Bangladesh University of Business & Technology

Control System Lab

EEE 402

Experiment No: 01

Experiment Name: Representation of Linear Time-Invariant Systems using Matlab.

Objectives:

1. Learn about different Matlab commands to represent Transfer functions.
2. Observe the response of the systems for different types of inputs.
3. Learn about Feedback control system.

Example – 01

$$G(s) = \frac{s}{s^\wedge 2 + s + 4}$$

num= [1,0];

den= [1,1,4];

G= tf(num,den)

*here the built-in function 'tf' is used to represent the system.

*the coefficients of the variable is written. Be careful! You've to consider the coefficient of s^0 as well. Let's Look at another example.

Example -- 02

$$G(s) = \frac{4}{s^5 + 7}$$

num= [4];

den= [1,0,0,0,0,7];

G= tf(num den)

,

Example -- 03

$$G(s) = \frac{4s}{s^3 + s + 5}$$

s=tf(‘s’);

G= 4*s/(s^3+s+5)

* this way we can specify the polynomials directly in terms of ‘s’ - the laplace variable.

Example -- 04

$$G(s) = \frac{4s(s+1)}{(s+5)(s-4)}$$

* we can use ‘zpk’ function to represent this kind of systems.

* zpk -- zeroes, poles and gain.

G= zpk([0,-1],[-5,4],4)

Example -- 05

$$G(s) = \frac{s^2 + 5s + 9}{(s^3 + 7s^2 + s)(s-4)}$$

num= [1,5,9];

den= conv([1,7,1,0],[1,-4])

G=tf(num,den)

* w = conv(u,v) returns the convolution of vectors u and v. If u and v are vectors of polynomial coefficients, convolving them is equivalent to multiplying the two polynomials.

Obtaining poles,zeroes & gain of a transfer function:

Example -- 06

$$G(s)=\frac{s^2+5s+9}{(s^3+7s^2+s)(s-4)}$$

num= [1,5,9];

den= conv([1,7,1,0],[1,-4])

G=tf(num,den)

[z,p,k]=tf2zp(num,den)

Obtaining a transfer function from poles,zeroes & gain :

Example -- 07

Obtain the transfer function if the poles are located at -3,1; zeroes are at 7,0 and gain is 10.

P=[-3,1];

Z=[-1];

K=10;

[num,den]=zp2tf(z',p',k)

G=tf(num,den)

* you need column matrix. Hence you need to take the inverse matrix of z,p.

Plotting poles & zeroes of a system:

* you need to use 'pzmap' function for plotting.

* the poles are represented as x's and zeroes are represented as 0's.

pzmap(G)

Example - 08

$$G(s) = \frac{s^2 + 7s + 10}{s^3 + 6s^2 + 10s + 8}$$

G= tf([1,7,10],[1,6,10,8]);

sgrid;

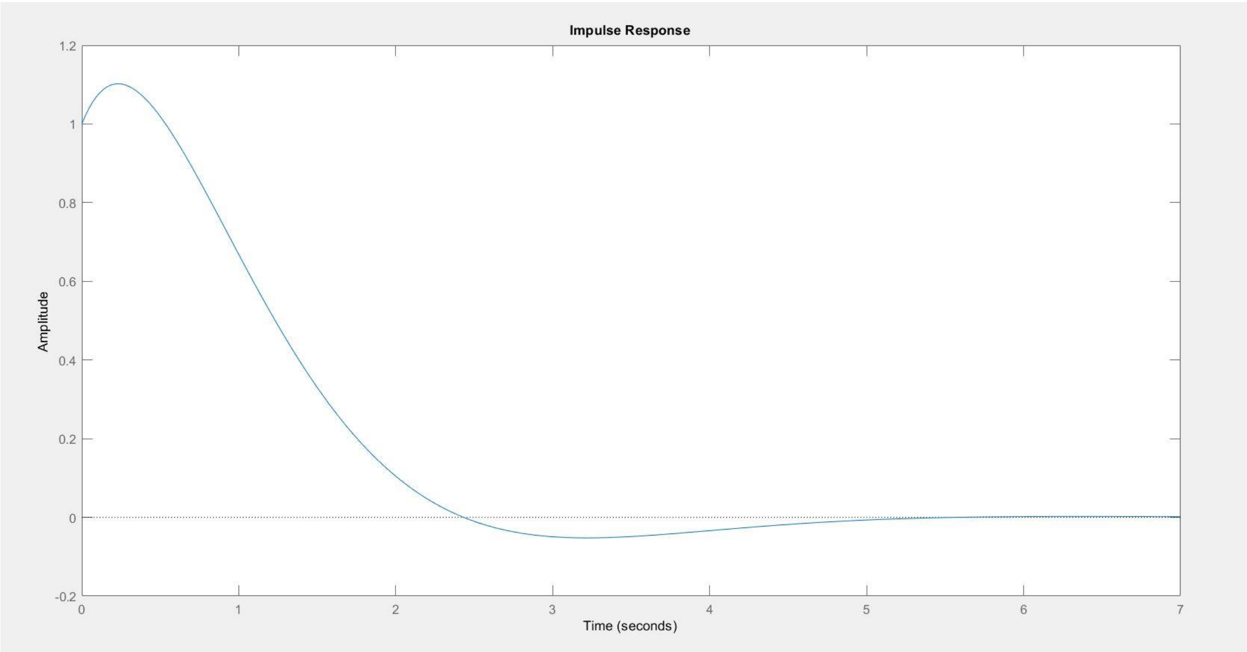
pzmap(G)

* You'll find complex poles in the map. Complex roots come as conjugate.

Simulation of LTI systems to different inputs:

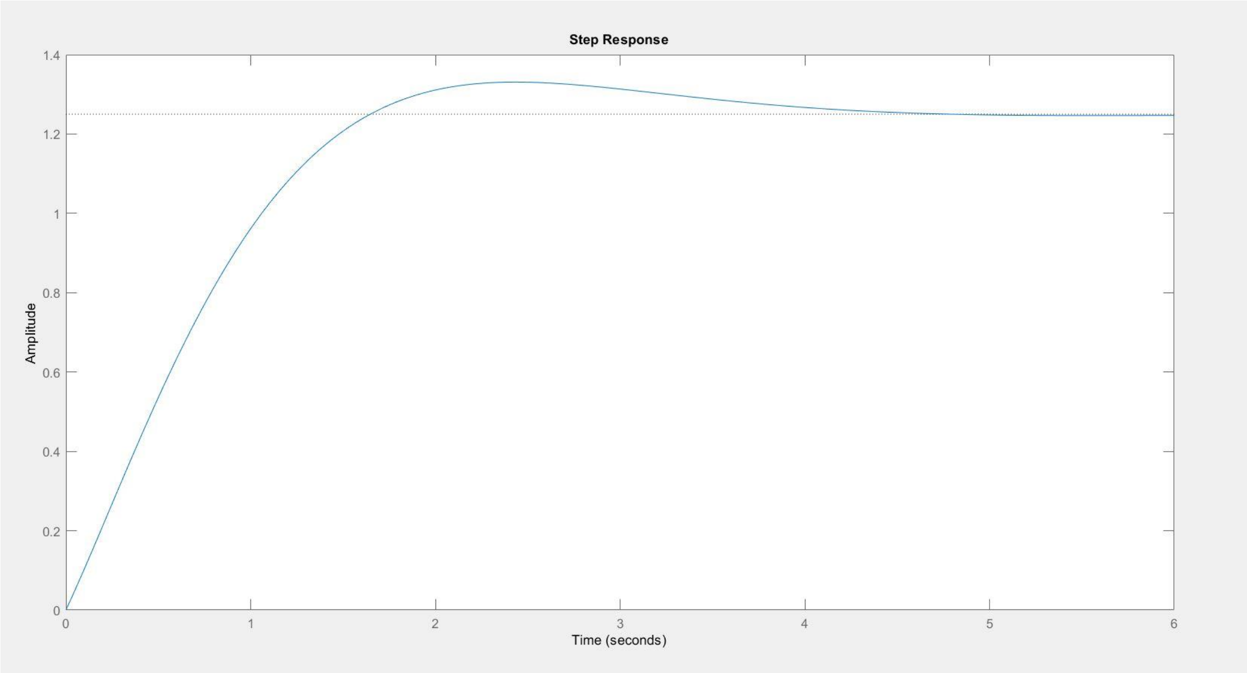
Impulse Response:

impulse(G)



Step Response:

step(G)



Ramp Response:

* there is no ramp command in Matlab. To obtain the ramp response, we need to multiply the transfer function by 1/s .

Example - 09

$$G(s) = \frac{s^2 + 7s + 10}{s^3 + 6s^2 + 10s + 8}$$

$$H(s) = \frac{s^2 + 7s + 10}{s(s^3 + 6s^2 + 10s + 8)}$$

H=tf([1,7,10],[1,6,10,8,0])

pzmap(H)

figure(2)

step(H)

*after multiplying by 1/s, taking the step response gives the ramp output.

*the figure command can be used to plot multiple figures simultaneously.

Arbitrary Response:

* lsim(linear simulation) command can be used.

*lsim(num,den,r,t)

Here, r is the input function and t is the time range.

R can be a sinusoidal function, exponential function etc.

```
num= [1,5];
den=[1,4];
t= 0:0.1:5;
r=exp(t);
y=lsim(num,den,r,t)
plot(t,y)
```

Feedback Control System:

* To apply positive feedback, use the syntax

```
sys = feedback(sys1,sys2,+1)
```

* By default, feedback(sys1,sys2) assumes negative feedback and is equivalent to feedback(sys1,sys2,-1).

$$G(s) = \frac{2s^2 + 5s + 1}{s^2 + 2s + 3}$$

$$H(s) = \frac{5(s+2)}{s+10}$$

```
G = tf([2 5 1],[1 2 3])
H = zpk(-2,-10,5)
Cloop = feedback(G,H)
step(Cloop)
```

Assignments

1. $G(s)=\frac{5}{s^2+10}$

2. $G(s)=\frac{6s^2}{s^7+10s^3}$

3. $G(s)=\frac{s}{(s+1)^3}$

4. Poles at -1+3i,-1-3i,-5. Zeroes at -4,-8. Gain 5. Obtain the transfer function.

Obtain the pzmap, step, impulse, ramp response for each of the cases.

5. $G(s)=\frac{s}{(s+1)(s^2+3s+5)}$

Find the step response for the unity feedback (both +ve and +ve) control system.