University of the District of Columbia

Control Systems Lab

Experiment #5

Dynamic system response

Impulse response

Impulse calculates the unit impulse response of a dynamic system model. For continuous-time dynamic systems, the impulse response is the response to a Dirac input $\delta(t)$. For discrete-time systems, the impulse response is the response to a unit area pulse of length `Ts` and height `1/Ts`, where `Ts` is the sample time of the system. (This pulse approaches $\delta(t)$ as `Ts` approaches zero.) For state-space models, impulse assumes initial state values are zero.

`impulse(sys)` plots the impulse response of the dynamic system model sys. This model can be continuous or discrete, and SISO or MIMO. The impulse response of multi-input systems is the collection of impulse responses for each input channel. The duration of simulation is determined automatically to display the transient behavior of the response.

To plot the impulse responses of several models sys1,..., sysN on a single figure, use:

```
impulse(sys1,sys2,...,sysN)
```

Step response

Step calculates the step response of a dynamic system. For the state-space case, zero initial state is assumed. When it is invoked with no output arguments, this function plots the step response on the screen.

`step(sys)` plots the step response of an arbitrary dynamic system model, sys. This model can be continuous- or discrete-time, and SISO or MIMO. The step response of multi-input systems is the collection of step responses for each input channel. The duration of simulation is determined automatically, based on the system poles and zeros.

To plot the impulse responses of several models sys1,..., sysN on a single figure, use:

```
step(sys1,sys2,...,sysN)
```

Example:

We would like to plot the impulse and step responses of the system below:

```
s=tf('s')
sys1=(2*s+1)/(s^2+3*s+2)
y1=impulse(sys1);
figure(1)
plot(y1)
title('Impulse Response');
xlabel('Time (sec)')
ylabel('y(t)')
grid on

y2=step(sys1);
figure(2)
plot(y2)
grid on
title('Step Response');
xlabel('Time (sec)')
ylabel('y(t)')
```

Assignments:

Please find the impulse and step responses of the systems below:

1- $\dfrac{30\,s + 180}{s^3 + 2\,s^2 + s}$

2- $\dfrac{wn^2}{s^2 + 2\,z\,wn\,s + wn^2}$

a) wn= 4 and z= 0.1, 0.3, 0.8;

b) wn=2.24 and z=-0.5, 0, 0.7, 1.2.

```
% Time Response for the second order systems

wn=2.24;
z1=0.1;
z2=0.5;
z3=0.8;

s=tf('s')
sys1=wn^2/(s^2+2*z1*wn*s+wn^2);
sys2=wn^2/(s^2+2*z2*wn*s+wn^2);
sys3=wn^2/(s^2+2*z3*wn*s+wn^2);

y1=impulse(sys1);
y2=impulse(sys2);
y3=impulse(sys3);

figure(1)
plot(y1)
hold on
plot(y2)
hold on
plot(y3)
title('Impulse Response');
xlabel('Time (sec)')
ylabel('y(t)')
grid on

y4=step(sys1);
y5=step(sys2);
y6=step(sys3);

figure(2)
plot(y4)
hold on
plot(y5)
hold on
plot(y6)
hold on

title('Step Response');
xlabel('Time (sec)')
ylabel('y(t)')
grid on
```