

Practical Manual

CONTROL SYSTEM ENGG.

ECE/EE 6TH SEMESTER

Electrical & Electronics Communication Engineering



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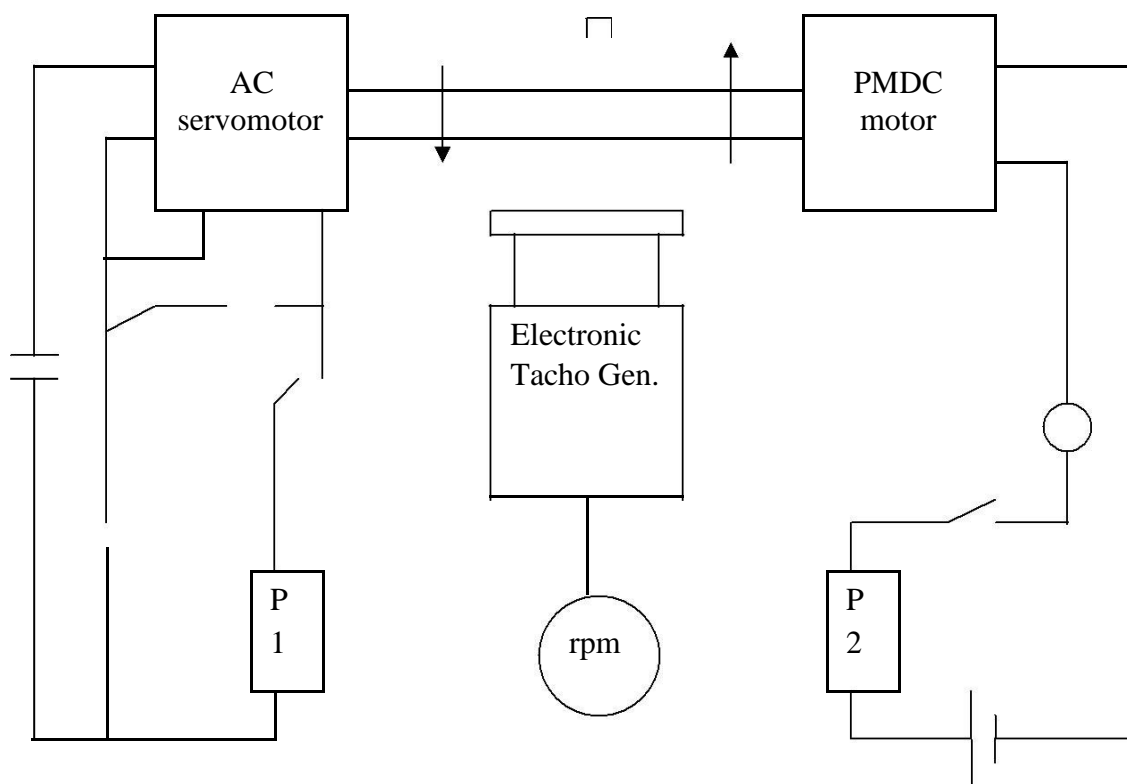
EXPERIMENT NO: 1

AIM: - To study AC servo motor and note its speed torque Characteristics.

APPARATUS REQUIRED: - AC Servo Motor Setup, Digital Multimeter and Connecting Leads.

THEORY: - AC servomotor has best use for low power control applications. Its important parameters are speed – torque characteristics. An AC servomotor is basically a two phase induction motor. Which consist of two stator winding oriented 90° electrically apart. In feedback application phase A is energized with fixed voltage known as “Reference” and phase B is energized with variable voltage called “Control voltage”. In this setup AC servomotor is mounted and mechanically coupled a small PMDC motor loading purpose. When DC supply is fed to DC motor it runs in reverse direction of servomotor direction to impose load on servomotor. The resultant torque developed by DC motor to overcome it increase the current through it which is indicated by panel meter.

CIRCUIT DIAGRAM:-



PROCEDURE: -

1. Switch ON the power supply, switch ON S1. Slowly increase control P1 so that AC servomotor starts rotating. Connect DVM across DC motor sockets (red & black). Vary the speed of servomotor gradually and note the speed N rpm and corresponding back emf Eb across DC motor.
2. Connect DVM across servo motor control winding socket (yellow) and adjust AC Servomotor voltage to 70V and note speed N rpm in table.
3. Switch on S2 to impose load on the motor due to which the speed of AC motor decreases. Increase the load current by means of P2 slowly and note corresponding speed N rpm and Ia. Calculate $P=I_a \cdot E_b$ and
Torque= $P \cdot 1.019 \cdot 10^4 / 60 / 2.2.14 \text{ Ngm/cm}$

OBSERVATION TABLE:-

TABLE-1

S.NO	SPEED N rpm	Eb volts
1.		
2.		
3.		
4.		

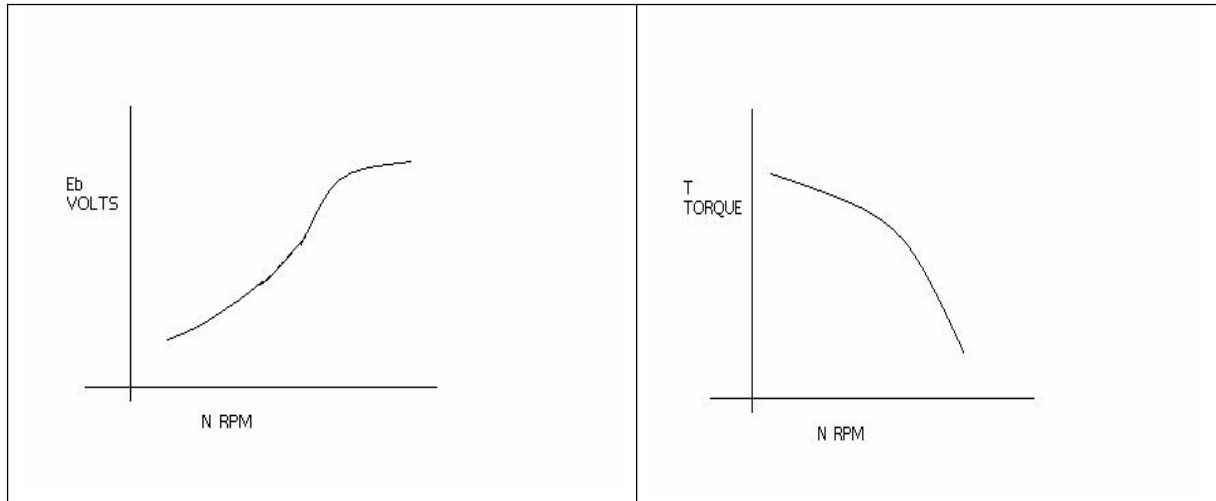
TABLE-2

S.NO	Ia amp	Eb (Tab 1)	Speed N rpm	P watt	Torque
1.					
2.					
3.					
4.					

PRECAUTIONS: -

1. Apply voltage to servomotor slowly to avoid errors.
2. Impose load by DC motor slowly.
3. Take the reading accurately as the meter fluctuates.
4. Switch OFF the setup when not in use.

GRAPH:



DISCUSSION: - The graph is plotted between speed and torque. As we reduce the speed of the motor the torque goes on increasing therefore the graph starts with a low value and rises to a high value approximately linearly. This rise in the graph is due to the rising speed- torque characteristics of AC servo motor.

QUESTIONS:-

Q 1. What is AC servo motor?

A. an AC servo motor is basically a two phase induction motor except for some Design feature.

Q.2 What is the use of AC servo motor?

A. AC servo motor has best use for low power control application.

Q.3 What are the advantages of AC servo motor?

A. It is rugged, light weighted, and has no brush contact as in DC servo motor

. Q4. What is the important parameter of AC servo motor?

A. The important parameter of AC servo motor is its speed – torque characteristics.

Q.5 On what factor does the direction of rotation of AC servo motor depend?

A. The direction of rotation of AC servo motor depends on the phase relationship of Input voltage V1 and V2.

Q.6. What is the drawback of AC servo motor?

A. The main drawback of AC servo motor is its positive slope which causes Negative damping to lead instability in control system.

Q.7 How the drawback of positive in AC servo motor is overcome?

A. The drawback of positive in AC servo motor is overcome by designing the rotor with very high resistance.

Q.8 What is the input of AC servo motor in feedback control application?

A. In feedback control application phase A is given a fixed rated voltage called Reference voltage and phase B is given a variable voltage called control Voltage.

Q.9 What is the phase relationship between reference voltage and control Voltage?

A. The reference voltage and control voltage are 90 degrees out of phase with Each other.

Q.10 What are the types of AC servo motor?

A. AC servo motors are of various type as squirrel cage rotor motor, drag cup Rotor and solid iron rotor motor.

EXPERIMENT NO:2

AIM:- To study dc servo motor and plot its speed torque characteristics.

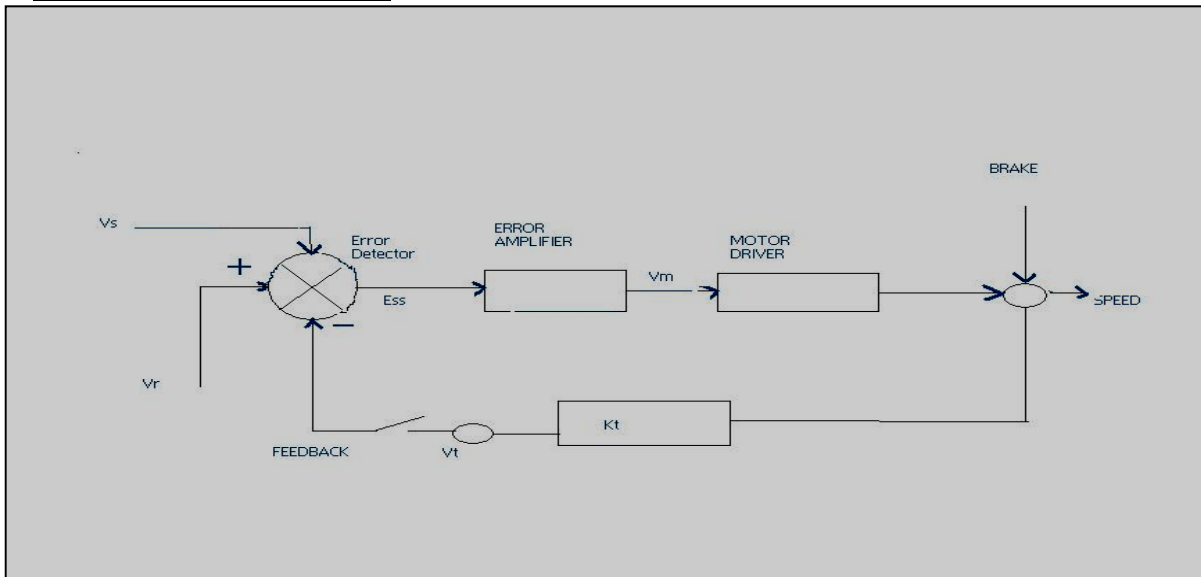
APPARATUS:- DC SERVO MOTOR KIT AND DVM.

THEORY:- The experiment is carried out in two steps.

1. open loop performance
2. close loop performance.

In first case the motor is run without feedback. The amplifier gain factor is kept at minimum gain = 3. motor is connected with main unit by 9 pin D Type socket. Step signal is kept off.

CIRCUIT DIAGRAM:-



PROCEDURE:-

OPEN LOOP PERFORMANCE:- Connect the main unit to the supply. Keep the gain switch off. Set $V_r = 0.7$ or 0.8 . connect DVM with feedback signal socket V_t . Note the speed N rpm from display and tacho output V_t in volts from DVM. Record N rpm and V_t volts for successive gain 4-10 in observation table. Calculate $V_m = V_r * K_a$. Where K_a is the gain set from control 3 – 10.

$$V_r = 0.7 \text{ V.}$$

$$V_m \text{ at gain 3} = 0.7 * 3$$

$$= 2.1 \text{ V.}$$

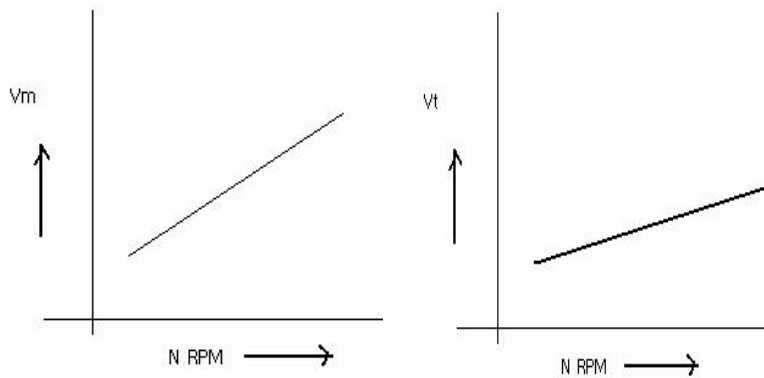
Plot N vs V_t and N Vs V_m graph.

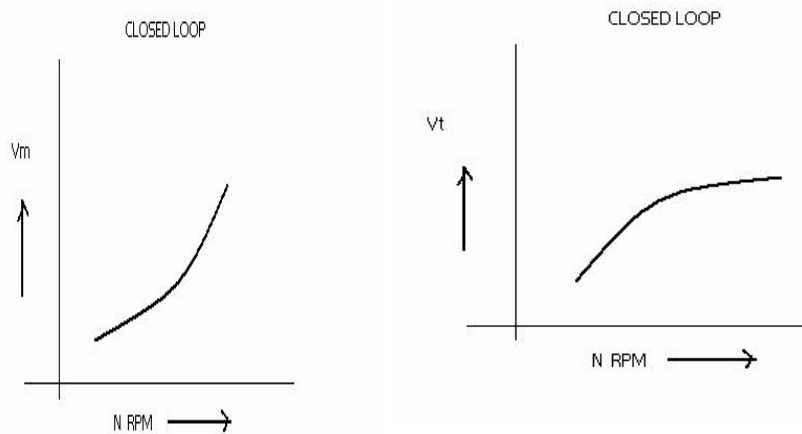
CLOSED LOOP PERFORMANCE:- In this case the gain switch is kept in on position thus feedback voltage gets subtracted from reference voltage. Which is observed by decreased motor speed. Record the result between gain factor K_a and speed N . draw the graph between tacho voltage V_t and speed N .

OBSERVATION TABLE:-

S.NO.	GAIN(Ka)	Vt (volts)	N(rpm)	Vm=Vr×Ka

- PRECAUTIONS:-**
1. Apply the voltage slowly to start the motor
 2. Take the reading properly.
 3. Do not apply breaks for long time as the coil may get heated up.
 4. Switch OFF the main power when not in use.

GRAPH:-



DISCUSSION:-

The graph is plotted between N(RPM) and V_t (tacho voltage) and N(rpm) & V_m (motor voltage). The tacho voltage increases linearly as the RPM of DC servo motor increases. Similarly the motor voltage increases with RPM. In open loop the slope is less but in close loop the slope is sharp. This is due to the feedback gain.

QUESTIONS:-

Q.1 What are the uses of DC servo motor?

A. DC servo motor is widely used in radars, computers, robots, machine tools Tracking systems and process controllers etc.

Q.2. What are the types of DC servo motors?

A. DC servo motors are separately excited or permanent magnet type.

Q.3. How the speed of DC servo motor is controlled?

A. The speed of DC servo motor is controlled by varying the armature voltage.

Q.4. What is the relation between torque and speed of DC servo motor?

A. The torque of DC servo motor decreases with increase in speed.

Q.5. Why the speed torque characteristics of DC servo motor has large negative Slope?

A. The speed – torque characteristics of DC SERVO MOTOR has a large negative Slope due to large armature resistance.

Q.6. What is the effect of negative slope?

A. The negative slope provides viscous damping for the servo drive system

Q.7. In which wattage the DC servo motors are available?

A. DC servo motors are available in fraction of a watt to a few hundred watts.

Q.8. What are the special features of DC SERVO MOTORS?

A. High torque to inertia ratio, High torque to value ratio, Low inductance of Winding and efficient heat dissipation is the special features of DC servomotor

Q.9. How the direction of rotation of DC servo motor can be changed?

A. The direction of rotation of DC servo motor can be changed by reversing the Phase difference from leading to lagging and vice versa between control voltages and reference voltage.

Q.10. What is transfer function of DC SERVO MOTOR?

A. The ratio of Laplace transform of output to the laplace transform of input.

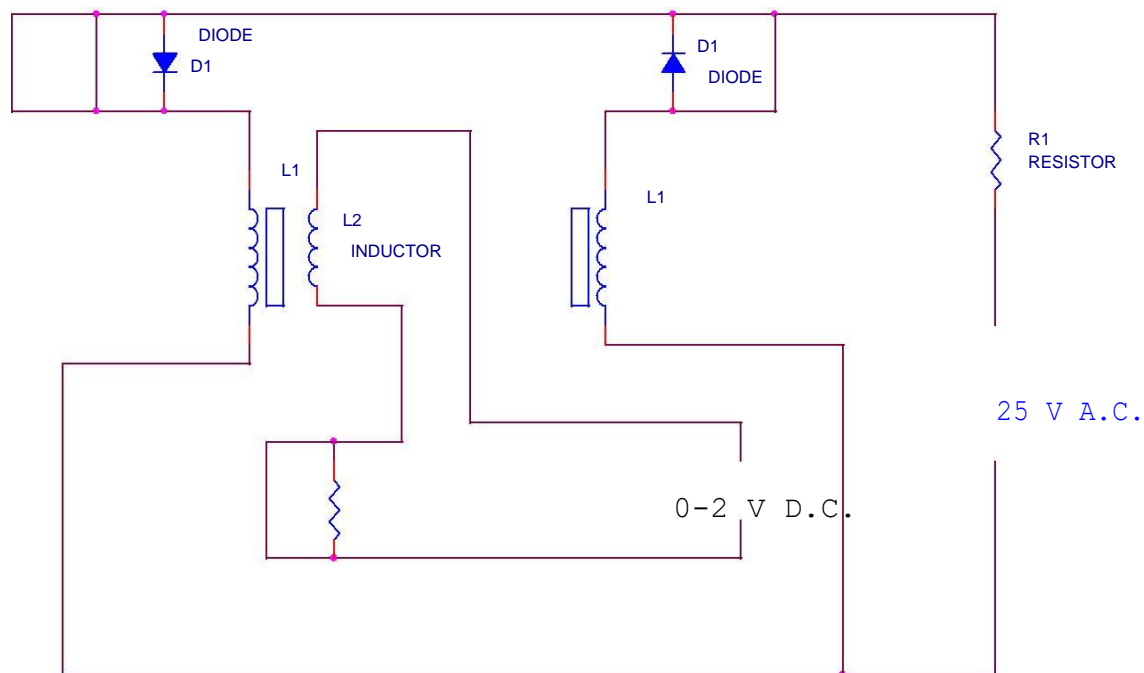
EXPERIMENT NO:3

AIM:- To study magnetic amplifier & plot its load current (IL) V/S control current (IC). Characteristics for parallel mode.

APPARATUS REQUIRED:- - Magnetic amplifier set up, digital multi meter & connecting leads.

THEORY :- - Amplification is the control of larger output by variation of a smaller input. Such amplification can be performed by a magnetic device called magnetic amplifier. This set up is designed to study basic characteristics of such amplifier. To set up consists of magnetic amplifier A.C & D.C power supply, to meters for load & control current & fixed value resistance of 50 ohms.

CIRCUIT DIAGRAM:-



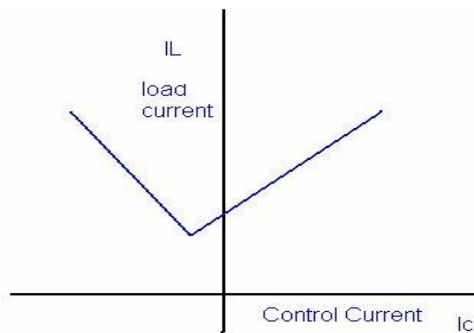
PROCEDURE:- - Connect the circuit as shown in fig. keep D.C. supply to minimum. Selects positive direction. Connect DVM across D.C. input socket. Increase the D.C. voltage slowly & note IL, IC & VC in observation & repeat the experiment. Plot the characteristics curve between IL & IC in both direction. Calculate power gain = $p_{out}/p_{in} = I_L * R_L / I_C * V_C$.

OBSERVATION TABLE:-

SNO.	IC(mA)	IL(mA)	Vc(+ve)

PRECAUTIONS:-

1. Apply voltage slowly to control winding as the coil may get heated up & burn.
2. Take the reading carefully & accurately.
3. switch off the set up when not in use.

GRAPH:-

DISCUSSION : - The graph is plotted between control current(I_C) and load current (I_L) For positive polarity the control current increases linearly with load current in forward Direction but for negative polarity the control current increases load current in reverse direction. This change in direction of control current is due to change in polarity of control voltage.

QUESTIONS:-

Q.1. What is amplification?

A. Amplification is the control of a larger output quantity by the variation of a smaller input quantity.

Q.2. What is magnetic amplifier?

A. Magnetic amplifier is a device which amplifies a small input quantity to a large output quantity. The saturable reactor is

Q.3. What is the working principle of magnetic amplifier?

A. A magnetic amplifier works on the principle of linkage of induced magnetomotive force (mmf).

Q.4. What is magnetomotive force?

A. Magnetomotive force in a magnetic circuit is similar to EMF in an electrical circuit.

Q.5. What is the basis of selection of core of transformer and number of turns?

A. The basis of selection of core of transformer and number of turns is the slope B-H loop.

Q.6. What is saturable reactor?

A. The saturable reactor is a specially wound transformer with three windings instead of two windings like a common transformer.

Q.7. What is drawback of a magnetic amplifier?

A. The main drawback of magnetic amplifier is to control small DC current a large number of turns are required which has a greater resistance requires large DC voltage. Q.8. How this problem is overcome in a magnetic amplifier?

A. This problem is overcome in a magnetic amplifier by self-saturation mode.

Q.9. What is the nature of saturable reactor?

A. The saturable reactor is inductive in nature.

Q.10. What is effect of sudden current application to control winding?

A. If a sudden current is applied to the control winding the current and ampere turns of control winding decrease slowly since it has large inductance.

EXPERIMENT NO-4

AIM: To study magnetic amplifier and plot its load current and control current characteristics for self

APPARATUS REQUIRED:

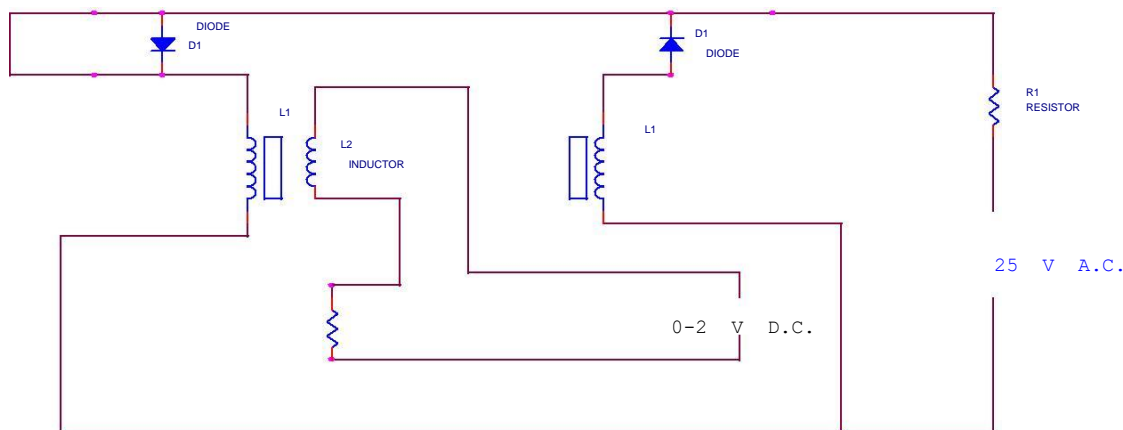
Magnetic amplifier set up, digital multimeter and connecting leads.

THEORY: Self saturation of core is achieved by using two diodes D1 and D2 in series with L1 and L2 load coils. The successive rectified half wave saturates the core in opposite direction in few cycles. This leads to flow of current in RL greatly when control winding in open or there is no current flow. The core does not saturate completely but operates to bring the core out of saturation. DC current is made to flow in controlwinding. The control winding has more number of turns than load winding. Applying a small DC current which oppose the magnetic flux caused by self saturation tends to cut off produced mmf in load magnetic path. This causes to increase inductance in l load winding and the voltage drop across then tends to rise which result in decrease in AC current in RL. If the polarity of DC current is reversed then the saturation of core takes place in opposite direction.

PROCEDURE: Connect the circuit as shown in fig. keep DC voltage to minimum. Select positive direction and switch ON the power. Increase the control current slowly and note the I_L , I_c and V_c in observation table. Bring DC voltage to minimum, select negative direction and repeat the characteristics curve in both direction. Calculate power gain

$$P(\text{gain}) = P(\text{out})/P(\text{in}) \text{ or } \Delta I_L * R_L / \Delta I_c * V_c$$

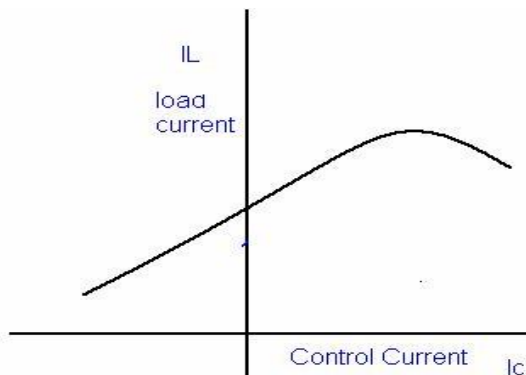
CIRCUIT DIAGRAM:



OBSERVATION TABLE

S.No	I _c (mA)	I _L (mA)	V _c (+ve)
1.			
2.			
3.			
4.			
5.			
S.No	I _c (mA)	I _L (mA)	V _c (-ve)
1.			
2.			
3.			
4.			
5.			

- PRECAUTIONS** :
1. Apply voltage slowly to control winding as the coil may get heated up and burn.
 2. Take the reading carefully and accurately.
 3. Switch off the set up when not in use.

GRAPH:-**DISCUSSION:-**

The graph is plotted between load current and control current. for positive polarity the Control current rises in the forward direction with rise in load current where as for negative polarity the control current decreases in the reverse direction with rise in load current .This is due to the self saturation of the magnetic core .

QUESTIONS:-

Q.1. What are the modes of operation of the magnetic amplifier?

A. The magnetic amplifier operates in two modes, series-parallel mode Self saturation mode.

Q.2. What is the value load resistance R_L for magnetic amplifier?

A. The value of load resistance R_L for magnetic amplifier is 50 ohms

Fix. Q.3. What is power gain in magnetic amplifier?

A. The power gain in magnetic amplifier is the ratio of output power to Input power. Q.4. What is current gain in magnetic amplifier?

A. The current gain in magnetic amplifier is the ratio of load current to Control current. Q.5. What is core saturation?

A. When MMF in a coil is varied due to a varying current it causes the Magnetization to approach to a limit called saturation.

Q.6. What is the direction of windings in the securable reactor?

A. In a securable reactor the two windings are anti- phase with each Other.

Q.7. How self saturation is achieved in a magnetic amplifier?

A. The self saturation of core is achieved by using two rectifier diodes D1 & D2 in series with load coil L1 & L2.

Q.8. How the magnetic core is brought out of saturation?

A. The core is brought out of saturation by passing a current through Control winding.

Q.9. Which winding has more number of turns?

A. The control winding has more number of turns than the load Winding.

Q.10. Between which parameter graph is plotted for magnetic amplifier?

A. The graph is plotted between load current and control current.

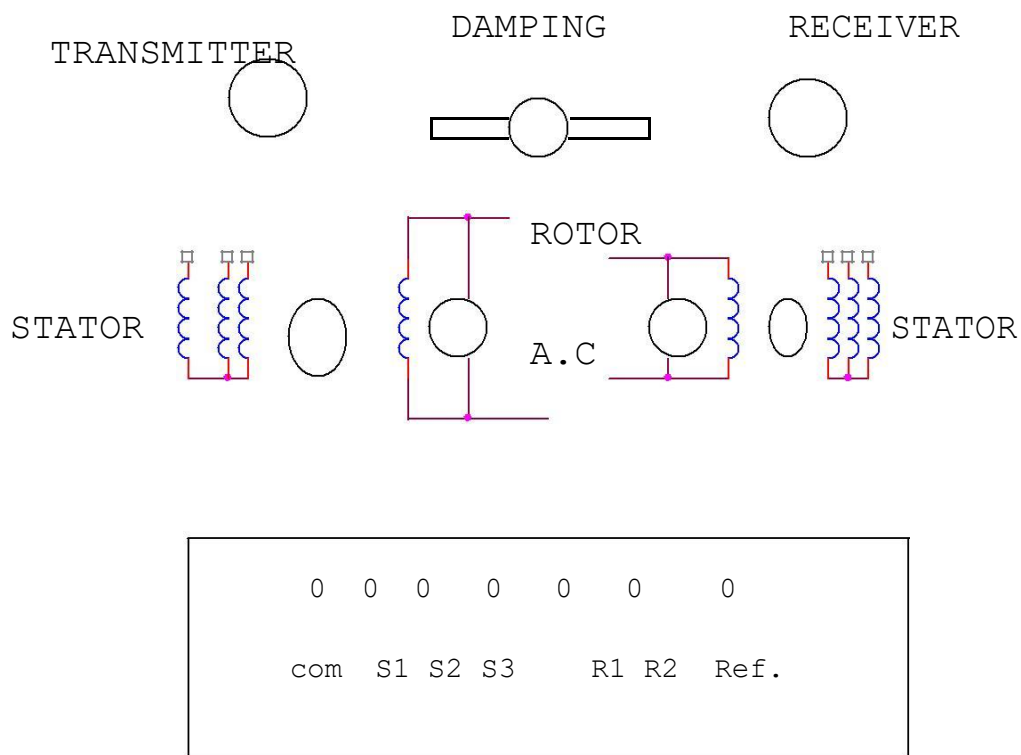
EXPERIMENT NO. 5

AIM: - To study of synchros (transmitter/ Receiver) system.

APPARATUS REQUIRED: - Synchro Tx & Rx set, A dual trace CRO and connecting leads.

BRIEF 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.

CIRCUIT DIAGRAM:-



PROCEDURE:-

The experiment is completed in three parts

1. To study of synchro Tx in terms of position V/s phase and voltage magnitude w.r.t. rotor voltage magnitude/ phase. Connect the circuit as shown in fig. Note the o/p V_{pp} and its phase angle either same as reference o/p or out of phase for each stator winding. Rotate Tx dial in 30 steps and note voltage magnitude and

- phase w.r. t. input as reference. Prepare an observation table.
- To study synchro Tx/Rx as an Error detector. Connect the circuit as shown in fig. Start from 60 or 90 and note the Rx R2 o/p voltage and phase.
 - To study of remote position indication system using synchro-Tx and Rx. Connect the circuit as shown in fig. Keep Tx dial at 0 and watch Rx dial if there is any error removes it. Increase Tx from 30 to 330 in steps of 30 and note the Rx

position record the observation in a table and find the difference between Tx and Rx dial position.

OBSERVATION TABLE:-1

S.No.	Angular Position in Deg. Tx	Magnitude Phase S1	Magnitude Phase S2	Magnitude Phase S3

OBSERVATION TABLE: - 2

S.No.	Angular Position in deg. Tx	Angular Position in deg. Rx

OBSERVATION TABLE:-3

S.No.	Angular Position in deg. Tx	Angular Position in deg. Rx	Difference in Degree Tx-Rx.

PRECAUTIONS: -

- Move the transmitter and receiver dials slowly to avoid errors in reading.
- Take the reading carefully in steady condition.
- Switch of the setup when not in use.

QUESTIONS:-

Q.1.What are synchros ?

A. Synchros are small motors used for remote transmission of shaft Angular position in AC servo system .

Q.2. What is use of synchro transmitter and receiver ?

A. Synchro transmitter receiver are designed to study remote transmission of

position in servo mechanism .

Q.3. What is the basic structure of synchro ?

A. The basic structure of synchro is wound rotor and wound stator .

Q.4. How the two windings are coupled to each other in synchro ?

A. The two windings are mutually coupled to each other in such a way that it gives substantially sinusoidal variation on a function of shaft angular position .

Q.5. What are the advantages of synchros ?

A. The operating speed of synchros is high, they have full 360 degree rotation without electrical break and they are highly reliable .

Q.6. What are advantages of synchros ?

A. They have full range in order of 30 degrees. linearity is not much better than modern potentiometers.

Q.7. What is the phase displacement of three windings of synchros ?

A. The three windings of synchros are 120 degrees apart .

Q.8. On what factor does the magnitude and polarity of voltage/phase depend?

A. The magnitude and polarity of voltage/phase depends upon the angular position of rotor.

Q.9. Where the primary winding is connected ?

A. The primary winding of synchro transmitter is wound on rotor and is connected to reference voltage .

Q.10. Where secondary winding is connected ?

A. The secondary winding is wound over slotted stator and is distributed around the periphery .

EXPERIMENT NO:6

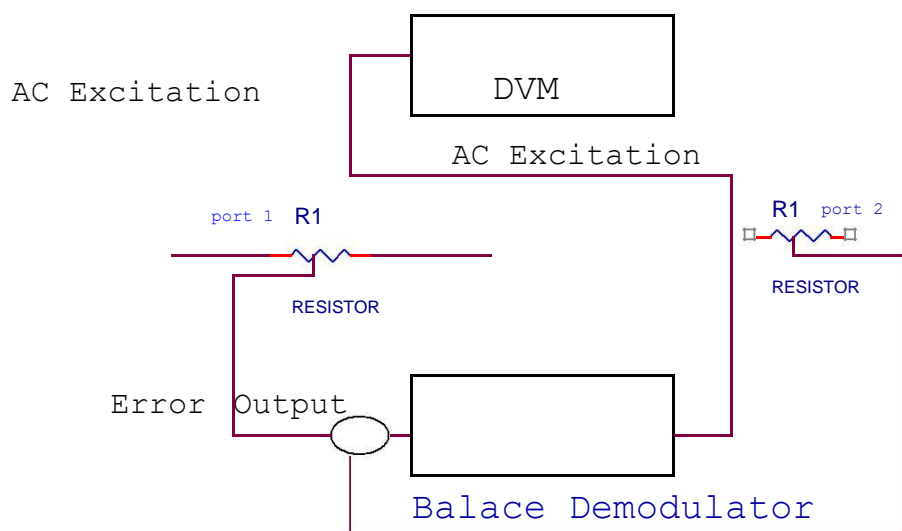
AIM : To study characteristics of positional error detector by angular displacement of two servo potentiometers.

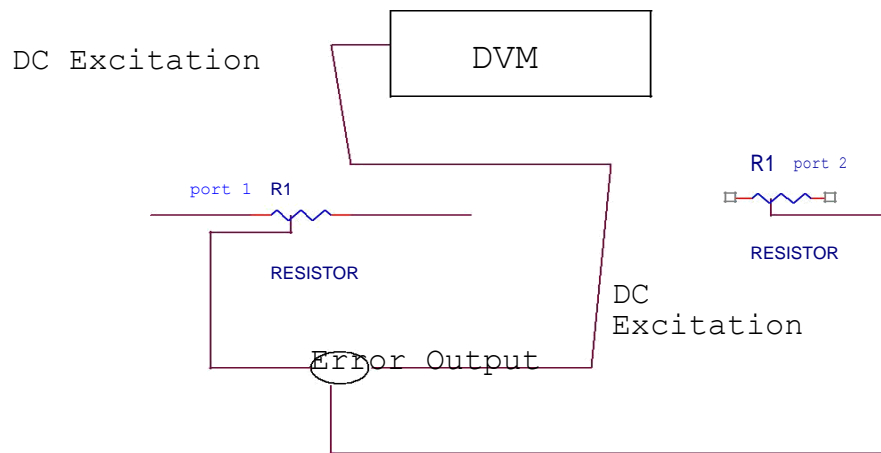
APPARATUS: Potentiometer kit,Dual trace CRO and connecting leads

THEORY:

Potentiometric transducers are used in control applications. The set-up has built –in source of +5V dc and about 2Vpp 400Hz AC output. A DVM is provided to read dc voltage and AC can be read on CRO. The potentiometers are electromechanical devices which contain resistance and a wiper arrangement for variation in resistance due to displacement. The potentiometers have three terminals. The reference DC or AC voltage is given at the fixed terminals and variable is taken from wiper terminals.

CIRCUIT DIAGRAM :





PROCEDURE :

1. Connect the power and select the excitation switch to DC. Keep Pot.1 to center =180°. Connect DVM to error output. Turn Pot.2 from 20° to 340° in regular steps. Note displacement in $0^\circ = \theta_2$ and output voltage E as V_0 . Plot graph between V_0 and $\theta_e = \theta_1 - \theta_2$.
2. Switch ON the power and select excitation switch to AC. Connect one of CRO input with carrier output socket and ground. Connect other input of CRO with error output socket. Keep pot.1 fixed at 180° and move pot.2 from 20° to 340°. Note displacement in θ° and Demodulator voltage V_{DM} . Plot graph between displacement and demodulator voltage.

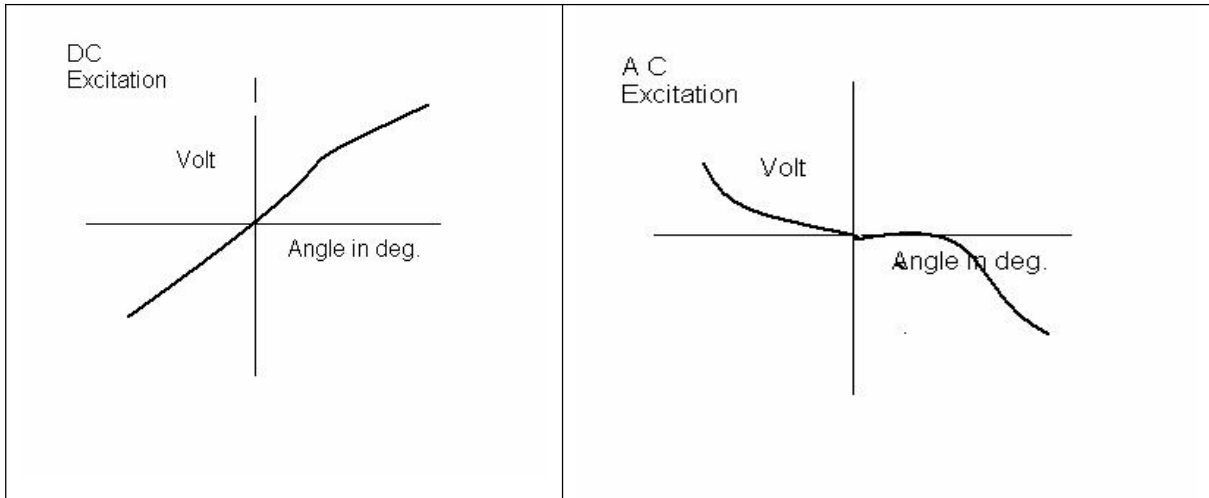
OBSERVATION TABLE :

Sl.No.	Pot.2 position in θ°	$\theta_e = \theta_1 - \theta_2$	Output Voltage = V_0

Sl.No.	Pot.2 position in θ°	$\theta_e = \theta_1 - \theta_2$	Output Voltage = V_0

- PRECAUTIONS** :1.Select the excitation switch as required, AC or DC. Wrong selection may cause error in experiment or damage the setup.
 2.Take the reading carefully.
 3.Switch OFF the setup when not in use.

GRAPH:-



DISCUSSION:-

The graph is plotted between displacement angle and output voltage. For DC Excitation the output voltage increases linearly with positive displacement angle and decreases with negative displacement angle. but for AC excitation it is reverse. The output voltage increases with negative displacement and decreases with positive displacement angle.

QUESTIONS:-

Q.1. What are potentiometers?

A. Potentiometers are electromechanical devices containing resistance and wiper arrangement for variation in resistance due to displacement .

Q.2. What is use of potentiometric error detector?

A. The potentiometric error detectors are used to compare the reference and feedback signal and detect the error.

Q.3. What is error signal?

A. The angular displacement between reference signal and feedback signal is called error signal .

Q.4. What is effective range of potentiometer ?

A. The effective range of potentiometer is approximately 270 degrees.

Q.5. What is balanced demodulator ?

A. The balanced demodulator is provided to produce phase sensitive DC Signal when potentiometers are fed with AC signal .

Q.6. How many terminals are there in potentiometers ?

A. There are three terminals in potentiometers, two are fixed and one is Variable.

Q.7. Where reference voltage is applied ?

A. Reference voltage is applied at fixed terminals .

Q.8. From where the variable output is taken ?

A. The variable output is taken from wiper terminals .

Q.9. What is linearity ?

A. Linearity is defined as the maximum deviation of output from ideal Voltage .

Q.10. What is instrumentation amplifier ?

A. The instrumentation amplifier is a high impedance differential amplifier Having nity gain .

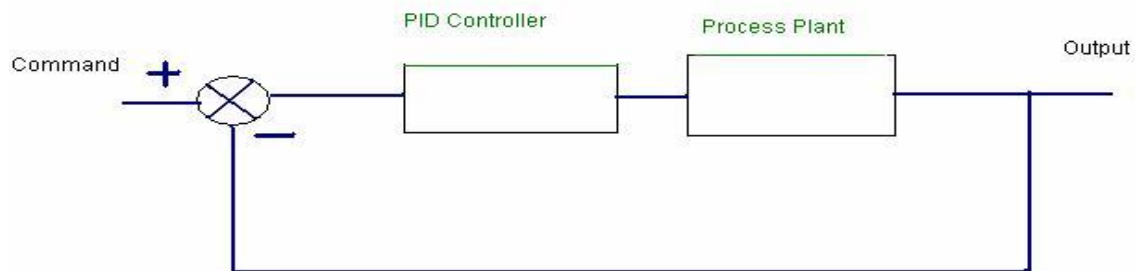
EXPERIMENT: - 7

AIM:- To study performance of PID controller with model as temperature control system.

APPARATUS:- PID control kit and stop watch. process as temperature control system.

THEORY:- - The set up has built in signal source as reference, DVM as temperature indicator; PID controller and DC supply to operate the system. The set has three controls, P for proportional gain, I for integrated gain, and D for derivative gain. A separate oven with fan is provided to raise the temperature.

CIRCUIT DIAGRAM:-



PROCEDURE:- The experiment is completed in four parts.

1. TO OBSERVE PROCESS CHARACTERISTICS: - Connect the oven and switch on the power. Select temperature switch to oven and note the temperature. Now select the temperature switch to S.P. adjust temperature to 20°C. again select temperature switch to oven, switch on the heater and start the stop watch. Note the temperature at intervals of 5, 10,20,30,40 seconds till the temperature is stable. Plot the curve between temperature and time.
2. TO OBSERVE SIGNAL CONDITIONAL CHARACTERISTICS:- Connect the Circuit as before and set the temp. about 10° C. Connect the DVM across ground 0And signal conditional socket. Select temp. switch to oven and note the temp. and voltage at error detector point. Switch on heater and note error detector negative side input voltage.

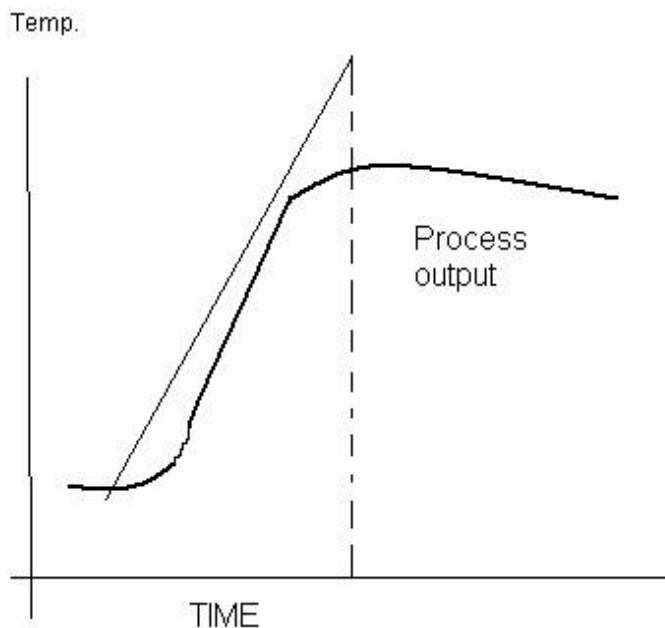
- 3 P. CONTROL:-Connect the set as before and set temp. to 60°C and P control Kp To 10. switch on the heater and note temp. at 10 sec. interval. Switch off the heater and allow it to cool with the help of fan. Now adjust Kp to 16. Switch on the heater and repeat the experiment. Plot graph between temp. and time.
- 4 PI CONTROL:- Set temp. to 60°C . Select oven temp. at display reading. Switch On the heater and stop watch. Note the temp. at 10 sec. interval. Plot graph between time and temp.
- 5 PID CONTROL:- Set temp. at 60°C select oven temp. at display reading. Switch on heater and stop watch. Note temp. at 10 sec. interval . plot response curve from results obtained from the experiment. Find out set temp. percentage from graph
as: $T(\text{set}) - T(\text{ovan}) / T(\text{set}) * 100$.

OBSERVATION TABLE:-

S. NO.	TIME(sec.)	TEMPRETURE (· C)

- PRECAUTIONS:-**
- 1 Do not switch on the heater for long time.
 - 2 Allow the heater to cool before next experiment.
 - 3 Take the reading carefully.
 - 4 Switch off the kit when not in use.

GRAPH:-



DISCUSSION:-

The graph is plotted between time and temperature. The temperature increases with time upto a certain limit and then becomes steady. This temperature graph is used to find out steady state error (E_{ss}) the rise in temperature depends upon feedback gain. More the feedback gain less the steady state error but it does not become zero.

QUESTIONS :-

- Q.1. What is full form of PID ?
A. P stands for proportional, I stands for integrated and D stands for Derivative gain.
- Q.2. What is derivative error compensation ?
A. A system is said to have derivative error compensation when the generation of its output depends in some way on its rate of change of actuating signal.
- Q.3. What is integral error compensation?
A. A system is said to have integral error compensation if its output Response depends in some way upon the integral of its actuating Signal.
- Q.4. What is effect of integral error compensation on the system ?
A. Integral error compensation changes a second order system to a Third order system.
- Q.5. How derivative error compensation is obtained ?
A. Derivative error compensation is obtained by using an amplifier Which provides a signal having two terms, one proportional to To derivative of actuating signal and other proportional to the actuating Signal itself.
- Q.6. How integrating error compensation is obtained?
A. Integrating error compensation is obtained by introducing a controller Which contains two terms, one is proportional to the integration of Actuating- signal and other proportional to actuating signal itself.
- Q.7. Where PID is used?
A. PID is used in process industries for feedback gain.
- Q.8. If dynamic model is not known then PID is tuned experimentally by Simulation.
- Q.9. How PID is tuned if dynamic model is known?
A. If dynamic model is known then PID is tuned by Ziegler-Nicholas Method.
- Q.10. What time response specifications are required to be met by the control System?
A. Three time response specifications are to be met by the control system, Steady- state accuracy, damping factor and settling time.

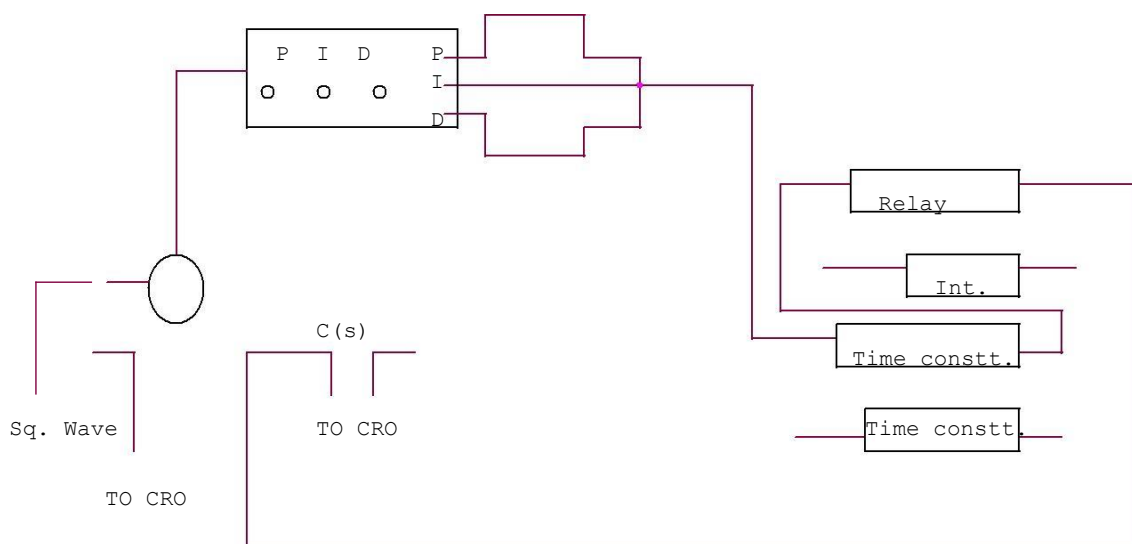
EXPERIMENT:- 8

AIM:- To study PID controller for level control of a plant.

APPARATUS REQUIRED: PID controller setup, CRO and connecting leads.

THEORY:- The setup is designed to study performance of analog PID controller with regulated system. The board has built in signal source, DVM, simulated process and three adjustable parameters as P, I for proportional gain, I for integrated gain and D for derivative gain. Three sockets are given to add or out any parameter PI & D. There are two signal sources of square wave which is adjustable in frequency (10-40 Hz) and amplitude (0-2 Vpp) and other signal source in shape of triangular wave to sweep CRO in X-direction. One DC voltage output which is continuously variable between -2V and +2V.

CIRCUIT DIAGRAM:-



PROCEDURE : P control mode: connect the circuit as shown in the figure. Switch over CRO for XY mode. Adjust P control to 0.1 and note the X and Y values. Increase the value of P and note the results in table. Input 1.0 Vpp, square wave of 50ms. I not connected to adder and D control at 00. switch over CRO in trigger mode and find out period of oscillation. Switch over again in XY mode and find out percentage over shoot and steady state error

PI control mode : connect the circuit as shown in figure set K_p =reading of dial. $K_d=00$. input signal of square wave amplitude = 1Vpp at 20 Hz. Switch over CRO in XY mode. Increase I in steps and note the reading . find the result of K_i for 10-15 % over shoot with minimum E_{ss} .

PID control mode : connect the circuit as shown in figure. Input =1Vpp square wave of same frequency adjust K_p and K_i as table 1 and 2 . increase K_d in steps and note the Ypp and Xpp output from CRO. The equation of PID controller is

$$M(t) = K_p e(t) + K_i \int e(t) dt + K_d \frac{de}{dt}$$

OBSERVATION TABLE :

S NO.	Kp	Xpp	Ypp	OSPP	ESSPP

PRECAUTIONS:

1. Do not keep CRO in XY mode for long time.
2. Take the reading carefully and accurately.
3. Apply the required signal to the kit to avoid error.
4. Switch off the kit when not in use.

DISCUSSION:- In open loop response the plots are performed between Magnitude/frequency and phase/frequency. The upper curve is for gain/ Frequency raised to 9.35 db. The middle curve is for frequency and the Lower curve is for phase. This shift in gain-cross over frequency and phase Margin is due to applied gain KA.

QUESTIONS :-

Q.1. What for compensation networks are used?

A. Compensation networks are used to make appreciable improvement in Transient response and small change in steady- state accuracy.

Q.2. What are the types of compensation networks?

A. There are three types of compensation networks, LEAD, LAG and LEAD-LAG Compensation network.

Q.3. What is the use of all pass filter?

A. The all pass filter is used to observe phase/frequency response.

Q.4. What is use of inverting amplifier?

A. The inverting amplifier is used to invert the phase oh feed back signal. It has gain $K=-1$

Q.5. What are the responses of compensation network?

A. Compensation network has two responses, open loop response and Close loop response.

Q.6. What is use of LEAD compensation?

A. LEAD compensation is used to improve the phase margin to any desired Value for a specified error constant.

Q.7. What is the use effect of LEAD compensation on the system?

A. It increases the bandwidth and makes the speed response faster.

Q.8. What is the effect of LAG compensator on the system?

A. It reduces the bandwidth and slows down the speed response.

Q.9. What is use of LAG compensation?

A. LAG compensation is used for high order system with large error Constant and large bandwidth.

Q.10. What is process or plant?

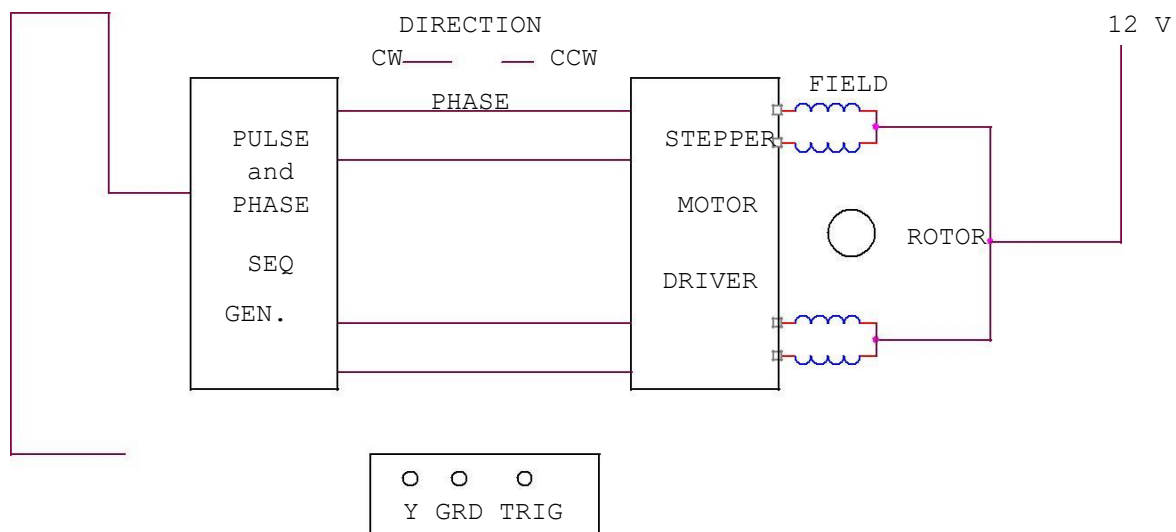
A. It consists of an active network simulation of second order system. Its transfer function is $K/(St+1)$.

EXPERIMENT NO. 9

AIM:- To study the stepper motor and to execute microprocessor computer based control of the same by changing number of steps, the direction of rotation and speed.

APPARATUS USED:- Stepper Motor Kit, μ P Kit, Interface Cord and Connecting Leads.

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 μ P 8085 kit. The stepper motor controller card remains active while the pulse sequence generator disabled as given plug is connected with μ p interface socket. Following programme enables the stepper motor to run with μ p 8085 kit. For two phase four winding stepper motor only four LSB signals are required.

CIRCUIT DIAGRAM:-

PROCEDURE:- Connect the stepper motor with μ p 8085 kit as shown in fig. press EXMEM key to enter the address as given then press NEXT to enter data.

<u>ADDRESS</u>	<u>DATA</u>
2000	3E 80 MVI A,80 Initialize port A as output port.
2002	D3 03 OUT 03 OB
2004	3E F9 Start MVI AFA
2006	D3 00 OUT 00 Output code for step o.
2008	CD 3020 call delay delay between two steps.
200B	3E F5 MVI A, F6 Location reserve for current Delay.
200d	D3 00 OUT 00 Output code for step 1.
200F	CD 3020 Call delay delay between two steps.
2012	3E F6 MVI A, F5
2014	D3 00 OUT 00 Output code for step 2.
2016	CD 3020 calls delay between two steps.
2019	3E FA MVI A, F9.
201B	D3 00 OUT 00 Output code for step 3.
201D	CD 3020 call delay delay between two steps.
2020	C3 04 20 JMP START Start.

Press FILL key to store data in memory area. This will complete the pulse sequence generation. To delay programme route, first press EXMEM to start, a dot sign will appear in address field then enter the start address. Press NEXT to enter data.

<u>ADDRESS</u>	<u>DATA</u>
2030	11 00 00 LXI D 00 00 Generates a delay.
2033	CD BC 03 CALL DELAY
2036	11 00 00 LXI D 00 00 Generates a delay.
2039	CD BC 03 CALL DELAY
203C	C9 RET

Press FILL to save data.to execute the programme press the key GO .The above programme is to rotate the motor at a particular as defined by the given address. Changing the following contents will change the motor speed.

<u>ADDRESS</u>	<u>DATA</u>
2030	11 00 20 AND 2036 TO SIMILAR 11 00 20
CHANGE	11 00 10 TO 11 00 10
CHANGE	11 00 05 TO 11 00 05
CHANGE	11 00 03 TO 11 00 03.

The motor direction depends upon codes FA, F6 ,F5 AND F9.Change in following codes will change the motor direction.

ADDRESS	DATA		
2005	3E F9	TO	3E FA
200C	3E F5	TO	3E F6
2012	3E F6	TO	3E F5
2019	3E FA	TO	3E F9.

OBSERVATION TABLE:-

Sr No.	No. of Pulses	Displacement	Step Angle

RESULT:- The stepper motor runs as per fed programme.

PRECAUTION:-

1. Make the connection of motor with μ p kit properly.
2. Feed the programme carefully and correctly.
3. Do not change the motor direction at high speed.

QUESTIONS:-

- Q.1. Why the application of stepper motor is increasing?
 A. The use of stepper motor is increasing due to availability in large power rating and reducing cost.
- Q.2. What is stable condition of rotor in stepper motor ?
 A. It is that angle at which torque is zero and is positive for smaller angle and negative for larger angle.
- Q.3. What are the modes of operation of stepper motor?
 A. There are two modes of operation of stepper motor, open loop and close loop mode.
- Q.4. What are the types of stepper motor?
 A. There are three types of stepper motors, VR stepper motor, PM stepper motor and hybrid stepper motor.
- Q.5. How the windings of stepper motor are wound?
 A. The windings of stepper motor are wound in such a way that

- there are only two phases.
- Q.6. How many logics are there in each sequence?
A. There are two logics in each sequence, 0 and 1.
- Q.7. In how many phases does the motor run?
A. the stepper motor runs in four phases, A,AB, B and AB.
- Q.8. Why the stepper motor is run in four phases?
A. The stepper motor is run in four phases to avoid over stepping and to improve the response
- Q.9. On what factor does the settling time of stepper motor depend?
A. The settling time of stepper motor depends upon loading and input sequence.
- Q.10 What is use of μ p kit?
A. The μ p kit is used to run the stepper motor as per the fed programme.

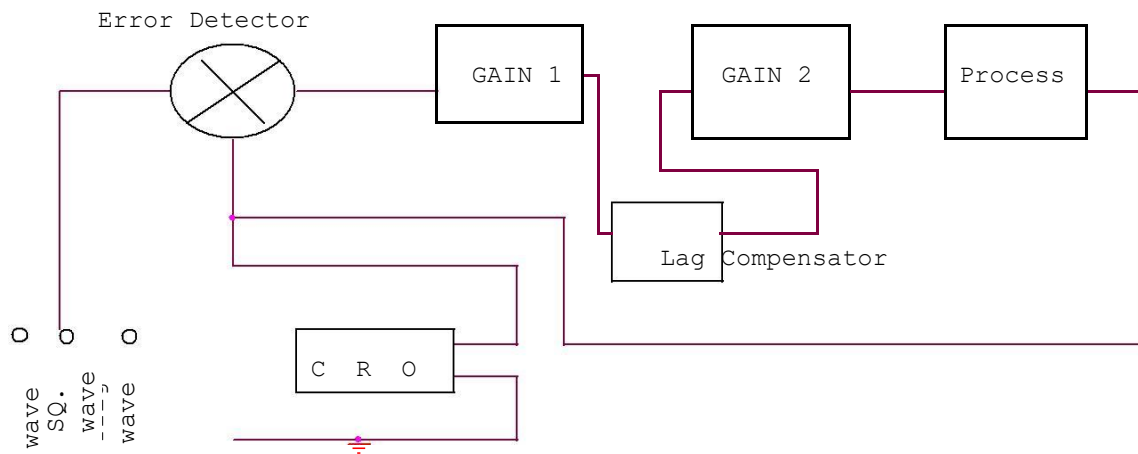
EXPERIMENT NO. 10

AIM: to study LAG compensator and draw its magnitude and phase plot.

APPARATUS REQUIRED: lead lag compensator kit, CRO, and connecting leads.

THEORY: compensation networks are often used to make improvement in transient response and small change in steady state accuracy. The set up is divided into three parts. Signal source: It has sine wave of 10-1200 Hz. Of 0-8 V_{pp}, Square wave of 20, 40 and 80 Hz of 0-2 V_{pp}. Trigger is available for trigger of CRO in external trigger mode. The amplitude is 1.2 V_{pp}. There are three compensation circuits as lag, Lead and Lag-Lead with transfer function. The set up has two DC regulated power supply for signal source and systems.

CIRCUIT DIAGRAM

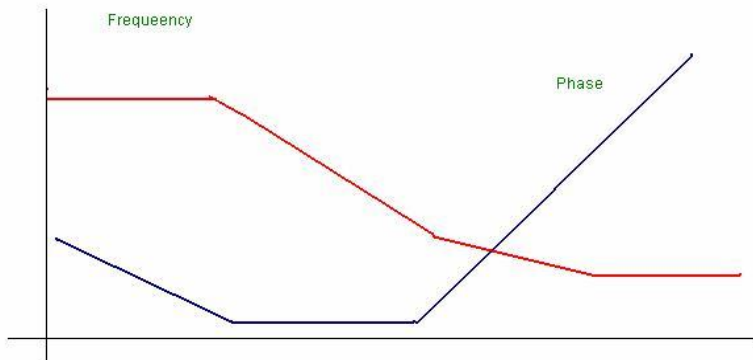


PROCEDURE: The experiment is divided in two parts.

1. Open Loop Response: Connect square wave to gain and CRO across input and output. Select frequency to 80 Hz at 0.2 Vpp. Measure input amplitude Vpp as A and output as amplitude as B. Calculate gain factor= B/A . Connect sine wave with process input, CRO across input and output. Set input voltage =8Vpp. From low frequency end 10Hz note output voltage Vpp as B. Note the phase difference for each test frequency. Connect the sine wave with lag input .connect CRO across input and output. Note the output voltage, phase difference for each test frequency. Prepare a table between input/output voltage, gain magnitude in db and phase angle in degrees. Plot a graph accordingly.
2. Close loop response: connect the square wave signal of 20Hz, 1Vpp at input of error detector. Adjust gain to the value found from plot for required shape of response and sketch it 0 the paper. From the transient response measure maximum over shoot Mp, steady state error Ess and peak time Tp. Select wave frequency to 40Hz, 1Vpp and adjust gain control to 60%. Not gain control setting. Trace wave form on paper with record of Ess, Mp, and Tp. Select frequency to 80Hz and adjust gain control for minimum Ess 0. Trace wave form with Mp and Tp. connect process with lag compensator and gain 2. Set square wave frequency to 20Hz, 1Vpp at error detector input . Adjunct gain control to for similar Ess. Note gain to from dial setting. Trace the wave form on paper with record of Mp, Tp and Ess.

OBSERVATION TABLE :

S.NO.	A Vpp	B Vpp	GAIN dB	PHASE ANGLE

GRAPH:**QUESTIONS :**

Q.1. What is the use of adder at the input of PID controller?

A. Adder is used to sum up the reference signal and feed Back signal.

Q.2. What is the use of time delay?

A. Time delay generates a delay of 1.3 seconds between input And output.

Q.3. What is uncommitted amplifier?

A. It is an operational amplifier configured as phase inverter. Its gain constant is= -1.

Q.4. What is the range of frequency and amplitude of square wave Source?

A. The range of frequency is from 10 to 40 hz and amplitude is From 0 to 2 Vpp.

Q.5. What is range of voltage source?

A. The range of voltage source is from -2 to +2 v.

Q.6. What is equation of PID controller?

A. The equation of PID controller is

$$m(t) = K_p e(t) + K_i \int e(t) dt + K_d \frac{de(t)}{dt}$$

Q.7. What is the transfer function of PID controller?

A. The transfer function of PID is $G(\text{PID}) = \frac{m(s)}{E(s)}$.

Q.8. What are the methods of tuning PID?

A. There are two methods of tuning PID, process reaction curve method and continuous cycling method.

Q.9. What is the main advantage of derivative error compensation?

A. Main advantage of this compensation is that as the damping increases due to compensation , system settling time reduces.

Q.10. How derivative output compensation is obtained?

A. Derivative output compensation is obtained by means of a Tachometer feedback.