University of Global Village (UGV), Barishal
Dept. of Electrical and Electronic Engineering (EEE)

Lab Manual

Communication Theory Sessional

EEE 0714-3102

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Contents

Course Title:	Communication Theory Sessional	Total Class Hour	37
Course Code:	EEE 0714-3102	Total Practice Hour	37
Supervised by	Noor Md Shahriar	Total Hour	85

Course Rationale

The Communication Theory Lab provides hands-on experience in signal processing and modulation techniques using MATLAB and Simulink. It bridges theory and real-world applications in telecommunications and wireless communication. Through experiments on signal generation, modulation, and digital communication, students develop problem-solving skills and gain practical insights into communication systems. The lab enhances analytical thinking, preparing students for advanced research and industry applications in modern communication technologies.

Course Objectives

- To develop practical skills in communication signal generation and processing using MATLAB and Simulink.
- To understand and implement various analog and digital modulation techniques.
- To analyze and interpret the performance of communication systems through hands-on experiments.
- To bridge theoretical concepts with real-world communication applications.
- To enhance problem-solving and analytical skills for research and industry.

Course Learning Outcomes (CLO)

CLOs	Course Learning Outcome Description
CLO1	Understand the fundamentals of MATLAB and Simulink for communication system design.
CLO2	Generate, analyze, and manipulate communication signals using MATLAB.
CLO3	Implement and evaluate amplitude modulation and demodulation techniques.
CLO4	Analyze and simulate digital modulation schemes such as ASK, PSK, and FSK.
CLO5	Demonstrate the working principles of Pulse Code Modulation (PCM) and Delta Modulation.

Course Outline

Sl. No.	Topic & Details	Class Hours	CLO Mapping
1	Introduction to MATLAB for Communication Systems – Basics of MATLAB and Simulink for communication system design.	5	CLO1
2	Communication Signals: Generation and Operations – Creating and manipulating signals in time and frequency domains.	5	CLO1, CLO2
3	Amplitude Modulation (AM) – Implementation and analysis using MATLAB and Simulink.	5	CLO2
4	Digital Modulation Techniques – ASK, PSK, and FSK implementation and performance evaluation.	5	CLO2, CLO3

5	Pulse Code Modulation (PCM) & Delta Modulation – Signal sampling, quantization, and reconstruction.	5	CLO3
6	Noise & Signal Distortion Analysis – Effect of noise in modulation techniques.	5	CLO3, CLO4
7	Practical Applications & System Evaluation – Real-world case studies and performance optimization.	5	CLO4

Course Schedule

Week	Topic & Details	Class Hours	CLO Mapping	Teaching-Learning Strategy	Assessment Strategy
1	MATLAB Basics for Communication System Design	2	CLO 1	Hands-on MATLAB session	Lab performance, viva
2	Communication Signals: Generation and Interpretation	2	CLO 2	MATLAB coding and signal visualization	Lab report, viva
3	Communication Signals: Operations (Shifting, Scaling, Folding)	2	CLO 2	Practical MATLAB exercises	Observation, report
4	Introduction to Amplitude Modulation (Simulink Implementation)	2	CLO 3	Simulink-based AM signal design	Lab report, viva
5	Introduction to Amplitude Modulation (MATLAB Implementation)	2	CLO 3	MATLAB-based AM implementation	Experiment evaluation
6	Amplitude Shift Keying (ASK)	2	CLO 4	MATLAB coding for digital modulation	Practical assessment
7	Phase Shift Keying (PSK)	2	CLO 4	MATLAB-based PSK implementation	Viva, report submission
8	Frequency Shift Keying (FSK)	2	CLO 4	MATLAB-based FSK implementation	Performance evaluation
9	Mid-term Review and Lab Project Discussion	2	All CLOs	Group discussion, problem-solving	Feedback, project proposal
10	Pulse Code Modulation (PCM)	2	CLO 5	MATLAB simulation of PCM encoding	Report evaluation, viva
11	PCM Demodulation	2	CLO 5	MATLAB-based PCM demodulation	Practical test, viva
12	Delta Modulation	2	CLO 5	MATLAB simulation of delta modulation	Lab report, oral questioning
13	Simulation of a Basic Communication System	2	All CLOs	Integrated system design using MATLAB/Simulink	Peer review, assessment
14	Final Project Implementation	2	All CLOs	Group-based project development	Project report
15	Project Testing and Debugging	2	All CLOs	Hands-on debugging session	Performance evaluation
16	Final Lab Exam	2	All CLOs	Practical exam covering all experiments	Graded evaluation
17	Final Report Submission & Review	2	All CLOs	Review of all lab work and reports	Submission review, feedback

Assessment Pattern

- Continuous Assessment

Bloom's Category	Tests
Imitation	12
Manipulation	8
Precision	6
Articulation	2
Naturalization	2

- Semester End Examination: (SEE):

Bloom's Category Marks (out of 30)	Tests (20)	Quiz (10)	External Participation in Curricular/Co-Curricular Activities (20)
Imitation	**06**	**06**	Bloom's Affective Domain: (Attitude or will) • **Attendance: 10** • **Viva-Voca: 5** • **Report Submission: 5**
Manipulation	**04**	**04**	
Precision	**06**		
Articulation	**02**		
Naturalization	**02**		

References

- B. P. Lathi, Zhi Ding – *Modern Digital and Analog Communication Systems*, Oxford University Press.
- Simon Haykin – *Communication Systems*, Wiley.
- John G. Proakis, Masoud Salehi – *Fundamentals of Communication Systems*, Pearson.
- Hwei P. Hsu – *Schaum's Outline of Analog and Digital Communications*, McGraw-Hill.
- MATLAB & Simulink Documentation – MathWorks (For signal processing and communication system simulations).

List of Experiments

Exp. No	Experiment Title
1.	MATLAB Basics for Communication System Design
2.	Communication Signals: Generation and Interpretation
3.	Communication Signals: Operations
4.	Introduction to Amplitude Modulation (Simulink Implementation)
5.	Introduction to Amplitude Modulation (MATLAB Implementation)
6.	Amplitude Shift Keying (ASK)
7.	Phase Shift Keying (PSK)
8.	Frequency Shift Keying (FSK)
9.	Pulse Code Modulation & Demodulation
10.	Delta Modulation

Experiment # 1

Experiment Title: 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 an understanding of the MATLAB environment, commands, and syntax.

MATLAB

MATLAB is a powerful tool used by engineers and other professionals in developing and testing various projects. It is versatile software that helps you solve and develop any sort of engineering problem. The name MATLAB stands for MATRIX LABORAORY. 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 has 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 MATLAB2015a. 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

a. $25 (3^{1/3}) + 2 (2+9^2) =$ _____

b. $5x^3 + 3x^2 + 5x + 14$ for x = 3 is _____

Vectors

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

```
>> X = [1 2 3 4]

>> Y = [2 5 8 9]
```

Try these two instructions in MATLAB and see the result

>> length (X) = _____

>> size (X) = _____

What is the difference between these two?

Try these instructions and see the results.

>> X.*Y = _____

>> X.^Y = _____

>> X+Y = _____

>> X-Y = _____

>> X./Y = _____

>> 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?

Now try this one.

>>A= [ones(1,3), [2:2:10], zeros(1,3)] What is the length and size of this?

>> Length = _____

Size = _____

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.

1. 6x + 12y + 4z = 70 7x – 2y + 3z= 5
   2x + 8y -9z = 64

2. A = [2 3 4 5; 1 8 9 0; 2 3 1 3; 5 8 9 3] Solve $6A - 2I + A^2$ =

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;
>> hold on;
>> subplot (3,1,3);
>> 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.

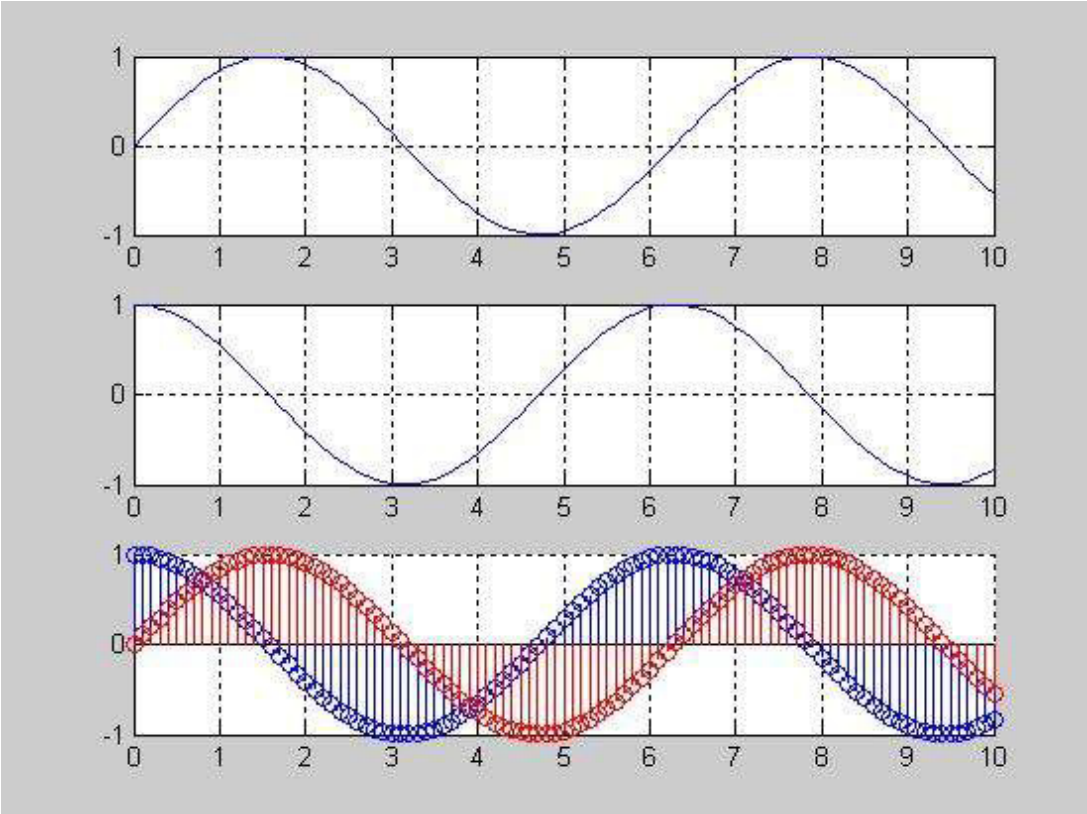


Figure 1.1

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 excurse 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
= 90;
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;
```

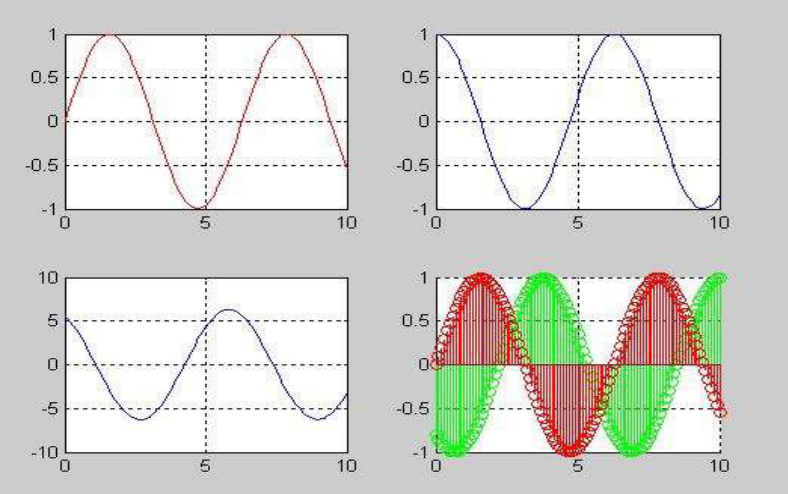


Figure 1.2

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.

Experiment # 2

Experiment Title: Communication Signals: Generation and Interpretation

Objective

- To the use of MATLAB for the generation of different signals important in communication theory.
- Learn the basics of signals and its operations as used in Analogue Communication.
- To develop an understanding of communication signals and their properties.

Generation of Signals

Signals are represented mathematically as a function of one or more independent variables. We will generally refer to the independent variable as time. Therefore we can say a signal is a function of time. Write these instructions in m-file as execute to see the result.

Sinusoidal Sequence:

```
% Example 2.1
% Generation of sinusoidal signals
% 2sin( 2πτ-π/2)
t=[-5:0.01:5];
x=2*sin((2*pi*t)-(pi/2));
plot(t,x)
grid on;
axis([-6 6 -3 3])
ylabel ('x(t)')
xlabel ('Time(sec)')
title ('Figure 2.1')
```

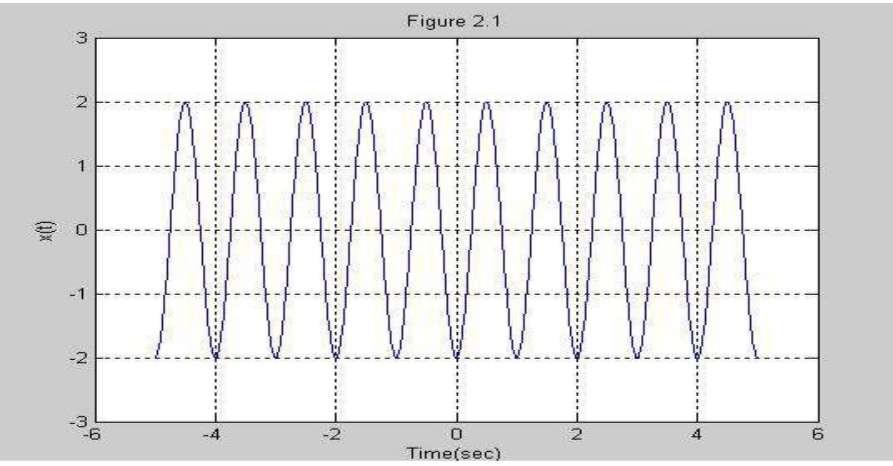


Figure 2.1

See the output, change the phase shift value and observe the differences.

Discrete Time Sequences:

See the example below:

```
 % Example 2.2
% Generation of discrete time signals n =
[-5:5];
x = [0 0 1 1 -1 0 2 -2 3 0 -1];
stem (n,x);
axis ([-6 6 -3 3]);
xlabel ('n'); ylabel
('x[n]'); title
('Figure 2.2');
```

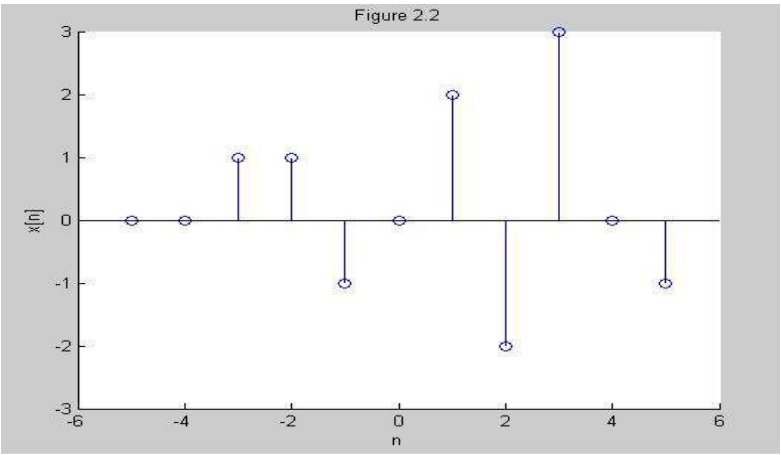


Figure 2.2

Unit Impulse Sequence:

A unit impulse sequence is defined as

Delta (n) = 1 n = 0

= 0 n ≠ 0

We are making a function named imseq and we further use this function in next experiments of this lab. The MATLAB code is given below:

```
function [x,n] = impseq(n0,n1,n2)

% Generates x(n) = delta (n-n0); n1<=n,n0 <= n2
% x[x,n] = imseq(n0,n1,n2)
% n0 = impulse position, n1 = starting index, n2 = ending index If ((n0
< n1) | (n0 > n2) | (n1 > n2))
    Error('arguments must satisfy n1 <= n0 <= n2')
end
n = [n1:n2];
% x = [zeros(1,(n0-n1)),1,zeros(1,(n2-n0))]; x

= [(n-n0) == 0];
```

Unit Step Sequence:

It is defined as

u(n) = 1 n ≥ 0

0 n ≤ 0

The MATLAB code for stem sequence function is given below:

```
function [x,n] = stepseq(n0,n1,n2)
% Generates x(n) = u(n-n0); n1 <= n, n0<=n2
% [x,n] = stepseq(n0,n1,n2)
if ((n0 < n1) | (n0 > n2) | (n1 > n2)) error('arguments
    must satisfy n1 <= n0 <= n2')
end
n = [n1:n2];
% x = [zeros(1,(n0-n1)),ones(1,(n2-n0+1))]; x
= [(n-n0) >= 0];
```

Real Valued Exponential Sequence:

It is define as:

x (n) = an, for all n; a € Real numbers

We require an array operator " **.^** " to implement a real exponential sequence. See the MATLAB code below

```
>> n = [0:10];
>>x = (0.9).^n;
```

Observe the result

Complex Valued Exponential Sequence:

It is define as:

x(n) = e (a + jb) n , for all n

Where **a** is called the attenuation and **b** is the frequency in radians. It can be implemented by following MATLAB script.

```
>> n = [0:10];
>> x = exp ((2+3j)*n);
```

Random Sequence:

Many practical sequences cannot be described by the mathematical expressions like above, these are called random sequences. In MATLAB two types of random sequences are available. See the code below:

```
>>rand (1,N)
```

>> randn (1,N)

The above instruction generates a length **N** random sequence whose elements are uniformly distributed between [0,1]. And the last instruction, **randn** generates a length **N** Gaussian random sequence with mean 0 and variance 1. Plot these sequences.

% example 2.3

```
%Generation of random sequence n =
[0:10];
x = rand (1, length (n));  y
= randn (1, length (n));
plot (n,x) ;
grid on; hold
on;
plot(n,y,'r');
ylabel ('x & y')
xlabel ('n')
title ('Figure 2.3')
```

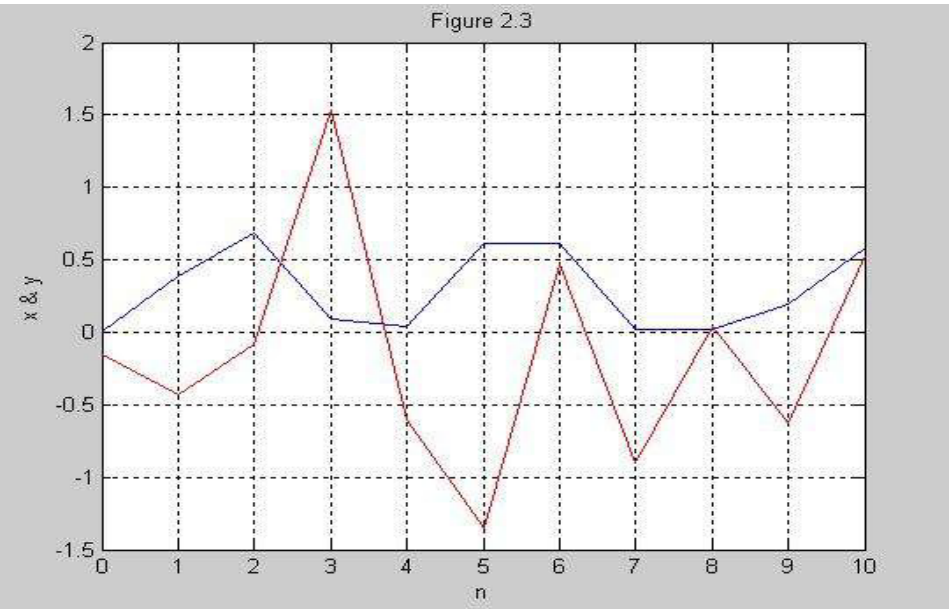


Figure 2.3

Periodic Sequences:

A sequence is periodic if it repeats itself after equal interval of time. The smallest interval is called the fundamental period. Implement code given below and see the periodicity.

%Example 2.4

```
% Generation of periodic sequences
```

```
n = [0:4];
x = [1 1 2 -1 0];
subplot (2,1,1);
stem (n,x);
grid on;
axis ([0 14 -1 2]);
xlabel ('n');
ylabel ('x(n)');
title ('Figure 2.4(a)');
xtilde = [x,x,x];
length_xtilde = length (xtilde); n_new
= [0:length_xtilde-1]; subplot (2,1,2);
stem (n_new,xtilde,'r');
grid on;
xlabel ('n');
ylabel ('perodic x(n)');
title ('Figure 2.4(b)');
```

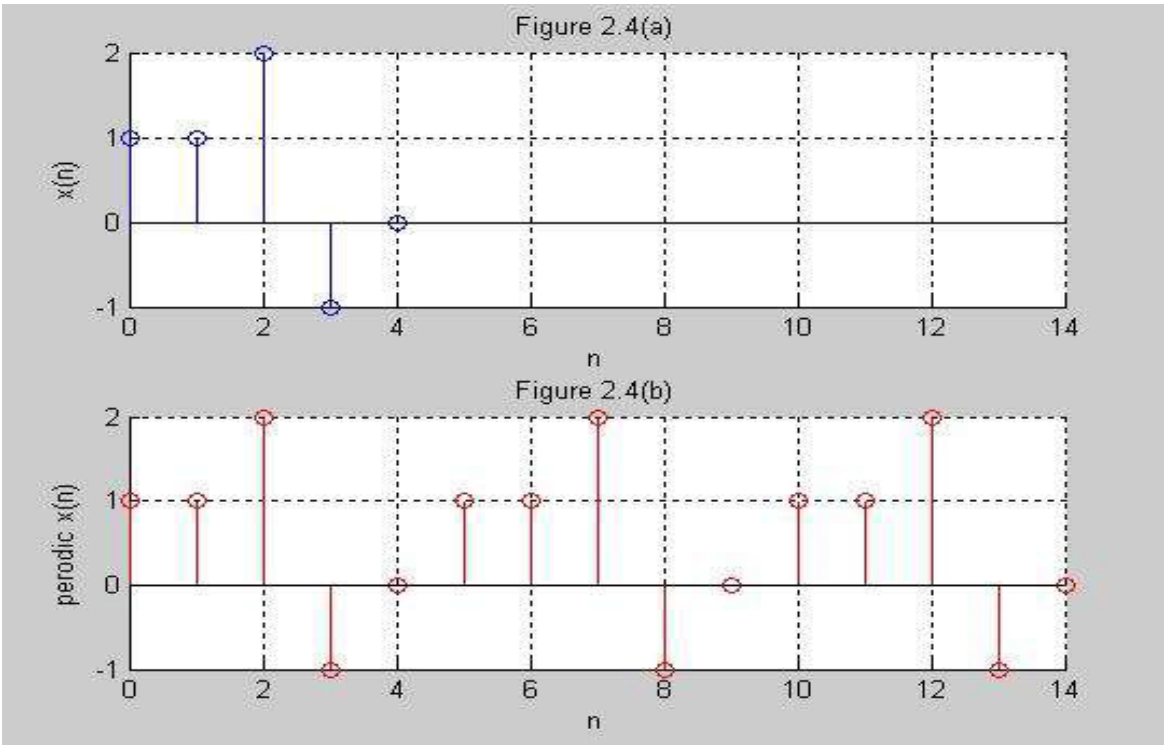


Figure 2.4

SIGNALS OPERATIONS:

Signal Addition

This is basically sample by sample addition. The definition is given below:

{x1(n)} + {x2(n)} = {x1(n) + x2(n)}

The length of x1 and x2 should be equal. See the MATLAB code below:

```
function [y,n] = sigadd(x1,n1,x2,n2)
% implement y(n) = x1(n) + x2 (n)
% [y,n] = sigadd (x1,n1,x2,n2)
% y = sum sequence over n, which include n1 and n2
% x1 = first sequence over n1
% x2 = second sequence over n2 (n2 can be different from n1)
n = min(min(n1),min(n2)): max(max(n1),max(n2));                    %duration of y(n)
y1    = zeros(1,length(n));                                        % initialization
y2    = y1;
y1(find((n>=min(n1))&(n<=max(n1))==1))=x1;                         % x1 with duration of y
y2(find((n>=min(n2))&(n<=max(n2))==1))=x2;                         % x2 with duration of y y
= y1 + y2;
```

See example of signal addition below

%Example 2.5

```
% signal addition using sigadd function clear;
clc;
n1 = [0:10];
x1 = sin (n1);
n2 = [-5:7];
x2 = 4*sin(n2);
[y,n] = sigadd(x1,n1,x2,n2); subplot
(3,1,1);
stem (n1,x1);
grid on;
axis ([-5 10 -5 5]);
xlabel ('n1');       ylabel ('x1(n)');
title ('1st signal');
subplot (3,1,2);
stem (n2,x2); grid
on; hold on; axis
([-5 10 -5 5]);
xlabel ('n2');         ylabel ('x2(n)');
title ('2nd signal');
subplot (3,1,3);      stem (n,y,'r');
grid on;
```

```
axis ([-5 10 -5 5]);
xlabel ('n');          ylabel ('y(n)');
title ('Added Signals');
```

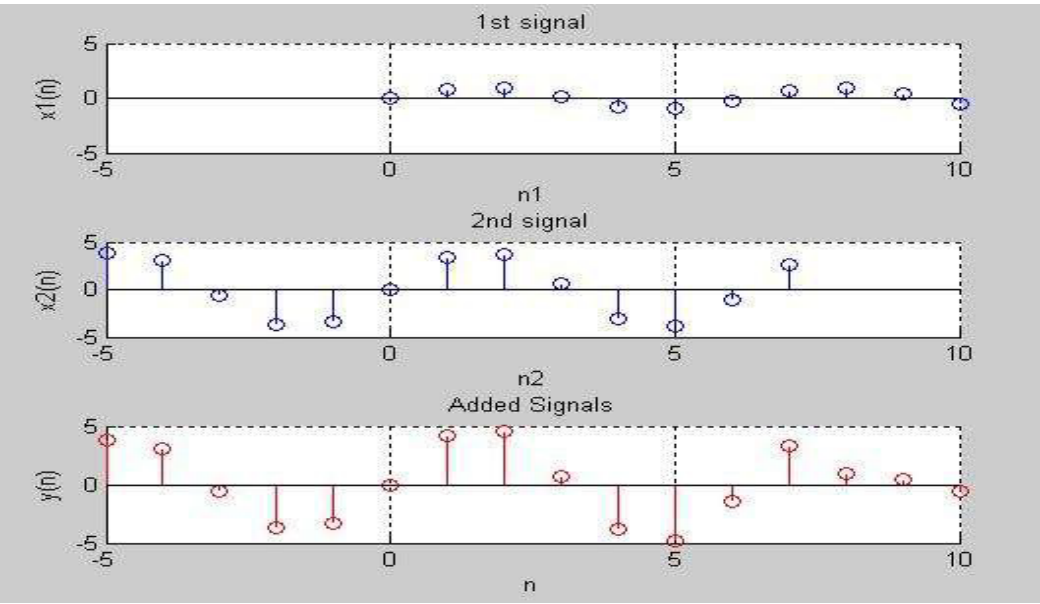


Figure 2.5

Signal Multiplication:

The multiplication of two signals is basically sample by sample multiplication or you can say dot multiplication. By definition it is

{x1(n)} . {x2(n)} = {x1(n)x2(n)}

It is implemented by the array operator ' **.*** ' that we studied in last lab. A signal multiplication function is developed that is similar to the sigadd function. See the code below:

```
function [y,n] = sigmult (x1,n1,x2,n2)

% implement y(n) = x1(n) * x2 (n)

% [y,n] = sigmult (x1,n1,x2,n2)

% y = product sequence over n, which include n1 and n2

% x1 = first sequence over n1

% x2 = second sequence over n2 (n2 can be different from n1)

n = min(min(n1),min(n2)): 0.1 : max(max(n1),max(n2));   %duration of y(n)
```

```
y1 = zeros(1,length(n));                                    %  initialization
y2 = y1;
y1(find((n>=min(n1))&(n<=max(n1))==1))=x1;                  % x1 with duration of y
y2(find((n>=min(n2))&(n<=max(n2))==1))=x2;                  % x2 with duration of y y
= y1 .* y2;
```

See the example below:

%**Example 2.6**

```
% signal multiplication using sigmult function clear;
clc;
n1 = [0:0.1:10];
x1 = sin (n1);
n2 = [-5:0.1:7];
x2 = 4*sin (n2);
[y,n] = sigmult(x1,n1,x2,n2); subplot
(3,1,1);
stem (n1,x1);
grid on;
axis ([-5 10 -5 5]);
xlabel ('n1');
ylabel ('x1(n)'); title
('1st signal');
subplot (3,1,2);
stem (n2,x2);
grid on;  hold
on;
axis ([-5 10 -5 5]);
xlabel ('n2');
ylabel ('x2(n)'); title
('2nd signal');
subplot (3,1,3);
stem (n,y,'r');
grid on;
axis ([-5 10 -5 5]);
xlabel ('n');
ylabel ('y(n)');
title ('Multiplied Signals');
```

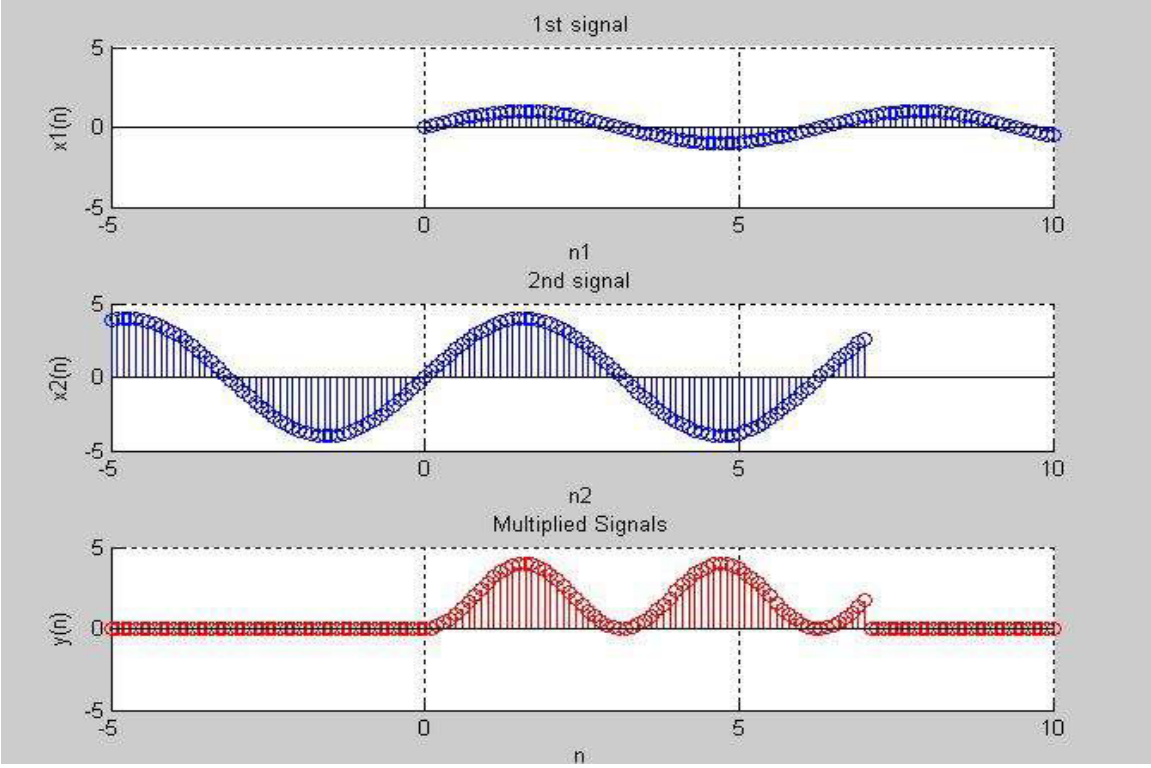


Figure 2.6

POST LAB: (please send to email: phamthaokhuong@gmail.com)

Write MATLAB code to plot these signals:

a. x [n] = 2sin (3n) + 2cos (3n)
b. x [n] = u[n] + 4cos (3n)
c. x [n] = n[u(n) – u(n-10)] + 10e-0.3(n-10)[u(n-10)-u(n-20)]

You are not allowed to multiply impulse sequences with a number. Implement this by using **impseq**, **stepseq** and **sigadd** functions.

Experiment # 3

Experiment Title: Communication Signals: Operations

Objective

- To learn the use of MATLAB for different operations on signals.
- To develop a thorough understanding of communication signals and their basic operations as used in Analogue Communication.

SUMMARY

- Signal operations (Scaling, Shifting, Folding, Sample Summation, Sample product, Energy, Even and Odd sequences, Convolution)

SIGNAL OPERATIONS:

1. Scaling:

In this operation the samples of the signal is multiplied by a scalar α. The mathematical operator * is used for the implementation of the scaling property.

α{x(n)} = { α x(n)}

```
>> [x,n] = stepseq (-1,-5,5);
>> a = 2;
>> y = a*x;
  >>  subplot (2,1,1);
>>stem (n,x);grid on;
>> subplot (2,1,2);
>> stem (n,y, 'r');
>> grid on;
```

2. **Shifting**

In this operation, each sample of the signal is shifted by **k** to get a shifted signal. By definition: **y(n) = {x (n-k)}**

In this operation there is no change in the array or vector x, that contains the samples of the signal. Only n is changed be adding **k** to each element. The function is given below:

```
function [y,n] = sigshift (x,m,n0)
% implement y(n) = x(n-n0)
```

```
% x = samples of original signal
% m = index values of the signal
% n0 = shift amount , may be positive or negative
% [y,n] = sigshift(x,m,n0) n
= m+n0;
y = x;
```

See the example of above function:

%Example 3.1

```
% This example demonstrate the use of stepseq, sigshift, sidadd & sigmult
   function clc; clear;
   %- - - - - - - - - - - - - - - - - - - - - - - - - -
   [x,n] = stepseq (0,-
   10,10); subplot (3,2,1);
   stem (n,x);
   axis ([-12 12 0
   3]); grid on;
   xlabel ('n');
   ylabel
   ('x(n)');
   title ('Original Signals');
   %- - - - - - - - - - - - - - - - - - - - - - - - - -
   [y1,n1] = sigshift(x,n,2.5); subplot
   (3,2,2);
   stem (n1,y1); axis ([-12 12 0 3]); grid on;
   xlabel ('n');
   ylabel
   ('y1(n)');
   title ('Shifted signal,x(n-2.5)');
```

```
%- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
[y2,n2] = sigshift (x,n,-2.5);
subplot (3,2,4);
stem (n2,y2);   axis
([-12 12 0 3]);
grid on;
xlabel ('n');
ylabel ('y2(n)');
title ('Shifted signal,x(n+2.5)');
%- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
[y_add,n_add] = sigadd(y1,n1,y2,n2); subplot
(3,2,6);
stem (n_add,y_add,'r');
axis ([-12 12 0 3]);
grid on;
xlabel ('n');
ylabel ('y1(n) + y2(n)');
title ('Added Signal');
%- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
[y_mul,n_mul] = sigmult(y1,n1,y2,n2);
subplot (3,2,5);
stem (n_mul,y_mul,'k');
axis ([-12 12 0 3]);
grid on;
xlabel ('n');
ylabel ('y1(n) * y2(n)'); title
('Multiplied Signal');
%- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

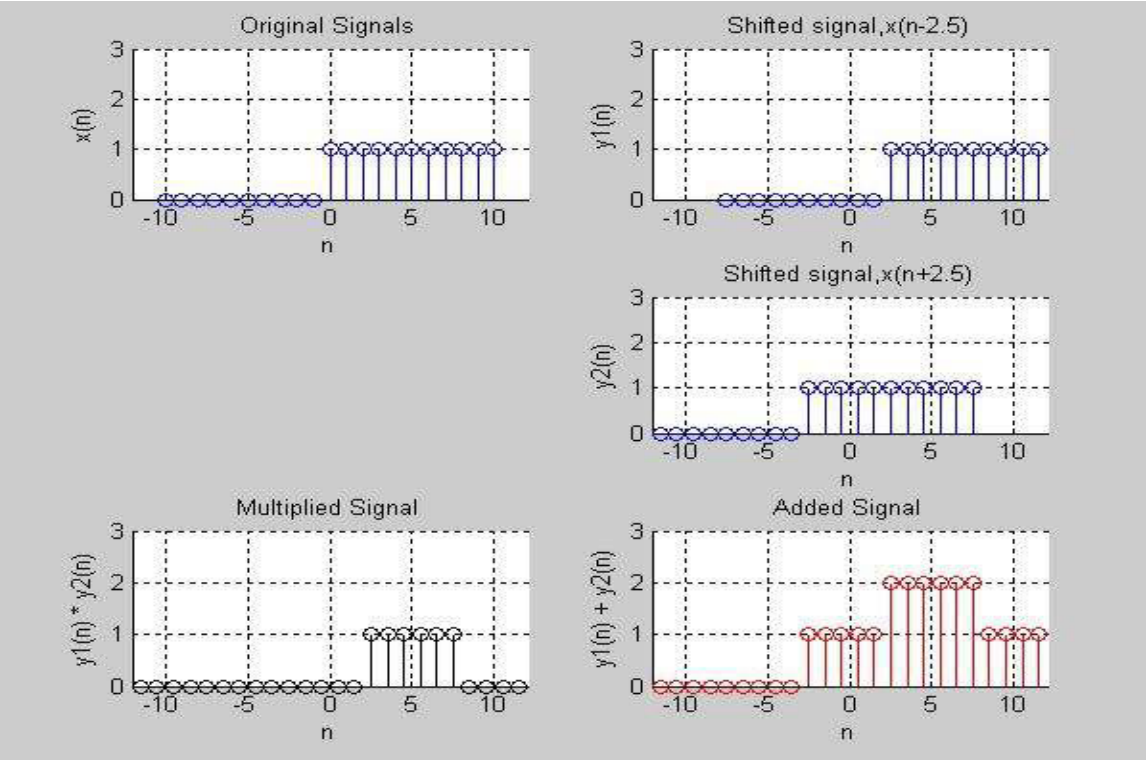


Figure 3.1

3. Folding:

In this operation each sample of **x(n)** is flipped around **n=0** to obtain a folded

signal **y(n)**. **y (n) = {x(-n)}**

In MATLAB, this function is implemented by using a built-in function **fliplr(x)** and – **fliplr(x).** Its implementation is given below:

```
function [y,n] = sigfold(x,n)
% implements y(n) = x(-n)
% [y,n] = sigfold(x,n)
% x = samples of the original signal
% n = indexes of the original signal y =
fliplr(x);
n = -fliplr (n);
```

Do its example by yourself from any example signals.

4. Sample Summation:

This operation is different from **sigadd** function. In this operation we add all the sample values of any signal **x(n)** between any two of its index values. By definition

$$\sum \mathbf{x(n) = x(n1) + \ldots\ldots\ldots + x(n2)}$$

In MATLAB it is implemented by the **sum(x(n1:n2))** command. See the code below for the demonstration of above function.

```
>> [x,n] = stepseq (5,0,10)

>> sum(x(2:7))
```

5. Sample Product:

This operation also differs from the **sigmult** function. It implies the sample values over the range **n1:n2**. It is implemented by the **prod(x(n1:n2))**. See the code below.

```
>> x = [0 1 2 3 4 5]

>> prod(x(2:5))
```

6. Energy:

The energy of any signal x is computed by the mathematical relation:

$$\mathbf{Ex = \sum x(n)\, x^*(n) = \sum \left| x(n) \right| 2}$$

Where the subscript * is used for complex conjugate of the signal x. The energy of the finite duration signal is computed in MATLAB as.

```
>> Ex = sum (x.*conj(x));
```

Or

```
>> Ex = sum (abs(x).^2);
```

7. Even and Odd Sequence:

A real valued sequence $x_e(n)$ is called even if the following condition satisfies.

$$\mathbf{x_e(-n) = x_e(n)}$$

Similarly a signal is said to be an odd signal if

$$\mathbf{xo(-n) = -xo(n)}$$

See the example below:

%example 3.2

```
% Generation of even and odd signals n1 =

[0:0.01:1];
```

```
x1 = 2*n1;
n2 = [1:0.01:2];
x2 = -2*n2+4;
n = [n1,n2];
x = [x1,x2];
%Even Signal
[xe,ne] = sigfold(x,n);
%Plotting of original signal subplot
(3,1,1);
plot (n,x);
axis ([-4 4 0 2.5]);
grid on;
%Plotting of original signal + even signal subplot
(3,1,2);
plot (n,x/2,ne,xe/2);
axis ([-4 4 0 2.5]);
grid on;
% Plotting of original signal + odd signal
xo = -xe;
no = ne; subplot
(3,1,3);
plot (n,x/2,no,xo/2); axis
([-4 4 -2.5 2.5]);
grid on;
```

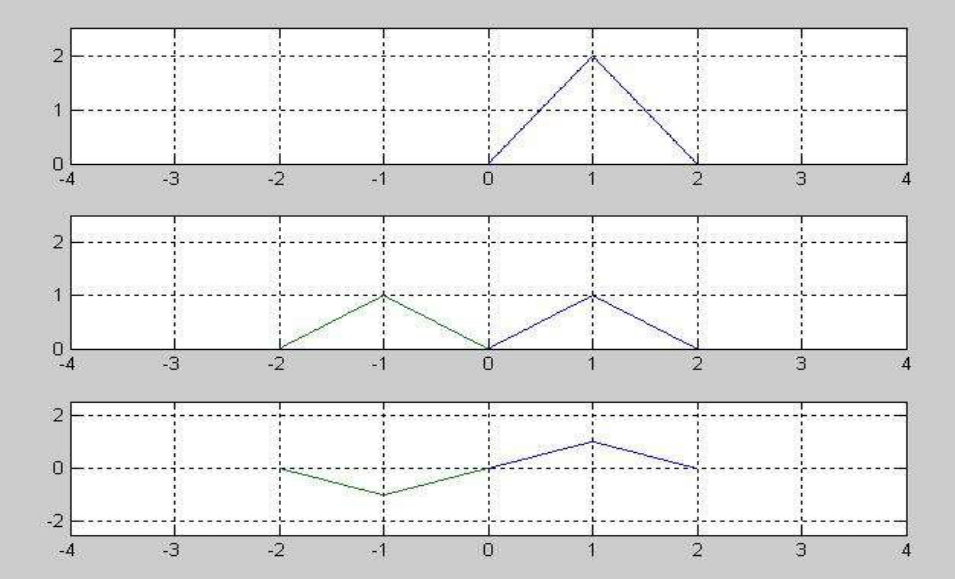


Figure 3.2

The above example shows to develop the even and odd signals from a given signal. Now we are going to develop a function to compute the even and odd signals for ourselves. See the code of function file below:

```
function [xe,xo,m] = evenodd (x,n)

% Decomposes a real function into its even and odd parts

% [xe,xo,m] = evenodd(x,n)

% xe = even signal

% xo = odd signal

% m = indexes

% x = original signal

% n = indexes for original signal if

any(imag(x)~=0)

                error('x is not a real sequence')

end

m = -fliplr(n);  m1

= min([m,n]);

m2 = max([m,n]); m

= m1:m2;

nm = n(1)-m(1);
```

```
n1 = 1:length(n);

x1 = zeros(1,length(m));

x1(n1+nm) = x;

x = x1;

xe = 0.5*(x+fliplr(x));

xo = 0.5*(x-fliplr(x));
```

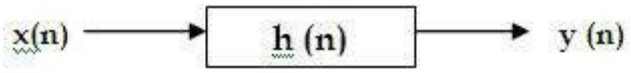
Now change the example 3.2 code to implement the same example with this function.

8. Convolution:

The convolution is very important operation as far the system as their impulse responses are concern. It is mathematically defines as:

$$y(n) = x(n) * h(n)$$

Where **h(n)** is the impulse response of the system. The above definition is best depicted by the following diagram.



In MATLAB convolution is implemented by the following instructions.

```
>> x = [1 5 3 9 1 2 3 8 5 -3 0 4];

>> h = [1 0 2 3];

>> y = conv(x,h);
```

A function is developed which will evaluate convolution in a more precise form and also calculate the indexes to help us plot the sequences.

```
function [y,ny] = conv_m(x,nx,h,nh)

% Modified convolution routine for signal processing

% [y,ny] = conv_m(x,nx,h,nh)

% [y,ny] = convolution result

% x = original signal

% nx = index values

% h = impulse response signal

% nh = index values for impulse response nyb

= nx(1) + nh(1);
```

```
nye = nx(length(x)) + nh(length(h)); ny =

[nyb:nye];

y = conv(x,h);
```

POST LAB (please send to my email before next class)

a. x(n) = u(n) – u(n-5). Decompose into even and odd components and plot them.
b. n = [-2:2]

```
x1 = [3,2,1,-2,-3];

x2 = [1,1,1,1,1]
```

Implement y = x1*x2

Experiment # 4

Experiment Title: Introduction to Amplitude Modulation (Simulink Implementation)

Objective

- To identify the spectrum analyzer as used in frequency domain analysis
- To identify various types of linear modulated waveforms in time and frequency domain representation
- To implement theoretically functional circuits using the Communication Module Design System (CMDS)

Spectrum Analyzer and Function Generator

This section deals with looking at the spectrum of simple waves. We first look at the spectrum of a simple sine wave

.

To start Simulink: Start MATLAB then type simulink on the command line. A Simulink Library Window opens up as shown in figure 13.1.

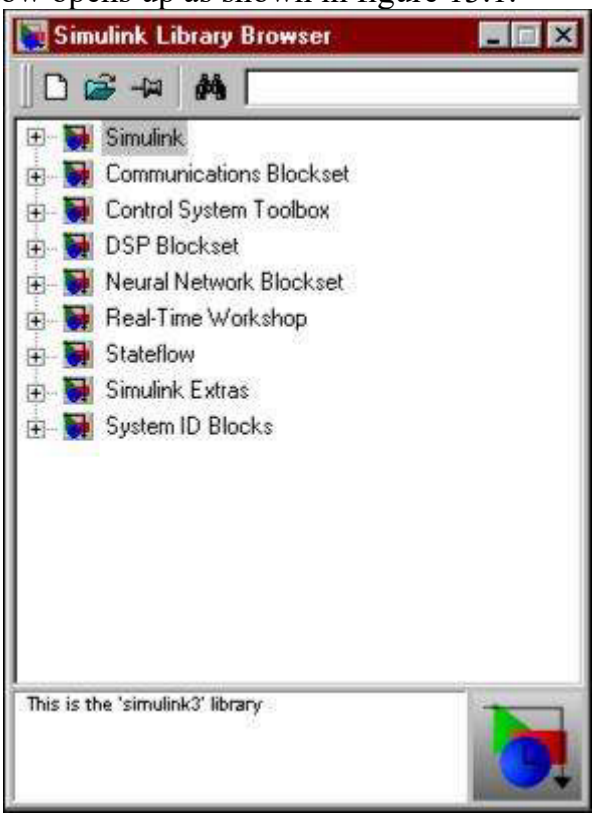


Figure 4.1

Spectrum of a simple sine wave: - Figure 13.2 shows the design for viewing the spectrum of

a simple sine wave.

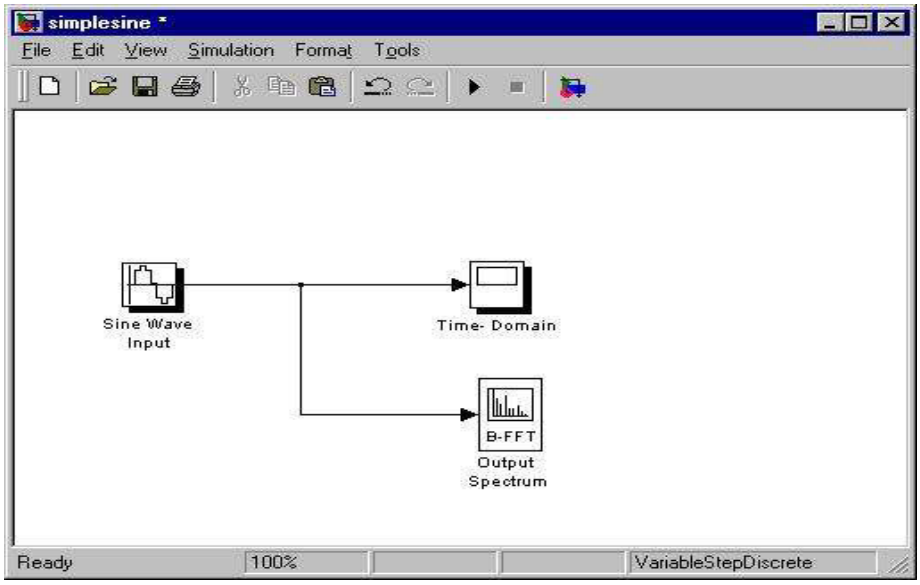


Figure 4 .2

Figure 4.3 shows the time-domain sine wave and the corresponding frequency domain is shown in figure 4.4. The frequency domain spectrum is obtained through a buffered-FFT scope, which comprises of a Fast Fourier Transform of 128 samples which also has a buffering of 64 of them in one frame. The property block of the B-FFT is also displayed in figure 4.5.

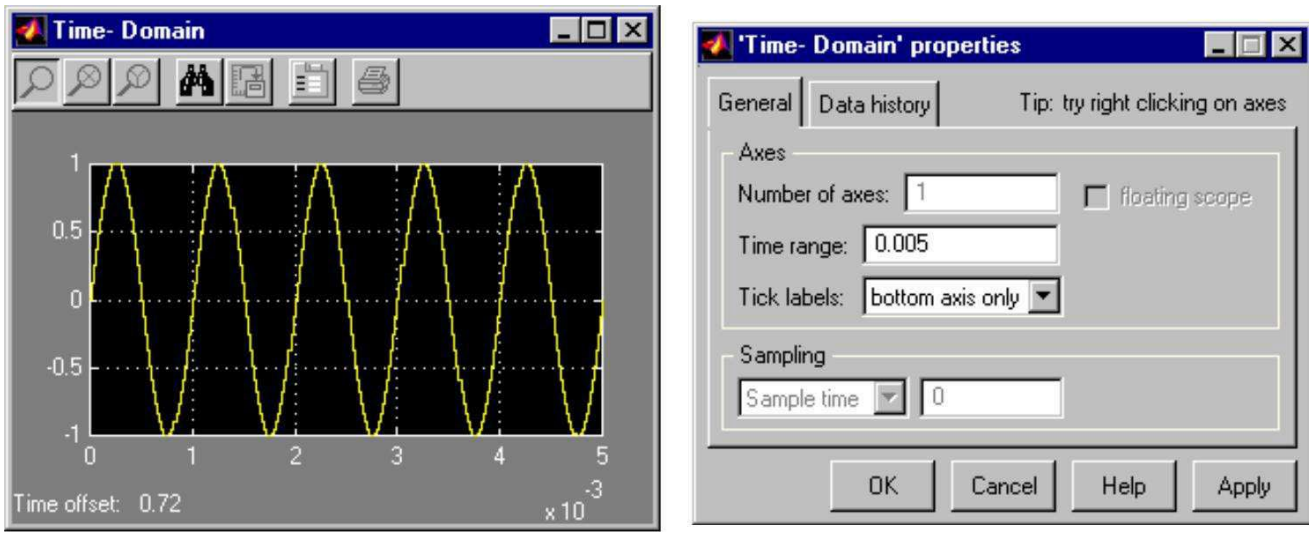


Figure 4.3

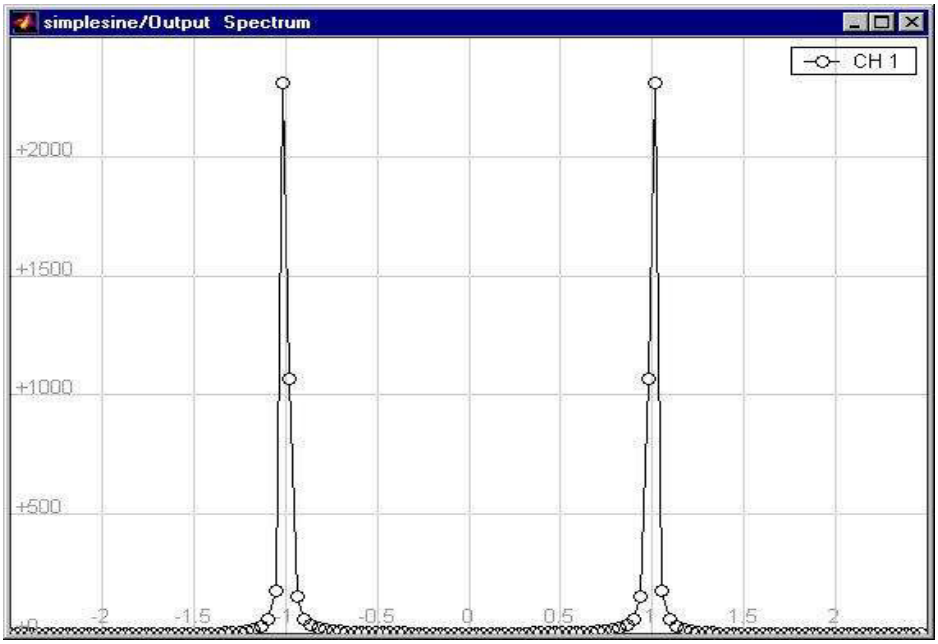


Figure 4.4

This is the property box of the Spectrum Analyzer

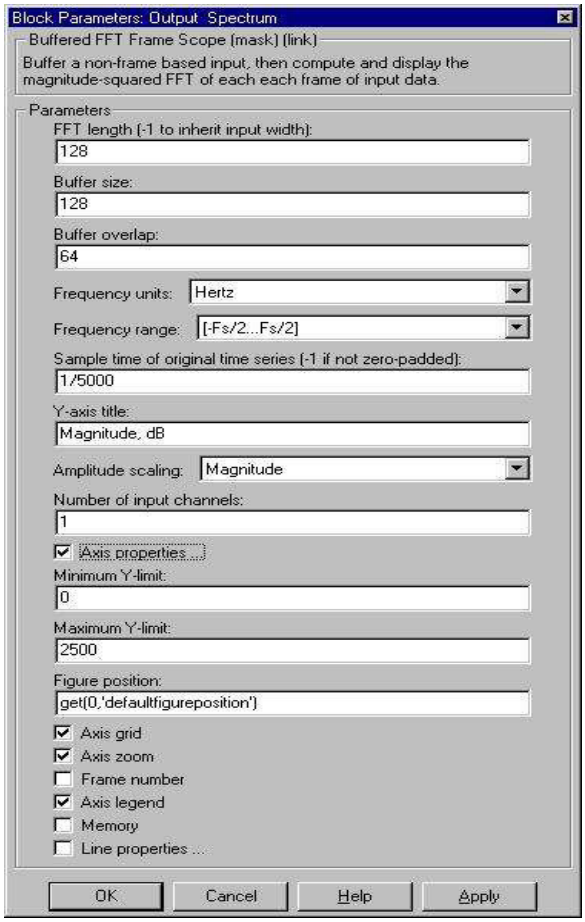


Figure 4.5

From the property box of the B-FFT scope the axis properties can be changed and the Line properties can be changed. The line properties are not shown in the above. The Frequency range can be changed by using the frequency range pop down menu and so can be the y-axis the amplitude scaling be changed to either real magnitude or the dB (log of magnitude) scale. The upper limit can be specified as shown by the Min and Max Y-limits edit box. The sampling time in this case has been set to 1/5000.

Note: The sampling frequency of the B-FFT scope should match with the sampling time of the input time signal.

Also as indicated above the FFT is taken for 128 points and buffered with half of them for an overlap.

Calculating the Power:
The power can be calculated by squaring the value of the voltage of the spectrum analyzer.

Note: The signal analyzer if chosen with half the scale, the spectrum is the single-sided analyzer, so the power in the spectrum is the total power.

Similar operations can be done for other waveforms – like the square wave, triangular. These signals can be generated from the signal generator block.

II. Waveform Multiplication (Modulation)

The equation $y = k_m \cos^2(2\pi\,(1{,}000)t)$ was implemented as in fig. 1B peak to peak voltage of the input and output signal of the multiplier was measured. Then km can be computed as

The spectrum of the output when $k_m=1$ was shown below:

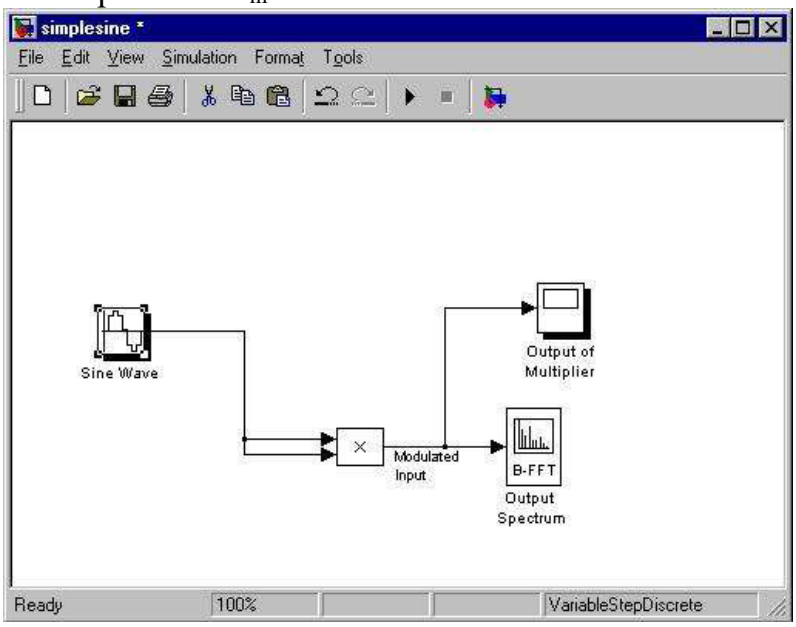


Figure 4.6

The following figure demonstrates the waveform multiplication. A sine wave of 1 kHz is generated using a sine wave generator and multiplied with a replica signal. The input signal and the output are shown in figures.

The input signal as generated by the sine wave is shown in figure.
The output of the multiplier is shown in figure and the spectral output is shown in figure.

It can be seen that the output of the multiplier in time domain is basically a sine wave but doesn't have the negative sides since they get cancelled out in the multiplication.

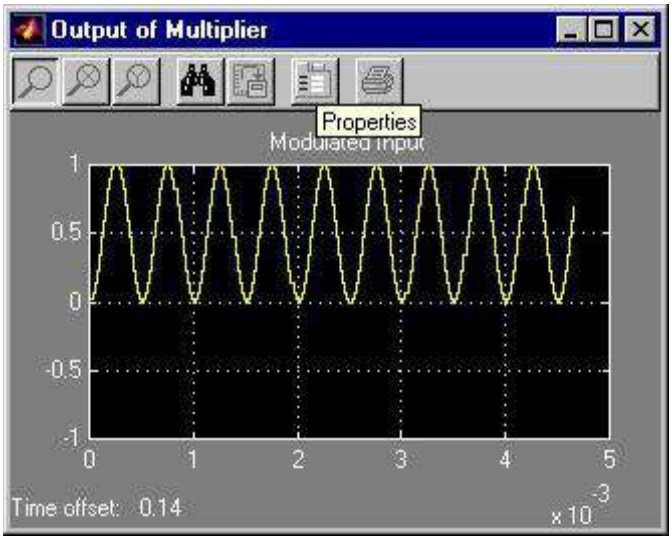


Figure 4.7

The spectral output of the spectrum is shown below. It can be seen that there are two side components in spectrum. The components at fc + fm and –(fc + fm) can be seen along with a central impulse.

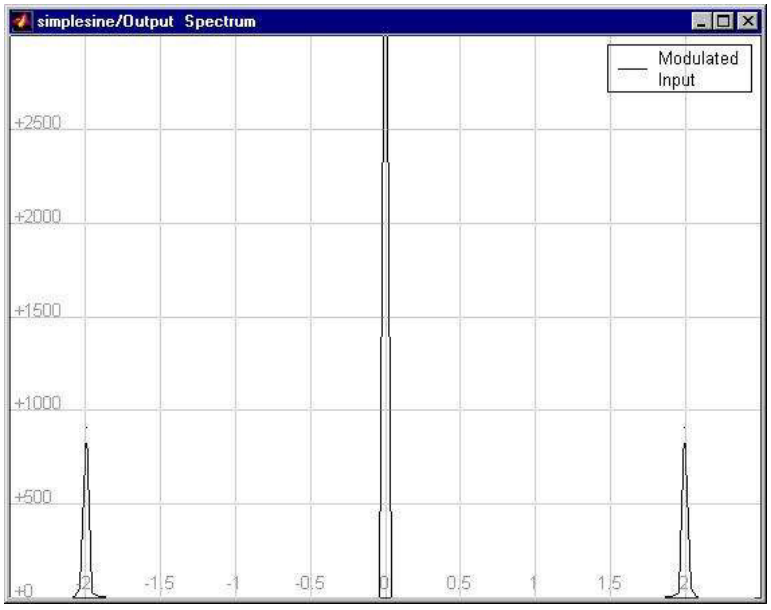


Figure 4.8

If a DC component was present in the input waveform, then

$$y = k_m*(\cos(2\pi(1{,}000)t) + V_{dc})^2$$

The effect of adding a dc component to the input has the overall effect of raising the amplitude of the 2 KHz component and decreases the 2 KHz component. However, for a value of V_{dc} = 0.1V, the 1KHz component reduces and for any other increase in the V_{dc} value, the 1KHz component increases.

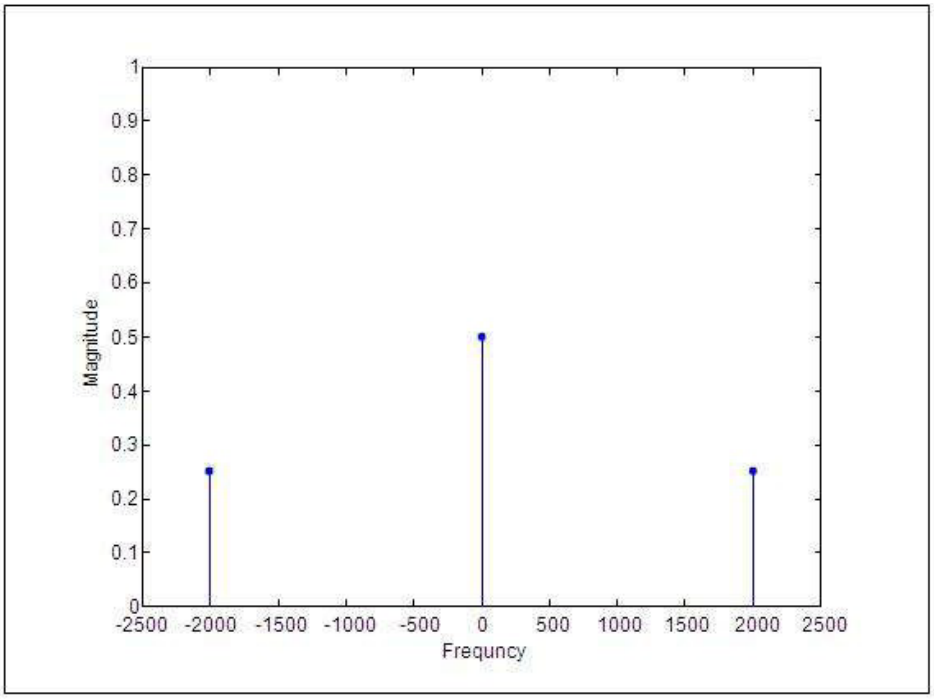


Figure 4.9

I. Double Side-Band Suppressed Carrier Modulation

Figure shows the implementation of a DSB-SC signal. The Signals are at 1 kHz and 10 kHz.

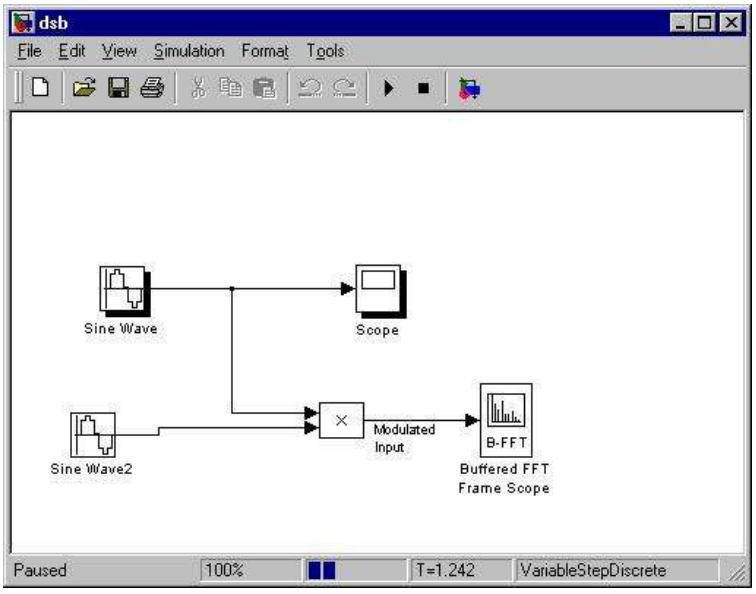


Figure 4.10

The output is shown below. It can be seen that the output consists of just two side bands at +(fc + fm) and the other at –(fc + fm) , i.e. at 9kHz and 11kHz.

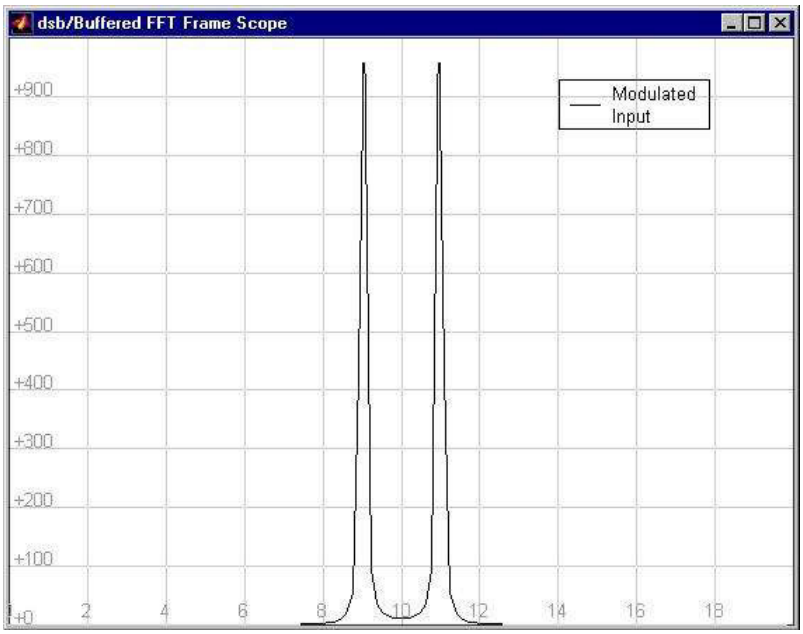


Figure 4.11

By multiplying the carrier signal and the message signal, we achieve modulation.

$Y*m(t) = [km \cos(2\pi 1000t) * \cos(2\pi 10000t)]$

We observe the output to have no 10 KHz component i.e., the carrier is not present. The output contains a band at 9 KHz (fc-fm) and a band at 11 KHz (fc + fm). Thus we observe a double side band suppressed carrier. All the transmitted power is in the 2 sidebands.

Effect of Variations in Modulating and Carrier frequencies on DSB – SC signal.

By varying the carrier and message signal frequencies, we observe that the 2 sidebands move according to equation fc ± fm.

Now, using a square wave as modulating signal, we see that DSBSC is still achieved.

The output from spectrum analyzer was slightly different from the theoretical output. In the result from the spectrum analyzer, there is a small peak at frequency = 10kHz (the carrier frequency) and other 2 peak at 0 and 1000 Hz. This may caused by the incorrectly calibrated multiplier.

Next, the changes to the waveform parameters have been made and then the outputs have been observed. And here are the changes that have been made

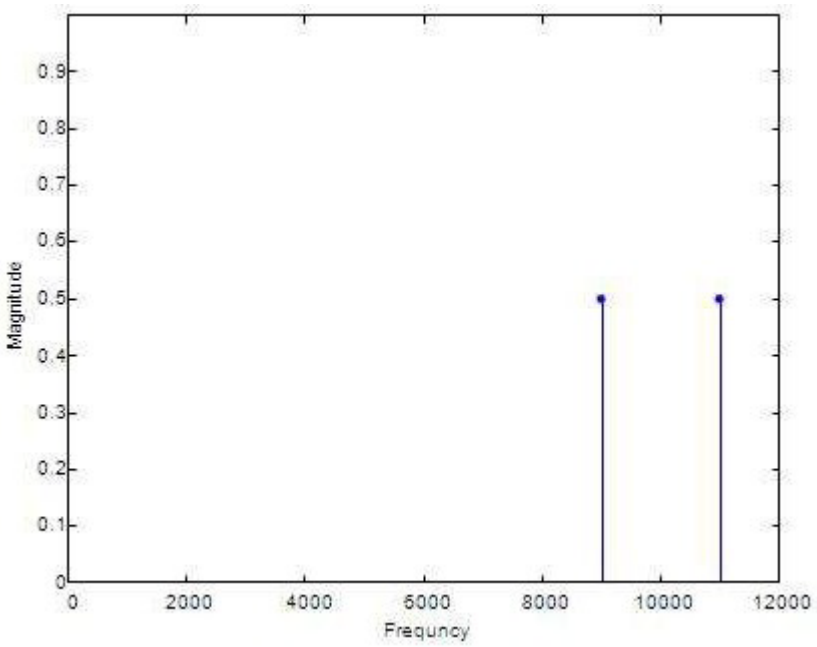


Figure 4.12

Amplitude Modulation

This experiment is the amplitude modulation for modulation index a = 1 and 0.5.
From the equation of the AM

$$y = k_m\,(1 + a \cdot \cos(2\pi\,(1000)t) \cdot \cos(2\pi\,(10000)t$$

The representation of the signal in both time-domain and frequency domain when km=1 for a=1 and a=0.5 were found to be as shown in figures.
The experimental set up for generating an AM signal looks like this: -

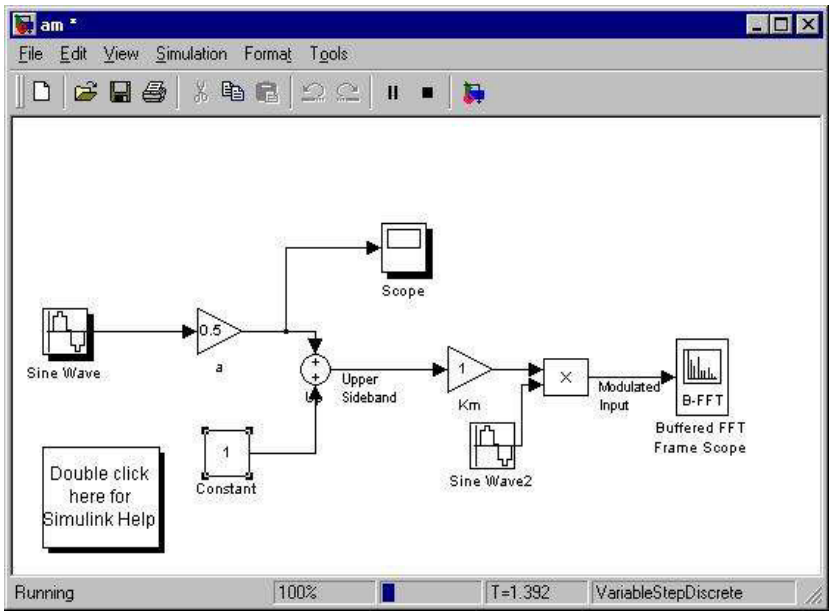


Figure 4.12

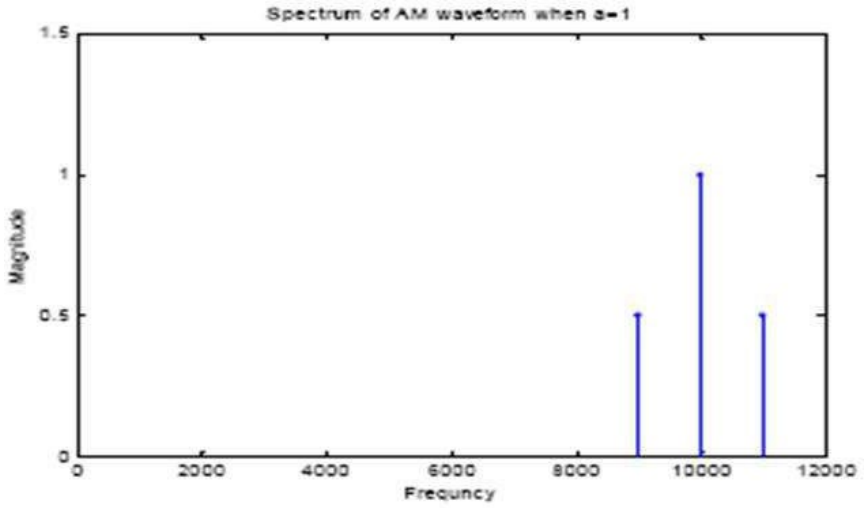


Figure 4.13

The input waveform 50% modulated is shown in figure:

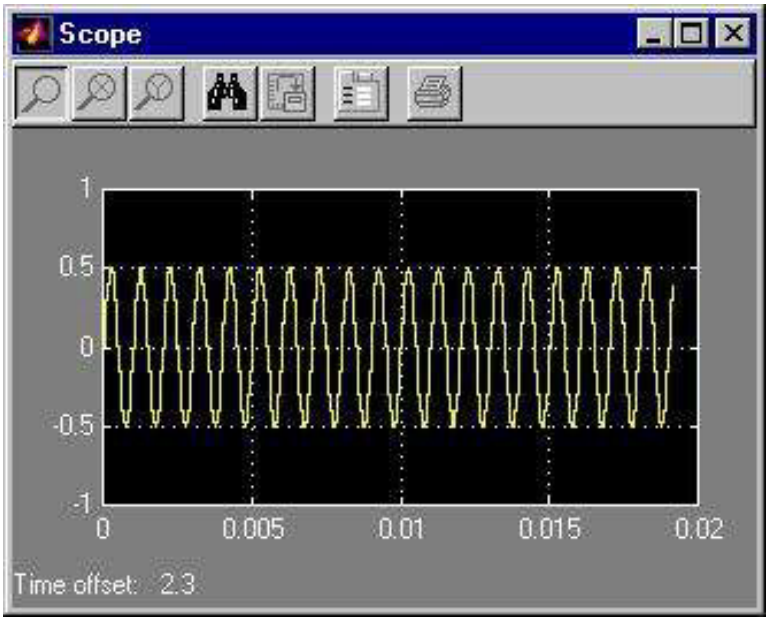


Figure 4.14

The output spectrum is shown below

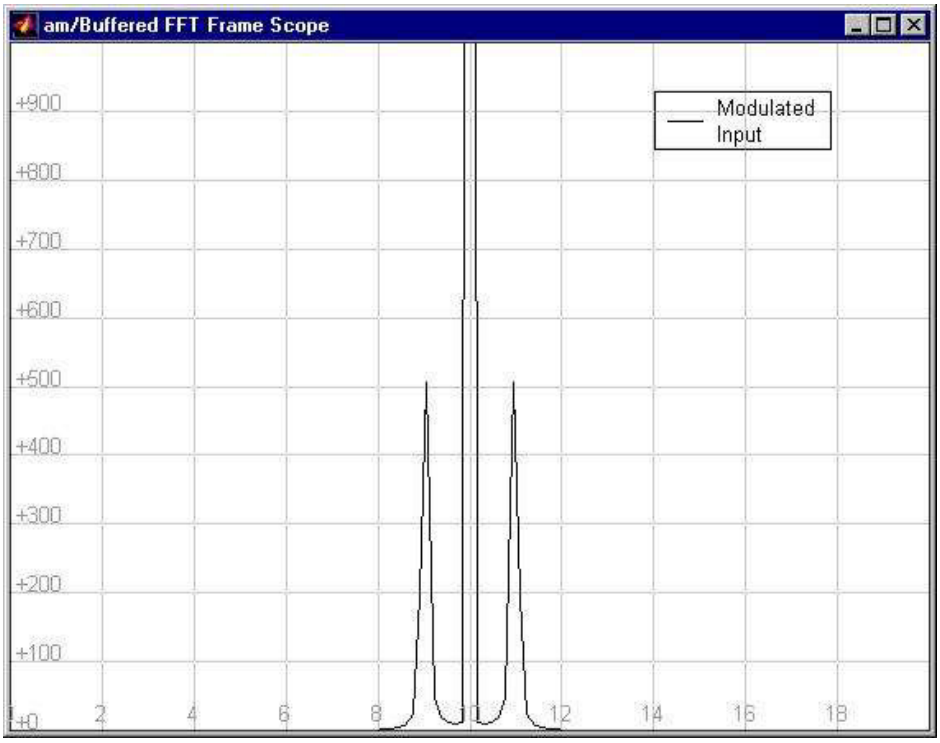


Figure 4.15

It must be noted here that the A.M signal can be converted into a DSB-SC signal by making the constant = 0.

The waveforms at various levels of modulation are shown in the following figures.

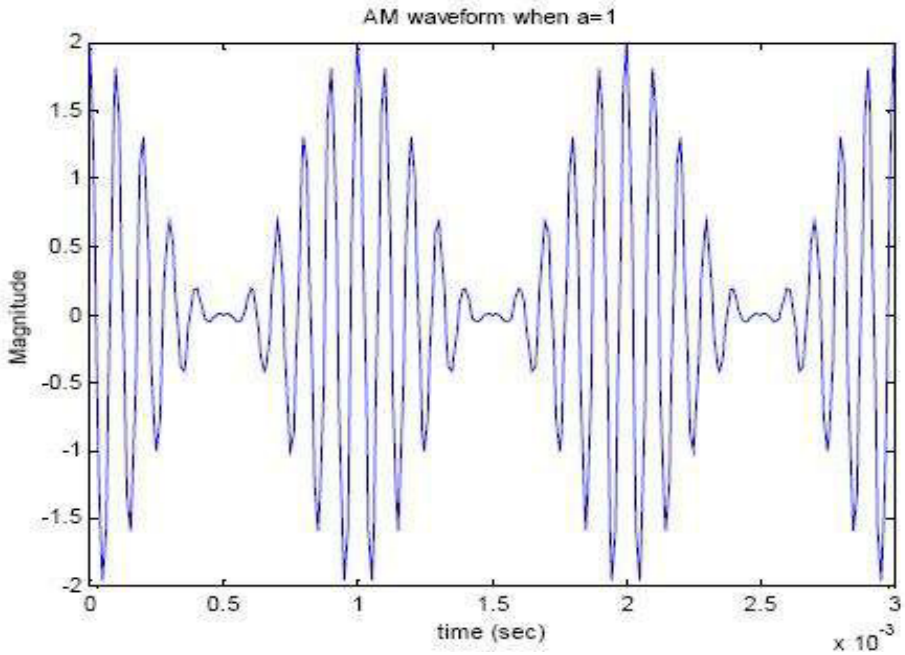


Figure 4.16

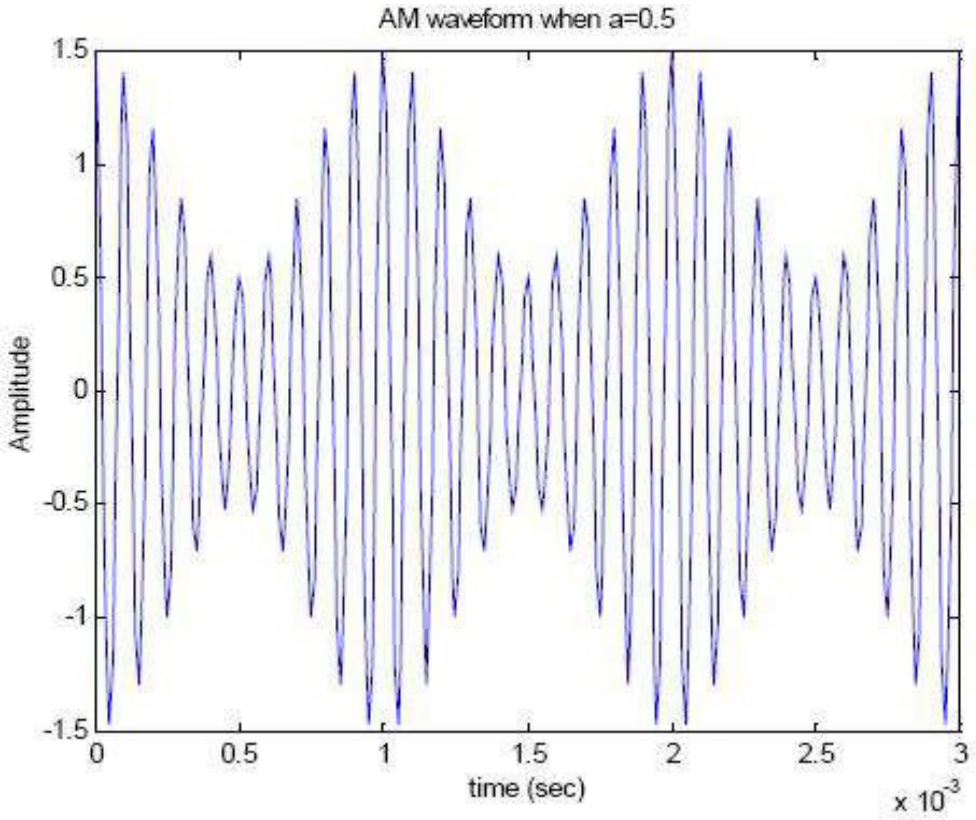


Figure 4.17

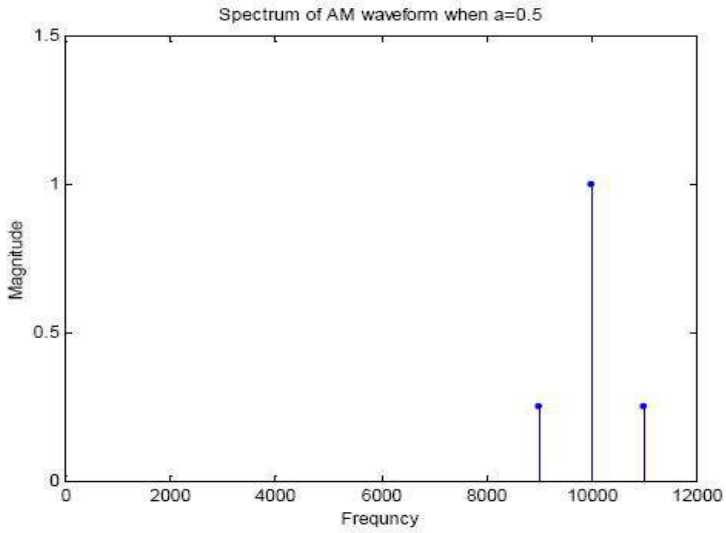


Figure 4.18

The results from the experiment were shown. The results from the experiment are pretty much the same as in the theoretical ones except there are 2 other peaks at 0 and 1000 kHz. This is the same as earlier experiment. The cause of this problem is probably the multiplier.

II. Two Tone Modulation

The last experiment in this section is the two tone modulation. In this experiment, the 2 kHz signal had been added to the modulating signal in the above experiment. Theoretically, the representation of the modulated signal in time-domain and frequency domain would have been as in the figure below. In the figure, 1 kHz and 2 kHz signals were modulated with 10 kHz carrier.

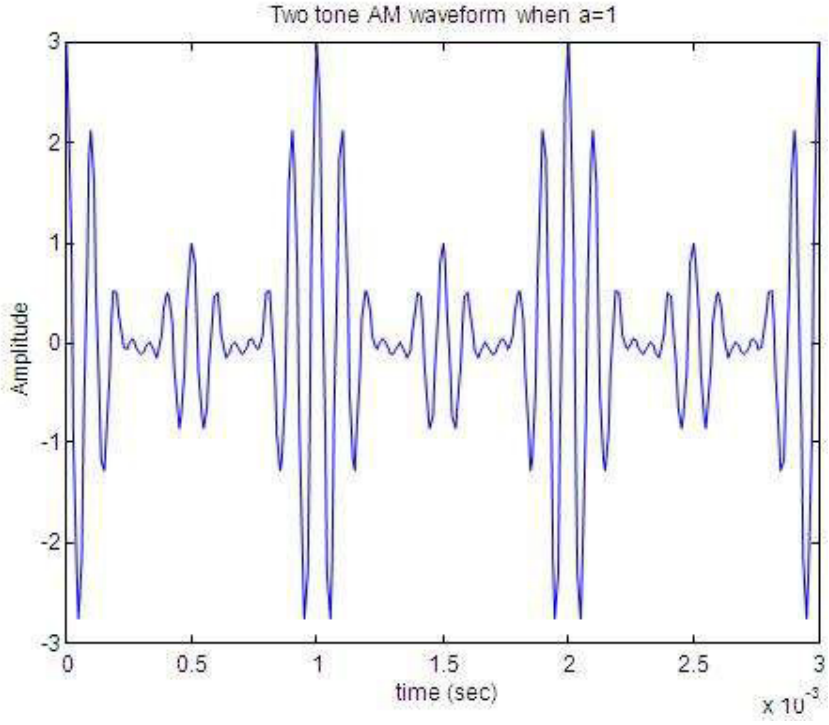


Figure 4.19

The experimental setup is shown below.

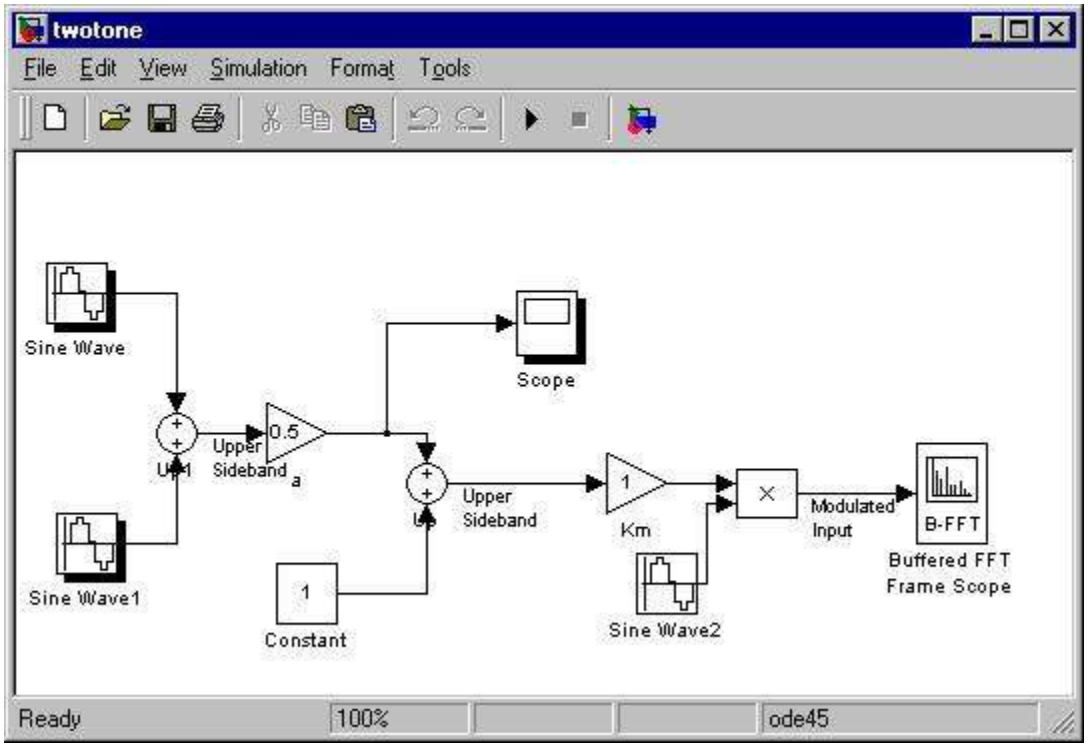


Figure 4.20

The two-tone waveform before being amplitude modulated.

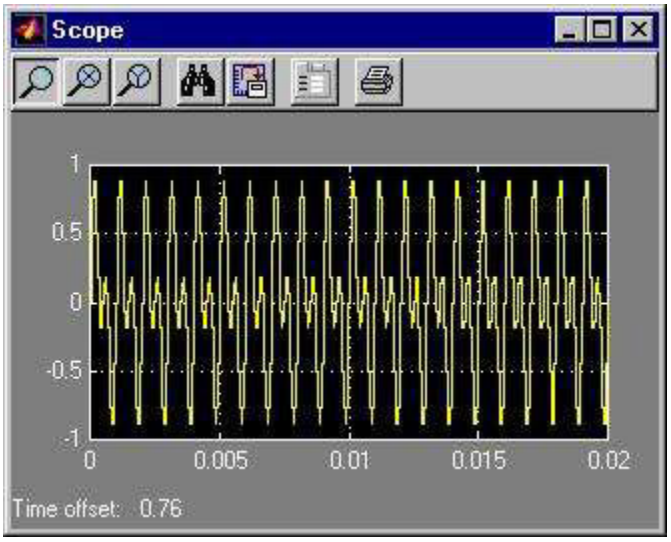


Figure 4.21

The two-tone signal is amplitude modulated using the same block model discussed in the previous section. The output spectrum is shown in figure. In this case the signals of 1 kHz and 2 kHz are modulated by a 10kHz carrier. The output spectrum is shown in figure

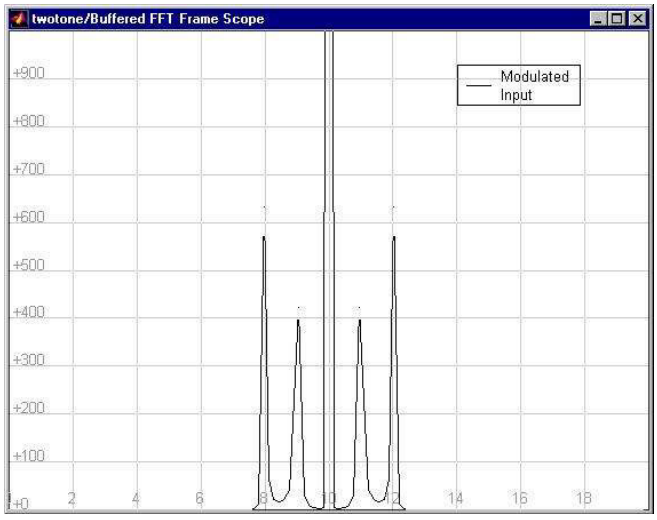


Figure 4.21

The result from the experiment was shown. The highest peak is at the carrier frequency as in the theoretical result. But there were differences on the sidebands. In the figure from MATLAB, both frequencies in the sidebands have the same magnitude, but from the experiment, the components at 9000Hz and 11000Hz have higher magnitude than the components at 8000Hz and 12000 Hz. There're also many small peaks of about 1000Hz apart in the experiment result. This might come from the incorrectly calibrated multiplier.

The final experiment in this section is to change the carrier frequency and the modulating frequency. When the carrier frequency increases, the spectrum of the modulated signal is expected to have the two sidebands centered at the new carrier frequency. And when one of the two modulating signals changes in frequency, the spectrum of the output signal should have two components move away from their original positions according to the change in frequency. The result from the experiment was shown. Both change in carrier frequency and modulating frequency is shown.

Experiment # 5

Experiment Title: Introduction to Amplitude Modulation (MATLAB Implementation)

Objective

- To analyze the spectrum, in time and frequency domain, of Amplitude Modulation.

In this first part of the lab we will focus on a couple of simple examples and plot their spectrum, in time and in frequency domain. In second part of this lab we will write the code for Amplitude modulation with carrier and suppress carrier and then focus on two tune modulation and at the end of this lab we will write a code for single side band.

Sketch the time and frequency domain representations (magnitude only) of the following

$\cos 2\pi ft$ $f = 1kHz$

The time and frequency domain of the input signal is shown as below.

CODE:

```
%%Time specifications:
Fs = 10000;
dt = 1/Fs; StopTime = 0.5; t =
(0:dt:StopTime-dt)'; N = size(t,1);
Fc = 1000;
x = cos(2*pi*Fc*t);

subplot(2,1,1) plot(t,x);
axis([0 1/100 -1 1]); xlabel('Time'); ylabel('Magnitude')
%%Fourier Transform:
X = fftshift(fft(x));
%%Frequency specifications:
dF = Fs/N;
f = -Fs/2:dF:Fs/2-dF;
%%Plot the spectrum: subplot(2,1,2) plot(f,abs(X)/N); xlabel('Frequency (in hertz)'); ylabel('Magnitude')
%%
```

B. Square wave period = 1msec, amplitude = 1v

```
Fs = 1000000;
dt = 1/Fs;
StopTime = 0.5;
t          = (0:dt:StopTime-dt)'; N = size(t,1); Fc = 1000;
x = SQUARE(2*3.14*Fc*t);                                                    :

subplot(2,1,1) plot(t,x);
axis([0 1/200 -2 2]); xlabel('Time'); ylabel('Magnitude');
      %%Fourier Transform:
X = fftshift(fft(x));
      %%Frequency specifications: dF = Fs/N;
f = -Fs/2:dF:Fs/2-dF;
      %%Plot the spectrum:
subplot(2,1,2) plot(f,abs(X)/N); axis([-100000 100000 0 0.5]); xlabel('Frequency (in hertz)'); ylabel('Magnitude');
```

C. $Cos^2(2\pi ft)$ f = 1kHz

```
Fs = 30000;
dt = 1/Fs;
StopTime = 0.5;
t= (0:dt:StopTime-dt)'; N = size(t,1); Fc = 1000;
x = cos(2*pi*Fc*t); x=x.*x;

subplot(2,1,1) plot(t,x);
xlabel('Time'); ylabel('Magnitude');
axis([0 1/100 -1 1]);
X = fftshift(fft(x)); dF = Fs/N;
f= -Fs/2:dF:Fs/2-dF; subplot(2,1,2) plot(f,abs(X)/N); axis([-5000 5000 0 0.75]) zoom on
xlabel('Frequency (in hertz)'); ylabel('Magnitude');
```

Experiment # 6

Experiment Title: AMPLITUDE SHIFT KEYING

Aim: To generate and demodulate amplitude shift keyed (ASK) signal using MATLAB

Theory

Generation of ASK

Amplitude shift keying - ASK - is a modulation process, which imparts to a sinusoid two or more discrete amplitude levels. These are related to the number of levels adopted by the digital message. For a binary message sequence there are two levels, one of which is typically zero. The data rate is a sub-multiple of the carrier frequency. Thus the modulated waveform consists of bursts of a sinusoid. One of the disadvantages of ASK, compared with FSK and PSK, for example, is that it has not got a constant envelope. This makes its processing (eg, power amplification) more difficult, since linearity becomes an important factor. However, it does make for ease of demodulation with an envelope detector.

Demodulation

ASK signal has a well defined envelope. Thus it is amenable to demodulation by an envelope detector. Some sort of decision-making circuitry is necessary for detecting the message. The signal is recovered by using a correlator and decision making circuitry is used to recover the binary sequence.

Algorithm

Initialization commands

ASK modulation

1. Generate carrier signal.
2. Start FOR loop
3. Generate binary data, message signal(on-off form)
4. Generate ASK modulated signal.
5. Plot message signal and ASK modulated signal.
6. End FOR loop.
7. Plot the binary data and carrier.

ASK demodulation

1. Start FOR loop
2. Perform correlation of ASK signal with carrier to get decision variable
3. Make decision to get demodulated binary data. If x>0, choose ‘1’ else choose ‘0’
4. Plot the demodulated binary data.

Program

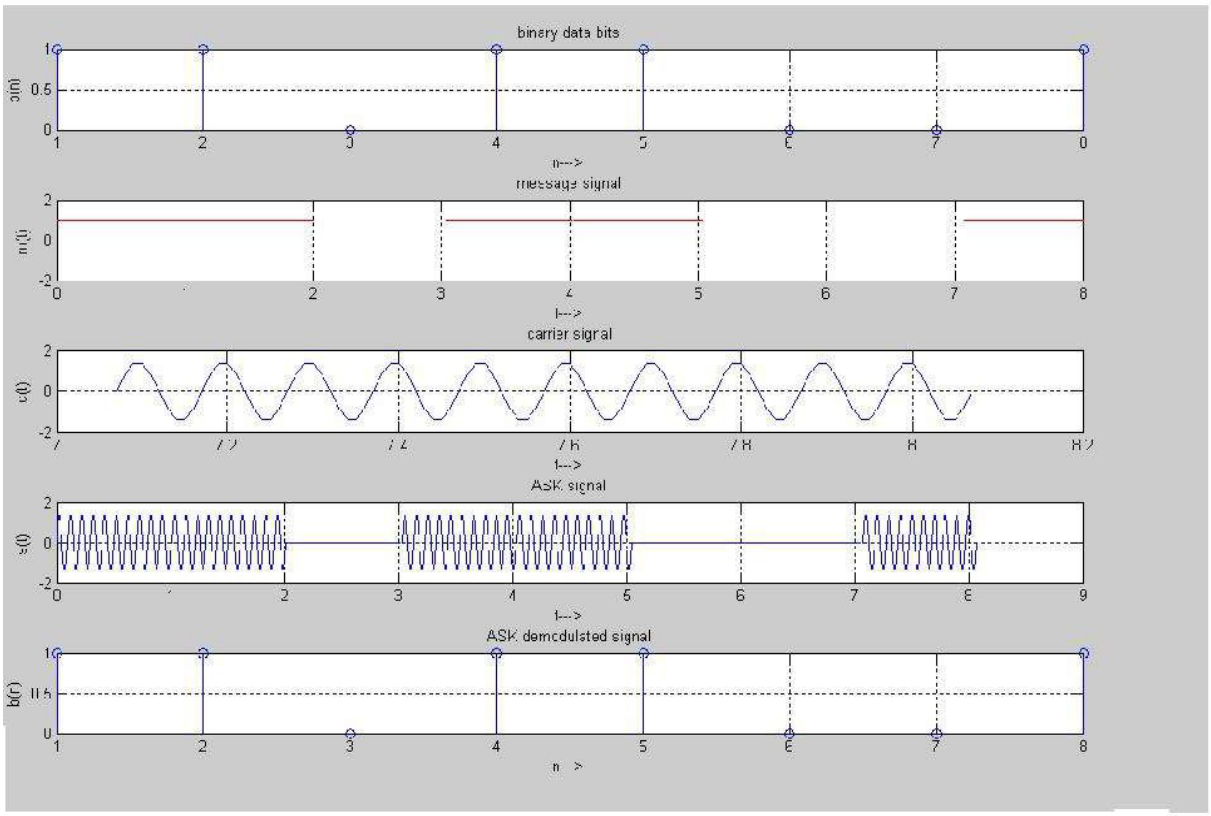
%ASK Modulation

```
clc;  clear all;
close all;
%GENERATE CARRIER SIGNAL
Tb=1; fc=10; t=0:Tb/100:1;
c=sqrt(2/Tb)*sin(2*pi*fc*t);
%generate message signal N=8;
m=rand(1,N);
t1=0;t2=Tb for
i=1:N t=[t1:.01:t2]
 if m(i)>0.5 m(i)=1;
        m_s=ones(1,length(t)); else
        m(i)=0;
        m_s=zeros(1,length(t)); end
message(i,:)=m_s;
%product of carrier and message
ask_sig(i,:)=c.*m_s; t1=t1+(Tb+.01);
t2=t2+(Tb+.01);
%plot the message and ASK signal subplot(5,1,2);axis([0 N -2 2]);
plot(t,message(i,:),'r');
title('message signal');xlabel('t--->');ylabel('m(t)'); grid on hold on;
subplot(5,1,4);plot(t,ask_sig(i,:));
title('ASK signal');xlabel('t--->');ylabel('s(t)');grid on hold on end
hold off
%Plot the carrier signal and input binary data subplot(5,1,3);plot(t,c);
title('carrier signal');xlabel('t--->');ylabel('c(t)');grid on subplot(5,1,1);stem(m);
title('binary data bits');xlabel('n--->');ylabel('b(n)');grid on
```

% **ASK Demodulation**

```
t1=0;t2=Tb for
i=1:N
t=[t1:Tb/100:t2]
%correlator x=sum(c.*ask_sig(i,:));
%decision device if x>0
        demod(i)=1; else
        demod(i)=0; end
t1=t1+(Tb+.01);
t2=t2+(Tb+.01);
  end
%plot demodulated binary data bits subplot(5,1,5);stem(demod);
title('ASK demodulated signal'); xlabel('n--->');ylabel('b(n)');grid on
```

Model Graphs



Experiment # 7

Experiment Title: Phase Shift Keying

Aim: To generate and demodulate phase shift keyed (PSK) signal using MATLAB

Generation of PSK signal

PSK is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave). PSK uses a finite number of phases, each assigned a unique pattern of binary digits. Usually, each phase encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data.

In a coherent binary PSK system, the pair of signal $S_1(t)$ and $S_2(t)$ used to represent binary symbols 1 & 0 are defined by

$S_1(t) = \sqrt{2E_b/T_b} \cos 2\pi f_c t$
$S_2(t) = \sqrt{2E_b/T_b}\,(2\pi f_c t+\pi) = -\sqrt{2E_b/T_b} \cos 2\pi f_c t$ where $0 \leq t < T_b$ and
Eb = Transmitted signed energy for bit
The carrier frequency $f_c = n/T_b$ for some fixed integer n.

Algorithm

Initialization commands

PSK modulation

1. Generate carrier signal.
2. Start FOR loop
3. Generate binary data, message signal in polar form
4. Generate PSK modulated signal.
5. Plot message signal and PSK modulated signal.
6. End FOR loop.
7. Plot the binary data and carrier.

PSK demodulation

1. Start FOR loop
   Perform correlation of PSK signal with carrier to get decision variable
2. Make decision to get demodulated binary data. If x>0, choose '1' else choose '0'
3. Plot the demodulated binary data.

Program

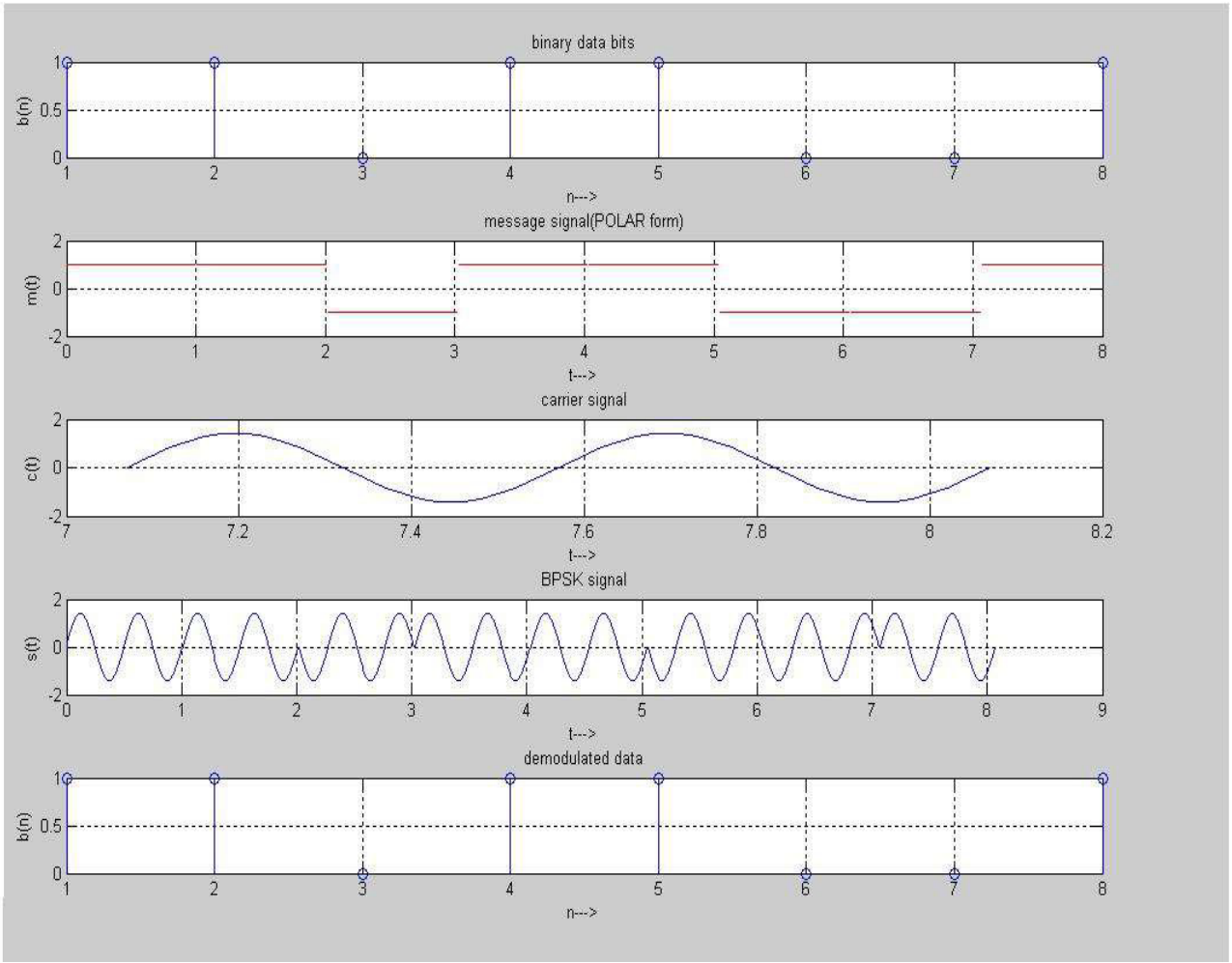
% **PSK modulation**

```
clc;  clearall;
close all;
%GENERATE CARRIER SIGNAL
Tb=1;
t=0:Tb/100:Tb;
fc=2; c=sqrt(2/Tb)*sin(2*pi*fc*t);
%generate message signal N=8;
m=rand(1,N);
t1=0;t2=Tb for
i=1:N t=[t1:.01:t2]
 ifm(i)>0.5 m(i)=1;
        m_s=ones(1,length(t)); else
        m(i)=0;
        m_s=-1*ones(1,length(t)); end
message(i,:)=m_s;
%product of carrier and message signal bpsk_sig(i,:)=c.*m_s;
%Plot the message and BPSK modulated signal subplot(5,1,2);axis([0 N -2
2]);plot(t,message(i,:),'r');
title('message signal(POLAR form)');xlabel('t--->');ylabel('m(t)'); grid on; hold on;
subplot(5,1,4);plot(t,bpsk_sig(i,:));
title('BPSK signal');xlabel('t--->');ylabel('s(t)'); grid on; hold on;
t1=t1+1.01; t2=t2+1.01;
end  hold
off
%plot the input binary data and carrier signal subplot(5,1,1);stem(m);
title('binary data bits');xlabel('n--->');ylabel('b(n)'); grid on;
subplot(5,1,3);plot(t,c);
title('carrier signal');xlabel('t--->');ylabel('c(t)'); grid on;
```

% PSK Demodulation

```
t1=0;t2=Tb for
  i=1:N
    t=[t1:.01:t2]
%correlator x=sum(c.*bpsk_sig(i,:));
%decision device if x>0
        demod(i)=1; else
        demod(i)=0; end
    t1=t1+1.01;
    t2=t2+1.01;
  end
 %plot the demodulated data bits
  subplot(5,1,5);stem(demod);
  title('demodulated data');xlabel('n--->');ylabel('b(n)'); grid on
```

Modal Graphs



Experiment # 8

Experiment Title: FREQUENCY SHIFT KEYING

Aim: To generate and demodulate frequency shift keyed (FSK) signal using MATLAB

Theory

Generation of FSK

Frequency- shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave. The simplest FSK is binary FSK (BFSK). BFSK uses a pair of discrete frequencies to transmit binary (0s and 1s) information. With this scheme, the "1" is called the mark frequency and the "0" is called the space frequency.

In binary FSK system, symbol 1 & 0 are distinguished from each other by transmitting one of the two sinusoidal waves that differ in frequency by a fixed amount.

$S_i(t) = \sqrt{2E/T_b} \cos 2\pi f_1 t \qquad 0 \leq t \leq T_b$

0 elsewhere Where i=1, 2 &

E_b=Transmitted energy/bit

Transmitted freq= $f_i = (nc+i)/T_b$, and n = constant (integer), T_b = bit interval

Symbol 1 is represented by $S_1(t)$

Symbol 0 is represented by $S_0(t)$

Algorithm

Initialization commands

FSK modulation

1. Generate two carriers signal.
2. Start FOR loop
3. Generate binary data, message signal and inverted message signal
4. Multiply carrier 1 with message signal and carrier 2 with inverted message signal
5. Perform addition to get the FSK modulated signal
6. Plot message signal and FSK modulated signal.
7. End FOR loop.
8. Plot the binary data and carriers.

FSK demodulation

1. Start FOR loop
2. Perform correlation of FSK modulated signal with carrier 1 and carrier 2 to get two decision variables x1 and x2.

3. Make decisionon x = x1-x2 to get demodulated binary data. If x>0, choose ‘1’ else choose ‘0’.
4. Plot the demodulated binary data.

Program

```
% FSK Modulation

cl
c;
cl
ea
r
al
l;
cl
os
e
al
l;
%GENERATE CARRIER
SIGNAL Tb=1;
fc1=2;fc2=5;
t=0:(Tb/100):Tb;
c1=sqrt(2/Tb)*sin(2*pi*fc1*t);
c2=sqrt(2/Tb)*sin(2*pi*fc2*t);
%generate message signal
N=8;
m=ra
nd(1,
N);
t1=0;
t2=T
b for
i=1:
N
   t=[t1:(Tb/100):t2]
   if
      m(i)
      >0.
      5
      m(i)
      =1;
      m_s=ones(1,length(t)); invm_s=zeros(1,length(t));
   else
      m(i)=0;
      m_s=zeros(1,length(t)); invm_s=ones(1,length(t));
   end
   message(i,:)
   =m_s;
%Multiplier
   fsk_sig1(i,:)=c1.*m_s;
   fsk_sig2(i,:)=c2.*invm_s;
   fsk=fsk_sig1+fsk_sig2;
%plotting the message signal and the modulated signal subplot(3,2,2);axis([0 N -2
```

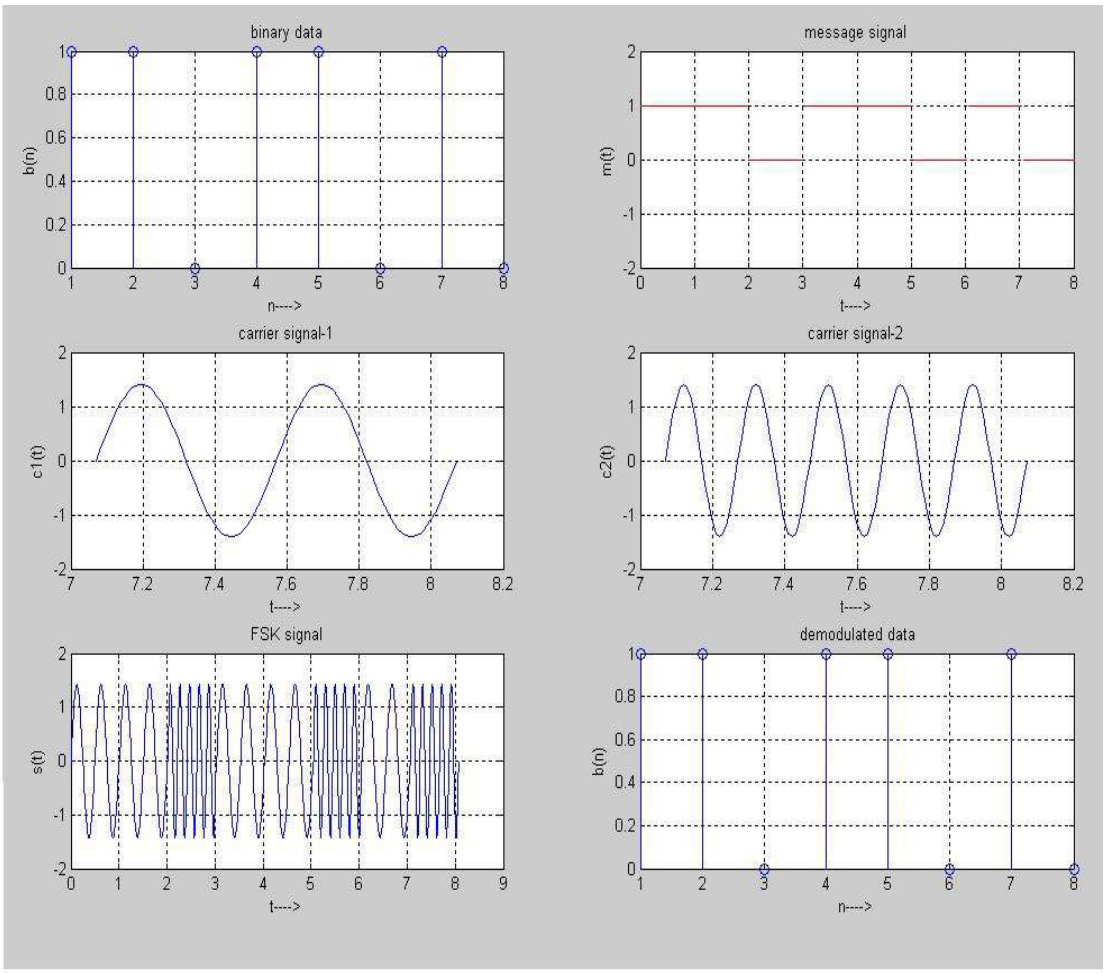
```
2]);plot(t,message(i,:),'r'); title('message
signal');xlabel('t---->');ylabel('m(t)');grid on;hold on; subplot(3,2,5);plot(t,fsk(i,:));
title('FSK signal');xlabel('t---->');ylabel('s(t)');grid on;hold on; t1=t1+(Tb+.01); t2=t2+(Tb+.01); end

hold off
%Plotting binary data bits and carrier signal
subplot(3,2,1);stem(m);
title('binary data');xlabel('n------------------------------>');
ylabel('b(n)');grid on;
subplot(3,2,3);plot(t,c1);
title('carrier signal-1');xlabel('t---->');ylabel('c1(t)');grid on; subplot(3,2,4);plot(t,c2);
title('carrier signal-2');xlabel('t---->');ylabel('c2(t)');grid on;
```

% **FSK Demodulation**

```
 t1=0
  ;t2=
  Tb
  for
  i=1:
  N
    t=[t1:(Tb/100):t2]
%correlator
    x1=sum(c1.*fsk_sig1(i,:));
    x2=sum(c2.*fsk_sig2(i,:));
    x=x1-x2;
%decision
    device if
    x>0
        dem
    od(i)=
    1; else
        demod(
    i)=0; end
    t1=t1+(Tb
    +.01);
    t2=t2+(Tb
    +.01);
  end
%Plotting the demodulated data bits
  subplot(3,2,6);stem(demod);
  title(' demodulated data');xlabel('n---->');ylabel('b(n)'); grid on;
```

Modal Graphs


binary data
b(n)
n---->
message signal
m(t)
t---->
carrier signal-1
c1(t)
t---->
carrier signal-2
c2(t)
t---->
FSK signal
s(t)
t---->
demodulated data
b(n)
n--->

Experiment # 09

Experiment Title: Pulse Code Modulation & Demodulation

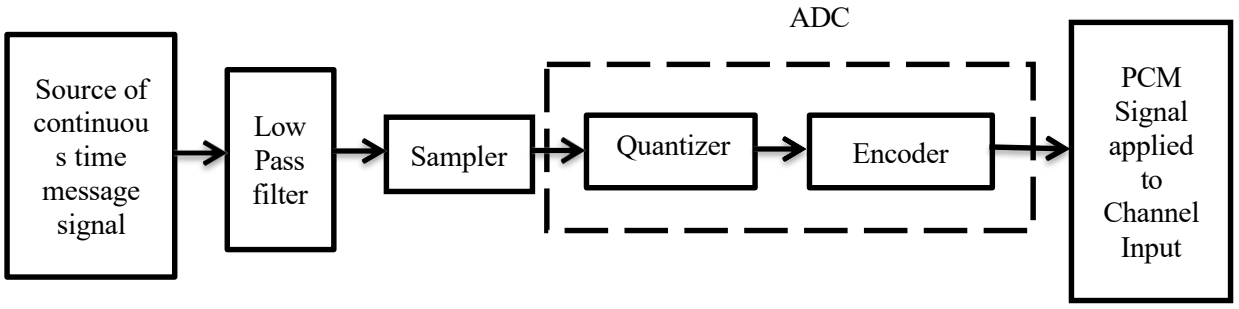
Aim:

Generate Pulse code Modulation and Demodulation.

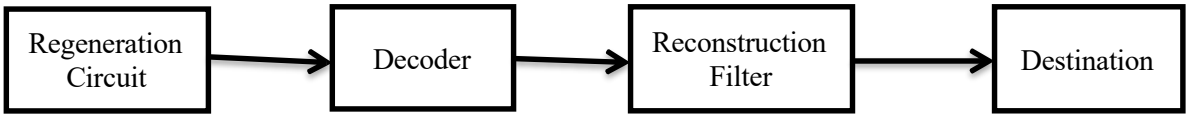
Experimental Requirements:

PC Loaded with MATLAB

Block Diagram:



(a) Transmission Path



(b) Receiver

MatLab Program:

% Pulse code modulation & Demodulation

```
clc;
clear
all;
close
all; a=4;
fm=2;
fs=100*fm;
t=0:1/fs:1;
x=a*sin(2*pi*fm*t);
subplot(5,1,1);
plot(t,x,'r');
xlabel('time');
ylabel('amplitude');
title('Original message
signal'); subplot(5,1,2);
```

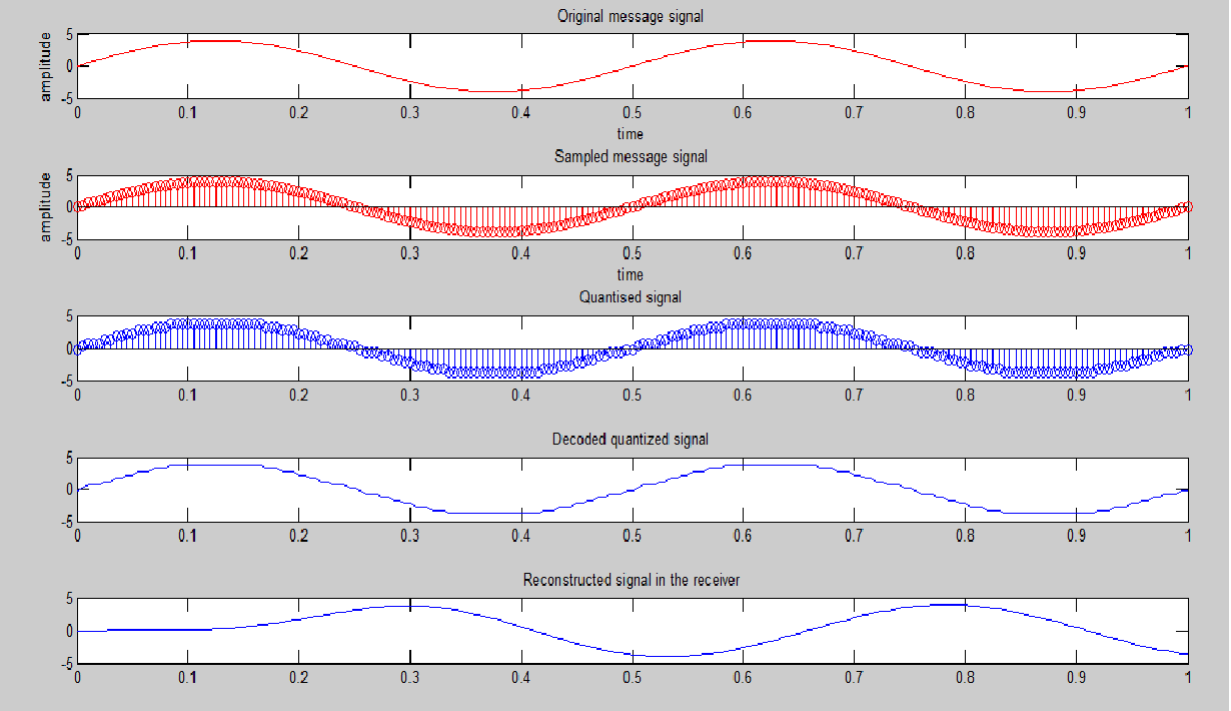
```
stem(t,x,'r');
xlabel('time');
ylabel('amplitude');
title('Sampled message
signal'); enc=[];
for(i=1:length(x))
 if (x(i)>0 && x(i)<=1)
 e=[1 0 0];
 xq(i)=0.5;
 elseif (x(i)>1 &&
 x(i)<=2) e=[1 0 1];
 xq(i)=1.5;
 elseif (x(i)>2 &&
 x(i)<=3) e=[1 1 0];
 xq(i)=2.5;
 elseif (x(i)>3 &&
 x(i)<=4) e=[1 1 1];
 xq(i)=3.5;
 elseif (x(i)>-4 && x(i)<=-3)
 e=[0 0 0];
 xq(i)=-3.5;
 elseif (x(i)>-3 && x(i)<=-2)
 e=[0 0 1];
 xq(i)=-2.5;
 elseif (x(i)>-2 && x(i)<=-1)
 e=[0 1 0];
 xq(i)=-1.5;
 else (x(i)>-1 &&
 x(i)<=0) e=[0 1 1];
 xq(i)=-0.5;
 end
 enc=[enc
 e]; end
 subplot(5,1,3);
 plot(t,xq,'b');
 title('Quantised signla');

% decoding(Receiver

 section) X_Q=[];
 for i=1:3:length(enc)-2
 if(enc(i)==0 && enc(i+1)==0 &&
 enc(i+2)==0) x_q=-3.5;
 elseif(enc(i)==0 && enc(i+1)==0 &&
 enc(i+2)==1) x_q=-2.5;
 elseif(enc(i)==0 && enc(i+1)==1 &&
 enc(i+2)==0) x_q=-1.5;
```

```
 elseif(enc(i)==0 && enc(i+1)==1 &&
 enc(i+2)==1) x_q=-0.5;
 elseif(enc(i)==1 && enc(i+1)==0 && enc(i+2)==0)
 x_q=0.5;
 elseif(enc(i)==1 && enc(i+1)==0 &&
 enc(i+2)==1) x_q=1.5;
elseif(enc(i)==1 && enc(i+1)==1 &&
 enc(i+2)==0) x_q=2.5;
 elseif(enc(i)==1 && enc(i+1)==1 &&
 enc(i+2)==1) x_q=3.5;
 end
 X_Q=[X_Q
 x_q]; end
 subplot(5,1,4);
 plot(t,X_Q);
 title('Decoded
 signal');
 [num,den]=butter(6,4*fm/fs)
 ;
 recon=filter(num,den,X_Q);
 subplot(5,1,5);
 plot(t,recon);
 title('Reconstructed signal in the receiver');
```

Wave forms:



Result:

Conclusion:

Experiment # 10

Experiment Title: Delta Modulation

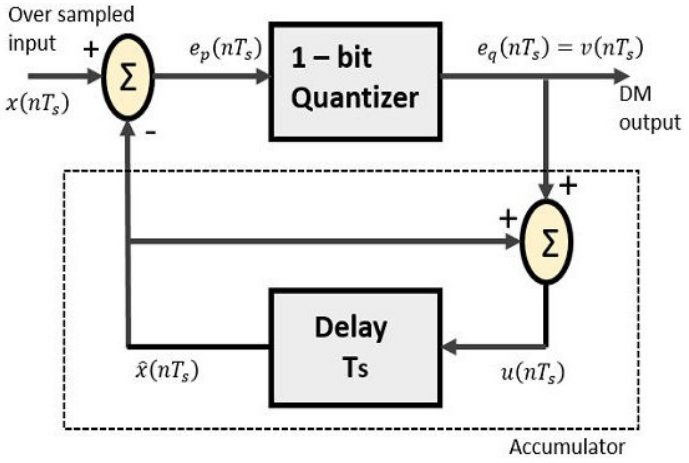
Aim:

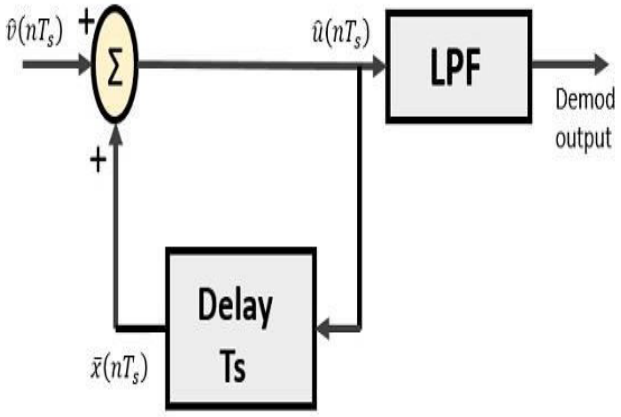
Implementation of Delta Modulated signal

Experimental Requirements:

PC Loaded with MATLAB

Block Diagram:





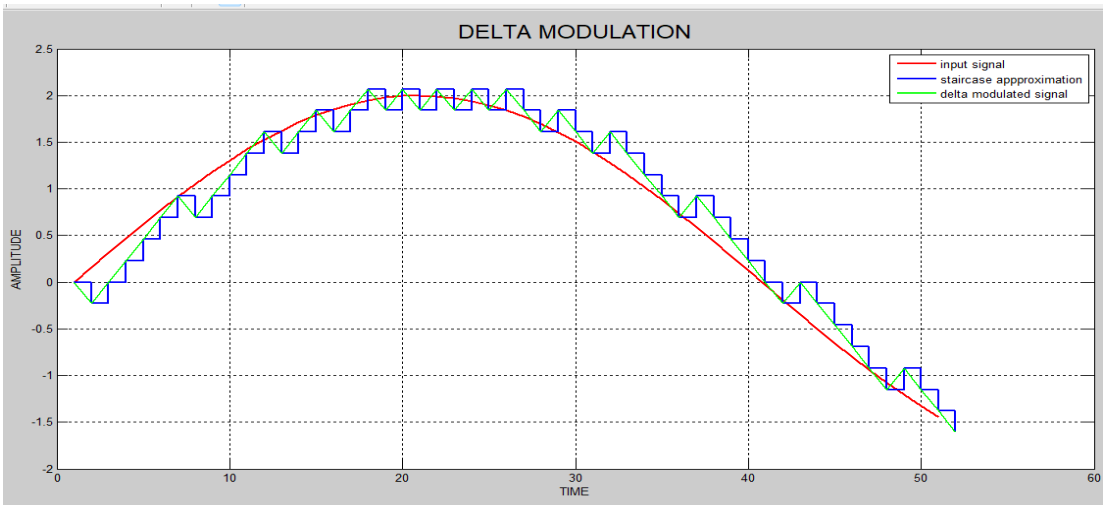
MatLab Program

CASE 1

```
clc;
clear
close
all; a=2;
t=0:2*pi/50:2*pi;
```

```
x=a*sin(2*pi/10*t); l=length(x);
plot(x,'r','linewidth',2); delta=0.2;
hold on xn=0; for
i=1:l
if x(i)>xn(i)
d(i)=1;
xn(i+1)=xn(i)+delta; else
d(i)=0;
xn(i+1)=xn(i)-delta; end
end stairs(xn,'b','linewidth',2) hold
on plot(xn,'g','linewidth',2);
xlabel('TIME');
ylabel('AMPLITUDE');
title('DELTA MODULATION','fontsize',18);
legend('input signal','staircase appproximaton','delta modulated signal'); grid
on
```

Waveform:

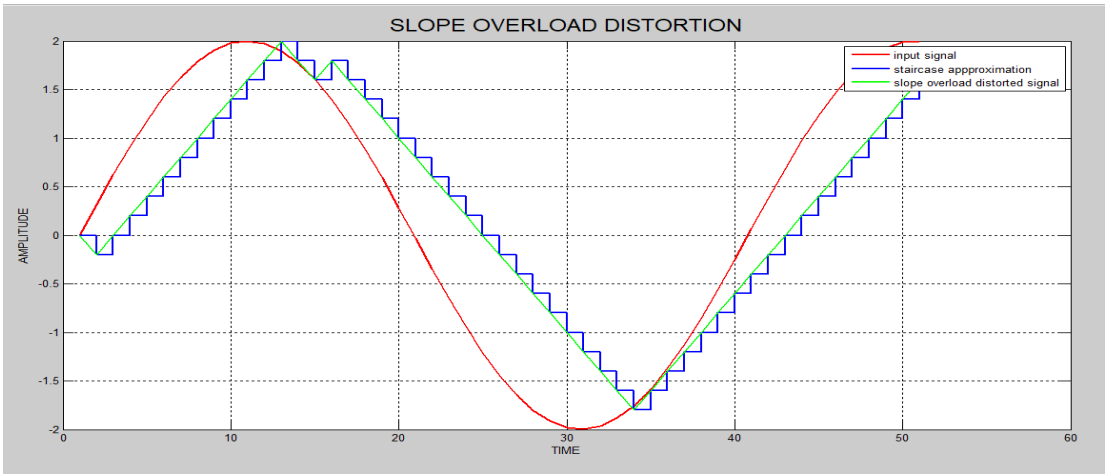


CASE 2

```
clc;  clear close all;
a=2;
t=0:2*pi/50:2*pi; x=a*sin(2*pi/5*t);
l=length(x);
plot(x,'r','linewidth',2); delta=0.2;
hold on xn=0; for
i=1:l
if x(i)>xn(i)
d(i)=1;
xn(i+1)=xn(i)+delta; else
d(i)=0;
xn(i+1)=xn(i)-delta; end
```

```
end stairs(xn,'b','linewidth',2) hold
on plot(xn,'g','linewidth',2);
xlabel('TIME');
ylabel('AMPLITUDE');
title('SLOPE OVERLOAD DISTORTION','fontsize',18);
legend('input signal','staircase appproximaton','slope overload distortedsignal'); grid on
```

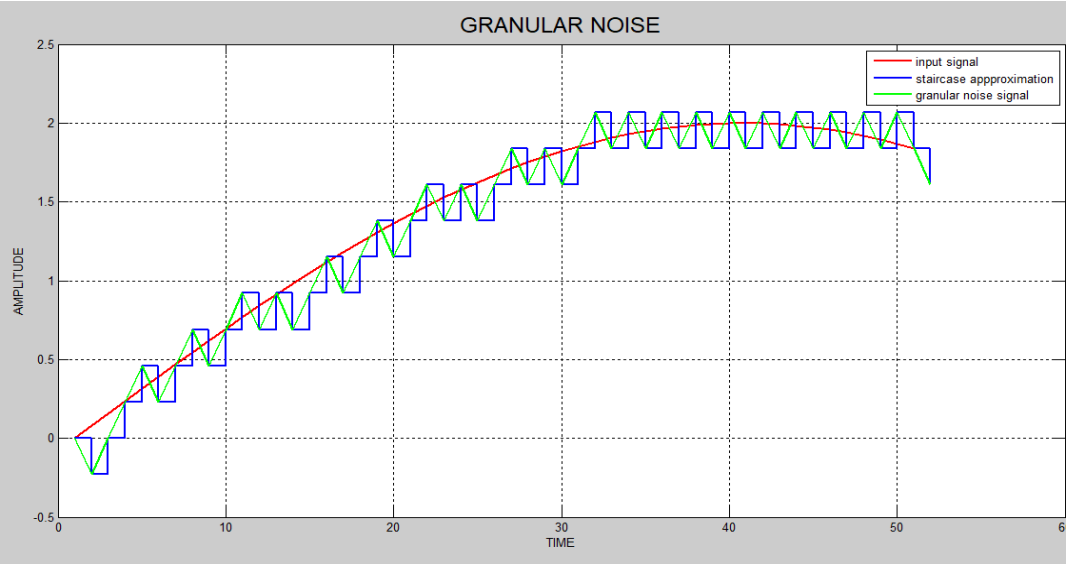
Waveform:



CASE 3

```
clc;  clear close all;
a=2;
t=0:2*pi/50:2*pi;
x=a*sin(2*pi/20*t); l=length(x);
plot(x,'r','linewidth',2); delta=0.23;
hold on xn=0; for
i=1:l
if x(i)>xn(i)
d(i)=1;
xn(i+1)=xn(i)+delta; else
d(i)=0;
xn(i+1)=xn(i)-delta; end
end stairs(xn,'b','linewidth',2) hold
on plot(xn,'g','linewidth',2);
xlabel('TIME');
ylabel('AMPLITUDE');
title('GRANULAR NOISE','fontsize',18);
legend('input signal','staircase appproximation','delta modulated signal');
grid on;
```

Waveform:



Result:

Conclusion: