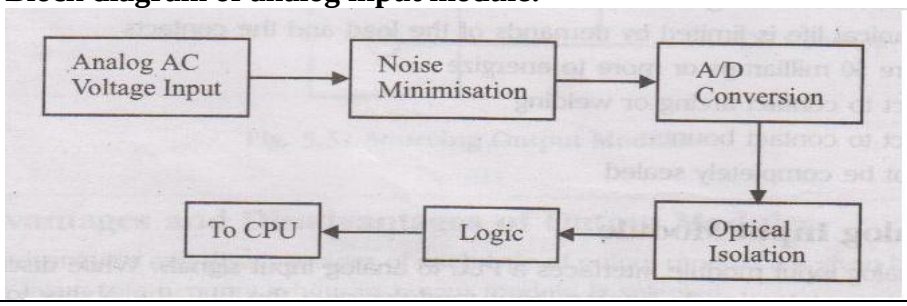
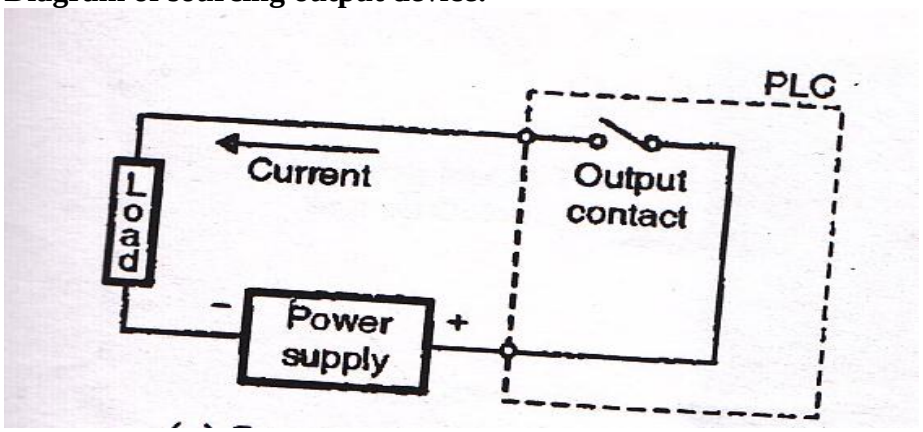
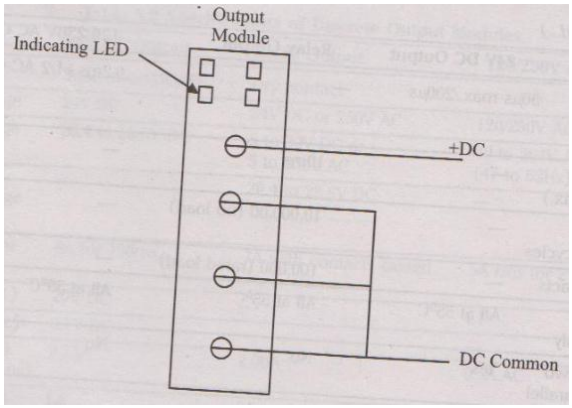
Important Instructions to examiners:

1) The answers should be examined by keywords 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 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 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.

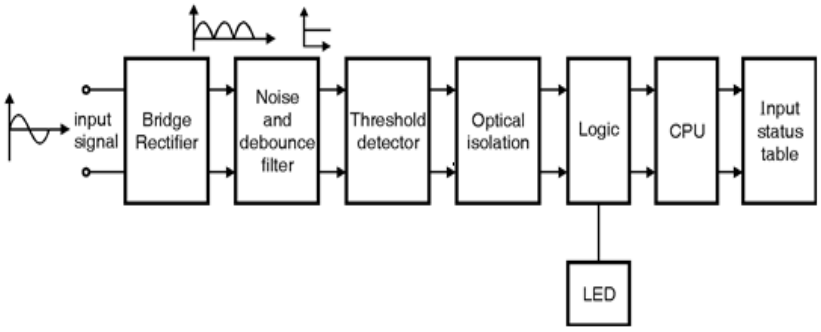
Q.1 A	**Attempt any Three**		**12**
a)	**List any four benefits of automation.**		**04**
Ans.	**Benefits of Automation:** 1. Increases productivity. 2. Increases product quality. 3. Increases flexibility and convertibility. 4. Reduces manpower. 5. Reduction of personal accident. 6. Reduces cost of product. 7. Better inventory control. 8. Increases profit.	**01mark for any 4 points**	
b)	**Draw the block diagram of analog input module.**		**04**
Ans.	**Block diagram of analog input module:** 	**04 marks for relevant diagram**	

c)	**State the file no. of the following data files:** **1. Integer** **2. Counter** **3. Bit** **4. Control**		**04**
Ans.	1. Integer: 7 or N7 2. Counter: 5 or C5 3. Bit: 3 or B3 4. Control: 6 or R6	**01 mark for each file no.**	
d)	**Draw and explain PLC as a sourcing output device.**		**04**
Ans.	**Diagram of sourcing output device:**  **Fig. Sourcing type output contact (PLC)**  **Fig. Sourcing output module interface to field devices.** The interface diagram of PLC as output module is shown in above, In operation with PLC as sourcing output module, current from positive terminal of power supply flows first from output module to output device and then to common terminal so the output module acts as source of current for output devices.	**02 marks for diagram & 02 marks for relevant Expl.**	

Q.1 B	**Attempt any One**		**06**
a) i	**State relay control and PLC control on the basis of:** **1. Power consumption** **2. Maintenance**		**06**
Ans.	Comparison of relay control and PLC control on the basis of:	**03 Marks for relevant comparison of two points**	

Parameter	Conventional relay control panel	PLC based control panel
Power consumption	Higher power consumption. Approximate power requirement for a contactor consisting of 500 I/O devices is 220 V * 0.2 Amps * 500 =22 KVA	Much lower power consumption. Approximate power requirement for PLC controlling 500 I/O devices is 0.1 KVA. This is because PLCs do not require hard wiring and actual circuits for controlling operations.
Maintenance	Regular wear and tear of relay and hard wire takes place. As a result, extensive maintenance of system is required	As the software program is not subject to wear and tear, not much effort is required in normal maintenance. Only the cables connecting in the real world devices to the PLC need to maintain.

ii	**List the types of PLCs. State the number or input/output in each type.**		
	PLC types are as follows: A) Micro PLC (Fixed I/O) Limited I/O (20 Input and 12 outputs, 32 I/O) B) Modular PLC: - i) Small PLC- Less than 100 I/O additional can be added (20 Input and 12 outputs mounted locally with the process) ii) Medium PLC-4000 to 8000 I /O. iii) Large	**03 marks for type and I/O of various PLC types.**	

b)	**Draw the block diagram of AC input module. State the function of each block.**		**06**
Ans.	**Diagram:**  In the AC input module alternating current enters the input module and then given to rectifier and filter ckt. **Rectifier and filter ckt :** • This section consists of resistors and a bridge rectifier to convert the incoming AC signal to a pulsating DC signal. • The pulsating DC signal is then passed through filter and other logic circuitry in order to get clean, denounced DC input signal to the threshold detection. **Threshold detection:** • Threshold detection circuitry detects whether the incoming signal has reached or exceeded a predetermined voltage level for a predetermined time and whether it should be classified as a valid ON or OFF signal. • A typical valid OFF state is below 0 and 20 or 30 V_{AC} depending on the module's manufacture and a valid ON state is between 80 and 132 V_{AC} again depending on the module's manufacturer. • The signal area between the upper voltage limit for a valid OFF state (20 V_{AC}) and minimum voltage for a valid ON state (80 V_{AC}) is called **undefined zone or input state not guaranteed**	**03 Marks for diagram** **03 marks for suitable explanation**	

zone. The signals falling within this undefined zone may be ON or OFF making them unstable and unreliable.

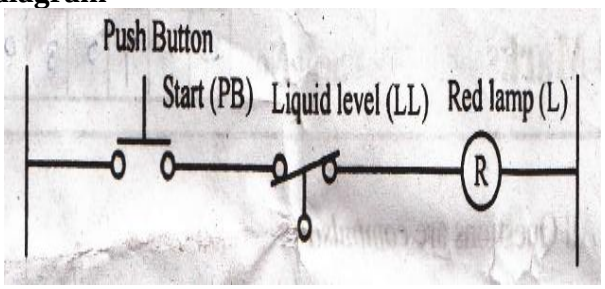
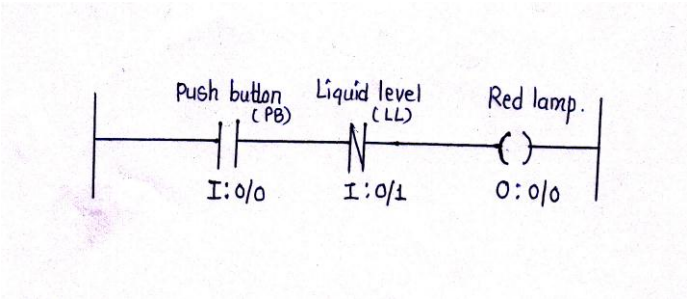
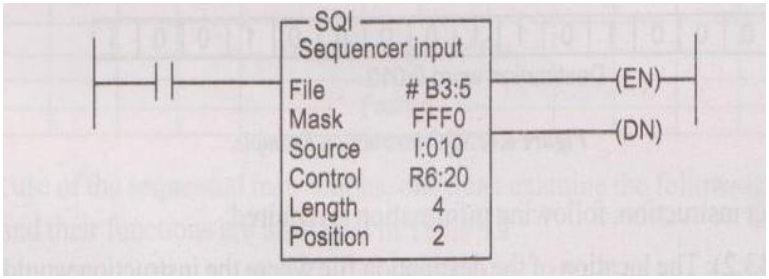
- Filtering and time delays are used to filter out electrical noise that may be interrupted as a false input pulse.
- To eliminate the possibility a faulty operation due to electrical noise, a valid AC input signal must not only be a specific value, but must be present for a specific amount of time before the input module allows the valid signal to pass to the isolation section.

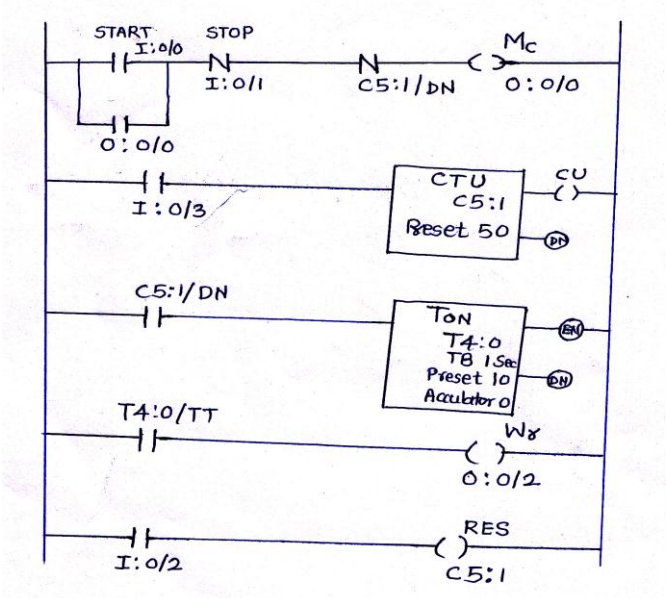
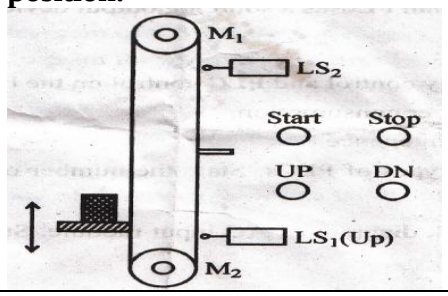
Isolation :

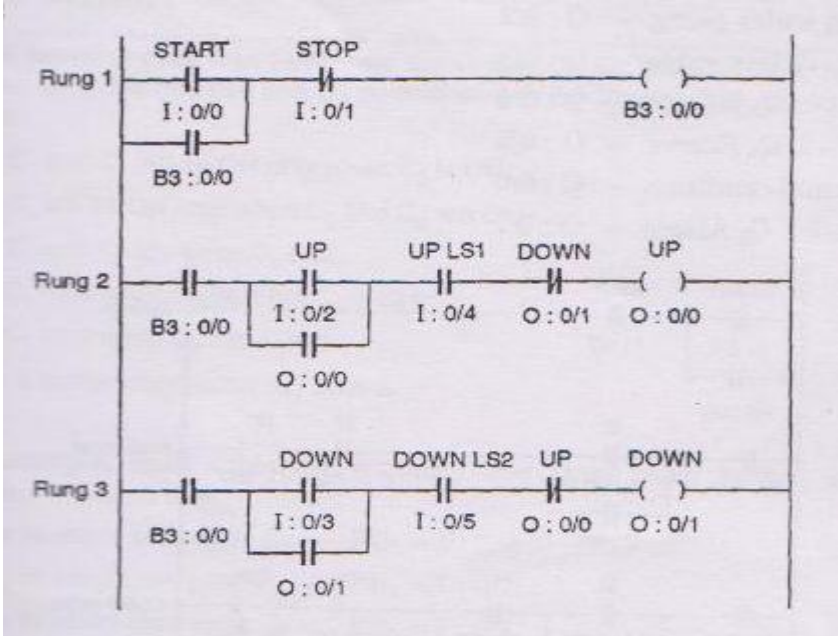
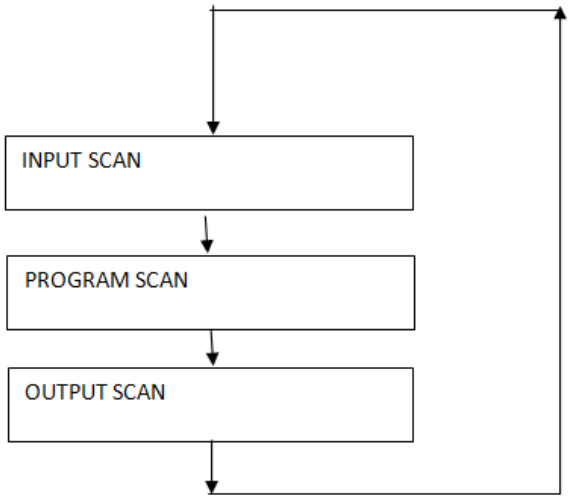
- The isolation section of the input circuit is usually made up of an opto-isolator or it may called as opto-coupler. Where a light source (e.g. LED) and a photo detector (e.g. photo diode, photo transistor, photo voltaic cell etc.) are placed in signal package.
- In a 115 V_{AC} input module isolation separates the high-voltage, 110 V_{AC} input signal from the CPU's low voltage control logic (typically 5 to 18 V_{DC}) depending on the module manufacturer and the type of logic employed.
- Isolation is accomplished by the input signal energizing a light-emitting diode (LED), which transmits a signal of light energy to a receiver in the form of photo conductive diode. Here LED converts the electrical signal to an optical signal and receiver usually a photo-transistor, converts the optical signal back to the electrical signal.
- There is no actual physical or electrical coupling between the sending LED, it's associated input circuitry and the optical receiver and it's low-voltage associated logic circuitry. The signal is transferred by light (photon particles) from the LED.

The logic section :

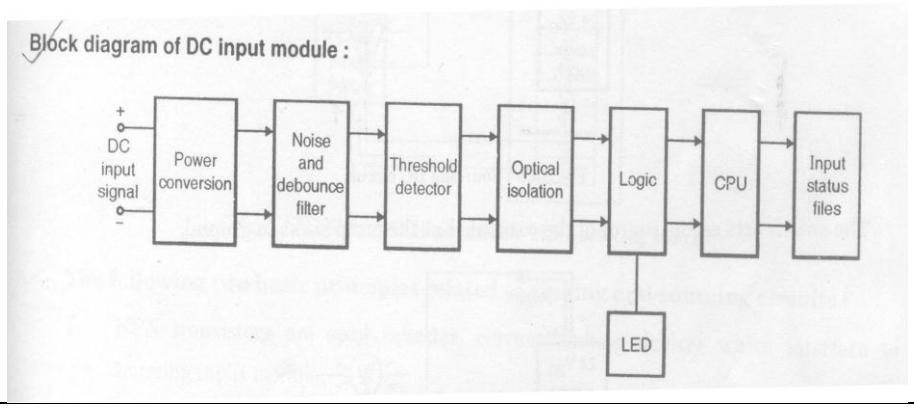
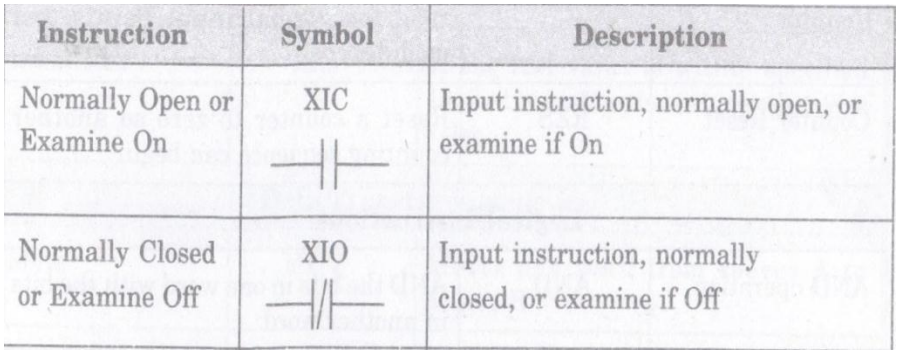
DC signals from the opto-coupler are used by the logic section to pass the input signal to the module's input address LED and the CPU.

Q.2	Attempt any Two		16
a)	i) Draw the PLC ladder diagram for the following electrical ladder diagram  ii) Draw the format of SQI instruction w.r.t PLC. Explain the terms: File, Mask, and Source.		08
Ans.	i)  ii)Format of SQI instruction w.r.t PLC:  **Explain the term:** • File (#B3:5): Location of the reference data file. Symbol indicates that this is user defined file. • Mask (FFF0): fix hexadecimal number is used to represent the mask word. The address FFF0 has binary equivalent of 1111 1111 1111 0000 • Source (I:010): the input image address to be compared against the current step of sequencer file.	**02 Marks for relevant ladder** **03 mark for instruction format & 03 mark for explanation.**	

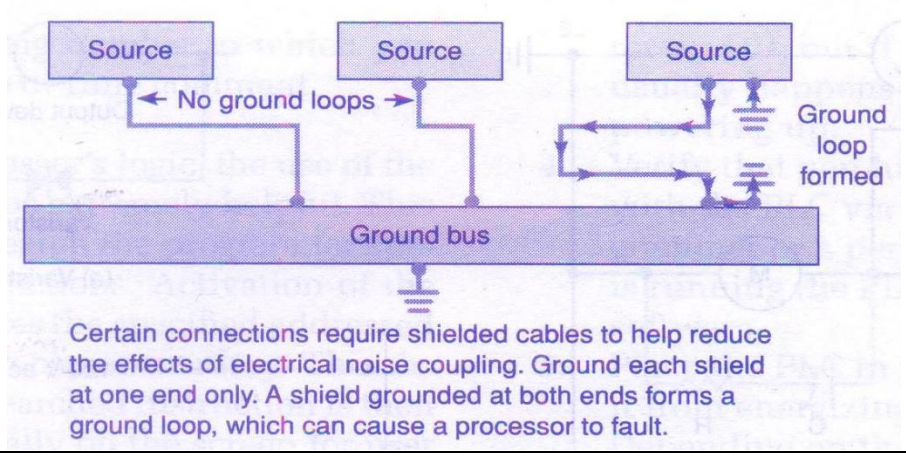
b)	**Draw the ladder diagram for the following condition:** **i. A conveyor belt has a limit switch to count the items on it.** **ii. After 50 items sensed by limit switch, it stops the conveyor and starts the wrapper motor.** **iii. The wrapper motor wraps the 50 items together in 10 seconds.** **iv. The process is started by START push button and stopped by STOP push button. It restarts by RESTART switch.**		**08**
Ans.	**Diagram:**  **Note: Logic relevancy in change of rung may be considered**	**08 Mark for relevant ladder diagram**	
c)	**Write the ladder diagram for an elevator system with the following conditions.** **i. START and STOP push buttons start and stop elevator.** **ii. When UP push button is pressed, the up motion motor M1 is ON until NC limit switch LS2 senses down position.** **iii. Similarly DN push button starts the down motion motor M2 that is ON until NC limit switch LS2 senses down position.**  		**08**

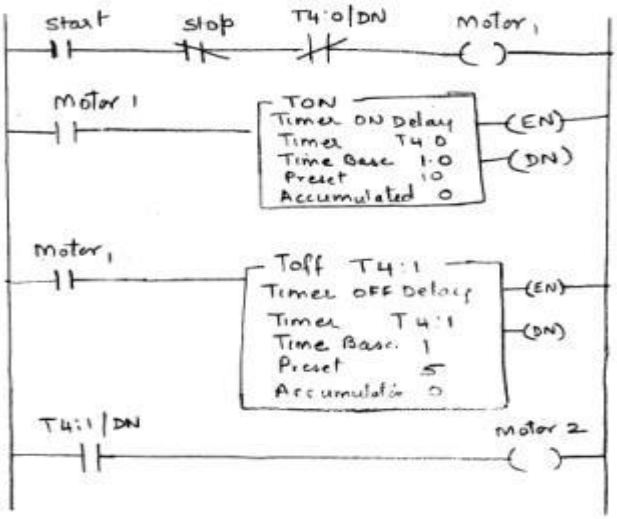
Ans.	**Diagram:**  **Note: Logic relevancy in change of rung may be considered**	**08 Mark for relevant ladder diagram**	
Q.3	**Attempt any Four**		**16**
a)	**Explain the scan cycle of PLC.**		**04**
Ans.	**Diagram:**  **Explanation:** The processor controls the operating cycle or processor scan. This operating cycle consists of a series of operations performed	**2 marks for diagram**	

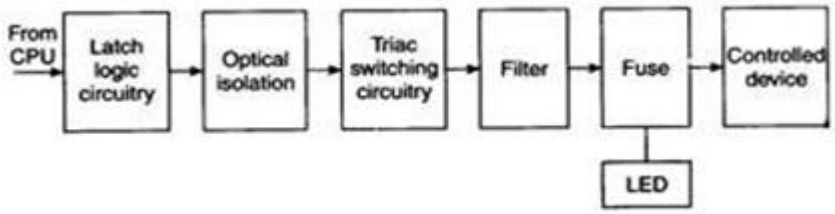
	sequentially and repeatedly. Input scan: During input scan, the CPU scans (examines) the external input devices. The ON or OFF input states are stored in the input status table. Program scan: During the program scan, the processor scans the instructions in the control program, uses the input status from the input status file and determines if an output will or will not be energized Output status: During output scan, the processor writes ON or OFF status, one word at a time, to the associated output module. The operating cycle typically takes 1 to 25 millisecond. The input and output scan are normally short, relative to the time required for the program scan.	**02 marks for explanation**	
b)	**List tools of automation. State any two tools of (automation) it.**		**04**
Ans.	**Tools of Automation:** a) PLC- Programmable Logic Controller b) SCADA – Supervisory control and data acquisition c) DCS – Distributed Control System **PLC- Programmable Logic Controller:** • Relay logic is replaced by PLC for automation in industries. • PLC is a digital system which can store program in memory, it has inbuilt timers, counters, special modules, input/output modules. • PLC can store various parameters like temperature, pressure, flow etc on real time basis. • PLC are robust and are designed for factory environment. PLC can sustain electrical noise, vibration and impact. **SCADA Supervisory:** • SCADA is a supervisory control and Data Acquisition system. • SCADA is basically software which runs on a central PC and connected to different field devices in the factory through the PLC.	**01 mark for List** **03 marks for brief explanation**	

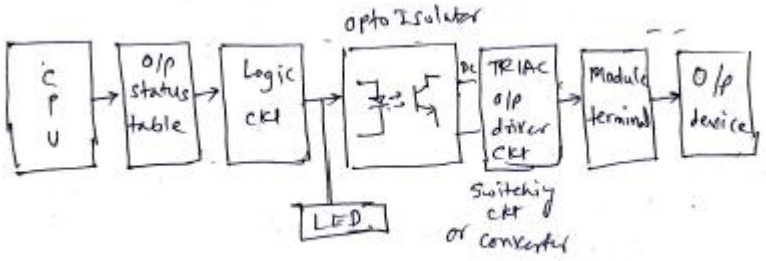
	• It receives signals from the field (input) devices and sends control signals to the field (output) devices. **DCS- Distributed Control System :** • A distributed control system (DCS) is a control system for a process or plant, wherein control elements are distributed throughout the system. • This is in contrast to non-distributed systems, which use a single controller at a central location. In a DCS, a hierarchy of controllers is connected by communications networks for command and monitoring		
c)	**Draw the block diagram of DC input module.**		**04**
Ans.	**block diagram of DC input module:** 	**04 mark for diagram**	
d)	**Explain the instructions:** **i. XIC** **ii. XIO** **Which types of relay contacts use these instructions?**		**04**
Ans.		**2 marks for each instruction**	

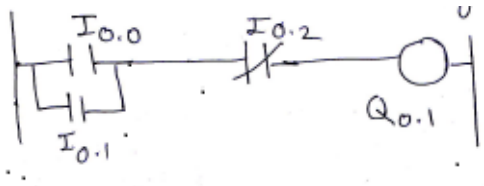
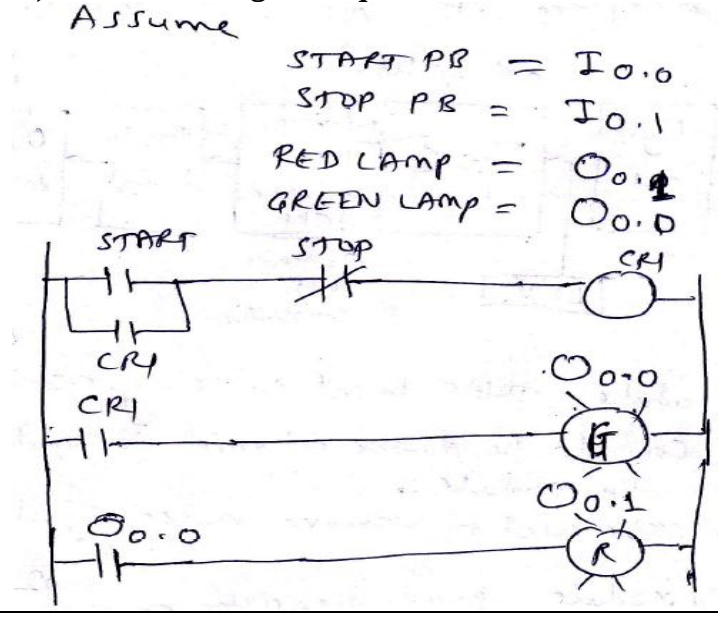
e)	**Explain why grounding is necessary for PLC during installation.**		**04**
Ans.	Proper grounding is an important safety measure in all electrical installations. The authorative source on grounding requirements for a PLC installation is the National Electrical Code. The code specifies the type of conductors, color codes, and connections necessary for safe grounding of electrical components. According to the code, the grounding path must be permanent (no solder), continuous, and able to conduct safely the ground-fault current in the system with minimal impedance. In the event of a high value of ground current, the temperature of the conductor could cause the solder to melt, resulting in interruption of the ground connection. In addition to the grounding required for the controller and its enclosure, you must also provide proper grounding for all controlled devices in your application. The following grounding practices will help reduce electrical noise interference: • All PLC equipment and enclosure back plates should be grounded individually to a central point on the enclosure frame. • Ground wires should be separated from power wiring at the point of entry to the enclosure. • All ground connections should be made with star washers between the grounding wire and lug and metal enclosure surface. • Paint or other nonconductive material should be scraped away from the area where a chassis makes contact with the enclosure. • The minimum ground wire size should be No.12 AWG stranded copper for PLC equipment grounds and No.8 AWG stranded copper for enclosure backplate grounds. • The enclosure should be grounded properly to the ground bus. • The machine ground should be connected to the enclosure and to earth ground. • The ground connection should have a very low resistance. A rule of thumb would be less than 0.1Ωdc resistance between the device and ground.	**04 marks for explanation**	

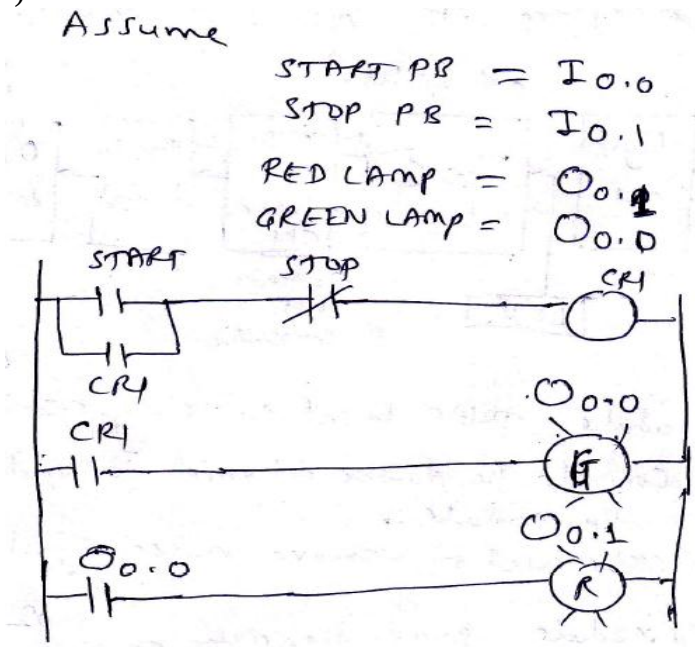
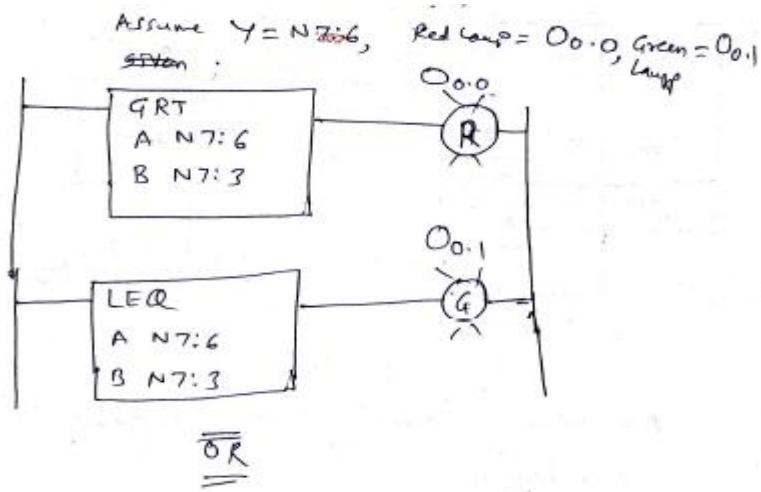
			
Q.4 A	**Attempt any Three**		**12**
a)	**In the given ladder diagram, the alarm is ON for 10 sec. After 10 sec LED is ON. What will be the value of PRE and what are S1, S2 and O1 bits?**		**04**
Ans.	i) Value of PRE is 100 ii) S_1 is Timer T4 Timer – timing (TT) bit iii) S_2 is Timer T4 DONE (DN) bit iv) O1 is ENABLE (EN) bit.	**1 Mark for each**	
b)	**Explain the following specialty I/O modules:** **i. Communication module** **ii. RTD input module**		**04**
Ans.	i. **Communication module: -** The communication modules are used to communicate with programming devices, displays, plant computers, other PLC's. The four common communication modules are ASCII modules, local I/O adapter modules, the serial data modules, network interface modules. ii. **RTD input module: -** This module interfaces RTD's to a PLC and other types of resistance input devices such as potentiometers. It consists of bridge circuit filter, amplifier, and isolator circuits.	**2 marks for each**	
c)	**Draw the ladder diagram to start 'motor 1' when 'start' button is pressed. After 10 sec motor 2 will be ON, 'stop' switch stops 'motor 1' and 5 sec later 'motor 2' stops.**		**04**

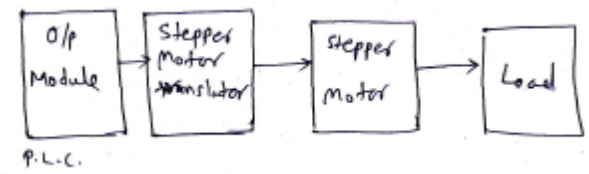
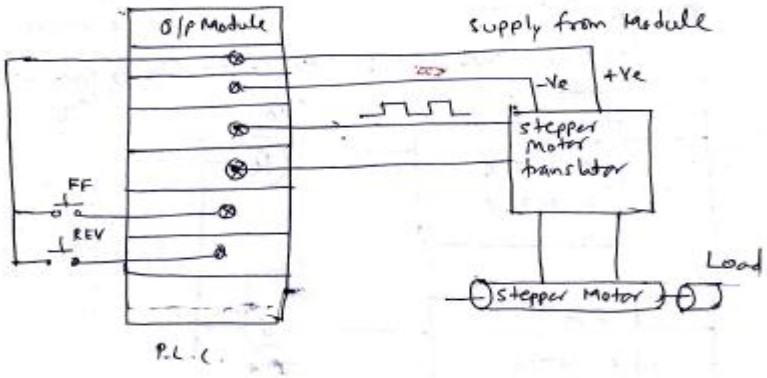
Ans.	**Diagram:**  	**04 marks for relevant diagram**	
d)	**Explain how faulty LEDs of I/o modules are detected.**		**04**
Ans.	• PLC manufacturer usually provides LED status indicator for every input and output terminals • There is a LED for power indication. It will be illuminated when power is ON otherwise it is off • When supply is ON but power indicator LED is OFF, it means there is a problem in power supply • Mode indicator LEDs are also on PLC which indicates the program or run mode of the PLC • For input status LED when there is a input high signal at input terminal then this LED is ON it indicates that valid input is arrived. For low input signal this LED turns OFF • If the output LED is on and the output devices is not on, test for power at the suspected output terminals. If there is a power at output terminal, the PLC is functioning. • If power is not present on PLC output terminal, the PLC has failed and must be replaced. • Next test for power at nonfunctioning output device. If there is a power at the output terminal then the device is faulty and should be fixed or replaced	**4 marks for explanation**	

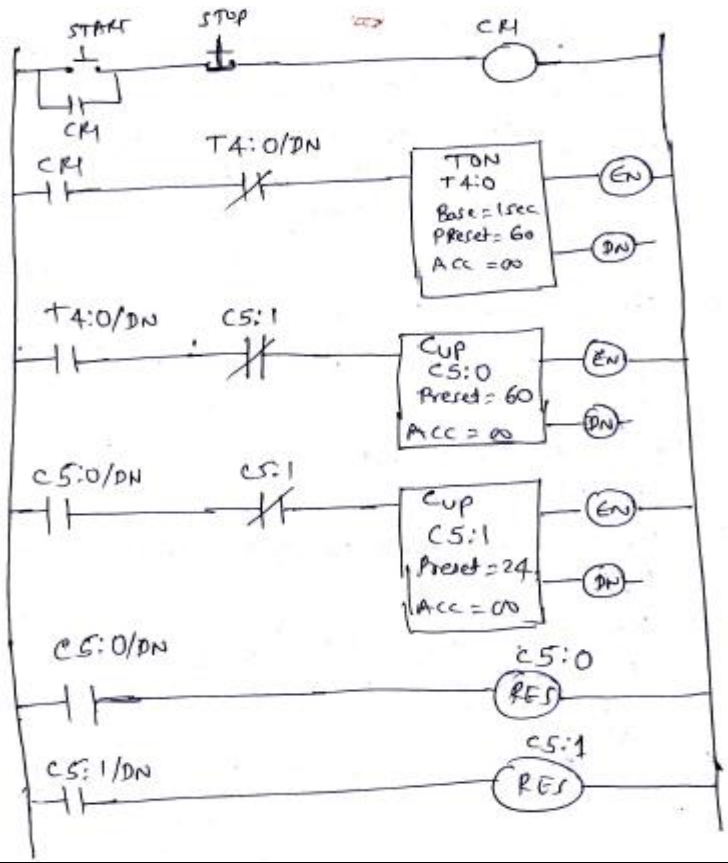
Q.4 B	Attempt any One		06
a)	**Name any six types of switches used as input devices with respect to PLC**		06
Ans.	**Types of switches used as input devices with respect to PLC:** 1. Pressure switch 2. Level switch 3. Float (liquid level) switches 4. Hall devices 5. Magnetic sensitive switches 6. Photo electric system 7. Inductive sensitive switches 8. Single pole single throw switches 9. Single pole double throw switches 10. double pole double throw switches 11. Push button 12. Proximity switches 13. Selector switches	**06 mark for any 6 type**	
b)	**Draw the block diagram of analog output module and explain.**		06
Ans.	**Analog output module :**  **Explanation:** Analog output modules accept 16 bit output status word, which they convert to an analog value through a digital to analog converter. The converter is a part of the electronics inside the analog output module. Typical analog signals are 0 to 10 V DC, -10 to 10 V DC, 0 to 5 V DC, 1 to 5 V DC, 0 to 20 milliamps, -20 to +20 milliamp or 4 to 20 milliamps. Analog output modules are selected to send out either a varying current or voltage signal. An analog output sends a 4 to 20 milliamp signal to variable speed drive. The drive will control the speed of a motor in proportion to the analog signal received from the analog output module.	**03 mark for diagram** **03 mark for explanation**	

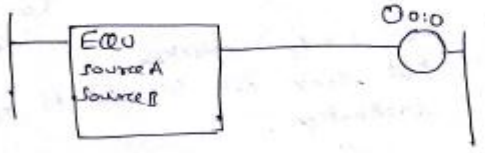
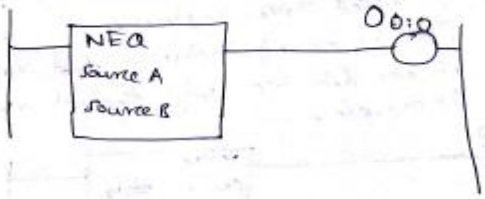
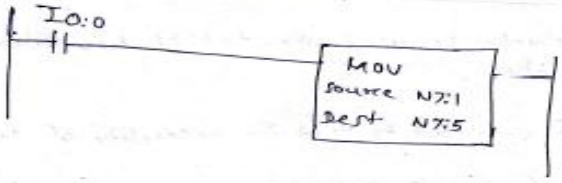
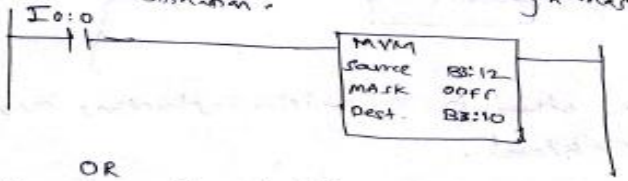
	An analog valve can provide precise control. An analog output module could output a 0 to 10 volt signal to an analog valve to provide the needed control. The output signal can be divided into 32,767 increments and represented in a 16-bit word. Output module automatically converts the 1-bit output word to the proper analog voltage, the programmer only has to output the desired decimal integer value to the output status file. The above figure shows value position variations with analog signals and its decimal equivalent. **OR** Analog output modules receive data in digital form and convert it into voltage or current to control the analog device. The binary numbers are converted into analog voltage or current by the digital to analog converter. Analog output module accept a 16 bit output status word, which the convert to analog value through a digital to analog converter. Typical analog signals are 0 to 10 V DC, -10 to +10 V DC, 0 to 5 V DC, 0 to 20 mA, -20 to +20 mA, or 4 to 20 mA. Analog output modules are selected to send out either a varying current or voltage signal. Each value of current or voltage will represent a particular operation. Ex. If the speed of DC motor is to be varied over a range of 1000-3000 rpm, the voltage of an output module of range 0-1 V DC will represent a specific speed over the range		
Q.5	**Attempt any Two**		**16**
a)	**Draw the block diagram of AC output module. Which devices are used as switching circuit and filter and why? Which device is used as switching device in DC output module?**		**08**
Ans.	**Block dig of AC O/P Module:** 	**04 marks For diagram**	

	• In this module TRIAC based switching ckt is used and peak voltage detector ckt is used as filter ckt because TRIAC ckt controls power delivered to o/p device and filter ckt reduces noise signal and gives appropriate voltage to device. • IN DC o/p Module power transistor or relay is used as switching device.	**02 marks for switching ckt and filter** **02 marks for switching device**	
b)	**i. Write the ladder program for the following instruction list program:** **LD $I_{0,0}$** **OR $I_{0,1}$** **ANN $I_{0,2}$** **ST $Q_{0,1}$** **ii. Write a ladder program for sequential ON/OFF control lamps.**		**08**
Ans.	**i) Ladder dig for given IL program:**  **ii) Ladder dig for sequential ON/OFF control of Lamp:** 	**04 marks For relevant ladder using given instructions** **04 marks**	

c)	**Write the program for following conditions:** **i. Calculate the output y= A^B + tan C** **Where A= N7:0, B= N7:1 , C= N7:2** **ii. If Y>N7:3 switch ON red LED** **If Y<= N7:3 switch ON green LED**		**08**
Ans.	i)  ii)  OR Any other relevant ladder diagram may be considered.	**04 marks for relevant diagram** **04 marks for relevant diagram**	

Q.6	Attempt any Four		16
a)	Draw the block diagram of stepper motor control module.		04
Ans.	**Block dig of stepper motor control module:**  **OR**  OR Any other relevant block diagram may be considered	**04 marks for block diagram with labeling**	

b)	**Develop ladder diagram for 24 hours day time clock.**		**04**
Ans.		**04 marks for ladder dig of 24 hrs delay time clock**	
c)	**What are the important guidelines for maintenance of PLC?**		**04**
Ans.	Guidelines for maintenance of PLC • Periodically check the tightness of I/O Module terminal screws. They can became loose over period • Periodically check for corrosion of connecting terminals. moisture & corrosion atmospheres can cause porr electrical connections • Make sure that components are free of dust • Stock commonly needed spare parts • Keep duplicate record of operating programs being used • Replace the PLC batteries used for backup in time • Have a written check list , control list for each PLC Keep additional check list for each PLC with records of what , who , when should be kept	**01 mark for each point (max 04 marks)**	
d)	**State any:** **i. Two comparison instruction** **ii. Two data handling instruction used in PLC**		**04**

Ans.	(a) EQU (Source , source) or ---01 Mark  This instruction is used when to test two values for equality. (b) NEQ :- Used to test for inequality of two values. NEQ (Source, source) or ---01 Mark.  OR any other OR comparision instructions may be Considered. ① MOV :- It is o/p instruction that copies data file word to specified destination.  ② MVM :- Masked Move instruction. ---01 Mark This is an o/p instruction that moves a copy of one data file word through mask to destination.  OR Any two data handling instructions of PLC may be Considered.	**01 marks for each instruction (max 02 marks)** **01 marks for each instruction (max 02 marks)**	

e)	**Explain the method of detecting fault in ladder program in PLC.**		**04**
Ans.	Many PLC gives inbuilt simulation for ladder program In This simulation tool user can see the real time status of all i/p's and o/P devices on screen For example i/p switch is pressed but not showing as pressed or logic '1' Then it means there is problem with switch or its connection with i/p terminal. Also in many PLC FORCE mode is used to find fault in ladder program. In Offline user forcefully make i/p status to '0' or '1' and check working of ladder program.	**04 marks for explanation**	