Preetham - 4NM18EC130
Amulya - 4NM18EC019

CONTROL SYSTEM - TASK-2

1) A unity feedback system has given open loop transfer function
2) Sketch root locus plot
3) Determine the value of K for damping ratio $\xi = 0.5$
4) Plot the range of value of K for which the system is stable, marginally stable & unstable
5) Show rootlocus and bode simulation in MATLAB
6) Find step response for closed loop transfer function obtained from (3)

$$G(S)H(S) = \frac{K(S+6)}{S^2+4S+20}$$

Number of poles $P = 2$

$s_1 = -2+4i$ $\quad s_2 = -2-4i$

Number of zeroes $Z = 1$

$Z = -6$

$q = 0 \ldots P-Z-1$

$q = 0$

Asymptotes

$$\theta = \frac{(2q+1)180^\circ}{P-Z}$$

$$\theta_0 = \frac{(2(0)+1)\,180^\circ}{1} = \underline{\underline{180^\circ}}$$

Centroid

$$\sigma = \frac{\sum \text{Real part of poles} - \sum \text{real part of zeroes}}{P-Z}$$

$$\sigma = \frac{-2+(-2)-(-6)}{1}$$

$$\sigma = \underline{\underline{2}}$$

Breakaway point

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

$$1 + \frac{K(s+6)}{s^2+4s+20} = 0$$

$$s^2 + 4s + 20 + Ks + 6K = 0$$

$$K = -\frac{s^2+4s+20}{s+6}$$

$$\frac{dK}{ds} = \frac{(s+6)(-2s-4) - (-s^2-4s-20)}{(s+6)^2}$$

$$\frac{dK}{ds} = 0$$

$$\Rightarrow \quad -\frac{s^2+12s-4}{(s+6)^2} = 0$$

$$-s^2 - 12s - 4 = 0$$

$s_1 = -0.343$ invalid

$s_2 = -11.65$ valid

Intersection points

RH Array

s^2	$s(k+4) + 20+6k$
s^2	$1 \quad 20+6k$
s^1	$k+4$
s^0	$20+6k$

$$20+6k > 0$$
$$6k > -20$$
$$k > -\frac{20}{6}$$
$$k > -3.33$$

$$k+4 > 0$$
$$k > -4$$

System is stable $k > -3.33$

marginally stable for $k = -3.33$

system is unstable for $k < -3.33$

Intersection point

$A(s) = s^2 + 20 + 6(-3.33)$

$s^2 = 0$

No. intersection point with imaginary axis

Damping ratio $\xi = 0.5$

$\theta = \cos^{-1}(\xi)$

$\theta = \cos^{-1}(0.5)$

$= 60^\circ$

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

$s^2 + s(K+4) + 20 + 6K = 0$

$s^2 + 2\xi\omega_n s + \omega_n^2$

$\omega_n = K + 4 \qquad \omega_n^2 = 20 + 6K$

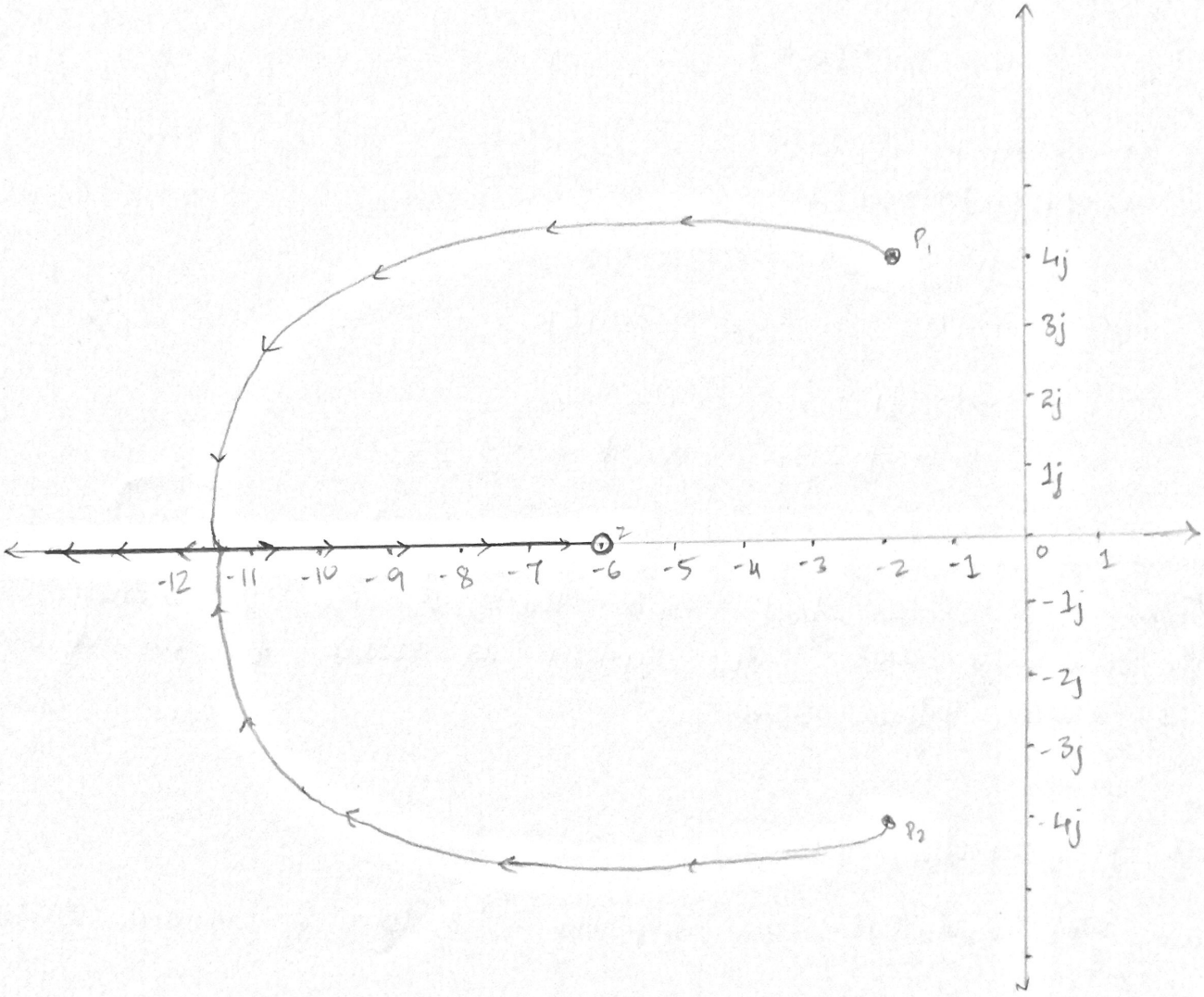
$K^2 + 2K - 4 = 0$

$K = 1.23$ or $K = -3.23$

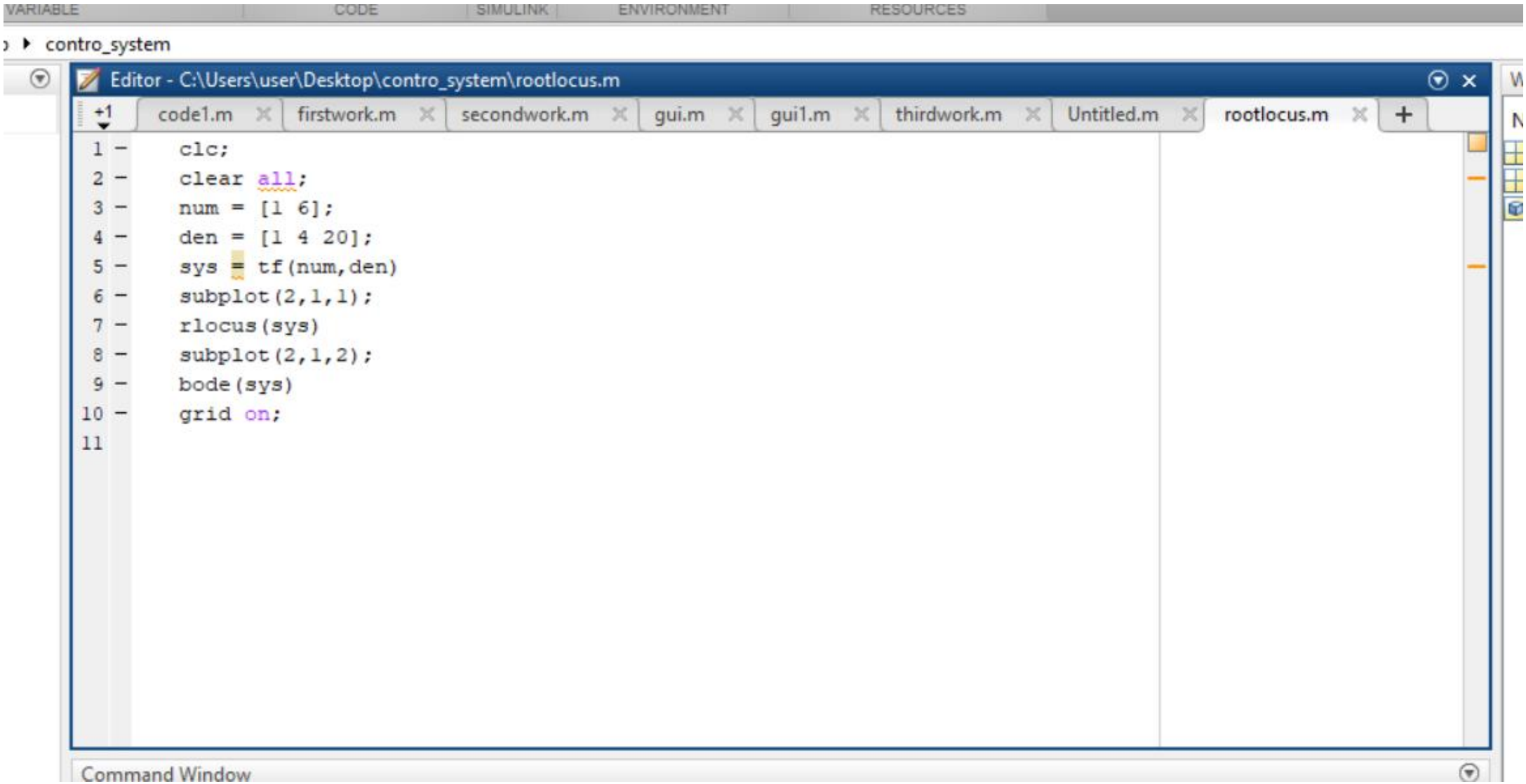
From root locus plot since there is no intersection with imaginary axis, the system is stable for all values of K greater than zero.

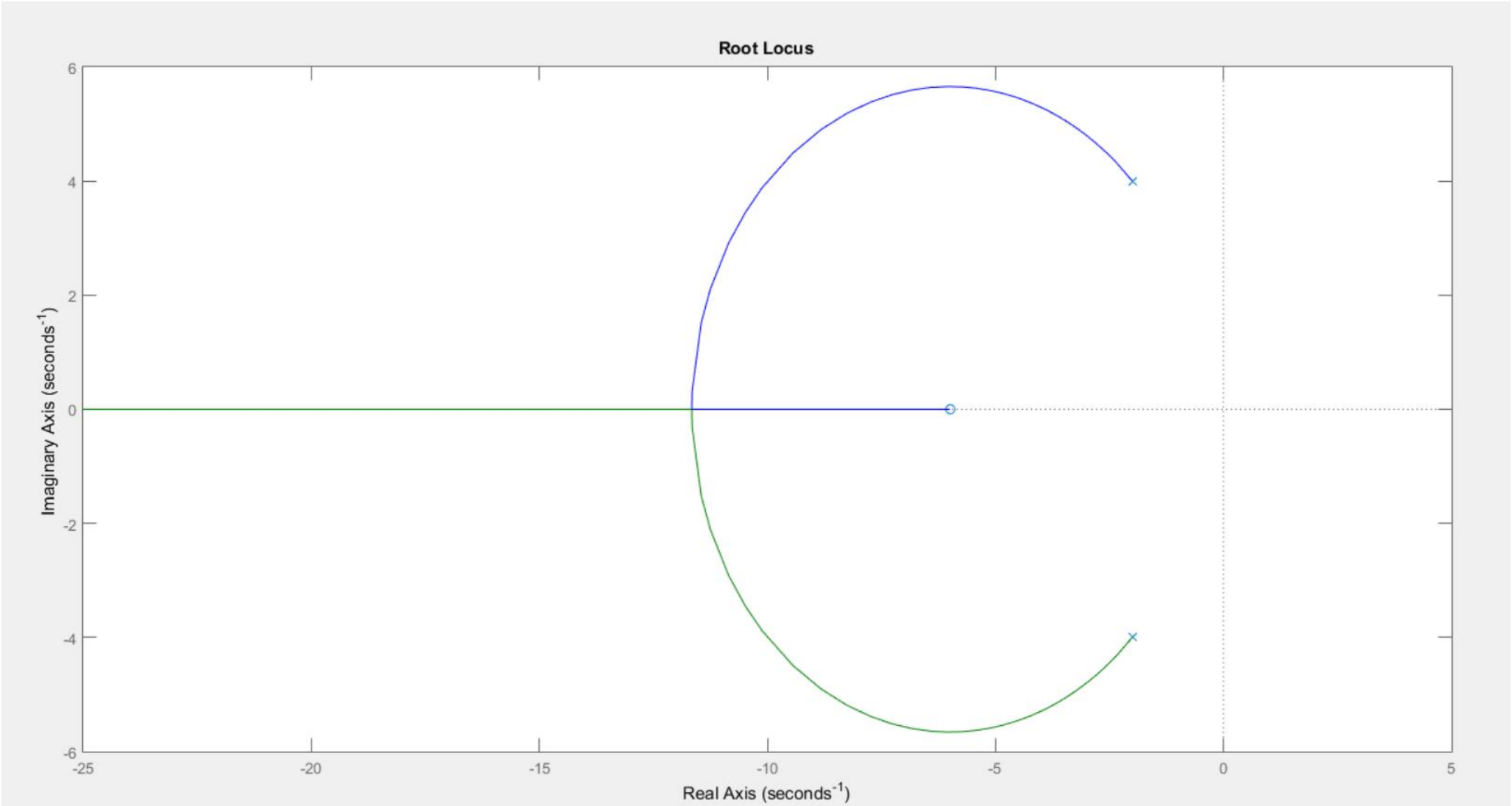
Bode plot stability ($K = 1$)

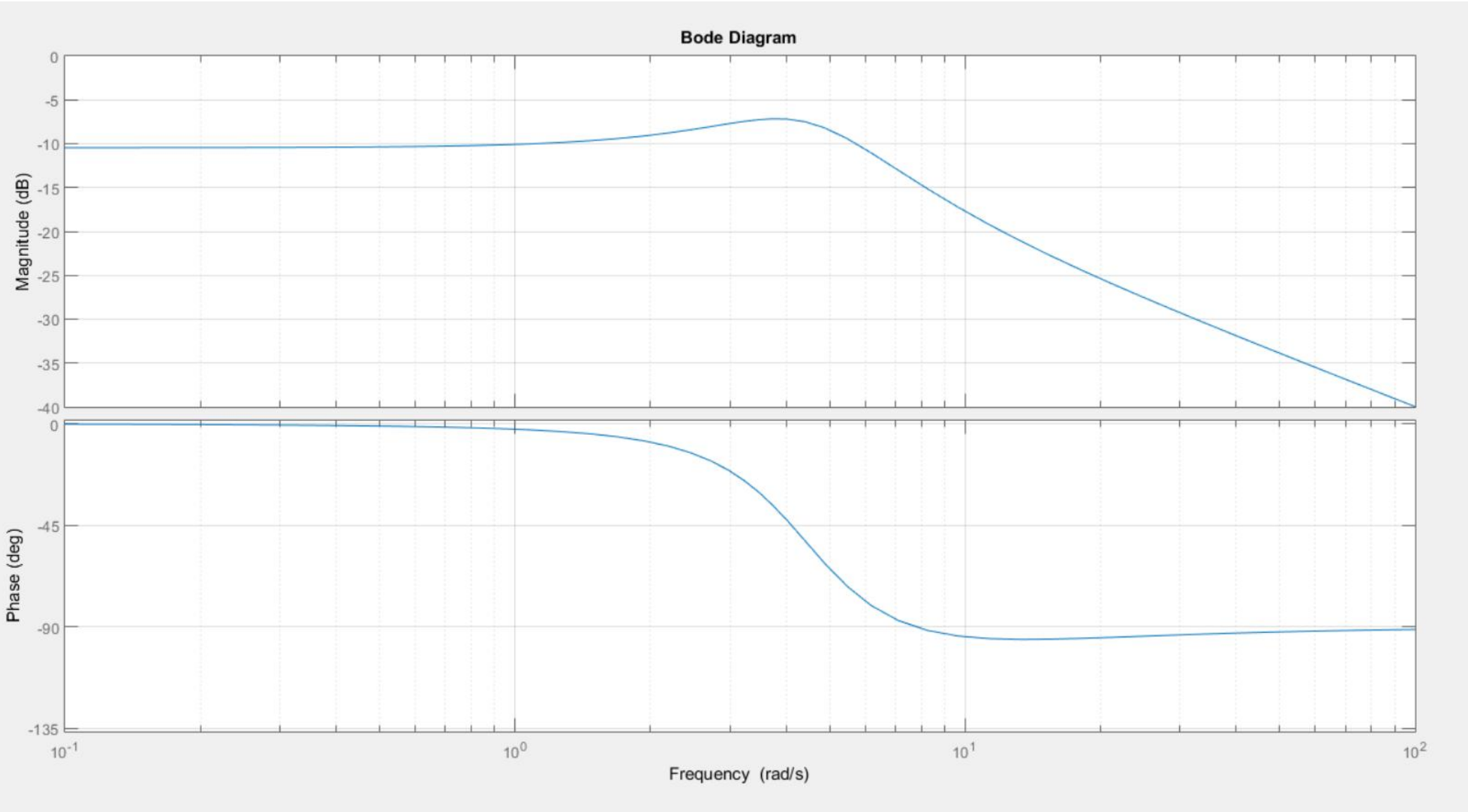
Since PM and GM are infinity, system is always stable.



Root locus plot


VARIABLE
CODE
SIMULINK
ENVIRONMENT
RESOURCES
contro_system
Editor - C:\Users\user\Desktop\contro_system\rootlocus.m
code1.m
firstwork.m
secondwork.m
gui.m
gui1.m
thirdwork.m
Untitled.m
rootlocus.m
clc;
clear all;
num = [1 6];
den = [1 4 20];
sys = tf(num,den)
subplot(2,1,1);
rlocus(sys)
subplot(2,1,2);
bode(sys)
grid on;
Command Window


Root Locus
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})
6
4
2
0
-2
-4
-6
-25
-20
-15
-10
-5
0
5


Bode Diagram
Magnitude (dB)
0
-5
-10
-15
-20
-25
-30
-35
-40
Phase (deg)
0
-45
-90
-135
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/s)