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MECH 421 - Homework 6 Solution

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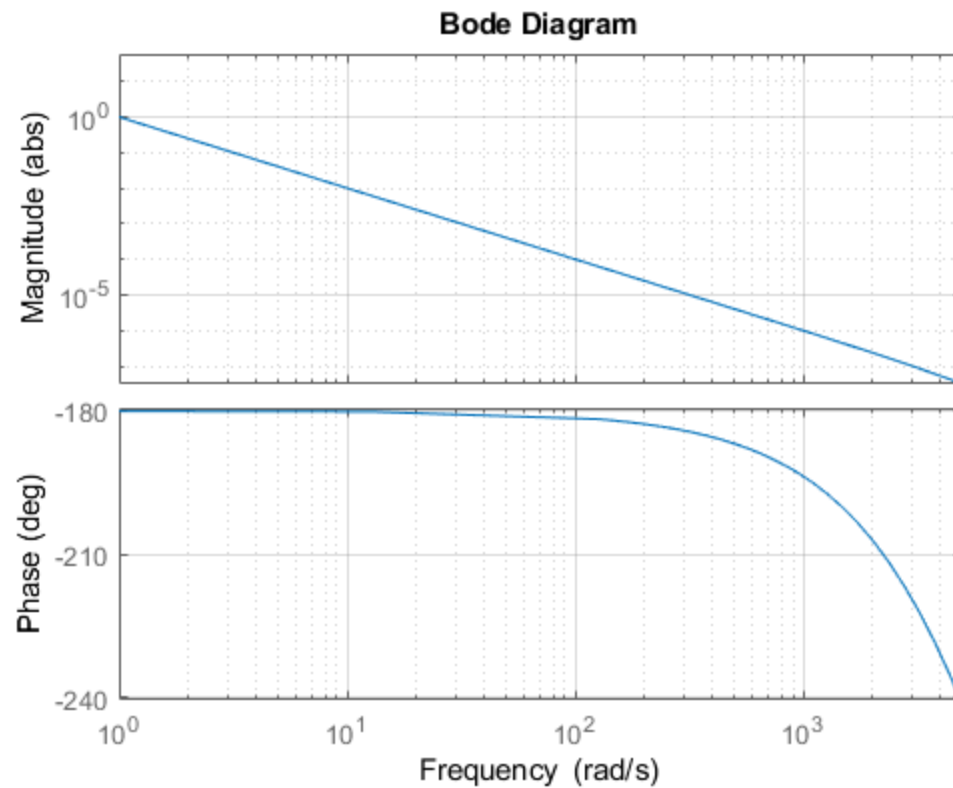
```
clc
clear all
close all

s = tf('s');

m = 1;
Kf = 1;
fs = 10e3;
T = 1/fs;

Gm = 1/(m*s^2);
Ga = 1/(s/(1000*2*pi)+1);
Gs = 1/(s/(5000*2*pi)+1);
ADC = 0.1;
DAC = 10*exp(-T/2*s);
P = DAC*Ga*Kf*Gm*Gs*ADC;
```
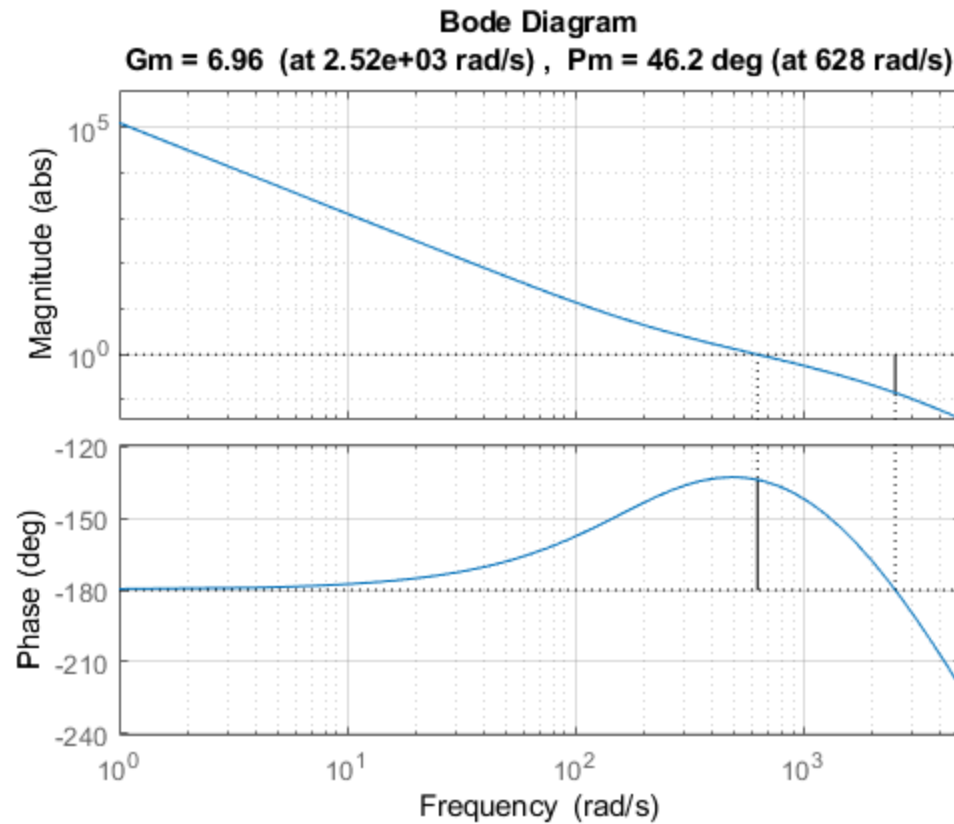
(a) Plant

```
figure(1)
bode(P)
grid on
xlim([1 5e3])
```

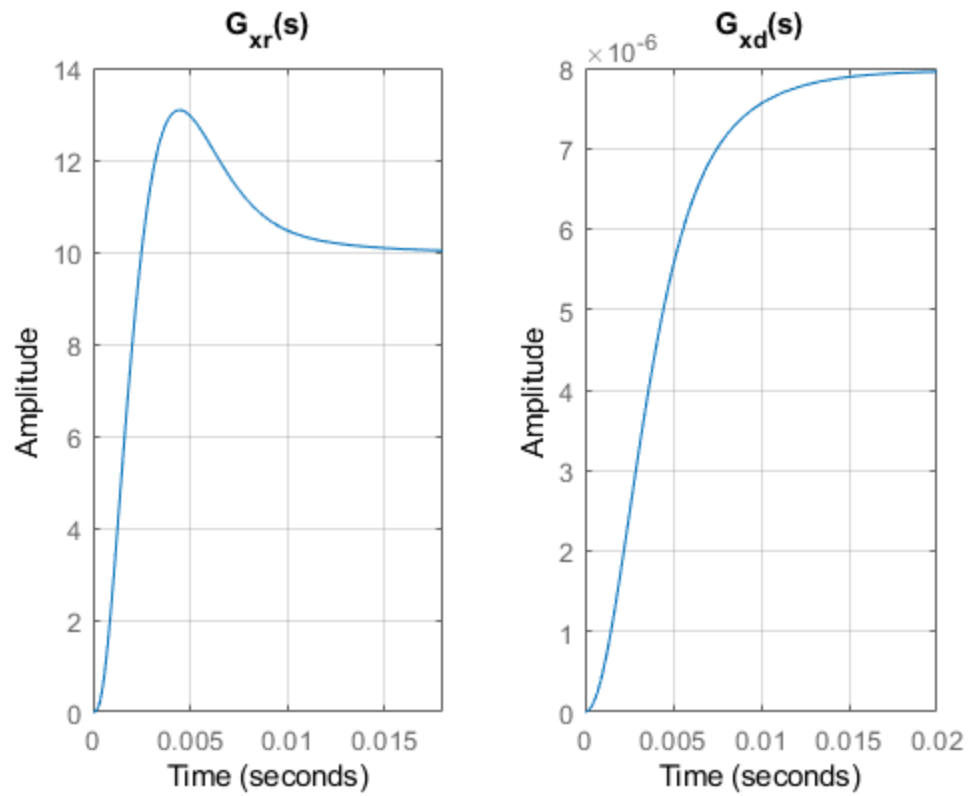## Bode Diagram

(b) Lead compensator

```
wc = 100*2*pi;
alpha = 10;
tau = 1/wc/sqrt(alpha);
Lead = (alpha*tau*s+1)/(tau*s+1);
Kp = 1/abs(squeeze(freqresp(P,wc)))/sqrt(alpha);
C = Kp*Lead;
L = C*P;

figure(2)
margin(L)
grid on
xlim([1 5e3])
```

Bode Diagram

Gm = 6.96 (at 2.52e+03 rad/s) , Pm = 46.2 deg (at 628 rad/s)
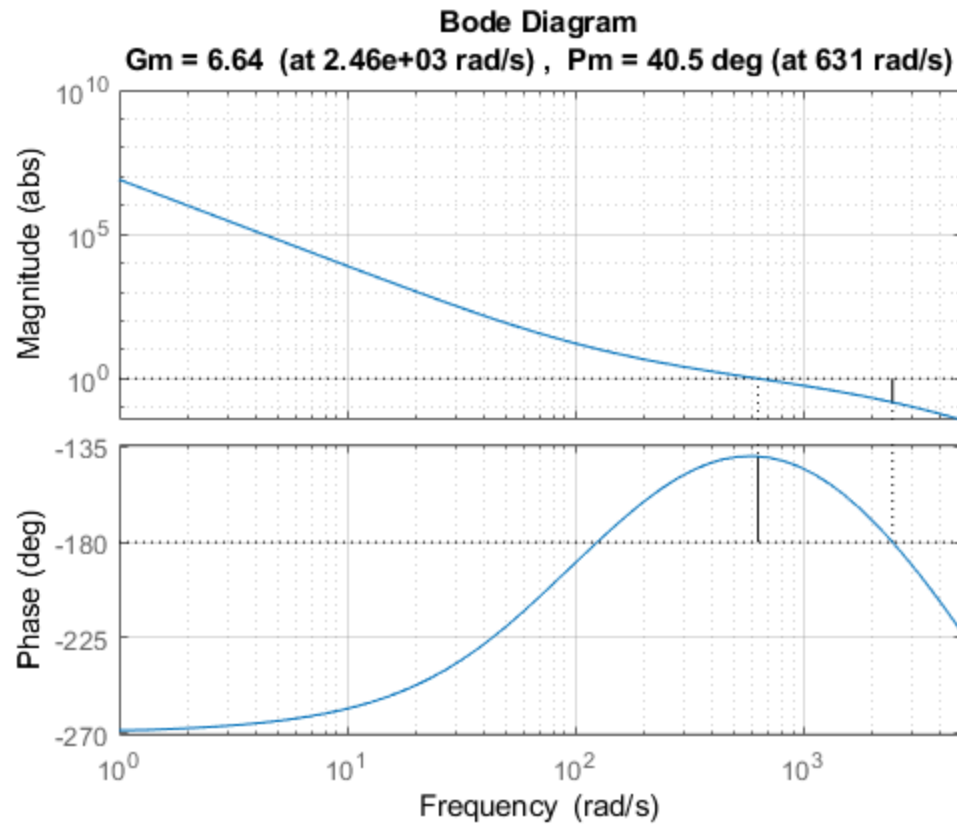
(d) Step responses

```
G_xr = C*DAC*Ga *Kf*Gm/(1+L);
G_xd = Gm/(1+L);

figure(3)
subplot(121)
step(G_xr)
grid on
title('G_{xr}(s)')
subplot(122)
step(G_xd)
grid on
title('G_{xd}(s)')
```

$G_{xr}(s)$

(graph: Amplitude vs Time (seconds), curve rising to a peak near 13 at about 0.005 s then settling to about 10)

$G_{xd}(s)$

(graph: Amplitude ($\times 10^{-6}$) vs Time (seconds), curve rising from 0 and settling to about 8)

(d) PI compensator

```
wi = wc/10;
Ti = 1/wi;
PI = 1+1/(Ti*s);
C = Kp*PI*Lead;
L = C*P;

figure(4)
margin(L)
grid on
xlim([1 5e3])
```

Bode Diagram
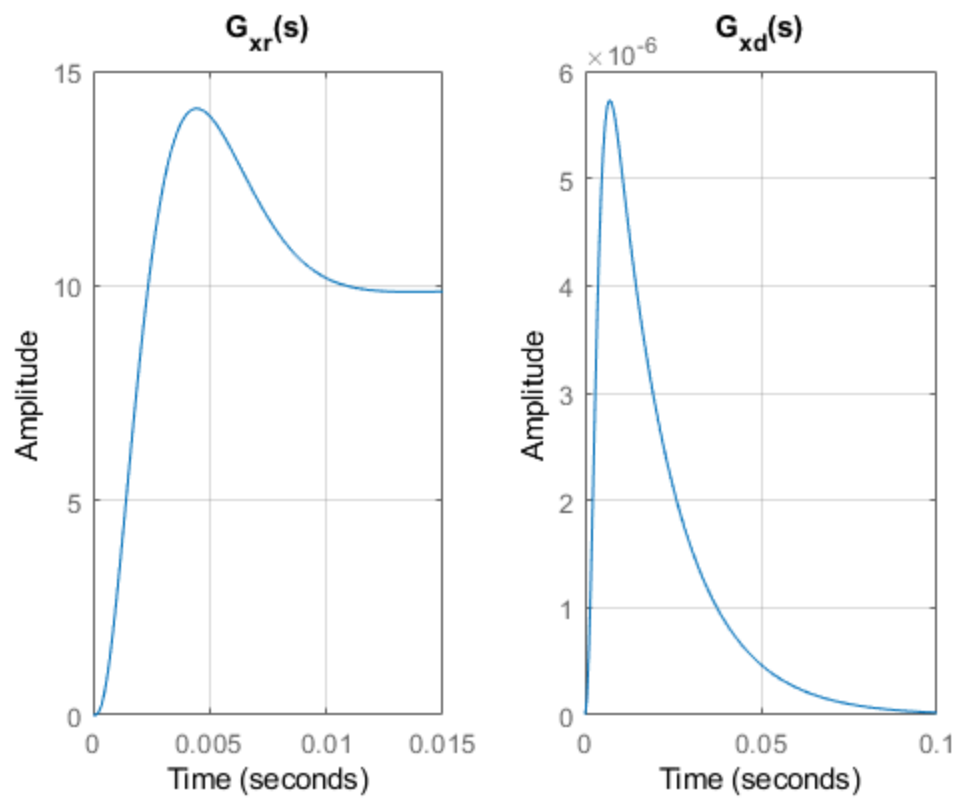Gm = 6.64 (at 2.46e+03 rad/s), Pm = 40.5 deg (at 631 rad/s)

(e) Step resonse

```matlab
G_xr = C*DAC*Ga *Kf*Gm/(1+L);
G_xd = Gm/(1+L);

figure(5)
subplot(121)
step(G_xr)
grid on
title('G_{xr}(s)')
subplot(122)
step(G_xd)
grid on
title('G_{xd}(s)')

% The step response of G_xr remains similar. The step response of G_xd
% converges to zero. This is because of the integral control.
```

$G_{xr}(s)$ and $G_{xd}(s)$

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