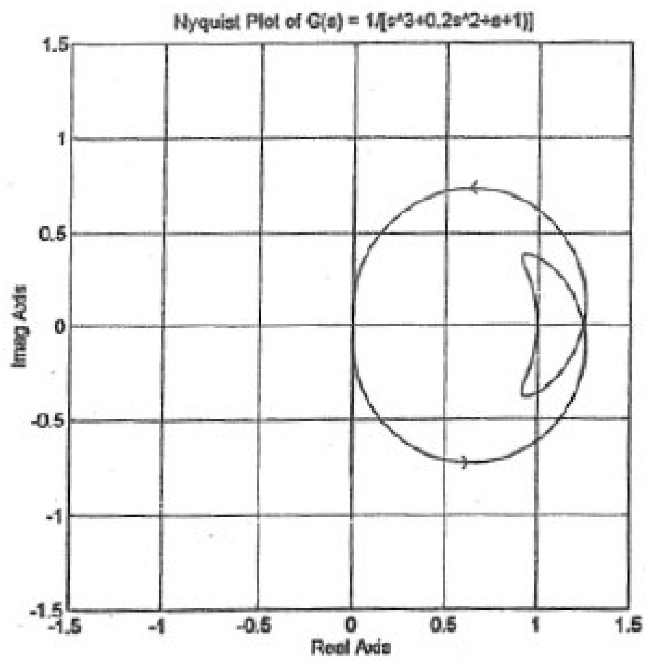
Homework # 6 Solution (Exercises 8.15, 18 & 23)

B-8-15. Note that G(s) has two open-loop poles in the right-hals s plane, as seen from the following MATLAB output.

```
p = [1   0.2   1   1];
roots(p)

ans =

   0.2623 + 1.1451i
   0.2623 - 1.1451i
  -0.7246
```

The following MATLAB program produces the Nyquist plot shown below.

```
% ***** Nyquist plot *****

num = [0   0   0   1];
den = [1   0.2   1   1];
nyquist(num,den)
v = [-1.5   1.5   -1.5   1.5]; axis(v); axis('square')
grid
title('Nyquist Plot of G(s) = 1/[s^3+0.2s^2+s+1]')
```

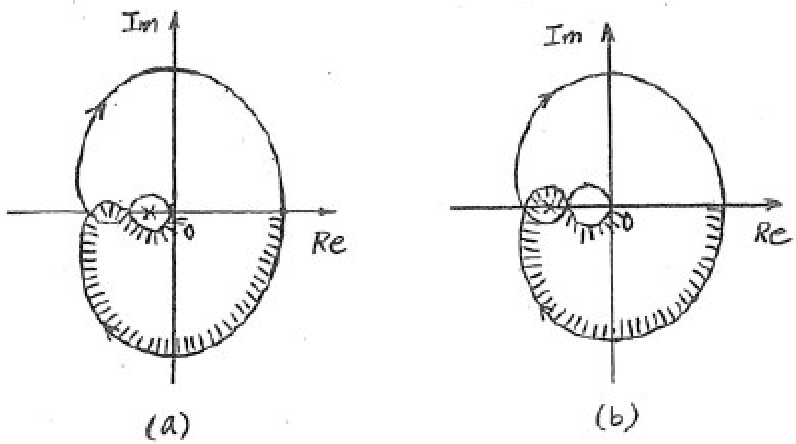


From the plot notice that the critical point (-1+j0) is not encircled. Because there are two open-loop poles in the right-half s plane and no encirclement of the critical point, the closed-loop system is unstable.

B-8-18. Since G(s) has no poles in the right-half s plane, the stability of the system can be studied by checking the enclosure of the $-1 + j0$ point by the Nyquist locus for $0 < \omega < \infty$.

If the Nyquist plot of G(s) is as shown in Figure 8-119(a), then there is no enclosure of the $-1 + j0$ point. [See Figure (a) below.] Hence, the system is stable.

For the case of the Nyquist plot shown in Figure 8-119(b), the $-1 + j0$ point is enclosed by the Nyquist plot of $G(j\omega)$ for $0 < \omega < \infty$. [See Figure (b) below.] Hence, the system is unstable.

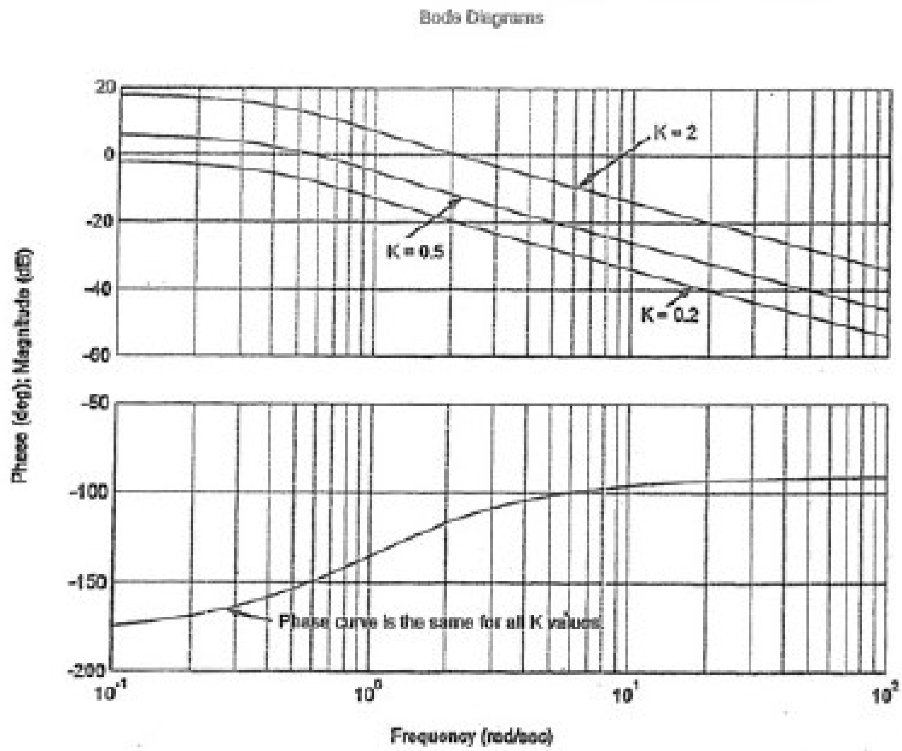


B-8-23.

$$G(s) = \frac{K(s+1)}{s^2 - 0.25}$$

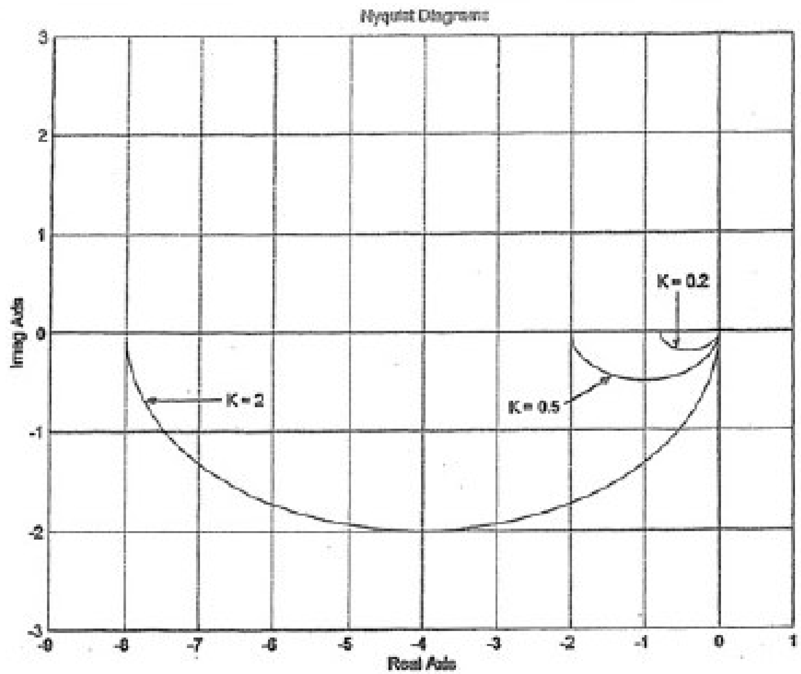
A MATLAB program to plot Bode diagrams of G(s) for K = 0.2, 0.5, and 2 is shown below. The resulting Bode diagrams are shown on the next page.

```
% ***** Bode Diagrams *****

num = [0  1  1];
den = [1  0  -0.25];
w = logspace(-1,2,100);
bode(0.2*num,den,w)
hold
Current plot held
bode(0.5*num,den,w)
bode(2*num,den,w)
gtext('K = 0.2')
gtext('K = 0.5')
gtext('K = 2')
gtext('Phase curve is the same for all K values.')
```

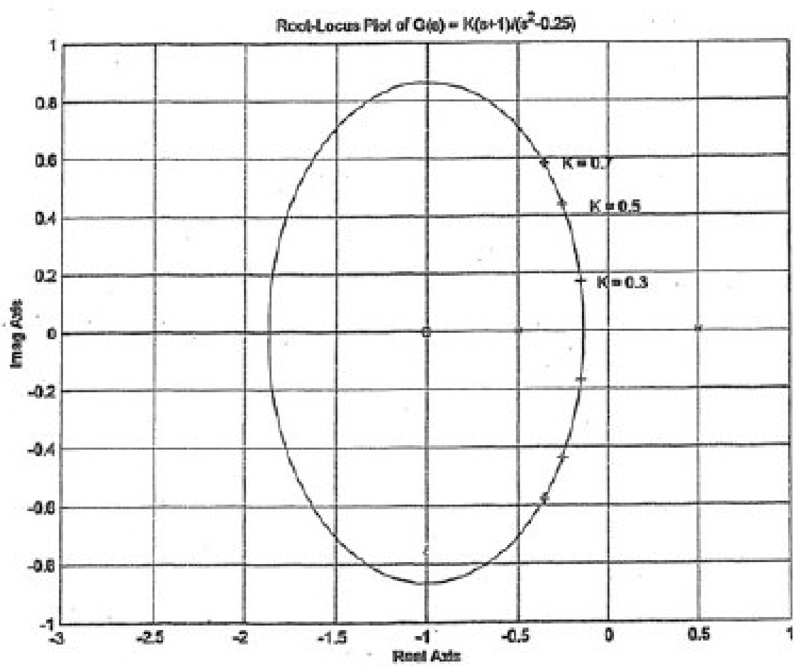


A MATLAB program to plot Nyquist diagrams of G(s) for K = 0.2, 0.5, and 2 is shown below. The resulting Nyquist diagrams are shown on the next page.

```
% ***** Nyquist Diagrams *****

num = [0  1  1];
den = [1  0  -0.25];
w = 0.01:0.01:20;
[re1,im1,w] = nyquist(0.2*num,den,w);
[re2,im2,w] = nyquist(0.5*num,den,w);
[re3,im3,w] = nyquist(2*num,den,w);
plot(re1,im1,re2,im2,re3,im3)
v = [-9  1  -3  3]; axis(v)
grid
gtext('K = 0.2')
gtext('K = 0.5')
gtext('K = 2')
title('Nyquist Diagrams')
xlabel('Real Axis')
ylabel('Imag Axis')
```



A root-locus diagram for the given G(s) is shown below. The MATLAB program that produced this root-locus diagram is shown on the next page.



```
% ***** Root-Locus Plot *****

num = [0   1   1];
den = [1   0.0000001   -0.25];
rlocus(num,den)
grid
title('Root-Locus Plot of G(s) = K(s+1)/(s^2-0.25)')
text(-0.06,0.166,'K = 0.3')
text(-0.1,0.43,'K = 0.5')
text(-0.25,0.58,'K = 0.7')

% To locate a point where K assumes a given value, we may use the
% rlocfind command.  For example, to locate a point where K = 0.3,
% enter the command [K,r] = rlocfind(num,den) and select a probable
% point on a root locus.

[K,r] = rlocfind(num,den)
Select a point in the graphics window

selected_point =

  -0.1594+ 0.1642i


K =

   0.3000


r =

  -0.1500+ 0.1658i
  -0.1500- 0.1658i

% At point -0.1500 + j0.1658, the K value is 0.30000.
```