EE228 Spring 2007

LABORATORY EXPERIMENT #5

Engineering Problem: You are presented impulse response data from two remote systems A and B that have not been modeled and for which you do not have a circuit description. You are asked to predict the output of these systems to other input signals. There are two solutions to this problem: determine a transfer function that "fits" the impulse response data (sometimes challenging) or perform convolution. We will investigate both using impulse response data emailed to you in Excel files d5a.xls and d5b.xls. *Save these files in the directory you plan to place your MATLAB work.*

Problem A: The data for System A is listed in d5a.xls (time is column one and h(t) is column two). Load the data into Matlab as we did previously

FILE > IMPORT DATA

- Select the desired Excel file
- The data is loaded in as a matrix (Hint: use Matlab whos command to get the name)
- Copy the data into more convenient variable names, say tA for time and hA for the impulse response (Hint: the expression A(:,1) grabs all elements from column 1)

Complete the following steps:

1. Plot the impulse response. Does it appear that the response is over-damped or under- damped? How long does it take for the impulse response to decay (this is the settling time for the transient response)?
2. We wish to create the step response using convolution. You should consider using an M-file to expedite troubleshooting!
    a. Convert hA from a column vector to a row vector using the transpose operator '
    b. Create a row vector for the input that is 1.2 times the length of hA. Call this variable xA (Hint: to create a vector of ones, see the ones function in Matlab. Further, length(hA) gives you the number of values in hA, the round command rounds to the nearest integer). Over what time interval would xA be defined (assume uniform sampling)?
    c. Implement the convolution

```
% Identify the sampling time
>> dt = tA(2) – tA(1);

% Perform the convolution
>> yout = [ 0  ,  dt*conv( xA  ,  hA  ) ];
```

```
% Load up the output times
>> tout = linspace( 0 , dt*(length(xA)+length(hA)-1) , length(xA)+length(hA) );
```

d. Plot the result. Why do you get the second transient at the time corresponding to the end of the input?

e. Create youtA and toutA from yout and tout. These "shortened" outputs should be as long as the defined input. Generate a plot of toutA vs. youtA. Estimate the overshoot from your plot. **Have the instructor verify your results.**

Clear the Matlab workspace by typing >> clear all

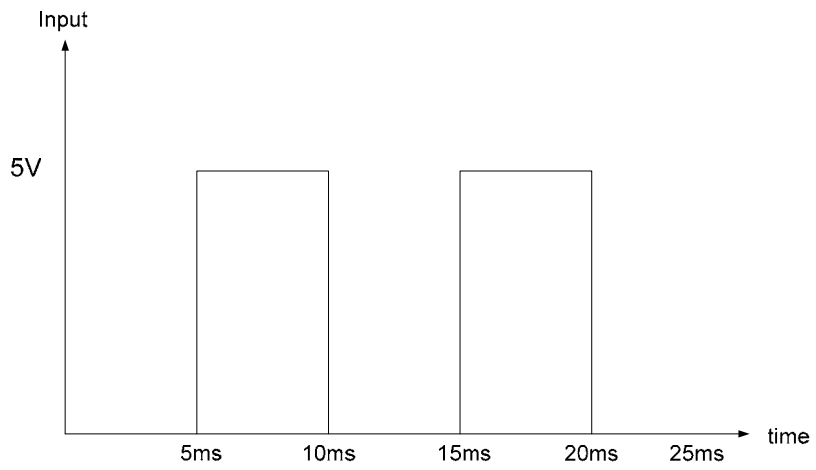
<u>Problem B</u>: The data for System B is listed in d5b.xls (time is column one and h(t) is column two). Load the data into Matlab as we did previously.

- Copy the data into more convenient variable names, say tB for time and h for the impulse response.

Complete the following steps:

1. Plot the impulse response. Note, this time you are told that the response is adequately described by a second-order critically damped transfer function. From your plot (or data), determine the peak value of the impulse response and the time that it occurs.
2. Create the step response for this system using convolution (Follow the steps from Problem A and plot the "shortened" response).
3. Next, let's try to "fit" our impulse response data to a transfer function and create the step response.
   a. Assume that the impulse response data can be adequately described by $hB(t) = ate^{-bt}u(t)$ where a and b are constants to be determined from our plot generated in Step 1. Take the derivative of this expression and set it equal to zero so you can establish an expression for the time at which the peak occurs (match with your data to estimate b). Substitute the maximum time expression back into hB(t) to establish an expression for the peak value (match with your data to estimate a). **Have your instructor verify your results**.
   b. Laplace transform hB(t) to determine our "estimate" of the transfer function.
   c. Use the step command in Matlab to create the step response (use the help command if you forget the correct syntax). Compare with that achieved using convolution.

4. Use convolution to create the output for System B due to the following "interesting" input (place your code in a separate M-file for ease of debugging).
    - Use the same dt for the input as you have for the hB(t) data
    - The input needs to be defined from 0s to 25ms. The find command may be useful to assign when the signal is 0V and when it is 5V
    - Plot the result



Please hand in any M-files that you create to generate output. Organize your results so that the data is sequentially presented and the relevant questions answered.