



CONTROL SYSTEMS & SIMULATION

LAB MANUAL

III -B.Tech (EEE)



Department of EEE

Aurora's Technological and Research Institute
Parvathapur, Uppal, Hyderabad-500 039





LABORATORY PRACTICE

I HEAR, I FORGET
I SEE, I REMEMBER
I DO, I UNDERSTAND

**PRACTICAL APPROACH IS PROBABLY THE BEST
APPROACH TO GAIN A CLEAR INSIGHT**



CODE OF CONDUCT FOR THE LABORATORIES

- ❖ All students must observe the Dress Code while in the laboratory.
- ❖ Sandals or open-toed shoes are NOT allowed.
- ❖ Foods, drinks and smoking are NOT allowed.
- ❖ All bags must be left at the indicated place.
- ❖ The lab timetable must be strictly followed.
- ❖ Be PUNCTUAL for your laboratory session.
- ❖ Experiment must be completed within the given time.
- ❖ Noise must be kept to a minimum.
- ❖ Workspace must be kept clean and tidy at all time.
- ❖ Handle all apparatus with care.
- ❖ All students are liable for any damage to equipment due to their own negligence.
- ❖ All equipment, apparatus, tools and components must be RETURNED to their original place after use.
- ❖ Students are strictly PROHIBITED from taking out any items from the laboratory.
- ❖ Students are NOT allowed to work alone in the laboratory without the Lab Supervisor
- ❖ Report immediately to the Lab Supervisor if any injury occurred.
- ❖ Report immediately to the Lab Supervisor any damages to equipment.

Before leaving the lab

- ❖ Place the stools under the lab bench.
- ❖ Turn off the power to all instruments.
- ❖ Turn off the main power switch to the lab bench.
- ❖ Please check the laboratory notice board regularly for updates



GENERAL LABORATORY INSTRUCTIONS

- You should be punctual for your laboratory session and should not leave the lab without the permission of the teacher.
- Each student is expected to have his/her own lab book where they will take notes on the experiments as they are completed.
- The lab books will be checked at the end of each lab session. Lab notes are a primary source from which you will write your lab reports.
- You and your batch mates will work closely on the experiments together. One partner doing all the work will not be tolerated. All the Batch mates should be able to explain the purpose of the experiment and the underlying concepts.
- Please report immediately to the member of staff or lab assistant present in the laboratory; if any equipment is faulty.

Organization of the Laboratory

- It is important that the experiments are done according to the timetable and completed within the scheduled time.
- You should complete the prelab work in advance and utilize the laboratory time for verification only.
- The aim of these exercises is to develop your ability to understand, analyze and test them in the laboratory.
- A member of staff and a Lab assistant will be available during scheduled laboratory sessions to provide assistance.
- Always attempt experiments; first without seeking help.
- When you get into difficulty; ask for assistance.

Assessment

- The laboratory work of a student will be evaluated continuously during the semester for 25 marks. Of the 25 marks, 15 marks will be awarded for day-to-day work.
- For each experiment marks are awarded under three heads:
 - _ Prelab preparation – 5 marks
 - _ Practical work – 5marks, and
 - _ Record of the Experiment – 5marks
- Internal lab test(s) conducted during the semester carries 10 marks.
- End semester lab examination, conducted as per the JNTU regulations, carries 50 marks.



- At the end of each laboratory session you must obtain the signature of the teacher along with the marks for the session out of 10 on the lab notebook.

Lab Reports

- Note that, although students are encouraged to collaborate during lab, each must individually prepare a report and submit.
- They must be organized, neat and legible.
- Your report should be complete, thorough, understandable and literate.
- You should include a well-drawn and labeled engineering schematic for each circuit
- Investigated.
- Your reports should follow the prescribed format, to give your report structure and to make sure that you address all of the important points.
- Graphics requiring- drawn straight lines should be done with a straight edge. Well drawn freehand sketches are permissible for schematics.
- Space must be provided in the flow of your discussion for any tables or figures. Do not collect figures and drawings in a single appendix at the end of the report.
- Reports should be submitted within one week after completing a scheduled lab session.

Presentation

- Experimental facts should always be given in the past tense.
- Discussions or remarks about the presentation of data should mainly be in the present tense.
- Discussion of results can be in both the present and past tenses, shifting back and forth from experimental facts to the presentation.
- Any specific conclusions or deductions should be expressed in the past tense.

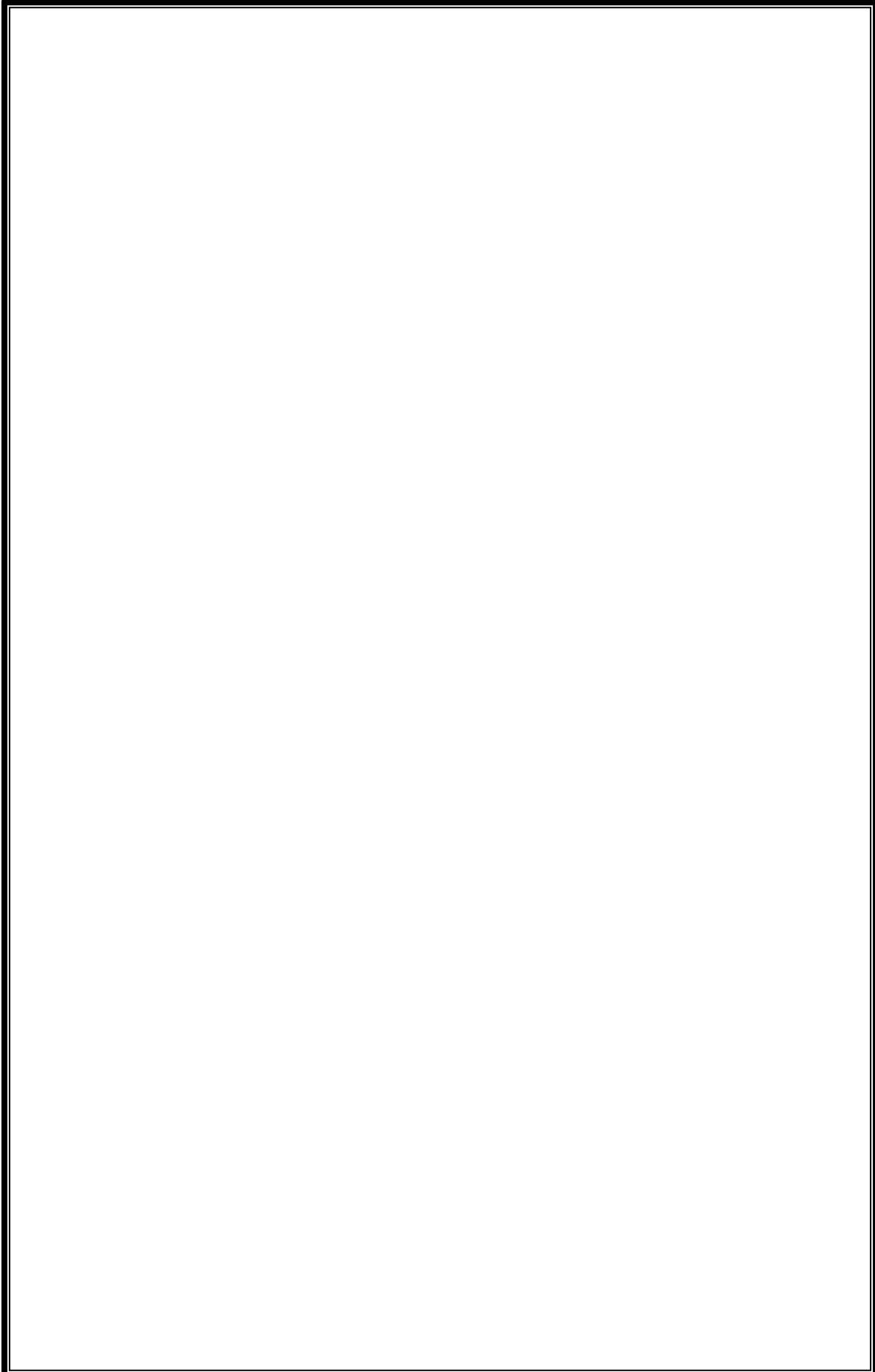
Report Format

Lab write ups should consist of the following sections:

- **Aim:** A concise statement describing the experiment and the results. This is usually not more than 3 sentences. Since the abstract is a summary of what you have done, it's a good idea to write this last.



- **Apparatus:** Describe what equipment and components you used to conduct the experiment.
- **Theory:** Several paragraphs that explain the motivation of the experiment. Usually in this statement you state what you intent to accomplish as well as the expected results of the experiment.
- **Procedure:** Describe how you conducted the experiment
- **Results and Analysis:** This is the main body of the report. Graphs, tables, schematics, diagrams should all be included and explained. Results of any calculations should be explained and shown. State the results of the experiment. Include any problems encountered.
- **Conclusion:** Explain how the experiment went, and whether you were able to achieve the expected results stated in the introduction.





Name of the student: _____

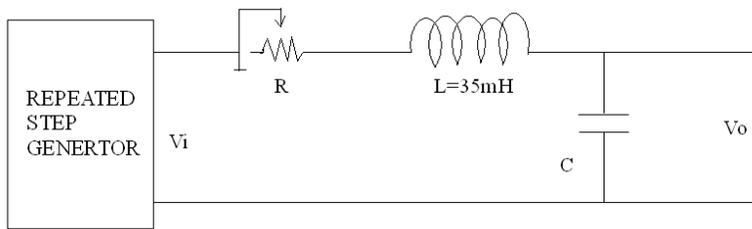
Roll Number: _____

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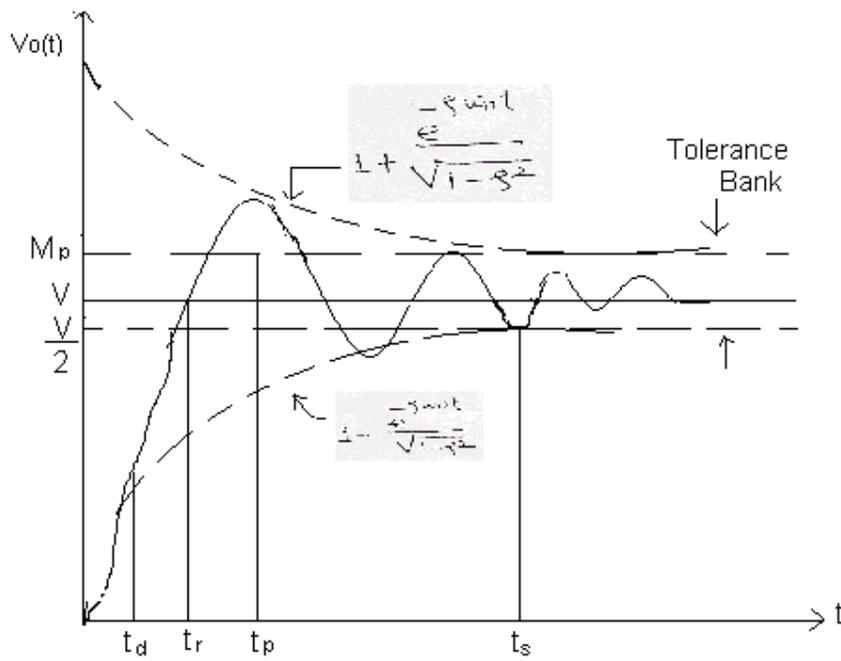
Sl. No	Name of the Experiment	Page No.	Date of conduction	Grade / Marks	Incharge sign.
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CIRCUIT DIAGRAM :

A SECOND ORDER SYSTEM



GRAPHS :



TIME RESPONSE SPECIFICATIONS

1. TIME RESPONSE OF SECOND ORDER SYSTEM

AIM :

To obtain the time response of a second order system.

APPARATUS :

Sl.No.	Item	Type	Range	Quantity
1	Time Response Kit			1
2	Patch Cords			
3	Cathode Ray Oscilloscope			1

THEORY:

When a system is given an excitation (INPUT), there is a response (OUTPUT). This response varies with time, and is called the time response.

Time response is divided into two parts.

- 1) Transient Response - It is the part of response that goes to zero as the time increases.
- 2) Steady state Response - That part of the response that remains after the transients have died out

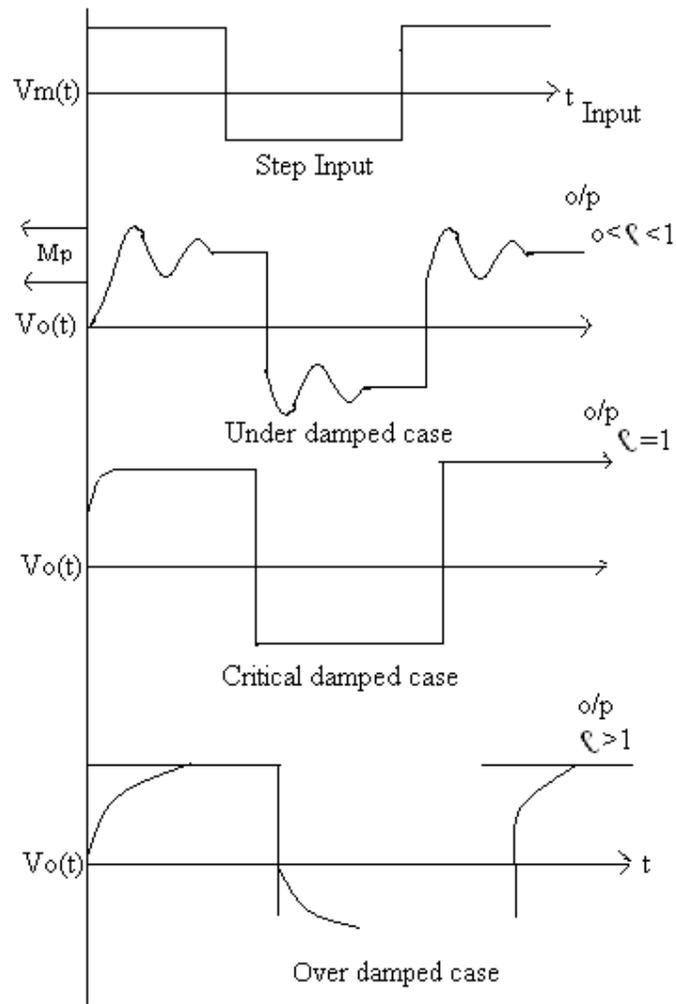
TIME RESPONSE SPECIFICATIONS:

1. Delay Time (t_d): - It is the value of time required for the response to reach 50% of final value in first attempt.
2. Rise Time (t_r):- It is the time required for the response to rise from 10% to 90% of the final value for the over damped system and 0 to 100% value for under damped system.
3. Peak Time (t_p) : - It is the time required for the response to reach the peak of the time response or the peak overshoot.
4. Peak Overshoot (MP): - It indicates the normalized difference between the time response peak & steady state output. It is defined as peak percent overshoot.

$$\% M P = \frac{C(t_p) - C(00)}{C(00)} \times 100$$

Where $C(t_p)$ is output at $t = t_p$ & $C(00)$ is steady state output.

5. Settling time (t_s): - It is the time required for the response to reach and stay within a specific tolerance band (usually 2 to 5%) of its final value.



OBSERVATIONS :

	R	L	C	$\zeta = R \sqrt{\frac{C}{L}}$	$\omega_n = \frac{1}{\sqrt{LC}}$	ω_d
SET1 $0 < \zeta < 1$						
SET2 $\zeta = 1$						
SET3 $\zeta > 1$						

6. Steady State Error: - It indicates the error between the actual output & desired output as t tends to infinity.
- $$E_{ss} = \lim_{t \rightarrow \infty} [r(t) - c(t)]$$

PROCEDURE :

1. Make connections as shown in circuit diagram.
2. Connect repeated step input to RLC circuit.
3. Make power on to the unit.
4. Connect C.R.O. at the output and adjust C.R.O. to get stable pattern on C.R.O.
5. Vary R by potentiometer and for a given set of values of L & C , note down R for critically damped response
6. Vary R to obtain under damped response and measure R value, time response specifications.
7. Plot the same response on Graph paper.

NOTE: Actual value of R is $R +$ resistance of Inductance

PRECAUTIONS :

1. Loose connections are to be avoided.
2. Circuit connections should not be made while power is on.
3. Readings of meters must be taken without parallax error.

RESULT: Time Response specifications are obtained

ASSESSMENT QUESTIONS :

1. What is delay time?
2. What is rise time?
3. What is peak time?
4. What is peak overshoot?
5. What is settling time?



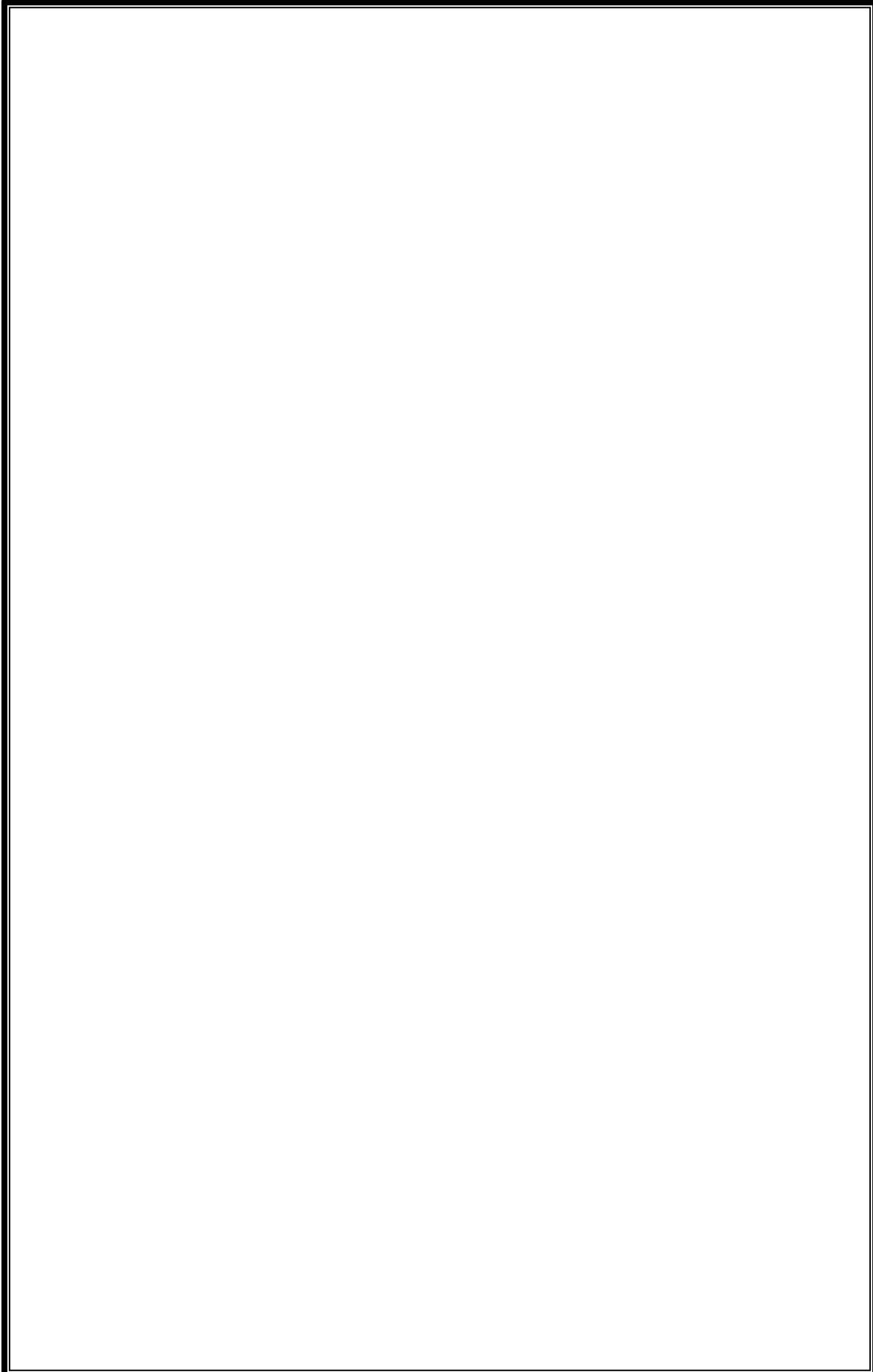
	THEORETICAL PEAK OVERSHOOT	OBSERVED PEAK OVERSHOOT
SET 1		
SET 2		
SET 3		

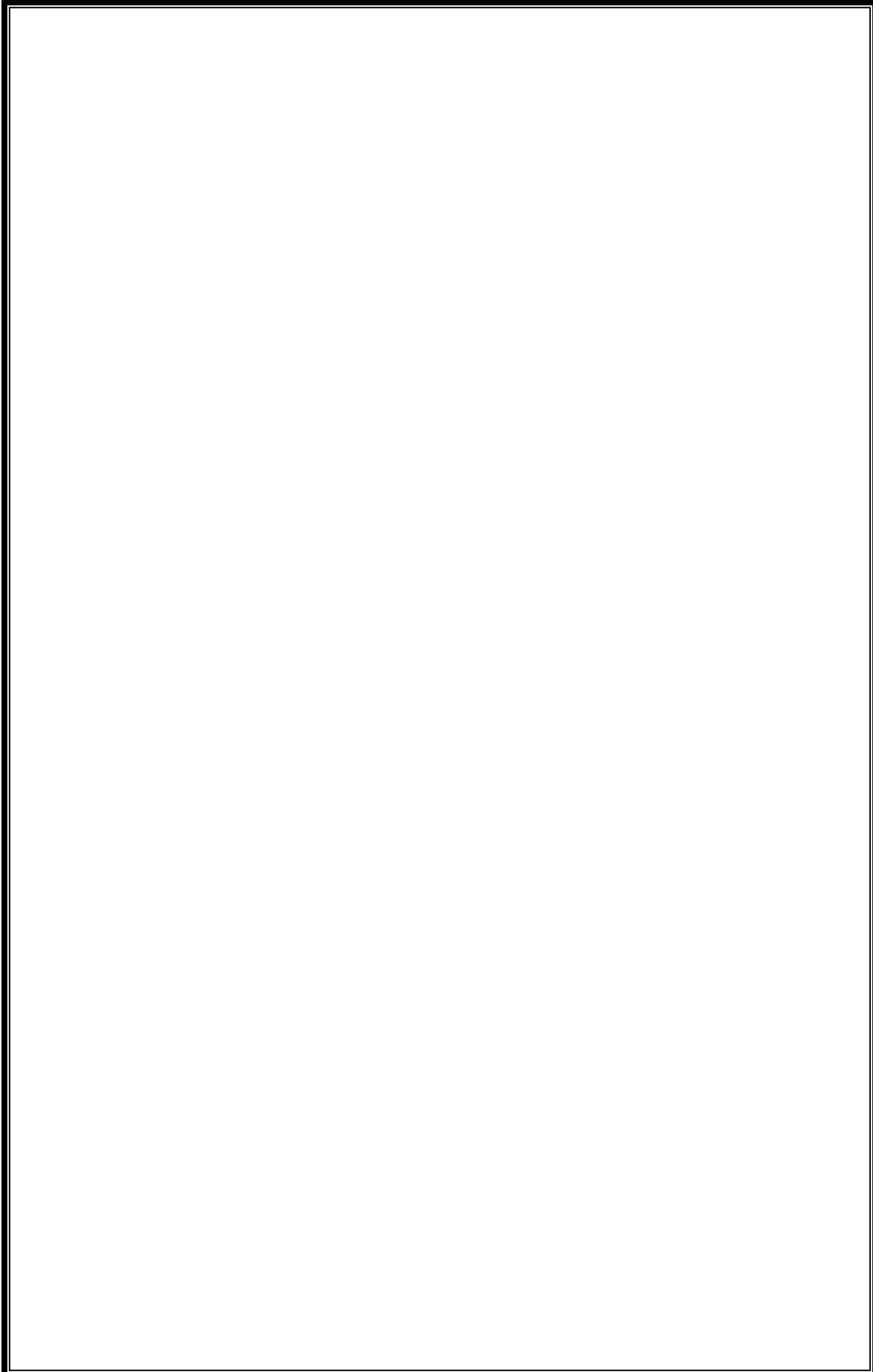
CALCULATIONS :

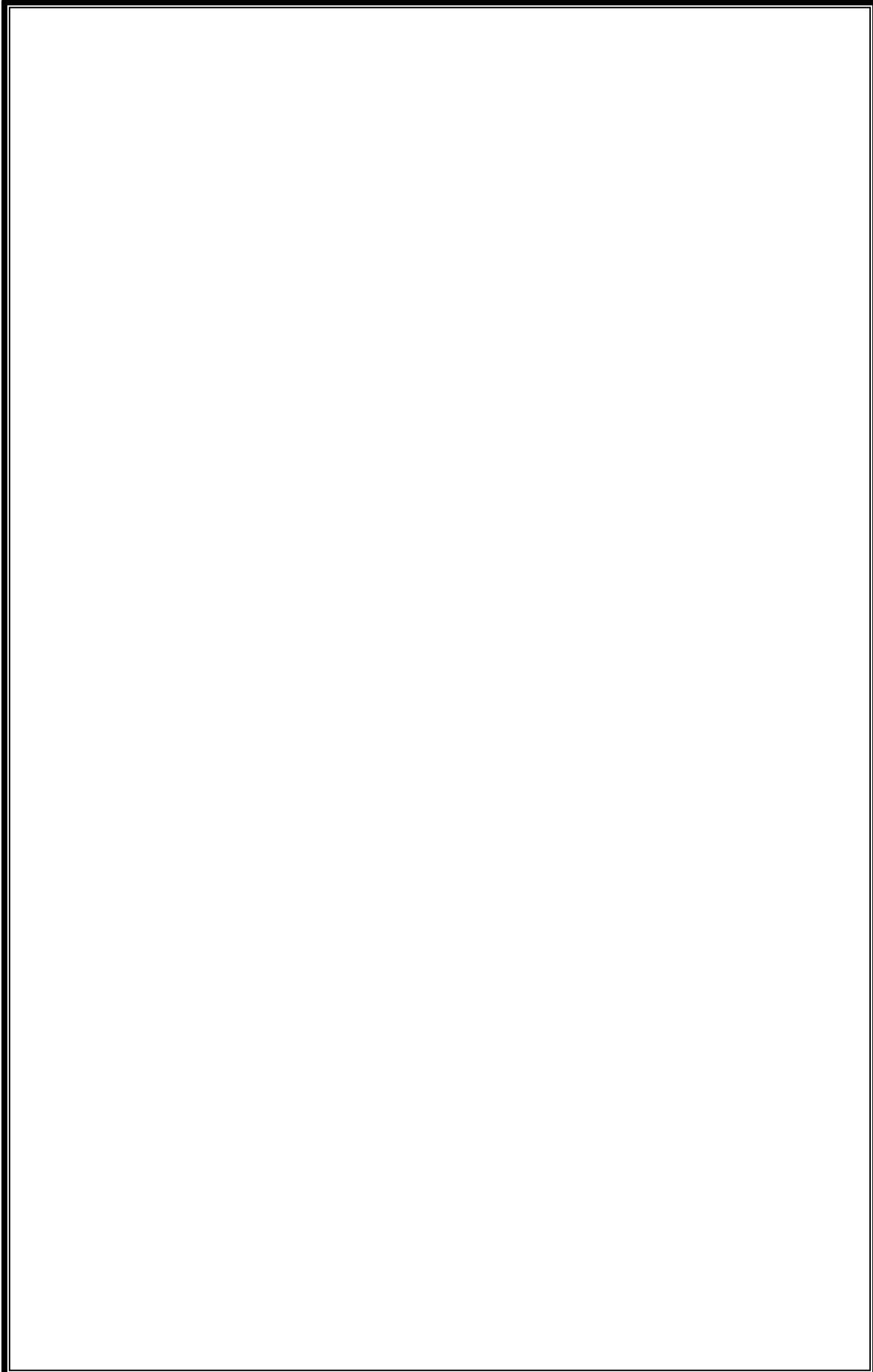
- $MP = e^{-\pi\zeta/\sqrt{1-\zeta^2}} \times 100 \%$
- $tr = \frac{\pi - \phi}{\omega_d}$
- Damping Angle $\phi = \cos^{-1} \zeta$
- $tp = \frac{\pi}{\omega_d} = \dots\dots\dots \mu s$
- $ts = \frac{4}{\zeta\omega_n} = \dots\dots\dots$ For 2% tolerance.

UNDER DAMPED SYSTEMS**OBSERVATION**

Practical Specific	t_d	t_r	t_p	M_p	e_{ss}	t_s
Practical						
Theoretical						







2. STUDY OF CHARACTERISTICS OF SYNCHROS

AIM :

To study the characteristics of synchro transmitter and receiver system.

APPARATUS :

S.NO	ITEM	TYPE	RANGE	QUANTITY
1	Synchros Kit			1
2	Patch Cords			
3	Multimeter			1

THEORY :

The term synchro is a generic name for a family of inductive devices which works on the principle of a rotating transformer basically they are electro-mechanical devices or electromagnetic transducers which produces an o/p voltage depending upon angular position of the rotor a synchro system is formed by inter connection. The basic synchro is usually called a synchro transmitter. Its construction is similar to that of a three phase alternator. The stator (stationary member) is of laminated silicon steel and is slotted to accommodate a balanced three phase winding which is usually of concentric coil type f (three identical coils are placed in the stator with their axis 120 degree apart) and is Y connected. The rotor is a dumb bell shape type in construction and wound with a concentric coil. An a.c. voltage is applied to the rotor winding through slip rings. The system set up is consists of synchro transmitter and synchro receiver on a single rigid panel housed in MS cabinet plates, Rotor position of Tx and Rx is marked by graduated angular scale with pointer arrangement. AC input excitation supply for rotor of Tx and Rx is provided internally and panel switches are provided to make it On and Off independently. Test points for Tx and Rx stator and Rotor points are provided on panel.

PROCEDURE :

1. Connect the mains supply to the unit.
2. Varying rotor position of Transmitter in steps of 30° note down V_{S1S2} , V_{S2S3} , V_{S3S1} readings.

3. Connect S1, S2, S3 of Transmitter to S1, S2, S3 of receiver respectively.
4. Move the rotor of synchro Transmitter in steps of 30 degrees and note down the change in Receiver rotor.
5. Enter the input angular position Transmitter rotor and output angular position of Receiver rotor in tabular form and plot a graph.
6. Plot graph settings :
 - a) $(V_{s1s2}, V_{s2s3}, V_{s3s1}) V_s \theta_t$
 - b) $\theta_r V_s \theta_t$

RESULT :

The characteristics of synchros are obtained from the graphs drawn.

PRECAUTIONS :

- 1 Loose connections are to be avoided.
- 2 Circuit connections should not be made while power is on.
- 3 Readings of meters must be taken without parallax error
- 4 Handle the pointers in gentle manner.
- 5 Do not attempt to pull out the pointers.
- 6 Do not short rotor or stator terminals.

ASSESMENT QUESTIONS :

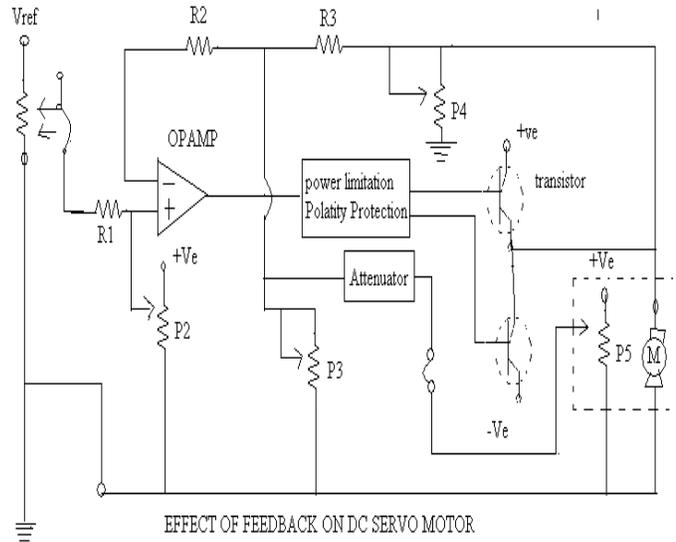
1. What is a synchro?
2. What is the use of synchro?
3. What is the constructional difference between synchro transmitter & synchro receiver?
4. What is the relation between a synchro & a transformer?
5. Where do we get maximum e m f in a synchro?
6. When we will get maximum e m f in a synchro?
7. What is the phase different between three voltages induced in the stator of synchro and why ?
8. How do you determine zero position of synchro
9. what is the error voltage induced ?





CIRCUIT DIAGRAM :

DC SERVO MOTOR CONTROL SYSTEM



OBSERVATIONS

Without feedback

S.No	Input angular displacement (degrees)	Output angular displacement (degrees)	Comment

3. EFFECT OF FEED BACK ON DC SERVO MOTOR

AIM :

To Study the effect feed back on D C Servomotor.

APPARATUS :

S.No	ITEM	Type	Range	Quantity
1	D.C servomotor kit			1
2	Patch cords			As required

Theory :**PROCEDURE :**

1. Switch on the main power supply to the kit without the connecting the feedback path.
2. Adjust it to Zero position by using Zero adjustment knob.
3. Varying the input potentiometer (P1) & Tabulate the angular displacement (P5) of Servo motor
4. Note the observation in tabular form
5. Switch off the power supply now connect the feed back path.
6. Switch on the power supply and adjust the gain knob to certain value.
7. Varying the input potentiometer (P1) & Tabulate the angular displacement (P5) of Servo motor.
8. Repeat the procedure for 2 or 3 values of gain. Plot the graph between input and output angular displacement potent
9. Now tabulated the comments observed before and after feed back.

RESULT :

The feedback characteristics are drawn & calculated by dc servomotor.



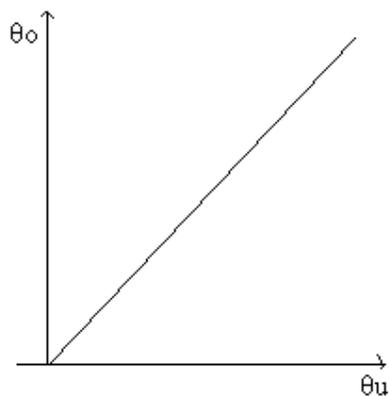
With feedback Gain P1 = Centre position

S. No	Input angular displacement (degrees)	Output angular displacement (degrees)	Comment

With feedback Gain P1 = Maximum position

S. No	Input angular displacement (degrees)	Output angular displacement (degrees)	Comment

GRAPHS :



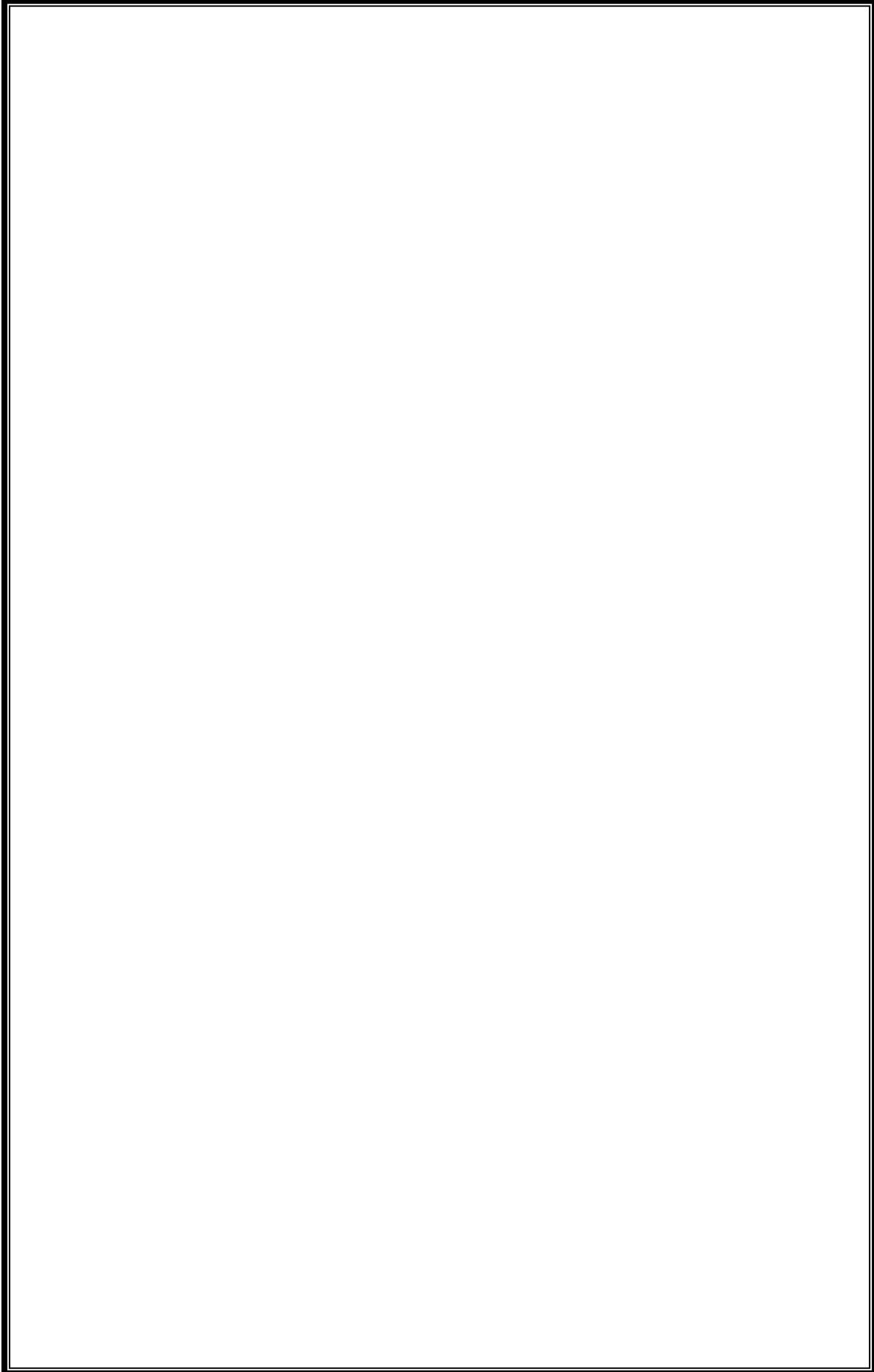


PRECAUTIONS :

1. Loose connections are to be avoided.
2. Circuit connections should not be made while power is on.
3. Readings of meters must be taken without parallax error

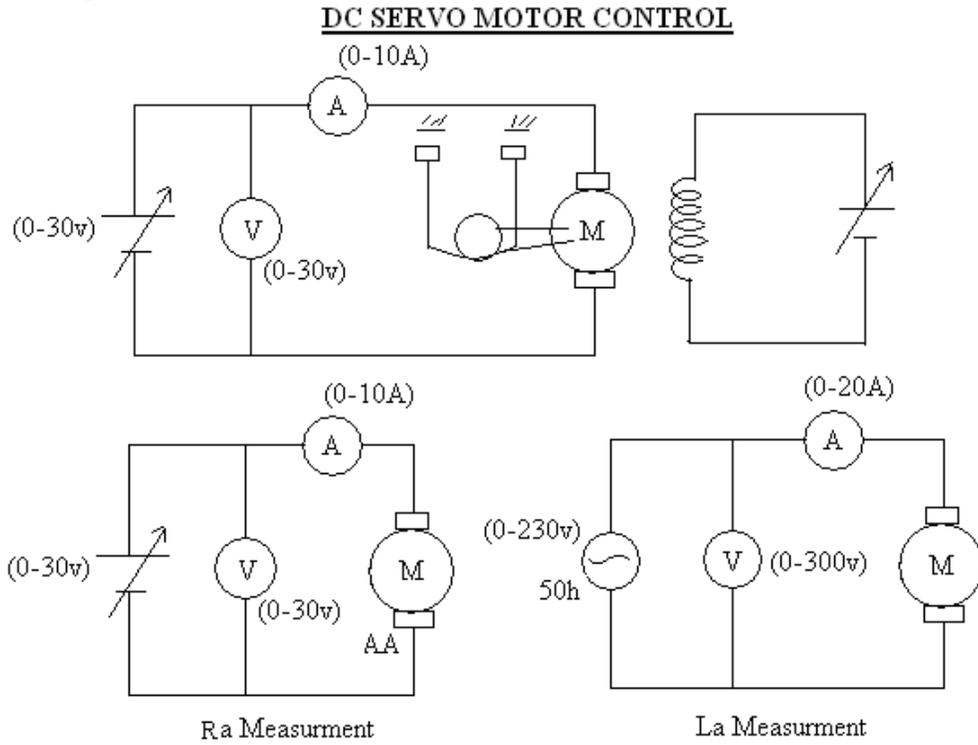
ASSESSMENT QUESTIONS :

1. What is a servomotor?
2. What are the applications of servomotor?
3. How do you load the D.C Servomotor?
4. Why a servomotor should not be switched on load?
5. What are the elements used as feedback
6. What are the general input and o/p parameters of D.C. servomotor
7. What is the element used as error detector in the given circuit.





Circuit diagram :



OBSERVATIONS :

For 8v.

S.No.	S ₁	S ₂	$T=9.81 (S_1-S_2) r$ Kg - m	Speed Nrpm	I _A amp

4. CHARACTERISTICS OF DC SERVO MOTOR

AIM :

To Study the D C Servomotor characteristics.

APPARATUS :

S.No	ITEM	Type	Range	Quantity
1	D.C servomotor kit			1
2	Multimeter			2
3	Patch cords			

THEORY :

DC Servomotor are broadly classified as:-

- i) Armature controlled dc servomotor.
- ii) Field controlled dc servomotor.

In Armature controlled DC Servo motor the field is excited by a constant dc supply. If the field current is constant then speed is directly proportional to armature voltage and torque is proportional to armature current. Hence torque and speed can be controlled by armature voltage reversible operation is possible by reversing the armature voltage. In small motors the armature voltage is controlled by a variable resistance.

In field controlled dc servomotor the armature is supplied with a constant current or voltage. When armature voltage is constant the torque is proportional to field flux since the field current is proportional to flux, the torque of the motor is controlled by controlling the field current. Reversible operation is possible by reversing the field current the response of field controlled motor is however slowed by field inductance.

$$V_a(s) - E_b(s) = (R_a + sL_a) I_a(s)$$

$$E_b(s) = K_b \omega(s)$$

$$T(s) = K_T I_a(s)$$

$$T(s) = (JS^2 + fS) I_a(s)$$

$$\frac{\theta(s)}{V_a(s)} = \frac{K_T}{(R_a + sL_a)(JS^2 + fS) + K_b K_T S}$$



For 10v.

S.No.	S ₁	S ₂	$T=9.81 (S_1-S_2) r$ Kg - m	Speed Nrpm	I _A amp

BACK -EMF Characteristics:-

S. NO.	Armature Voltage V _A (V)	I _A (Amp)	SPEED N(rpm)	ω $2\pi n/60$ (rad/sec)	Back emf E _b =V _A + I _A R _A	Feed back Voltage V _f (V)

PROCEDURE :**A) CONNECTION**

1. Connect the power supply cables of motor to respective A, AA, F FF terminals on the kit.
2. Connect the speed measurement chord to the kit

B) DETERMINATION OF K_T

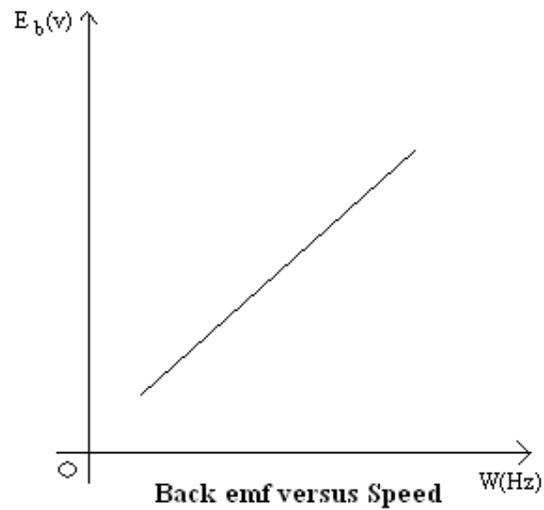
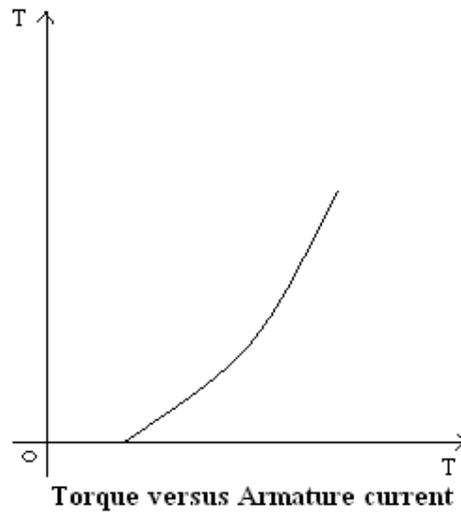
1. Switch on the power supply to the kit.
2. Vary the armature voltage such that the motor runs at rated speed
3. Take the no load readings of V_a , I_a , V_f , I_f , speed and S_1 , S_2
4. Repeat the step 3 by loading the machine, for 5 to 6 different sets of loads for 10v.
5. Calculate torque $T = (S_2 - S_1) 9.81 r$.
6. Plot the graph between torque T Vs I_a , to obtain K_T

C) DETERMINATION OF K_b

1. Connect the circuit as per the circuit diagram and switch on the main power supply
2. Varying the armature voltage in steps and note down V_a , I_a , Speed.
3. Bring the armature voltage pot to minimum position and switch off the supply.
4. Calculate back emf $E_b = V_a - I_a R_a$
5. Plot graph between E_b Vs N and determine the slope of the curve, to obtain K_b

D) DETERMINATION OF R_a

1. Connect the circuit as per the circuit diagram
2. Ensuring that armature is connected to D.C. supply. Switch on the main power supply.
3. Vary the armature voltage in steps and note down armature current
4. Determine $R_a = V_a / I_a$ and take the average of it

Graphs :


1. Determine $Z_a = \frac{V_a}{I_a}$, Take the average of it
2. Calculate $X_a = \sqrt{Z_a^2 - R_a^2}$
 $L_a = X_a / 2\pi f$

E) DETERMINATION OF L_a

3. Connect the circuit as per the circuit diagram
4. Ensure that armature is connected to a.c. supply. Switch ON the main power supply
3. Vary armature voltage in steps and note down armature current.

RESULT :

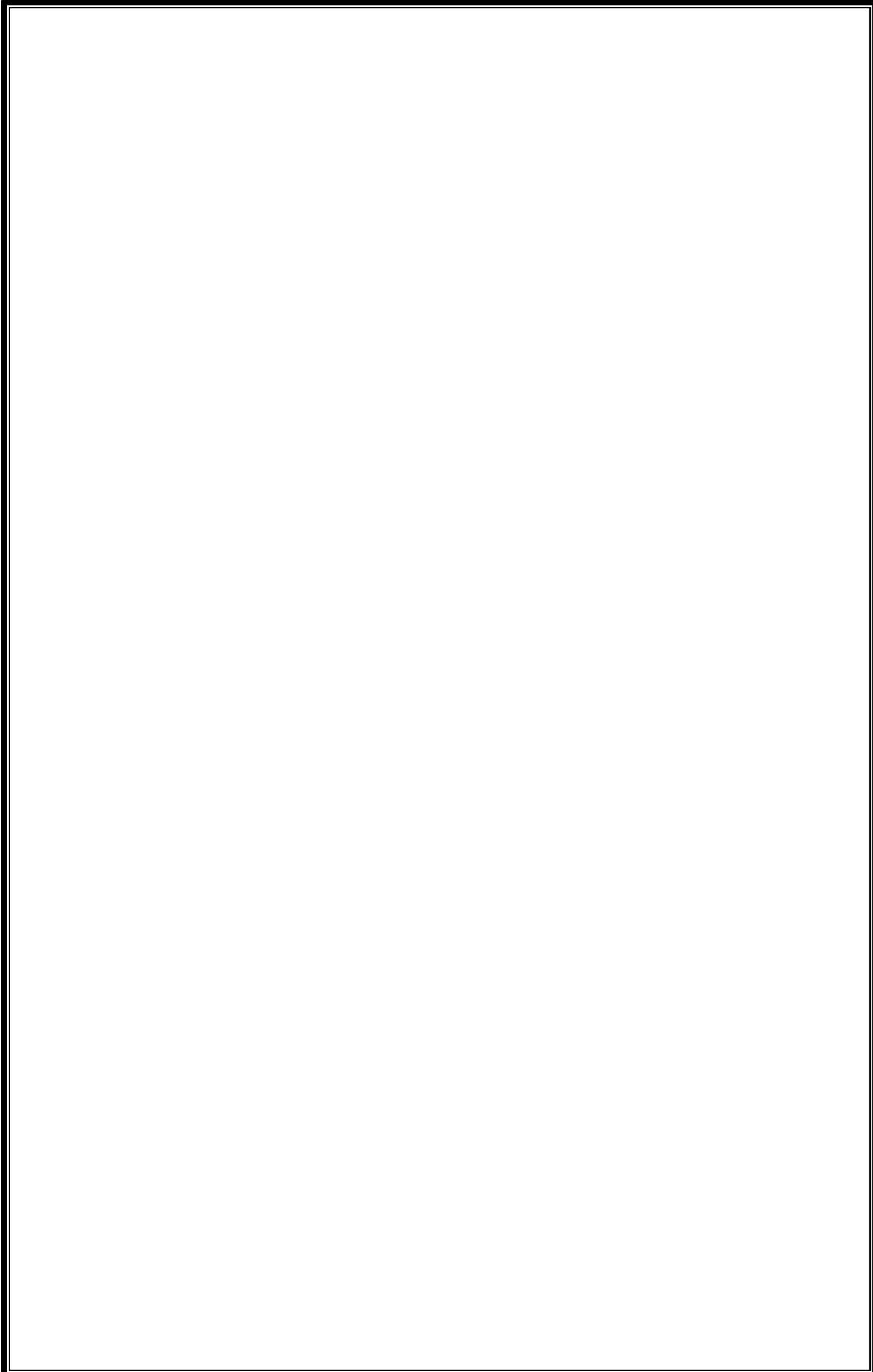
The transferfunction of DC servo motor is thus obtained.

PRECAUTIONS :

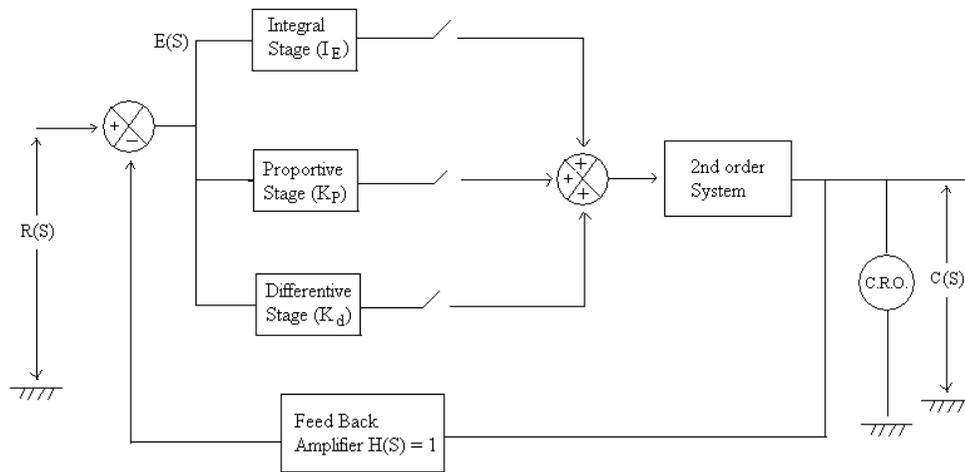
1. Loose connections are to be avoided.
2. Circuit connections should not be made while power is on.
3. Readings of meters must be taken without parallax error

ASSESSMENT QUESTIONS:

1. What is a servomotor?
2. What are the applications of servomotor?
3. How can we get the feed back characteristics of D.C Servomotor?
4. How do you load the D.C Servomotor?
5. Why a servomotor should not be switched on load?
6. What is a mathematical model ? What is its importance?
7. How do you define transfer function? What is its significance?
8. What are K_b , K_T





CIRCUITE DIAGRAM :

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

AIM :

To observe the effect of P,PD,PI,PID Controller on Second Order System.

APPARATUS:

S.No	Item	Type	Range	Qty
1	P,PD,PI,PID Controller Kit			1
2	Patch chords			As required
3	C.R.O			1

THEORY :

INTEGRAL ACTION (I ACTION):

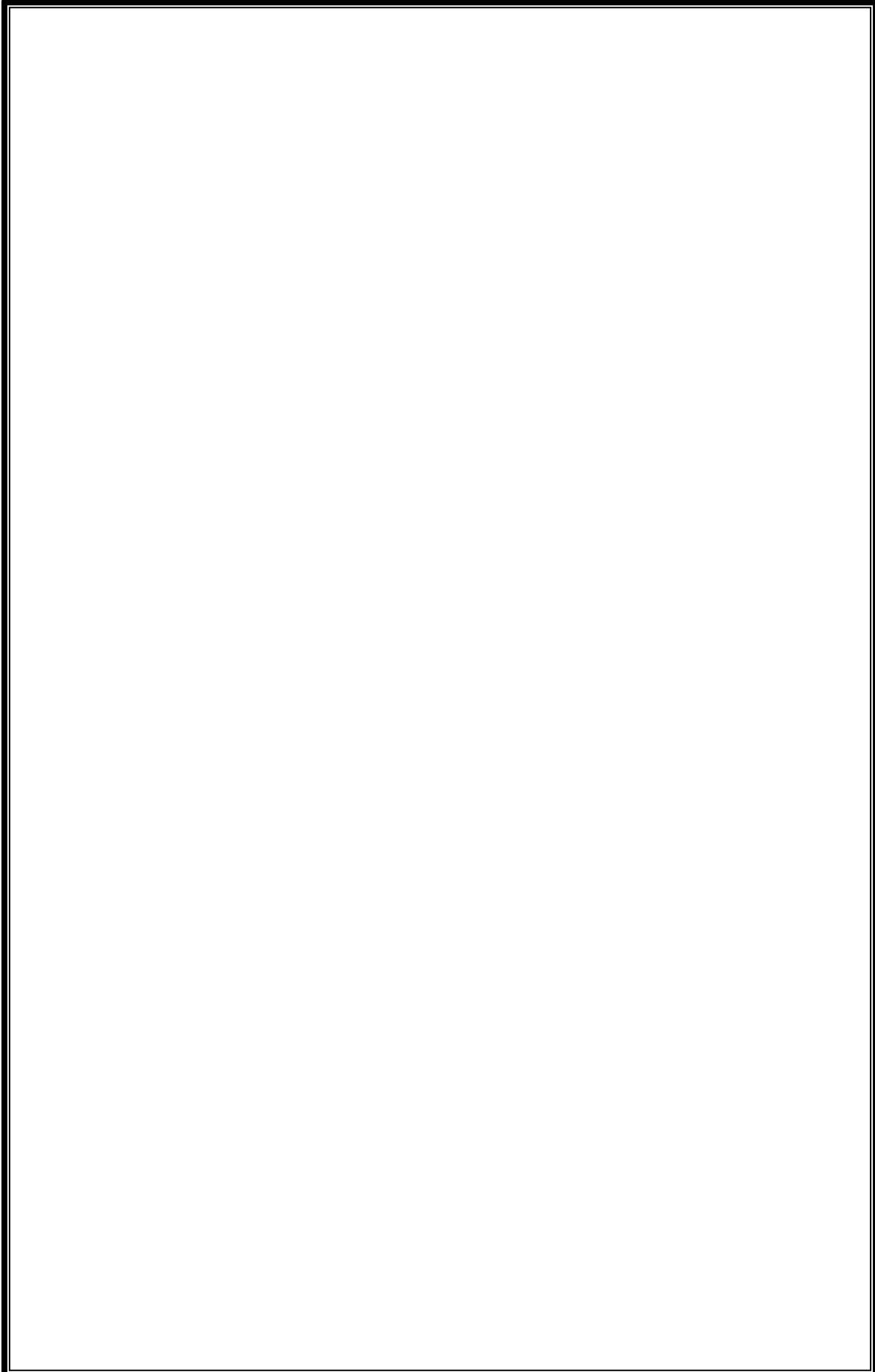
This is proportional to the integral of error, thus is dependent on the history of the out put and not only the current value. thus, the value of integral action contribution is not as obvious from the apparent output plot as in case of proportional contribution. The effect of I action is to reduce average value of the steady state error. Note that if steady state error is not constant(for example steady state error of sinusoidal + some constant value) then PI controller reduces the dc part (the average value) to zero and now sinusoidal variation about zero dc value remains. The disadvantage of integral action is that it increases system's setting time. A typical output plot with PI action (proportional+ integral) is shown below. For this K_d is set to zero.

DERIVATIVE ACTION (D ACTION):

The third term of PID controller transfer equation contributes proportional to the time derivative of error (or rate of change of error). This part is introduced to compensate against the output variations with respect to time.

If steady state error is not constant (for example steady state error of sinusoidal+ some constant value) then PD controller reduces the varying part to zero and the constant steady error of average value remains.

The D action depends on few past and the current error value and not the complete history as in case of integral action. The contribution is high - speed changes in output that may occur because of various reasons. This



also responds to the output variations that may rise due to noise in the sensing, conditioning and feedback network which is unnecessary and hence these parts must be precision type.

PROCEDURE :

1. Connect the circuit as per the block diagram shown
2. Switch ON the main power supply and select Input square wave signal of certain amplitude and frequency. Note the input waveform from C.R.o.

P-Controller:

3. Switch ON Proportional stage keeping integral, derivative stage in OFF position
4. Vary the proportional gain K_P for 3 to 4 values and note down the Output $C(S)$ waveforms for each value.

PD Controller:

5. Switch ON derivative stage keeping integral stage OFF and fix K_P at certain value.
6. Vary Derivative gain D_t for 3 to 4 values and Note down the Output $C(S)$ waveforms for each value

PI Controller:

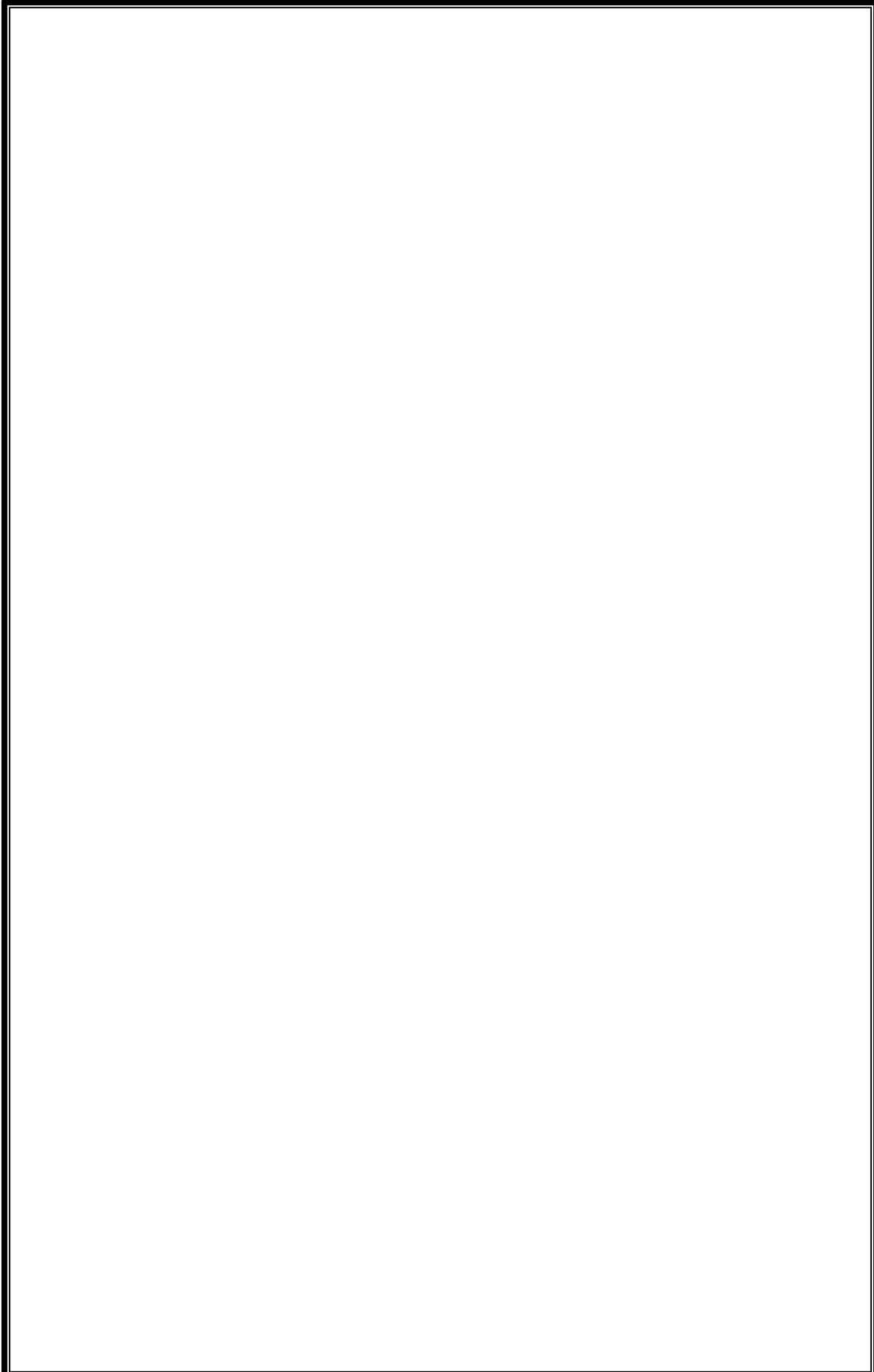
7. Switch OFF D_t stage, Switch ON Integral stage and Fix K_P at certain value
8. Vary Integral gain I_{nt} for 3 to 4 values and note down the output $C(S)$ waveforms for each value.

PID Controller:

9. Switch ON all the three controllers fix derivative, Integral controller at certain values.
10. Vary proportional controller gain K_P and note down output $C(S)$ waveforms.
11. Compare the output waveforms for different controller gains and write remarks on the effects of various controller gains on 2nd order system time response specifications.

RESULT :

The effect of P, PI, PD, PID controllers are studied





PRECAUTIONS :

1. Loose connections are to be avoided.
2. Circuit connections should not be made while power is on.
3. Readings of meters must be taken without parallax error

ASSESSMENT QUESTIONS:

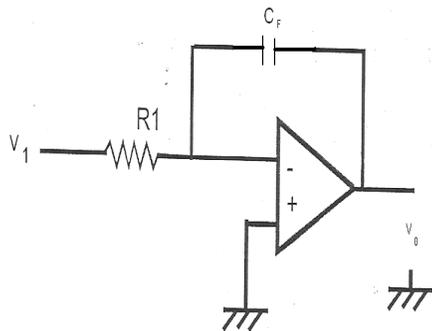
1. What is the use of a controller in control system?
2. What is the use of proportionality controller?
3. Why is integral controller used?
4. Why is differential controller used?
5. How can you rectify an error using controller?
6. What is meant by sampling network?
7. How do you sense the errors in a control system?
8. What do you mean by tuning of controller?
9. Which controller is most commonly used?



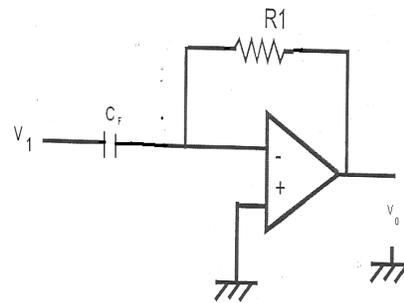


CIRCUIT DIAGRAM:

INTEGRATOR



DIFFERENTIATOR





6. SIMULATION OF OP-AMP BASED INTEGRATOR AND DIFFERENTIATOR CIRCUIT

AIM: Simulation of Op-amp based differentiator circuit using PSPICE.

DIFFERENTIATOR

PROGRAM:

```
.SUBCKT OPAMP 1 2 7 4
EA 4 5 3 4 2E+5
RI 1 2 2E6
GB 4 3 1 2 0.1M
R1 3 4 10K
C1 3 4 1.5619UF
RO 5 7 75
.ENDS
```

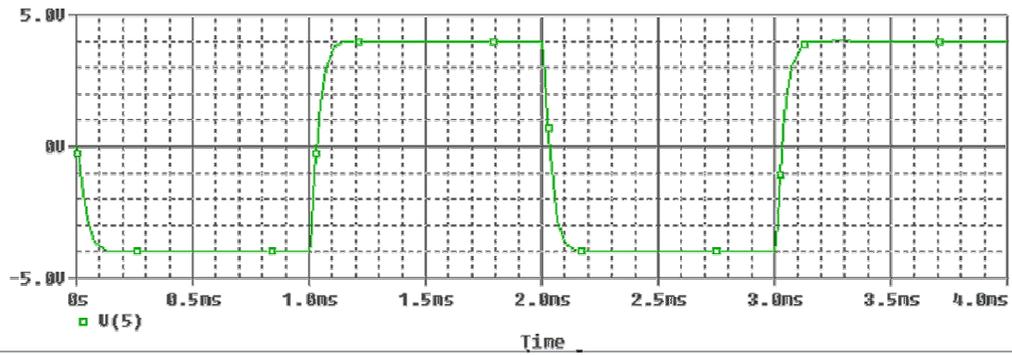
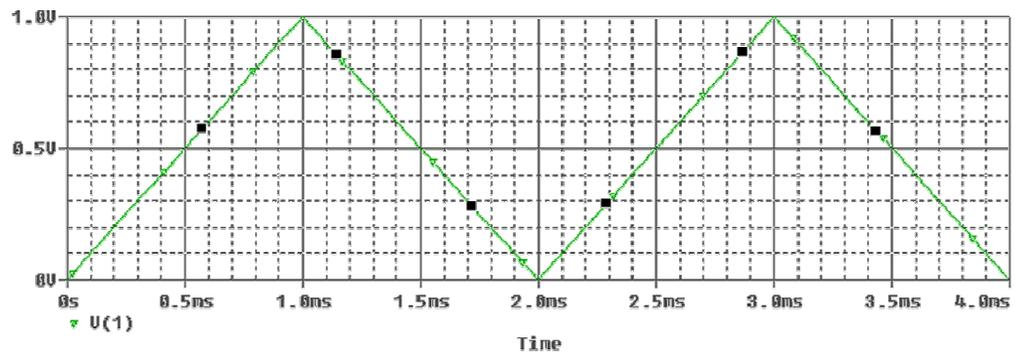
```
Vs 1 0 PWL(0 0 1M 1 2M 0 3M 1 4M 0)
```

```
R1 1 2 100
C1 2 3 0.4U
RX 4 0 10K
RL 5 0 100K
RF 3 5 10K
XA1 3 4 5 0 OPAMP
.TRAN 0 4M
.PROBE
.END
```

INTEGRATOR

PROGRAM:

```
.SUBCKT OPAMP 1 2 7 4
EA 4 5 3 4 2E+5
RI 1 2 2E6
GB 4 3 1 2 0.1M
R1 3 4 10K
C1 3 4 1.5619UF
RO 5 7 75
.ENDS
```

DIFFERENTIATOR OUT PUT WAVEFORMS:

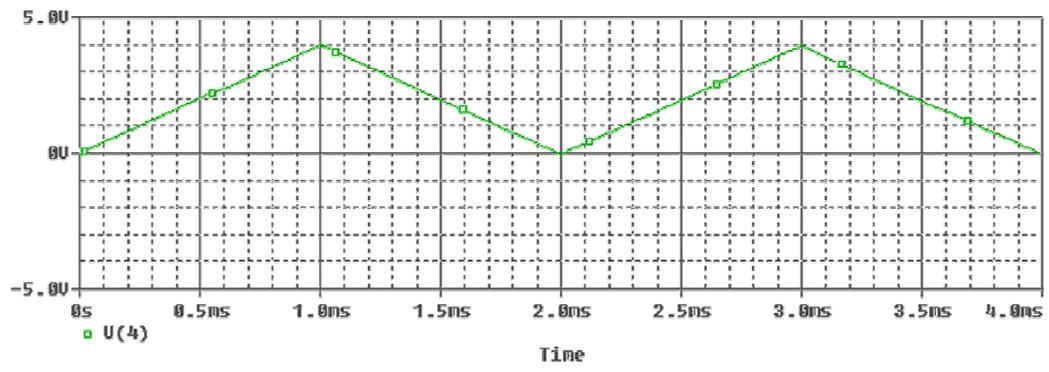
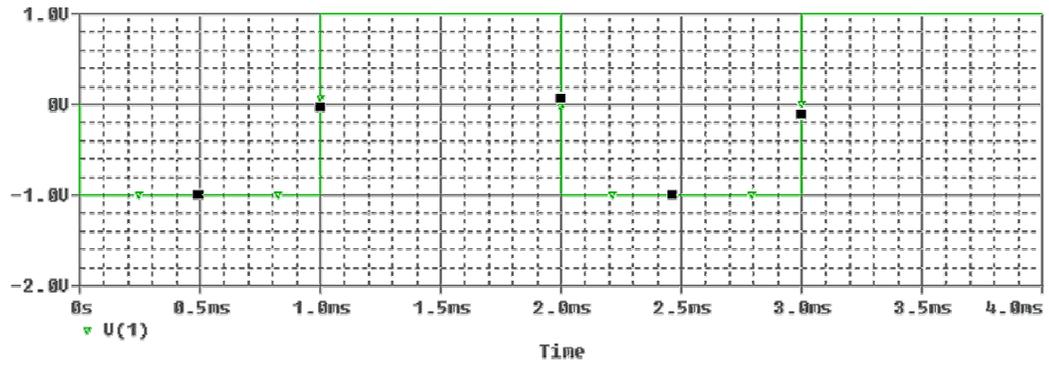


```
Vs 1 0 PWL(0 0 1N -1 1M -1 1.0001M 1 2M 1 2.0001M -1 3M -1 3.0001M 1 4M 1)
R1 1 2 2.5K
Rf 2 4 1MEG
Rx 3 0 2.5K
RI 4 0 100K
C1 2 4 0.1U
XA1 2 3 4 0 OPAMP
.TRAN 0 4M
.PROBE
.END
```

Procedure :

1. Represent nodes for the given circuit
2. Write PSPICE program in the PSPICE text editor and run the program
3. Make the connections if required
4. Observe the output and plot the waveform

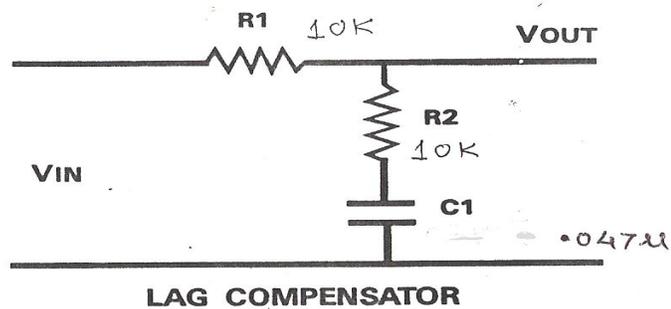
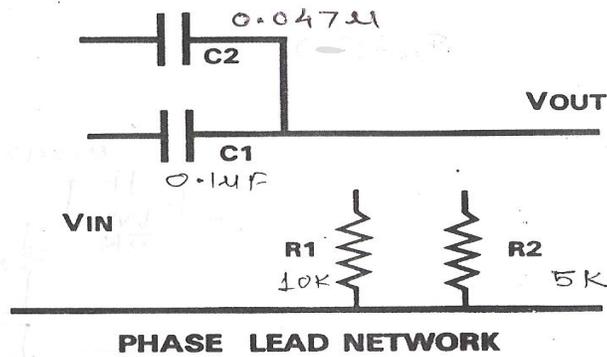
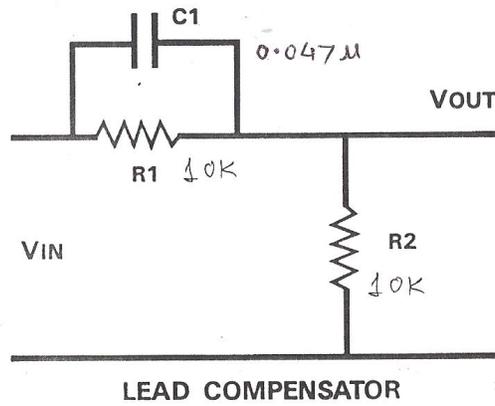
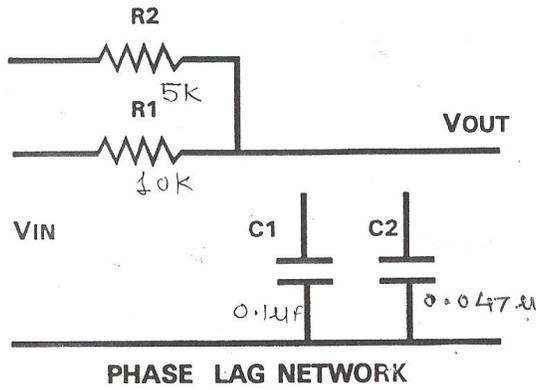
RESULT:

INTEGRATOR OUT PUT WAVEFORMS:







CIRCUIT DIAGRAM:

7. STUDY OF LAG LEAD COMPENSATION

AIM :

To study the characteristics of lag lead compensators

APPARATUS :

S.No	Item	Type	Range	Quantity
1.	LAG LEAD Trainee kit			1
2	Patch cords			
3	Multimeter			2

Theory :

Passive electric components –resistors, capacitors and inductors are used for implementation of a compensator. However the inductor is a very bulky component at low frequencies, passive networks are made up of only resistors and capacitors are used in practice. Condition for reliability of transfer function $D(s)$ with passive resistor capacitor (RC) networks is that all finite poles of $D(s)$ may lie anywhere in s-plane. By taking an operational amplifier to the output of passive RC network, it is possible to realize a specified gain of the compensator.

STUDY OF SIMPLE PHASE LEAD NETWORK:

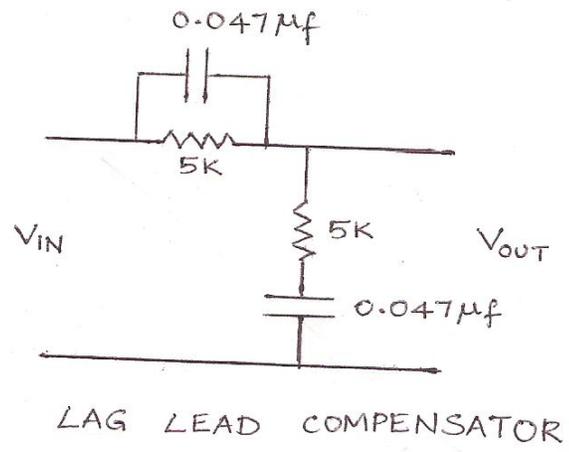
Lead compensator has a single pole and a single zero with the pole lying to the left of the zero on the negative real axis of the complex plane. The first order compensator is a lead compensator if $p > z$.

STUDY OF SIMPLE PHASE LAG NETWORK

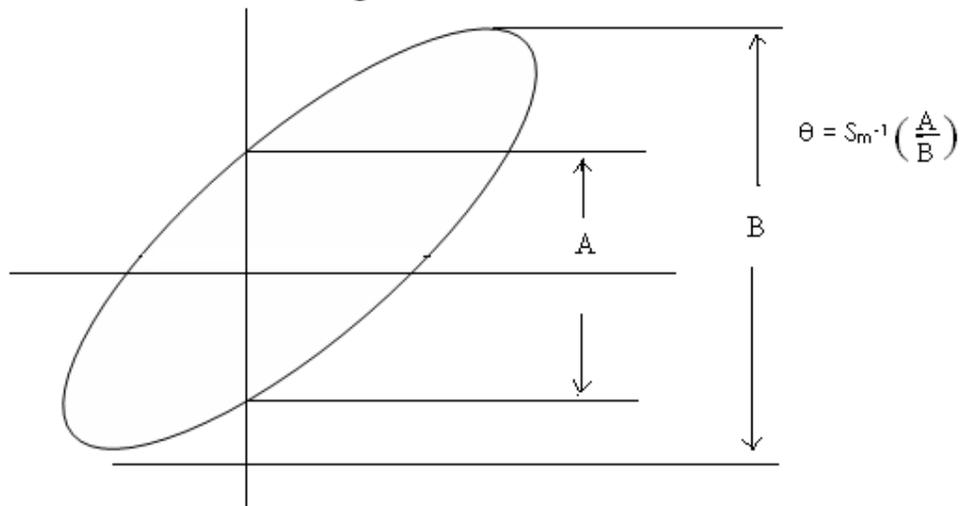
A lag compensator has a single pole and a single zero with the pole lying to the right of zero on negative real axis of the complex plane. The first order compensator is therefore a lag compensator if $p < z$.

PROCEDURE:

1. Connect the circuit as per circuit diagram for phase lag network.
2. Switch ON the power supply to function generator and adjust input sine wave to say 5V.



Angle measurement in C.R.O.

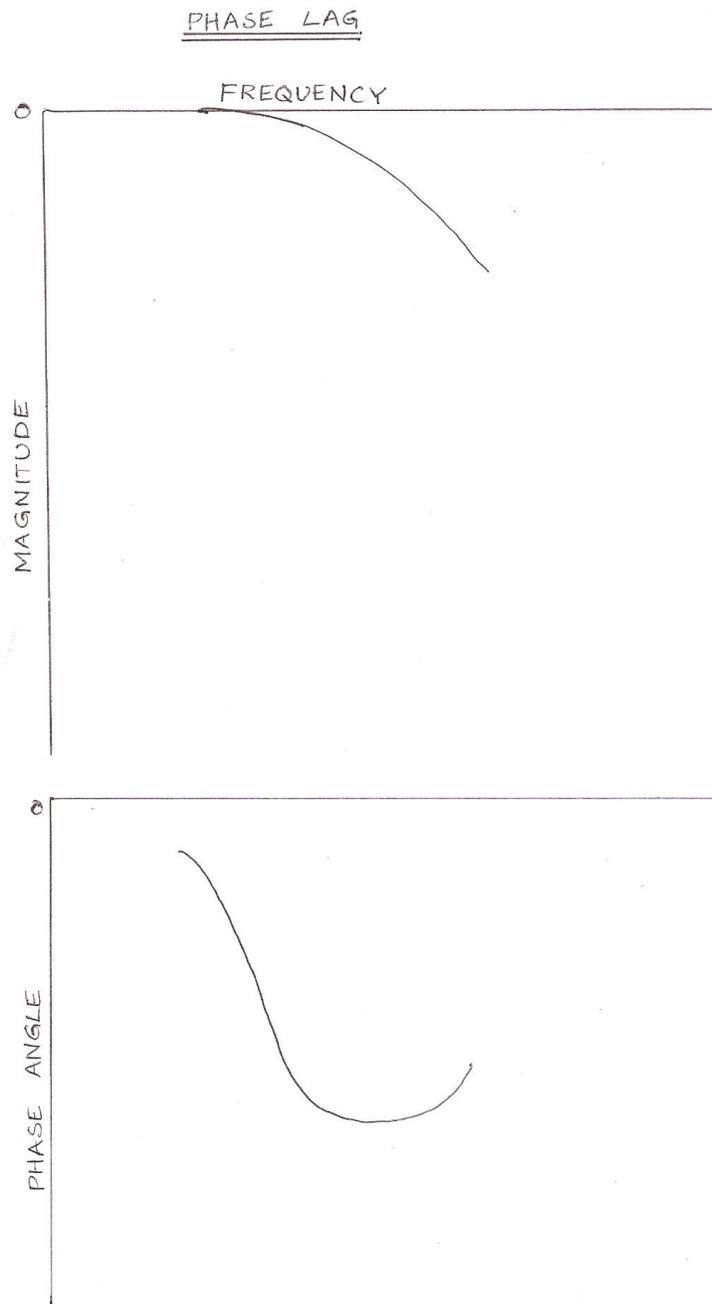


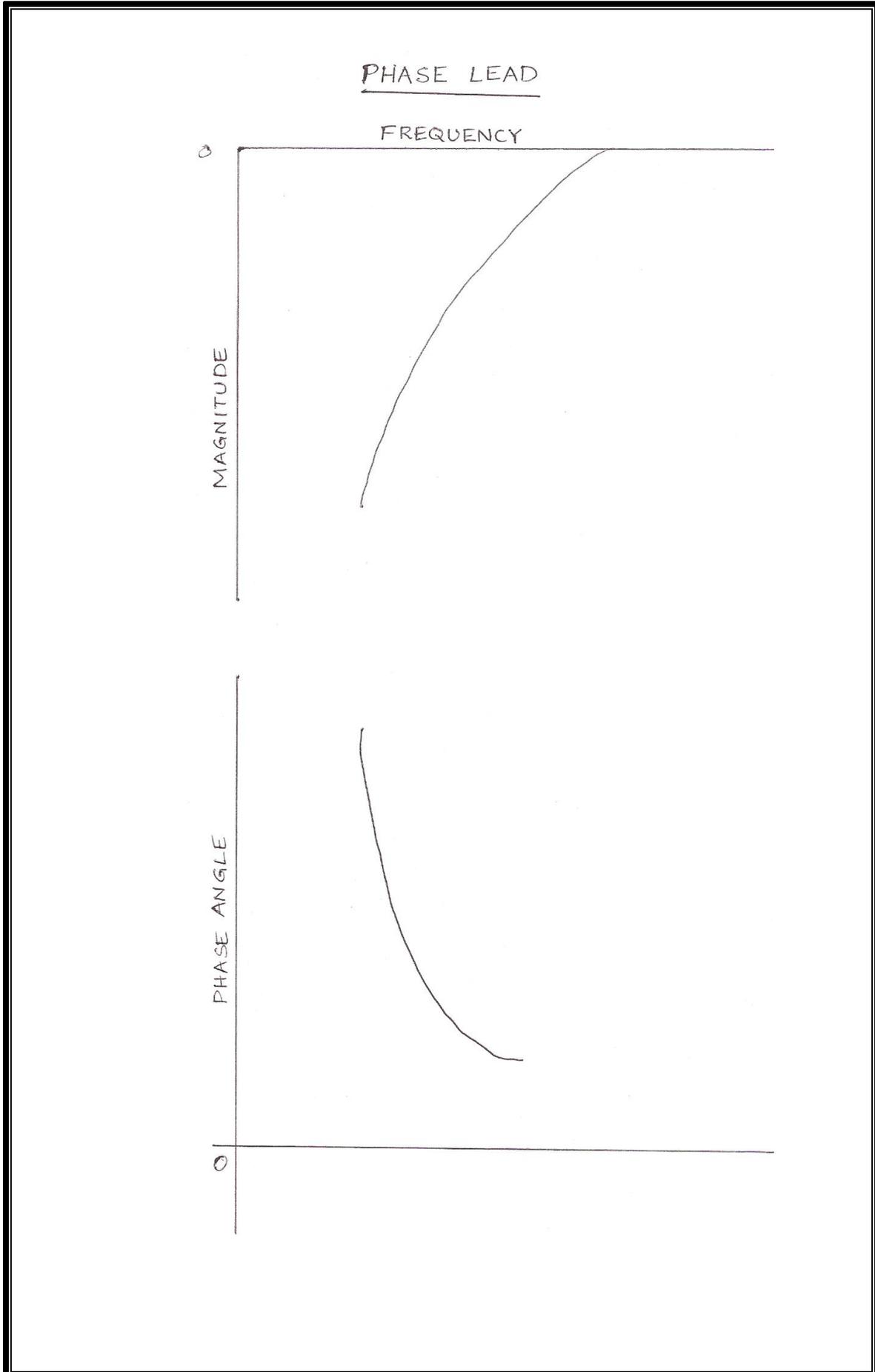


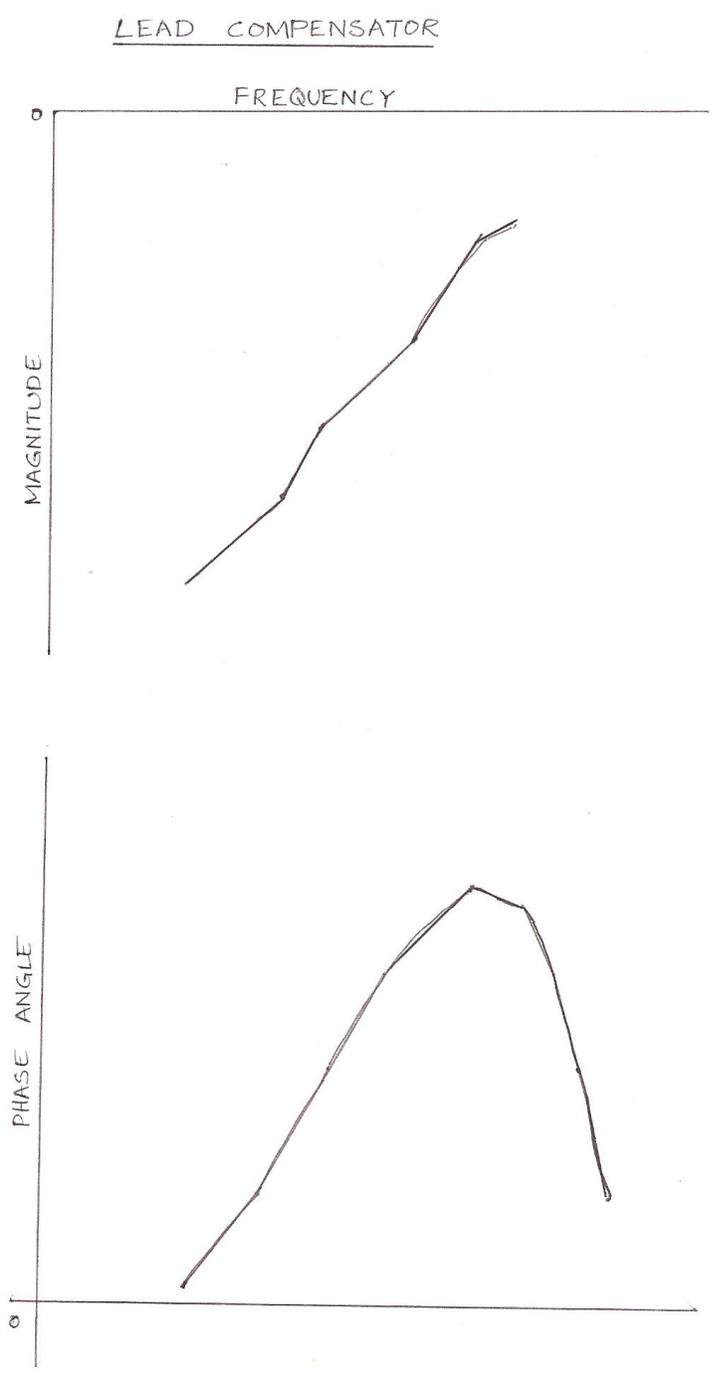
3. C.R.O. is to be connected in X-Y mode for phase displacement measurement connect X-input of CRO to input of lag network and Y- input of C.R.O to output of lag network.
4. Slowly vary the input frequency and note down the output magnitude to calculate gain $|T(j\omega)|$ and change in phase shift $\angle T(j\omega)$ using Bode's figures concept
5. Calculate the theoretical values of $|T(j\omega)|$ and θ from the formula given above.
6. Plot the graphs of $|T(j\omega)|$ and θ adjusting frequency. Find the common frequency.
7. Repeat the above procedure for lead network, lead compensator, lag compensator.
8. Draw Bode plot for all the system.



GRAPHS :

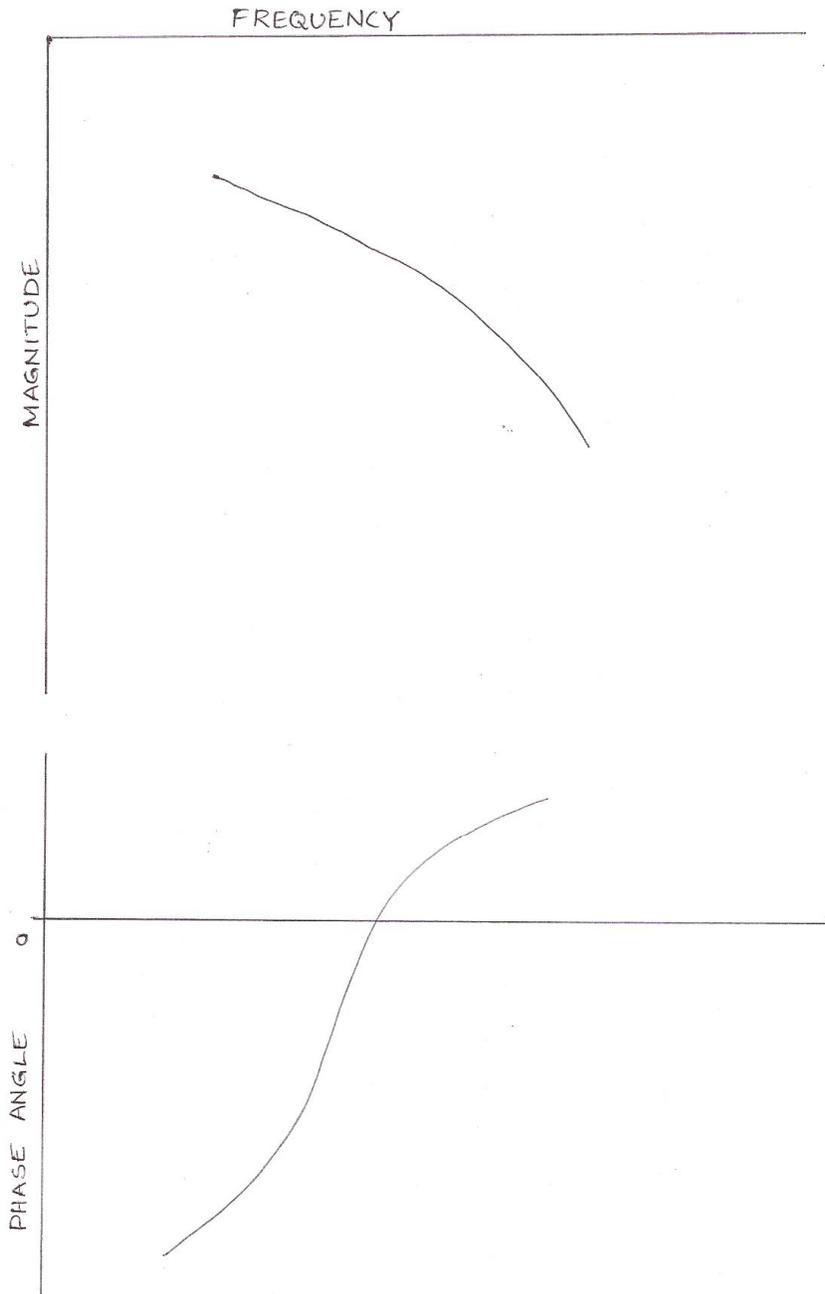








LEAD LAG COMPENSATOR



**OBSERVATIONS:****LAG NETWORK:**

S. No.	f (Hz)	V _o (V)	V _i (V)	Practical		Theoretical	
				$ T(j\omega) $ db $20 \log T(j\omega) $	θ Degrees	$ T(j\omega) $	θ
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

LEAD NETWORK:

S. No.	f (Hz)	V _o (V)	V _i (V)	Practical		Theoretical	
				$ T(j\omega) $ 20 log $ T(j\omega) $ db	θ Degrees	$ T(j\omega) $	θ
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							



**LAG COMPENSATOR:**

S. No.	f (Hz)	V_o (V)	Practical		Theoretical		
			V_i (V)	$ T(j\omega) $ db $20 \log T(j\omega) $	θ	$ T(j\omega) $	θ
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

LEAD COMPEASATOR:

S. No.	f (Hz)	V_o (V)	V_i (V)	Practical		Theoretical	
				$ T(j\omega) $ db $20 \log T(j\omega) $	θ	$ T(j\omega) $	θ
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							



RESULT:

Thus the design of lag lead compensator network has been verified.

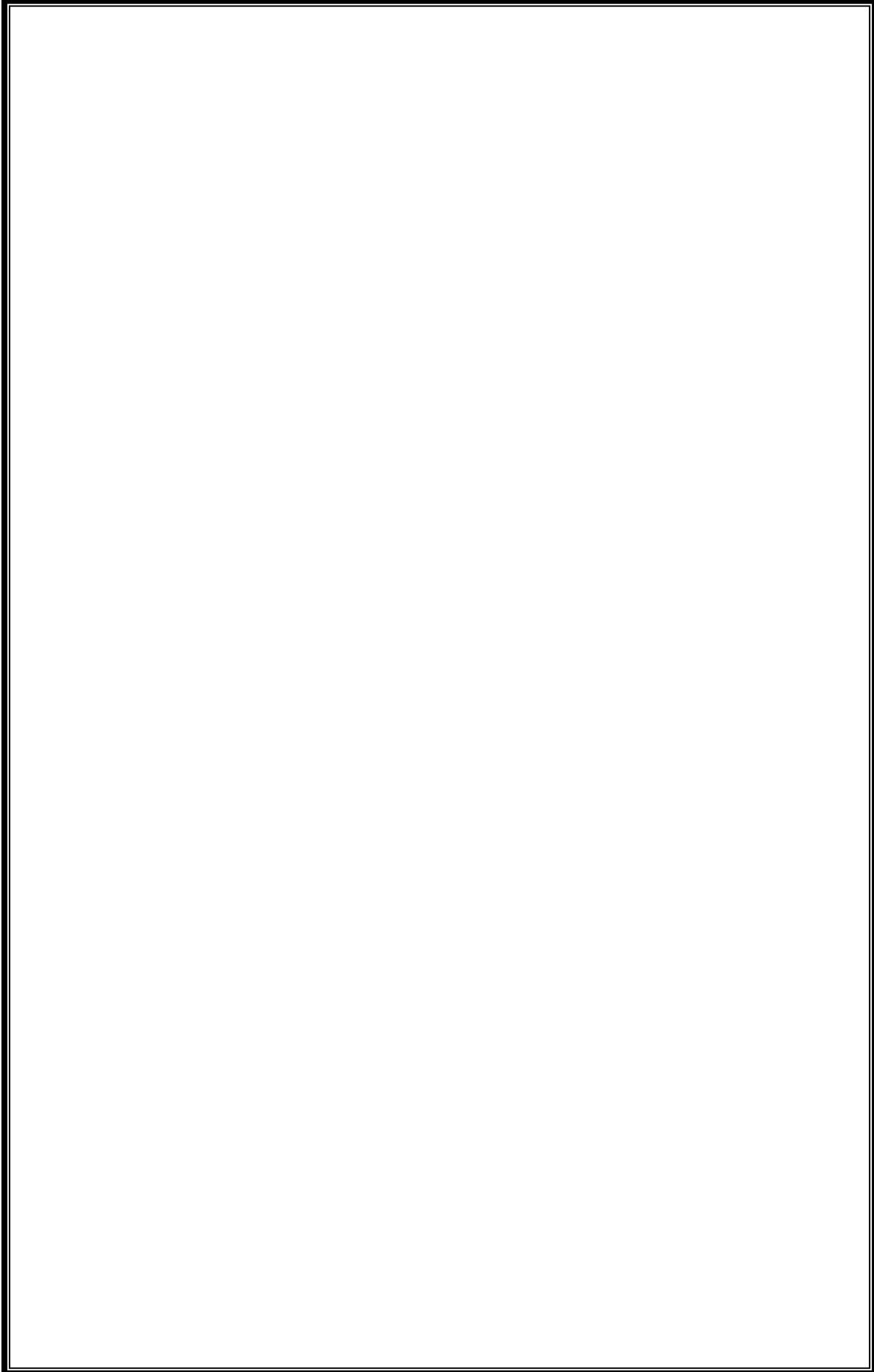
PRECAUTIONS :

1. Loose connections are to be avoided.
2. Circuit connections should not be made while power is on.
3. Readings of meters must be taken without parallax error.

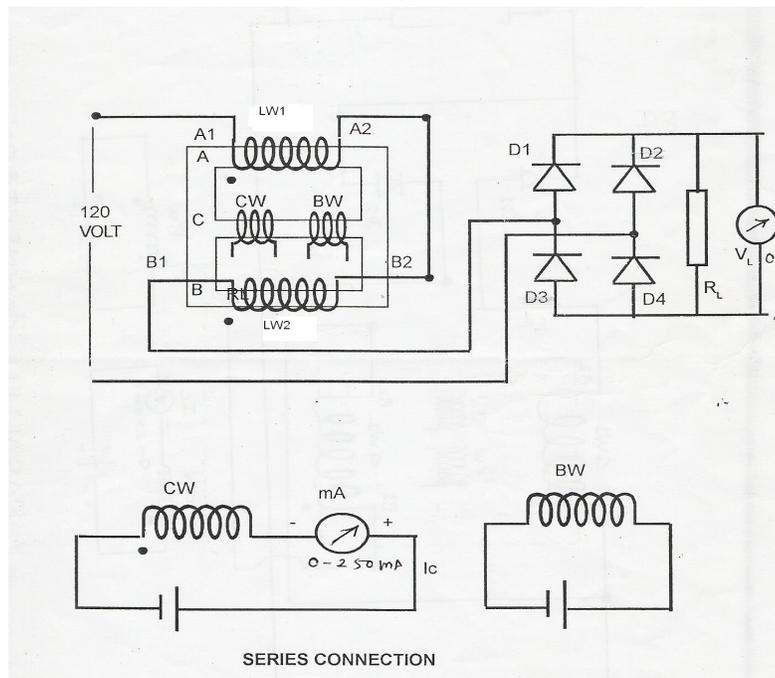
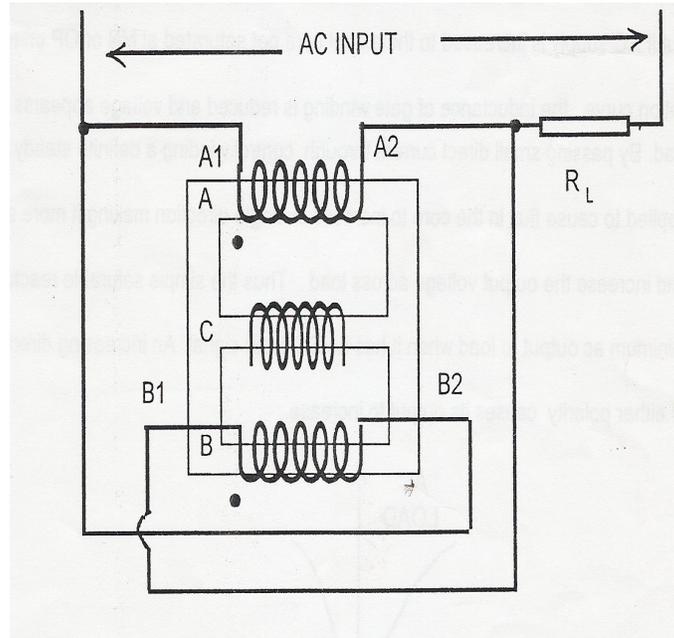
ASSESSMENT QUESTIONS:

1. What is the formula for calculating phase angle?
2. What is the formula magnitude of phase lead circuit lag network & loss?
3. What is the difference between lag network & low pass filter?
4. What is meant by compensation?
5. How a lag network can be compensated?





CIRCUIT DIAGRAM:



8. CHARACTERISTICS OF MAGNETIC AMPLIFIER

AIM:

To study the characteristics of magnetic amplifier.

APPARATUS:

S.NO	ITEM	TYPE	RANG E	QUANTITY
1	Magnetic Amplifier Kit			1
2	Patch Cords			
3	Multimeter			1

THEORY:

Amplification is the control of a larger output quantity by the variation of a small input quantity. Magnetic device used to perform such ctrl is the magnetic amplifier. The combination of saturable reactor with rectifier is called magnetic amplifier.

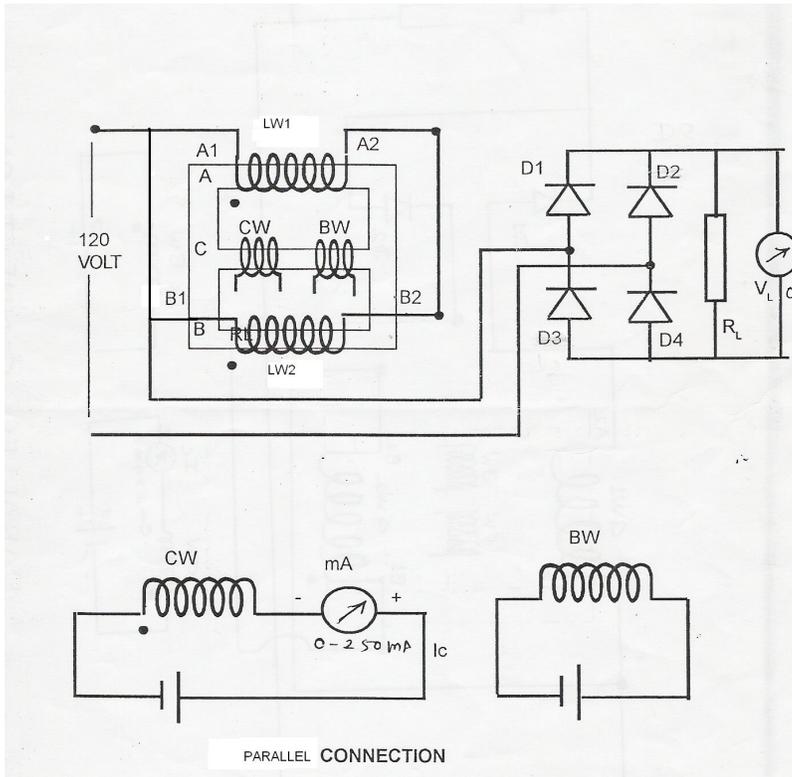
Saturable reactor:- This device acts as a variable inductance connected in series with a load across an a c power supply. It is nothing but a transformer, having two or more windings around a core of steel core A&B has it's own ac windings connected her in phase opposition so that when flux moves to the right with in the upper A coil an equal flux moves to the left with in the lower B coil with in the ctrl coil Two flux movements are in opposite direction. There by no objectionable ac voltage is induced in the control winding.

Operation:- Gate winding is when operated sin. O&M the voltage across load is very small. But if ac supply is increase to the extent core get saturated at MN or OP on magnetization curve, the inductance of gate winding is reduced & voltage appears across load by passing small dc through control windings .a definite steady MMF is applied to cause flux in the core to increase in single direction making it more saturated and increase the o/p voltage across the load.

Magnetic Amplifier :- When Si diode are added in series with each gate winding of the saturable reactor. It becomes self saturated reactor also called as magnetic amplifier.

Effect of connecting diode:- When AC power is first applied to the circuit small magnetizing current flow in gate winding and produces initial flux x. during first part of second wave the core flux raises from x to y and during reverse current , the part of y say y flux remains in core. In succeeding cycles, the flux in core is increase to such an extent that the core operate on the flat portion of the curve through out the entire half cycle. Thus although no direct current yet flows in the ctrl

MAGNETIC AMPLIFIER



Observations:

Parallel Connection:- $R_L = 156\Omega$.

S.NO	I_c (ma)	$V_{DC}(v)$	$V_L(v)$	$I_L = \frac{V_L}{R_L}$

Gain A

windings on the central leg of the core, the reactor has become self saturated, entirely because of the action caused by gate windings combined with diode.

Bias windings:- However like C_w if extra winding is provided with fixed dc bias to self saturated reactor, then in power on condition, reactor will be unsaturated and load current is small. If required the dc bias of bias windings can be fixed to get zero current of ctrl winding at any desired it on the curve of load current.

PROCEDURE:

a) Parallel connection:-

1. Make the connections as shown in circuit diagram.
2. Make power on to the circuit.
3. Keep C_w dc supply and B_w dc supply to zero .note load voltage.
4. Adjust B_w dc supply to get minimum load voltage(V_L).
5. Now slowly increase the C_w dc supply in steps and note the ctrl current and load current.
6. Plot the graph of load current against control current.
7. Calculate the gain of amplifier $A = \frac{\Delta I_L}{\Delta I_c}$.
8. Calculate power gain = $\frac{V_L^2 / R_L}{V_{DC} I_{DC}}$

RESULT:

Thus the characteristics of Magnetic Amplifier determined and its gain is calculated.

SERIES

A=

P=

PARALLEL

A=

P=

PRECAUTIONS:

1. Loose connections are to be avoided.
2. Circuit connections should not be made while power is on.
3. Readings of meters must be taken without parallax error

ASSESSMENT QUESTIONS:

1. What is a magnetic amplifier?
2. What is the difference between magnetic amplifier & electronic amplifier?
3. Which amplifier (series parallel) gives maximum amplification?
4. What is the need of control winding?
5. What is the need of bias winding?

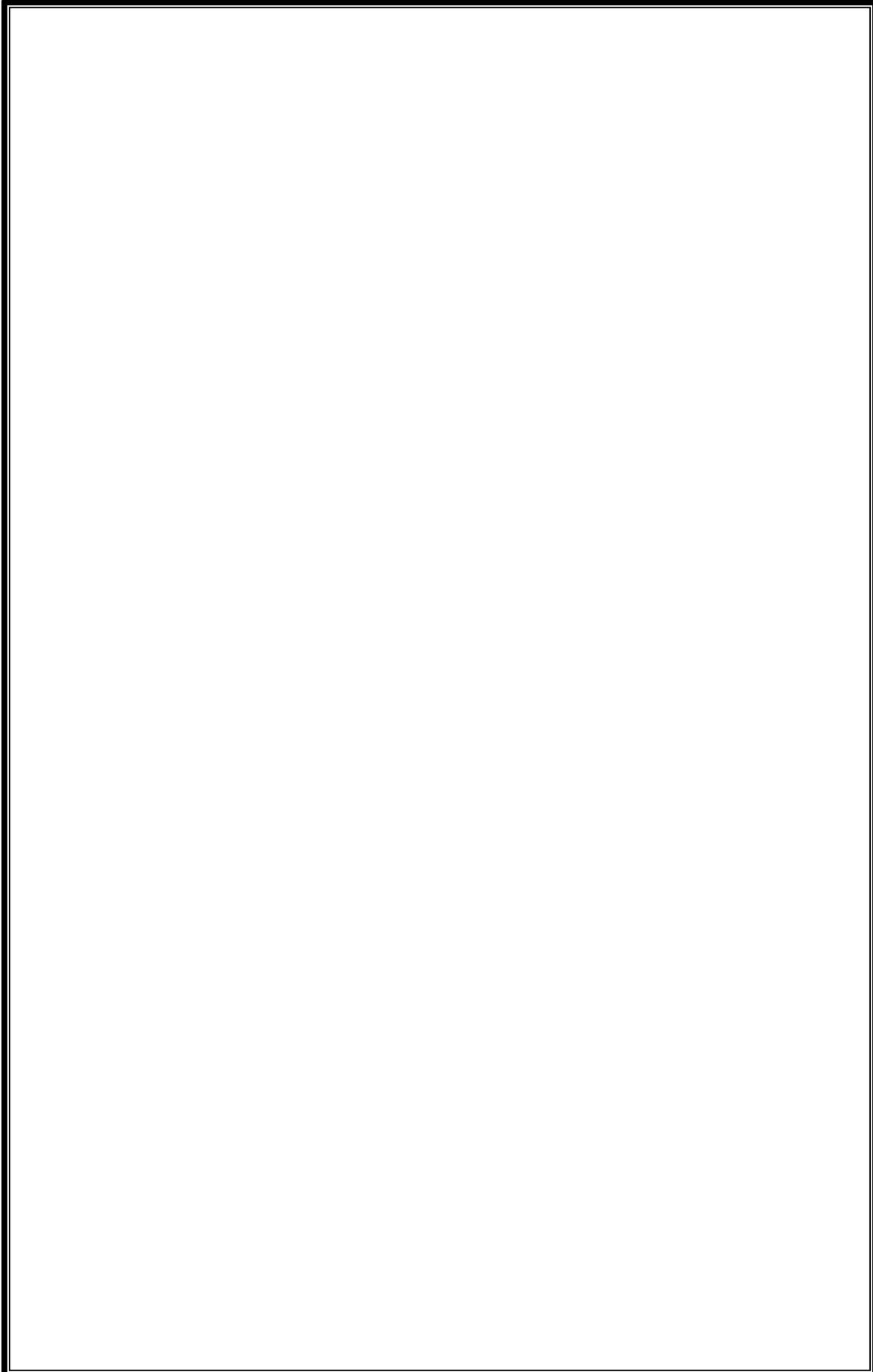


Series Connection:-

S.NO	I _c (ma)	V _{DC} (v)	V _L (v)	$I_L = \frac{V_L}{R_L}$

A=

P=







9. ROOT LOCUS AND BODE PLOT USING MAT LAB

AIM: To plot root locus and bode plot from the mat lab.

APPARATUS: Computer with MATLAB software.

THEORY:

- COMMAND 1: CLC: It clears the MATLAB command window
COMMAND 2: CLEAR: it clears the MATLAB work shop variables.
COMMAND 3: DISP: Syntax – disp (variable): It displays the variable specified on command window.
COMMAND 4: PAUSE: With this command the execution will be stopped and it waits for the enter key.
COMMAND 5: INPUT: Syntax: Variable = Input ('Comment');
COMMAND 6: PERCENTAGE: It is used at the beginning of any statement to make it as a comment in the program.
COMMAND 7: R-LOCUS: Syntax: r locus (Variable): With this we can plot the root locus of any transfer function. That means in the above syntax the variable is nothing but a transfer function.
COMMAND 8: BODE: Syntax: Bode (Variable): With this command we can get bode plot of the given transfer function.
COMMAND 9: MARGIN: Syntax: Margin (Variable): With this command we can get gain and phase margin of a bode plot of the given transfer function.
COMMAND10: SS: Syntax: Variable1= SS(Variable2): With this command we can get state space model for the given transfer function. Variable 2 is a transfer function and variable 1 holds the SS model.
COMMAND11: SS DATA: Syntax: [a,b,c,d] = Ssdata (Variable):
With this command we can retrieve the a,b,c,d matrices of a state space model. Variable holds the state space model.

PROCEDURE:

1. Write the programme in MATLAB text editor using mat lab instructions for state model of classical transfer function and for transfer function from state model.
2. Run the programs.
3. Note down the outputs.

PROGRAM:

```
Num = input ("Enter numerator polynomial values in the form of  
matrix array" );  
num = input ("Enter denominator 1 values" );  
den = input ("Enter denominator 2 values" );  
den = conv (num,den);  
H = tf (num,den);  
r locus (H);  
pause;
```





```
Bode(H);  
Pause;  
Margin(H);  
nyquist (H);  
pause;  
end
```

RESULT:

The root locus, bode plot and nyquist plot of a transfer function were plotted using MATLAB software.

PRECAUTIONS:

1. There should be no errors while typing the program.
2. There should not be any syntax errors in the program.

ASSIGNMENT QUESTIONS:

1. What is MATLAB?
2. What are the applications of MATLAB?
3. What is the instruction used for plotting root locus?
4. What is the instruction used for plotting bode plot?
5. How do we get transfer function of a control system using MATLAB?
6. How many windows does it has?
7. How do you differentiate C language programming with MATLAB?





10. STATE MODEL FOR CLASSICAL TRANSFER FUNCTION & VICE VERSA USING MATLAB

AIM:

To find state model for classical transfer function and transfer function from state model using MATLAB.

APPARATUS: Computer with MATLAB software

THEORY:

- COMMAND 1: CLC: It clears the MATLAB command window
COMMAND 2: CLEAR: it clears the MATLAB work shop variables.
COMMAND 3: DISP: Syntax – disp (variable): It displays the variable specified on command window.
COMMAND 4: PAUSE: With this command the execution will be stopped and it waits for the enter key.
COMMAND 5: INPUT: Syntax: Variable = Input ('Comment');
COMMAND 6: PERCENTAGE: It is used at the beginning of any statement to make it as a comment in the program.
COMMAND 7: R-LOCUS: Syntax: r locus (Variable): With this we can plot the root locus of any transfer function. That means in the above syntax the variable is nothing but a transfer function.
COMMAND 8: BODE: Syntax: Bode (Variable): With this command we can get bode plot of the given transfer function.
COMMAND 9: MARGIN: Syntax: Margin (Variable): With this command we can get gain and phase margin of a bode plot of the given transfer function.
COMMAND10: SS: Syntax: Variable1= SS(Variable2): With this command we can get state space model for the given transfer function. Variable 2 is a transfer function and variable 1 holds the SS model.
COMMAND11: SS DATA:Syntax: [a,b,c,d]=SSdata (Variable):
With this command we can retrieve the a,b,c,d matrices of a state space model. Variable holds the state space model.

PROCEDURE:

1. Write the programme in MATLAB text editor using mat lab instructions for state model of classical transfer function and for transfer function from state model.
2. Run the programs.
3. Note down the outputs.



**PROGRAM 1:**

```
a= input ( "Enter the values of a matrix" );  
b= input ( "Enter the values of b matrix" );  
c= input ( "Enter the values of c matrix" );  
d= input ( "Enter the values of d matrix" );
```

```
[num , den] = SS2 tf (a,b,c,d,1)  
S1=tf (num(1, : ) , den );  
S2=tf (num(2, : ) , den );  
[num1 , den1 ] = SS2 tf (a,b,c,d,2);  
S3=tf (num1 (1, : ) , den1 );  
S4=tf (num1 (2, : ) , den1 );  
DISP [S1,S2,S3,S4];
```

PROGRAM 2:

```
Num = input ("Enter numerator polynomial values in the form of matrix  
array" );  
den1 = input ("Enter denominator 1 values" );  
den2 = input ("Enter denominator 2 values" );  
den = conv (den1,den2);  
H = tf (num,den);  
P = SS(H);  
[a,b,c,d] = SS data(P);
```

RESULT:

The state model for classical transfer function and transfer function from state model are obtained using MATLAB software.

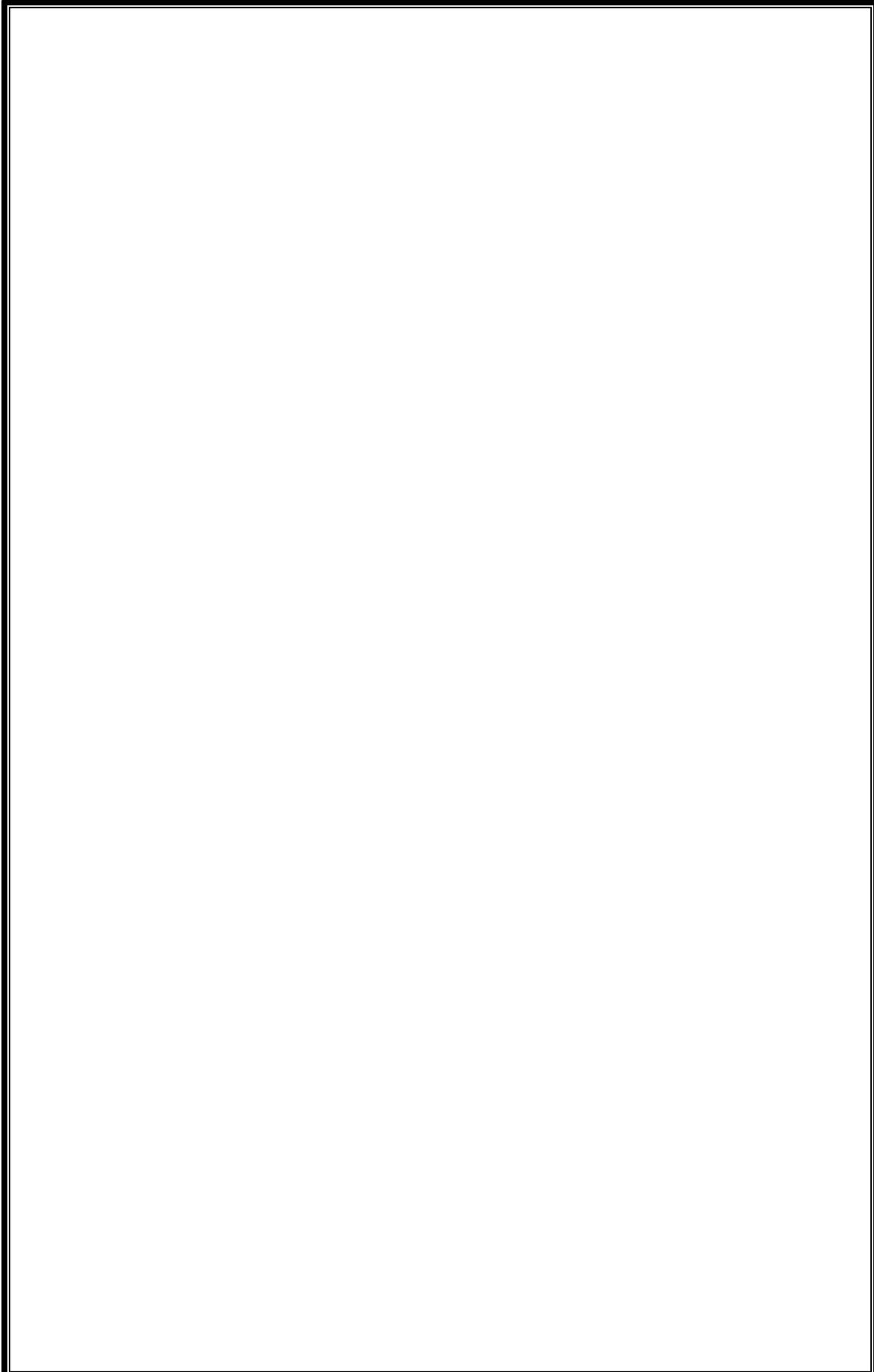
PRECAUTIONS:

1. There should be no errors while typing the program.
2. There should not be any syntax errors in the program.

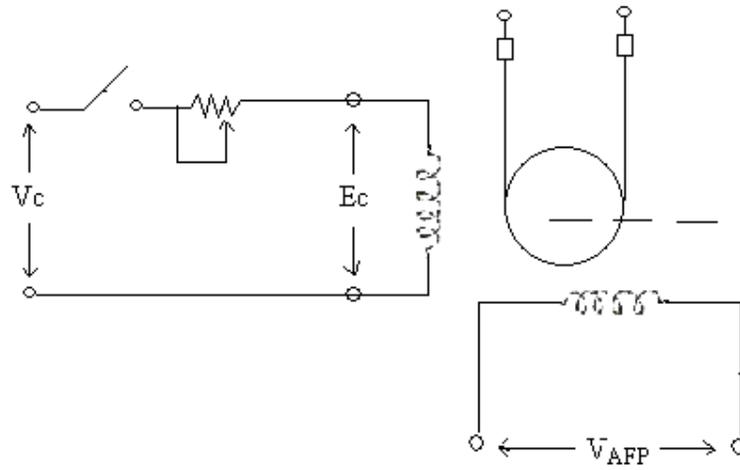
ASSESSMENT QUESTIONS:

1. What is MATLAB?
2. What are the applications of MATLAB?
3. What is the instruction used for plotting root locus?
4. What is the instruction used for plotting bode plot?
5. How do we get transfer function of a control system using MATLAB?



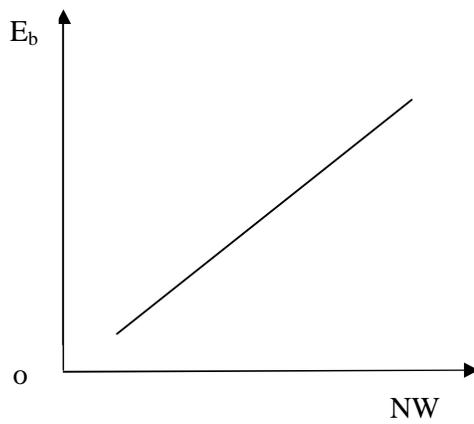


CIRCUIT DIAGRAM:

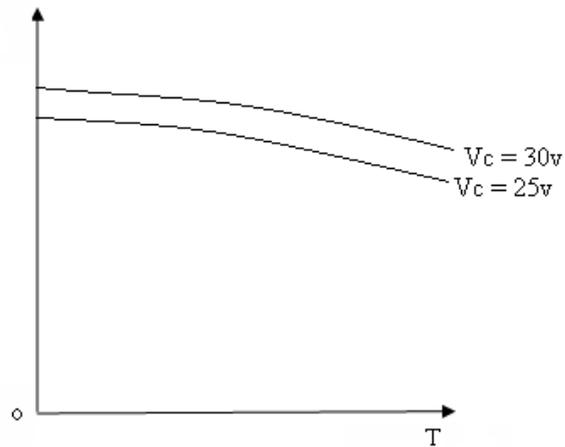


GRAPHS

BACK EMF CHARACTERISTICS



SPEED-TORQUE CHARACTERISTIC



11. CHARACTERISTICS OF AC SERVOMOTOR

AIM:

To determine the speed torque characteristics of AC Servomotor

APPARATUS:

Sl. No.	Item	Type	Range	Quantity
1	A.C Servomotor Kit			1
2	Multimeter			1
3	Patch cords			

THEORY:

An A.C servomotor is basically a two phase induction motor except for certain special design features. A two phase induction motor consisting of two stator windings oriented 90 degrees electrically apart in space and excited by a.c voltages which differ in time phase by 90 degrees. Generally voltages of equal magnitude and 90 degrees phase difference are applied to the two stator phases thus making their respective fields 90 degrees apart in both time and space at synchronous speed.

The stator windings are excited by voltages of equal r.m.s magnitude & 90° phase difference these currents give rise to a rotating magnetic field of constant magnitude the direction of rotation depends of on the phase relationship of the two currents (or voltages) the exciting currents produce a clock wise rotating magnetic field & phase shift of 180° in i_1 will produce an anti clock wise rotating magnetic field.

Due to the interaction of stator & rotor flux, a mechanical force (or torque) is developed on the rotor & so the rotor starts moving in same direction as that of rotating magnetic field.

PROCEDURE

1. Ensure that all control pots are in minimum position and motor brake drum is free to rotate.
2. Switch on the power supply and adjust the control voltage to a certain value and fix it.
3. Note down the No-load speed
4. Now load the motor by tightening the wheels of spring balance. Note down speed, S_1 , & S_2 values.
5. Repeat step 4 by increasing the load for 4 different set of loads.



OBSERVATIONS:

S.No	SPEED(r.p.m)	E _b (Volts)

S.No	V _c (V)	N (r.p.m)	S _b	S ₂	Torque



6. Now remove the brake on the motor by loosening the wheels
7. Fix the control voltage at 4 different values and for each value perform steps 3,4,5.
8. Calculate torque and plot Torque VS speed characteristic for different control voltages.

PRECAUTION:

1. Before switching on the speed, adjust & had control pot should always at the most anticlockwise position & should be operated in gentle position.
2. Loose connections are to be avoided.
3. Circuit connections should not be made while power is on.
4. Readings of meters must be taken without parallax error

RESULT: Speed torque characteristics of AC Servomotor are observed.

ASSESMENT QUESTIONS:

1. What is a servomotor?
2. What are the applications of servomotor?
3. How can we get the feed back characteristics of A.C Servomotor?
4. How do you load the A.C Servomotor?
5. Why a servomotor should not be switched on load?
6. How can a A.C servomotor be controlled?







12. PROGRAMMABLE LOGICAL CONTROLLER

AIM:

To implement various logics using PLC trainer

APPARATUS:

PLC – 51
EPROM Chip
FANMOTOR
COMPUTER
CONNECTING CHORD

THEORY:

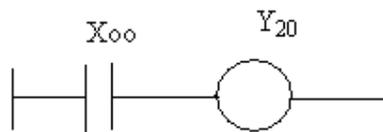
A programmable controller, formerly called as programmable logic controller PLC can be defined as a solid state device member of the computer family. It is capable of strong instructions to implement control function such as servicing timing, counting arithmetic, data manipulation & communication to control industrial machines & processed.

PLC Programming:

Implement the following ladder network (shown in figure)

1. **PROGRAM:**

```
LD 0 0  
OUT 20  
END
```

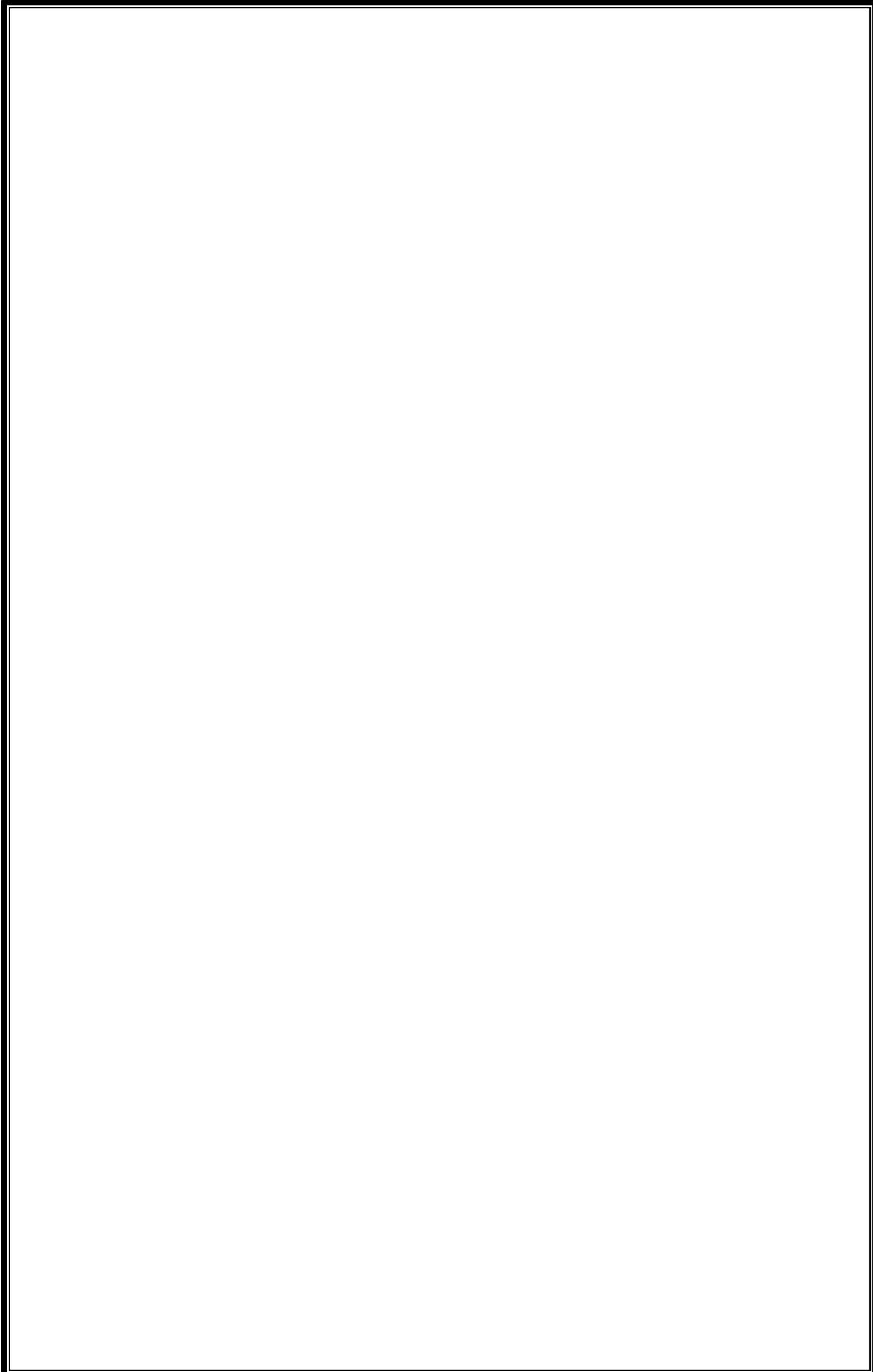


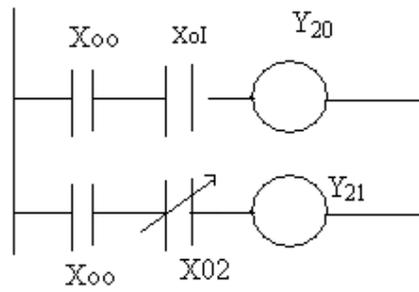
LADDER NETWORK I

2. **PROGRAM:**

To implement the following ladder Network.

```
LD 0 0  
AMD 01  
OUT 20  
LD 00  
ANI 02  
OUT 21  
END
```



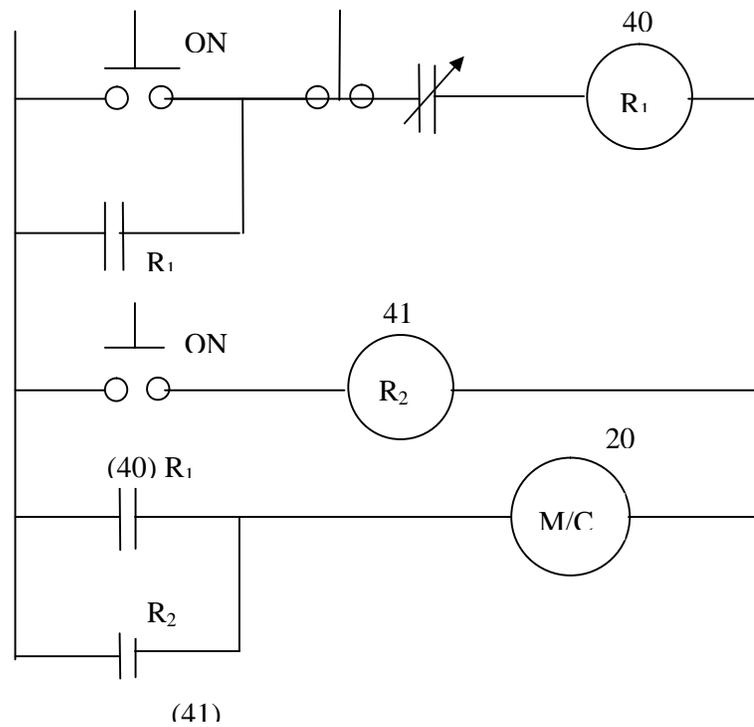


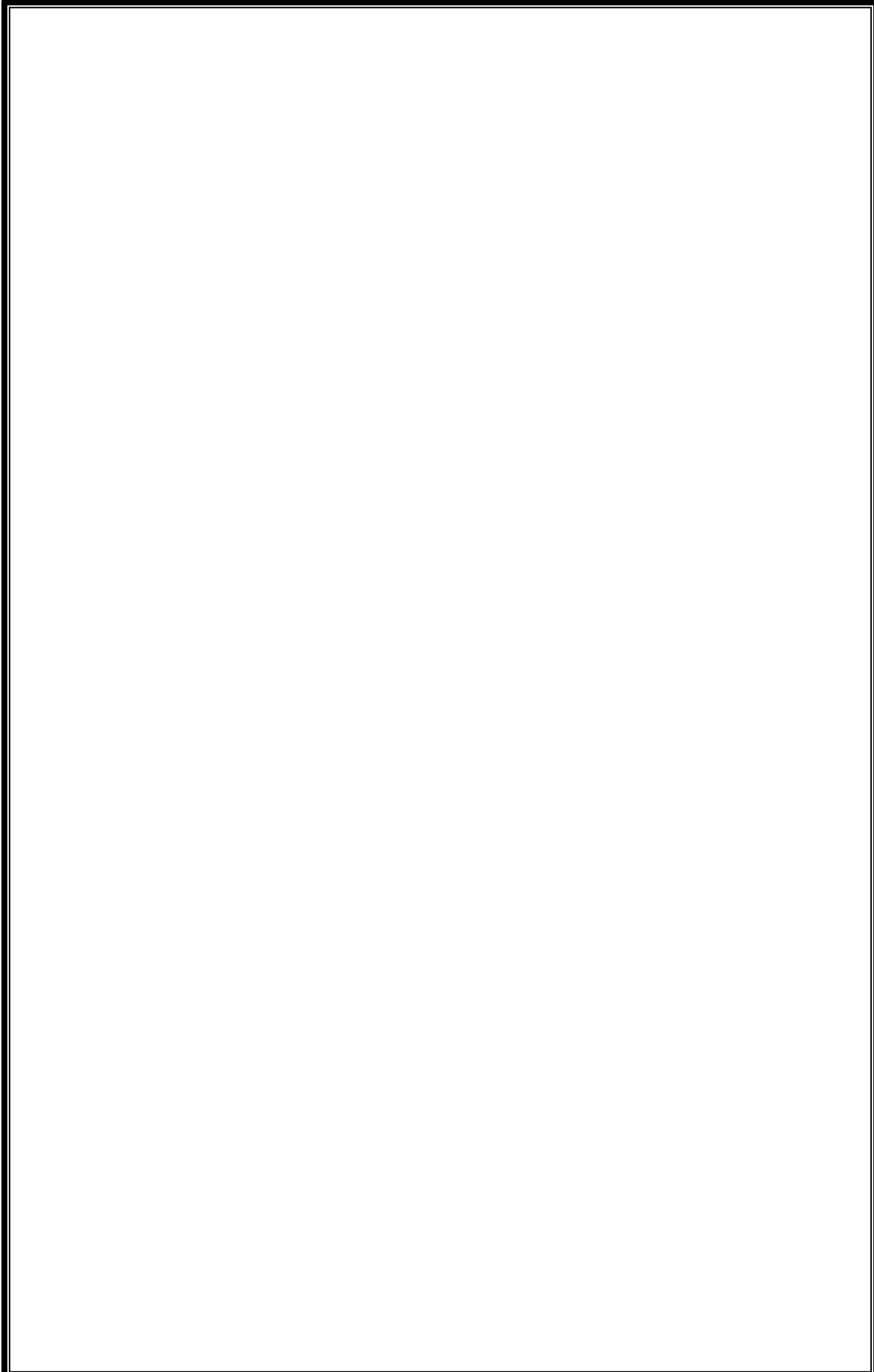
LADDER NETWORK II

3. PROGRAM:

Implement the following mechanical logic using PLC

```
LD 00
OR 40
ANI 01
ANI 41
OUT 40
LD 01
OUT 41
LD 40
OR 41
OUT 20
END
```





MECHANICAL LOGIC USING PLC**LOGIC:**

The above circuit uses internal relays. There are 16 relays M & M & M. Here we use the relays 40 & 41. Once 00 is ON & output 20 is ON permanently. Once 01 is ON, R gets off but N is On. So 20 continues to be ON but when 01 is removed 20 gets OFF because M does not have a feedback as mechanism as M.

RESULT:

The above programs



