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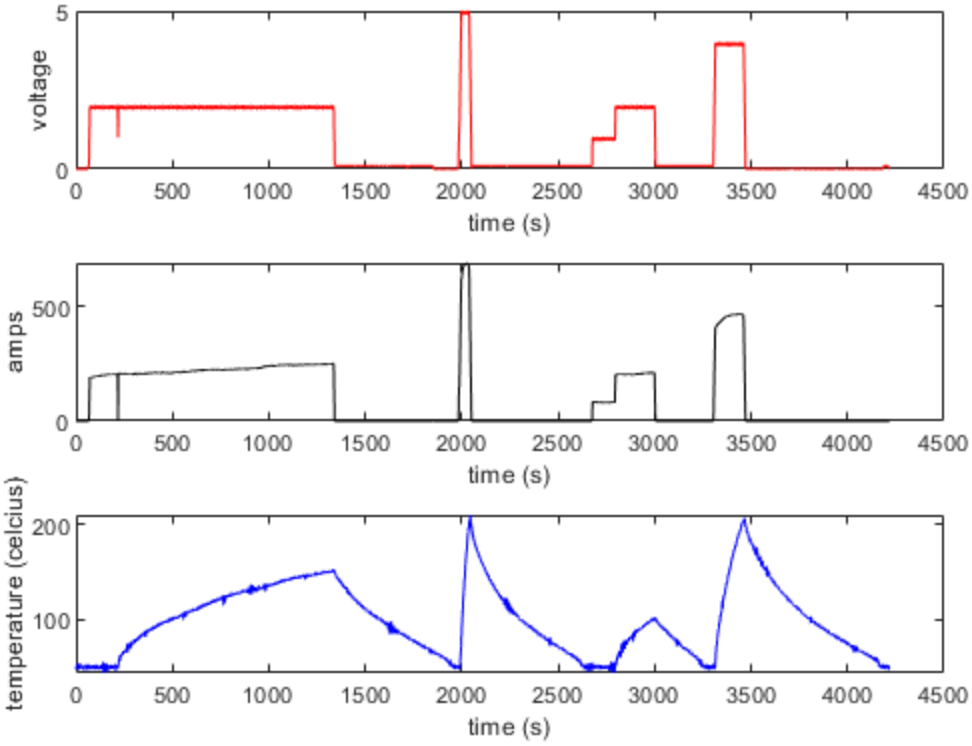
CEFAS SID : Golam Gause Jaman

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%              CEFAS SID                 %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

clc; clear all; close all;
```

Load Data

```
matrix0=readmatrix('sidCEFAS.xlsx');
time=matrix0(:,2);
volt=matrix0(:,3);
amps=matrix0(:,4);
temp=matrix0(:,5);

figure(1)
subplot(3,1,1);
plot(time,volt,'r');
xlabel('time (s)');
ylabel('voltage');

subplot(3,1,2);
plot(time,amps,'k');
xlabel('time (s)');
ylabel('amps');

subplot(3,1,3);
plot(time,temp,'b');
xlabel('time (s)');
ylabel('temperature (celcius)');


Ts=mean(time(2:end,1)-time(1:end-1,1));
```



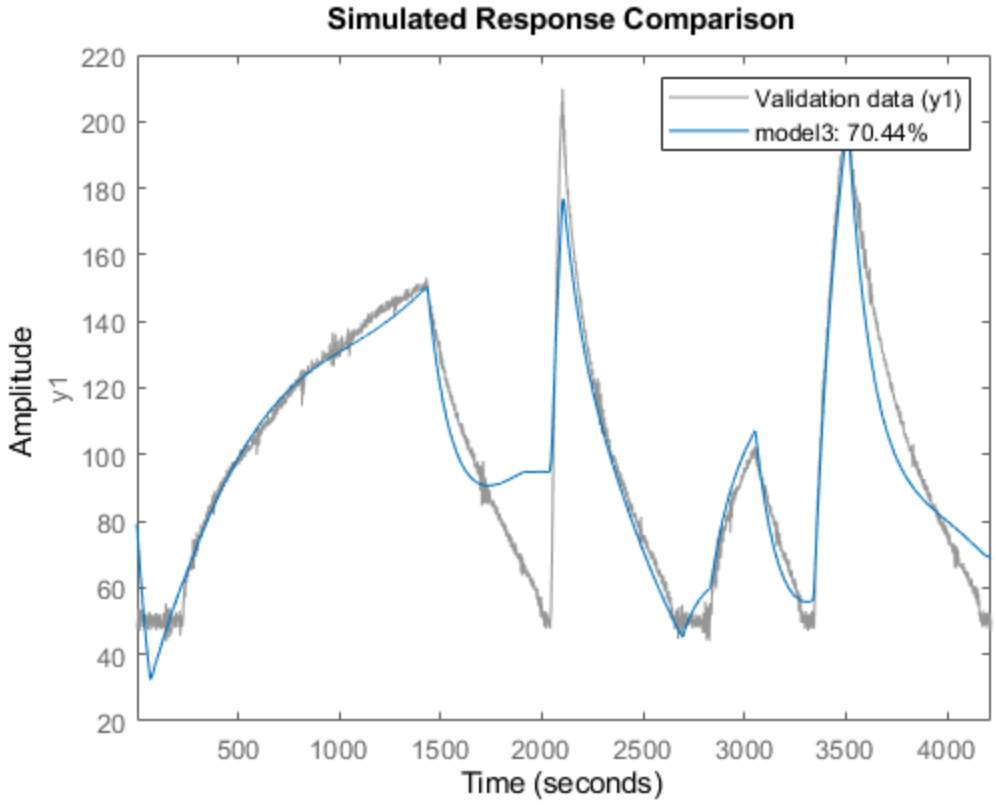
SID Construction

```
u_=volt;
y_=temp;
data_=iddata(y_,u_,Ts);

nx=[1:10];
sys_d=n4sid(data_, nx)
sys=d2c(sys_d)
[num,den]=ss2tf(sys.A, sys.B, sys.C, sys.D);
model0=tf(num,den)

poles_=length(eig(model0));
model1=tfest(data_, poles_)
model2=c2d(model0,Ts)

% Best model (validation fit%) appeared : transfer function (4 pole, 3 zero)
% and NARX

model3=tfest(data_, 4)
figure(2)
%compare(data_,sys_d)
compare(data_,model3)
model4=c2d(model3,Ts,'foh')
```

```
sys_d =
  Discrete-time identified state-space model:
    x(t+Ts) = A x(t) + B u(t) + K e(t)
       y(t) = C x(t) + D u(t) + e(t)

  A =
          x1
   x1  0.9964

  B =
              u1
   x1  -8.327e-05

  C =
         x1
   y1  -4381

  D =
       u1
   y1   0

  K =
              y1
   x1  -6.799e-05

Sample time: 1.2273 seconds

Parameterization:
   FREE form (all coefficients in A, B, C free).
   Feedthrough: none
   Disturbance component: estimate
   Number of free coefficients: 4
   Use "idssdata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Estimated using N4SID on time domain data "data_".
Fit to estimation data: 94.87% (prediction focus)
FPE: 3.664, MSE: 3.655


sys =
  Continuous-time identified state-space model:
      dx/dt = A x(t) + B u(t) + K e(t)
       y(t) = C x(t) + D u(t) + e(t)

  A =
            x1
   x1  -0.00294

  B =
              u1
   x1  -6.797e-05

  C =
```

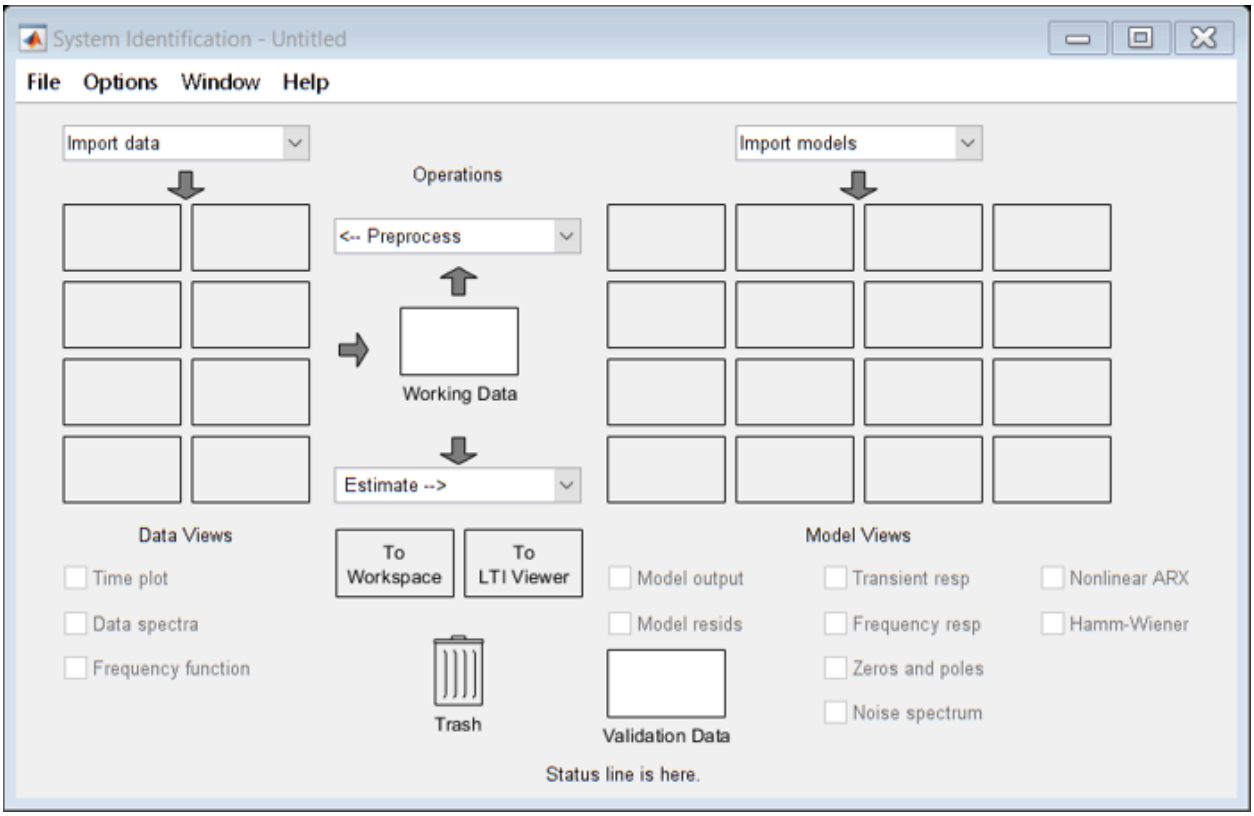
```
          x1
   y1  -4381

  D =
       u1
   y1   0

  K =
              y1
   x1  -5.55e-05

Parameterization:
   FREE form (all coefficients in A, B, C free).
   Feedthrough: none
   Disturbance component: estimate
   Number of free coefficients: 4
   Use "idssdata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Created by direct construction or transformation. Not estimated.


model0 =

    0.2978
  -----------
  s + 0.00294

Continuous-time transfer function.


model1 =
  From input "u1" to output "y1":
     0.1218
  ------------
  s + 0.001204

Continuous-time identified transfer function.

Parameterization:
   Number of poles: 1   Number of zeros: 0
   Number of free coefficients: 2
   Use "tfdata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Estimated using TFEST on time domain data "data_".
Fit to estimation data: 37.45%
FPE: 544, MSE: 543.1


model2 =

    0.3648
  ----------
```

```
  z - 0.9964

Sample time: 1.2273 seconds
Discrete-time transfer function.


model3 =
  From input "u1" to output "y1":
      0.3658 s^3 + 0.0006586 s^2 + 4.078e-06 s + 1.172e-08
  ------------------------------------------------------------
  s^4 + 0.009481 s^3 + 2.199e-05 s^2 + 1.436e-07 s + 1.036e-10

Continuous-time identified transfer function.

Parameterization:
   Number of poles: 4   Number of zeros: 3
   Number of free coefficients: 8
   Use "tfdata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Estimated using TFEST on time domain data "data_".
Fit to estimation data: 70.44%
FPE: 122.1, MSE: 121.3


model4 =
  From input "u1" to output "y1":
  0.2238 - 0.4478 z^-1 + 0.001611 z^-2 + 0.445 z^-3 - 0.2226 z^-4
  ---------------------------------------------------------------
      1 - 3.988 z^-1 + 5.965 z^-2 - 3.965 z^-3 + 0.9884 z^-4

Sample time: 1.2273 seconds
Discrete-time identified transfer function.

Parameterization:
   Number of poles: 4   Number of zeros: 4
   Number of free coefficients: 9
   Use "tfdata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Created by direct construction or transformation. Not estimated.
```



Apply SID GUI to find best model and apply in simulink defining the PID/LQG/RL controller.

```
systemIdentification
%nntart
```

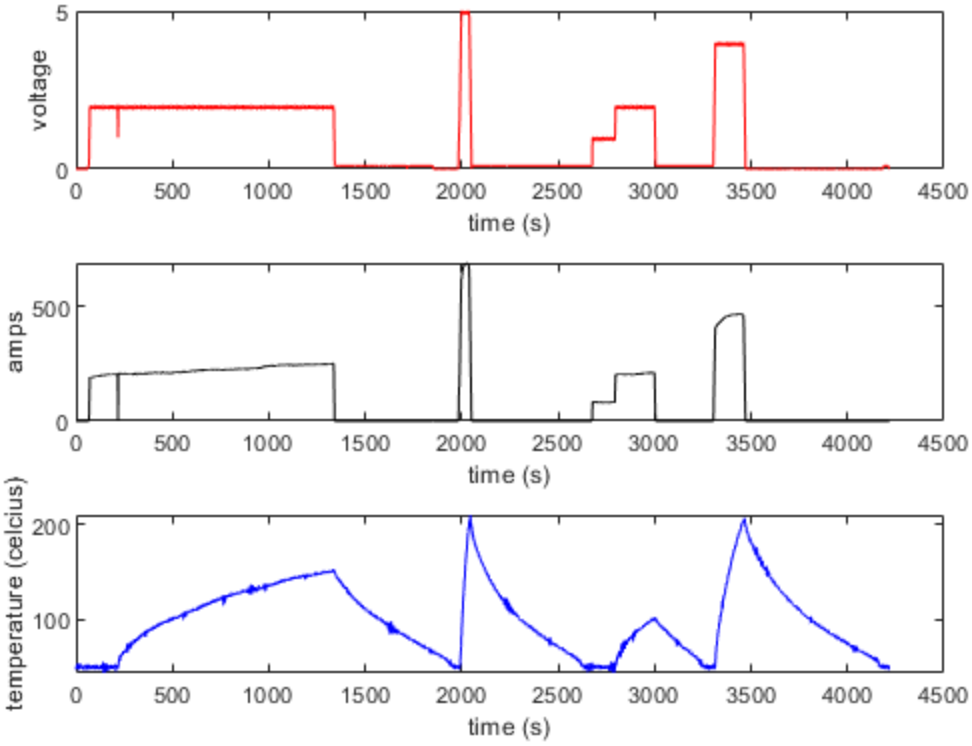


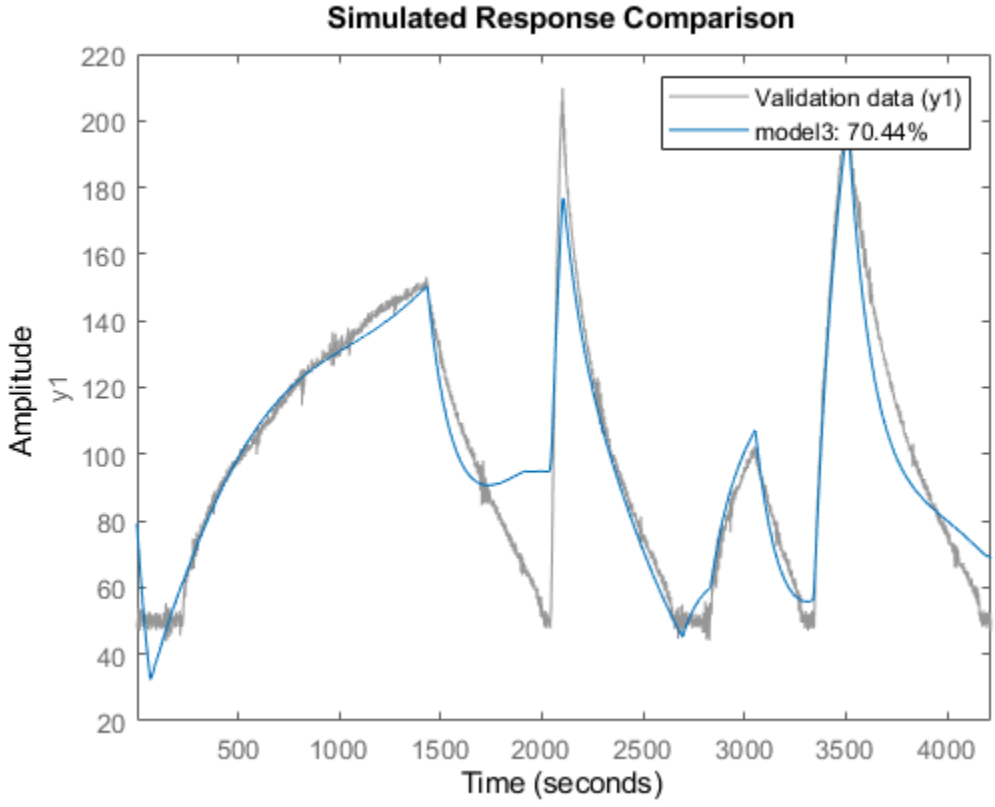
Evaluate continuous plant

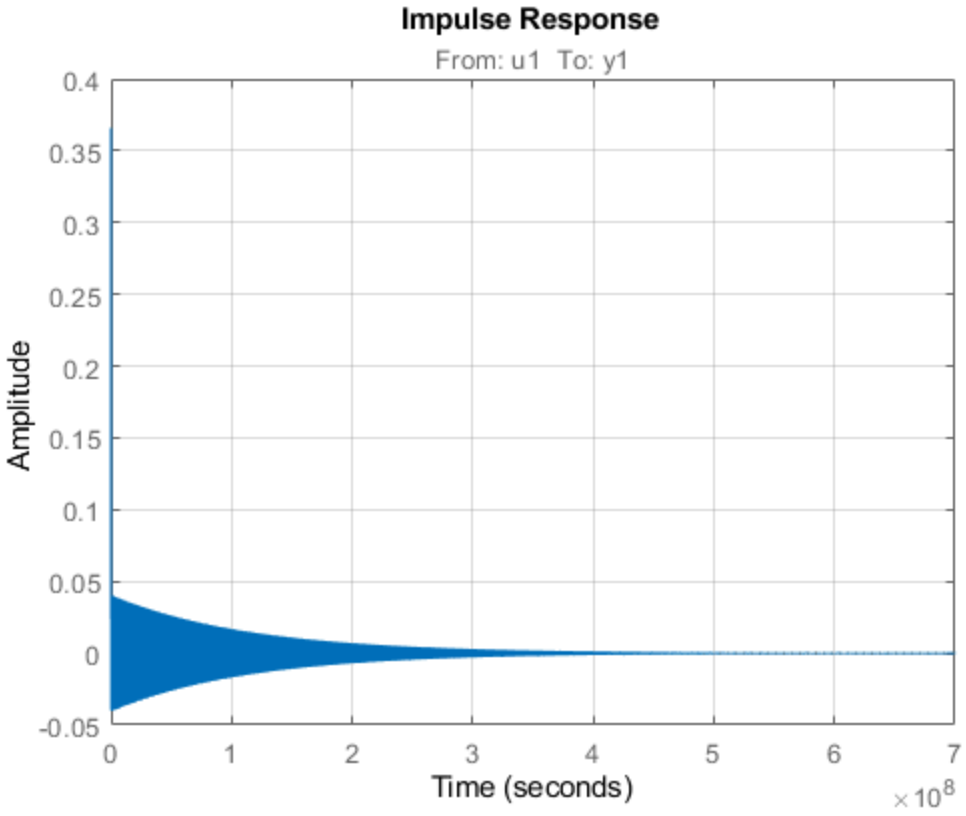
```
EIG=eig(model3)
% Impulse response
figure(3);
impulse(model3);
grid on;
% Step response
figure(4);
step(model4);
grid on;
% Margin (Bode)
figure(5);
margin(model3);
grid on;
% PZ-map
figure(6);
pzmap(model3);
grid on;
% Nyquist plot
figure(7);
nyquist(model3);
grid on;


Fs=1/Ts;
```

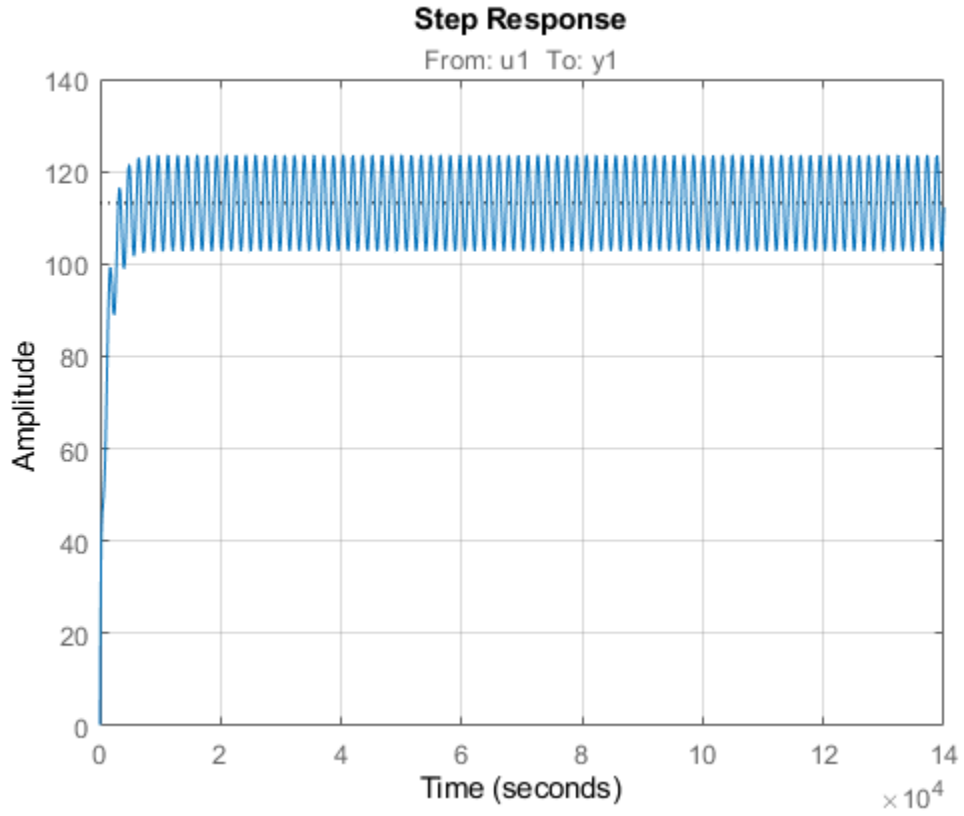
```
L=length(time);
Freq=(Fs/L)*(0:L-1);

Y_=fft(y_);
figure(8)
plot(Freq(500:end-500), abs(Y_(500:end-500)), 'k', 'linewidth', 1);
xlabel('Hz');
ylabel('|fft(y)|');
title('FFT of y')
grid on;

U_=fft(u_);
figure(9)
plot(Freq(500:end-500), abs(U_(500:end-500)), 'b', 'linewidth', 1);
xlabel('Hz');
ylabel('|fft(u)|');
title('FFT of u')
grid on;
```

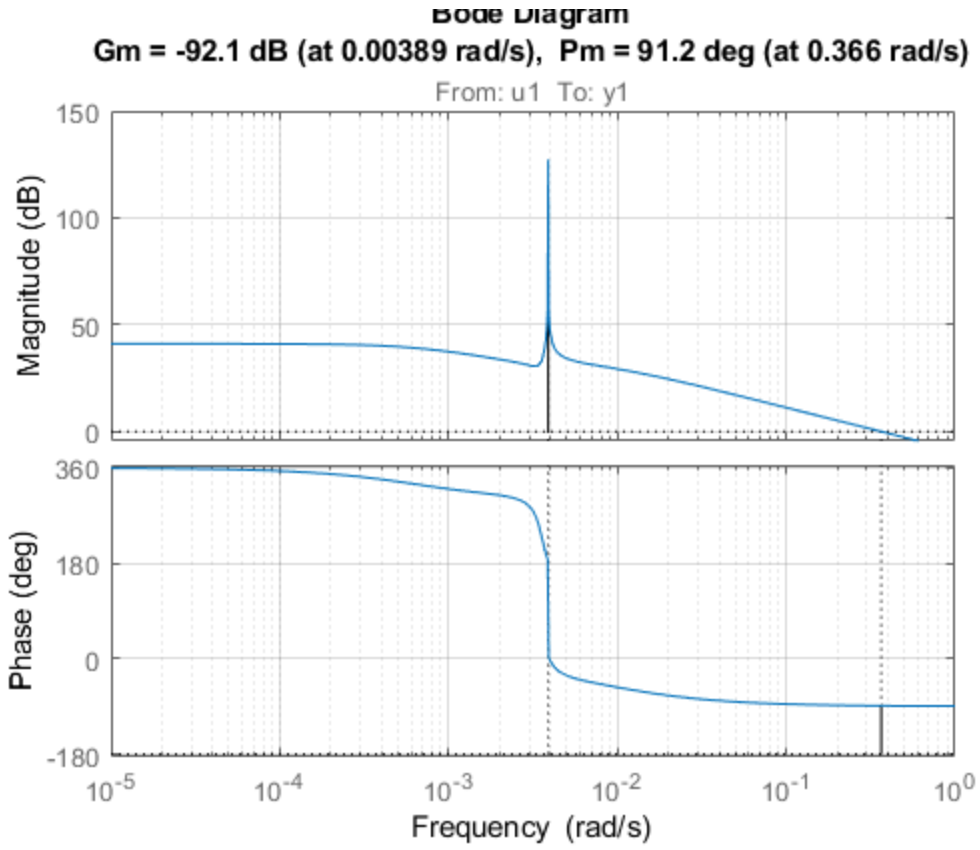
```
EIG =

  -0.0087 + 0.0000i
  -0.0000 + 0.0039i
  -0.0000 - 0.0039i
  -0.0008 + 0.0000i
```

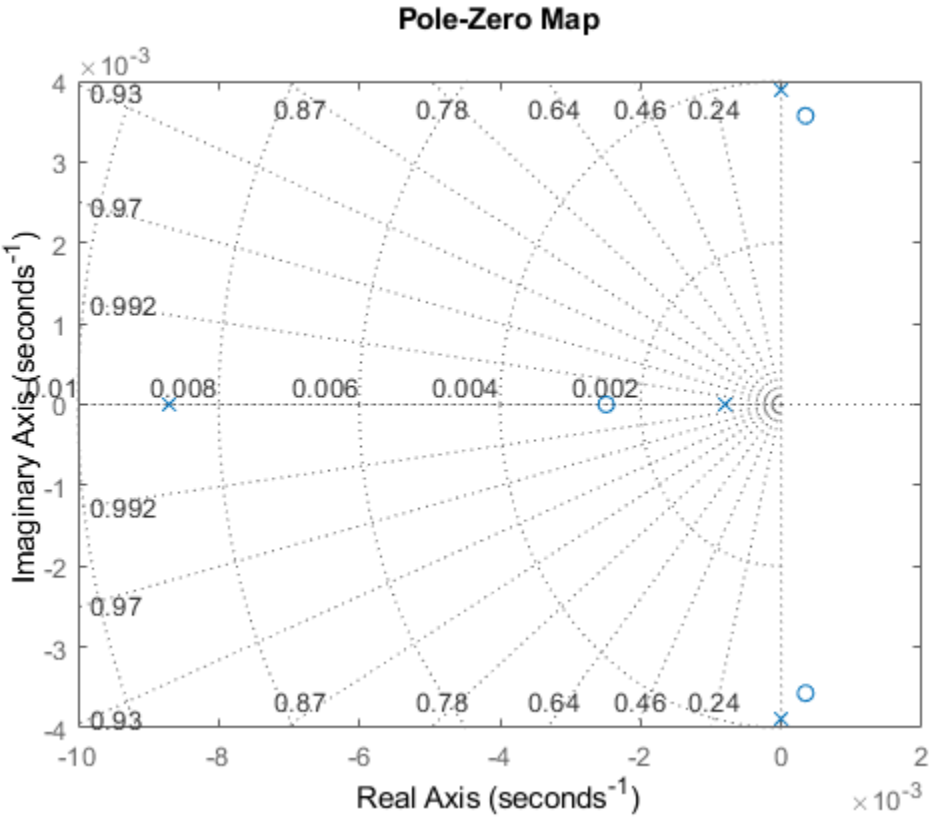

voltage
5
0
0 500 1000 1500 2000 2500 3000 3500 4000 4500
time (s)
amps
500
0
0 500 1000 1500 2000 2500 3000 3500 4000 4500
time (s)
temperature (celcius)
200
100
0 500 1000 1500 2000 2500 3000 3500 4000 4500
time (s)

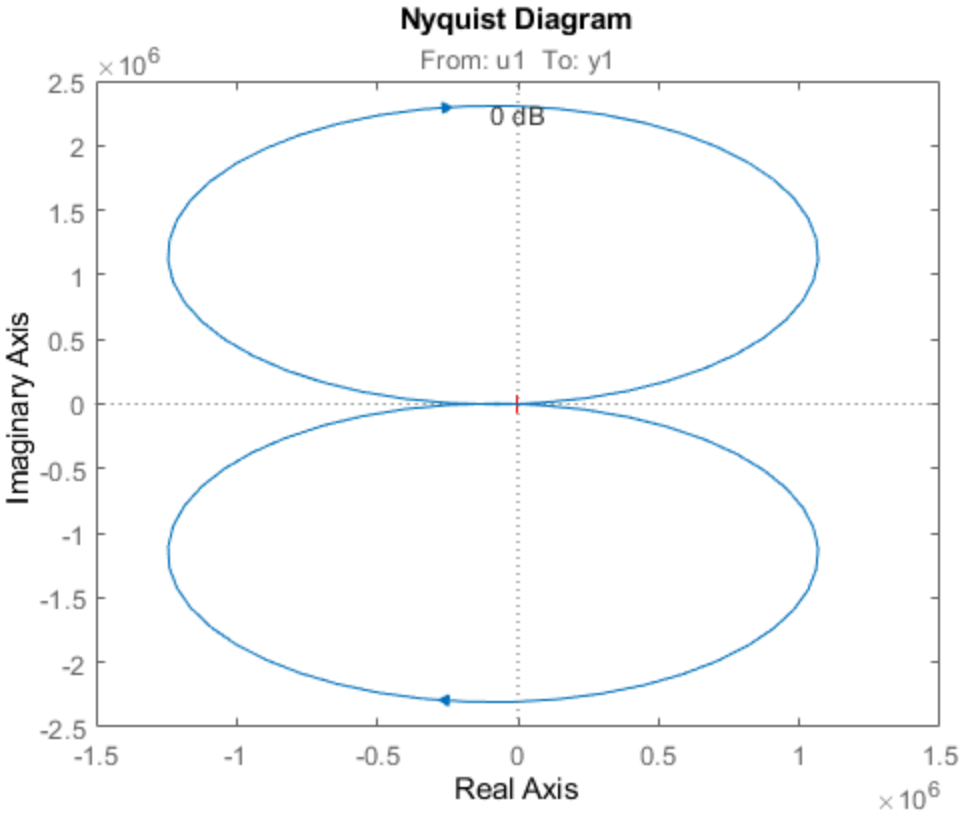

Simulated Response Comparison
Validation data (y1)
model3: 70.44%
Amplitude
y1
220
200
180
160
140
120
100
80
60
40
20
500 1000 1500 2000 2500 3000 3500 4000
Time (seconds)

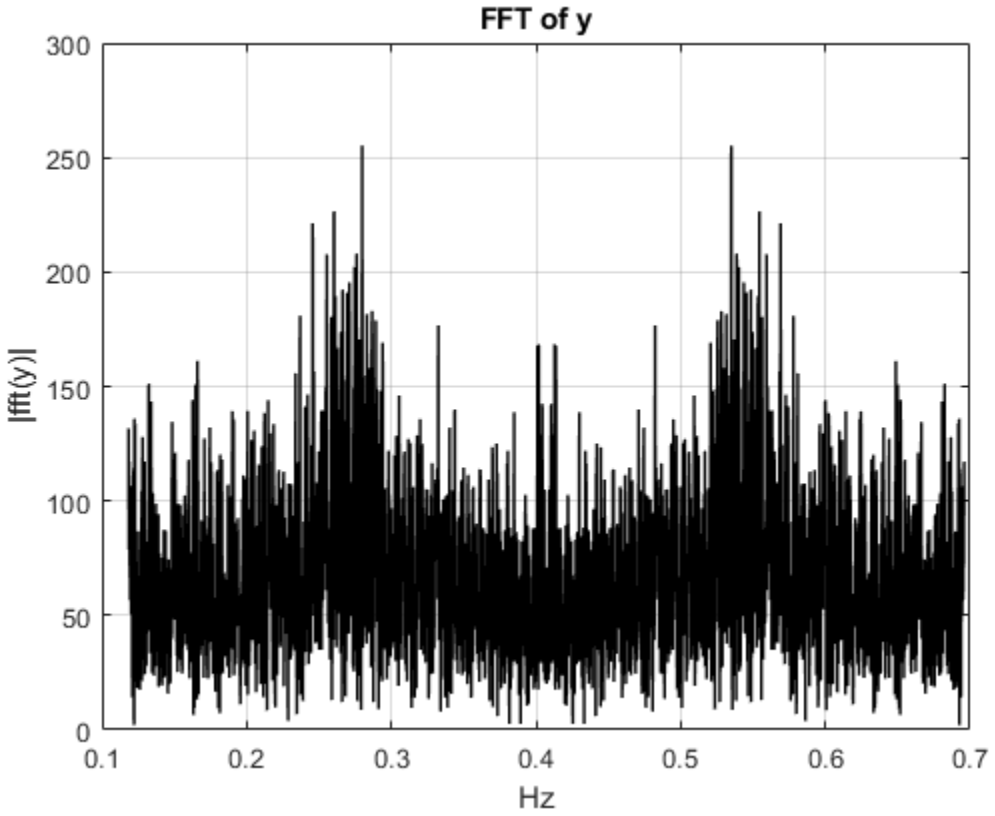

Impulse Response
From: u1 To: y1
Amplitude
Time (seconds)
×10^8

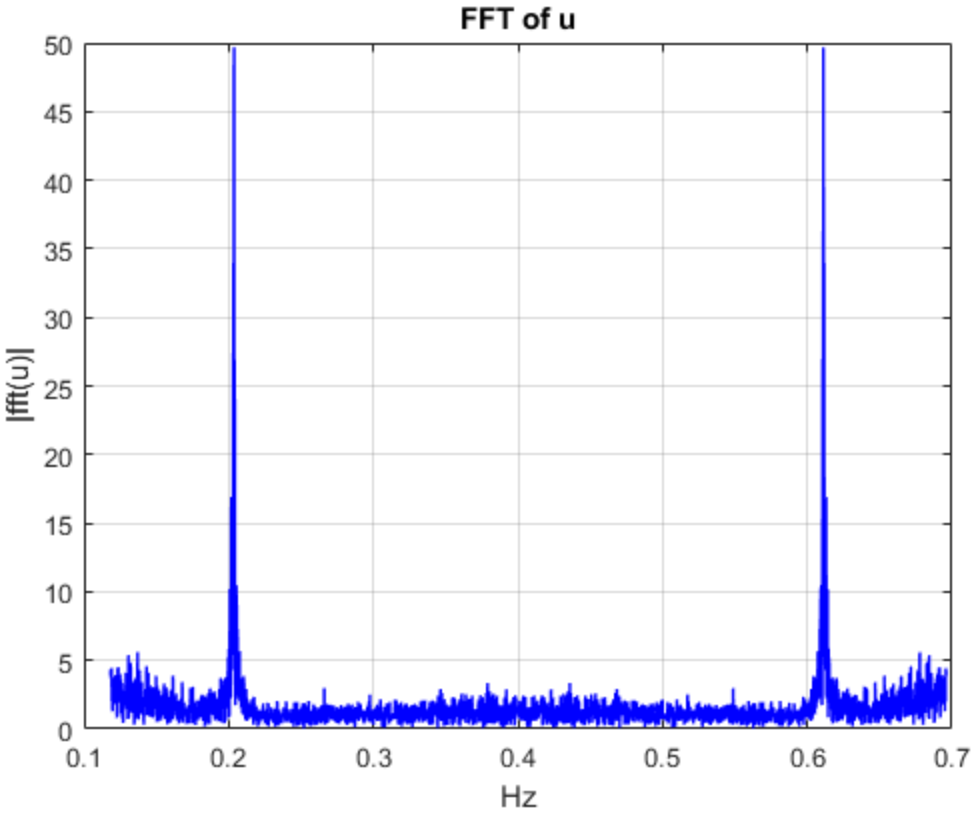

Step Response
From: u1 To: y1
Amplitude
Time (seconds)
×10^4


Bode Diagram
Gm = -92.1 dB (at 0.00389 rad/s), Pm = 91.2 deg (at 0.366 rad/s)
From: u1 To: y1
Magnitude (dB)
Phase (deg)
Frequency (rad/s)


Pole-Zero Map
Imaginary Axis (seconds-1)
Real Axis (seconds-1)
0.93
0.87
0.78
0.64
0.46
0.24
0.97
0.992
0.01
0.008
0.006
0.004
0.002


Nyquist Diagram
From: u1 To: y1
×10^6
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
0 dB
Imaginary Axis
-1.5
-1
-0.5
0
0.5
1
1.5
Real Axis
×10^6


FFT of y
300
250
200
150
100
50
0
|fft(y)|
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Hz



Published with MATLAB® R2022b