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Subject Code: **17641**
Model Answer
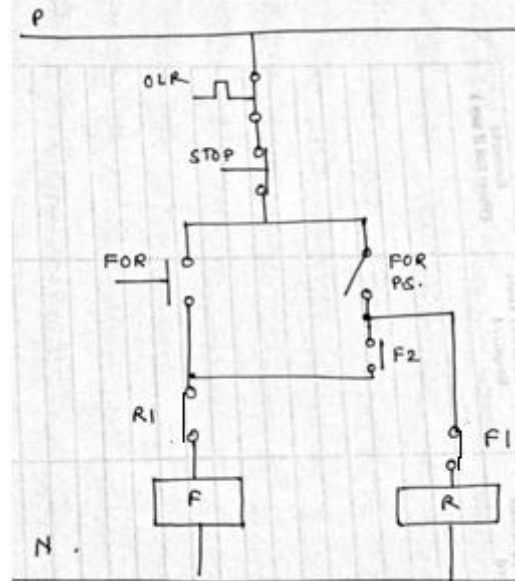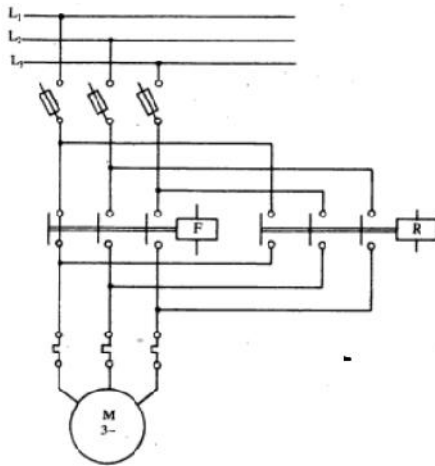**WINTER – 15 EXAMINATION**   Page No:1/ 16
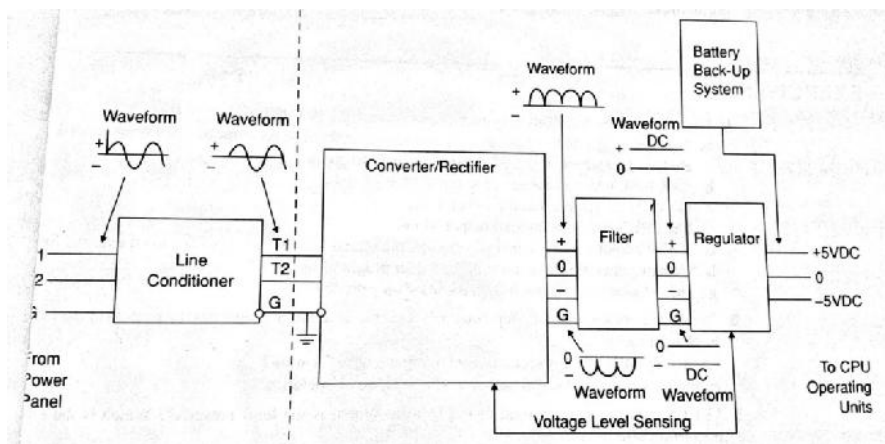
Important Instructions to examiners:

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.Atempt any FIVE :	20
a) Explain concept of two wire control circuit. In two wire control circuit, two wires are used to energize motor control coil. It provides low voltage release but no low voltage protection. It is suited for applications where the motor is located at remote locations such as submersible pumps. As shown in the circuit diagram, the control circuit connected between two wires consists of a pilot switch (such as float switch) and overload release connected is series with motor control coil. When the switch is closed, the motor will start. In the event of power failure, the motor coil will be de-energize and motor will stop. When the power is resumed, the motor will automatically start. This feature makes two wire control suitable for remotely located loads. But this feature is unsafe for operator. 	**2+2**
b) Describe control and power circuit for simple plugging of Induction motor with neat diagram. An induction motor can be stopped suddenly by interchanging the phase sequencewhich is known as *plugging.* The rotating magnetic field rotates backwards relative to the rotor.The slip becomes greater than unity and the developed torque tries to force the motor to rotate in the opposite direction. If only stopping of the drive is required, the motor should be disconnected from the power line at about the instant of zero speed. The power circuit consists of forward and reverse motor contactors. When FOR is pressed, forward contactor F gets energized and motor runs in forward direction and the seal-in is provided by FOR Plugging switch P.S. and F2 aux contact. When STOP is pressed forward contactor F gets de-energized. When STOP is released, REV contactor gets energized through FORWARD P.S. and braking is applied. The motor comes to stop and the zero speed plugging switch is opened. REVERSE contactor is de-energized as P.S. is opened.	**2+2**

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c) Describe block diagram of PLC power supply with neat diagram.

4

2+2

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

4) 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

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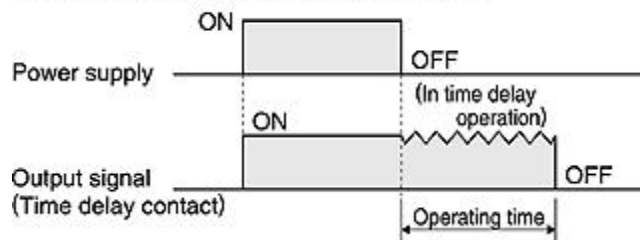|	
d) Describe off delay timer instructions.	**4**
The off-delay operation is an operation to turn OFF output when preset time expires after a predetermined input is given to the power supply circuit or input circuit, and at the same time output signal is given and predetermined input is turned OFF.	**2+2**
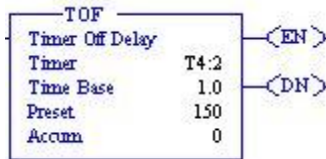
Example of power supply off-delay operation

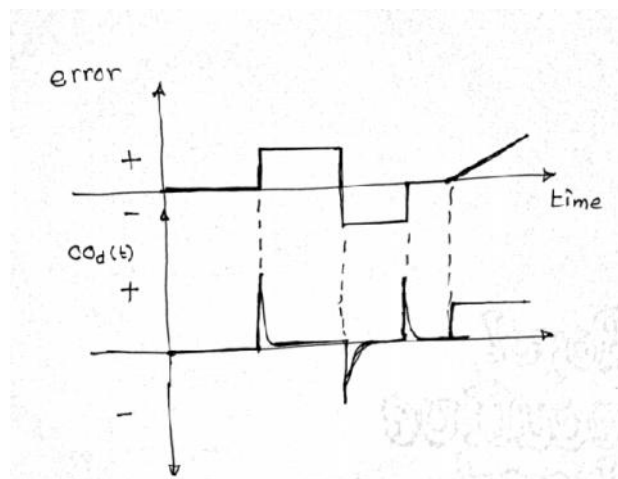|	
e) State the principle of derivate control action. Write its standard equation.	**4**
For derivative control action, the controller output depends upon rate of change of error i.e. time derivative of error. The basic equation of derivative control action is	**2+2**

$$CO_d(t) = K_d \frac{de}{dt}$$
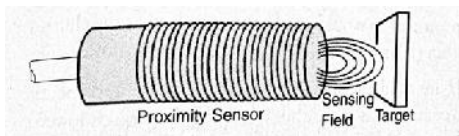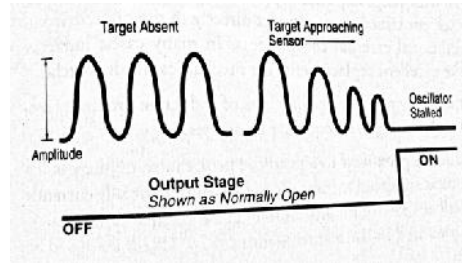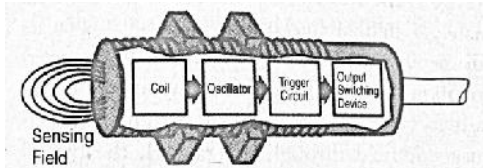
K_d (sec) is called as derivative gain.

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.

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|	
f) Describe inductive proximity switch with neat diagram.	**4**
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.	**2+2**

g) Describe standard start-stop-seal circuit with neat diagram.	**4**
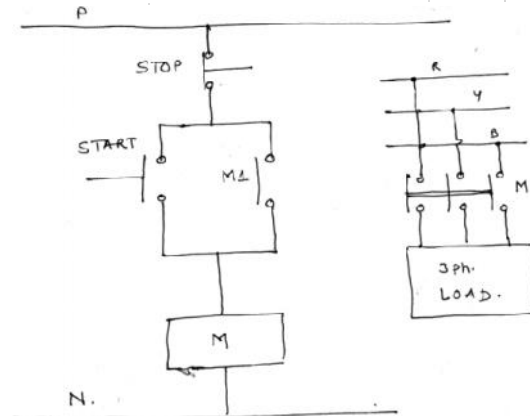
The START-STOP-SEAL circuit is as shown in figure. The power circuit consists of 3ph load controlled by a main contactor M. The control circuit consists of START, STOP push button and main contactor coil. When START push button is pressed M gets energized and the load is connected across supply. When START is released, supply to M is maintained through M1 (aux contact of M). When STOP is pressed, M gets de-energized and load gets disconnected from supply

2+2

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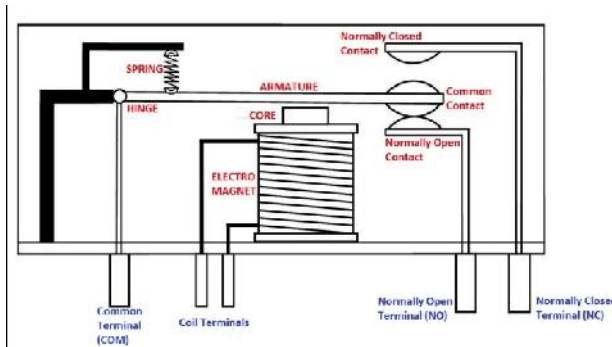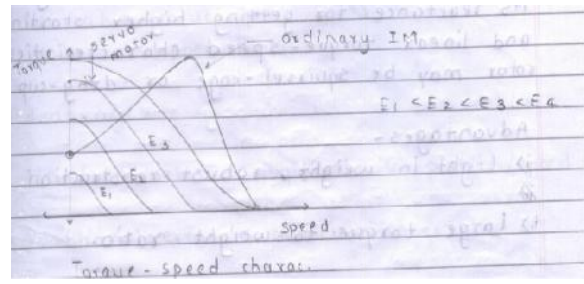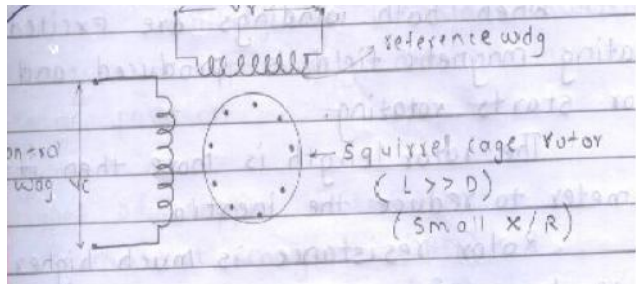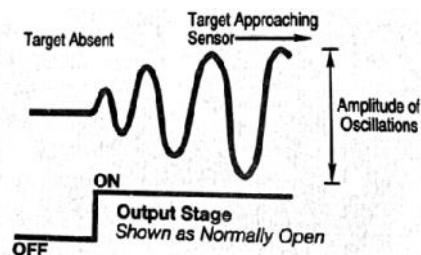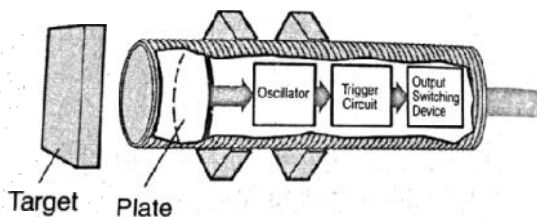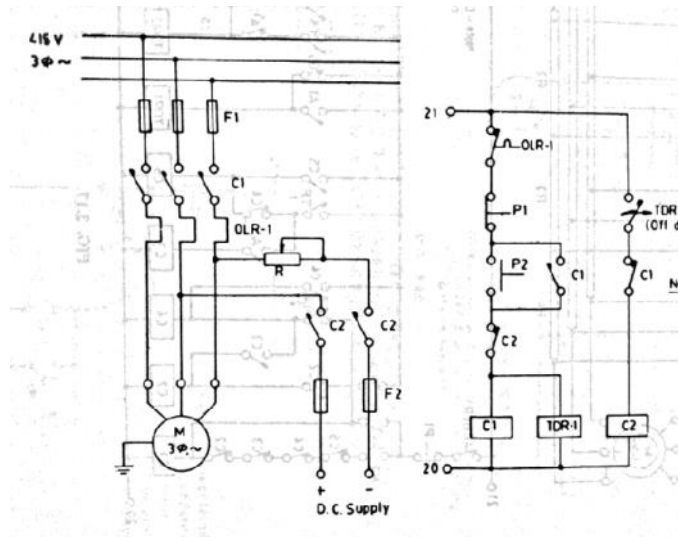|	
2. Attempt any FOUR of the following:	**16**
a) Describe electromagnetic relay with neat diagram.	**4**
A relay is an electro mechanical device used to make or break the circuit in response to application of control signal. A relay consists of a wound coil on a former. It has a movable plunger inside. When current flows through coil, magnetic field are produced, which attracts the armature and contact position is changed. A typical SPST relay has five terminals: two coil terminals, COM, NC and NO. Typical coil voltages are 6V,12V,24V and coil resistances are few hundred ohms. Transistorised circuit is used for driving a relay. A freewheeling diode is connected across the relay coil to discharge the stored energy in the coil when it is turned off. 	**2+2**
b) Describe the construction and working of AC servomotor.	**4**
AC servo motors are is wound with two windings at 90^0 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. 	**2+2**
c) Describe capacitive type proximity switches with neat diagram	**4**
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. 	**2+2**

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d) Describe control and power circuit for dynamic braking.	**4**
	2+2

In dynamic braking, motor is disconnected from the line and a DC supply is connected to any two terminals of the stator through a current-limiting resistance. The DC voltage sets up a stationary magnetic field that generates a voltage in the rotor windings, dissipating energy as I^2R losses, slowing the motor. As rotor tries to catch the steady magnetic field produced by DC supply, it tends to stop.

When P1 is pressed, C1 is OFF and C2 becomes ON as it is connected through TDR and NC contact of C1. DC supply is connected to stator winding terminals through C2 contactor and braking is applied. After certain time delay TDR is opened and DC is disconnected.

e) Describe on delay timer instruction	**4**
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.	**2+2**

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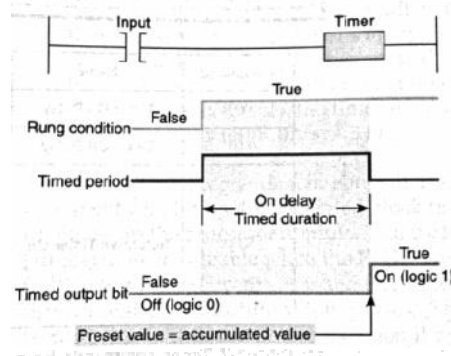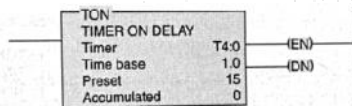
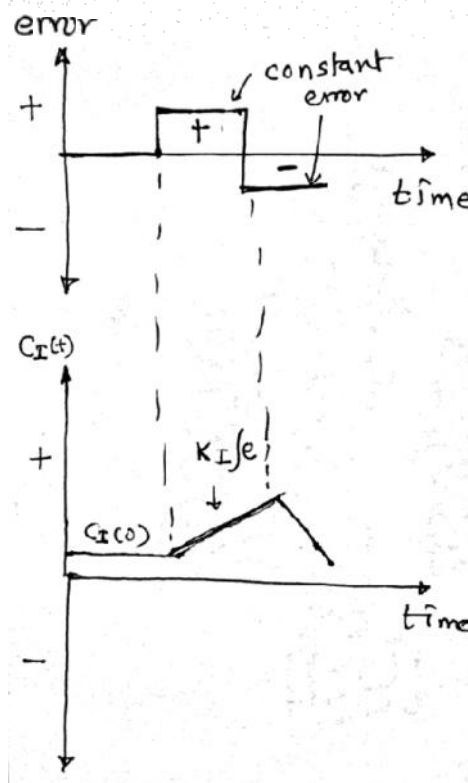|	
f) Describe the principle of integral control action. Write its standard equation.	**4**

Integral control action, controller output depends upon time integration of error. When the error is constant, controller output increases linearly. The equation of integral control action is given by

2+2

$$CO_I(t) = K_I \int e(t) + CO_I(0) \quad \text{Ki is the integral gain (sec}^{-1})$$

Q3. Attempt any TWO of the following	**16**

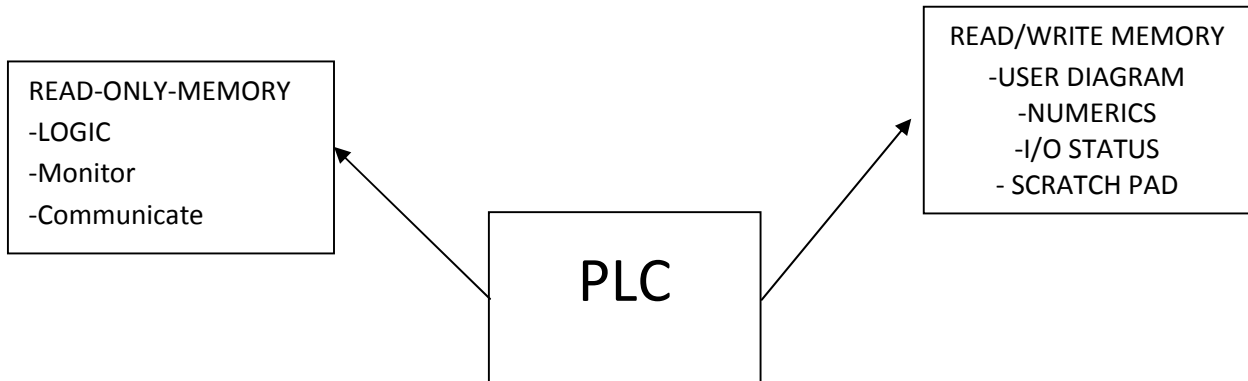|	

a) Draw a ladder diagram for two motor system having following conditions:
  (i)   Starting push button starts motor 1
  (ii) After 10 seconds, motor - 2 is ON
  (iii) Stopping the switch stops motor 1 and 2 (Time base = 1 sec)
	8
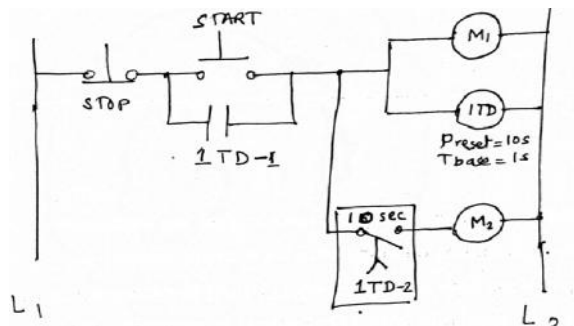
(partial correct diagram may be given due credit)

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b) Describe in detail the memory organisation list and explain types of memory	**8**

4+4

```
READ-ONLY-MEMORY              READ/WRITE MEMORY
-LOGIC                         -USER DIAGRAM
-Monitor                        -NUMERICS
-Communicate                    -I/O STATUS
                                - SCRATCH PAD

                PLC
```

PLC memory can be divided into two broad sections: Read-ONLY memory and READ/WRITE memory. The Read-ONLY memory stores operating system of the PLC and factory set data. The READ/WRITE memory is that memory which can be altered during design as well as run time of PLC. It is mainly used for storing USER LADDER DIAGRAM while running, image of INPUT/OUTPUT signals and scratch pad purpose.

Various types of READ-ONLY memory used by PLCS are:

1) PROM
2) EPROM
3) EEPROM

1) PROM: - (Programmable Read Only Memory): In this memory it may be programed once and once only, by the user/programmer. The user than programs the chip to his/her requirements. No erasures are possible. To change program in a programmed PROM, you may throw it away and replace it with a new un-programmed PROM. The PROM is rarely used because it requires special programming circuits .It does however the advantages of being an unalterable backup to a ROM

2) EPROM: (Erasable Programmable Read Only Memory): It is a PROM that can be erased. The EPROM is erased by subjecting a window in its top to ultraviolet light for a few minutes. It is also called as Ultra Violet RAM. When exposed to UV light the chips memory bits are reset to 0 the chips window is covered during normal use to prevent unwanted eraser. When the EPROM is exposed to ultraviolet light all of memory locations are erased. This can be reused.

3) EEPROM: (Electrically Erasable Programmable read only memory): It is similar to EPROM instead of UV light exposer for eraser through an electrical signal is applied to the chip. The EEPROM advantages over the EPROM is the easy and speed with which it is reset & erased. The EEPROM is used in place of RAM when they want to fast eraser without using time for individual reprogramming of each part of the chips memory. EEPROM is the memory of choice for storing, backing up and transferring PLC programs

READ-WRITE memory also called as RANDOM ACCESS MEMORY (RAM) is capable of READING and WRITING as required. The advantage of this type of memory is faster writing and reading speed. The basic drawback is that the data in RAM is lost in absence of power. Most of the PLCs use CMOS-RAM chips as they demand very small drain current when not being used. This enables retention of RAM data using lithium batteries mounted on-chip. Such types of memories are called as NVRAM (No-Volatile RAM)

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c) Describe power and control circuit diagram of forward stop reverse type DOL starter with neat sketch.	**8**
	5+3

Connect 20 and 21 to secondary of control transformer.
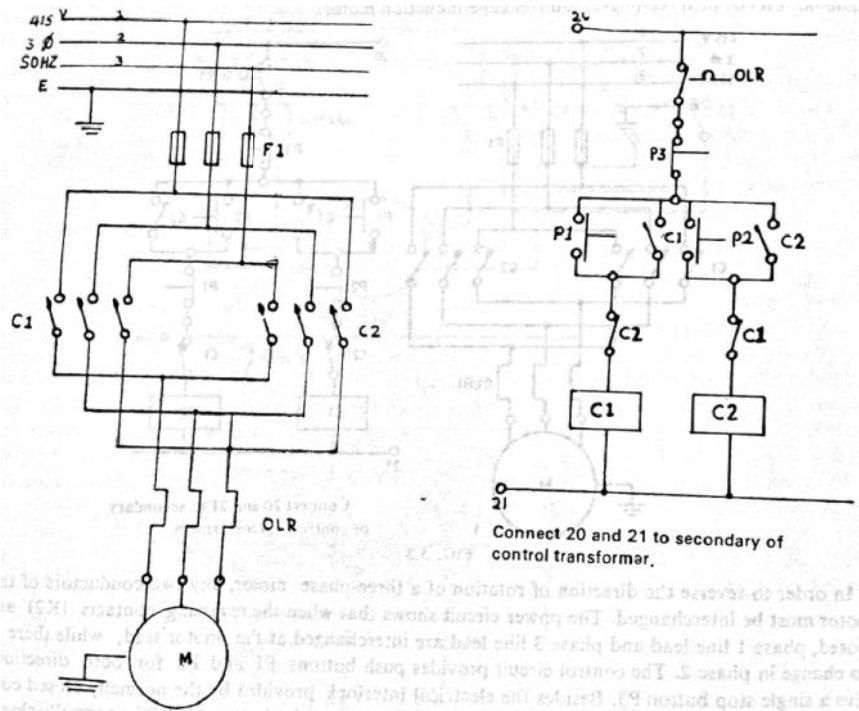
C1 and C2 are forward and reverse contactors. Pressing P1 turns ON C1 and runs the motor in forward direction. When C1 is ON C2 remains OFF because of C1 NC auxiliary contact. To run the motor in reverse direction, P3 must be pressed. When P3 is pressed, C1 is OFF. Now pressing P2 turns ON C2 and motor runs in reverse direction. Motor STOP is a must before changing direction of rotation of the motor.

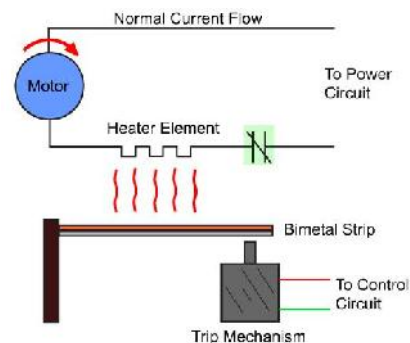|	
Q4. Attempt any FOUR of the following:	**16**
a) Describe bimetallic thermal overload relay with neat sketch.	**4**
A bimetallic overload relay consists of a small heater element wired in series with the motor and a bimetal strip that can be used as a trip lever. The bimetal strip is made of two dissimilar metals bonded together. The two metals have different thermal expansion characteristics, so the bimetal strip bends at a given rate when heated. Under normal operating conditions, the heat generated by the heater element will be insufficient to cause the bimetal strip to bend enough to trip the overload relay. As current rises, heat also rises. The hotter the bimetal strip becomes, the more it bends. In an overload condition, the heat generated from the heater will cause the bimetal strip to bend until the mechanism is tripped, stopping the motor. If the cause of the overload still exists, the relay will trip again and reset at given intervals.	**2+2**

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b)	**Describe power and control circuit diagram of current limit acceleration starter for slipring induction motor with neat diagram.**	**4** **3+1**
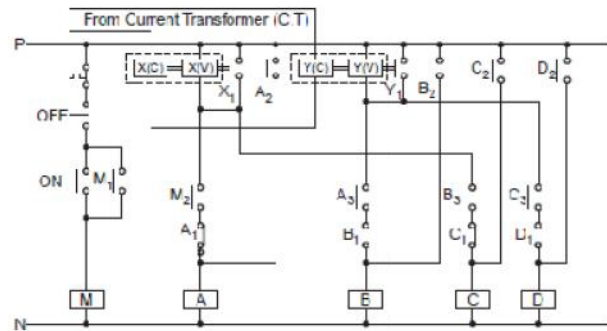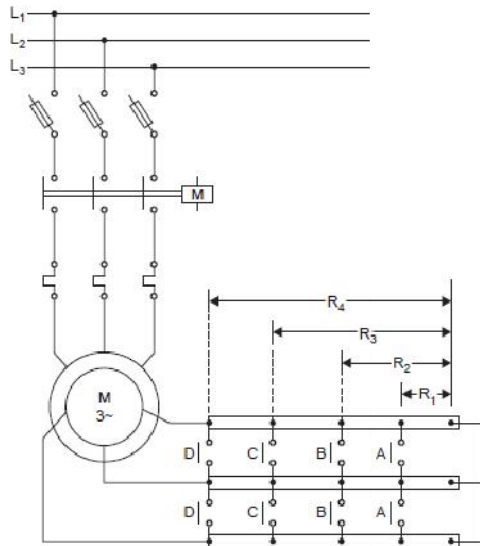
In this type of starter, the accelerating contactor closes depending upon the amount of stator/rotor current. Accelerating contactors are energised when current peak falls to a pre-determined value equal to full-load current. The accelerating contactors A B C D are energised and they cut off resistance in steps. A current limit acceleration starter uses a special relay known as current limit relay.

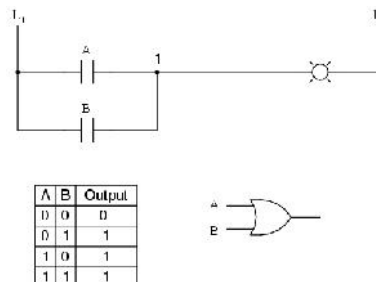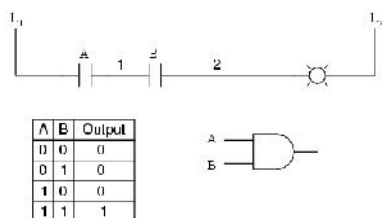|		
c)	**Describe classification of PLC I/O module**	**4**
	Different types of PLC I/O modules are:	**1**
	1) Discrete I/O module: This type is the most commonly used I/O module type which is useful for controlling ON/OFF types of devices. Input devices such as push buttons, selector switch, limit switches and output devices such as contactor coils, alram/annunciators, buzzer, solenoids can be controlled using discrete I/O modules	**Each**
	2) Analog I/O module: This type of module has a provision to input and output analog voltage from PLC. The input analog voltage is converted to digital by using ADC and the digital data is accessed by the PLC. The analog output voltage is generated by using a DAC in response to digital data sent by PLC.	
	3) Control M odules: Process control often needs PID controls. PID modules are used for that purpose	
	4) Special I/O modules: In addition to above there are some special modules that can be interface to PLC. Thumbwheel module, TTL module, Encoder module, stepper motor,servomotor module etc.	

d)	**Draw the ladder diagram to verify the truth table of: i) AND gate ii) OR gate**	**4** **2+2**

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e) **Describe control action of proportional - Integral controllers.**	**4**
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. The equation of the P+I controller is $$CO = K_p e(t) + K_I \int e(t) + CO(0)$$	**2+2**
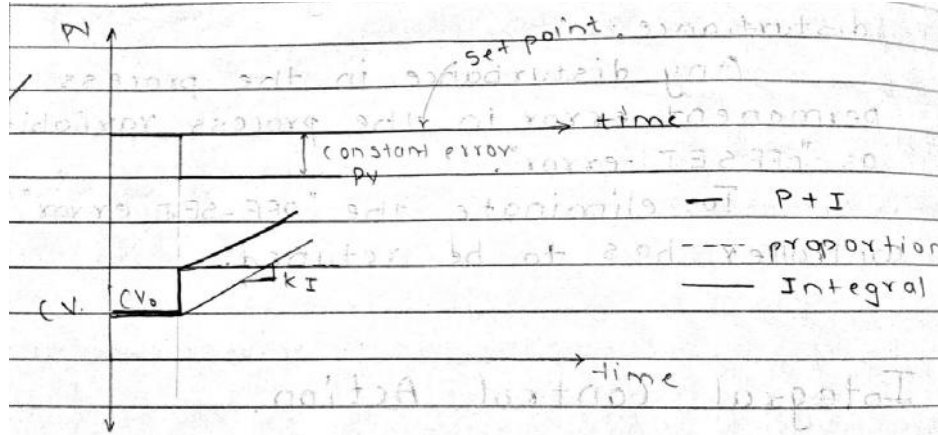
f) **Describe control action of Integral controllers.**	**4**
Refer Question 2f	

Q5. Attempt any FOUR of the following	**16**

**a)** Differentiate power and control wiring.   **4**

Power Wiring	Control Wiring
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.
Power wiring is connected between main supply and load	Control wiring is connected at the secondary of a control transformer
It is at main supply voltage level (e.g. 440V)	It's a low voltage (e.g. 110VAC)
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 consume higher current

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b) Describe power and control action circuit diagram of definite time limit starter for slipring induction motor with neat diagram.	**4**
	3+1
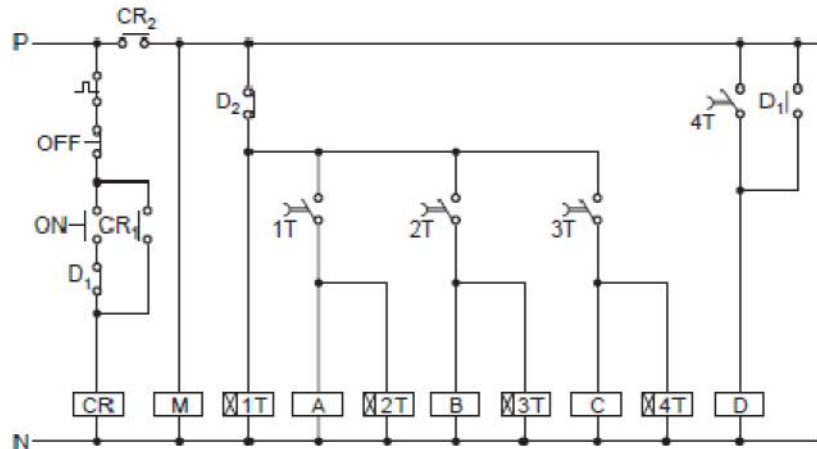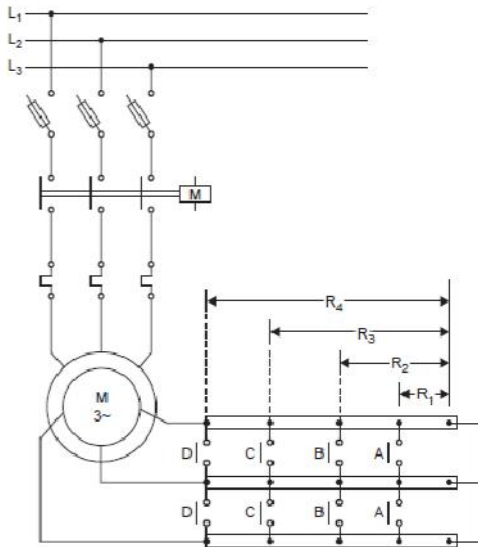
In definite time limit starters, the accelerating contactors close after pre-set delays determined by the timers. The time periods are so adjusted that when a resistance step is cut off, the resulting current peaks remain within limits. The time delay between energisation of successive accelerating contactors can be obtained by using individual timers. When ON is pressed Main contactor turns ON. Contactors A-B-C-D operate at preset time intervals

c) List two advantages and two disadvantages of PLC.	**4**
Advantages	**2+2**

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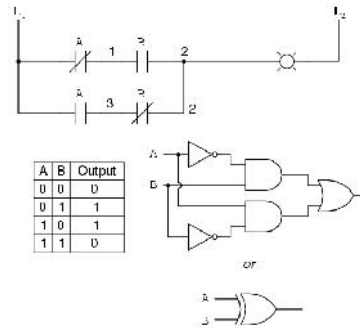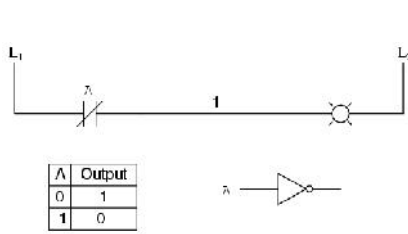10)   PLC can provide security for ladder programming.
Drawbacks:
1)   PLC code is not portable.
2)   Cost of PLCs with analog I/O is very high as comp to digital i/o PLC
3)   Use of PLCs may be restricted in some high heat, vibration environment not suitable for electronic circuit.

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d) Draw ladder diagrams for following logic operations: (i) NOT (ii) Ex-OR	**4**
	2+2

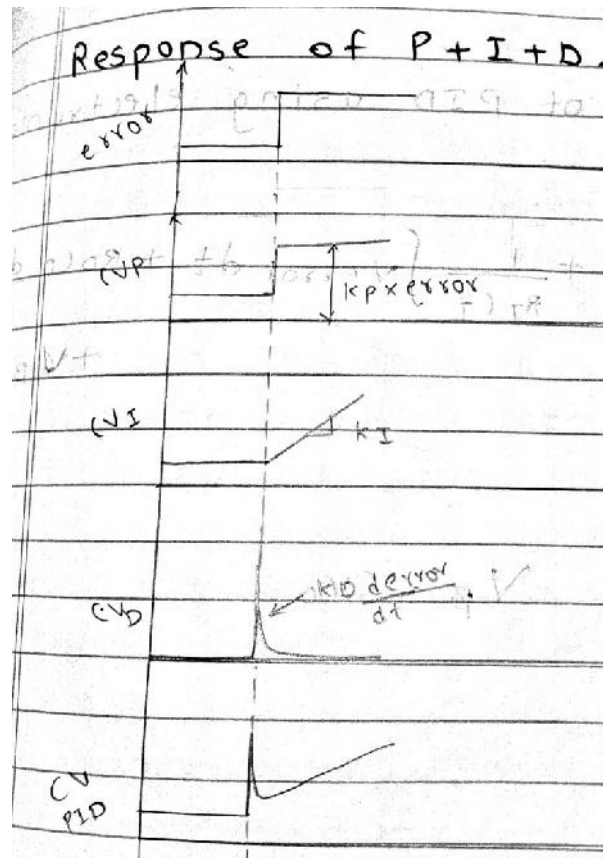|	
e) Describe proportional - Integral derivative controllers.	**4**
Proportional controller action produces one-to-one relationship between error and controller output within proportional band. KP is the proportional gain and proportional band PB = 100/Kp. Proportional band is the range of error for which controller output is directly proportional to error.	**2+2**

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

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

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f) **Explain the concept of NO and NC contact.**	**4**
	NO and NC contacts are standard set of contacts available with an electromechanical relay.	**2+2**
	NO contacts are open in normal condition. When the relay coil is energized, NO contacts are closed.	
	NC contacts are closed in normal conditions. When the relay coil is energized, NC contacts are opened.	

NC contact   NO contact
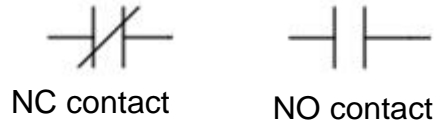
NO and NC contacts are most commonly used symbols in PLC ladder logic or any industrial control circuit to indicate digital input. They are derived from relay contacts. The input can be switch closure, push button closure etc.

1) Physical NO/NC contacts are used in relay based control circuits
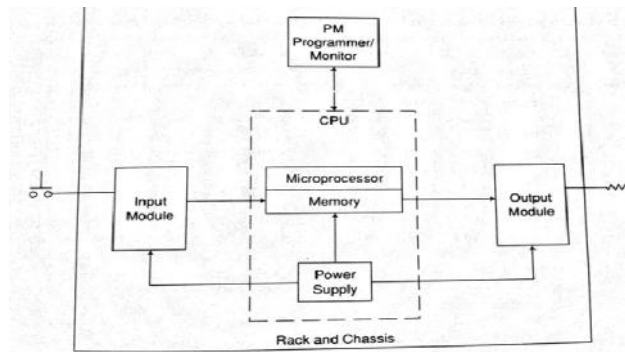2) Relay equivalent of NO/NC contacts are used in all ladder diagrams.

|		
Q6. Attempt any TWO of the following:	**16**
a) **Draw block diagram of PLC and explain each block in detail.**	**8**
	4+4

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.

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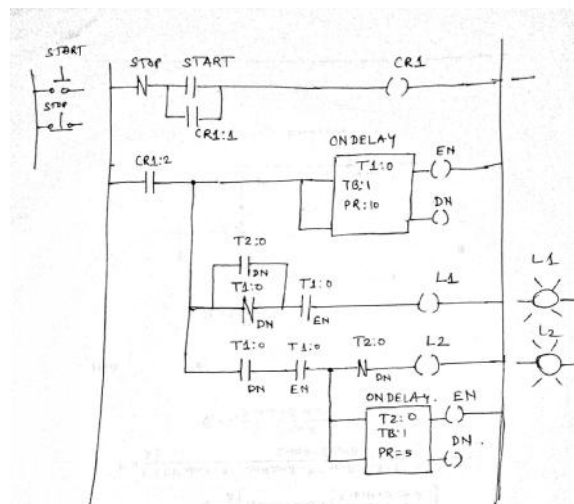|	
b) Describe power and control circuit diagram of forward and random reversing type DOL starter with neat sketch.	**8** **5+3**
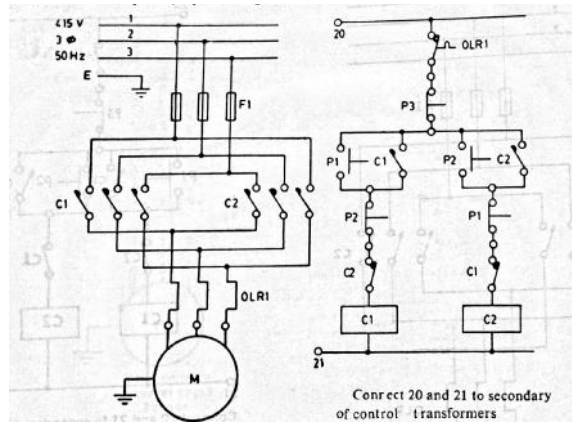
C1 and C2 are forward and reverse contactors respectively. Pressing P1 turns ON C1 through P2 NC-C2 NC. The motor runs in forward direction. Now P2 can be randomly pressed at any time. Pressing P2 ineediately open P2 NC and C1 is imeediatley disconnected. Pressing P2 turns on C2 through P1 NC-C1 NC.

c) Draw a ladder diagram for a two motor system having following conditions: **(i) When start button is pushed, motor lamp 1 is ON.** **(ii) After 10 sec, lamp 2 is ON and lamp 1 turns OFF.** **(iii) After step 2, lamp. 2 turns OFF after 5 sec and lamp 1 turns ON.** **(iv) When stop button is pressed, both the lamps turn OFF.**	**8**

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