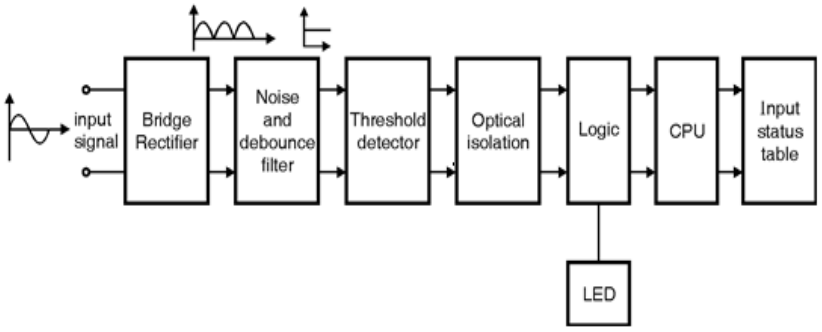
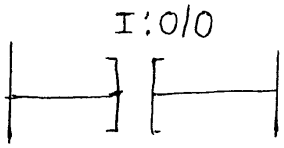
Important Instructions to examiners:

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 asses understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance. (Not applicable subject English and Communication Skills.)
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figure 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. No.	Question & Answer	Remark	Total Marks
Q1 A	**Attempt any THREE**		**12**
(a)	**Define automation. State need of automation**		**04**
Ans.	**Definition:** The technology which can perform all processes or system to operate automatically (without manual operator) is called Automation. **OR** The technique consist of mechanical, electrical, control system with base applications from physics to operate process or system without manual operator is called as Automation. **OR** **Any other relevant definition shall be considered** **Need of Automation in process : (Any THREE points)** • To fulfill the demand of product at right time. • To reduce the human errors and involvement of human being in the process. • For better productivity. • For better control of process. • For better quality . • For reducing man power. • For reducing cost of product. **Note : Any other relevant points should be considered**	01 mark for Definition 01 mark for each point	
(b)	**Draw block diagram of AC input module of PLC and write function of threshold detector block.**		**04**
Ans.			

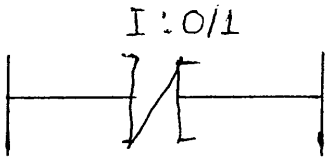
	 **Function of Threshold detector block:** • Threshold detection circuitry detects whether the incoming signal has reached or exceeded a predetermined voltage level for a predetermined time and whether it should be classified as a valid ON or OFF signal. • A typical valid OFF state is below 0 and 20 or 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 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.	02 mark for diagram 02 mark for function	
c)	**Describe functioning of NO, NC, Latch and Unlatch instructions with their symbols.**		**04**
Ans	1) NO (Examine if Closed)		



01 mark

- Examines a bit for an On condition
- Use the XIC instruction in your ladder logic to determine if a bit is ON.
- 0 = False
- 1 = True

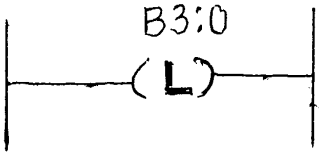
2) NC (Examine if Open)



01 mark

- Examines a bit for an off condition.
- Use an XIO instruction in your ladder logic to determine if a bit if off.
- 1 = True
- 0 = False

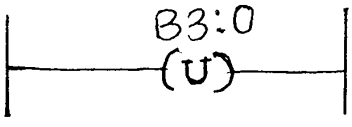
3) OUTPUT LATCH



01 mark

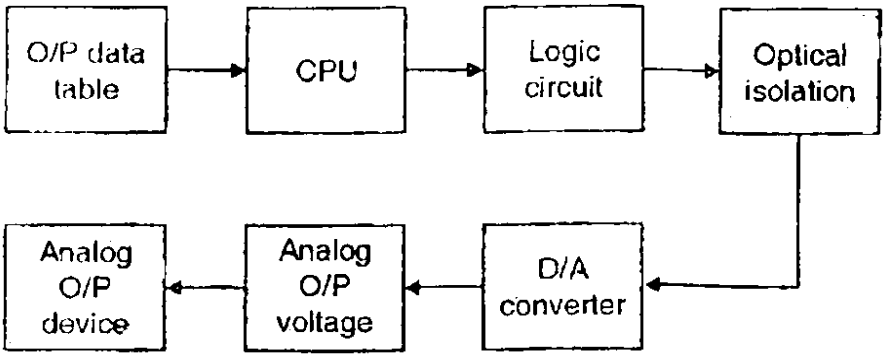
- Turns a bit on when the rung is executed, and this bit retains its state when the rung is not executed or a power cycle power occurs.

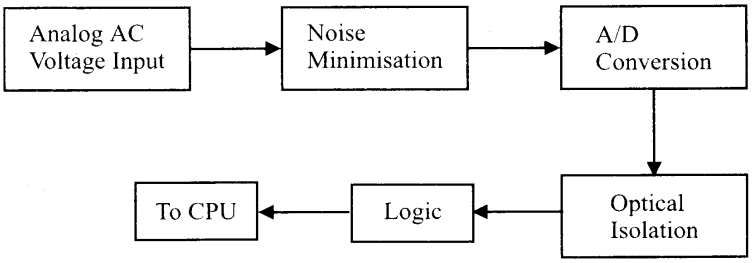
4) OUTPUT UNLATCH



01 mark

- Turns a bit off when the rung is executed, and this bit retains its state when the rung is not executed or when power cycle occurs.

d)	**Draw labeled block diagram of analog output module**		**04**
Ans	**Block diagram of analog output module** 	04 Marks for labeled diagram	
B)	**Attempt any ONE**		**06**
a)	**i)Enlist advantages of PLC over relay logic** **ii)Enlist any four output devices used with PLC. And state their uses**		**06**
Ans	**i) Advantages of PLC over relay logic: (Any three)** 1. PLC are more flexible than relay logic circuit 2. PLC offer easy troubleshooting and correcting any errors. 3. PLC are designed for high speed and real time applications. 4. Power required for PLC is less than relay control logic. 5. PLC is more reliable than relay and life is more than relay. 6. PLC system has less downtime than relay logic . 7. Internal memory available in PLC system and not in relay logic. 8. PLC system are quickly reprogrammable over relay logic. 9. Maintenance cost of PLC is less than relay logic. **ii)Output devices used with PLC: (Any two)** 1.Motor 2.Solenoid 3.Output relay 4.Timers 5.Heating devices 6.Alarms 7.Indicator Lamps. **Uses of Output devices: (Any one)** 1. These are used to produce actual work output. 2. Output relay are used in control system. 3. Relay is used as power switch.	01 Mark for each advantage 01 Mark for each Output device 01 Mark	
b)	**Draw neat block diagram of analog input module and explain, enlist its two specifications**		**06**
Ans	**Diagram of analog input module**	02 Mark	

	 **Explanation:-** Analog input module interface a PLC to analog input signals. It gives ability to PLC to monitor a continuously changing input signals such as pressure, temperature, flow etc. The module converts analog input signals to 16 bit binary values storage in the processor's input status table. Analog modules are designed to accept current and voltage signals such as 0-10 Vdc,-10-10 Vdc,0-5Vdc and 0-20mA,4-20mA,-20 -20mA etc. When signal reaches an input module,it is rich in different noise signals. The signal is freed from noise through noise minimization circuits. The signal is then digitized and sent to logic section through an isolation circuit. The logic section allows the digitized signal to go to the CPU following the predetermined logic. **Specification of analog input module: (Any two)** • i/p accepted signal levels are 0 to 10V dc, -10V to +10 V dc, 4 to 20 mA • Module with 2 ,4, 8 differential of voltage or current • Module with 2 ,4, 8 selectable of voltage or current • Module with 16 single ended for voltage or current • ADC with 14 bits • ADC with LSB resolution for voltage i/p 305 microvolt **OR** **Any other relevant specification shall be considered**	for diagram 02 Mark for explanation 01 Mark for each Specification	
2)	**Attempt any TWO**		**16**
a)	**i)Give detailed classification of PLC programming languages** **ii)Explain sequencer instruction with example.**		**08**
Ans	**i)PLC programming languages:**		

- This standard specifies five languages divided into two parts namely- graphical languages and text-based languages.

A) Graphical languages :

i) Ladder Logic Diagram (LD)

ii) Function Block Diagram (FBD)

iii) Sequential Function Chart or Grafcet (SFC)

B) Text-based languages :

i) Instruction List (IL)

ii) Structured Text (ST)

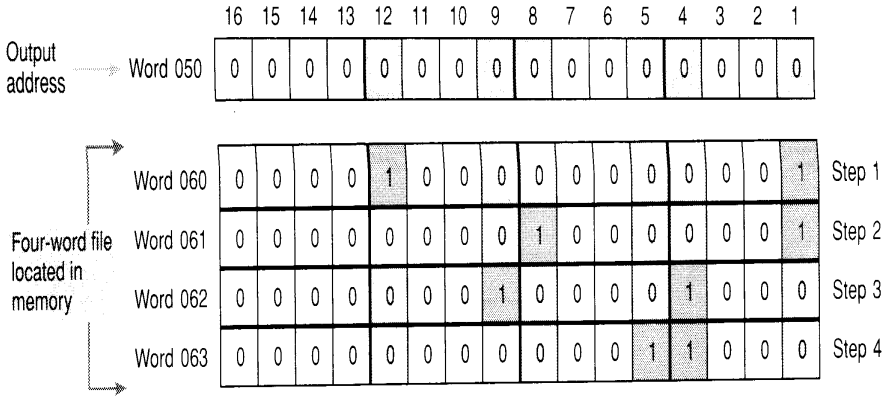
04 Marks for classification

ii)Description of Sequencer instruction with example.

PLC sequencer replaces the mechanical drum sequence that was used to control the sequences of repeatable operations.It acts as pointer and points one of the word from block of data words stored in memory. It fetches the words one at a time from memory and transfer or move to another memory or to the output.When block of data is finished the PLC sequencer again point the first word from the block and process begins again.

04 Marks For description

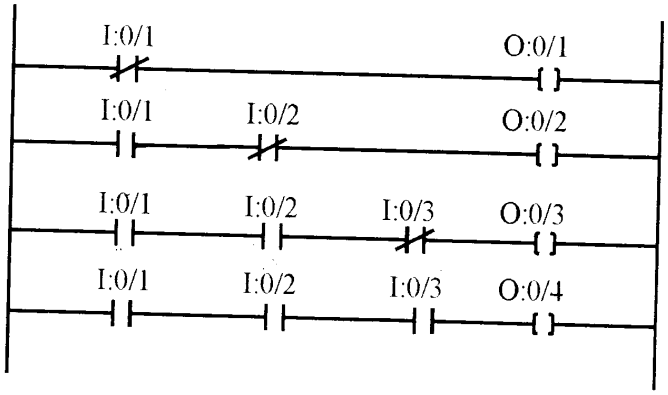
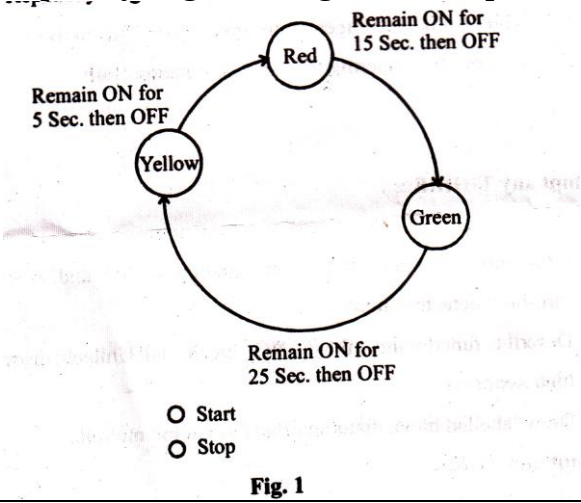
Traffic light controller is a simple example of sequencer which is controlled with electronics and PLC sequencer output.16 lights are used for output.each light represent one bit address of output word 050.the lights are programmed in a four step sequence to simulate the operation of two way traffic light .Data are entered into word file for each sequencer step as shown fig.

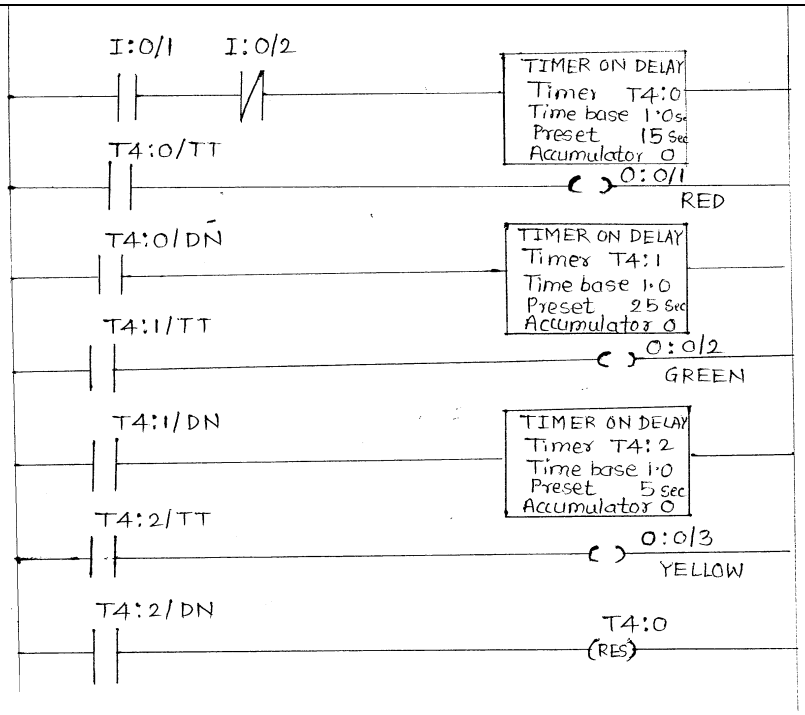


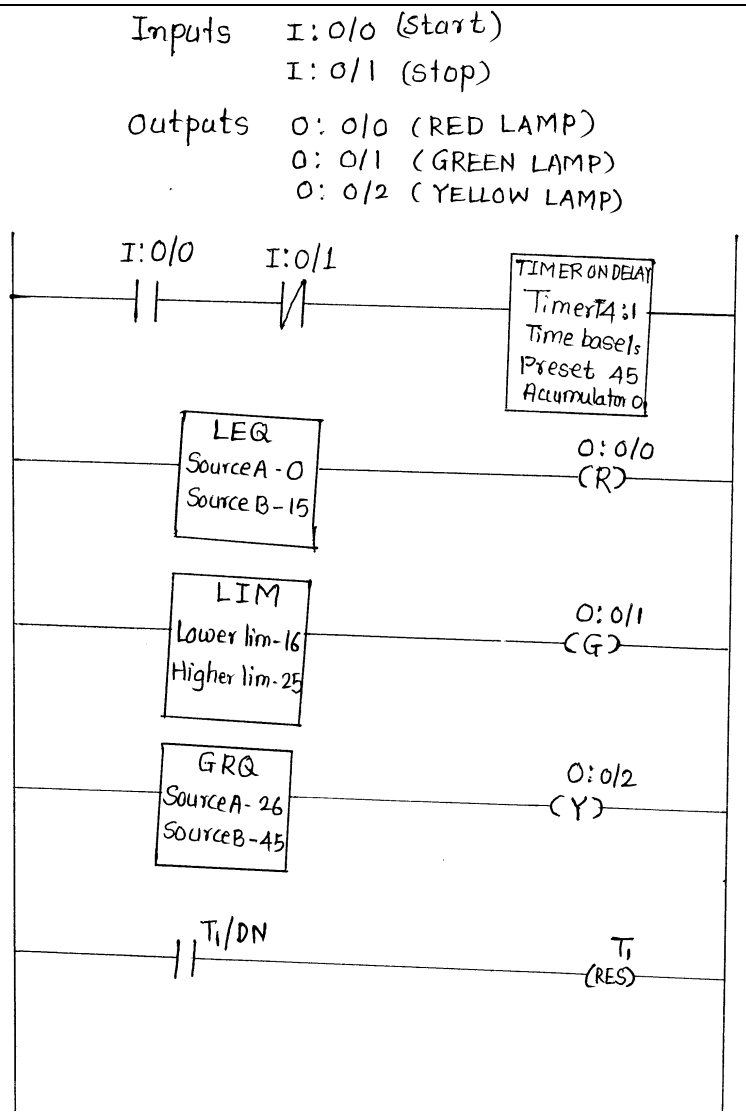
	When sequencer is activated and advanced to step 1 the binary information in word 060 of file is transferred into word 050 of output as a result light 1 and 12 are switched ON and rest remains off.Advancing the sequencer to step 2 will transfer the data from 061 to word 050,as aresult lamp 1 and 8 will be on and all the rest will be off and thus advancement in step 3 and step 4 is followed and finally when last step is reached,the sequencer is either automatically or manually reset to step 1. **OR** **Any other sequencer instruction SQI/SQL/SQO with example should be considered**		
b)	**A railway station has 3 platforms A,B and C. One train is coming into station. The entry to this train is given to platform A if platform A is empty, if both platforms A and B are occupied then it has to be given entry to platform C, if all platforms are full then train has to wait. Design necessary ladder diagram with proper assumption and truth table.**		**08**
Ans	The input signals with address are as follows, Ta- Train present at A => I:0/1 Tb - Train present at B => I:0/2 Tc - Train present at C => I:0/3 The outputs with address are as , Pa – Go to platform A => O:0/1 Pb- Go to platform B => O:0/2 Pc - Go to platform C => O:0/3 W –wait => O:0/4	02 marks Proper I/O Assumptions(addressing)	

Input Ta	Input Tb	Input Tc	Output Pa	Output Pb	Output Pc	Output W
0	1	1	1	0	0	0
1	0	1	0	1	0	0
1	1	0	0	0	1	0
1	1	1	0	0	0	1

02 marks for truth table

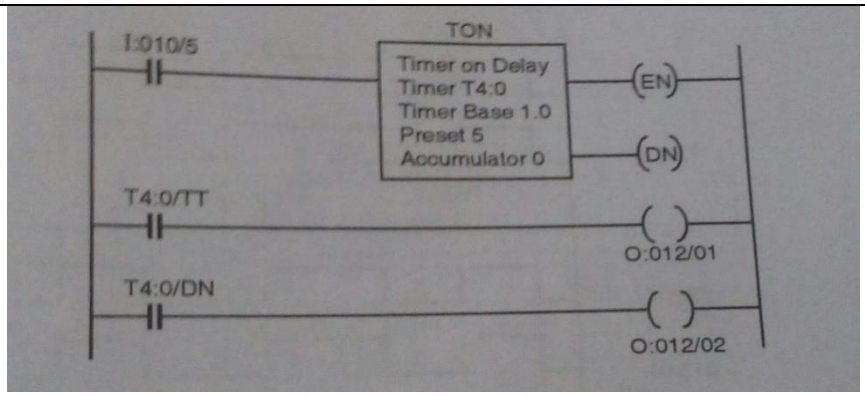
	Ladder diagram:  **OR** **Any other relevant ladder diagram shall be considered**	04 marks for ladder diagram	
c)	**Design a traffic light control program with following conditions:** (1) **Two inputs – START & STOP (Both push buttons)** (2) **Three outputs –Red ,Green and Yellow lamps** (3) **Repeat cycle given in fig.1 until, stop button is pressed.**  **Fig. 1**		**08**
Ans	No of Inputs Start - I:0/0 Stop - I:0/1 No of Outputs RED Lamp - O:0/0 GREEN Lamp - O:0/1 YELLOW Lamp - O:0/2	02 Marks for I/O addressing	

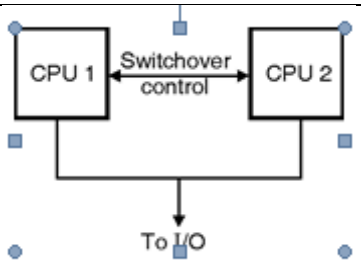
	 **OR**	06 marks for ladder diagram	

	 **OR** **Any other relevant ladder diagram shall be considered**		
Q.3	**Attempt any FOUR:**		**16**
a)	**State classification of PLC based on type and size.**		**04**
Ans	**Classification of PLC based on type and size:** PLC : - A) Micro PLC (Fixed I/O) B) Modular PLC: - i) Small PLC ii) Medium iii) Large	04 Marks for classification	
b)	**Enlist any four automation tools used in process. Explain DCS.**		**04**
Ans	**Automation tools used in process : (Any two)** 1) PLC 2) SCADA	01 mark for each point	

	3) HMI 4)DCS 5)CNC 6)DNC **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	02 marks for explanation	
c)	**Give specifications of AC and DC input modules (2 each).**		**04**
Ans	**Specification of AC i/p module at rated 120V AC: (Any two)** 1)Input per module-32(8 group of four) 2) Voltage range- 85 to 135 Vac , 50/60 Hz 3) I/P voltage -120Vac 4) I/p current- 8.8 ma@ 115v,50Hz 5)Minimum on state current- 4.2ma @85Vac, 50Hz 6)Minimum off state current- 1.9ma@30Vac,50Hz 7) Power dissipation-4.5w(max),1.0w(min) **Specification of DC i/p module at rated 24V DC: (Any two)** 1) Rated voltage and current - +24V DC at 4mA 2) Specified operational voltage range - 0- +30V DC 3) Absolute maximum i/p voltage- +35V DC for 0.5 sec. 4) Signal Delay -5 millisecond (ON to OFF or OFF to ON) 5) Input power – 0.2 Watts/point at 24V DC. **OR** **Any other relevant specification shall be considered**	01 marks for each specification 01 marks for each specification	
d)	**For timer instruction, if addressing is** **T4 : 1/DN, what does T4, :, 1, / and DN indicates.**		**04**
Ans	**T4:1/DN**, This bit indicates **T4** = timer file no.**4**, **1** =timer **1** ,it stores timer information **:** =Element Delimiter **/** = Bit Delimiter **DN** = Done bit	01 mark For each point (4 marks maximum)	
e)	**Enlist any four parameters to be considered while PLC installation. Describe grounding.**		**04**
Ans	Parameters to be considered while PLC installation: **(Any two)**	01 marks for each point	

	• Verify safety circuits correctly in PLC applications to protect people and equipment • Prevent noise, heat, and voltage variations from ruining your PLC System • Implement a step-by-step static and dynamic start-up checkout to guarantee smooth PLC system operation • Verify that all I/O wiring connections at the controller end are in place and securely terminated. • Inspect all CPU components and I/O modules to ensure that they are installed in the correct slot locations and placed securely in position • Visually inspect the system to ensure that all PLC hardware compo-nents are present. Verify correct model numbers for each component • Easy accessible of PLC for maintenance **Grounding:** 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 application.	02 marks for description	
Q.4 A)	**Attempt any THREE:**		**12**
a)	**Draw functional block of on- delay timer instruction, state function of** **(i) Enable bit (EN)** **(ii) Done bit (DN)** **(iii) Timing bit (TT)**		**04**
Ans	ON Delay timer:	01 mark for format	

	 **OR** **Any other relevant functional block shall be considered** **Functions of parameters:** i)EN : Enable bit-This bit is set ,when input to timer is true. Indicates timer operation has begun. ii) DN : Done bit-This bit is set, when accumulator value becomes equal to preset value and then respective output becomes ON. Indicates timing operation is complete. iii) TT: Timer timing bit- This bit is set when timer is running . Indicates timing operation is running	01 mark 01 mark 01 mark	
b)	**Describe term Redundancy, list its types.**		**04**
Ans	**Description of Redundancy :** • Redundancy means extra system components or mechanisms added to decrease the chance of total system failure. • Different types of redundancy are available in PLC like redundancy for a CPU module, power module, bases and communication module is available. • CPU redundancy system is composed of separate bases for ideal redundancy structure. • In case an error occurs in an active CPU module, a backup module is automatically converted to active one for continuous operation. • In these cases two processors can be tied into one I/O system and some means is provided that switches control from the failure CPU to the backup when a failure CPU to the backup when a failure occurs as shown in Fig.	03 marks for description	



- The working of total system is reliability of its operation.
- The safety of critical load is increased by transferring it from a failed power module to an alternative source of power.
- Thus, reliability can be increased by selective use of redundancy.

Types of Redundancy:-

i)Redundancy for CPU
ii) Redundancy Power supply module
iii) Redundancy for basic and communication module

OR

a)Hot Redundancy
b)Warm Redundancy
c) Cold Redundancy

OR

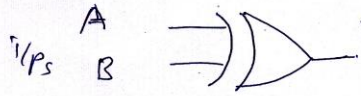
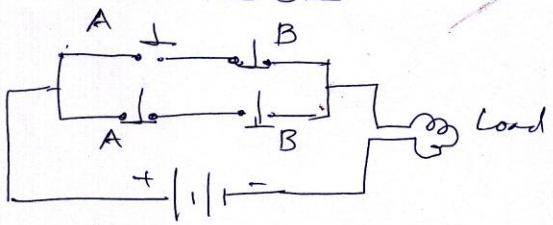
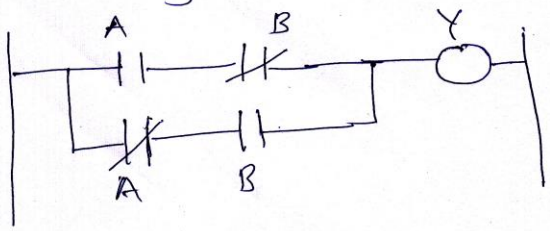
1) Separate mode
2) Shadow mode
3) Split mode
4) Voting mode

01 mark for list

c) **Draw symbol, Boolean equation, electrical and ladder diagram from given truth table.** **04**

Input		**Output**
A	**B**	**Y**
0	**0**	**0**
0	**1**	**1**
1	**0**	**1**
1	**1**	**0**

Ans

	* Symbol:- As per given T-T., it is EX-OR Gate.  Two i/p EX-OR Gate (symbol) * Boolean equation for given truth table. $Y = A \cdot \bar{B} + \bar{A} \cdot B$ * electrical diagram :-  * Ladder diagram for given T.T.  	01 mark for symbol 01 marks for Boolean equation 01 mark for electrical diagram 01 mark for ladder diagram	
d	**What are the guidelines to maintain PLC in good running condition?**		**04**
Ans	**Guidelines for maintenance of PLC: (Any four)** 1) Periodically check the tightness of I/O Module terminal screws. They can became loose over period 2) Periodically check for corrosion of connecting terminals. moisture & corrosion atmospheres can cause porr electrical connections 3) Replace the PLC batteries used for backup in time 4) Have a written check list , control list for each PLC 5)Make sure that components are free of dust 6) Stock commonly needed spare parts 7) Keep duplicate record of operating programs being use **OR** **Any other relevant guidelines shall be considered**	01 marks for each point	

Q.4 B)	**Attempt any ONE:**		**06**
a)	**Explain the term 'speed of execution' with proper example.**		**06**
Ans	This is one of the characteristics of PLC "Speed at PLC scans memory and executes instructions is speed of execution" • A period between one I/O update and the next is termed as "One scan" • Time taken by PLC to update one of I/O terminal is Scan time • Scan time is generally measured in msec. • Speed of execution depends on speed of CPU, length of ladder diagram, types of instruction used in program. • Slower the CPU speed or longer the ladder diagram, takes more time to execute the program **For example.** • In AB SLC 500 PLC • For execution of XIO , XIC takes 4 microsecond for true and false of instruction • But for OTE instruction 18 microsecond are required • If ladder diagram is with XIC, OTE then total time required to execute the program is 22 microsecond	03 marks for description 03 marks for example	
b)	**Describe criteria on which input/output modules are selected.**		**06**
Ans	**Criteria's for selection of I/O module: (any six)** • Number of analog and digital inputs • Numbers of analog and digital outputs • Type of isolation in I/O module • Sourcing and sinking type of I/O terminals • DC voltage and current ratings for discrete i/p modules • DC voltage and current ratings for discrete o/p modules • Resolution of analog i/p module • Resolution of analog o/p module • Power supply voltage • Type of I/O signals –temperature, pressure, speed control etc	01 mark for each point	
Q.5	**Attempt any TWO:**		**16**
a)	**Draw neatly and explain sourcing and sinking I/O modules in detail.**		**08**
Ans	**Sourcing output module:**	02 marks for sourcing o/p module.	

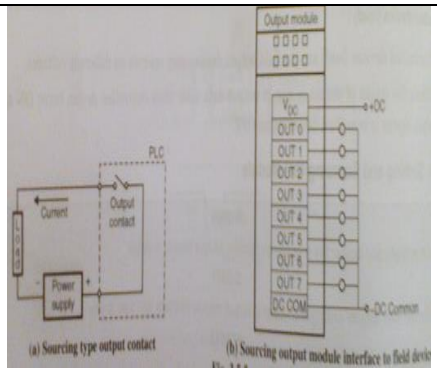
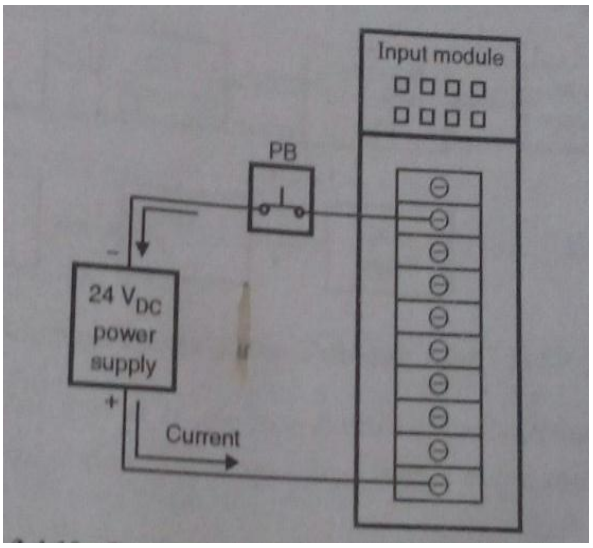


Fig –Sourcing o/p module interface to field devices.

The interface diagram of PLC as output module is shown in above fig. 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.

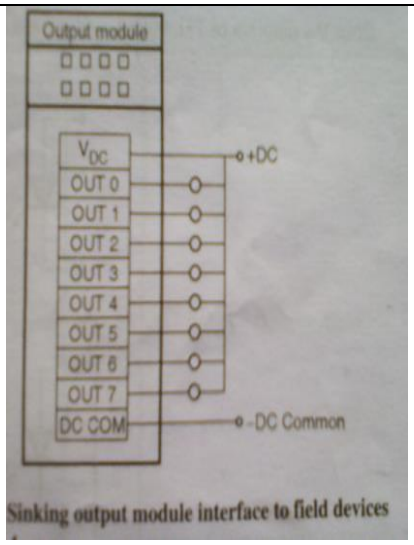
Sourcing input module:

The interface diagram of PLC input module as sourcing is shown in figure. In operation ,PLC input module as sourcing, current from power supply first flows from input module to load and then to common terminal so the input module acts as source of current .



02 marks for sourcing i/p module.

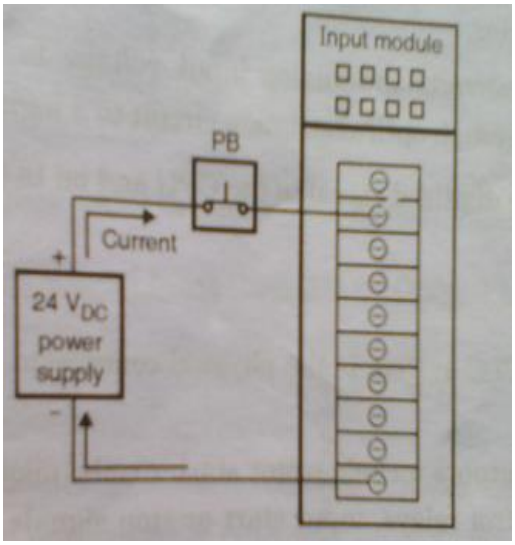
Sinking Output Module:



Figure, Shows sinking o/p module where current from positive terminal of DC power supply flows first from o/p device to o/p module and then to common terminal. So here, output module is sinking current from output device so it is sinking output module.

02 marks for sinking o/p module.

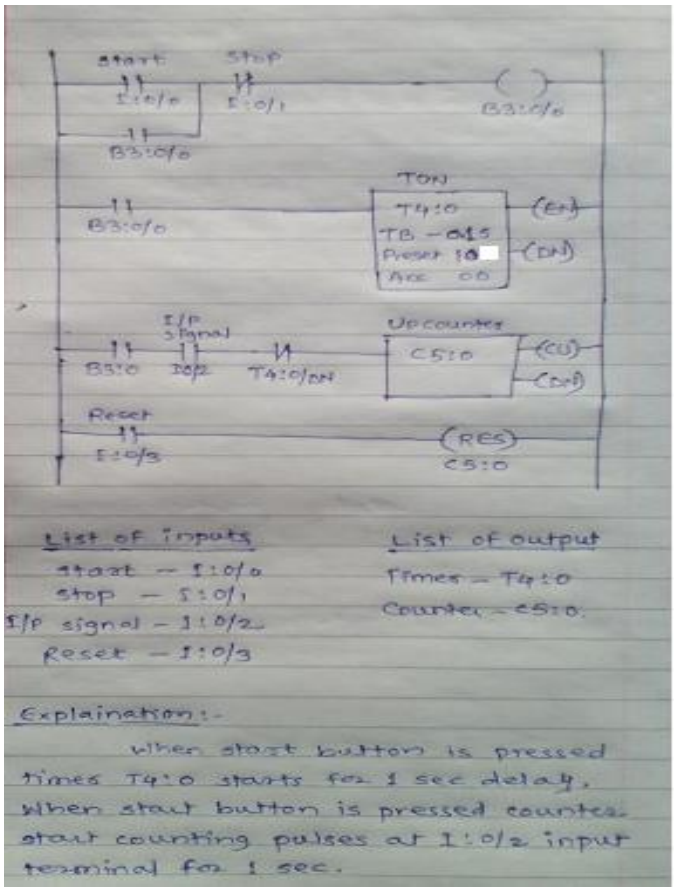
Sinking Input Module:

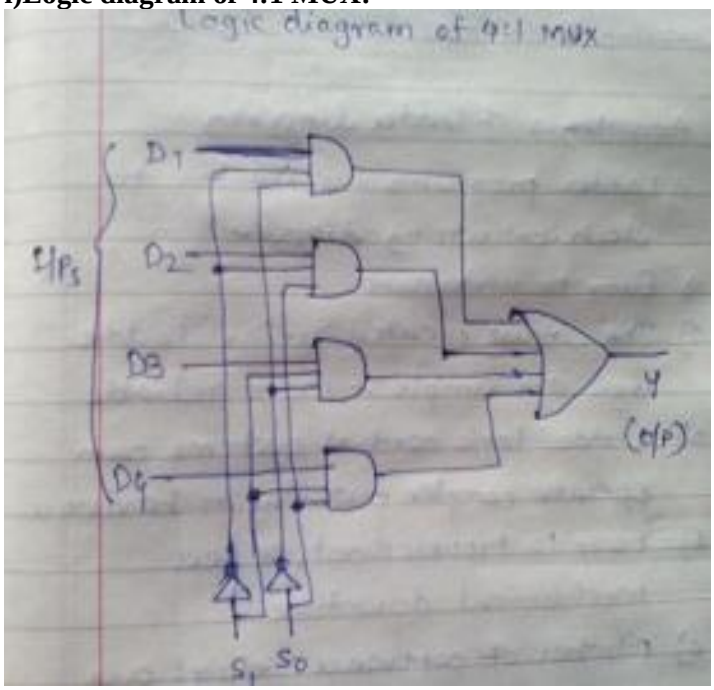
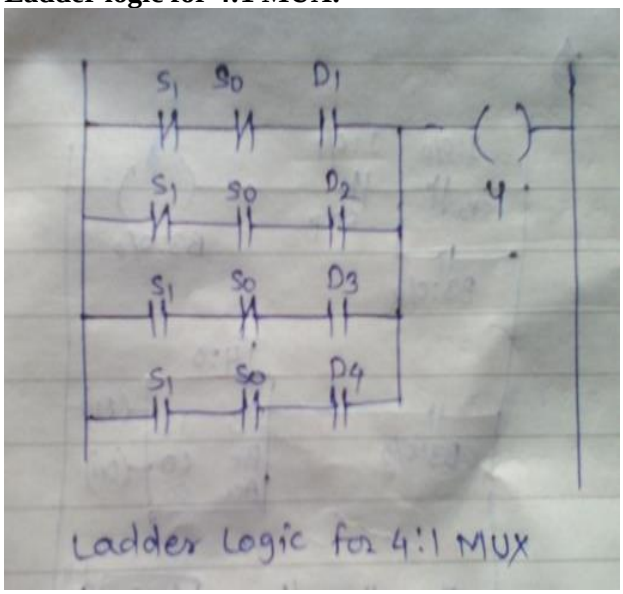


Figure, Shows sinking i/p module where current from positive terminal of DC power supply flows first from i/p device to i/p module and then to common terminal. So here, input module is sinking current from input device so it is sinking input module.

02 marks for sinking i/p module

b)	**(i) Enlist four advantages of ladder programming.** **(ii) Write PLC ladder program to measure frequency of events using**		**08**

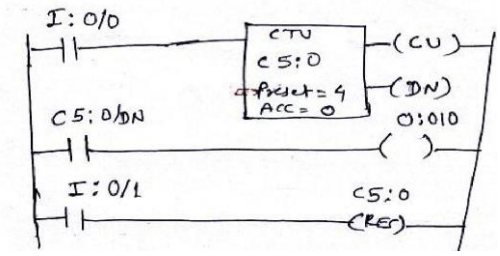
	timer and counter and explain it.		
Ans	**i) Advantages of ladder programing:- (Any four)** 1]Ladder programs are similar to electrical wiring diagram 2]Easy to understand. 3]The circuit created using ladder logic are simple and more reliable. 4]Ladder logic control system can operate complex automation hardware. 5]Easy to troubleshoot so less mechanical down time. 6]Number of software relays are available, so reduces hardware. **OR** **Any other four relevant points should be considered.** **ii)**  So after 1 second counter stop counting the pulses and it shows number of pulses within 1 second of input signal i.e. the frequency of input signal which is to be measured. **OR** **Any other relevant ladder diagram shall be considered**	01 mark for each advantage 03 marks for ladder diagram 01 marks for explanation	
c)	**(i) Draw logic diagram and PLC ladder diagram for 4:1 multiplexer.** **(ii) Write Boolean equation and truth table**		**08**

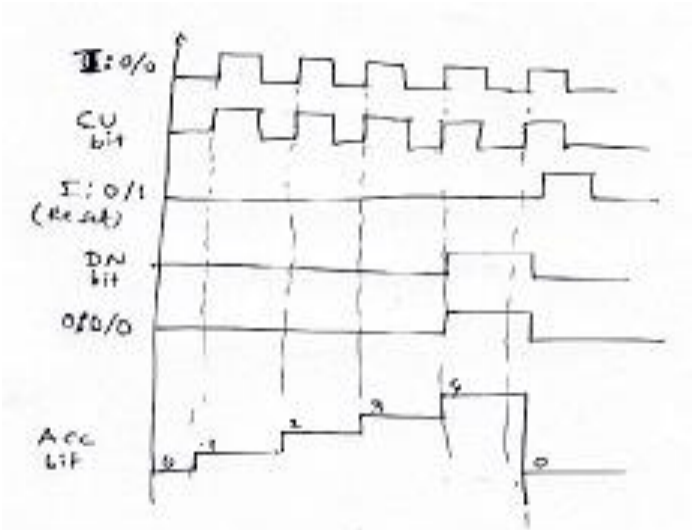
Ans	**i)Logic diagram of 4:1 MUX:**  **Ladder logic for 4:1 MUX:**  **ii) Boolean equation for 4:1 MUX:** $Y=\overline{S}\,\overline{0}S1D0+S\overline{0}S1D1+\overline{S}0S1D2+S0S1D3$	02 marks for logic diagram 02 marks for ladder diagram 02 marks for equation	

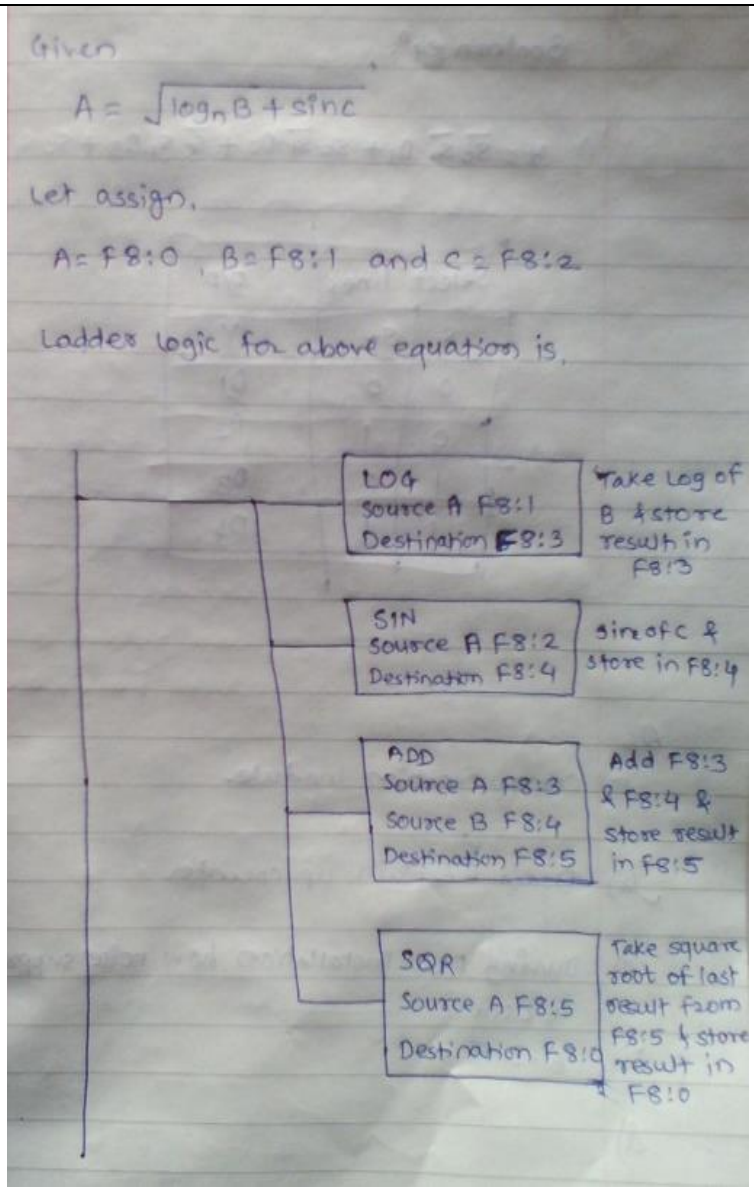
Truth Table For 4:1 MUX:-

Select Lines		Output
S1	**S0**	**Y**
0	**0**	**D1**
0	**1**	**D2**
1	**0**	**D3**
1	**1**	**D4**

02 marks for truth table

Q.6	**Attempt any FOUR:**		**16**
a)	**Explain communication module in detail**		**04**
Ans	**Communication Module:-** **ASCII I/O module:-** ASCII I/O modules accepts and processes on only ASCII data It is used to interface the peripheral devices like barcode reader ,printer, meters etc which uses ASCII data with the PLC. **RS-232 Interface Modules:-** Rs-232 interface module is used to interface PLC to telephone line using modern. Using telephone line ,control room operator can easily control and modify the program of remote PLC through this module e.g:-unmanned application areas like forging, oil and gas, waste water plants.	04 marks for explanation	
b)	**Draw and explain instruction format of up-counter with waveforms.**		**04**
Ans	**Format of up-counter:**  **Explanation:** When i/p to count up counter goes true the Acc value will be increased by 1 , not matter how long the i/p is true.	01 marks for format 02 marks for	

	So every true rung condition acc will increment by 1. When acc value reaches the preset value the counter DN bit will be set. For example as shown in figure, IN example preset value is 5 , in waveform when /p goes high then CU bit also goes high and Acc values is incremented by one .When next high i/p arises at counter i/p then CU bit also goes high and Acc is incremented by 1. Like this when Acc value becomes equal to preset value then DN bit is set and related o/p device is ON. This DN bit remains high until counter is reset by reset instruction. When reset instruction is executed counter gets reset and DN bit also goes low and Acc also goes to zero. **Waveform:** 	explanation 01 mark for waveform	
c)	**During PLC installation, how noise suppression is done?**		**04**
Ans	**Noise Suppression during PLC installation:** • Noise suppression is an important parameter in PLC installation because noise is nothing but unwanted signal which produce undesirable effect. • To reduce the noise following points must be considered: o High voltage power cables and low voltage control cables must be routed separately. o Grounding of PLC and other devices must be proper with low resistance path. o Large voltage and high frequency devices must be placed	04 marks for explanation	

	away from PLC. o If possible fiber optic cables can be used which reduces noise significantly. Noise signal immediately affect the analog I/O signal so analog devices should keep away from noise generating devices.		
d)	**Convert following equation into ladder logic.** $A=\sqrt{\text{Logn B+ sin C}}$		**04**
Ans	 **OR** **Any other relevant ladder diagram shall be considered**	04 marks for ladder diagram	

e)	**Illustrate fault detection technique for LED status of input and output module.**		**04**
Ans	1)PLC manufacturer usually provides LED status indicator for every input and output terminals. 2) There is a LED for power indication. It will be illuminated when power is ON otherwise it is off. 3) When supply is ON but power indicator LED is OFF, it means there is a problem in power supply. 4)Mode indicator LEDs are also on PLC which indicates the program or run mode of the PLC. 5) 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. 6) 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. 7)If power is not present on PLC output terminal, the PLC has failed and must be replaced. 8)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.	04 marks for explanation	