EE132 Automatic Control

Lab 3: Transient Spcs & Dominant Poles (Phase Locked Loop)

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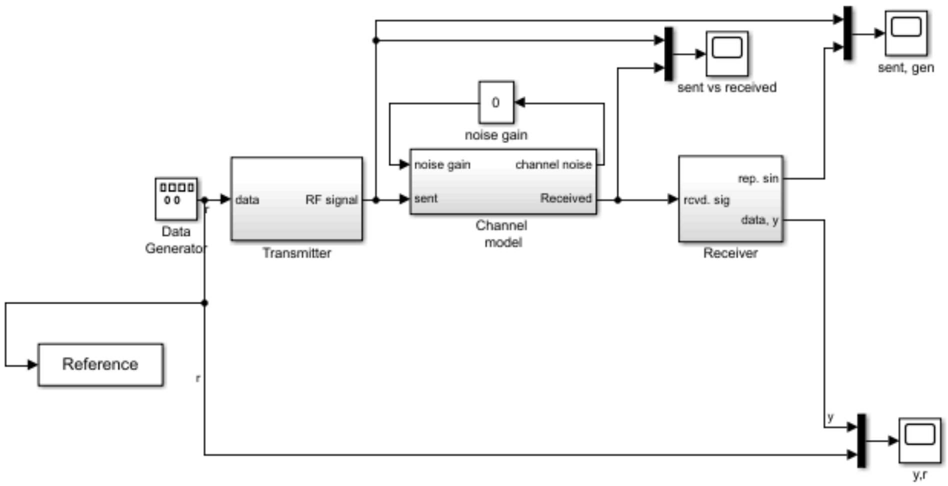
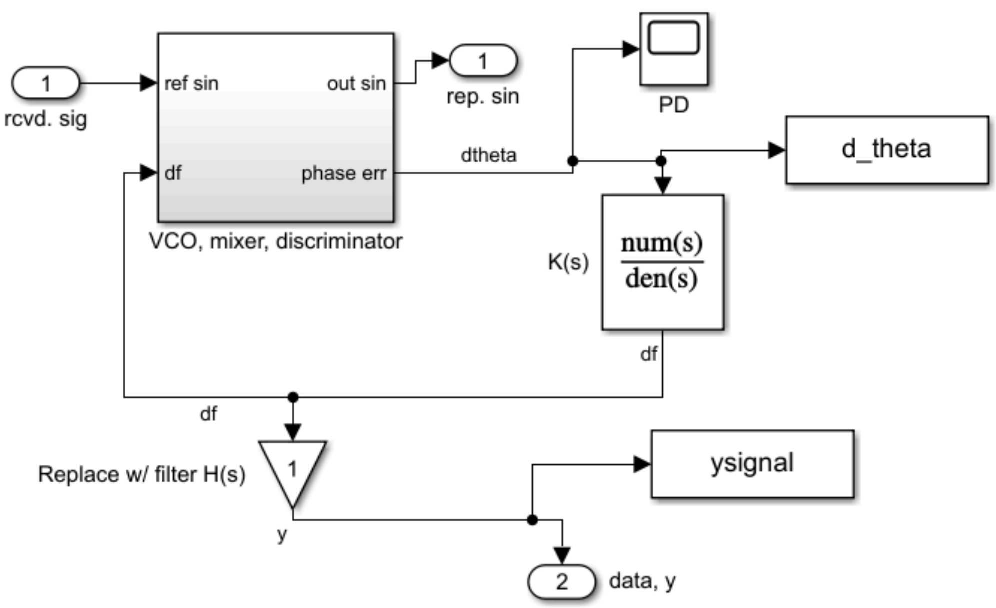
Block Diagrams:



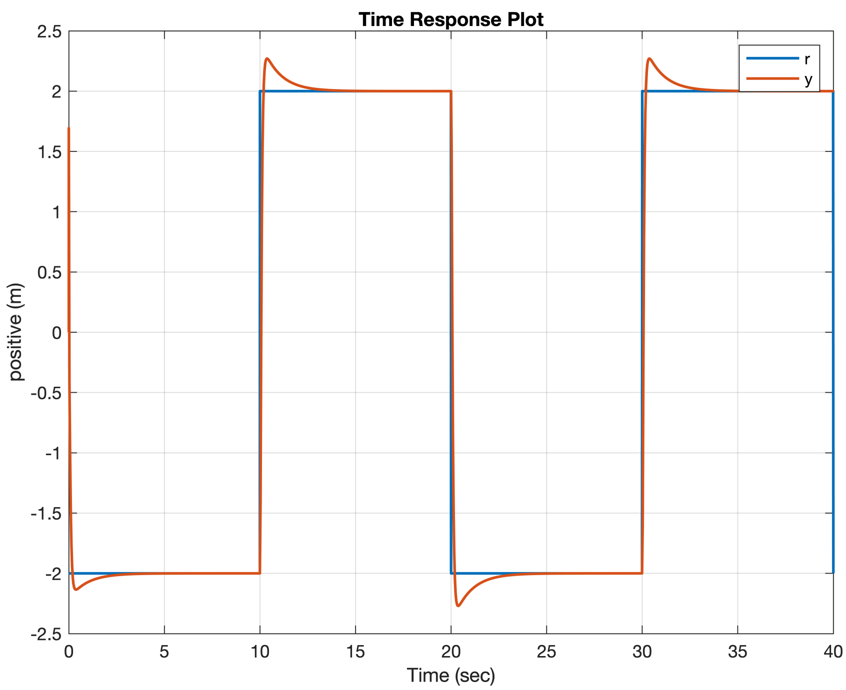


Part 1 (a, b, &c)

```
t = d_theta.time;
```

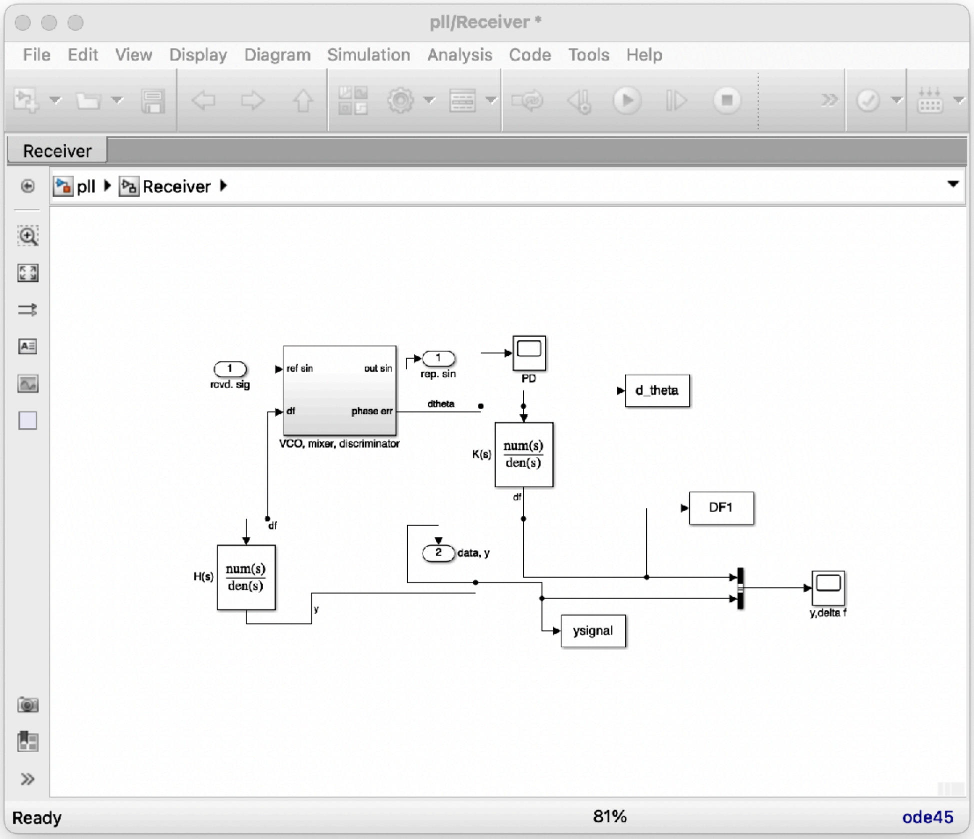
```
t = reference.time;
t = ysignal.time;
r = reference.signals.values(:,1);
y = ysignal.signals.values(:,1);

figure(1)
plot(t,r,'LineWidth',1.5)
hold on
plot(t,y, 'LineWidth', 1.5)
hold on
grid on
xlabel('Time (sec)')
ylabel('positive (m)')
title('Time Response Plot')
legend('r', 'y')
```



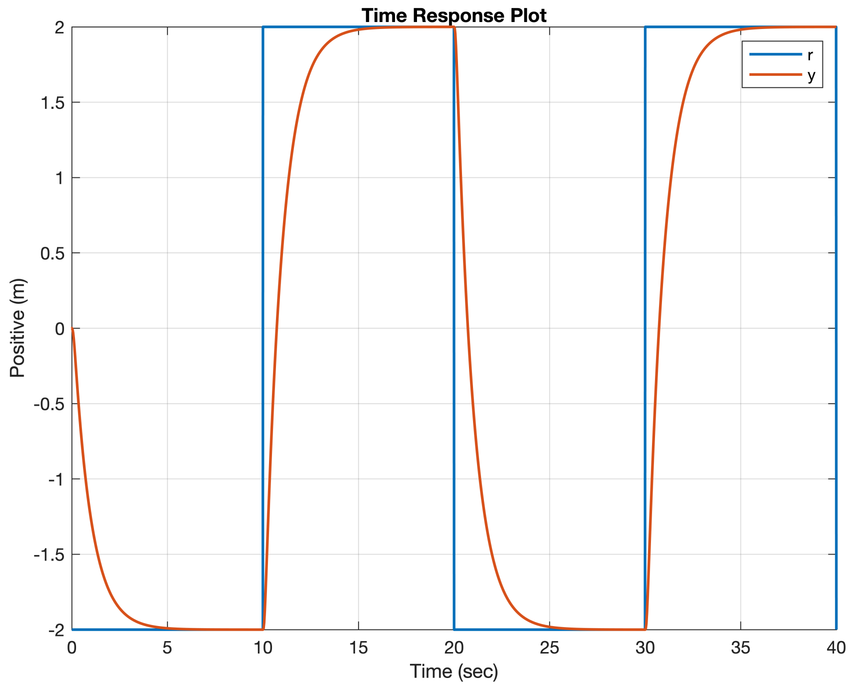
From the graph we can see that y(t) does infact track and converges with r(t).

Part 1 d) plot r and y



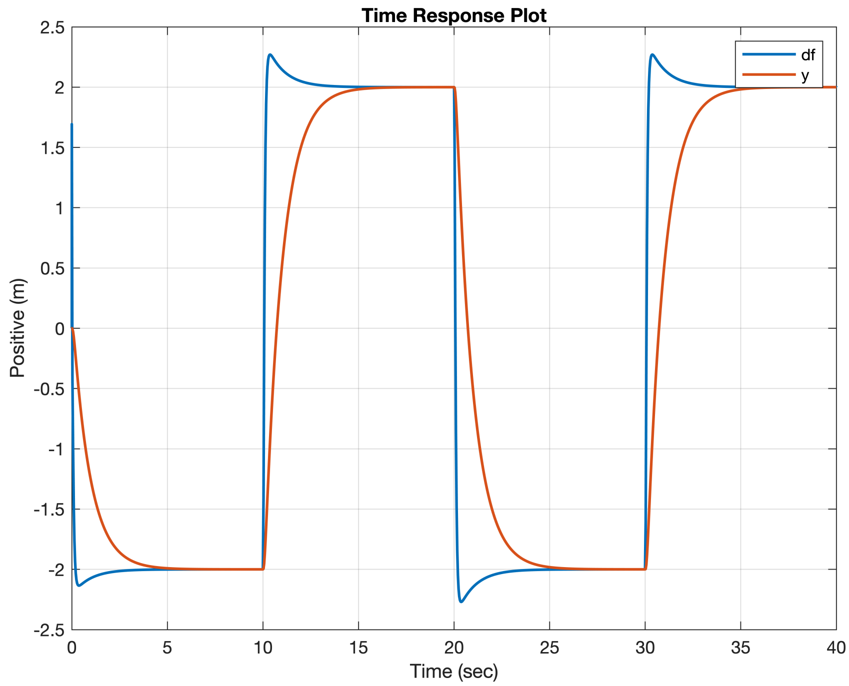

```
close all
t = d_theta.time;
df = DF1.signals.values(:,1);
r = reference.signals.values(:,1);
y = ysignal.signals.values(:,1);

figure(1)
plot(t,r,'LineWidth',1.5)
hold on
plot(t,y,'LineWidth', 1.5)
hold on
grid on
xlabel('Time (sec)')
ylabel('Positive (m)')
title('Time Response Plot')
legend('r', 'y')
```



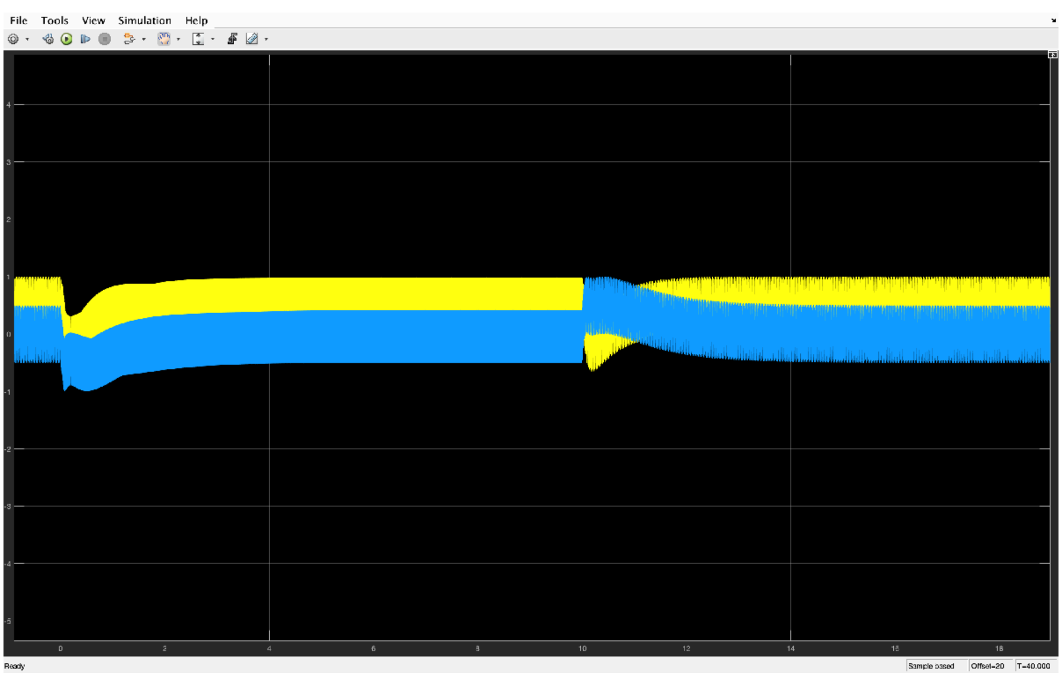
From this graph we can see that the reference and output plots are close to one another.

```
figure(2)
plot(t, df,'LineWidth',1.5)
hold on
plot(t,y,'LineWidth',1.5)
hold on
grid on
xlabel('Time (sec)')
ylabel('Positive (m)')
title('Time Response Plot');
legend ('df', 'y')
```



From this graph we can see a degradation in the closeness with which the reference input tracks the output signal. They do converge later in time.

Part 2 a)

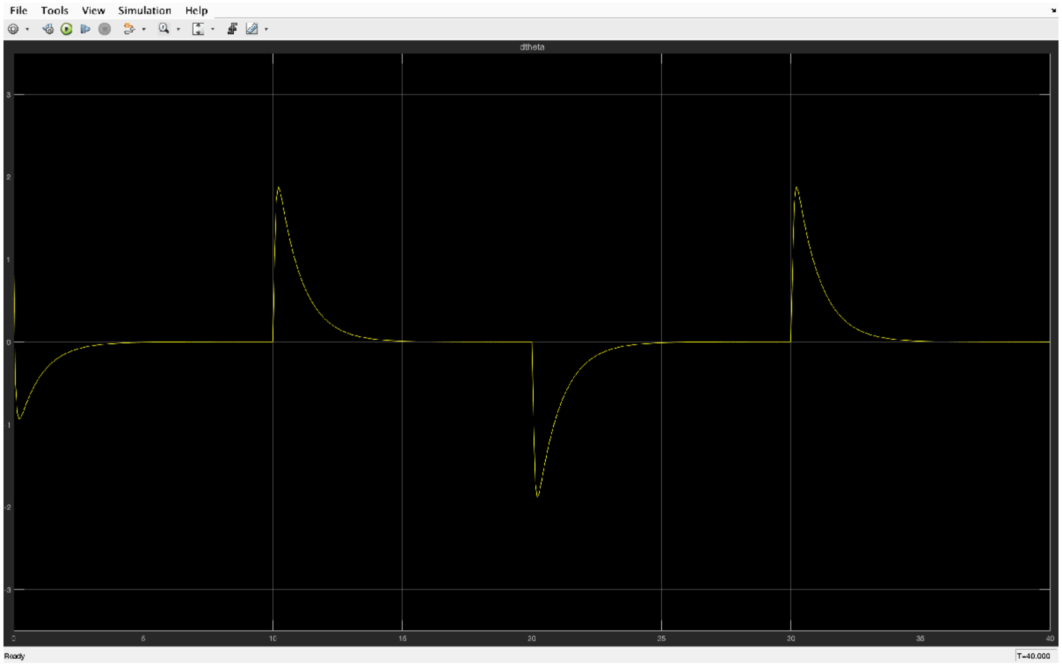


i. Yes, we observed a signal with the characteristics described. Both signals have high and low frequencies. The large value of omega c is because of the high frequencies At some time in the future, the graphs converge.

ii. I-pole: -100

Q-pole: -100

iii.

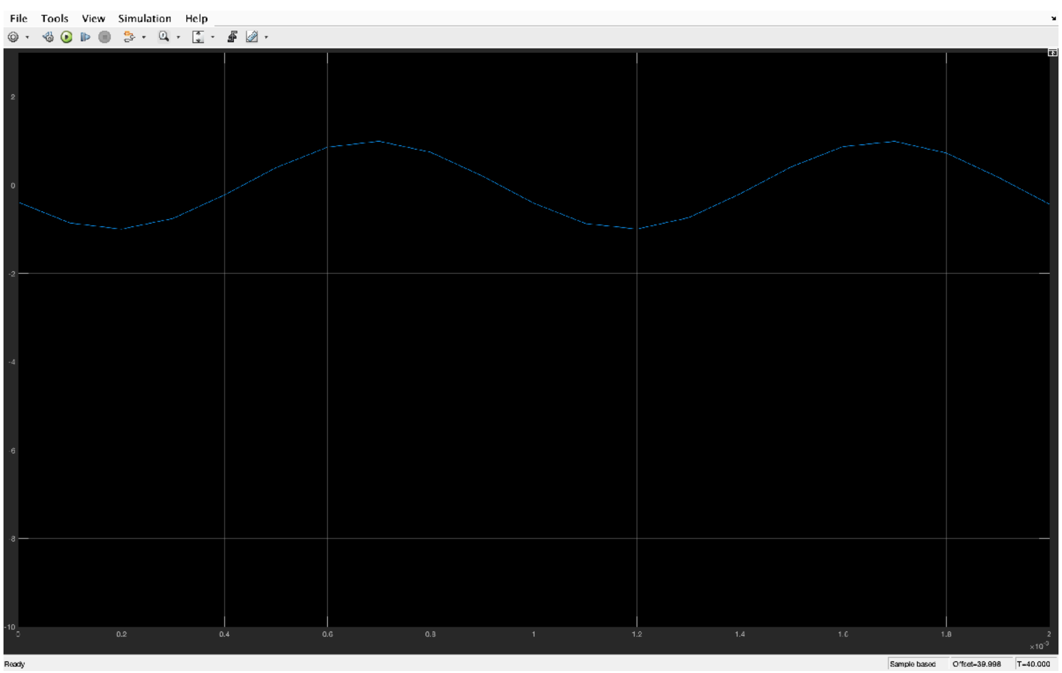


D_theta is converging to zero.

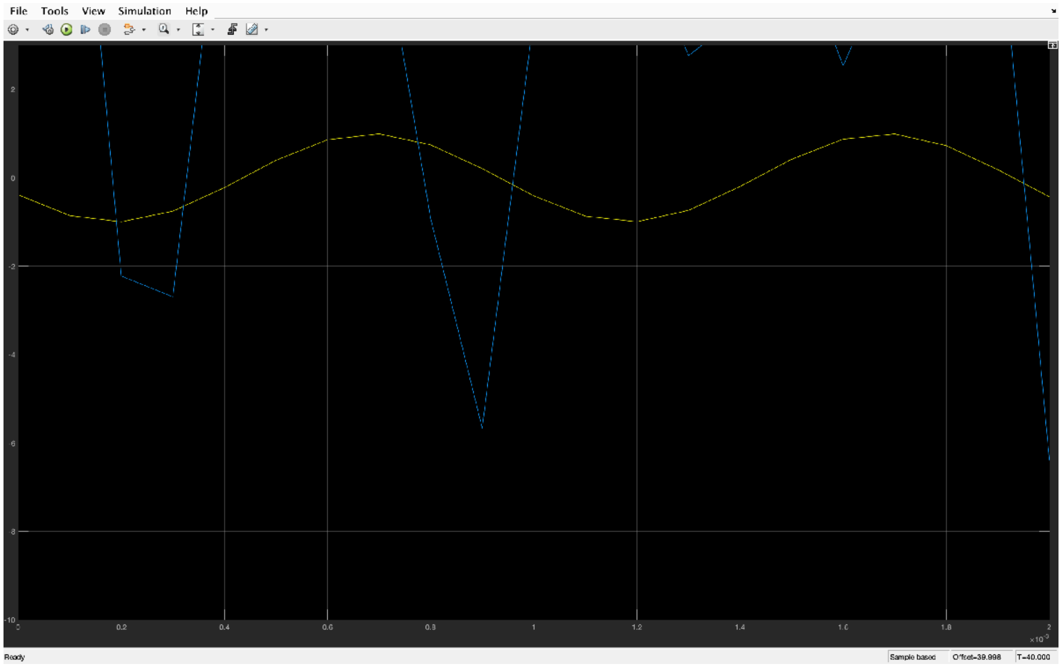
2b)

No phase lock is achieved for two reasons: the poles of the system are at 0 making the system unstable; the two signals have delays

Part 3



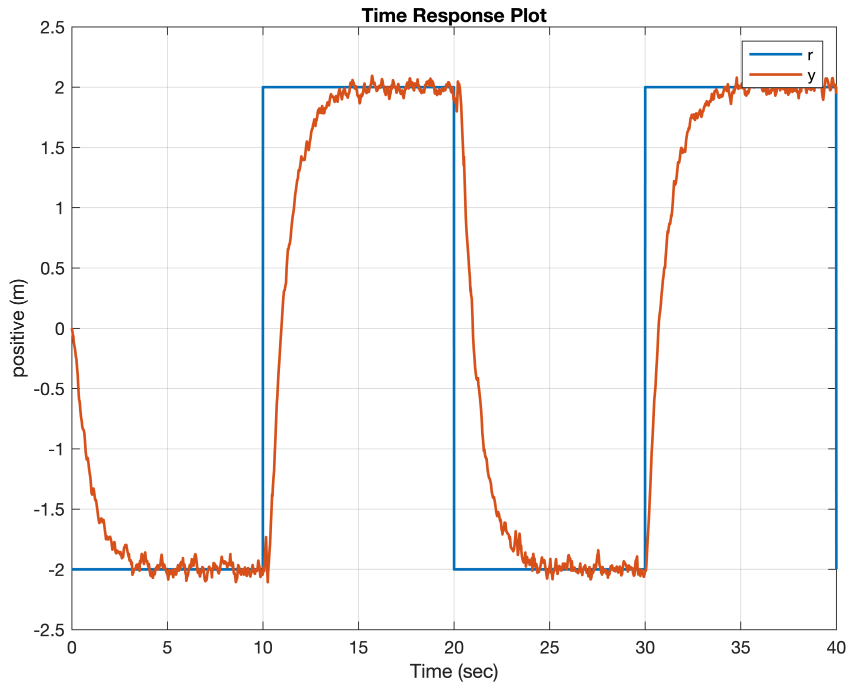
Yes, the scope does contain the original sinusodial signal in yellow




```
close all
t = d_theta.time;
df = DF1.signals.values(:,1);
r = reference.signals.values(:,1);
y = ysignal.signals.valu
```

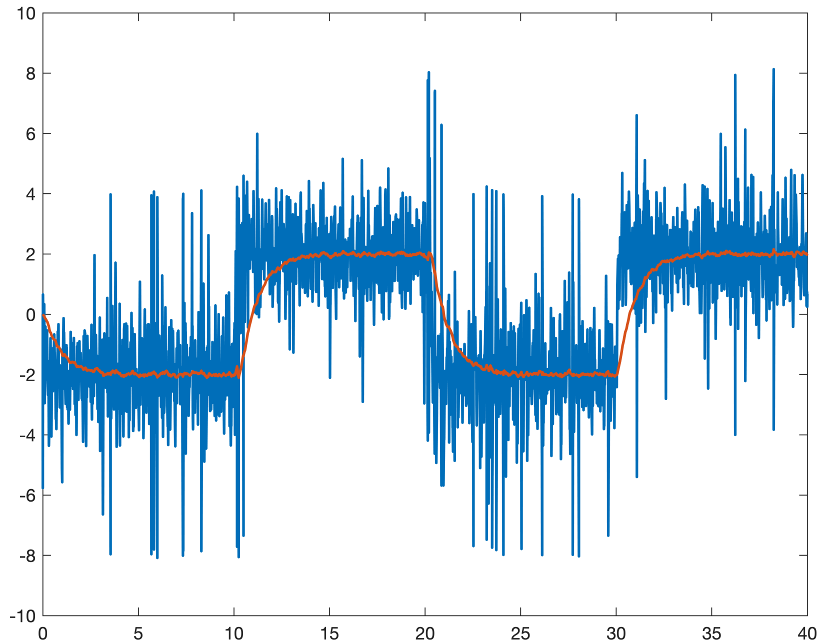
```
es(:,1);

figure(1)
plot(t,r,'LineWidth',1.5)
hold on
plot(t,y, 'LineWidth', 1.5)
hold on
grid on
xlabel('Time (sec)')
ylabel('positive (m)')
title('Time Response Plot')
legend('r', 'y')
```

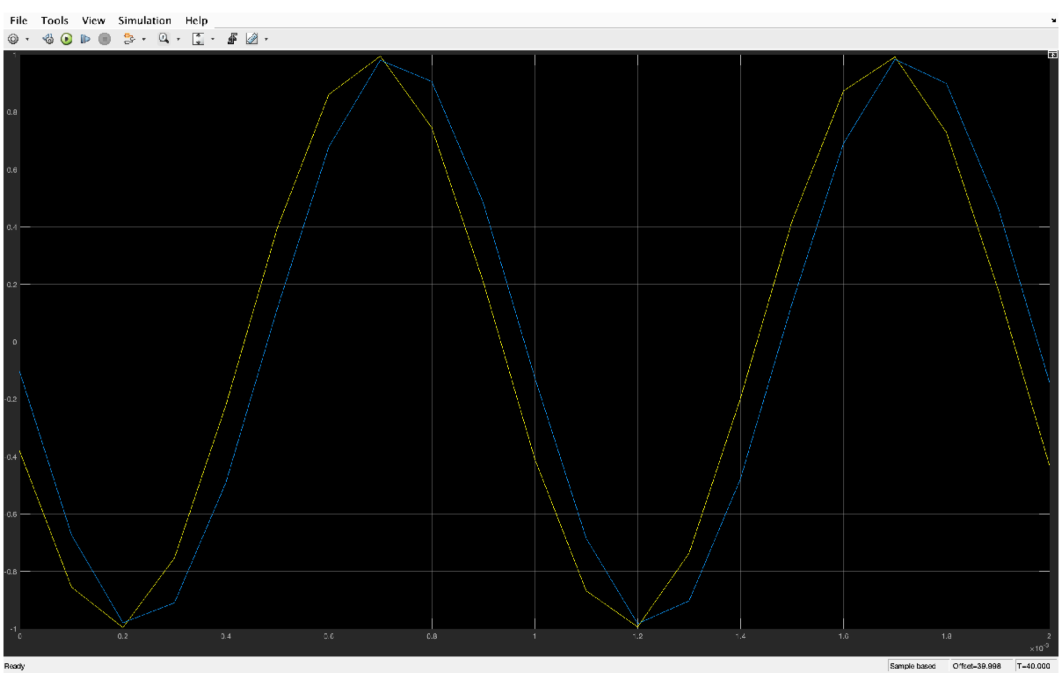


Even with high noise, our output signal still closely tracks our reference signal.

```
figure(2)
plot(t,df,'LineWidth',1.5)
hold on
plot(t,y,'LineWidth',1.5)
hold on
```



In this graph we can see the purpose of using a PL controller. Our reference signal is very noisey, however, our output signal is somewhat being tracked. From this graph we can see why we should use a phase-locked configuration.



The maxes and mins of the reference signal match those of the output signal.

5) 24:24

Nicolas Andrade

Lab 3 Prelab

1) $T_p = \pi = \pi/\omega_d \quad \boxed{\therefore \omega_d = 1} \qquad M_p = 5\% = e^{-\zeta\pi/\sqrt{1-\zeta^2}}$

$T_s = 4.6/\zeta\omega_n \qquad T_r = 1.8/\omega_n \qquad \omega_n = \omega_d/\sqrt{1-\zeta^2}$

$s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$

$0.05 = e^{-\zeta\pi/\sqrt{1-\zeta^2}} \qquad \ln(0.05) = \frac{-\zeta\pi}{\sqrt{1-\zeta^2}} \qquad -\zeta\pi = \ln(0.05)\sqrt{1-\zeta^2}$

$\sqrt{1-\zeta^2} = \frac{-\zeta\pi}{\ln(.05)} \qquad \boxed{\zeta = 0.69}$

2) $\omega_n = \omega_d/\sqrt{1-\zeta^2} = 1/\sqrt{1-(.69)^2} = 1.381$

$T_s = 4.6/\zeta\omega_n = 4.6/(.69)(1.38) = 4.83$

$T_r = 1.8/\omega_n = 1.8/1.38 = 1.304$

3) $G(s) = \frac{\delta f(s)}{R(s)}$

$\Phi_r(s) = R(s)\frac{1}{s}$

$\Phi(s) = \delta f(s)\frac{1}{s}$

$\delta\theta(s) = \Phi_r(s) - \Phi(s)$

$= R(s)\frac{1}{s} - \delta f(s)\frac{1}{s}$

$\delta f(s) = K(s) * \delta\theta(s)$

$\Rightarrow G(s) = \frac{\delta\theta(s)\,K(s)}{s\,\delta\theta(s) + \delta\theta(s)\,K(s)} = \frac{K(s)}{s + K(s)}$ ✓

4) $T(s) = Y(s)/R(s)$

$= \frac{H(s)\,\delta f(s)}{[s+K(s)]\,\delta\theta(s)}$

$= \frac{H(s)\,K(s)\,\cancel{\delta\theta(s)}}{[s+K(s)]\,\cancel{\delta\theta(s)}}$

$= H(s)\,G(s)$

$= T(s)$ ✓

Nick

5) Assuming $K(s) = P_1 + P_2/s$, derive $G(s) = \frac{P_1 s + P_2}{s^2 + P_1 s + P_2}$

$$G(s) = \frac{K(s)}{s+K(s)} = \frac{P_1 + \frac{P_2}{s}}{P_1 + \frac{P_2}{s} + s} \begin{matrix} *s \\ *s \end{matrix} = \frac{P_1 s + P_2}{s^2 + P_1 s + P_2}$$

where P_1 = proportional gain & P_2 = integral gain

6) Let $H(s) = \frac{P_2}{P_1 s + P_2}$, derive $T(s) = \frac{P_2}{s^2 + P_1 s + P_2}$

$$T(s) = H(s)G(s) = \frac{P_2}{\cancel{P_1 s + P_2}} * \frac{\cancel{P_1 s + P_2}}{s^2 + P_1 s + P_2} = \frac{P_2}{s^2 + P_1 s + P_2}$$

7) $s^2 + P_1 s + P_2 = 0$

$s^2 + 2\zeta\omega_n s + \omega_n^2$

$\therefore P_1 = 2\zeta\omega_n = 2(.69)(1.38) = 1.9044$

$P_2 = \omega_n^2 = 1.9044$

Christopher Hwang

Pre-lab 3

1) $T_p = \pi$ sec

$M_p = 5\%$ or 0.05

$T_p = \frac{\pi}{\omega_d}$

$\pi = \frac{\pi}{\omega_d}$

$\boxed{\omega_d = 1}$

$M_p = e^{-\frac{\delta\pi}{\sqrt{1-\delta^2}}}$

$0.05 = e^{-\frac{\delta\pi}{\sqrt{1-\delta^2}}}$

$\ln(0.05) = -\frac{\delta\pi}{\sqrt{1-\delta^2}}$

$\sqrt{1-\delta^2} = \frac{-\delta\pi}{\ln(0.05)}$

$\sqrt{1-\delta^2} = \delta(1.049)$

$1-\delta^2 = \delta^2(1.0997)$

$1 = \delta^2(2.0997)$

$\delta^2 = 0.4762$

$\boxed{\delta = 0.690}$

2) $\omega_n = \frac{\omega_d}{\sqrt{1-\delta^2}}$

$= \frac{1}{\sqrt{1-(0.690)^2}}$

$\boxed{\omega_n = 1.381}$

$T_s = \frac{4.6}{\delta\omega_n}$

$= \frac{4.6}{(0.690)(1.909)}$

$\boxed{T_s = 4.824 \text{ sec}}$

$T_r = \frac{1.8}{\omega_n}$

$= \frac{1.8}{1.381}$

$\boxed{T_r = 1.302 \text{ sec}}$

Christopher Hwang

3) $G(s) = \dfrac{\delta f(s)}{R(s)}$

$\phi_r(s) = R(s) \cdot \dfrac{1}{s}$

$\phi(s) = \delta f(s) \cdot \dfrac{1}{s}$

$\delta\theta(s) = \phi_r(s) - \phi(s)$ $\qquad\qquad \delta f(s) = k(s) \cdot \delta\theta(s)$

$= R(s)\dfrac{1}{s} - \delta f(s) \cdot \dfrac{1}{s}$

$\Rightarrow G(s) = \dfrac{\delta\theta(s) \cdot k(s)}{s\,\delta\theta(s) + \delta\theta(s)K(s)} = \dfrac{k(s)}{s + k(s)}$

4) similar to 3

$T(s) = \dfrac{Y(s)}{R(s)}$

$= \dfrac{H(s) \cdot \delta f(s)}{[s + k(s)]\,\delta f(s)}$

$= \dfrac{H(s) \cdot k(s) \cdot \cancel{\delta\theta(s)}}{(s + k(s))\,\cancel{\delta\theta(s)}}$

$= \dfrac{H(s) \cdot k(s)}{s + k(s)}$

$T(s) = H(s)G(s)$

Christopher Hwang

5) $G(s) = \dfrac{k(s)}{s + k(s)} = \dfrac{P_1 + \frac{P_2}{s}}{s + P_1 + \frac{P_2}{s}} = \dfrac{sP_1 + P_2}{s^2 + sP_1 + P_2}$

$$\boxed{G(s) = \frac{P_1 s + P_2}{s^2 + P_1 s + P_2}}$$

P_1 is the proportional gain

P_2 is the integral gain

6) $T(s) = H(s)G(s) = \dfrac{P_2}{\cancel{P_1 s + P_2}} \left(\dfrac{\cancel{P_1 s + P_2}}{s^2 + P_1 s + P_2} \right)$

$$\boxed{T(s) = \frac{P_2}{s^2 + P_1 s + P_2}}$$

7) $s^2 + P_1 s + P_2 = 0$

very similar to

$s^2 + 2\delta W_n s + W_n^2$

$P_1 = 2\delta W_n$

$= 2(0.690)(1.381)$

$\boxed{P_1 = 1.907}$

$P_2 = W_n^2$

$= (1.381)^2$

$\boxed{P_2 = 1.909}$

In this lab, we will analyze the transient respon using the concept of dominant poles

Reference noise denoted by R

For the reference ~~period~~ signal

Period = $T = 20s$

$$F = \frac{1}{T} = \frac{1}{20} = 0.05$$

Amplitude = 2

we want to design the controller $K(s)$ and the filter $H(s)$ such that the output of the system, $y(t)$, will track the reference signal $r(t)$

$T_p = \pi$

$$G(s) = \frac{\delta F(s)}{R(s)}$$

$$\phi_r(s) = R(s) \cdot \frac{1}{s}$$

$$\phi(s) = \delta F(s) \cdot \frac{1}{s}$$

$$\delta \phi(s) = \phi_r(s) - \phi(s)$$

$$= R(s) \cdot \frac{1}{s} - \delta F(s) \cdot \frac{1}{s} \quad (1)$$

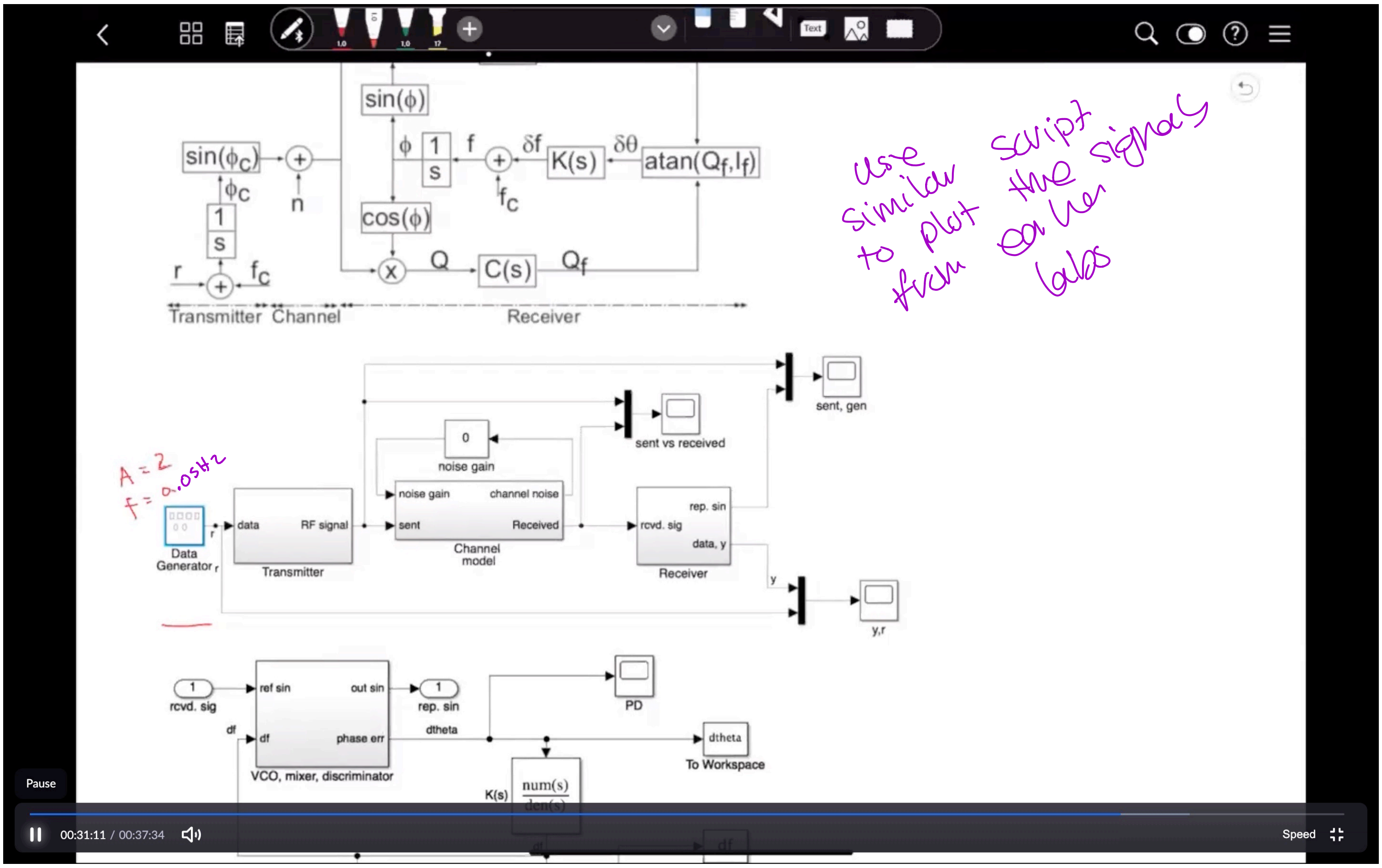
$$\delta(s) = K(s) \cdot \delta\Theta(s) \quad (2)$$

$$G(s) = \frac{\delta\Theta(s) \cdot K(s)}{s\,\delta\Theta(s) + \delta\Theta(s) \cdot K(s)} = \frac{K(s)}{s + K(s)}$$

$$T(s) = \frac{Y(s)}{R(s)} = \frac{H(s) \cdot \delta F(s)}{[s + K(s)]\,\delta\Theta(s)}$$

$$= \frac{H(s) \cdot K(s) \cdot \cancel{\delta\Theta(s)}}{[s + K(s)]\,\cancel{\delta\Theta(s)}} = \frac{H(s) \cdot K(s)}{[s + K(s)]} = H(s) \cdot G(s)$$

$[s + K(s)]\ \delta\theta(s) \qquad [s + K(s)]$



$T_p = \pi \text{ sec} = \pi/\omega_d \Rightarrow \omega_d = 1$

$M_p = 5\% = e^{-\zeta\pi/\sqrt{1-\zeta^2}}$

$\omega_n = \dfrac{\omega_d}{\sqrt{1-\zeta^2}} = 1.381$

$s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$

$$\begin{cases} T_s = \dfrac{4.6}{\zeta\omega_n} \approx 4.83 \\ T_r = \dfrac{1.8}{\omega_n} = 1.304 \end{cases}$$

$0.05 = e^{-\zeta\pi/\sqrt{1-\zeta^2}}$

$\ln(0.05) = -\dfrac{\zeta\pi}{\sqrt{1-\zeta^2}}$ $= \zeta\pi = \ln(0.05)\sqrt{1-\zeta^2}$

$= 0.69$

5) P_1 is proportional gain
P_2 is integral gain

(5) $G(s) = \frac{K(s)}{s + K(s)} = \frac{P_1 s + P_2}{s_2 + P_1 s + P_2}$

(6) $T(s) = H(s) \cdot G(s) = \frac{P_2}{\cancel{P_1 s + P_2}} \cdot \frac{\cancel{P_1 s + P_2}}{s_2 + P_1 s + P_2}$

$= \frac{P_2}{s^2 + P_1 s + P_2}$

$s^2 + P_1 s + P_2 = 0 \quad 2(.69)(1.38) = 1.9044 \quad P_2 = \omega_n^2 = 1.9044$

$[s \; 1 \; K(s)] \; \delta \cancel{\theta}(s)$ $\qquad$ $[s \; 1 \; K(s)]$