ECE 332 Lab 14m

Laplace and Matlab

While we are working in the Laplace (s) domain, we can use Matlab to do all sorts of work for us. Matlab can perform both Laplace and inverse Laplace transforms. It can plot the s-plane. It can generate the step and the impulse response of a system. It can plot a Bode diagram for a system and characterize its frequency response.

In this lab, we are going to concentrate just on using Matlab to do our work in the s-domain. We'll learn a number of new Matlab commands for doing this, and while we are learning, we'll also learn to use Matlab's notebook scheme to create a professional report of the result.

Goals

All of our goals revolve around Matlab:

- Learn to do Laplace and inverse-Laplace transforms.
- Learn to create time-domain results from systems described in the s-domain.
- Learn to use Matlab's notebook feature to create a report in Microsoft Word.

Laplace-Domain Matlab

This table lists a number of Matlab commands that are useful when working in the s-domain. If you want to know more about them, go to the MathWorks site shown below. Type into the search field the command you want to know about and you'll have lots of information:

`http://www.mathworks.com/help/techdoc/learn_ matlab/bqr_2pl.html`

A confusion that often arises in Matlab is the difference between transfer function and symbolic expression. It is important to distinguish these because some commands work with one, some with the other. The Table shows which commands work with which form, and some examples that follow will clarify things.

Some Matlab Commands

Matlab	Purpose
tf	Create transfer function
pzmap	Pole-zero plot of tf
impulse	Impulse response of tf
step	Step response of tf
damp	Poles, ζ, ω_o of tf
bode	Bode plot of tf
stepinfo	Rise and settle times, overshoot, peak
syms	Create symbolic variables
laplace	Transform the symbolic expression
ilaplace	Inverse transform symbolic expression
simplify	Simplify symbolic expression
collect	Gather terms of symbolic expression
pretty	Improve appearance of result
heaviside	Unit step function
dirac	Unit impulse function
subplot	Put plot on page in m-by-n grid cell

Notebook and Word

Before we start writing code, we need to learn how to write it so that what we produce makes an orderly, readable report rather than just a collection of Matlab code. The basic unit for the Matlab code is the cell, which is a grouping of related Matlab code that allows testing of each cell individually. The original document is created as an m-file that contains the code separated into cells.

Let's create a sample of this and demonstrate some of the s-domain Matlab commands at the same time. Here is the exercise:

- Plot a Bode diagram for $H_1(s) = \frac{5}{s+10}$.

- Plot a similar diagram for $H_2(s) = \frac{s}{s^2+5s+10}$ using a different way of stating the transfer function.
- Display the inverse Lapalce transform for $H_3(s) = \frac{3s}{(s+5)(s+40)}$.
- Display the Laplace transform for $v_4(t) = 10\cos(50t)$.

Link Matlab and Word

If you haven't linked Matlab and Word to make notebook possible, launch Matlab and type notebook -setup (note the space before the hyphen). This will take a few seconds, but once set up, the link should be permanent.

Create a Matlab Source File

The source code that will eventually be transferred to Word should be written first as an m-file formatted in cells so that sections can be tested individually. It is possible to write code directly into the linked file, but any error messages have to be cleaned out of the Word text.

Begin by creating an m-file via *File ⇒ New ⇒ Script*.

1. A cell begins with %% and, preferably, a title.
2. Cells can be evaluated to test the code one by one. Merely click anywhere inside a cell to highlight it. Then click the *Evaluate* cell button on the far left of the bar just above your working area.
3. Enter the code for the first task.

```
%% H1(s)
clear all
s = tf('s');
H1 = 5/(s+20)
bode(H1)
grid on
title('Bode plot for H1(s)')
```

4. Test your code in this cell by clicking anywhere inside the cell, which will highlight the cell, then clicking the *Evaluate* cell button on the far left of the bar just above your working area. If the outcome is acceptable, go on to write the next cell. If not, fix it.
5. Write the cell for the second task

```
%% H2(s)
H2 = tf([1],[1 5 10]);
bode(H2)
grid on
title('Bode plot of H2')
```

   Notice the two different ways of writing the transfer function. H_1 is written in algebraic form but only after defining s to be a transfer function variable. H_2 is written in a numerical transfer-function code, stating the coefficients of the numerator and denominator polynomials starting with the highest power of s. Test the code in this cell

6. Write and test a new cell to handle the inverse Laplace transform of H_3. For this, the function must be in the form of a symbolic expression. This requires defining two symbolic variables, s and t.

```
%% Inverse transform
syms s t
H3 = 3*s/((s+5)*(s+40));
h3 = ilaplace(H3);  % Note semicolon
pretty(h3)  % Make output neat
```

7. Write and test the last cell:

```
%% Laplace transform
syms s t
v4 = 10*cos(50*t) ;
V4 = laplace(v4);
pretty(V4)
```

Create a notebook in Word

Once you have all the Matlab code fully tested, transfer the code to a Word notebook to produce your report:

1. At the Matlab command prompt, type *notebook*, which will launch a blank Word document.
2. Write appropriate text for your report, such as a title and paragraphs as needed. In the sample report contained on the course website in the Handouts section, titled *Lab 14m Notebook.pdf*, the style has been set to *Traditional* using first-and second-level headings and normal text.
3. Insert the code from the first cell by copy and paste.
4. Execute this code by selecting all the lines of the code and doing <Ctrl><Enter>. You should see the same result as you got in your test.
5. Similarly, add headings and text, then copy and paste and execute the Matlab code for each of the remaining cells.
6. Improve your report as you see fit. You can delete outcomes and rerun the code segments. You can resize graphs and plots. You can copy and paste graphics from other sources, such as circuits and plots from Multisim. You are working with a standard Word document that happens to include executable Matlab code.

Lab Exercise

The work for this lab is divided into two parts, but all of this work is to be submitted as one notebook document. Your document should have a title and appropriate section titles. Graphs must have proper axis labels and titles. Your work will be judged by the readability and appearance of your report.

Part 1: Functions in the s-Domain

For each of the following functions, use Matlab to produce:

- Pole-zero diagram
- Bode plot
- Step response
- Inverse Laplace Transform

$$H_1(s) = \frac{40s}{s^2 + 1{,}000{,}000}$$

$$H_2(s) = \frac{200(s+10)}{s^2 + 10000s + 1{,}000{,}000}$$

$$H_3(s) = \frac{20{,}000}{s(s^2 + 10{,}000s + 1{,}000{,}000)}$$

$$H_4(s) = \frac{10{,}000s^3}{(s+10)(s+10)(s+10)(s+10)(s+10)(s+10)}$$

Part 2: Laplace Transform

For each of the following functions, use Matlab to produce the Laplace transform in proper form:

$$v_1(t) = [100\cos(10t) - 50]\, u(t)\ V$$

$$v_2(t) = e^{-50t}\,[100\cos(10t) - 50\sin(10t)]\, u(t)\ V$$

$$i_1(t) = 10\delta(t) + \left[100e^{-50t} - 100e^{-200t}\right] u(t)\ mA$$

$$i_2(t) = \left[10 + 100e^{-100t} - 100te^{-200t}\right] u(t)\ mA$$

Reporting

Save your notebook file and submit to your instructor via email. Name your file like the following:

```
ECE332_Lastname_Lab14m.doc
```

The End

You are finished with the tasks assigned in this lab when you have emailed your report to your instructor.