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# **DIGITAL COMMUNICATIONS**

## **LAB MANUAL**

**Fall-2016**

## Lab Manual of Digital Communications

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## EXPERIMENT # 1

### **MATLAB Basics for Communication System Design**

#### **Objective**

- To understand the use of MATLAB for solving communication engineering problems.
- Learn the basics of MATLAB as used in Analogue Communication.
- To develop understanding of MATLAB environment, commands and syntax.

#### **MATLAB**

MATLAB is a powerful tool that is utilized by the engineers and others professionals in development and testing of various projects. It is versatile software, with the help of which you can solve and develop any sort of engineering problem. The name MATLAB stands for MATRIX LABORATORY. All the work done in MATLAB is basically in the form of matrices. Scalars are referred as 1-to-1 matrix and vectors are matrices having more than 1 row and column. MATLAB is programmable and have the same logical, relational, conditional and loop structures as in other programming languages, such as C, Java etc. It's very easy to use MATLAB, all we need is to practice it and become a friend of it.

#### **Summary:**

- **Scalars**
- **Vectors**
- **Matrices**
- **Plotting**
- **m-files**
- **functions**

#### **Getting Started:**

a) Go to the start button, then programs, MATLAB and then start MATLAB. It is preferred that you have MATLAB7. You can then start MATLAB by double clicking on its icon on Desktop, if there is any.

b) The Prompt:

```
>>
```

The operator shows above is the prompt in MATLAB. MATLAB is interactive language like C, Java etc. We can write the commands over here.

c) In MATLAB we can see our previous commands and instructions by pressing the up key. Press the key once to see the previous entry, twice to see the entry before that and so on. We can also edit the text by using forward and back-word keys.

#### **Help in MATLAB**

In order to use the built-in help of the MATLAB we use the **help** keyword. Write it on the prompt and see the output.

```
>> help sin
```

Also try

>> lookfor sin

### Scalars

A scalar is a single number. A scalar is stored in the MATLAB as a 1 x 1 matrix. Try these on the prompt.

>> A = 2;

>> B = 3;

>> C = A^B

>> C = A\*B

Try these instructions as well

>> C = A+B

>> C = A-B

>> C = A/B

>> C = A\B

Note the difference between last two instructions.

Try to implement these two relations and show the result in the provided space

تمرین (۱) مقادیر عبارات زیر را با استفاده از نرم افزار مطلب محاسبه نمایید.

a)  $25 (3^{1/3}) + 2 (2+9^2) =$  \_\_\_\_\_

b)  $5x^3 + 3x^2 + 5x + 14$  for  $x = 3$  is \_\_\_\_\_

c) Solve this quadratic equation using quadratic formula.

تمرین (۲) ریشه های معادله درجه ۲ با ضرایب زیر را توسط نرم افزار مطلب محاسبه نمایید.

$a = 2.5, b = 5, c = -6$

$x =$  \_\_\_\_\_ and \_\_\_\_\_

### Vectors

Vectors are also called arrays in MATLAB. Vectors are declared in the following format.

تمرین (۳) دستورات زیر را در پنجره فرمان مطلب وارد کرده و جاهای خالی را پر کنید.

>> clear all; X = [1 2 3 4+j]

>> Y = [2 5 8 9]

Try these two instructions in MATLAB and see the results.

>> length(X) = \_\_\_\_\_

>> size(X) = \_\_\_\_\_

What is the difference between these two?

تفاوت دو دستور بالا چیست؟

---

Try these instructions and see the results.

>> X.\*Y = \_\_\_\_\_

>> X.^Y = \_\_\_\_\_

>> X+Y = \_\_\_\_\_

>> X-Y = \_\_\_\_\_

>> X./Y = \_\_\_\_\_

>> X.\Y = \_\_\_\_\_

>> X' = \_\_\_\_\_

>> X.' = \_\_\_\_\_

>> exp(Y)=\_\_\_\_\_

>> sum(Y)=\_\_\_\_\_

>> 4+Y=\_\_\_\_\_

>> 4\*Y=\_\_\_\_\_

>> 4./Y=\_\_\_\_\_

>> Y/5=\_\_\_\_\_

>> Y.^2+X.^3=\_\_\_\_\_

>> real(X)=\_\_\_\_\_

>> imag(X)=\_\_\_\_\_

>> abs(X)=\_\_\_\_\_

>> angle(X)=\_\_\_\_\_

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>> conj(X)=\_\_\_\_\_

Also try some new instructions for this like and notice the outputs in each case.

>> ones (1,4)

>> ones (2,4)

>> ones (4,1)

>> zeros (1,4)

>> zeros (2,4)

There is an important operator, the colon operator (:), it is very important operator and frequently used during these labs. Try this one.

>> X = [0:0.1:1]

Notice the result. And now type this

>> length (X) = \_\_\_\_\_

>> size (X) = \_\_\_\_\_

What did the first and second number represent in the output of last instruction?

عدد اول و دوم در خروجی آخرین دستور چه چیزی را مشخص می کنند؟

---

Now try this one.

>> A= [ones(1,3), [2:2:10], zeros(1,3)]

What is the length and size of this?

length(A) = \_\_\_\_\_

size(A) = \_\_\_\_\_

Try 'help ones' and 'help zeros' as well, and note down its important features.

### MATRICES

Try this and see the output.

>> A = [1 2 3;4 5 6;7 8 9]

>> B = [1,2,3;4,5,6;7,8,9]

Is there any difference between the two? Try to implement 2-to-3 matrix and 3-to-2 matrix.

Also take help on **mod**, **rem**, **det**, **inv** and **eye** and try to implement them. Try to use **length** and **size** commands with these matrices as well and see the results.

Try to solve these.

تمرین ۴) دستگاه معادلات زیر را با استفاده از روابط ماتریسی حل کنید.

1.  $6x + 12y + 4z = 70$

$$7x - 2y + 3z = 5$$

$$2x + 8y - 9z = 64$$

تمرین ۵) به ازای ماتریس داده شده حاصل عبارت ماتریسی زیرش را بیابید.

2.  $A = [2 \ 3 \ 4 \ 5; 1 \ 8 \ 9 \ 0; 2 \ 3 \ 1 \ 3; 5 \ 8 \ 9 \ 3]$

$$6A - 2I + A^2 =$$

### PLOTTING

Plotting is very important as we have to deal with various type of waves and we have to view them as well. Try these and have a look on the results.

```
>> x = [0:0.1:10];
>> y = sin (x);
>> z = cos (x);
>> subplot (3,1,1);
>> plot (x,y); >> grid on;
>> subplot (3,1,2);
>> plot (x,z);
>> grid on; hold on;
>> subplot (3,1,3);
>> stem (x,z);
>> grid on;
>> stem (x,y,'r');
```

Take **help** on the functions and commands that you don't know. See the difference between the **stem** and **plot**.

See help on plot, figure, grid, hold, subplot, stem and other features of it.

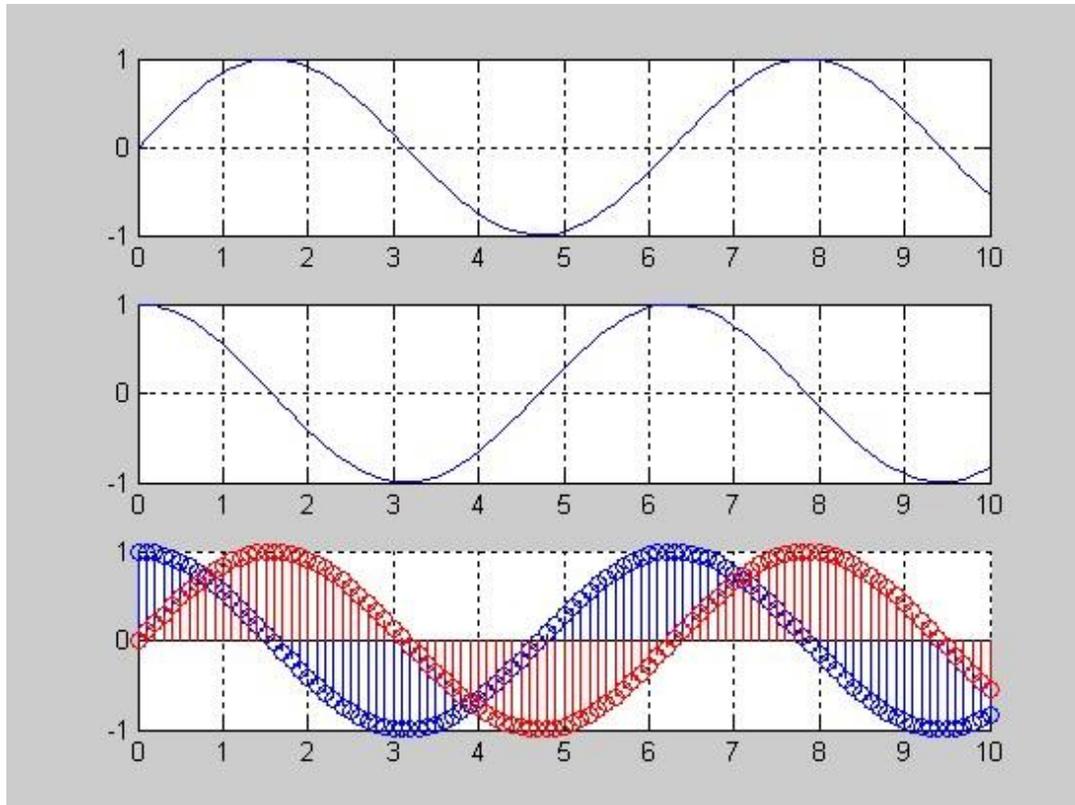


Figure 1.1

## M-FILES

MATLAB can execute a sequence of statements stored in disk files. Such files are called M-files because they must have the file type **‘.m’**. Lot of our work will be done with creation of m-files.

There are two types of m-files: Script and function files.

### Script Files

We can use script files in order to write long programs such as one on the previous page. A script file may contain any command that can be entered on the prompt. Script files can have any name but they should be saved with “.m” extension. In order to execute an m-file from the prompt, just type its name on the prompt. You can make an m-file by typing **edit** on the prompt or by clicking on the file then new and m-file. See an example of m-file. Write it and see the results.

```
% This is comment
```

```
% A comment begins with a percent symbol
```

```
% The text written in the comments is ignored by the MATLAB
```

```
% comments in your m-files.
```

```
clear;
```

```

clc;
x = [0:0.1:10];
y = sin (x);
subplot (2,2,1);
plot (x,y,'r');
grid on;
z = cos (x);
subplot (2,2,2);
plot (x,z); grid on;
w =pi/2;
yy = 2*pi*sin (x+w);
subplot (2,2,3);
plot (x,yy);
grid on;
zz = sin(x+2*w);
subplot (2,2,4);
stem (x,zz,'g');
hold on;
stem (x,y,'r');
grid on;

```

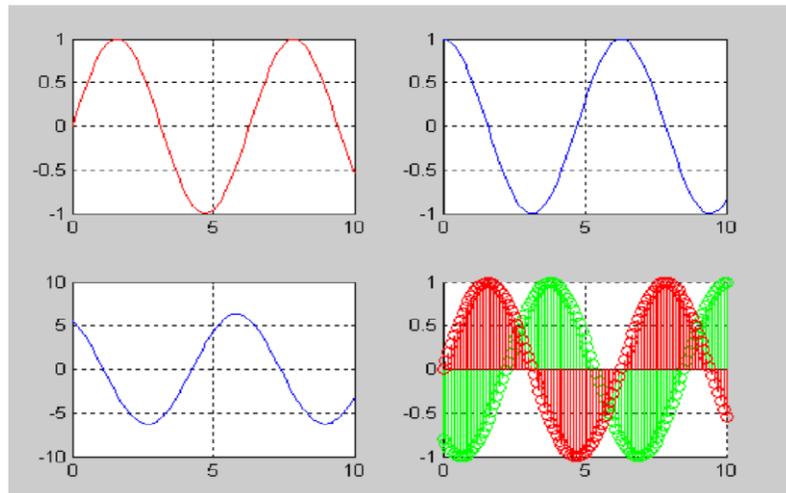


Figure 1.2

### Function Files

MATLAB have many built-in functions including trigonometry, logarithm, calculus and hyperbolic functions etc. In addition we can define our own functions and we can use built-in functions in our functions files as well. The function files should be started with the function definition and should be saved with the name of function. The general format of the function file is

`function [output_variables] = function_name (input_variables)`

See the following example and implement it.

```
% this is a function file

% this function computes the factorial of a number
function [y] = my_func (x)

y = factorial (x);
```

## POST LAB

Try to develop a function that will compute the maximum and minimum of two numbers.

تمرین ۶) تابعی را ایجاد کنید که یک بردار را به عنوان ورودی گرفته و حاصل جمع تمامی عناصر و همچنین حاصل ضرب تمامی عناصر آنرا به ترتیب به خروجی اول و خروجی دوم ارسال نماید. (راهنمایی: از دستور `length` و حلقه `for` استفاده نمایید.)

تمرین ۷) تابعی ایجاد کنید که یک بردار را به عنوان ورودی گرفته و میانگین عناصر آنرا به خروجی می فرستد. (راهنمایی: از دستور `length` و حلقه `for` استفاده نمایید.)

تمرین ۸) دستور `sum` را بر روی چند ماتریس اعمال کرده و استنباط خود را از نتایج حاصل بیان کنید. با استفاده از اسنباط بدست آمده بیان کنید برای محاسبه حاصل جمع تمامی عناصر ماتریس چگونه می توان از دستور `sum` استفاده نمود؟