G.PULLA REDDY ENGINEERING COLLEGE (AUTONOMOUS): KURNOOL
ELECTRICAL & ELECTRONICS ENGINEERING DEPARTMENT
IV Semester B.Tech. - E.E.E. (Scheme-20)
CONTROL SYSTEMS LAB (CS (P))

List of Experiments

1. Study of Characteristics of A.C. Servo Motor
2. Study of Characteristics of D.C.Servo Motor
3. Study of Stepper Motor Control
4. Study of Compensation Design
5. Study of Characteristics of Synchro pair
6. Study of time response of a system using Linear System Simulator
7. Study of PID controller
8. Study of DC Position Control Systems
9. Analysis of Root Locus plot using MATLAB
10. Analysis of Bode plot using MATLAB
11. Analysis of Polar plot using MATLAB
12. Analysis of Nyquist plot using MATLAB
13. Study of Characteristics of Magnetic Amplifier
14. Study of Temperature control system.
15. Study of potentiometer

TITLE: **STUDY OF AC SERVOMOTOR**	GPREC/DEEE/EXPT-CSP-1 Date: 02-03-2022

1. AC SERVO MOTOR

AIM: To study speed-torque characteristics of an AC servo motor

APPARATUS: AC Servomotor and Digital Multimeter

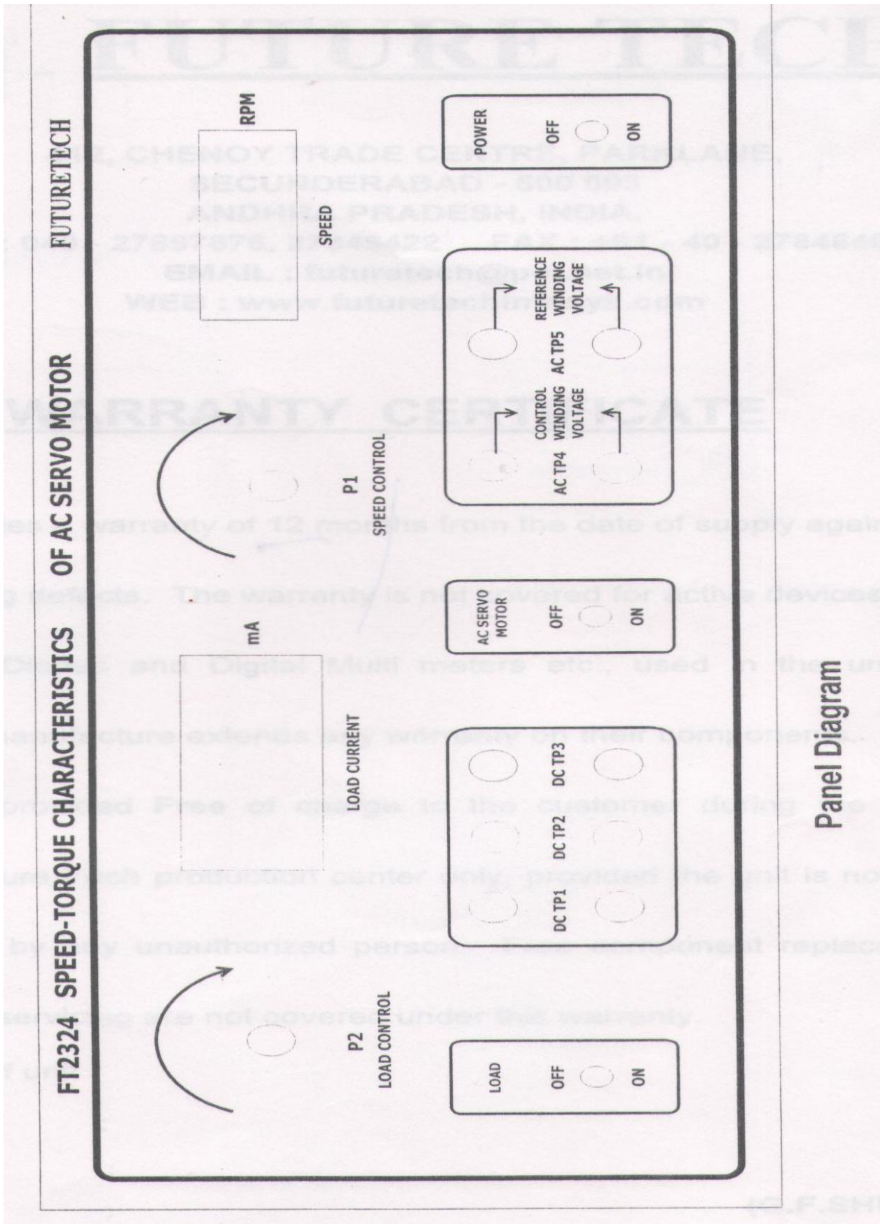
THEORY: Most of the servomotors used in the low power servomechanism are a.c. servomotors. The a.c. servomotor is basically two phase induction motor. The output power of a.c. servomotor varies from fraction of watts to few hundred of watts. The operating frequency is 50 Hz to 400 Hz. The a.c. servomotor is basically consists of a stator and a rotor. The stator carries two windings, uniformly distributed and displaced by 90^o in space, from each other. On winding is called as main winding or fixed winding or reference winding. The reference winding is excited by a constant voltage a.c. supply. The other winding is called as control winding. It is excited by variable control voltage, which is obtained from a servo amplifier. The winding are 90^o away from each other and control voltage is 90^o out of phase with respect to the voltage applied to the reference winding. This is necessary to obtain rotating magnetic field. The rotor is generally of two types. The two types of rotors are,

1. Squirrel cage rotor
2. Drag cup type rotor

The operating principle of two phase a.c. servomotor is same as that of normal three phase induction motor. The control voltage applied to the control winding and the voltage applied to the reference winding are 90^o out of phase. Hence the flux produces by current through control winding is also 90^o out of phase with respect to the flux produced by the current through the reference winding. The resultant flux in the air gap is hence rotating flux sweeps over the rotor, the e.m.f. gets induced in the rotor. This e.m.f. circulates the current through the rotor. The rotor current produces its own flux called as rotor flux. This flux interacts with the rotating magnetic field, producing a torque on the rotor and rotor starts rotating.

TITLE: **STUDY OF AC SERVOMOTOR**	GPREC/DEEE/EXPT-CSP-1 Date: 02-03-2022

CIRCUIT:



Panel Diagram

PROCEDURE:

1. Keep the load switch in **OFF** position, indicating that the armature circuit of DC machine is not connected to auxiliary power supply (6V), AC servo meter switch should also be in **OFF** position.
2. Ensure speed control pot and load control pot are fully in **anticlockwise** position
3. Now switch on power switch and also AC servo motor switch. You can observe that AC servo motor will start rotating and the speed will be indicated by RPM meter on the front panel.
4. With load switch in OFF position, vary the speed of the AC servo Motor by varying speed control pot in **clockwise** direction and note the back e.m.f. generated by the DC machine at DC TP1. Enter the results in table No.1.(use a DC voltmeter in the range 0 to 10V)
5. Now switch ON load and start loading AC servomotor by varying load control pot P2 in a slow fashion. Note down corresponding values on current (Ia) and speed (N). Enter these values in Table2.
6. Now you may set AC servo control winding voltage to a new value after switching OFF load switch. Again repeat the process as indicated in step No.5 i.e. table 2 for new value of control winding voltage.
7. Plot the speed torque characteristics for various values of control winding voltages study their nature.

TABLE- 1

Sl.No.	Speed (RPM)	Back EMF(Eb)in volts at DCTP1

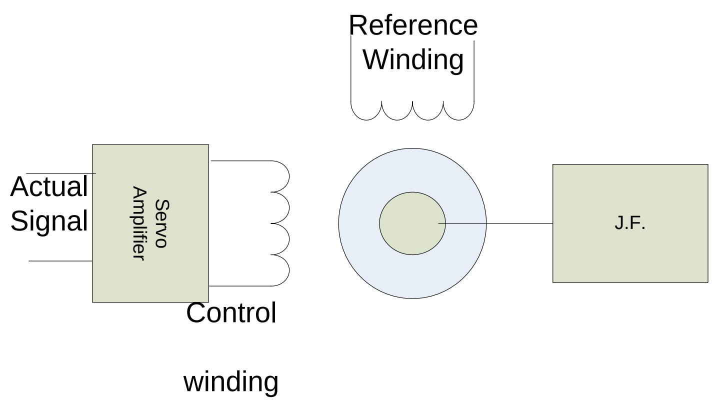
TABLE _ 2

Sl.No.	Ia (Amps)	Speed (N- RPM)	Back EMF(Eb) Volts - DC TP2	P=Eb x Ia	Torque (T) $T = \frac{P \times 60}{2\pi N}$

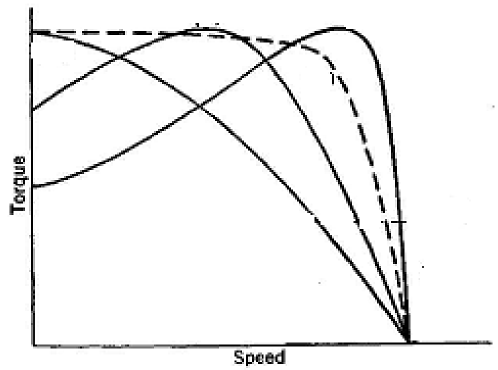
PRECAUTIONS

1. **Before switch on P1 and P2 should be always brought to most anticlockwise position.**

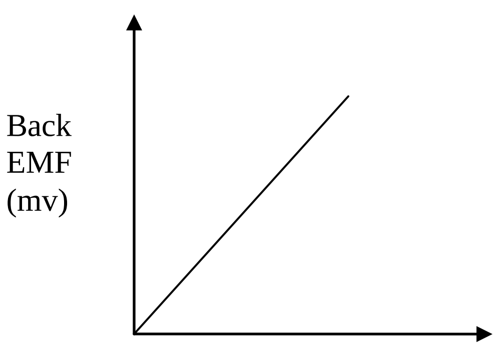
2. **Control P1 and P2 should be operated in a gentle fashion.**

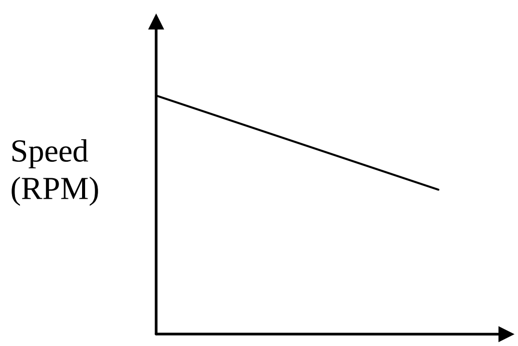


SCHEMATIC DIAGRAM OF TWO PHASE INDUCTION MOTOR



TORQUE-SPEED CHARACTERISTICS OF INDUCTION MOTOR





RESULT:

QUIZ:

1. What is AC servo motor?
2 What is the use of AC servo motor?
3 What are the advantages of AC servo motor?
4. What is the important parameter of AC servo motor?
5 On what factor does the direction of rotation of AC servo motor Depend.
6. What is the drawback of AC servo motor?
7 How to overcome the drawback of AC servo motor?
8 What is the input of AC servo motor in feedback control application?
9 What is the phase relationship between reference voltage and control Voltage?
10 What are the types of AC servo motor?

2. DC SERVO MOTOR CONTROL SYSTEM

EXPERIMENT NO.1: SPEED Vs VOLTAGE CHARACTERISTICS

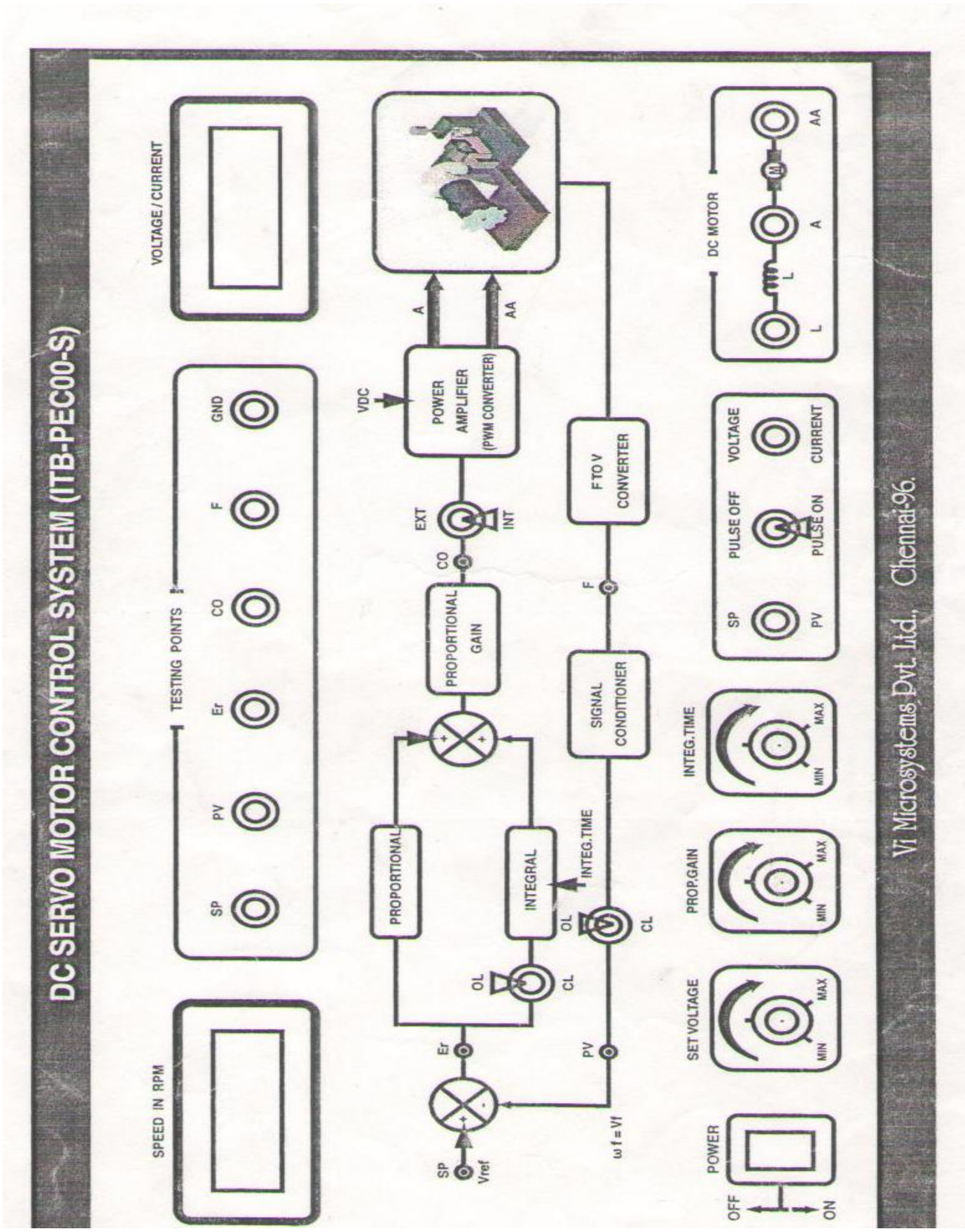
AIM: To obtain the speed Vs voltage characteristics of the DC motor.

APPARATUS: DC servo motor, ITB-PEC00S unit, Digital Multimeter/CRO

THEORY: In servo applications a DC motor is required to produce rapid accelerations from standstill. Therefore the physical requirements of such a motor are low inertia and high starting torque. Low inertia is attained with reduced armature diameter with a consequent increase in the armature length such that the desired power output is achieved. Thus, except for minor differences in constructional features a DC servomotor is essentially an ordinary DC motor. A DC servomotor is a torque transducer which converts electrical energy into mechanical energy. It is basically a separately excited type DC motor. The torque developed on the motor shaft is directly proportional to the field flux and armature current, $T_m = K_m \Phi I_a$. The back emf developed by the motor is $E_b = K_b \Phi \omega_m$. In an armature controlled DC Servo motor, the field winding is supplied with constant current hence the flux remains constant. Therefore these motors are also called as constant magnetic flux motors. Armature control scheme is suitable for large size motors.

TITLE: **DC SERVO MOTOR CONTROL SYSTEM**	GPREC/DEEE/EXPT-CSP-2 Date: 02-03-2022

CIRCUIT:



PROCEDURE:

1. Before switch ON the unit
   (i) EXT/INT switch should be in INT mode
   (ii) Integral open/close switch in open (OL) mode.
   (iii) Signal conditioner switch in open(OL) mode.
   (iv) Interface the motor supply sensor with module.
2. Initially, pulse ON/OFF switch should be in OFF module.
3. Switch ON the unit, and keep the pulse ON/OFF to ON mode.
4. Set the proportional gain K_p at minimum
5. Set V_{ref} =1 Volt. Slowly increase the gain K_p voltage by means of the proportional gain adjustment pot, and find the voltage at which the motor just starts running.
6. Vary the reference voltage in steps, and for each step, note down the motor speed and armature voltage. Tabulate the readings as shown in table.1
7. Plot the ω verses V_a characteristics. It will be as shown in fig.1

TABLE: Speed (ω) verses Voltage (V_a) Characteristics

SL.No.	Vref (v)	Va(v)	N (rpm)	ω (rad/Sec)

SAMPLE GRAPH:

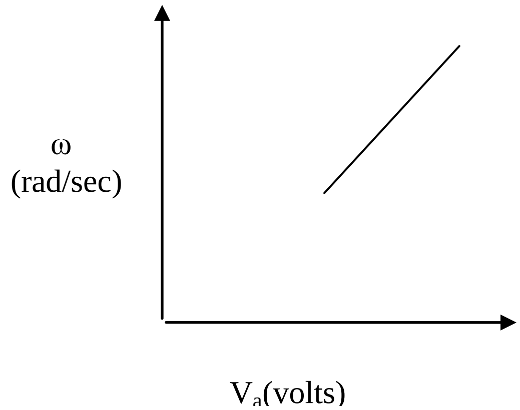


Fig. 1. SPEED Vs VOLTAGE CHARACTERISTICS

RESULT:

EXPERIMENT NO.2: SPEED Vs TORQUE CHARACTERISTICS

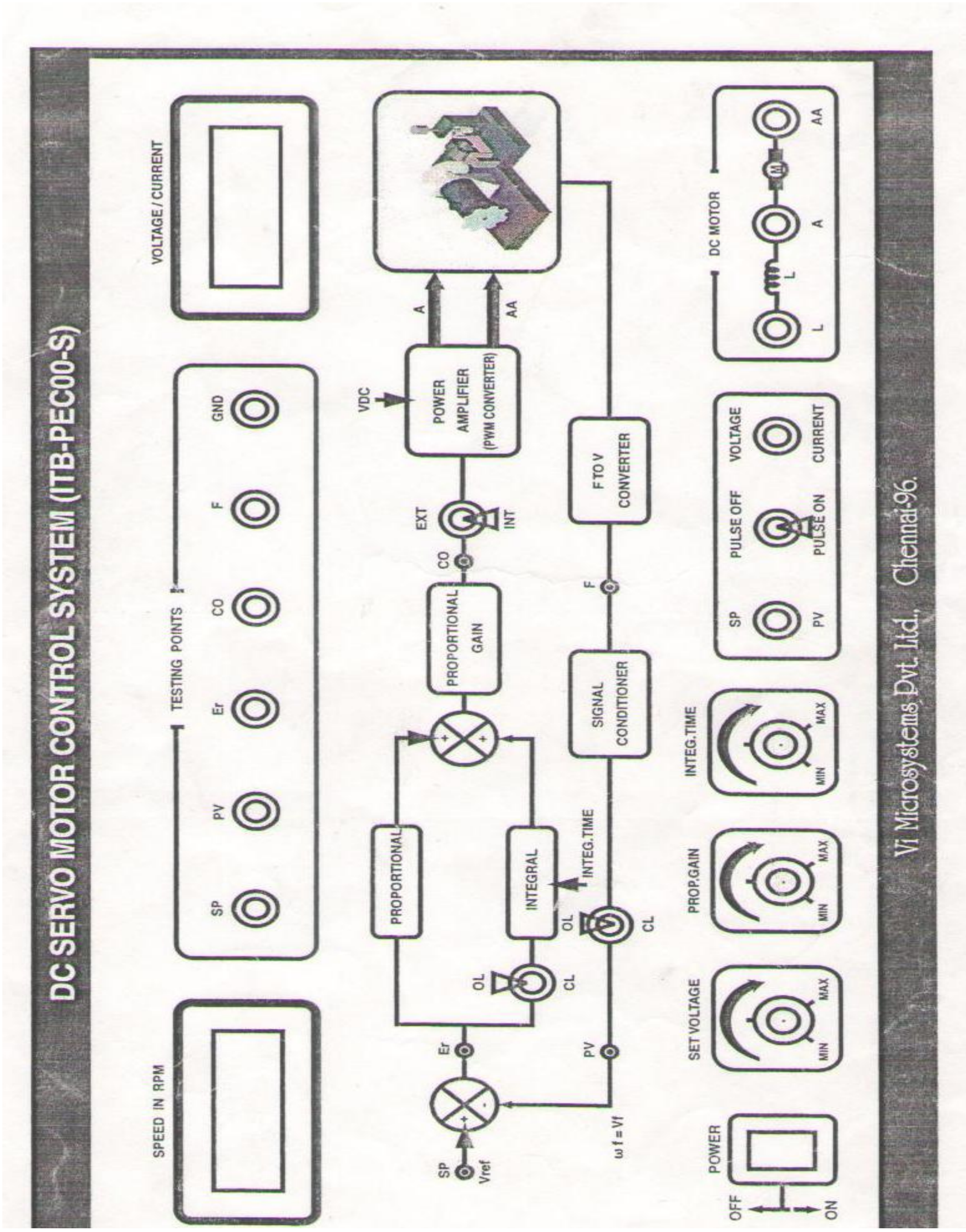
AIM: To obtain the speed Vs Torque characteristics of the DC motor.

APPRATUS: DC servo motor, ITB-PEC00S unit, Digital Multimeter/CRO

THEORY: The dc servo motors are separately excited or permanent magnet dc servo motors. The armature of dc servo motor has large resistance therefore its torque speed characteristics is linear. The dc sevo motors can be controlled from the armature side or wheel side. in the field controlled dc servo motor L/R ratio is large i.e time constant for the field circuit is large. Due to which the response is low and hence they are not commonly used. The speed of motor can be controlled by adjusting the voltage applied to the armature. In the armature controlled type the time constant is small and hence the response is fast. The efficiency of the armature controlled dc servomotor is better than field controlled motor.

TITLE: **DC SERVO MOTOR CONTROL SYSTEM** GPREC/DEEE/EXPT-CSP-2
Date: 02-03-2022

CIRCUIT:



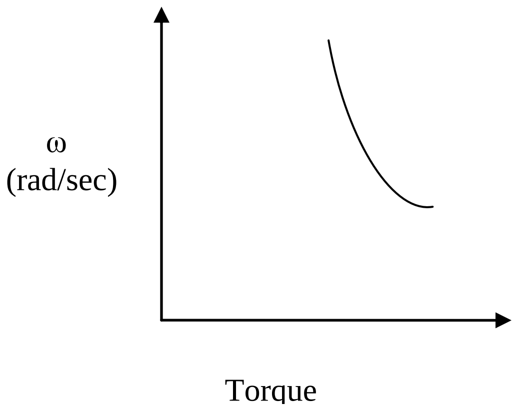
PROCEDURE:

1. Before switch ON the unit
   (i) EXT/INT switch should be in INT mode
   (ii) Integral open/close switch in open (OL) mode.
   (iii) Signal conditioner switch in open(OL) mode.
   (iv) Interface the motor supply sensor with module.
2. Initially, pulse ON/OFF switch should be in OFF module.
3. Set the proportional gain K_p at minimum
4. Switch ON the unit, and keep the pulse ON/OFF to ON mode
5. Run the motor at 1500 rpm by suitably adjusting the V_{ref} and K_p. Note down the armature voltage(Va) armature current (Ia) and speed (N) as shown in table 2.
6. Apply load by brake magnet close to the disc. Apply the load in steps such a way that the current is increased by 0.25A in each step. Note the armature current, voltage and speed of the each step. Tabulate the readings.
7. It may noticed that the motor armature current may not be increased when the speed drops below a certain value. This is because the speed is low the eddy current induced in the disc becomes less, which reduces the load torque.
8. Decrease the load and reduce the gain to minimum.
9. Switch OFF the power supply.
10. Calculate the torque as $T = k_t I_a$ where K_t is torque constant
11. Plot the **ω verses Torque** Characteristics.
12. Plot the Ia verses **Torque** Characteristics.

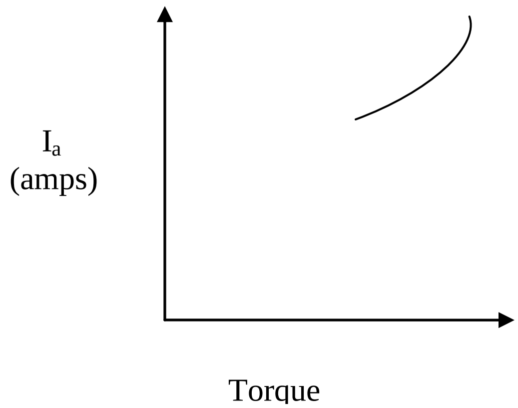
TABLE: ω verses Ta and Ia verses T_L Characteristics

SL.No.	Vref (v)	Va(v)	N (rpm)	ω (rad/Sec)

SAMPLE GRAPH:



ω verses T Characteristics



I_a verses T Characteristics

RESULT:

QUIZ:

1 What are the uses of DC servo motor?
2. What are the types of DC servo motors?
3. How the speed of DC servo motor is controlled?
4. What is the relation between torque and speed of DC servo motor?
5. Why the speed torque characteristics of DC servo motor has large Negative Slope?
6. What is the effect of negative slope?
7. In which wattage the DC servo motors are available?
8. What are the special features of DC SERVO MOTORS?
9. How the direction of rotation of DC servo motor can be changed?
10. What is transfer function of DC SERVO MOTOR?

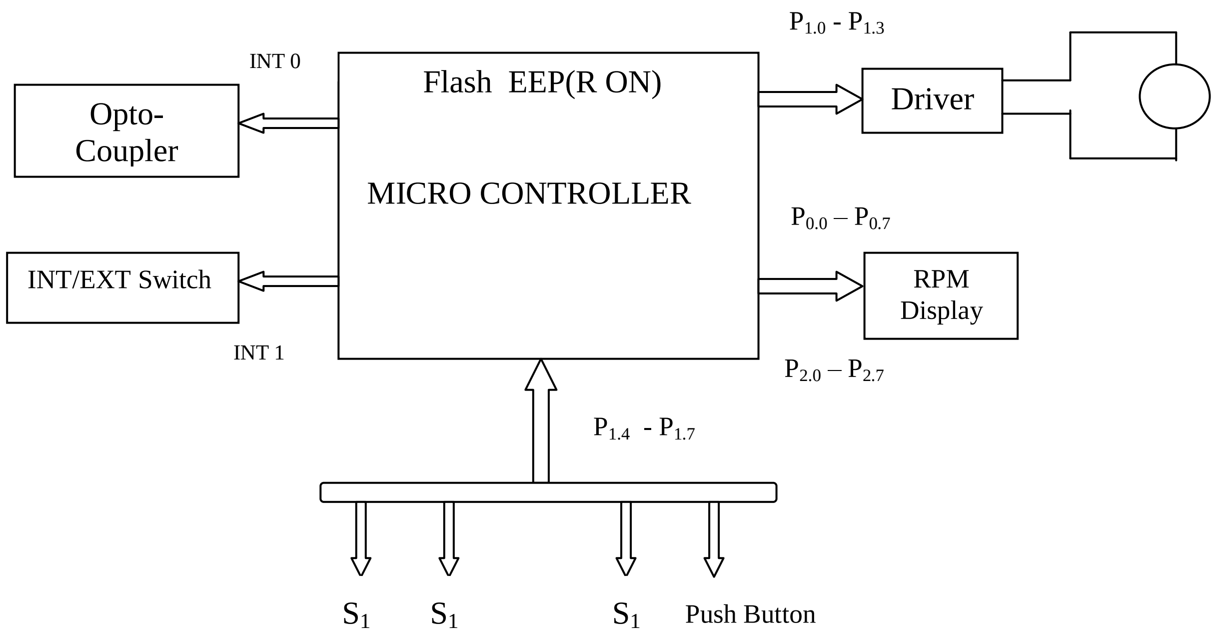
TITLE: STEPPER MOTOR CONTROL	GPREC/DEEE/EXPT-CSP-3 Date: 02-03-2022

3. STEPPER MOTOR CONTROL

OBJECTIVE: To study the operating characteristic of a stepper motor and its controller.

APPARATUS: Trainer kit

THEORY: The stepper motor is a special type of motor which is designed to rotate through a specific angle called step for each electrical pulse received from its control unit. It is used in digitally controlled position control system in open loop mode. The input command is in form of a train of pulses to turn the shaft through a specified angle. The main unit is designed to interface with microcontroller kit. The stepper motor controller card remains active while the pulse sequence generator disabled as given plug is connected with microcontroller interface socket.



PROCEDURE:

Forward Speed Control Mode:

1. Push the switch button SW_1 to position '1'
2. Push the switch SW_3 to position '1' for increasing speed mode of operation and to position '0' for decreasing speed mode of operation.
3. Note down the speed readings for pulses and see how the speed varies with each pulse.

Reverse Speed Control Mode:

1. Push the switch button SW_1 to position '1' and SW_2 to position '2'
2. Push the switch SW_3 to position '1' for increasing speed mode of operation and to position '0' for decreasing speed mode of operation.
3. Note down the speed readings for pulses and see how the speed varies with each pulse

Manual Mode of operation:

1. Push the switch button SW_1 to position 'zero' and SW_2 to position '1' for the manual mode of operation.
2. Push the switch SW_3 to position '1' for increasing speed mode of operation and to position '0' for decreasing speed mode of operation.
3. Note down the speed readings for pulses and see how the speed varies with each pulse
4. Observe the angle of rotation of the stepper motor and note down one corresponding speed.

TITLE: STEPPER MOTOR CONTROL	GPREC/DEEE/EXPT-CSP-3 Date: 02-03-2022

OBSERVATIONS:

SWITCH POSITION:

INT/EXT	S1	S2	S3	
0	1	1	1	Motor rotates in forward direction and speed can be increased by pressing the PUSH BUTTON
0	1	1	0	Motor rotates in forward direction and speed can be decreased by pressing the PUSH BUTTON
0	1	0	1	Motor rotates in reverse direction and speed can be increased by pressing PUSH BUTTON
0	1	0	0	Motor rotates in reverse direction and speed can be decreased by pressing the PUSH BUTTON
0	0	0	X	PUSH BUTTON is pressed, motor rotates 90^o in forward direction from its current position. If once again push button is pressed, motor rotates 90^o reverse direction and comes to its original position.
0	0	1	0	Motor rotates 1.8^o step angle in reverse direction whenever the PUSH BUTTON is pressed.
0	0	1	1	Motor rotates 1.8^o step angle in forward direction whenever the PUSH BUTTON is pressed.
1	X	X	X	External mode is enabled. The user program takes control of MOSFET driver input pulses.

X= Don’t care
0= Switch position low
1= Switch position high

RESULT:

REMARKS IF ANY:

TITLE: STEPPER MOTOR CONTROL	GPREC/DEEE/EXPT-CSP-3 Date: 02-03-2022

QUIZ:

1. Why the application of stepper motor is increasing?
2. What is stable condition of rotor in stepper motor ?
3. What are the modes of operation of stepper motor?
4. What are the types of stepper motor?
5. How the windings of stepper motor are wound?
6. How many logics are there in each sequence?
7. In how many phases does the motor run?
8. Why the stepper motor is run in four phases?
9. On what factor does the settling time of stepper motor depend?
10. Define stepper motor. What is the use of stepper motor?

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4. COMPENSATION DESIGN

EXPERIMENT NO.1

AIM: To study the frequency response of the lag process.

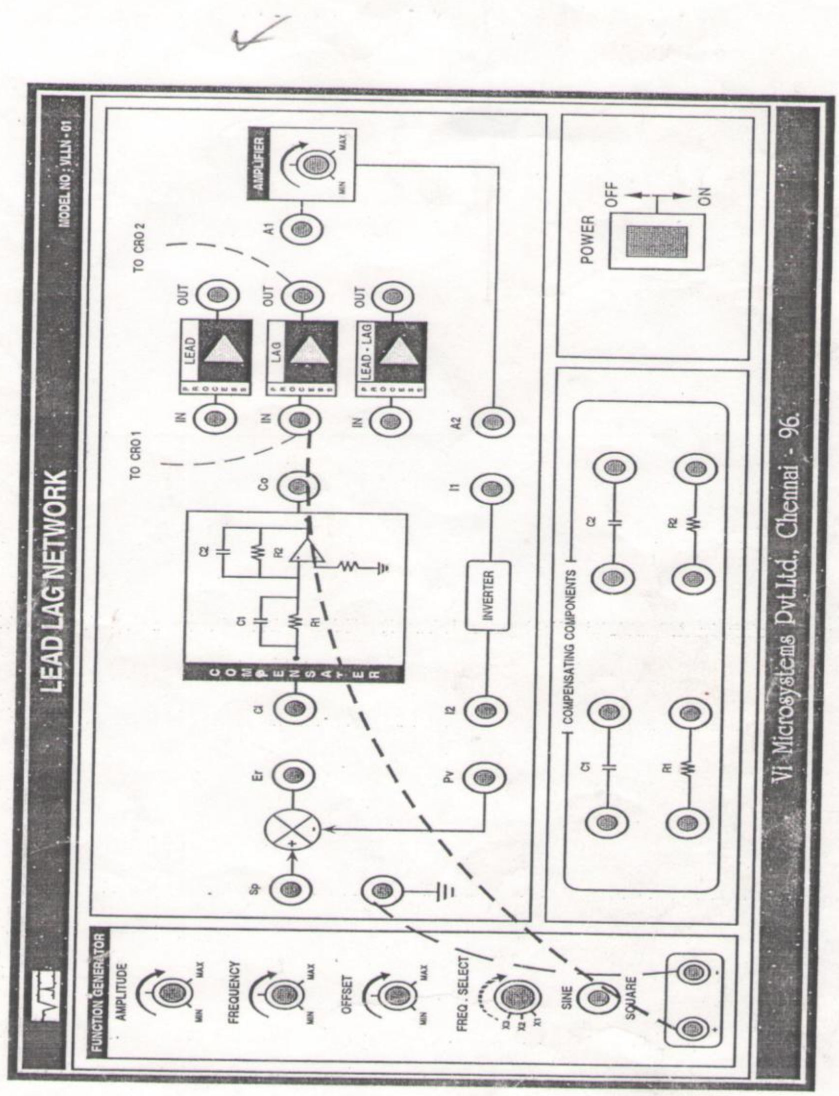
APPARATUS: Lead –Lag network kit, Patch chords

THEORY: The lead lag network consists of a type0, order 2 process for studying the Lag-Lead compensation effect. The process may be lag, lead. There are given individually to perform frequency domain analysis process**.** A process having the characteristics of lag network is called a lag process if a sinusoidal signal is applied to lag network, then its steady state output will have a phase lag with respect to its input. Lag process results in a large improvement in steady state performance but results in slower response due to reduced bandwidth. The attenuation due to the lag compensator will shift the gain crossover frequency to a lower frequency point where the phase margin is acceptable. Thus, the alg process will reduce the bandwidth of the system and will result in slower transient response. Lag process is essentially a low pass filter and so high frequency noise signals are attenuated. If the pole introduced by the process is not controlled by zero in the system, then lag compensator increases the order of the system by one.

TITLE: **COMPENSATION DESIGN** (LEAD, LAG NETWORK)	GPRECD/EEE/EXPT-CSP-4 Date: 02-03-2022

CIRCUIT:

FREQUENCY RESPONSE OF LAG PROCESS



TITLE: **COMPENSATION DESIGN** (LEAD, LAG NETWORK)	GPRECD/EEE/EXPT-CSP-4 Date: 02-03-2022

PROCEDURE:

1. Connections are made as per the connection diagram shown in fig.2
2. Switch ON the unit.
3. Give the sine wave as input.
4. Note down the amplitude and frequency of the input signal.
5. Observe the Lissajous pattern through CRO, by keeping the CRO in X-Y mode and calculate the phase shift (Φ) of the output signal with the input.
6. Conduct the experiment for various frequencies.
7. Plot the bode plot and conclude the behavior of lead process.
8. The gain is measured from the formula.

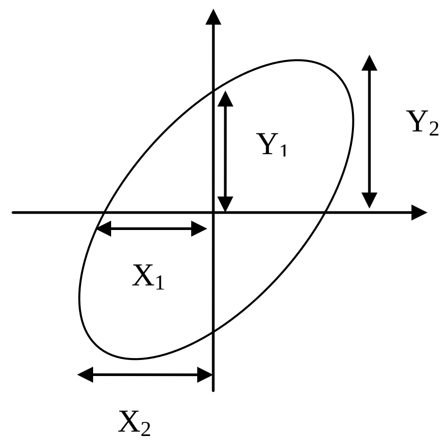
$$A_v = 20Log_{10}\frac{V_0}{V_i}\,dB$$

9. The phase is measured from Lissajous pattern is shown in figure.

$$\sin\phi = \frac{x_1}{x_2} = \frac{y_1}{y_2} \quad \text{and} \quad \phi = \sin^{-1}\left(\frac{x_1}{x_2}\right) = \sin^{-1}\left(\frac{y_1}{y_2}\right)$$

TITLE: **COMPENSATION DESIGN** (LEAD, LAG NETWORK)	GPRECD/EEE/EXPT-CSP-4 Date: 02-03-2022

MODEL GRAPH



LISSJOUS PATTERN

TABLE:

SL.No.	Frequency (Hz)	Phase Shift(Φ)

RESULT:

TITLE: **COMPENSATION DESIGN** (LEAD, LAG NETWORK)	GPRECD/EEE/EXPT-CSP-4 Date: 02-03-2022

EPERIMENT NO.2

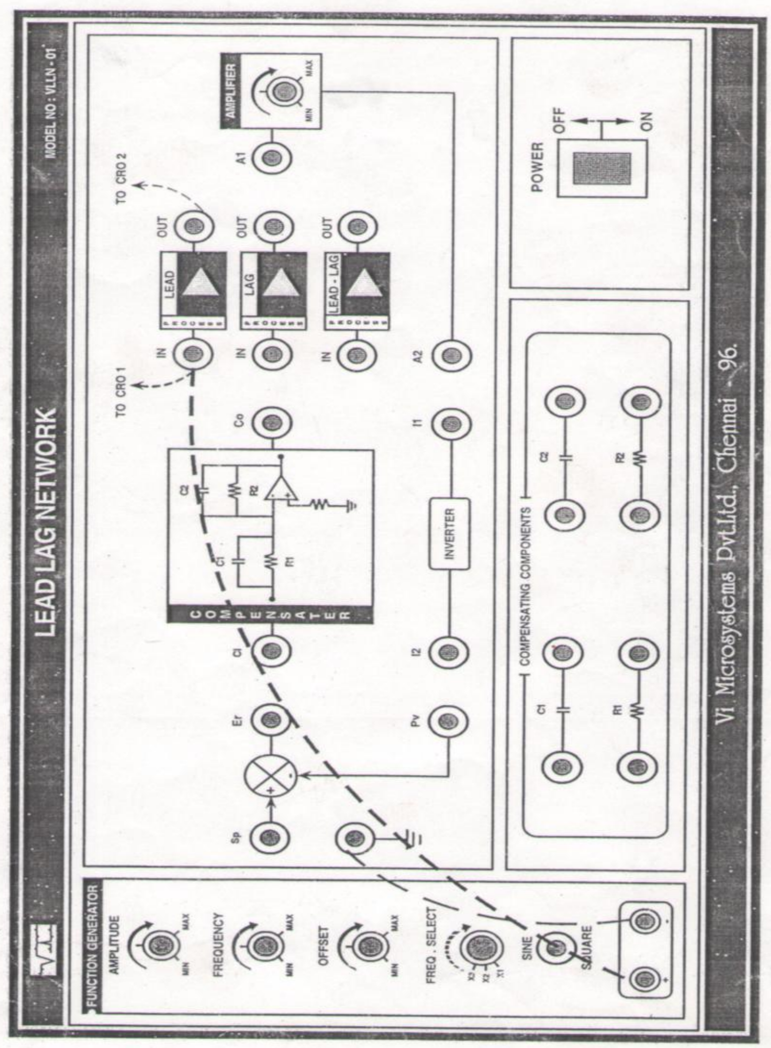
AIM: To study the frequency response of the lead process.

APPRATUS: Lead –Lag network kit, Patch chords

THEORY: A process having the characteristics of lead network is called a lead process. If a sinusoidal signal is applied to lead network, then its steady state output will have a phase lead with respect to its input. Lead compensation increases the bandwidth, which improves the speed of response and also reduces the amount of overshoot. Lead compensation appreciably improves the transient reponse, whereas there is a small change in steady state accuracy. Generally, lead compensation is provided to make an unstable system as stable system. A lead process is basically a high pass filter and so it amplifies high frequency noise signals. If a pole is introduced by the process and it is not cancelled by zero in the system, then lead compensation increases the order of the system by one.

CIRCUIT:

FREQUENCY RESPONSE OF LEAD PROCESS



PROCEDURE:

1. Connections are made as per the connection diagram shown in fig.3
2. Switch ON the unit.
3. Give the sine wave as input.
4. Measure the amplitude and frequency of the input signal and tabulate it.
5. Observe the Lissajous pattern through CRO, by keeping the CRO in X-Y mode and calculate the phase shift(Φ) of the output signal with the input.
6. Conduct the experiment for various frequencies.
7. Plot the bode plot and conclude the behavior of lead process.
8. The gain is measured from the formula.

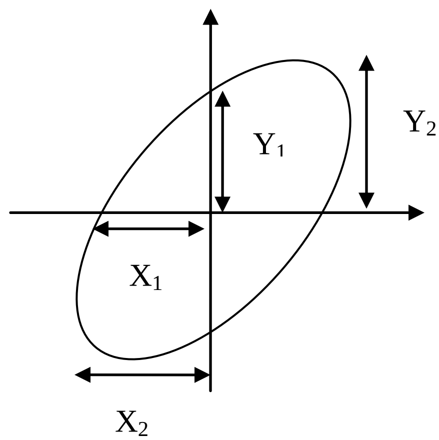
$$A_v = 20 Log_{10} \frac{V_0}{V_i} dB$$

9. The phase is measured from Lissajous pattern is shown in figure.

$$\sin\phi = \frac{x_1}{x_2} = \frac{y_1}{y_2} \qquad \text{and} \qquad \phi = \sin^{-1}\left(\frac{x_1}{x_2}\right) = \sin^{-1}\left(\frac{y_1}{y_2}\right)$$

TITLE: **COMPENSATION DESIGN** (LEAD, LAG NETWORK)	GPRECD/EEE/EXPT-CSP-4 Date: 02-03-2022

MODEL GRAPH



LISSJOUS PATTERN

TABLE:

SL.No.	Frequency (Hz)	Phase Shift(Φ)

RESULT:

QUIZ:

1. What for compensation networks are used?
2. What are the types of compensation networks?
3. What is the use of all pass filter?
4. What is use of inverting amplifier?
5. What are the responses of compensation network?
6. What is use of LEAD compensation?
7. What is the use effect of LEAD compensation on the system?
8. What is the effect of LAG compensator on the system?
9. What is use of LAG compensation?
10. What is process or plant?

TITLE: **SYNCHRO PAIR**	GPREC/DEEE/EXPT-CSP-5 Date: 02-03-2022

5. STUDY OF SYNCHRO TRANSMITTER AND RECEIVER PAIR

AIM: To study the characteristics of Synchro Transmitter and Receiver Pair

APPARATUS: Synchro Transmitter – Receiver Pair and Digital Multimeter

THEORY: The synchro Transmitter/ Receiver demonstrator unit is designed to study of remote transmission of position in AC servomechanism. These are also called as torque Tx and Rx. The unit has one pair of Tx –Rx synchro motors powered by 60 V AC inbuilt supply. The synchro Tx has dumb ball shaped magnetic structure having primary winding upon rotor which is connected with the line through set of slip rings and brushes. The secondary windings are wound in slotted stator and distributed around its periphery.

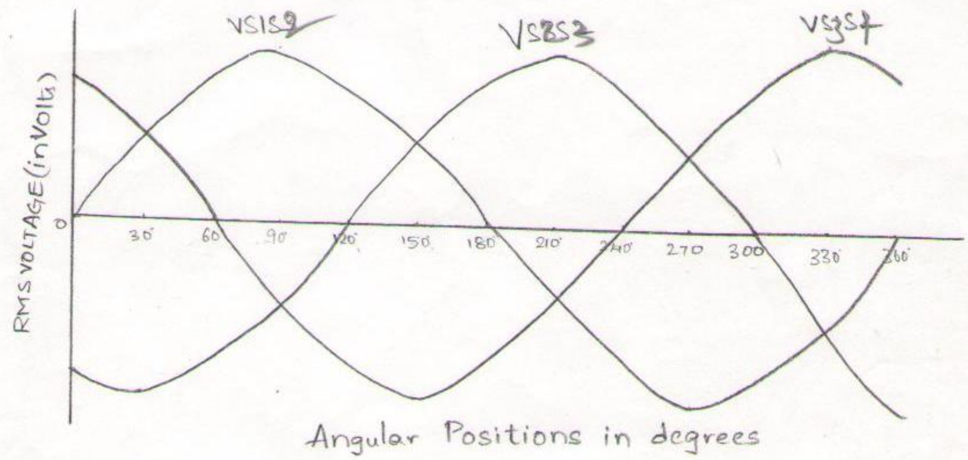
<u>EXPERIMENT-1</u>: Study of Synchro Transmitter

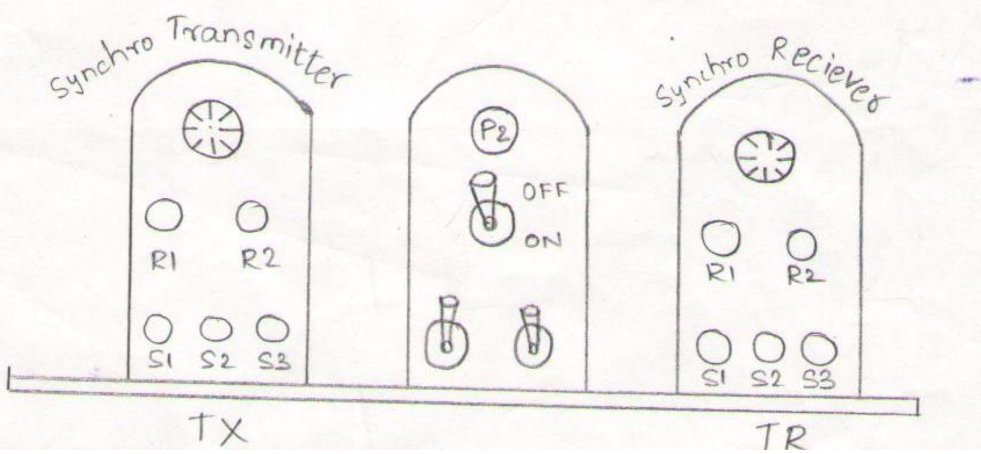
PROCEDURE:

1. Connect the mains supply to the system with the help of cable provided. Do not connect any ptach cords to terminals marked “S1,S2,S3”
2. Switch on mains supply for the unit.
3. Starting from zero position, note down the voltage between stator winding terminals that are VS1S2, VS2S3, and VS3S1 in a sequential manner. Enter readings in a tabular form and plot a graph of angular position of rotor voltages for all three phases.
4. Note that zero position of the stator rotor coincides with VS3S1 voltages equal to zero voltage. Do not disturb this condition.

TITLE: **SYNCHRO PAIR**	GPREC/DEEE/EXPT-CSP-5 Date: 02-03-2022

Expected wave form and circuit:





TITLE: **SYNCHRO PAIR**	GPREC/DEEE/EXPT-CSP-5 Date: 02-03-2022

TABLE- 1

S.No.	Rotor Position (In degrees)	RMS Voltage for Stator Terminal VS1S2	RMS Voltage for Stator Terminal VS2S3	RMS Voltage for Stator Terminal VS3S1

EXPERIMENT-2: Study of synchro transmitter and receiver pair.

PROCEDURE:

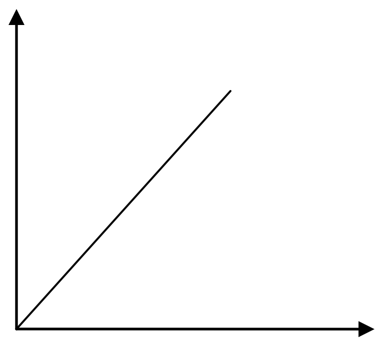
1. Connect mains supply cable.
2. Connect S1,S2,and S3 terminals of transmitter to S1,S2,and S3 of synchro receiver by patch cords provided respectively.
3. Switch on SW1 and SW2 and also switch on mains supply.
4. Move the pointer i.e rotor position of synchro transmitter Tx in steps of 30 degrees and observe the new rotor potion. Observe that whenever Tx rotor is rotated, the Rx rotor follows it for both the directions of rotation and their positions are good agreement.
5. Enter the input angular position and output angular position in the tabular form and plot a graph.

TABLE : 2

S.No.	Angular Position (In degrees) Synchro Transmitter Input	Angular Position (In degrees) Synchro Transmitter output

Expected Graph:

Output Angular
Position
(Receiver side)



Input Angular position
(Transmitter Side)

PRECAUTIONS

1. **Before switch on P1 and P2 should be always brought to most anticlockwise position.**
2. **Control P1 and P2 should be operated in a gentle fashion.**

RESULT:

QUIZ:

1. What are synchros?
2. What is use of synchro transmitter and receiver?
3. What is the basic structure of synchro?
4. How the two windings are coupled to each other in synchro?
5. What are the advantages of synchros?
6 What are advantages of synchros?
7. What is the phase displacement of three windings of synchros?
8. On what factor does the magnitude and polarity of voltage/phase depend?
9. Where the primary winding is connected?
10. Where secondary winding is connected?

TITLE: **LINERA SYSTEM SIMULATOR**	GPREC/DEEE/EXPT-CSP-6 Date: 02-03-2022

6. LINEAR SYSTEM SIMULATOR

AIM: To study the Transient response of first order and second order type zero system

APPARATUS: Linear system simulator Kit, CRO, Connecting probes

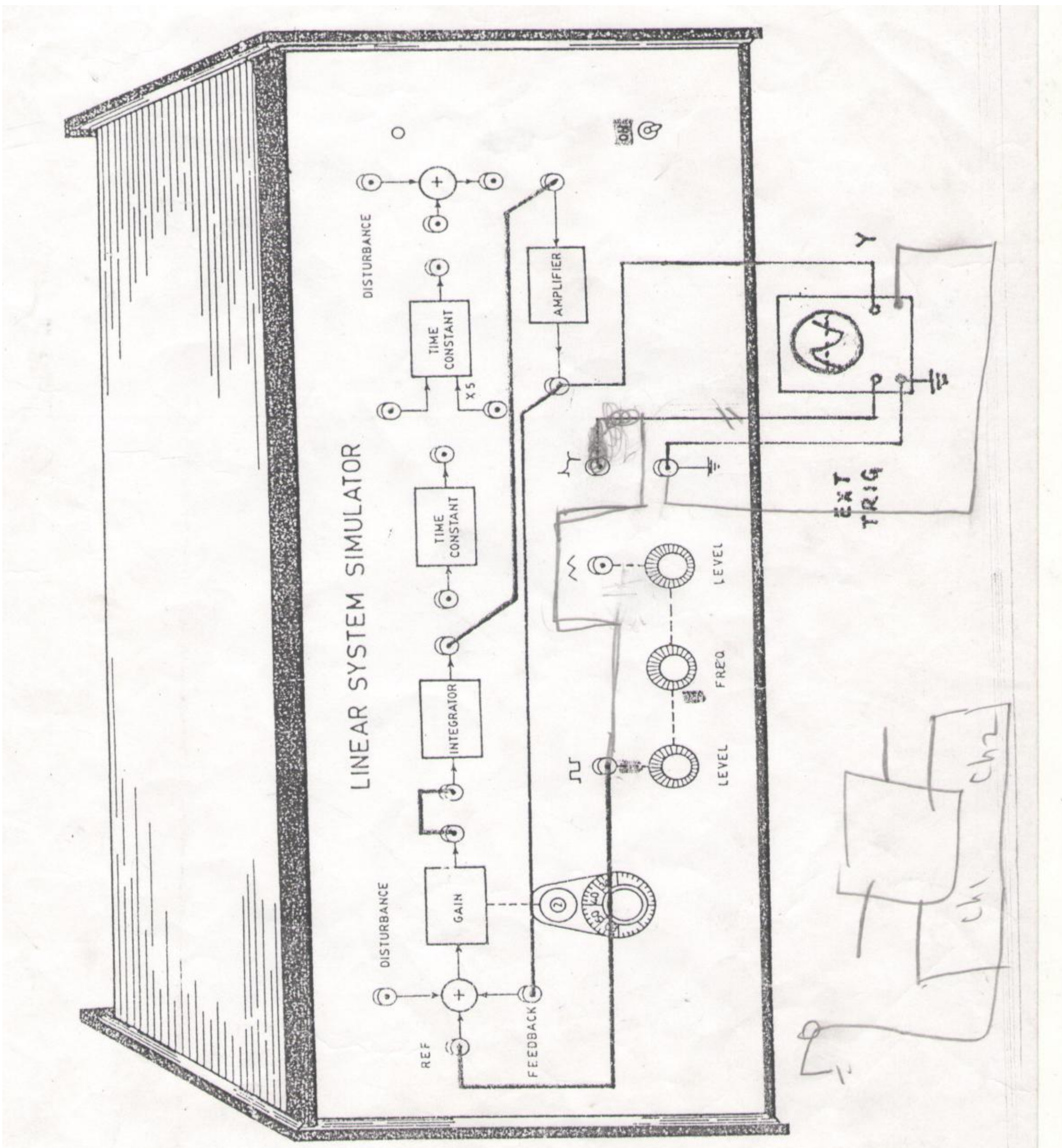
THEORY: The type number of the system is obtained from the number of poles located at origin in a given system. Type – 0 system means there is no pole at origin. Type – 1 system means there is one pole located at the origin. The order of the system is obtained from the highest power of s in the denominator of closed loop transfer function of the system. The first order system is characterized by one pole or a zero. Examples of first order systems are a pure integrator and a single time constant having transfer function of the form K/s and K/(sT+1). The second order system is characterized by two poles and up to two zeros. The standard form of a second order system is $G(s) = \omega_n^2 / (s^2 + 2\zeta\omega_n s + \omega_n^2)$ where ζ is damping ratio and ω_n is undamped natural frequency. The time response characteristics of control systems are specified in terms of time domain specifications. Systems with energy storage elements cannot respond instantaneously and will exhibit transient responses, whenever they are subjected to inputs or disturbances.

The desired performance characteristics of a system of any order may be specified in terms of transient response to a unit step input signal. The transient response characteristics of a control system to a unit step input is specified in terms of the following time domain specifications

- Delay time t_d
- Rise time tr
- Peak time t_p
- Maximum peak overshoot M_p
- Settling time t_s

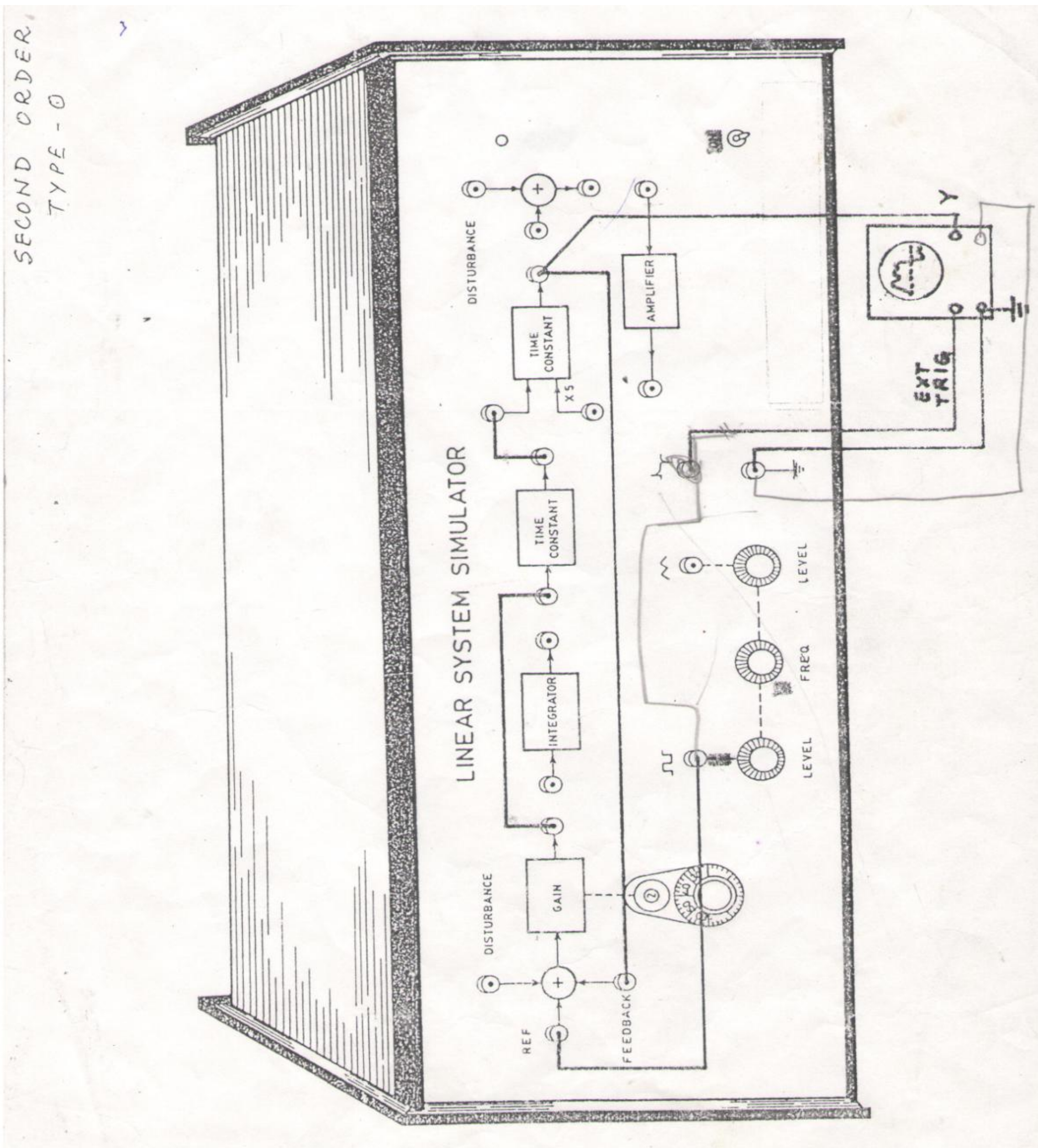
TITLE: **LINERA SYSTEM SIMULATOR**	GPREC/DEEE/EXPT-CSP-6 Date: 02-03-2022

CIRCUIT:



First Order System

TITLE: **LINERA SYSTEM SIMULATOR**	GPREC/DEEE/EXPT-CSP-6 Date: 02-03-2022



Second Order System

TITLE: **LINERA SYSTEM SIMULATOR**	GPREC/DEEE/EXPT-CSP-6 Date: 02-03-2022

PROCEDURE:

1. The transfer function of the system is

$$\frac{C(s)}{R(s)} = \frac{\theta_c(s)}{\theta_R(s)}$$

2. By varying the values of gain 'A' at each step calculate the values of ω_r, rise time, peak time, peak overshoot, settling time. The value of 'A' is varied from A= 100.200,…… [A is gain]
3. Calculate the time domain specifications, ω_d, rise time, peak time, peak overshoot, settling time

$$t_r = \frac{\pi - \theta}{\omega_d} \quad \textbf{where } \theta = \tan^{-1}\frac{\sqrt{1-\zeta^2}}{\zeta}$$

$$t_p = \frac{\pi}{\omega_d} \quad \textbf{and} \quad t_s = \frac{4}{\zeta\omega_n} \quad \textbf{for 2\% error}$$

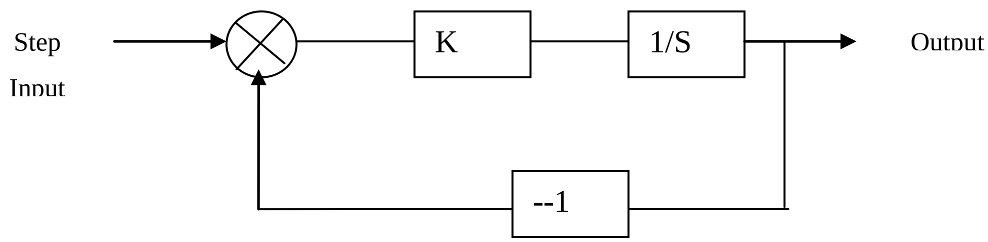
$$M_p = e^{-\frac{\pi\zeta}{\sqrt{1-\zeta^2}}} * 100$$

TABLE: only for second order system

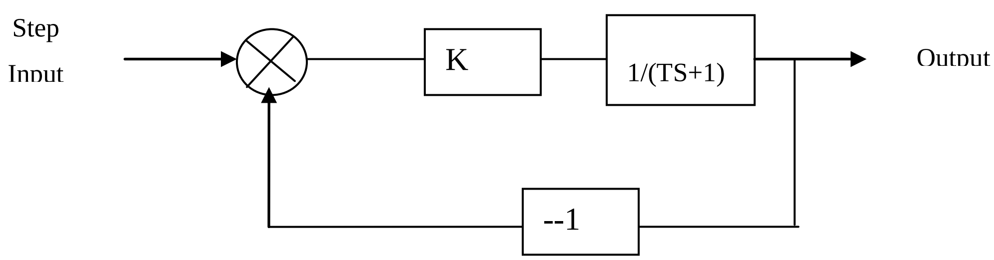
GAIN.	DAMPING RATIO ς	ωn	ωd	Tr	Tp	Ts	Mp	ς

TITLE: **LINERA SYSTEM SIMULATOR**	GPREC/DEEE/EXPT-CSP-6 Date: 02-03-2022

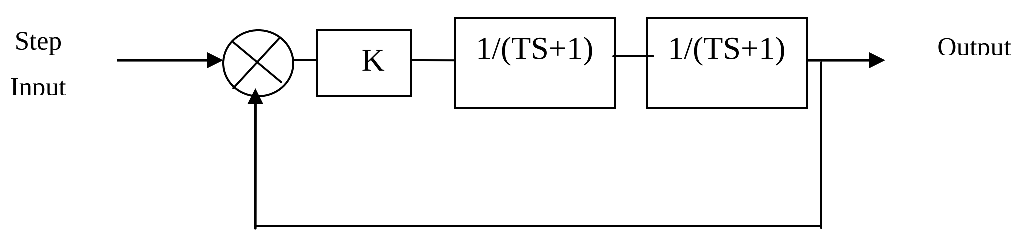
First Order Type-I System



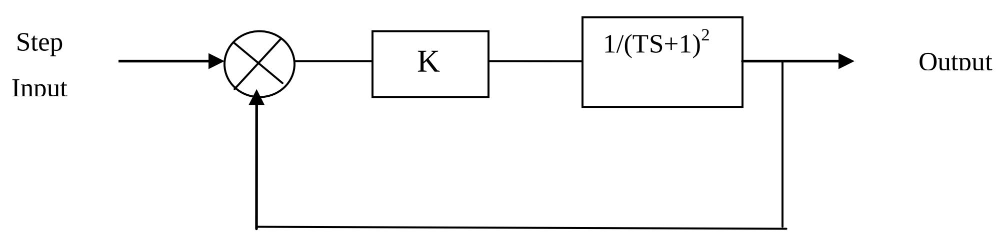
First Order Type-0 System



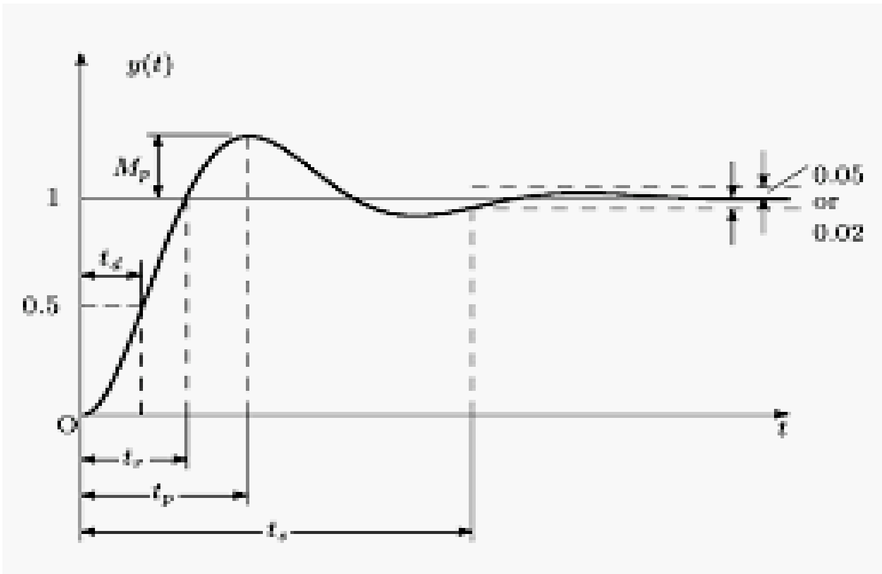
Second Order Type-0 System



Second Order Type-I System



TITLE: **LINERA SYSTEM SIMULATOR**	GPREC/DEEE/EXPT-CSP-6 Date: 02-03-2022



RESULT:

QUIZ:

1. What are time domain specifications?
2. Define steady state error.
3. What is transfer function.
4. What is peak overshoot.
5. What is Peak time?
6. What is settling time
7. What is rise time
8. What is transient response?
9. What is damping ratio?
10. What is steady state system?

TITLE: **PID CONTROLLER**	GPREC/DEEE/EXPT-CSP-7 Date: 02-03-2022

7. PID CONTOLLER

AIM: To study the performance characteristics of an analog PID controller using simulated system

APPARATUS: PID controller simulated system Kit, CRO, Connecting probes

THEORY: PID controllers are commercially successful and widely used as controllers in industries. For example, in a typical paper mill there may be about 1500 controllers and out of these 90 percent would be PID controllers. The PID controller consists of a proportional mode, an Integral mode and a Derivative mode. The first letters of these modes make up the name PID controller. Depending upon the application one or more combinations of these modes are used. For example, in a liquid control system where we want zero steady state error, a PI controller can be used and in a temperature control system where zero stead state error is not specified, a simple P controller can be used.
The equation of a PID controller in time-domain is given by

$$u(t) = K_p e(t) + K_i \int_o^t e(t)dt + k_d \frac{de(t)}{dt}$$

Where k_p, , k_i and k_d, all non-negative, denote the coefficients for the proportional, integral, and derivative terms, respectively.

- *P* accounts for present values of the error. For example, if the error is large and positive, the control output will also be large and positive.
- *I* accounts for past values of the error. For example, if the current output is not sufficiently strong, error will accumulate over time, and the controller will respond by applying a stronger action.
- *D* accounts for possible future values of the error, based on its current rate of change

TITLE: **PID CONTROLLER**	GPREC/DEEE/EXPT-CSP-7 Date: 02-03-2022

PROCEDURE:

PROPORTIONAL-INTEGRAL-DERIVATIVE CONTROL

1. Make connections as shown in fig. with proper integral and derivative blocks connected.
2. Set input amplitude 1Volt (p-p), frequency a low value, $K_c = 0.6$ $K_c = 54.85$(Scale setting of 0,06) and $K_d = 0$
3. The system shows a fairly large overshoot. Record the peak overshoot and steady state error.
4. Repeat the above step for a few non-zero values of K_d
5. Observe the improvement in transient performance with increasing values of K_d ,while to steady state error remains unchanged.
6. For $K_c = 0.6$ adjust K_i and K_d by trial and error to obtain the best overall response.

TABLE:

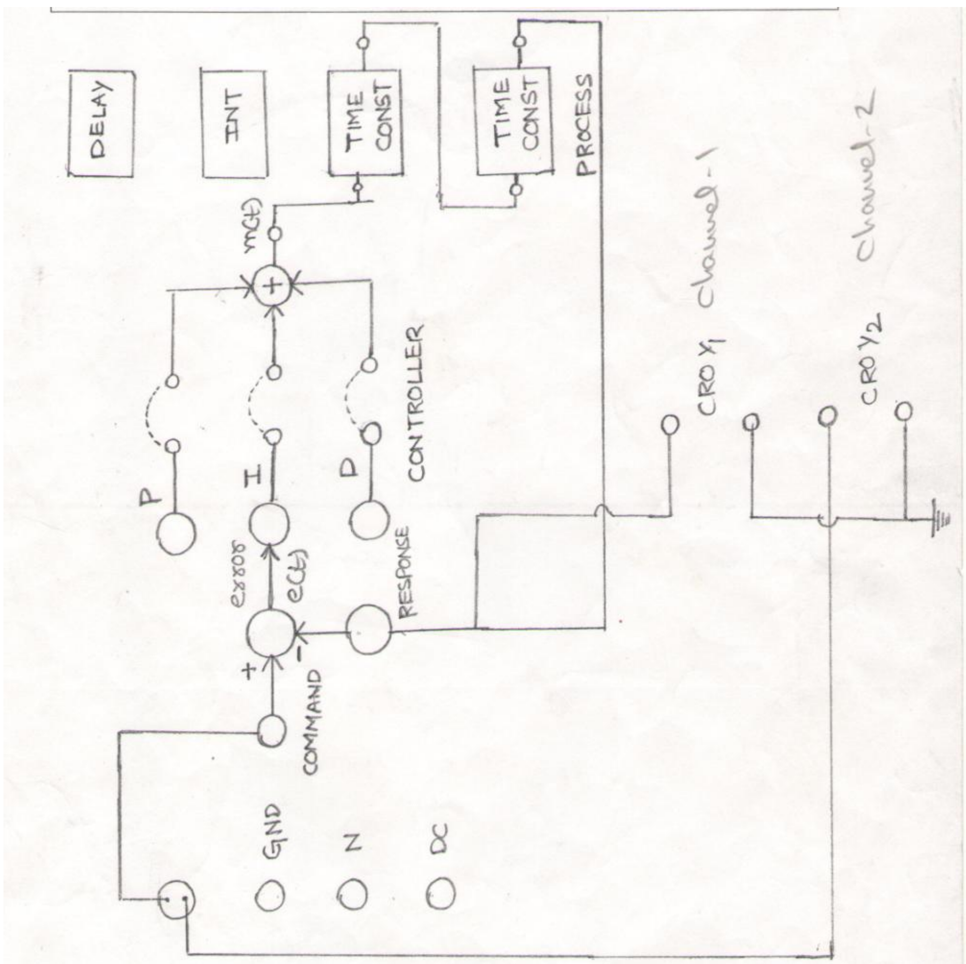
Scale Reading	K_i	X=2*steady State	Y=2*Peak to peak	steady State error	% overshoot

$$\text{S.S. Error} = \frac{(p-p)Input - X}{(P-P)Input}$$

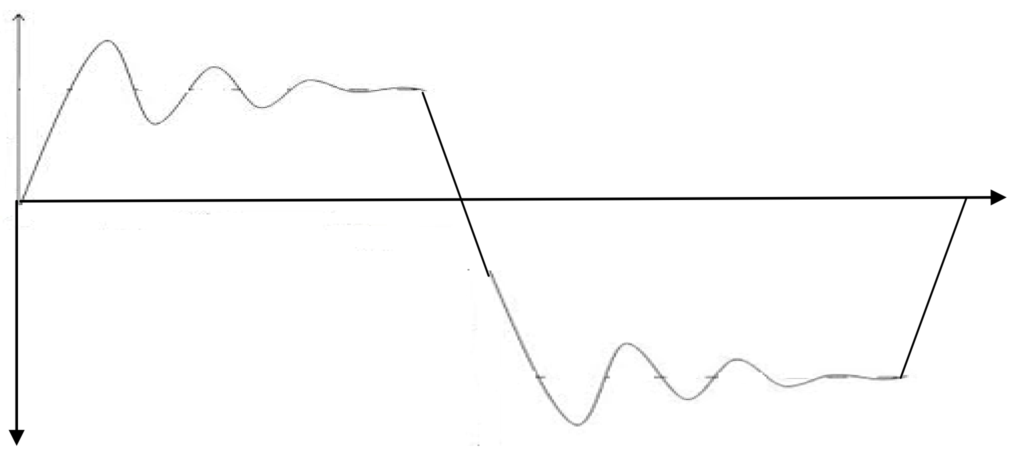
$$\text{Peak Percent overshoot} = \frac{Y-X}{X} * 100$$

TITLE: **PID CONTROLLER**	GPREC/DEEE/EXPT-CSP-7 Date: 02-03-2022

CIRCUIT:



TITLE: **PID CONTROLLER**	GPREC/DEEE/EXPT-CSP-7 Date: 02-03-2022



CRO Display of Step Response using Triangular Time base

RESULT:

QUIZ:

1. What are the different compensation techniques?
2. What is derivative output compensation?.
3. What is called a proportional plus integral controller?
4. What is called a PID controller?.
5. What is the advantage of PD controller?
6. What is the effect of PD controller on the system performance?
7. What is the effect of PI controller on the system performance?
8. Why derivative controller is not used alone in control systems?
9**.** What is meant by a controller?
10. Define manually controlled systems?

8. DC POSITION CONTROL SYSTEMS

EXPERIMENT-1

OBJECTIVE:

To study the DC servomotor position controller with P controller using the DC position control system trainer module (PEC-01).

APPARATUS:

1. PEC-01 module
2. Patch Chords
3. Motor setup
4. CRO

THEORY: A DC position control system is a closed loop control system in which the position of the mechanical load is controlled with the position of the reference shaft. A pair of potentiometers acts as error-measuring device. They convert the input and output positions into proportional electric signals. The desired position is set on the input potentiometer and the actual position is fed to feedback potentiometer. The difference between the two angular positions generates an error signal, which is amplified and fed to armature circuit of the DC motor. The tachogenerator attached to the motor shaft produces a voltage proportional to the speed which is used for feedback. If an error exists, the motor develops a torque to rotate the output in such a way as to reduce the error to zero. The rotation of the motor stops when the error signal is zero, i.e., when the desired position is reached

TITLE: **DC POSITION CONTROL SYSTEM**	GPRECD/EEE/EXPT-CSP-8 Date: 02-03-2022

PROCEDURE:

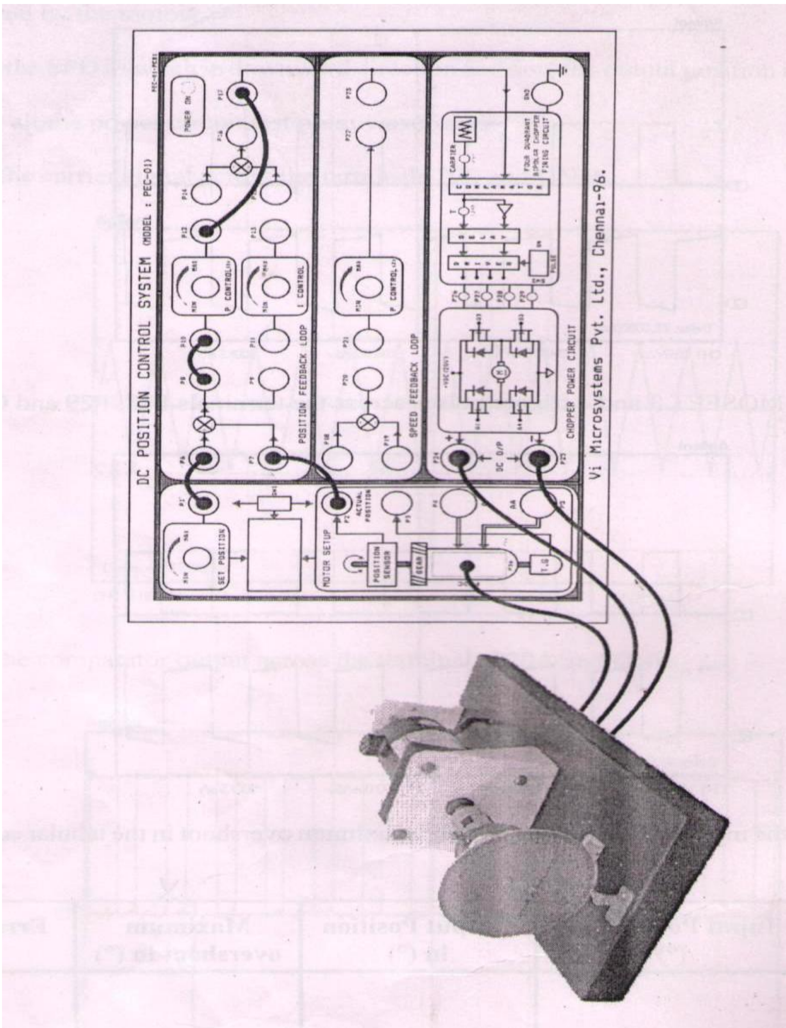
1. Connect the terminal P1 to P6 using patch chord.
2. Connect the motor actual position terminal P2 to P7 using patch chord.
3. Connect the terminal P8 to P10 and P12 to P14 and P16 to P17 using patch chords.
4. DC output from P24 & P25 is connected to the input of permanent magnet DC motor.
5. Verify the connection as per the connection diagram and steps 1 to 4.
6. Set the pulse release switch in OFF position.
7. Switch ON the power supply.
8. Vary the set position knob and set the motor position at any value.
9. Select the SPDT switch in upward direction and note the input position in digital display.
10. Slightly vary the P control knob.
11. Switch ON the pulse release switch S2. Note the maximum overshoot or maximum position achieved by the motor.
12. Select the SPDT switch in downward direction and note the output position in digital display.

OBSERVATIONS:

S.No	Input position in (^{o})	Output position in (^{o})	Error in (^{o})

TITLE: **DC POSITION CONTROL SYSTEM** GPRECD/EEE/EXPT-CSP-8
Date: 02-03-2022

CONNECTION DIAGRAM:



RESULT:

REMARKS IF ANY:

EXPERIMENT-2

OBJECTIVE:

To study the DC servomotor position controller with PI controller using the DC position control system trainer module (PEC-01).

APPARATUS:

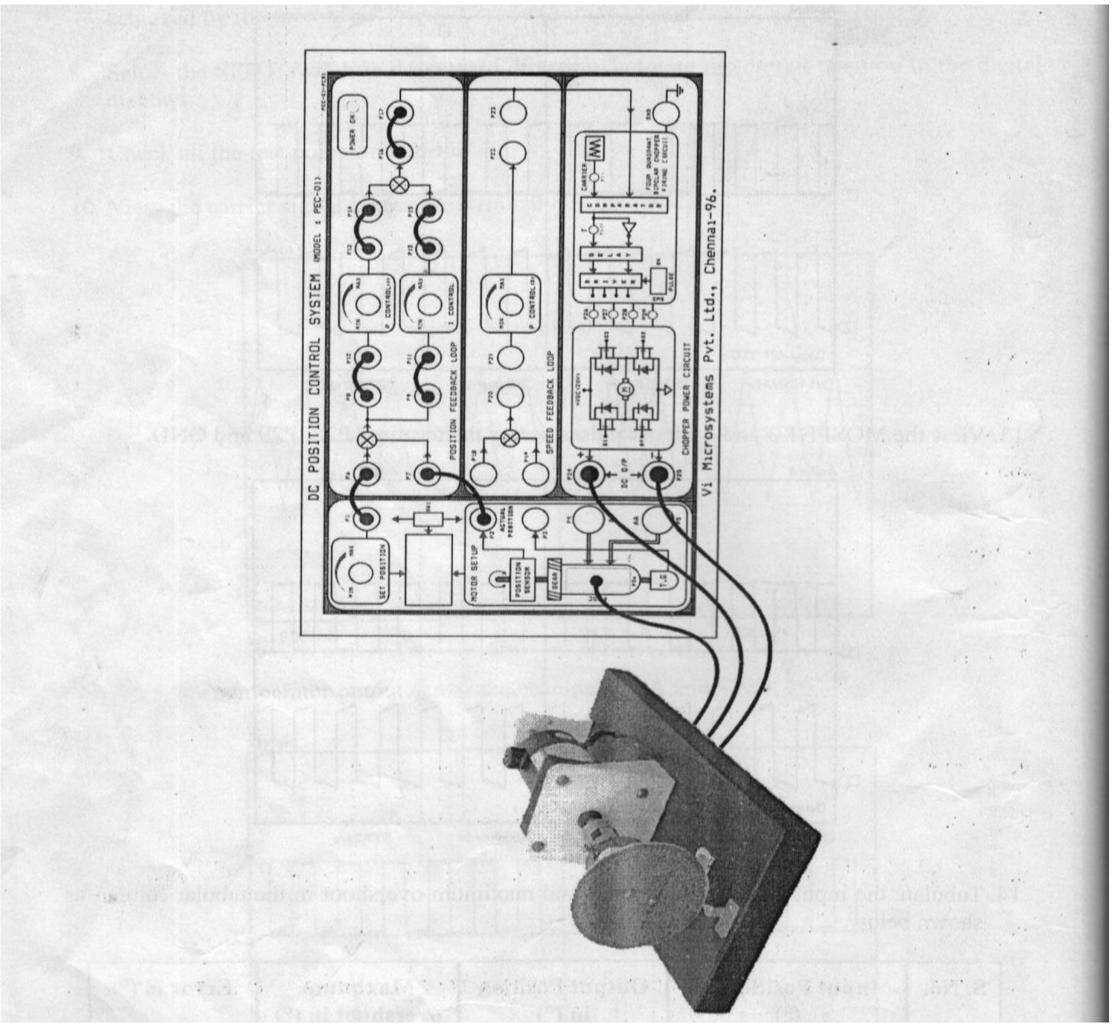
1. PEC-01 module
2. Patch Chords
3. Motor setup
4. CRO

PROCEDURE:

1. Connect the terminal P1 to P6 using patch chord.
2. Connect the motor actual position terminal P2 to P7 using patch chord.
3. Connect the terminal P8 to P10 and P9 to P11 using patch chords.
4. Connect the terminal P12 to P14 and P13 to P15 using patch chords.
5. DC output from P24 & P25 is connected to the input of permanent magnet DC motor.
6. Verify the connection as per the connection diagram and steps 1 to 5.
7. Set the pulse release switch in OFF position.
8. Switch ON the power supply.
9. Vary the set position knob and set the motor position at any value.
10. Select the SPDT switch in upward direction and note the input position in digital display.
11. Slightly vary the P and I control knobs.
12. Switch ON the pulse release switch S2. Note the maximum overshoot or maximum position achieved by the motor.
13. Select the SPDT switch in downward direction and note the output position in digital display.

TITLE: **DC POSITION CONTROL SYSTEM**	GPRECD/EEE/EXPT-CSP-8 Date: 02-03-2022

CONNECTION DIAGRAM:



OBSERVATIONS:

S.No	Input position in (^{o})	Output position in (^{o})	Error in (^{o})

RESULT:

REMARKS IF ANY:

EXPERIMENT-3

OBJECTIVE:

To study the DC servomotor position controller with speed feedback loop using the DC position control system trainer module (PEC-01).

APPARATUS:

1. PEC-01 module
2. Patch Chords
3. Motor setup
4. CRO

PROCEDURE:

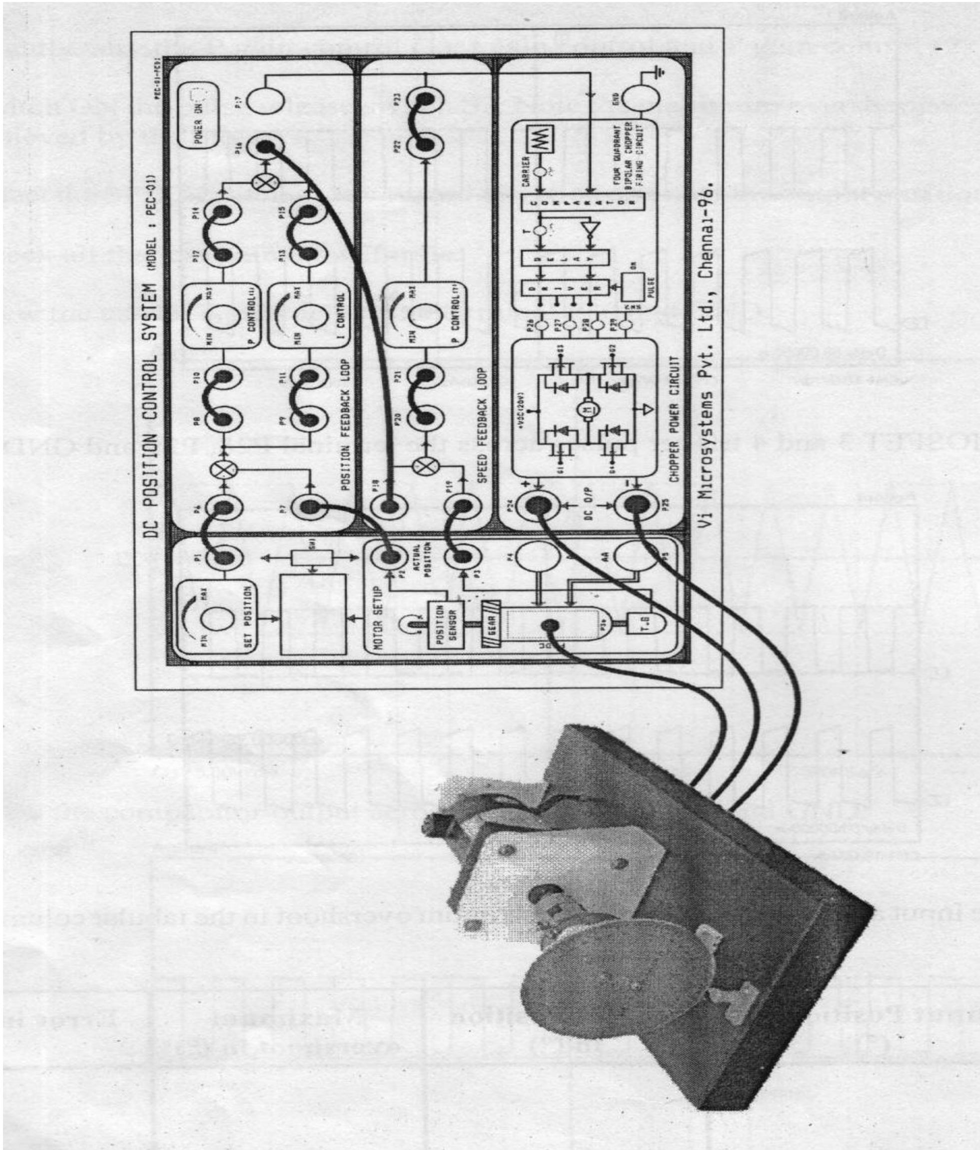
1. Connect the terminal P1 to P6 using patch chord.
2. Connect the motor actual position terminal P2 to P7 using patch chord.
3. Connect the terminal P8 to P10 and P9 to P11 using patch chords.
4. Connect the terminal P12 to P14 and P13 to P15 using patch chords.
5. Connect the terminal P3 to P19 and P20 to P21 using patch chords.
6. DC output from P24 & P25 is connected to the input of permanent magnet DC motor.
7. Verify the connection as per the connection diagram and steps 1 to 6.
8. Set the pulse release switch in OFF position.
9. Switch ON the power supply and switch ON the power ON/OFF switch.
10. Vary the set position knob and set the motor position at any value.
11. Select the SPDT switch in upward direction and note the input position in digital display.
12. Slightly vary the P gain control, I gain control knobs.
13. Switch ON the pulse release switch S2. Note the maximum overshoot or maximum position achieved by the motor.
14. Select the SPDT switch in downward direction and note the output position in digital display.

OBSERVATIONS:

S.No	Input position in (^{o})	Output position in (^{o})	Error in (^{o})

TITLE: **DC POSITION CONTROL SYSTEM**	GPRECD/EEE/EXPT-CSP-8 Date: 02-03-2022

CONNECTION DIAGRAM:



RESULT:

REMARKS IF ANY:

Quiz:

1. What is the function of DC Servo motor?
2. What is the function of P-Controller?
3. What is the function of PI-Controller?
4. Define error?
5. What is the difference between AC and DC Servo motor?
6. What are the uses of DC servo motor?
7. What is transfer function of DC Servo Motor?
8. What is the relation between torque and speed of DC servo motor?
9. What is the effect of negative slope?
10. What are the special features of DC Servo Motors?

TITLE: **ROOT LOCUS**	GPRECD/EEE/EXPT-CSP-9 Date: 02-03-2022

9. ROOT LOCUS

AIM: To obtain the Root Locus plot using MATLAB

APPARATUS: Personal computer, MATLAB

THEORY:

ROOT LOCUS

A simple technique known as "Root Locus Technique" used for studying linear control systems in the investigation of the trajectories of the roots of the characteristic equation. This technique provides a graphical method of plotting the locus of the roots as gain k is varied be from zero to infinity. The roots corresponding to a particular value of the system parameter can then be located on the locus or the value of the parameter for a desired root location can be determined form the locus. The root locus is a powerful technique as it brings into focus the complete dynamic response of the system. The root locus also provides a measure of sensitivity of roots to the variation in the parameter being considered. This technique is applicable to both single as well as multiple-loop systems**.**

PROCEDURE:

<u>Root Locus:</u>

Given Transfer function G(s) =

Commands

```
NUM = [            ];
DEN  = [            ];
rlocus (NUM, DEN);
```

TITLE: **ROOT LOCUS**	GPRECD/EEE/EXPT-CSP-9 Date: 02-03-2022

RESULT:

QUIZ:

1: What do you understand by MATLAB software?
2. What does MATLAB stands for?
3. Where can we use MATLAB?
4. Name some tool boxes?
5. What is system requirement for MATLAB?
6. What is transfer function?
7. What are zeros and poles in control system?
8: What is Root Locus?
9: What is the stability in control system?
10. Name some tool boxes in MATLAB?

TITLE: **BODE PLOT**	GPRECD/EEE/EXPT-CSP-10 Date: 02-03-2022

10. BODE PLOT

AIM: To obtain the Bode plot using MATLAB

APPARATUS: Personal computer, MATLAB

THEORY:

BODE PLOT

The bode plot is the frequency response plot of the transfer function of a system. A bode plot consists of two graphs. One is a plot of the magnitude of a sinusoidal transfer function versus log ω, the other is a plot of the phase angle of sinusoidal transfer function versus log ω. The bode plot can be drawn for both open loop and closed loop transfer function. Usually the bode plot is drawn for open loop system. The curve are drawn on semi log paper, using the log scale (abscissa) for frequency and the linear scale (ordinate) for either magnitude (in decibels) or phase angle (in degrees). The main advantage of the bode plot is that multiplication of magnitudes can be converted into addition. Also a simple method for sketching an approximate log magnitude curve is available.

PROCEDURE:

Bode Plot:

Given Transfer function G(s) =

Commands

```
NUM = [            ];
DEN=[         ];
bode (NUM,DEN);
```

TITLE: **BODE PLOT**	GPRECD/EEE/EXPT-CSP-10 Date: 02-03-2022

RESULT:

QUIZ:

1: What do you understand by MATLAB software?
2. What does MATLAB stands for?
3. Where can we use MATLAB?
4. Name some tool boxes?
5. What is system requirement for MATLAB?
6. What is transfer function?
7. What are zeros and poles in control system?
8: What is Bode Plot?
9: What is meant by phase margin?
10. What is meant by gain margin?

TITLE: **POLAR PLOT**	GPRECD/EEE/EXPT-CSP-11 Date: 02-03-2022

11. POLAR PLOT

AIM: To obtain the Polar plot using MATLAB

APPARATUS: Personal computer, MATLAB

THEORY:

POLAR PLOT.

The major advantage of the polar plot lies in stability study of systems. Nyquist related the stability of a system to the form of these plots. Polar plots are referred as Nyquist Plot.

PROCEDURE:

Polar Plot:

Given Transfer function G(s) =

Commands

g =tf [ ];

freq=logspace( );

[mag,phase]=bode(g,freq)

Mag=mag( );

Phase=phase( );

Pase=(phase*π)/180

Polar(phase,mag);

TITLE: **POLAR PLOT**	GPRECD/EEE/EXPT-CSP-11 Date: 02-03-2022

RESULT:

QUIZ:

1: What do you understand by MATLAB software?
2. What does MATLAB stands for?
3. What is meant by stability?
4. Name some tool boxes?
5. What is system requirement for MATLAB?
6. What is transfer function?
7. What are zeros and poles in control system?
8: What is Polar Plot?
9: What is the advantage of polar plot?
10. What is meant by gain margin?

TITLE: **NYQUIST PLOT**	GPRECD/EEE/EXPT-CSP-12 Date: 02-03-2022

12. NYQUIST PLOT

AIM: To obtain the Nyquist plot using MATLAB

APPARATUS: Personal computer, MATLAB

THEORY:

NYQUIST PLOT

NYQUIST stability criterion of determining the stability of a closed loop system by investigating the properties of the frequency domain plot of the loop transfer function G(s) H(s). Nyquist stability criterion provides the information on the absolute stability of a control system as similar to Routh- Hurwitz criterion. Not only giving the absolute stability, but indicates "Degree of Stability**"** i.e"Relative Stability" of a stable system and the degree of instability of an unstable system and indicates how the system stability can be improved. The Nyquist stability citerion is based on a Cauchy's Residue Theorem of complex variables which is referred to as the **"**principle of argument".

The principle of argument is given by N= Z – P.

PROCEDURE:

<u>Nyquist Plot:</u>

Given Transfer function G(s) =

Commands

NUM = [ ];
DEN= [ ];
nyquist (NUM, DEN);

TITLE: **NYQUIST PLOT**	GPRECD/EEE/EXPT-CSP-12 Date: 02-03-2022

RESULT:

QUIZ:

1: What do you understand by MATLAB software?
2. What does MATLAB stands for?
3. What is meant by stability?
4. Name some tool boxes?
5. What is system requirement for MATLAB?
6. What is transfer function?
7. What are zeros and poles in control system?
8: What is Nyquist Plot?
9: What is the advantage of Nyquist plot?
10.What is meant by gain margin?