ECE355L Signals and Systems Lab

Project 2: Linear Time-Invariant System Response

Report due: 03/27/2024

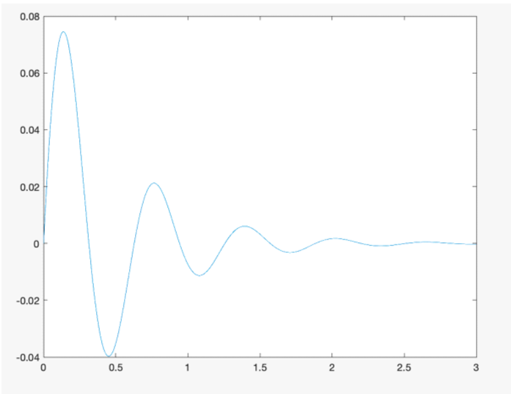
- **Zero-input Response**

The zero-input response can be solved symbolically using *dsolve*. To find the zero-input response of the system described by the differential equation with initial conditions (IC's):

$$y'' + 4y' + 104y = f' + 104f,\ y(0) = 0,\ y'(0) = 1$$

Enter the following code in command window to get the expressional form:

```
yo = dsolve('D2y + 4*Dy + 104*y = 0', 'y(0) = 0', 'Dy(0) = 1');

t = 0:0.001:3;

y = 1/10*exp(-2*t).*sin(10*t);

plot(t, y);

xlabel('t');

ylabel('y(t)');

title('Plot of Zero-Input Response');
```

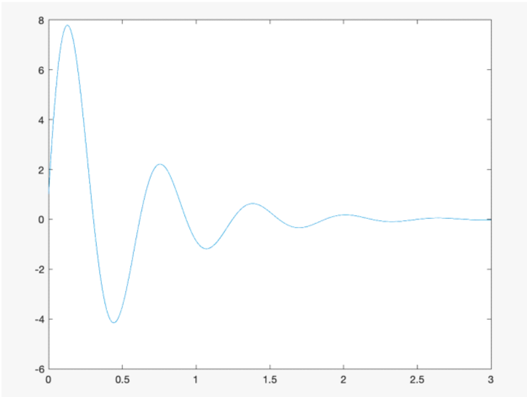


- **Zero-state Response**

The zero-state response can be found using *dsolve*. To find the zero-state response to a unit impulse (impulse response, $h(t)$) enter the following code.

```
syms t;

yn = dsolve('D2y + 4*Dy + 104*y = 0', 'y(0) = 0', 'Dy(0) = 1');
```

```
h = diff(yn) + 104*yn;

ht = matlabFunction(h); % Convert symbolic expression to a function handle

t_values = linspace(0, 10, 100); % Generate values of t for plotting

plot(t_values, ht(t_values));

xlabel('t');

ylabel('h(t)');

title('Plot of h(t)');
```



Continuous-time transfer function.

To find the zero-state response to a unit step function use the *step* function, this is part of the control system toolbox. There is also an *impulse* function for finding the impulse response and the *lsim* function for finding the response to an arbitrary input. All of these response generators assume zero initial conditions. Enter the following commands to plot the step and impulse responses.

```
% Define the numerator and denominator coefficients

num = [1 2];

den = [1 3 4];


% Create the transfer function object

TFsys = tf(num, den);


% Remove the roots from the transfer function

TFsys_no_roots = tzero(TFsys);
```

```
% Define the time vector

t_vec = 0:0.01:10; % Time vector from 0 to 10 with a step size of 0.01


% Calculate the step response

[ystep, t_step] = step(TFsys_no_roots, t_vec);


% Calculate the impulse response

[h, t_impulse] = impulse(TFsys_no_roots, t_vec);


% Plot the step response

subplot(2, 1, 1);

plot(t_vec(1:length(ystep)), ystep); % Adjust the length of t_vec

title('Step Response');

xlabel('t');

ylabel('y_{step}(t)');


% Plot the impulse response

subplot(2, 1, 2);
```

- **Exercises**

Please complete these exercises. Please submit the project 2 report at D2L by 03/27/2024. The report should include the results and commands that you used in these exercises.

1.) Use *dsolve* to obtain a symbolic expression for the zero-input response for the following system:

$$y''' + 8y'' + 2521y' + 5018y = f'' + 5018f, \quad y(0) = 1,\ y'(0) = 1,\ y''(0) = 0$$

2.) Plot the zero-input response for the system from part 1 with $0 \le t \le 4$.

3.) Create a system object using *tf* for the system from part 1 and obtain the zero-state impulse and step response using impulse and *step function.*