VASAVI COLLEGE OF ENGINEERING

(AUTONOMOUS)
(Affiliated to Osmania University)
Hyderabad - 500 031.

DEPARTMENT OF : ECE

NAME OF THE LABORATORY : Control Systems Engineering

Name G-Sri Ganga Pranav Roll No. 1602-21-735-117 Page No.

Root Locus - Effect of adding poles and zeros

Aim:-

1) To plot the root locus of a open loop transfer function for various values of damping factor.
2) To observe the effect of adding poles and zeros in root locus

Tools Required:- A PC loaded with MATLAB

Theory:-

The root locus method in control systems engineering is a fundamental technique used to analyze the behaviour of closed-loop control systems. It provides insights into the stability and performance characteristics of the system by examining how the poles of the closed loop transfer function vary as gain varies

The root locus plot typically begins with the poles of the open-loop transfer function. As the gain increases from zero, the poles of the closed loop system move along trajectories determined by the system's characteristic equation. These trajectories converge or diverge towards or away from certain regions of the complex plane indicating regions of stability or instability.

ζ	ω_n	Rise time (sec)	settling time (sec)	Peak overshoot
0	2	0.578	12.2	1.6, 59.8%
0.2	2	0.653	10.1	1.5, 50.7%
0.4	2	1	5.69	1.26, 25.8%
0.5	2	1.23	6.21	1.17, 17.5%
0.7	2	1.95	5.67	1.05, 5%
1	2	6.47	11.9	1, 0%

Theorotical calculations for $\zeta = 0.2$:-

1) $\% M_P = 100 \times e^{-\pi\zeta/\sqrt{1-\zeta^2}}$

$= 100 \times e^{-\pi(0.2)/\sqrt{1-(0.2)^2}}$

$= 52.6\%$

2) $t_r = \dfrac{\pi - \phi}{\omega_d} = \dfrac{\pi - \tan^{-1}\left(\frac{\sqrt{1-\zeta^2}}{\zeta}\right)}{\omega_n\sqrt{1-\zeta^2}}$

$= \dfrac{\pi - \tan^{-1}\left(\frac{1}{0}\right)}{2\sqrt{1-(0.2)^2}} = \dfrac{\pi - \frac{\pi}{2}}{2\sqrt{0.96}} = 0.8 \text{ sec}$

3) $t_s \approx \dfrac{4}{\zeta\omega_n} = \dfrac{4}{(0.2)(2)} = 10 \text{ sec}$

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Program:- % Plotting root locus and step response

```
clc;
clear;
close all;
zeta = [0  0.2  0.4  0.5  0.7  1 1.5];
s= tf('s');
Gs = 1/(s*(s+2)*(s+4));
for i= 1: length(zeta)
  figure;
rlocus(Gs);
sgrid (zeta(i),2);
[k, r] = rlocfind(Gs);
CLTF = feedback (k*Gs, 1);
stepplot(CLTF);
title(['step response for zeta = ' num2str(zeta(i))]);
end
```

```
% Effect of adding poles and zeros
clc;
clear;
close all;
s= tf('s');
Gs= 1/(s*(s+2)*(s+4));
```

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```
%Adding a zero
Gs1 = (s+1)/(s*(s+2)*(s+4));
rlocus(Gs1);
figure;
%Adding multiple zeros
Gs2 = ((s+1)*(s+4))/(s*(s+2)*(s+4));
rlocus(Gs2);
figure;
%Adding zero far from imaginary axis
Gs3 = ((s+1)*(s+10))/(s*(s+2)*(s+4));
rlocus(Gs3);
figure;
%Adding zero at zero
Gs4 = (s*(s+1))/(s*(s+2)*(s+4));
rlocus(Gs4);
figure;
%Adding pole at zero
Gs4 = (s+1)/(s*s*(s+2)*(s+4));
rlocus(Gs5);
```

Observations:-

a) Addition of zeros and multiple zeros:-
The angle of asymptutes increases and the root locus shift towards the left of the s plane slightly more and the system becomes more stable.

b) Addition of zero near to imaginary axis:-
When zero is added near to imaginary axis, it tends to pull the branches of the root locus towards the zero. If the zero is close enough to imaginary axis, it can lead to instability in the system.

c) Addition of zero far from imaginary axis:-
Zeros that are far from imaginary axis tend to have less influence on the poles of the system and thus do not significantly alter the root locus pattern.

d) Addition of poles and multiple poles:-
When poles are added in the root locus ~~plot~~, they tend to shift the path of the locus towards themselves. The branch of the root locus move towards the newly added poles.

e) Addition of poles near to imaginary axis:-
If the added poles are ~~far from~~ closer to ~~the~~ the existing poles, they may repeat the branches of the ~~closer to~~ root locus away from them, leading to a more complex path for the locus.

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f) Addition of poles far from imaginary axis:-
If the newly added poles are far from the existing poles, they will pull the branches of the root locus towards themselves.

Result:-
The effect of varying zeta, addition of poles and zeros on the root locus was observed.