

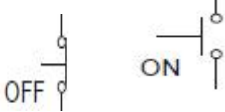

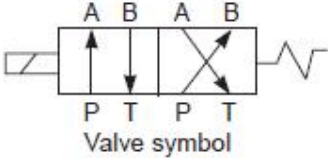



SUMMER– 2017 Examinations

Subject Code: 17641 Model Answer Page 1 of 16

**Important suggestions 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 principle components indicated in a figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent 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 some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

<b>Q.1 A)</b>	<b>Attempt any Five:20 Marks</b>
<b>a)</b>	<b>Draw the symbol and state the applications of : 1) Push button switch 2) Selector switch 3) Solenoid valve 4) Limit switch ( 1m each)</b>
Ans:	<p>1) Push Button It is used in start-stop control circuit</p>  <p>2) Selector Switch : It is used to select one input out of many,</p>  <p>3) Solenoid valve: is used to control flow of fluid such as air, pressurized oil.</p>  <p>Valve symbol</p> <p>4) Limit switch: It is used to detect presence of object</p> 

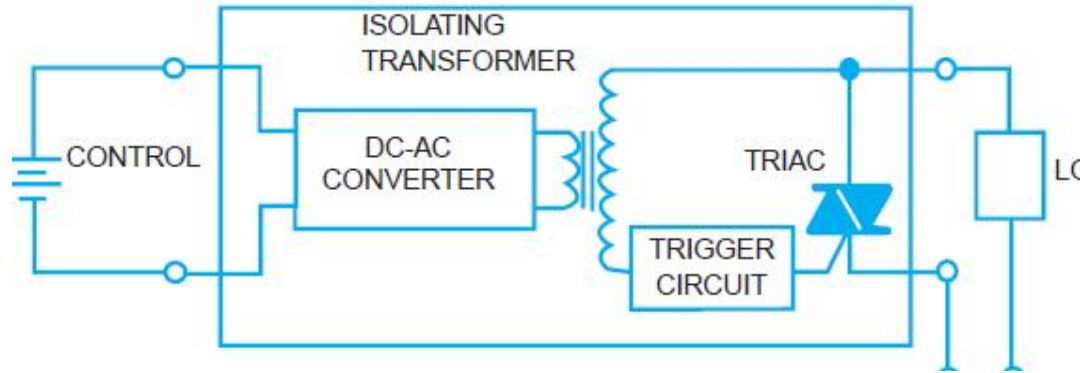


SUMMER- 2017 Examinations

Subject Code: 17641 Model Answer Page 2 of 16

b) Describe the operation of solid state relay. (2m+2m)

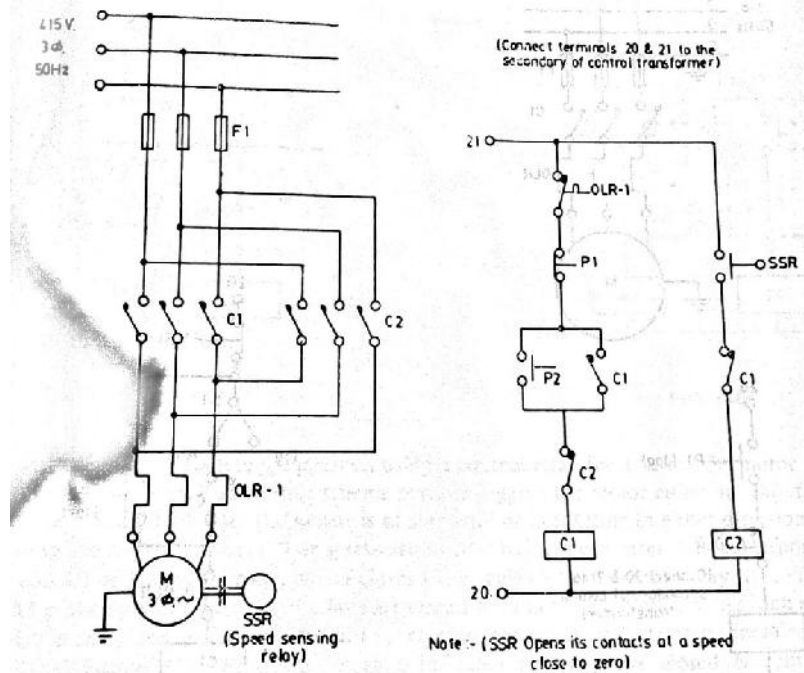
Ans:



Solidstate relay is electronic equivalent of an electromechanical relay. It consists of controlled power semiconductor switch like triac. There are four terminals. Two are the power terminals for load and two control terminals for applying control signal. Control signal is generally 5V,12V,24V DC. When control signal is applied, the triac is turned ON. When triac is ON, the load is connected to AC supply

c) Draw power and control circuit for simple plugging of induction motor. (2m +2m)

Ans:

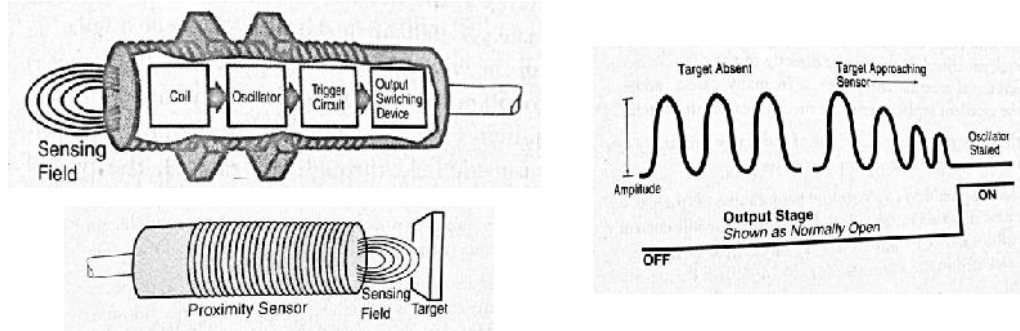




SUMMER- 2017 Examinations

Subject Code: 17641 Model Answer Page 3 of 16

d) Explain the working of inductive proximity sensor. State any two applications. (2m+2m)

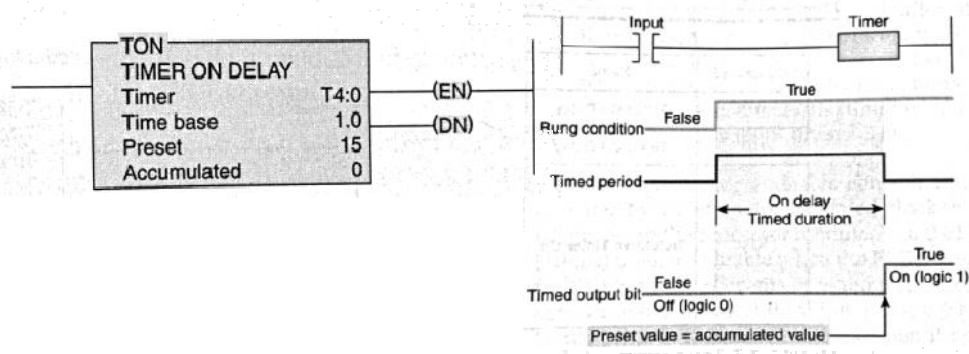


Ans: Proximity sensors are input devices that detect presence of an object without physical contact. Internal construction of inductive proximity switch is as shown in figure. It consists of a tuned circuit formed by coil and oscillator. When the switch is away from any metallic object the oscillator will oscillate. As soon as the metallic object comes near to the surface of the switch, oscillator gets loaded as eddy currents are induced in the metallic object. Drop in the amplitude of oscillations are detected by a threshold detect circuit and output stage. Normal sensing distance is 5mm.  
Applications: 1) gear teeth sensing 2) RPM measurement 3) Object counting 4) Obstacle detection.

e) Explain ON delay timer and OFF delay timer of PLC. (2m +2m)

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.

Ans:





**SUMMER– 2017 Examinations**

**Subject Code: 17641 Model Answer Page 4 of 16**

The off-delay operation is an operation to turn OFF output when preset time expires after a predetermined input is given.

TOF  
Timer Off Delay

Timer	T4.2
Time Base	1.0
Preset	150
Accum	0

EN
DN

Example of power supply off-delay operation

**f) Explain why derivative control action is not used alone. (1m equation+3 m)**

Ans: The basic equation of derivative action is

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

The above equation clearly indicate that derivative mode is active when there is change is error along with time. There is no one-to-one relationship between error and controller output. Using derivative controller alone will not produce any output for constant error and thus will not produce any control action.

**g) Explain the integral control action in detail. (2m+2m)**

Ans: The integral controller produce output depending upon integral of error over a period of time. I controller can be expressed by following equation.

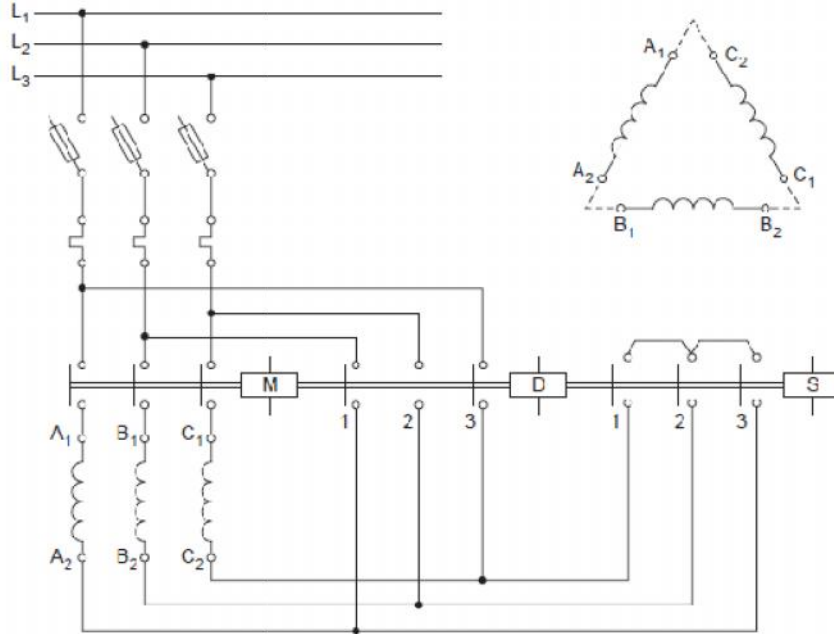
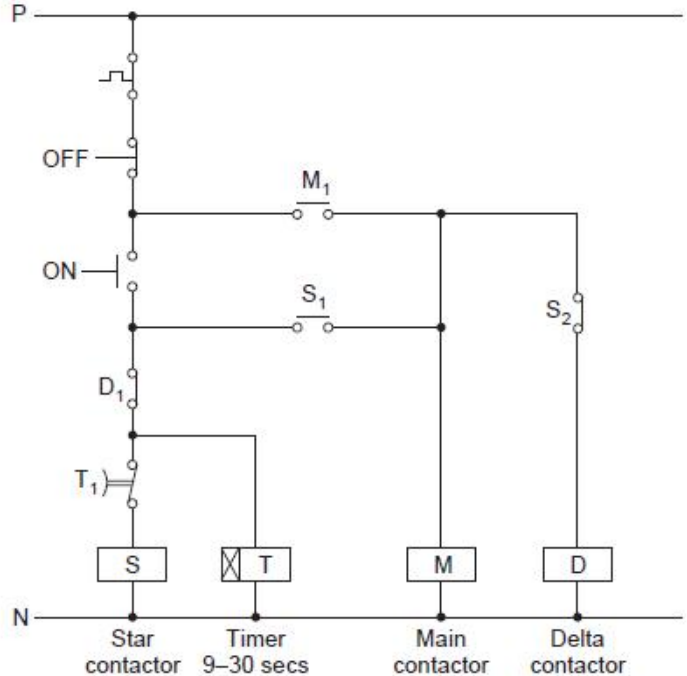
$$CO_I(t) = K_I \int e(t)dt \quad \text{where } K_I \text{ is integral gain in sec}^{-1}$$

It is seen that, for constant error, output of integral controller increases with positive slope.



SUMMER- 2017 Examinations

Subject Code: 17641Model AnswerPage 5 of 16

<b>Q.2</b>	<b>Attempt any TWO : 16 Marks</b>
a)	<b>Describe the power and control circuit for automatic Star-Delta starter for 3-phase induction motor. (4m +4m)</b>
Ans:	<p>Power circuit</p>  <p>Control circuit:</p>  <p>Star contactor    Timer 9-30 secs    Main contactor    Delta contactor</p>

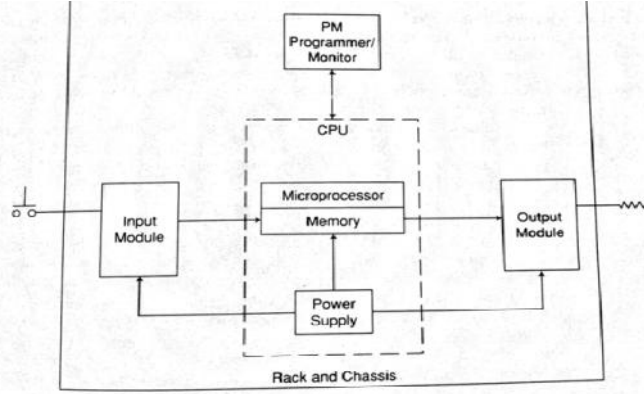


SUMMER– 2017 Examinations

Subject Code: 17641 Model Answer Page 6 of 16

b) Draw a neat labelled diagram of PLC. Explain the function of each block. (4m+4m)

Ans:



The main parts of a PLC are,

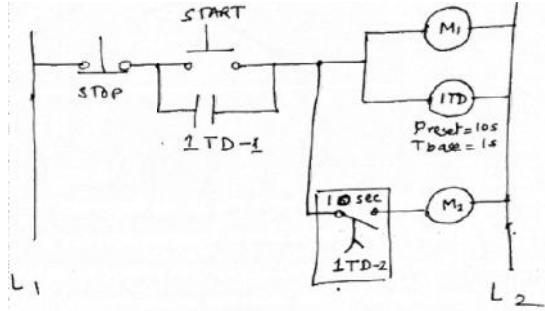
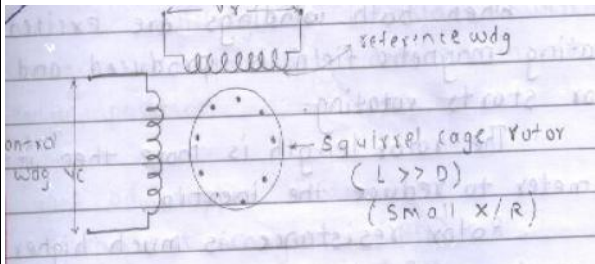
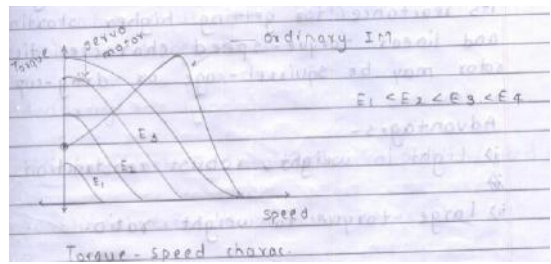
- 1) Central Processing Unit consisting of a microprocessor, and memory unit. A microprocessor is essentially a logic solver. Memory unit is used to store operating system of PLC, user program and temporary data.
- 2) Power supply: A switched mode power supply is used which generates the required dc 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.
- 5) Analog I/O module: These for connecting analog input signals derived from different sensors and transducers





SUMMER- 2017 Examinations

Subject Code: 17641 Model Answer Page 7 of 16

c)	<b>Starting push button, start motor-1. 2) After 20 second, motor-2 is ON. 3) Stopping the switch, stops motor 1 and 2. (Time base =1 Sec.)</b>
Ans:	
<b>Q.3</b>	<b>Attempt any FOUR : 16 Marks</b>
a)	<b>Describe the construction and working of AC servo motor (2m +2m)</b>
Ans:	<p>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.</p> <div data-bbox="282 1285 873 1547"></div> <div data-bbox="878 1285 1425 1547"></div>



SUMMER- 2017 Examinations

Subject Code: 17641 Model Answer Page 8 of 16

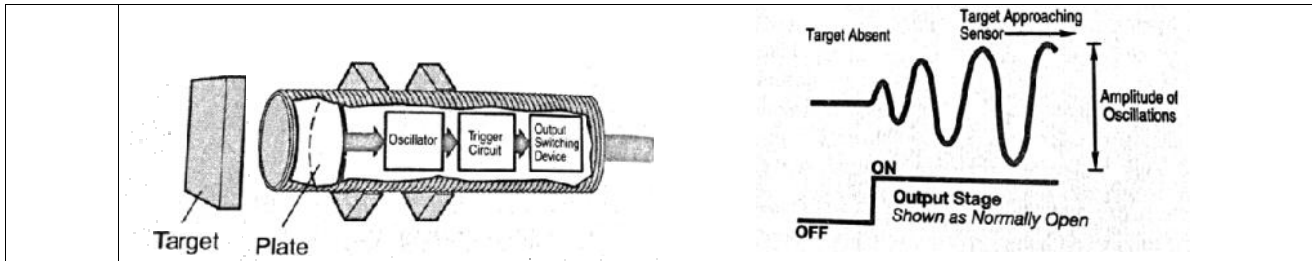
<b>b)</b>	<b>Draw the power and control circuit diagram for forward — stop — Reverse type DOL starter for 3 phase induction motor. (2m+2m)</b>
Ans:	
<b>c)</b>	<b>Define opto-isolator. Explain the role of opto-isolator in PLC. (2m+2m)</b>
Ans:	<p>An opto isolator is a device which consists of a light producing device such as LED and a light sensing element such as photo transistor. When a voltage is applied to LED, a light is produced which strikes the photo detector. The photo detector then changes its output. Optoisolator provides electrical isolation between input and output side. Opto isolator is an important part of I/O module of PLC. Both input and output module have Optoisolator to achieve electrical isolation between outside electrical circuit and PLC circuit.</p>
<b>d)</b>	<b>Describe capacitive type proximity switch with neat diagram. (2m+2m)</b>
Ans:	<p>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.</p>





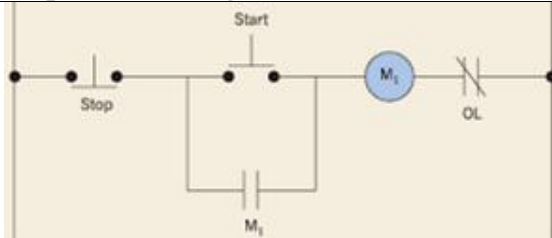
SUMMER- 2017 Examinations

Subject Code: 17641 Model Answer Page 9 of 16



e) **Develop a ladder diagram for Direct On Line (DOL) starter.**

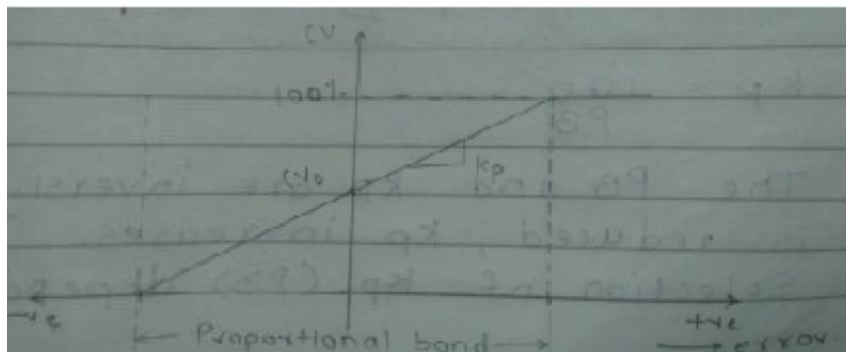
Ans:



f) **Explain the proportional control action in detail. (2m+2m)**

Ans:

In proportional control action, controller output is directly proportional to error when the error is within proportional band (PB). The slope of the characteristics between controller output to error is called as proportional gain  $K_p$ . The advantage of proportional action is one-to-one relationship between error and controller output. Mathematical equation of proportional control action is

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




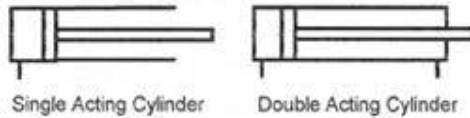
SUMMER- 2017 Examinations

Subject Code: 17641 Model Answer Page 10 of 16

**Q.4 Attempt any FOUR :16 Marks**

**a) Explain the operation of pneumatic cylinder with neat diagram. (2m+2m)**

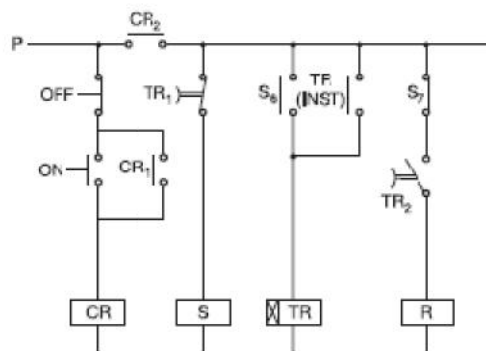
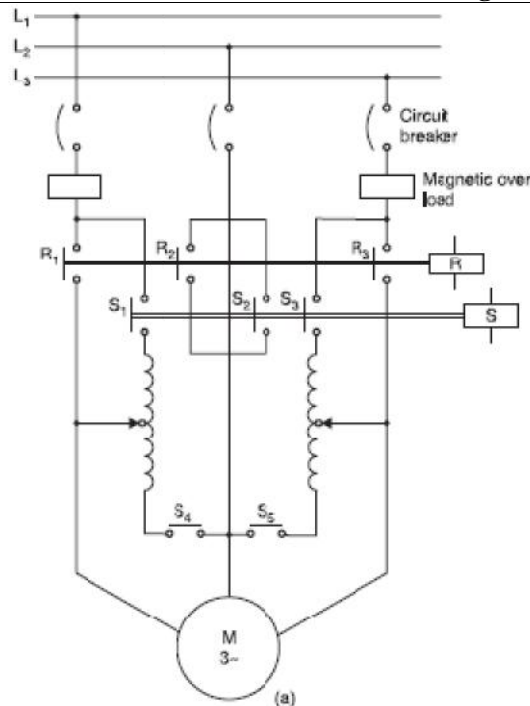
Ans:



Pneumatic cylinder is mechanical device which use power of compressed gas to produce a force in reciprocating linear motion. There is a cylinder having one or two openings for compressed gas and there is a piston. When the compressed gas enters into cylinder, it causes movement of piston from high pressure to low pressure side. They are used as linear motion actuators in industrial applications

**b) Draw the power and control circuit for motors using autotransformer type starter. (2+2)**

Ans:





**SUMMER– 2017 Examinations**

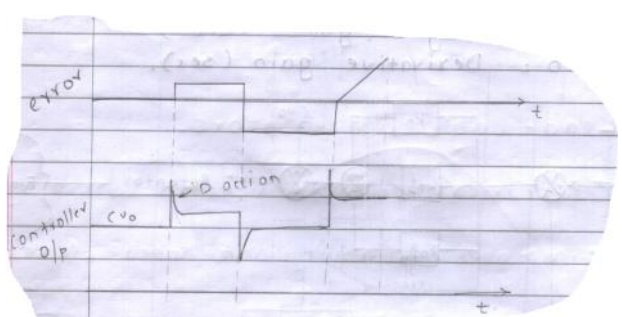
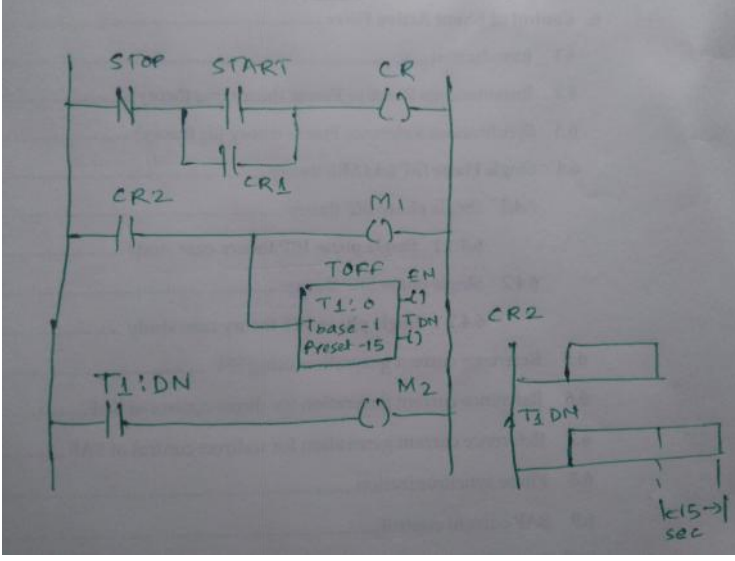
**Subject Code: 17641** Model Answer **Page 11 of 16**

<b>c)</b>	<b>Explain the role of watch dog timer in programmable logic controller.</b>																														
Ans:	Watch dog timer is a type of timer used to protect maloperation of PLC. It independently works( starts counting internal clock pulses) each time when PLC starts its execution. User program must reset the timer some where in the program. If the user program stops working because of some fault or some unknown condition, then watch dog timer overflows and generates nonmaskable interrupt to reset PLC.																														
<b>d)</b>	<b>List typical inputs and outputs for PLC (four input and any four output). (2m+2m)</b>																														
Ans:	<p><b>Typical PLC inputs</b></p> <ul style="list-style-type: none"> <li>Push Button</li> <li>Selector Switch</li> <li>Proximity switch</li> <li>FOOT switch, level switch</li> <li>Analog input</li> </ul> <p><b>Typical PLC outputs</b></p> <ul style="list-style-type: none"> <li>Contactors Coil, solenoid, relay</li> <li>Indicating Lamp</li> <li>Buzzer</li> <li>Alaram annunciator</li> </ul>																														
<b>e)</b>	<b>Draw the ladder diagram for 1) AND gate      2) OR gate (2m+2m)</b>																														
Ans:	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <table border="1" style="margin: 10px auto;"> <thead> <tr><th>A</th><th>B</th><th>Output</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>1</td></tr> </tbody> </table> </div> <div style="text-align: center;"> <table border="1" style="margin: 10px auto;"> <thead> <tr><th>A</th><th>B</th><th>Output</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>1</td></tr> </tbody> </table> </div> </div>	A	B	Output	0	0	0	0	1	0	1	0	0	1	1	1	A	B	Output	0	0	0	0	1	1	1	0	1	1	1	1
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SUMMER- 2017 Examinations

Subject Code: 17641 Model Answer Page 12 of 16

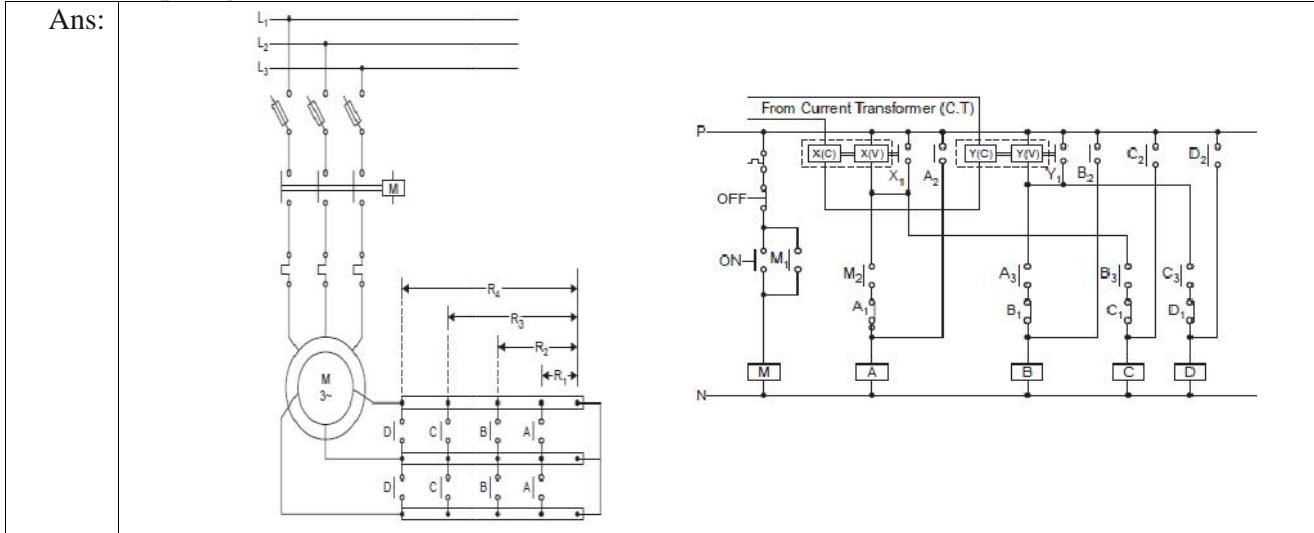
<p>f)</p> <p>Ans:</p>	<p><b>Describe the working of Proportional-Integral-Derivative (PID) controller. (2m +2m)</b></p> <p>The equation for P+D controller is</p> $C_v = K_p \times e(t) + K_D \frac{de(t)}{dt} + C_v(0)$ <p>Where <math>C_v</math> is the controller output, <math>C_v(0)</math> is the zero error controller output. <math>K_p</math> (%/%) is the proportional gain, <math>K_D</math>(sec) is the derivative gain.</p> <p>The proportional action maintains one-to-one relationship between error and controller output and the derivative action generates output w.r.t. rate of change of error. The derivative action improves the dynamic response and disturbance rejection. The time response of the PD action is shown in the diagram</p> 
<p><b>Q.5</b></p>	<p><b>Attempt any TWO 16 Marks</b></p>
<p>a)</p>	<p><b>Draw a ladder diagram for following condition.</b></p> <p><b>i) Start push button starts motor M1 and motor M2.</b></p> <p><b>ii) Stop push button stop motor M1 first and after 15 sec. motor M2.</b></p>
<p>Ans:</p>	



**SUMMER– 2017 Examinations**

**Subject Code: 17641 Model Answer Page 13 of 16**

**b) Draw and explain the power and control of circuit for current limit acceleration starter for slip ring induction motor. (4m+4m)**



**c) Explain how a Programmable Logic Controller (PLC) is different from an ordinary personal computer. Also write the advantages and disadvantages of PLC. (4+4)**

Ans:

	PLC	PC
<b>1)</b>	It has embedded processor with limited computing power	It has a CPU with high computing power
<b>2)</b>	Design of PLC is for reliable operation in industrial environment with noise,	Design of PC is suitable for indoor or office use or mid range industrial environment
<b>3)</b>	Start up time is negligible	Longer startup time
<b>4)</b>	PLC has high reliability	PC is less reliable as comp to PLC
<b>5)</b>	Software of PLC is mainly for real time	Software of PC is designed for information processing
<b>6)</b>	PLCs are available in compact sizes	Size of PLC is larger than PLC
<b>7)</b>	Modularity is design of PLC makes it very	Addition of I/O module to PC is hardware dependant and

**Advantages**

- 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.
- 9) PLC can keep records of status of Input & Output signals.



SUMMER- 2017 Examinations

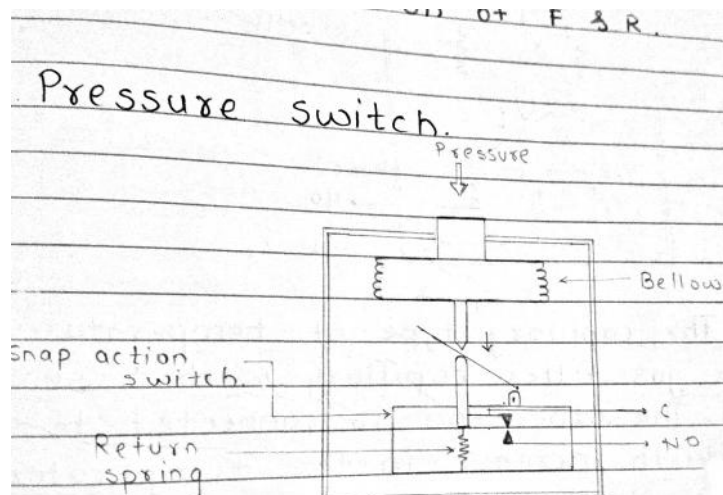
Subject Code: 17641 Model Answer Page 14 of 16

- 10) PLC can provide security for ladder programming.  
Drawbacks:
- 1) PLC code is not portable.
  - 2) Cost of PLCs with analog I/O is very high as comp to digital i/o PLC
  - 3) Use of PLCs may be restricted in some high heat, vibration environment not suitable for electronic circuit.

**Q.6 Attempt any FOUR :16 Marks**

- a) **Explain working of pressure switch with suitable diagram. State the function of differential setting in pressure switch. (2m+2m)**

Ans:



Pressure switch is used to turn on/off when specified pressure is reached. It consists of a pressure port and bellows. When pressure is applied, bellows expand and actuate the snap action switch against return spring force. Differential setting allows setting of cut-in and cut-out pressure setting i.e. hysteresis setting. This prevents chattering of pressure switch contacts.

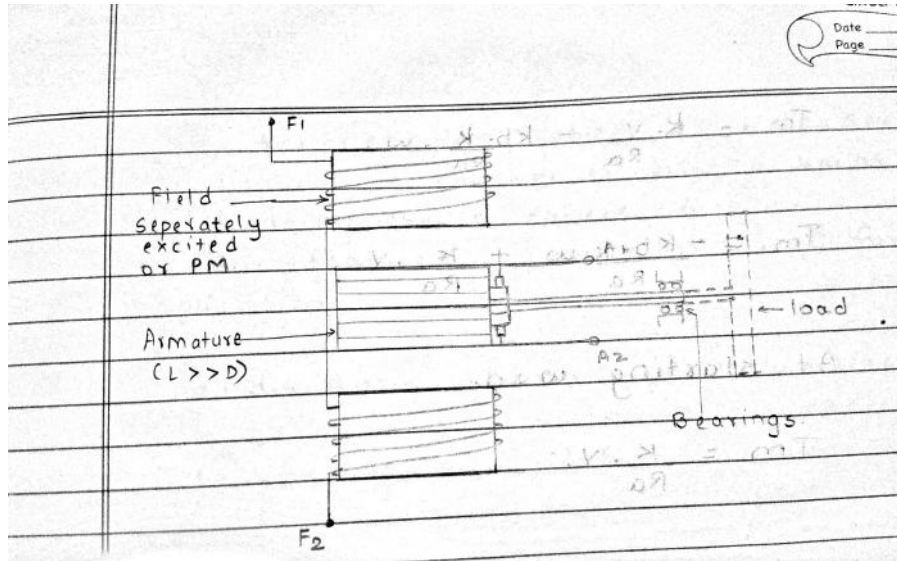


SUMMER- 2017 Examinations

Subject Code: 17641 Model Answer Page 15 of 16

b) Describe the construction and working of DC servomotor. (2m+2m)

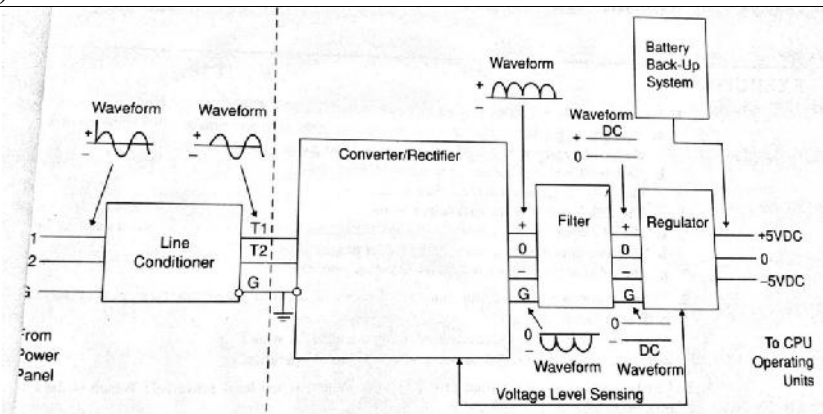
Ans:



DC servomotors are used in closed loop position control systems. The basic working principle of DC servo is same as that of ordinary DC motor. They have fast response, linear torque speed characteristics. To reduce inertia of rotor, diameter is kept much smaller than length.

c) Draw the block diagram for PLC power supply and explain the function of each block. (2+2)

Ans:



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:

**Line conditioner:** Line conditioner unit filters the input AC voltage and removes any glitches,





**SUMMER– 2017 Examinations**

**Subject Code: 17641** Model Answer **Page 16 of 16**

	<p>noise, EMI</p> <p><b>Converter:</b> Converter unit converts AC into DC This is basically a switched mode power supply.</p> <p><b>Regulator:</b> Regulator unit generates the required voltage levels for the PLC internal circuit</p> <p><b>Battery Backup:</b> 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</p>
<b>d)</b>	<b>Draw labelled diagram for automatic star-delta starter.</b>
Ans:	Ref Q2a
<b>e)</b>	<b>Explain the offset in proportional controller. (1 equation+3m)</b>
Ans:	<p>Offset is a sustained error that cannot be eliminated by proportional control alone The basic equation of proportional control is as follows:</p> $CO(t) = K_p e(t) + CO(0)$ <p>Where CO(t) is the controller output, CO(0) is the zero error controller output. when PV equals SP, then error is zero: <math>e(t) = 0</math> if <math>e(t)</math> is zero, then CO equals the CO(0) if CO is steady at CO(0), then the PV settles to some steady value. The steady value is known by performing experiment on the system. And value CO(0) is adjusted so that PV settles in the range of set point. If a process disturbance occurs, CO(0) value will not change and it will cause permanent change in error and this is offset error in proportional control.</p>
<b>f)</b>	<b>Draw and explain working of (PI) Proportional-Integral controller.(2m +2m)</b>
Ans:	<p>Proportional control provides one-to-one relationship between error and controller output. The output of integral controller is dependent on accumulation of error over a period of time. When there is steady state error in the controlled variable, it is eliminated by integral action. The output of integral term will continue to increase as long as there is error. P+I action improves steady state response of the system.</p> <p>The equation of the P+I controller is <math>CO = K_p e(t) + K_I \int e(t) + CO(0)</math></p>