MAE 438
Assignment 5

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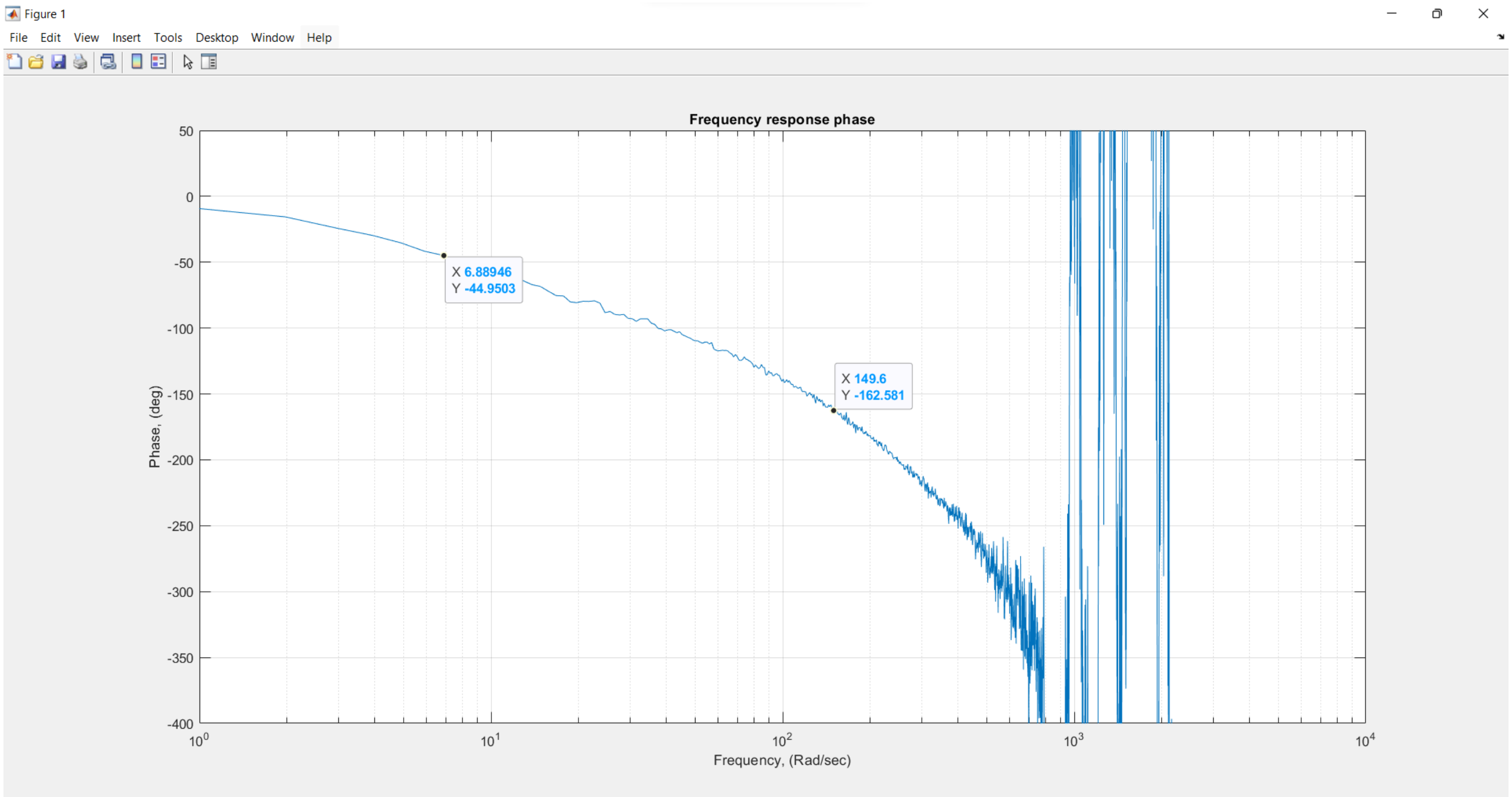
due: 3/17/2022 @ 7:10 pm



Poles: $\omega_n = 7, 150$

From lab, gain found to be Kp = 1.625

Transfer Function: $G(s) = \dfrac{1.625}{(s\text{-}7)(s\text{-}150)}$

$$\frac{G(s)}{s} = \frac{1.625}{s(s\text{-}7)(s\text{-}150)}$$

Hand calculation yields same result as c2d function

$$G(s) = \frac{1.625}{(s-7)(s-150)} = \frac{1.625}{s^2 - 157s + 1050}$$

$$\frac{1.625}{(s-7)(s-150)} = \frac{A}{s-7} + \frac{B}{s-150} = \frac{0.0114}{s-150} - \frac{0.0114}{s-7}$$

$$\frac{1.625}{s(s-7)(s-150)} = \frac{0.0001}{s-150} - \frac{0.0016}{s-7} + \frac{0.0015}{s}$$

$$\mathcal{Z}\left\{\frac{0.0015}{s}\right\} = \frac{0.0015\,z}{z-1} \qquad T = 0.001$$

$$\mathcal{Z}\left\{\frac{0.0001}{s-150}\right\} = \frac{0.0001\,z}{z - e^{10T}} = \frac{0.0001\,z}{z - 1.0101}$$

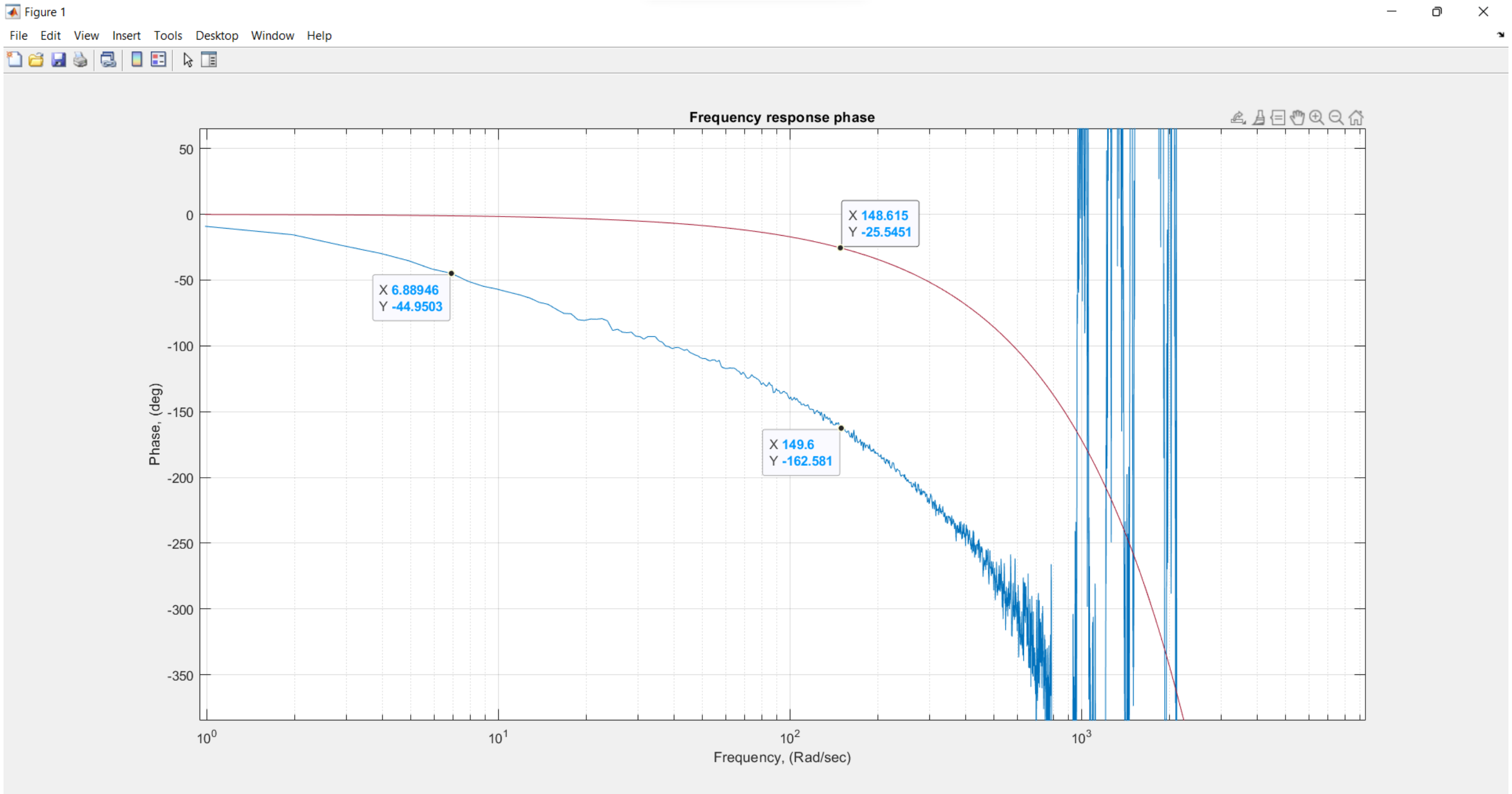
$$\mathcal{Z}\left\{\frac{0.0016}{s-7}\right\} = \frac{0.0016\,z}{z - e^{7T}} = \frac{0.0016\,z}{z - 1.007}$$

$$\therefore \mathcal{Z}\left\{\frac{G(s)}{s}\right\} = \frac{0.0001\,z}{z-1.0101} - \frac{0.0016\,z}{z-1.007} + \frac{0.0015\,z}{z-1}$$

$$= \frac{(0.0001z)(z-1.007)(z-1) - (0.0016z)(z-1.0101)(z-1) + (0.0015z)(z-1.0101)(z-1.007)}{(z-1.0101)(z-1.007)(z-1)}$$

$$= \frac{(8.5667 \times 10^{-7})(z+1.054)}{(z-1.007)(z-1.162)}$$

```
g =

      1.625
  -------------
  (s-7) (s-150)

Continuous-time zero/pole/gain model.

>> gz = c2d(g,0.001,'zoh')

gz =

  8.5667e-07 (z+1.054)
  --------------------
  (z-1.007) (z-1.162)

Sample time: 0.001 seconds
Discrete-time zero/pole/gain model.
```



Plotted line corresponds to command >> semilogx(f,-f*3/Fs*360/2/pi)

$$-162.581 + 25.5451 = -137.0359 \approx -135$$

Therefore, the right number of time delays is 3

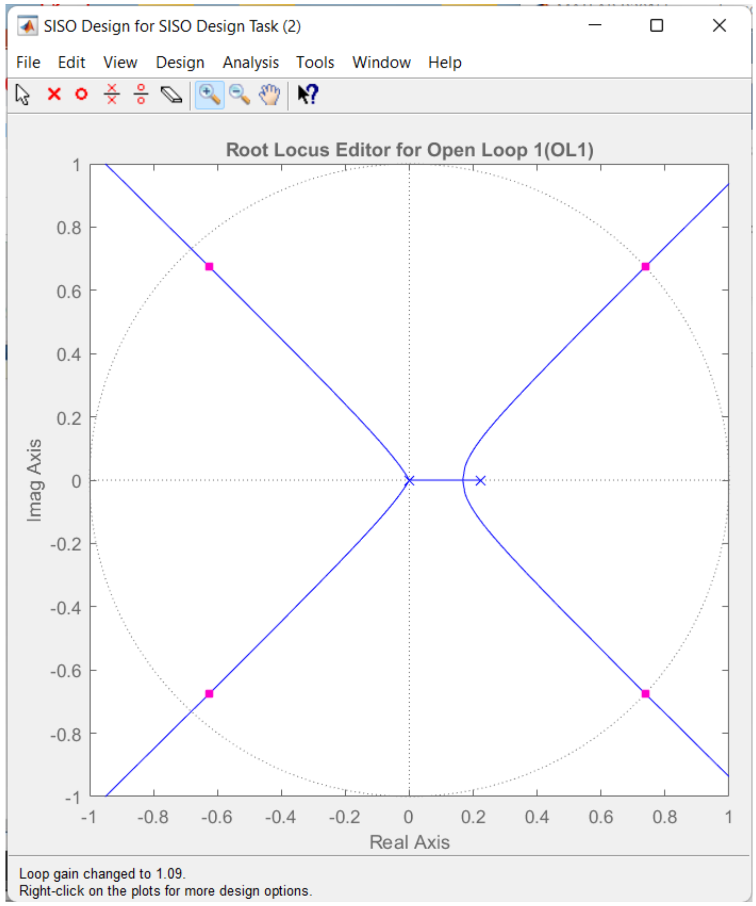
N = 3

```
>> gd = tf(1.625,conv([1 -7],[1 -150]),'inputdelay',0.03)

gd =

                         1.625
  exp(-0.03*s) * ------------------
                 s^2 - 157 s + 1050

Continuous-time transfer function.
```

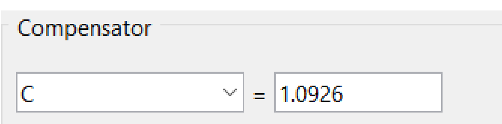
```
>> gzd = c2d(gd,0.001,'zoh')

gzd =

            8.567e-07 z + 9.027e-07
  z^(-30) * -----------------------
              z^2 - 2.169 z + 1.17

Sample time: 0.001 seconds
Discrete-time transfer function.
```

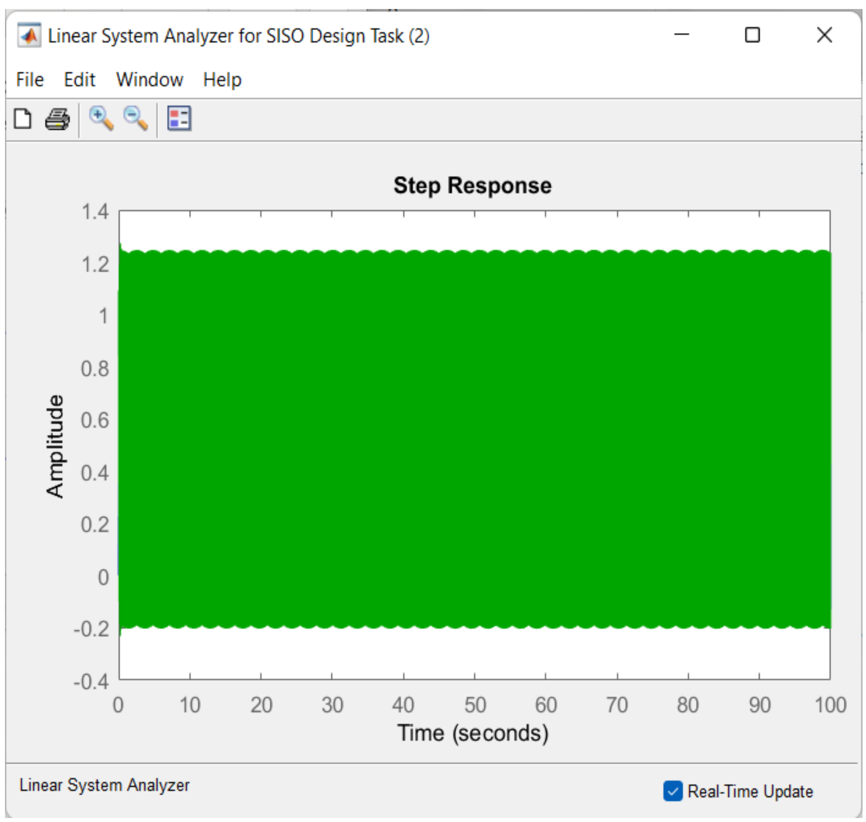
Using the sisotool command:

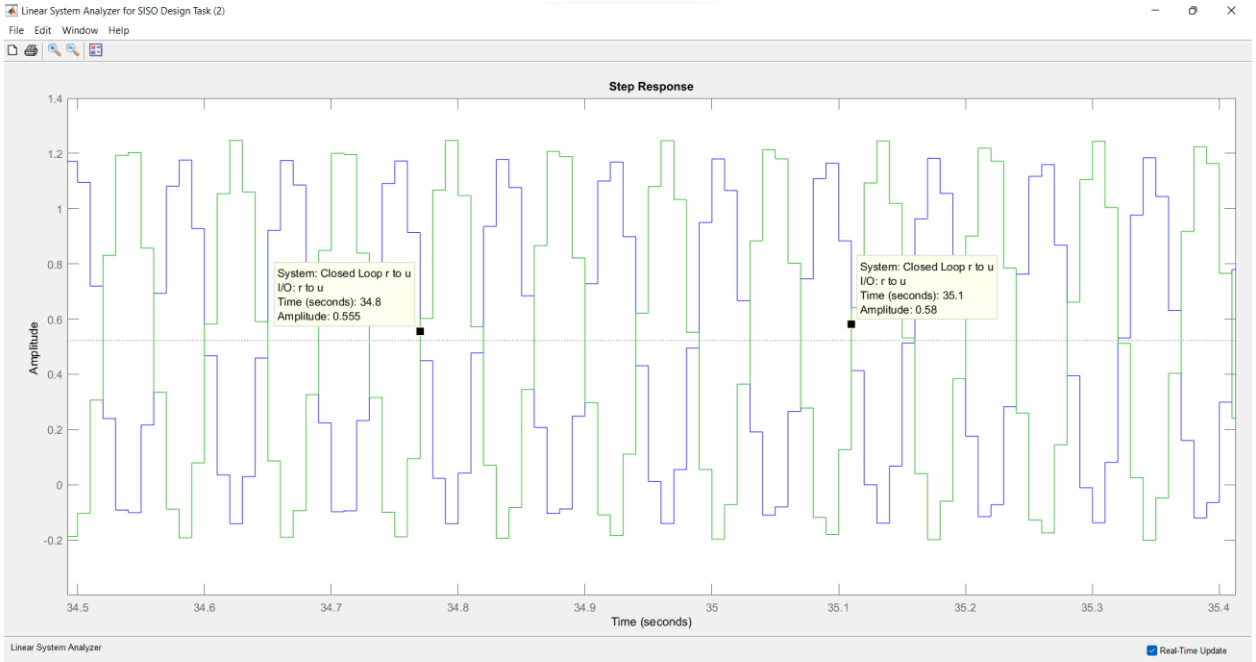
```
>> gzd = c2d(gd,0.01,'zoh')

gzd =

             0.7769
  z^(-3) * ----------
           z - 0.2231

Sample time: 0.01 seconds
Discrete-time transfer function.

>> sisotool('rlocus',gzd)
>> gd

gd =

                  150
  exp(-0.03*s) * -------
                 s + 150

Continuous-time transfer function.
```



Loop gain is 1.0926







Time between waves = (35.1-34.8)/5 = 0.0600

Therefore, this is the frequency of the system, or ultimate period P_u

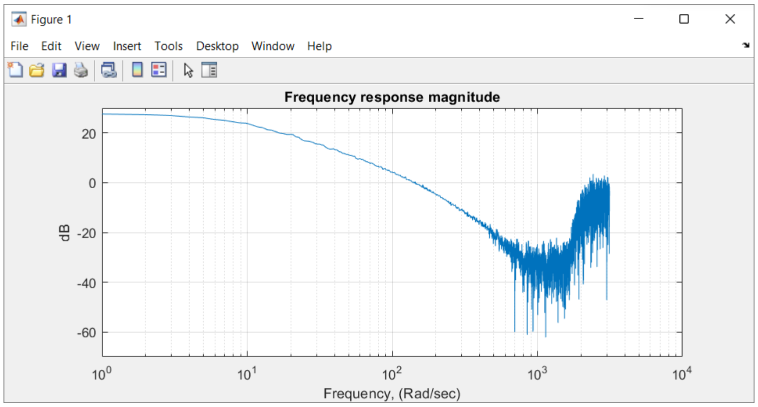


Figure 1
File Edit View Insert Tools Desktop Window Help
Frequency response magnitude
20
0
-20
-40
-60
dB
10^0
10^1
10^2
10^3
10^4
Frequency, (Rad/sec)

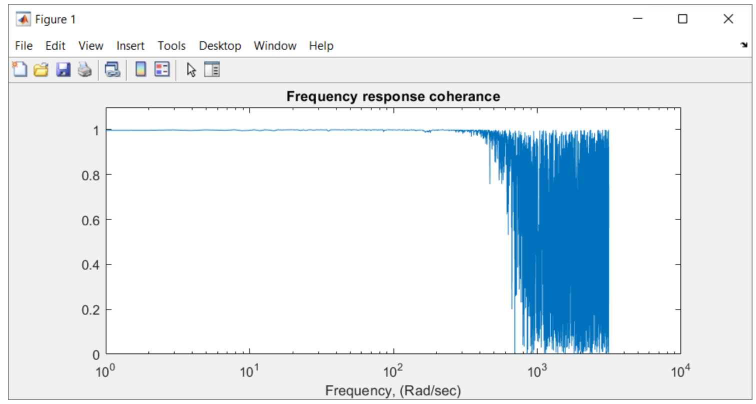


Figure 1
File Edit View Insert Tools Desktop Window Help
Frequency response coherance
1
0.8
0.6
0.4
0.2
0
10^0
10^1
10^2
10^3
10^4
Frequency, (Rad/sec)

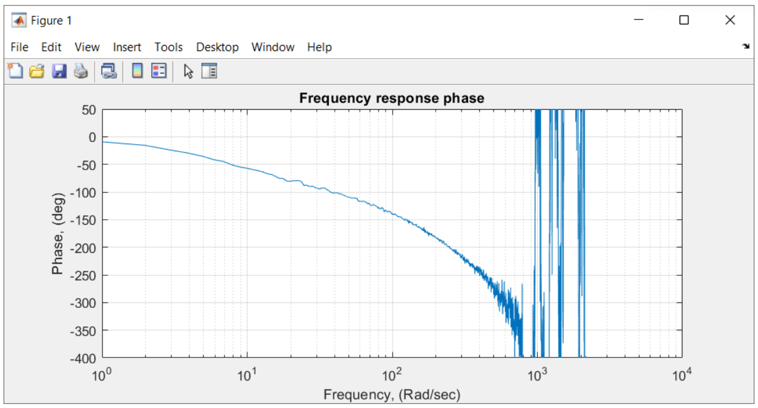


Figure 1
File Edit View Insert Tools Desktop Window Help
Frequency response phase
50
0
-50
-100
-150
-200
-250
-300
-350
-400
Phase, (deg)
10^0
10^1
10^2
10^3
10^4
Frequency, (Rad/sec)

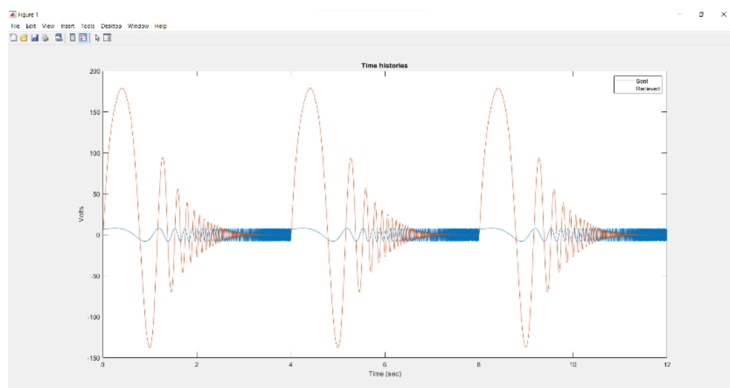


Figure 1
File Edit View Insert Tools Desktop Window Help
Time histories
Sent
Recieved
200
150
100
50
0
-50
-100
-150
Volts
0
2
4
6
8
10
12
Time (sec)