QMP 7.1 D/F

Channabasaveshwara Institute of Technology

(An ISO 9001:2008 Certified Institution)

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

Department of Electrical & Electronics Engineering

LAB MANUAL

(2016-17)

10EEL68
CONTROL SYSTEMS LABORATORY

VI Semester E&E Engineering

Name : ____

U S N : ____

Batch : ________________________ **Section :** ________________

Caution

1. *Do not play with electricity.*
2. *Carelessness not only destroys the valuable equipment in the lab but also costs your life.*
3. *Mere conductivity of the experiment without a clear knowledge of the theory is of no value.*
4. *Before you close a switch, think of the consequences.*
5. *Do not close the switch until the faculty in charge checks the circuit.*
6. *What matters is not what you conduct but why you conduct.*

‘Instructions to the Candidates’

1. Students should come with thorough preparation for the experiment to be conducted.
2. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
3. Name plate details including the serial number of the machine used for the experiment should be invariably recorded.
4. Experiment should be started only after the staff-in-charge has checked the circuit diagram.
5. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
6. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
7. Practical record should be neatly maintained.
8. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
9. Theory regarding each experiment should be written in the practical record before procedure in your own words.

SYLLABUS

CONTROL SYSTEMS LABORATORY

Subject Code	**: 10EEL68**	**IA Marks**	**: 25**
No. of Practical Hrs./ Week	**: 03**	**Exam Hours**	**: 03**
Total No. of Practical Hrs.	**: 42**	**Exam Marks**	**: 50**

1. Using MATLAB/SCILAB a) Simulation of a typical second order system and determination of step response and evaluation of time-domain specifications.

b) Evaluation of the effect of additional poles and zeroes on time response of second order system

c) Evaluation of effect of pole location on stability

d) Effect of loop gain of a negative feedback system on stability

2. (a) To design a passive RC lead compensating network for the given specifications, viz., the maximum phase lead and the frequency at which it occurs and to obtain its frequency response.

(b) To determine experimentally the transfer function of the lead compensating network.

3. (a) To design RC lag compensating network for the given specifications., viz., the maximum phase lag and the frequency at which it occurs, and to obtain its frequency response.

(b) To determine experimentally the transfer function of the lag compensating network.

4. Experiment to draw the frequency response characteristic of a given lag- lead compensating network.

5. To study the effect of P, PI, PD and PID controller on the step response of a feedback control system (using control engineering trainer/process control simulator). Verify the same by simulation.

6. a) Experiment to draw the speed – torque characteristic of a two - phase A.C. servomotor.

b) Experiment to draw speed torque characteristic of a D.C. servomotor.

7. To determine experimentally the frequency response of a second - order system and evaluation of frequency domain specifications.

8. Using MATLAB/SCILAB a) Simulate a D. C. position control system and obtain its step response

b) To verify the effect of the input wave form, loop gain system type on steady state errors.

c) To perform a trade-off study for lead compensation

d) To design a PI controller and study its effect on steady state error

9. Using MATLAB/SCILAB

a) To examine the relationships between open-loop frequency response and stability , open loop frequency and closed loop transient response

b) To study the effect of addition closed loop poles and zeroes on the closed loop transient response

10. Using MATLAB/SCILAB

a) Effect of open loop and zeroes on root locus contour

b) To estimate the effect of open loop gain on the transient response of closed loop system by using Root locus

c) Comparative study of Bode, Nyquist and Root locus with respect to Stability.

11.Experiment to draw to syncro pair characteristics.

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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGG.

CONTENTS

Annexure

Channabasaveshwara Institute of Technology

(An ISO 9001:2008 Certified Institution)

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.

OUR VISION

To create centers of excellence in education and to serve the society by enhancing the quality of life through value based professional leadership.

OUR MISSION

- To provide high quality technical and professionally relevant education in a diverse learning environment.
- To provide the values that prepare students to lead their lives with personal integrity, professional ethics and civic responsibility in a global society.
- To prepare the next generation of skilled professionals to successfully compete in the diverse global market.
- To promote a campus environment that welcomes and honors women and men of all races, creeds and cultures, values and intellectual curiosity, pursuit of knowledge and academic integrity and freedom.
- To offer a wide variety of off-campus education and training programmes to individuals and groups.
- To stimulate collaborative efforts with industry, universities, government and professional societies.
- To facilitate public understanding of technical issues and achieve excellence in the operations of the institute.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

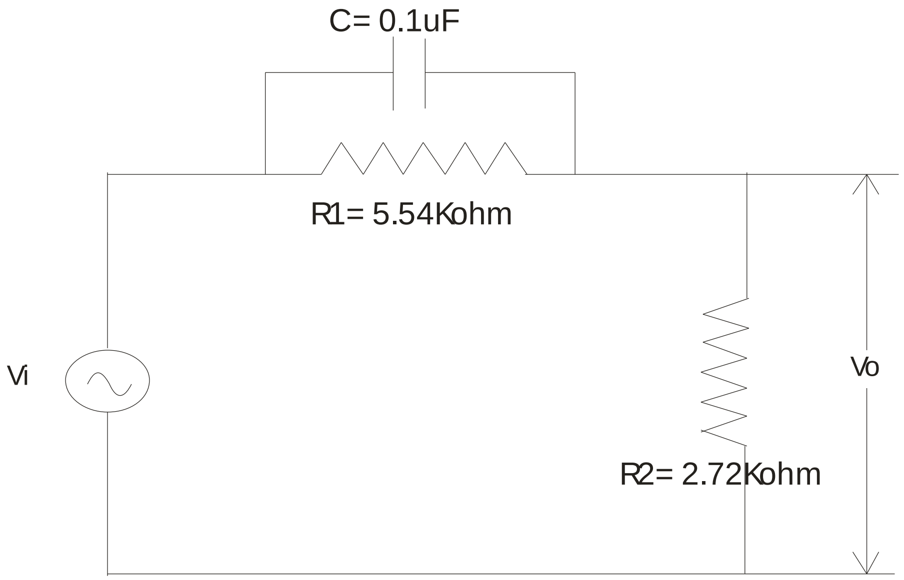
VISION:

To be a department of excellence in electrical and electronics Engineering education and Research, thereby to provide technically competent and ethical professionals to serve the society.

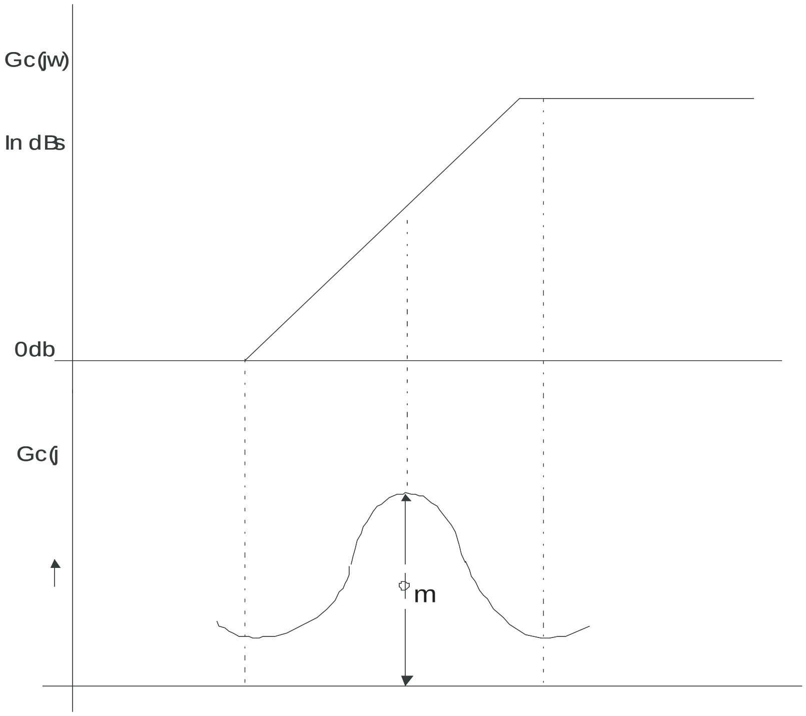
MISSION:

- To provide high quality technical and professionally relevant education in the field of electrical engineering.
- To prepare the next generation of electrically skilled professionals to successfully compete in the diverse global market.
- To nurture their creative ideas through research activities.
- To promote research and development in electrical technology and management for the benefit of the society.
- To provide right ambience and opportunities for the students to develop into creative, talented and globally competent professionals in electrical sector.

Circuit Diagram:



Graph:



Exp: 1 **Date:___________**

DESIGN, DETERMINATION OF TRANSFER FUNCTION & FREQUENCY RESPONSE FOR LEAD NETWORK

Aim: a) To design a passive RC Lead compensating network for the given specifications, viz, the maximum phase lead and the frequency at which it occurs and to obtain its frequency response.

b) To determine experimentally the transfer function of the lead Compensating network.

Apparatus:

Sl. No	Apparatus	Range	Nos.
1	Resistor	5.54KΩ,2.72KΩ	2
2	Capacitor	0.1μF	1
3	Signal generator		1
4	CRO		1
5	Probe		3
6	Wire		1set

Procedure:

1) Connection is made as shown in circuit diagram.
2) The output voltage of the sine generator is set to 10V peak.
3) Input frequency is varied in steps (in the range of 1 to 1MHz) and at each step the output voltage and phase angle are noted down using CRO.
4) All the readings are tabulated and the gain characteristic & phase characteristics are plotted on semi log sheet.

Lissajous figure:-

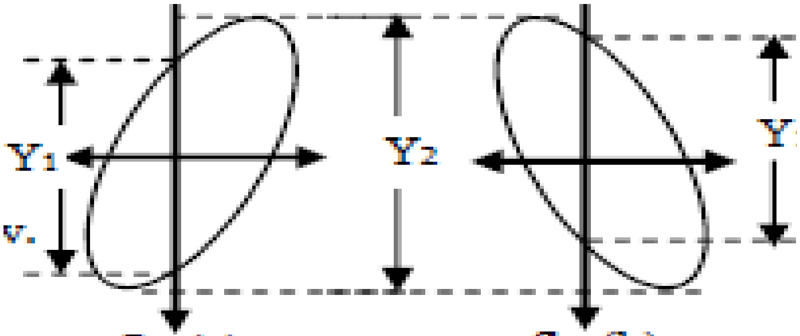


fig (a) fig (b)

Design:

The general transfer function of the lead compensator is

$$G_C(s) = \frac{s+(1/T)}{s+(1/\alpha T)}, \alpha < 1, T > 0 ------------------------------> A$$

Where $\alpha = \frac{R_2}{R_1 + R_2}$

Time constant T= R_1C--→1

The corner frequencies are 1/T and 1/ α T------------------------------------→2

The maximum phase lead $\varphi_m = \sin^{-1}(\frac{[1-\alpha]}{[1+\alpha]}) ---------------> 3$

Or $\alpha = \frac{1-\sin\phi_m}{1+\sin\phi_m}$

and ω_m is the frequency at with ϕ_m occurs

$$\omega_m = \sqrt{1/T * 1\alpha T} = \frac{1}{\sqrt{\alpha}} * \frac{1}{T}$$ --→4

(1) For a given system phase lead φ_m find the α using equation (3)

(2) Assuming R_1, find R_2 from equation (1)

(3) For a given ω_m or time constant T, find C using equation (4) and or (2)

(4) Find the corner frequencies $\omega_1 = \frac{1}{T}$, $f_1 = \frac{\omega_1}{2\pi} Hz$.

$\omega 2 = \frac{1}{\alpha T}$, $f_2 = \frac{\omega_2}{2\pi}$ and also $\omega_m = \frac{1}{\sqrt{\alpha}} * \frac{1}{T}$ $f_m = \frac{\omega_m}{2\pi} Hz$

Example:

Design a phase lead compensator which provides a maximum phase angle of 30°at 500Hz.

Given: $\Phi_m = 30^o$ $\omega_m = 2\pi f$ *f*=50Hz

$\omega_m = 2\pi f = 2\pi * 500$ =3141.59rad/sec.

$\omega_m = \frac{1}{\sqrt{\alpha T}}$ $\alpha = \frac{R_2}{R_1 + R_2}$ *T=R₁C*

$$\alpha = \frac{1 - Sin\phi_m}{1 + Sin\phi_m}$$

$$\alpha = 0.33$$

$$3141.56 = \frac{1}{\sqrt{0.33}T}$$

$$T = 6.54 * 10^{-4} \sec$$

$T = R_1 C$

Tabular Column:

SL.No	Frequency (Hz)	V_i (volts)	Vo (volts)	Amplified o/p $V_0^{'} = (v_0 / \alpha)$ (volts)	Magnitude in dB $=20\log(\frac{V_o^{'}}{V_i})$	Phase angle (Degrees)

$$\alpha = \frac{1 - Sin\phi_m}{1 + Sin\phi_m}$$

AAssume C=0.1μf

$$\alpha = 0.33$$

R $R_1 = 5.54K\Omega$

$$3141.56 = \frac{1}{\sqrt{0.33}T}$$

$$\alpha = \frac{R_2}{R_1 + R_2}$$

$T = 6.54 * 10^{-4} \sec$ $T = R_1 C$

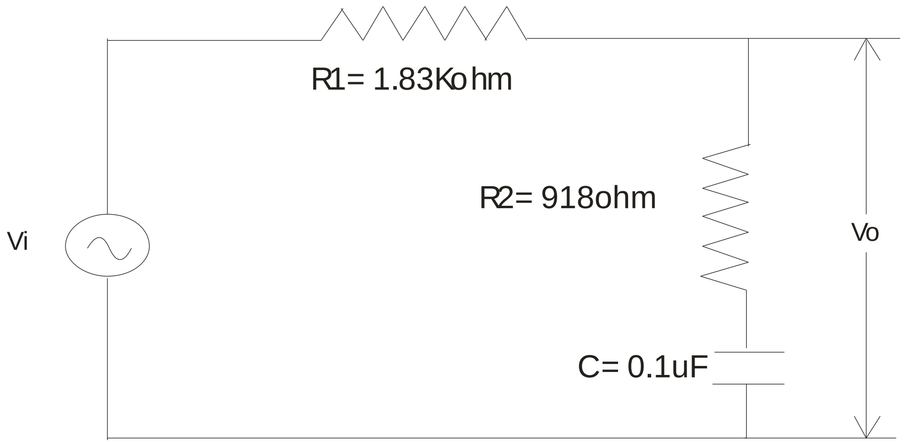
R $R_2 = 2.72K\Omega$

Transfer Function:

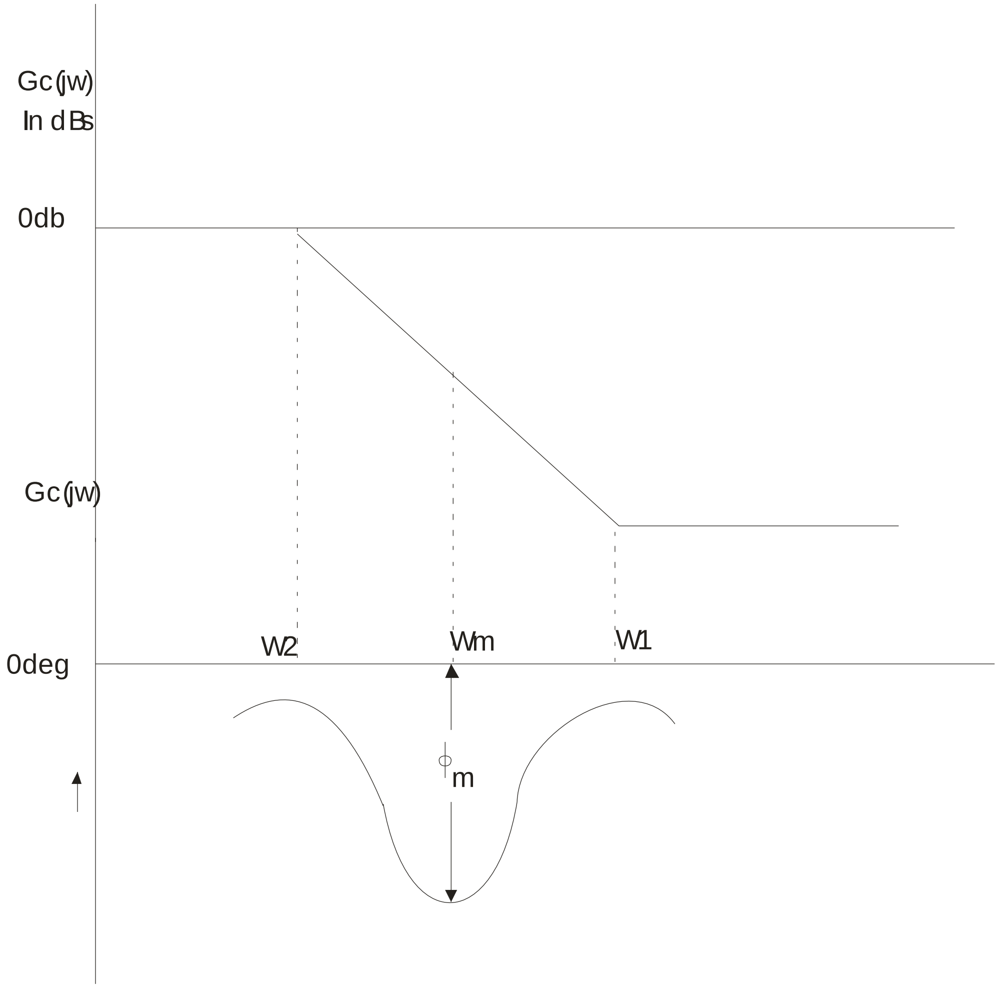
Result:

Date: ____________ **Signature of Faculty**

Circuit Diagram:



Graph:



Exp: 2 **Date:___________**

DESIGN, DETERMINATION OF TRANSFER FUNCTION & FREQUENCY RESPONSE FOR LAG NETWORK

Aim: 1) To design a passive RC Lag compensating network for the given specifications,viz, the maximum phase lag and the frequency at which it occurs and to obtain its frequency response.

2)To determine experimentally the transfer function of the lag compensating network.

Apparatus:

Sl.No.	Apparatus	Range	Nos.
1.	Resistor	1.83KΩ,918Ω	2
2.	Capacitor	0.1μF	1
3.	Signal generator		1
4.	CRO		1
5.	Probe		3
6.	Wire		1set

Procedure:

1) Connection are made as shown in circuit diagram.
2) The output voltage of the sine generator is set to 10V peak.
3) Input frequency is varied in steps (in the range of 1 to 1MHz) and at each step the output voltage and phase angle are noted down using CRO.
4) All the readings are tabulated and the gain characteristic & phase characteristics are plotted on semi log sheet.

Design:

The general transfer function of the lead compensator is

$$G_C(s) = \frac{s + (1/T)}{s + (1/\beta T)}, \beta < 1, T > 0 ------------------------------- > A$$

Where $\beta = \frac{R_1 + R_2}{R_2}$ --→1

Time constant T= R_1C--→2

The corner frequencies are ω_1 = 1/T and $\omega_2 = 1/$ β T

The maximum phase lag

C= $= \sin^{-1}(\frac{[1-\beta]}{[1+\beta]}) ------------------------------------ > 3$

and ω_m is the frequency at with ϕ_m occurs.

ω_m is the geometric mean of two frequencies.

$$\omega_m = \sqrt{1/T * 1\beta T} = \frac{1}{\sqrt{\beta}} * \frac{1}{T}$$ --→4

Example:

Design a phase Lag compensator which provides a maximum phase angle of 30°at 500Hz.

Given: $\Phi_m = 30^o$ $\omega_m = 2\pi f$ *f*=50Hz

$\omega_m = 2\pi f = 2\pi * 500$ =3141.59rad/sec.

$\omega_m = \frac{1}{\sqrt{\beta T}}$ $\beta = \frac{R_1 + R_2}{R_2}$ *T=R₁C*

$$Sin\phi_m = \frac{\beta - 1}{\beta + 1}$$

$$0.5 = \frac{\beta - 1}{\beta + 1}$$

$\beta = 3$

$$3141.56 = \frac{1}{\sqrt{3T}}$$

$T = 1.837 * 10^{-4}$ sec

$T=R_1C$

Assume $C=0.1\mu f$

$R_1=1.83K\Omega$

$$\beta = \frac{R_1 + R_2}{R_2}$$

$R_2=918\Omega$

Tabular Column:

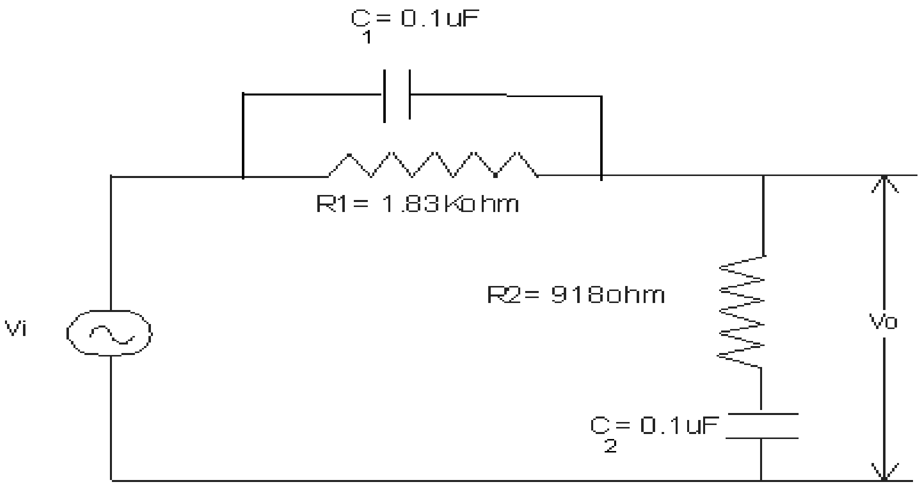
SL.No	Frequency (Hz)	V_i (volts)	Vo (volts)	Amplified o/p $V_0^{'} = (v_0 / \alpha)$ (volts)	Magnitude in dB =20log($\frac{V_o^{'}}{V_i}$)	Phase angle (Degrees)

Transfer Function:

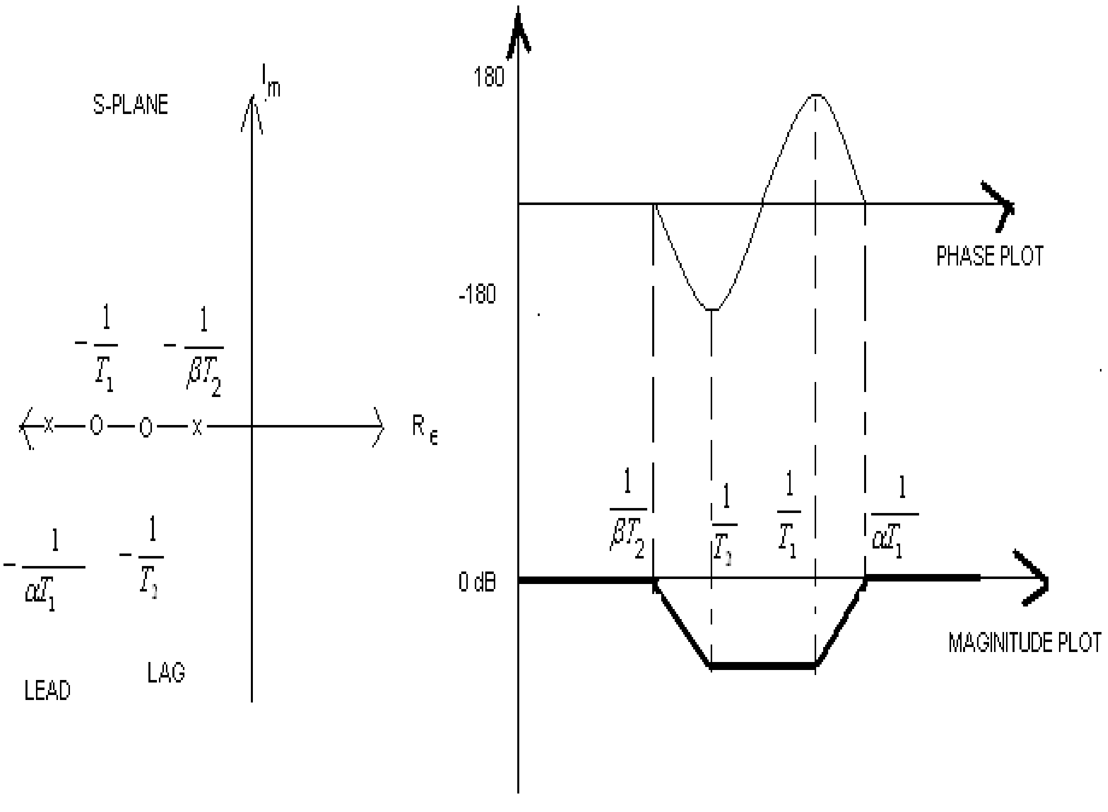
Result:

Date: ___________ **Signature of Faculty**

Circuit Diagram:



Graph:



Exp: 3 **Date:___________**

DESIGN, DETERMINATION OF TRANSFER FUNCTION & FREQUENCY RESPONSE FOR LAG-LEAD NETWORK

Aim: To design a passive Lag-Lead compensating network for the given Specifications and its frequency response characteristics.

Apparatus:

Sl.No.	Apparatus	Range	Nos.
1.	Resistor	5.5KΩ, 918Ω	2
2.	Capacitor	0.1μF	2
3.	Signal generator		1
4.	CRO		1
5.	Probe		3
6.	Wire		1set

Procedure:

5) Connection are made as shown in circuit diagram.
6) The output voltage of the sine generator is set to 10V peak.
7) Input frequency is varied in steps (in the range of 1 to 1MHz) and at each step the output voltage and phase angle are noted down using CRO.
8) All the readings are tabulated and the gain characteristic & phase characteristics are plotted on semi log sheet.

Design:

The general transfer function of the lag-lead compensator is

$$G_C(s) = \frac{(S+\frac{1}{T_1})*(S+\frac{1}{T_2})}{(S+\frac{1}{\beta T_1})*(S+\frac{1}{\beta T_2})}, \beta > 1$$

LAG LEAD

The corner frequencies are

$$\omega_1 = \frac{1}{T_1}, \omega_2 = \frac{1}{\beta T_1}, \omega_3 = \frac{1}{T_2} \ \& \ \omega_4 = \frac{\beta}{T_2}$$

Where

$T_1 = R_1 C_1$

$T_2 = R_2 C_2$

$\beta = (R_1 + R_2)/R_2$

The frequency at which the phase angle is zero is $\omega_1 = \frac{1}{\sqrt{T_1 T_2}}$

Tabular Column:

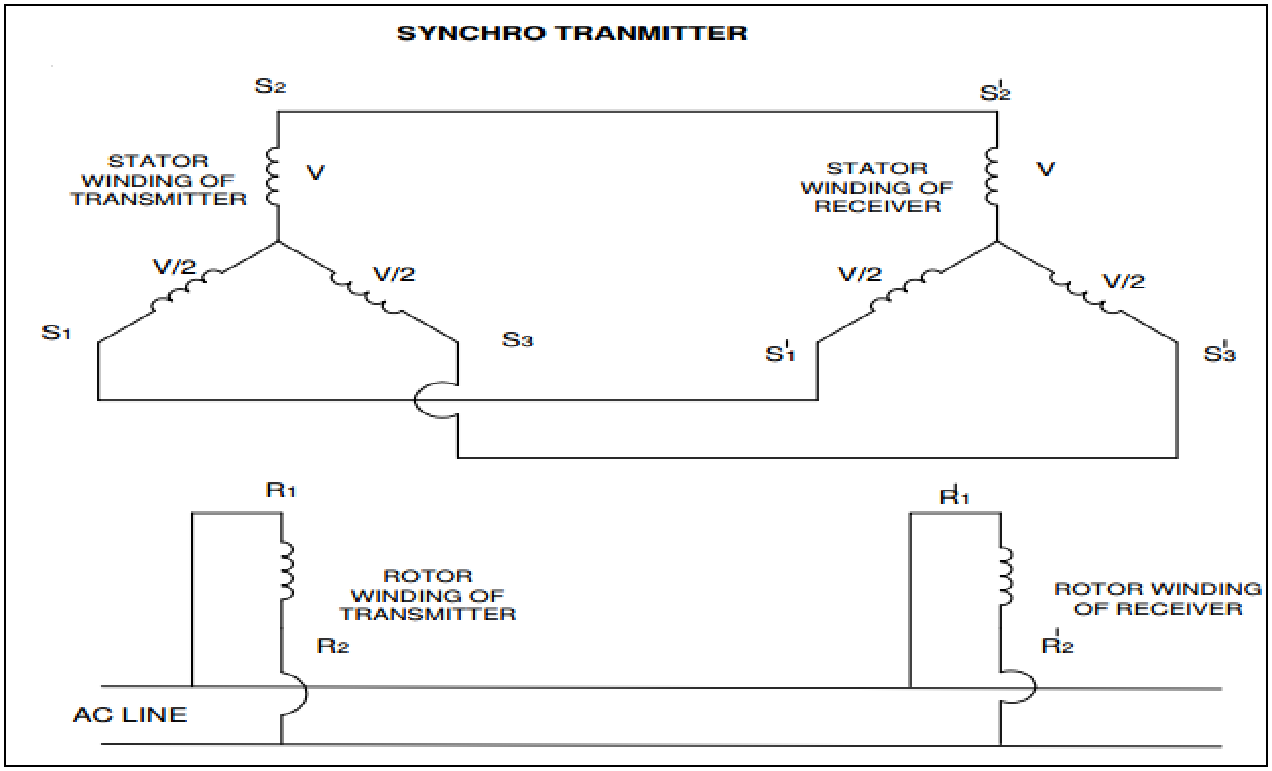
Sl.No	**Frequency (Hz)**	**V_i (Volt)**	**V_o (Volt)**	**Gain=20log $\frac{V_o}{V_i}$**	**Phase angle (degree)**

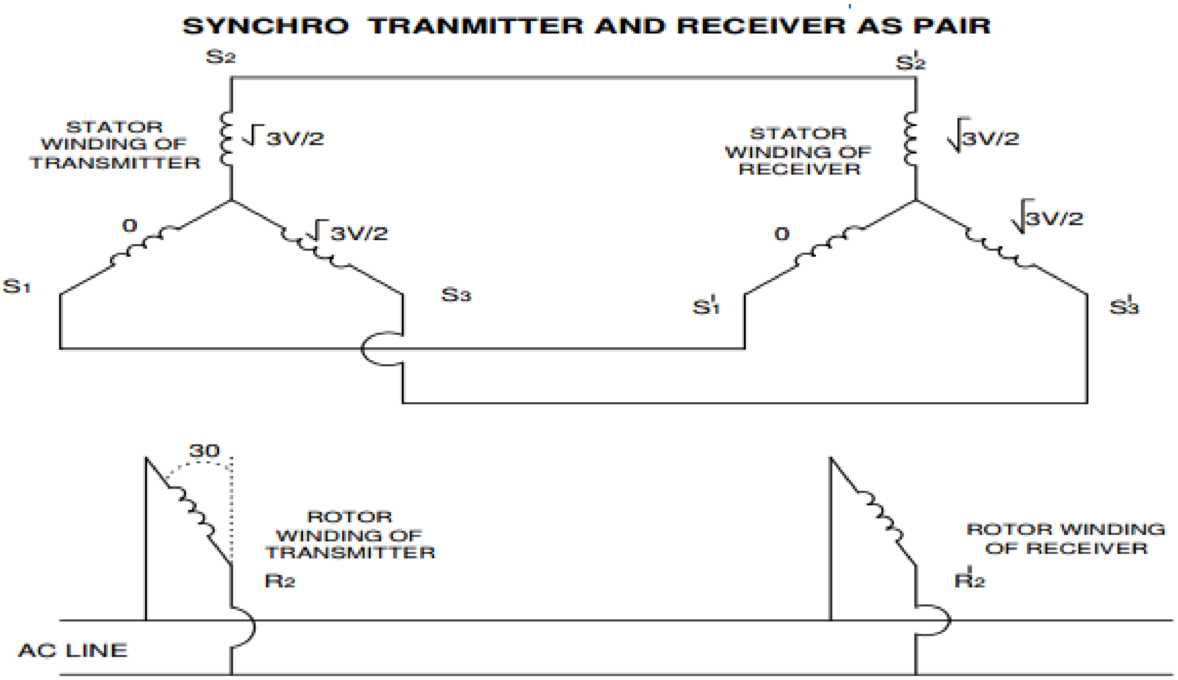
Transfer Function :

Result:

Date: ___________ **Signature of Faculty**

Circuit Diagram:





Exp: 4 **Date:___________**

SYNCRO PAIR CHARACTERISTICS

Aim: To study synchro transmitter and receiver.

Apparatus:

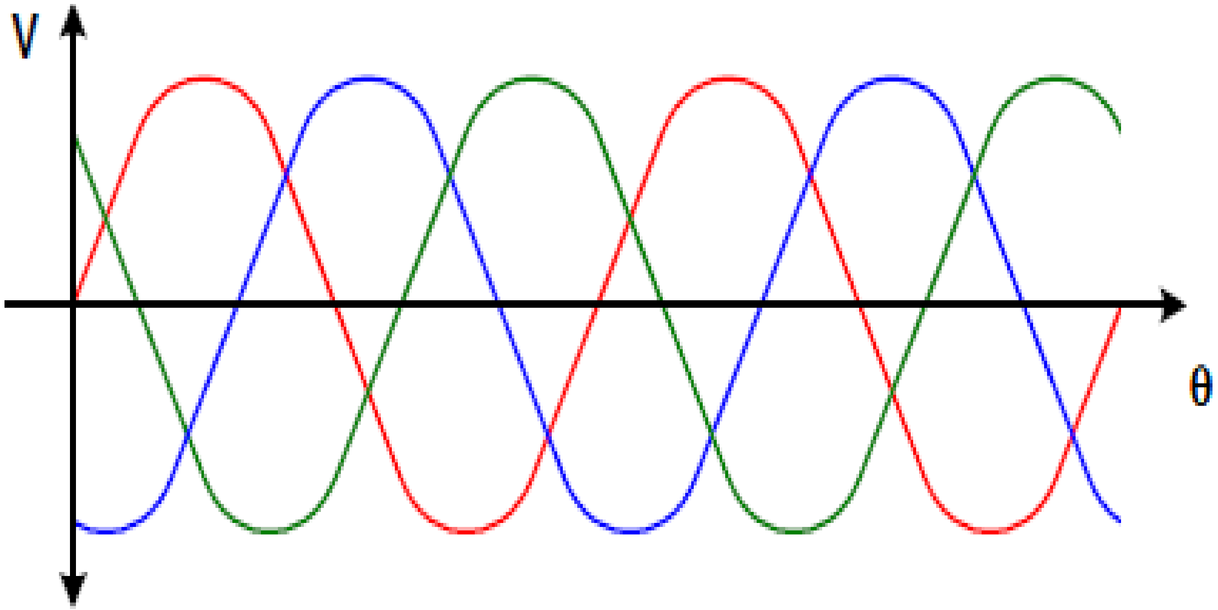
Sl.No.	Apparatus	Nos.
1.	synchro transmitter and receiver unit	1
2.	Patch cards	1

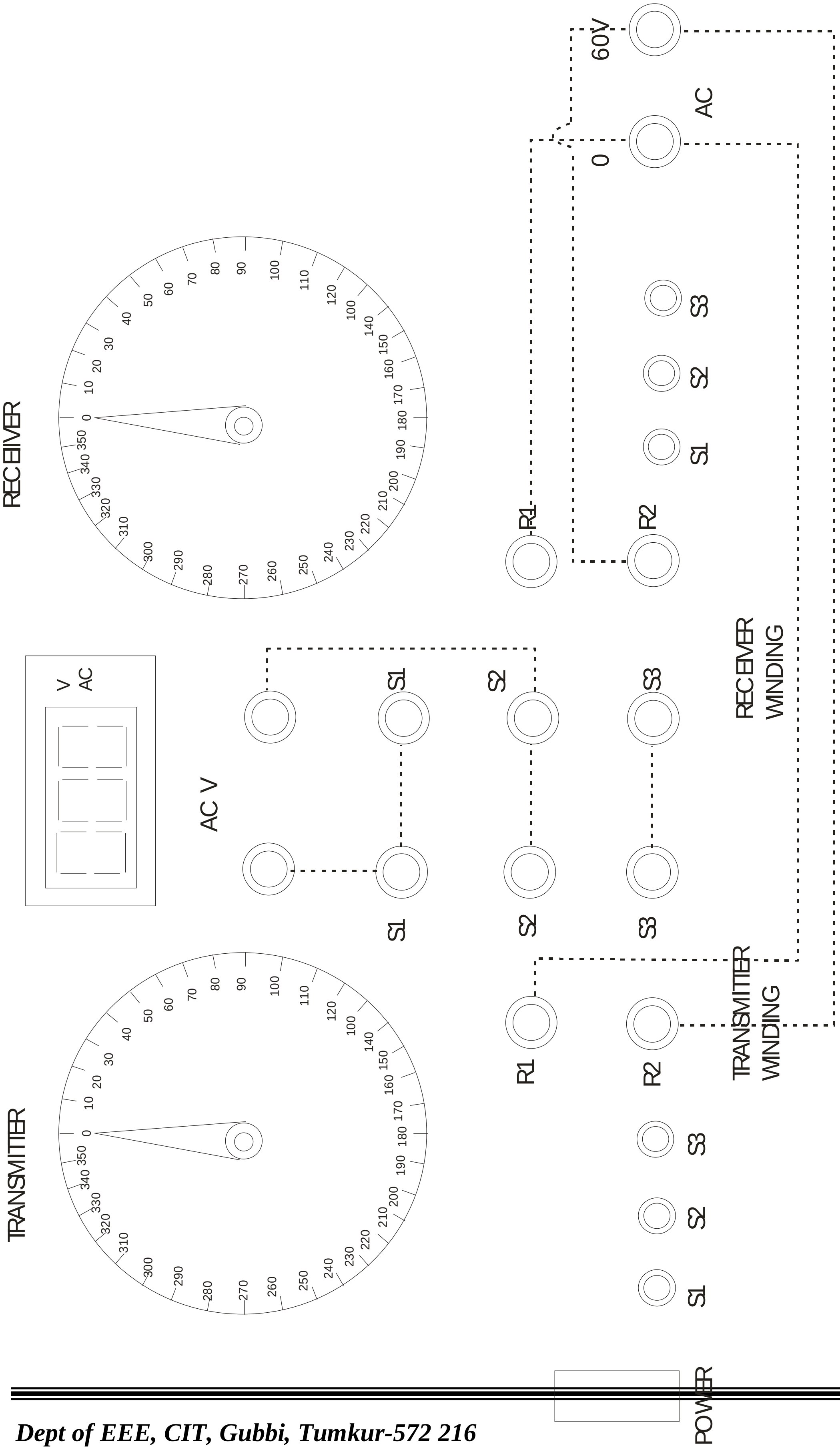
Procedure:

Rotor position verses stator voltages:

1. Connect the main supply to the system with help of cable provided.
2. Connect 60V AC supply to R_1 & R_2 of the transmitter.
3. Starting from zero position note down the voltage between stator winding terminals V_{S1S2}, V_{S2S3} and V_{S3S1} in a sequence manner i.e in the interval of 30 degrees. Enter the reading in a tabular column & plot graph of angular position of rotor verses stator voltages for all three phases.

Graph:




RECEIVER
TRANSMITTER
V
AC
AC V
S1
S2
S3
R1
R2
60V
0
AC
RECEIVER WINDING
TRANSMITTER WINDING
POWER

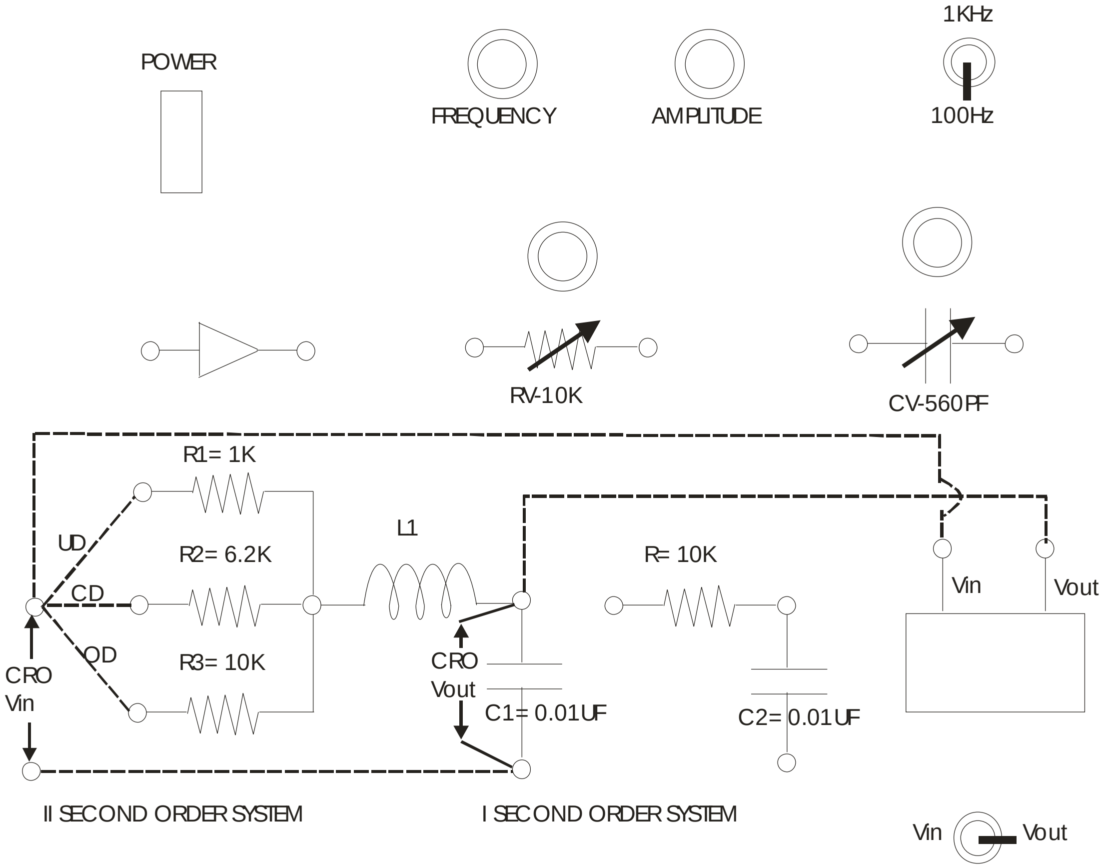
Tabular Column:

Sl.no.	Rotor position	Stator terminal voltages		
		V_{S1S2}	V_{S2S3}	V_{S3S1}
1	0°			
2	30°			
3	60°			
4	90°			
5	120°			
6	150°			
7	180°			
8	210°			
9	240°			
10	280°			
11	300°			
12	330°			

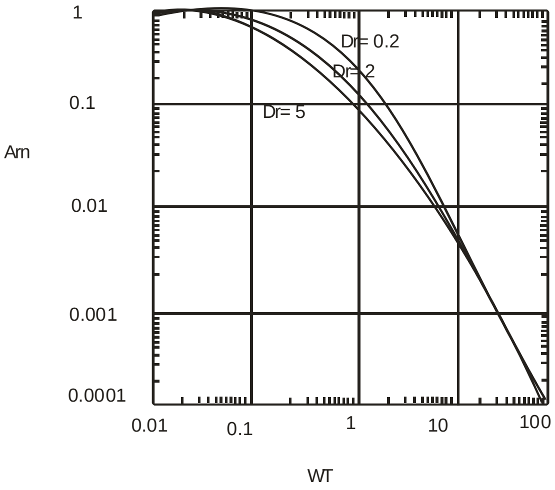
Result:

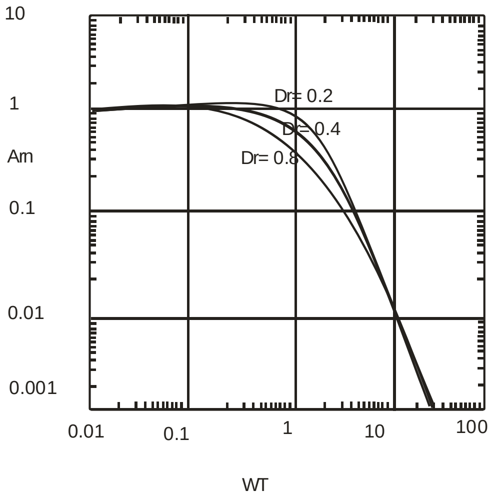
Date: ____________ **Signature of Faculty**

Circuit Diagram:



Graph:





Exp: 5 **Date:___________**

FREQUENCY RESPONSE CHARACTERISTICS OF SECOND ORDER SYSTEM

Aim: To plot frequency response/bode plot for a given second order system and to find various parameter.

Apparatus:

Sl.No.	Apparatus	Nos.
1.	Second order system unit	1
2.	Patch cards	1
3.	CRO	1

Procedure:

1) Connection are made as shown in circuit diagram.
2) Switch on the apparatus.
3) Set the signal generator to sine output. Adjust the amplitude of the sine signal to suitable voltage.
4) Enter various readings in the table for the frequency from 100Hz to 10KHz in steps.
5) Plot a graph of Gain v/s $\omega\tau$.

Note: For under damped system, $0 < \delta < 1$, Choose $R=R_1$

For Critically damped system, $\delta = 1$, Choose $R=R_2$

For Over damped system, $\delta > 1$, Choose $R=R_3$

Design:

$R_1=1K\Omega$

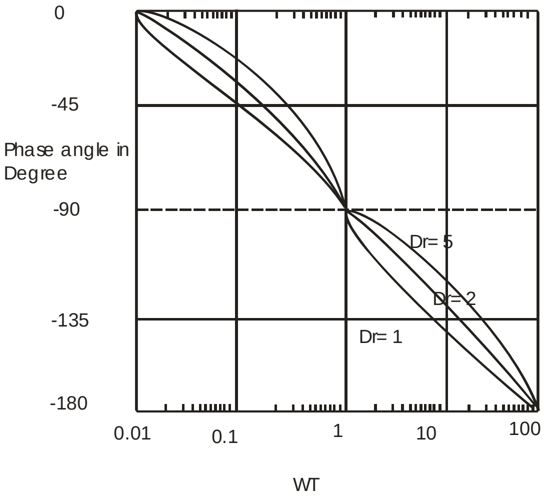
$R_2=6.23K\Omega$

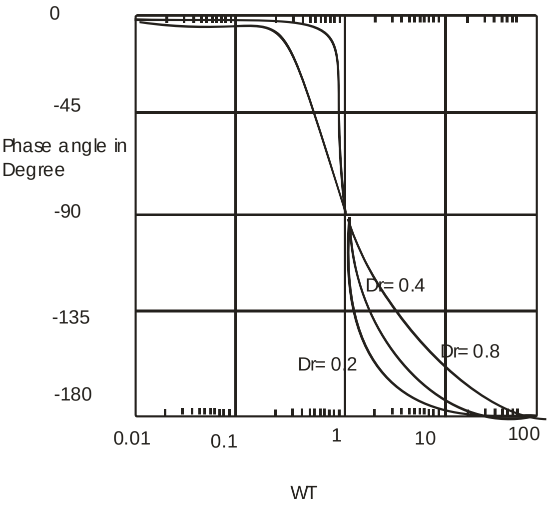
$R_3=10K\Omega$

$L = 100mH$

$C=0.01\mu F$

$\tau = \sqrt{LC}$





Tabular Column:

Freq Hz	$\omega = 2\pi f$	$\omega\tau$ radians	δ=0.158(underdamped)			
			V_i	V_o	Gain= 20log(V_o/ V_i)	Phase angle Φ
100						
200						
400						
600						
800						
1K						
2K						
4K						
4.5K						
5K						
6K						
8K						

$$R = \frac{2\delta}{\sqrt{\frac{C}{L}}}$$

$$AR_N = \frac{1}{\sqrt{(1-\omega^2\tau^2)^2 + (2\omega\tau\delta)^2}}$$

$$\phi = \tan^{-1}\left[\frac{-2\omega\tau\delta}{1-\omega^2\tau^2}\right]$$

At $\omega=0$, $\Phi=0$

At $\omega=\infty$, $\Phi=-180°$

Front Panel Details:

- Power : Mains ON/OFF switch with built-in indicator.
- AC output : Sine/ square wave output w.r.t GND for the experiment.
- Frequency : Varies from 10Hz to 100KHz.
- Amplitude : Varies up to 5V.
- R_1 : 1KΩ
- R_2 : 6.23KΩ
- R_3 : 10KΩ
- L : 100mH
- C : 0.01μF

Freq Hz	$\omega =$ $2\pi f$	$\omega\tau$ radians	δ=1(Critically damped)			
			V_i	V_o	Gain= 20log(V_o/ V_i)	Phase angle Φ
100						
200						
400						
600						
800						
1K						
2K						
4K						
4.5K						
5K						
6K						
8K						

Freq Hz	$\omega =$ $2\pi f$	$\omega\tau$ radians	δ=1.58(over damped)			
			V_i	V_o	Gain= 20log(V_o/ V_i)	Phase angle Φ
100						
200						
400						
600						
800						
1K						
2K						
4K						
4.5K						
5K						
6K						
8K						

$$\mathrm{Re}\,sonantpeak\,\_\,M_r = \frac{1}{2\xi\sqrt{(1-\xi^2)}}$$

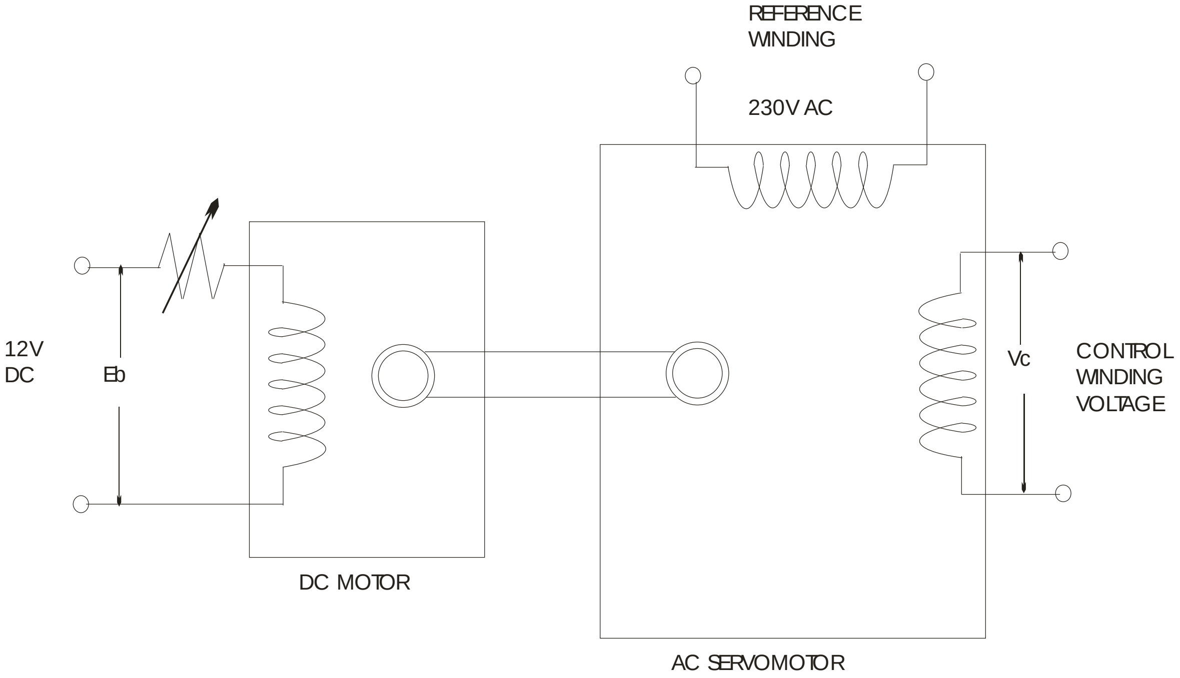
$$\mathrm{Re}\,sonatFrequ\,ency\,\_\,\omega_r = \omega_n\sqrt{(1-\xi^2)}$$

$$Bandwidth\,\_\,\omega_b = \omega_b\sqrt{(1-\xi^2)+\sqrt{4\xi^4-4\xi^2+1}}$$

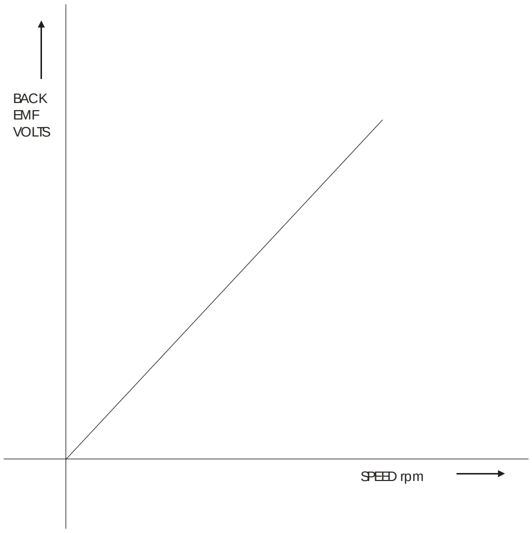
Result:

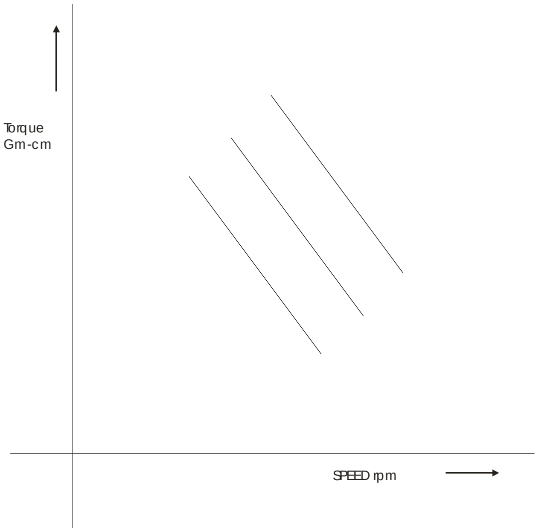
Date: ___________ **Signature of Faculty**

Circuit Diagram:



Graph:





Exp: 6a. **Date:___________**

SPEED TORQUE CHARACTERISTICS OF TWO PHASE AC SERVOMOTOR

Aim: To draw the speed torque characteristics of AC servomotor.

Apparatus:

Sl.No.	Apparatus	Nos.
1.	AC servomotor Unit	1
2.	multimeter	1

Procedure:

1) Keep load control switch & AC servo meter supply switch at OFF position.
2) Keep load Potentiometer & control voltage at minimum position.
3) Switch ON the main supply to the unit & also AC servomotor supply switch.
4) Vary the control winding voltage by varying the speed Potentiometer (speed proportional to voltage). Now the servomotor starts rotating & the speed will be indicated by the tachometer on the front panel.
5) With load switch in OFF position, vary the speed Potentiometer in steps & note down the speed & back emf generated by dc machine.
6) Set the control winding voltage for maximum value (230V,AC). Now switch on the load switch & start loading AC servomotor by varying the load Potentiometer slowly & note down the values of armature current I_a & speed of servomotor.
7) Bring the load potentiometer to zero position & switch off the load switch.
8) Repeat steps 6 & 7 for 70%, 50% & 30% of rated control winding voltage(or speed).
9) Reduce the control voltage to zero & switch OFF AC servomotor supply switch & main supply switch.

Tabular Column:

Speed V / S back emf on no load:

Sl.No	Speed rpm	Bacf emf Volts

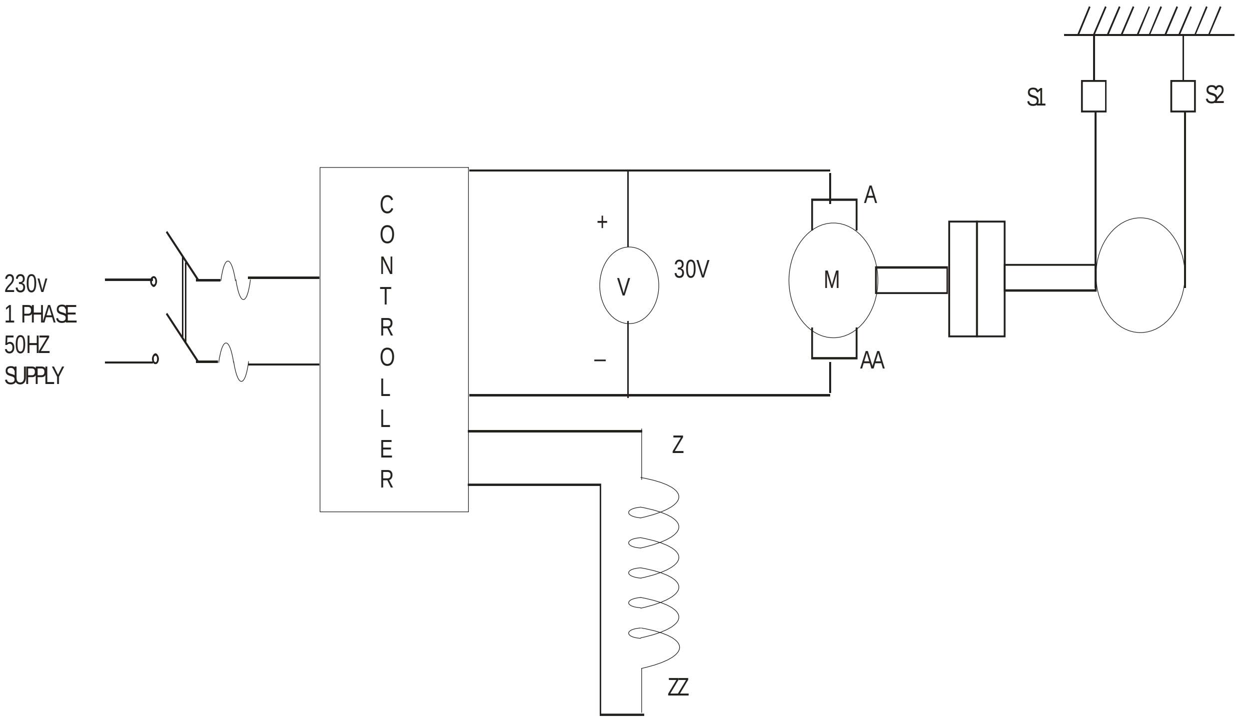
Torque V/S speed on Load:

% of Voltage	Speed (N) rpm	Bacf emf(E_b) Volts	I_a Amps	Torque $=\{E_b*I_a*60*(1.019*10^4)\}/\{2*\Pi*N)$ gm-cm
100% (230V)				
70%				
50%				
30%				

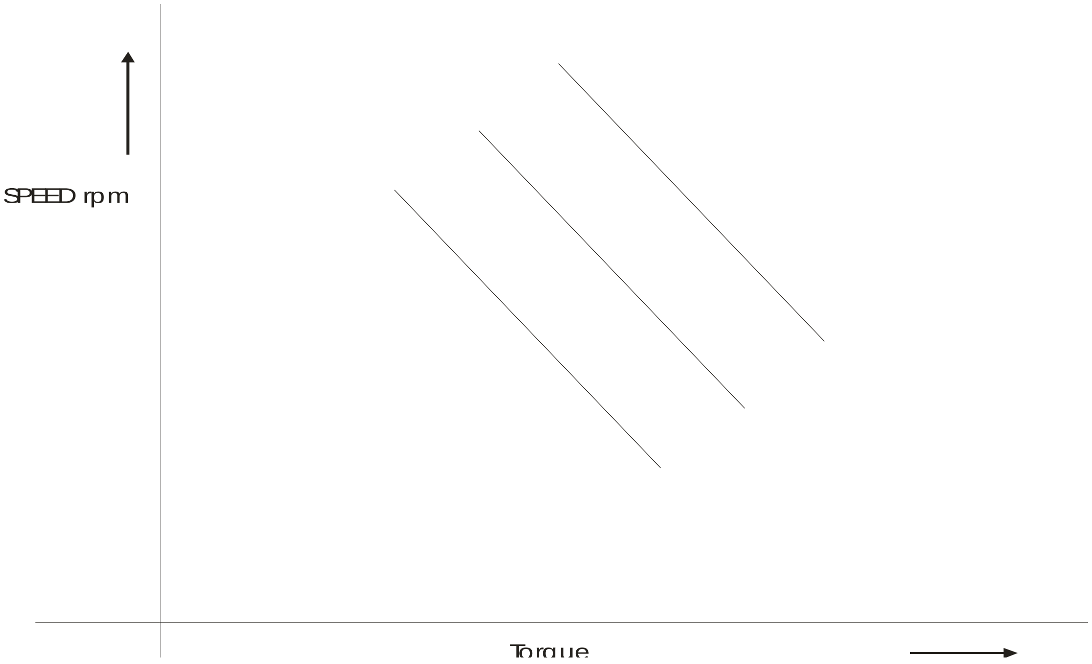
Result:

Date: ___________ **Signature of Faculty**

Circuit Diagram:



Graph:



Exp: 6b **Date:____________**

SPEED TORQUE CHARACTERISTICS OF DC SERVOMOTOR

Aim: To draw the speed torque characteristics of DC servomotor.

Apparatus:

Sl.No.	Apparatus	Nos.
1.	DC servomotor Unit	1
2.	multimeter	1

Procedure:

1) Remove the load on the brake drum and connect a 30V voltmeter across the motor armature.
2) Switch on the main supply to the unit. Now both tachometer and ammeter reads zero.
3) Switch on the servomotor switch. Now the motor starts rotating.
4) Set the voltage of the motor to maximum value at 24volts using speed variation knob. Note down the no load readings.
5) Now apply the load in steps and note down the speed and spring balance readings till the rated current of motor.
6) Remove the load on the brake drum.
7) Repeat steps 4,5 & 6 for 60%& 40% of armature rated voltage also.
8) Reduce the voltage of the motor to zero and switch off the servomotor switch and the main switch to the unit.
9) Draw the graph of speed V/S torque for all the 3 cases.

Name plate details:

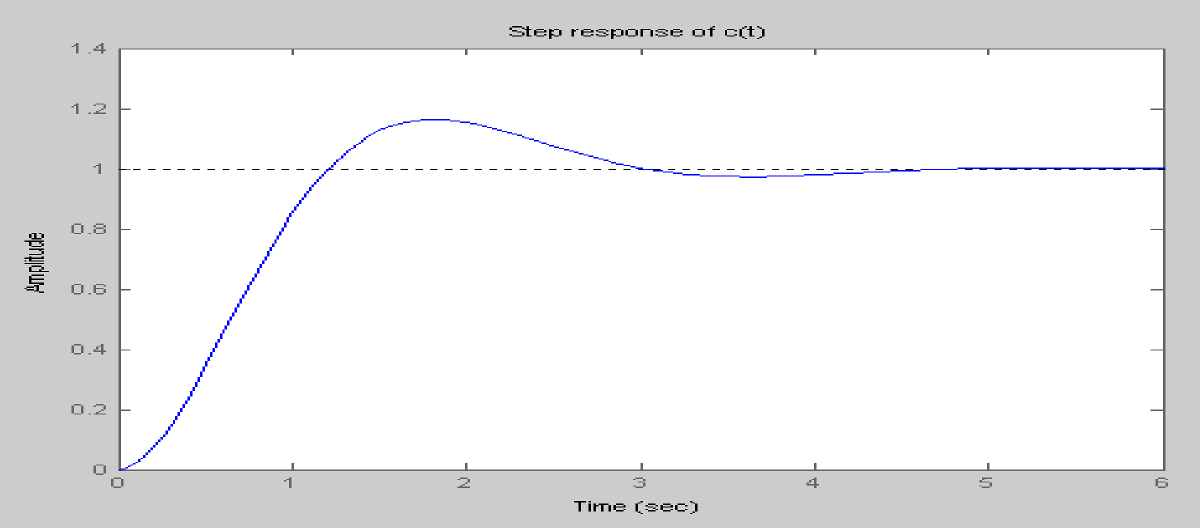
Speed- 4400rpm
Voltage- 24Volts
Current-2 amps
Torque-400gm-cm
Radius of brakedrum(r)-2.75cm

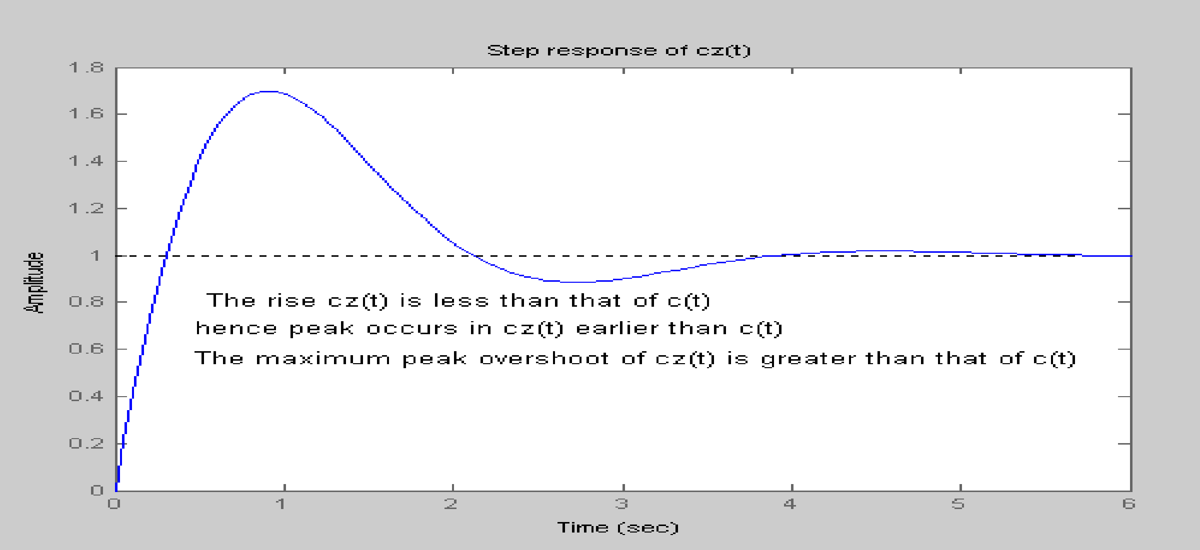
Tabular Column

% of Voltage	Speed rpm	S_1 gms	S_2 gms	$(S_1 \approx S_2)$ gms	$T=(S_1 \approx S_2)r$ gm-cm
100% **(230V)**					
60%					
40%					

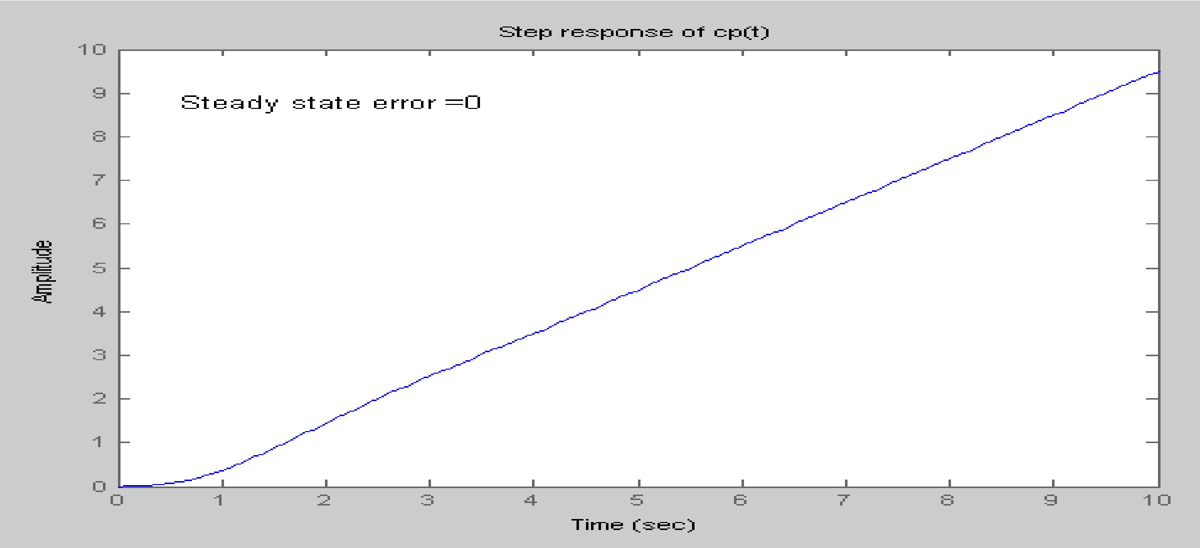
Result:

Date: ____________ **Signature of Faculty**


Step response of c(t)


Step response of cz(t)

The rise cz(t) is less than that of c(t)
hence peak occurs in cz(t) earlier than c(t)
The maximum peak overshoot of cz(t) is greater than that of c(t)


Step response of cp(t)

Steady state error =0

Exp: 7 **Date:** ___________

STEP RESPONSE OF SECOND ORDER SYSTEM

Aim1: (a) Simulation of a typical second order system using mat lab and determination of step response and evaluation of time domain specifications

(b) Evaluation of effect of additional poles and zeros on time response of second Order system.

Procedure:

1) Consider a transfer function

$$\frac{C(s)}{R(s)} = \frac{1}{S^2 + 2S + 4}$$

2) Write the program using matlab to simulate step response of the given system.

3) Evaluate time domain specifications :

i. Run the program. Step response appears on the screen.

ii. Right click anywhere in the plot region, this opens the following menu

list in the plot region.

Plot type >
System >
Characteristics >
Zoom >
Grid >

iii. Click on **Characteristics**, the following submenu will appear in the plot region.

Peak response
Setting time
Rise time
Steady state

iv. Select the submenu item, the LTI viewer displays the respective marker on the plot, click on the marker and hold the mouse button down to read the values of the plot.

v. Left click anywhere on a particular point to see the response values of that plot at that point

4. Evaluate the of effect of additional poles and zeros on step response of the system.

Program (1a)

```
clc
% prg c(t)
num = 1;
den = [1 2 4];
G = tf(num, den)
kp=dcgain(G)
ess=1/(1+kp)
w = sqrt (den(3))
zeta = den(2) / (2*w)
TD=(1+0.7*zeta)/w
TS = 4/ (zeta*w)
TP = pi/ (w*sqrt(1-zeta^2))
TR=(pi-atan((sqrt(1-zeta^2))/zeta))/(w*sqrt(1-zeta^2))
Percentovershoot= exp(-zeta*pi/ sqrt(1-zeta^2))*100
step(G)
title('Step response of c(t)')
figure
pzmap(G)
title('pole zero map of c(t)')
figure

%prg cz(t) " adding Zero to the given system"
num1 = conv(num,[1 1]);
G1 = tf(num1, den)
step(G1)
gtext('The rise cz(t) is less than that of c(t)')
gtext('hence peak occurs in cz(t) earlier than c(t)')
gtext('The maximum peak overshoot of cz(t) is greater than that of c(t)')
title('Step response of cz(t)')
figure
pzmap(G1)
title('pole zero map of cz(t)')

%prg cp(t) " adding Pole to the given system"
den2=conv(den,[1 0]);
G2=tf(num, den2);
kp1=dcgain(G2)
ess1=1/(1+kp1)
step(G2)
title('Step response of cp(t)')
figure
gtext('Steady state error =0')
pzmap(G2)
title('pole zero map of c(t)')
```

Note:

Second order system is represented by the transfer function.

$$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{\left(s^2 + 2\xi\omega_n s + \omega_n^2\right)}$$

Where ξ = damping ratio

ω_n = undamped natural frequency.

Time Domain specification:

Percentage maximum overshoot $\%M_p = 100 \times e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}}$

Peak time $t_p = \dfrac{\pi}{\omega_n\sqrt{1-\xi^2}}$

Rise time $t_r = \dfrac{\pi - \tan^{-1}(\omega_d / \xi\omega_n)}{\omega_d}$

ω_d=damped natural frequency = $\omega_n\sqrt{1-\xi^2}$

ω_n= undamped natural frequency.

ξ=damping ratio.

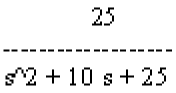
Delay time $t_d = \dfrac{1+0.7\xi}{\omega_n}$

Settling time $t_s = \dfrac{4}{\xi\omega_n}\ for 2\% tolerance$

$$t_s = \frac{3}{\xi\omega_n}\ for 5\% tolerance$$

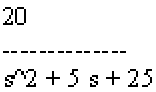
Exercise: Try the program for different Transfer functions.

1. TF=



```
        25
------------------
s^2 + 10 s + 25
```

2.TF=



```
      20
-------------
s^2 + 5 s + 25
```

Result:

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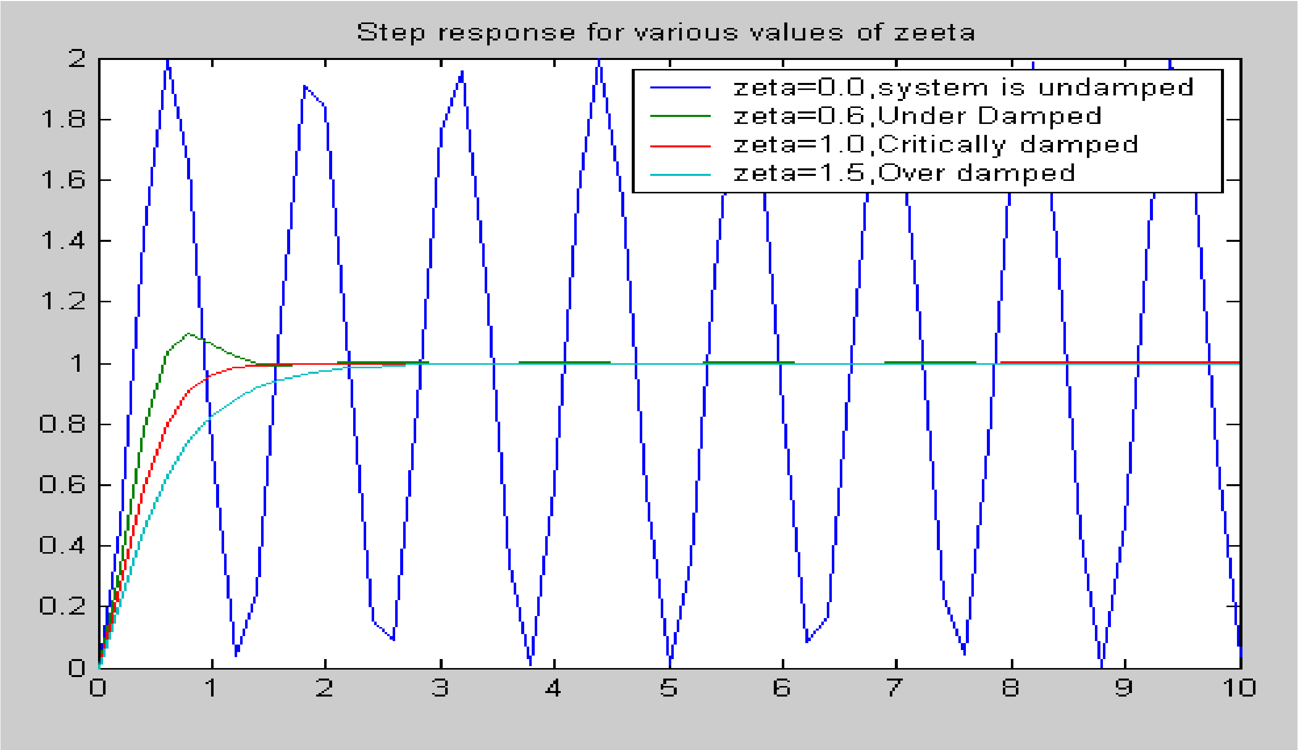
Graph:



Program(1b)

```
clc;
zeta=[0.0 0.6 1.0 1.5];
t=0:0.2:10;
for n=1:4;
   num=[0 0 25];
   den=[1 10*zeta(n) 25];
   [y(1:51,n),x,t]=step(num,den,t);
end
plot(t,y)
legend('zeta=0.0,system is undamped','zeta=0.6,Under Damped','zeta=1.0,Critically
damped','zeta=1.5,Over damped')
title('Step response for various values of zeeta')
```

7b. Aim2: Simulation of a typical second order system using mat lab and determination of step response for various values of zeta.

Procedure:

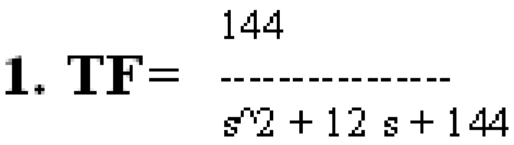
1) Consider a transfer function

$$\frac{C(s)}{R(s)}=\frac{25}{S^2+10S+25}$$

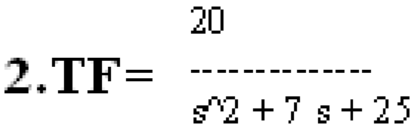
2) Write the program using matlab to simulate step response of the given system
3) observe the simulation graph for different values of zeta.

Note: Do the Excise problems and Change the values of Zeta.

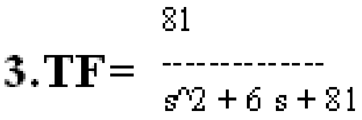
Exercise:



```
         144
1. TF= ---------------
       s^2 + 12 s + 144
```



```
       20
2.TF= -------------
      s^2 + 7 s + 25
```



```
      81
3.TF= -------------
      s^2 + 6 s + 81
```

Result:

Date: ___________ **Signature of Faculty**

Program:

```
% DC position step response
clc;
clear all
w=4; g=0.8;
k1=w^2/8;
K=(2*g*w)/(80*k1);
num1=[ 8*k1];
den1=[1 80*K*k1 8*k1];
sys=tf(num1,den1)
step(sys)
title('1.Dc position step response for given')
figure

% step response With Feed back

G = tf(num1,den1)
sys = feedback(G,1)
kv=dcgain(G)
ess=1/kv
t = 0:0.1:50;
u = t;
[Y,t] = step(sys,u);
plot(t,Y,'-',t,u,'o')
xlabel('Time(secs)')
ylabel('Amplitude')
title('2. Dc position step response with step as
imput')
legend('Input', 'Output')
figure
```

Exp: 8 **Date:____________**

DC POSITION CONTROL SYSTEM

Aim:1. To obtain the step response of a DC Position control system using MAT LAB.

2. To verify the effect of input wave form,loop gain system type on steady state Errors.

Procedure:

1) A DC position control servomechanism comprises of a DC servometer with constant armature current, potentiometer error detector DC amplifier and a tachogenerator coupled to motor shaft. A fraction K of tachogenerator output is feedback to procedure stabilization effect. The following particulars refer to the system.

Moment of inertia of motor $J_m=3x10^{-3}Kg\text{-}m^2$

Moment of inertia of load $J_L=5Kg\text{-}m^2$

Motor to load gear ratio,$\theta_L/\theta_m=1/50$ =n

Motor torque constant,K_1 = 2 Newton–m/amp,

Tachogenerator constant K= 0.2 volt/rad/sec,

Sensitivity of error detector,K_p=1 Volt/Rad

Amplifier gain =K_1 amps/volt

Undamped natural frequency=w= 4 rad/sec

Damped ratio =g=0.8

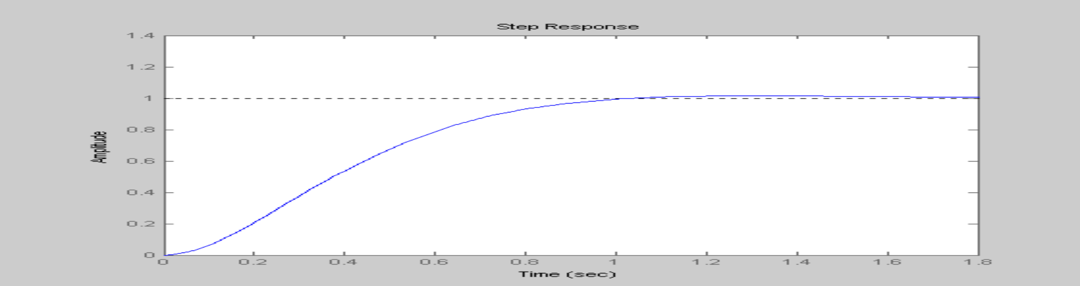
Motor and load friction and motor field time constant are assumed to negligible.

Transfer function : $$\frac{\theta_L}{\theta_m}=\frac{8K_1}{(S^2+80KK_1S+8*K_1)}$$

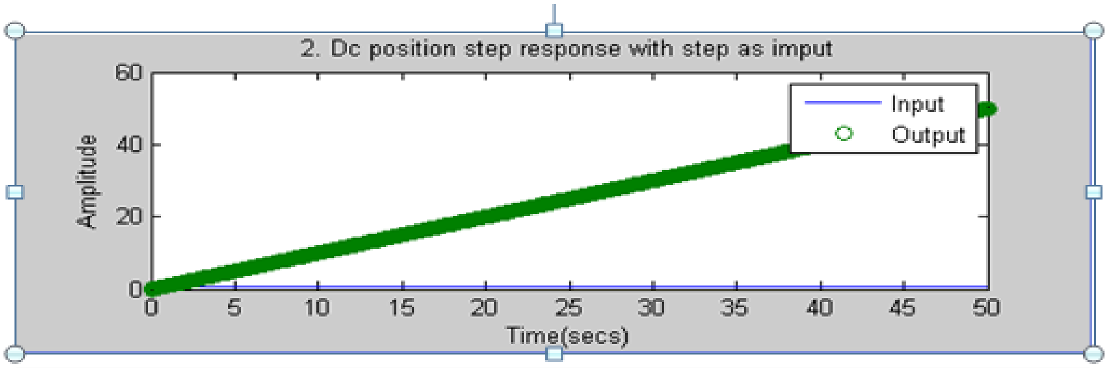
Note: $$\frac{C(s)}{R(s)}=\frac{\omega_n^2}{\left(s^2+2\xi\omega_n s+\omega_n^2\right)}$$

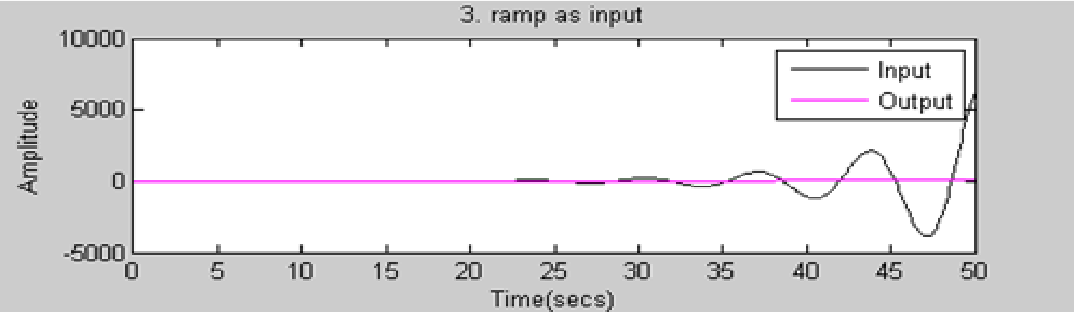
Graph:

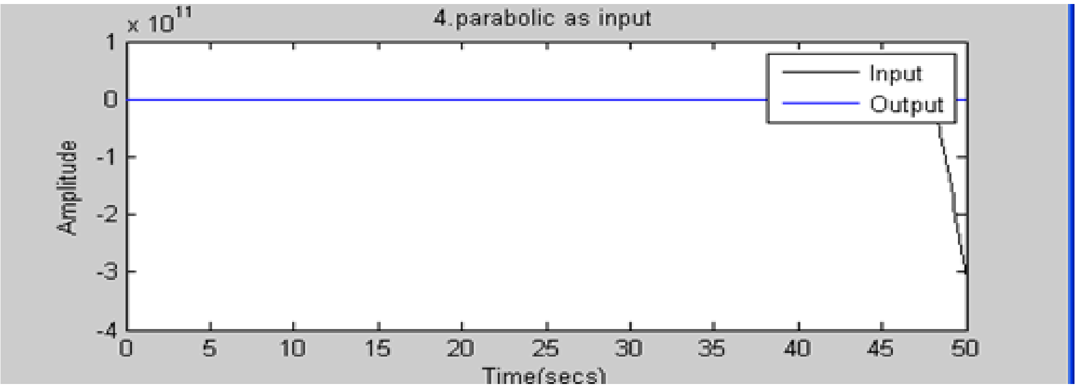
%



```
ramp input
d=conv(den1,[1 0 0]);
G = tf(num1,d)
sys = feedback(G,1)
kv=dcgain(G)
ess=1/kv
t = 0:0.1:50;
u = t;
[Y,t] = step(sys,u);
plot(t,Y,'k',t,u,'m')
xlabel('Time(secs)')
ylabel('Amplitude')
title('3. ramp as input')
legend('Input', 'Output')
figure

% parabolic input
dr=conv(den1,[1 0 0 0 ]);
G = tf(num1,dr)
sys = feedback(G,1)
kv=dcgain(G)
ess=1/kv
t = 0:0.1:50;
u = t;
[Y,t] = step(sys,u);
plot(t,Y,'--',t,u,'m')
xlabel('Time(secs)')
ylabel('Amplitude')
title('4.parabolic as input')
legend('Input', 'Output')
```







Exercise:

1. TF=

```
      144
-----------------
s^2 + 12 s + 144
```

2.TF=

```
     20
--------------
s^2 + 7 s + 25
```

Result:

Date: ___________ **Signature of Faculty**

```
%Program to observe the effect P,PD,PI and PID controllers
clear all
clc
num=[1];
den=[0.5 1 4];
display('Transfer function for step response for given
TF');
sys1=tf(num,den)
display('Transfer function for step response for given TF
with FB');
f=feedback(sys1,1)
f1=step(f);
subplot(2,3,1);plot(f1);
title('Step response of given system')

% Proportional controller
kp=10;
numP=kp*num;
display('Transfer function for P controller with out FB');
sys=tf(numP,den)
display('Transfer function for P controller with FB');
G=feedback(sys,1)
m=step(G);
subplot(2,3,2);plot(m);
title('Proportional contol Kp=10')
k=dcgain(G)
essP=1/(1+k)

% PD controler
Kd=10;
numc=[Kd kd];
nr=conv(num,numc);
display('Transfer function for PD controller with out
FB');
sys1=tf(nr,den)
display('Transfer function for PD controller with FB');
G1=feedback(sys1,1)
m=step(G1);
subplot(2,3,3);plot(m);
title('PD control Kp=10 and Kd=10')
```

Exp: 9 **Date:____________**

P,PI,PD AND PID CONTROLLER

Aim: To obtain step response of the given system and evaluate the effect P,PD,PI and PID controllers.

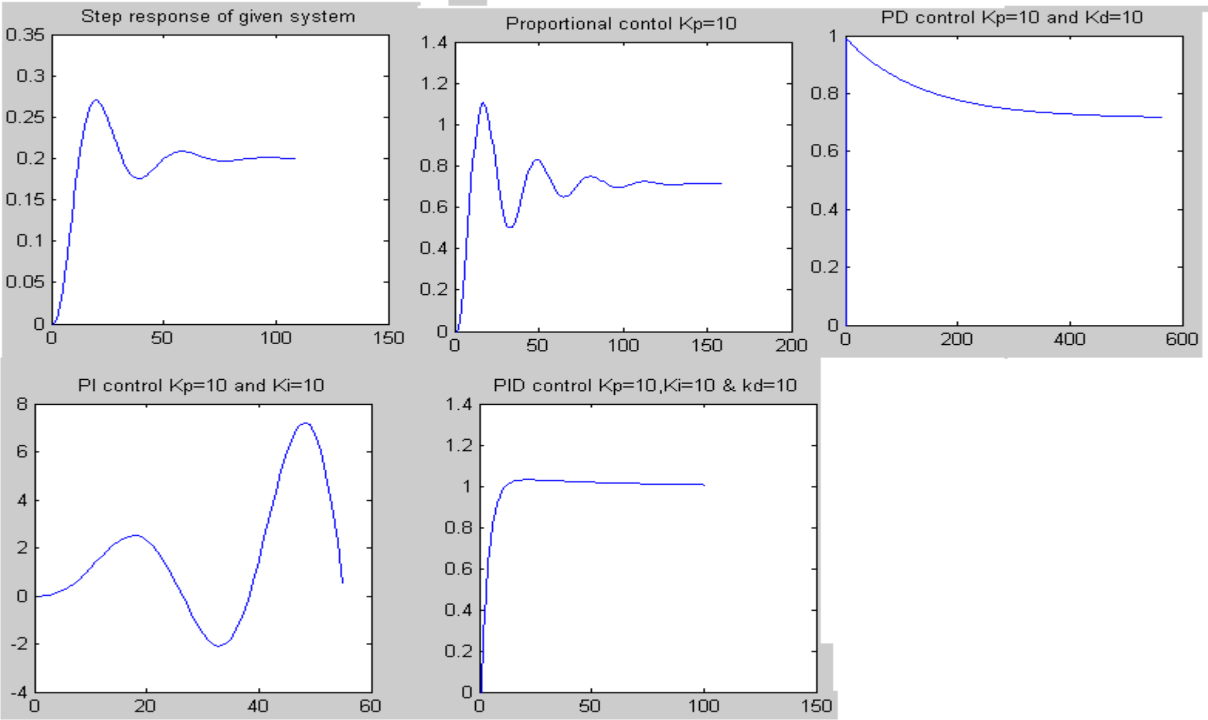
Procedure:

1) Consider the open loop transfer function

$$G(s)=\frac{1}{0.5S^2+S+4}$$

2) Write the program using matlab to simulate step response of the given System.
3) Evaluate the effect of P,PI,PD and PID controllers

Graph:



```
%PI controller
ki=10;
numI=[kp ki*kp];
```

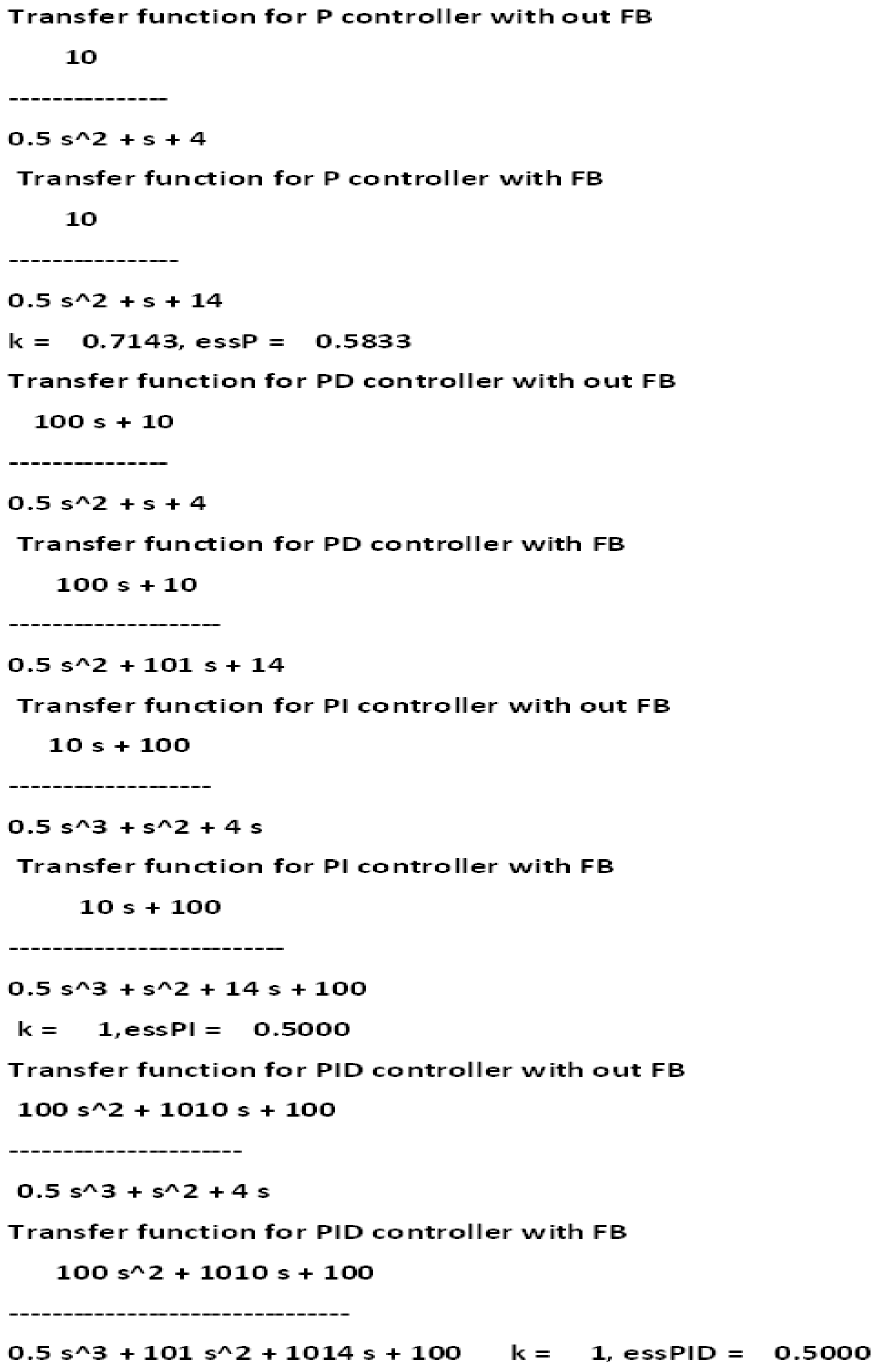
```
denI=[1 0];
dr=conv(denI,den);
display('Transfer function for PI controller with out
FB');
sys2=tf(numI,dr)
display('Transfer function for PI controller with FB');
G2=feedback(sys2,1)
m=step(G2);
subplot(2,3,4);plot(m);
k=dcgain(G2)
essPI=1/(1+k)
title('PI control Kp=10 and Ki=10')

%PID controller
nr1=conv(numc,[1 ki]);
display('Transfer function for PID controller with out
FB');
sys3=tf(nr1,dr)
display('Transfer function for PID controller with FB');
G3=feedback(sys3,1)
m=step(G3);
subplot(2,3,5);plot(m);
k=dcgain(G3)
essPID=1/(1+k)
title('PID control Kp=10,Ki=10 & kd=10')
```

Result: **Transfer function for step response for given TF**

```
     1
---------------
0.5 s^2 + s + 4
```

Transfer function for step response for given TF with FB

```
     1
---------------
0.5 s^2 + s + 5
```



```
Transfer function for P controller with out FB
      10
---------------
0.5 s^2 + s + 4
 Transfer function for P controller with FB
      10
----------------
0.5 s^2 + s + 14
k =    0.7143, essP =    0.5833
Transfer function for PD controller with out FB
   100 s + 10
---------------
0.5 s^2 + s + 4
 Transfer function for PD controller with FB
     100 s + 10
--------------------
0.5 s^2 + 101 s + 14
 Transfer function for PI controller with out FB
    10 s + 100
-------------------
0.5 s^3 + s^2 + 4 s
 Transfer function for PI controller with FB
        10 s + 100
--------------------------
0.5 s^3 + s^2 + 14 s + 100
 k =     1,essPI =    0.5000
Transfer function for PID controller with out FB
 100 s^2 + 1010 s + 100
----------------------
 0.5 s^3 + s^2 + 4 s
Transfer function for PID controller with FB
     100 s^2 + 1010 s + 100
--------------------------------
0.5 s^3 + 101 s^2 + 1014 s + 100      k =     1, essPID =    0.5000
```

xercise:

1. TF= $\dfrac{144}{s^2 + 12\,s + 144}$ **2.TF=** $\dfrac{20}{s^2 + 7\,s + 25}$

Result:

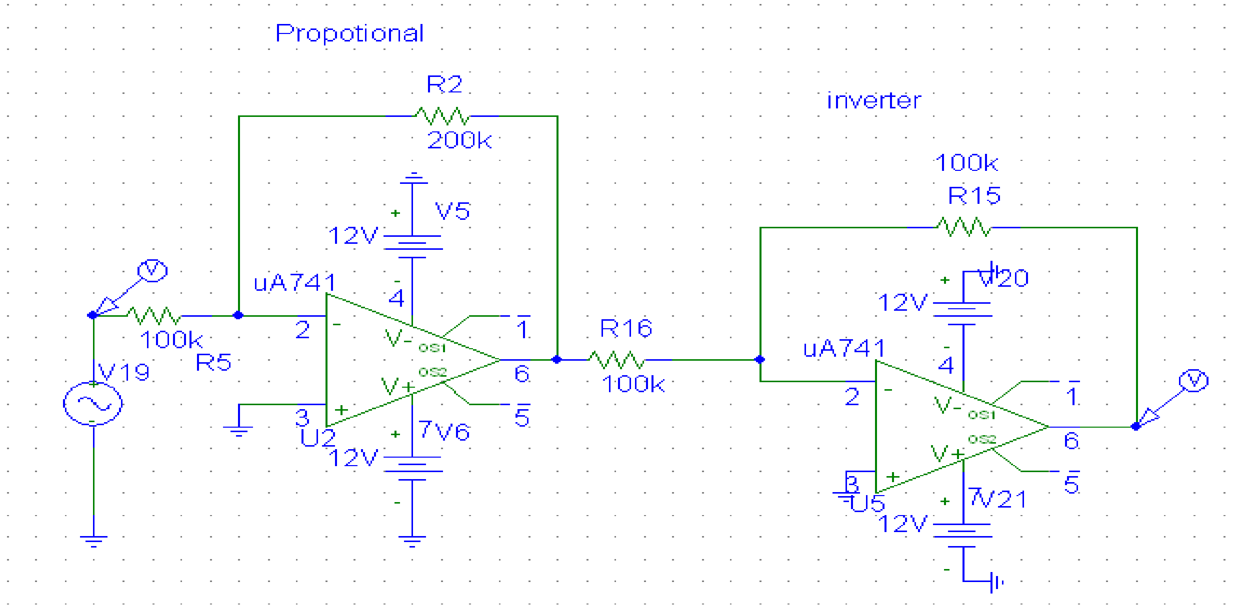
Date: ___________ **Signature of Faculty**

Other type program for PID controller

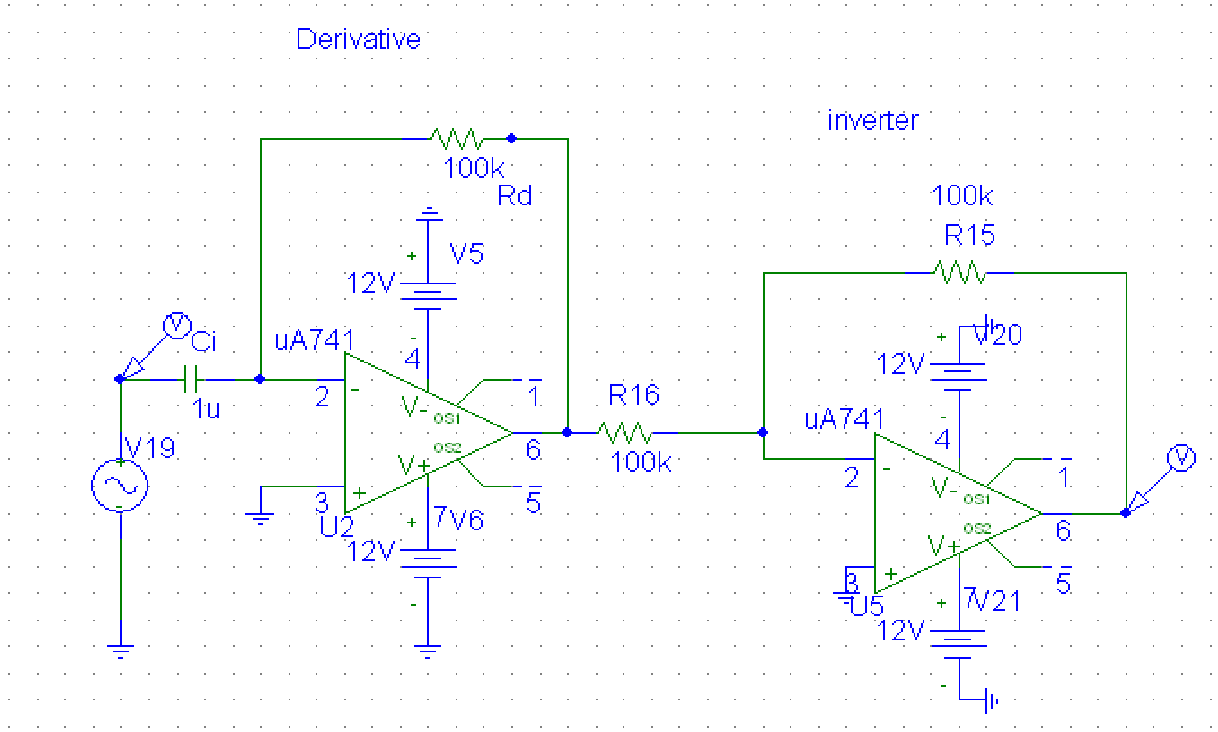
```
num=[1];
den=[0.5 1 4];
plant=tf(num,den)

step(plant)
title('Step response plant');
figure
kp=30;
b= feedback(plant*kp,1);

step(b)
title('Step response proportional controller');
figure
ki=40;
control=tf([kp ki],[1 0]);
b1=feedback(plant*control,1)
step(b1)
title('Step response proportional & intergral controller');
 figure
 kd= 20

 control=tf([kp kd],1);
b1=feedback(plant*control,1)
step(b1)
title('Step response proportional & derivative controller');
figure

control=tf([kd 0  ki],[1 0]);
b1=feedback(plant*control,1)
step(b1)
title('Step response derivative & intergral controller');

control=tf([kd kp ki],[1 0]);
b1=feedback(plant*control,1)
step(b1)
title('Step response proportional , derivate & intergral controller');
```

Simulation Circuit: **Using Op amp Circuits:**

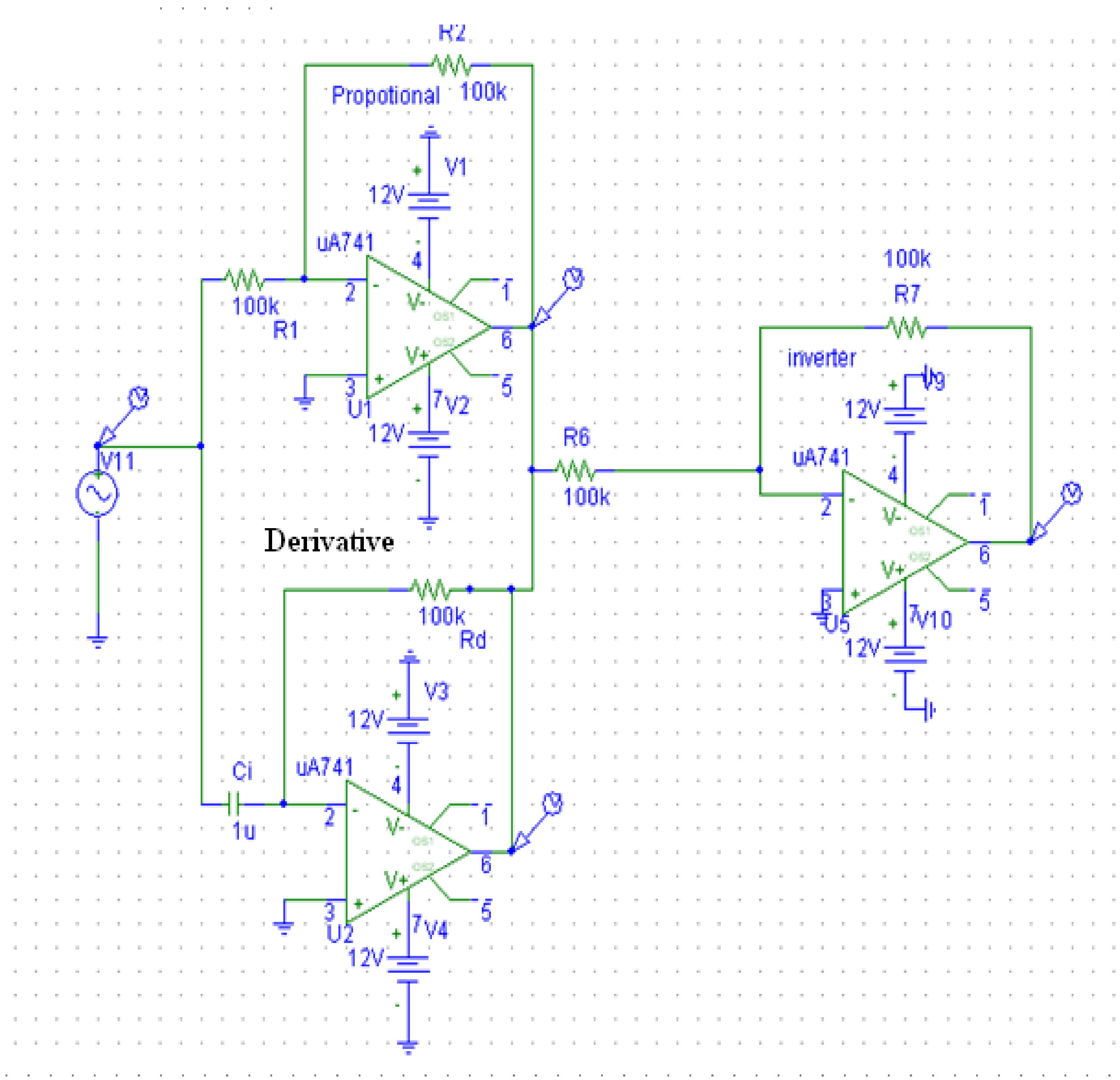
Proportional controller:



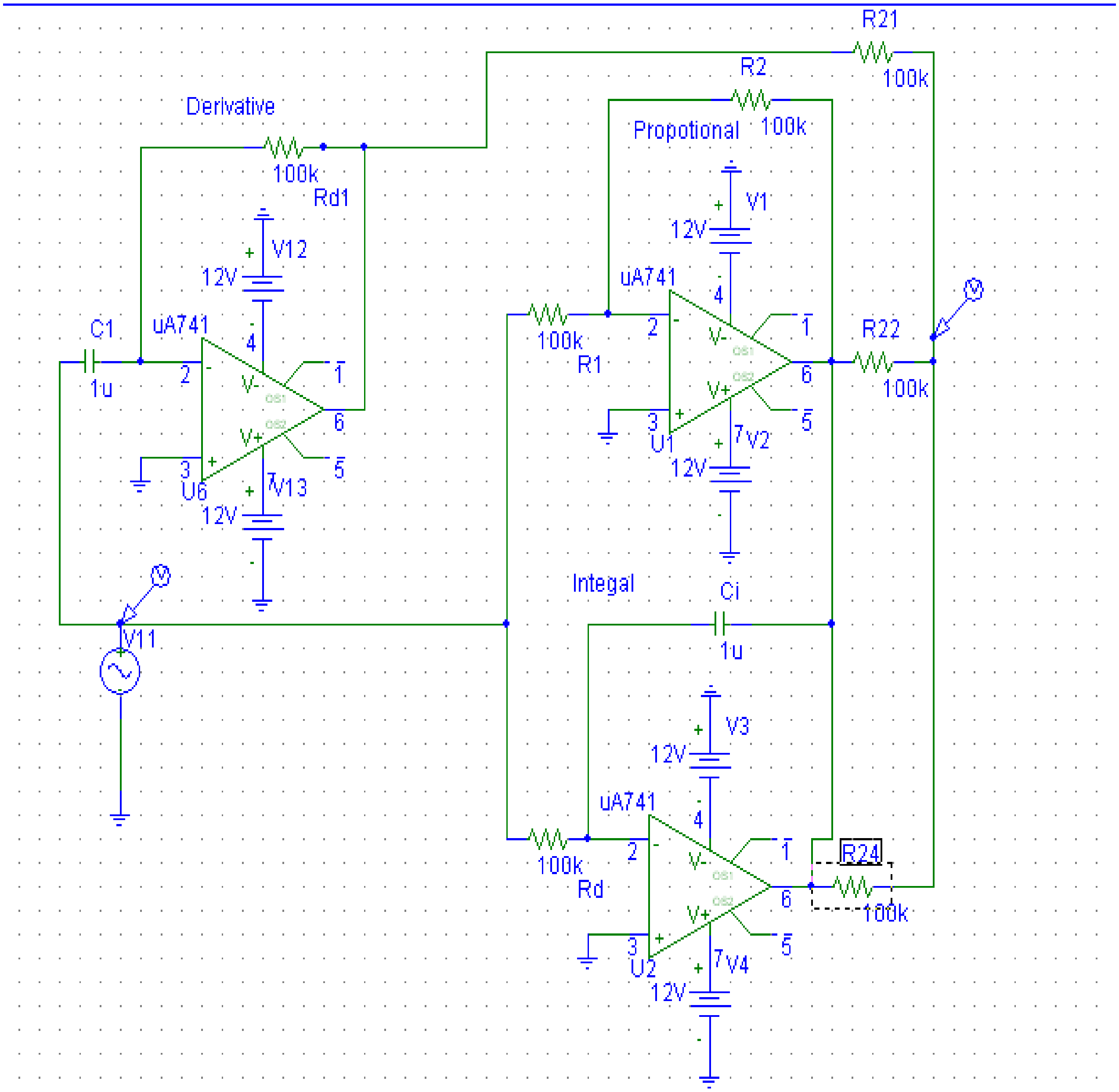
Derivative controller:



Proportional & Derivative controller:



Proportional, Derivative & Integral controller:



Program

```
n=[0 0 0 1];
d=[1 5 6 0];
sys=tf(n,d);
rlocus(sys);
sgrid(0.2,0.0);
k=rlocfind(sys)
title('Root locus');
figure

%Effect of adding poles
dr=conv([1 10],d);
sys1=tf(n,dr);
rlocus(sys1);
title(' Effect of adding poles in Root locus');
figure

%Effect of adding zeros
nr=conv([1 1],n);
sys2=tf(nr,d);
rlocus(sys2);
title(' Effect of adding zeros in Root locus');
figure

% effect of k on the transient response
t=0:0.01:20;
n=[0 0 0 k]
d=[1 5 6 0+k];
c=step(n,d,t);
plot(t,c)
title('Effect of k on transient response');
figure
```

Exp: 10 **Date:___________**

ROOT LOCUS, BODE & NYQUIST PLOT USING MAT LAB

Aim: 1) To sketch the root locus for the given transfer function and hence to verify, using MAT LAB, Break away point, Intersection with Imaginary axis, range of K for Stability and to find Closed loop transfer function at any value of K.

2) To sketch the nyquist plots for the given transfer function

3) To sketch the bode plots for the given transfer function and hence to verify, using MAT LAB,GM, PM, gain cross over frequency ωcg, phase cross over frequency ωcp and the value of K for a specified GM/PM.

Procedure:

1) Draw root loci for the given transfer function & find the breakaway point and Imaginary axis Intersection point, range of K for stability.
2) Verify the values using MAT LAB.

Let the open loop transfer function is $G(S) = \frac{1}{S^3 + 5S^2 + 6S}$

3) Draw bode plots for the given transfer function & find Gain margin, Phase margin and their corresponding frequencies. Also find the value of K for specified Gain margin/Phase margin.
4) Verify the above values using Mat Lab.
5) Draw Nyquist plot for the given transfer function.

Note:

The coefficients of numerator & denominator of G(S) to be typed depends on the given transfer function.

Stability:

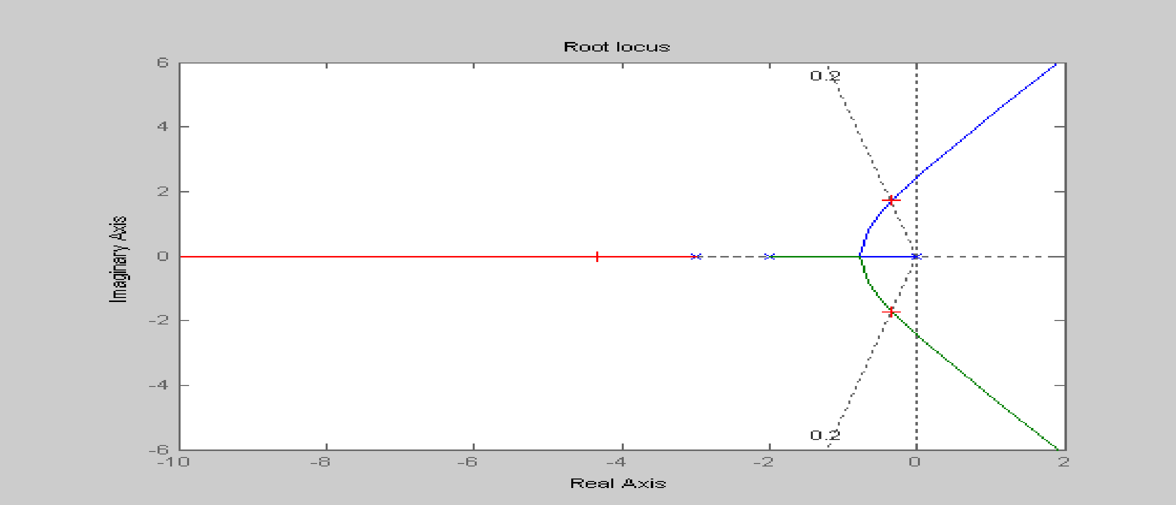
If the Gain margin and Phase margin are positive, the given minimum phase system is stable.

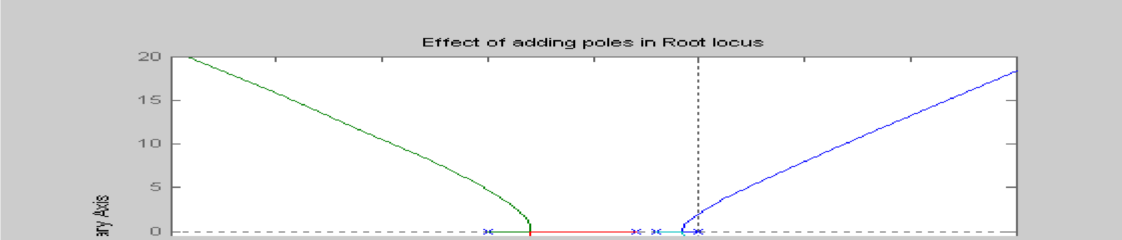
ω_{cg} is gain cross over frequency.

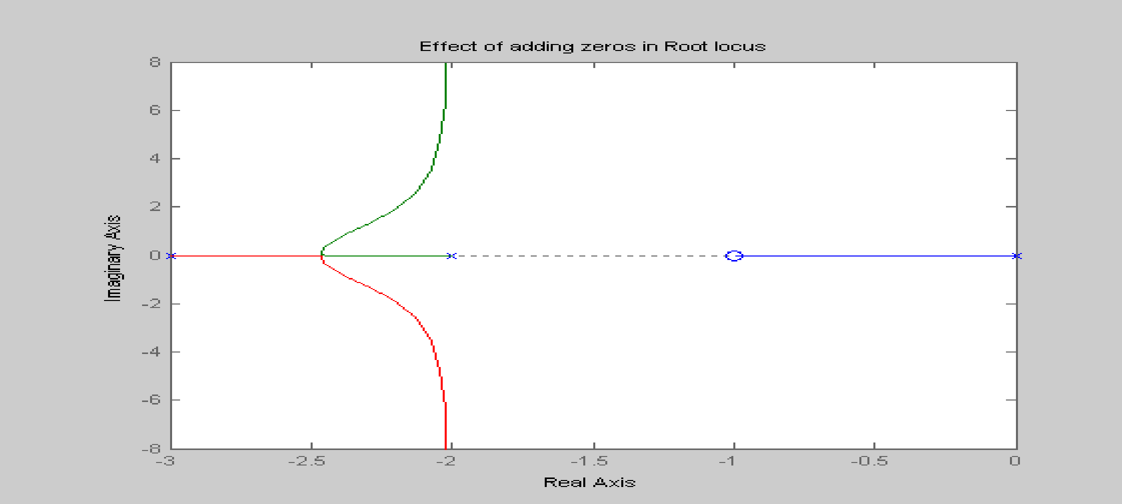
ω_{cp} is phase cross over frequency.

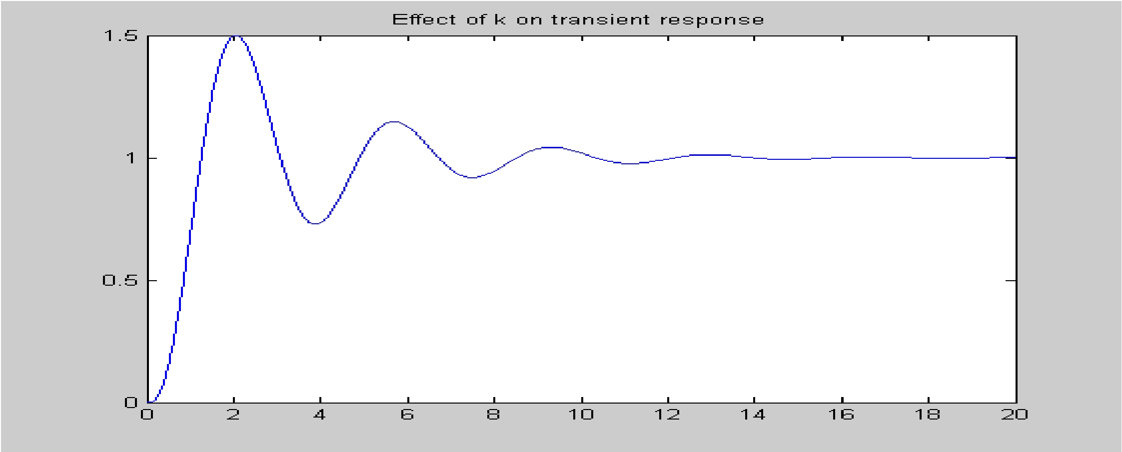
```
% bode plot for the given system
bode(sys)
margin(sys)
[gm,pm,wcp,wcg]=margin(sys);
gmdb=20*log10(gm)
title(' Bode plot');

% nyquist plot
nyquist(sys)
title(' Nyquist plot');
```

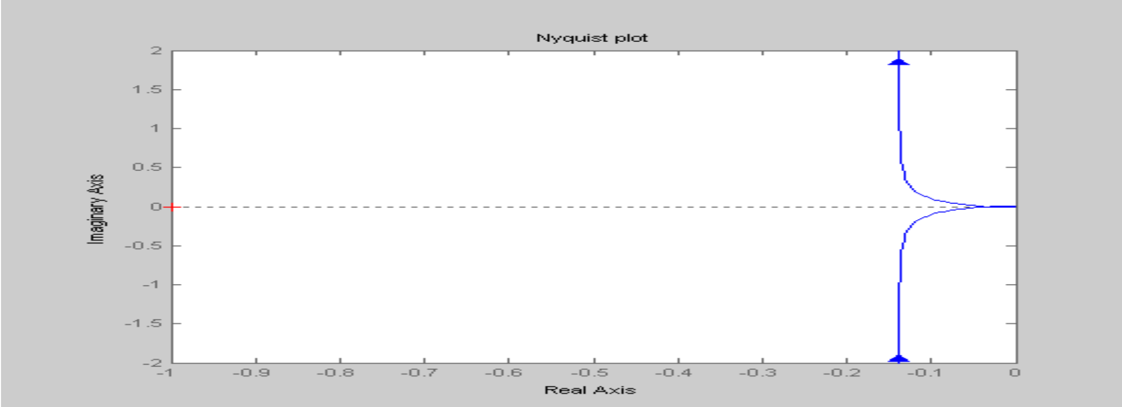
Graph:











Exercise :

Root locus:

1. Num= [1] & den=[s(s+2)(s+4)] 2. num=[10] & den=[1 9 10 0]

Bode Plots

3. Num: [25] & den=[1 4 25] 4. Num: [40] & den=[s^2(s+2)(s+5)]

Nquist plots:

5. num=[1 2] & den=[(s-1)(s+1) 6. num=s(s-3) & den=s(s+1)(s-1)

Result:

Date: ___________ **Signature of Faculty**

Program

```
% to obtain the relation between frequency response and
transient response
n=[1];
d=conv([1 0],[0.1 1])
g=tf(n,d);
bode(g)
margin(g)
[gm,pm,wcp,wcg]=margin(g)
GMdb=20*log10(gm)
figure
fplot('1/(2*z*sqrt(1-z^2))',[0.0 0.8,0.01 10])
hold on
fplot('exp(-pi*z/sqrt(1-z^2))',[0.0 0.8,0.01 10])
hold off
xlabel('zeta')
ylabel('resonant peak,max.overshoot')
figure
fplot('1*sqrt((1-2*z^2)+sqrt(4*z^4-4*z^2+2))',[0.0 0.8,0.01 2])
xlabel('zeta')
ylabel('bandwidth')
```

Exp: 11 **Date:___________**

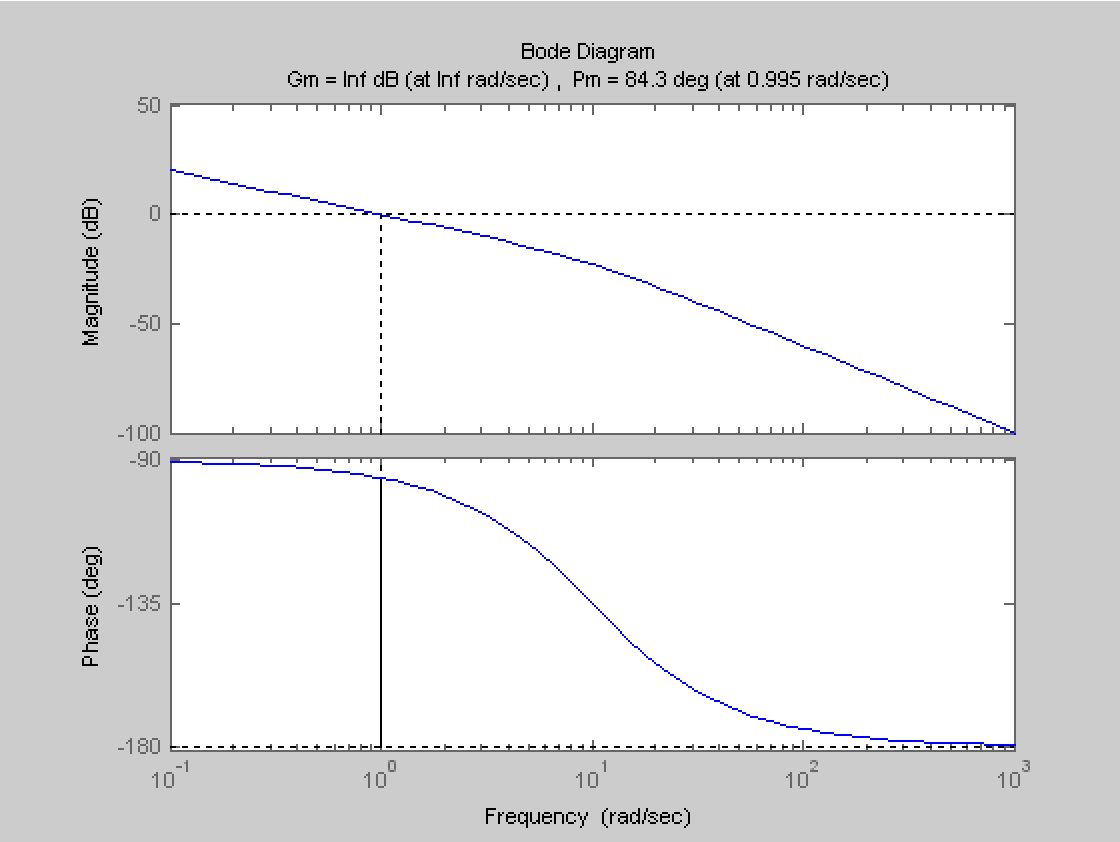
RELATIONSHIP BETWEEN FREQUENCY RESPONSE AND TRANSIENT RESPONSE

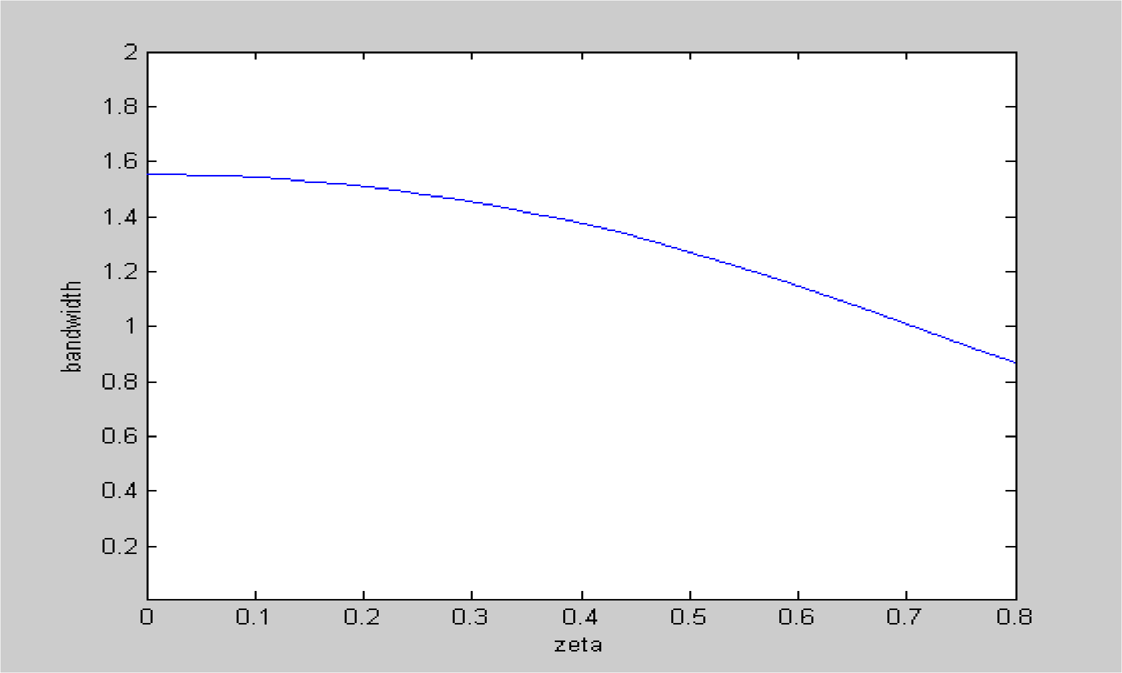
Aim: To obtain the relation between frequency response and transient response

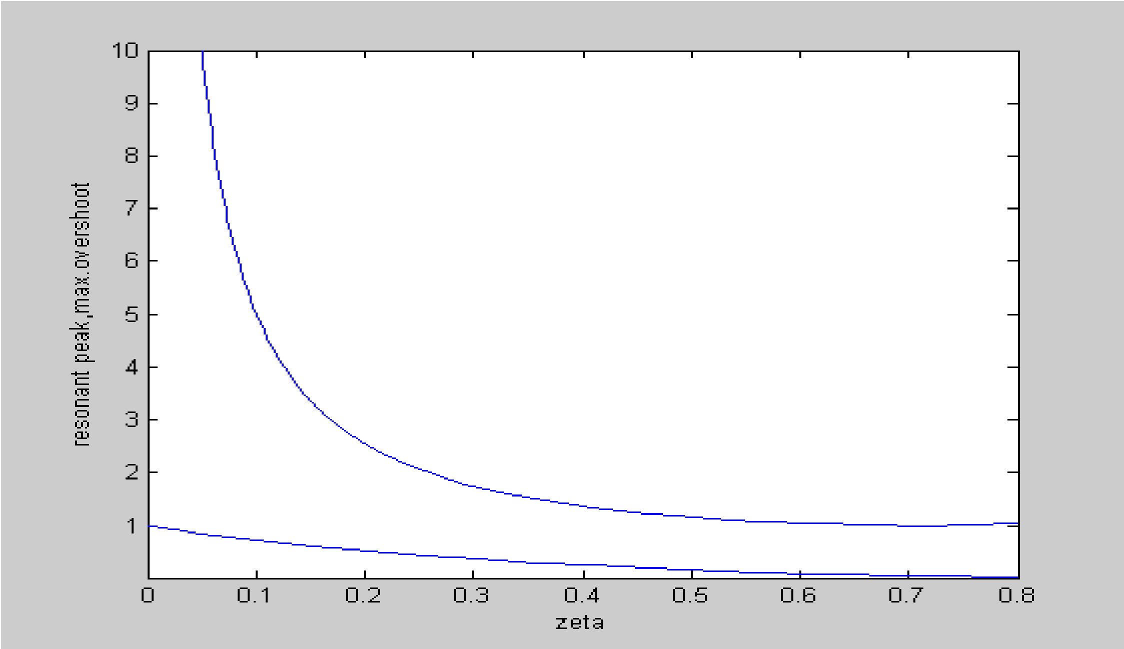
Procedure:

1. Write a Mat Lab program to:
    a) obtain the bode plot for the given transfer function and find the stability
    b) draw graph of peak overshoot and resonant peak Vs damping ratio
    c) draw a graph of bandwidth Vs damping ratio

Graph:




bandwidth
zeta
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8


resonant peak,max.overshoot
zeta
10
9
8
7
6
5
4
3
2
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

Open source Engineering Scientific Lab Programs (SCI-lab)

Program (7a)

```
clc;
clear;
close;
s=%s; // first create a variable
num=1;
den=20+10*s+s^2;
//create a scilab continuous system LTI object
TF=syslin('c',num,den)
disp(TF,'Transfer Function')
t=linspace(0,5,50);
step_res=csim('step',t,TF);
plot(t,step_res),xgrid(),xtitle('Step response','time','response');

//Adding poles to given transfer function
clc;
clear;
close;
s=%s; // first create a variable
num=1;
den=20+10*s+s^2;
num1=num*((s+1))
disp(num1,'num1=')
TF1=syslin('c',num1,den)
disp(TF1,'Transfer Function after adding poles')
t=linspace(0,5,50);
step_res=csim('step',t,TF1);
plot(t,step_res),xgrid(),xtitle('Step response after adding
poles','time','response');
```

```
figure
plzr(TF1)

//Adding Zeros to given transfer function
clc;
clear;
close;
s=%s; // first create a variable
num=1;
den=s^2+20+10*s;
disp(den,'den=')
den1=den*((s+0))
disp(den1,'den1=')
TF2=syslin('c',num,den1)
disp(TF2,'Transfer Function after adding poles')
t=linspace(0,5,50);
step_res=csim('step',t,TF2);
plot(t,step_res),xgrid(),xtitle('Step response after adding
poles','time','response');
figure
plzr(TF2)
```

// program 7b

```
clc;
s=%s;
t=linspace(0,10,100);
num=25;
//zeta=0.0
den=25+10*0*s+s^2;
TF1=syslin('c',num,den)
step_res1=csim('step',t,TF1);
//zeta=0.6
den2=25+10*0.6*s+s^2;
TF2=syslin('c',num,den2)
step_res2=csim('step',t,TF2);

//zeta=1.0
den3=25+10*1.0*s+s^2;
TF3=syslin('c',num,den3)
step_res3=csim('step',t,TF3);
//zeta=1.5
den4=25+10*1.5*s+s^2;
TF4=syslin('c',num,den4)
step_res4=csim('step',t,TF4);

plot(t, step_res1,'red')
plot(t, step_res2,'yellow')
plot(t, step_res3,'green')
plot(t, step_res4)
legend('zeeta=0.0','zeeta=0.6','zeeta=1.0','zeeta=1.5')
```

Program 8

```
//DC position step response
clc;
s=%s;
w=4; g=0.8;
k1=w^2/8;
K=(2*g*w)/(80*k1);
num1= 8*k1;
den1=s^2+ 80*K*k1*s+ 8*k1
//disp(den1,'den=')
TF1=syslin('c',num1,den1)
disp(TF1,'Transfer Function ')
t=[0:.1:50]';
step_res1=csim('step',t,TF1)
plot(t,step_res1),xgrid(),xtitle('DC position Step response ','time','Amplitude');
figure

//with feed back

TF2=syslin('c',num1,(den1+num1))
disp(TF2,'Transfer Function ')
sys=csim('step',t,TF2)
u=t;
plot(u,sys)
xlabel('Time(secs)')
ylabel('Amplitude')
title('feed back of dc position')
figure
```

```
//with ramp input

F3=syslin('c',[num1/(den1*(s^2+0*s+0))]); //Creates transfer function in forward path
B3=syslin('c',(1+0*s)/(1+0*s)); //Creates transfer function in backward path
OL3=F3*B3; //Calculates open-loop transfer function
CL3=F3/.B3; //Calculates closed-loop transfer function
step_res3=csim('step',t,CL3);
plot(t,step_res3),xgrid(),xtitle('ramp input ','time','Amplitude');
figure
//with parabolic input

F3=syslin('c',[num1/(den1*(s^3+0*s^2+0*s+0))]); //Creates transfer function in forward path
B3=syslin('c',(1+0*s)/(1+0*s)); //Creates transfer function in backward path
OL3=F3*B3; //Calculates open-loop transfer function
CL3=F3/.B3; //Calculates closed-loop transfer function
step_res3=csim('step',t,CL3);
plot(t,step_res3),xgrid(),xtitle('parabolic input ','time','Amplitude');
```

Program9

```
clc;
clear;
close ;
s=%s; // first create a variable
num=1;
den=20+10*s+s^2;
//create a scilab continuous system LTI object
TF=syslin('c',num,den)
disp(TF,'Transfer Function')

t=linspace(0,5,100);
plant=csim('step',t,TF);
plot(t,plant),
xgrid(),xtitle('STEP RESPONSE OF PLANT','time','Amplitude');
figure

// Proportional controller

kp=30;
num2=num*kp;
den2=den+(kp);
prop=syslin('c',num2,den2)
disp(prop,'Transfer Function')
plant1=csim('step',t,prop)
plot(t,plant1),
xgrid(),xtitle('STEP RESPONSE OF PROPOTIONAL
CONTROLLER PLANT','time','Amplitude');
figure
// P I controller

ki=40;
num3=num*(kp*s+ki);
den3=den*(s)+(kp*s+ki);
```

```
prop3=syslin('c',num3,den3)
disp(prop3,'Transfer Function')
plant3=csim('step',t,prop3);
plot(t,plant3),
xgrid(),xtitle('STEP RESPONSE OF PROPOTIONAL & INTEGRAL CONTROLLER PLANT','time','Amplitude');
figure
// P D controller

kd=20;
num4=num*(kp*s+kd);
den4=den+(kp*s+kd);
prop4=syslin('c',num4,den4)
disp(prop4,'Transfer Function')
plant4=csim('step',t,prop4);
plot(t,plant4),
xgrid(),xtitle('STEP RESPONSE OF PROPOTIONAL & DERIVATIVE CONTROLLER PLANT','time','Amplitude');
figure
// P iD controller

num5=num*(kd*s^2+kp*s+ki);
den5=den*s+(kd*s^2+kp*s+ki);
prop5=syslin('c',num5,den5)
disp(prop5,'Transfer Function')
plant5=csim('step',t,prop5);
plot(t,plant5),
xgrid(),xtitle('STEP RESPONSE OF PROPOTIONAL INTEGRAL & DERIVATIVE CONTROLLER PLANT','time','Amplitude');
```

Program10

```
//Bode Plot
s=poly(0,'s');
F=syslin('c',[20/(s+2)])
B=syslin('c',(1+0*s)/(1+0*s))// Creates transfer function in backward path
OL =F*B //Calculates open-loop transfer function
fmin =0.1;
fmax=100;
scf(1);
clf;
bode(OL, fmin,fmax); // Plot s   frequency response of open loop
show_margins(OL) // Displays GM,PH,Cross over frequency

//Root Locus
clear;
close;
clc;
s=%s;
n=20;
d=s^3+5*s^2+6*s+0;
TF2=syslin('c',n,d)
disp(TF2,'TF2')
```

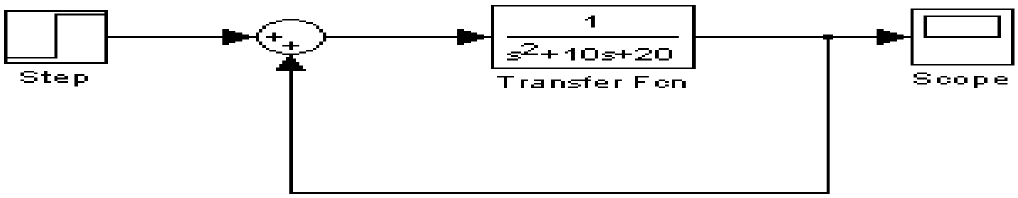
```
evans(TF2,20)
xgrid

//Nyquisy Plot
clc;
clear;
close;
s=%s ;
sys=syslin('c',1/(s+2))
nyquist(sys)
show_margins(sys,'nyquist')
```

Progam 11

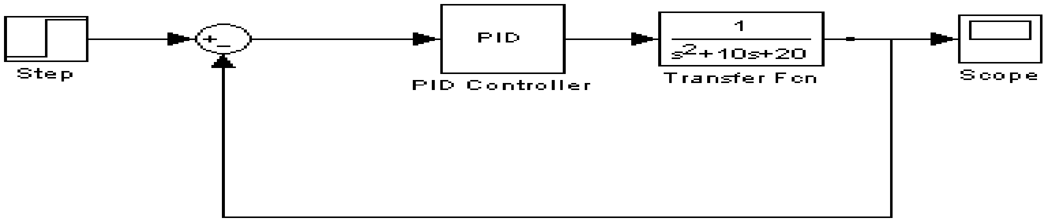
```
clc;
s=poly(0,'s');
F=syslin('c',[1/(0.1*s^2+s)])
fmin =0.1;
fmax=100;
bode(F, fmin,fmax); // Plot s   frequency response of open loop
show_margins(OL) // Displays GM,PH,Cross over frequency
```

Simulink Model

Transfer function:



PID:



Procedure:

1. Go to simulink icon, click on it on the mat lab menu bar.
2. Go continuous time function, select the transfer function & Double click on it change according given transfer function.
3. Go to the sources select the Step response.
4. Go to the math operational, select the summer and change ++ to +-
5. Select the pid controller in the continuous & change the values p, I & D .
6. select the scope from sink .
7. Save the file & Run it.
8. Check for different transfer functions & different P,I,D values & Compare it

Viva Questions

1. Define control system.
2. Explain the classification of control system.
3. What is the necessity of introducing feedback in to control system.
4. Explain the effects of PI,PD & PID controllers.
5. Define stability & relative stability.
6. Explain different methods of finding stability of control system.
7. Define Gain Margin, Phase Margin, Gain cross over frequency & phase cross over frequency with respect to bode plots.
8. Define Nyquist stability criteria.
9. Define steady state & transient response.
10. What is meant by Damping, overshoot & settling time.
11. Discuss the effect of damping ratio on the stability of control system.
12. What is lag, lead & lag lead compensation.
13. Why compensation is required.
14. What are time domain & frequency domain specification. Define them.
15. Why these specification are required.
16. Define steady state error.
17. Define steady state response.
18. What are static error constants.
19. What is servomotor.
20. What is frequency response.
21. What is the difference between induction motor & servomotor.
22. What is root locus technique.
23. Question on MATLAB
24. Difference between AC servomotor & DC servomotor.
25. Application of AC servomotor.
26. Difference between Stepper motor & DC servomotor.
27. How damping ratio affects the time response of second order system.
28. What is PID controllers.

Model Questions

1. Simulate the second order system given by the transfer function---------------, using MAT Lab and obtain the step response and evaluate the time domain specification. Also evaluate the effect of additional pole and zero on the time response of the system.

2. Simulate the second order system given by the transfer function------------------, using MAT Lab 'FOR' loop and obtain the step responses for damping ratio $\xi =$ ________________________ and between t=____ to ____ Seconds. Evaluate the effect of pole location on stability.

3. Write a MAT Lab program to plot the step response of unity feedback system whose open loop transfer function $G(s) =$ ------------------ Also study effect of P,PI,PD and PID controller on the step response of the system(Using Mat lab &simulation).

4. Design a passive RC LAG Compensating network for the given specifications. Obtain the frequency response experimentally and draw bode magnitude and phase angle plots.

5. Design a passive RC LEAD Compensating network for the given specifications. Obtain the frequency response experimentally and draw bode magnitude and phase angle plots.

6. Obtain the frequency response for Lag-Lead compensating network by conducting suitable experiment.

7. Obtain the Torque/speed characteristics of AC servomotor with following control voltage.
   i) Rated value
   ii) 70% of the rated value
   iii) 50% of the rated value

8. Obtain the Torque/speed characteristics of DC servomotor with following control voltage.
   i) Rated value
   ii) 60% of the rated value

iii) 40% of the rated value

9. Conduct an experiment to demonstrate the frequency response of a second order system using simulator Kit and also evaluate Resonant Peak M_r, resonant frequency w_r and band width w_b.

10. Write a MAT Lab program to plot the root locus of the feedback system whose open loop transfer function is $(i) G(s) = \frac{K}{S(S+2)(S+3)}$

$$(ii) G(s) = \frac{K}{S^3 + 2S^2 + 5S + 1}$$

(a) Evaluate the effect of adding open loop pole and zero on the root locus contour.

(b) Find the value of open loop gain K of the closed loop system for a damping ratio $\xi =$ ____ and plot the step response of the closed loop system with this value of K.

(c) Determine the maximum value of k from the root locus plot show that this value K_{max} exhibits sustained oscillations for a unit step input.

11. Write a MAT Lab program to plot the root locus of unity feedback system whose open loop transfer function is $(i) G(s) = \frac{K}{S(S+2)(S+3)}$

$$(ii) G(s) = \frac{K}{S^3 + 2S^2 + 5S + 1}$$

a) Evaluate the effect adding open loop ploe and zero on the root locus contour.

b) Estimate the effect of open loop gain on the transient response of the closed loop system by using root locus.

c) Estimate the stability of given unity feed back system using root locus and bode plot.

12. Conduct an experiment to demonstrate synchro transmitter and receiver.

13. Simulate the step response of DC position control system using MATLAB.

14. Using MAT LAB

(a) Obtain the bode plot for the given transfer function and find its stability.

(b) Draw a graph of resonant peak and peak overshoot Vs damping ratio.

(c) Draw the graph bandwidth Vs damping ratio.

REFERENCES

1. **J. Nagarath and M.Gopal**, "Control Systems Engineering", New Age International (P) Limited, Publishers, Fourth edition – 2005
2. **"Modern Control Engineering ",** K. Ogata, Pearson Education Asia/ PHI, 4th Edition, 2002.
3. **"Control Systems – Principles and Design",** M. Gopal, TMH, 1999

P Controller:

In general it can be said that P controller cannot stabilize higher order processes.For the 1st order processes, meaning the processes with one energy storage, alarge increase in gain can be tolerated. Proportional controller can stabilize only 1st order unstable process. Changing controller gain K can change closed loop dynamics. A large controller gain will result in control system with:

a) smaller steady state error, i.e. better reference following b) faster dynamics, i.e. broader signal frequency band of the closed loop system and larger sensitivity with respect to measuring noise

c) smaller amplitude and phase margin When P controller is used, large gain is needed to improve steady state error. Stable systems do not have problems when large gain is used. Such systems are systems with one energy storage (1st order capacitive systems). If constant steady state error can be accepted with such processes, than P controller can be used. Small steady state errors can be accepted if sensor will give measured value with error or if importance of measured value is not too great anyway.

PD Controller:

D mode is used when prediction of the error can improve control or when it necessary to stabilize the system. From the frequency characteristic of D element it can be seen that it has phase lead of 0°.Often derivative is not taken from the error signal but from the system output variable. This is done to avoid effects of the sudden change of the reference input that will cause sudden change in the value of error signal. Sudden change in error signal will cause sudden change in control output. To avoid that it is suitable to design D mode to be proportional to the change of the output variable.

PD controller is often used in control of moving objects such are flying and underwater vehicles, ships, rockets etc. One of the reason is in stabilizing effect of PD controller on sudden changes in heading variable y(t). Often a "rate gyro" for velocity measurement is used as sensor of heading change of moving object.

PI Controller:

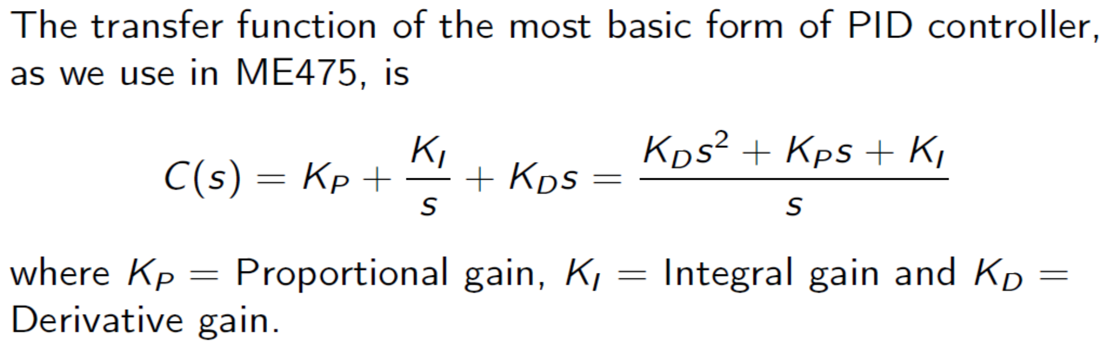
PI controller will eliminate forced oscillations and steady state error resulting inoperation of on-off controller and P controller respectively.However, introducing integral mode has a negative effect on speed of theresponse and overall stability of the system.Thus, PI controller will not increase the speed of response. It can be expected since PIcontroller does not have means to predict what will happen with the error in near future. This problem can be solved by introducing derivative mode which has ability to predict what will happen with the error in near future and thus to decrease a reaction time of the controller. PI controllers are very often used in industry, especially when speed of the response is not an issue. A control without D mode is used when: a) fast response of the system is not required

b) large disturbances and noise are present during operation of the process c) there is only one energy storage in process (capacitive or inductive) d) there are large transport delays in the system

PID Controller:

PID controller has all the necessary dynamics: fast reaction on change of the controller input (D mode), increase in control signal to lead error towards zero (I mode) and suitable action inside control error area to eliminate oscillations (P mode).

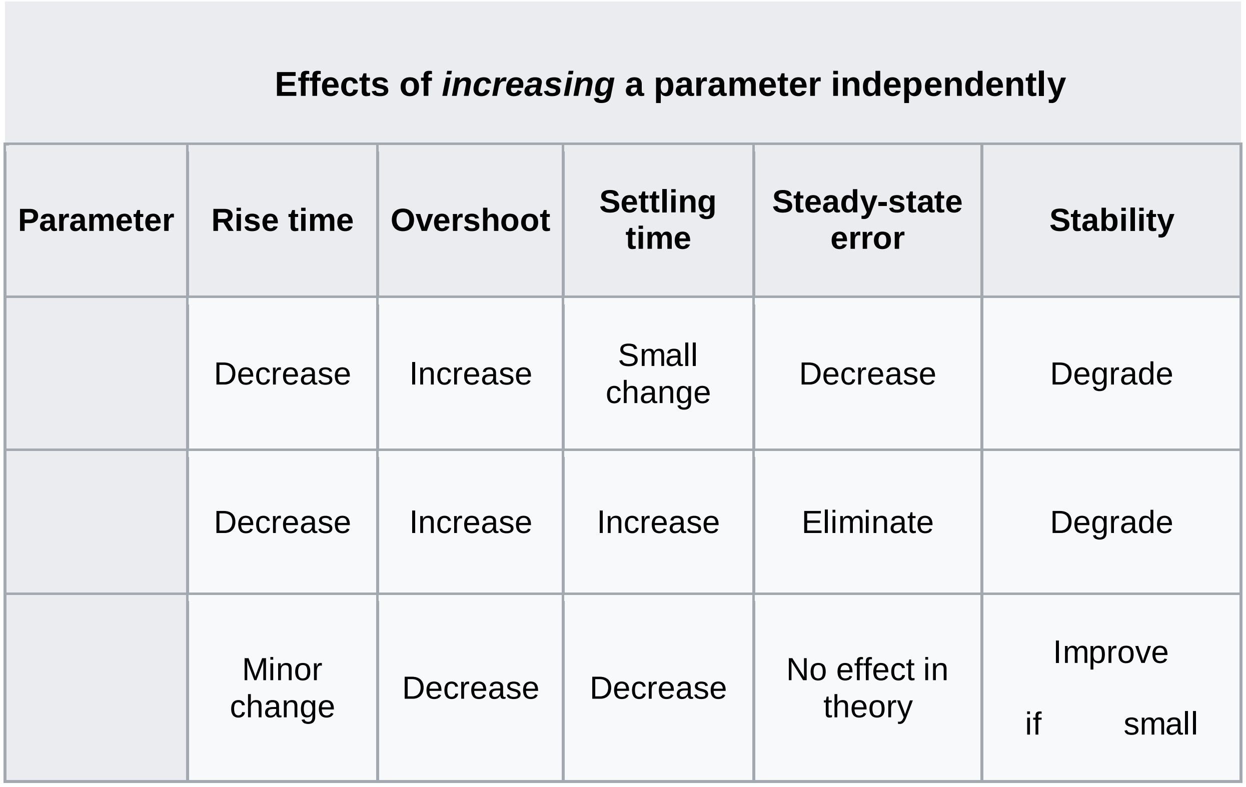
Derivative mode improves stability of the system and enables increase in gain K and decrease in integral time constant Ti, which increases speed of the controller response. PID controller is used when dealing with higher order capacitive processes (processes with more than one energy storage) when their dynamic is not similar to the dynamics of an integrator (like in many thermal processes). PID controller is often used in industry, but also in the control of mobile objects (course and trajectory following included) when stability and precise reference following are required. Conventional autopilot is for the most part PID type controllers.



The transfer function of the most basic form of PID controller, as we use in ME475, is

$$C(s) = K_P + \frac{K_I}{s} + K_D s = \frac{K_D s^2 + K_P s + K_I}{s}$$

where K_P = Proportional gain, K_I = Integral gain and K_D = Derivative gain.



Effects of *increasing* a parameter independently

Parameter	Rise time	Overshoot	Settling time	Steady-state error	Stability
	Decrease	Increase	Small change	Decrease	Degrade
	Decrease	Increase	Increase	Eliminate	Degrade
	Minor change	Decrease	Decrease	No effect in theory	Improve if small