Expt. No: Date: ………………..

TIME RESPONSE OF SECOND ORDER SYSTEM

Aim:

To study the time response of closed loop second order system and to correlate the studies with theoretical result

Apparatus Required:

1. Liner system simulator kit -----1
2. Cathode ray oscilloscope -----1
3. Patch cords -----10
4. CRO probes -----2

Theory:

The desired performance characteristics of the control system are specified in terms of time domain specification system with energy source elements respond instantaneously and exhibit transient response whenever they are subjected to inputs or disturbance.

The desired performance characteristics of the control system of any order may be specified in terms of transient response to the input unit step signal. The response of second order system for unit step system input various values of damping ratio also vary.

In specifying the transient-response characteristics of a control system to a unit step input, we usually specify the following:

1. Delay time, t_d
2. Rise time, t_r
3. Peak time, t_p
4. Peak overshoot, M_p
5. Settling time, t_s
6. Steady-state error, e_{ss}

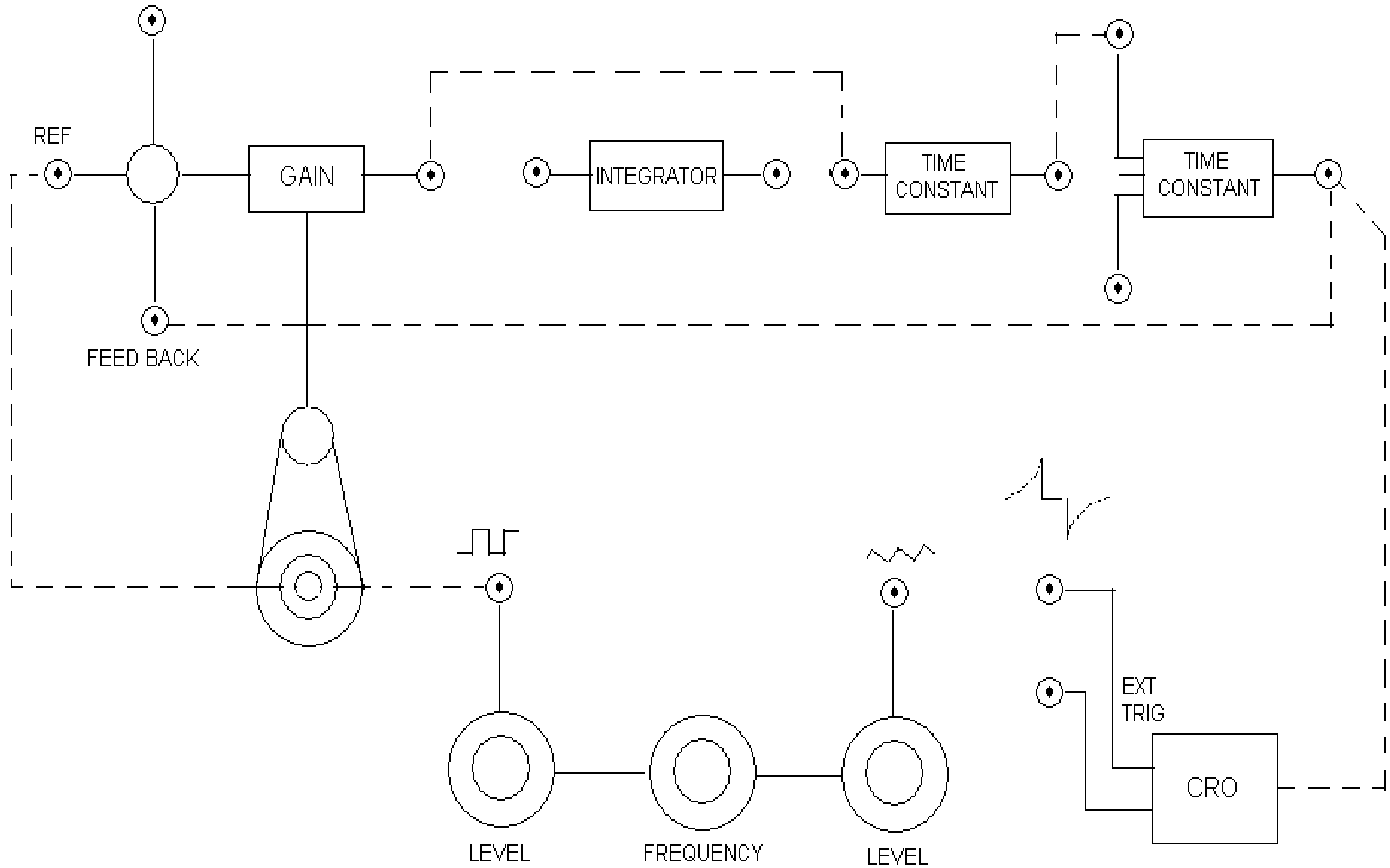

Fig 1.1 Circuit Diagram for Time Response of Second Order System

1. **Delay time,** t_d **:** It is the time required for the response to reach 50% of the final value in first attempt.
2. **Rise time,** t_r **:** It is the time required for the response to rise from 0 to 100% of the final value for the under damped system.
3. **Peak time,** t_p **:** It is the time required for the response to reach the peak of time response or the peak overshoot.
4. **Settling time,** t_s **:** It is the time required for the response to reach and stay within a specified tolerance band (2% or 5%) of its final value.
5. **Peak overshoot,** M_p **:** It is the normalized difference between the time response peak and the steady output and is defined as,

$$\%M_p = \frac{c(t_p) - c(\infty)}{c(\infty)} \times 100\%$$

6. **Steady-state error,** e_{ss} **:** It indicates the error between the actual output and desired output as 't' tends to infinity.

$$e_{ss} = \lim_{t \to \infty} [r(t) - c(t)].$$

Procedure:

1. Choose and wire a suitable second order system configuration as shown in circuit diagram.
2. Apply a 1V peak-peak sequence wave input and trace the output wave form on a tracing paper for different values of K obtain peak percentage overshoot, T_d, e_{ss} from the tracing.
3. Observe the output waveforms of first order system.

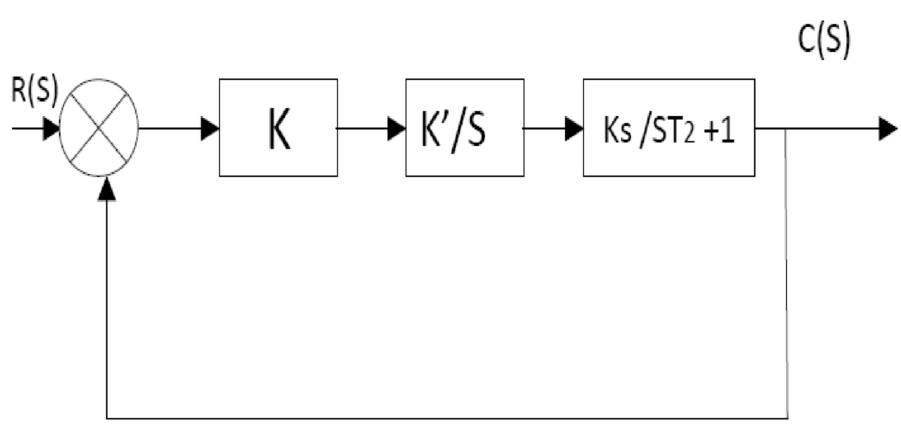

Fig 1.2 Block Diagram of Closed Loop Second Order System

Table 1.1: Time response readings

K(gain)	M_p(v)	T_d(ms)	T_r(ms)	T_p(ms)	T_s(ms)

Model Graph:

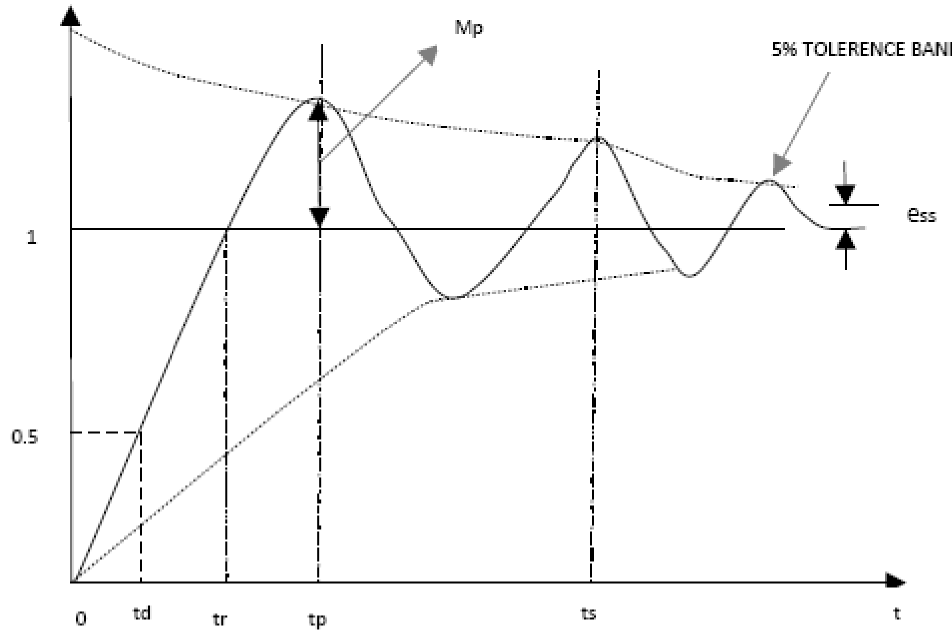

Fig 1.32 Graph for time response of second order system

Observations:

Result:

Viva Questions :

1. What is time response?
2. What is transient and steady state response?
3. What is importance of test signals?
4. Name the test signals used in the control systems?
5. Define Damping ratio?
6. Define step and ramp signal?
7. Define parabolic signal?
8. What is the first and second order of a system?
9. List the time domain specifications?
10. What are different types of damping systems?

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Circuit Diagrams:

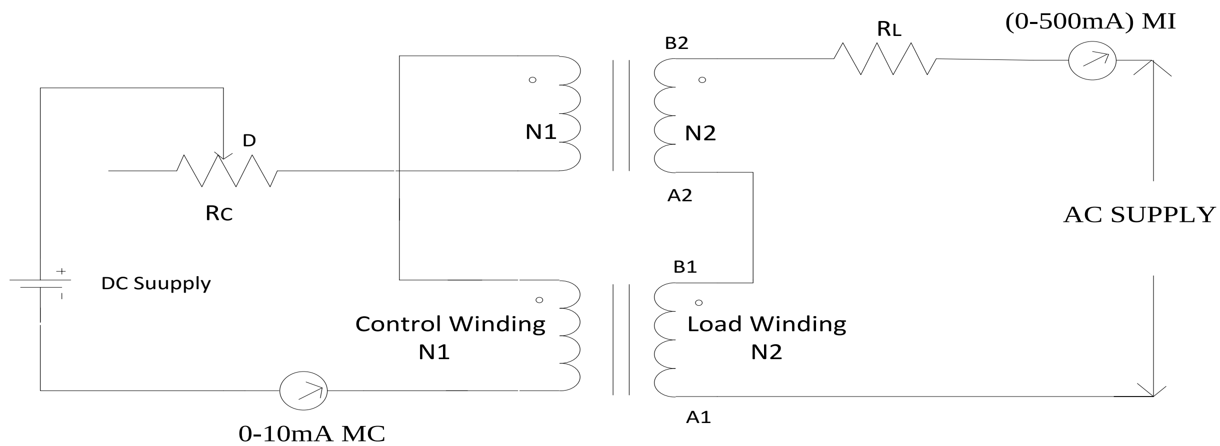

Fig 2.1 Circuit Diagrams for Series Magnetic Amplifier

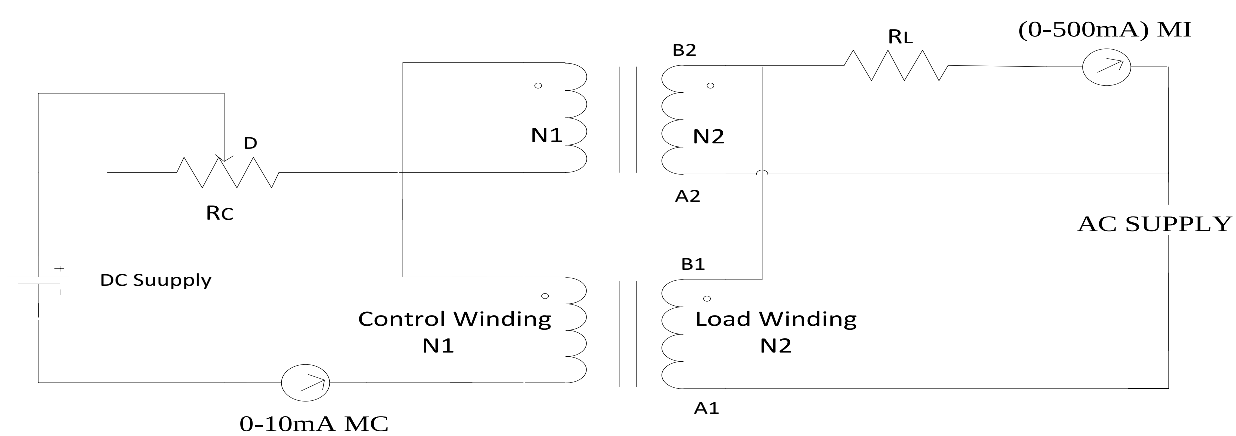

Fig 2.2 Circuit Diagrams for Parallel Magnetic Amplifier

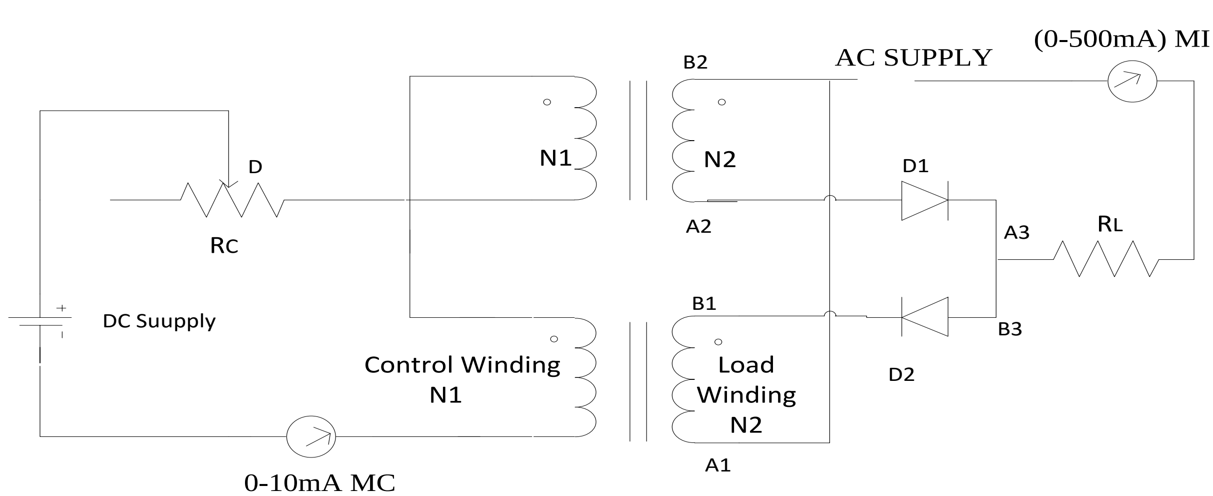

Fig 2.3 Circuit Diagrams for Self Saturated Magnetic Amplifier

Expt. No: Date: ………………..

CHARACTERISTICS OF A MAGNETIC AMPLIFIER

Aim:

To plot the characteristics of series, parallel and self saturated magnetic amplifier.

Apparatus Required:

1. Magnetic amplifier kit -----1
2. Incandescent lamp 100w -----1
3. Patch cords -----6

Theory:

Magnetic amplifier is a device consisting of a combination of suitable reactor, rectifier and conventional transformer used in control of large AC loads with small DC current. Load current in the circuit is controlled by DC magnetizing current which is comparatively low.

1. SERIES CONNECTION: The series connection magnetic amplifier has two windings which are connected in series. The control winding of reactor will be controlling flow of I_L in the load winding. In series connection, I_L can be controlled from nearly 0 to max, depending upon the rating of the load.

2. PARALLEL CONNECTION: The parallel connection magnetic amplifier has two windings which are connected in parallel. The total reactance in this case will be decreased. At zero control current there will be appreciable load current when compared to series connected magnetic amplifier. Initial load current with zero control current will be as near as to the maximum value of load current.

3. SELF SATURATED CONNECTION: The AC windings may be connected either in series or in parallel, resulting in different types of magnetic amplifiers. The amount of control current fed into the control winding sets the point in the AC winding at which either core will saturate. In saturation, the AC winding on the saturated core will go from a high impedance state to a very low impedance state i.e., the control current at which the magnetic amplifier switches. A relatively small DC current on the control winding is able to control or switch large AC currents on the AC windings. This results in current amplification.

Tabular Forms:

Table 2.1: Series Connection

S.No.	Control current(I_C) in mA	Load current(I_L) in mA

Table 2.2: Parallel Connection

S.No.	Control current(I_C) in mA	Load current(I_L) in mA

Procedure:

Series-Connected Magnetic Amplifier:

1. Keep toggle switch in position D on the panel
2. Keep control current setting knob at its extreme left position, which ensures zero control Current.
3. With the help of patch cords connect the following terminals.
   a) Connect AC to A1
   b) Connect B1 to A2
   c) Connect B2 to L
4. Now put 100W lamp in its provided position
5. Now once again check connections
6. Switch on the unit
7. Now by increasing the control current gradually note down the corresponding load current
8. Plot the graph between load current Vs control current.

Parallel Connected Magnetic Amplifier:

1. Keep toggle switch in position D on the panel
2. Keep control current setting knob at its extreme left position, which ensures zero control Current.
3. With the help of patch cords connect the following terminals.
   a) Connect AC to A1
   b) Connect A1 to A2
   c) Connect B2 to L
   d) Connect B2 to B1
4. Now put 100W lamp in its provided position
5. Now once again check connections
6. Switch on the unit
7. Now by increasing the control current gradually note down the corresponding load current
8. Plot the graph between load current Vs control current.

Table 2.3: Self Saturated Connection

S.No.	Control current(I_C) in mA	Load current(I_L) in mA

Model Graphs:

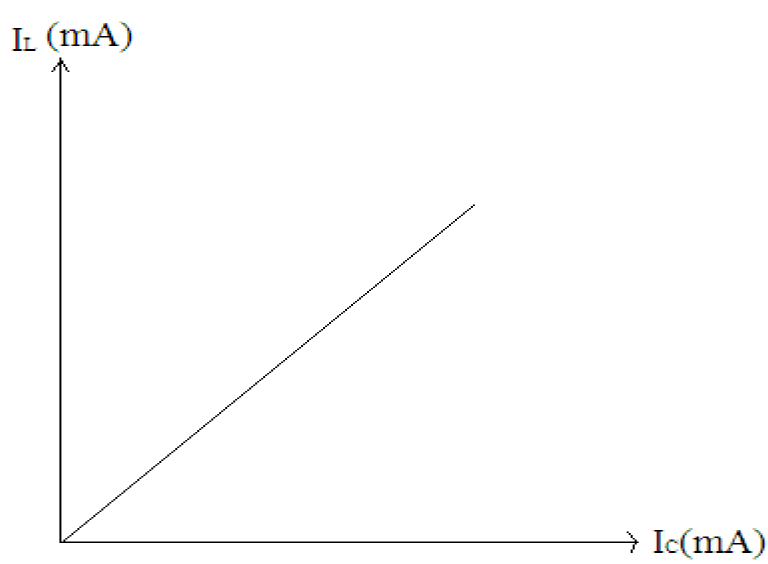

Fig 2.4 Series magnetic amplifier characteristics

Self saturated magnetic amplifier:

1. Keep toggle switch in position E on the panel
2. Keep control current setting knob at its extreme left position, which ensures zero control Current.
3. With the help of patch cords connect the following terminals.
    a) Connect AC to C1
    b) Connect A3 to B3
    c) Connect B3 to L
4. Now put 100W lamp in its provided position
5. Now once again check connections
6. Switch on the unit
7. Now by increasing the control current gradually note down the corresponding load current
8. Plot the graph between load current Vs control current.

Observations:

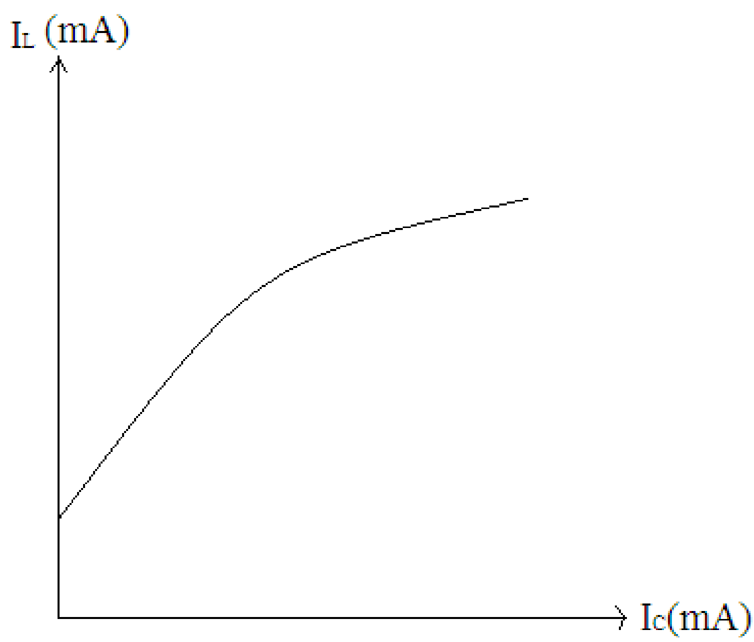

Fig 2.5 Parallel magnetic amplifier characteristics

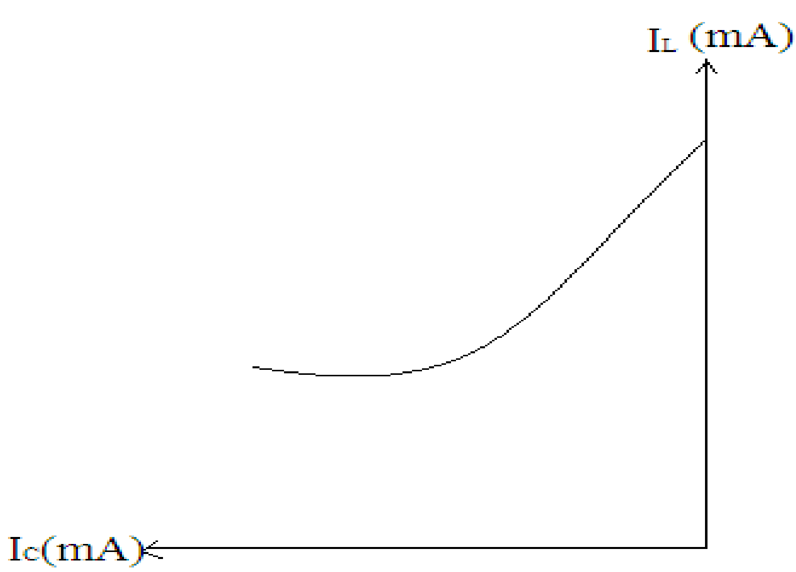

Fig 2.6 Self-saturated magnetic amplifier characteristics

Result:

Viva Questions:

1) What is a Magnetic Amplifier?
2) What is the purpose of Magnetic Amplifier?
3) What are the various practical applications of Magnetic Amplifier?
4) What is the principle behind operation of Magnetic Amplifier?
5) What are the major drawbacks of Magnetic Amplifier?

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Block Diagram:

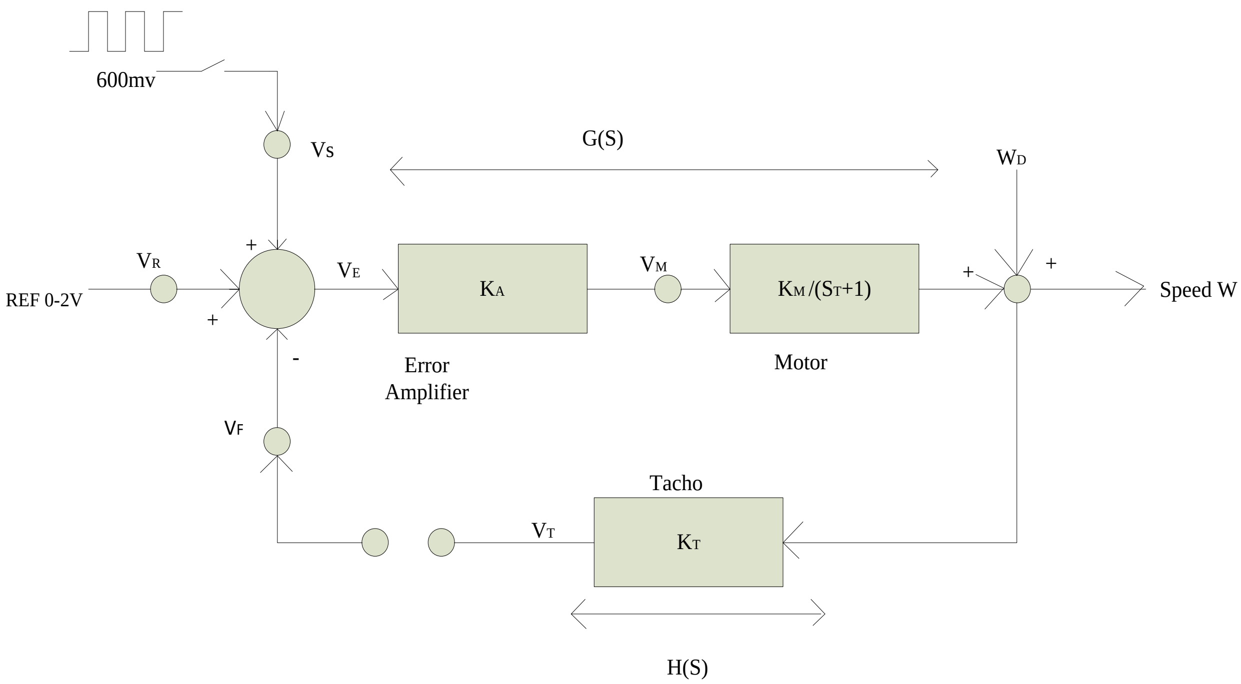

Fig 3.1 Block Diagram of DC Servo Motor

Expt. No: Date: ………………..

EFFECT OF FEEDBACK ON DC SERVO MOTOR

Aim:

To study the performance characteristics of a dc servo motor speed control system.

Apparatus:

DC servo motor kit	----1
Multimeter	----1
Patch cords	----5

Theory:

Servo motors are either separately excited dc motors or permanent dc motor. Thus armature is deliberately designed to have large resistance so, that torque speed characteristics are linear and has large negative slope. The negative slope serves the purpose of providing viscous damping for servo drive system. The armature mmf and field mmf are in phase quadrature. This fact provides a fast torque response. Accordingly a step change in armature voltage or current produces a quick change in speed or torque.

Procedure:

1. Connect the circuit as shown in the Fig 3.1
2. Set the reference voltage to 1V DC.
3. By varying the error amplifier gain, note down the corresponding V_M and speed.
4. Repeat the process for different gain values.
5. Now connect the V_T feedback terminal and repeat the steps 3 and 4.
6. Now with K_A=1, apply breaking to the motor and note down the speed values for both open loop and closed loop circuits.
7. Plot the graph between N and V_M.

SET V_R=1V

Table 3.1: Motor and Tacho Generator Characteristics

S.No.	K_A	N(rpm)	V_T(V)	V_M(V)	Experimental $K_A=V_M/V_R$

SET V_R=1V **Table 3.2:Closed Loop Performance**

S.No.	K_A	N(rpm)	V_T(V)	Experimental $K_A= (V_M/V_R) = (V_R- V_T)/ V_R$	Theoretical $E_{SS}=1/(1+K_AK_MK_T)$

Calculations:

W_{SS} = N * 2π/60

K_m = Shaft Speed /motor voltage = W_{SS}/V_m =

$K_T = V_T / W_{SS}$ =

N=

W_{SS} = N * 2π/60 =

$K_m = W_{SS}/V_m$ =

$E_{gg} = 1/(1+K_A K_m K_T)$

E_{gg} =

E_{gg} =

Table 3.3: Braking Arrangement Table

Braking Point Position	**0**	**1**	**2**	**3**	**4**	**5**
Speed for Open Loop with K_A=1						
Speed for Closed Loop with K_A=1						
Speed for Closed Loop with K_A=2						

Model Graph:

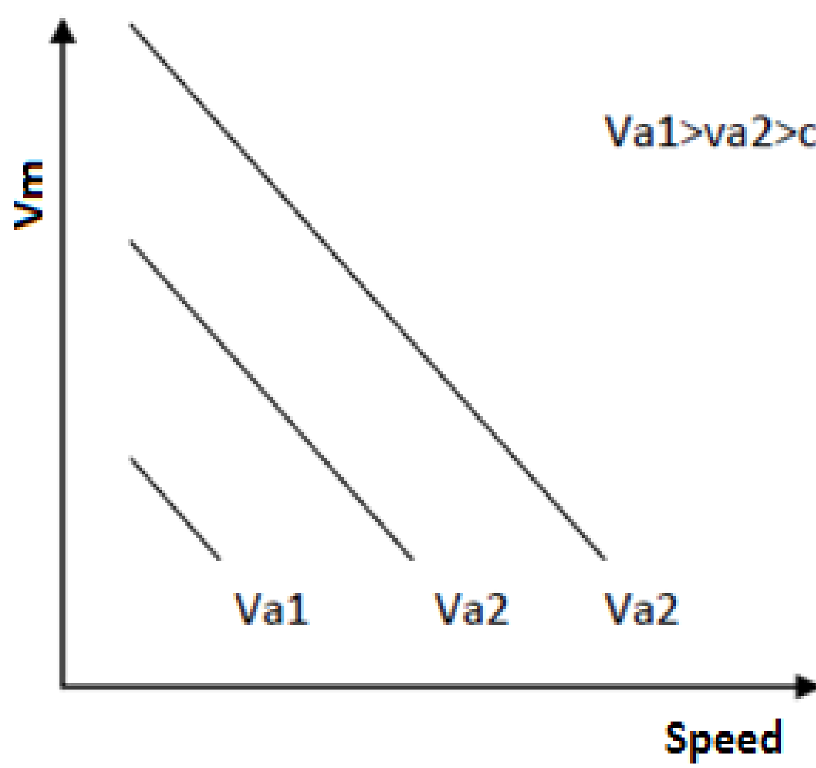

Fig 3.2 Speed Vs V_M

Observations:

Result:

Viva Questions:

1. What is servomotor?

2. What are the characteristics of servo motors?

3. Differences between AC and DC servo motors?

4. What is a DC servo motor?

5. What are the applications of DC and AC servo motor?

6. Give three major differences between Servo motors and Stepper motors?

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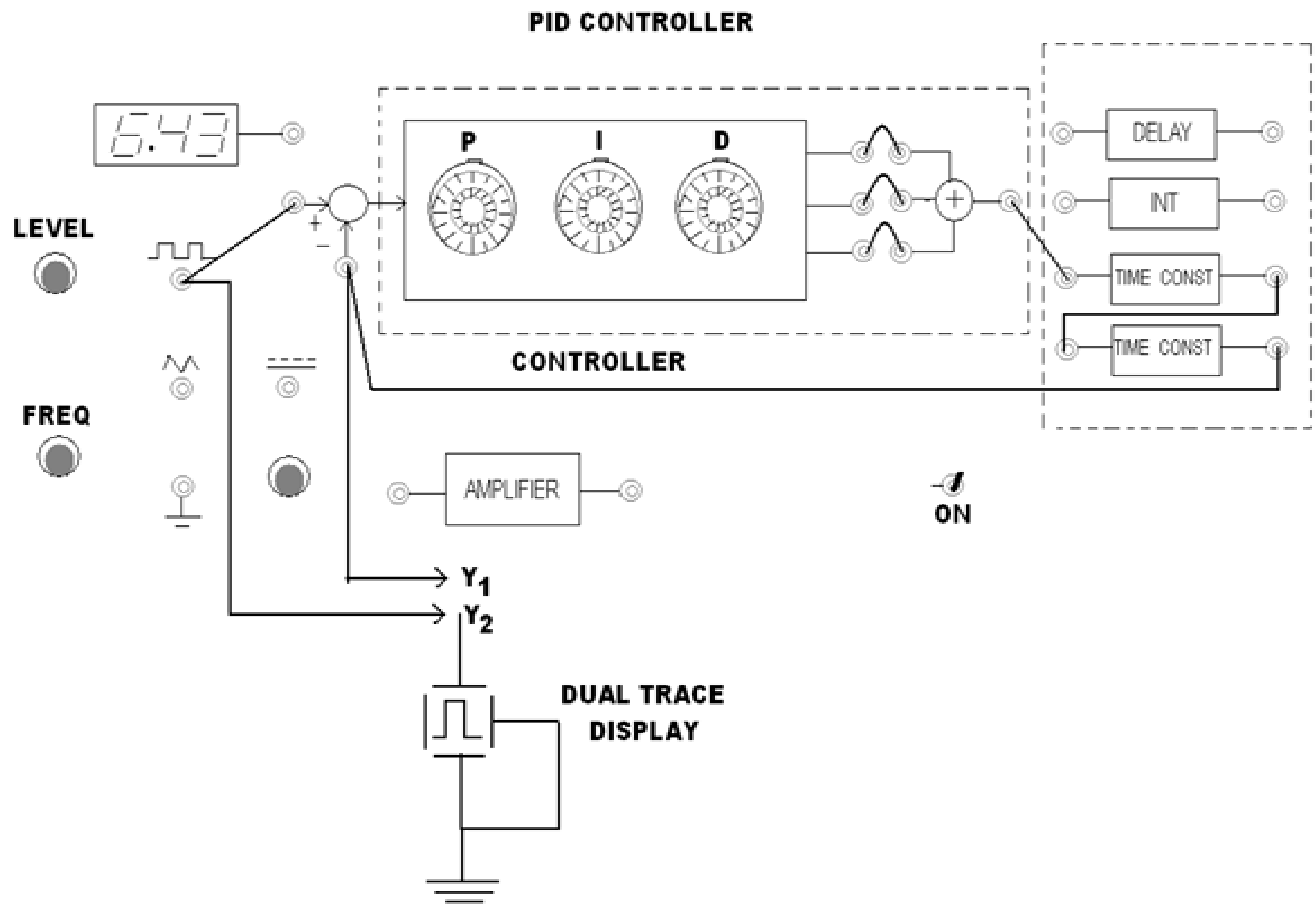


Fig 4.1 Circuit for Effect of P, PD, PI, PID Controller on a Second Order System

Expt. No: Date: ………………..

EFFECT OF P, PD, PI, PID CONTROLLER ON A SECOND ORDER SYSTEM

Aim:

To study the effect of P, PD, PI, PID controller on a second order system.

Apparatus:

PID Controller kit	----1
Patch cords	----8
CRO Probes	----2
CRO	----1

Theory:

The combination of proportional control action, integral action and the derivative control action is called PID controller. The combined action is advantageous.

The P-controller stabilizes the gain but produces a steady state error. The integral controller reduces or eliminates the steady state error. The derivative controller reduces the rate of change of error.

The equation of a PID controller is given by

$$m(t) = k_c e(t) + k_i \int e(t)dt + k_d \frac{d}{dt} e(t)$$

% overshoot = $\frac{y-x}{x} X\ 100$

Where $e(t)$ = error Signal

$m(t)$ = PID output or plant output

k_c = Proportinal Gain

k_i = Integral Gain

k_d= Derivative gain

Proportional-Integral-Derivative (PID) control has been especially popular in industrial processes like chemical, petroleum, power, food and manufacturing industries. These systems

PID Controller Block Diagram:

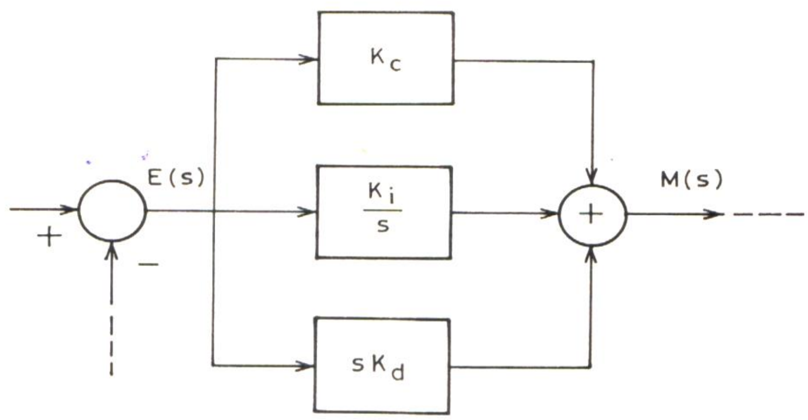


Fig 4.2 Block Diagram of PID Controller

Table 4.1: P Controller Readings

S.No.	K_C	X	Y	Steady state error	% over shoot

Table 4.2: P-I Controller Readings

S.No.	K_C	X	Y	Steady state error	% over shoot

are usually slow, complex and are characterized by relatively incomplete or uncertain mathematical description. The PID controller, parameters of which may be adjusted experimentally, is therefore particularly attractive in such situations.

Procedure:

Proportional (P) Control:

1. Make connections as shown with process made up of time delay and time constant blocks.
2. Set input amplitude to 1V (P – P) and frequency to a low value
3. For various values of K_C = 0.2 , 0.4 measure from the screen.

Proportional – Integral (PI) Control:

1. Make connections for 1st order type – 0 systems with time delay with proportional and integral blocks.
2. Set input amplitude to 1V (P-P), frequency to a low value and K_c=0.6, K_i=0 and K_d=0.
3. The system shows fairly large over shoot. Record the peak over shoot and steady state error.
4. Repeat the above step for a few non zero values of K_i

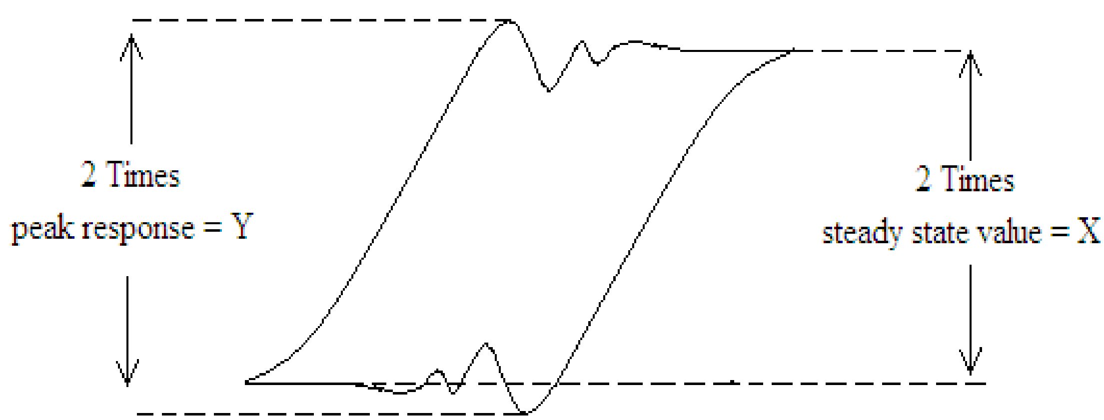
Proportional – Integral - Derivative (PID) Control:

1. Make connections for 1st order type – 0 systems with time delay with proportional and integral and derivative blocks.
2. Set input amplitude to 1V (P-P), frequency to a low value and K_c=0.6, K_i=54.85 and K_d=0.
3. The system shows fairly large over shoot. Record the peak over shoot and steady state error.
4. Repeat the above step for a few non zero values of K_d

Table 4.3: P-I-D Controller Readings

S.No.	K_C	X	Y	Steady state error	% over shoot

Model Graph:



$$\text{Steady state error} = \frac{(p\text{-}p)\text{input} - X}{(p\text{-}p)\text{input}}$$

$$\text{Peak percent overshoot} = \frac{Y - X}{X} \quad 100\%$$

Fig 4.3 Graph for Second Order PID Controller

Precautions:

1. Care must be taken while operating CRO in X-Y mode.
2. Select K_p and K_i Values properly.

Observations:

Calculations:

Result:

Viva Questions:

1. Define proportional controller?
2. Define integral controller?
3. Why should we don’t connect first order &second order in the loop of PID controller?
4. Define second order system?
5. Where shall we apply PID controller?
6. Give two differences between P, PI, PD and PID Controller?

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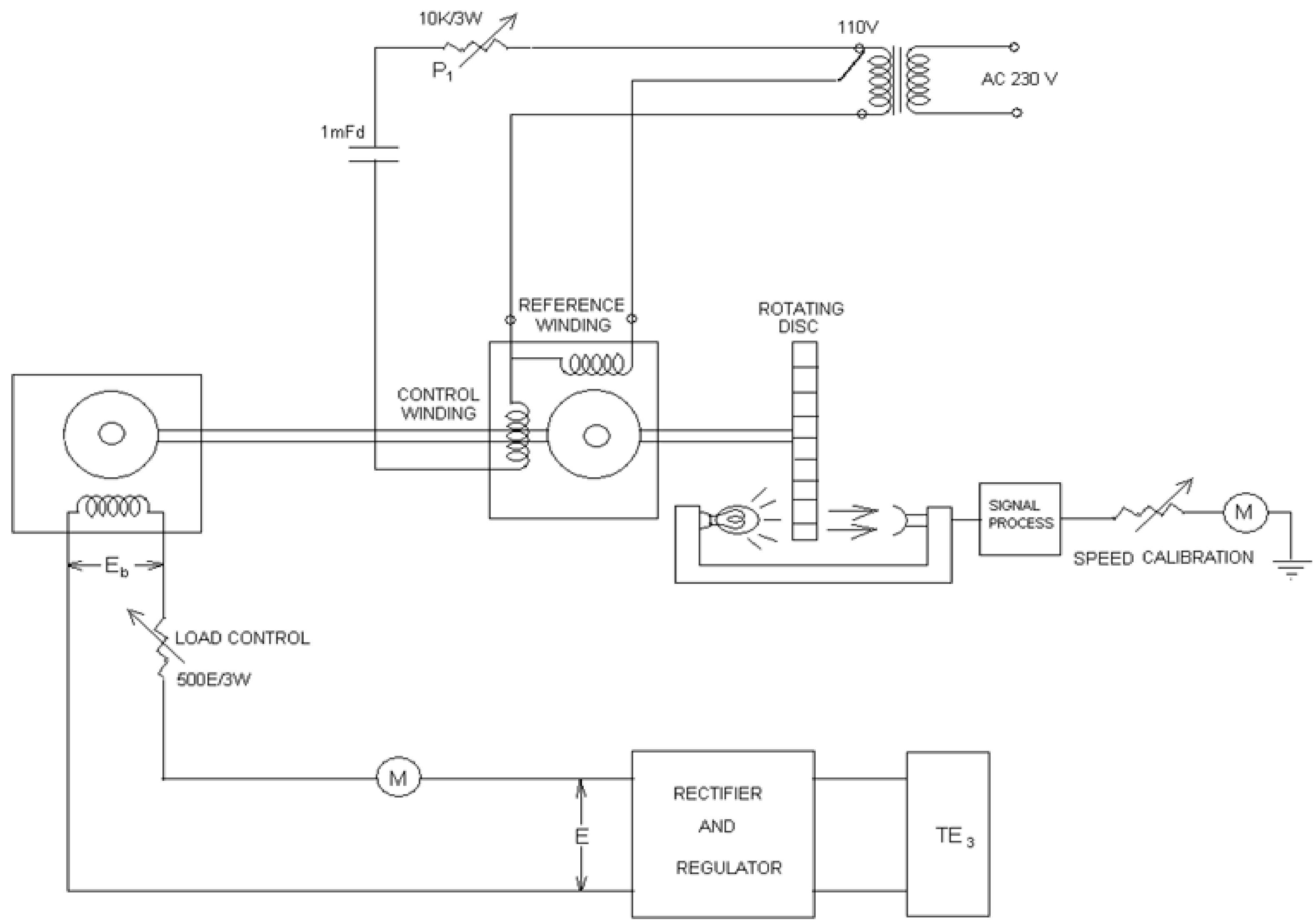

Fig 5.1 Circuit for Speed Torque Characteristics of AC Servo Motor

Expt. No: Date: ………………..

CHARACTERISTICS OF AC SERVOMOTOR

Aim:

To obtain the performance characteristics of AC servo motor

Apparatus:

AC servo motor kit	--- 1
Patch cords	— 6
Multimeter	— 1

Theory:

An AC servo motor is basically a two phase induction motor except for certain special design features. A two phase servo motor differs from a normal induction motor. One the rotor of servo is build with high resistance. So that X/R ratio is small. Second the excitation voltage applied to two stator winding should have a phase difference of 90^0. These currents give raise to a rotating magnetic field of constant magnitude. The rotating magnetic field sweeps over the rotor conductors so voltage is induced in rotor conductors. So rotor starts moving in the same direction of rotor magnetic field. An AC servomotor respectively less power output than a DC servomotor of same size.

Procedure:

1. Keep the switch SW3 in upward position, indicating that the armature circuit of auxiliary power supply. Switch SW2 should also be in off position.
2. Ensure P1 & P2 are in fully anti clockwise direction.
3. Now, switch on the SW2 & vary the speed of ac servo motor and the speed will be indicated by the motor M on the front panel.
4. Now keep SW3 in off position and vary the speed of ac servo motor by moving P1 in clock wise direction & note the emf generated by the dc machine.
5. Now keep switch SW3 in off position and switch on SW2 & keep pot P1 in min position.
6. Observe that the AC servo motor starts moving with the speed being indicated by rpm indicator. Measure the reference winding voltage & control winding voltage.
7. Note the speed of ac servo motor now switch on SW3 and start loading ac servo motor by controlling pot P2 in slow passion. Note values of Ia & N.
8. You may set control winding voltage to a new value of 30V after switching off SW3. Again repeat the process in step5, for a new value of control winding.

Block Diagram:

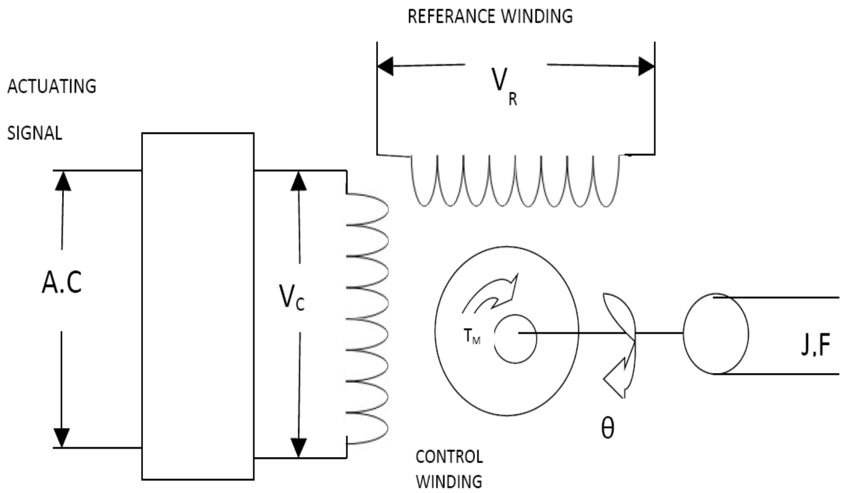

Fig 5.2 Block Diagram of AC Servo Motor

Table 5.1:No-load characteristics

S.No	Speed(rpm)	E_b(volts)

Table 5.2: On-load characteristics

V_c=		V_R=	speed(N) =	
I_a(A)	Speed(rpm)	E_b(mV)	Power(mW)	Torque(gm-cm)

Precautions:

1. The pulley- belt system need to be clean after sometime if there is moist environment.
2. Clean the belt and pulley with dry lint free piece of cloth.
3. Cover the set up with cloth cover when the set up is not in practice.

Observations:

Table 5.3:On-load characteristics

V_C=		V_R=	speed(N) =	
Ia(A)	**Speed(rpm)**	**Eb(mV)**	**Power(mW)**	**Torque(gm-cm)**

Model Graphs:

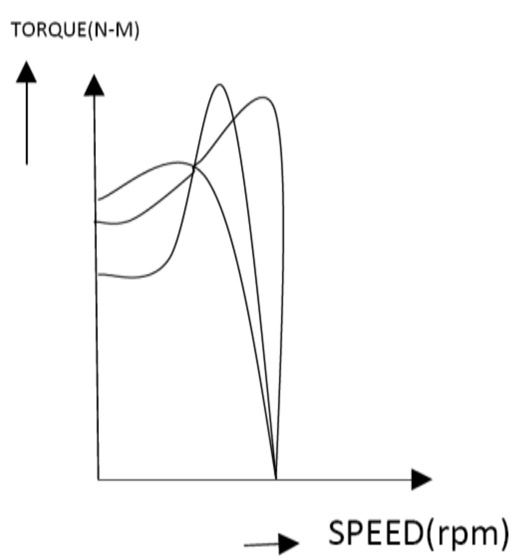

Fig 5.3 Torque Vs Speed graph

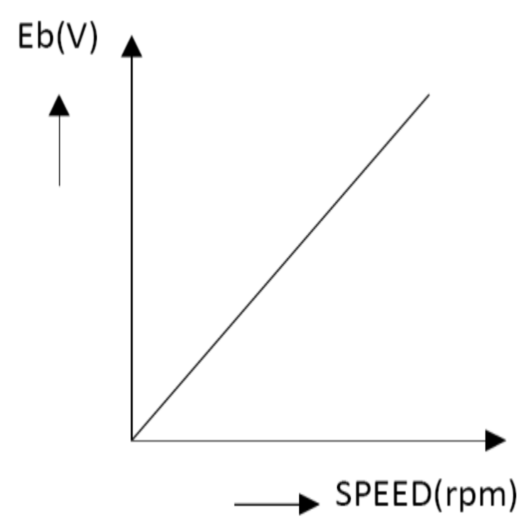

Fig 5.4 Speed VsE$_b$

Result:

Viva Questions:

1. What is servo motor?

2. What are the characteristics of servo motors?

3. Compare the AC and DC servo motors?

4. What is difference between AC servomotor and two phase induction motor?

5. Write the differential equation governing the AC servomotor?

6. What are the applications of AC servomotor and DC servo motor?

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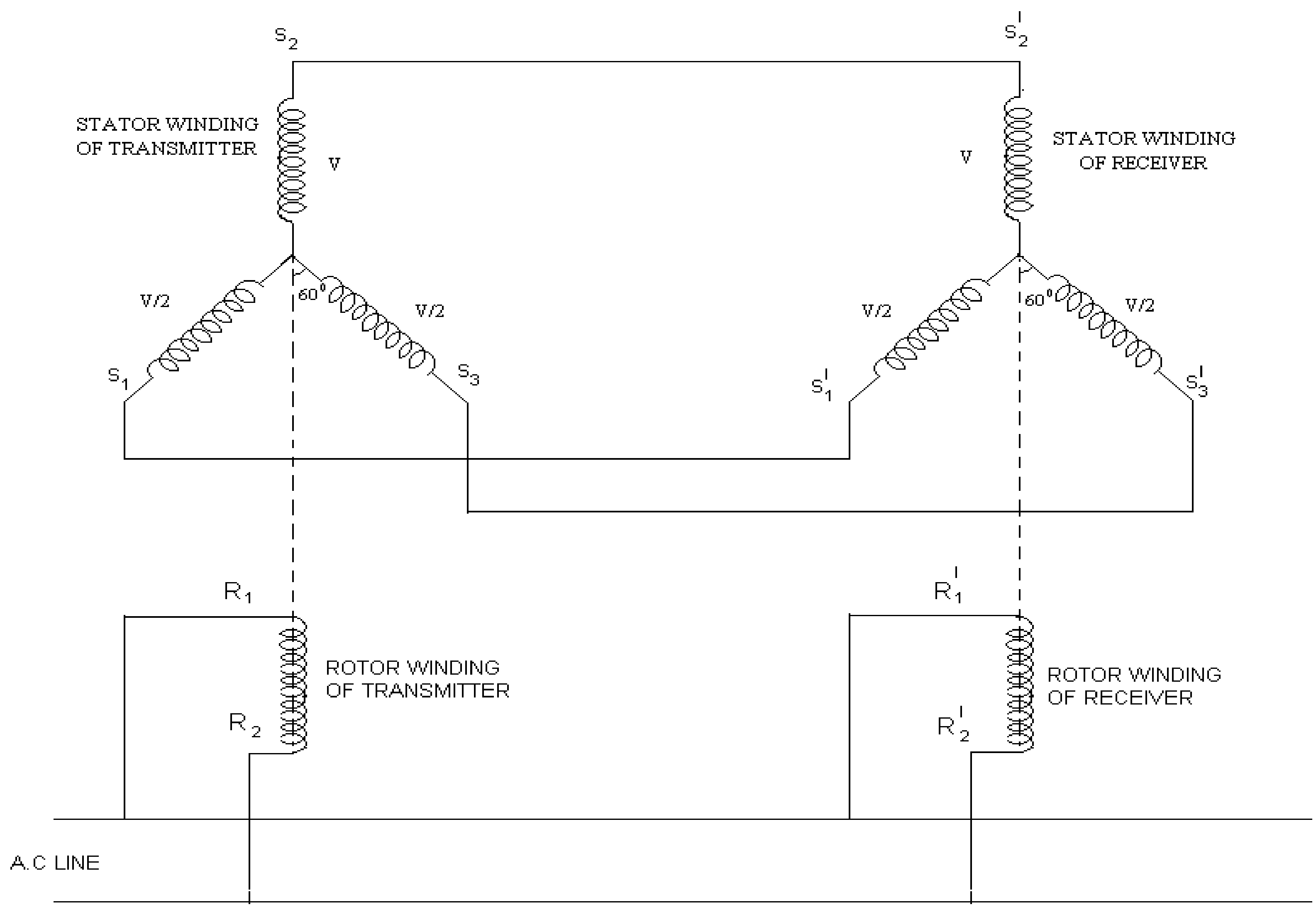

Fig 6.1 Circuit Diagram for Synchro Transmitter and Receiver Pair

Expt. No: Date: ………………..

CHARACTERSTICS OF SYNCHROS

Aim:

To study the characteristics of the synchros as transmitter and synchro transmitter- receiver pair.

Apparatus:

Synchro transmitter and receiver pair kit	----1
Patch cords	----5
Multimeter	----1

Theory:

A synchro is an electromagnetic transducer commonly used to convert an angular position of a shaft into an electric signal.In this part of experiment we can see that because of the transformer action the angular position of rotor is transformed into a unique set of stator voltages.

A synchro is an electromagnetic transducer commonly used to convert an angular position of shaft into an electrical signal. It is commercially used as “selsyn” or “auto transducer”. An ac voltage is to be applied to rotor of synchro transmitter.

The stator coil voltage is of course in time phase with each other. Thus we see that synchro transmitter the stator coil voltages are of course acts like a 1-ϕ transformer in which rotor coil is primary and stator coil is secondary.

Let$V_{S1,S2}$, $V_{S2,S3}$ & $V_{S1,S3}$ from secondary’s respectively be voltages induced in stator coils S_1, S_2 &S_3 with respect to the neutral. The input of the synchro transmitter in the angular position of its rotor shaft & output is set of three 1-ϕ voltages.

Table 6.1: Synchro Transmitter

S.No	Position of Rotor (in degrees)	Stator Terminal Voltage		
		$V_{S1,S2}$(V)	$V_{S1,S3}$(V)	$V_{S2,S3}$(V)

Table 6.2: Synchro Transmitter- Receiver Pair

S.No	Angular Position Synchro Transmitter (In Degrees)	Angular Position Synchro Receiver (In Degrees)

Procedure :

Synchro Transmitter:

1. Connect the kit to the main supply
2. Connect S_1, S_2 & S_3 of synchro receiver by patch cards provided respectively
3. Switch on main supply and also switch on SW_1, SW_2
4. Move the pointer i.e. rotor position of synchro transmitter T_X in step of 30^0& observe the new rotor position observe that T_r rotor is rotated, the T_r rotor follows it with the direction of rotation.
5. Enter the input signal angular position & adjustment output position in tabularform and plot the graph.
6. Switch off SW_1, SW_2 and switch off main supply.

Synchro Transmitter-Receiver Pair:

1. Connect the main supply cables.
2. Switch on main supply and also switch on S_{W1}, S_{W2}
3. Starting from zero position, note down the voltages b/w stator winding terminals i.e. $V_{S1,S2}$, $V_{S2,S3}$ & $V_{S1,S3}$ in sequential manner
4. Enter readings in tabular form and plot graph of angular position.
5. Note down the zero position of stator coincides with V_{S3S1} voltage. Don't disturb this condition.
6. Switch off SW_1, SW_2 and switch off main supply.

Model Graph:

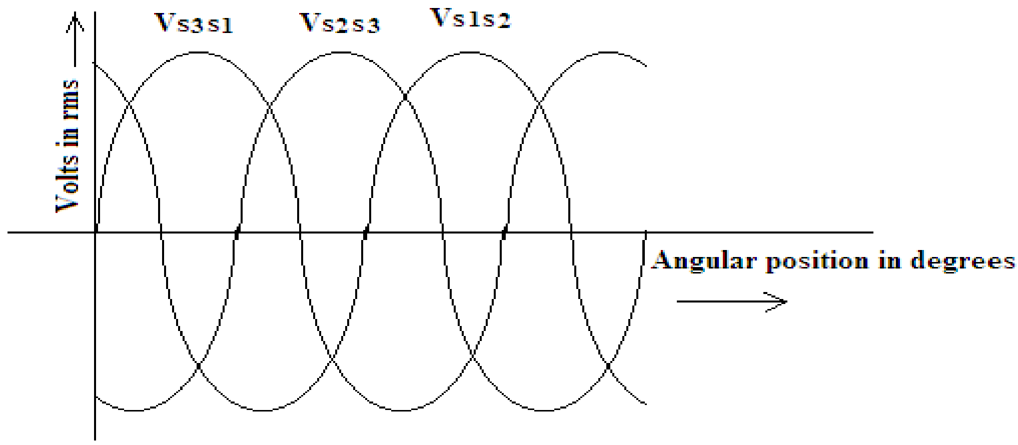

Fig 6.2 Synchro-Transmitter and Receiver Pair Output Waveform

Precautions:

1. Handle the pointer for both rotors in gentle manner.
2. Don’t attempt to pull out the pointer.
3. Don’t short rotor or stator terminals.

Observations:

Result:

Viva Questions:

1. Define synchros?
2. What do you understood by this experiment?
3. Write principal how angular position is converted to voltage?
4. Write the applications of synchro transmitter?
5. Write the applications of synchro receiver?

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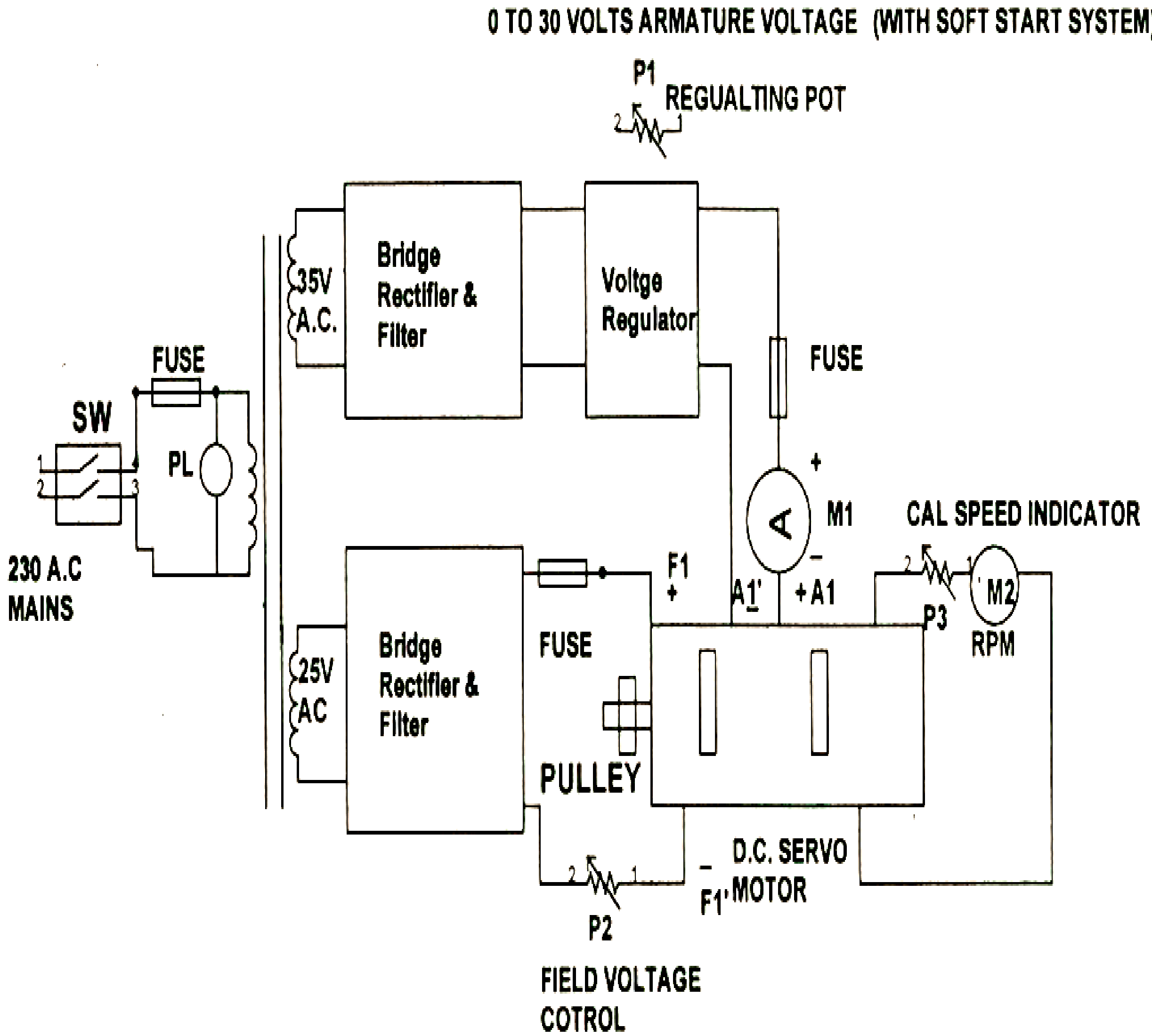

Fig 7.1 Speed Torque Characteristics Circuit

Expt. No: Date: ………………..

CHARACTERISTICS OF DC SERVO MOTOR

Aim:

To obtain the speed- torque characteristics curve for given armature controlled DC servomotor.

Apparatus Required:

Experimental kit	---	1
Multimeter	---	1
Connecting cords	---	As Required

Theory:

The function of the servo is to receive a control signal that represents a desired output position of the servo shaft, and apply power to its DC motor until its shaft turns to that position. The term correctly applies only to systems where the feedback or error-correction signals help control mechanical position, speed or other parameters. For example, an automotive power window control is not a servomechanism, as there is no automatic feedback that controls position.

A DC servomotor is basically a shunt wound motor with only difference is made that its armature and field resistance is normally kept equal to obtain steeper torque- speed characteristics. These motor operated as separately excited motoring mode in which field is energized by constant voltage source and armature is controlled by an amplifier. Recently rare earth permanent magnet dc motors are available which give excellent stepper slope because of it does not suffer from field saturation and having low mass high resistance armature facilitates to operate it from wide range input voltages.

As stated earlier dc servomotor is used in control applications. In either way the dc servomotor is basically a torque transducer which converts electric energy into proportional mechanical energy. The torque developed on motor shaft is directly proportional to armature current and field flux.

The relationship between motor torque and Tm, field flux and armature current is given as

$$T_m = K_m W^1 I_a$$

Where, K_m = motor torque constant

W^1 = magnetic field strength

I_a = armature current

Table 7.1: Observations

(i)Va = 10V V_f= 20V

S.No.	I_a (in Amp)	N(speed)	S_1 Kg	S_2 Kg	Net Weight	T Kg-cm

Table 7.2: Observations

(ii)Va = 20V V_f= 30V

S.No.	I_a (in Amp)	N(speed)	S_1 Kg	S_2 Kg	Net Weight	T Kg-cm

Procedure:

1. After familiarization of control, adjust lead – screw knob to adjust spring balance to read 0’s in both ends.
2. Switch on the power. A neon light will glow to commence the power is applied to set up.
3. Select current read switch to field side. Adjust field supply to control to read 0.25 A at current meter.
4. Select current read switch to armature side. Adjust armature supply to control to read 30 V dc. It may be require applying full voltage to armature once and as motor runs than adjusting it back to 30 volt.
5. Note no load speed from rpm meter and no load current from current meter. Observe at spring balances that these are at 0 reading.
6. Increase load by means of lead- screw adjuster mounted upon one spring balance S2, to read other balance some reading say 50 gm.
7. Increase tension of spring balance S2 slowly in 50 gm steps and note reading of load from spring balances, armature current and corresponding speed in RPM.
8. Increase S2 tension till motor goes very slow or it stops. If ammeter overshoots decrease the armature voltage to read reasonable armature current. Note these values of voltage and current.
9. Prepare a table from the observations.
10. Calculate torque T = (S1- S2)*r, where S1 & S2 = reading of spring balance, r = radius of pulley. Calculate armature resistance in steady state condition Ra = V/ Ia.
11. Prepare two more set of table adjusting armature voltage at 20 and 25 volts.
12. Draw speed- torque curves from the tables..
13. From the point T stall (torque at zero speed), find its value form the graph.
14. Plot the graph between torque and armature current. Find the armature current at no load

Model Graph:

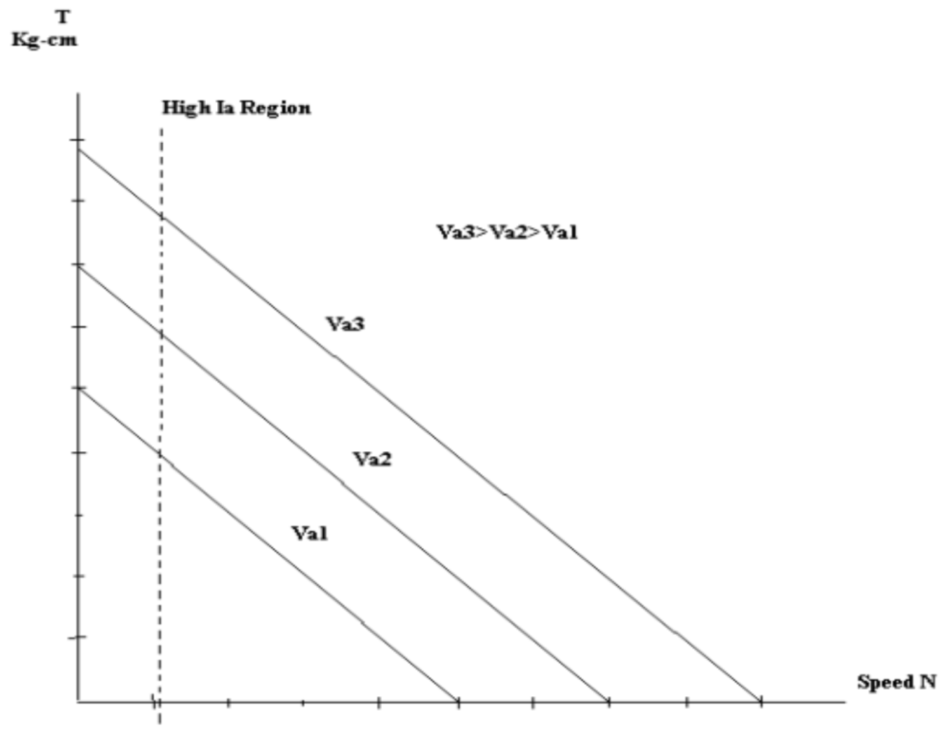

Fig 7.2 Speed -Torque characteristics curves

Precautions:

1) The pulley- belt system need to be clean after sometime if there is moist environment.
2) Clean the belt and pulley with dry lint free piece of cloth.
3) Keep covered the set up with cloth cover when the set up is not in practice.

Observations:

Result:

Viva Questions:

1. What is a DC servo motor and how it is differentiated with normal motor?
2. What are the applications of DC servo motor?
3. What are the main differences between AC and DC servo motor?
4. What are the differences between servo motor and stepper motor?
5. Explain the construction of DC servo motor?

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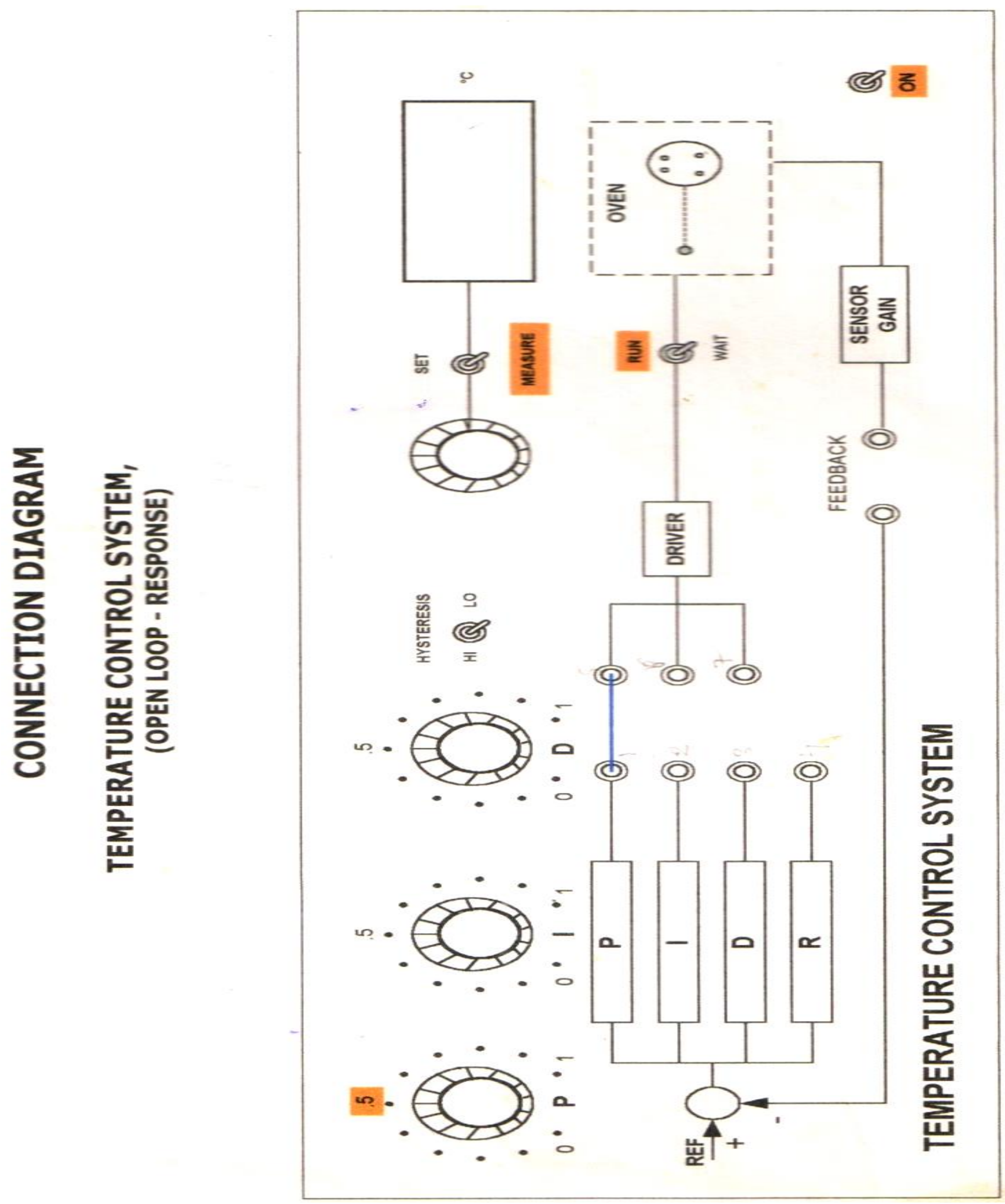

Fig 8.1 Temperature controller system of open loop type

Expt. No: Date: ………………..

TEMPARATURE CONTROLLER USING PID

Aim:

To study the performance of a PID type of controller is used to control the temperature of the oven.

Apparatus:

Temperature control kit	---1
Heater	---1
Stop watch	---1
Patch cords	---5

EXPERIMENT NO-I

Aim:

To study the phenomenon of set for proportional controller when the load process is varied.

Procedure:

1.Establish the connection between the conditioning unit and the model process with the help of cables provided.

2.Refer to fig. and connect red-3 and black- 1 with the help of patch card.

3.Set the“SET” potentiometer at the position of 20 Ohm corresponding to degree centigrade of temperature.

4.Set proportional band control to 10% i.e K_L=10.

5.Now turn ON the power supply and also turn ON the fan. Place the fan regulator at low position.

6.Wait until the deviation indicator stabilizes at some point. Record the deviation and readings and percentage of power reading at interval of 15 seconds.

7.Now suddenly increase the fan speed to full level by moving fan control to high position.

8.Now note the deviation meter reading when the pointer stabilizes. Record the deviation and meter readings. The differences between the two

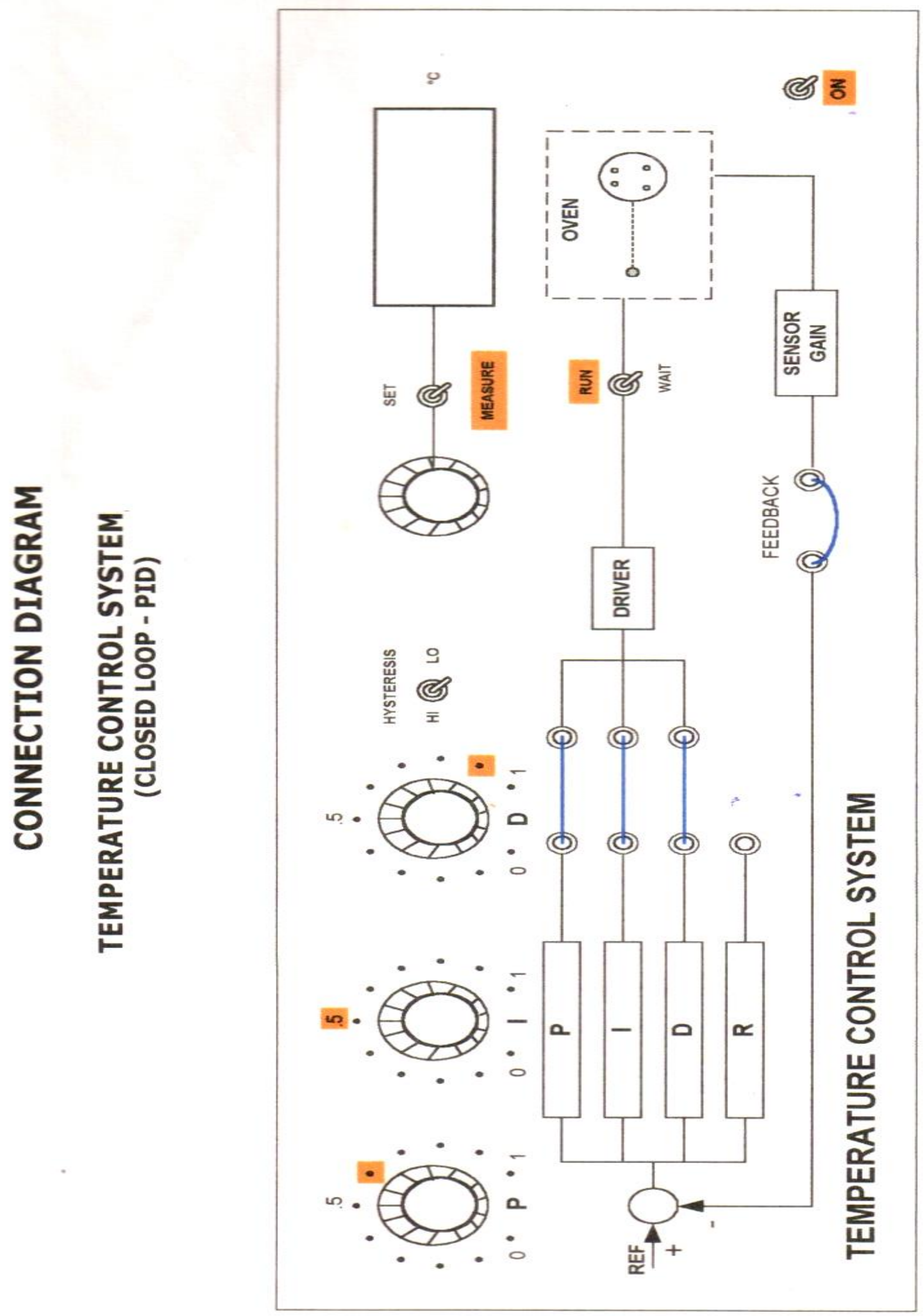

Fig 8.2: Temperature controller system of closed loop(PID) type

readings i,e steps 6 is the offset, (steady state error)associated with the proportional control.

9. Now you may increase the gain to 100 i.e proportional band to that and repeat the steps 5 to 8. In this expt. You will observe that the offset error is reduced.
10. You may perform experiments with various gain settings.

Integral Control:

Integral action is a made of control action in which the value of the manipulated variable is changed at a rate proportional to the deviation. Thus if the deviation is doubled over a previous value, the final controlelement is moved twice as fast. The integral action adjustment is the integral time. For a step change of deviation, the integral time is the time required to add and increment, the response equal to the original step change of response. Integral action is used alone very seldom.

Integral action is generally used in association with proportional action as a result of integral action the action the offset error is almost reduced to zero, but the transient is adversely effect on the process under the conditions of load variations.

Derivative Action:

A derivative control action may be added to proportional control and continued P+D control action obtained. Derivative control action may be defined as control action in which magnitude of the manipulated variable is proportional to the rate of change of derivation.

The net effect of the derivative action to shift the manipulated variable ahead by a time Td,the derivative time.

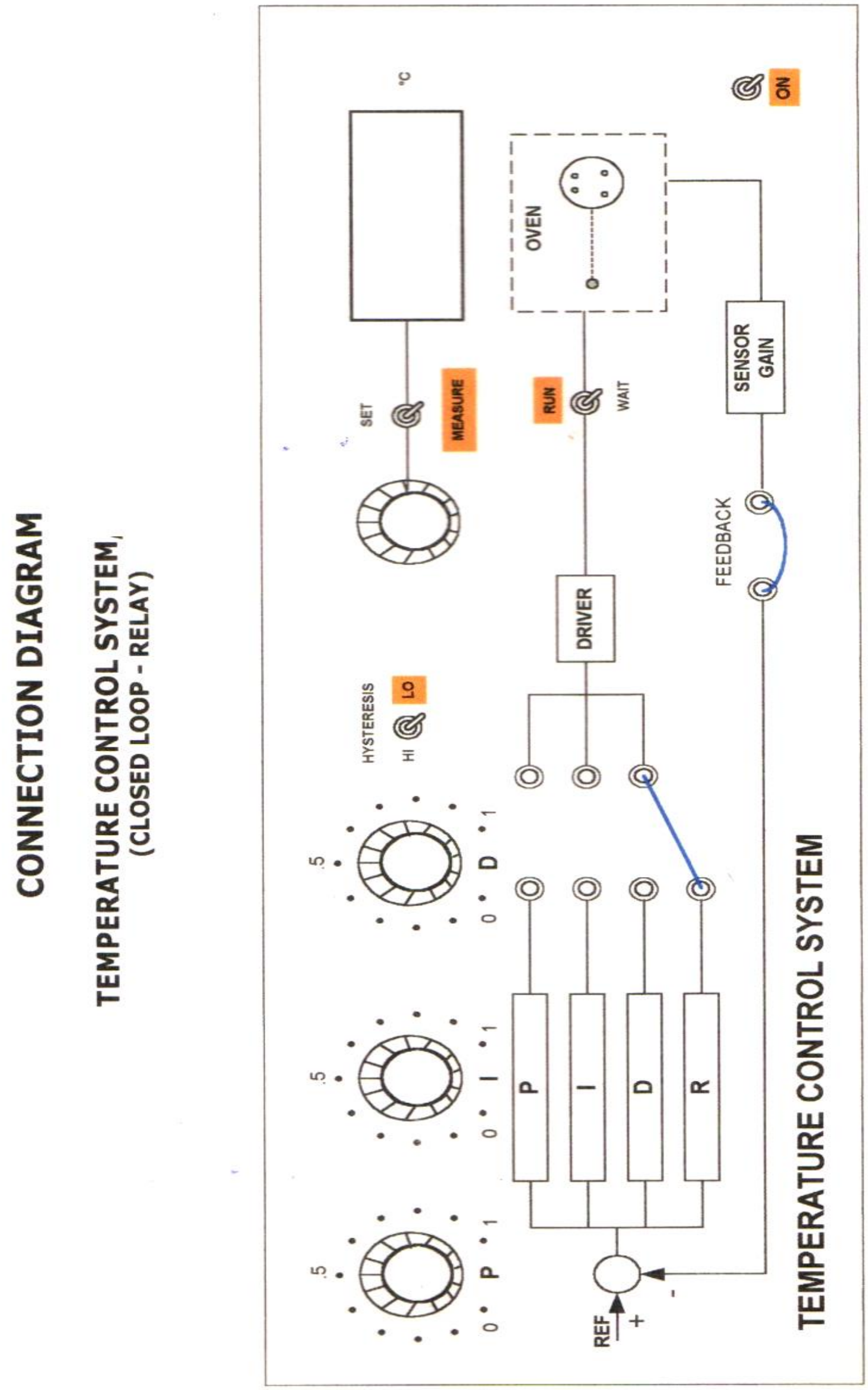

Fig 8.3: Temperature controller system of closed loop (Relay) type

The controller response now leads the time changer of deviation to this extent the derivative response anticipates. Derivative time is defined as the amount of lead. Expressed in minute of time that control action is given. The signal feedback is

$$(1/(1+SCR))* V/K1$$

Experiment No-I (P+I)

AIM:

To show the effect of integral action in eliminating the offset. To observe that the integral action has destabilizing effect on the process when load changes occur.

Procedure:

Establish the connections as per fig.5 with the help of patch cords. Get the indicating settings for the various controls .a) SET = 20ohms (i.e50 degrees centigrade) The advantages of derivative action are that the proportional gain made larger without producing excessive oscillations.

This turn reduces offset. It is sometimes possible through the use of P+D to reduce offset to such a small value that integral action required. The action improves that transient response considerably under larger load change

EXPERIMENT NO-II (P+D)

Aim:

To observe the establishing effect of the derivative action.

Procedure:

1. Establish the connections as per fig.8 with the help of patch cords get the indicating settings for the various controls.

   SET= 20ohms (i.e50 degrees centigrade)

   PB= 10%. Coarse control for derivative action = 2.5sec. Fine control = midway.

Tabular 8.1:

Set Reference Temp=60 Deg.

Time(Sec)	P-Controlled (Open Loop)Temp	PID Controlled (Closed Loop)Temp	Relay Connection (Closed Loop)

2.Turn off the fan with fan control is low position.

3.Wait until the process stabilizes.

4.Now introduce the load change by moving the fan control to high position. Take the record for deviation meter at the interval of 5 to10sec .You may observe that the process comes to almost zero deviation point quickly. Infact in this process the performance of P+D and P+I+D are almost identical.

5. You may perform experiments for settings of derivative time and PB element.

Result:

Vivaqustions:

1.Define proportional controller?

2.Define integral controller?

3.Why should we do not connect first order & second order in the loop of PID controller?

4.Define second order system?

5. Where shall we apply PID controller?

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CIRCUIT DIAGRAMS:

Lag Compensator

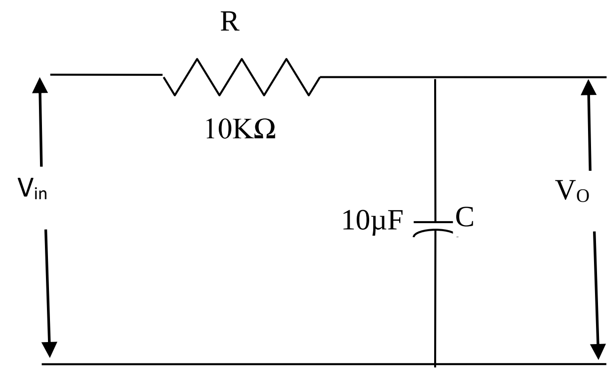

Fig 9.1: Circuit diagram for Lag compensator

$\emptyset = \tan^{-1} \omega RC$

$$\frac{V_o}{V_{in}} = \frac{\left(1/_{RC}\right)}{\sqrt{\omega^2 + \left(\left(1/_{RC}\right)\right)^2}}$$

Lead Compensator

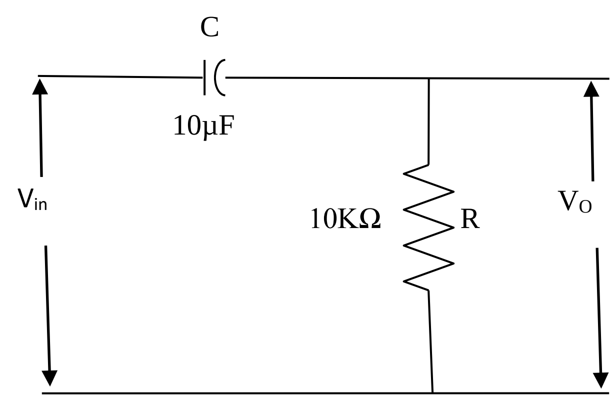

Fig 9.2: Circuit diagram for Lead compensator

$\emptyset = \tan^{-1} 1/_{\omega RC}$

$$\frac{V_o}{V_{in}} = \sqrt{\omega^2 + \left(\left(1/_{RC}\right)\right)^2}$$

Expt. No: Date: ………………..

STUDY OF LEAD-LAG COMPENSATION NETWORKS

Aim:

To determine and study the performance of lag lead compensation networks.

APPARATUS:

Resistance box	---1
Capacitance box	---1
Patch cords	---8
CRO Probes	---2
CRO	---1
Function generator	---1

Theory:

Study Of Lead-Lag Compensating Network:

Every control system designed for a specific application has to meet certain performance specifications. Setting the gain is the first step in adjusting the system for satisfactory performance. In many practical cases, however the adjustment of the gain alone may not provide sufficient alternation of the system behavior try to meet the gain performance. As frequently the case is increasing the gain value will improve the steady state behavior. It is when necessary to design the system in order to alter the overall behavior so that the system will behave as desired.

An additional device inserted in the system for such purpose is called a COMPENSATOR. This device compensates for deficient performance of the
Original system.

They are usually electrical, mechanical, and hydraulic and consist of RC networks and amplifiers. We shall study compensating network in the form of electrical RC network.

Lead Lag compensator

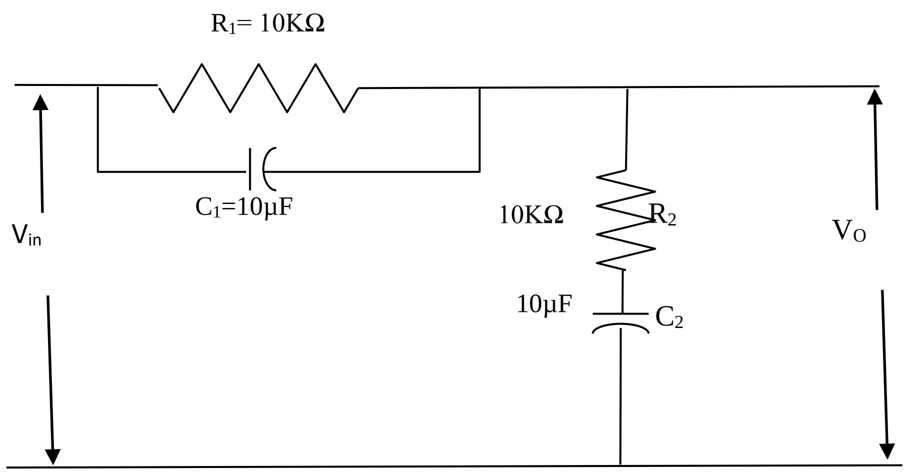

Fig 9.3: Circuit diagram for Lead-Lag compensator

$$\mathrm{R_1C_1 = Z_1}$$

$$\mathrm{R_2C_2 = Z_2}$$

$$\beta = \frac{R_1 + R_2}{R_2} > 1$$

$$\alpha = \frac{R_2}{R_1 + R_2} < 1$$

Experiment No. I

Study of Simple Phase Lag Network

Procedure:

1. Make the connections as shown in fig.
2. Select the components R=10kohm, C=0.1uf. Connect these components so as to rig up phase lag circuit.
3. Switch on the supply
4. Check calibration of phase angle meter by throwing sw2 in CAL position. If meter does not indicate 180, adjust the CAL potentiometer & get 180degrees direction.
5. Keep sw3 in LAG position.
6. Adjust the input excitation to 3volts R.M.S.
7. Now change the audio oscillator output frequency in the range of 20hz to100hz and enter the result in table1 below.
8. Calculate the theoretical value of modulus of T(jw) and teta from the formula given below.
9. Plot the graphs of modulus of T(jw) and teta against frequency. Find out corner frequency.
10. Connect the resistance of 10kohms or 1kohms across the output terminals of the lag network. You may again repeat the experiment. Because of the loading effect, the characteristics of network are drastically affected.

Repeat steps as in expt1, you may connect a load of 1k or 10k across the network and observe the effect of the load on the frequency response and change in phase shift pattern.

Limited Lead compensator

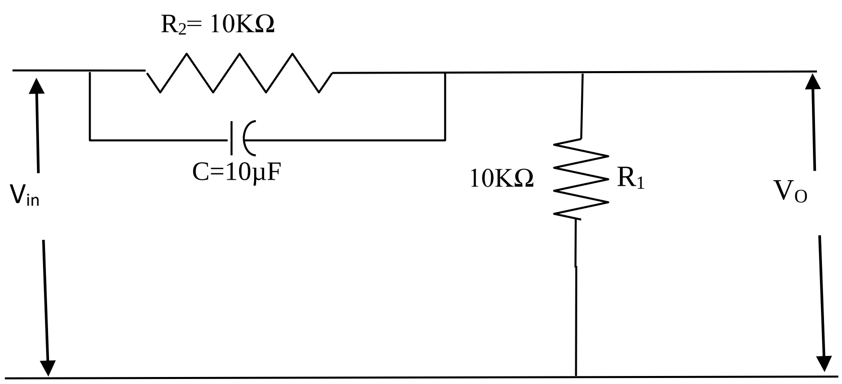

Fig 9.4: Circuit diagram for Limited Lead compensator

$$T = R_1 C$$

$$\alpha = \frac{R_1}{R_1 + R_2} = 0.5 \quad T = 1msec$$

$$\text{Phase angle } \emptyset = \tan^{-1} \omega T - \tan^{-1} \alpha\omega T$$

Limited Lag compensator

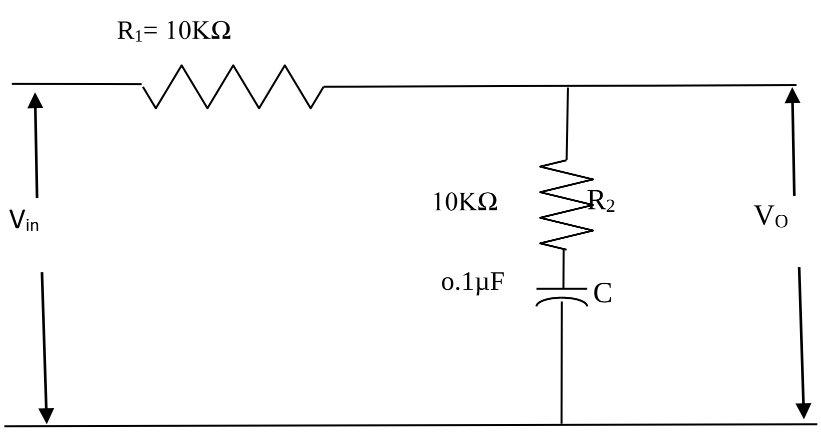

Fig 9.5: Circuit diagram for Limited Lag compensator

$$\beta = \frac{R_1 + R_2}{R_2} = 2$$

$$T = R_2 C = 1\ msec$$

$$\emptyset = \tan^{-1} \omega T - \tan^{-1} \beta\omega T$$

Experiment No:II

Study of Simple Phase Lag Network

1.Make the connections as shown in figure.

2.Select the components R=10K, C=0.1mfd .connect these components so as to rig up phase lead circuit.

3.Switch on the supply

4.Check calibration of phase angle meter by throwing sw2 in CAL position. If meter does not indicate 180, adjust CAL potentiometer & get 180 degree indication.

5.Keep the sw3 in lead position.

Repeat steps as in expt1, you may connect a load of 1k or 10k across the network and observe the effect of the load on the frequency response and change in phase shift pattern

You may perform the experiment for some other combinations of B andC,but the excitation frequency must be in the range of 20hz to 1000hz.

Experiment No III

Study of Lag Lead Compensator

The LEAD-LAG compensator is a combination of lag compensator of lead compensator.

Make the connections as shown in figure.

Select components R1=R2=10K, C1=C2=0.2mfd & rig up to lag lead compensator. Repeat the steps

You may have to change sw3 from lag to lead as you sweep through the frequency range when meter goes off the scale then you have to effect the change over the lead lag switch(sw3).

Table 9.1 : Lag compensation network

Frequency in Hz.	Practical		Theoretical	
	Phase angle	V_o/V_{in}	Phase angle	V_o/V_{in}

Table 9.2: Lead compensation network

Frequency in Hz.	Practical		Theoretical	
	Phase angle	V_o/V_{in}	Phase angle	V_o/V_{in}

Result:

Viva Questions:

1. What is compensation?

2. What is mean lag-lead compensation?

3. What is mean limited lag compensation?

4. What is mean limited lead compensation?

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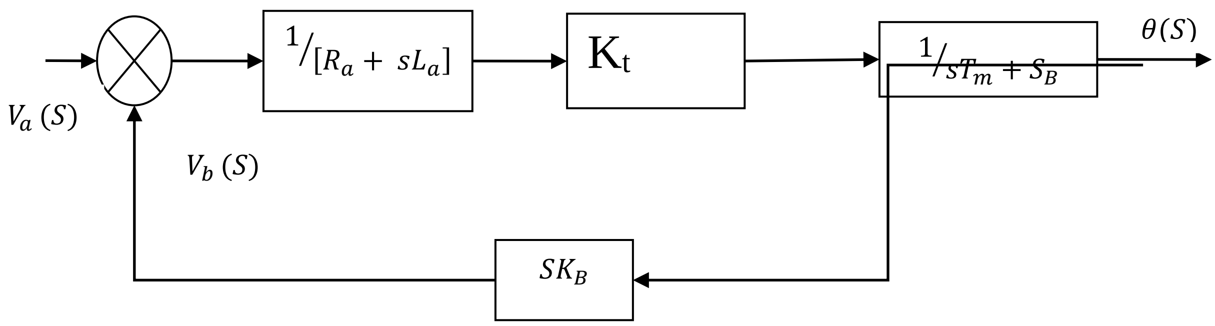


Fig 10.1: Block diagram for transfer function of DC Motor

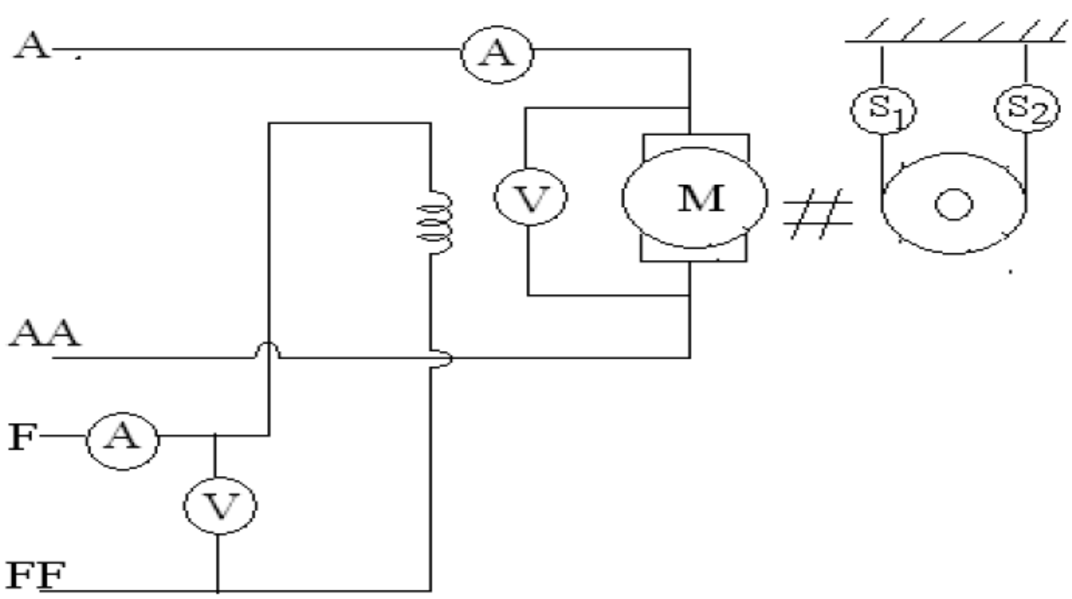


Fig 10.2: Circuit diagram to determine Kt and Kb

Expt. No: Date: ………………..

TRANSFER FUNCTION OF DC SHUNT MOTOR

Aim: - To determine the transfer function of armature controlled DC shunt motor.

Apparatus:

S.No	Name of the Apparatus	Range	Type	Quantity
1	Rheostat	360Ω/1.2A	W.W	1No.
2	Rheostat	50Ω/5A	W.W	1No.
3	Ammeter	(0-5)A	M.C	1No.
4	Ammeter	(0-2)A	M.C	1No.
5	Voltmeter	(0-300)V	M.C	1No.
6	wattmeter	300V/5A	UPF	1No.
7	Tachometer	1500 RPM	Digital	1No.

Theory:

DC motors are commonly used to provide rotary (or linear) motion to a variety of electromechanical devices and servo systems. In most applications the speed or position of the shaft of these motors must be accurately controlled. In order to design such velocity and position control systems it is necessary to obtain, analytically or experimentally, a mathematical model for the motor or system to be controlled. If the system is predominantly linear a suitable model is given by its Transfer Function. In the previous laboratory experiment some parameters of the Motor Board, including DC motor + amplifier, tachogenerator and potentiometer transfer functions were identified. In this lab,students will design an experiment to identify the "dynamic characteristics" (e.g. the time constants) of the DC motor transfer function. The transfer function of a typical permanent magnet DC motor has the general form:

$$\boxed{G_m = \frac{K_m}{(s\tau_m + 1)(s\tau_e + 1)},}$$

where $\tau_m = -\frac{1}{p_1}$ is the "mechanical" time constant and $\tau_e = -\frac{1}{p_2}$ is the "electrical" time constant and p_1 and p_2 the corresponding poles.

If $\tau_m > 10\,\tau_e$, e.g., the electrical time constant is at least an order of magnitude (ten times) faster the response is dominated by the slow mechanical pole and the system can be well approximated by a single pole transfer function:

$$G_m = \frac{K_m}{(s\tau_m + 1)}$$

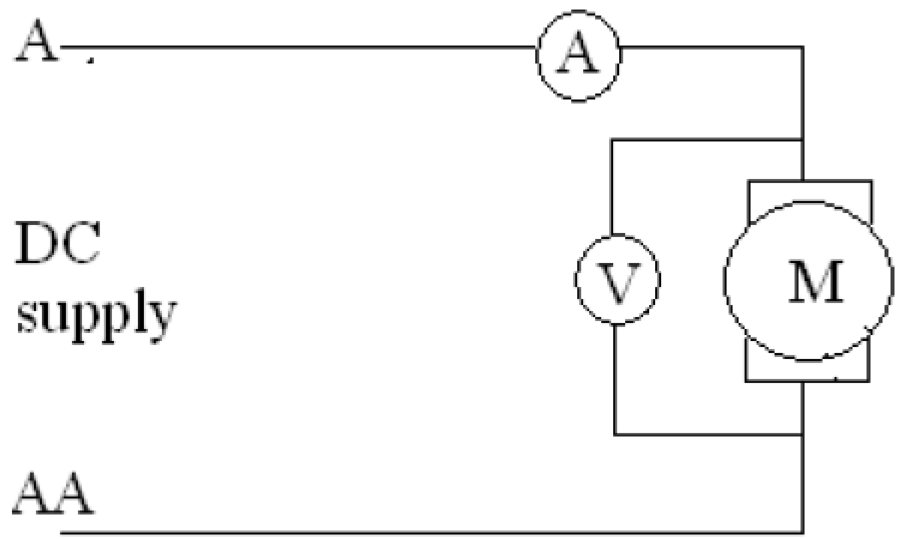


Fig 10.3: Circuit diagram to determine Ra

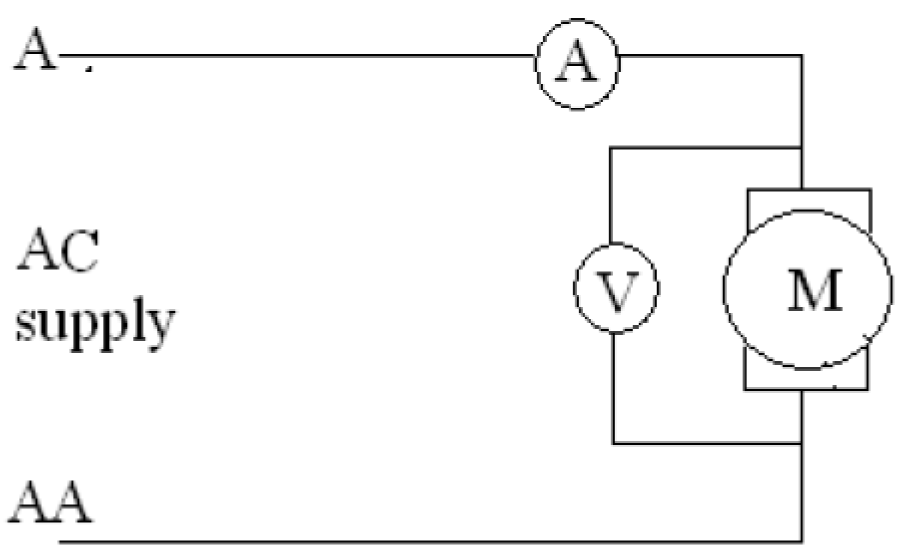


Fig 10.4: Circuit diagram to determine La

Model calculations:

$W_{intial} = 2\prod N/60$

$W_{final} = 2\prod N_1/60$

$dw/dt = (W_{intial} - W_{final})/(T_{intial} - T_{final})$

$K_b = E_b/(dw/dt)$

$W^1 = V * I$

$W = J * (2\prod N_1/60) * dw/dt$

$W + W^1 = (J * (2\prod N_2/60) * 2\prod (N_{initial} - N_2)/60) / (T_{intial} - T_{final})$

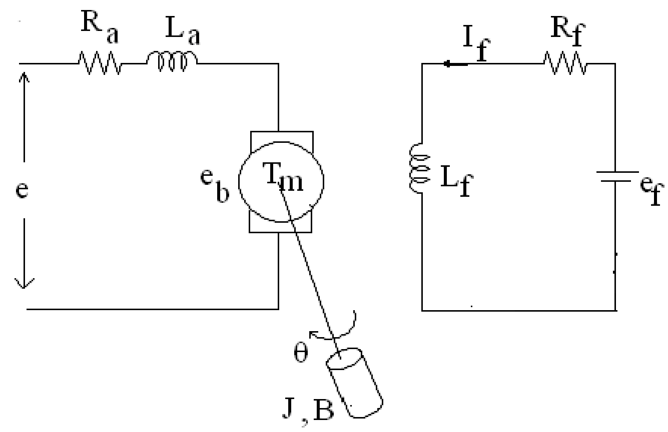
$W^1 = (W+W^1) – W^1 = VI$

from the graph find Time constant τ

But $\tau = J/f$ and hence find friction coefficient f.

Therefore transfer function,

$T(s) = kt / s [(L_a s+Ra) (Js+f) + k_b k_t]$


R a
L a
e
e b
Tm
θ
J , B
I f
R f
L f
e f

In this system, R_a = Resistance of armature in W
L_a= Inductance of armature windings in H
I_a = Armature current in A
I_f = Field current in A
e = Applied armature voltage in V
e_b = back emf in V
T_m = Torque developed by the motor in N_m
J = Equivalent moment of inertia of motor and load referred to motor shaft in kgm2
B= Equivalent viscous friction coefficient of inertia of motor and load referred to motor shaft in Nm/(rad/s)

In Servo applications, DC motors are generally used in the linear range of the magnetization curve. Therefore, the air gap flux Ø is proportional to the field current.

$$\emptyset \propto I_F$$

Ø= K_f I_f ,where K_f is a constant. ----------------------------- (1)

The torque T_m developed by the motor is proportional to the product of the armature current and air gap flux.

$$T_m \,\alpha\, \emptyset\, I_a$$

$T_m = K_i \emptyset I_a = K_i K_f I_f I_a$ where K_i is a constant --------------(2)

In the armature controlled DC motor, the field current is kept constant. So the above equation can be written as

T_m = K_t I_a , Where K_t is known as motor torque constant.------ (3)

The motor back emf being proportional to speed is given by

$$e_b \propto d\theta/dt$$

$e_b = K_b\, d\theta/dt$, where Kb is the back emf constant.----------------(4)

The differential equation of the armature circuit is

$$e = I_a R_a + L_a \, {dI_a}/{dt} + e_b \text{ --- (5)}$$

The torque equation is

$$T_m = J \, {d^2\theta}/{dt^2} + B \, \frac{d\theta}{dt} \qquad \text{--- (6)}$$

Equating equations (3) and (6)

$$J \, {d^2\theta}/{dt^2} \; + \; B \, \frac{d\theta}{dt} = K_t I_a \text{--- (7)}$$

Taking Laplace transforms for the equations (4) to (7), we get

$$E_b(s) = K_b s \, \theta(s) \qquad \text{--- (8)}$$

$$(s \, L_a + \; R_a) \, I_a(s) = \; E(s) - \; E_b(s) \qquad \text{------------------------ (9)}$$

$$(J \, S^2 + \; Bs) \, \theta(s) = \; T_m(s) = \; K_t \, I_a(s) \text{ --- (10)}$$

From equations (8) to (10) , the transfer function of the system is obtained as

$$G(s) = \frac{\theta(s)}{E(s)} = \frac{K_t}{s \, [(R_a + \; s \, L_a)(Js + B) + K_t K_b]}$$

Procedure:

1. Make the connections as per the circuit diagram.
2. By varying the armature rheostat rotate the motor at constant speed i.e. 1500 RPM.
3. Note down the Voltmeter, Ammeter, and Wattmeter readings at constant speed.
4. Decrease the speed of the motor by varying the armature rheostat in the steps of 100 RPM. Note down the corresponding readings of Voltmeter, Ammeter, and Wattmeter.
5. Again rotate the motor at rated speed i.e. 1500 RPM and open the DPST switch at this instant note down the time taken by the motor to reach 1000 RPM.
6. The fractional losses are obtained by plotting graph between P and V^2.

Precautions:

1) Make the connections correctly as per the circuit diagram and all the connections should be tight.
2) Take the meter readings without any parallax error.

Result :

Viva Questions :

1) What is need of obtaining the Transfer Function of a DC motor

2) What are the terms are considered in the transfer function evaluation

Signature of Faculty in Charge

Expt. No: Date: ………………..

PROGRAMABLE LOGIC CONTROLLERS

Aim:

To write a ladder program and simulate the following task using PLC.
1. Digital Input Output
2. Analog Input Output
3. Timer
4. Counter

Apparatus:

PLC kit	--- 1
Computer	— 6
Multimeter	— 1

Theory:

Hardware Description

NI-BPT-SI Basic PLC Trainer consists of three major components which are listed below
1. PLC [S7-1200 Series]
3. SMPS
2. Relay module

Specifications

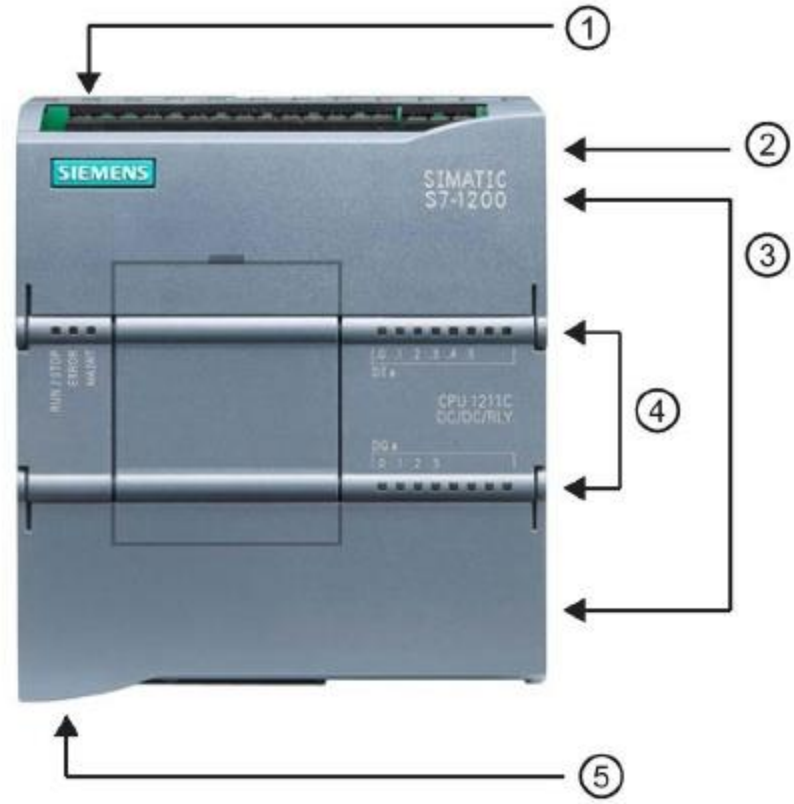
- Model NO : 6ES7215-1AG40-0XB0 ,CPU 1215C
- Power Module: 24VDC Supply
- Communication Ports: 2 Ethernet port
- Digital Input 14 Ch. 24 VDC input
- Digital Output 10 Ch. 24 VDC output
- Analog Input 2 Ch. Analog Voltage Input
- Analog Output 2 Ch. Analog Current Output

Features

- 8 regular input (maximum frequency of 5 kHz) /6 fast inputs (HSC). (can be used either as regular inputs or as fast inputs for counting or event functions)

- Source outputs: 10 regular outputs among them 4 can be used as fast outputs (PWM/PTO) via section switch (can be used either as regular relayed outputs, or for PWM, PTO functions, or reflex outputs for HSC)
- RAM 125 Kbyte
- Communication Ports for PLC: 2 Ethernet port

Description of Different Parts



Digital Input

There are 14 nos. of discrete input including 6 fast input. Specification	Description
Discrete input logic	Sink or source (positive/negative)
Discrete input voltage	24 V
Discrete input voltage type	DC
Discrete input current	5 V DC at 1 mA 15 V DC at 2.5 mA
Configurable filtering time	1μs settings: 0.1μs-12.8μs 20.0ms settings: 0.05-20.0ms
Counting input number	6 fast input (HSC mode) (counting frequency: 100kHz)
Counter function	Encoder outputs [A/B-Pulse/Direction]

Communication Ports

Ethernet Port The 6ES7215-1AG40-0XB0is equipped with a two Ethernet communication port (Interface type PROFINET, Physics Ethernet, 2-port switch, 2*RJ45)

About The Trainer

There are mainly five sections, Supply section, Digital Input section, Digital Output section, Analog Input section, Analog Output section. The distinct features of the trainer are as listed below: NI-BPT-SI Basic PLC Trainer consists of

1. Power connector
2. Memory card slot under top
3. dRoeomr ovable user wiring connectors
4. (Sbteahtuins dL tEhDe sd ofoorr sth) e onboard
5. IP/ROO FINET connector (on the bottom of the CPU)

SIEMENS Make S7-1200 PLC

(6ES7215-1AG40-0XB0 with 14 nos. of Digital inputs, 10 nos. of Digital outputs, 02 nos. of Analog inputs, 02 nos. of Analog outputs)

- +24V DC SMPS
- Relay Board
- Switches to simulate Field inputs
- Indicators for PLC input and outputs
- Connectors to connect field input like limit switch, push buttons, proximity sensors etc. and outputs like solenoid valve, hooters, actuators etc.

Digital Output

There are 10 nos. of discrete output. Specification	Description
Discrete output type	Solid state - MOSFET (sourcing)
Discrete output number	10 including 4 high-speed outputs
Discrete output voltage	24 V DC
Discrete output current	0.5 A
Discrete output	logic Positive logic (source)
Switching delay	1.0 µs max.- OFFtoON,3.0 µs max.-ON to OFF for Qa.0 to Qa.3 5 µs max.-OFF to ON,20 µs max.-ON to OFF for Qa.4 to Qb.1 100 kHz for fast output (PWM/PTO mode) at Qa.0 to Qa.3terminals
Leakage current	10 µA max.
Lamp load	5W
Output delay with resistive load	"0" to "1", : max. 1 µs | "1" to "0", : max. 5 µs

Analog input

There are 2 no. of Analog inputs. Specification	Description
Analog input number 2 at input range	0...10 V
Analog input resolution	10 bits
LSB value	10 mV
Overflow range	11.760 to 11.852 V
Overshoot range	10.001 to 11.759 V

Analog Output

There are 2 nos. of Analog output. Specification	Description
Analog output number	2
Analog output type	0...20 mA current
Analogue output resolution	10 bits
Overshoot range	20.01 to 23.52 mA
Output drive impedance	<=500 Ω max.
Settling time	2.0 ms

PRECAUTION AND PROTECTION

Instruction for Safety

- when handling the equipment please check out surrounding there is no obstacle around the equipment
- heck out electrical system before powering the equipment
- Use right power source so it works fine
- Use power outlet with its ground so it prevents from leaking electricity and electric shock
- Keep the equipment away from magnetic material to prevent from malfunction
- Keep the equipment in clean area and away from moisture atmosphere to prevent from over heat and error in the equipment
- Do not ride over, smash, or drop off from a distance this can cause error, damage, oil leak, or malfunction
- Do not handle the electrical material or touch power plug with wet hands
- Do not cause problems that cause physical injury by inserting a part of physical body
- Do not use loose power cable this can cause electric spark and fire on

Maintenance of Equipment

Follow the step below and do significant job like cleaning, tightening the bolts.
Making the regular time schedule for maintenance is recommended.
Wiring check

- ✓ Check out loose point of connection and short circuit
- ✓ Check out if there is connection problem
- ✓ Check out wires that disturb any moving part of equipment

Checking equipment

- ✓ Check out if there is vibration and bad smell
- ✓ Check out any bolts loosing off
- ✓ Check out if there is any error in displacement of equipment

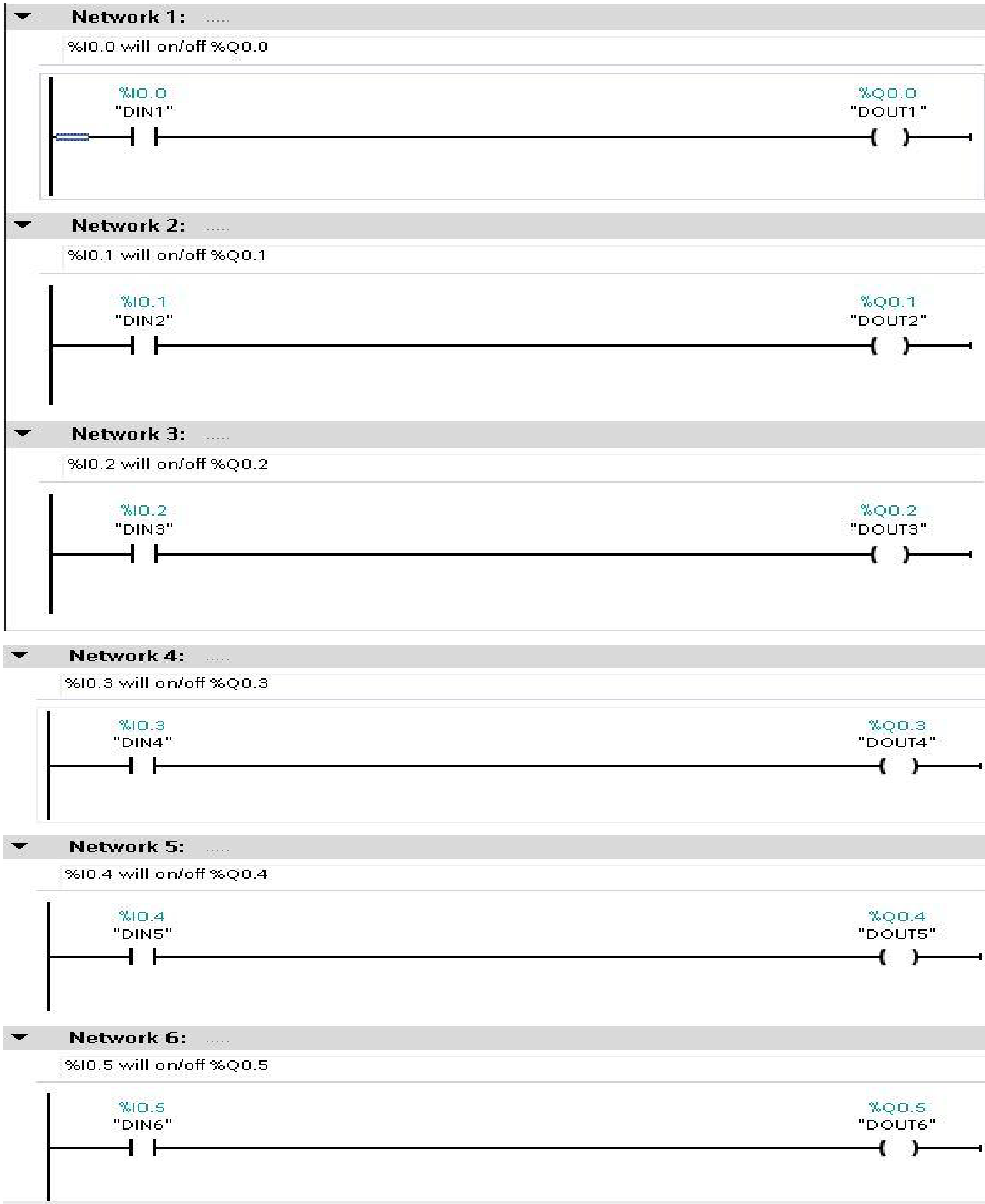
  Maintain of cleaning
  - Please remove any disturbance or obstacle around that gets equipment in trouble
  - Check out whether indicator, lamp, work fine or not

Customers are prohibited to remodel any product

SOFTWARE DESCRIPTION

STEP-7 Basic Software

Introduction: STEP 7 provides a user-friendly environment to develop, edit, and monitor the logic needed to control your application, including the tools for managing and configuring all of the devices in your project, such as controllers and HMI devices. To help you find the information you need, STEP 7 provides an extensive online help system .STEP 7 is the programming and configuration software component of the TIA Portal. The TIA Portal, in addition to STEP 7, also includes WinCC for designing and executing run time process visualization, and includes online help for WinCC as well as STEP 7.

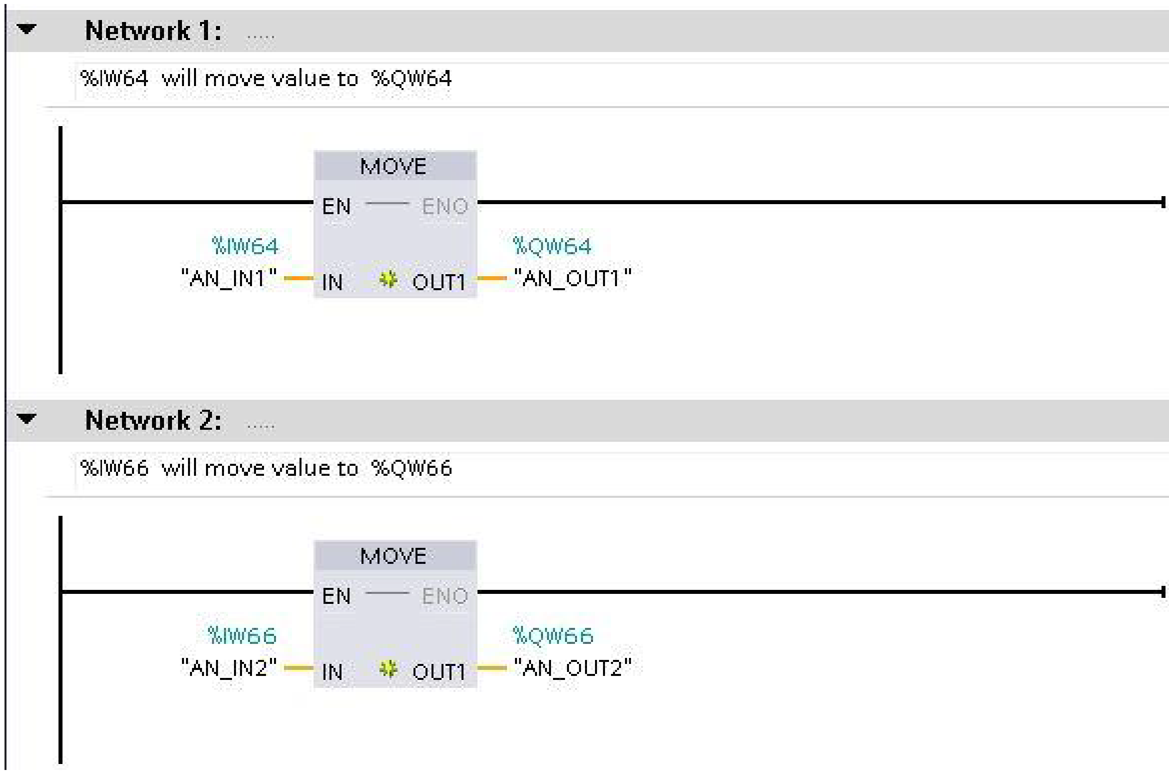

Network 1:
%I0.0 will on/off %Q0.0
%I0.0
"DIN1"
%Q0.0
"DOUT1"
Network 2:
%I0.1 will on/off %Q0.1
%I0.1
"DIN2"
%Q0.1
"DOUT2"
Network 3:
%I0.2 will on/off %Q0.2
%I0.2
"DIN3"
%Q0.2
"DOUT3"
Network 4:
%I0.3 will on/off %Q0.3
%I0.3
"DIN4"
%Q0.3
"DOUT4"
Network 5:
%I0.4 will on/off %Q0.4
%I0.4
"DIN5"
%Q0.4
"DOUT5"
Network 6:
%I0.5 will on/off %Q0.5
%I0.5
"DIN6"
%Q0.5
"DOUT6"

Procedure:

1. Digital Input Output Demo

This program will demonstrate how to work with Trainer's inputs and outputs. Download the sample program of digital input-output in PLC. There are Switches provided on panel to simulate field inputs. Program will on output for respective inputs.

- %I0.0 will on/off %Q0.0
- %I0.1 will on/off %Q0.1
- %I0.2 will on/off %Q0.2
- %I0.3 will on/off %Q0.3
- %I0.4 will on/off %Q0.4
- %I0.5 will on/off %Q0.5


Network 1:
%IW64 will move value to %QW64
MOVE
EN
ENO
%IW64
"AN_IN1"
IN
OUT1
%QW64
"AN_OUT1"
Network 2:
%IW66 will move value to %QW66
MOVE
EN
ENO
%IW66
"AN_IN2"
IN
OUT1
%QW66
"AN_OUT2"

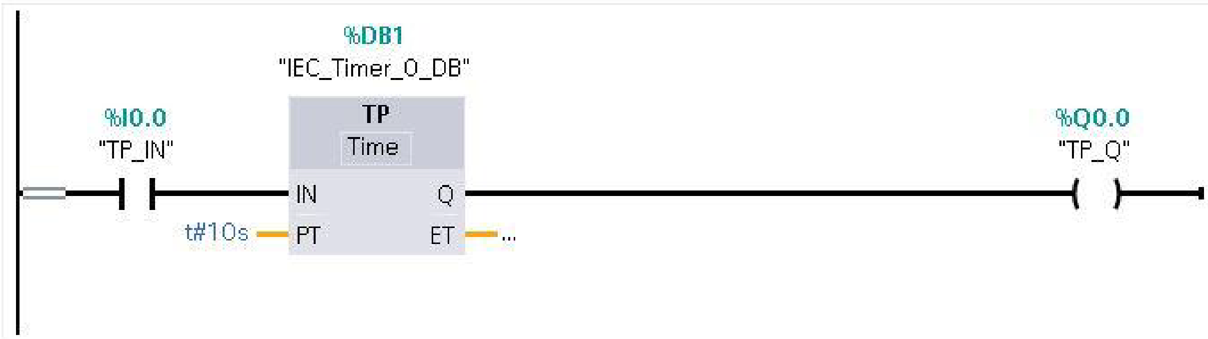
2. Analog Input Output Demo

This program will demonstrate how to work with Trainer’s Analog inputs and outputs. Download the sample program of analog input-output in PLC. There are Switches provided on panel to simulate field inputs. Program will vary values of output for respective inputs.

- %IW64 will move value to %QW64
- %IW66 will move value to %QW66

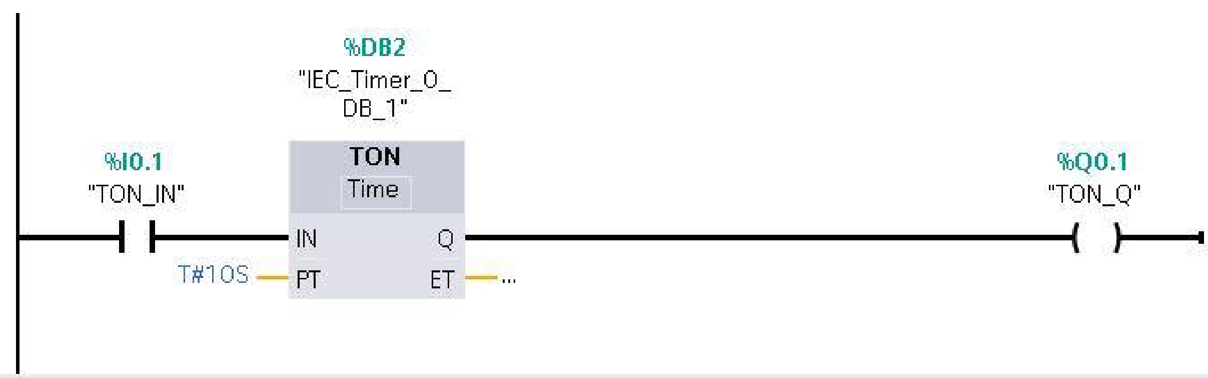
Network 1: PULSE TIMER

When low to high pulse arrive at %I0.0(TP_IN), Output Q(%Q0.0) remains high upto time defined in PT (10 secomd)



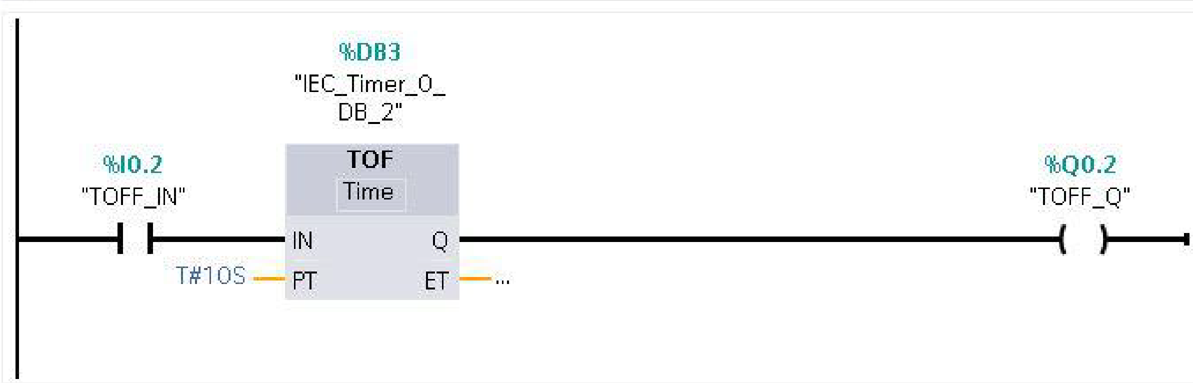
Network 2: TIMER ON

When low to high transition arrive at %I0.1 (TON_IN) and remains high, Output Q(%Q0.1) will on after time defined in PT (...



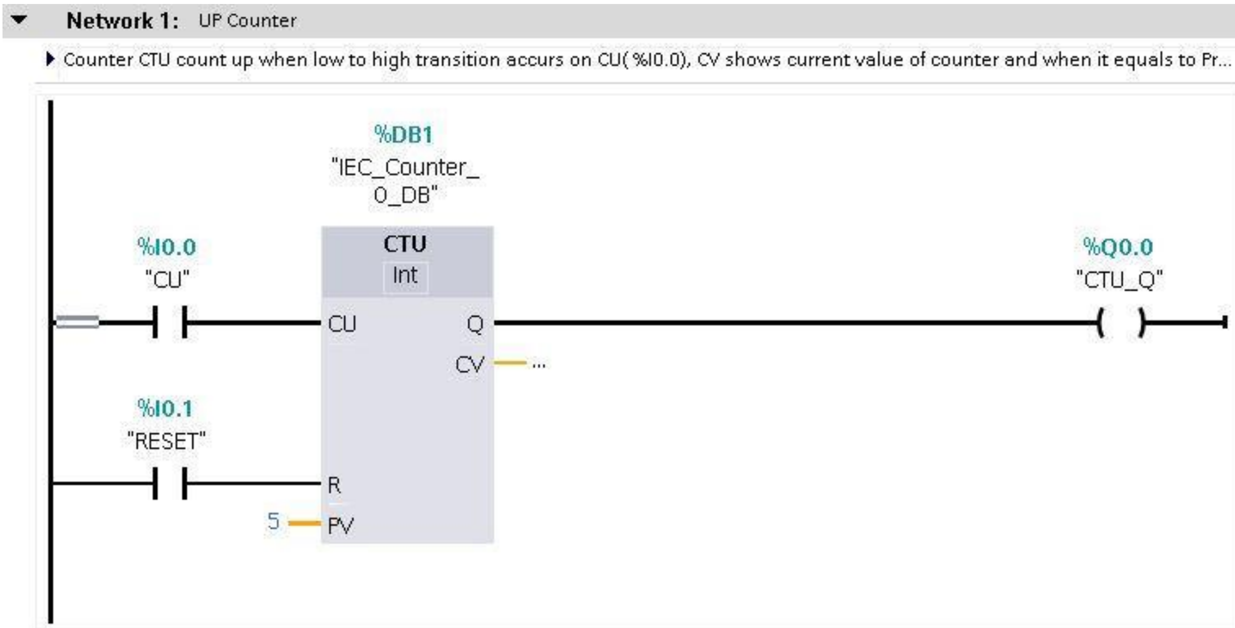
Network 3: TIMER OFF

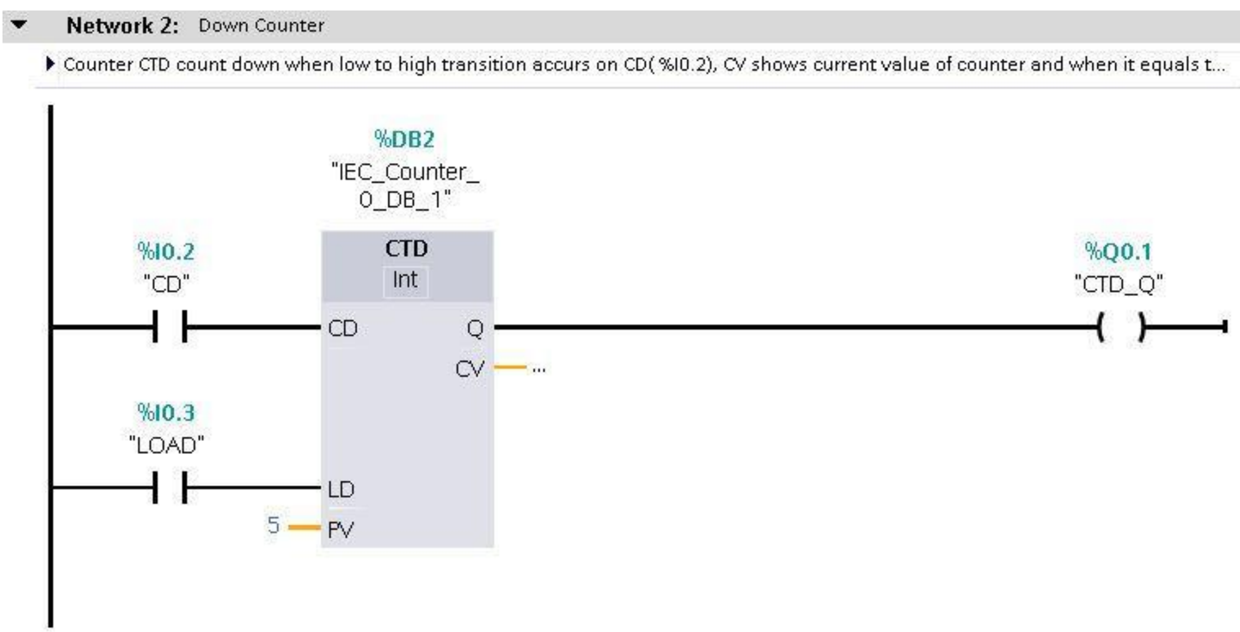
When high to low transition accurs on %I0.2(TOFF_IN) and remains in low state, Output Q(%Q0.2) will off after time defin...



Timer Demo

Three basic timer modes (ON, OFF, PULSE TIMER) are demonstrated here..


Network 1: UP Counter
Counter CTU count up when low to high transition accurs on CU(%I0.0), CV shows current value of counter and when it equals to Pr...
%DB1
"IEC_Counter_0_DB"
%I0.0
"CU"
CTU
Int
CU
Q
CV
...
%I0.1
"RESET"
R
5
PV
%Q0.0
"CTU_Q"


Network 2: Down Counter
Counter CTD count down when low to high transition accurs on CD(%I0.2), CV shows current value of counter and when it equals t...
%DB2
"IEC_Counter_0_DB_1"
%I0.2
"CD"
CTD
Int
CD
Q
CV
...
%I0.3
"LOAD"
LD
5
PV
%Q0.1
"CTD_Q"

4. Counter Demo

By this program you learn about Up Counter and Down Counter.

Result :

Viva Questions :

1. What is PLC?

2. What is ladder diagram?

3. What are the applications of PLC?

4. What are the different types of PLCs?

5. Define DCS, SCADA, HMI, Autoation?

Signature of Faculty in Charge