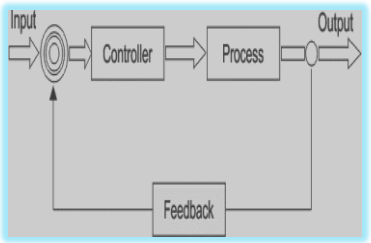
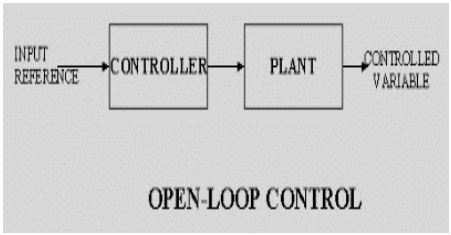
MODEL ANSWER

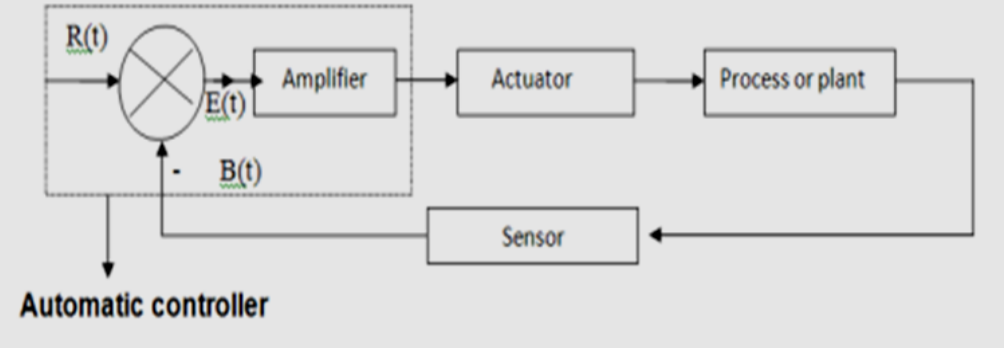
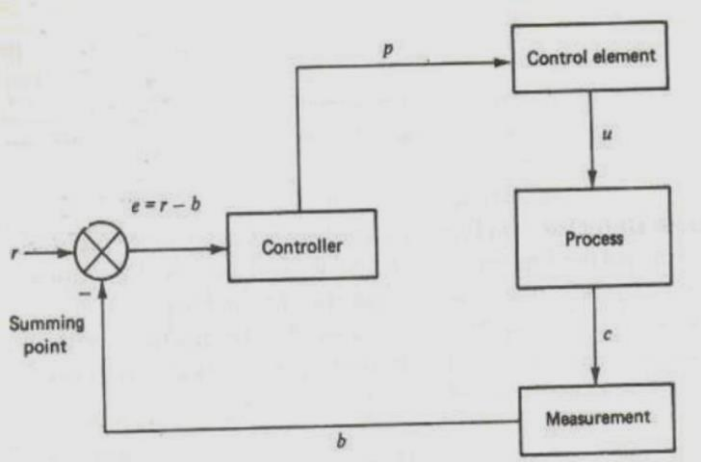
SUMMER– 18 EXAMINATION

Subject Title:-CONTROL SYSTEM & PLC **Subject Code:-** **17536**

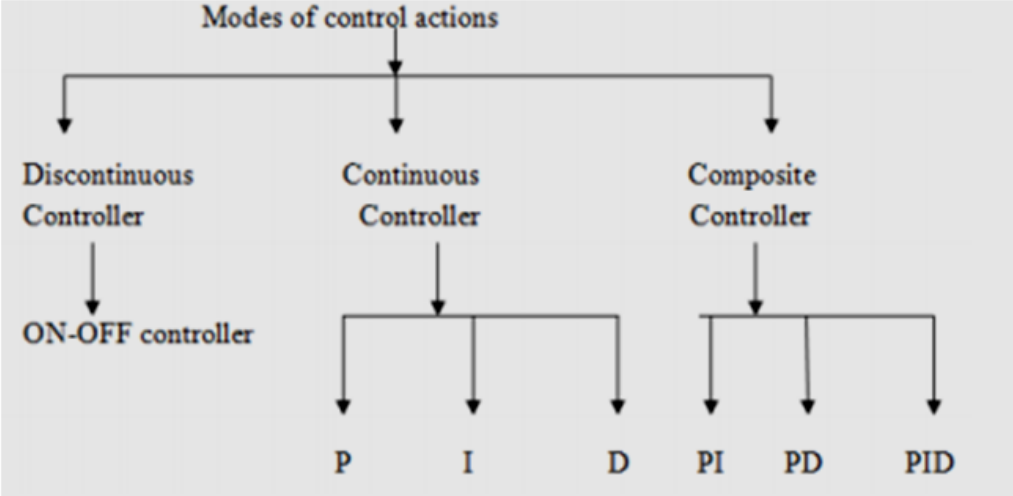
Important Instructions to examiners:

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 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.

<table>
<tr><th>Q. No.</th><th>Sub Q.N.</th><th>Answer</th><th>Marking Scheme</th></tr>
<tr><td>Q.1</td><td>A)</td><td>Attempt any THREE :</td><td>12 Marks</td></tr>
<tr><td></td><td>a)</td><td>Compare open loop and closed loop control system based on block diagram, transfer function, examples and stability.</td><td>4 Marks</td></tr>
<tr><td></td><td>Ans:</td><td>
<table>
<tr><th>Parameter</th><th>Closed loop control system</th><th>Open loop control system</th></tr>
<tr><td>block diagram</td><td> 
</td><td> 
</td></tr>
<tr><td>transfer function</td><td>$\frac{G(s)}{1+G(s)H(s)}$</td><td>$G(s)H(s)$</td></tr>
<tr><td>examples</td><td>Human Being,Voltage stabiliser</td><td>Washing machine,Toaster</td></tr>
<tr><td>Stability.</td><td>Less Stable</td><td>More Stable</td></tr>
</table>
</td><td>Each point 1M</td></tr>
</table>

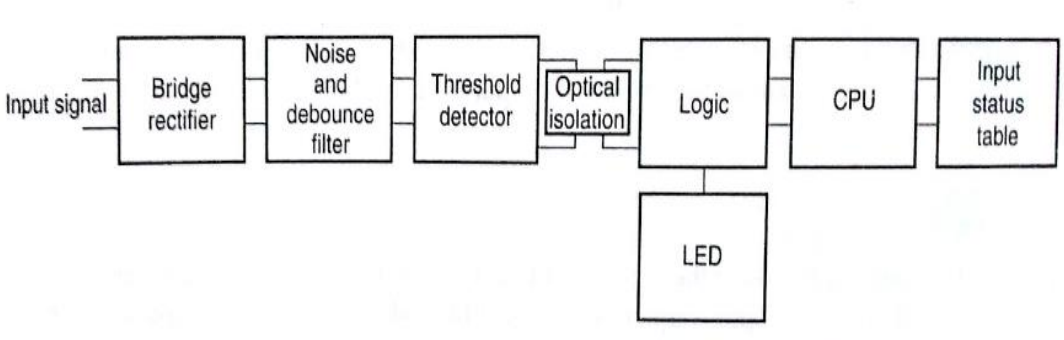
	b)	**Describe role of PLC in automation.**	**4 Marks**
	Ans:	**Role of PLC in automation:-** • To reduce human efforts. • To get maximum efficiency from machine and control them with human logic • To reduce complex circuitry of entire system • To eliminate the high costs associated with inflexible, relay controlled systems. • Replacing Human Operators (Dangerous Environments & Beyond Human • Capabilities) • Higher productivity. • Superior quality of end product • Efficient usage of energy and raw materials • Improved safety in working conditions. • Fast • Easily programmed and have an easily understood programming language.	**Each point1M (any 4)**
	c)	**Draw labelled block diagram of Process Control System. Give classification of control actions.**	**4 Marks**
	Ans:	**Block diagram of Process Control System**  **OR** 	**block diagram 2M, Classification 2M**

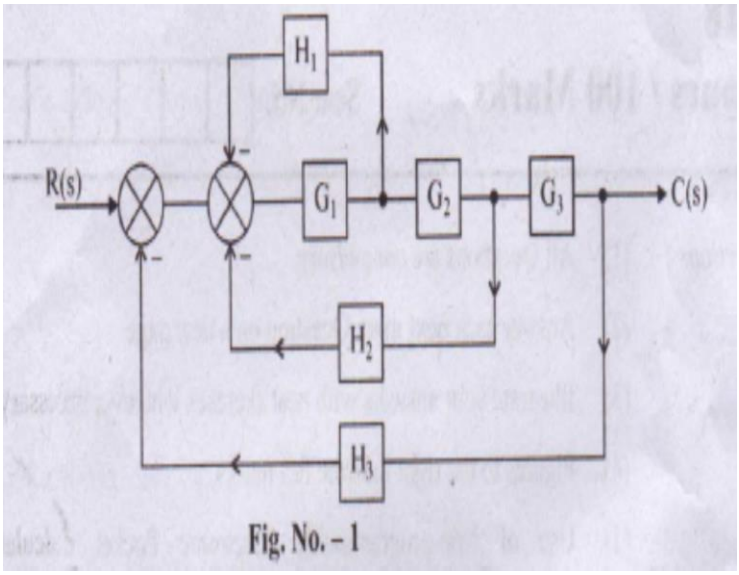
Classification of control actions.

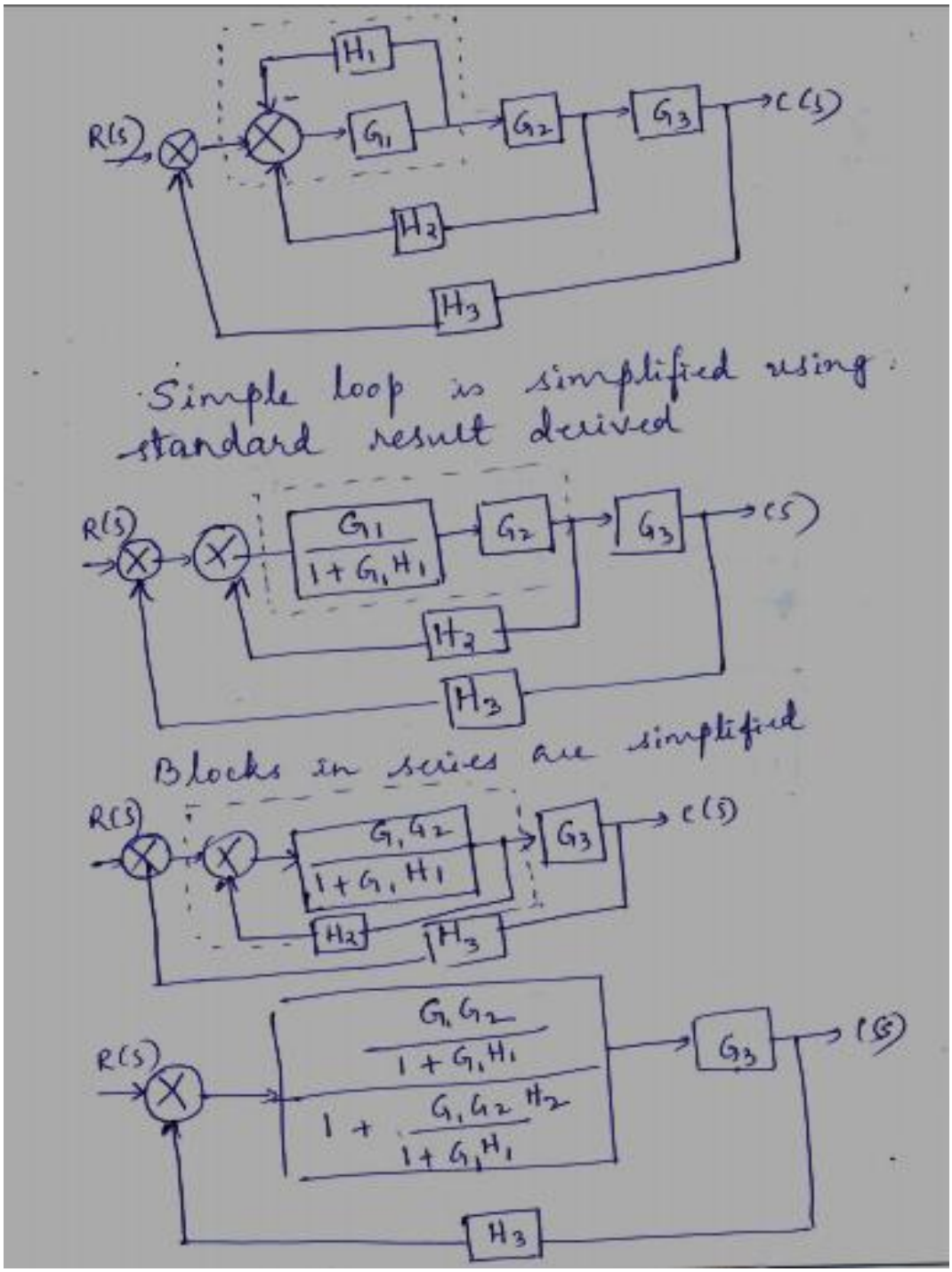


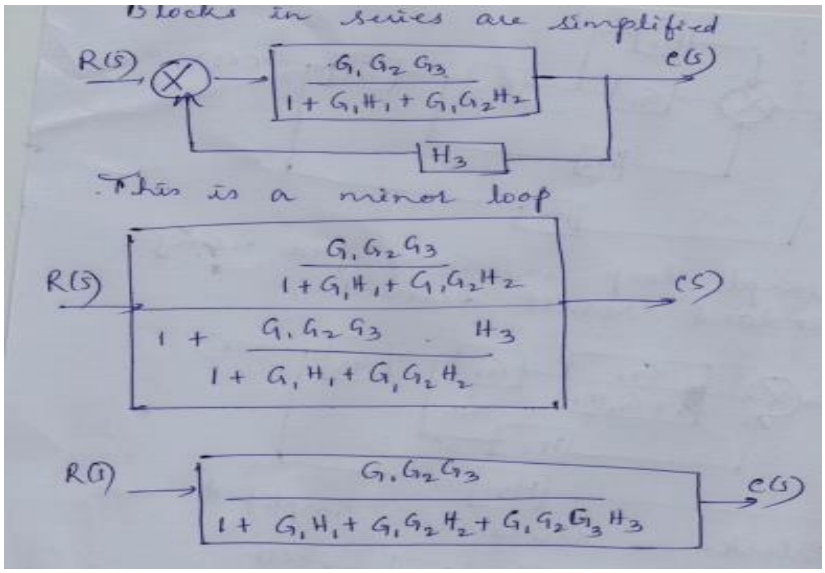
d)	**List standard test input signals. Give their laplace representation.**	**4 Marks**
Ans:	1. Step input 2. Ramp input 3. Parabolic input 4. Impulse input	**List 1M , Laplace 3M**

Standard test input	**Laplace Representation**
Step input(position function) r(t)	R(s)=A/s
Ramp input(Velocity function) r(t)	$R(s)=A/s^2$
Parabolic input(Acceleration r(t) function)	$R(s)=A/s^3$
Impulse input r(t)	R(s)= 1 if A=1

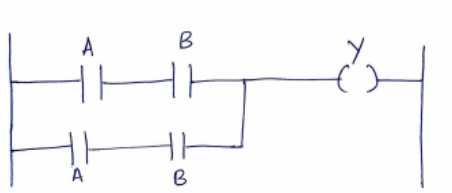
B)	**Attempt any ONE :**	**6 Marks**
a)	**Draw block diagram of AC input module of PLC. Describe function of each block.**	**6 Marks**
Ans:	 Block diagram of a typical AC input circuit.	**block diagram 2M, Explanation 4M**

		• **Power conversion:** The power conversion section usually consists of resistors and bridge rectifier. The bridge rectifier converts the incoming AC signal to a pulsating DC level. The DC level is passed through filters and other logic circuits in order to deliver a clean, debounced, DC input signal. The filtered DC signal goes on to the threshold detector. • **Threshold detection:** Threshold detection circuitry detects if the incoming signal has reached or exceeded a predetermined value for a predetermine time, and whether it should be classified as valid ON or OFF signal. • **Isolation:** Isolation section of the input ckt. Is usually made up of an optical isolator, or opt coupler. In a 120VAC input module, isolation separates the high voltage, 120VAC input signal from the CPUs low voltage control logic. • **Logic section:** DC signal 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 and then on to the input status file.	
	b)	**Derive the transfer function of block diagram using block diagram reduction rules.**  Fig. No. – 1	**6 Marks**
	Ans:		

		 H1 R(s) G1 G2 G3 C(s) H2 H3 Simple loop is simplified using standard result derived R(s) G1 / 1+G1H1 G2 G3 C(s) H2 H3 Blocks in series are simplified R(s) G1G2 / 1+G1H1 G3 C(s) H2 H3 R(s) G1G2 / 1+G1H1 / 1 + G1G2H2 / 1+G1H1 G3 C(s) H3	**Each Step 1M**

			
Q 2		**Attempt any TWO :**	**16 Marks**
	a)	**Determine the range of values of K for system to be stable whose characteristic equation is** $s^4 + 22s^3 + 10s^2 + s + K = 0$	**8 Marks**
	Ans:	$s^4 + 22s^3 + 10s^2 + s + K = 0$ $a_0 = 1,\ a_1 = 22,\ a_3 = 10,\ a_4 = 1,\ a_5 = K$ Routh's array can be written as s^4 | 1 10 K s^3 | 22 1 s^2 | 9.95 K s^1 | $\frac{9.95-22K}{9.95}$ 0 s^0 | K For stability of a system there should be no change in sign From s^1 row $\frac{9.95-22K}{9.95} > 0$ i.e. $9.95 - 22K > 0$ $9.95 > 22K$ $0.45 > K$ From s^0 row $K > 0$ Combining both conditions for stability we get $0 < K < 0.45$	**Rouths array 4M , Condition 4M**

	b)	**For a system having closed loop transfer function** $\frac{C(s)}{R(s)} = \frac{18}{s^2+4s+18}$ **(i) W_d — damped frequency of oscillations.** **(ii) Peak time** **(iii) % Peak overshoot** **(iv) Settling time**	**8 Marks**
	Ans:	$\frac{C(s)}{R(s)} = \frac{18}{s^2+4s+18}$ Comparing this with standard equation $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$ $\omega_n^2 = 18 \Rightarrow \omega_n = 4.24$ rad/sec $2\xi\omega_n = 4$, So $\xi = \frac{4}{2(4.24)} = 0.47$ i) $\omega_d = \omega_n\sqrt{1-\xi^2}$ $= 4.24\sqrt{1-(0.47)^2}$ $= 3.74$ rad/sec 2) Peak time $T_p = \frac{\pi}{\omega_d} = \frac{\pi}{3.74} = 0.839$ seconds 3) Peak Overshoot $\% M_p = e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}} \times 100$ $= e^{\frac{-\pi(0.47)}{\sqrt{1-(0.47)^2}}} \times 100 = 19.01\%$ 4) Setting time $T_s = \frac{4}{\xi\omega_n}$ $= \frac{4}{(0.47)(4.24)} = 2$ seconds	**Each value 2M**
	c)	**Draw ladder diagram for following logical equations:** (i) $Y = \bar{A}B + A\bar{B}$ (ii) $Y = (\bar{A}+B)(A+\bar{B})$	**8 Marks**
	Ans:	**i)** **a) Inputs :** A and B **Outputs :** Y **b) Ladder diagram:**	**02 Mark**

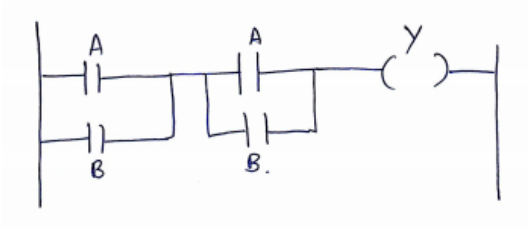


c) Explanation: In above ladder diagram Input A and B are in series (AND) and this combination is in parallel (OR) with the series combination of A and B.
When A and B both are 'ON' Then Output Y goes 'ON' else it is 'OFF'

ii)

a) Inputs: A and B
Outputs: Y

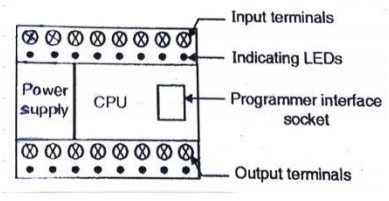
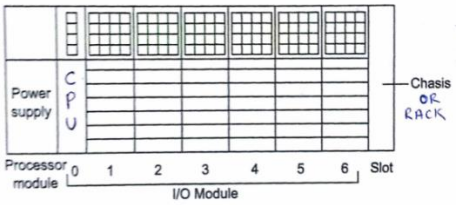
b) Ladder Diagram:

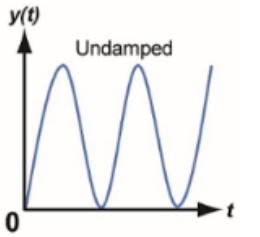
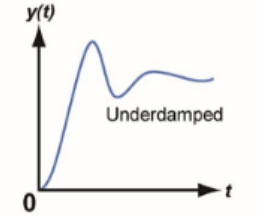
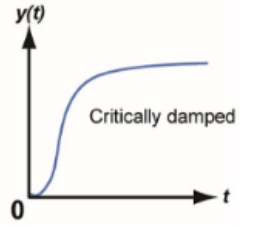
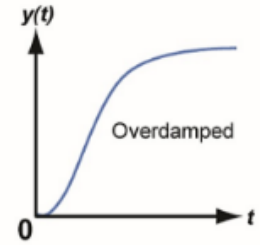


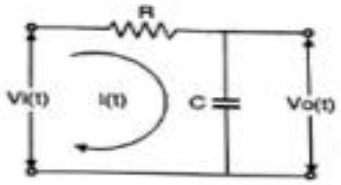
c) Explanation: In above ladder diagram Input A and B are in Parallel (OR) and this combination is in series (AND) with the parallel combination of A and B.
If either A is 'ON' or B is 'ON' then Y goes 'ON' else it is 'OFF'.

02 Marks

Q. 3		**Attempt any Four:**	**16 Marks**
	a)	**Compare fixed and modular PLC. (any 4 points)**	**4 Marks**
	Ans:		**Any 04 points – 01 M each.**

Sr. No.	Fixed PLC	Modular PLC
1	Fixed PLC consist of input section , output section , CPU, and Power supply included within the self-contained package	Modular PLC uses separate modules (unit) for input, output, CPU and Power supply.
2	**Diagram:** 	**Diagram:** 
3	Types: Pico PLC , Micro PLC	Types: Small PLC, Medium PLC, Large PLC, Very Large PLC.

		4	In Fixed PLC I/O Points cannot be increased or decreased i. e Fixed PLC's are not flexible.	In Modular PLC Number of input points and output points can be increased or decreased i.e. Modular PLC's are flexible.
		5	CPU and Power supply redundancy is not possible in fixed PLC.	CPU and Power supply redundancy is possible in Modular PLC.
		6	Fixed PLC is useful for small application or laboratory use.	Modular PLC is useful for bigger or large industrial application.
	b)	**Draw response of 2nd order system for step input for given values of zeta (ξ) (i) ξ =0 (ii) ξ =O.5 (iii) ξ =1 (iv) ξ =5**		**4 Marks**
	Ans:	 **I)ξ =0**  **ii) ξ =O.5**  **(iii) ξ =1**  **(iv) ξ =5**	**Each Response 1 M**
	c)	**Define transfer function. Obtain transfer function of RC network.**		**4 Marks**
	Ans:	Definition-Transfer function is the ratio of Laplace transform of output of system to Laplace transform of input of system ,when all initial conditions are assumed to be zero.		**Definition 1M , Derivation 3M**



R-C circuit

- **Transfer function of the circuit is defined as,**

$$L\frac{\{Output\}}{\{Input\}} = \frac{L\{V_o(t)\}}{L\{V_i(t)\}} = \frac{V_o(s)}{V_i(s)}$$

From figure apply KVL to input loop we get,

$$V_i(t) = R_i(t) + \frac{1}{C}\int i(t)dt$$

$$V_o(t) = \frac{1}{C}\int i(t)\,dt$$

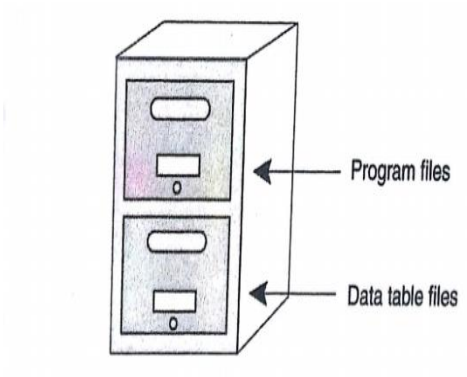
- **Neglecting initial conditions, taking Laplace of $V_i(t)$ and $V_o(t)$ we get,**

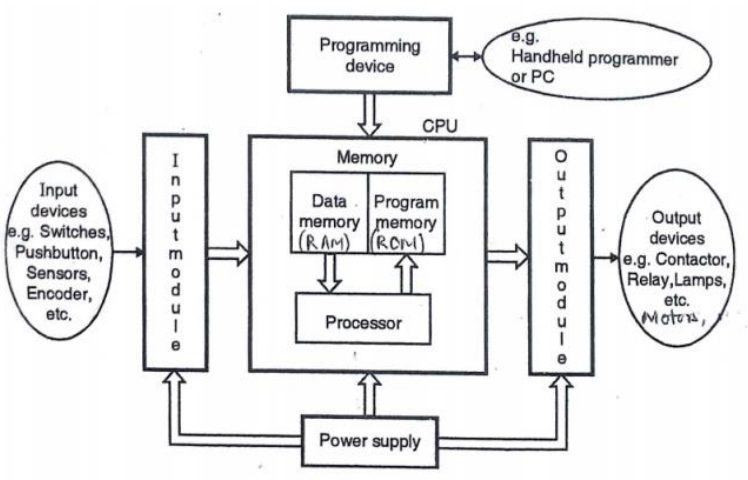
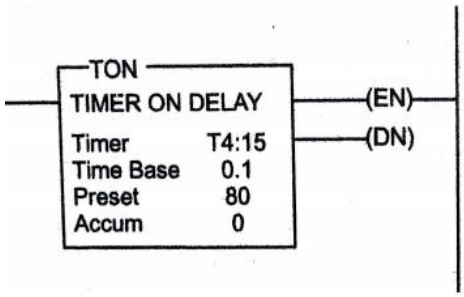
$$V_i(s) = R \cdot I(s) + \frac{1}{sC} \cdot I(s)$$

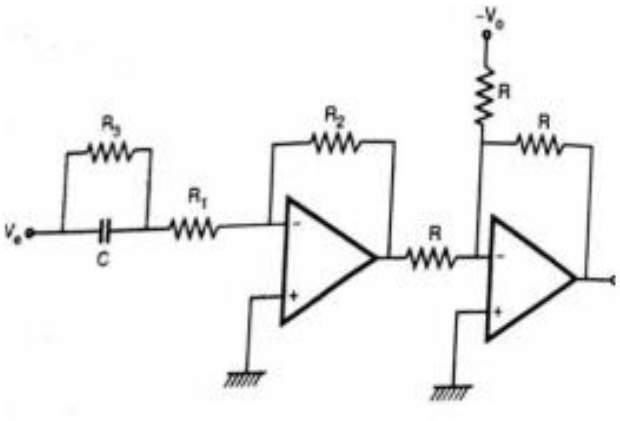
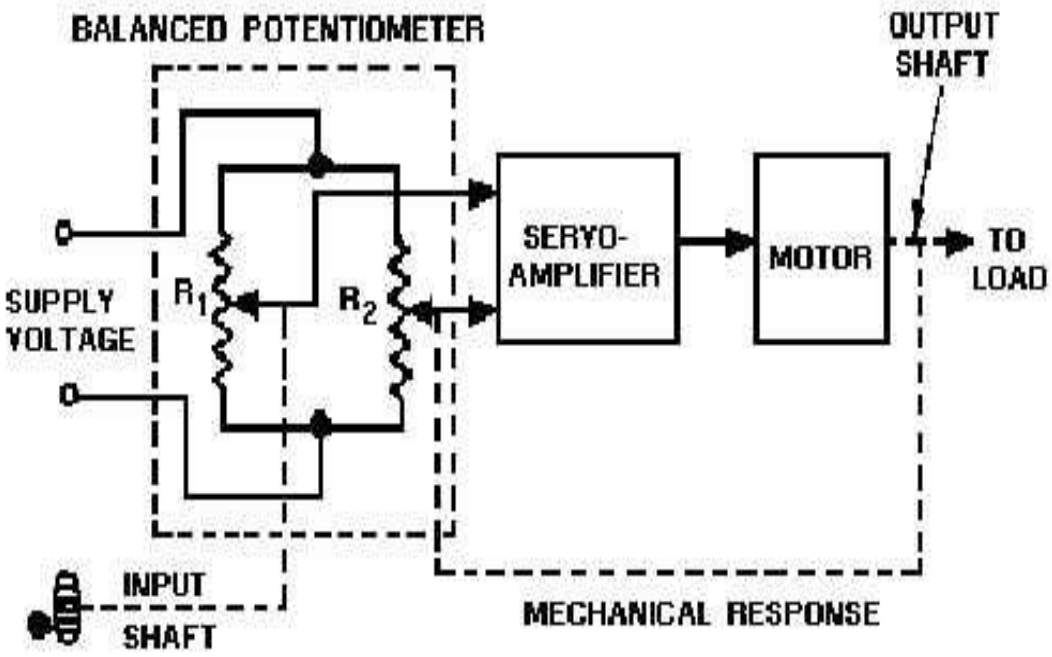
$$V_o(s) = \frac{1}{sC} \cdot I(s)$$

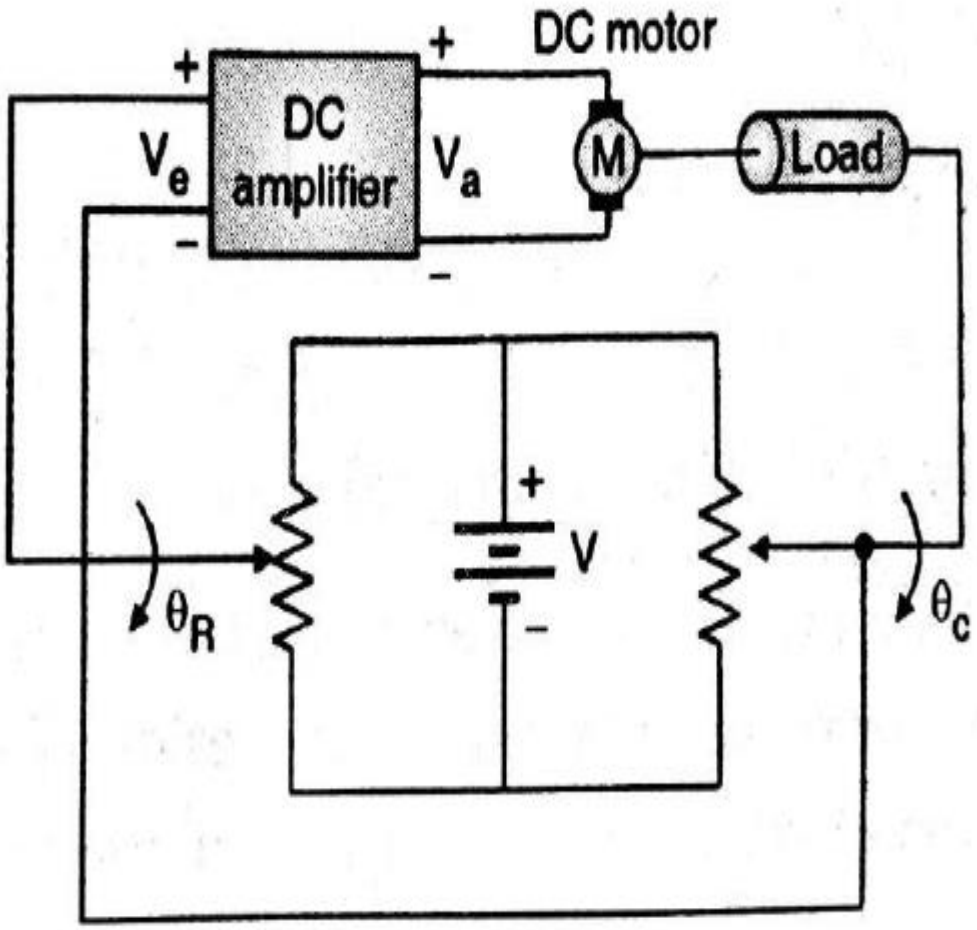
- Transfer function $\frac{V_0(S)}{V_I(S)} = \frac{\frac{I(S)}{sC}}{R\,I(S)+\frac{I(S)}{sC}} = \frac{1}{RCs+1}$

	d)	**Draw and explain memory organization in PLC.**	**4 Marks**
	Ans:	The PLC CPU has 1000 of memory location that stores information in the form of "0" or "1". These are known as words of registers. The purpose of memory is to 1. store system program , 2. user program , 3. Status of various inputs and outputs, 4. Timer data, 5. Counter data, 6. Alphanumeric data related to user program etc. All above information which is stored in memory must be stored in an orderly manner, so that whenever processor requires fetching any specific information that can be easily available. Therefore, to achieve this processor memory is divided into two parts or files, such as – a. Program Files b. Data Files Think of program files and data files like a two drawer file cabinet where program files are in one drawer and data files are in the other drawer as shown in following figure.	**Diagram 1 M , Explanation 3M**

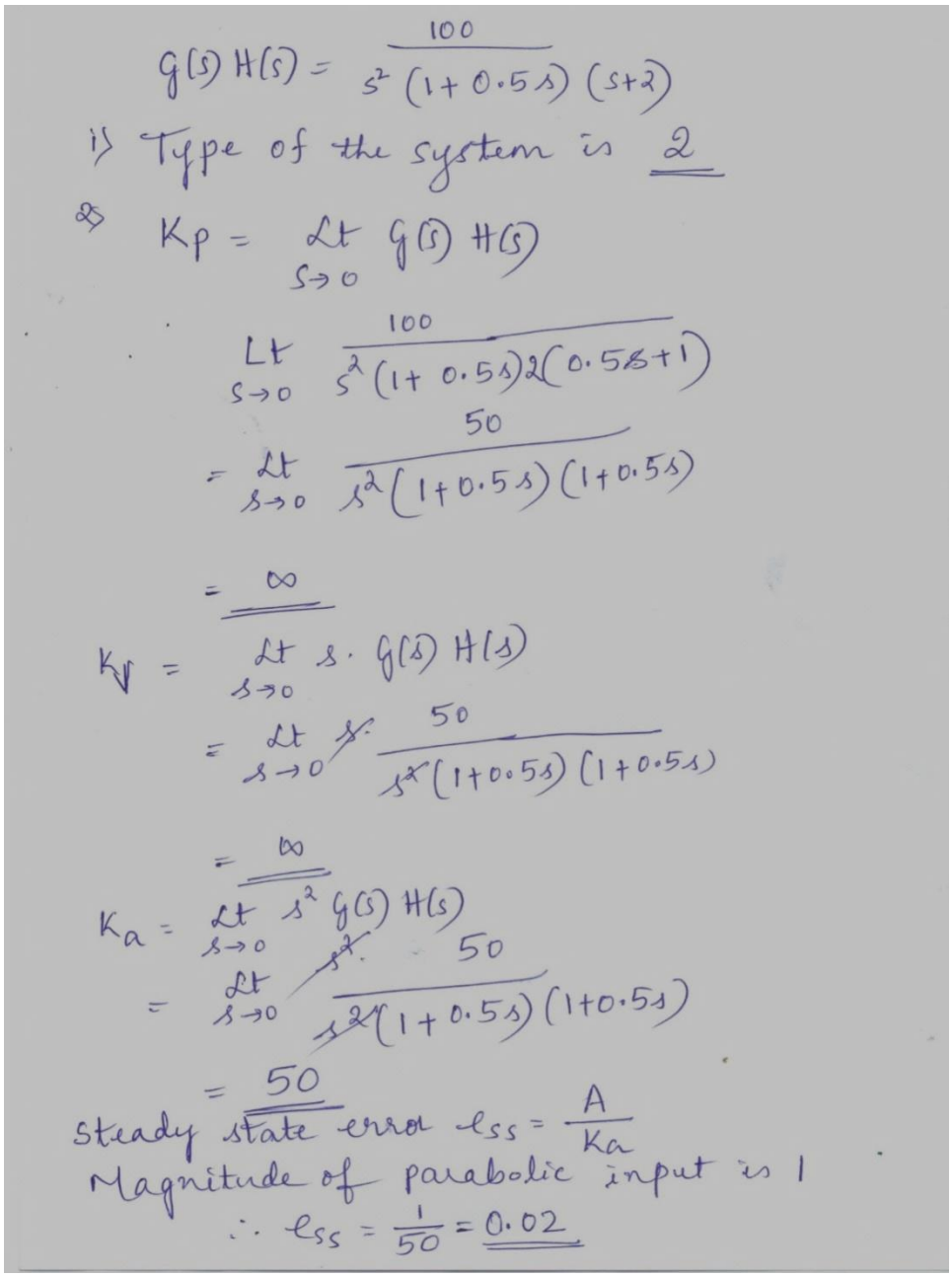
		 Processor memory is like a two-drawer file cabinet. **Program files:** The PLC Processor keeps different system information configuration and user program in one group of files called Program files. These files are arranged in a sequential manner. **Data Files:** The PLC processor stores data which is required to solve the user program in one group of files called data files. These files are arranged in sequential manner .	
	e)	**Define 'ON-OFF' controller. Describe its working principle using one example.**	**4 Marks**
	Ans:	This is one of the most common & simplest mode of controller. It controls two positions of control element, either on or off hence this mode is called as ON OFF controller. It is the cheapest controller. This controller mode has two possible output states namely 0 %& 100%. Mathematically this can be expressed as P (t) = 0% (OFF) for ep< 0 100% (ON) for ep> 0 Where p (t) – Controlled output ep - Error based on % of span Hence if the error rises above a certain critical value, the output changes from 0% to 100%. If the error decreases below certain critical value, the output falls from 100% to 0%. Example: Room temperature controller: If the temperature goes above 30^ocooler is turned ON.If the temperature goes below 25^o heater is turned ON. Thus the temperature is maintained between 25^o 30^o	**Definition 1M** **Explanation 3M**
Q. 4	**A)**	**Attempt any THREE :**	**12 Marks**
	a)	**Draw labelled block diagram of PLC. List any two output devices.**	**4 Marks**
	Ans:		

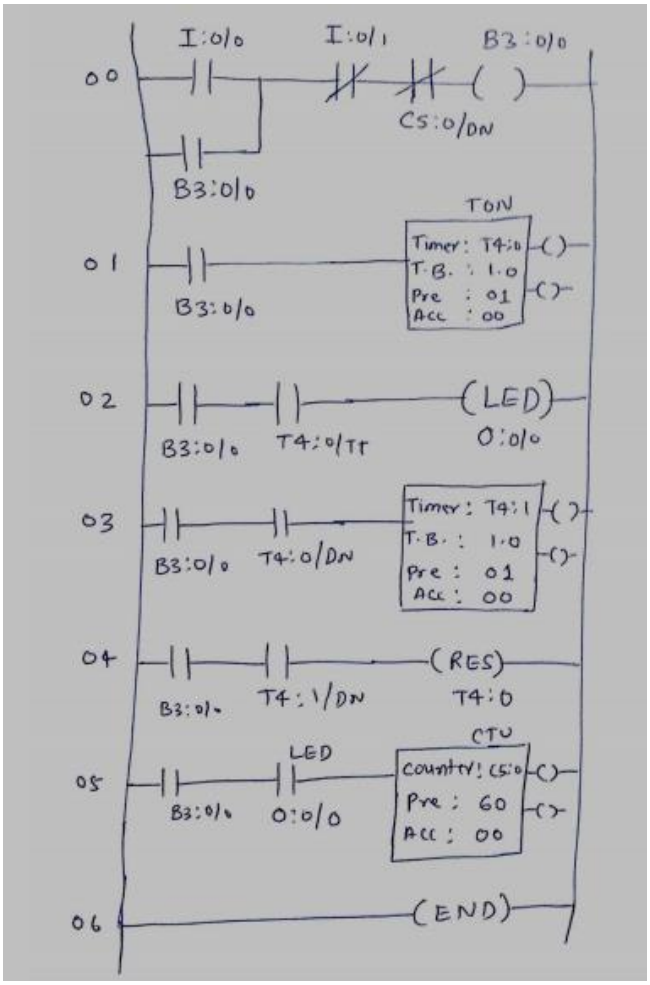
		Diagaram:  **List of output Devices:** 1. Lamp 2. Fan 3. Solenoid Valve 4. DC motors 5. AC motors 6. Stepper motors 7. Control Valve 8. Light Dimmer 9. Variable Drives	**Diagram 3 M Any two output devices 1 M each**
	b)	**Draw ON-Delay instruction format of PLC. Give significance of EN and DN bits.**	**4 Marks**
	Ans:	**Diagram:**  **Significance of EN Bit:** Enable bit is the status bit associated with On delay timer which indicates whether the timer is Enabled or Disabled. When timer is enabled it starts producing time delay. When the rung input condition is true then Timer is enabled and EN bit set to logic 1. **Significance of DN Bit:** Done (DN) bit is the status bit associated with On delay timer which is use to indicate whether Timer has completed the delay timing or not.	**Diagram 2M, Significance 1M each**

		When timer is enabled and completes the time delay then DN bit is set to 1.	
	c)	**Draw electronic circuit diagram for PD controller. Describe why derivative controller not used alone.**	**4 Marks**
	Ans:	The combination of proportional plus derivative mode gives PD controller  When the error is zero or when the error is constant, the output of the controller is 0. So **derivative controller is not used alone.**	**Diagram 2M, Description 2M**
	d)	**Define Servo-System. Draw block diagram of DC Servo-System.**	**4 Marks**
	Ans:	Definition: Servo system is defined as automatic feedback control system working on error signals giving the output as mechanical position, velocity or acceleration.  **OR**	**Definition 1M ,Block diagram 3M**

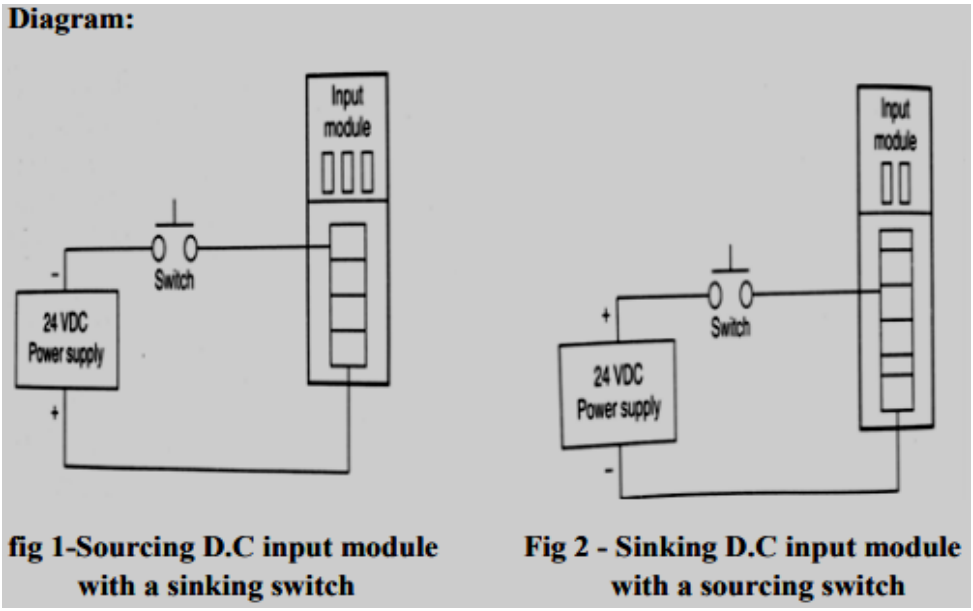


	B)	**Attempt any ONE :**	**6 Marks**
	a)	**For system whose open loop transfer function is** $G(s)\,H(s) = \frac{100}{s^2(1+0.5s)(s+2)}$ **Determine :** **(i) Type of system** **(ii) Error constants K_p, K_v, K_a** **(iii) Steady state error for unit parabolic input.**	**6 Marks**
	Ans:		

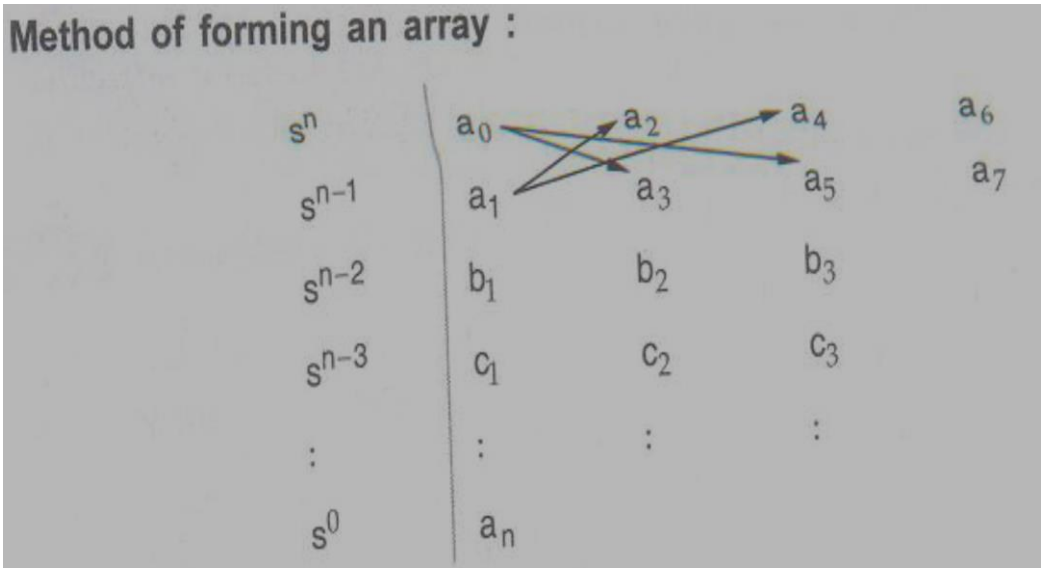
			**Type 1M Error constants 3 M Steady state error 2 M**
	b)	**Draw ladder diagram to blink LED continuously for 60 times. LED should be ON for one second and OFF for one second.**	**6 Marks**
	Ans:	**Note : Any other logically correct ladder diagram can also be considered.**	**06 marks**



Q.5		**Attempt any FOUR :**	**16 Marks**
	a)	**Obtain stability of system whose characteristic equation is** $s^5 + s^4 + 3s^3 + 9s^2 + 16s + 10 = 0$ **use Routh's criterion.**	**4 Marks**
	Ans:	1) Firstly Find even & odd coefficient from characteristics equation $S^5 + S^4 + 3.S^3 + 9.S^2 + 16.S + 10 = 0$ 2) The routh's array for above characteristics equation is formed as follows S^5 1 3 16 S^4 1 9 10 S^3 -6 6 0 S^2 10 10 0 S^1 12 0 S^0 10	**3 Marks**

		Conclusion: There are two sign changes in the first column of routh's array. So the system is unstable.	**1 Marks**
	b)	**Describe with neat diagram concept of sinking and sourcing in discrete input module.**	**4 Marks**
	Ans:	**Diagram:**  **fig 1-Sourcing D.C input module with a sinking switch** **Fig 2 - Sinking D.C input module with a sourcing switch** **Explanation** 1. Sinking and Sourcing are terms used to describe current flow through a field device in relation to the power supply and the Associated input, output point. 2. Solid state input devices with NPN transistors are called "Sinking input device" while input devices with PNP transistor are called "Sourcing input devices". 3. The commonly accepted definition by PLC manufactures about sinking & sourcing input & output circuit is current flows from Positive to negative. 4. Basic principle retain to sinking & sourcing circuits. ➢ NPN transistors are open collector current sinking devices which Interface to a sourcing input module. ➢ PNP transistors are open collector, current sources, which interface to a sinking input module. 5. In fig. no1 current flows from positive terminal of 24 volt DC supply to input module then through switch to negative terminal of supply, hence module acts as sinking device for DC supply but Sourcing device for switch. 6. In fig.2 current flows from positive terminal of 24 volt DC supply to switch then input module to negative terminal of supply, as far as input module is concern it act as sinking device for DC switch and Sourcing device for 24 volt DC supply.	**Diagram 2 Marks** **Explanation 2 marks**

	c)	**Define following terms :** **(i) Poles** **(ii) Zero's** **(iii) Order of system** **(iv) Characteristic equation**	**4 Marks**
	Ans:	Transfer function of standard control system is given as $$G(s) = \frac{K'(S-Z1)(S-Z2)\ldots.}{S^j(S-P1)(S-P2)\ldots.}$$ a) Poles: The poles of the system are roots of the denominator polynomial of transfer function. i.e. in above transfer function G(s) P1, P2,…. are poles of the system. It is also the value of S which makes the transfer function equal to ∞ b) Zeros: The zeros of the system are roots of the numerator polynomial of transfer function. i.e. in above transfer function G(s), Z1, Z2,…. are zeros of the system. It is also the value of S which makes the transfer function equal to **0.** **c)** Order of system: It is highest power of „S" at denominator of closed loop T.F. In case of electrical circuit network, number of energy storing device also give order of system. **d)** Characteristics Equation: The characteristics equation of the control system can be obtained by simplifying the denominator of the transfer function. In above transfer function G(s), the characteristics equation can be obtained from by salving equation S j (S-P 1) (S-P 2) …=0	**1 Marks each**
	d)	**State Routh's stability criterion. Explain with example.**	**4 Marks**
	Ans:	**Statement**: Rouths stability criterion: The necessary and sufficient condition for a system to be stable is **"**All the terms in the first column of Rouths array must have same sign.There should not be any sign change in the first column of Rouths array." If there are any sign changes then, a) The system is unstable. b) The number of sign changes is equal to the number of poles lying in the right half of s- plane. Determination of whether system is stable or unstable: To apply Rouths stability criterion, consider the system whose characteristic equation is given by: $F(s) = a_0 s_n + a_1 s_{n-1} + a_2 s_{n-2} + \text{----------} + a_n = 0.$ The coefficients of the characteristic equation of the given system are arranged in an array called Rouths array in the following way:	**4 Marks**



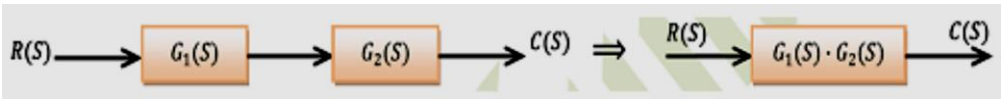
The values of b_1, b_2,c_1 ,$c_2$etc are obtained as follows:

$$b_1 = \frac{a_1a_2 - a_0a_3}{a_1}; \quad b_2 = \frac{a_1a_4 - a_0a_5}{a_1}; \quad b_3 = \frac{a_1a_6 - a_0a_7}{a_1}$$

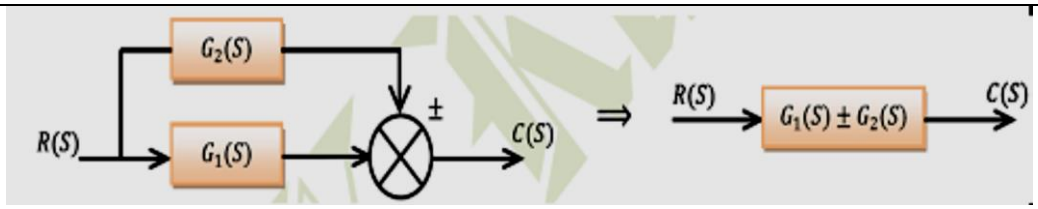
$$c_1 = \frac{b_1a_3 - a_1b_2}{b_1}; \quad c_2 = \frac{b_1a_5 - a_1b_3}{b_1}$$

The process is continued till the coefficient for s_0 is obtained which will be a_n. From this array, the stability of the system is predicted

e)	**State and explain any four block diagram reduction rules.**	**4 Marks**
Ans:	i) Combining a block in cascade: When two or more blocks are connected in series, their overall transfer function is the product of individual block transfer function.	**Any four, 1 Mark each**

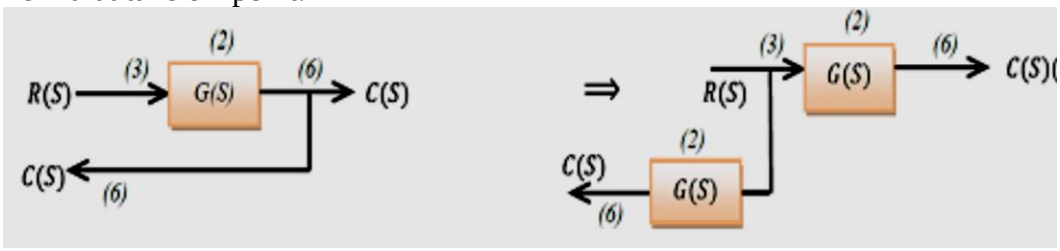


ii) Combining two blocks in parallel: When two or more blocks are connected in parallel, their overall transfer function is the addition or difference of individual transfer function.

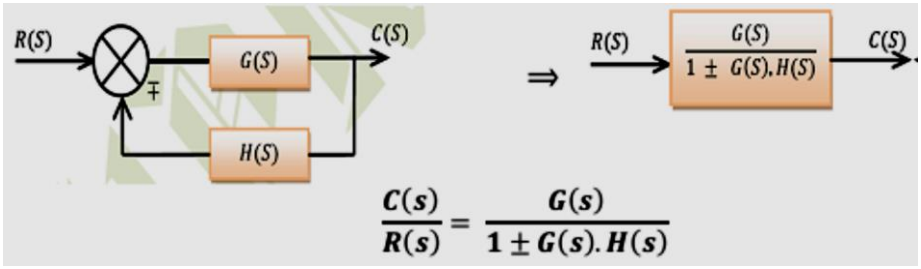


iii) Shifting a take off point after a block: To shift take off point after a block, we shall add a block with transfer function 1/G in series with signal which is taking off from that take off point.

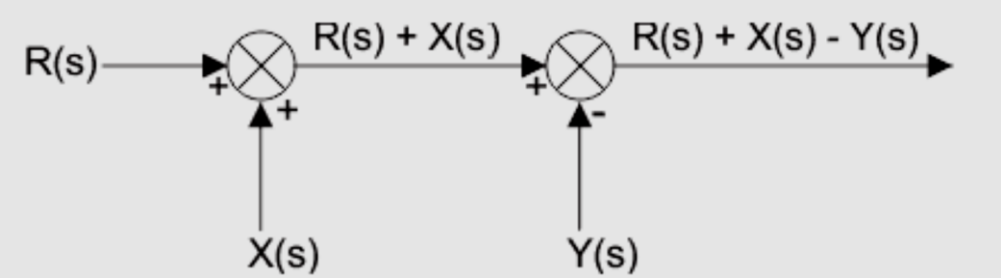
iv) Shifting a take off point before a block: To shift take off point before a block, we shall add a block with transfer function G in series with signal which is taking off from that take off point.



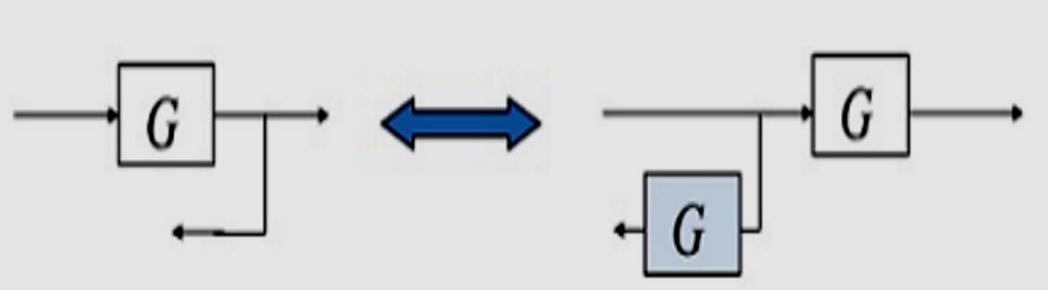
v) Eliminating Feedback Loop:



vi) Interchanging Summing Points: The order of summing points can be interchanged, if two or more summing points are in series and output remains the same.



vii) Moving Take off point before a summing point: To shift a take off point before summing point, add a summing point in series with take off point.

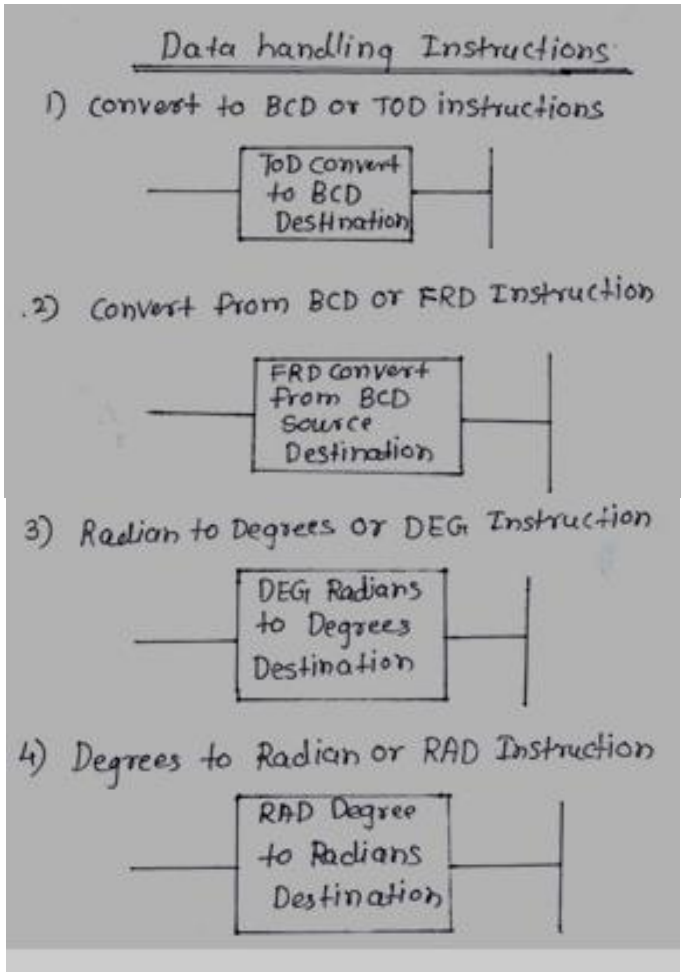


viii) Moving Take off point after a summing point: To shift a take off point after summing point, one more summing point is added in series withtake off point.

ix) Moving summing point after a block: To shift summing point after a block, another block having transfer function G is added before the summing point.

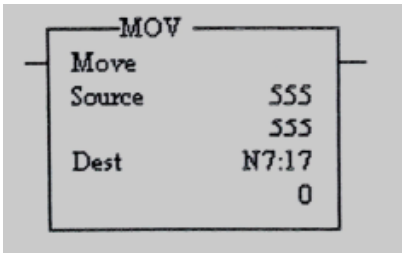
x) Moving summing point before a block: To shift summing point before a block, another block having transfer function 1/G is added before the summing point.

	f)	**List data handling instructions of PLC. Describe any one in details.**	**4 Marks**
	Ans:		**List 02M (Any four)**

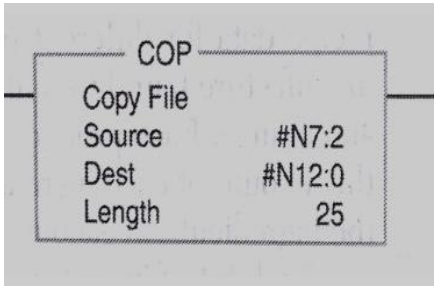


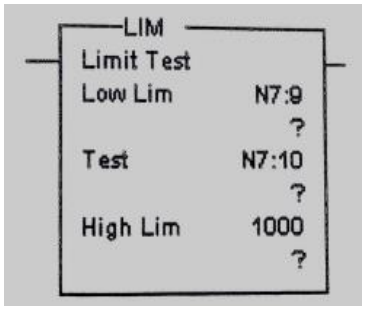
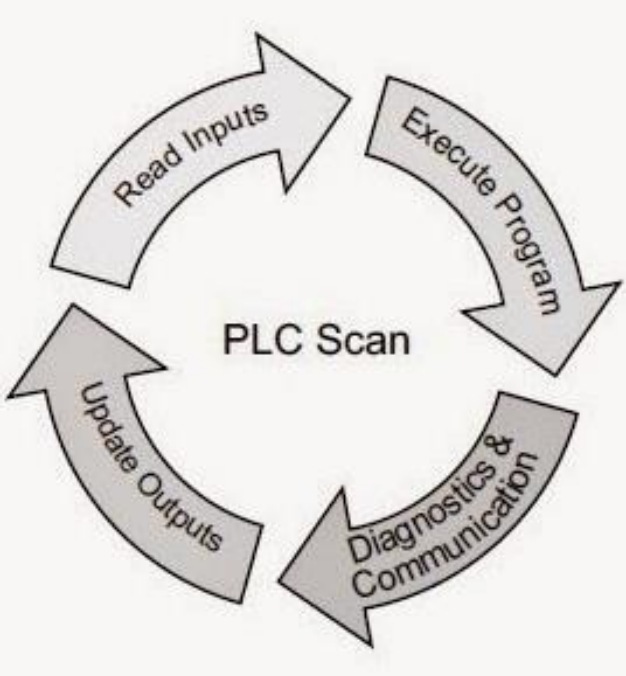
Explain any one with diagram – 02 M

5) Mov instruction:



6) Copy instruction:



		7) Limit test instruction: 	
Q.6		**Attempt any FOUR :**	**16 Marks**
	a)	**Define following terms related to PLC (i) Scanning cycle (ii) Speed of execution.**	**4 Marks**
	Ans:	**Scanning Cycle** ➢ It is number of states/steps which the controller follows when it is put in RUN mode. ➢ It is also called as operating cycle and is defined as "the number of states through which the controller scan the program before execution" ➢ The loaded program is kept in memory of PLC and every time the program will be scan by the PLC. It has four states which are shown in fig. below. ➢ The significance of scan cycle in PLC is to test the program and make it error free by going through above four states i.e. self test, input scan, program scan and output scan.  \	**2 Mark each**

Speed of execution: The speed at which PLC scans memory and executes the program is referred as a speed of execution. Higher CPU speeds provide faster performance that shortens task time.

b) Compare Proportional and Integral control action on basis of (i) Response to error (ii) Output equation (iii) Applications (iv) limitations. — **4 Marks**

Ans: — **1 M each**

Parameters	Proportional controller	Integral controller
Response to error	Response to direction of error. Controller output is proportional to error	Response to magnitude of error i.e size and time duration. Rate of change in output is proportional to error
Output equation	Pout = KpEp + P_0 Pout= Controller output Ep=Error Percentage Kp=Proportionality constant P_0= Controller Output at SP	Pout = $K_i \int_0^t E_p dt + P_0$ Pout =Controller output Ep=Error Percentage Ki =Integral constant P_0=Controller Output at *t=0*
Applications	Used in processes with moderate to small process time lags	Used in processes with small process lags and small capacitance such as flow, level, pressure control system
Limitation	Offset is present	Slow response time

c) Derive unit step response of 1st order system. — **4 Marks**

Ans: — **4 Marks**

Unit Step input Function -

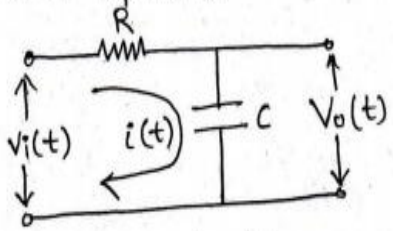
$V_i(t) = 1 \quad t \geq 0$

$= 0 \quad t < 0$

Therefor laplace of unit step i/p is -

$V_i(s) = 1/s$

first Order System:-



Apply KVL to input side, we get

$$V_i(t) - Ri(t) - \frac{1}{C}\int i(t)\,dt = 0$$

Take Laplace of above equation

$$V_i(s) - RI(s) - \frac{1}{sC} I(s) = 0$$

$$V_i(s) = \left(R + \frac{1}{sC}\right) I(s) \quad \text{---------- (1)}$$

Apply KVL to Output Side, we get

$$V_o(t) = \frac{1}{C}\int i(t)\cdot dt$$

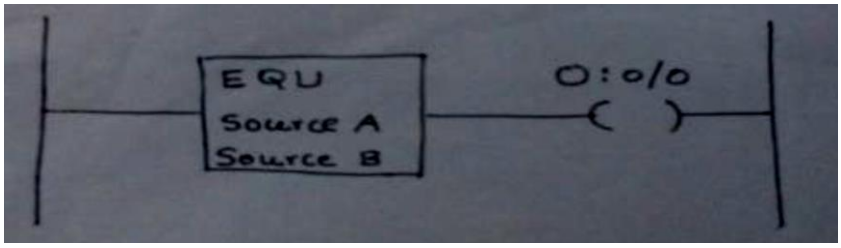
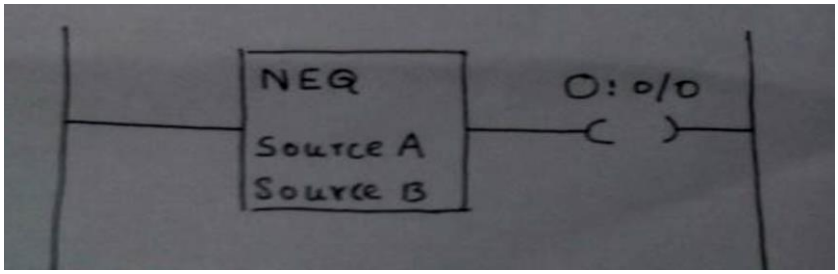
$$V_o(s) = \frac{1}{CS} I(s) \quad \text{---------- (2)}$$

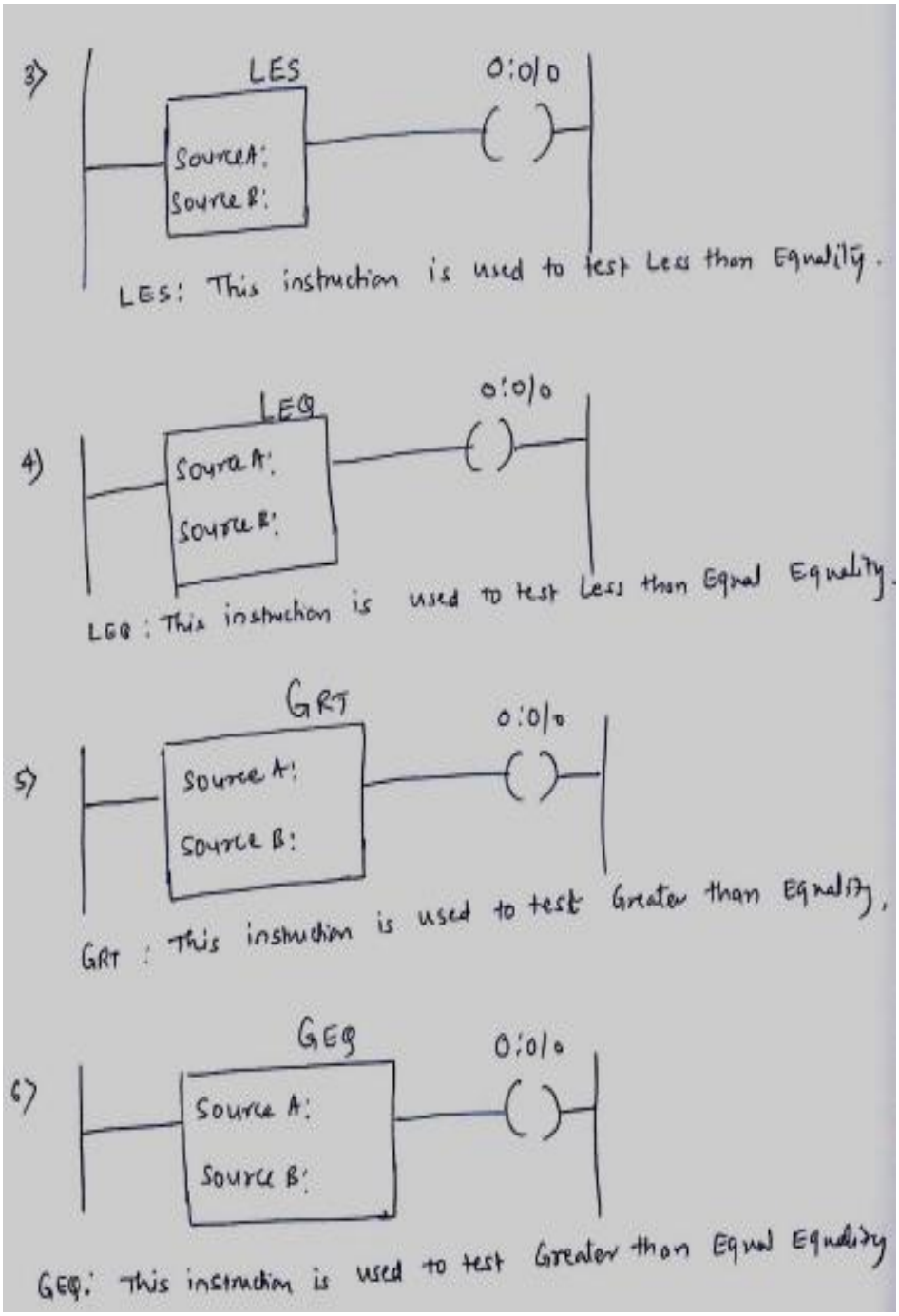
Devide Equation (2) by equation (1)

$$\frac{V_o(s)}{V_i(s)} = \frac{1/cs \cdot I(s)}{\left(R + \frac{1}{cs}\right) \cdot I(s)}$$

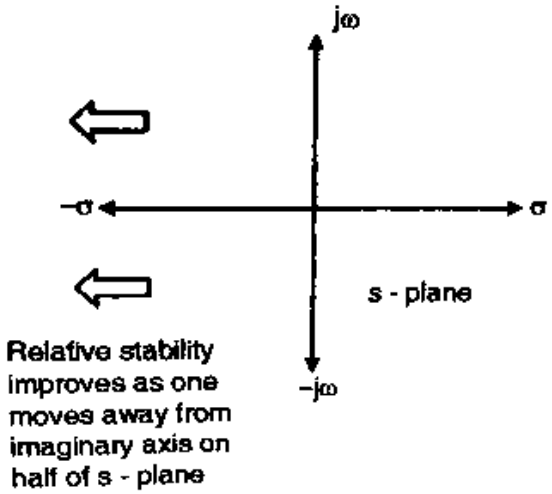
$$\frac{V_o(s)}{V_i(s)} = \frac{1}{(1 + sRC)}$$

Substitute $V_i(s) = 1/s$

		$V_o(s) = \frac{1}{S(1+SRC)} = \frac{A}{S} + \frac{B}{(1+SRC)}$ $1 = A(1+SRC) + BS$ $1 = A + ASRC + BS$ $1 = A + (ARC + B)S$ $\therefore A = 1 \;,\; B = -RC$ $\therefore V_o(s) = \frac{1}{S} - \frac{RC}{(1+SRC)}$ $= \frac{1}{S} - \frac{1}{S + 1/RC}$ Taking laplace inverse $V_o(t) = 1 - e^{-t/RC}$	
	d)	**List comparison instruction of PLC. Describe any two with diagram.**	**4 Marks**
	Ans:	Types of comparison instruction: 1)EQU(Value, Value) 2)NEQ(Value, Value) 3)LES(Value, Value) 4)LEQ(Value, Value) 5)GRT(Value, Value) 6)GEQ(Value, Value) **1) EQU:** This instruction is used to check or test two values for equality  **2) NEQ:** This is used to test inequality of two values  	**02 mark for types** **02marks (01 mark for each Instruction)**



	e)	**Define : (i) Relative Stability (ii) Marginally Stable System.**	**4 Marks**
	Ans:	**Relative stability-** ➢ Relative stability may be measured by relative settling times of each root/ pole or pair of roots. If the settling time is less, relative stability improves. ➢ As the poles move further away from the imaginary axis towards left side, the relative stability of the system improves.	**2 M each**

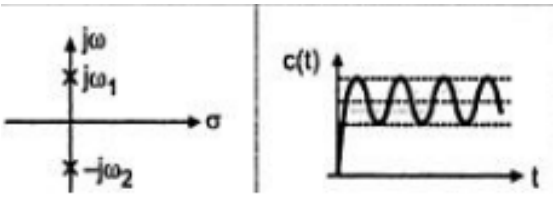


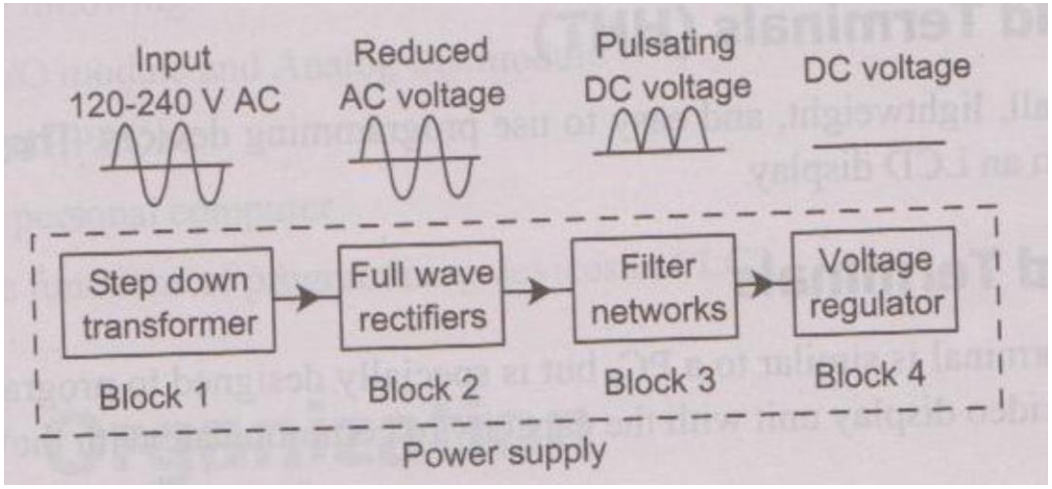
Relative stability improvement area.

Marginally stable system:

A linear time invariant system is said to be critically or marginally stable if for a bounded inputs its output oscillates with constant frequency and amplitude. Such oscillations of output are called undamped or sustained oscillations. Such systems are neither stable nor unstable because their magnitude remains constant.

In such systems, One or more pairs of non-repeated roots are located on imaginary axis.



	f)	**Draw block diagram of power supply used in PLC. Describe function of each**	**4 Marks**
	Ans:	 Explanation: It consists step down transformer , rectifier , filter and regulator **Step down transformer**	**2 Mark diagram** **2 Mark explanation**

		1.The step-down transformer converts the high voltage (HV) and low current from the primary side to the low voltage (LV) and high current value on the secondary side **Rectifier**: 1.It converts ac into dc voltage. 2.o/p of is fed to filter **Filter**: 1.This removes ac part present in the o/p of rectifier 2.It gives pure dc signal **Regulator**: 1.This regulates o/p voltage level	