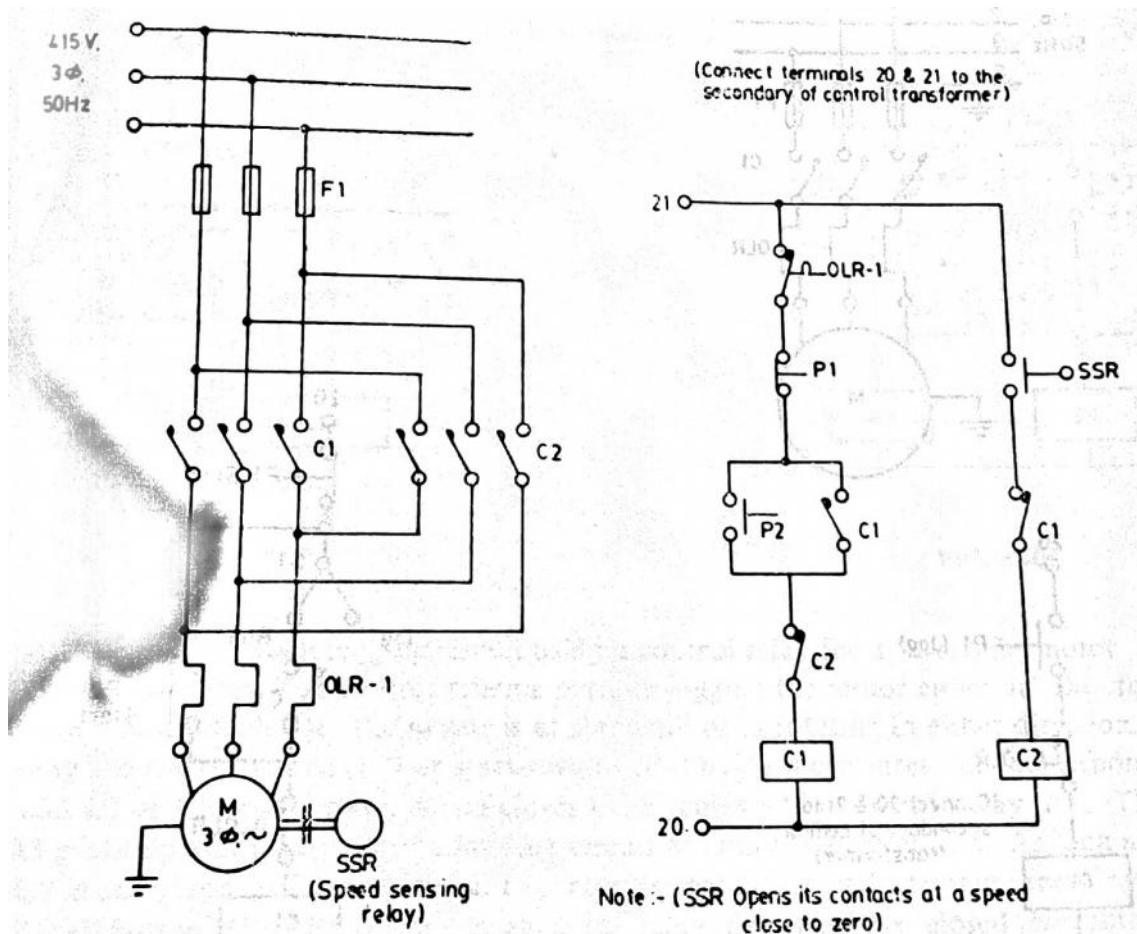
$$CO(t) = K_p e(t) + K_i \int e(t) + K_d \frac{de(t)}{dt} + CO(0)$$



**Q4.A Attempt any Three****12****i. Draw neat control and power circuit diagram of simple plugging of motor. Explain its working.****4**

The Induction motor can be stopped immediately by just interchanging any two of the stator leads. When an induction motor is rotating at a high speed, during emergency if situation arises that the motor has to be stopped immediately, can be done by interchanging any 2 leads of the stator supply. By doing this, it reverses the direction of the revolving flux, which produces a torque in the reverse direction, thus causing a braking effect on the rotor.

The control and power circuit are shown in the above diagram. When C2 contactor is ON two supply leads of motor are interchanged causing plugging.



**ii. Compare between inductive and capacitive type proximity switch****4**

Inductive proximity	Capacitive proximity
Detects metallic objects(conductive)	Metallic as well as non metallic objects (non-conductive)
Works on the principle of variable inductance	Works on the principle of variable capacitance
There is drop in amplitude of coil current when object is near	There is increase in oscillation amplitude
Not sensitive to dust , humidity	Sensitive to dust, humidity

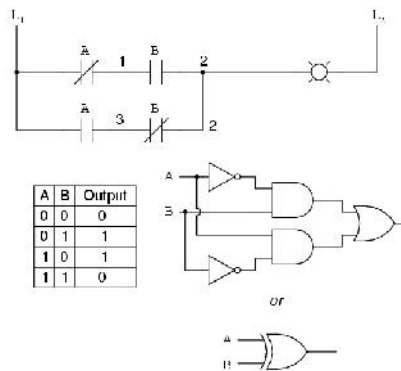
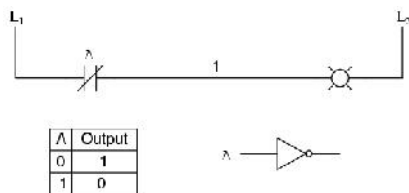
(iii) State function of following: EPROM EEPROM**4**

EPROM is read only memory mainly used for storing permanent information such as operating system program

EEPROM is read only memory mainly used for storing information which is rarely altered such as calibration data. User parameters etc

(iv) Develop ladder diagram for logic operations :**4**

- (a) NOT
(b) EX OR





(B) Attempt any ONE :

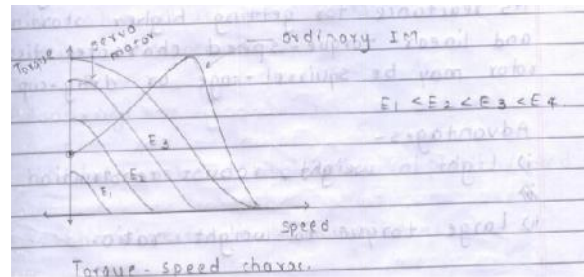
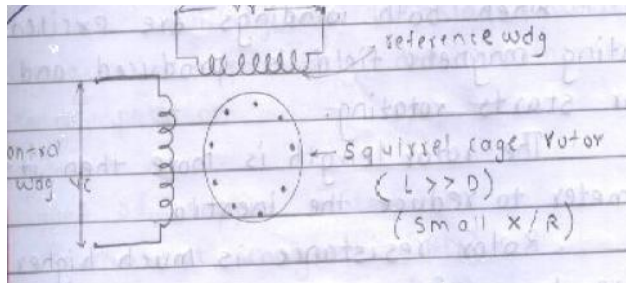
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(i) Describe working of A.C. servomotor with neat diagram. State their application.

6

Describe the construction and working of AC servomotor.

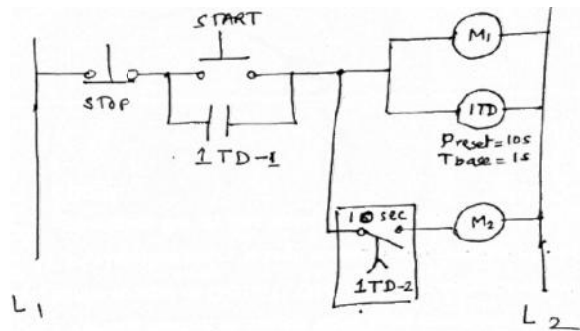
AC servo motors are wound with two windings at 90° with respect to each other. One winding is called as reference winding (fixed voltage) and the other as control winding (variable voltage). The rotor is squirrel cage with longer length and small diameter. The rotor has high resistance to increase starting torque and linear torque speed characteristics. AC servos are used for closed loop position control systems.



(ii) Draw ladder diagram for two motor system with following conditions :

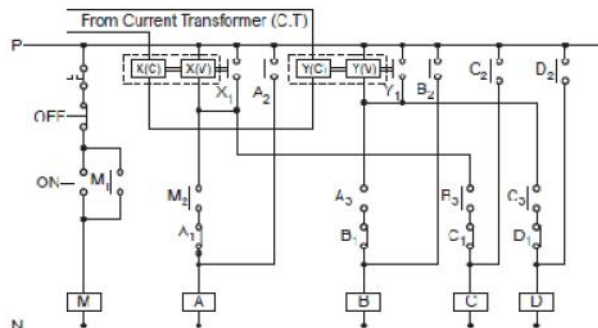
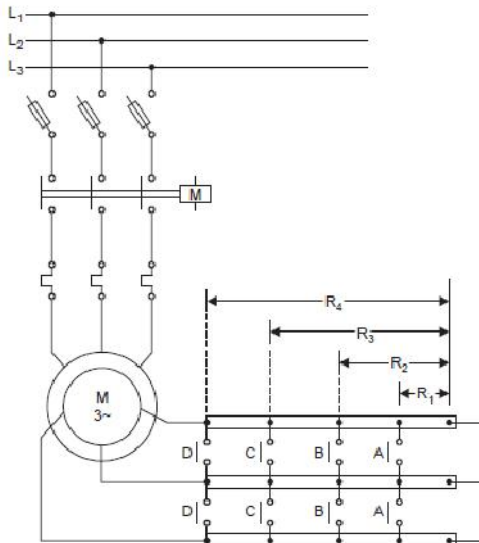
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- (a) Starting push button starts motor-1
- (b) After 10 sec. motor - 2 is ON.
- (c) Stopping switch stops motor 1 & 2.



**Q5. Attempt any FOUR :****16**

(a) Draw power & control circuit diagram of starter for slipring induction motor with current limit acceleration starter. Explain its working.

4

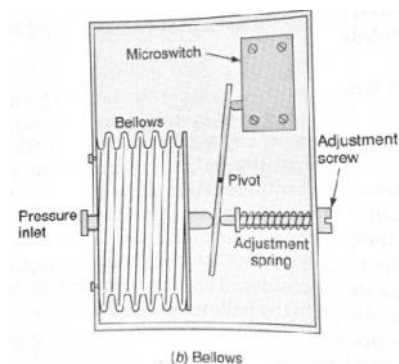
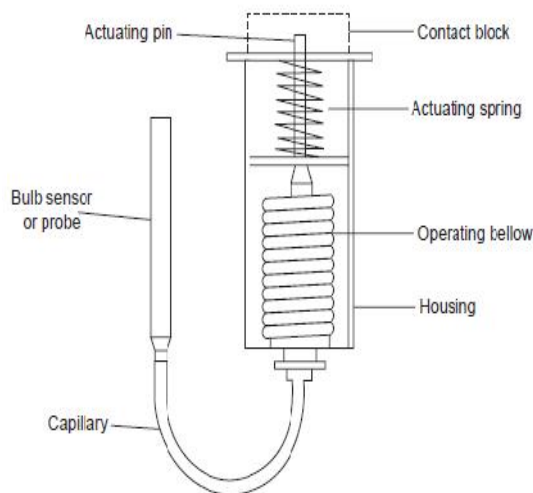
In this type of starter, the accelerating contactor closes depending upon the amount of stator/rotor current. Accelerating contactors are energised when current peak falls to a pre-determined value equal to full-load current. The accelerating contactors A B C D are energised and they cut off resistance in steps. A current limit acceleration starter uses a special relay known as current limit relay.

(b) Explain the following:

4

(i) pressure switch

(ii) temperature switch with diagrams.



Temperature switch

Expansion of gas inside the capillary expands the bellows and actuates the snap switch inside capillary type temperature switch.

Increase in pressure causes expansion of bellows against return spring and actuates snap action switch

Pressure switch



(c) Differentiate between RAM & ROM in PLC memory

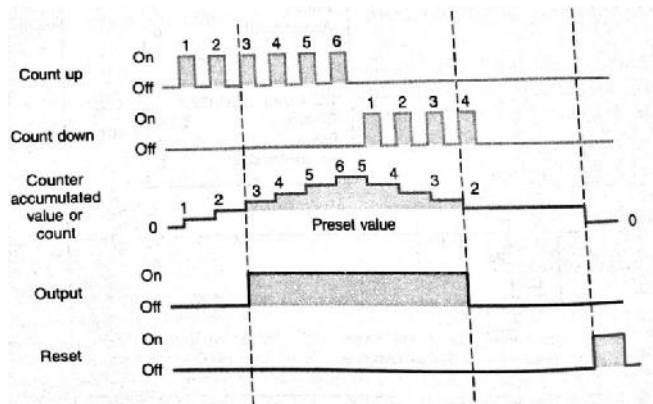
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RAM	ROM
Random access memory	Read Only memory
Used for storing temporary data	Used for storing fixed data such as programs
Data is lost when power is removed	Data is retained in case of power loss
Read write speed is quite faster	Write operation is slow

(d) Describe working pf up/down counter

4

The up-down counter has three inputs, count up, count down and reset.



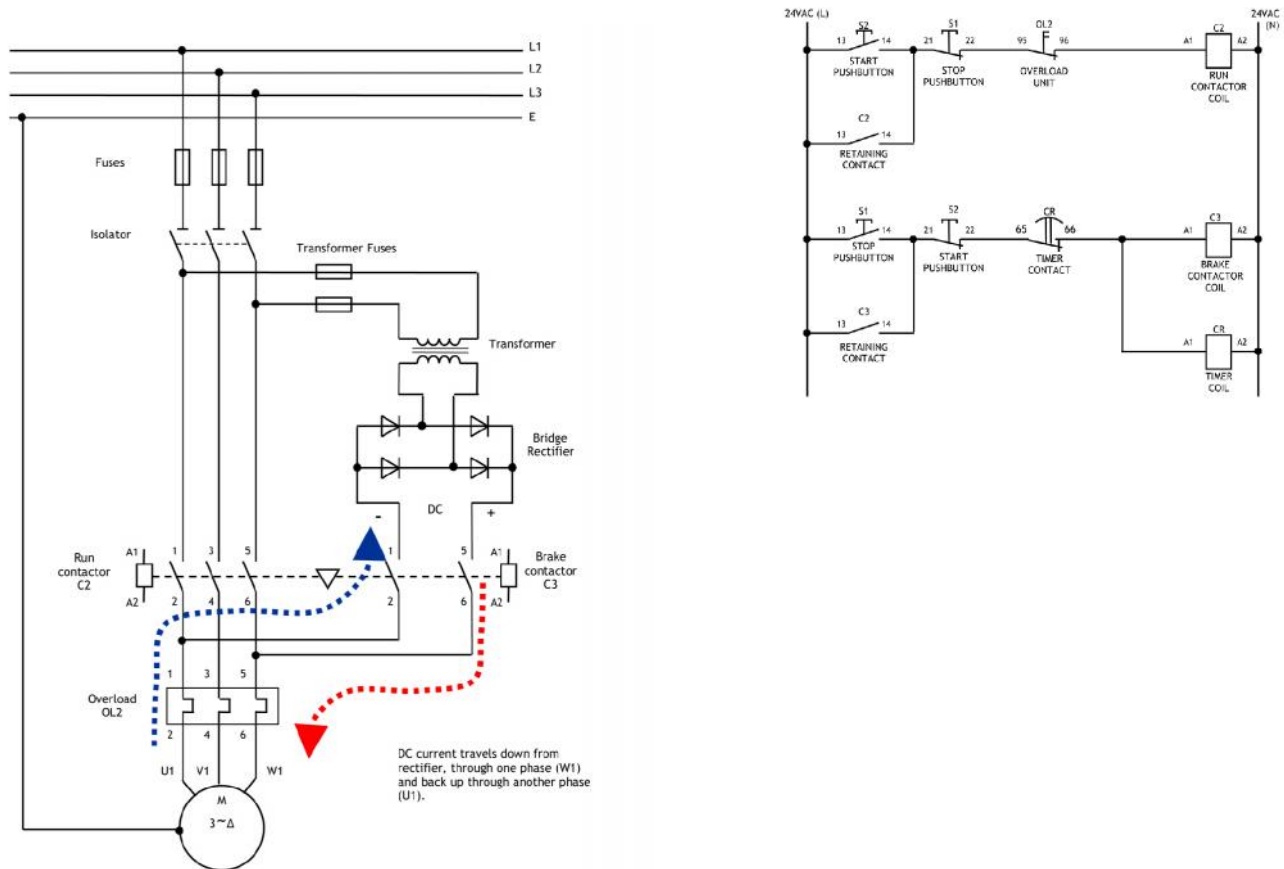
(e) Define Integral controller. State their advantages

4

For integral controller working, please refer earlier questions

Advantages of integral control action:

- 1) Improves steady state response
- 2) Removes offset error in the process variable.
- 3) Eliminates steady state error

**Q6. Attempt any Four****16****(a) Draw power and control circuit diagram for D.C. injection braking of induction motor. Explain its working****Circuit Operation**

- 1) **Starting & Running** - Pressing the start button S2 will energise coil C2 provided the stop button S1 is not pressed and the overload OL2 has not tripped. The retaining contact of C2 will keep the contactor energised when the start button S2 is released. The motor then runs up to speed.
- 2) **Stopping & Braking** - Pressing the stop button S1 will de-energise contactor C2 and energise contactor C3 provided the start button S2 is not pressed. The retaining contact of C3 will keep the contactor energised when the stop button S1 is released. This causes the motor to stop due to the injection of DC. C3 will remain energised until the timer CR finishes timing. Then its normally closed contact will open de-energising C3 and removing DC from the stator. This in turn de-energises the timer coil.

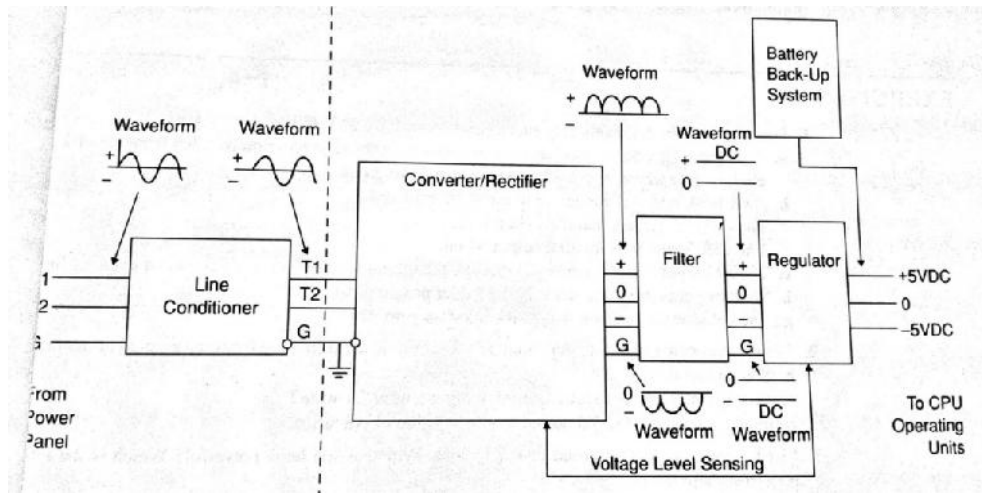
(b) Compare between AC & DC servomotor**4**

AC servo motor	DC servo motor
Has no brushes	Brushes dc servo has brushes
Maintenance is less	Maintenance is more
Max RPM is higher than DC servo	MAX RPM is less
Use sinusoidal PWM	Used duty cycle control PWM
Control is complicated	Control is simple



(c) Draw block diagram of PLC power supply. Explain its working.

4



PLC power supply generates the required dc voltage levels for operation of the internal circuit of PLC. It is a switched mode power supply which accepts wide range of AC/ DC input voltages.

Parts of PLC Power supply are:

- 1) Line conditioner: Line conditioner unit filters the input AC voltage and removes any glitches, noise, EMI
- 2) Converter: Converter unit converts AC into DC This is basically a switched mode power supply.
- 3) Regulator: Regulator unit generates the required voltage levels for the PLC internal circuit

Battery Backup: for reliable operation of PLC, there is a battery backup. In the event of power failure from AC input, Battery backup becomes active and prevents accidental shut down of PLC

(d) List any four typical input and outputs of PLC.

4

Typical PLC inputs

- 1) Push Button
- 2) Selector Switch
- 3) Proximity switch
- 4) FOOT switch, level switch
- 5) Analog input

Typical PLC outputs

- 1) Contactor Coil, solenoid, relay
- 2) Indicating Lamp
- 3) Buzzer
- 4) Alarm annunciator



(e) Compare between Pi-controller & PID controller control action

PI	PID
Derivative action absent	Derivative action present
Dynamic performance is not improved	Dynamic performance is improved
Not sensitive to noise	Sensitive to noise
$CO(t) = K_p e(t) + K_I \int e(t) + CO(0)$	$CO(t) = K_p e(t) + K_I \int e(t) + K_d \frac{de(t)}{dt} + CO(0)$