Lab # 3
Determination Of Bode Plot, Root Locus & Nyquist Plot Using Transfer Function

Objective:

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Bode Plot:

In electrical engineering and control theory, a **Bode plot** is a graph of the frequency response of a system. It is usually a combination of a Bode magnitude plot, expressing the magnitude (usually in decibels) of the frequency response, and a Bode phase plot, expressing the phase shift.

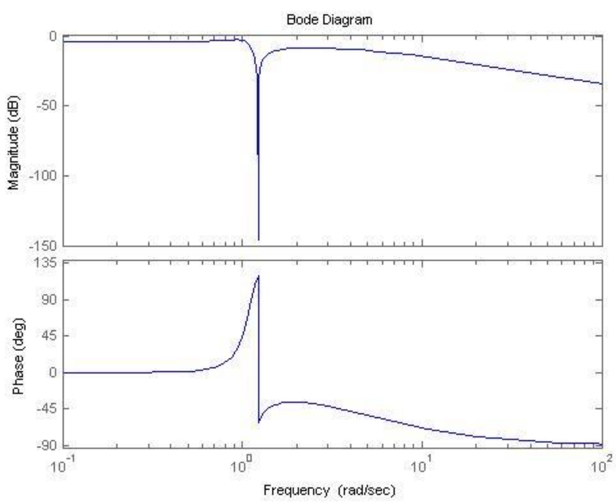
Example:

Given the following transfer function,

$$H(S) = \frac{2S^2 + 3}{S^3 + 4S^2 + 5}$$

Matlab Code

```
num=[2 0 3];
den=[1 4 0 5];
h=tf(num,den);
w=pi:pi/1000:2*pi*f;
[h,k]=freqz(num,den,w);
bode(num,den)
```



Root Locus:

In control theory and stability theory, root locus analysis is a graphical method for examining how the roots of a system change with variation of a certain system parameter, commonly a gain within a feedback system.
This is a technique used as a stability criterion in the field of classical control theory developed by Walter R. Evans which can determine stability of the system. In **root locus technique in control system** we will evaluate the position of the roots, their locus of movement and associated information. These information will be used to comment upon the system performance.

Any physical system is represented by a transfer function in the form of:

$$G(s) = k \times \frac{numerator\ of\ s}{denomerator\ of\ s}$$

Some of the advantages of root locus technique are written below.

Advantages of Root Locus Technique

1. Root locus technique in control system is easy to implement as compared to other methods.
2. With the help of root locus we can easily predict the performance of the whole system.
3. Root locus provides the better way to indicate the parameters.

Now there are various terms related to root locus technique :

1. **Characteristic Equation Related to Root Locus Technique :**

   1+ G(s)H(s) = 0 is known as characteristic equation. Now on differentiating the characteristic equation and on equating dk/ds equals to zero, we can get break away points.

2. **Break away Points :**

   Suppose two root loci which start from pole and moves in opposite direction collide with each other such that after collision they start moving in different directions in the symmetrical way. Or the breakaway points at which multiple roots of the characteristic equation 1 + G(s)H(s)= 0 occur. The value of K is maximum at the points where the branches of root loci break away. Break away points may be real, imaginary or complex.

3. **Break in Point :**

   Condition of break in to be there on the plot is: "Root locus must be present between two adjacent zeros on the real axis."

4. **Angle of Arrival or Departure :**

We calculate angle of departure when there exists complex poles in the system. Angle of departure can be calculated as 180-{(sum of angles to a complex pole from the other poles)-(sum of angle to a complex pole from the zeros)}.

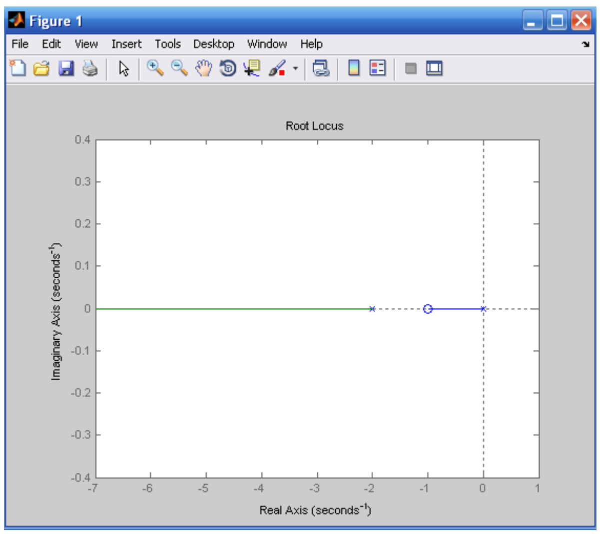
Example:

Obtain Root Locus Plot of a system having forward path transfer function of

$$\frac{1+s}{s(1+0.5s)}$$

Matlab Code

```
num=[1 1]
den=[0.5 1 0]
a=tf(num,den)
rlocus(a)
```



NYQUIST PLOT

In control theory and stability theory, the Nyquist stability criterion, is a graphical technique for determining the stability of a dynamical system. Because it only looks at the Nyquist plot of the open loop systems, it can be applied without explicitly computing the poles and zeros of either the closed-loop or open-loop system (although the number of each type of right-half-plane singularities must be known).

A Nyquist plot is a parametric plot of a frequency response used in automatic control and signal processing. The most common use of Nyquist plots is for assessing the stability of a system with feedback.

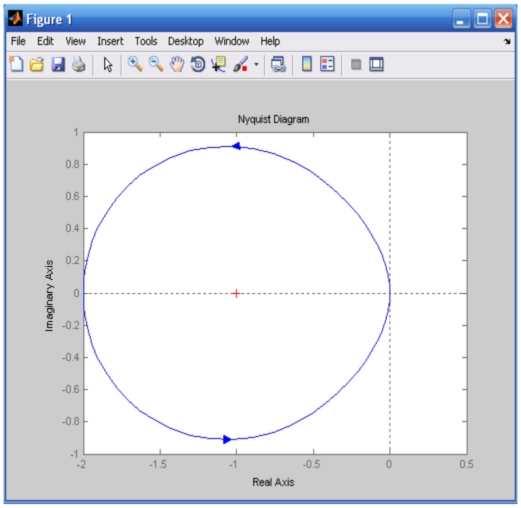
Example 1:

Obtain Nyquist Plot of a system having forward path transfer function:

$$G(s) = \frac{2+s}{(s+1)(s-1)}$$

<u>Matlab code:</u>

```
num=[1 2];
den=[1 0 -1];
x=tf(num,den)
nyquist(x)
```



Post Lab Questions

a) **Fill the following table:**

S.No	Name	Definition	Command Used
1	Root Locus		
2	Bode Plot		
3	Nyquist Plot		

Lab Tasks

Task 1

a) Find the root locus of the following transfer function:

1. Numerator= [1]
   Denominator=[s(s+2)(s+4)]

2. Numerator=[10]
   Denominator=[1 9 10 0]

Task 2

Obtain Nyquist plot of the following Transfer function :

1. num=[1 2]
   den=[(s-1)(s+1)

2. num=s(s-3)
   den=s(s+1)(s-1)

Task 3

Find the magnitude, frequency and phase response of the following transfer function:

$$H(s) = \frac{2s^2 + 3s + 4}{5s + 9}$$