

MENG366 SYSTEM DYNAMICS AND CONTROL LABORATORY

LABORATORY 11: FREQUENCY RESPONSE ANALYSIS USING POLAR PLOT

1. OBJECTIVE

To analyze the stability of the given linear system using polar plot.

2. COMPONENTS & EQUIPMENT

PC with MATLAB and Simulink toolbox installed.

3. BACKGROUND

The Polar plot provides a simple test for stability of a closed-loop control system by examining the open-loop system. Stability of the closed-loop control system may be determined directly by computing the poles of the closed-loop transfer function. The Polar Criteria can tell us things about the frequency characteristics of the system. A Polar plot is used in automatic control and signal processing for assessing the stability of a system with feedback. It is represented by a graph in polar coordinates in which the gain and phase of a frequency response are plotted. The plot of these phasor quantities shows the phase as the angle and the magnitude as the distance from the origin. This plot combines the two types of Bode plot — magnitude and phase — on a single graph with frequency as a parameter along the curve.

4. DESIGN PROCEDURE/ DESIGN CALCULATIONS:

Problem:

The open loop transfer function of a unity feedback system

$$G(s)=K/s(s^2 +2s+3)$$

- a) Draw the Polar Plot.
- b) Find:
 - (i) Gain Margin
 - (ii) Phase Margin
 - (iii) Gain cross over frequency.
 - (iv) Phase cross over frequency and check the same results using MATLAB Software. (Assume K=1)

Matlab Program:

```
%Polar Plot for the Transfer Function  $G(s)=1/(s+1)^3$ 

num=[1];

den=[1 3 3 1];

figure(1);

polar (num,den)

Title('Polar Plot for the Transfer Function  $G(s)=1/(s+1)^3$ ')

[Gm,Pm,Wcg,Wcp] = margin(num,den)

grid;

[Gm,Pm,Wcg,Wcp] = margin(num,den);

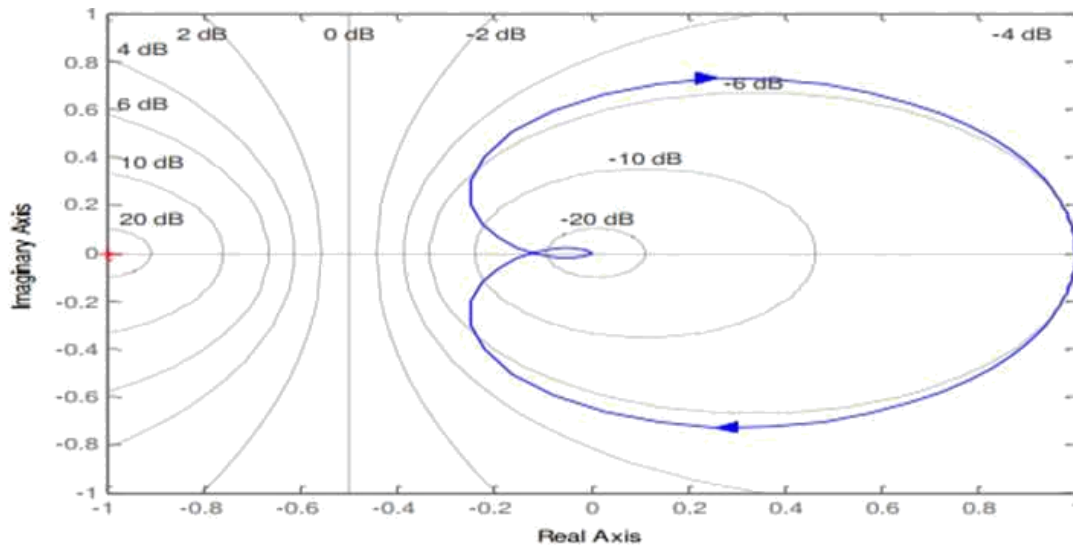
Gain_Margin = Gm

Phase_Margin = Pm

PhaseCrossover_Frequency = Wcg

GainCrossover_Frequency = Wc
```

Matlab Output:



Gain_Margin = 8.0011

Phase_Margin = -180

PhaseCrossover_Frequency = 1.7322 rad/sec

GainCrossover_Frequency = 0 rad/sec

Pre lab questions:

- What is contour?
- Define the type number and order of the system.

Post lab questions:

- Explain the conditions for stable system in Polar plot.
- State Polar stability criterion.