Examine Bode Plots for Different System Responses

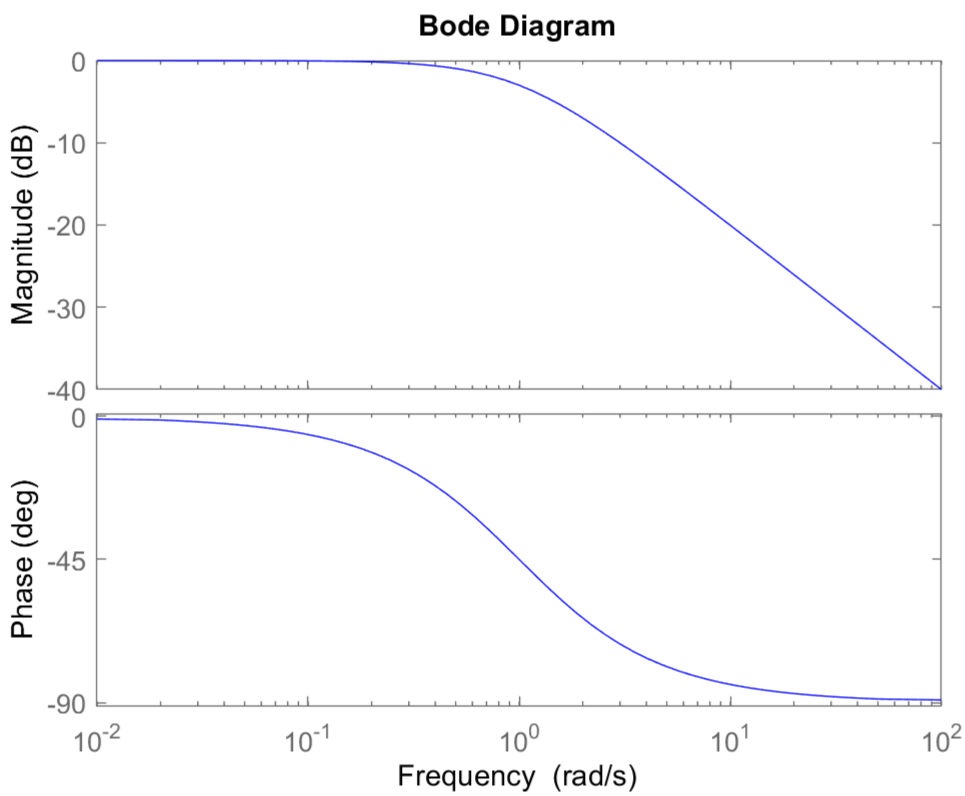
Examine Frequency Response of Transfer Function:

$$G(s) = \frac{1}{1+as} \rightarrow \frac{1}{1+j\omega a}$$

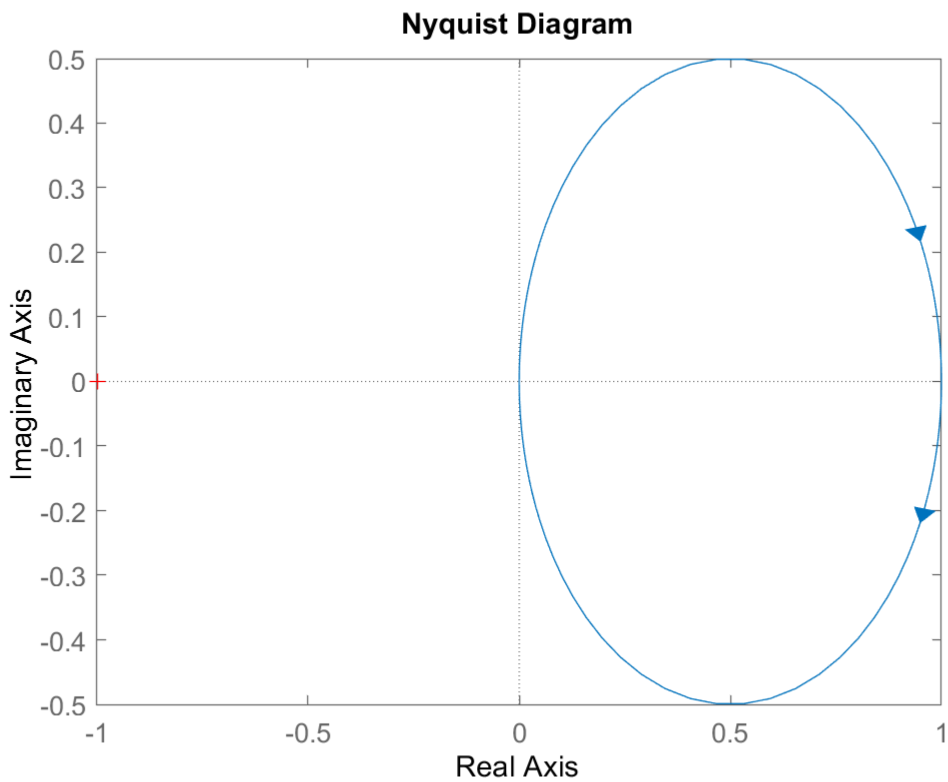
```
clc; close all; clear;
% First order Frequency Response
s = tf('s');
a = 1;
G = 1/(1 + a*s)
```

```
G =

    1
  -----
  s + 1

Continuous-time transfer function.
```

```
figure, G_bode = bodeplot(G,'b');
```




```
figure, nyquist(G)
```



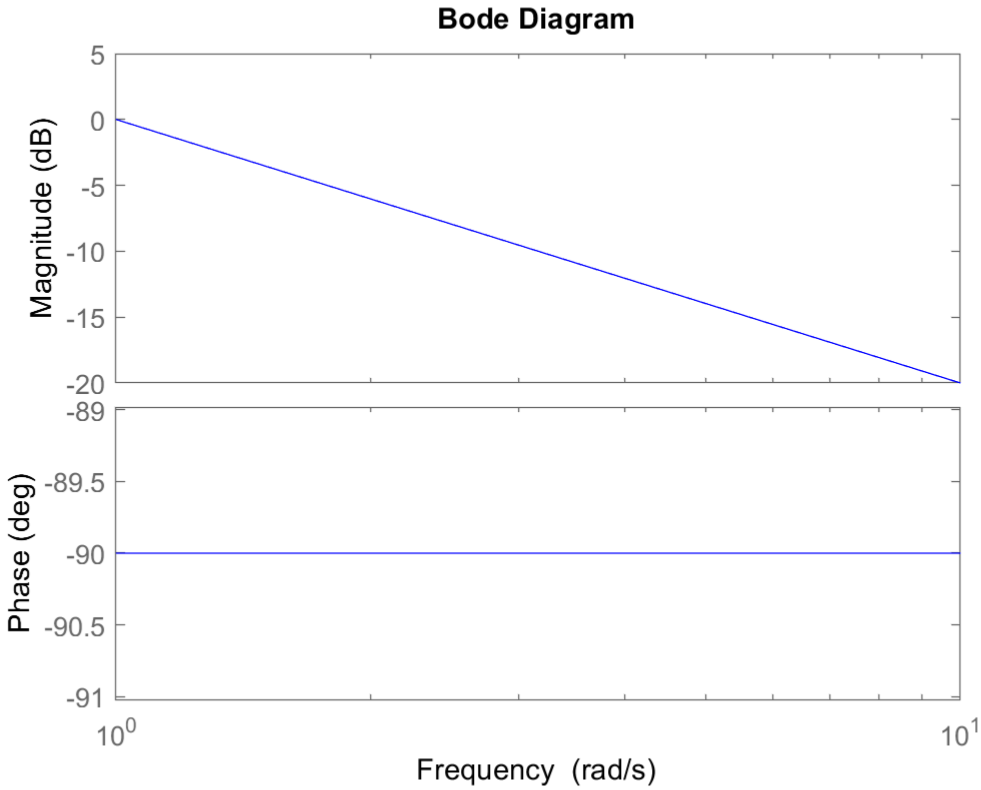
Examine Frequency Response of Integrator Controller:

$$G(s) = \frac{1}{bs} \rightarrow \frac{1}{j\omega b}$$

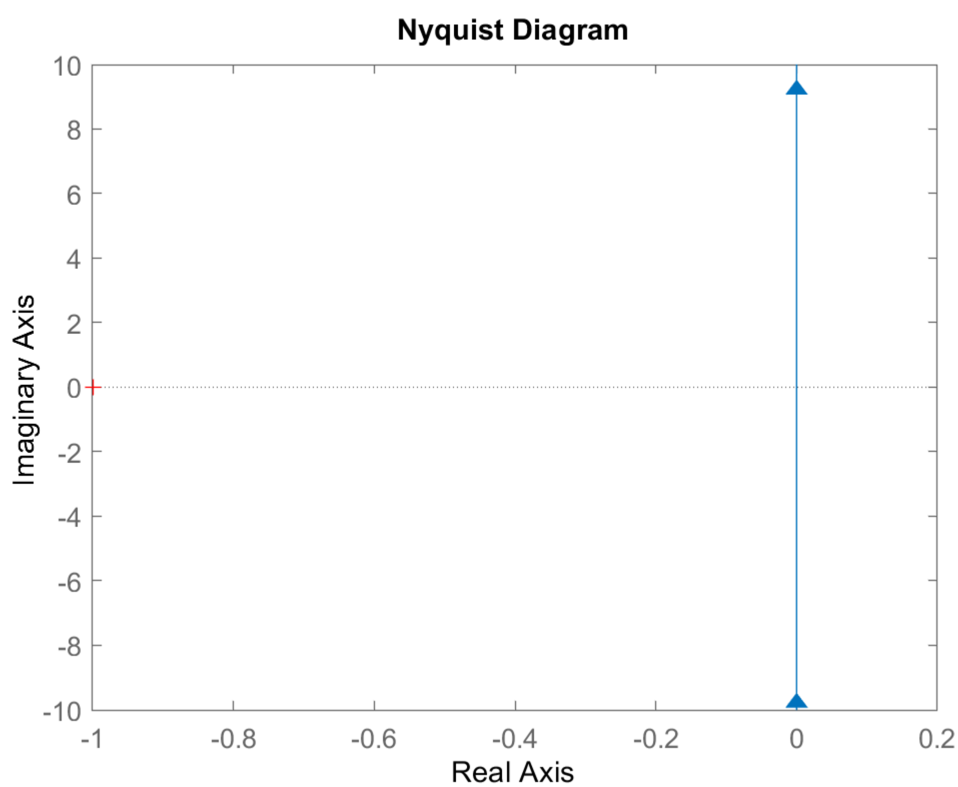
```
% Integrator Frequency Response
b = 1; Int = 1/(b*s)
```

```
Int =

  1
  -
  s

Continuous-time transfer function.
```

```
figure, h_i = bodeplot(Int,'b');
```




```
figure, nyquist(Int)
```



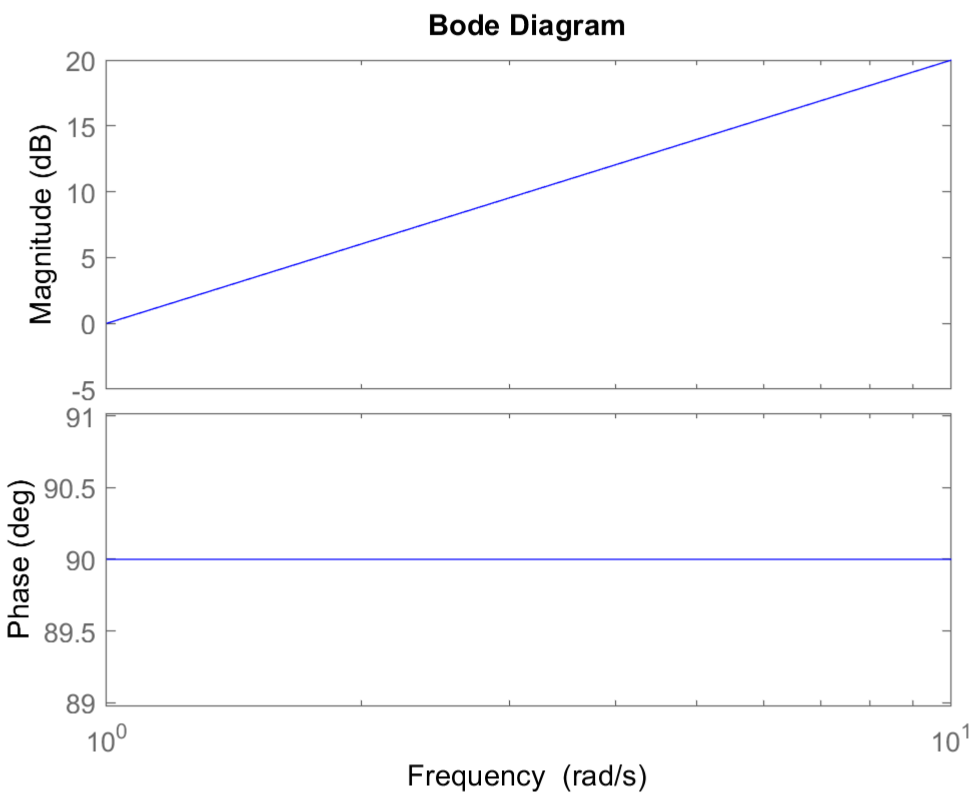
Examine Frequency Reponse of Derivative Controller:

$G(s) = sc \rightarrow j\omega c$

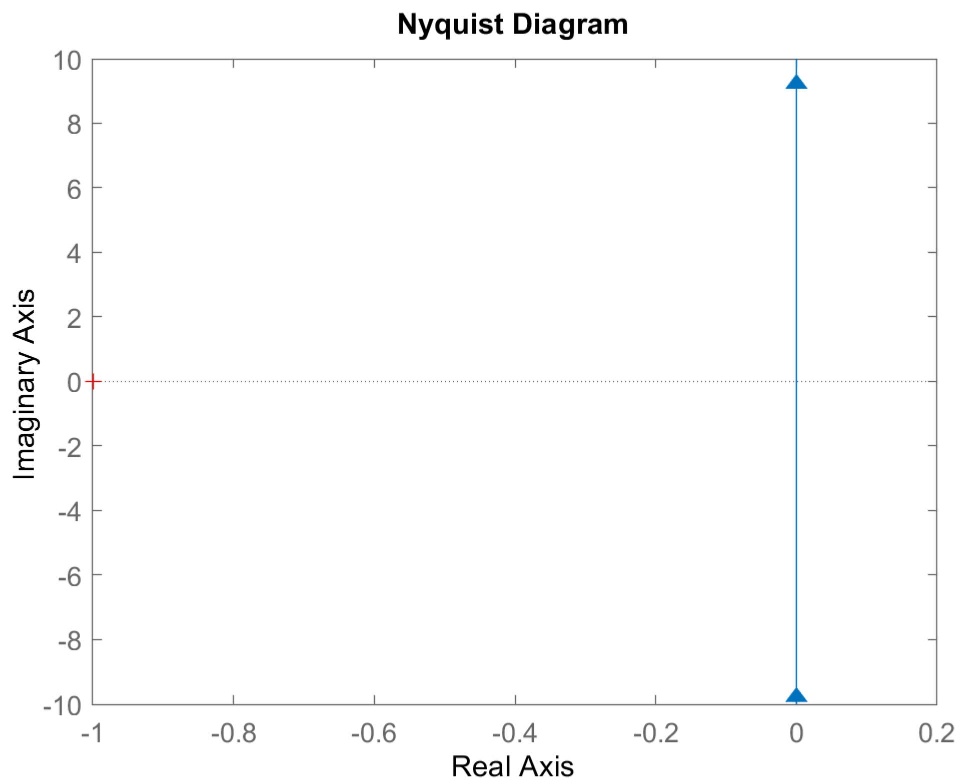
```
% Derivative Frequency Response
c = 1; Deriv = (c*s)
```

```
Deriv =

  s

Continuous-time transfer function.
```

```
figure, h_d = bodeplot(Deriv,'b');
```



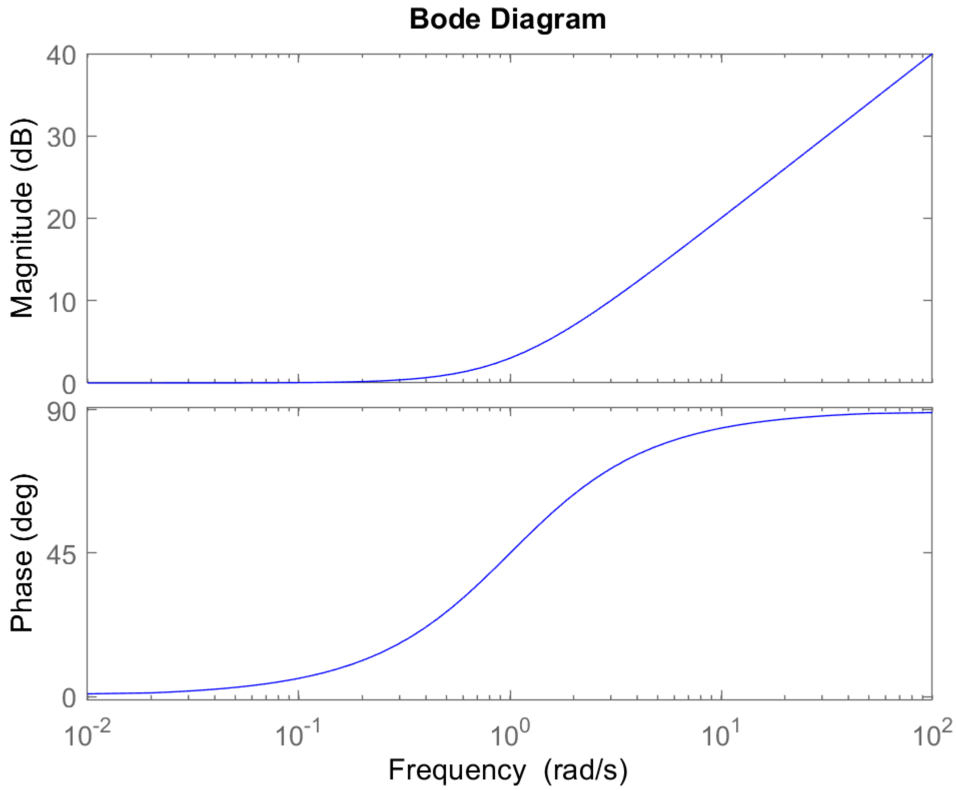

```
figure, nyquist(Deriv)
```



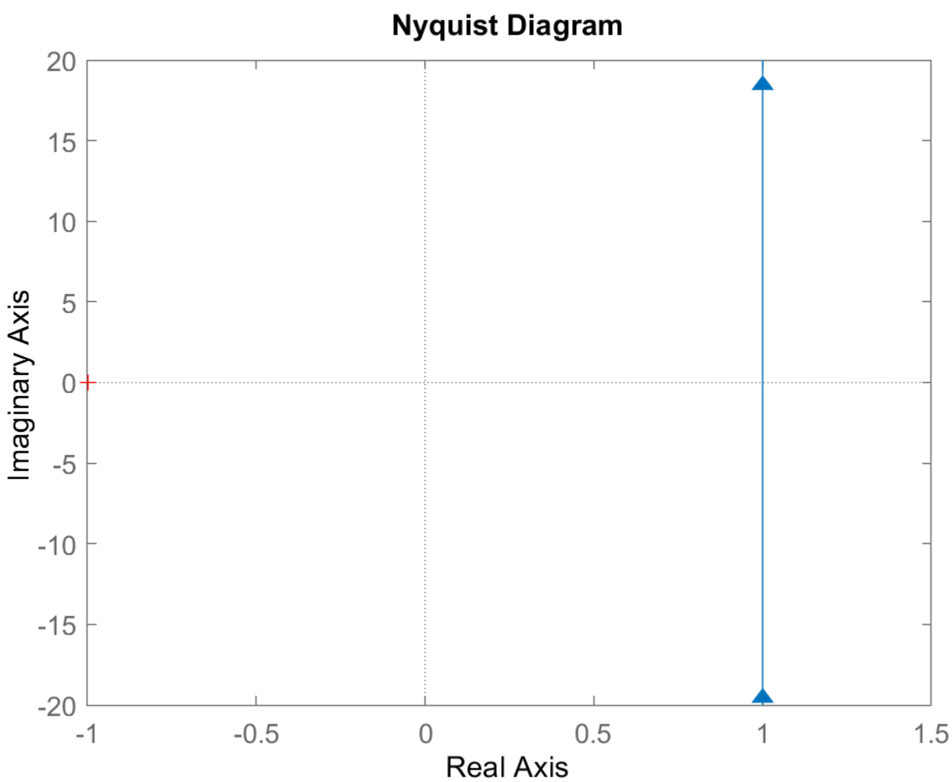
Examine Frequency Response of Zero:

$G(s) = 1 + sd \rightarrow 1 + j\omega d$

```
% Single Zero Frequency Response
d = 1;
G1 = 1 + d*s;
figure, h_g1 = bodeplot(G1,'b');
```




```
figure, nyquist(G1)
```



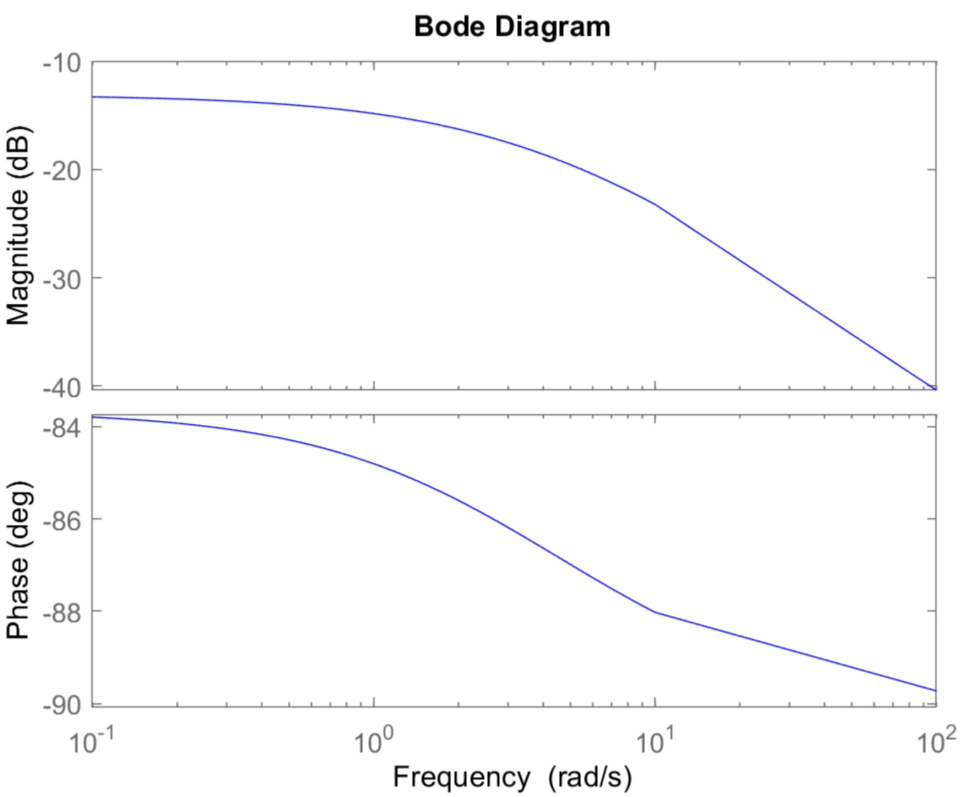
Examine the Frequency Response of Complex Pole:

$$G(s) = \frac{1}{s + a + jb} \rightarrow \frac{1}{a + j(\omega + b)}$$

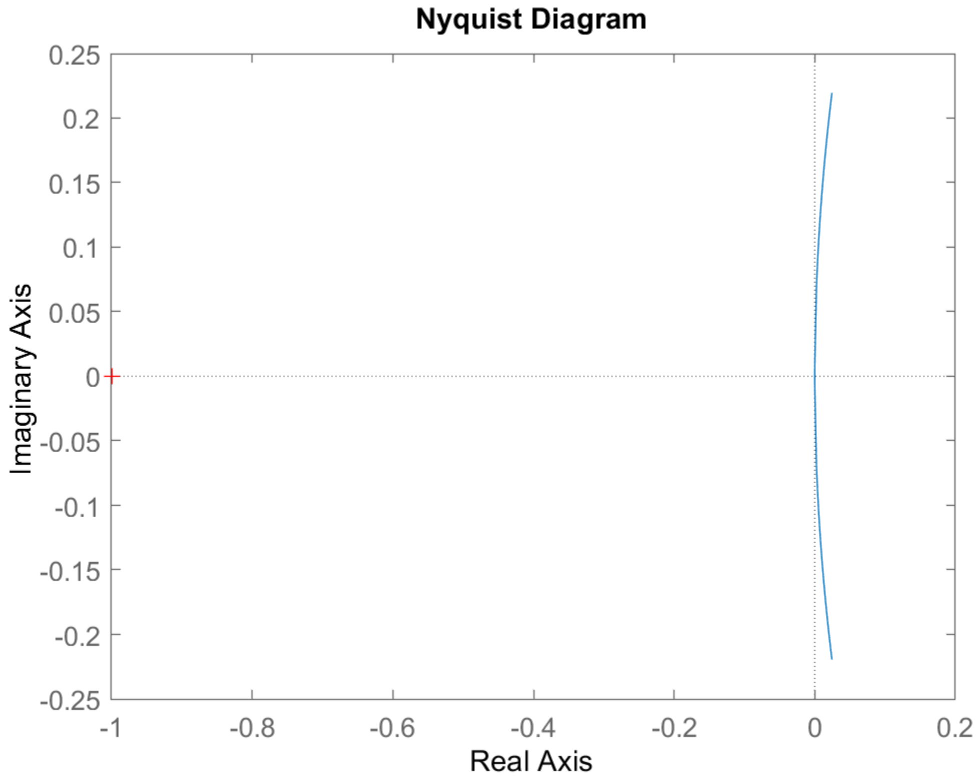
```
% Single Complex Pole Frequency Response
a = 0.5; b = 4.5;
G2 = 1/(s + a + 1i*b)
```

```
G2 =

        1
  -------------
  s + (0.5+4.5i)

Continuous-time transfer function.
```

```
figure, h_g2 = bodeplot(G2,'b');
```




```
figure, nyquist(G2)
```



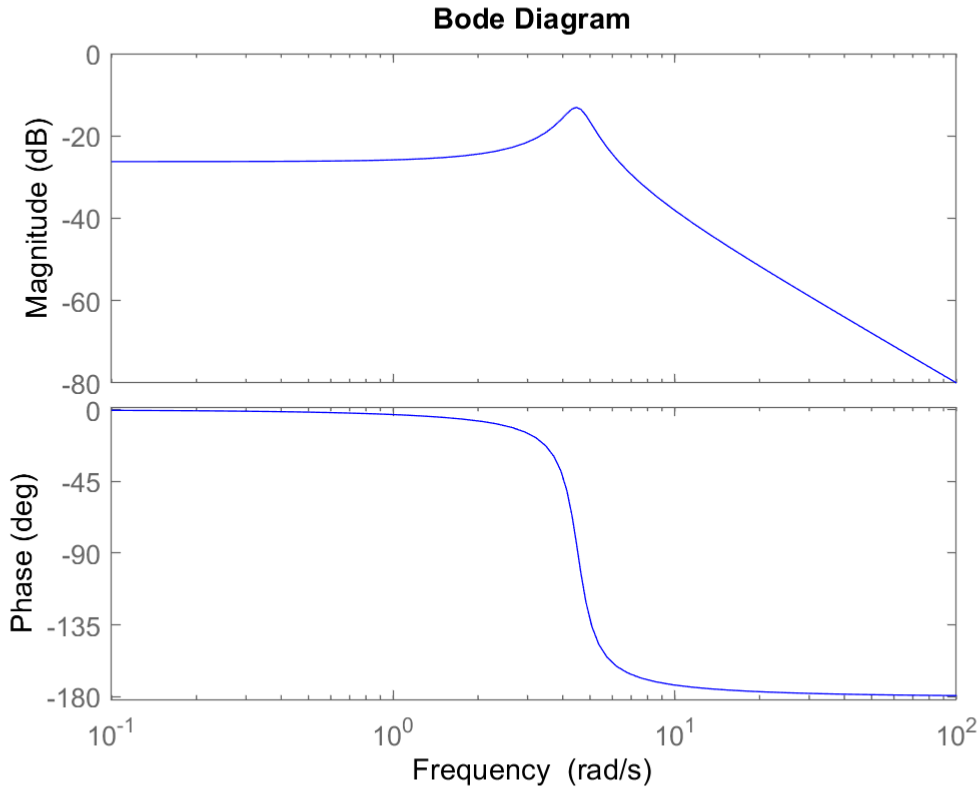
Examine the Frequency Response of Two Complex Poles:

$$G(s) = \frac{1}{s^2 + 2as + a^2 + b^2} \rightarrow \frac{1}{(j\omega)^2 + 2aj\omega + a^2 + b^2)}$$

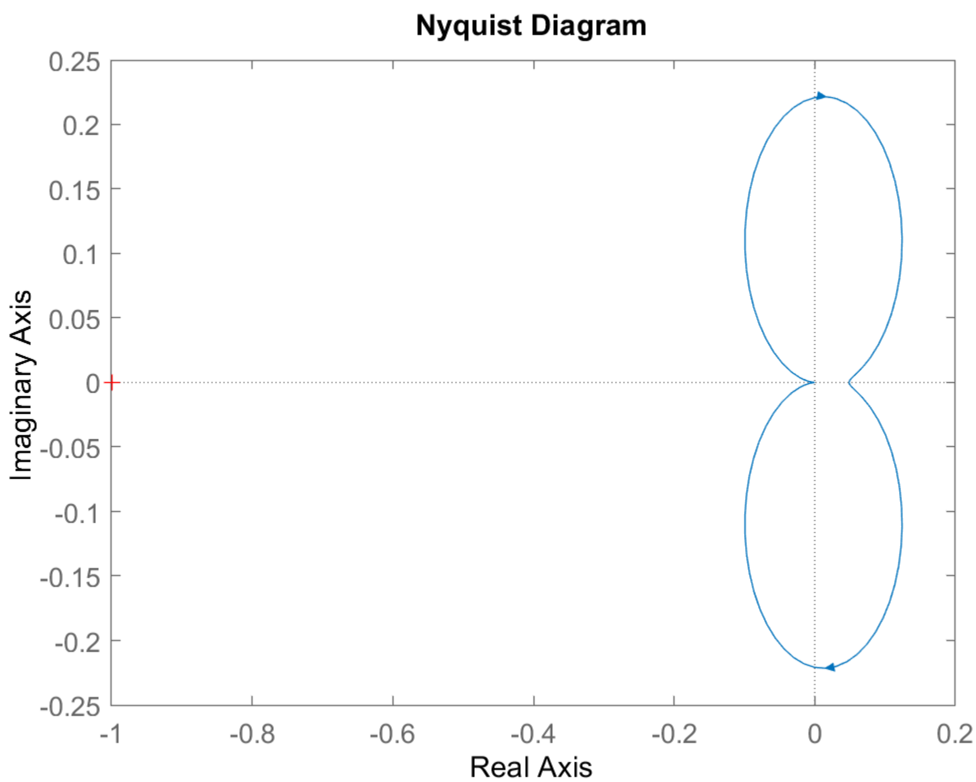
```
% Two Complex Pole Frequency Response
G3 = 1/(s^2 + 2*a*s + a^2 + b^2)
```

```
G3 =

        1
  --------------
  s^2 + s + 20.5

Continuous-time transfer function.
```

```
figure, h_g3 = bodeplot(G3,'b');
```




```
figure, nyquist(G3)
```



Unit Delay

$u(t) \leftrightarrow u(t-T)$

```
s = tf('s');
U = 1/s
```

```
U =

  1
  -
  s

Continuous-time transfer function.
```

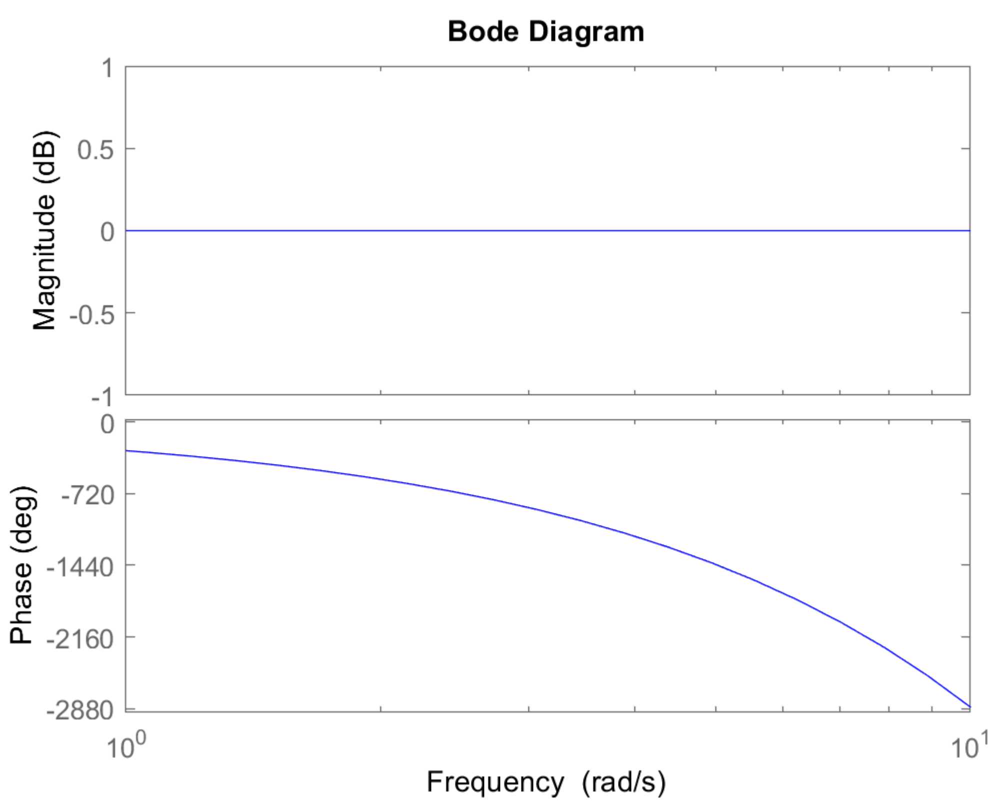
```
T = 5; shift = exp(-s*T)
```

```
shift =

  exp(-5*s) * (1)

Continuous-time transfer function.
```

Taking the Laplace Transform of the Unit Delay, we get:

$L\{u(t-T)\} = e^{-sT}U(s)$

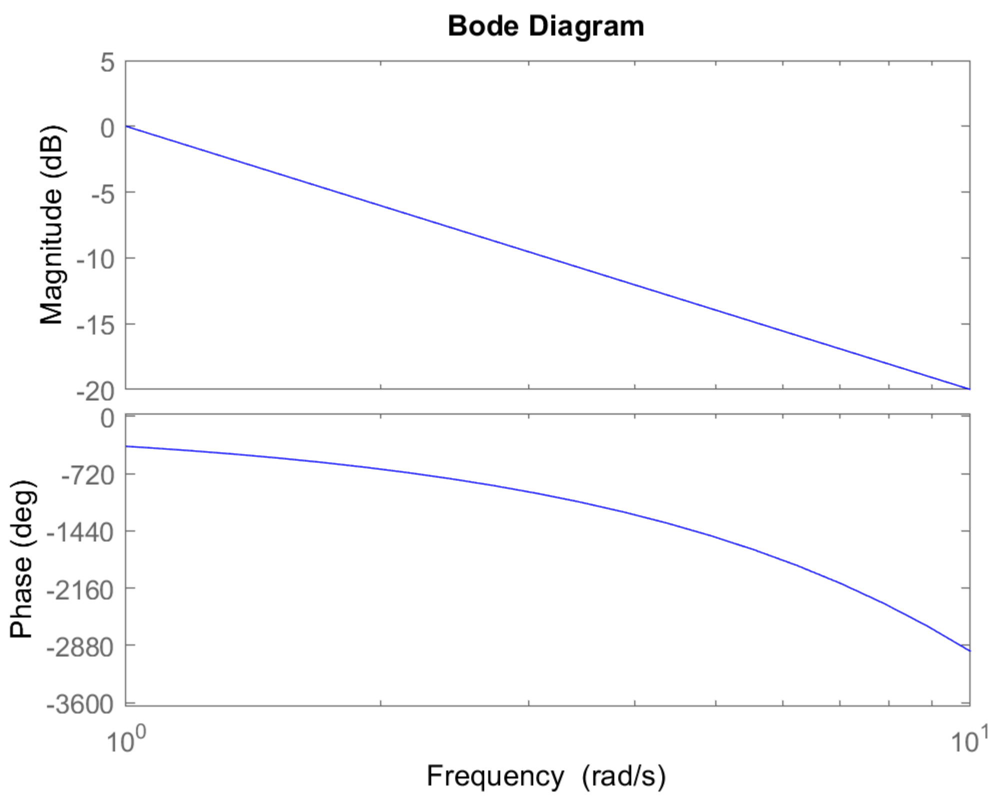
```
figure, h_shift = bodeplot(shift,'b');
```



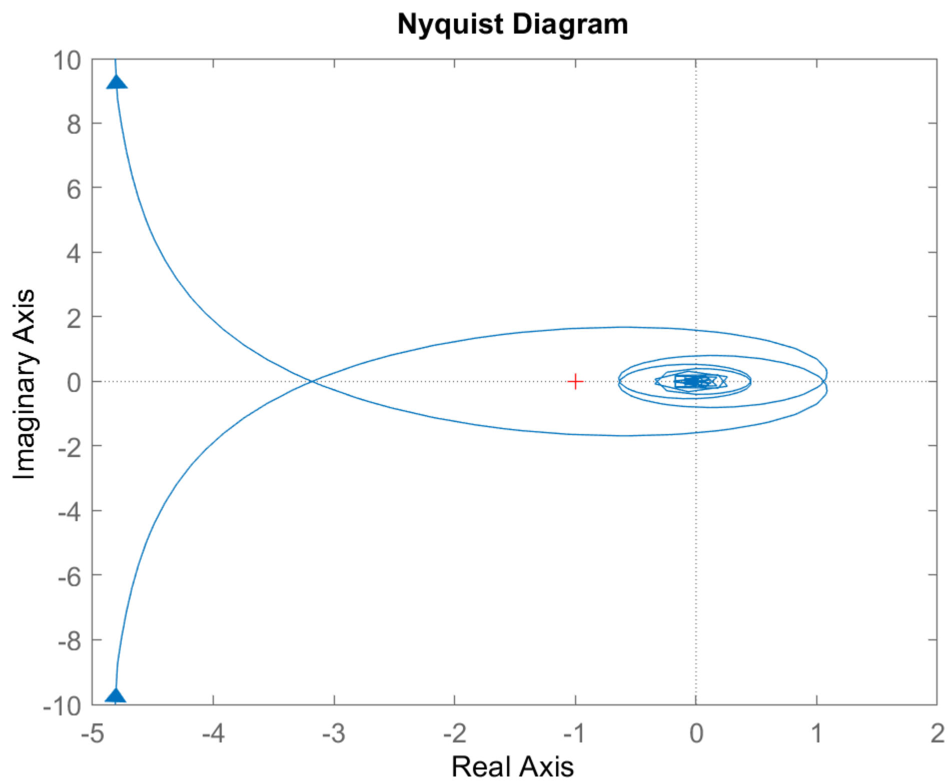

```
Us = U*shift
```

```
Us =

                 1
  exp(-5*s) * -
                 s

Continuous-time transfer function.
```

```
figure, h_U = bodeplot(Us,'b');
```




```
figure, nyquist(Us)
```



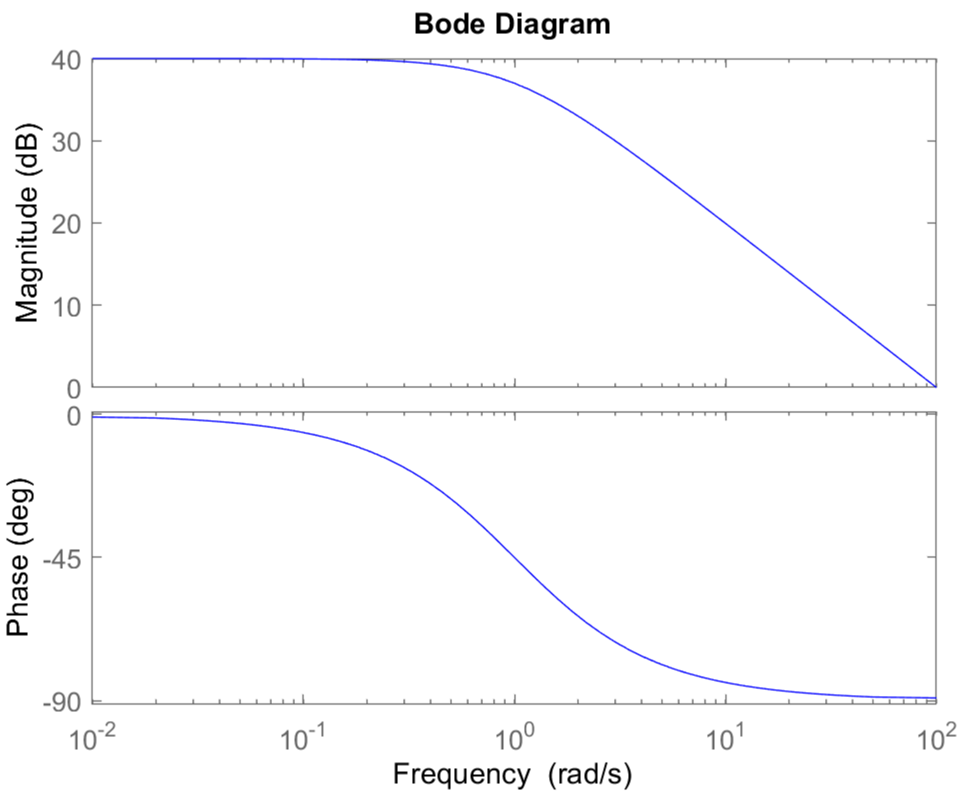
Next we define our next system, $F(s)$ as:

$$F(s) = \frac{k}{1+s}$$

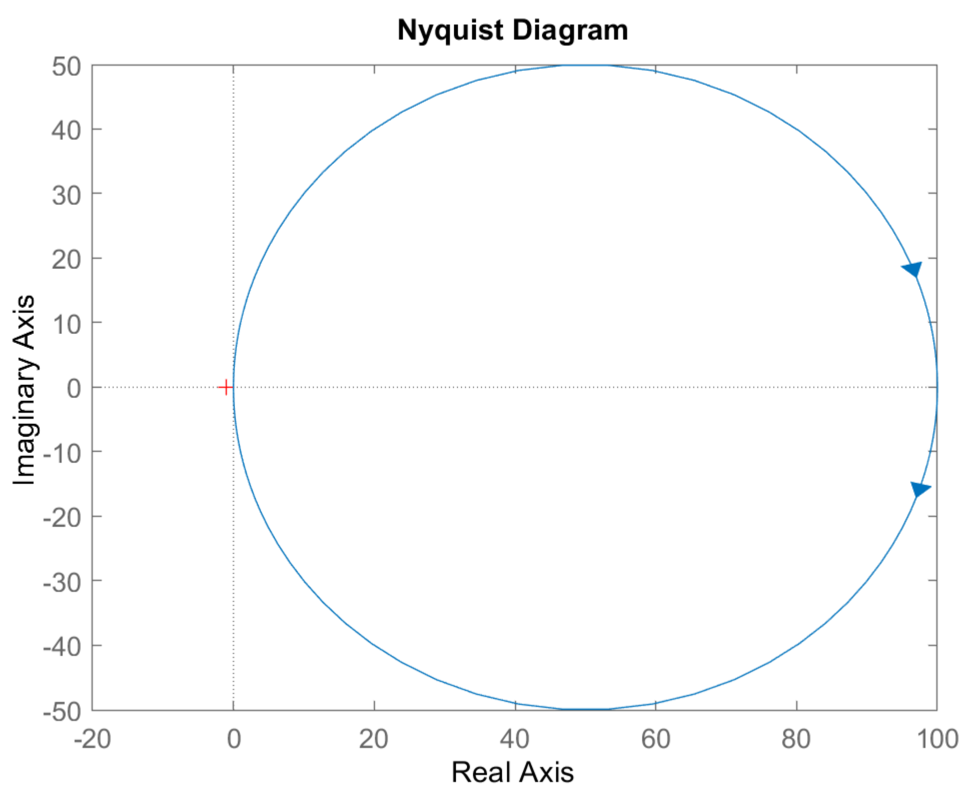
```
k = 100; Fs = k/(1 + s)
```

```
Fs =

   100
  -----
  s + 1

Continuous-time transfer function.
```

```
figure, h_F = bodeplot(Fs,'b');
```




```
figure, nyquist(Fs)
```



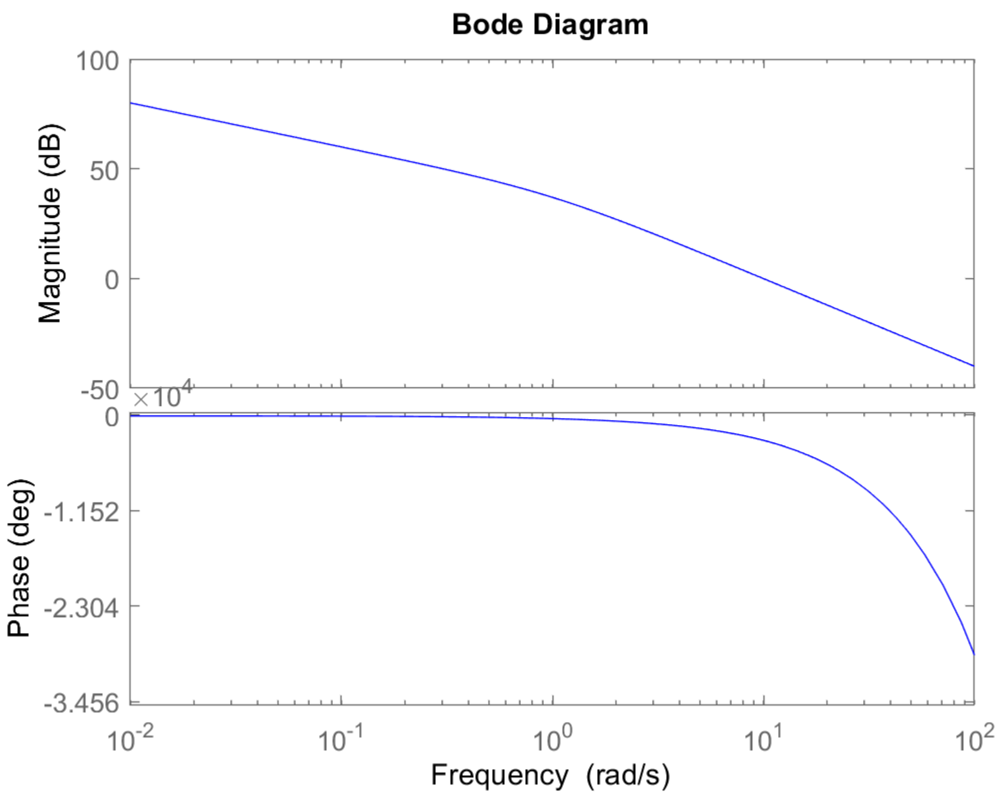
Then the output, $Y(s)$ is the product of $Y(s) = e^{-sT}U(s) * F(s)$

$$Y(s) = \frac{100e^{-5j\omega}}{s^2 + s}$$

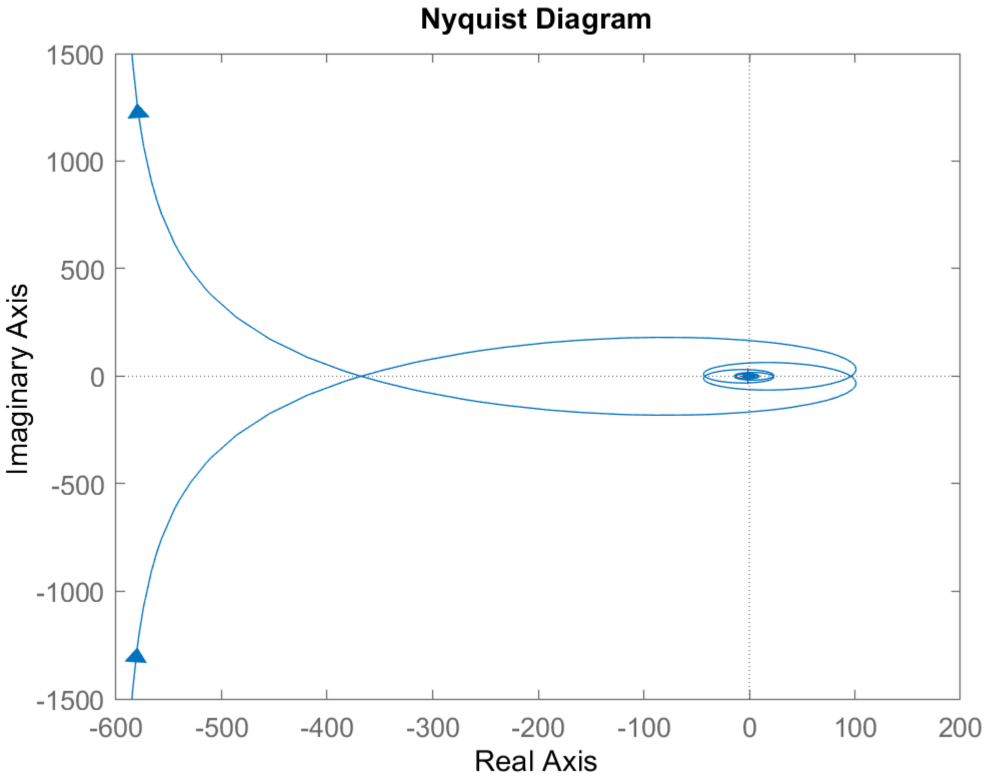
```
Ys = Us*Fs
```

```
Ys =

                100
  exp(-5*s) * -------
              s^2 + s

Continuous-time transfer function.
```

```
figure, h_Ys = bodeplot(Ys,'b');
```




```
figure, nyquist(Ys)
```


Nyquist Diagram
Imaginary Axis
Real Axis
1500
1000
500
0
-500
-1000
-1500
-600
-500
-400
-300
-200
-100
0
100
200