ROSE-HULMAN INSTITUTE OF TECHNOLOGY
Department of Electrical and Computer Engineering

EC 300 Signals and Systems — Fall 2000

B.A. Black

Introduction to MATLAB

Objectives

The purpose of this lab is to play with MATLAB. While playing you should learn many of the commands we will be using throughout the quarter. Don't be afraid to try things. You can't break it. The best source of information on MATLAB is the `help` command.

Pre-Lab

The pre-lab for this first lab is to get MATLAB and the signal processing toolbox installed on your laptop. The MATLAB password will be given out in class. Be sure to have MATLAB installed and running before you come into lab. Each student will need a copy. There will not be time during lab to do the installation. Make an entry in one partner's lab notebook indicating the date and time that you and your partner each successfully installed MATLAB. Photocopy the notebook entry and hand it in.

Play Time

(a) Explore the MATLAB help capability. Try the following:

```
help
help plot
helpwin plot
help colon
lookfor filter % keyword search
```

The text following the % is a comment; such text may be omitted without altering the command function.

(b) Make sure that you understand the colon notation. In particular, explain what the following MATLAB code will produce:

```
jkl = 2:4:17
jkl = 99:-1:88
ttt = 2:1/9:4
tpi = pi*[2:-1/9:0]
```

(c) Extracting and/or inserting numbers in a vector is very easy to do. Consider the following definition:

```
x = [ones(1,3),[5:2:13],zeros(1,4)]
x(6:9)
```

Explain the result echoed from `x(6:9)`. Now write a single statement that will replace `x(6:9)` in the existing vector `x` with zeros.

(d) Use MATLAB as a calculator. Try the following:

```
pi*pi-10
sin(pi/4)
```

```
ans^2*3 % ans holds the last result
```

(e) Do variable name assignment in MATLAB . Try the following:

```
x = sin(pi/5);
cos(pi/5) % assigned to what?
y = sqrt(1-x*x)
ans
```

NOTE: The semicolon at the end of a statement will suppress the echo to the screen.

(f) Experiment with vectors in MATLAB. Think of the vector as a set of numbers. Try the following:

```
kset = -3:11;
kset
cos(pi*kset/4) % compute cosines
```

Explain how the last example computes the different values of cosine.

(g) Loops can be done in MATLAB, but they are NOT the most efficient way to get things done. It's better to **avoid loops** and use the vector notation instead. Here is a loop that computes values of the sine function. (The index of `x()` must start at 1.) Rewrite this computation without using the loop.

```
x = []; % initialize the x vector to a null
for i=0:7
   x(i+1)=sin(i*pi/4)
end
x
```

(h) Complex numbers are natural in MATLAB. The basic operations are supported. Try the following:

```
z = 3+j*4
conj(z)
abs(z)
angle(z)
real(z)
imag(z)
exp(j*pi)
exp(j*[pi/4 -pi/4])
```

(i) Plotting is easy in MATLAB, for both real and complex numbers. The basic plot command will plot a vector `y` versus a vector `x`. Try the following:

```
x = [-3 -1 0 1 3];
y = x.*x-3*x;
plot(x,y)
z=x + x*j
plot(z) % complex values can be plotted
subplot(2,1,1), plot(x,y)
subplot(2,1,2), plot(z)
subplot(1,1,1)
```

Use `helpwin arith` *to learn how the operation* `x.*x` *works. Compare to matrix multiplication* `x*x`*.*

(j) Use the MATLAB editor ("File → New → M-File") to create a file called `sintest.m` containing the following lines:

```
t = -2:0.05:3;
x = sin(2*pi*0.789*t); % plot a sinusoid
plot(t,x), grid
title('Test Plot of Sinusoid')
xlabel('Time (s)');
```

Run your function from MATLAB by typing its name (`sintest`) at the MATLAB prompt (note that `sintest` must reside in MATLAB's search path. See `helpwin path` for details.) You can verify the contents of `sintest` by typing `type sintest`.

(k) Edit `sintest.m` to use the `hold on` function followed by another plot command to add a plot of `0.5*cos(2*pi*0.789*t)` to the plot created above.

(l) Run the MATLAB demos; enter `demo` and explore some of the different demos of basic MATLAB commands and plots.

Manipulating Sinusoids with MATLAB

Generate two five-kilohertz sinusoids with arbitrary amplitude and phase:

$$x_1(t) = A_1 \cos(2\pi 5000t + \phi_1)$$

$$x_2(t) = A_2 \cos(2\pi 5000t + \phi_2)$$

1. Select the value of the amplitudes and phases at random. Use your age for A_1, and the largest digit of your SSN for A_2. For the phases, use the last two digits of your SSN for ϕ_1 (in degrees), and take $\phi_2 = -75^\circ$. NOTE: When doing computations, make sure to convert degrees to radians!

2. Make a plot of both signals over a range of t that will exhibit approximately three cycles. Include appropriate title and axis labels. Make sure the plot starts at a negative time so that it will include one cycle before time $t = 0$ AND make sure that you have at least twenty samples per period of the wave.

3. Verify that the phases of the two signals $x_1(t)$ and $x_2(t)$ are correct by examining the plot at $t = 0$, and also verify that each signal has the correct amplitude.

4. Use `subplot(3,1,1)` and `subplot(3,1,2)` to make a three-panel subplot that puts both of these plots on the same page. See `help subplot`.

5. Create a third sinusoid as the sum $x_3(t) = x_1(t) + x_2(t)$. In MATLAB this amounts to summing the vectors that hold the samples of each sinusoid. Make a plot of $x_3(t)$ over the

same range of time as used in the last plot. Include this as the third panel in the plot by using `subplot(3,1,3)`.

6. Measure the magnitude and phase of $x_3(t)$ directly from the plot. Make sure that you **show on the plot how the magnitude and phase were measured**.

Report

Record the results of all of your work in one partner's lab notebook. Tape any printout (graphs, for example) into the notebook as specified in the Lab Manual for the course. (You must provide your own tape.) Be sure that all members of your lab group sign the lab notebook, and hand the notebook in at the end of lab.