CONTROL SYSTEM LAB

(EE-307-G)

LAB MANUAL

V SEMESTER

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Control Systems Laboratory

Theory : 25
Class Work: 25
Total : 50

Course Code	LC-EE-307G		
Category	Program Core Course		
Course title	Control Systems Laboratory		
Scheme	**L**	**T**	**P**
	-	**-**	**02**

Notes:

(i) At least 10 experiments are to be performed by students in the semester.
(ii) At least 7 experiments should be performed from the list, remaining three experiments may either be performed from the above list or designed and set by the concerned institution as per the scope of the syllabus.
(iii) Group of students for practical should be 15 to 20 in number.

LIST OF EXPERIMENTS: ANY SIX EXPERIEMENTS

1. To study speed Torque characteristics of
   a) A.C. servo motor b) DC servo motor.
2. (a) To demonstrate simple motor driven closed loop DC position control system.
   (b) To study and demonstrate simple closed loop speed control system.
3. To study the lead, lag, lead-lag compensators and to draw their magnitude and phase plots.
4. To study a stepper motor & to execute microprocessor or computer-based control of the same by changing number of steps, direction of rotation & speed.
5. To implement a PID controller for temperature control of a pilot plant.
6. To study behavior of 1^{st} order, 2^{nd} order type 0, type 1 system.
7. To study control action of light control device.
8. To study water level control using a industrial PLC.
9. To study motion control of a conveyor belt using a industrial PLC

Software Based (ANY FOUR EXPT.)

10. Introduction to software (Control System Toolbox), Implement at least any
    - Different Toolboxes in software, Introduction to Control Systems Toolbox.
    - Determine transpose, inverse values of given matrix.
    - Plot the pole-zero configuration in s-plane for the given transfer function. Plot unitstep response of given transfer function and find peak overshoot, peak time.
    - Plot unit step response and to find rise time and delay time.
    - Plot locus of given transfer function, locate closed loop poles for different values of k.
    - Plot root locus of given transfer function and to find out S, Wd, Wn at given root & to discuss stability.

Plot bode plot of given transfer function and find gain and phase margins Plot the Nyquist plot for given transfer function and to discuss closed loop stability, gain andphase margin.

CONTROL SYSTEM

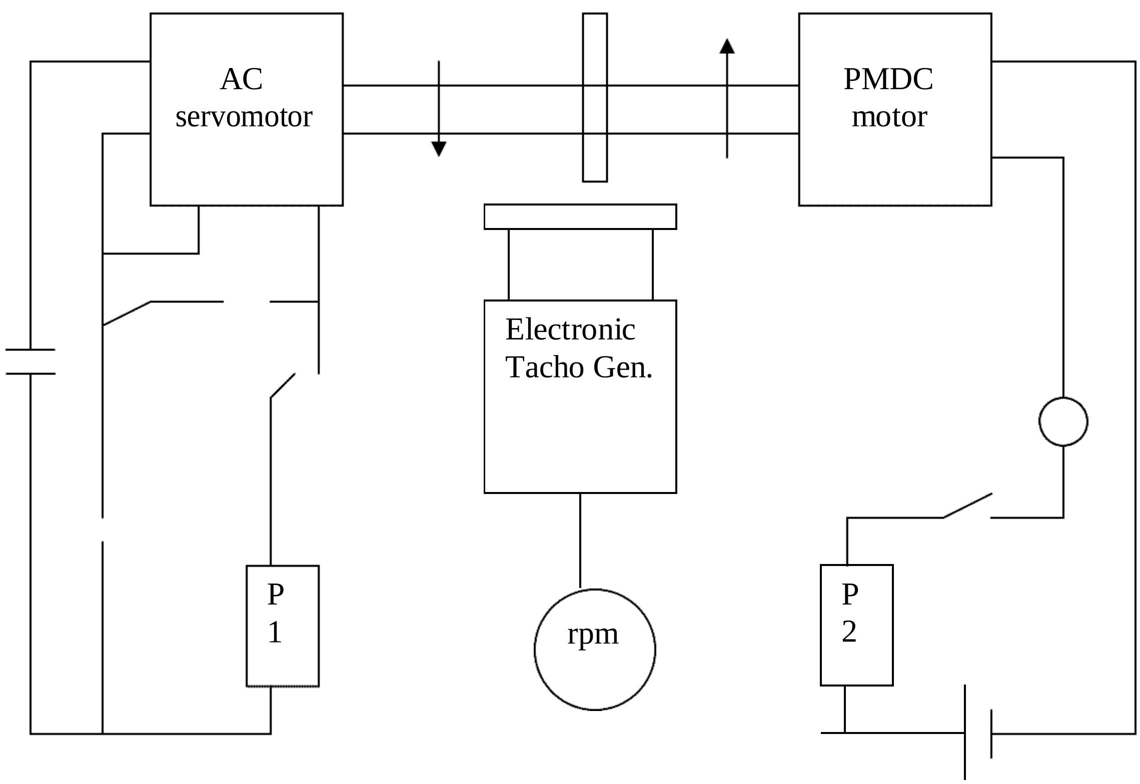
EXPERIMENT NO: 1(a)

AIM: - To study AC servo motor and note it 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 energised 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 **O**N the power supply, switches ON S1. Slowly increase control P1 so that AC servomotor starts rotating. Connect DVM across DC motor sockets (red & black). Very 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 socked (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=Ia*Eb and Torque=P*1.019*$10^4$60/2.2.14Ngm/cm

<u>OBSERVATION TABLE</u>:-

TABLE-1

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

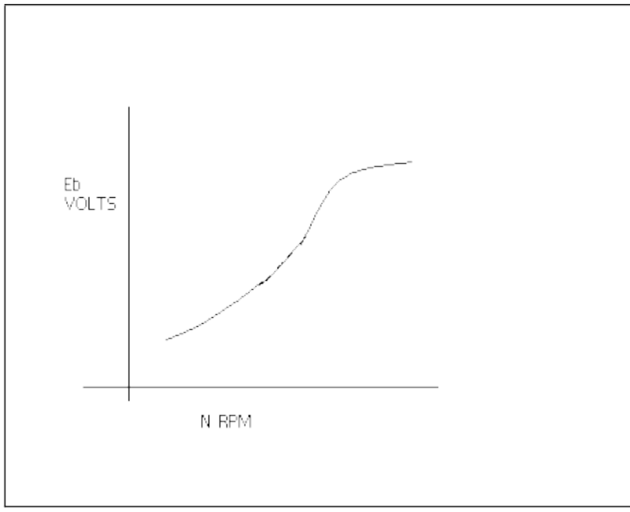
TABLE-2

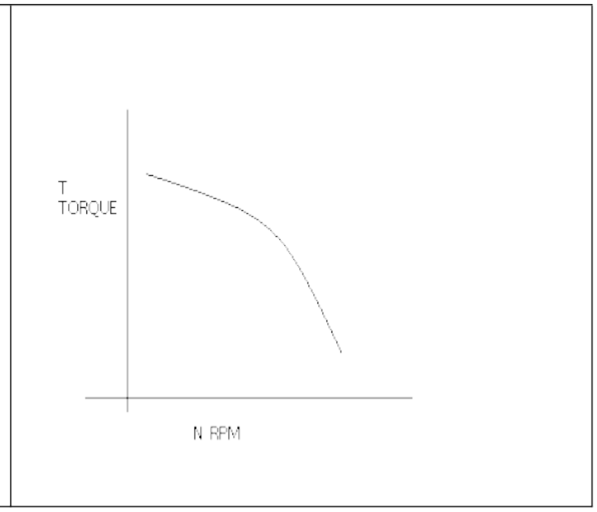
S.NO	Ia amp	Eb (Tab 1)	Speed N rpm	P watt	Torque
1.					
2.					
3.					
4.					

<u>PRECAUTIONS</u>: -

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 note in use.

<u>GRAPH</u>:-





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 .

EXPERIMENT NO: 1(b)

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

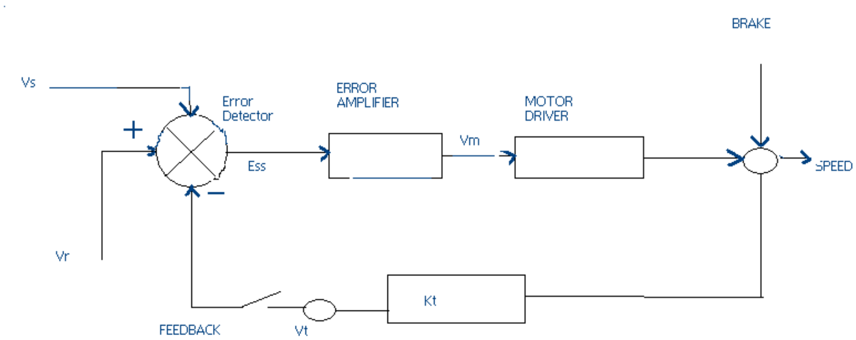
APPARATUS:- DC SERVO MOTOR KIT AND DVM.

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 Vr = 0.7 or 0.8. Connect DVM with feedback signal socket Vt. Note the speed N rpm from display and tacho output Vt in volts from DVM. Record N rpm and Vt volts for successive gain 4-10 in observation table. Calculate Vm = Vr * Ka. Where Ka is the gain set from control 3 – 10.

Vr = 0.7 V.

Vm at gain 3 = 0.7 * 3

= 2.1 V.

Plot N vs Vt and **N Vs Vm** graph.

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

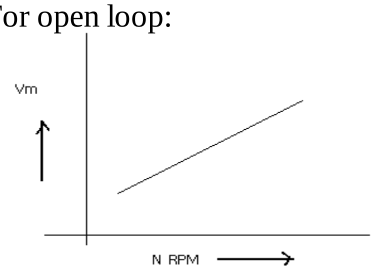
<u>OBSERVATION TABLE</u>:-

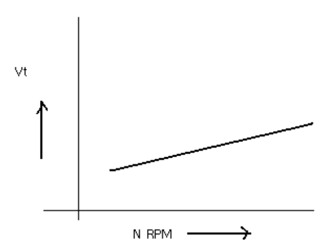
S.NO.	GAIN(Ka)	Vt (volts)	N(rpm)	Vm=Vr×Ka

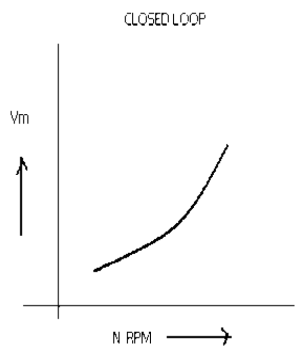
<u>PRECAUTIONS</u>:-1. Apply the voltage slowly to start the motor
2. Take the reading properly.
3. Do not apply breaks for long time as the coil may get heated up.
4. Switch OFF the main power when not in use.

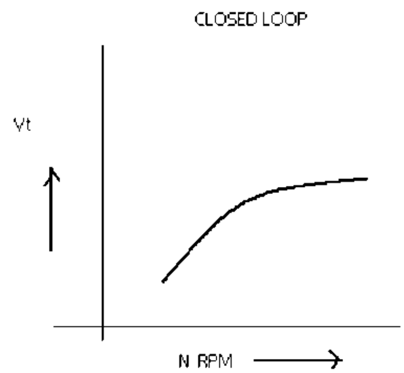
<u>GRAPH:-</u>

For open loop:









DISCUSSION:-

The graph is plotted between N (RPM) and Vt (techo voltage) and N(rpm) & Vm (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 and this is due to the feed back gain.

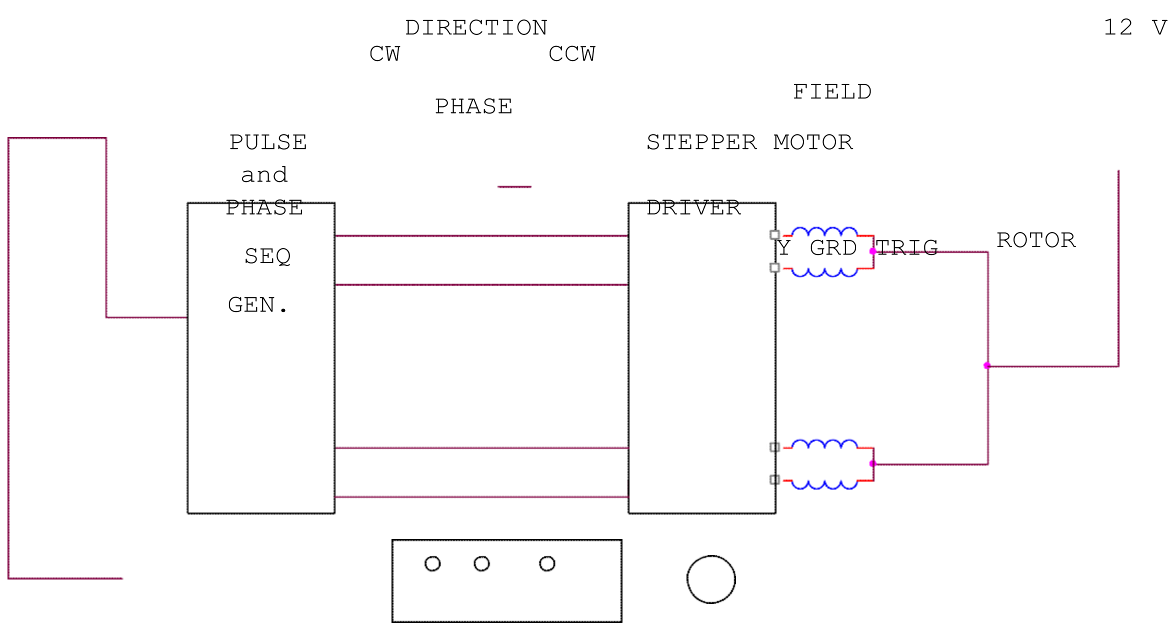
EXPERIMENT – 2

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, µP 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 µP 8085 kit. The stepper motor controller card remains active while the pulse sequence generator disabled as given plug is connected with µp interface socket . The following programme enables the stepper motor to run with µp 8085 kit. For two phases four winding stepper motor only four LSB signals are required.

CIRCUIT DIAGRAM:-



PROCEDURE:-

Connect the stepper motor with µp 8085 kit as shown in fig. press EXMEM key to enter the address as given then press NEXT to enter data .

ADDRESS DATA

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 OO OUT OO Output code for step
1. 200F CD 3020 Call delay delay between two steps.
2012 3E F6 MVI A, F5
2014 D3 OO OUT OO Output code for step 2. 2016
CD 3020 calls delay between two steps.
2019 3E FA MVI A, F9.
201B D3 OO OUT OO 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.

ADDRESS DATA

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 programmed 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.

ADDRESS DATA

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 µp kit properly.
2. Feed the programme carefully and correctly.
3. Do not change the motor direction at high speed.

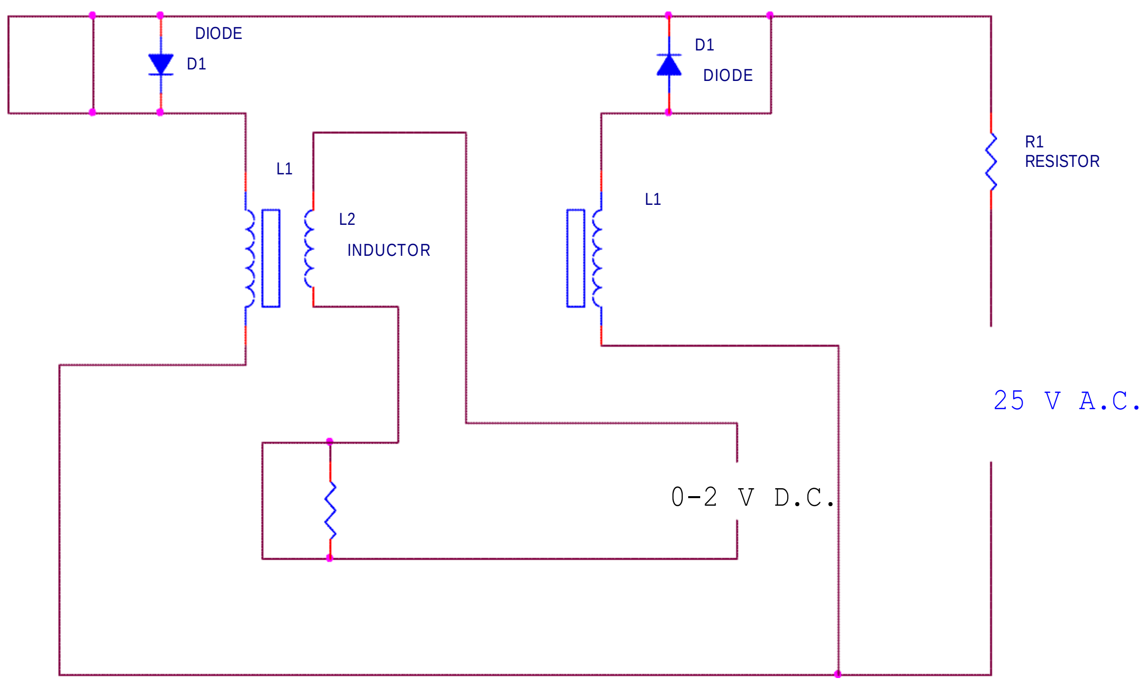
EXPERIMENT NO:3

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 multimeter & 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 amplified 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 character tics curve between IL & IC in both direction. Calculate power gain = pout/pin=ΔIL*RL/Δ IC*VC.

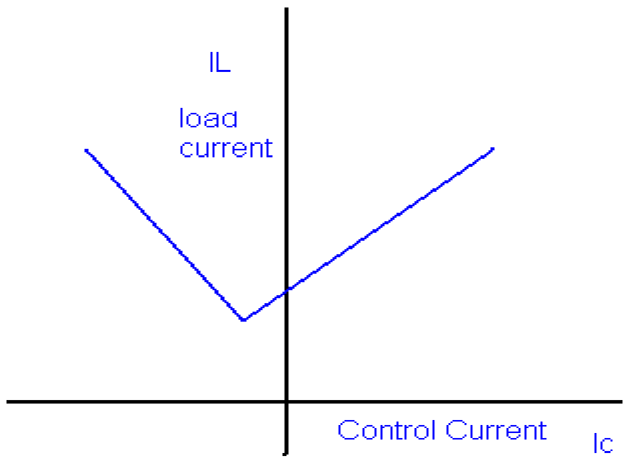
OBSERVATION TABLE:-

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(IC) and load current (IL)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.

EXPERIMENT NO-4

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

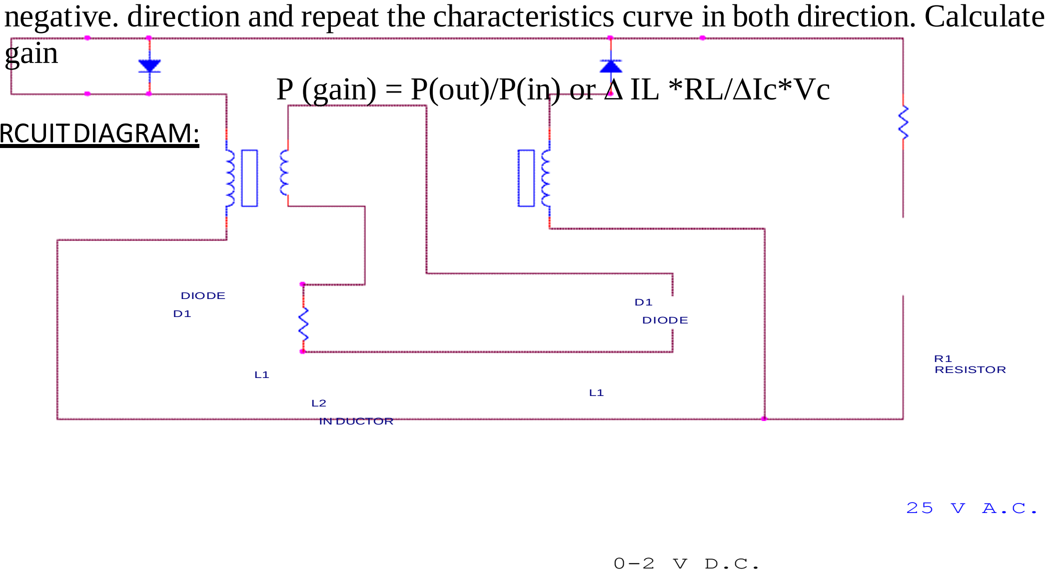
APPARATUS REQUIRED: Magnetic amplifier set up, digital multimeter and connecting leads.

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 IL, Ic and Vc in observation table. Bring DC voltage to minimum, select negative. direction and repeat the characteristics curve in both direction. Calculate power gain

$$P\ (\text{gain}) = P(\text{out})/P(\text{in}) \text{ or } \Delta IL * RL/\Delta Ic * Vc$$

CIRCUIT DIAGRAM:



OBSERVATIONTABLE

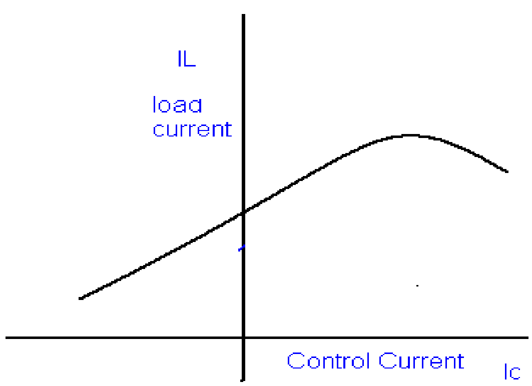
S.No	Ic(mA)	IL(mA)	Vc(+ve)
1.			
2.			
3.			
4.			

S.No	Ic(mA)	IL(mA)	Vc(-ve)
1.			
2.			
3.			
4.			
5.			

PRECAUTION :

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 .

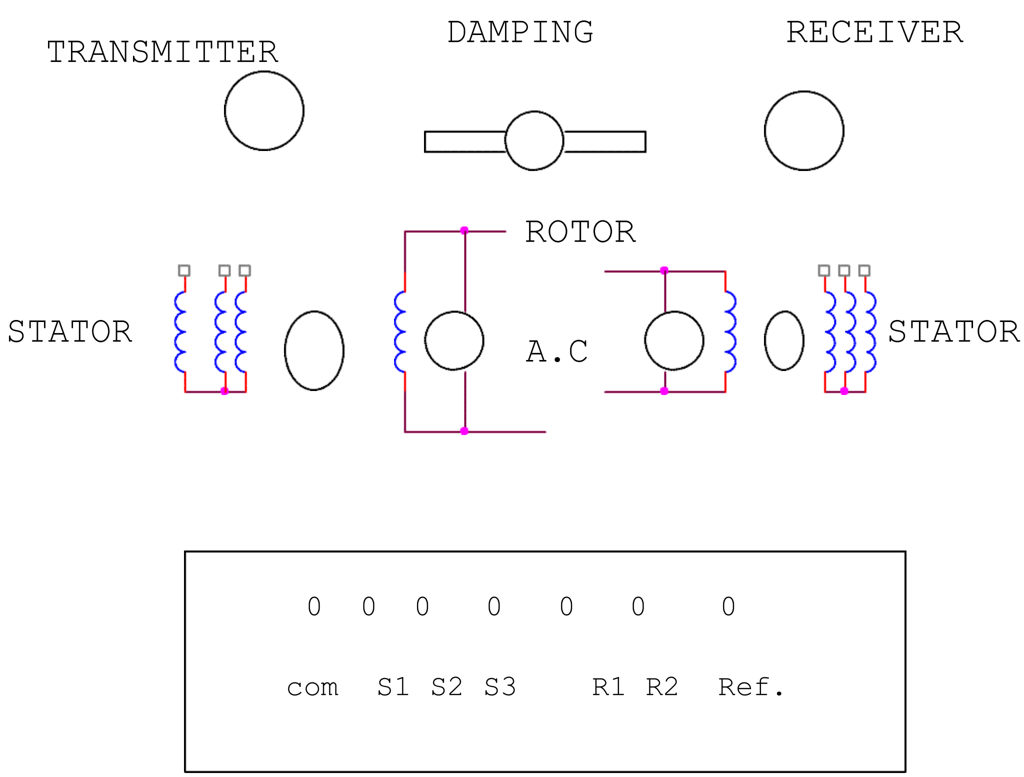
EXPERIMENT NO. 5

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 is 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 Vpp 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.

2. 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.
3. 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: -

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

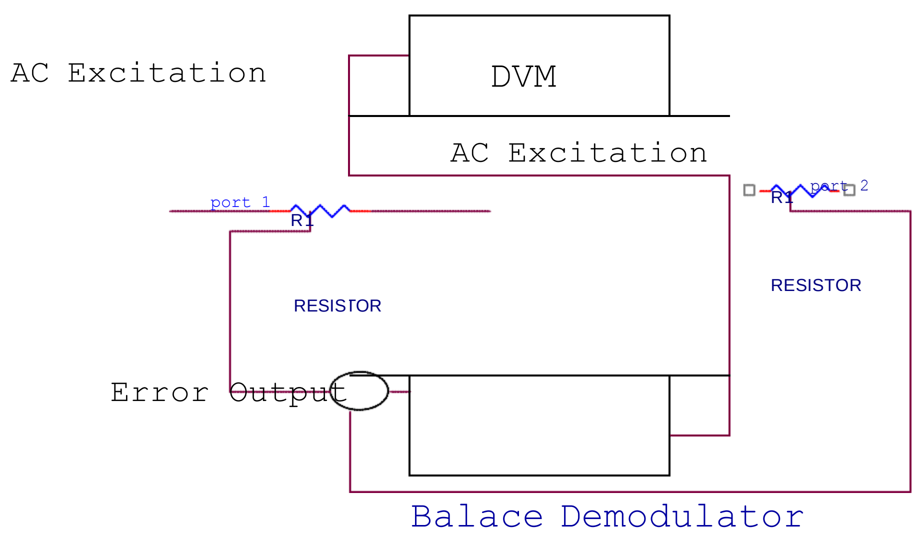
EXPERIMENT NO: 6

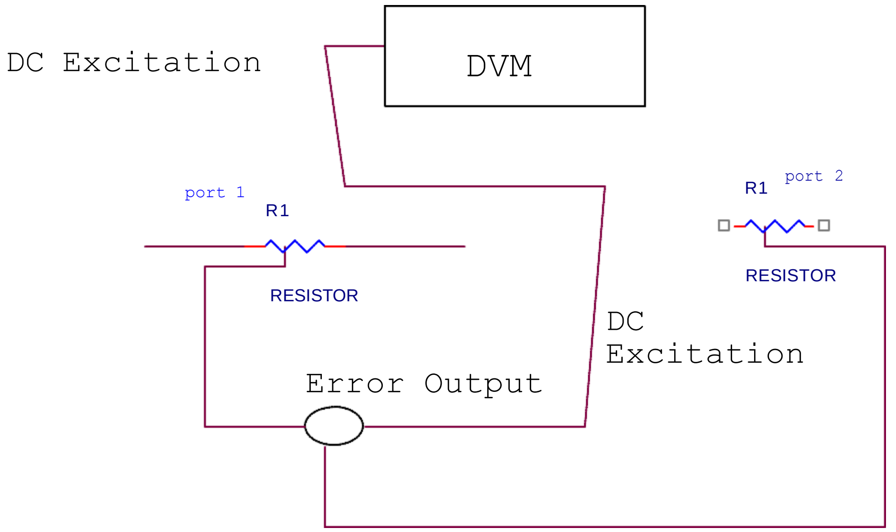
AIM: To study characteristics of positional error detector by angular displacement of two servo potentiometers.

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 electrtomechanical 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˚=θ2 and output voltage E as V_0. Plot graph between V_0 and θe= θ1- θ2.
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 at180˚ 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:

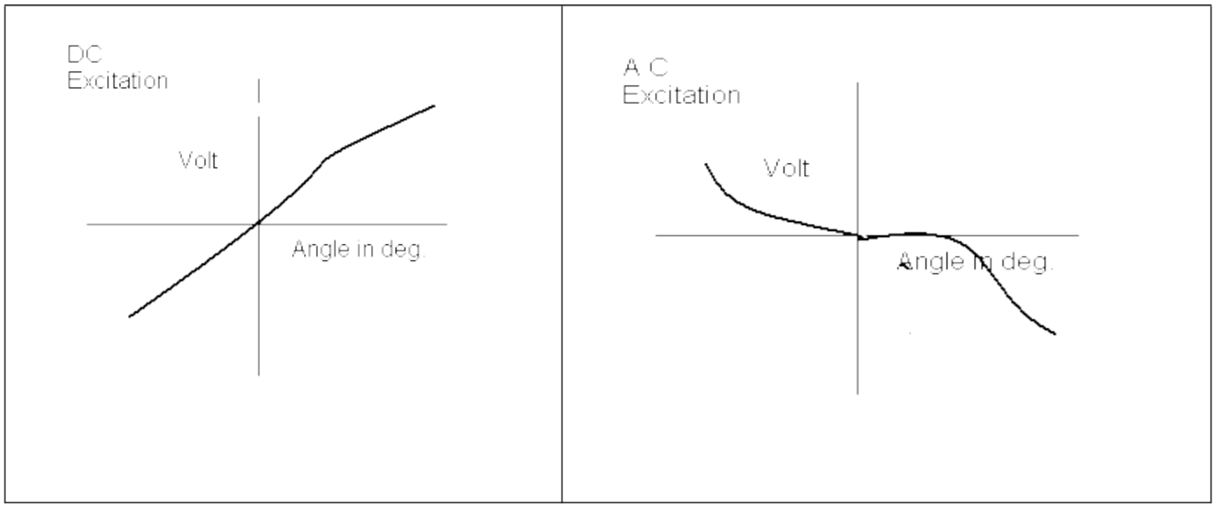
Sl.No.	**Pot.2 position in θ˚**	**θe= θ1- θ2**	**Output Voltage = V_0**

Sl.No.	**Pot.2 position in θ˚**	**θe= θ1- θ2**	**Output Voltage = V_0**

PRECAUTIONS :

1. Select the excitation switch as required, AC or DC. Wrong selection may cause error 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.

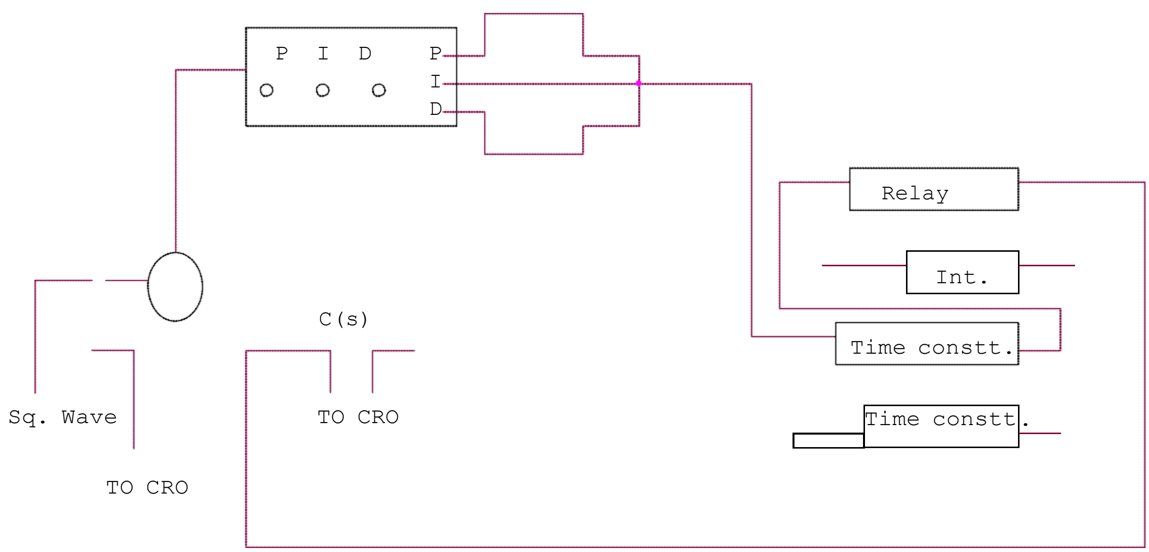
EXPERIMENT:-7

AIM:-To study PID controller for level control of a plant.
(a)To observe open loop performance of building block and calibration of PID controls
(b)To study P, PI, PID controller with type 0 system with delay
(c) To study P, PI, PID controller with type 1 system

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 thre adjustable parameters as PID,Pfor proportional gain , I for integrated gain and D for derivative gain .three socket are given to add or out any parameter PI &D .threr are two signal sources of squire 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 – 2Vand +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 , squire wave of 50ms . I not connected to adder and D control at 00. switch over CRO in tigger 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 Kp =reading of dial. Kd=00. input signal of squire wave amplitude = 1Vpp at 20 Hz. Switch over CRO in XY mode. Increase I in steps and note the reading . find the result of Ki for 10-15 % over shoot with minimum Ess .

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

$$M(t) = Kp\ e(t) + Ki\ e(t)\ dt + Kd\ de / dt$$

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.

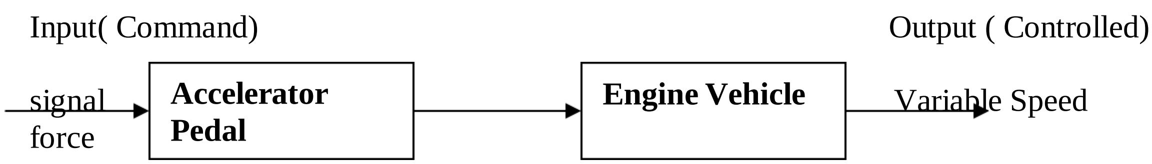
EXPERIMENT NO. 8

AIM:- To study basic open loop and close loop control systems.

Control System :-
A control system is a combination of elements intended to act together to accomplish an objective. Control systems are classified into two general categories. Open loop and closed loop control system. The distinction is determined by the control action, which is that quantity responsible for activating the system to produce the output.

Open loop control system:-
An open loop control system is one in which the control action is independent of the output. The important features of open loop control system are:-
(1) Their ability to perform accurately is determined by their calibration, which implies to establish the input-output relation to obtain a desired system accuracy.
(2) They are not generally troubled with problems of instability.

BLOCK DIAGRAM:-



Examples of open loop control system:-

1. A man working on a road with his eyes closed is an example of open loop control system. The major components in walking are the brain, the eyes and the feet. The input may be chosen as desired work direction and the output actual work direction. The control action is determined by the eyes which detect the difference between input and output and send information to brain. Since the eyes are closed therefore the system is open loop.
2. Another example of open loop control system is an electric automatic coffee maker. One possible input for coffee maker is amount of coffee used. In addition most coffee makers have a dial which can be set for weak, medium or strong coffee. This setting usually regulates a timing mechanism. There for brewing time of coffee is another possible input and the output of any coffee maker can be chosen as coffee strength.

CLOSE LOOP CONTROL SYSTEM:-

A close loop control system is one in which the control action is some how dependent of the output. Close loop control systems are commonly called feedback control system. Feedback is that characteristics of close loop control system which differentiates it from open loop. It is the property of closed loop system which permits the output to be compared with the input. So that appropriate control action maybe formed as a function of input and output.

Important features of feedback are:-

1. Reduced effects of non linearites and distortion.
2. Increased accuracy.
3. Increased bandwidth.
4. Reduced sensitivity of the ratio of output to input to variations in system characteristics.
5. Tendency towards oscillation or instability.

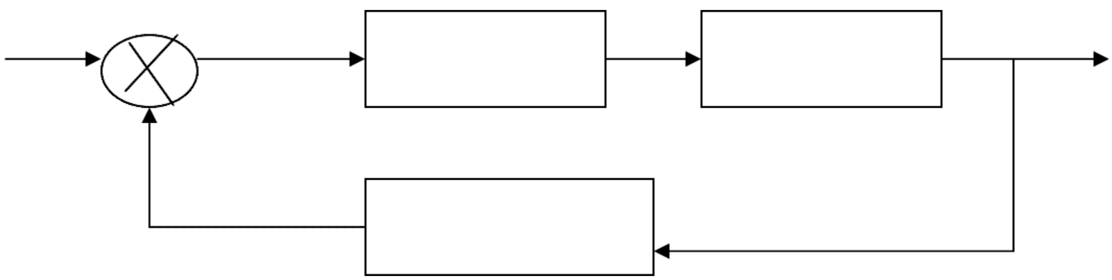
BLOCK DIAGRAM:-

Reference Input Error **Control Elements** **Plant** Controlled Output

Feedback Path Elements

Examples of closed loop control system:-

1. A man working on a road with his eyes open is an example of closed loop control system. As eyes can distinguish between the desired walk direction and actual walk direction and make the necessary correction therefore the system is closed loop.
2. Another example of closed loop control system is an automatic toaster. In which each heating element supplies same amount of heat to both sides of the bread. And toast quality can be determined by its color. The toaster is initially calibrated for a desired toast quality which needs no re-adjustment. The toaster is automatically switched off when the sensor sees the desired color with the help of feedback linkage which may be electrical or mechanical. Since the output (color of toast) is dependent on input (temperature setting) there for the system is closed loop.



EXPERIMENT NO:9

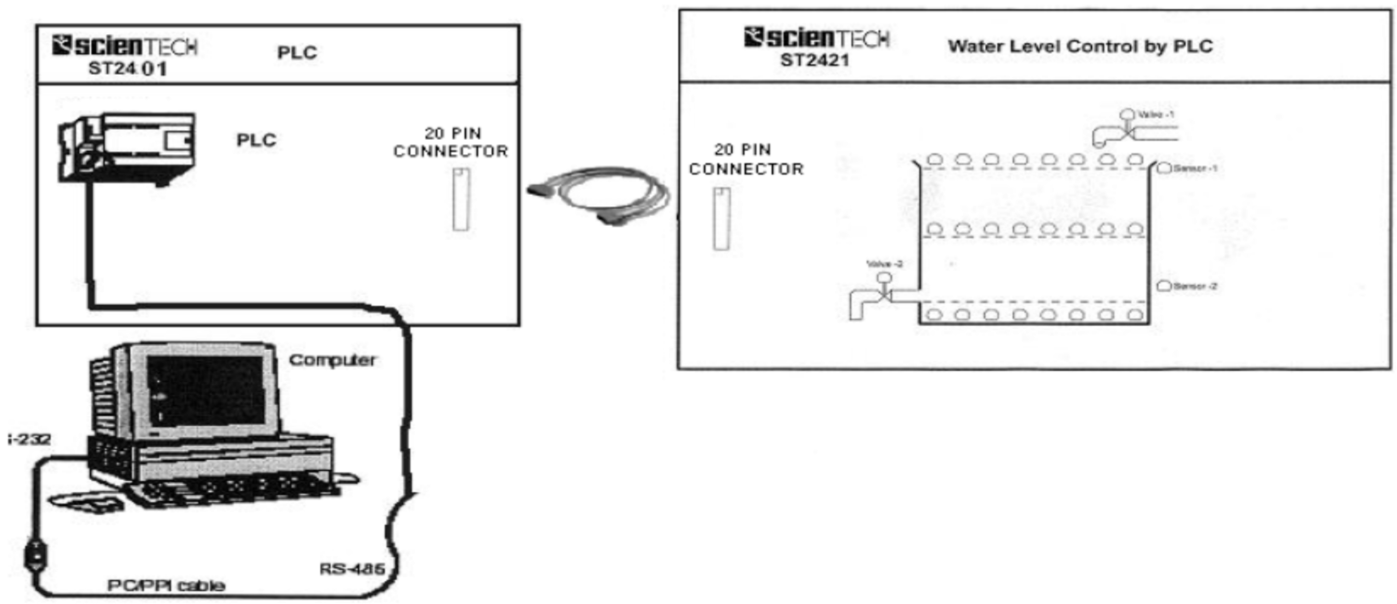
AIM: To study water level control using industrial PLC

APPARATUS REQUIRED: -Trainer kit ST2421 PLC trainer ST2401, ST2402 and connector.

THEORY:

Water level controlling is shown with the help of LEDs. The apparatus is connected with output of PLC. Two valves for filling and draining water are shown, for indicating ON\OFF condition of valve LED is used. Filling of tank indicated by two sensors, positioned to sense maximum and minimum water levels of tank.

CONNECTION DIAGRAM:-



PIN CONFIGURATION OF CONNECTOR:-

I/P - 0.0	M (GND)
I/P - 0.1	O/P -0.0
I/P - 0.2	O/P - 0.1
I/P - 0.3	O/P - 0.2
I/P - 0.4	O/P -0.3
I/P - 0.5	O/P - 0.4
I/P - 0.6	O/P -0.5
I/P - 0.7	O/P - 0.6
I/P - 1.0	O/P - 0.7
+L (V)	O/P - 1.0

PROCEDURE:

CONTROL SYSTEM LAB

1. First the valve-1 will open (LED is ON),then water level will increase (row of LEDs will glow)
2. As level reaches above sensor-1, sensor LED will glow. As water level reaches above sensor-2 valve-1 gets closed.
3. After some delay valve-2 will get ON , which will drain water. As soon as water level goes below sensor-1, valve-2 will close. And same process will go on.

Truth Table

Sensor-1	Sensor-2	Valve-1	Valve-2
OFF	OFF	ON	OFF
ON	OFF	ON	OFF
ON	ON	OFF	ON

PRECAUTIONS:-

1. Use only the mains cord designed for this instrument
2. To avoid fire or shock hazards, observe all ratings and marks on the instrument.
3. Use the fuse type and rating specified for this instrument.
4. Do not operate in wet / damp conditions.
5. Do not operate in an explosive atmosphere.
6. Keep the product dust free, clean and dry.

EXPERIMENT NO. 10

AIM: - To study motion control of a conveyor belt using a industrial PLC

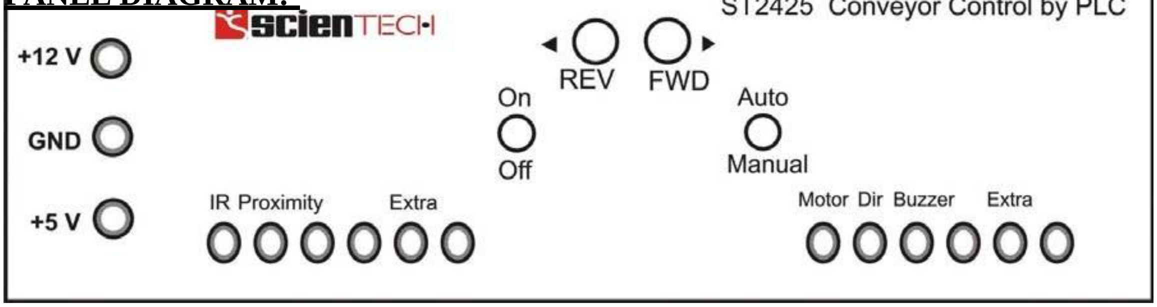
APPARATUS REQUIRED: - Trainer kit ST2425, Connecting wires.

THEORY:-

Conveyors are basically material handling equipments. Conveyors used for moving materials over a fixed path. There is a broad range of types of conveyor systems. Wheel conveyor, roller conveyor, chain conveyor, Magnetic conveyor, pneumatic conveyor are the major types.

ST2425 Conveyor Control by PLC is a *Flat Belt Conveyor* system. It consists of two sensors one is IR sensor and other is proximity sensor. Belt is driven by a DC motor. Output of proximity sensor, output of IR sensor are the inputs of PLC and motor, motor direction, buzzer are the outputs of PLC. Some additional I/Os also given for users.

PANEL DIAGRAM:-



PROCEDURE:-

There are two modes of operation of ST2425 one is "Auto Mode" and other is "Manual Mode".

Auto Mode:
1. Switch on the Trainer
2. The switch indicated by arrow should be placed in Auto mode
3. Connect +24 V & +5 V supplies
4. Connect inputs and outputs to PLC
5. Set the total count
6. Place containers on the belt randomly

Manual Mode:
1. Switch on the Trainer
2. The switch indicated by arrow should be placed in Manual mode

3. You can change the direction of motor by using push buttons

PRECAUTIONS:-

1. Make sure that connections are tight.
2. Properly connect inputs and outputs to PLC
3. Switch off the set when not in use.

EXPERIMENT NO. 11

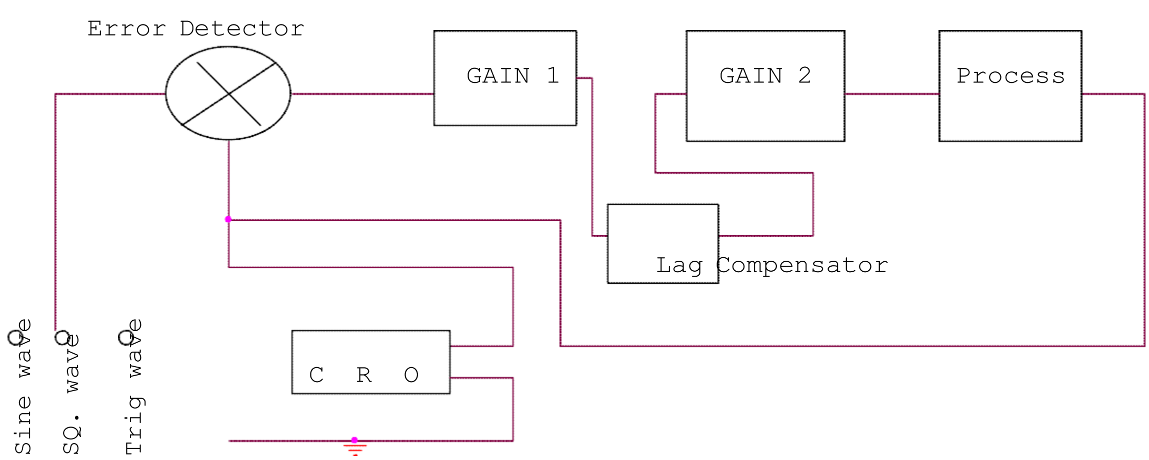
AIM: To study LEAD LAG compensator and draw magnitude and phase plot.

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

THEORY:

Compensation network are often used to make improvement in transient response and small change in steady state accuracy. The set up is divided in to three parts. Signal source: It has sine wave of 10-1200 Hz. Of 0-8 Vpp, Square wave of 20, 40 and 80 Hz of 0-2 Vpp. Trigger is available for trigger of CRO in external trigger mode. The amplitude is 1.2 Vpp. 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.

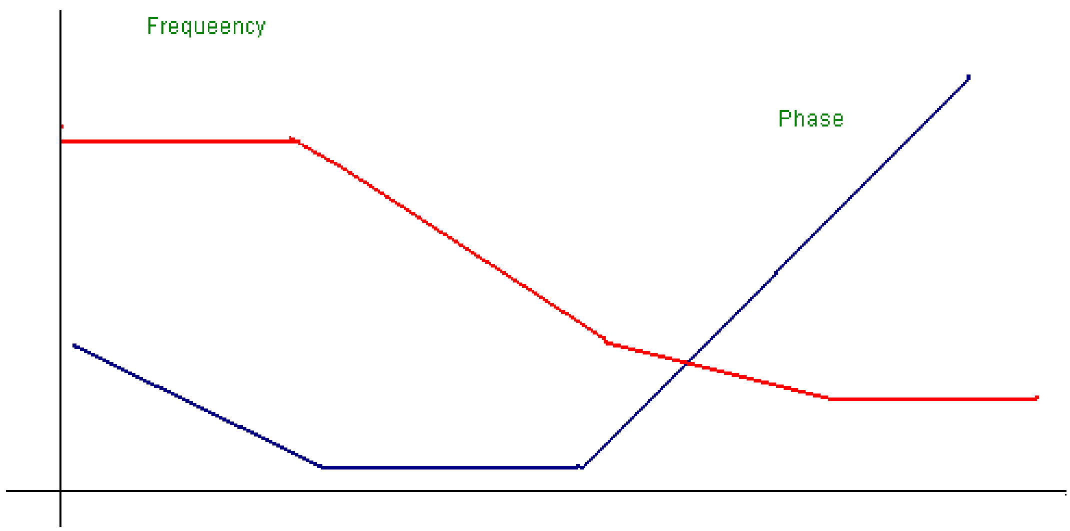
1. Open Loop Response: Connect square wave to gain and CRO across input and output. Select frequency to 80 Hz at 0.2 Vpp. Measure input amplitude Vpp as A and output as amplitude as B. Calculate gain factor=B/A. Connect sine wave with process input, CRO across input and output. Set input voltage =8Vpp. 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:

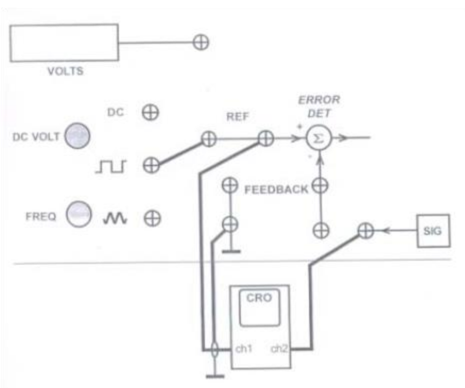


EXPERIMENT NO:-12

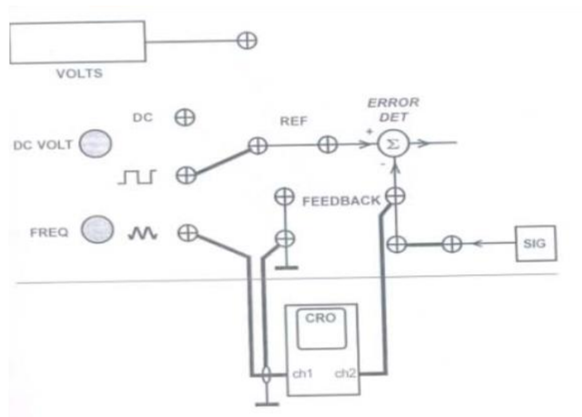
AIM: To study control action of light control system (a) the study of lamp response (b) the controller with amplifier in closed loop (c) and the introduction of P-I controller to improve the response.

APPARATUS REQUIRED: Dual trace CRO, DVM

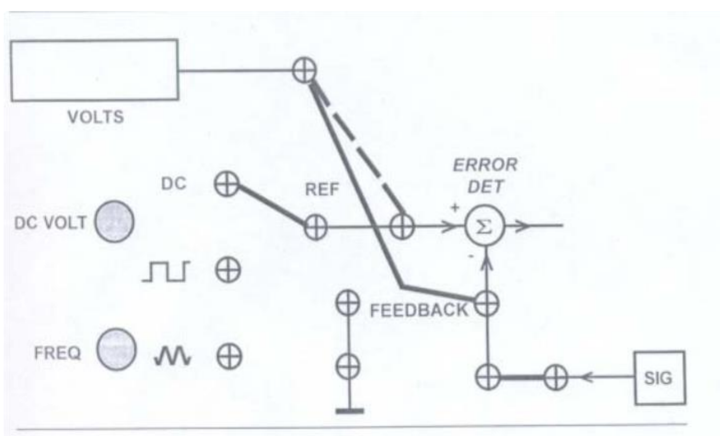
CIRUIT DIAGRAM:



Connection diagram for exp a.



Connection diagram for exp b.



PROCEDURE:

(a) To study the dynamic response of lamp:

1. A square wave signal of 5-20 Hz, is given with the main unit
2. Connect the CRO one channel with the reference input socket of error detector block. Connect the 15.9Hz (60mSec) square wave signal with the same input of error detector

3. Connect the other channel of CRO with the signal conditioner output socket. Select the amplifier mode from the selector switch and keep the disturbance switches in off condition.
4. Switch on the power supply and adjust the amplifier gain select to number 6,means the amplifier is selected to amplifying factor 6.
5. Adjust the CRO time base and amplitude controls toobtain the steady waveform pattern showing the input and output signal. Note the output signal is taken from the sensor signal conditioner which is negative in polarity thus its inverted form is applied as the lamp response signal .
6. Observe and trace the response curve of both the actuating signal and the lamp output. Note the +ve lead signal of square wave is 60 mSec duration.
7. Decrease the amplifier gain to 4 and observe its effect upon the lamp output response. It is observed that the amplitude of lamp intensity is decreased, since the sensor output is directly in proportion of lamp intensity.

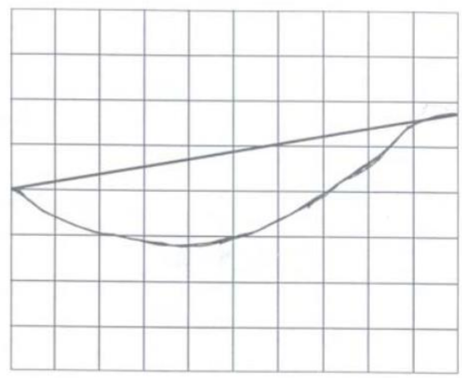
(b) To study the controller with amplifier in closed loop

1. Now connect the feedback path to form the close loop circuit. Connect the signal conditioner output with the feedback socket of error detector block. Unplug the square wave signal and connect the reference voltage socket there with the error detector block input.Connect the given DVM lead with the error detector socket (remove CRO).
2. Select the amplifier gain =1. Adjust the reference voltage to 4.00 volt dc. Now connect the DVM socket with feedback socket. Note the voltage there. Find out the steady state error as Vr-Vf.
3. Increase the amplifier gain in steps and note the feedback voltage and find out ess.
4. Keep the amplifier gain at 10. Now connect the CRO in place of DVM connect the square wave signal at the ref. input of error detector block while remove the dc reference from there. Connect the CRO other channel with triangular wave(X input channel) signal. Select X-Y mode of CRO . Adjust the waveform position to obtain full screen waveform pattern. Note that the overlap shown in the waveform.
5. As the input signal has fixed time duration 50 msec, the timing of delay and overshoot is easily measured..Select different gain and observe its effect upon the overshoot and ess.

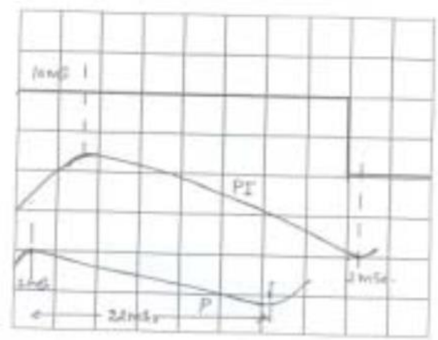
(c) To study the introduction of P-I controller to improve the response.

1. Now switchover to the P-I control where the sockets connections are as the step b.4.Adjust CRO controls to obtain the stationary waveform pattern .Observe the first overshoot and response of P-I controller.
2. Switch over to CRO normal operation. Connect the X input channel of CRO with the reference input of error block input. A square wave signal with the the lamp output response inform of feedback signal appear upon screen.
3. Observe the time lag (produced by the lamp) and the P-I controller response.
4. Now remove the CRO and connect the DVM at error detector reference input. Connect the same input with the dc reference socket. Adjust the reference for +4.00 volt dc.
5. Connect the DVM at the feedback socket. Note the output voltage there. Note the output voltage there. Note the feedback voltage is in propotion of light intensity. Find out the steady state error.

WAVEFORMS



Dynamic response in X - Y mode. X with triangular and Y with square wave excited. Freq = 15.9 Hz.



P and P - I controller dynamic response. f = 15.9 Hz

PRECAUTIONS:

1. Use only the main cord designed for this instrument
2. To avoid fire or shock hazards, observe all the ratings.
3. Use the fuze type and the rating specified for this instrument
4. Don’t operate in wet /damp conditions
5. Do not operate in an explosive atmosphere
6. Keep the product dust free, clean and dry

EXPERIMENT NO:-13

EXPERIMENT: Determine transpose, inverse values of given matrix.

APPARATUS REQUIRED: Computer with MATLAB software

THEORY: Open M-files
And start performing the following

Entering matrices into Matlab is the same as entering a vector, except each row of elements is separated by a semicolon (;) or a return:

```
B = [1 2 3 4;5 6 7 8;9 10 11 12]

    B =
         1     2     3     4
         5     6     7     8
         9    10    11    12

B = [ 1  2  3  4
      5  6  7  8
      9 10 11 12]

    B =
         1     2     3     4
         5     6     7     8
         9    10    11    12
```

Matrices in Matlab can be manipulated in many ways. For one, you can find the transpose of a matrix using the apostrophe key:

```
C = B'

    C =
         1    5     9
         2    6    10
         3    7    11
         4    8    12
```

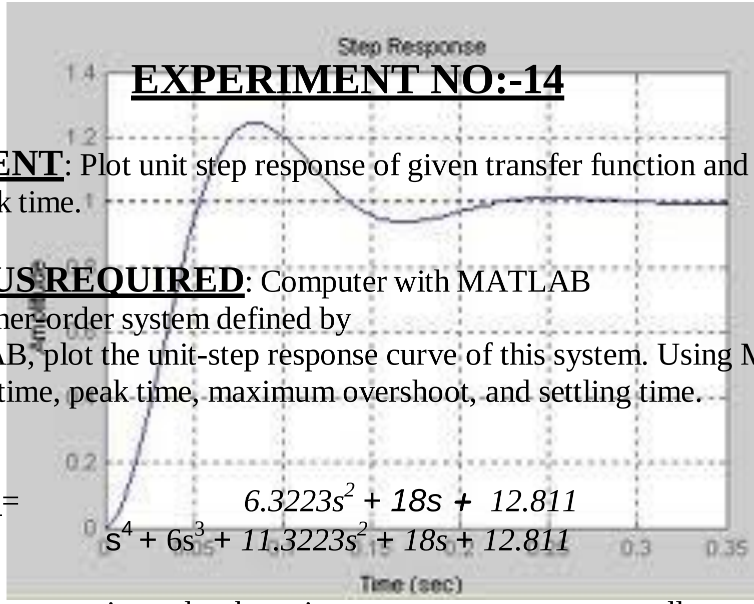
To find the inverse
Let us take

```
E = [1 2;3 4]
```

The inverse of a matrix:

```
X = inv(E)

    X =
       -2.0000    1.0000
        1.5000   -0.5000
```



EXPERIMENT NO:-14

EXPERIMENT: Plot unit step response of given transfer function and find peak overshoot, peak time.

APPARATUS REQUIRED: Computer with MATLAB
Consider a higher-order system defined by
Using MATLAB, plot the unit-step response curve of this system. Using MATLAB, obtain the rise time, peak time, maximum overshoot, and settling time.

$$\frac{C(s)}{R(s)} = \frac{6.3223s^2 + 18s + 12.811}{s^4 + 6s^3 + 11.3223s^2 + 18s + 12.811}$$

% ------- This program is to plot the unit-step response curve, as well as to find the rise time, peak time, maximum overshoot, and settling time.
% In this program the rise time is calculated as the time required for the
%" response to rise from 10% to 90'% of its final value. -------

```
num = [0 O 6.3223 18 12.811 1;
d e n = [ l 6 11.3223 18 12.8111;
t = 0:0.02:20;
[y,x,t] = step(num,den,t);
plot(t,y)
grid
title('Unit-Step Response')
xlabel('t (set)')
ylabel('0utput y(t)')
r l = 1; while y(r1) < 0.1, rl= r l+ 1; end;
r2 = 1; while y(r2) < 0.9, r2 = r2+l; end;
rise-time = (r2-rl)*O. 02
rise-time =
0.5800
[ymax,tp] = max(y); peak-
time = (tp-1)*0.02 peak-time
=
max-overshoot = ymax-l
max_overshoot =
0.6182
s = 1001; while y(s) > 0.98 8( y(s) < 1.02; s = s-1; end;
settlingtime = (s-1)*0.02
settling-time =
10.0200
```

EXPERIMENT NO:-15

EXPERIMENT: Plot the pole-zero configurations in s-plane for the given transfer function

APPARATUS REQUIRED

: Computer with MATLAB

PROCEDURE

-

$$H(s) = \frac{2s^2 + 5s + 1}{s^2 + 2s + 3}$$

: Plot
s-plane grid lines on the root locus for the following system.

You can do this by typing in MATLAB

```
H = tf([2 5 1],[1 2 3])

Transfer function:
2 s^2 + 5 s + 1
---------------
 s^2 + 2 s + 3
```