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Steering

```
clear all;
close all;
clc;
format shortg;

L=2.77; %m
Ae=-.0547;
Vref=31.1; %m/s 70mph
s=tf('s');
E=119/Vref;%m/s^2

A=[0 Vref;0 0];
B=[0;Vref/L];
C=eye(2);
D=0*B;

G=C*(s*eye(2)-A)^-1*B;
```

PID Controller

```
Kp=[1/3 0.5];
Ki=[3/30, 1/30];
Kd=[2/3000, 4/3000];

n=.15;

K=(s^2*(Kp+Kd*n)+s*(Kp*n+Ki)+Ki*n)/(s^2+s*n);

% Wi
tau=.2;
r0=0.1;
rinf=.3;
wi=(tau*s+r0)/((tau/rinf)*s+1);

% Wp
wb=3;
m=1;
A=.75;
N=2;
wp=(s/m^(1/N)+wb)^N/(s+wb*A^(1/N))^N;
```

```matlab
%NS
L=G*K;
T=(eye(2)+L)^-1*L;
Tmin=minreal(T,1);
NScondition=pole(Tmin)

%NP
S=(eye(2)+L)^-1;
Smin=minreal(S,1);
NPcondition=norm(wp*Smin,inf)

%RS
Si=(1+K*G)^-1;
Ti=K*G*(1+K*G)^-1;
Simin=minreal(Si,1);
Timin=minreal(Ti,1);

RScondition=norm(wi*Timin,inf)


NScondition =

    -2.6564 +    10.399i
    -2.6564 -    10.399i
    -2.6564 +    10.399i
    -2.6564 -    10.399i


NPcondition =

     3.7675


RScondition =

    0.31443
```

RP

```matlab
M=[wp*Smin, wp*G*Simin;
    -wi*Simin*K, -wi*Timin];

Mmin=minreal(M,1);
Mnorm=norm(Mmin,inf)
BLK3=[3 0];
BLK1=[1 0];
BLK2=[2 0];

Mfrd=frd(M,logspace(-1,2,200));

PIDboundsMfull = mussv(Mfrd,BLK3,'s');
PIDboundsM11= mussv(Mfrd(1,1),BLK1,'s');
```

```matlab
PIDboundsM22= mussv(Mfrd(2:3,2:3),BLK2,'s');

% Plotting
figure(1);
loglog(PIDboundsMfull(1));
hold on;grid on;
loglog(PIDboundsM11(1));
loglog(PIDboundsM22(1));

title('PID Controller \mu (M)')
xlabel('Frequency (rad/s)')
ylabel('Magnitude')
legend('Mfull','M11','M22','location','best')
hold off;

% Time Response Plots
L=2.77; %m
Ae=-.0547;
Vref=31.1; %m/s 70mph
s=tf('s');
E=119/Vref;%m/s^2
tend=2;
dt=.001;
X0=[.44;0];
Xr=[0;0];
MaxCMD=[10*pi/180];
MinCMD=[-10*pi/180];
A=[0 Vref;0 0];
B=[0;Vref/L];
C=eye(2);
D=0*B;
SimOut = sim('controlsprojectsimulinkupdated');
solution=Statehistory;
t=solution.time;
figure(2)
subplot(311)
plot(t,solution.data(:,1));
grid on;
ylabel('X Position Error (m)');
title('Response to an X Position Error')
subplot(312)
plot(t,solution.data(:,2)*180/pi);
grid on;
ylabel('Theta (Deg)');
subplot(313)
t=Commandhistory.time;
plot(t,Commandhistory.data(:,1)*180/pi);
grid on;
ylabel('Steering Wheel Command (Deg)');
xlabel('Time (Seconds)')


Mnorm =
```
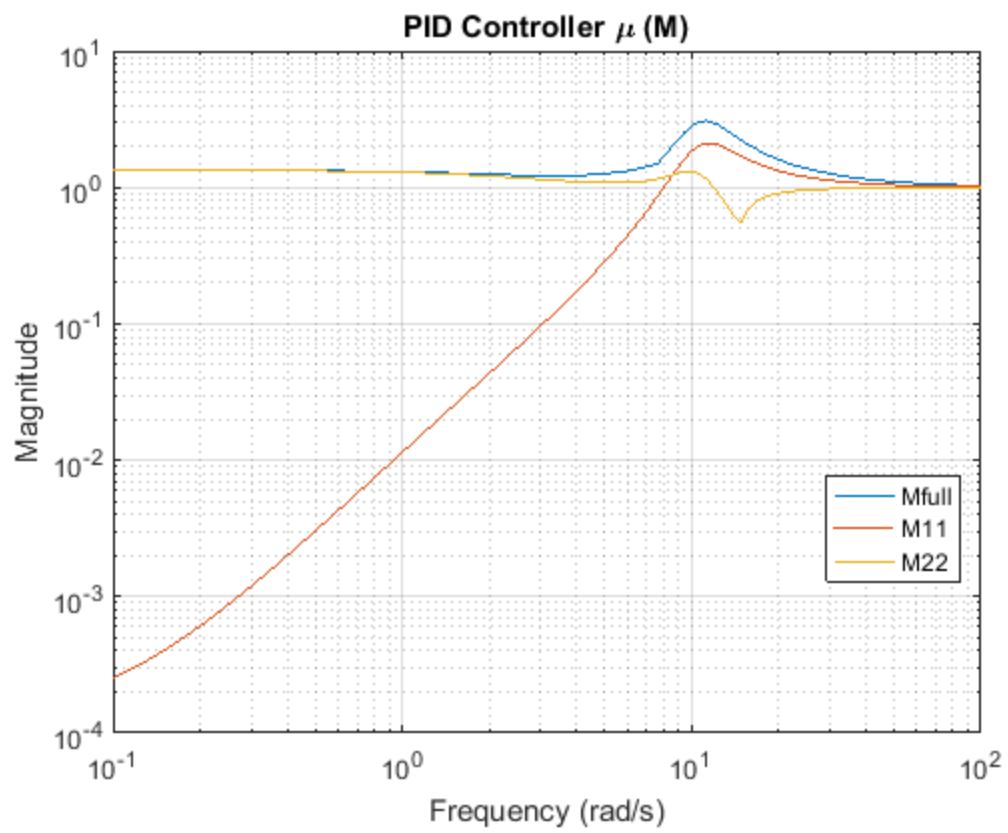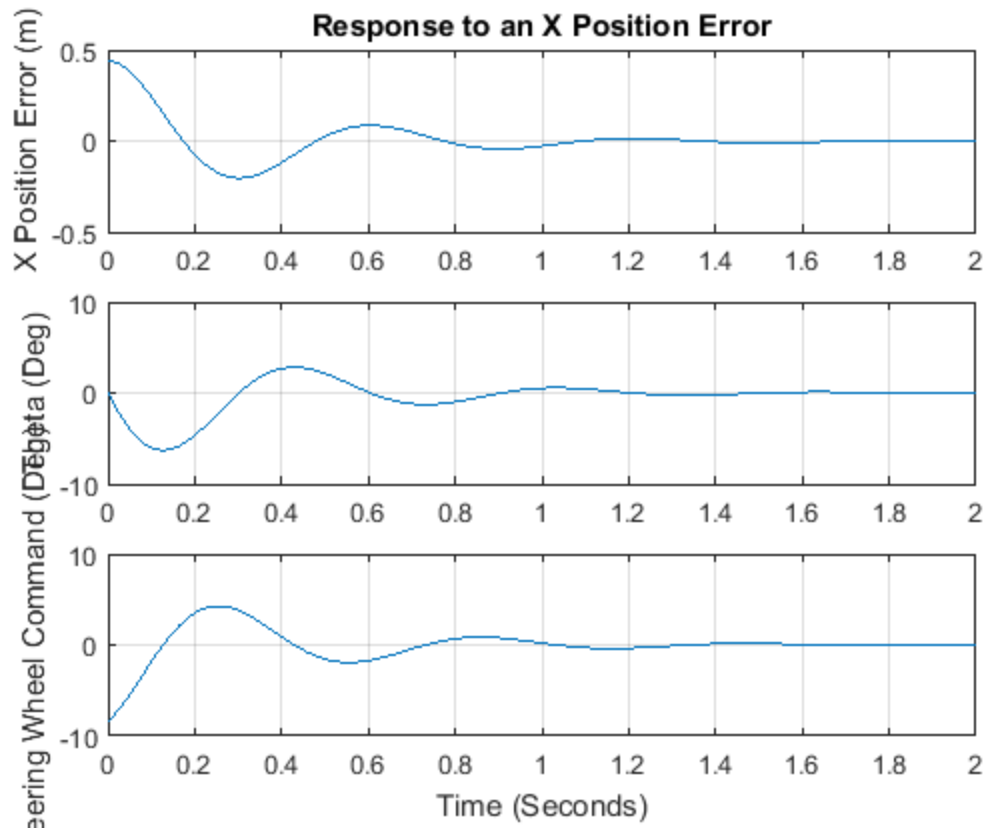
```
7.4825
```


PID Controller μ (M)

Response to an X Position Error

Hinf Controller

```
Wp

wb=3;
m=1;
A=0.0;
N=2;
wp=(s/m^(1/N)+wb)^N/(s+wb*A^(1/N))^N;

% Wi
tau=.2;
r0=0.1;
rinf=.3;
wi=(tau*s+r0)/((tau/rinf)*s+1);

% K
[K,CL,GAM,INFO]=ncfsyn(G,wp,wi);

L=G*K;
T=(eye(2)+L)^-1*L;
S=(eye(2)+L)^-1;
Si=(1+K*G)^-1;
Ti=K*G*(1+K*G)^-1;

% Minimal Realizations
```

```
CLmin=minreal(CL,[],false);
Smin=minreal(S,[],false);
Simin=minreal(Si,[],false);
Timin=minreal(Ti,[],false);
Tmin=minreal(T,[],false);
Kmin=minreal(K,.1,false);

wb=3;
m=1;
A=0.75;
N=2;
wp=(s/m^(1/N)+wb)^N/(s+wb*A^(1/N))^N;

NScondition=pole(CLmin)
NPcondition=norm(wp*Smin,inf)
RScondition=norm(wi*Timin,inf)
```

NScondition =

```
    -13.897 +           0i
    -4.2926 +      6.3038i
    -4.2926 -      6.3038i
   -0.50003 +           0i
    -3.2133 +           0i
    -2.8195 +     0.42074i
    -2.8195 -     0.42074i
    -2.8351 +           0i
```

NPcondition =

```
     1.9692
```

RScondition =

```
     0.46847
```

RP

```
M=[wp*Smin, wp*G*Simin;
    -wi*Simin*K, -wi*Timin];
Mmin=minreal(M,[],false);

Mfrd=frd(Mmin,logspace(-1,2,200));

HinfboundsMfull = mussv(Mfrd,BLK3,'s');
HinfboundsM11= mussv(Mfrd(1:2,1:2),BLK2,'s');
HinfboundsM22= mussv(Mfrd(3,3),BLK1,'s');

% Plotting
```
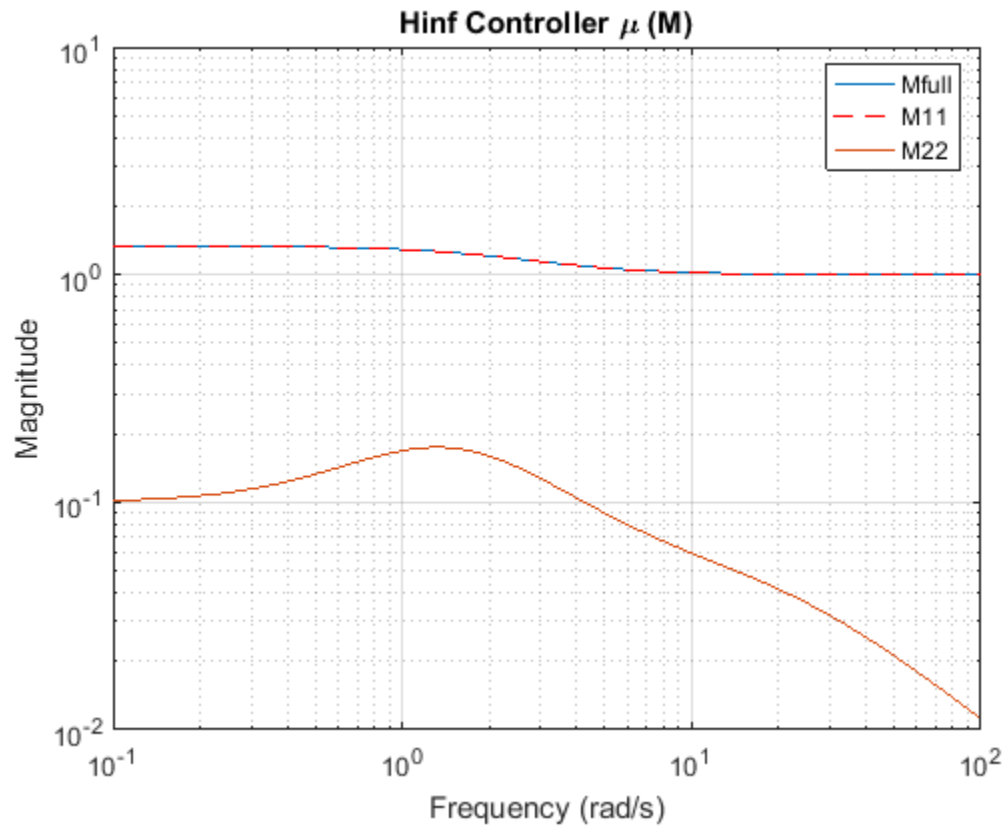
```
figure(3)
loglog(HinfboundsMfull(1));
hold on;grid on;
loglog(HinfboundsM11(1),'r--');
loglog(HinfboundsM22(1));

title('Hinf Controller \mu (M)')
xlabel('Frequency (rad/s)')
ylabel('Magnitude')
legend('Mfull','M11','M22','location','best')
```


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