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CONTENTS

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CONTENTS

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Introduction

→ Elements of a Communication System

Communication means reading, sending, receiving and processing of information between two or more devices. A collection of elements (devices) which work together to establish communication b/w the sender and receiver is called a communication system.

Some examples of communication system includes radio broadcasting, television broadcasting, radio, telegraphy, mobile communication, computer communication etc. Two or more people communicating with each other by using sound signal is also known as the communication system.

→ Block diagram of Communication System

The basic components of a communication system: information source, input transducer, transmitter, communication channel, receiver, output resistance and destination.

Information Source

As we know that the communication system establishes the communication bridge b/w the sender and receiver to establish this communication bridge b/w the sender and receiver. first we need information to send. this information originates in information source.

The information generated by the source may be in the form of sound (human speech), picture (image source) and words (plain text in particular language) for example if you are talking with your friend on a phone. you are considered as the information source that generates information in the form of sound for beginers to communication its important to understand difference b/w message and information the message is part of communication which involves sending information from source to destination. Information is a meaningfull data that reciever consumer

Input Transducer

If you want to talk (Communicate) with your friend who is sitting beside you, then you can directly talk with him by using voice signal (sound signals) But if the same friend is far away from you, then you can't directly communicate with him by using voice signals (sound signals) because sound signals cannot travel large distance

So inorder to overcome this problem and transmit information to large distance, first we need to convert this sound signal another from of signal (electrical signal or light signal) which travel larger distance. This device is used to convert this sound signal into another (electric) from of signal is called transducer A transducer is a device which convert from of energy or signal into another from of energy or signal The transducer is present at input side and output side of communication system. Transducer

Generally input transducer converts non-electric signals (physical forms) into an electrical signal

The best example of an input transducer is microphone which placed b/w the information source & transmitter section A microphone is a device which converts your voice signal to electrical goals

Transmitter

It is a device which converts signal produced by source into a form that is suitable for transmission over a given channel or medium, Transmitter user technique called modulation to convert the electrical signal int a form that siutable for transmission over a given channel or medium modulation is main function of a

$$L = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3\times10^{8}}{4\times5\times10^{3}} = 5km$$

it is practical to Construct & install an antenna of such height However this height of antenna may be reduced by modulation techniques & get effective radiation & reception are achived

$$L = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3\times10^{8}}{4\times3\times10^{6}} = 25 \text{ meters}$$

To remove interference

As an example in Amplitude modulation radio broadcast the max modulating signal frequency permitted is 5KHz Amplitude modulation requires bandwidth of 10KHz for each station or channel. therefore broadcast channels can be placed adjacent to each other, each channel Occupying band width 0KHz, Hence different station may be allocated bandwidth say from 790 to 800KHz 800 to 810 KHz and so on in a radio reciver a tuned ckt i/p select desired station & reject all other

Increase the signal strength

The baseband signals transmitted by sender are not Capable of direct transmission, the strength of message signal should be increased so that it can travel longer distance this is where modulation is essential the most vital need of modulation is to enhance strength of signal without affecting the parameters of carrier signal

Output transducer

Transducer present at O/P side of system is called O/P transducer. Generally these convert electrical signals into a non electric signal or best example for O/P transducer is loud speaker this converts Electrical signals to voice

Destination

This is final stage of Communication Generally humans at same place are considered as destination for example if you are watching TV, you are considered as destination

Need for Modulation Benefits of Modulation

The message signal or baseband signal is used to modulate a high frequency carrier signal inside the transmiter after modulation the resulting modulated signal is transmitted with help of an antena which is connected to the O/P side of transmitter. This modulated signal then travel down channel to reach i/p of receiver now one question can why do we use modulation in communication system what will happen if we transmit a message signal or audio signal without modulation. the answer is that the modulation serves purpose in a Communication as discussed below

Practicality of Antenna

we known that incase of free space it is used as medicine are transmitted & received with help of antennas. messages are transmitted or efficient radiation & reception. The transmitting & receivers antenna must have length Comparable to quarter wavelength of frequency used for eg- in AM broadcast system. the maximum audio frequency transmitted from a rationation is of order 5 kHz it this message audio signal were to be transmitted without modulation transmitter

when we send the signal to larger distance it undergoes various circumstances which make signal week inorder to send signal to larger distance without any loss of information it has to undergo process named modulation increases the strength of signal without changing parameter of signal

Communication Channel

The communication channel is a medium through which the signal travels. communication channels are divided into two categories wired & wiredless some examples of wired channels includes coaxial cables fibre Optic cables and pair telephones lines. Example of wireless channels are water and vacuum Although channel reduces signal strength. This loss of signal in channel is mainly caused due to external noise, physical surroundings and travel distance. Thus signal recieved by receiver is very weak. To compensate this signal loss amplifiers are used at both transmitter and receiver side

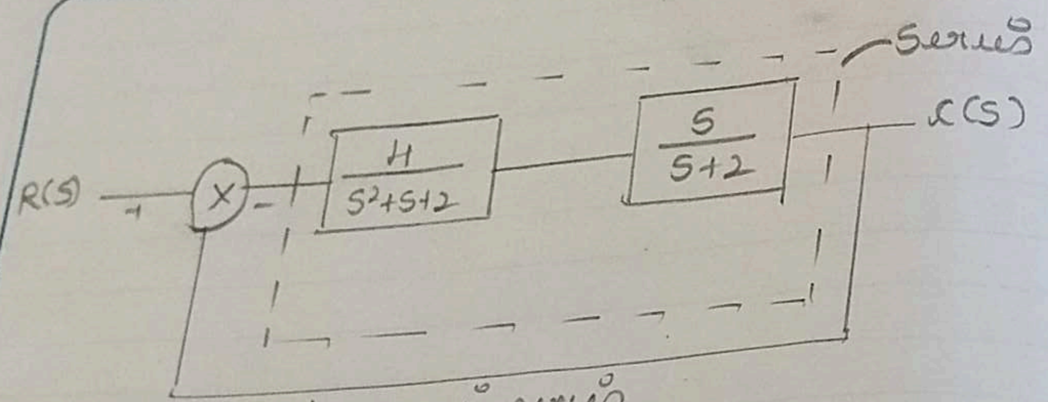
Noise

Noise is uncounted signal that enters the Communication system via the Communication channel and interfers with transmitted signal the noise signal degrades the transmitted signal

Receiver

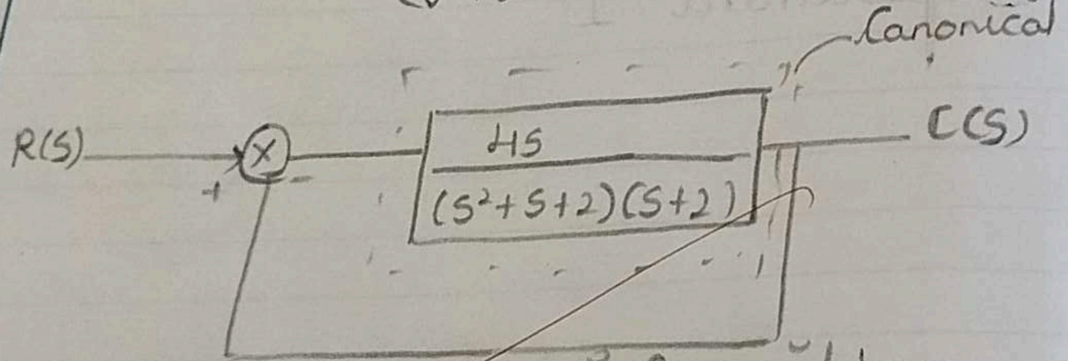
The receiver is the device that receives the signal from channel and converts the signal back to its Original form which is understandable by Humans at destination TV set is example of receivers

Experiment - 1



As the blocks are in series

$$\frac{4S}{(S^2+S+2)(S+2)}$$



As the block are in canonical form

$$\frac{C(S)}{R(S)} = \frac{G(S)}{1+G(S)H(S)}$$

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

$$= \frac{4S}{(S^2+S+2)(S+2)+4S}$$

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Program 1

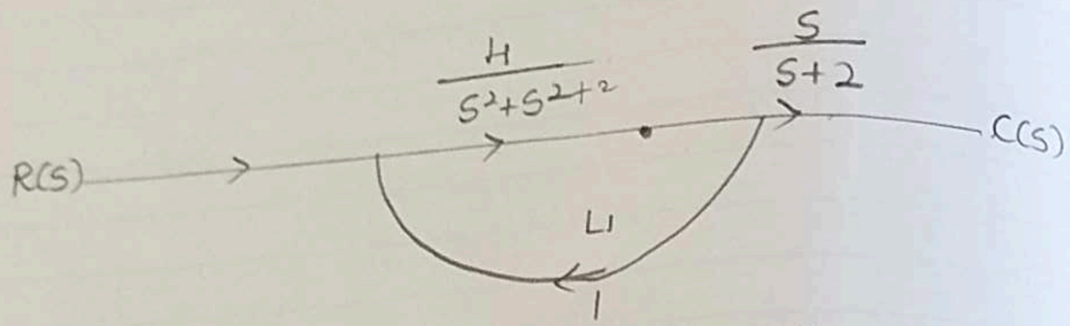
Implement Block diagram reduction technique to Obtain transfer function a control system

```
close all;
clear
P=4
Q=[1 1 2]
A=tf(P,Q)
R=[1 0]
S=[1 2]
B=tf(R,S)
C=series(A,B)
Ans=feedback(C,1,-1)
```

Results & Conclusion :- The program for the block diagram reduction technique to Obtain transfer func^n of a control system is successfully executed & hence verified

```
P = 4
Q = 1x3
      1      1      2

A =

       4
  -----------
  s^2 + s + 2

Continuous-time transfer function.
Model Properties
R = 1x2
      1      0

S = 1x2
      1      2

B =

    s
  -----
  s + 2

Continuous-time transfer function.
Model Properties
C =

           4 s
  ---------------------
  s^3 + 3 s^2 + 4 s + 4

Continuous-time transfer function.
Model Properties
Ans =

           4 s
  ---------------------
  s^3 + 3 s^2 + 8 s + 4

Continuous-time transfer function.
Model Properties
```


Experiment - 2



no of forward path $=1 \Rightarrow P_1 = \frac{H}{S^2+S+2} \times \frac{S}{S+2}$

$P_1 = \frac{HS}{(S^2+S+2)(S+2)}$

Individual loop gain $\Rightarrow L_1 = \frac{-HS}{(S^2+S+2)(S+2)}$

determine of graph

$\Delta = 1 - \Sigma$ Individual loop

$\Delta = 1 + \frac{HS}{(S^2+S+2)(S+2)}$

Finding ΔR

$\Delta_1 = 1 - [L_1]$

$= 1 - [0]$

$= 1$

$\therefore$ TS by mason's formula

$\frac{C}{R} = \frac{\sum_{R=1}^{\infty} R_K \Delta R}{\Delta} = \frac{P_1 \Delta_1}{\Delta}$

$= \frac{HS}{S3 + 3S^2 + 8S + 4}$

Program 2

Implement Signal Flow graph to Obtain transfer function a Control system

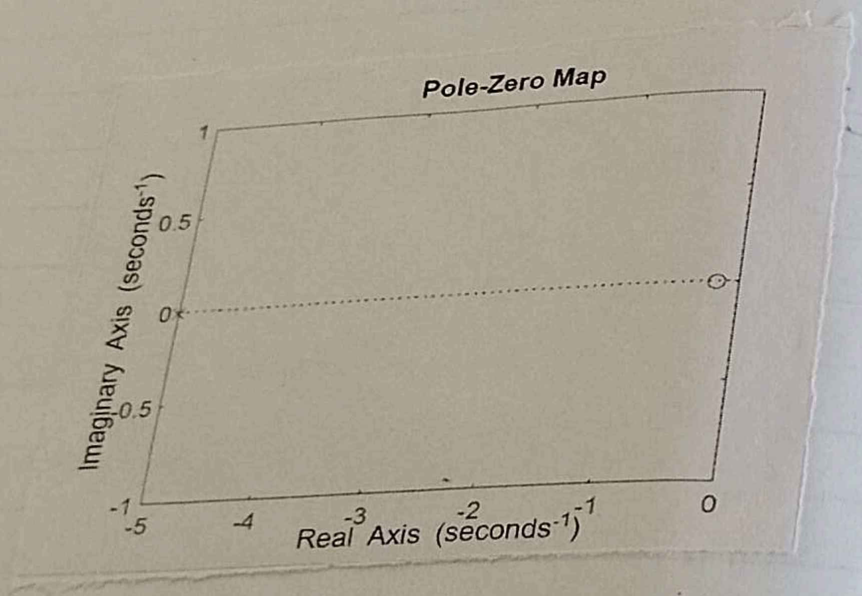
```
Close all;
clear
P = H
Q = [1 1 2]
A = tf (P, Q)
R = [1 0]
S = [1 2]
B = tf (R, S)
C = Series (A, B)
Ans = feedback (C, 1, -1)
```

Theory :- Signal flow graphs visually represent system Components as node & their interaction as branches with gains

Result & Conclusion :- The program for implemenation of signal flow graph to obtain transfer funcn has been sucessfully signal

```
P = 4
Q = 1x3
     1     1     2

A =

      4
  -----------
  s^2 + s + 2

Continuous-time transfer function.
Model Properties
R = 1x2
     1     0

S = 1x2
     1     2

B =

    s
  -----
  s + 2

Continuous-time transfer function.
Model Properties
C =

           4 s
  ---------------------
  s^3 + 3 s^2 + 4 s + 4

Continuous-time transfer function.
Model Properties
Ans =

           4 s
  ---------------------
  s^3 + 3 s^2 + 8 s + 4

Continuous-time transfer function.
Model Properties
```


Experiment -3



~~rogram~~
~~trial step~~
&D
imulation of poles and zeros of a transfer function

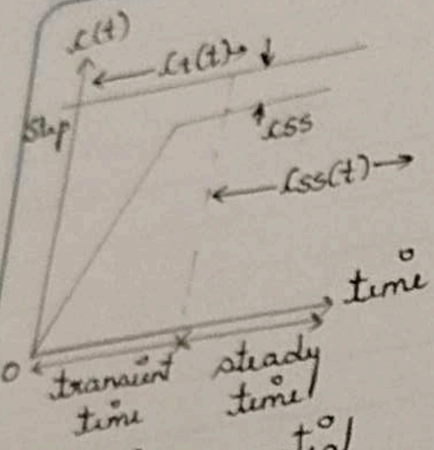
num/den =
 6s+1
 ----
 s+5

```
num=[6,1];
den=[1,5];
sys=tf(num,den);
printsys(num,den);
[Z,P]=tf2zp(num,den)
pzmap(P,Z)
```

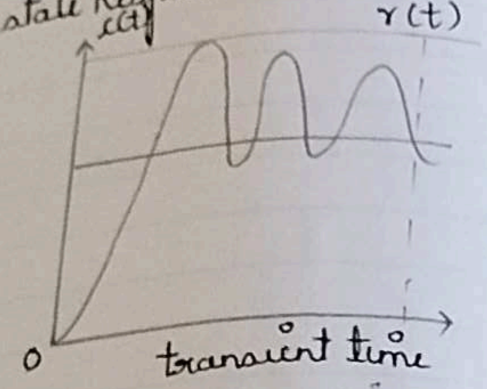
Result & Conclusion :- The program for simulation of poles zero of a transfer function has been successfully & verified

Program-4

Steady state Response

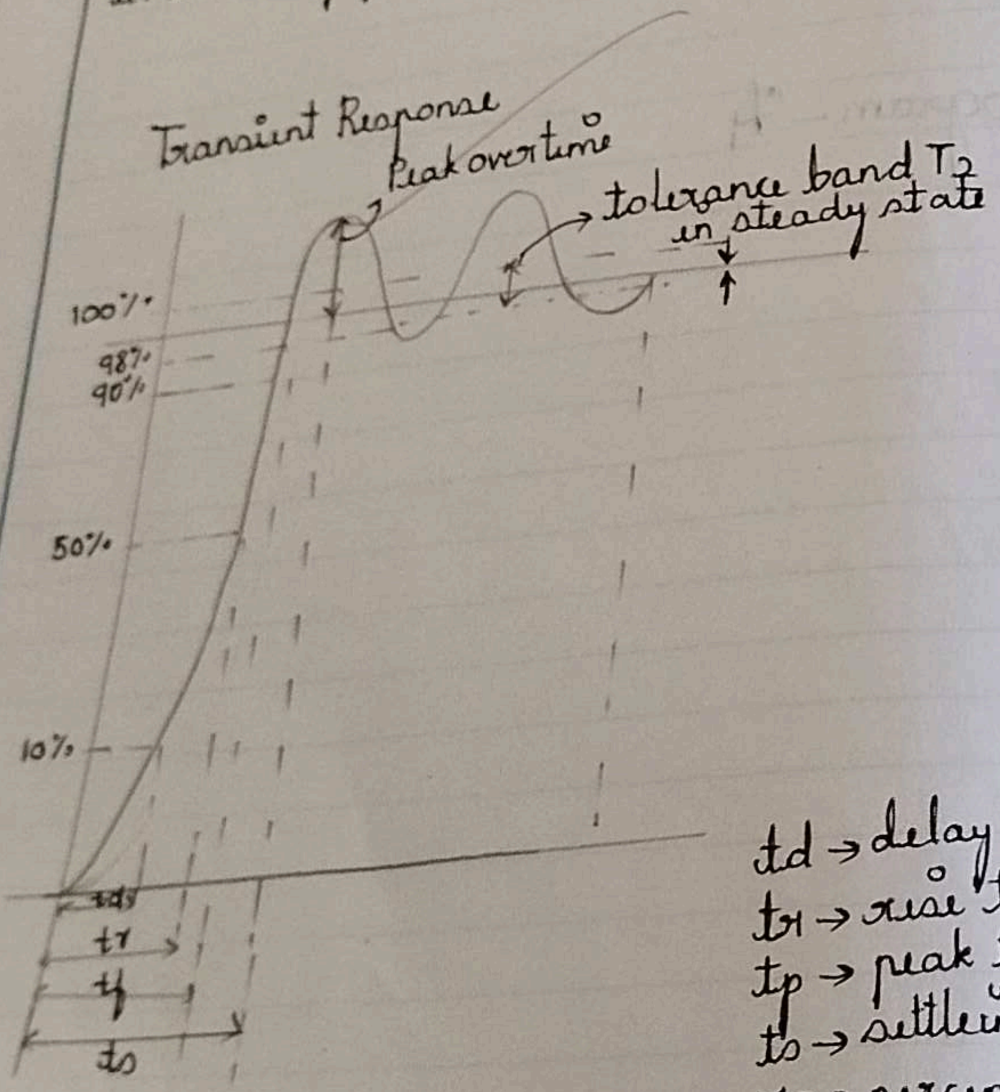


a) c(t) is exponential



b) c(t) is oscillating

Transient Response



td → delay time in sec
tr → rise time in sec
tp → peak time in sec
ts → settling time in sec
Mp → percent overboot sec

Program 7

Aim :- Determine of time response specification of a second order under damped system for different damping factor

Software :- MATLAB 2023

Theory :- time response :- The response given by the system which is func of the time of the applied excitation called time response of a Control system

transient response :- The O/P variation during the time takes to achieve its final value is called as transient response. the time required to achieve the final value called transient response

Steady state response :- It is that part of the time response which remains after complete transient response vanished from the system O/P

The total time response c(t) written as

$$c(t) = c_{ss} + c_{tr}(t)$$

Transient Response Specification

1) Delay time (td): It is the time required for response to reach 50% of the final value the first attempt

2) Rise time (Tr): is the time required for the response to rise from 10% to 90% of final value for underdamped systems

3) Peak time (tp) : it is the required for the response to reach its peak value

4) Peak overshoot (Mp): it is the largest error b/w sequence i/p & O/p during transient period

5) Settling Time (Ts): This is defined as the time required for the response to decrease & stay with specified percentage of its final value

Formulae

$\omega_n = 10\ rad/s$

$\xi = 0.5$

$t_d = \frac{1+0.7\xi}{\omega_n}$

$t_r = \frac{\pi-\theta}{\omega_n}$

$t_r = \frac{\pi-\tan^{-1}\frac{\sqrt{1-\xi^2}}{\xi}}{\omega_d}$

$\omega_d = \omega_n\sqrt{1-\xi^2}$

$t_p = \frac{\pi}{\omega_d}$ $\quad t_s = \frac{4}{\xi\omega_n}$ $\quad M_p = e^{-\xi\pi/\sqrt{1-\xi^2}} \times 100$

Calculations

if $\omega_n = 10$ $\quad \xi = 0.5$

$t_d = \frac{1+0.7\xi}{\omega_n} = \frac{1+0.7(0.5)}{10} = 0.135$

$\omega_d = \omega_n\sqrt{1-\xi^2} = 10\sqrt{1-0.5} = 8.66\ rad/s$

$t_r = \frac{\pi-\tan^{-1}(\sqrt{1-\xi^2}/\xi)}{\omega_d} = \frac{\pi-60^\circ}{8.66} = 0.2417\ sec$

$t_p = \frac{4}{\xi\omega_n} = \frac{4}{10(0.5)} = 0.8\ sec$

$\therefore M_p = e^{-\xi\pi/\sqrt{1-\xi^2}} \times 100 = e^{-0.5\pi/\sqrt{1-0.5^2}} \times 100 = 0.1613$

$\% M_p = 16.31\%$

Program

```
wn=10;
z=0.5;
wd=wn*sqrt(1-z^2);
td=(1+(0.7*z))/wn;
tr=(pi-atan(sqrt(1-z^2/z))/wd;
tp=pi/wd;
ts=4/(z/wn);
Mp=exp(-z*pi/sqrt(1-z^2))*100;
printf("damping ratio=%.% f\n",z);
printf("damped natural frequency=%.2f rad/s.\n',wd);
printf("delay time=%.2f sec\n',td);
printf("Peak time=%.2f sec\n',tp);
printf("Rise time=%.2f sec\n',tr);
printf("Settling time=%.2f sec\n',ts);
printf("percent overshoot=%.2f%.%\n\n',Mp);
```

Output

ξ = Damping ratio = 0.5

ω_n = Damped natural frequency = 8.66 rad/s

t_d = Delay time = 0.14 sec

t_p = Peak time = 0.36 sec

t_r = Rise time = 0.24 sec

t_s = settling time = 0.80 sec

M_p = percent overshoot = 16.30%

$\omega_n = 5 \quad \xi = 0.7$

$t_d = \frac{1+0.7\xi}{\omega_n} = \frac{1+0.7(0.7)}{5} = 0.298$

$\omega_d = \omega_n\sqrt{1-\xi^2} = 5\sqrt{1-(0.7)^2} = 3.57$ rad/s

$t_r = \frac{\pi - \tan^{-1}\frac{\sqrt{1-\xi^2}}{\xi}}{\omega_d} = \frac{\pi - 4.556}{3.570} = 0.660$

$t_p = \frac{\pi}{\omega_d} = 0.880$

$t_s = \frac{4}{\xi\omega_n} = \frac{4}{0.7(5)} = 1.142$ sec

$M_p = e^{-\xi\pi/\sqrt{1-\xi^2}} = e^{-0.7\pi/\sqrt{1-0.7^2}} = 0.046\times100$

$M_p = 4.6\%$

Tabular Column

	$\omega_n=10$ $\xi=0.5$	$\omega_n=5$, $\xi=0.7$
t_d	0.1350	0.298s
ω_d	3.57 rad/s	8.66 rad/s
t_r	0.2417s	0.660s
t_p	0.880s	0.362s
t_s	1.142s	0.80s
M_p	4.6%	16.31%

Procedure

1. Double click on MATLAB 2023 app to open it
2. Take a new script & save the project
3. write prgm for determination of time response
4. Run the pgm & Observe the O/P
5. note down all the values
6. Calculate all the specification manually & note it down
7. check wheather the theoritical values & pratical values are matching

Results & Conclusion

The prgm for determination of time response specification of second order underdamped system is written. the theortical values & practical value are matching with each other

Damping Ratio = 0.1
Damped Natural Frequency = 9.95 rad/s
Rise Time = 0.32 s
Settling Time = 4.02 s
Percent Overshoot = 72.92 %

Damping Ratio = 0.3
Damped Natural Frequency = 9.54 rad/s
Rise Time = 0.35 s
Settling Time = 1.40 s
Percent Overshoot = 37.23 %

Damping Ratio = 0.5
Damped Natural Frequency = 8.66 rad/s
Rise Time = 0.42 s
Settling Time = 0.92 s
Percent Overshoot = 16.30 %

Damping Ratio = 0.7
Damped Natural Frequency = 7.14 rad/s
Rise Time = 0.62 s
Settling Time = 0.80 s
Percent Overshoot = 4.60 %

Damping Ratio = 0.9
Damped Natural Frequency = 4.36 rad/s
Rise Time = 1.65 s
Settling Time = 1.02 s
Percent Overshoot = 0.15 %

Experiment-5

Given $\omega_n = 10\ rad/sec$

$\xi = 0.5$

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

$$H(s) = \frac{10^2}{s^2+2(0.5)(10)s+10^2}$$

$$H(s) = \frac{100}{s^2+10s+100} \Big|_{s\to j\omega}$$

$$H(j\omega) = \frac{100}{(j\omega)^2+10(j\omega)+100}$$

$$= \frac{100}{-\omega^2+j10\omega+100}$$

$$= \frac{100}{(100-\omega^2)+j10\omega}$$

magnitude

$$|H(j\omega)| = \frac{100}{\sqrt{(100-\omega^2)+j10\omega}}$$

Program - 5

Aim : Determine the frequency response of a second order system

Software used : MATLAB 2023

Theory : The second order systems are the systems or network which contain two or more storage elements and have describing equations that are second order differential equations
The second order system is given by a transfer func^n as

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

Ex :- Determine the frequency response of a 2nd order system Given the natural frequency of the system is 10 rad/sec & damping ratio is as

$$H(s) = \frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2} \Big|_{s\to j\omega}$$

magnitude plot

$$H(j\omega) = \frac{100}{\sqrt{(100-\omega^2)^2+100\omega^2}}$$

phase plot

The phase of any Complex Conjugate is found with std formula $\tan^{-1}(b/a)$

where b is imaginary part

a is real part

$\therefore$ The phase is found as

$$\angle H(j\omega) = \frac{\tan^{-1}(10/\omega)}{\tan^{-1}(10\omega/100-\omega^2)}$$

$$\angle H(j\omega) = 0-\tan^{-1}\left(\frac{10\omega}{100-\omega^2}\right)$$

$$\angle H(j\omega) = \tan^{-1}(10\omega/100-\omega^2)$$

Tabular Colum for magnitude Plot

w	|H(jw)|	20log|H(jw)| 0
0	1	0
0.1	1	0
0.2	1	0
0.3	1	0
0.4	1	0
0.5	1	0
1	1	0
2	1	0
5	1	0
10	1	-11.13
20	0.27	-18.63
30	0.11	-23.83
40	0.06	-27.78
50	0.04	-39.82
100	0.01	-52.04
200	0.0025	-59.17
300	0.0011	-64.08
400	0.000525	-67.95
500	0.00040	-80
1000	0.00010	

Program

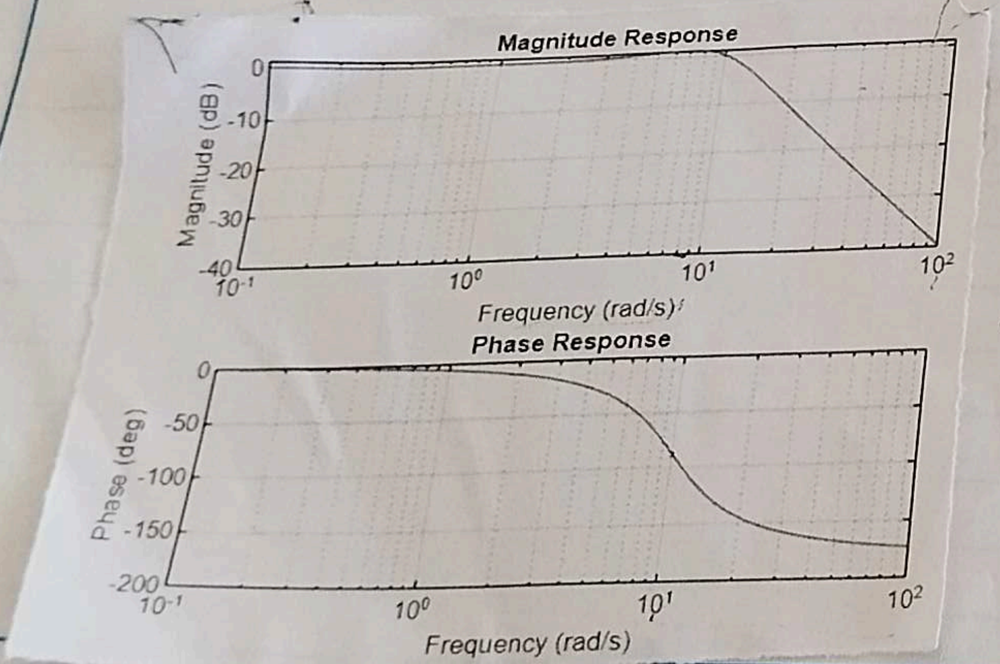
```
wn=10;
zeta=0.5;
num=wn^2;
dem=[1 2* zeta * wn wn^2];        10^-1 to 10^2 to generate within the range
sys= tf(num, den);        No of points   0.1 to 100 radsec we logspace
w = logspace (-1, 2, 1000);   -> To get frequency range of collect the data of scale
[mag, phase] = bode (sys, w); ] ->  It gives data of magnitude of phase
mag2d = reshape (mag, [], sys(mag, 3)); 5 values on plot
phase2d = reshape (phase[], size(phase,3));
figure;                              2 rows 1 collumn graph
subplot (2,1,1); 1st position  ->
semilogx(w, 20* log10(mag2d)); -> To convert magnitude to decibels
grid on;
title ('magnitude response');
xlabel ('frequency (rad/s)');
ylabel ('magnitude (dB)');
Subplot (2,1,2);   Second position
semilogx (w, phase2d);
grid on;
title
xlabel ('Phase response');
ylabel('frequency (rad/s)');
```

Phase

$\angle H_j(\omega) = -\tan^{-1}\left(\frac{10\omega}{100-\omega^2}\right)$

Tabular Column for phase plot

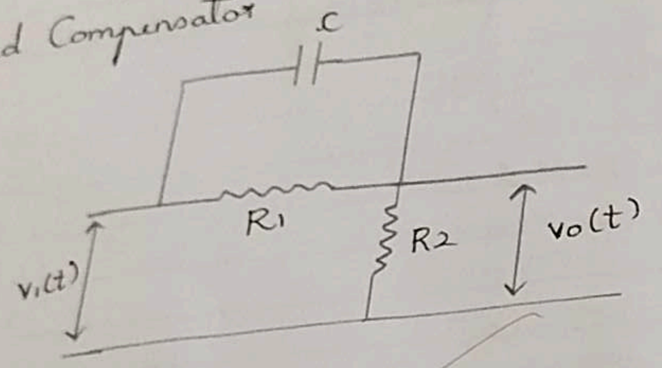
w	$\angle H(j\omega)$ in degree
0	0
0.1	-0.3729
0.2	-1.1462
0.3	-1.7199
0.4	-2.2942
0.5	-2.8695
1	-6.4830
2	-11.7682
3	-18.2458
4	-25.4633
5	-33.6900
6	-43.1523
7	-53.9239
8	-65.7722



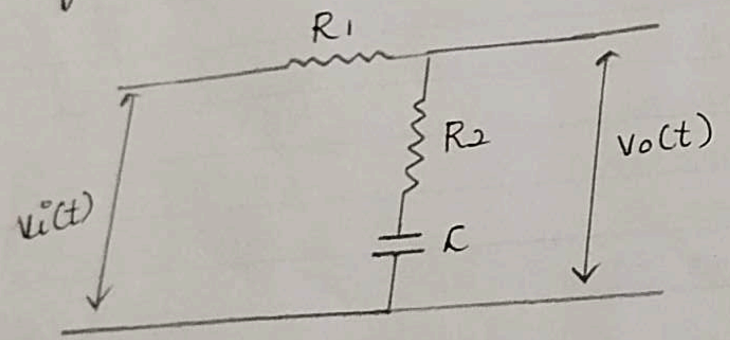
Experiment-6

Circuit diagram

1) Lead Compensator



2) lag Compensator



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Program - 6

Aim: Determination of frequency response of a lead lag Compensator

Software used : MATLAB

Theory

A lead lag Compensator is a Component in control system that improves an undesirable frequency response in a feedback & control system. both lead Compensator and lag Compensator introduce a pole - zero pair into the Open loop transfer func^n in laplace transform as $\frac{y}{x} = \frac{s-z}{s-p}$

where

x is i/p to the Compensator

y is o/p

s is Complex laplace transform

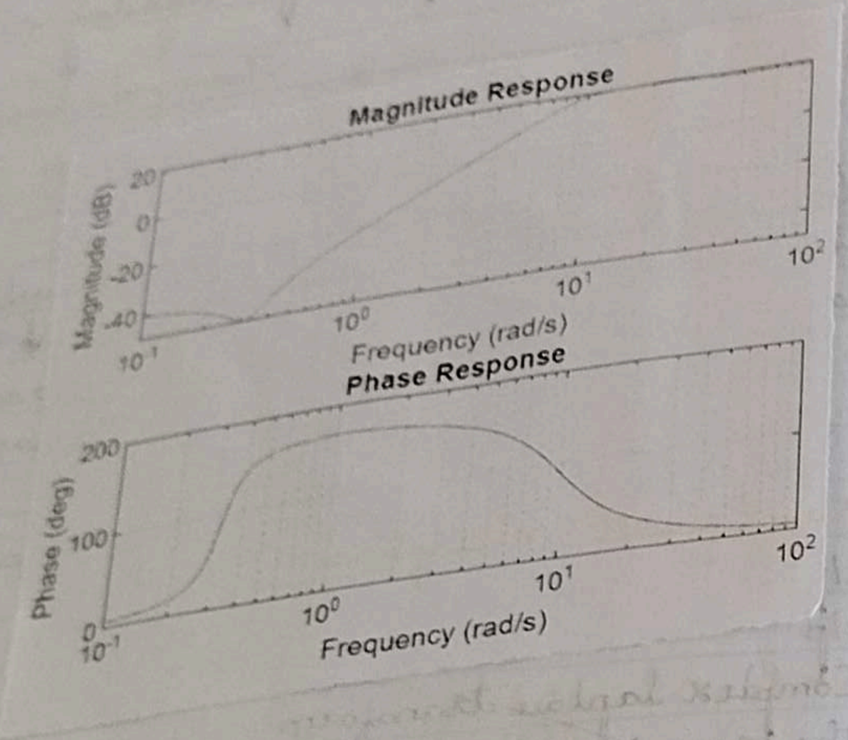
z is the zero frequency

p is the pole frequency

The pole & zero are both typically -ve are left side of Origin in the complex plane. in a lead Compensator $|z| < |p|$ while in a lag Compensator

The Overall T.F is written as $\frac{y}{x} = \frac{(s-z_1)(s-z_2)}{(s-p_1)(s-p_2)}$

Typically $|p_1| > |z_1| > |z_2| > |p_2|$ where z_1 & p_1 are the zeroes and poles of lead Compensator of z_1 & z_2 are the zeroes and poles of lag Compensator



Date :

Program

```
k=1;
wn = 10;
m = 10;
zeta = 0.5;
alpha = 0.1;
beta = 10;
num [~~m * alpha * beta k * m * alpha k~~]; [m*alpha*beta  k*m*alpha  k]
den = [1 2* zeta * wn. wn^2];
sys = tf (num, den);
w = logspace (-1, 2, 1000);
[mag, phase] = bode (sys, w);
mag2d = reshape (mag[], size (mag3));
phase 2d = reshape (phase[], size (phase3));
figure
subplot (2,1,1);
semilog (w, 20 * log10 (mag2d));
grid on;
title (" Magnitude response");
xlabel (' freq(rad/sec));
ylabel (' magnitude (dB));
subplot (2,1,2);
semilog (w, phase2d);
grid on;
```

Result & Conclusion

The program for determination of frequency responses of a lead lag Compensator is written and executed in MATLAB graphs are obtained as shown

```
Characteristic Polynomial:
   s^4 + 8 s^3 + 18 s^2 + 16 s + 5
Routh array = 5x3
     1     18     5
     8     16     0
   144      0     0
     0      0     0
     0      0     0
Routh array = 5x3
     1     18     5
     8     16     0
   144     40     0
     0      0     0
     0      0     0
¬Routh array = 5x3
     1     18     5
     8     16     0
   144     40     0
  2304      0     0
     0      0     0
Routh array = 5x3
     1     18     5
     8     16     0
   144     40     0
  2304      0     0
     0      0     0
¬Routh array = 5x3
     1     18     5
     8     16     0
   144     40     0
  2304      0     0
 92160      0     0
Routh Array:
   1.00   18.00    5.00    8.00   16.00
 0.00e+00
 144.00   40.00
 0.00e+00
 2304.00
 0.00e+00  0.00e+00
 92160.00 |
 0.00e+00  0.00e+00
The system is stable.
```


Experiment-4

RH criteria table

$C.E = S^4 + 8S^3 + 18S^2 + 16S + 5 = 0$

S^4	1	18	5
S^3	8	16	0
S^2	16	5	0
S^1	13.81	0	0
S^0	5	0	0

From RH table it is observed that there is no sign change in 1st column, hence the system is stable

Program 7

Aim: Using suitable package. Obtain the time response from state model of a system

Software used : MATLAB 2023

Program

```
A=[-1,-1;1,0];
B=[1;0];
C=[0,1];
D=0;
sys=ss(A,B,C,D);
%Define i/p signal
t=linspace(0,10,1000);
u=s(n(+));
% Stimulate system response
[y,t,x]=lsim(sym.u,t);
figure;
plot(t,y);
grid on;
legend('input','Output');
```

Result & Conclusion

Hence simulation package study of speed control of DC motor is proved & gives the O/P in the form of graph

$$X = \begin{bmatrix} -1 & -1 \\ 1 & 0 \end{bmatrix} \quad B = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \quad C = [0 \ 1]$$

Given $X = \begin{bmatrix} -1 & -1 \\ 1 & 0 \end{bmatrix}$

$$TF = C\,(SI - X)^{-1}\,]B + D$$

$$SI - X = \begin{bmatrix} S & 0 \\ 0 & S \end{bmatrix} - \begin{bmatrix} -1 & -1 \\ 1 & 0 \end{bmatrix}$$

$$\begin{bmatrix} S+1 & 1 \\ -1 & S \end{bmatrix}$$

$$(SI - X)^{-1} = \frac{\begin{bmatrix} S & -1 \\ 1 & S+1 \end{bmatrix}}{S^2+S+1}$$

$$TF = [0 \ 1] \frac{\begin{bmatrix} S & -1 \\ 1 & S+1 \end{bmatrix}}{S^2+S+1} \begin{bmatrix} 1 \\ 0 \end{bmatrix} + 0$$

$$\frac{[0 \ 1] \begin{bmatrix} S \\ 1 \end{bmatrix}}{S^2+S+1}$$

$$TF = \frac{1}{S^2+S+1}$$

Experiment - 8

Example

1. Sketch the root locus for a negative feedback control system having Open loop transfer function

$$G(S)\,H(S) = \frac{K}{S(S+5)(S+0)}$$

→ Step 1 : no of poles : $P = S, S=0, S=5, S=-10$

no of zeroes : $z = 0$

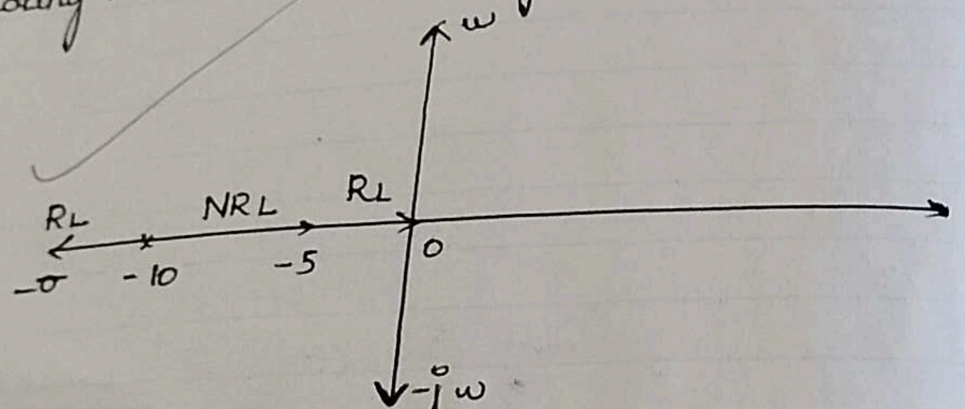
Here $P > z$ $3 > 0$

Root locus start from open loop poles & terminate at open loop zeroes

Starting pt of root locus : $0, -5, -10$

Ending pt of root locus : ∞, ∞, ∞

Step 2 : Ploting the root locus (RL) region & non root locus (NRL) region



Step 3 : no of asymptotes $= P-2, = 3-0 = 3$

Asymptotic angles $\theta A = \frac{(2q+1)\,180}{P-2}$ $q = 0, 1, P+2$ ..

$$\phi_1 = \left(\frac{2\times 0+1}{3}\right) \times 180 = 60^\circ$$

$$\phi_2 = \left(\frac{2\times 1+1}{3}\right) \times 180 = 180$$

$$\phi_3 = \left(\frac{2\times 2+1}{3}\right) \times 180 = 300$$

8, ~~9, 10~~ Experiment

Aim – using suitable simulation package draw root locus and bode plot of a given transfer function

Software used : MATLAB 2023

Theory

Root Locus : if start from poles ends at zeros to find Coefficient of poles, equal to the deno of 0 & take the coefficient of poles equal to the deno of 0 & take the Coefficient in descending order of power of S

$$G(S)H(S) = \frac{K.1}{S(S+5)(S+10)}$$

denominator : $S(S+5)(S+10) = 0$

$S^3 + 10S^2 + 50S + 0S^0 = 0$

deno coff $= [1, 10, 50, 0]$

numerator coff $= [1]$

Bode plot : given $G(S)H(S) = \frac{50}{S(0.5S+1)(0.5S+1)}$

denominator $= S(0.5S+1)(0.5S+1) = 0$

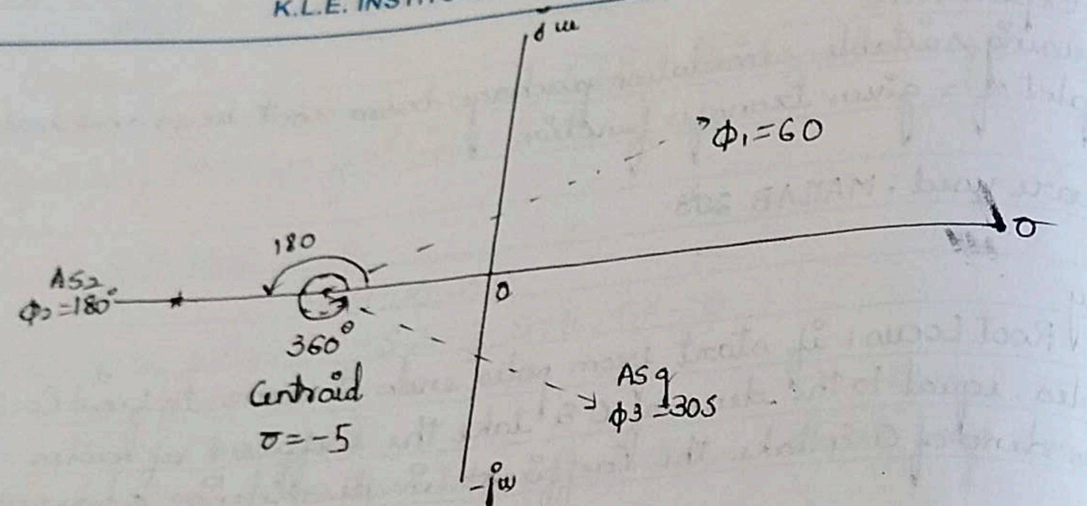
$(0.5S^2 S)(0.55S+1) = 0$

$0.25S^3 + 0.5S^2 + 0.05S^2 + S$

$0.025S^4 + 0.55S^2 + S + 0S^0 = 0$

denominator coefficient $= [0, 0.25, 0.55, 1, 0]$

numerator Coeff $= [50]$



Step 4 : Centroid of root locus

$$\sigma = \frac{\Sigma \text{ real parts of poles} - \Sigma \text{ real part of zeros}}{p-z}$$

$$\sigma = \frac{(0-5-10)-(0)}{3-0} = -5$$

Step 5: to find BAP

$$1 + G(s)H(s) = 0$$

$$\frac{1+k}{s(s+3)(s+10)} = 0$$

$$(s^2+5s)(s+10)+k=0$$

$$15 = -(s^3+15s^2+50s)$$

$$\frac{dk}{ds} = 3s^2+30s+50$$

$$s_1 = -2.1 \quad s_2 = -2.1$$

$$k/s = -2.1 = 90.76$$

Program for root locus

```
clc;
clear all;
close all;
num=[1];
den=[1 15 50 0]
locus(num,den)
grid on;
title ~~Hore~~('rootlocus of g(s) H(s) = k / s(s+5)(s+10)');
```

program for bode plot

```
clc;
clear all;
close all;
num = [50];
den = [0.125 0.55 1 0];
bode(num,den);
grid on;
title('bode plot of g(s) H(s) = 50 / s(0.5s+1)(0.05s+1)');
```

Step 6 Intersection with imaginary axis consider CE

$1+G(s)H(s)=0$

i.e, $s^3+15s^2+50s+k=0$

s^3	1	50
s^2	15	k
s^1	$\frac{750-k}{15}$	0
0	k	

$\frac{750-k}{15}=0$

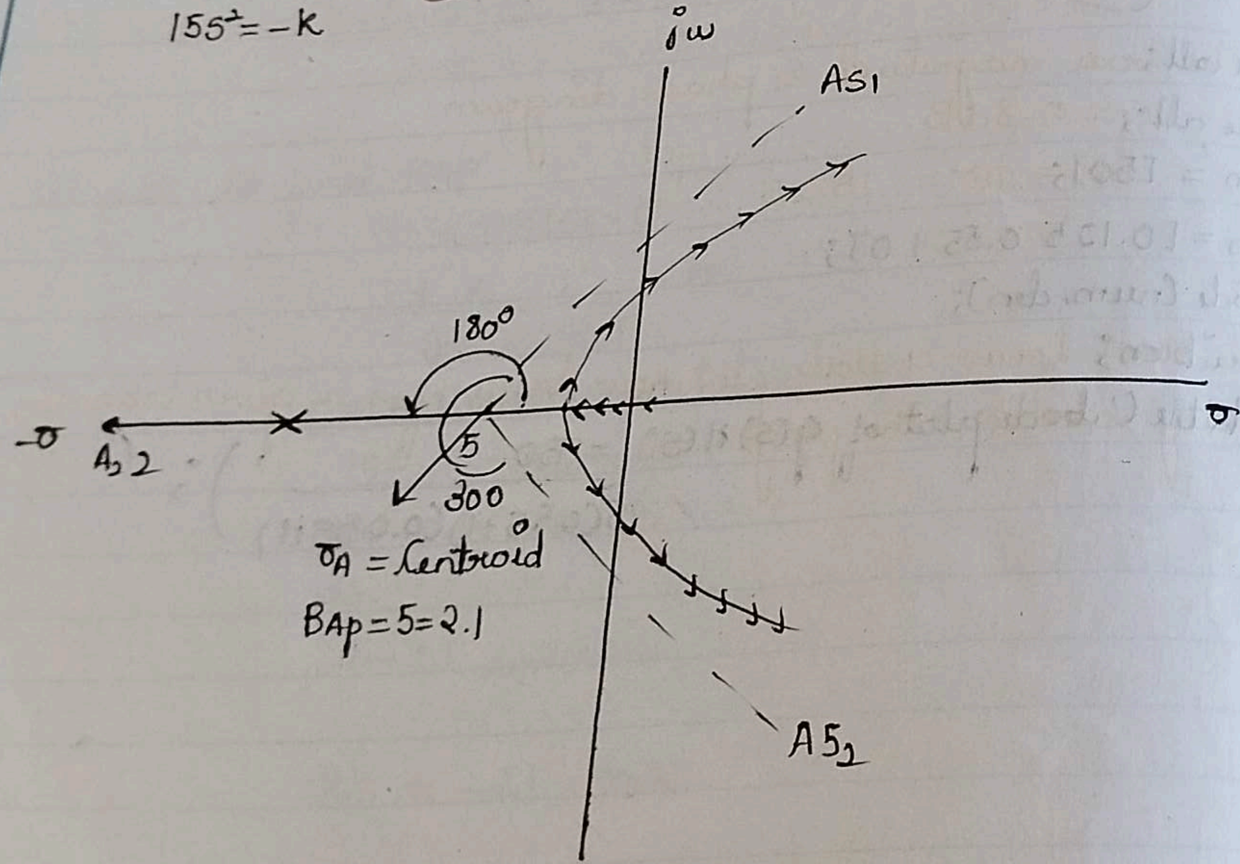
$k=750$

$k_{max}=750$

frequency of Oscillation where root locus intersects the imaginary axis

$15s^2+k=0$

$15s^2=-k$



σ_A = Centroid

$BAp=5=2.1$

Result

The root locus & bode plot are drawn for a given transfer funcⁿ by writing the program

phase plot

$\phi w = -90\ \tan^{-1}0.5w - \tan^{-1}0.05w$

w(rad/sec)	φ(w)(deg)	w(rad/sec)	φ(w)(deg)
2	−140	7	−183.3
3	−154.8	8	−187.3
4	−164.7	9	−191.7
5	−172.2	10	−195.25
6	−178.2	20	−219.3
6.32	−180.0		

From the bode magnitude & phase diagram

$GM=-8dB$

$PM=\phi M=-15.25$

Result

The root locus & bode plot are drawn for a given transfer funcⁿ by writing the program

Ex: investigate the stability of a -ve feedback control system where Open loop TF is given by

$$g(s)H(s) = \frac{50}{s(0.5s+1)(0.05s+1)}$$

put $s=j\omega$ $\quad g(j\omega)H(j\omega) = \frac{50}{j\omega(0.5j\omega+1)(0.5j\omega+1)}$

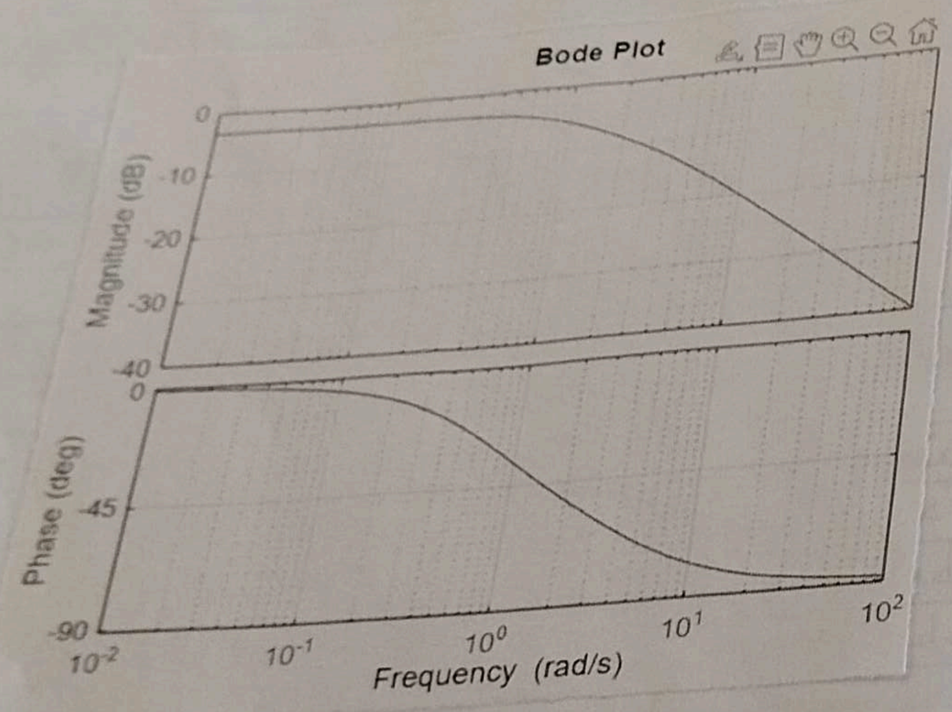
$$y(j\omega) = \frac{50}{j\omega}$$

$$20\log|y(j\omega)| = 20\log 50 - 20\log\omega = 54\,dB$$

Tabular Column

Factor	Corner frequency	Magnitude & slope characteristic of valuable asymprote (2ex)
$\frac{50}{j\omega}$	—	The factor for a magnitude $= 54\,dB$ at $\omega = 0.1$ & slope $= -20\,dB/dec$
$\frac{1}{1+0.5j\omega}$	$\omega_1 = \frac{1}{0.5}$ $\omega_2 = 2$	Net slope b/n ω_1 & ω_2 = slope contributed by $(1+0.5j\omega)$ for $\omega > \omega_1$ provides slope $= 20 = -20-20 = -40\,dB/dec$
$\frac{1}{1+0.05j\omega}$	$\omega_2 = \frac{1}{0.005}$ $\omega_2 = 20$	Net slope ω_2 onwards slope contributed by $(1+0.05j\omega)$ for $\omega > \omega_2$ provides slope $= -20-40 = -60\,dB/dec$

Experiment - 9



Program - 9

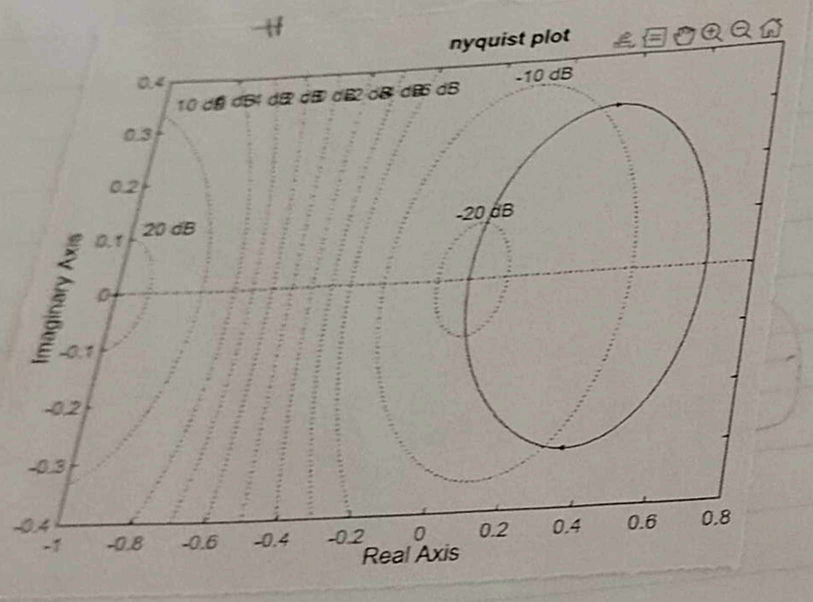
Aim - Analyze the stability of given system bode plots

Theory - Bode plots graphically represent a system frequency response, providing insights into stability by determining the gain & phase margins are concerns a systems robustness to disturbance

```
num = [1, 2];
den = [1, 4, 3];
sys = tf(num, den);
figure;
  bode(sys);
   grid on;
    title('Bode plot');
```

Result & Conclusion :- The program for analyzing the stability of given system using pole is successfully executed & verified

Experiment - 10



Program-10

Aim :- Analyze the stability of given system using nyquist plot

Software :- MATLAB 2024

Theory :- Nyquist plot maps system's frequency response onto the complex plane. stability is known by analyzing the plots encirclement of $-1+j0$ point

```
num = [1,2];
den = [1 4 3];
sys = tf(num, den);
figure;
nyquist plot (sys);
grid on;
title ('nyquist Plot');
```

Result & Conclusion - The program to analyze the stability of given system using nyquist plot is successfully executed & verified

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Experiment - 11

$X = \begin{bmatrix} -1 & -1 \\ 1 & 0 \end{bmatrix}$ $B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ $C = [0 \ 1]$

given $X = \begin{bmatrix} -1 & -1 \\ 1 & 0 \end{bmatrix}$

$TF = C(SI - X)^{-1} B + D$

$$SI - X = \begin{bmatrix} S & 0 \\ 0 & S \end{bmatrix} - \begin{bmatrix} -1 & 0 \\ 1 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} S+1 & 1 \\ -1 & S \end{bmatrix}$$

$$(SI - X)^{-1} = \frac{\begin{bmatrix} S & -1 \\ 1 & S+1 \end{bmatrix}}{S^2 + S + 1}$$

$$T.F = [0 \ 1] \begin{bmatrix} S & -1 \\ 1 & S+1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} + 0$$

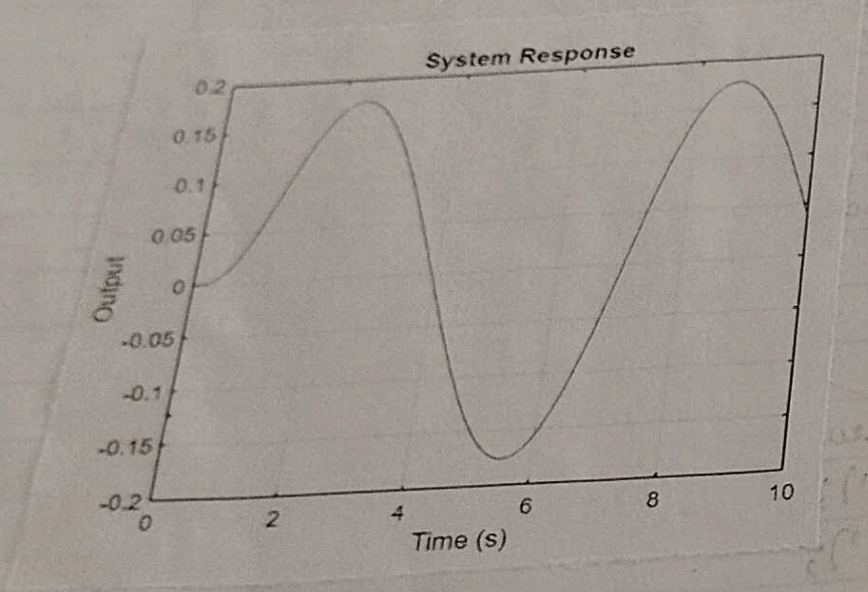
$$= \frac{[0 \ 1] \begin{bmatrix} S \\ 1 \end{bmatrix}}{S^2 + 3 + 1}$$

$$T.F = \frac{1}{S^2 + S + 1}$$

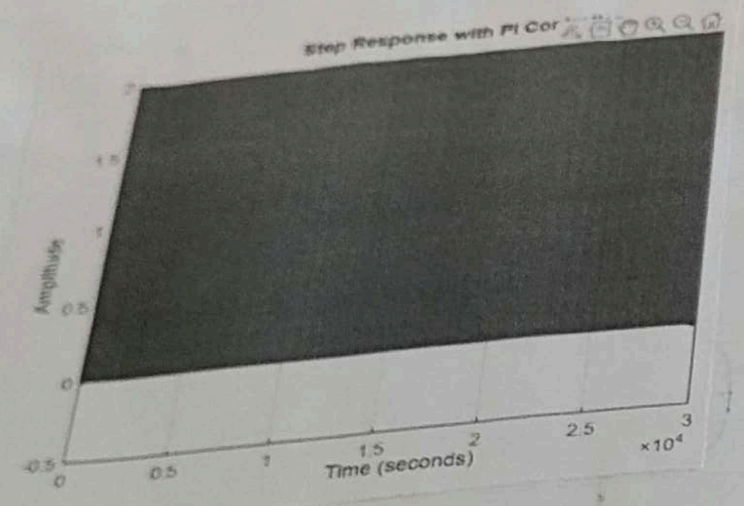
Program 11

Using suitable simulation package, Obtain the time response from

```
A = [-2 -1; 1 -2];
B = [1:0];
C = [0 1];
D = 0;
Sys = ss(A,B,C,D);
t = linspace(0,10,1000);
u = sin(t);
[y,t,x] = lsim(Sys,u,t);
% Plot system Response
figure
plot(t,y);
grid on;
title('System Response');
xlabel('Time(S)');
ylabel('Output');
```



Experiment - 12



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Program 12
Implementation of PI, PD Controllers
* PI controllers

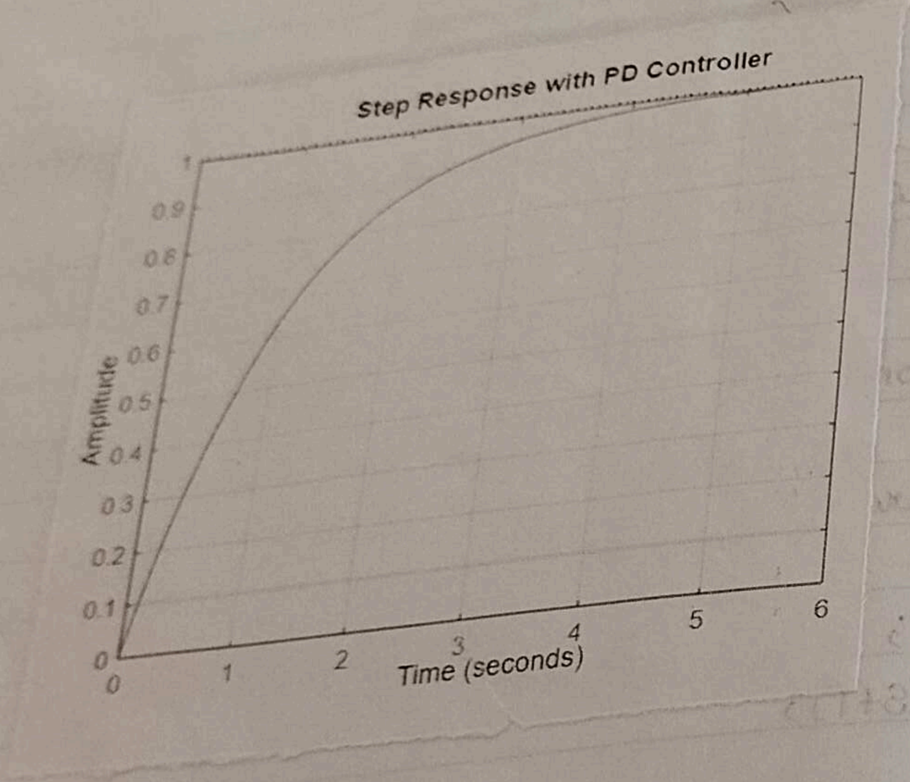
```
s = tf('s');
g = 1/(s*(s+1));
kp = 1;
ki = 1;
c = kp + ki/s;
sys = feedback(c*g, 1);
step(sys);
grid on;
title('Step Response with PI Controller');
```

* PD Controllers

```
S = tf('S');
g = 1/(S*(S+1));
Kp = 1;
kd = 1;
c = Kp + Kd*S
Sys = feedback(c*g, 1);
Step(sys);
grid on;
title('Step response with PD Controller');
```

Theory * PI Controller :- Combines proportional c(P) and integral (I) terms

* PD Controller :- Combines proportional (P) & derivative (D) term



PD Controller

```
s = tf('s');
G = 1/(s*(s+1));
kp=1;
kd =1;
C = kp+kd *s;
sys = feedback (C * G, 1);
step(sys);
grid on;
title ('Step Response with PD Controller');
```

Result & Conclusion :- The program to implement PD & PD controllers has been executed successfully verified