Department of

Electrical Engineering

LAB MANUAL

Control System LAB

B.Tech– IV Semester

KCT College OF ENGG AND TECH.

VILLAGE FATEHGARH

DISTT.SANGRUR

INDEX

Sr.No:	Experiments
1	To study the characteristics of potentiometers and to use 2- potentiometers as an error detector in a control system.
2	To study the synchro Transmitter-Receiver set and to use it as an error detector
3	To study the Speed – Torque characteristics of an AC Servo Motor and to explore its applications.
4	. To study the Speed – Torque characteristics of an DC Servo Motor and explore its applications.
5	To study various electro-mechanical transducers i.e. resistive, capacitive and inductive transducers
6	To study a LVDT (AC-AC, DC-DC) as a transducer and its processing circuits
7	. To study the characteristics of a thermocouple, a thermostat and a RTD
8	To study photo-conductive cell, semi-conductor photodiode and a silicon photo voltaic cell
9	To study a silicon phototransistor and obtain response of photo conductive cell
10	To study the variations of time lag by changing the time constant using control engineering trainer
11	To simulate a third order differential equations using an analog computer and calculate time response specifications
12	To obtain the transfer function of a D.C. motor – D.C. Generator set using Transfer Function Trainer
13	To study the speed control of an A.C. Servo Motor using a closed loop and an open loop systems
14	(i) To study the operation of a position sensor and study the conversion of position in to corresponding voltage (ii) To study an PI control action and show its usefulness for minimizing steady state error of time response.
15	To measure Force / Displacement using Strain Gauge in a wheat stone bridge
16	. To design a Lag compensator and test its performance characteristics.
17	To design a Lead-compensator and test its performance characteristics.
18	To design a Lead-Lag compensator and test its performance characteristics.

Note: At least 10 Experiments, out of above list of experiments are to be performed in the semester.

EXPERIMENT NO: 1

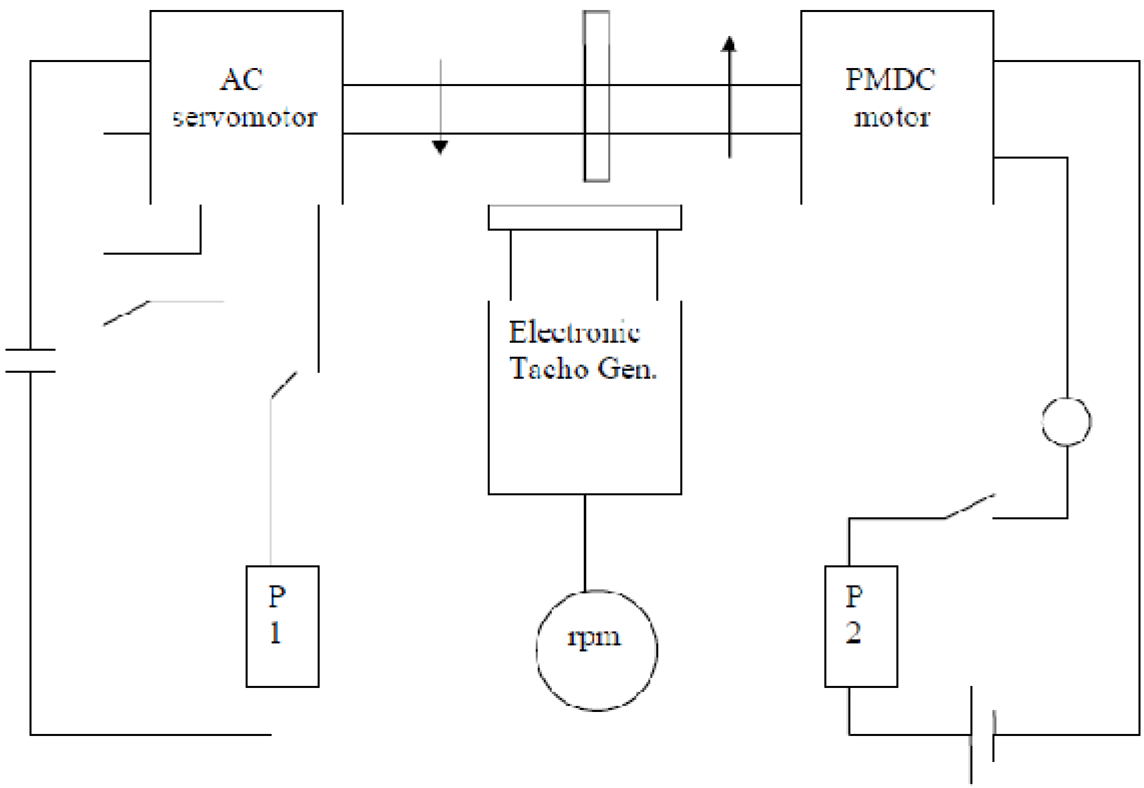
AIM: - To study AC servo motor and note it speed torque Characteristics.

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 ACservomotor 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 phaseB is energized with variable voltage called "Control voltage". In this setupAC servomotor is mounted and mechanically coupled a small PMDCmotor 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 switches ON S1. Slowly increase controls P1 so that ACservomotor starts rotating. Connect DVM across DC motor sockets (red & black). Very the speed

ofservomotorgraduallyand note the speed N rpm and corresponding back emfEb across DC motor. AC servomotorPMDC motor Electronic Tacho Gen. P1P rpm 2

2. Connect DVM across servo motor control winding socked (yellow) and adjust ACServomotor 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*10460/2.2.14Ngm/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: -

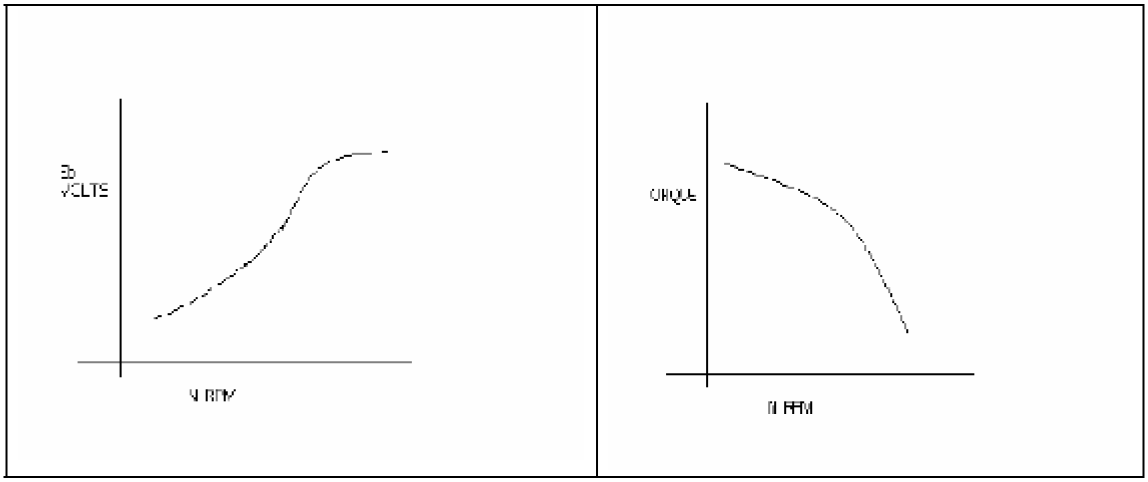
1. Apply voltage to servomotor slowly to avoid errors.

2. Impose load by DC motor slowly.

3. Take the reading accurately as the meter fluctuates.

4. Switch OFF the setup when note 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.

EXPERIMENT NO:2

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

APPARATUS:-

DC SERVO MOTOR KIT AND DVM.

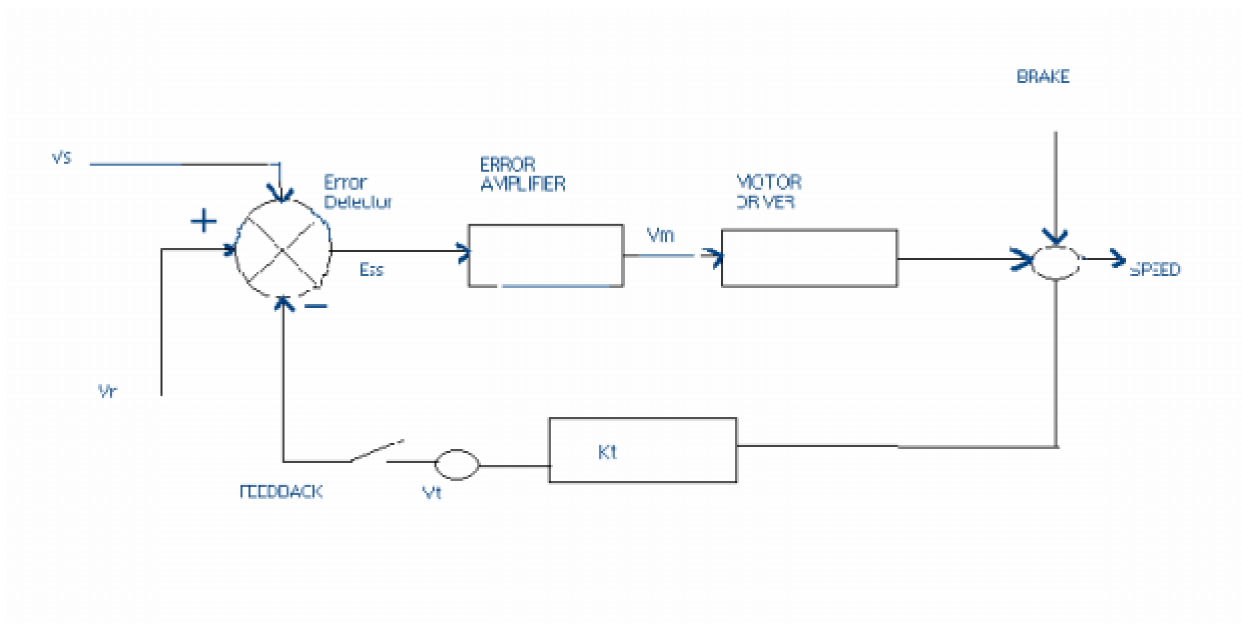
THEORY:-

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 gainswitch 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 Vtvolts for successive gain 4-10 in observation table.

Calculate Vm = Vr * Ka.

Where Ka isthe 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.

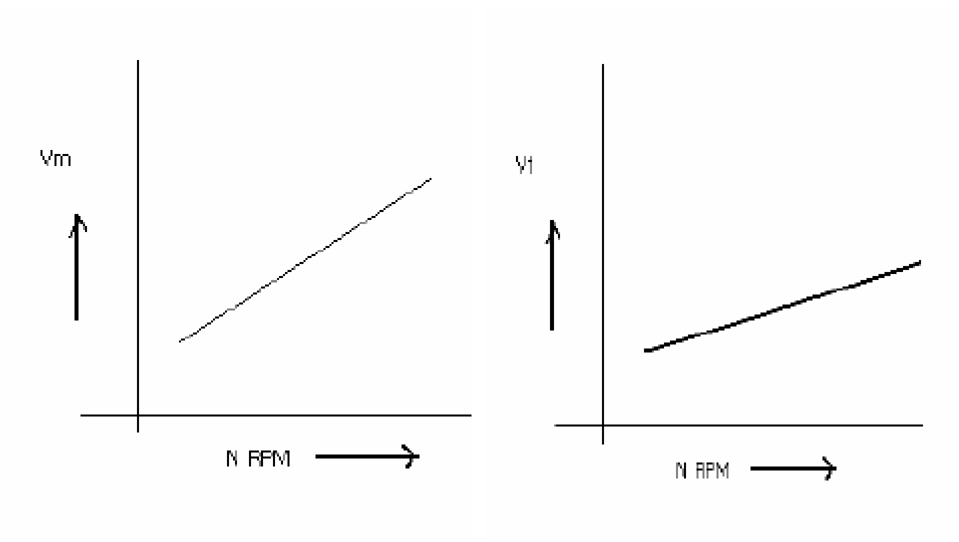
CLOSED LOOP PERFORMANCE:- In this case the gain switch is kept in on position thus feedback voltage gets subtracted from reference voltage. This is observed by decreased motor speed. Record the result between gain factor Ka and speed N. draw the graph between techo voltage Vt and speed N.

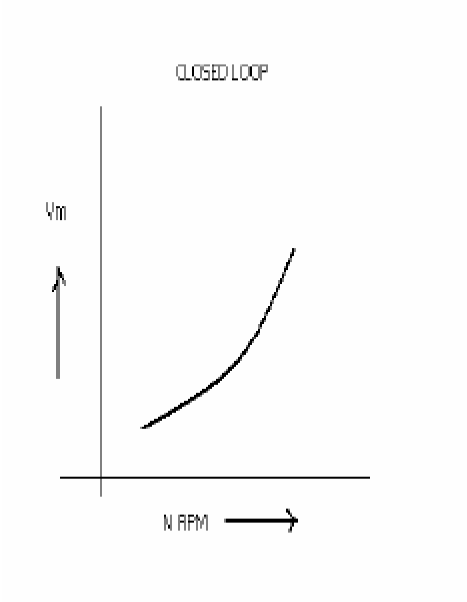
OBSERVATION TABLE:-

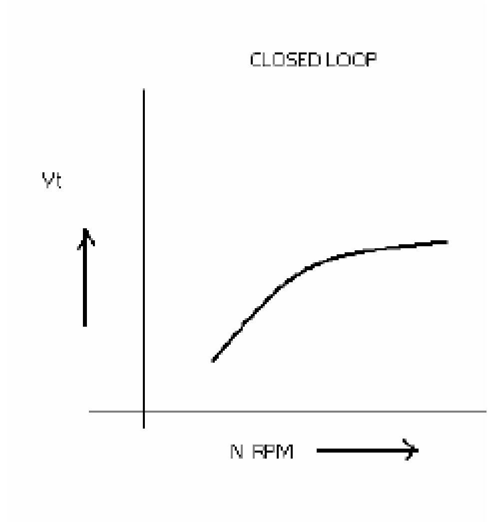
S.NO.	GAIN(Ka)	Vt (volts)	N(rpm)	Vm=Vr×Ka

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 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. This is due to the feedback gain.

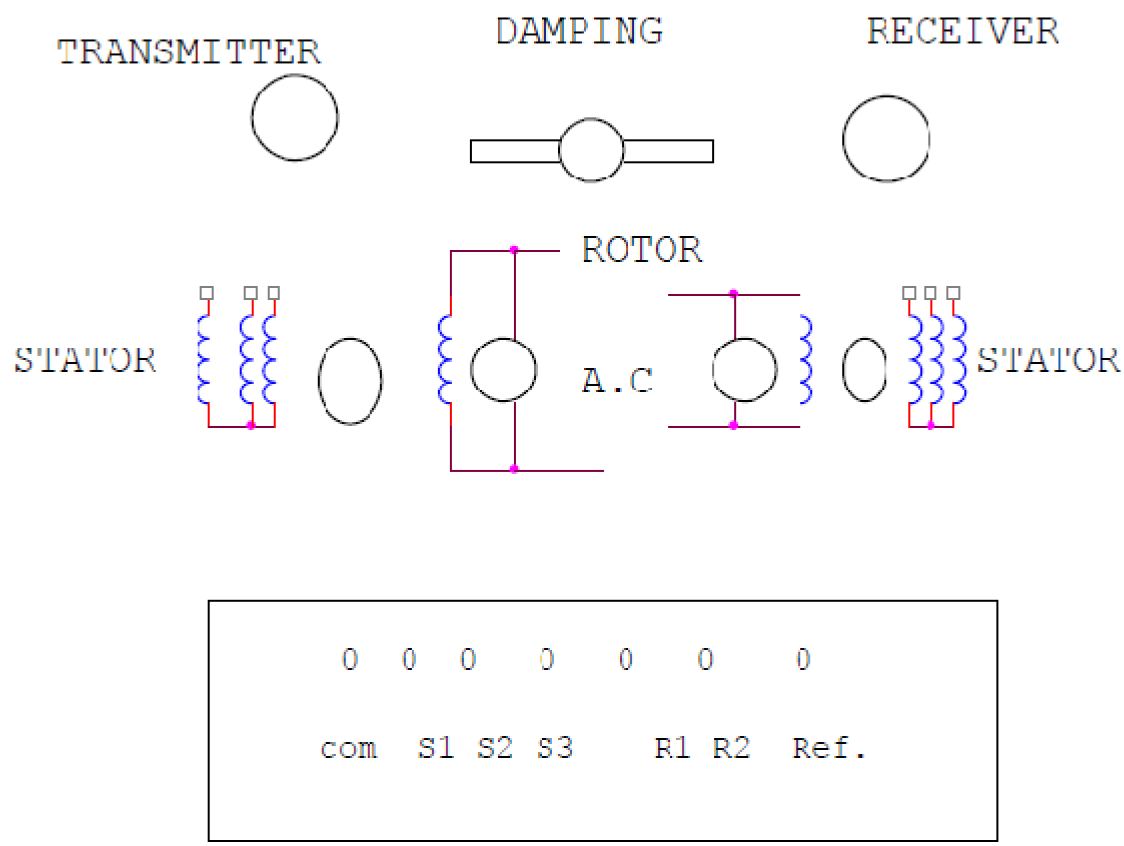
EXPERIMENT NO. 3

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 magnitudew.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 dials 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: 4

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

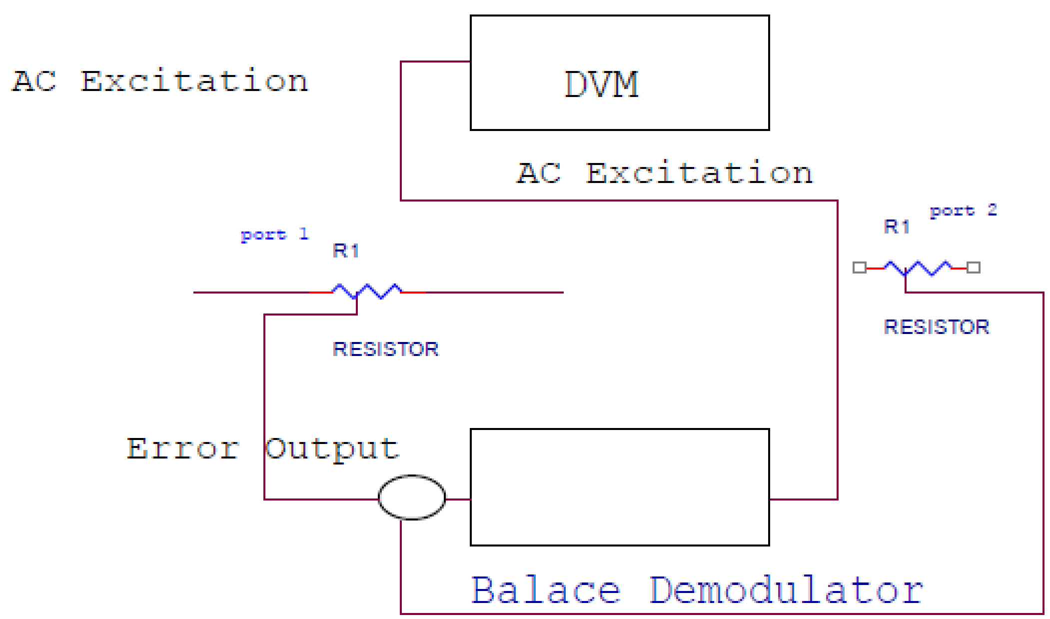
APPARATUS:

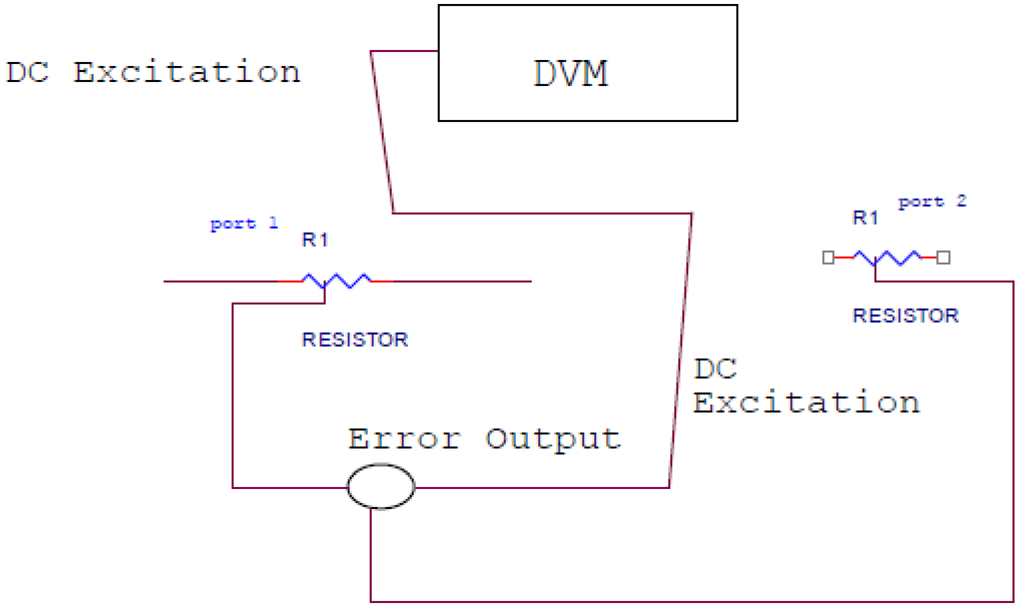
Potentiometer kit, Dual trace CRO and connecting leads

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 electromechanically 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 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

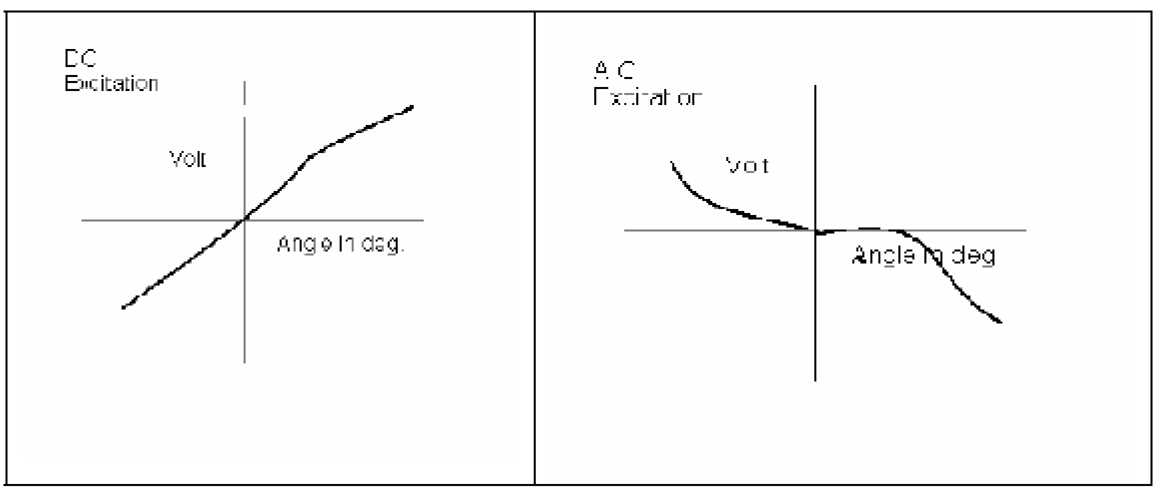
Sl.No.	Pot.2 position in θ°	$\theta_e = \theta_1 - \theta_2$	Output Voltage = V_0

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.

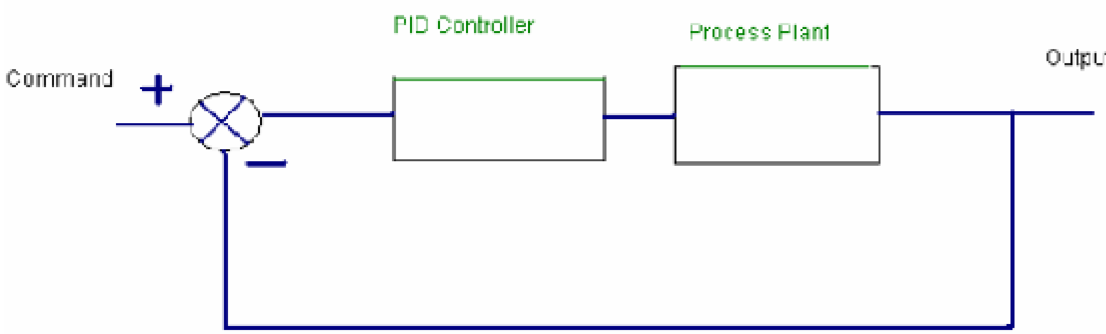
EXPERIMENT :- 5

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 ground0And 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 KpTo 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 Kip 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 ovan 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:

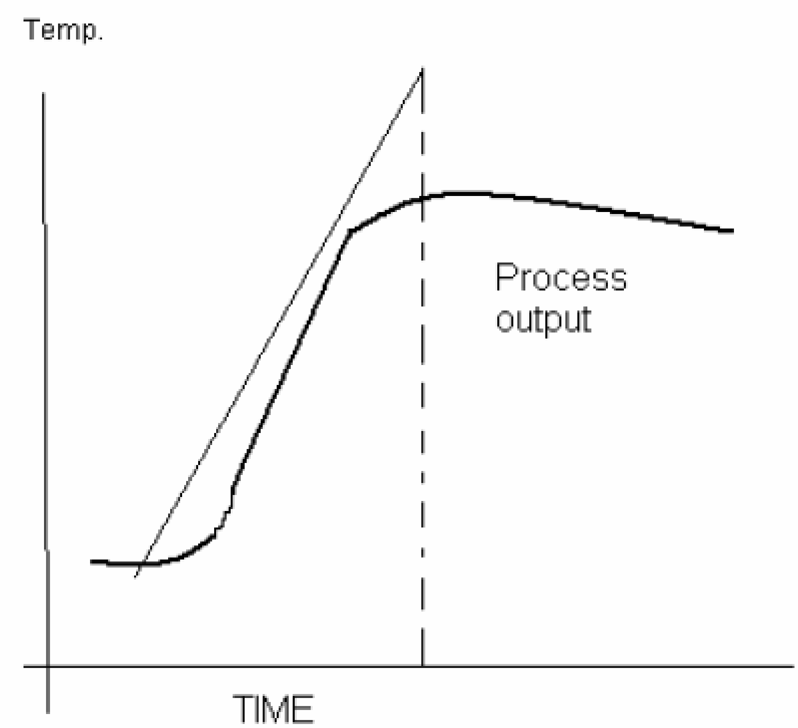
T(set) – T(ovan) / T(set) * 100.

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 up to a certain limit and then becomes steady

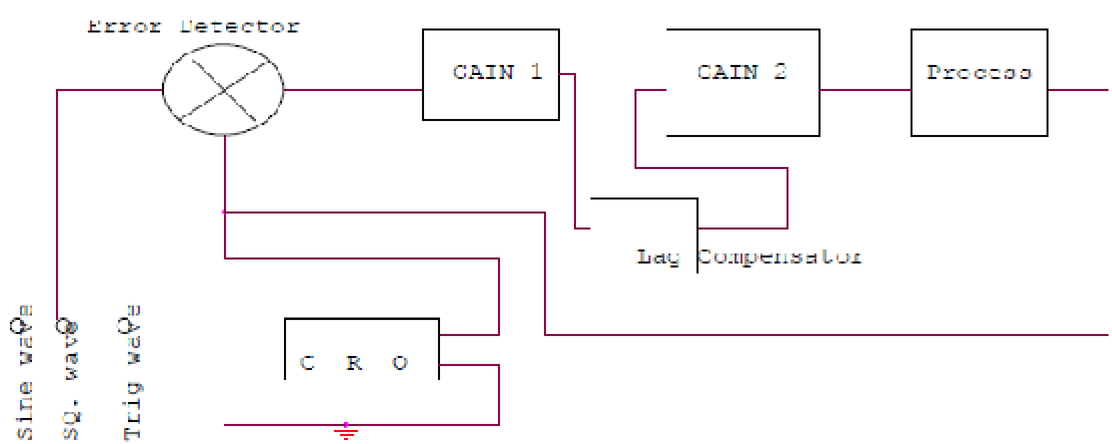
EXPERIMENT NO. 6

AIM: to study LAG compensator and draw eats 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

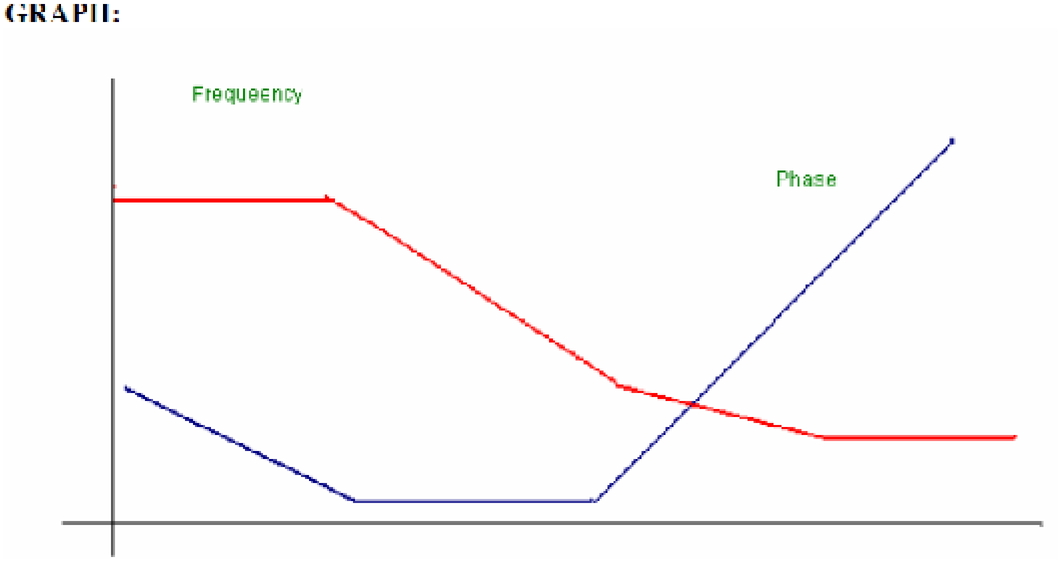
time Tp. Select wave frequency to 40Hz, 1Vpp and adjust gain control to 60%. Not gain control setting. Trace wave form on paper with record of Ess, Mp, and Tp. Select frequency to 80Hz and adjust gain control for minimum Ess 0. Trace wave form with Mp and Tp. connect process with lag compensator and 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 :

OBSERVATION TABLE :

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

GRAPH:

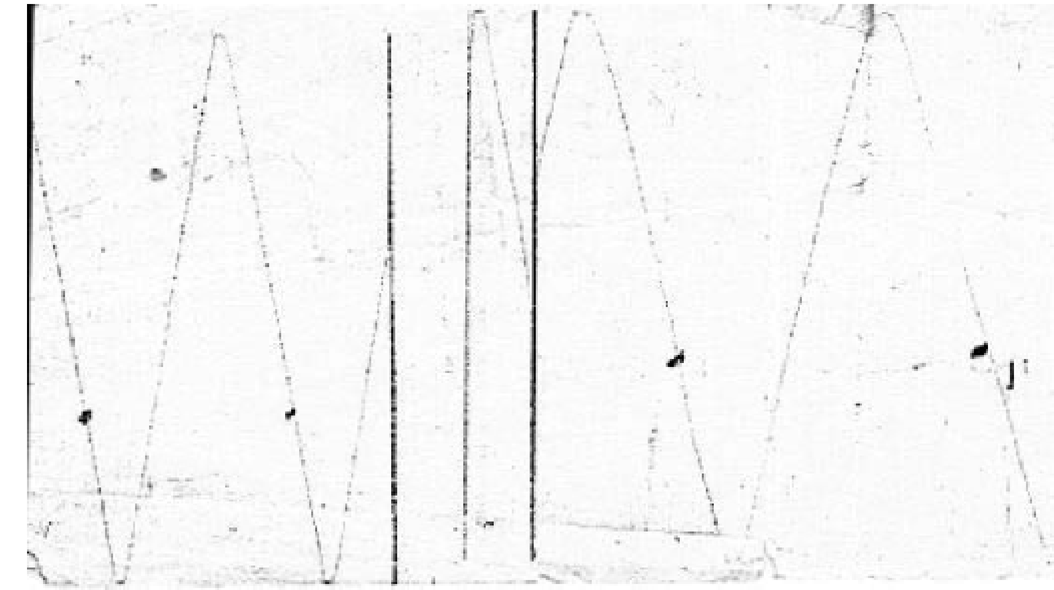


EXPERIMENT- 7

OBJECT :
Speed control of servo machine by OPEN LOOP system.
APPARATUS :
Servo Amplifier (ESP721)
Servo mechanism (ESP722)
Voltmeter (0-10V) DC
Resistance's (10k, 5.6k & 1k)
Pencil or ball-point
Power Supply ±15V
We consider open loop and closed loop systems separately and then we compare the result of these.
(a) OPEN LOOP SPEED CONTROL :
THEORY :
Open-loop speed control of a motor means that there is no automatic connection for unwanted speed variations. For examples when a load is applied to the motor shaft , this can result in a reduction of speed. Unless the load is removed , the speed would have to be manually corrected by adjusting the input setting .The OPEN-LOOP experiments requires the pen carriage, and pen to be raised , and lowered to show how this applied load affects the motor speed .
PROCEDURE :

(1) Complete experimental SET - UP
(2) Disconnect the YELLOW lead (y) and BLACK lead from the position feedback potentiometer .
(3) Plug-in Re=10 kohm, RT=5.8 kohm, RVEL=10 kohm.
(4) Raise the pen carriage and pen , and lower to the rear of the servomechanism (load removed).
(5) Connect a d.c voltmeter (10 V range) across the velocity Feedback Signal socket. and ground.
(6) Switch on 15V supplies, and turn the INPUT potentiometer, until the motor stops.
(7) Slowly turn the INPUT potentiometer RIGHT, until the voltmeter reading is varying about 2 volts .
(8) Switch off 15 V supplies .
(9) Return the carriage and pen to the normal position (this is the load applied) , and check that the pen projects sufficiently from the holder to allow the carriage clearance of the servo side cheeks when it moves across the paper
(10) Switch on 15V supplies
(11) Make a note of the velocity signal on the voltmeter (load on) .
(12) Switch POWER On for paper drive, and record two complete revolutions of the cam ; switch off paper drive (Rear switch) .
(13) Slowly turn the INPUT (manual correction) potentiometer until the velocity signal is varying about 2 volts again (this was the no load speed) .
(14) Switch POWER ON for paper drive, and record two complete revolutions of the cam, switch off paper drive.
(15) Switch off 15V supplies.
(16) Raise the pen carriage (no load) .
(17) Switch on 15V supplies, and note that the velocity signal exceeds 2. volts, manual correction is again- required .
(18) Switch off 15V supplies, and carefully return the pen carriage to the normal position.

OBSERVATION :



BEFORE AFTER
(1) Velocity Feedback Signal
(2) Distance for 1 revolution
(3) Speed of Paper
(4) Time to complete 1 revolution
(5) Speed of Servo Motor = Number of Seconds in a minute
Time to complete 1 revolution
= ________________________
(6) Error = Measured voltage - Desired =
at NO Load Voltage
=

RESULT :
We have derived that speed regulation of Servo Motor is very poor for OPEN LOOP system.

EXPERIMENT 8

OBJECT : Speed control of servo machine by CLOSE LOOP system

APPARATUS:

Power supply 15V
DC Voltmeter (0-10V)
Re=10 kohm , Rt=5.6 kohm, Rvel= 10kohms.
ESP 721
ESP 722

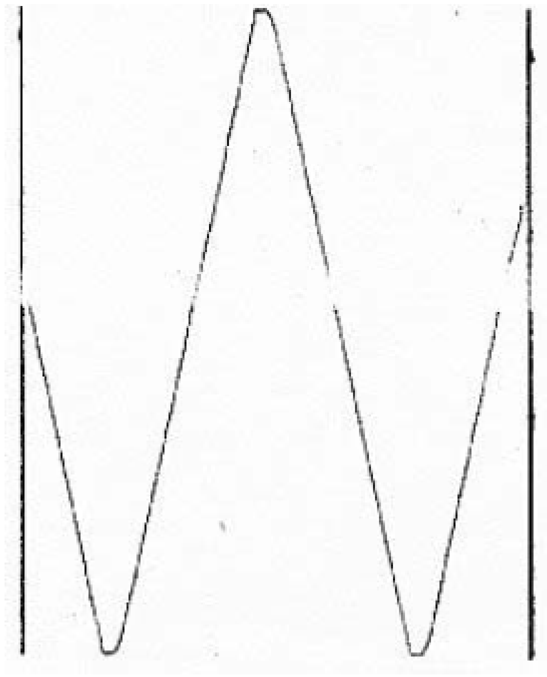
THEORY:

In closed loop speed control system, the output signal is feedback (velocity feedback) and compared with the input speed demand at the summing point the error signal produced causes the servo amplifier to regulate the motor speed load changes on the motor shaft or internal disturbances in the system are automatically compensated for if within the range of control of the system.

PROCEDURE :

(1) Complete experimental SET - UP
(2) Disconnect the YELLOW lead (y) lead from the position feedback potentiometer .
(3) Plug-in Re=10 kohm, RT=5.6 kohm, RVEL=10 kohm.
(4) Raise the pen carriage and pen , and lower to the rear of the servomechanism (load removed).
(5) Connect a d.c voltmeter (10 V range) across the velocity Feedback Signal socket. and ground.
(6) Switch on 15V supplies, and turn the INPUT potentiometer, until the motor stops.
(7) Slowly turn the INPUT potentiometer RIGHT, until the voltmeter reading is varying about 2 volts .
(8) Switch off 15 V supplies .
(9) Return the carriage and pen to the normal position (this is the load applied) , and check that the pen projects sufficiently from the holder to allow the carriage clearance of the servo side cheeks when it moves across the paper
(10) Switch on 15V supplies
(11) Make a note of the velocity signal on the voltmeter (load on) .
(12) Switch POWER On for paper drive, and record two complete revolutions of the cam ; switch off paper drive (Rear switch) .
(13) Switch off 15V supplies.
(14) Raise the pen carriage (no load) .
(15) Switch on 15V supplies, and note that the velocity signal does not exceeds 2. volts, manual correction is not required again .
(16) Switch off 15V supplies, and carefully return the pen carriage to the normal position.

OBSERVATION :



(6) Velocity Feedback Signal
(7) Distance for 1 revolution
(8) Speed of Paper
(9) Time to complete 1 revolution
(10) Speed of Servo Motor = Number of Seconds in a minute
Time to complete 1 revolution
= __________________________ =
14
(6) Error = Measured voltage - Desired =
at NO Load Voltage
=

RESULT :

We have derived that speed regulation of Servo Motor is very good for CLOSE LOOP system.

EXPERIMENT 9

OBJECT:
Plot the characteristic curve of Phototransistor at variation of illumination.

EQUIPMENT REQUIRED:
Module Holder
Light Transducer and Control Module G13/EV
Light Transducer Interface Unit TY13/EV
PS1-PSU- Power supply unit
Measurement unit IU9/EV.
Connecting wires
DIN Cable

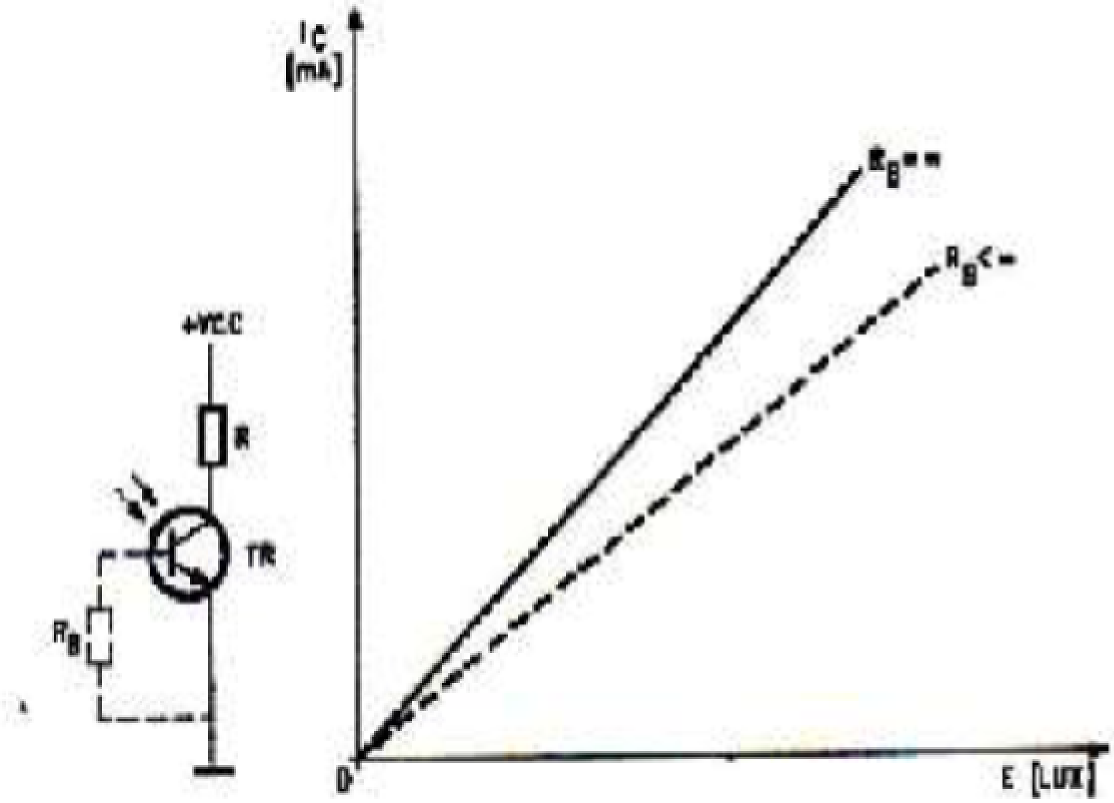
THEORY:
Phototransistor
The phototransistor is a device with a structure similar to the one of a standard transistor, but with a photo sensible base. It is generally NPN kind, it is powered with apositive voltage between collector and emitter while the base can be left open orconnected to the emitter with a resistor. In the second case, the sensitivity of the phototransistor can be adjusted by varying the value of the resistor used. In dark conditions, the current of the collector Ic is minimum and increases with illumination. Figure shows the symbol with the typical diagram of the connection of the phototransistor; furthermore it shows the characteristic curve with the relation between the variations of Ic and the variations of the illumination.

The main parameters of a phototransistor, in addition to the characteristic curve, are:
- The maximum dark current.
- The wavelength of maximum sensitivity.
- The switching speed (rise and fall times).
- The maximum admitted values of current, voltage and power.

The phototransistor used in the equipment has the following main characteristics:
- Dark current: 20 μA
- Rise time: 8 μs
- Fall time: 6 μs
- Vce max: 30 V DC

PROCEDURE:
- Carry out the circuit of figure and connect module G-13 to units TY13/EV as in figure
- Set the switch of the PHOTODIODE CONDITIONER block to the position A, set the multimeter for D.C. current measurement and connect it between terminals 23 and ground.
- Connect module G13 to all the necessary supplies.
- Set the lamp to the maximum distance with the slide.
- Set the potentiometer of the SET-POINT block to the maximum value (300 Lux).

• Move the lamp near the light transducers with the slide, and in correspondence to the divisions shown on the panel of unit TY13/EV, read thev current values indicated by the multimeter and report them in table
• Plot a graph with illumination on the x-axis and current on the y-axis and draw the points detected.
• The characteristic curve of the transducer is obtained by joining these points.
• Set the switch to B and insert the multimeter, selected as voltmeter for D.C. voltage, between terminal 28 and ground.
• Repeat all the last measurements: in this case measure the response of the transducer together with the one of the signal conditioner.
• Plot a graph with illumination on the x-axis and voltage on the y-axis and draw the points detected.
• The characteristic curve of the transducer together with its signal conditioneris obtained by joining these points.
• Confront the quality of the two graphs.



OBSERVATION:

S no	Lux	Ampere	Volt
1	57		
2	68		
3	83		
4	104		
5	133		
6	177		
7	248		
8	370		
9	612		
10	1200		
11	3330		

RESULT:

The characteristic curve of Phototransistor is drawn and studied.

EXPERIMENT 10

.OBJECT:

Plot the characteristic curve of J type thermo couple and to determine thermo conditioner Couple linearity.

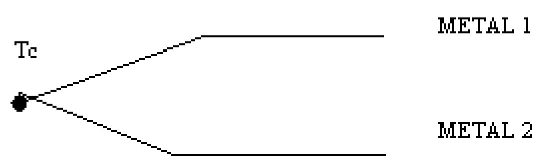
EQUIPMENT REQUIRED:

1. Module Holder
2. Module for transducer control G34/ EV
3. PS1-PSU- Power supply unit
4. Transducer attachment TY 34/EV
5. Measurement unit IU9/EV.
6. Connecting wires
7. Thermo Couple DIN cable.

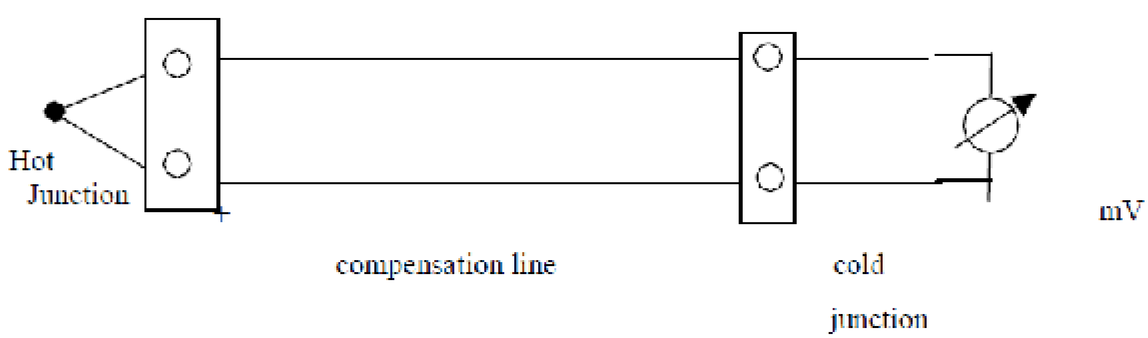
THEORY:

Thermocouple:

Thermocouples consist of two different metallic conductors, which are joined at one end by a galvanic contact (i.e. soldered) as shown



The thermocouple (or hot junction) is introduced into the surrounding where the temperature is to be measured (e.g. inside an oven) and the conductors are brought to the point of measurement (cold junction), which is at a different temperature (see fig.). This circuit generates a thermoelectric E.M.F. (Electromotive force), which varies according to the difference between TC and TF (Seebeck effect)



• **Fe-Constantan (type J)**

• **Ni-NiCr (type K)**
• **Cu-Constantan (type T)**

The E.M.F. of the Fe-Constantan thermocouple (J type) is much greater than that of the other types; its linearity is good, and it is inexpensive. One disadvantage is that the maximum temperature is limited by the iron element (700-800 °C). The thermocouple examined in this case is of the Fe-Constantan type (type J), and has the
following main characteristics:

• Transduction constant: 53 μV/°C
• Error: ±2.2°C in the 0 - 270°C range
±0.75% in the 270 - 760°C range
• Protected against atmospheric agents by metallic sheath

PROCEDURE:

• Set up the apparatus as described in the previous experiment replacing the signal conditioner for the (STT) with the signal conditioner for the thermocouple.
• Starting from ambient temperature, adjust the Set-Point knob in order to increase the temperature of the oven in 10°C step (i.e. bring the voltage on jack 2 to a value which corresponds to ambient temperature, then increase this voltage by a quantity which corresponds to a 10°C temperature increase). Measure the output voltage of the signal conditioner as soon as the temperature is stabilized. If the temperature exceeds 150°C, remove the semiconductor transducer in order to avoid the possibility of damages.
• The reference temperature is given by a precision mercury thermometer
(Centigrade scale)
• Compile a Voltage/Temperature table and then plot the characteristic curve on a
graph
• Calculate the linearity of the thermocouple as described in the previous experiment.

OBSERVATION

S. No.	T (°C)	Output Voltage of STT Sensor (V)
1	30 °C	
2	40 °C	
3	50 °C	
4	60 °C	
5	70 °C	
6	80 °C	
7	90 °C	
8	100 °C	
9	110 °C	
10	120 °C	
11	130 °C	

RESULT:

1. The characteristic curve of thermocouple is determined and studied.
2. The linearity of thermocouple is found to be %.

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EXPERIMENT 11

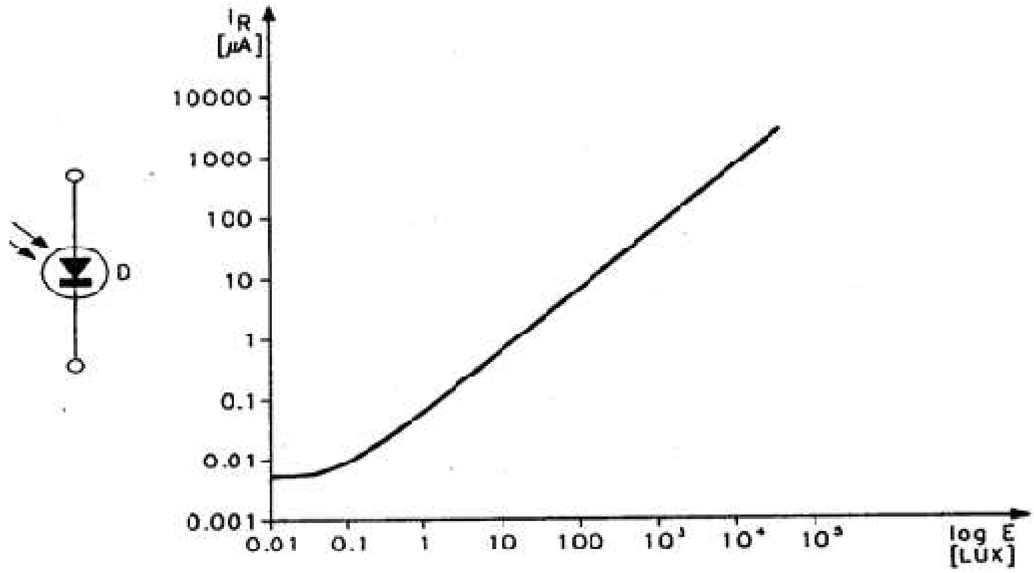
OBJECT:
Plot the characteristic curve of photodiode at variation of illumination.

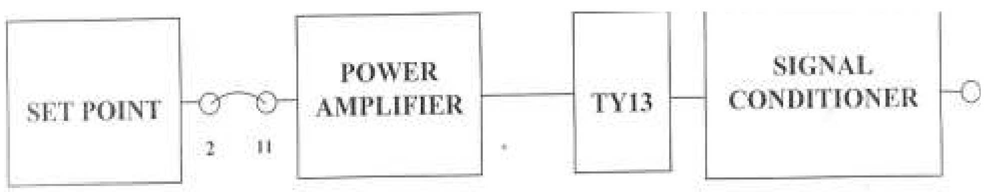
EQUIPMENT REQUIRED:
1. Module Holder
2. Light Transducer and Control Module G13/EV
3. Light Transducer Interface Unit TY13/EV
4. PS1-PSU- Power supply unit
5. Measurement unit IU9/EV.
6. Connecting wires
7. DIN Cable

THEORY:
The photodiode is a device, which is similar in structure to a common semiconductor diode, with a P-N junction, and, for this kind of use, it is reverse biased. In dark conditions the photodiode operates as a common semiconductor diode, while when the junction is crossed by a light radiation, the reverse current increases. Fig shows a typical relation between illumination and reverse current together with the symbol of the device. The reverse current of photodiodes can take values ranging inside some nA and some tens of mA. The mostly used semiconductor materials are silicon, germanium, gallium arsenide and other semiconductor compounds. If a photodiode, which is not biased and without load is illuminated, it is crossed by a voltage generated inside the junction by the interaction between the light radiation and the semi conductive material (photovoltaic effect). If, then a load is applied to the photodiode, there is a passage of current and in this way generation of electrical energy takes place. The said is the operating principle of "**Photovoltaic cells".**

The typical parameters of photodiodes, beside the characteristic curve are:
• The maximum reverse voltage that can be applied across it.
• The maximum power that can be dissipated.
• Maximum switching speed (rise and fall times).

The photodiode used in unit TY13/EV is P-I-N silicon type and has the following characteristics (see data sheet for details):
• Maximum reverse voltage: 32 volts DC
• Maximum sensitivity: 0.9 µm
• Maximum dark current: 30 nA.
• Reverse current with illumination equal to 1mW/cm2: 50 µA.
• No-load voltage (1000 lux): 350 mV
• Rise and fall times: 50 ns





PROCEDURE

1. Carry out the circuit of figure and connect module G-13 to unit TY13/EV as in figure
2. Set the switch of the "Photodiode Conditioner block to position A (with switch in position A, the transducer is disconnected from the operational amplifier and connected to resistor R7 so that it can be analyzed without the influence of the other components).
3. Set the multimeter for voltage measurement and connect it between terminal 19 and ground. In this case although a current is generated by the transducer, it is preferable to measure the fall this current determines on the resistor R7 as the same current is a very small.
4. Connect module G13 to all the necessary supplies.
5. Set the lamp to the maximum distance with the slide.
6. Set the potentiometer of the SET-POINT block to the maximum value (300 Lux).
7. Move the lamp near the light transducers with the slide and in correspondence to

OBSERVATION

S No	LUX	V_{out} (19)	V_{out} (22)
1	57		
2	68		
3	83		
4	104		
5	133		
6	177		
7	248		
8	370		
9	612		
10	1200		
11	3330		

RESULT:

The characteristic curve of photodiode is drawn and studied