



# Basic Simulation Lab Manual

# 2022

Basic Simulation Lab with MATLAB Written for under graduate students in the fields of electronics and communication, this Manual is meant to supplement the theoretical concepts taught in an introductory course on signals and systems. Each Simulation contains all the theoretical background information needed for the simulations as well as the required MATLAB code. Topics include an introduction to vectors and matrices, operations on signals and sequences, and the Fourier transform etc.

A Guide to  
Student for BS  
LAB

# **LABORATORY MANUAL**

## **BASIC SIMULATION**

**II B. TECH -I Semester (ECE-R22)**



**J. B. Institute of Engineering & Technology**  
**(UGC Autonomous)**

**Accredited by NAAC & NBA, approved by AICTE & Permanently Affiliated to JNTUH**  
**Department of Electronics & Communication Engineering**

## DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

### VISION AND MISSION

#### VISION

- To be a guiding force enabling multifarious applications in Electronics and Communications Engineering, promote innovative research in the latest technologies to meet societal needs

#### MISSION

- To provide and strengthen core competencies among the students through expert training and industry interaction.
- To promote advanced designing and modeling skills to sustain technical development and lifelong learning in ECE.
- To promote social responsibility and ethical values, within and outside the department.

### PEO'S, PO'S & PSOS

Program Educational Objectives (PEOs):	
<b>PEO 1</b>	Practice Technical skills widely in industrial, societal and real time applications.
<b>PEO 2</b>	Engage in the pursuit of higher education, delve into extensive research and development endeavours, and explore creative and innovative ventures in the domains of science, engineering, technology.
<b>PEO 3</b>	Exhibit professional ethics and moral values and capability of working with professional skills to contribute towards the need of industry and society.

## PROGRAM OUTCOMES (POs)

### Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9. **Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

- 11. Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- 12. Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):	
<b>PSO 1</b>	Carry out the Analysis and Design different Analog & Digital circuits with given specifications.
<b>PSO 2</b>	Construct and test different communication systems for various applications.

**INSTRUCTIONS TO THE STUDENTS**

1. Students are required to attend all labs.
2. Students will work individually in hardware laboratories and in computer laboratories.
3. While coming to the lab bring the lab manual cum observation book, record etc.
4. Take only the lab manual, calculator (if needed) and a pen or pencil to the work area.
5. Before coming to the lab, prepare the prelab questions. Read through the lab experiment to familiarize yourself with the components and assembly sequence.
6. Utilize 2 hours time properly to perform the experiment (both in software and hardware) and note down the readings properly. Do the calculations, draw the graph and take signature from the instructor.
7. If the experiment is not completed in the prescribed time, the pending work has to be done in the leisure hour or extended hours.
8. You have to submit the completed record book according to the deadlines set up by your instructor.
9. For practical subjects there shall be a continuous evaluation during the semester for 30 sessional marks and 70 end examination marks.
10. Of the 30 marks for internal, 20 marks shall be awarded for day-to-day work and 10 marks to be awarded by conducting an internal laboratory test.

## INDEX

SL.NO.	EXPERIMENT NAME	PAGENO.
1	Basic Operations on Matrices.	8
2	Generation of Various Signals and Sequences (Periodic and Aperiodic), such as Unit impulse, unit step, square, saw tooth, triangular, sinusoidal, ramp, sinc.	14
3	Observations on signals and sequences such as addition, multiplication, scaling, shifting, folding, computation of energy and average power.	31
4	Finding the even and odd parts of signal/ sequence and real and imaginary parts of signal.	41
5	Convolution between signals and sequences.	49
6	Autocorrelation and cross correlation between signals and sequences.	56
7	Verification of linearity and time invariance properties of a given continuous /discrete system.	66
8	Computation of unit samples, unit step and sinusoidal response of the given LTI system and verifying its physical realizability and stability properties.	74
9	Gibbs phenomenon.	79
10	Finding the Fourier transform of a given signal and plotting its magnitude and Phase spectrum.	84
11	Waveform synthesis using Laplace Transform.	91
12	Checking a random process for stationary in wide sense.	95
13	Generation of Gaussian noise (real and complex), computation of its mean, M.S. Value and its Skew, Kurtosis, and PSD, Probability Distribution Function.	100
14	Sampling theorem verification.	109
15	Removal of noise by autocorrelation / cross correlation.	117
16	Extraction of periodic signal masked by noise using correlation	123
17	Verification of Wiener- Khinchin relations.	128
18	Locating the zeros and poles and plotting the pole-zero maps in S plane and Z-plane for the given transfer function (Experiment beyond syllabus)	134

**EXPERIMENT NO:1**  
**BASIC OPERATIONS ON MATRICES**

AIM: - To write a MATLAB program to perform some basic operation on matrices such as addition, subtraction, multiplication.

**SOFTWARE REQUIRED: -**

1. MATLAB R2010a.
2. Windows XP SP2.

**THEORY: -**

MATLAB, which stands for MATRIX Laboratory, is a state-of-the-art mathematical software package, which is used extensively in both academia and industry. It is an interactive program for numerical computation and data visualization, which along with its programming capabilities provides a very useful tool for almost all areas of science and engineering. Unlike other mathematical packages, such as MAPLE or MATHEMATICA, MATLAB cannot perform symbolic manipulations without the use of additional Toolboxes. It remains however, one of the leading software packages for numerical computation.

As you might guess from its name, MATLAB deals mainly with matrices. A scalar is a 1-by-1 matrix and a row vector of length say 5, is a 1-by-5 matrix.. One of the many advantages of MATLAB is the natural notation used. It looks a lot like the notation that you encounter in a linear algebra. This makes the use of the program especially easy and it is what makes MATLAB a natural choice for numerical computations. The purpose of this experiment is to familiarize MATLAB, by introducing the basic features and commands of the program.

**Built in Functions:****1. Scalar Functions:**

Certain MATLAB functions are essentially used on scalars, but operate element-wise when applied to a matrix (or vector). They are summarized below.

1. sin - trigonometric sine
2. cos - trigonometric cosine
3. tan - trigonometric tangent
4. asin - trigonometric inverse sine (arcsine)
5. acos - trigonometric inverse cosine (arccosine)
6. atan - trigonometric inverse tangent (arctangent)
7. exp - exponential
8. log - natural logarithm
9. abs - absolute value



10. sqrt - square root
11. rem - remainder
12. round - round towards nearest integer
13. floor - round towards negative infinity
14. ceil - round towards positive infinity

## 2. Vector Functions:

Other MATLAB functions operate essentially on vectors returning a scalar value. Some of these functions are given below.

1. max largest component : get the row in which the maximum element lies
2. min smallest component
3. length length of a vector
4. sort sort in ascending order
5. sum sum of elements
6. prod product of elements
7. median median value
8. mean mean value std standard deviation

## 3. Matrix Functions:

Much of MATLAB's power comes from its matrix functions. These can be further separated into two sub-categories.

The first one consists of convenient matrix building functions, some of which are given below.

1. eye - identity matrix
2. zeros - matrix of zeros
3. ones - matrix of ones
4. diag - extract diagonal of a matrix or create diagonal matrices
5. triu - upper triangular part of a matrix
6. tril - lower triangular part of a matrix
7. rand - randomly generated

matrixeg:

```
diag([0.9092;0.5163;0.2661])
```

```
ans =
```

```
0.9092 0 0
```

```
0 0.5163 0
```

```
0 0 0.2661
```

commands in the second sub-category of matrix functions are

1. size size of a matrix
2. det determinant of a square matrix
3. inv inverse of a matrix
4. rank rank of a matrix
5. rref reduced row echelon form
6. eig eigenvalues and eigenvectors
7. poly characteristic polynomial

**PROCEDURE:-**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM:-**

```
clc;
close
all;clear
all;
a=[1 2 -9 ; 2 -1 2; 3 -4 3];
b=[1 2 3; 4 5 6; 7 8 9];
disp('The matrix a= ');
a
disp('The matrix b= ');
b
% to find sum of a and b
c=a+b;
disp('The sum of a and b is ');
c
% to find difference of a and b
d=a-b;
disp('The difference of a and b is ');
d
%to find multiplication of a and b
e=a*b;
disp('The product of a and b is ');
e
```

\

**OUTPUT:-**

The matrix

a=a =

```
1  2  -9
2  -1  2
3  -4  3
```

The matrix

b=b =

```
1  2  3
4  5  6
7  8  9
```

The sum of a and b is c =

```
2  4  -6
6  4  8
10 4  12
```

The difference of a and b is d =

```
0  0 -12
-2 -6 -4
-4 -12 -6
```

The product of a and b is e =

```
-54 -60 66
12  15 18
8   10 12
```

**RESULT:-**

Finding addition, subtraction, multiplication using MATLAB was Successfully completed.

**VIVA QUESTIONS:-**

1. Expand MATLAB? And importance of MATLAB?
2. What is clear all and close all will do?
3. What is disp() and input()?
4. What is the syntax to find the eigen values and eigenvectors of the matrix?
5. What is the syntax to find the rank of the matrix?
6. How to determine rank of Matrix?
7. How to determine Rank of Matrix?
8. How to determine Transpose of Matrix?
9. How to determine Trace of Matrix?
10. How to determine Inverse of Matrix?

**EXERCISE PROGRAMS**

1. Enter the matrix  $M = [1, 3, -1, 6; 2, 4, 0, -1; 0, -2, 3, -1; -1, 2, -5, 1]$  and  $N = [-1, -3, 3; 2, -1, 6; 1, 4, -1; 2, -1, 2]$ , perform multiplication on M and N. Can order of multiplication be switched? Why or why not?
2. Enter the matrix  
 $M = [1, -2, 8, 0]$  and  $N = [1 \ 5 \ 6 \ 8; 2 \ 5 \ 6 \ 9]$   
 Perform addition on M and N and see how matlab reacts.
3. Find the transpose of null matrix using matlab
4. Write a MATLAB program to perform the division operation on the following  
 $\text{matrixA} = [24, -30, 64, -81]$ ,  $b = [6, 5, 8, 9]$  and verify the result.
5. Write a matlab program to perform addition operation using 2x3 matrix. Assume any numbers
6. Enter the matrix  
 $A = [1 \ 6 \ 9 \ 8 \ 5; 9 \ 3 \ 5 \ 8 \ 4; 5 \ 6 \ 3 \ 5 \ 7]$ ,  $B = [6 \ 5 \ 9 \ 3 \ 5; 6 \ 5 \ 4 \ 8 \ 5; 6 \ 3 \ 5 \ 7 \ 9]$ ,  
 $C = [2 \ 5 \ 9 \ 3 \ 4; 5 \ 6 \ 3 \ 7 \ 8; 9 \ 8 \ 6 \ 5 \ 4]$   
 Find  $[(A+B)+C]^T$
7. Enter the matrix  
 $A = [1 \ 6 \ 9 \ 8 \ 5; 9 \ 3 \ 5 \ 8 \ 4; 5 \ 6 \ 3 \ 5 \ 7]$ ,  $B = [6 \ 5 \ 9 \ 3 \ 5; 6 \ 5 \ 4 \ 8 \ 5; 6 \ 3 \ 5 \ 7 \ 9]$ ,  
 $C = [2 \ 5 \ 9 \ 3 \ 4; 5 \ 6 \ 3 \ 7 \ 8; 9 \ 8 \ 6 \ 5 \ 4]$   
 Find  $[(A-B)+C]^{-1}$
8. Write a matlab program to perform addition operation using 3x2 matrix. Assume any numbers
9. Write a MATLAB program to perform the division operation on the following  
 $\text{matrix A} = [25, -35, 121, -21]$ ,  $b = [5, 5, 11, 3]$  and perform the transpose function on the answer
10. Find the addition of null matrix and unity matrix of order 3x3.
11. Write a MATLAB program to find rank of the matrix  $A = [6 \ 5 \ 9 \ 3 \ 5; 6 \ 5 \ 4 \ 8 \ 5; 6 \ 3 \ 5 \ 7 \ 9]$ .
12. Write a MATLAB program to find Eigen of the matrix  $A = [2 \ 5 \ 9 \ 3 \ 4; 5 \ 6 \ 3 \ 7 \ 8; 9 \ 8 \ 6 \ 5 \ 4]$ .
13. Write a MATLAB program to find inverse of the matrix  $A = [1 \ 6 \ 9 \ 8 \ 5; 9 \ 3 \ 5 \ 8 \ 4; 5 \ 6 \ 3 \ 5 \ 7]$
14. Write a MATLAB program to find determinant of the  
 $\text{matrixA} = [1 \ 6 \ 9 \ 8 \ 5; 9 \ 3 \ 5 \ 8 \ 4; 5 \ 6 \ 3 \ 5 \ 7]$ .
15. Write a MATLAB program to find Transpose of the  
 $\text{matrixA} = [1 \ 6 \ 9 \ 8 \ 5; 9 \ 3 \ 5 \ 8 \ 4; 5 \ 6 \ 3 \ 5 \ 7]$

## Basic Simulation Lab Manual

16. Find the multiplication of null matrix and unity matrix of order 3x3.
17. Write a matlab program to perform multiplication operation using 2x3 matrix. Assume any numbers.
18. Write a MATLAB program to perform the division operation on the following  
matrixA = [2,-5, 21,-21], b= [5,15,11,13].
19. Enter the matrix  
A = [6 9 8 5;3 5 8 4;6 3 5 7], B = [5 9 3 5;5 4 8 5;3 5 7 9],  
C = [5 9 3 4;6 3 7 8;8 6 5 4]  
Find [(A-B)+C]<sup>-1</sup>
20. Write a matlab program to perform division operation using 3x2 matrix. Assume any numbers
21. Write a MATLAB program to perform the division operation on the following  
matrixA = [5,-3,11,-1], b= [6,5,1,13] and perform the transpose function on the answer.
22. Find the addition of null matrix and Identity matrix of order 4x4.
23. Enter the matrix M=[2,13,-11;12,4,2;-2,3,-1] and N=[2,-1,6;1,4,-1;2,-1,2], perform multiplication on M and N.
24. Enter the matrix M = [-2,8,0] and N = [1 5 6 8; 2 5 6 9]  
Perform addition and multiplication on M and N and see how matlab reacts.
25. Enter the matrix A = [6 9 8 5;3 5 8 4;6 3 5 7], B = [5 9 3 5;5 4 8 5;3 5 7 9],  
C = [2 5 9 3 4; 5 6 3 7 8; 9 8 6 5 4]  
Find [(A+B)+C]<sup>T</sup>
26. Find the addition of null matrix and unity matrix of order 4x4.
27. Write a MATLAB program to find rank of the matrix A= [6 4 9 3 5; 6 2 4 8 5; 6 3 1 7 9].
28. Write a MATLAB program to find Eigen of the matrix A= [2 5 0 3 4; 5 4 3 7 8; 9 1 6 5 4].
29. Write a MATLAB program to find inverse of the matrix A= [1 5 9 8 5;4 3 5 8 4; 5 6 3 5 0]
30. Write a MATLAB program to find determinant of the  
matrixA= [1 6 9 8 5; 9 3 5 6 4; 1 6 3 5 6].

**Real Time application:**

We see the results of matrix mathematics in every computer-generated image that has areflection, or distortion effects such as light passing through rippling water.

**EXPERMENT NO:2****GENERATION OF VARIOUS SIGNALS & SEQUENCES**

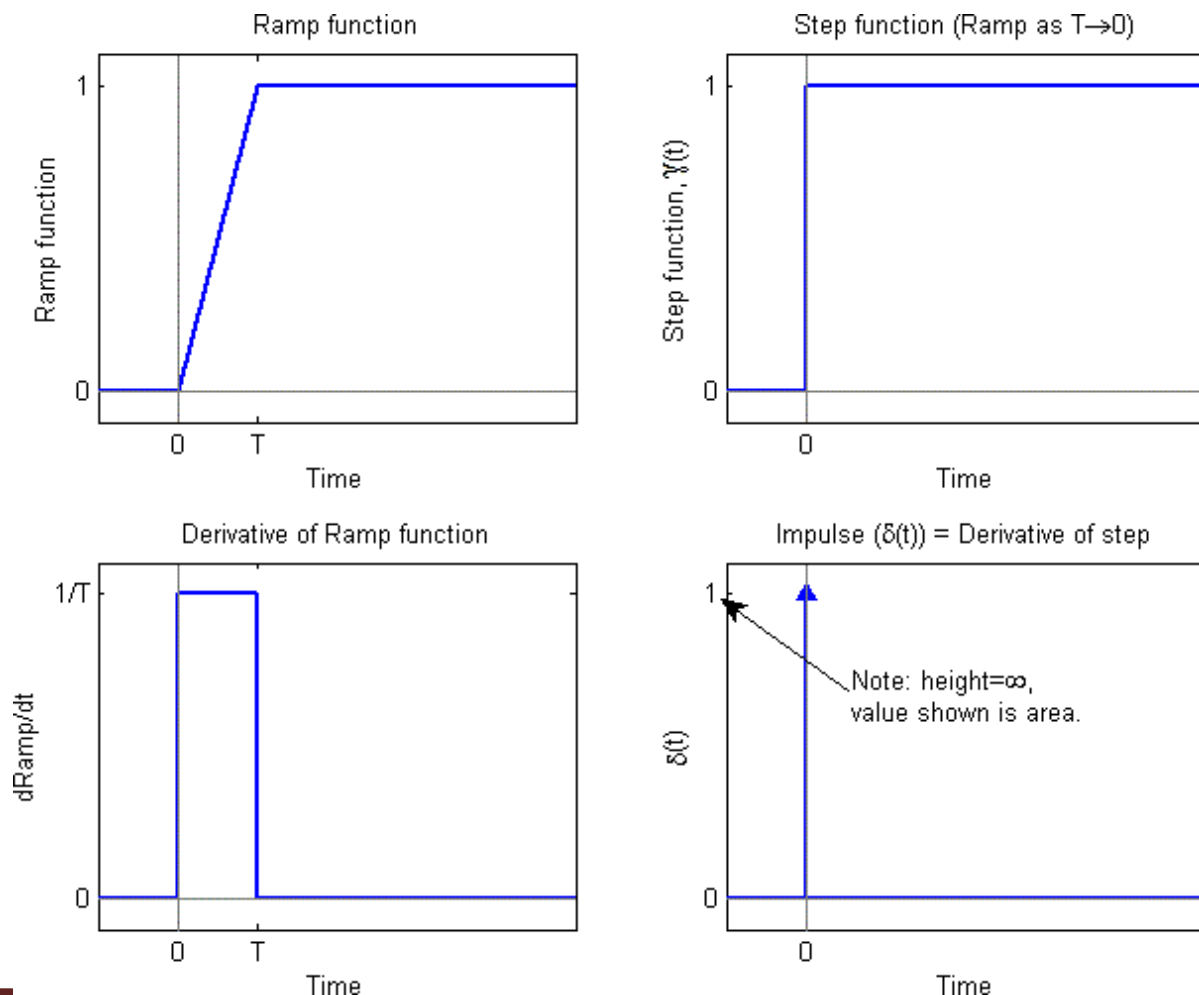
**AIM:-** To write a "MATLAB" Program to generate various signals and sequences, such as unit impulse, unit step, unit ramp, sinusoidal, square, sawtooth, triangular, sinc functions.

**SOFTWARE REQUIRED:-**

1. MATLAB R2010a.
2. Windows XP SP2.

**THEORY:-**

One of the more useful functions in the study of linear systems is the "unit impulse function." An ideal impulse function is a function that is zero everywhere but at the origin, where it is infinitely high. However, the *area* of the impulse is finite. This is, at first hard to visualize but we can do so by using the graphs shown below.



## Key Concept: Sifting Property of the Impulse

If  $b > a$ , then

$$\int_a^b \delta(t - T) \cdot f(t) dt = \begin{cases} f(T), & a < T < b \\ 0, & \text{otherwise} \end{cases}$$

Example: Another integral problem

Assume  $a < b$ , and evaluate the integral

$$\int_a^b \delta(t) \cdot f(t - T) dt$$

**Solution:**

We now that the impulse is zero except at  $t=0$  so

$$\delta(t) \cdot f(t - T) = \delta(t) \cdot f(0 - T) = \delta(t) \cdot f(-T)$$

and

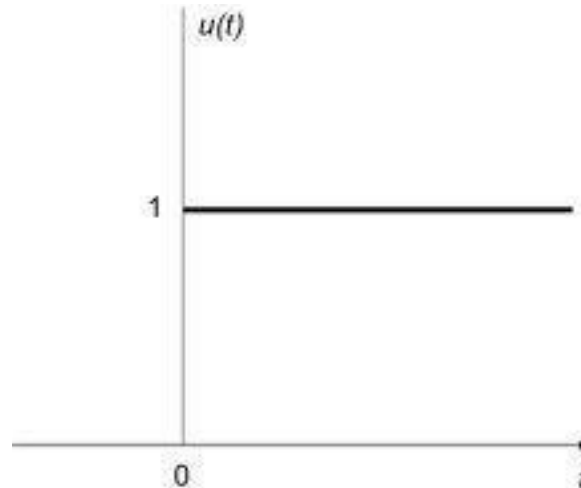
$$\begin{aligned} \int_a^b \delta(t) \cdot f(t - T) dt &= \int_a^b \delta(t) \cdot f(-T) dt \\ &= f(-T) \cdot \int_a^b \delta(t) dt \\ &= \begin{cases} f(-T), & a < 0 < b \\ 0, & \text{otherwise} \end{cases} \end{aligned}$$

## Unit Step Function

The unit step function and the impulse function are considered to be fundamental functions in engineering, and it is strongly recommended that the reader becomes very familiar with both of these functions.

The unit step function, also known as the [Heaviside function](#), is defined as such:

$$u(t) = \begin{cases} 0, & \text{if } t < 0 \\ 1, & \text{if } t > 0 \\ \frac{1}{2}, & \text{if } t = 0 \end{cases}$$



Sometimes,  $u(0)$  is given other values, usually either 0 or 1. For many applications, it is irrelevant what the value at zero is.  $u(0)$  is generally written as undefined.

## Derivative

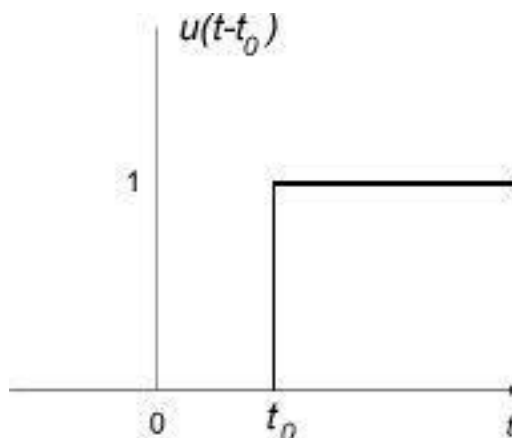
The unit step function is level in all places except for a discontinuity at  $t = 0$ . For this reason, the derivative of the unit step function is 0 at all points  $t$ , except where  $t = 0$ . Where  $t = 0$ , the derivative of the unit step function is infinite.

The derivative of a unit step function is called an **impulse function**. The impulse function will be described in more detail next.

## Integral

The integral of a unit step function is computed as such:

$$\int_{-\infty}^t u(s) ds = \begin{cases} 0, & \text{if } t < 0 \\ \int_0^t ds = t, & \text{if } t \geq 0 \end{cases} = tu(t)$$





## Sinc Function

There is a particular form that appears so frequently in communications engineering, that we give it its own name. This function is called the "Sinc function" and is discussed below:

The Sinc function is defined as below

$$\text{sinc}(x) = \frac{\sin(\pi x)}{\pi x} \text{ if } x \neq 0$$

and  $\text{Sinc}(0)=1$

The value of  $\text{sinc}(x)$  is defined as 1 at  $x = 0$ , since

$$\lim_{x \rightarrow 0} \text{sinc}(x) = 1$$

This fact can be proven by noting that for  $x$  near 0,

$$1 > \frac{\sin(x)}{x} > \cos(x)$$

Then, since  $\cos(0) = 1$ , we can apply the [Squeeze Theorem](#) to show that the sinc function approaches one as  $x$  goes to zero. Thus, defining  $\text{sinc}(0)$  to be 1 makes the sinc function continuous.

Also, the Sinc function approaches zero as  $x$  goes towards infinity, with the envelope of  $\text{sinc}(x)$  tapering off as  $1/x$ .

## Rect Function

The Rect Function is a function which produces a rectangular-shaped pulse with a width of 1 centered at  $t = 0$ . The Rect function pulse also has a height of 1. The Sinc function and the rectangular function form a Fourier transform pair.

A Rect function can be written in the form:

$$\text{rect}\left(\frac{t - X}{Y}\right)$$

where the pulse is centered at  $X$  and has width  $Y$ . We can define the impulse function above in terms of the rectangle function by centering the pulse at zero ( $X = 0$ ), setting it's height to  $1/A$  and setting the pulse width to  $A$ , which approaches zero:

## Basic Simulation Lab Manual

$$\delta(t) = \lim_{A \rightarrow 0} \frac{1}{A} \text{rect}\left(\frac{t-0}{A}\right)$$

We can also construct a Rect function out of a pair of unit step functions

$$\text{rect}\left(\frac{t-X}{Y}\right) = u(t-X+Y/2) - u(t-X-Y/2)$$

Here, both unit step functions are set a distance of  $Y/2$  away from the center point of  $(t-X)$ .

## SAW TOOTH:-

The sawtooth wave (or saw wave) is a kind of non-sinusoidal waveform. It is named a sawtooth based on its resemblance to the teeth on the blade of a saw. The convention is that a sawtooth wave ramps upward and then sharply drops. However, there are also sawtooth waves in which the wave ramps downward and then sharply rises. The latter type of sawtooth wave is called a 'reverse sawtooth wave' or 'inverse sawtooth wave'. As audio signals, the two orientations of sawtooth wave sound identical. The piecewise linear function based on the floor function of time  $t$ , is an example of a sawtooth wave with period 1.

$$x(t) = 2 \left( \frac{t}{a} - \text{floor} \left( \frac{t}{a} + \frac{1}{2} \right) \right)$$

**Triangle wave**

A triangle wave is a non-sinusoidal waveform named for its triangular shape. A bandlimited triangle wave pictured in the time domain (top) and frequency domain (bottom). The fundamental is at 220 Hz (A2). Like a square wave, the triangle wave contains only odd harmonics. However, the higher harmonics roll off much faster than in a square wave (proportional to the inverse square of the harmonic number as opposed to just the inverse). It is possible to approximate a triangle wave with additive synthesis by adding odd harmonics of the fundamental, multiplying every  $(4n-1)$ th harmonic by  $-1$  (or changing its phase by  $\pi$ ), and rolling off the harmonics by the inverse square of their relative frequency to the fundamental. This infinite Fourier series converges to the triangle wave:

$$\begin{aligned} x_{\text{triangle}}(t) &= \frac{8}{\pi^2} \sum_{k=0}^{\infty} (-1)^k \frac{\sin((2k+1)\omega t)}{(2k+1)^2} \\ &= \frac{8}{\pi^2} \left( \sin(\omega t) - \frac{1}{9} \sin(3\omega t) + \frac{1}{25} \sin(5\omega t) - \dots \right) \end{aligned}$$

where  $\omega$  is the angular frequency.

## Sinusoidal Signal Generation

The sine wave or sinusoid is a mathematical function that describes a smooth repetitive oscillation. It occurs often in pure mathematics, as well as physics, signal processing, electrical engineering and many other fields. Its most basic form as a function of time (t) is: where:

- A, the amplitude, is the peak deviation of the function from its center position.
- $\omega$ , the angular frequency, specifies how many oscillations occur in a unit time interval, in radians per second
- $\phi$ , the phase, specifies where in its cycle the oscillation begins at  $t = 0$ . A sampled sinusoid may be written as:

$$x(n) = A \sin(2\pi \frac{f}{f_s} n + \phi)$$

where f is the signal frequency,  $f_s$  is the sampling frequency,  $\phi$  is the phase and A is the amplitude of the signal.

### PROCEDURE:-

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

### PROGRAM:-

```
%unit impulse function%clc;
clear all; close
all; t=-10:1:10;
x=(t==0);
subplot(2,1,1);
plot(t,x,'g');
xlabel('time'); ylabel('amplitude');
title('unit impulse function');subplot(2,1,2);
stem(t,x,'r');
xlabel('time');
ylabel('amplitude');
title('unit impulse discreat function');
```

### %unit step function%

```
clc;
clear all; close
all; N=100;
t=1:100;
x=ones(1,N);
subplot(2,1,1);
plot(t,x,'g');
xlabel('time'); ylabel('amplitude');
title('unit step function'); subplot(2,1,2);
stem(t,x,'r');
xlabel('time');
ylabel('amplitude');
title('unit step discreat function');
```

### %unit ramp function%clc;

```
clear all;
close all;
t=0:20;
x=t; subplot(2,1,1);
plot(t,x,'g');
xlabel('time'); ylabel('amplitude');
title('unit ramp function'); subplot(2,1,2);
stem(t,x,'r');
xlabel('time');
ylabel('amplitude');
title('unit ramp discreat function');
```

### %sinusoidal function%clc;

```
clear all; close
all; t=0:0.01:2;
x=sin(2*pi*t);
subplot(2,1,1);
plot(t,x,'g');
xlabel('time');
```

```
ylabel('amplitude'); title('sinusoidal signal');  
subplot(2,1,2);  
stem(t,x,'r');  
xlabel('time'); ylabel('amplitude');  
title('sinusoidal sequence');
```

```
%square function%clc;  
clear all; close  
all; t=0:0.01:2;  
x=square(2*pi*t);  
subplot(2,1,1);  
plot(t,x,'g');  
xlabel('time');  
ylabel('amplitude'); title('square  
signal');subplot(2,1,2);  
stem(t,x,'r');  
xlabel('time'); ylabel('amplitude');  
title('square sequence');
```

```
%sawtooth function%clc;  
clear all; close  
all; t=0:0.01:2;  
x=sawtooth(2*pi*5*t);  
subplot(2,1,1);  
plot(t,x,'g');  
xlabel('time'); ylabel('amplitude');  
title('sawtooth signal');subplot(2,1,2);  
stem(t,x,'r');  
xlabel('time'); ylabel('amplitude');  
title('sawtooth sequence');
```

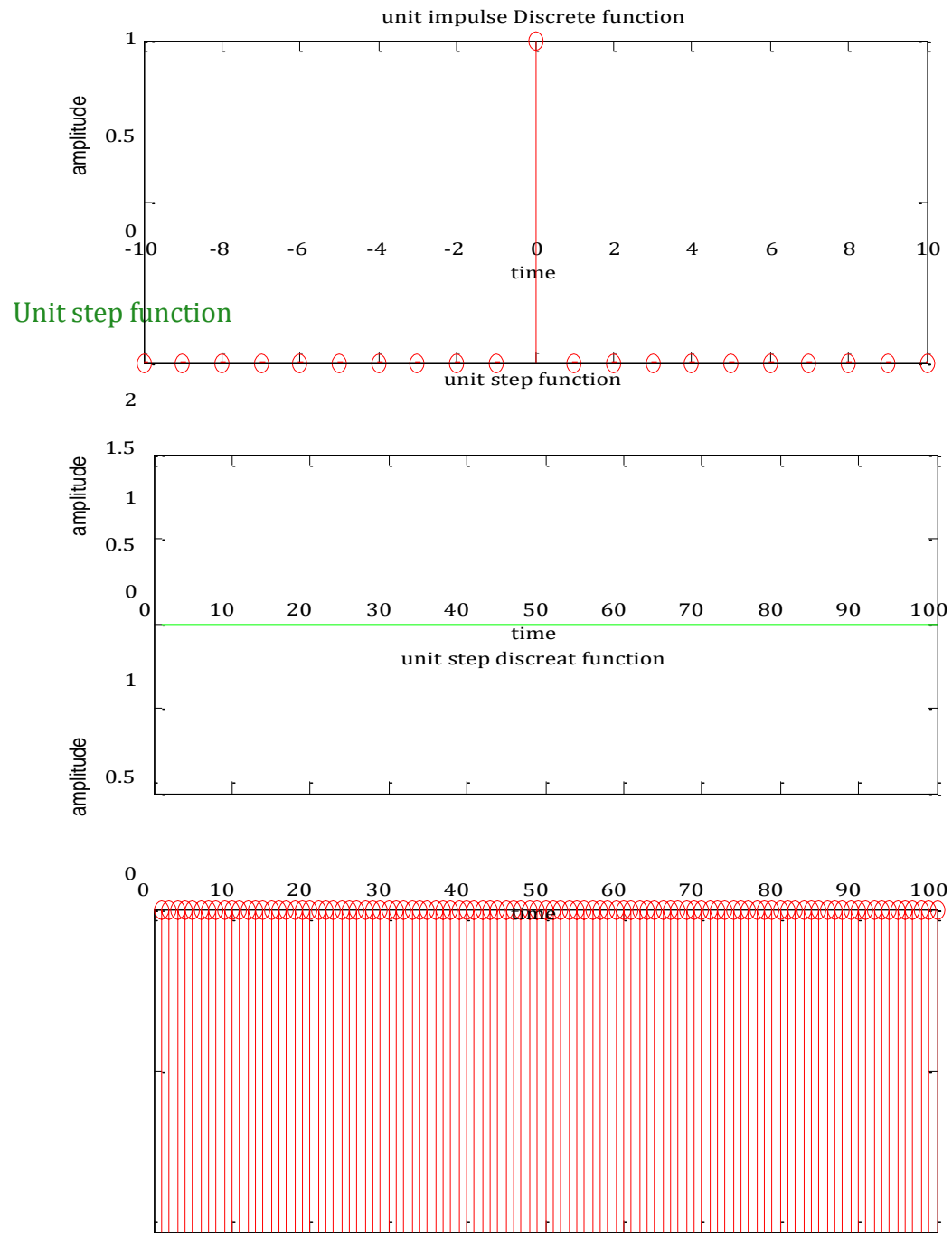
### %triangular function%

```
clc;
clear all; close
all; t=0:0.01:2;
x=sawtooth(2*pi*5*t,0.5);subplot(2,1,1);
plot(t,x,'g');
xlabel('time'); ylabel('amplitude');
title('triangular signal');subplot(2,1,2);
stem(t,x,'r');
xlabel('time'); ylabel('amplitude');
title('triangular sequence');
```

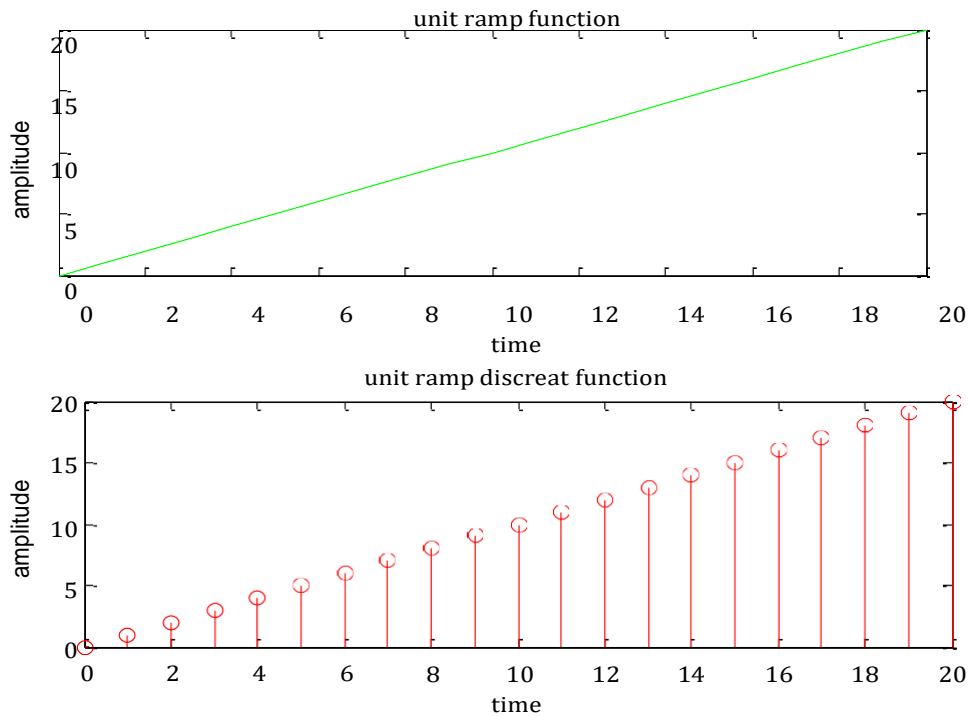
### %sinc function%

```
clc;
clear all;close
all;
t=linspace(-5,5);
x=sinc(t);
subplot(2,1,1);
plot(t,x,'g');
xlabel('time');
ylabel('amplitude');
title('sinc signal');
subplot(2,1,2);
stem(t,x,'r');
xlabel('time');
ylabel('amplitude'); title('sinc
sequence');
```

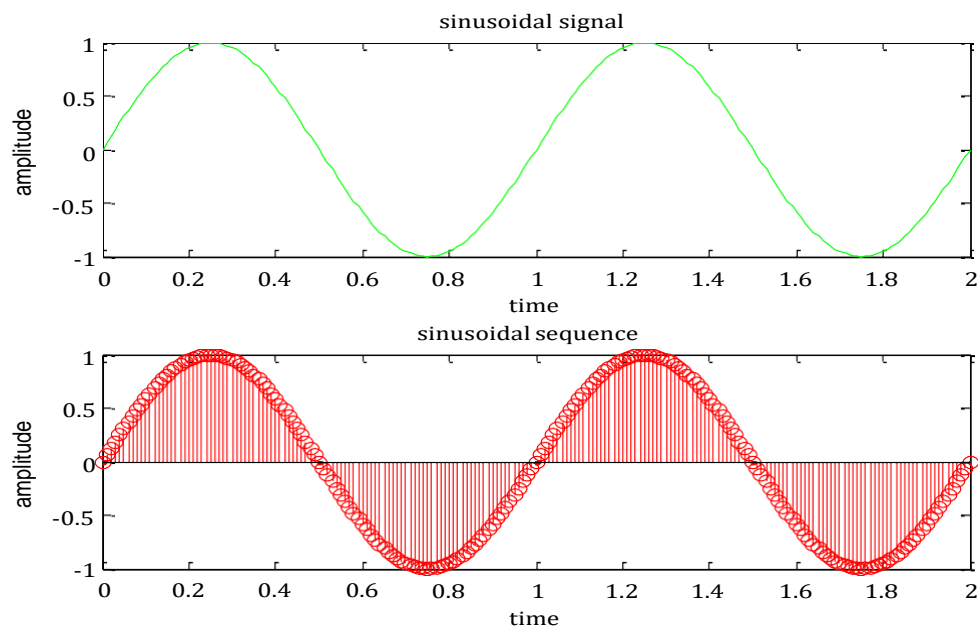
Simulations:



## Unit ramp function

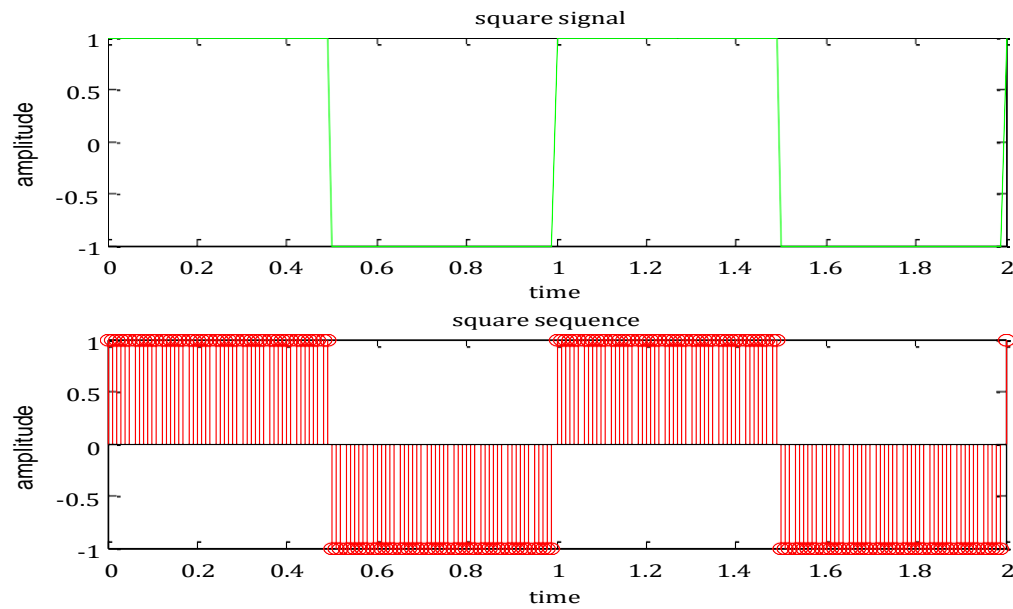


## Sinusoidal function

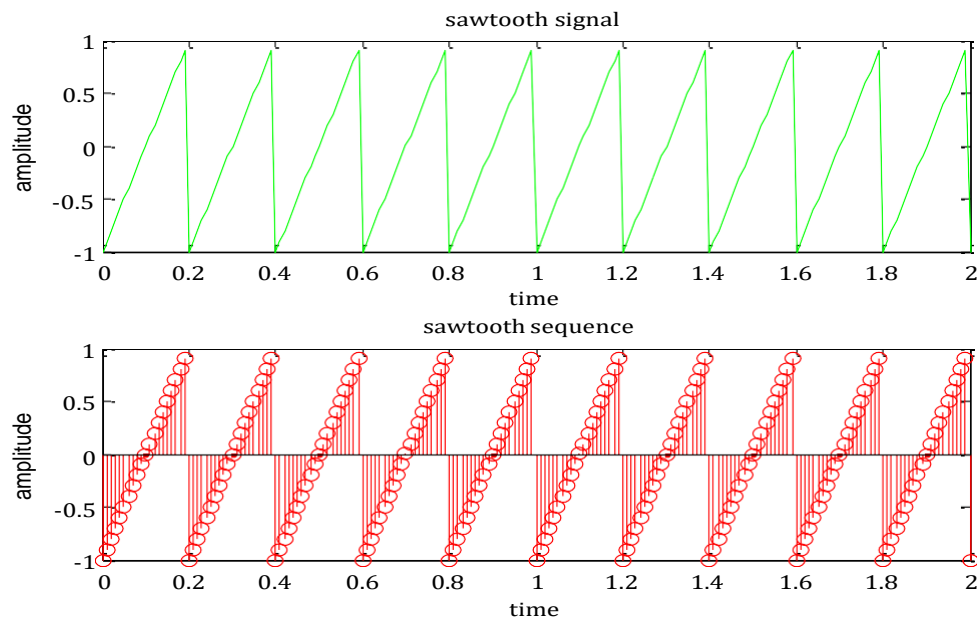




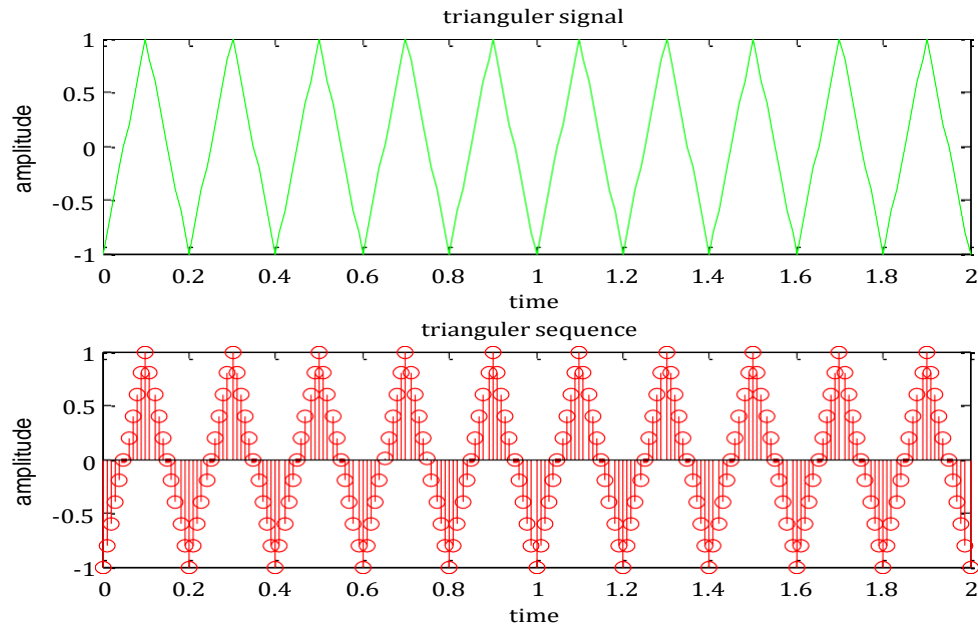
## Square function



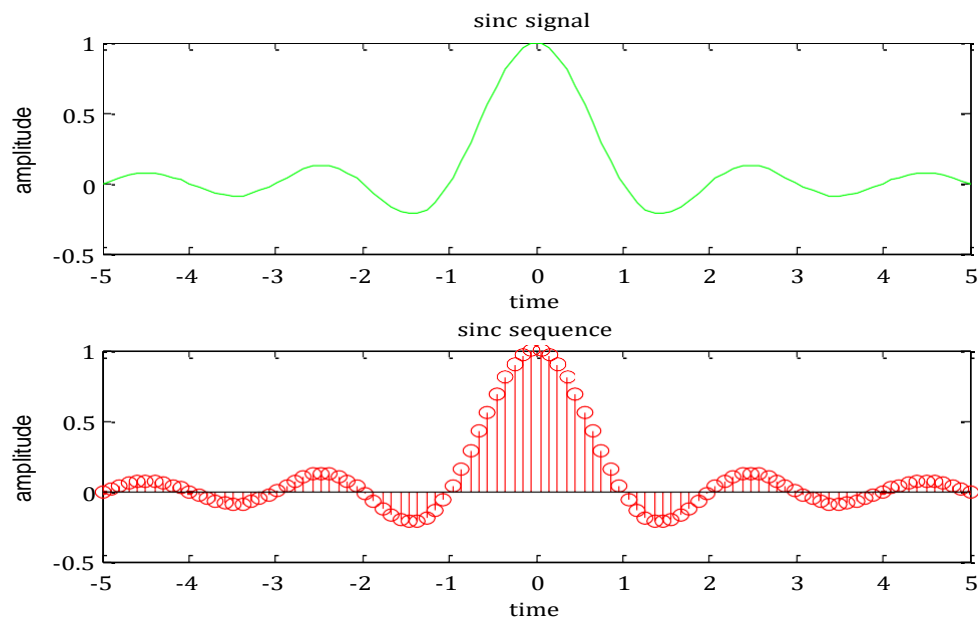
## Sawtooth function



## Triangular function



## Sinc Function



### RESULT: -

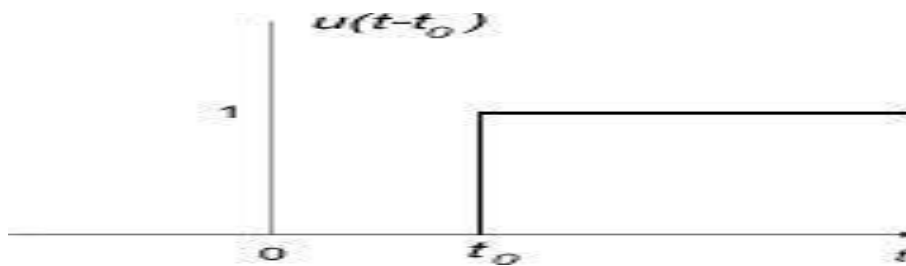
Thus the Generation of continuous time signals like unit step, sawtooth, triangular, sinusoidal, ramp and sinc functions are successfully completed by using MATLAB.

**VIVA QUESTIONS: -**

1. Define Signal?
2. Define deterministic and Random Signal?
3. Define Delta Function?
4. What is Signal Modeling?
5. Define Periodic and a periodic Signal?
6. Write the relation between Step and Impulse signals?
7. Write the relation between Ramp and impulse signals?
8. Write the relation between Ramp and Step signals?
9. Define Standard signals?
10. Give examples of Standard signals?

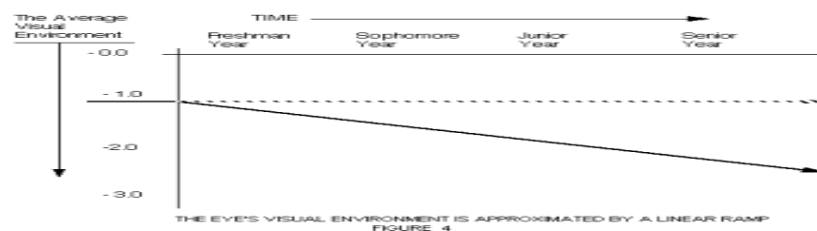
**EXERCISE QUESTIONS**

1. Generate rectangular pulse function by using MATLAB.
- 2.

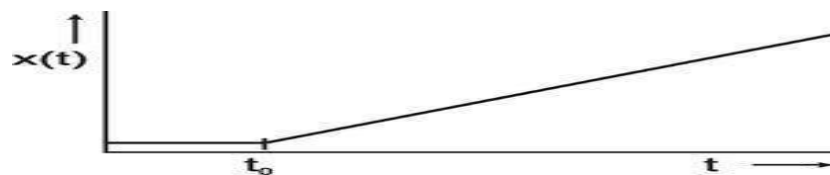


Write a matlab program to get the above output where  $t_0 = 2$

3. Write a program to get the result in  
 $\text{signalr}(t) = u(t) - 2*u(t+1)$
4. Write a program to get the following output  $t = -1: -5$



5.



Write mat lab program to get the above output  $X(t) = 1; (0 < t < 2)$   
 $= 10; (2 < t < 15)$  Note: Add ramp and unit

6. Write a matlab program to generate a sine wave with amplitude = 3, frequency 20Hz.
7. Write a matlab program to generate a cos wave with amplitude = 3, frequency 20Hz.
8. Write a matlab program to generate a triangular wave with amplitude = 8, frequency 10Hz.
9. Write a matlab program to generate a square wave with amplitude = 2, frequency 10kHz.
10. Write a matlab program to generate the signum function.
11. Write a matlab program to generate exponential growing signal.
12. Write a matlab program to generate exponential decaying signal.
13. Write a matlab program to generate a triangular wave with amplitude = 6, frequency 1Hz.
14. Write a matlab program to generate a square wave with amplitude = 5, frequency 5kHz.
15. Write a matlab program to generate a sawtooth wave with amplitude = 8, frequency 5KHz.
16. Write a matlab program to generate a sine wave with amplitude = 5, frequency 5Hz.
17. Write a matlab program to generate a cos wave with amplitude = 4, frequency 10Hz.
18. Write a matlab program to generate a triangular wave with amplitude = 5, frequency 4Hz.
19. Write a matlab program to generate a square wave with amplitude = 1, frequency 20kHz.
20. Write a matlab program to generate the signum function.
21. Write a matlab program to generate a square wave with amplitude = 4, frequency 5kHz.
22. Write a matlab program to generate a triangular wave with amplitude = 6, frequency 6Hz.
23. Write a matlab program to generate a triangular wave with amplitude = 8, frequency 2Hz.
24. Write a matlab program to generate a square wave with amplitude = 7, frequency 5kHz.
25. Write a matlab program to generate a sawtooth wave with amplitude = 10, frequency 10KHz.
26. Write a matlab program to generate the signum function in frequency domain?.
27. Write a matlab program to generate exponential growing signal in time domain?.
28. Write a matlab program to generate exponential decaying signal in time domain?.
29. Write a matlab program to generate a triangular wave with amplitude = 4, frequency 6Hz.
30. Write a matlab program to generate a square wave with amplitude = 8, frequency 4kHz.

### Real Time Applications:

- Industrial control and automation (Control the velocity or position of an object)
- Examples: Controlling the position of a valve or shaft of a motor
- Mechanical Translational Systems
- Mechanical Rotational Systems.

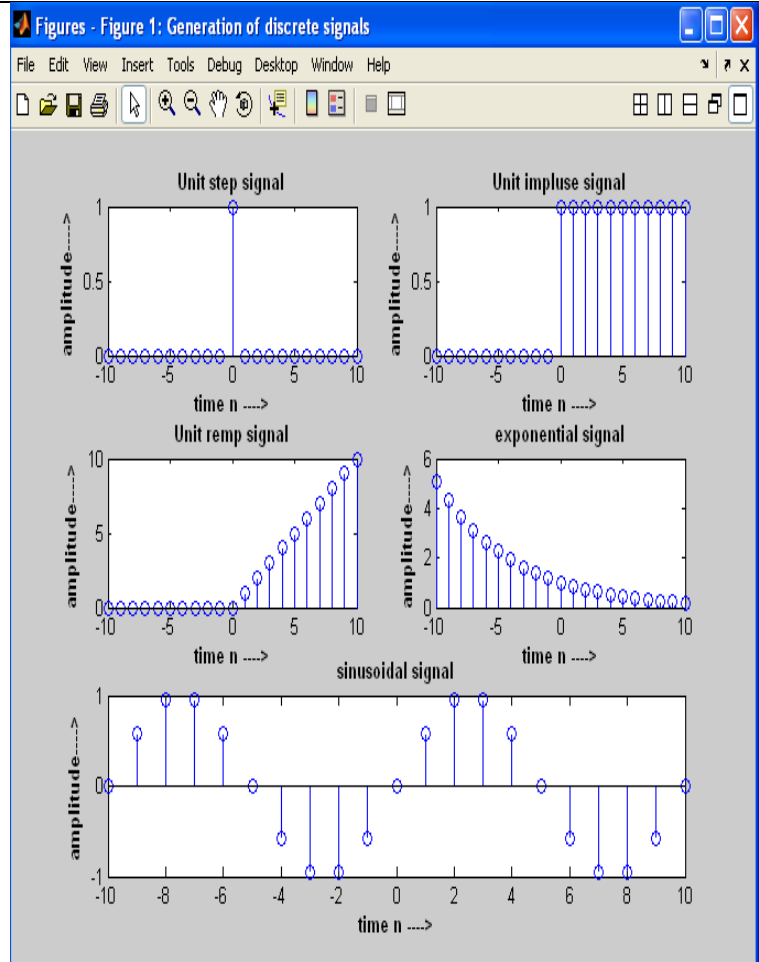
**GENERATION OF DISCRETE SIGNALS**

PROGRAM:-

```

clc; clear all; close all;
n=-10:1:10;
L=length(n); for i=1:L
if n(i)==0 x1(i)=1;
else
x1(i)=0;
end;
if n(i)>=0 x2(i)=1;
x3(i)=n(i); else
x2(i)=0;
x3(i)=0;
end; end;
% to generate exponential sequence
a=0.85;
x4=a.^n;
% to generate sinusoidal sequence
f=0.1;
x5=sin(2*pi*f*n); figure;
subplot(3,2,1);
stem(n,x1); xlabel('time n>');
ylabel('amplitude>');
title('Unit step signal'); subplot(3,2,2);
stem(n,x2); xlabel('time n>');
ylabel('amplitude>');
title('Unit impluse signal')
subplot(3,2,3);
stem(n,x3); xlabel('time n>');
ylabel('amplitude>');
title('Unit remp signal');
subplot(3,2,4);
stem(n,x4); xlabel('time n>');
ylabel('amplitude>');
title('exponential signal');
subplot(3,2,[5,6]); stem(n,x5);
xlabel('time n>');
ylabel('amplitude>');
title('sinusoidal signal');

```



### GENERATION OF CONTINUOUS SIGNALS

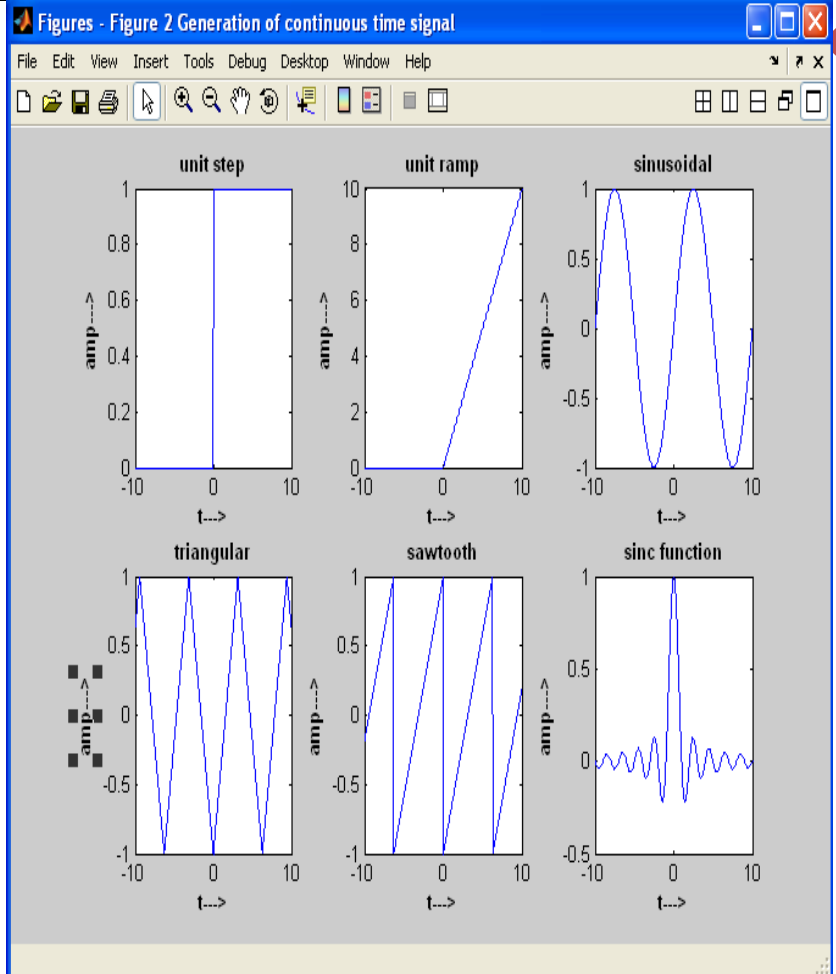
PROGRAM:-

```

clc;
Clear all;
Close all;
t=-10:0.01:10;
L=length(t); for i=1:L
%to generate unit Step and ramp
function if t(i)<0
x1(i)=0;
x2(i)=0;
else
x1(i)=1;
x2(i)=t(i); end;
end;
%to generate sinusoidal function
f=0.1;
x3=sin(2*pi*f*t);
%to generate Triangular and
Sawtooth waveforms
x4=sawtooth(t,0.5);
x5=sawtooth(t);

%to generate sinc function x6=sinc(t);
figure; subplot(2,3,1);
plot(t,x1);
xlabel('t--->');ylabel('amp--->');
title('unit step');
subplot(2,3,2);
plot(t,x2);
xlabel('t--->');ylabel('amp--->');
title('unit ramp'); subplot(2,3,3);
plot(t,x3);
xlabel('t--->');ylabel('amp--->');
title('sinusoidal'); subplot(2,3,4);
plot(t,x4);
xlabel('t--->');ylabel('amp--->');
title('triangular'); subplot(2,3,5);
plot(t,x5);
xlabel('t--->');ylabel('amp--->');
title('sawtooth');
subplot(2,3,6);
plot(t,x6);
xlabel('t--->');ylabel('amp--->');
title('sinc function');

```



**EXPERMENT NO:3****OPERATIONS ON SIGNALS & SEQUENCES****AIM: -**

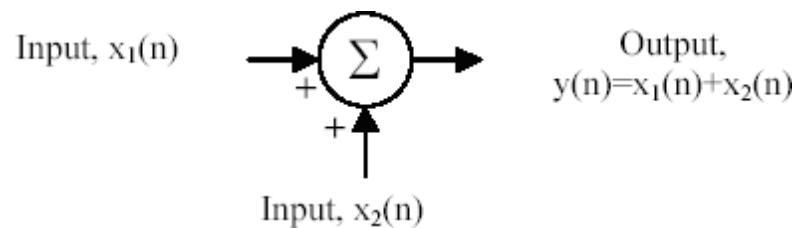
To performs operations on signals and sequences such as addition, multiplication, scaling, shifting, folding, computation of energy and average power.

**SOFTWARE REQUIRED: -**

1. MATLAB R2010a.
2. Windows XP SP2.

**THEORY: -****Basic Operation on Signals:**

Time shifting:  $y(t)=x(t-T)$  The effect that a time shift has on the appearance of a signal. If  $T$  is a positive number, the time shifted signal,  $x(t-T)$  gets shifted to the right, otherwise it gets shifted left.

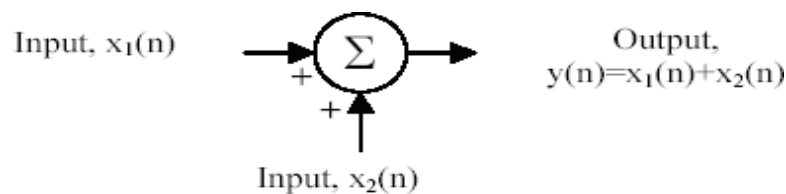
**Signal Shifting and Delay:**

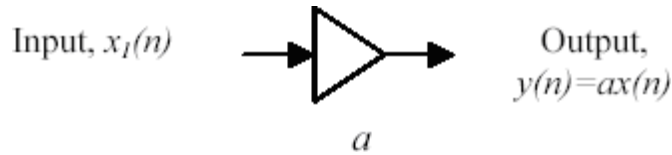
Shifting:  $y(n)=\{x(n-k)\}$  ;  $m=n-k$ ;  $y=x$ ;

Time reversal:  $Y(t)=y(-t)$  Time reversal flips the signal about  $t = 0$  as seen in Figure 1.

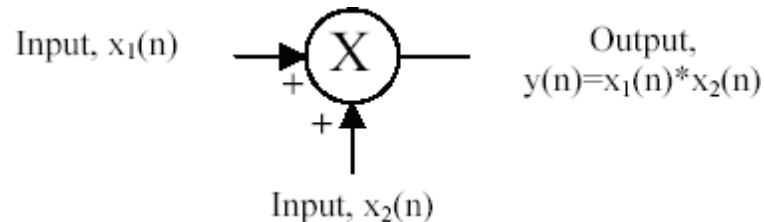
**Signal Addition and Subtraction:**

Addition: any two signals can be added to form a third signal,  $z(t) = x(t) + y(t)$



**Signal Amplification:****Multiplication/Division:**

of two signals, their product is also a



signal.  $z(t) = x(t) y(t)$

**folding:**

$y(n) = \{x(-n)\}$  ;  $y = \text{fliplr}(x)$ ;  $n = -\text{fliplr}(n)$ ;

**PROCEDURE:-**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM:-**

**%Addition and multiplication of two signals%**

```
clc;
clear all; close all;
t=0:0.001:2;
s1=6*sin(2*pi*5*t);
subplot(4,1,1);
plot(t,s1,'g');
xlabel('time');
ylabel('amplitude');
```



```

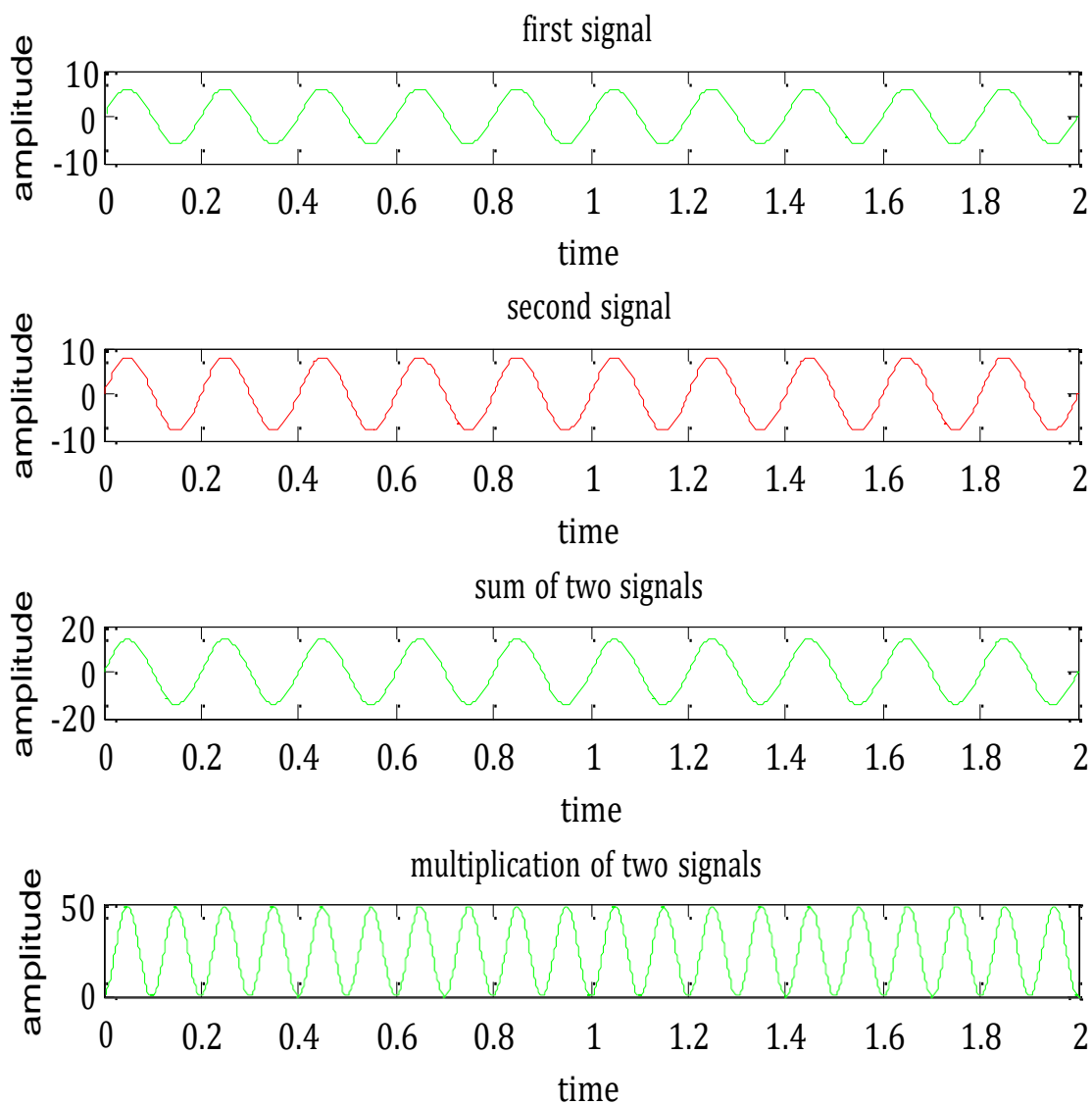
title('first signal'); s2=8*sin(2*pi*5*t);subplot(4,1,2);
plot(t,s2,'r');
xlabel('time'); ylabel('amplitude'); title('second signal');s3=s1+s2; subplot(4,1,3);
plot(t,s3,'g');
xlabel('time'); ylabel('amplitude'); title('sum of two signals');s4=s1.*s2;
subplot(4,1,4);
plot(t,s4,'g');
xlabel('time'); ylabel('amplitude');
title('multiplication of two signals');

```

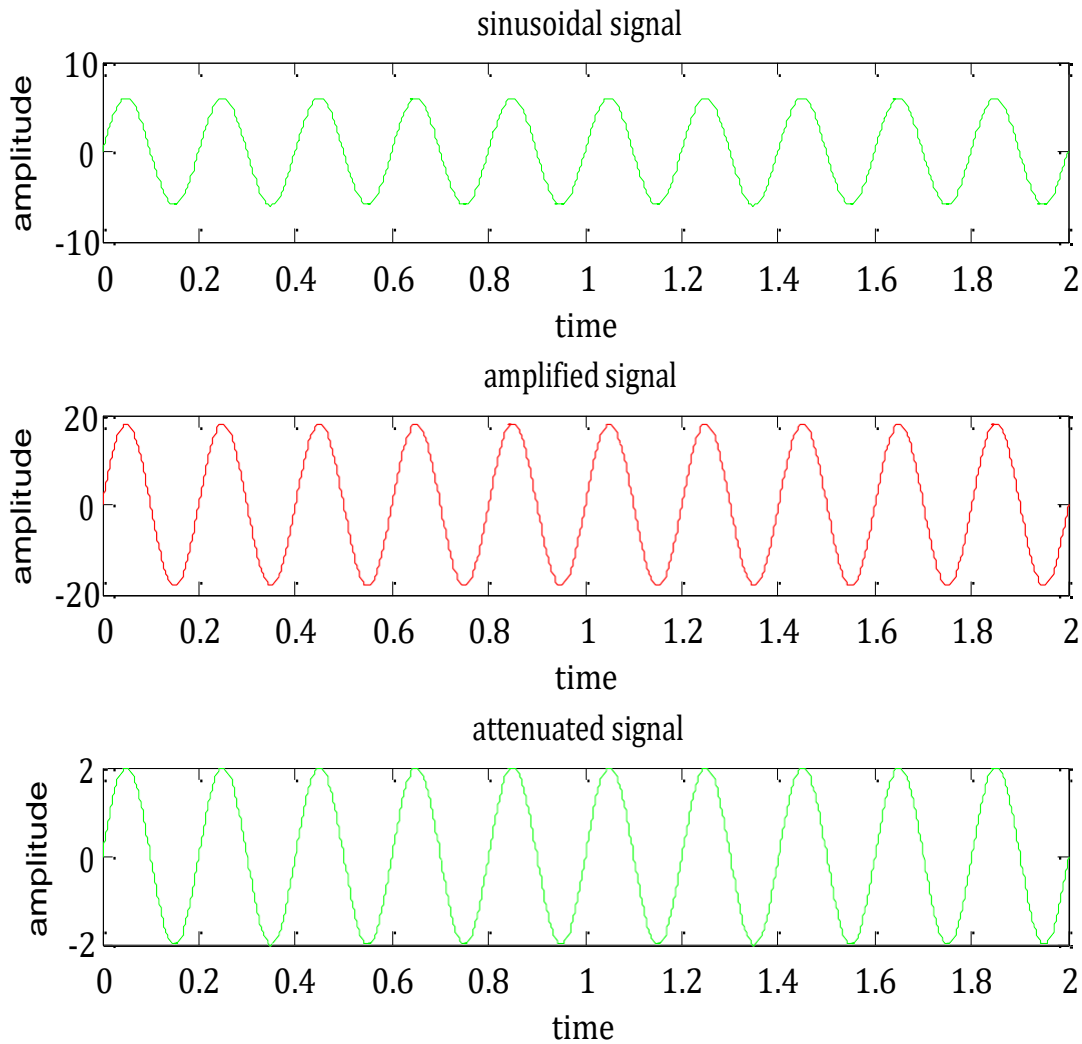
%Amplitude scaling for signals%	%Time scaling for signals%
<pre> clc; clear all; close all; t=0:0.001:2; s1=6*sin(2*pi*5*t);subplot(3,1,1); plot(t,s1,'g'); xlabel('time'); ylabel('amplitude'); title('sinusoidal signal'); s2=3*s1; subplot(3,1,2); plot(t,s2,'r'); xlabel('time'); ylabel('amplitude'); title('amplified signal'); s3=s1/3; subplot(3,1,3); plot(t,s3,'g'); xlabel('time'); ylabel('amplitude'); title('attenuated signal'); </pre>	<pre> clc; clear all; close all; t=0:0.001:2; s1=6*sin(2*pi*5*t); subplot(3,1,1); plot(t,s1,'g'); xlabel('time'); ylabel('amplitude'); title('sinusoidal signal'); t1=3*t; subplot(3,1,2); plot(t1,s1,'r'); xlabel('time'); ylabel('amplitude'); title('compressed signal'); t2=t/3; subplot(3,1,3); plot(t2,s1,'g'); xlabel('time'); ylabel('amplitude'); title('enlarged signal'); </pre>

<pre> %Time shifting of a signal%  clc; clear all; close all; t=0:0.001:3; s1=6*sin(2*pi*5*t);subplot(3,1,1); plot(t,s1,'g'); xlabel('time'); ylabel('amplitude'); title('sinusoidal signal');t1=t+10; subplot(3,1,2); plot(t1,s1,'r'); xlabel('time'); ylabel('amplitude'); title('right shift of the signal');t2=t-10; subplot(3,1,3); plot(t2,s1,'g'); xlabel('time'); ylabel('amplitude'); title('left shift of the signal'); </pre>	<pre> %Time folding of a signal%  clc; clear all; close all; t=0:0.001:2; s=sin(2*pi*5*t);m=length(s); n=[-m:m]; y=[0,zeros(1,m),s]; subplot(2,1,1); plot(n,y,'g'); xlabel('time'); ylabel('amplitude'); title('original signal'); y1=[fliplr(s),0,zeros(1,m)]; subplot(2,1,2); plot(n,y1,'r'); xlabel('time'); ylabel('amplitude'); title('folded signal'); </pre>
--	---

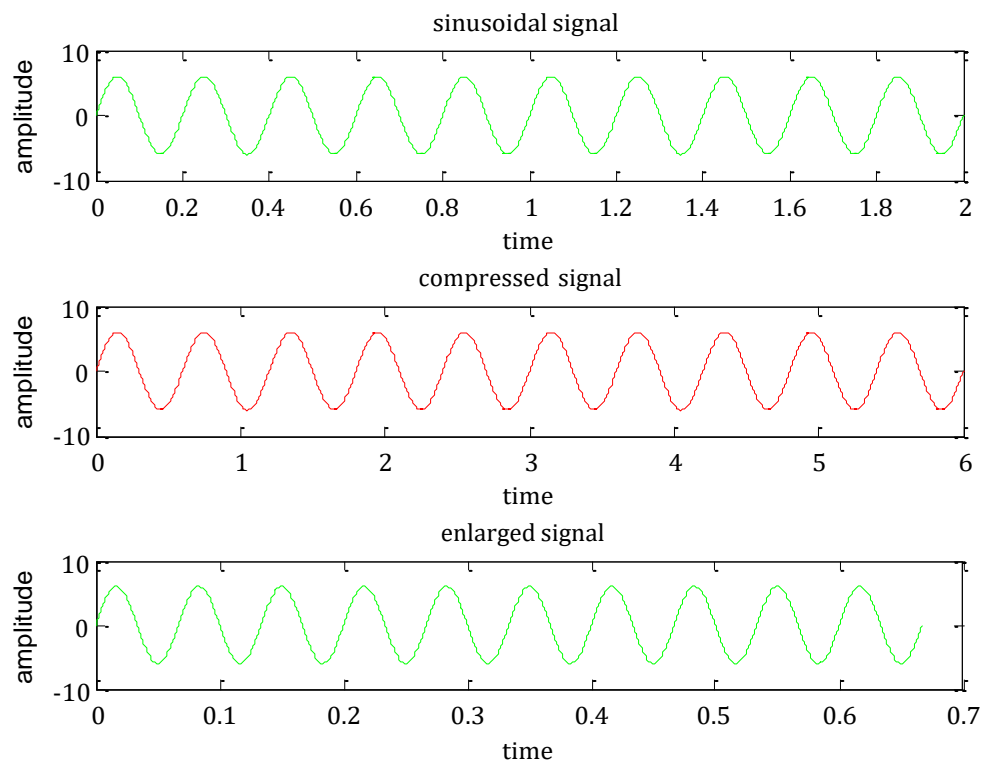
<pre> %Time shifting of a signal%  clc; clear all; close all; t=0:0.001:3; s1=6*sin(2*pi*5*t);subplot(3,1,1); plot(t,s1,'g'); xlabel('time'); ylabel('amplitude'); title('sinusoidal signal');t1=t+10; subplot(3,1,2); plot(t1,s1,'r'); xlabel('time'); ylabel('amplitude'); title('right shift of the signal');t2=t-10; subplot(3,1,3); plot(t2,s1,'g'); xlabel('time'); ylabel('amplitude'); title('left shift of the signal'); </pre>	<pre> %Time folding of a signal%clc; clear all; close all; t=0:0.001:2; s=sin(2*pi*5*t); m=length(s); n=[-m:m]; y=[0,zeros(1,m),s]; subplot(2,1,1); plot(n,y,'g'); xlabel('time'); ylabel('amplitude'); title('original signal'); y1=[fliplr(s),0,zeros(1,m)]; subplot(2,1,2); plot(n,y1,'r'); xlabel('time'); ylabel('amplitude'); title('folded signal'); </pre>
--	--

**OUTPUT: -****Addition and multiplication of two signals**

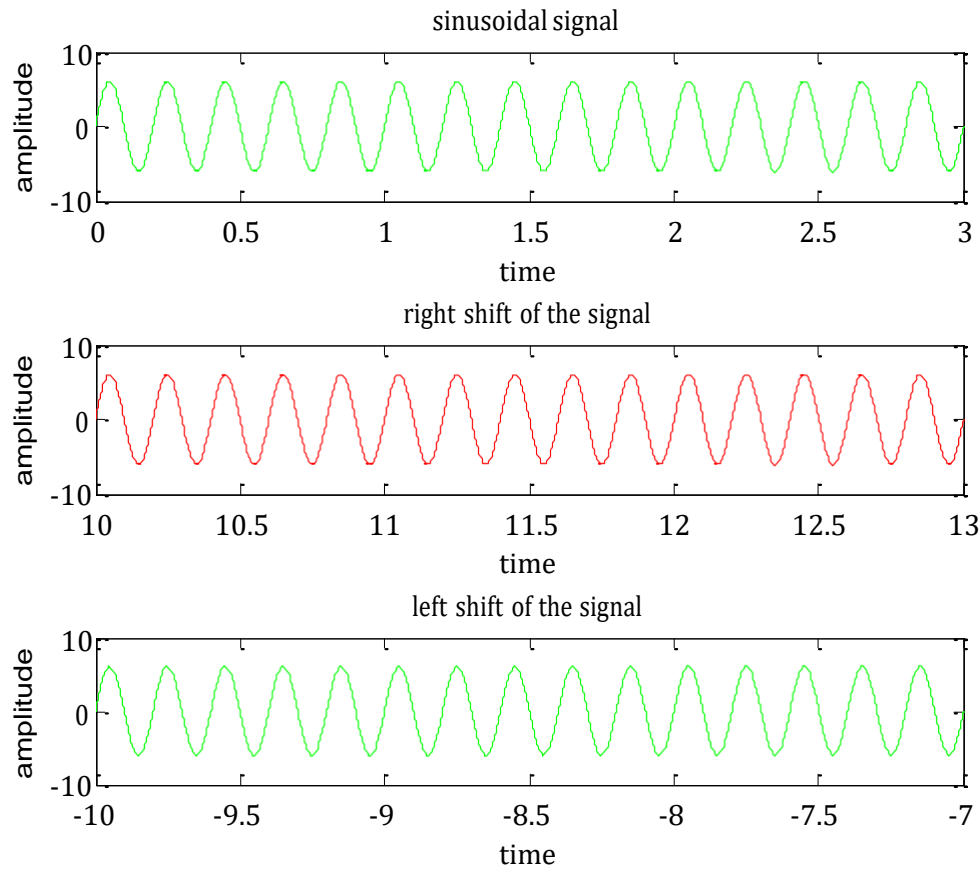
## Amplitude scaling for signals



## Time scaling for signals

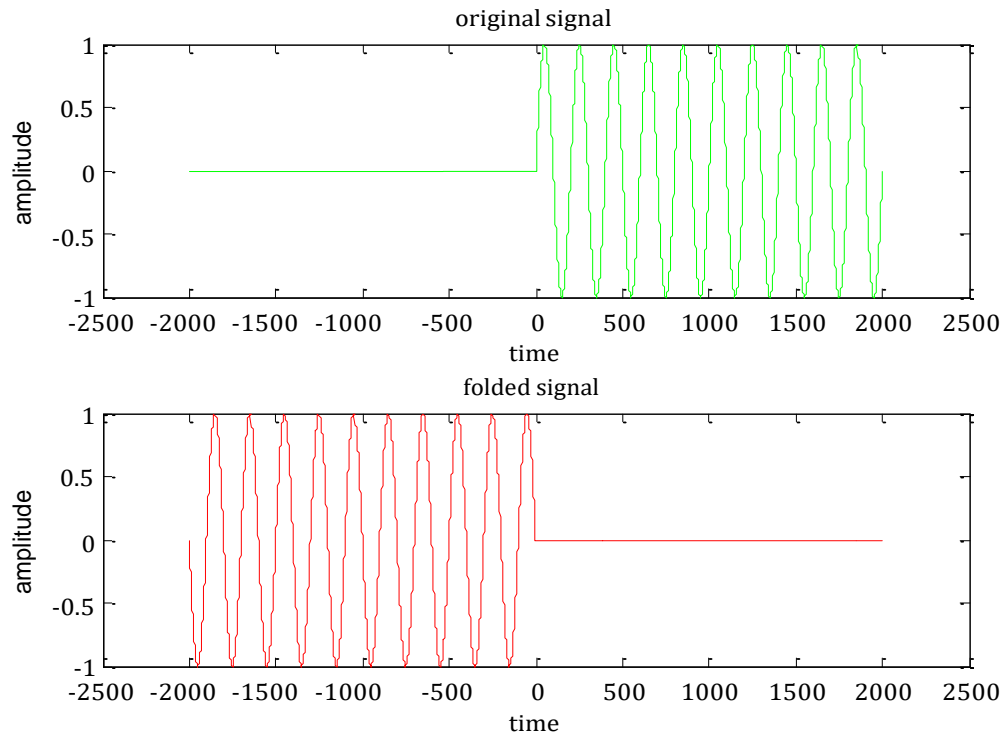


### Time shifting of a signal



\

### Time folding of a signal



#### RESULT: -

In this experiment the various operations on signals have been performed Using MATLAB have been demonstrated.

#### VIVA QUESTIONS: -

1. Define Symmetric and Anti-Symmetric Signals?
2. Define Continuous and Discrete Time Signals?
3. What are the Different types of representation of discrete time signals?
4. What are the Different types of Operation performed on signals?
5. What is System?
6. Explain Even Signals?
7. Explain Odd signals?
8. Define Periodic signals?
9. Define Aperiodic signals?
10. Differentiate Energy and Power signals with examples?

**EXERCISE PROGRAMS**

1. Write a MATLAB program to generate amplitude scaling of a sequence.
2. Write a MATLAB program to subtract two sinusoidal signals.
3. Write a MATLAB program to subtract and multiply two sinusoidal signals.
4. Write a MATLAB program to right shift the signal to 5 times of the original signal.
5. Write a MATLAB program to left shift the signal to 8 times of the original signal.
6. Write a MATLAB program to add two different signals with  $2 < t < 5$
7. Write a MATLAB program to shift a positive time line signal to negative timeline signal.
8. Write a MATLAB program to subtract co-sinusoidal signals.
9. Write a MATLAB program to subtract two sinusoidal signals
10. Write a MATLAB program to division and multiply two co-sinusoidal signals.
11. Write a MATLAB program to generate time scaling of a sequence.
12. Write a MATLAB program to generate time shifting of a sequence.
13. Write a MATLAB program to generate time folding of a sequence.
14. Write a MATLAB program to generate amplitude scaling of a sequence with amplitude 5.
15. Write a MATLAB program to generate time scaling of a sequence with time 2sec.
16. Write a MATLAB program to add two different signals with  $4 < t < 8$
17. Write a MATLAB program to shift a negative time line signal to positive timeline signal.
18. Write a MATLAB program to subtract sinusoidal signals.
19. Write a MATLAB program to subtract and divide two sinusoidal signals
20. Write a MATLAB program to add and multiply two co-sinusoidal signals.
21. Write a MATLAB program to generate time scaling of a signal.
22. Write a MATLAB program to generate time shifting of a signal.
23. Write a MATLAB program to generate time folding of a signal.
24. Write a MATLAB program to generate amplitude scaling of a sequence with amplitude 10.
25. Write a MATLAB program to generate time scaling of a sequence with time 5sec.
26. Write a MATLAB program to subtract two different signals with  $2 < t < 5$
27. Write a MATLAB program to compress a positive time line signal to negative timeline signal.
28. Write a MATLAB program to positive shift in delay of co-sinusoidal signals.
29. Write a MATLAB program to subtract two signals.
30. Write a MATLAB program to multiply two co-sinusoidal signals of different amplitude levels.

**Real Time Applications:**

- Stream processing
- Block processing
- Vector processing
- Digital Signal Processing Applications.



**EXPERIMENT NO: 4****FINDING EVEN AND ODD & REAL AND IMAGINARY PARTS OF SEQUENCES****AIM: -**

Program for finding even and odd parts of sequences Using MATLAB Software & Program for finding real and imaginary parts of sequences Using MATLAB Software

**SOFTWARE REQUIRED: -1.** MATLAB R2010a.

2.Windows XP SP2.

**THEORY: -****Even and Odd Signal**

One of characteristics of signal is symmetry that may be useful for signal analysis. Even signals are symmetric around vertical axis, and Odd signals are symmetric about origin.

Even Signal: A signal is referred to as an even if it is identical to its time-reversed counterparts;  $x(t) = x(-t)$ .

Odd Signal: A signal is odd if  $x(t) = -x(-t)$ .

An odd signal must be 0 at  $t=0$ , in other words, odd signal passes the origin.

Using the definition of even and odd signal, any signal may be decomposed into a sum of its even part,  $x_e(t)$ , and its odd part,  $x_o(t)$ , as follows:

$$x(t) = x_e(t) + x_o(t);$$

$$x(t) = 1/2\{x(t) + x(-t)\} + 1/2\{x(t) - x(-t)\} \text{ where}$$

$$x_e(t) = 1/2\{x(t) + x(-t)\} \text{ \& } x_o(t) = 1/2\{x(t) - x(-t)\}$$

It is an important fact because it is relative concept of Fourier series. In Fourier series, a periodic signal can be broken into a sum of sine and cosine signals. Notice that sine function is odd signal and cosine function is even signal.

**ENERGY AND POWER SIGNAL:**

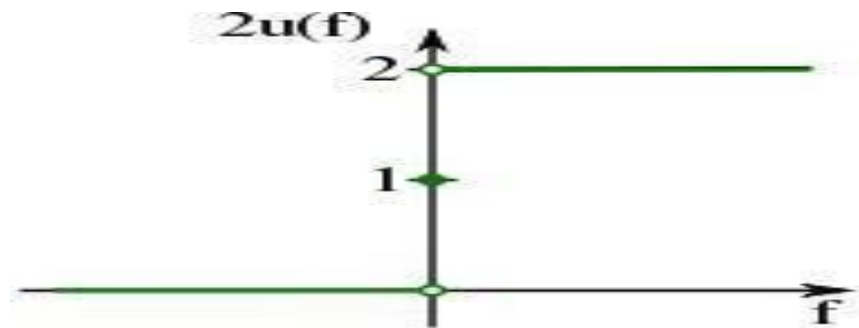
A signal can be categorized into energy signal or power

**signal:** An energy signal has a finite energy,  $0 < E < \infty$ . In other words, energy signals have values only in the limited time duration. For example, a signal having only one square pulse is energy signal. A signal that decays exponentially has finite energy, so, it is also an energy signal. The power of an energy signal is 0, because of dividing finite energy by infinite time (or length).

If  $x(t)$  is a real-valued signal with Fourier transform  $X(f)$ , and  $u(f)$  is the [Heaviside step function](#), then the function:

$$X_a(f) \stackrel{\text{def}}{=} \begin{cases} 2X(f), & \text{for } f > 0, \\ X(f), & \text{for } f = 0, \\ 0, & \text{for } f < 0, \end{cases}$$

$$= X(f) \cdot \underbrace{2u(f)}_{1+\text{sgn}(f)} = X(f) + X(f) \cdot \text{sgn}(f)$$



contains only the non-negative frequency components of  $X(f)$ . And the operation is reversible, due to the [Hermitian property](#) of  $X(f)$ :

$$X(f) = \begin{cases} \frac{1}{2}X_a(f), & \text{for } f > 0, \\ X_a(f) & \text{for } f = 0, \\ \frac{1}{2}X_a(-f)^*, & \text{for } f < 0 \end{cases}$$

$$= \frac{1}{2} (X_a(f) + X_a(-f)^*) .$$

$X(f)^*$  denotes the [complex conjugate](#) of  $X(f)$ .

The inverse Fourier transform of  $X_a(f)$  is the **analytic signal**:

$$\begin{aligned}
 x_a(t) &= \mathcal{F}^{-1}\{X(f) + X(f) \cdot \text{sgn}(f)\} \\
 &= \mathcal{F}^{-1}\{X(f)\} + \underbrace{\mathcal{F}^{-1}\{X(f)\} * \mathcal{F}^{-1}\{\text{sgn}(f)\}}_{\text{convolution}} \\
 &= x(t) + j \underbrace{\left[ x(t) * \frac{1}{\pi t} \right]}_{\hat{x}(t)},
 \end{aligned}$$

where  $\hat{x}(t)$  is the [Hilbert transform](#) of  $x(t)$  and  $j$  is the [imaginary unit](#).

**PROCEDURE: -**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM: -**

<pre> %Even, odd, real, imaginary parts of a sequences% clc; clear all; close all; h=input('enter no.of samples'); m=(h-1)/2; n=-m:m; x=input('enter sample values'); subplot(4,1,1); stem(n,x,'g'); xlabel('time'); ylabel('amplitude'); title('original sequence'); xmir=fliplr(x); subplot(4,1,2); stem(n,xmir,'r'); xlabel('time'); ylabel('amplitude'); title('folded sequence'); %even part of sequence% xeven=(x+xmir)/2; subplot(4,1,3); stem(n,xeven,'r'); xlabel('time'); ylabel('amplitude'); title('even part of sequence'); </pre>	<pre> %odd part of sequence%  xodd=(x-xmir)/2; subplot(4,1,4); stem(n,xodd,'g'); xlabel('time'); ylabel('amplitude'); title('odd part of sequence');  %Real&amp;Imaginary parts of a sequences% clc; clear all; close all; y=input('enter complex numbers'); yreal=real(y); disp('real values of y'); yreal yimag=imag(y); disp('imaginary values of y'); yimag </pre>
---	--

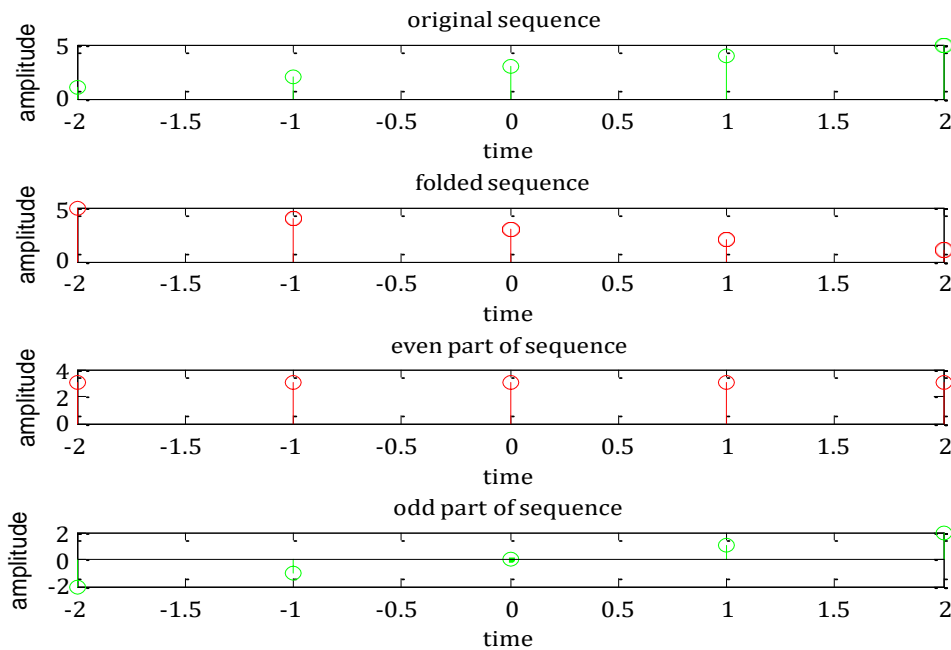
## Basic Simulation Lab Manual

**OUTPUT:-**

Even,odd,real,imaginary parts of a

sequences enter no.of samples 5

enter sample values [1 2 3 4 5]



Real & Imaginary parts of a sequences

enter complex numbers [1+6i 2-5i 3 4+3i

5i]real values of y

yreal = 1 2 3 4 0 imaginary values of y

yimag =

6 -5 0 3 5

**RESULT: -**

In this experiment even and odd parts of various signals and energy and power of signals have been calculated Using MATLAB.

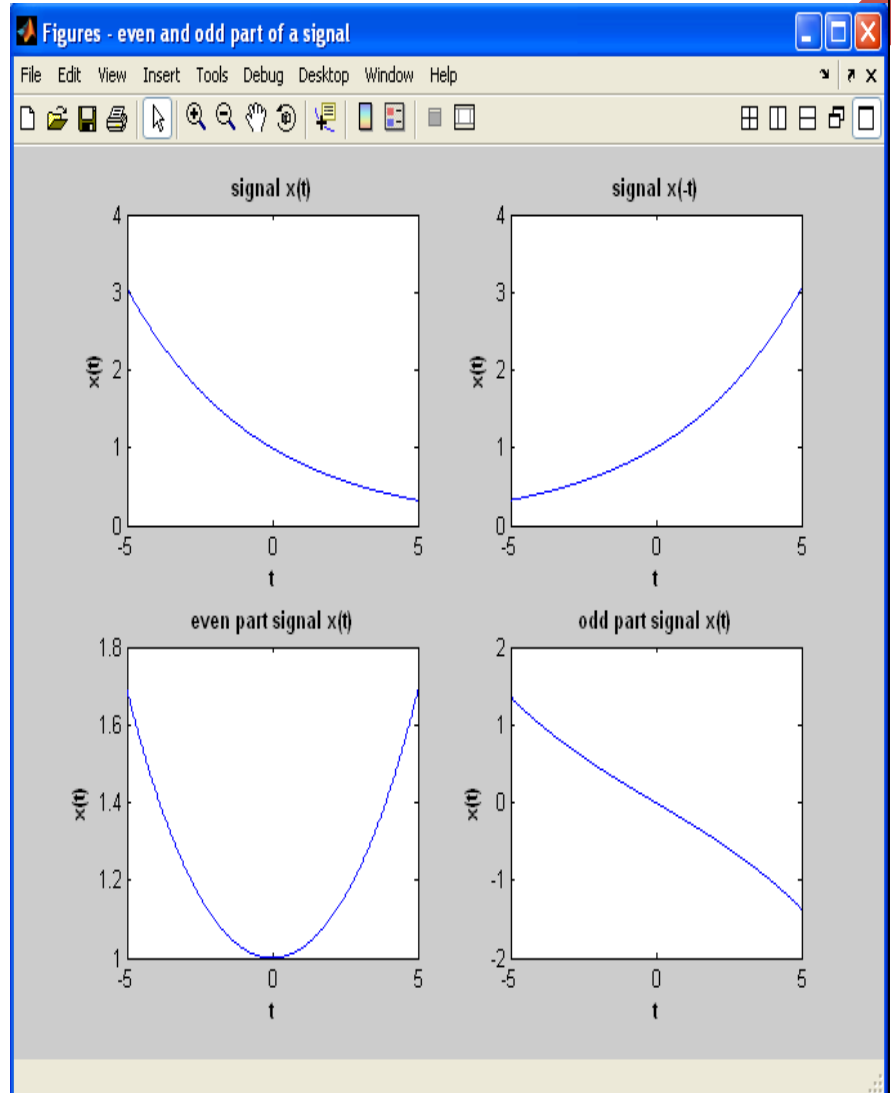
## PROGRAM:-

```

clc; clear all;
close all;
t=-5:0.001:5; A=0.8; x1=A.^(t);
x2=A.^(-t);
if(x2==x1)
disp('The given signal is even signal');
else
if(x2==(-x1))
disp('The given signal is odd signal');
else
disp('The given signal is neither even
nor odd');
end
end
xe=(x1+x2)/2; xo=(x1-x2)/2;
subplot(2,2,1);
plot(t,x1);
xlabel('t');ylabel('x(t)');title('signal
x(t)'); subplot(2,2,2);
plot(t,x2); xlabel('t');ylabel('x(t)');
title('signal x(-t)');
subplot(2,2,3);
plot(t,xe);

xlabel('t');ylabel('x(t)');title('even part
signal x(t)'); subplot(2,2,4);
plot(t,xo);
xlabel('t');ylabel('x(t)');title('odd part
signal x(t)');

```



### VIVA QUESTIONS

1. What is the formula to find odd part of signal?
2. What is Even Signal?
3. What is Odd Signal?
4. What is the formula to find even part of signal?
5. What is the difference b/w stem&plot?
6. What is Energy Signals?
7. What is Power signals?
- Define Systems?
9. How to determine time period of Periodic signals?
10. Define Frequency of signals?

### EXERCISE PROGRAM

1. Write a MATLAB program to find even part of a signal by considering 10 input samples.
2. Write a MATLAB program to find odd part of a signal by considering atleast 7 samples.
3. Write a MATLAB program to add even and odd part of a signal and see how matlab reacts for the above program.
4. Write a matlab program to get the out put as [-5, 3, 0, 8] as imaginary values and [2 4 6 8 0] as real values.
5. Write a MATLAB program to subtract even and odd part of a signal and see how matlab reacts for the above program.
6. Write a MATLAB program to find real & imaginary values of complex numbers [1+6i 2-5i 3+3i 5i].
7. Write a MATLAB program to find real & imaginary values of complex numbers [2+6i 7+5i 3 9+3i 5i].
8. Write a MATLAB program to find real & imaginary values of complex numbers [7+6i 2-5i 3+3i 7i].
9. Write a MATLAB program to find even & odd part of the sequence [5 6 3 2 3 4 7].
10. Write a MATLAB program to find even & odd part of the sequence [7 5 8 6 7].
11. Write a MATLAB program to find even part of a signal by considering 8 input samples.
12. Write a MATLAB program to find odd part of a signal by considering 10 samples.
13. Write a MATLAB program to multiply even and odd part of a signal and see how matlab reacts for the above program.
14. Write a matlab program to get the output as [2, 5, -1, 6] imaginary values and [4, 2, 8, 0] as real values.
15. Write a MATLAB program to divide even and odd part of a signal and see how matlab reacts for the above program.
16. Write a MATLAB program to find real & imaginary values of complex numbers [2+4i 1-6i 4+2i 8i].
17. Write a MATLAB program to find real & imaginary values of complex numbers [4+8i 6+4i 2 6+4i 6i].

18. Write a MATLAB program to find real & imaginary values of complex numbers  $[4+4i \ 2-5i \ 46+4i \ 6i]$ .
19. Write a MATLAB program to find even & odd part of the sequence  $[4 \ 9 \ 8 \ 4 \ 3 \ 2 \ 1]$ .
20. Write a MATLAB program to find even & odd part of the sequence  $[5 \ 7 \ 6 \ 7 \ 8]$ .
21. Write a MATLAB program to find even & odd part of the sequence  $[2 \ 3 \ 6 \ 3 \ 4 \ 3 \ 7]$ .
22. Write a MATLAB program to find even & odd part of the sequence  $[5 \ 4 \ 6 \ 8 \ 6]$ .
23. Write a MATLAB program to find even part of a signal by considering 6 input samples.
24. Write a MATLAB program to find odd part of a signal by considering 9 samples.
25. Write a matlab program to get the output as  $[2, 4, -6, 8]$  imaginary values and  $[1, 5, 9, 3]$  asreal values.
26. Write a MATLAB program to find even & odd part of the sequence  $[4 \ 6 \ 3 \ 2 \ 6 \ 3 \ 4 \ 7]$ .
10. Write a MATLAB program to find even & odd part of the sequence  $[7 \ 5 \ 8 \ 6 \ 4 \ 2 \ 1 \ 7]$ .
11. Write a MATLAB program to find even part of a signal by considering 10 input samples.
12. Write a MATLAB program to find odd part of a signal by considering 10 input samples.
13. Write a MATLAB program to multiply even and odd part of a signal.

### Real Time Applications:

- Synthesis and manipulation: E.g. speech synthesis, music synthesis, graphics.
- Analysis: Seismic data, atmospheric data, stock market analysis.
- Medical Applications.



**EXPERIMENT NO:5****Linear Convolution****AIM: -**

To find the output with linear convolution operation Using MATLAB Software.

**SOFTWARE REQUIRED:-**

1. MATLAB R2010a.
2. Windows XP SP2.

**THEORY:-**

Linear Convolution involves the following operations.

1. Folding
2. Multiplication
3. Addition
4. Shifting

These operations can be represented by a Mathematical Expression as follows:

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$

$x[n]$  = Input signal Samples

$h[n-k]$  = Impulse response co-

efficient.  $y[n]$  = Convolution output.

$n$  = No. of Input samples

$h$  = No. of Impulse response co-efficient.

Example :  $X(n) = \{1, 2, -1, 0, 1\}$ ,  $h(n) = \{1, 2, 3, -1\}$ .

**PROCEDURE:-**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM:-**

%Convolution of two

signals%

```
clc;
clear all;
close all; t=0:0.001:10;
x=sin(t); h=square(t); subplot(3,1,1);
plot(t,x,'g');
xlabel('time');
ylabel('amplitude');
title('sinusoidal
signal');
subplot(3,1,2);
plot(t,h,'r');
xlabel('time');
ylabel('amplitude');
title('square
function');
y=conv(x,h);
subplot(3,1,3); plot(y); xlabel('time'); ylabel('amplitude');
title('convolution signal');
```

%Convolution of two sequences%

```
clc;
clear all;
close all;
L=input('enter the length of 1st
sequence'); M=input('enter the length of
2nd sequence'); x=input('enter the first
sequence:x(n)='); h=input('enter the
second sequence:y(n)='); N=0:(L+M-1);
y=conv(x,h);
subplot(3,1,1);
stem(x,'g');
xlabel('discrete
time'); ylabel('x(n)');
title('1st sequence');
subplot(3,1,2);
stem(h,'r'); xlabel('discrete time');
```

## Basic Simulation Lab Manual

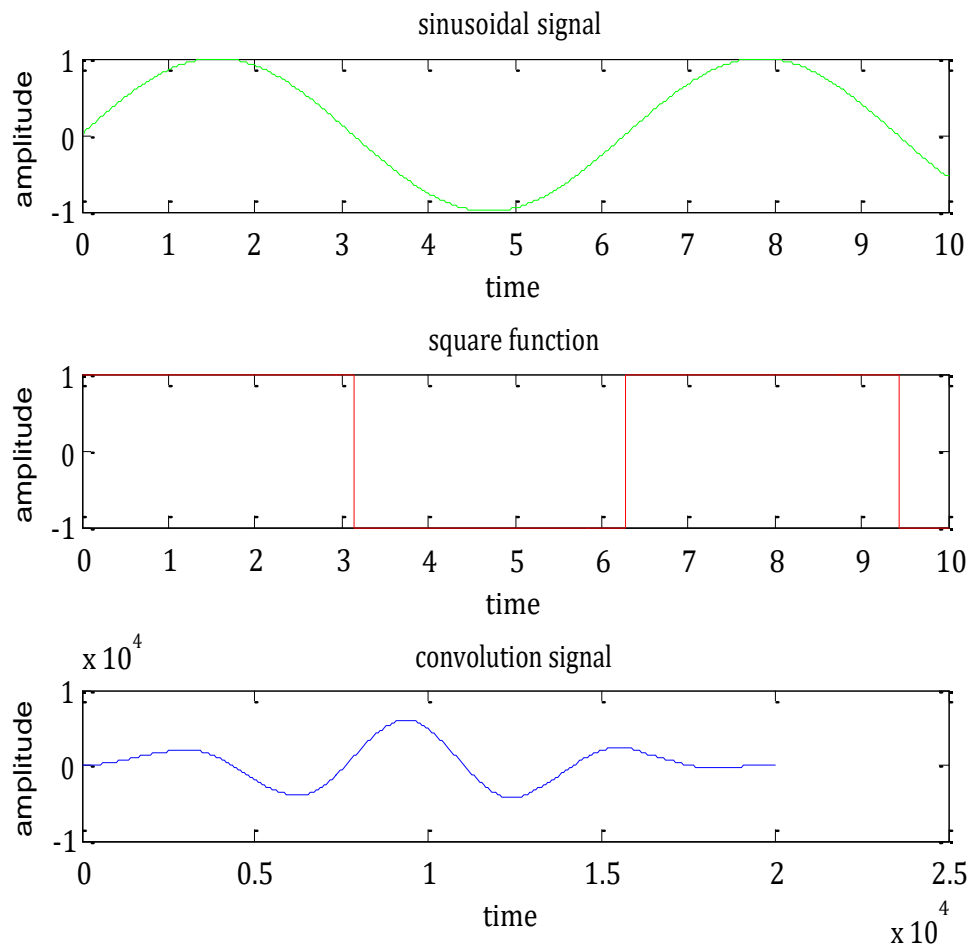
```

ylabel('h[n]'); title('second sequence');subplot(3,1,3);
stem(y); xlabel('discrete time');ylabel('y[n]');
title('convolution of two sequences');

```

**OUTPUT:-**

## Convolution of two signals



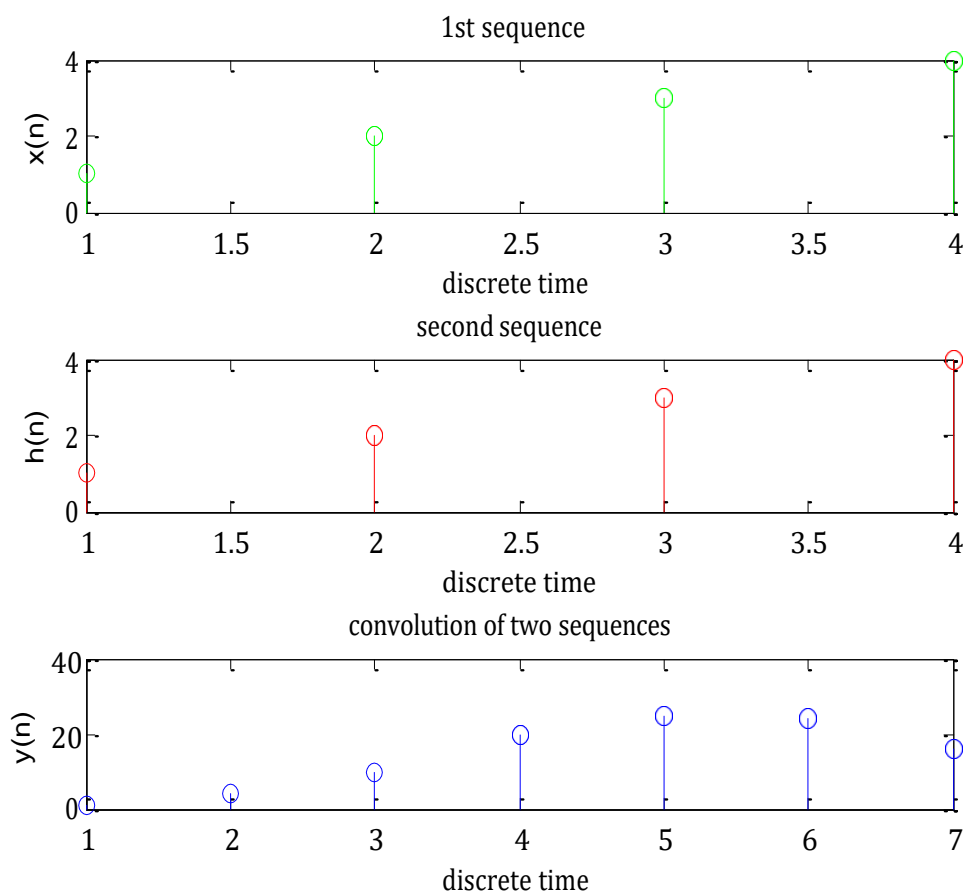
### Convolution of two sequences

enter the length of 1st sequence 4

enter the length of 2nd sequence 4

enter the first sequence:  $x(n)=[1 \ 2 \ 3 \ 4]$

enter the second sequence:  $y(n)=[1 \ 2 \ 3 \ 4]$



### RESULT:-

In this experiment convolution of various signals have been performed Using MATLAB.

## Basic Simulation Lab Manual

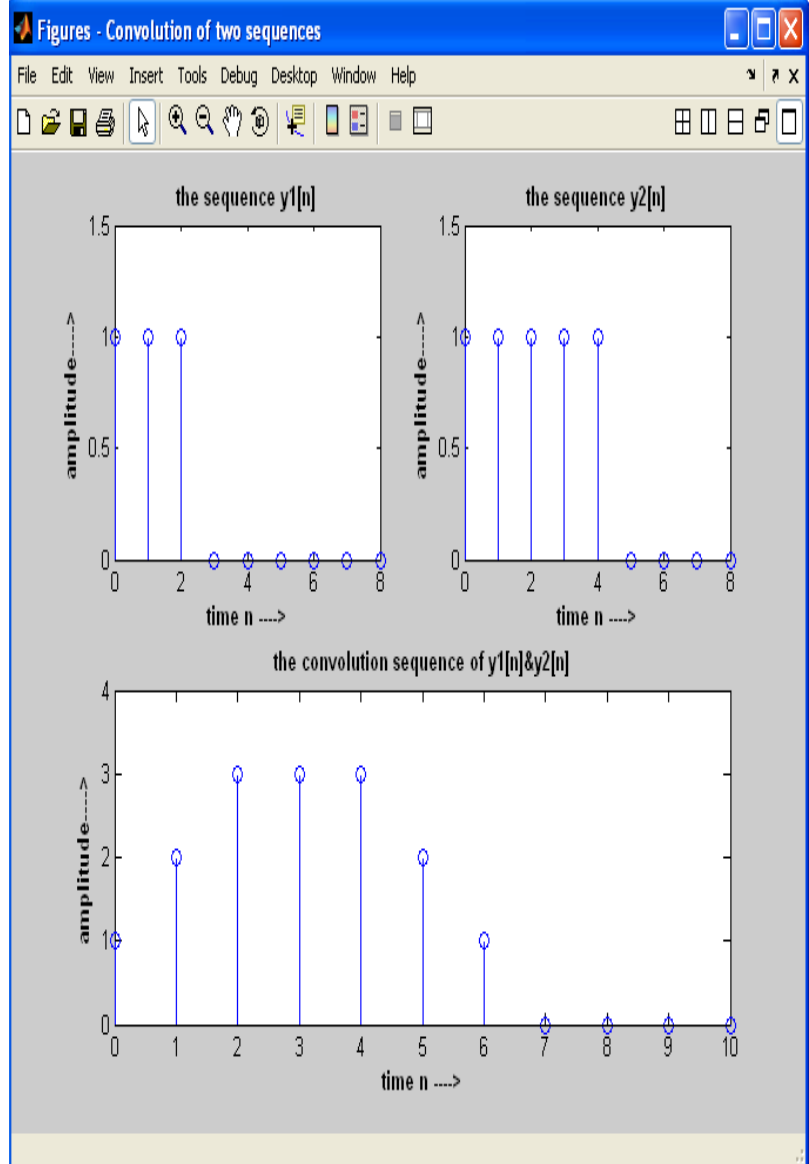
53

## PROGRAM:-

```

clc; clear all; close all;
n=0:8; x1=1; x2=0;
y1=x1.*(n>=0 & n<=2)+x2.*(n>=2 & n<=8);
subplot(2,2,1);
stem(n,y1); axis([0 8 0 1.5]);
xlabel('time n>');
ylabel('amplitude>');
title('the sequence y1[n]');
y2=x1.*(n>=0 & n<=4)+x2.*(n>=4 & n<=8);
subplot(2,2,2);
stem(n,y2); axis([0 8 0 1.5]);
xlabel('time n>');
ylabel('amplitude>');
title('the sequence y2[n]');
y=conv(y1,y2); L=length(y);
n=0:L-1;
subplot(2,2,[3,4]);
stem(n,y);
axis([0 10 0 4]);
xlabel('time n>');
ylabel('amplitude>');
title('the convolution sequence of
y1[n]&y2[n]');

```



**VIVA QUESTIONS: -**

1. Define Convolution?
2. Define Properties of Convolution?
3. What is the Difference Between Convolution & Correlation?
4. What are Dirichlet Conditions of Fourier Series?
5. What is Half Wave Symmetry?
6. Define Linear Convolution?
7. Define Properties of Convolution in time domain?
8. What is the Difference Between Linear Convolution & Circular Correlation?
9. What are Dirichlet Conditions for Fourier Transform?
10. What is Full Wave Symmetry?

**EXERCISE PROGRAMS**

1. Write the MATLAB program to perform convolution between the following sequences  $X(n)=[1 \ -1 \ 4]$ ,  $h(n)=[-1 \ 2 \ -3 \ 1]$ .
2. Write a mat lab program to perform the convolution between sinusoidal and ramp function and see how mat lab reacts to it.
3. Write a MATLAB program to perform convolution between square and step signal and see how mat lab reacts to it.
4. Write a MATLAB program to perform convolution between sinusoidal and ramp signal and see how mat lab reacts to it.
5. Write a MATLAB program to perform the convolution between  $X(n)=[1 \ 2 \ 3 \ 5]$  and  $y(n)=[-1 \ -2]$  and see how matlab reacts to it.
6. Write a MATLAB program to perform the convolution between  $X(n)=[1 \ -3 \ 5]$  and  $y(n)=[1 \ 2 \ 3 \ 4]$  and see how matlab reacts to it.
7. Write a MATLAB program to perform the convolution between  $X(n)=[1 \ 0 \ 1 \ 1]$  and  $y(n)=[1 \ 0 \ 0 \ 0]$  and see how matlab reacts to it.
8. Write a MATLAB program to perform the convolution between  $X(n)=[1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0]$  and  $y(n)=[1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
9. Write a MATLAB program to perform the convolution between  $X(n)=[1 \ 1 \ 0 \ 0]$  and  $y(n)=[1 \ 1 \ 1 \ 1]$  and see how matlab reacts to it.
10. Write a MATLAB program to perform the convolution between  $X(n)=[6 \ 7 \ 8 \ 9 \ 10]$  and  $y(n)=[5 \ 4 \ 3 \ 2 \ 1]$  and see how matlab reacts to it.
11. Write the MATLAB program to perform convolution between the following sequences  $X(n)=[2 \ -2 \ 3 \ 2]$ ,  $h(n)=[-2 \ 4 \ -5 \ 2]$ .
12. Write a mat lab program to perform the convolution between step and ramp function and see how mat lab reacts to it.
13. Write a MATLAB program to perform convolution between square and step signal and see how mat lab reacts to it.
14. Write a MATLAB program to perform convolution between sinusoidal and square signal and see how mat lab reacts to it.
15. Write a MATLAB program to perform the convolution between  $X(n)=[2 \ 3 \ 4 \ 5]$  and  $y(n)=[-2 \ -4]$  and see how matlab reacts to it.

16. Write a MATLAB program to perform the convolution between  $X(n) = [3 \ -4 \ 6]$  and  $y(n) = [2 \ 6 \ 8 \ 6]$  and see how matlab reacts to it.
17. Write a MATLAB program to perform the convolution between  $X(n) = [3 \ 1 \ 2 \ 0]$  and  $y(n) = [2 \ 4 \ 3 \ 4 \ 5]$  and see how matlab reacts to it.
18. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 2 \ 1 \ 0 \ 2 \ 1 \ 1 \ 0]$  and  $y(n) = [1 \ 1 \ 1 \ 2 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
19. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 1 \ 2 \ 1]$  and  $y(n) = [1 \ 2 \ 1 \ 2]$  and see how matlab reacts to it.
20. Write a MATLAB program to perform the convolution between  $X(n) = [5 \ 6 \ 9 \ 8 \ 7]$  and  $y(n) = [1 \ 2 \ 3 \ 2 \ 1]$  and see how matlab reacts to it.
21. Write the MATLAB program to perform convolution between the following sequences  $X(n) = [4 \ -6 \ 5 \ 1]$ ,  $h(n) = [-1 \ 3 \ -4 \ 3]$ .
22. Write a mat lab program to perform the convolution between ramp and step function and see how mat lab reacts to it.
23. Write a MATLAB program to perform convolution between square and step signal and see how mat lab reacts to it.
24. Write a MATLAB program to perform convolution between sinusoidal and step signal and see how mat lab reacts to it.
25. Write a MATLAB program to perform the convolution between  $X(n) = [1 \ 5 \ 6 \ 5]$  and  $y(n) = [-3 \ -6]$  and see how matlab reacts to it.
26. Write a MATLAB program to perform the Circular Convolution between  $X(n) = [1 \ 0 \ 1 \ 1 \ 0]$  and  $y(n) = [1 \ 0 \ 0 \ 0 \ 1]$  and see how matlab reacts to it.
27. Write a MATLAB program to perform the Circular Convolution between  $X(n) = [1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0]$  and  $y(n) = [1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
28. Write a MATLAB program to perform the Circular Convolution between  $X(n) = [1 \ 1 \ 0 \ 0]$  and  $y(n) = [1 \ 1 \ 1 \ 1]$  and see how matlab reacts to it.
29. Write a MATLAB program to perform the Circular Convolution between  $X(n) = [6 \ 7 \ 8 \ 9 \ 10]$  and  $y(n) = [5 \ 4 \ 3 \ 2 \ 1]$  and see how matlab reacts to it.
30. Write the MATLAB program to perform Circular Convolution between the following sequences  $X(n) = [2 \ -2 \ 3 \ 2]$ ,  $h(n) = [-2 \ 4 \ -5 \ 2]$ .

### Real Time Applications:

- The convolution is to determine the response  $y[n]$  of a system of a known impulse response  $h[n]$  for a given input signal  $x[n]$  to obtain  $y[n]$ .
- Digital Image Processing Applications such as Compression and Restoration.

**EXPERIMENT NO: 6****Auto correlation and cross correlation between Signals and sequences****AIM: -**

To compute auto correlation and cross correlation between signals and Sequences.

**SOFTWARE REQUIRED: -**

1. MATLAB R2010a.
2. Windows XP SP2.

**THEORY:-**

In Signal processing, When the autocorrelation function is normalized by mean and variance, it is sometimes referred to as the autocorrelation coefficient. Given a [signal](#)  $f(t)$ , the continuous autocorrelation  $R_{ff}(T)$  is most often defined as the continuous cross-correlation integral of  $f(t)$  with itself, at lag  $T$

$$R_{ff}(\tau) = (f(t) * \bar{f}(-t))(\tau) = \int_{-\infty}^{\infty} f(t + \tau) \bar{f}(t) dt = \int_{-\infty}^{\infty} f(t) \bar{f}(t - \tau) dt$$

The discrete autocorrelation  $R_{xx}$  at lag  $j$  for a discrete signal  $x(n)$  is

$$R_{xx}(j) = \sum_n x_n \bar{x}_{n-j}$$

In signal processing, cross-correlation is a measure of similarity of two waveforms as a function of a time-lag applied to one of them. This is also known as a sliding dot product or sliding inner-product. It is commonly used for searching a long signal for a shorter, known feature. It has applications in pattern recognition, single particle analysis, electron tomographic averaging, cryptanalysis, and neurophysiology.

For continuous functions  $f$  and  $g$ , the cross-correlation is defined as:

$$(f \star g)(\tau) \stackrel{\text{def}}{=} \int_{-\infty}^{\infty} f^*(t) g(t + \tau) dt,$$



## Basic Simulation Lab Manual

where  $f^*$  denotes the [complex conjugate](#) of  $f$  and  $t$  is the time lag.

Similarly, for discrete functions, the cross-correlation is defined as:

$$(f \star g)[n] \stackrel{\text{def}}{=} \sum_{m=-\infty}^{\infty} f^*[m] g[m+n].$$

**PROCEDURE:-**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM:-**

%Auto correlation for a

signal%

```
clc;
clear all;
close all; t=0:0.001:1;
x=cos(2*pi*3*t);a=xcorr(x); subplot(2,1,1);
plot(t,x,'g');
xlabel('time'); ylabel('amplitude');title('input signal');subplot(2,1,2);
plot(a,'r');
xlabel('time'); ylabel('amplitude');
title('auto correlation signal');
```

**%cross correlation for a signal%**

```
clc; clear all; close all;
t=0:0.001:1;
x=cos(2*pi*3*t); y=cos(2*pi*5*t); a=xcorr(x,y);
subplot(3,1,1);
plot(t,x,'g');
xlabel('time'); ylabel('amplitude'); title('1st signal'); subplot(3,1,2);
plot(t,y,'r');
xlabel('time'); ylabel('amplitude'); title('2nd signal'); subplot(3,1,3);
plot(a,'r');
xlabel('time'); ylabel('amplitude');
title('cross correlation signal');
```

**%Auto correlation for a sequence%**

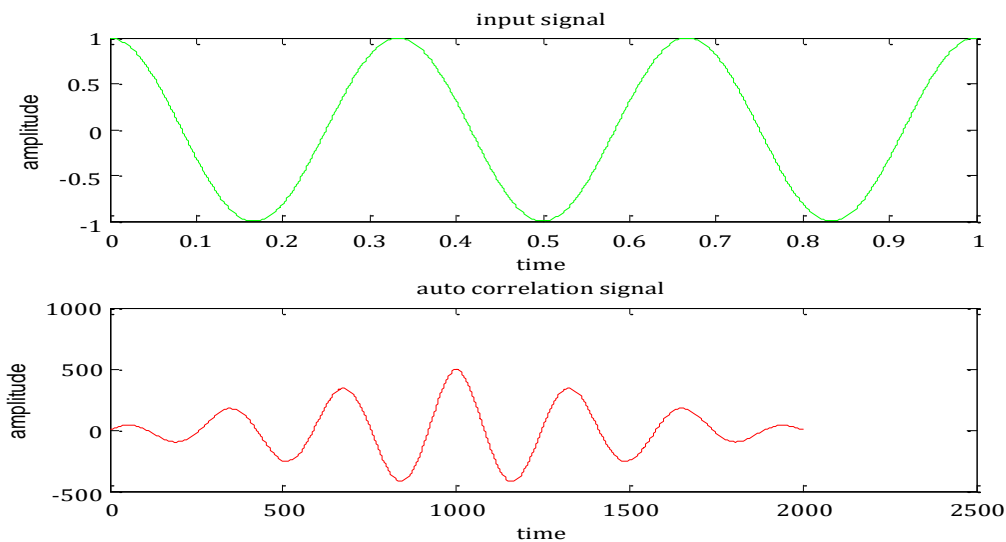
```
clc;
clear
all; close
all;
x=input('enter sample
values'); a=xcorr(x);
subplot(2,1,1);
stem(x,'g');
xlabel('time');
ylabel('amplitude');
title('input
sequence');
subplot(2,1,2);
stem(a,'r');
xlabel('time'); ylabel('amplitude');
title('auto correlation sequence');
```

%cross correlation for asequence%

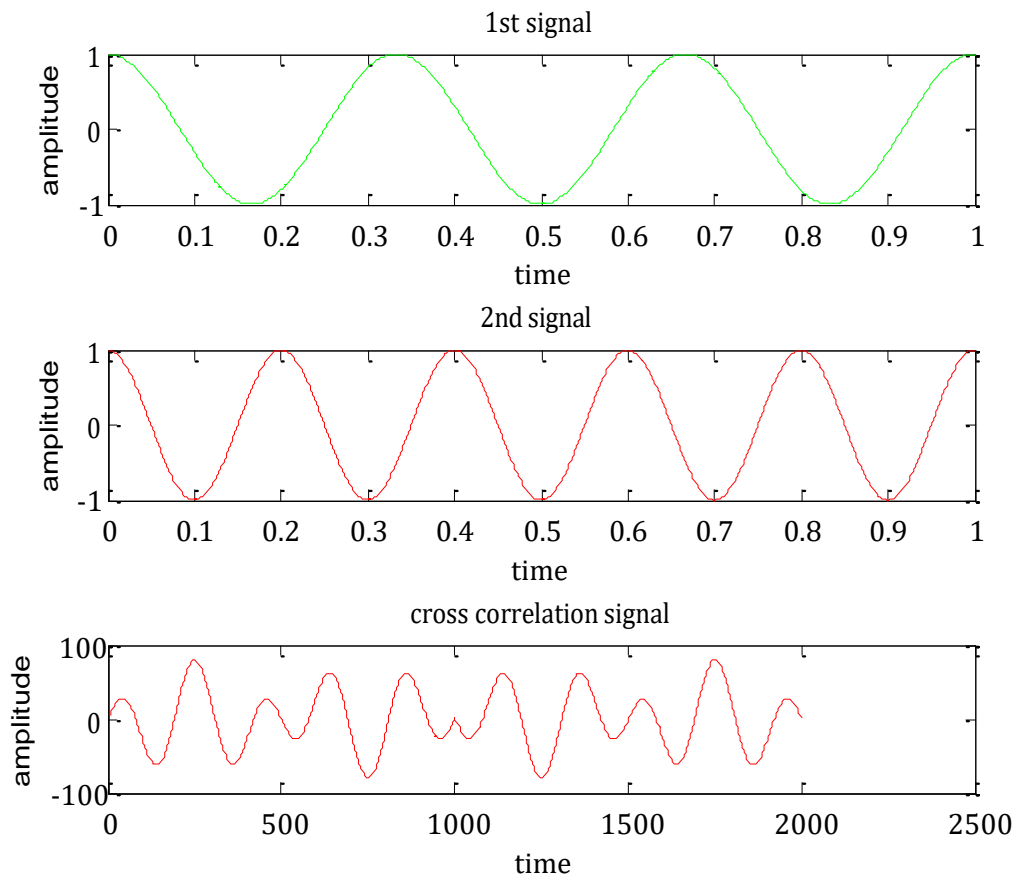
```
clc;
clear
all;close
all;
x=input('enter first sequence'); y=input('enter second sequence');a=xcorr(x,y);
subplot(3,1,1);
stem(x,'g');
xlabel('time'); ylabel('amplitude');title('1st sequence');subplot(3,1,2);
stem(y,'r');
xlabel('time'); ylabel('amplitude'); title('2nd sequence');subplot(3,1,3);
stem(a,'r');
xlabel('time'); ylabel('amplitude');
title('cross correlation sequence');
```

### OUTPUT:-

Auto correlation for a signal



### cross correlation for a signal



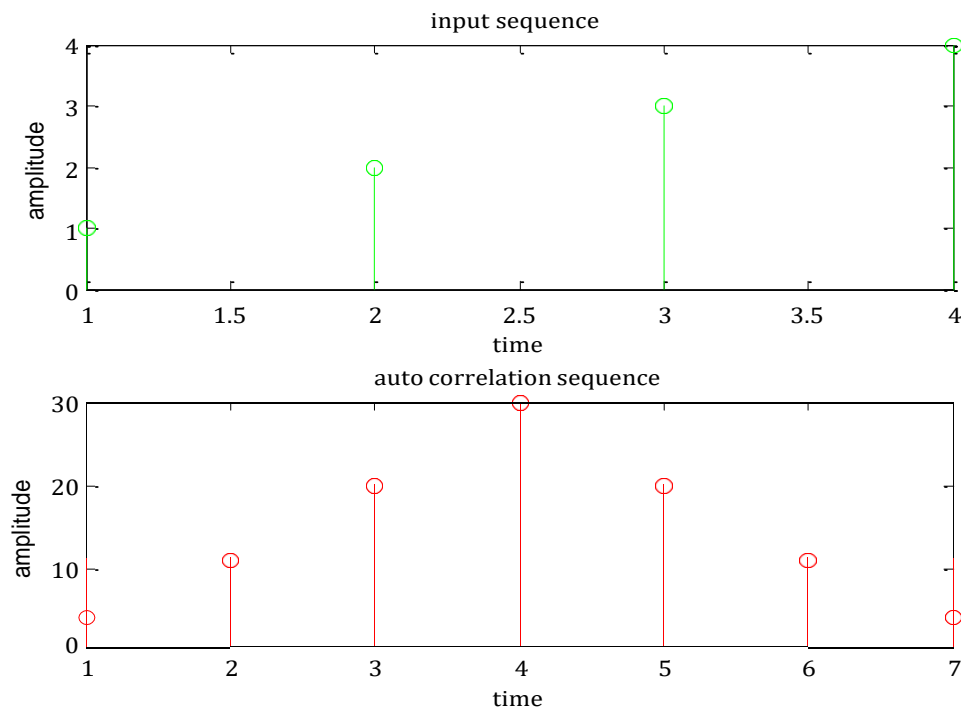
### Auto correlation for a sequence

enter sample values [1 2 3 4]

x =

1 2 3 4

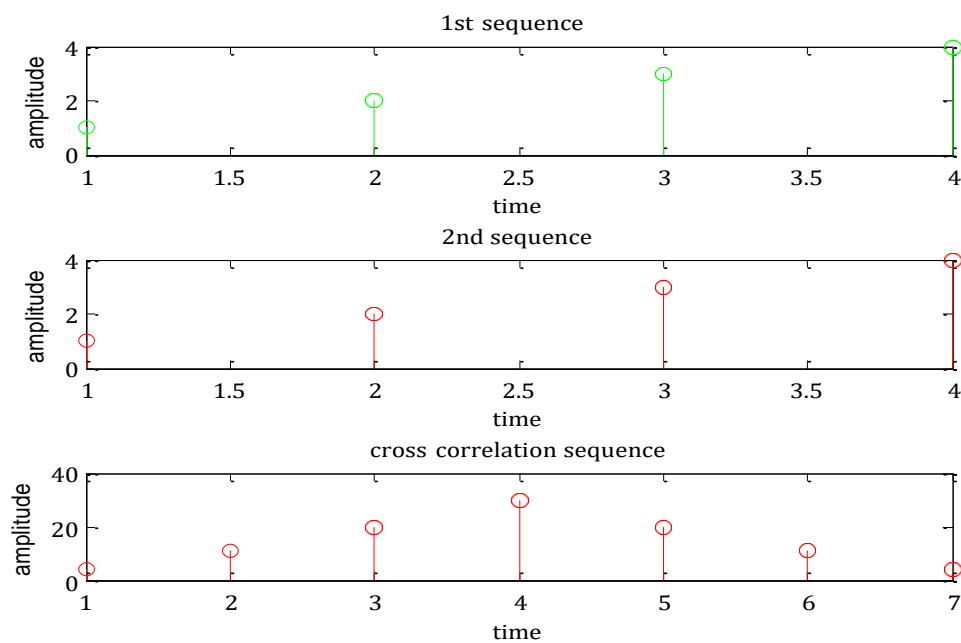
## Basic Simulation Lab Manual



## cross correlation for two sequences

enter first sequence [1 2 3 4]

enter second sequence [1 2 3 4]

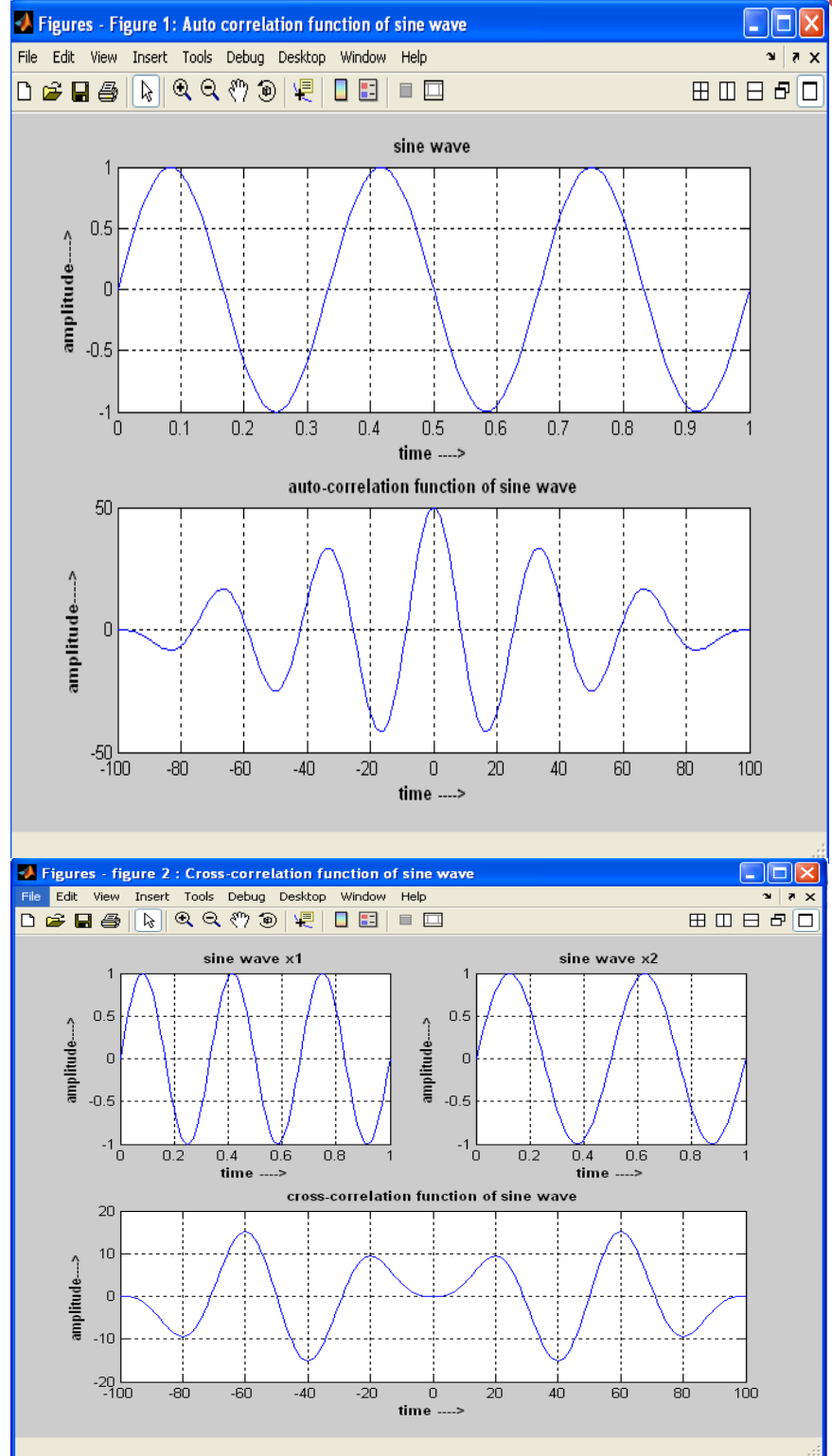


**PROGRAM:**

```

clc; clear all; close all;
t=0:0.01:1;
f1=3;
x1=sin(2*pi*f1*t); figure;
subplot(2,1,1);
plot(t,x1); title('sine wave');
xlabel('time>');
ylabel('amplitude>');
grid;
[rxx lag1]=xcorr(x1);
subplot(2,1,2); plot(lag1,rxx);
grid;
title('auto-correlation
function of sine wave');
figure;
subplot(2,2,1);
plot(t,x1);
title('sine wave x1');
xlabel('time>');
ylabel('amplitude>');
grid; f2=2;
x2=sin(2*pi*f2*t);
subplot(2,2,2);
plot(t,x2);
title('sine wave x2');
xlabel('time ---->');
ylabel('amplitude>');
grid;
[cxx lag2]=xcorr(x1,x2);
subplot(2,2,[3,4]);
plot(lag2,cxx);
grid;
title('cross-correlation function
of sine wave');

```



**RESULT: -**

In this experiment correlation of various signals have been performed Using MATLAB.

**VIVA QUESTIONS: -**

1. Define Correlation?
2. Define Auto-Correlation?
3. Define Cross-Correlation?
4. What is the importance of correlation?
5. What is the difference b/w correlation and convolution?
6. Explain two Properties of Auto-Correlation?
7. Explain two Properties of Cross-Correlation?
8. What is the difference b/w Auto-correlation and Cross-Correlation?
9. Define ESD?
10. Define PSD?

**EXERCISE PROGRAMS**

1. Write a MATLAB program to compute auto correlation between signals and Sequences.  
 $x = \cos(2\pi \cdot 10 \cdot t)$ ,  $y = \cos(2\pi \cdot 15 \cdot t)$ .
2. Write a MATLAB program to compute cross correlation between signals and Sequences.  
 $x = \cos(2\pi \cdot 7 \cdot t)$ ,  $y = \cos(2\pi \cdot 14 \cdot t)$ .
3. Write a MATLAB program to compute the cross correlation between signals and Sequences.  $x = \cos(2\pi \cdot 10 \cdot t)$ ,  $y = \cos(2\pi \cdot 15 \cdot t)$  by increasing the amplitude of the signal by 3 times and verify how matlab reacts to it.
4. Write a MATLAB program to compute the auto correlation between signals and Sequences.  $x = \cos(2\pi \cdot 15 \cdot t)$ ,  $y = \cos(2\pi \cdot 10 \cdot t)$  by increasing the amplitude of the signal by 2 times and verify how matlab reacts to it.
5. Write a MATLAB program to compute auto correlation between  $x = \sin(2\pi \cdot 5 \cdot t)$ ,  $y = \sin(2\pi \cdot 10 \cdot t)$ . and see how matlab reacts to it.
6. Write a MATLAB program to compute cross correlation between  $x = \sin(2\pi \cdot 5 \cdot t)$ ,  $y = \cos(2\pi \cdot 10 \cdot t)$ . and see how matlab reacts to it.
7. Write a MATLAB program to compute cross correlation between two signals  $x = 9 \cdot \cos(2\pi \cdot 7 \cdot t)$ ,  $y = 5 \cdot \cos(2\pi \cdot 14 \cdot t)$ .

8. Write a MATLAB program to compute cross correlation between two Sequences [1 2 3 45] & [9 8 7 6 5].
9. Write a MATLAB program to compute auto correlation between two signals  $x=9*\cos(2*\pi*7*t)$ ,  $y=5*\cos(2*\pi*14*t)$ .
10. Write a MATLAB program to compute auto correlation between two Sequences [2 4 3 4 5] & [7 9 4 6 3].
11. Write a MATLAB program to compute auto correlation between signals and Sequences.  $x=\cos(2*\pi*20*t)$ ,  $y=\cos(2*\pi*10*t)$ .
12. Write a MATLAB program to compute cross correlation between signals and Sequences.  $x=\cos(4*\pi*8*t)$ ,  $y=\cos(4*\pi*10*t)$ .
13. Write a MATLAB program to compute the cross correleation between signals and Sequences.  $x=\cos(2*\pi*20*t)$ ,  $y=\cos(2*\pi*10*t)$  by increasing the amplitude of the signal by 2 times and verify how matlab reacts to it.
14. Write a MATLAB program to compute the auto correleation between signals and Sequences.  $x=\cos(2*\pi*5*t)$ ,  $y=\cos(2*\pi*20*t)$  by increasing the amplitude of the signal by 4 times and verify how matlab reacts to it.
15. Write a MATLAB program to compute auto correlation between  $x = \sin(2*\pi*5*t)$  ,  $y = \sin(4*\pi*20*t)$ . and see how matlab reacts to it.
16. Write a MATLAB program to compute cross correlation between  $x = \sin(3*\pi*5*t)$  ,  $y = \cos(4*\pi*5*t)$ . and see how matlab reacts to it.
17. Write a MATLAB program to compute cross correlation between two signals  $x=4*\cos(2*\pi*5*t)$ ,  $y=6*\cos(2*\pi*10*t)$ .
18. Write a MATLAB program to compute cross correlation between two Sequences [2 6 4 8 5] & [8 9 6 7 5].
19. Write a MATLAB program to compute auto correlation between two signals  $x=5*\cos(2*\pi*10*t)$ ,  $y=5*\cos(2*\pi*10*t)$ .
20. Write a MATLAB program to compute auto correlation between two Sequences [1 1 4 4 5] & [9 9 7 5 5].
21. Write a MATLAB program to compute auto correlation between signals and Sequences.  $x=\cos(3*\pi*10*t)$ ,  $y=\cos(4*\pi*5*t)$ .



22. Write a MATLAB program to compute cross correlation between signals and Sequences.  $x=\cos(6*\pi*6*t), y=\cos(4*\pi*5*t)$ .
23. Write a MATLAB program to compute the cross correleation between signals and Sequences.  $x=\cos(2*\pi*10*t), y=\cos(2*\pi*5*t)$  by increasing the amplitude of the signal by 3 times and verify how matlab reacts to it.
24. Write a MATLAB program to compute the auto correleation between signals and Sequences.  $x=\cos(4*\pi*5*t), y=\cos(2*\pi*5*t)$  by increasing the amplitude of the signal by 4 times and verify how matlab reacts to it.
25. Write a MATLAB program to compute auto correlation between  $x = \sin(4*\pi*5*t)$  ,  $y = \sin(4*\pi*10*t)$ . and see how matlab reacts to it.
26. Write a MATLAB program to compute auto correlation between  $x = \sin(4*\pi*2*t)$  ,  $y = \sin(4*\pi*20*t)$ . and see how matlab reacts to it.
27. Write a MATLAB program to compute cross correlation between  $x = \sin(3*\pi*2*t)$  ,  $y = \cos(5*\pi*5*t)$ . and see how matlab reacts to it.
28. Write a MATLAB program to compute auto correlation between two signals  $x=4*\cos(2*\pi*10*t), y=6*\cos(6*\pi*10*t)$ .
29. Write a MATLAB program to compute cross correlation between two Sequences [2 6 4 8 5] & [8 9 6 7 5].
30. Write a MATLAB program to compute auto correlation between two signals  $x=5*\cos(8*\pi*10*t), y=6*\cos(7*\pi*10*t)$ .

### Real Time Applications:

- Correlation is used to extract second (and higher) order statistics from any randomsignal.
- Explains Energy and Power of Continuous and discrete systems.

**EXPERMENT NO:7****Verification of linearity and time invariance properties of a given continuous /discrete system.****AIM: -**

To compute linearity and time invariance properties of a given continuous /discrete System.

**SOFTWARE REQUIRED: -**

- 1.MATLAB R2010a.
- 2.Windows XP SP2.

**THEORY:-****LINEARITY PROPERTY**

- a) Homogeneity
- b) Superposition

satisfies the principle of superposition

$$L[a_1x_1(n) + a_2x_2(n)] = a_1L[x_1(n)] + a_2L[x_2(n)]$$

$$\forall a_1, a_2, x_1(n), x_2(n)$$

The output  $y(n)$  of a linear system to an arbitrary input  $x(n)$

$$y(n) = L[x(n)] = L\left[\sum_{k=-\infty}^{+\infty} x(k)\delta(n-k)\right] = \sum_{k=-\infty}^{+\infty} x(k)L[\delta(n-k)]$$

$L[\delta(n-k)]$  is called impulse response, and is denoted by  $h(n,k)$

$$y(n) = \sum_{k=-\infty}^{+\infty} x(k)h(n,k)$$

## LINEAR TIME INVARIANT SYSTEMS(LTI)

A linear system in which an input-output pair is invariant to a shift  $n$  in time is called a linear times-invariant system

$$y(n) = L[x(n)] \rightarrow y(n-k) = L[x(n-k)]$$

$$h(n, k) = L[\delta(n-k)] = h(n-k)$$

The output of a LTI system is call a *linear convolution sum*

$$y(n) = LTI[x(n)] = \sum_{k=-\infty}^{+\infty} x(k)h(n-k) \triangleq x(n) * h(n)$$

An LTI system is completely characterized in the time domain by the impulse response  $h(n)$ .

$$n = -\infty$$

### PROCEDURE:-

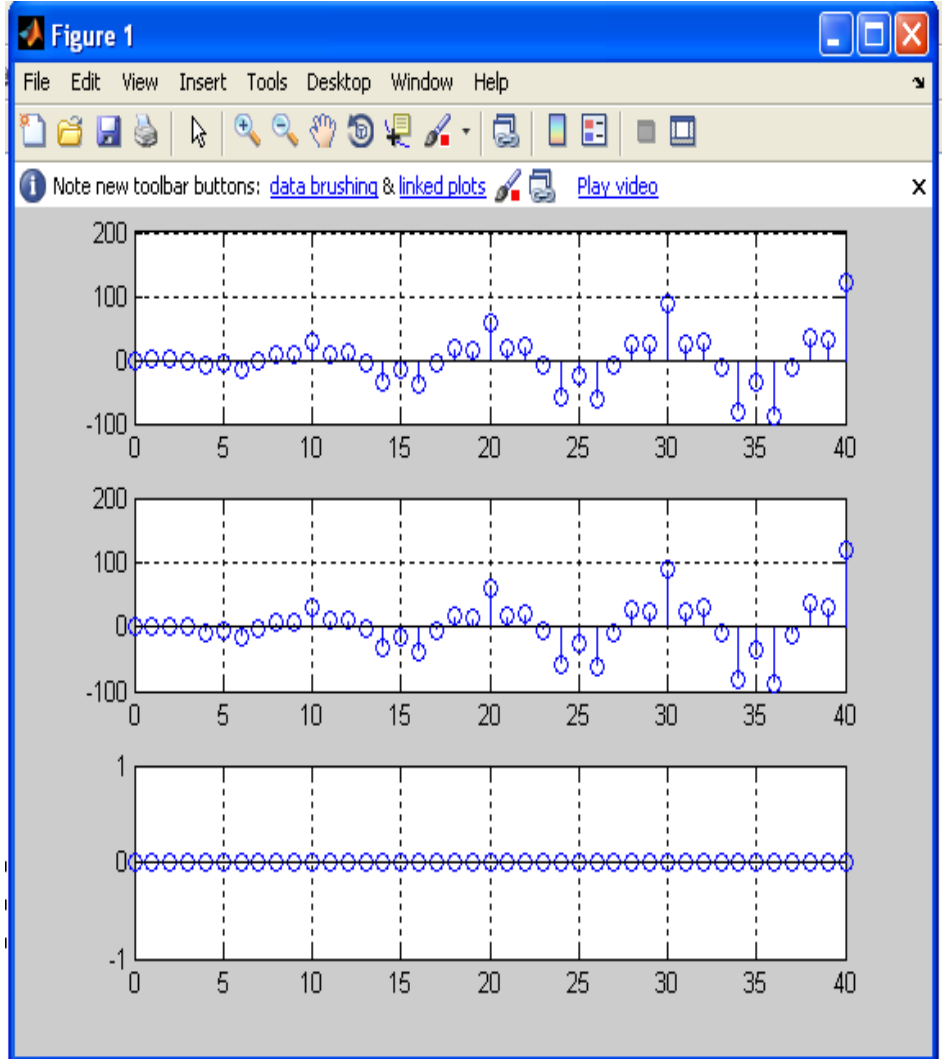
- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM: -**

```

%Program1:%
clc;
clear all; close all;
n=0:40; a=2; b=1;
x1=cos(2*pi*0.1*n);
x2=cos(2*pi*0.4*n);
x=a*x1+b*x2;
y=n.*x;
y1=n.*x1;
y2=n.*x2;
yt=a*y1+b*y2;
d=y-yt;
d=round(d)
if d
disp('Given system is not
satisfy linearity property');
else
disp('Given system is satisfy
linearity property');
end
subplot(3,1,1), stem(n,y);
grid;
subplot(3,1,2), stem(n,yt);
grid;
subplot(3,1,3), stem(n,d);
grid;

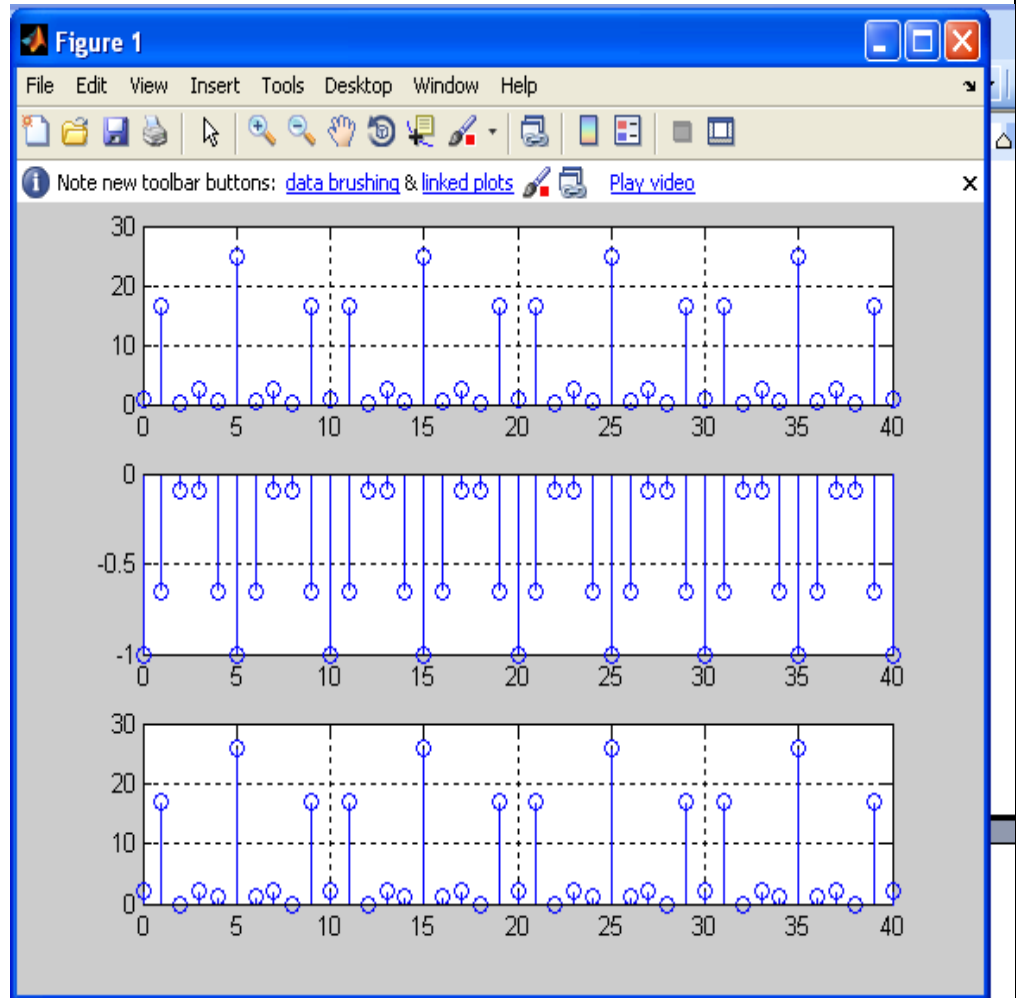
```



```

%Program2:%
clc;
clear all; close all;
n=0:40;
a=2; b=-3;
x1=cos(2*pi*0.1*n);
x2=cos(2*pi*0.4*n);
x=a*x1+b*x2;
y=x.^2;
y1=x1.^2;
y2=x2.^2;
yt=a*y1+b*y2;
d=y-yt;
d=round(d);
if d
disp('Given system is
not satisfy linearity
property'); else
disp('Given system is
satisfy linearity
property'); end
subplot(3,1,1),
stem(n,y); grid;
subplot(3,1,2),
stem(n,yt); grid;
subplot(3,1,3),
stem(n,d);
grid;

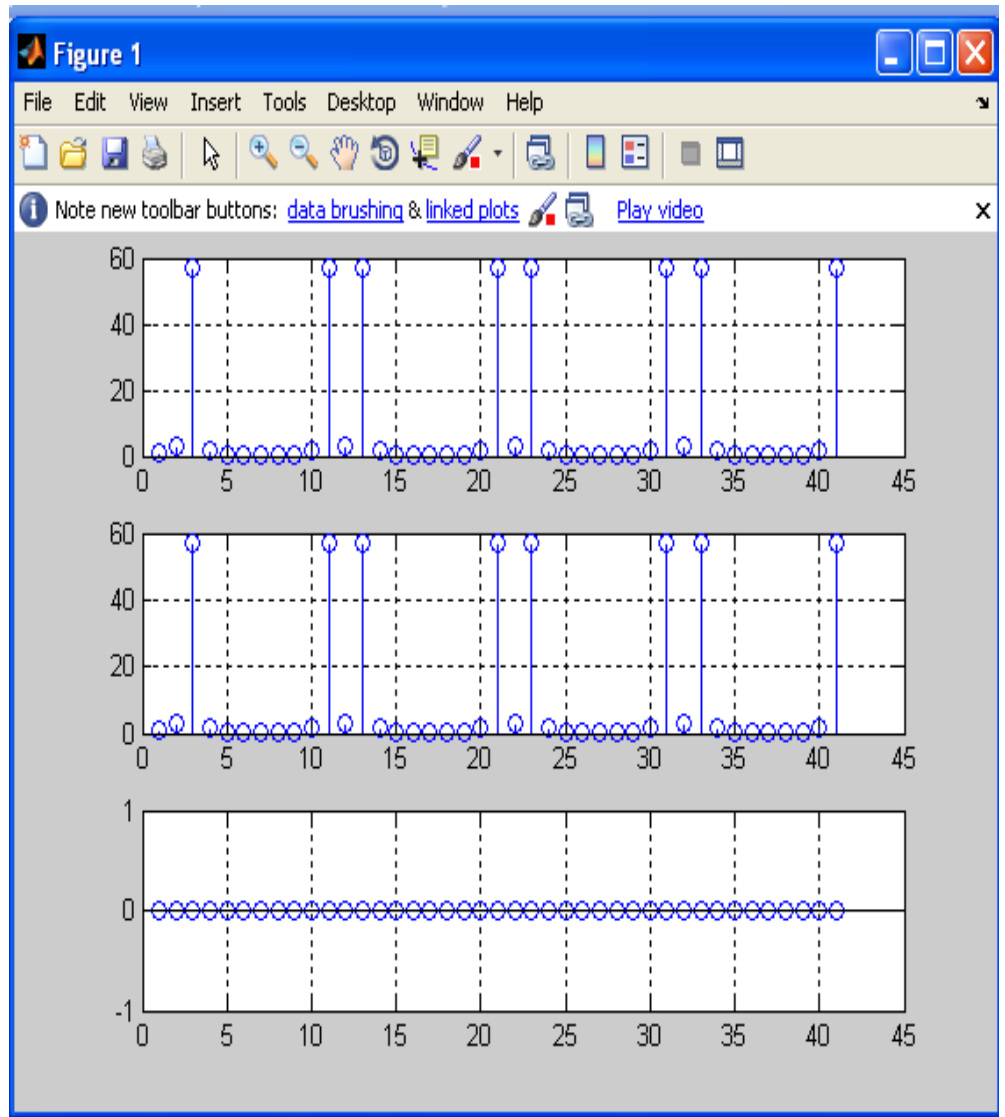
```



```

%Program3:%
clc;
close all; clear all;
n=0:40; D=10;
x=3*cos(2*pi*0.1*n)-
2*cos(2*pi*0.4*n);
xd=zeros(1,D) x;
y=n.*xd(n+D);
n1=n+D;
yd=n1.*x; d=y-yd;
if d
disp('Given system is
not satisfy time
shifting property');
else
disp('Given system is
satisfy time shifting
property'); end
subplot(3,1,1),
stem(y),
grid;
subplot(3,1,2),
stem(yd),
grid;
subplot(3,1,3),
stem(d),
grid;

```



**VIVA QUESTIONS: -**

1. Define Systems?
2. What is LTI Systems?
3. Describe LTV Systems?
4. What is the importance of Linear Systems?
5. What is the difference b/w Linear and Non-Linear Systems?
6. Explain two Properties of LTI Systems?
7. Explain two Properties of LTV Systems?
8. What is the Superposition Principal?
9. What is Difference between CT and DT systems?
10. Define Causality of LTI Systems?

**EXSERCISE QUESTIONS**

1. Write a MATLAB program to verify the linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and chech whether it satisfies the linearity property or not.
2. Write a MATLAB program to verify the linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and chech whether it satisfies the linearity property or not
3. Write a MATLAB program to verify the linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.3 \cdot n)$ , and chech whether it satisfies the linearity property or not
4. Write a MATLAB program to verify the time invariance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and chech whether it satisfies the time invariance property or not.
5. Write a MATLAB program to verify the time invariance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and chech whether it satisfies the time invariance property or not
6. Write a MATLAB program to verify the time invariance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.3 \cdot n)$ , and chech whether it satisfies the time invariance property or not.
7. Write a MATLAB program to verify the time variance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.3 \cdot n)$ , and chech whether it satisfies the time invariance property or not.
8. Write a MATLAB program to verify the non linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.3 \cdot n)$ , and chech whether it satisfies the linearity property or not
9. Write a MATLAB program to verify the time variance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the time invariance property or not.

10. Write a MATLAB program to verify the non linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the linearity property or not.
11. Write a MATLAB program to verify the linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the linearity property or not.
12. Write a MATLAB program to verify the linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the linearity property or not
13. Write a MATLAB program to verify the linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.3 \cdot n)$ , and check whether it satisfies the linearity property or not
14. Write a MATLAB program to verify the time invariance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the time invariance property or not.
15. Write a MATLAB program to verify the time invariance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the time invariance property or not
16. Write a MATLAB program to verify the time invariance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.3 \cdot n)$ , and check whether it satisfies the time invariance property or not.
17. Write a MATLAB program to verify the time variance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.3 \cdot n)$ , and check whether it satisfies the time invariance property or not.
18. Write a MATLAB program to verify the non linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.3 \cdot n)$ , and check whether it satisfies the linearity property or not
19. Write a MATLAB program to verify the time variance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the time invariance property or not.
20. Write a MATLAB program to verify the non linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the linearity property or not.
21. Write a MATLAB program to verify the linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the linearity property or not.
22. Write a MATLAB program to verify the linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the linearity property or not
23. Write a MATLAB program to verify the linearity prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.3 \cdot n)$ , and check whether it satisfies the linearity property or not
24. Write a MATLAB program to verify the time invariance prpoerty of the following sequency  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the time invariance property or not.



25. Write a MATLAB program to verify the time invariance property of the following sequence  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the time invariance property or not.
26. Write a MATLAB program to verify the time invariance property of the following sequence  $x_1 = \sin(2\pi \cdot 1 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 12 \cdot n)$ , and check whether it satisfies the time invariance property or not.
27. Write a MATLAB program to verify the time invariance property of the following sequence  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $2 \cdot \cos(2\pi \cdot 0.5 \cdot n)$ , and check whether it satisfies the time invariance property or not.
28. Write a MATLAB program to verify the time variance property of the following sequence  $x_1 = \cos(2\pi \cdot 0.1 \cdot n)$ ;  $\cos(2\pi \cdot 0.4 \cdot n)$ , and check whether it satisfies the time invariance property or not.
29. Write a MATLAB program to verify the non linearity property of the following sequence  $x_1 = \sin(2\pi \cdot 0.1 \cdot n)$ ;  $\sin(2\pi \cdot 0.3 \cdot n)$ , and check whether it satisfies the linearity property or not.
30. Write a MATLAB program to verify the time variance property of the following sequence  $x_1 = 6 \cdot \sin(2\pi \cdot 10 \cdot n)$ ;  $x_2 = \sin(2\pi \cdot 2 \cdot n)$ , and check whether it satisfies the time invariance property or not.

### Real Time Applications:

- Wave Propagation such as sound and electromagnetic waves.
- Electrical circuits composed of resistors, capacitors and inductors.
- Robotics Applications.

**EXPERIMENT NO:8**

**Computation of unit sample, unit step and sinusoidal response of the given LTI system and verifying its physical reliability and stability Properties.**

**AIM: -**

To Unit Step and Sinusoidal Response of The Given LTI System And Verifying Its Physical Reliability And Stability Properties.

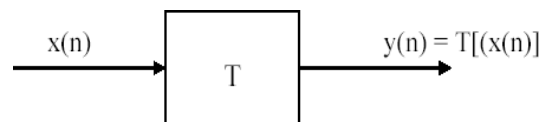
**SOFTWARE REQUIRED: -**

- 1.MATLAB R2010a.
- 2.Windows XP SP2.

**THEORY: -**

A discrete time system performs an operation on an input signal based on predefined criteria to produce a modified output signal. The input signal  $x(n)$  is the system excitation, and  $y(n)$  is the system response. The transform operation is shown as,

If the input to the system is unit impulse i.e.  $x(n) = \delta(n)$  then the output of the



system is known as impulse response denoted by  $h(n)$  where,

$$h(n) = T[\delta(n)]$$

we know that any arbitrary sequence  $x(n)$  can be represented as a weighted sum of discrete impulses. Now the system response is given by,

$$y(n) = T[x(n)] = T\left[\sum_{k=-\infty}^{\infty} x(k) \delta(n-k)\right]$$

For linear system (1) reduces to

$$y(n) = \sum_{k=-\infty}^{\infty} x(k) T[\delta(n-k)]$$

$$H(z) = \frac{b_0 + b_1 Z^{-1} + b_2 Z^{-2} + \dots + b_{N-1} Z^{-(N-1)} + b_N Z^{-N}}{1 + a_1 Z^{-1} + a_2 Z^{-2} + \dots + a_{N-1} Z^{-(N-1)} + a_N Z^{-N}} \quad H(Z) = \frac{\sum_{k=0}^M b_k X(n-k)}{\sum_{k=1}^N a_k X(n-k)}$$

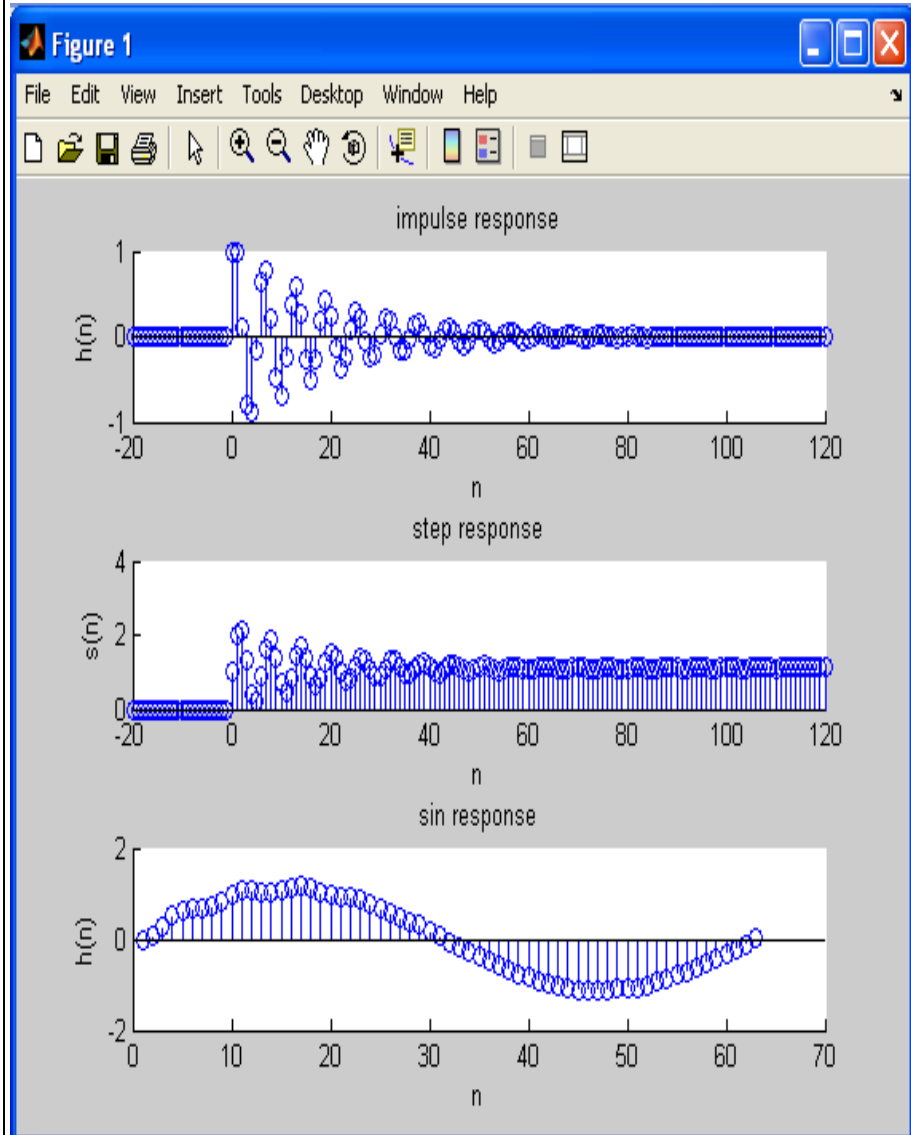
**PROCEDURE: -**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program

**PROGRAM: -**

%calculate and plot the  
impulse response and step  
response%

```
clc;
clear all;
close all;
b=[1];
a=[1,-1,9];
x=impzseq(0,-20,120);
n = [-20:120];
h=filter(b,a,x);
subplot(3,1,1);
stem(n,h);
title('impulse response');
xlabel('n');
ylabel('h(n)');
s=stepzseq(0,-20,120);
s=filter(b,a,s);
subplot(3,1,2);
stem(n,s);
title('step response');
xlabel('n');
ylabel('s(n)');
t=0:0.1:2*pi;
x1=sin(t);
%impzseq(0,-20,120);
n = [-20:120];
h=filter(b,a,x1);
subplot(3,1,3);stem(h);
title('sin response');
xlabel('n');
ylabel('h(n)'); figure;
zplane(b,a);
```

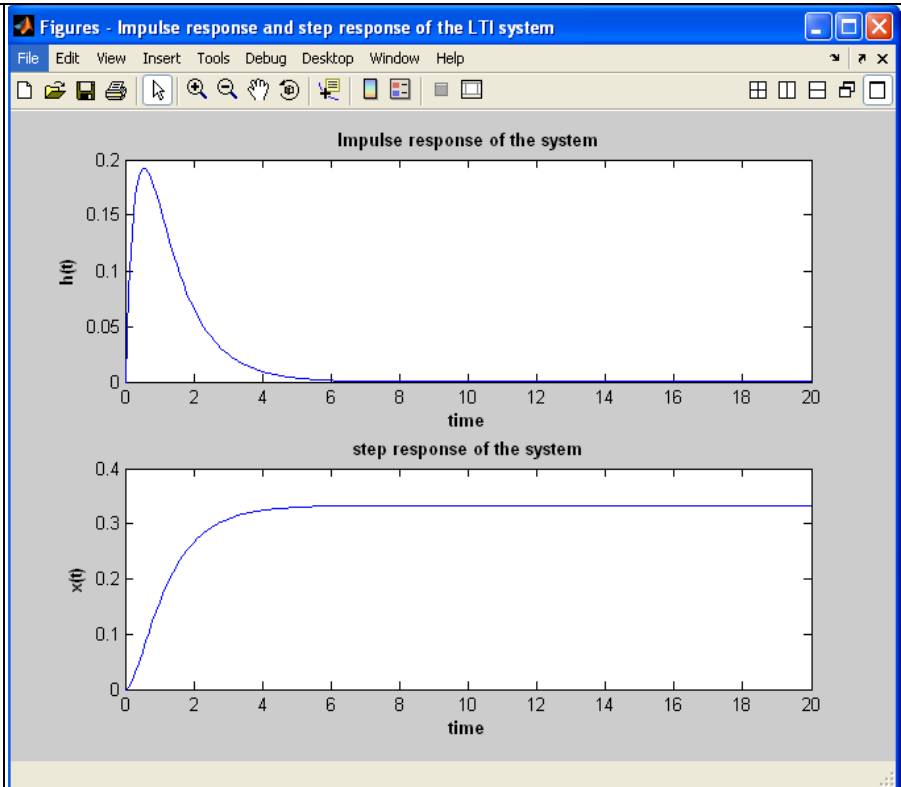


PROGRAM:-

```

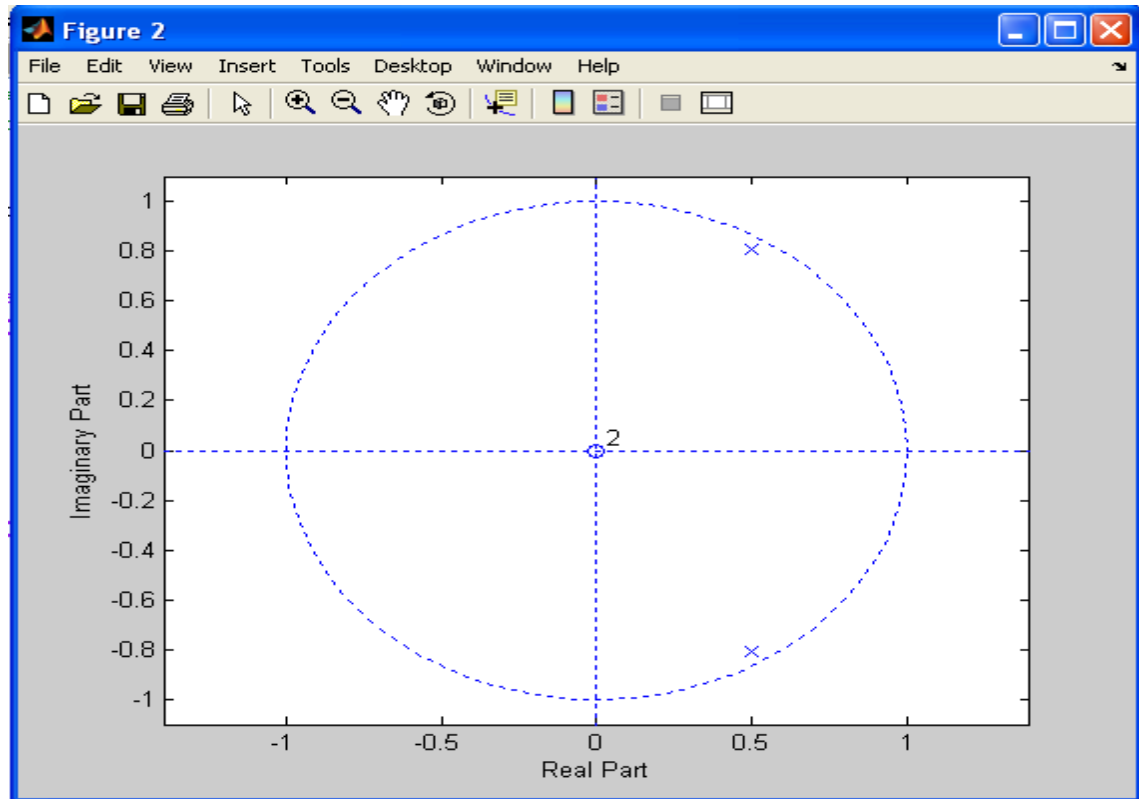
clc; clear all;
close all;
syms s complex;
H=1/(s^2+4*s+3);
disp('Impulse response of the
system h(t) is'); h=ilaplace(H);
simplify(h); disp(h);
Y=1/(s*(s^2+4*s+3));
disp('Step response of the
system is');
y=ilaplace(Y);
simplify(y); disp(y);
t=0:0.1:20;
h1=subs(h,t);
subplot(2,1,1);
plot(t,h1);
xlabel('time');
ylabel('h(t)');
title('Impulse response of the
system'); y1=subs(y,t);
subplot(2,1,2);
plot(t,y1);
xlabel('time');
ylabel('x(t)');
title('step response of the
system');

```



Impulse response of a system  $h(t)$  is  $\exp(-2t) \sinh(t)$ .  
 The step response of a system is  $\frac{1}{6} \exp(-3t) - \frac{1}{2} \exp(-t) + \frac{1}{3}$ .

## Basic Simulation Lab Manual

**RESULT: -**

In this experiment computation of unit sample, unit step and sinusoidal response of the given LTI system and verifying its physical Reliability and Stability Properties using MATLAB.

**VIVA QUESTIONS: -**

- 1.What operations can be performed on signals and sequence?
- 2.Define causality?
- 3.Define scaling property and give its importance?
- 4.Define shifting property and give its importance?
- 5.Define folding property and give its importance?
- 6.Define stability?
- 7.Give the importance of Causality?
- 8.Give the importance of Stability?
9. Define Impulse Response?
- 10.Define Step Response?

**EXERCISE PROGRAM: -**

1. Write a MATLAB program for generating  $u(n)-u(n-1)$ .
2. Write a MATLAB program for generating delayed unit step response
3. Write a MATLAB program for generating delayed impulse response
4. Write a MATLAB program for generating  $u(n)+u(n-1)$  and verify how matlab reacts to it.
5. write a MATLAB program to find the energy & power of the signal  $x(t)=10\sin(10t)$ .
6. write a MATLAB program to find the even & odd of the signal  $x(t)=e^{2t}$ .
7. write a MATLAB program to find the even & odd of the signal  $x(t)=\sin(t)$ .
8. write a MATLAB program to find the even & odd of the signal  $x(t)=\cos(t)$ .
9. write a MATLAB program to find the energy & power of the signal  $x(t)=\sin(t)$ .
10. write a MATLAB program to find the energy & power of the signal  $x(t)=e^{2t}$ .
11. Write a MATLAB program for generating  $u(n-2)-u(n-1)$ .
12. Write a MATLAB program for generating delayed step response with magnitude 2
13. Write a MATLAB program for generating delayed impulse response with magnitude 2.
14. Write a MATLAB program for generating  $u(n+1)+u(n-1)$  and verify how matlab reacts to it.
15. Write a MATLAB program to find the energy & power of the signal  $x(t)=20\sin(5t)$ .
16. Write a MATLAB program to find the even & odd of the signal  $x(t)=e^{3t}$ .
17. Write a MATLAB program to find the even & odd of the signal  $x(t)=\sin(t)+\cos(t)$ .
18. Write a MATLAB program to find the even & odd of the signal  $x(t)=\cos(t)-\sin(t)$ .
19. Write a MATLAB program to find the energy & power of the signal  $x(t)=\sin(t)-\cos(t)$ .
20. Write a MATLAB program to find the energy & power of the signal  $x(t)=e^{4t}$ .
21. Write a MATLAB program for generating  $u(n+2)-u(n-1)$ .
22. Write a MATLAB program for generating delayed unit step response
23. Write a MATLAB program for generating delayed impulse response
24. Write a MATLAB program for generating  $u(n-3)+u(n-1)$  and verify how matlab reacts to it.
25. Write a MATLAB program to find the energy & power of the signal  $x(t)=5\sin(20t)$ .
26. Write a MATLAB program to find the energy & power of the signal  $x(t)=30\sin(5t)$ .
27. Write a MATLAB program to find the even & odd of the signal  $x(t)=e^{4t}$ .
28. Write a MATLAB program to find the even & odd of the signal  $x(t)=\sin(t)-\cos(t)$ .
29. Write a MATLAB program to find the even & odd of the signal  $x(t)=\cos(t)-2\sin(t)$ .
30. Write a MATLAB program to find the energy & power of the signal  $x(t)=\sin(t)-3\cos(t)$ .

**Real Time Applications:**

- Electronic Circuits such as amplifiers and filters.
- Mechanical motion from the interaction of masses, springs and dashpots (dampers).
- LTI systems

**EXPERIMENT NO:9****Demonstration of Gibbs Phenomenon****AIM: -**

To demonstrate Gibbs Phenomenon using MATLAB.

**SOFTWARE REQUIRED: -**

- 1.MATLAB R2010a.
- 2.Windows XP SP2.

**THEORY: -****Gibbs Phenomenon:**

The peculiar manner in which the Fourier series of a piecewise continuously differentiable periodic function behaves at a jump discontinuity: the  $n$ th partial sum of the Fourier series has large oscillations near the jump, which might increase the maximum of the partial sum above that of the function itself. The overshoot does not die out as the frequency increases, but approaches a finite limit. The Gibbs phenomenon involves both the fact that Fourier sums overshoot at a jump discontinuity, and that this overshoot does not die out as the frequency increases.

The best known version of the Gibbs phenomenon is the overshoot that arises when a discontinuous function is represented by a truncated set of Fourier expansion terms. The situation is similar if the truncated Fourier expansion is instead obtained by means of interpolation on an equi spaced grid.

**PROCEDURE: -**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM: -**

%Gibbs phenomenon%

```

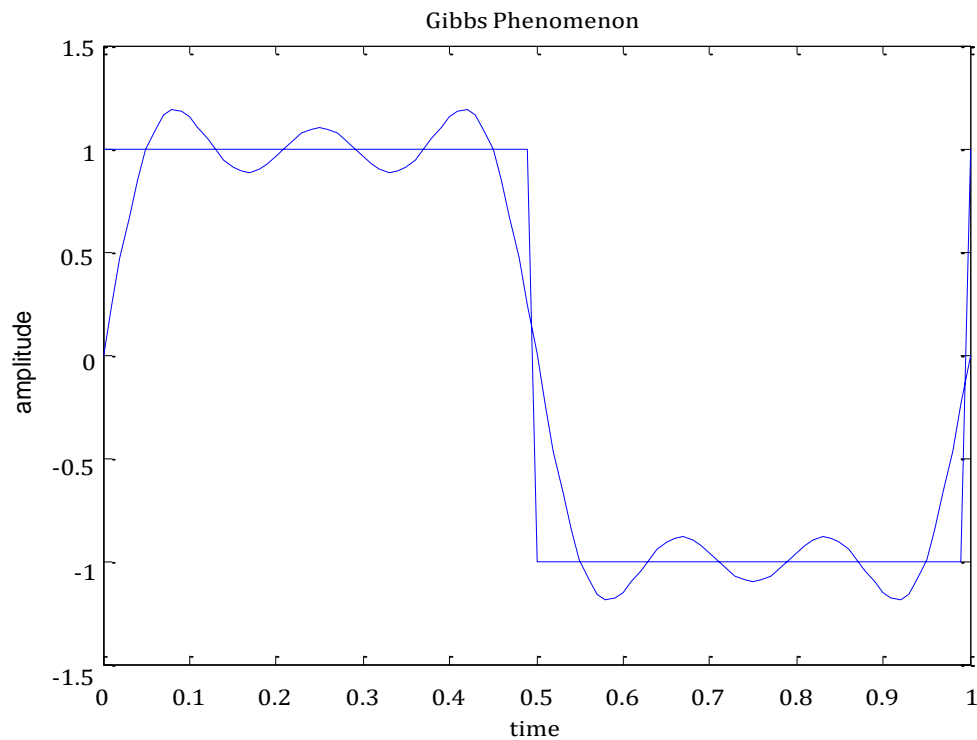
clc;
clear all;
close all; t=0:0.01:1;
N=input('enter no of harmonics');
x=square(2*pi*t);
plot(t,x);
hold on;
gp=0;
for n=1:2:N;
    gp=gp+(4/(n*pi))*sin(2*pi*n*t);
end; plot(t,gp); hold off;
xlabel('time');
ylabel('amplitude');
title('gibbs phenomenon');

```

**OUTPUT: -**

Gibbs phenomenon

enter no of harmonics 5



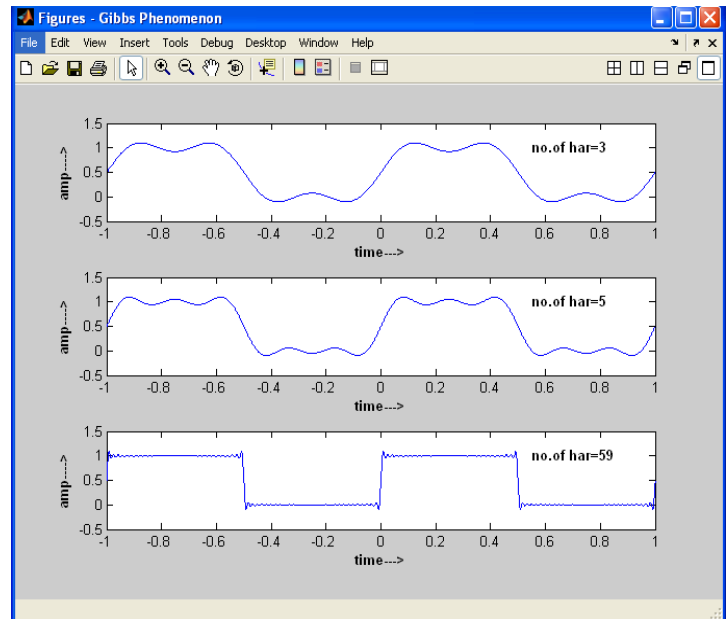


**PROGRAM: -**

```

clc; clear all;
close all;
N=input('enter the no. of signals to reconstruct=');
n_har=input('enter the no. of harmonics in each
signal=');
t=-1:0.001:1;
omega_0=2*pi;
for k=1:N
x=0.5;
for n=1:2:n_har(k) b_n=2/(n*pi);
x=x+b_n*sin(n*omega_0*t);
end subplot(N,1,k);
plot(t,x); xlabel('time--->');
ylabel('amp>');
axis([-1 1 -0.5 1.5]);
text(0.55,1.0,['no.of har=',num2str(n_har(k))]);
end

```



enter the no. of signals to reconstruct=3  
 enter the no. of harmonics in each signal=[3,5,59]

**RESULT: -**

In this experiment Gibbs phenomenon have been demonstrated Using MATLAB.

**EXERCISE PROGRAM: -**

1. Write the MATLAB program to perform convolution between the following sequences  $X(n)=[1 \ 8 \ 9 \ 3]$ ,  $h(n)=[2 \ 4 \ 5 \ 9]$ .
2. Write a mat lab program to perform the convolution between sinusoidal and ramp function and see how mat lab reacts to it.
3. Write a MATLAB program to perform convolution between square and step signal and see how mat lab reacts to it.
4. Write a MATLAB program to perform convolution between sinusoidal and ramp signal and see how mat lab reacts to it.
5. Write a MATLAB program to perform the convolution between  $X(n)=[8 \ 5 \ 6 \ 9]$  and  $y(n)=[-1 \ -2]$  and see how matlab reacts to it.
6. Write a MATLAB program to perform the convolution between  $X(n)=[1 \ -3 \ 4 \ 5]$  and  $y(n)=[1 \ 2 \ 3 \ 4]$  and see how matlab reacts to it.
7. Write a MATLAB program to perform the convolution between  $X(n)=[1 \ 0 \ 1 \ 1]$  and  $y(n)=[1 \ 0 \ 0 \ 0]$  and see how matlab reacts to it.
8. Write a MATLAB program to perform the convolution between  $X(n)=[1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0]$  and  $y(n)=[1 \ 0 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
9. Write a MATLAB program to perform the convolution between  $X(n)=[1 \ 1 \ 0 \ 0]$  and  $y(n)=[1 \ 1 \ 1 \ 1]$  and see how matlab reacts to it.

## Basic Simulation Lab Manual

10. Write a MATLAB program to perform the convolution between  $X(n) = [6 \ 9 \ 7 \ 5 \ 2]$  and  $y(n) = [8 \ 5 \ 6 \ 4 \ 2]$  and see how matlab reacts to it.
11. Write the MATLAB program to perform convolution between the following sequences  $X(n) = [2 \ 4 \ 9 \ 3]$ ,  $h(n) = [1 \ 3 \ 7 \ 5]$ .
12. Write a mat lab program to perform the convolution between step and ramp function and see how mat lab reacts to it.
13. Write a MATLAB program to perform convolution between sinusoidal and step signal and see how mat lab reacts to it.
14. Write a MATLAB program to perform convolution between impulse and ramp signal and see how mat lab reacts to it.
15. Write a MATLAB program to perform the convolution between  $X(n) = [3 \ 2 \ 6 \ 9]$  and  $y(n) = [-2 \ -4]$  and see how matlab reacts to it.
16. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ -4 \ 2 \ 5]$  and  $y(n) = [4 \ 2 \ 3 \ 4]$  and see how matlab reacts to it.
17. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 1 \ 0 \ 1]$  and  $y(n) = [1 \ 0 \ 1 \ 1]$  and see how matlab reacts to it.
18. Write a MATLAB program to perform the convolution between  $X(n) = [1 \ 2 \ 1 \ 2 \ 0 \ 1 \ 0 \ 1]$  and  $y(n) = [2 \ 0 \ 1 \ 1 \ 0 \ 0 \ 2 \ 0]$  and see how matlab reacts to it.
19. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 2 \ 0 \ 2]$  and  $y(n) = [1 \ 1 \ 2 \ 2]$  and see how matlab reacts to it.
20. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 1 \ 4 \ 5 \ 3]$  and  $y(n) = [2 \ 1 \ 6 \ 2 \ 1]$  and see how matlab reacts to it.
21. Write the MATLAB program to perform convolution between the following sequences  $X(n) = [2 \ 8 \ 7 \ 3]$ ,  $h(n) = [1 \ 4 \ 2 \ 9]$ .
22. Write a mat lab program to perform the convolution between sinusoidal and ramp function and see how mat lab reacts to it.
23. Write a MATLAB program to perform convolution between square and step signal and see how mat lab reacts to it.
24. Write a MATLAB program to perform convolution between sinusoidal and ramp signal and see how mat lab reacts to it.
25. Write a MATLAB program to perform the convolution between  $X(n) = [4 \ 5 \ 2 \ 1]$  and  $y(n) = [-2 \ -1]$  and see how matlab reacts to it.
26. Write a MATLAB program to perform the correlation between  $X(n) = [1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0]$  and  $y(n) = [1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
27. Write a MATLAB program to perform the correlation between  $X(n) = [1 \ 1 \ 0 \ 0]$  and  $y(n) = [1 \ 1 \ 1 \ 1]$  and see how matlab reacts to it.
28. Write a MATLAB program to perform the correlation between  $X(n) = [6 \ 9 \ 7 \ 5 \ 2]$  and  $y(n) = [8 \ 5 \ 6 \ 4 \ 2]$  and see how matlab reacts to it.
29. Write the MATLAB program to perform correlation between the following sequences  $X(n) = [2 \ 4 \ 9 \ 3]$ ,  $h(n) = [1 \ 3 \ 7 \ 5]$ .

30. Write a mat lab program to perform the correlation between step and ramp function and see how mat lab reacts to it.

**VIVA QUESTIONS: -**

1. Define Gibb's Phenomenon?
2. What is the importance of Gibb's Phenomenon?
3. What is Static and Dynamic System?
4. What is Causal Signal?
5. What is Causality Condition of the Signal?
6. Define Noise?
7. What is the importance of FS?
8. What is the importance of FT?
9. Define LTV system?
10. Define LTI system?

**Real Time Applications:**

- The **Gibbs phenomenon**, discovered by Henry Wilbraham and rediscovered by J. Willard Gibbs (1899), is the peculiar manner in which the Fourier series of a piecewise continuously differentiable periodic function behaves at a jump discontinuity.
- To Eliminate noise in Filters.

**EXPERIMENT NO: 10****Finding the Fourier transform of a given signal and plot its magnitude and phase spectrum****AIM: -**

To obtain Fourier Transform and Inverse Fourier Transform of a given signal / sequence and to plot its Magnitude and Phase Spectra.

**SOFTWARE REQUIRED: -**

1. MATLAB R2010a.
2. Windows XP SP2.

**THEORY: -****Fourier Transform Theorems:**

We may use Fourier series to motivate the Fourier transform as follows. Suppose that  $f$  is a function which is zero outside of some interval  $[-L/2, L/2]$ . Then for any  $T \geq L$  we may expand  $f$  in a Fourier series on the interval  $[-T/2, T/2]$ , where the "amount" of the wave  $e^{2\pi i n x/T}$  in the Fourier series of  $f$  is given by

By definition

- Fourier Transform of  $x(t)$ :  $\mathcal{F}[x(t)]$  or  $X(\omega)$ :

$$X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt$$

- Inverse Fourier Transform of  $X(\omega)$ :  $\mathcal{F}^{-1}[X(\omega)]$ :

$$x(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(\omega) e^{j\omega t} d\omega$$

## Basic Simulation Lab Manual

The fast Fourier transform (FFT) is an efficient algorithm for computing the DFT of a sequence; it is not a separate transform. It is particularly useful in areas such as signal and image processing, where its uses range from filtering, convolution, and frequency analysis to power spectrum estimation

For length N input vector x, the DFT is a length N vector X, with elements

$$X(k) = \sum x(n) \cdot \exp(-j \cdot 2 \cdot \pi \cdot (k-1) \cdot (n-1) / N), 1 \leq k \leq N, n=1$$

The inverse DFT (computed by IFFT) is given by

$$x(n) = (1/N) \sum X(k) \cdot \exp(j \cdot 2 \cdot \pi \cdot (k-1) \cdot (n-1) / N), 1 \leq n \leq N, k=1$$

**PROCEDURE: -**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM: -**

```

%Fourier Transform%
clc;
clear all;
close all;
syms t;
x=exp(-2*t)*heaviside(t);
y=fourier(x);
disp('Fourier Transform of input signal'); y
z=ifourier(y);
disp('Inverse Fourier Transform of input signal'); z
mg=abs(y);
subplot(2,1,1);
ezplot(mg); xlabel('time'); ylabel('amplitude');
title('magnitude spectrum of a input signal'); grid;
pha=atan(imag(y)/real(y)); subplot(2,1,2); ezplot(pha);
xlabel('time'); ylabel('amplitude');
title('phasespectrum of a input signal'); grid;

```

**OUTPUT:-**

Fourier Transform

Fourier Transform of input signal Y=

$$1/(2+w*i)$$

Inverse Fourier Transform of input signal Z=

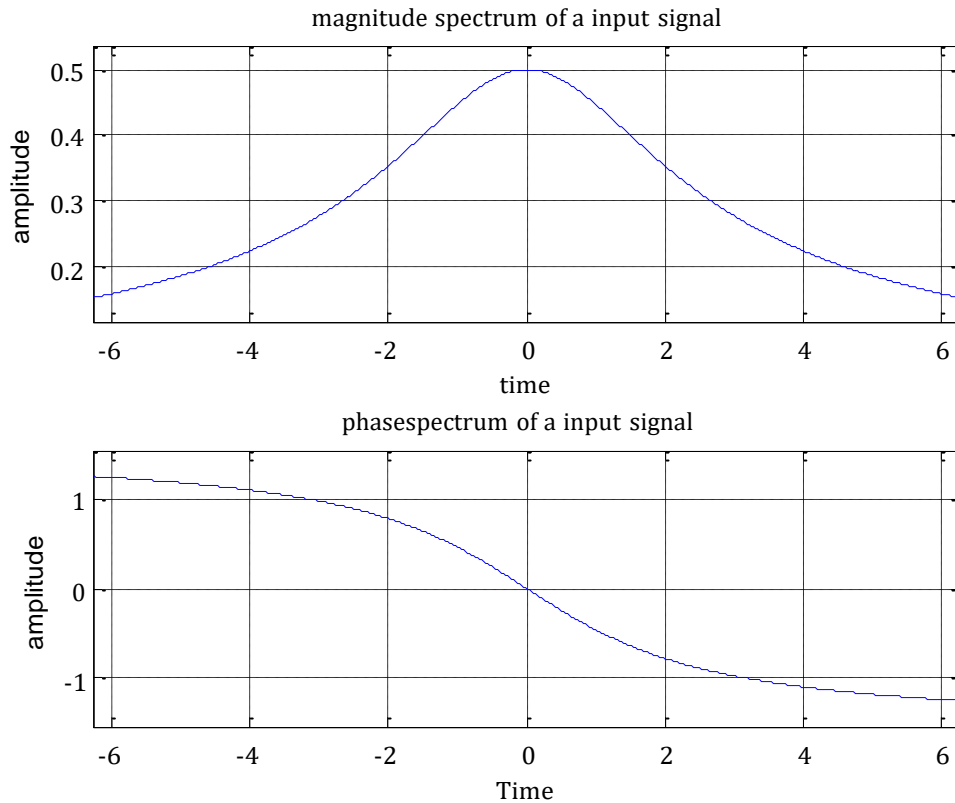
$$\text{Heaviside}(x)/\exp(2*x)$$

## Basic Simulation Lab Manual

87

<p><b>PROGRAM:-</b></p> <p>To find Fourier transform</p> <pre> clc; clear all; close all; syms t s; syms w real; syms A real; syms o real; syms b float; f=dirac(t); F=fourier(f); disp('the fourier transform of dirac(t) ='); disp(F); f1=A*heaviside(t); F1=fourier(f1); disp('the fourier transform of A ='); disp(F1); f2=A*exp(-t)*heaviside(t); F2=fourier(f2); disp('the fourier transform of exp(-t) ='); disp(F2); f3=A*t*exp(-b*t)*heaviside(t); F3=fourier(f3); disp('the fourier transform of A*t*exp(-b*t)*u(t) ='); disp(F3); f4=sin(o*t); F4=fourier(f4); disp('the fourier transform of sin(o*t) ='); disp(F4); </pre>	<p>To find inverse Fourier transforms of Given functions.</p> <pre> F1=A*pi*(dirac(w-o)+dirac(w+o)); f1=ifourier(F1,t); disp('the inverse fourier transform of ..... .....A*pi*(dirac(w-o)+dirac(w+o)='); disp(f1); F2=A*pi*(dirac(w-o)-dirac(w+o))/i; f2=ifourier(F2,t); disp('the inverse fourier transform of..... .....A*pi*(dirac(w-o)+dirac(w+o)/i='); disp(f2); F3=A/(1+i*w); f3=ifourier(F3,t); disp('the inverse fourier transform of A/(1+jw)='); disp(f3); F4=(3*i*w+14)/((i*w)^2+7*i*w+12); f4=ifourier(F4,t); disp('the inverse fourier transform of..... .....(3*i*w+14)/((i*w)^2+7*i*w+12)='); disp(f4); </pre>
<p><b>OUTPUT:-</b></p> <p>the fourier transform of dirac(t) =1</p> <p>the fourier transform of <math>A = A*(\pi*\text{dirac}(w)-i/w)</math> the fourier transform of <math>\exp(-t) = A/(1+i*w)</math></p> <p>the fourier transform of <math>A*t*\exp(-b*t)*u(t) = A/(b+i*w)^2</math></p> <p>the fourier transform of <math>\sin(o*t) = \pi*(\text{dirac}(w+o)-\text{dirac}(w-o))</math></p> <p>the inverse fourier transform of <math>A*\pi*(\text{dirac}(w-o)+\text{dirac}(w+o))=A*\cos(o*t)</math></p> <p>the inverse fourier transform of <math>A*\pi*(\text{dirac}(w-o)+\text{dirac}(w+o))/i=A*\sin(o*t)</math></p> <p>the inverse fourier transform of <math>A/(1+jw)=A*\exp(-t)*\text{heaviside}(t)</math></p> <p>the inverse fourier transform of <math>(3*i*w+14)/((i*w)^2+7*i*w+12)=\text{heaviside}(t)*(-2*\exp(-4*t)+5*\exp(-3*t))</math></p>	

## Basic Simulation Lab Manual



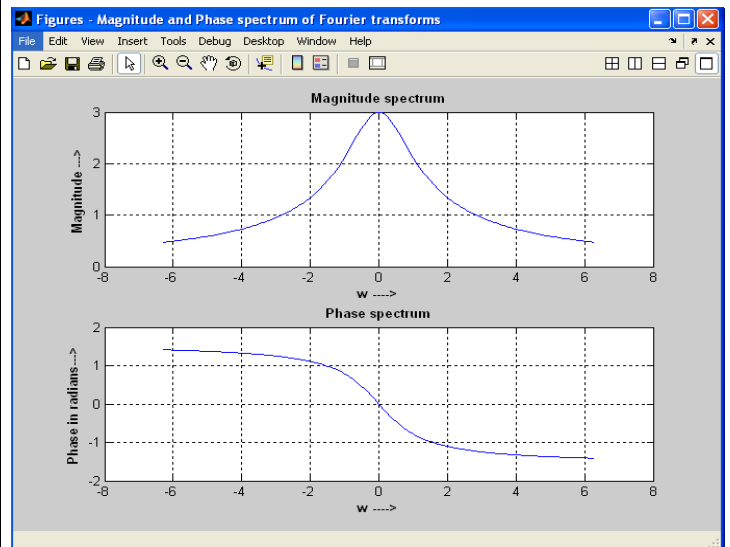
RESULT: -

In this experiment the Fourier transform of a given signal and plotting its magnitude and phase spectrum have been demonstrated using MATLAB.

### Magnitude and Phase Spectrum of Fourier Transform

```

PROGRAM:-
clc; clear all; close all; syms t s ;
syms w float;
f=3*exp(-t)*heaviside(t);
F=fourier(f);
disp('the fourier transform of .....
.....3*exp(-t)*u(t) =');
disp(F);
w=-2*pi:pi/50:2*pi;
F1=subs(F,w);
Fmag=abs(F1);% to find magnitude
Fphas=angle(F1);% to find phase
subplot(2,1,1);
plot(w,Fmag); xlabel('w>');
ylabel('Magnitude>');
title('Magnitude spectrum'); grid;
subplot(2,1,2);          plot(w,Fphas);
xlabel('w>');
ylabel('Phase in radians>');
title('Phase spectrum'); grid;
  
```





**VIVA QUESTIONS: -**

1. Define Fourier Series?
2. What are the properties of Continuous-Time Fourier Series?
3. What is the Sufficient condition for the existence of F.T?
4. Define the F.T of a signal?
5. What is the difference b/w F.T & F.S?
6. Define Scaling Property of FT?
7. Explain Time Convolution Property of FT?
8. Explain Frequency Convolution Property of FT?
9. Explain the linearity property?
10. Describe the advantages of FT?

**EXERCISE PROGRAMS**

1. Write a MATLAB program to find the cross correlation using FFT.
2. Write a MATLAB program to find F.T of the causal signal  $x(t)=t$
3. Write a MATLAB program to find F.T of the causal signal  $x(t)=e^{-at}$
4. Write a MATLAB program to find F.T of the causal signal  $x(t)=e^{at}$
5. Write a MATLAB program to find F.T of the causal signal  $x(t)=te^{at}$
6. Write a MATLAB program to find F.T of the causal signal  $x(t)=te^{-at}$
7. Write a MATLAB program to find F.T of the causal signal  $x(t)=\cos t$
8. Write a MATLAB program to find F.T of the causal signal  $x(t)=\sin t$
9. Write a MATLAB program to find F.T of the causal signal  $x(t)=e^{at}\cos t$
10. Write a MATLAB program to find F.T of the causal signal  $x(t)=e^{at}\sin t$
11. Write a MATLAB program to find the cross correlation using DFT.
12. Write a MATLAB program to find F.T of the causal signal  $x(t)=at$
13. Write a MATLAB program to find F.T of the causal signal  $x(t)=10e^{-at}$
14. Write a MATLAB program to find F.T of the signal  $x(t)=1$
15. Write a MATLAB program to find F.T of the causal signal  $x(t)=\text{impulse function}$
16. Write a MATLAB program to find F.T of the causal signal  $x(t)=\text{Delta function}$
17. Write a MATLAB program to find F.T of the causal signal  $x(t)=\cos(at)$
18. Write a MATLAB program to find F.T of the causal signal  $x(t)=\sin(at)$
19. Write a MATLAB program to find F.T of the causal signal  $x(t)=e^{at}\cos(at)$
20. Write a MATLAB program to find F.T of the causal signal  $x(t)=e^{at}\sin(at)$
21. Write a MATLAB program to find the auto correlation using FFT.
22. Write a MATLAB program to find F.T of the causal signal  $x(t)=5t$
23. Write a MATLAB program to find F.T of the causal signal  $x(t)=5e^{-at}$
24. Write a MATLAB program to find F.T of the causal signal  $x(t)=5e^{at}$
25. Write a MATLAB program to find F.T of the causal signal  $x(t)=5te^{at}$
26. Write a MATLAB program to find F.T of the causal signal  $x(t)=e^{-2t}$
27. Write a MATLAB program to find F.T of the causal signal  $x(t)=e^{5t}$

## Basic Simulation Lab Manual

28. Write a MATLAB program to find F.T of the causal signal  $x(t)=te^{4t}$
29. Write a MATLAB program to find F.T of the causal signal  $x(t)=te^{-4t}$
30. Write a MATLAB program to find F.T of the causal signal  $x(t)=4\cos t$

**Real Time Applications:**

Fourier transforms having following applications

- Analysis of differential equations
- Fourier transform spectroscopy
- Quantum mechanics
- Signal processing applications etc

.

**EXPERIMENT NO:11****Waveform Synthesis using Laplace Transform****AIM: -**

To perform waveform synthesis using Laplace Transforms of a given signal

**SOFTWARE REQUIRED: -1.**

- MATLAB R2010a.
- 2.Windows XP SP2.

**THEORY: -****Bilateral Laplace transform:**

When one says "the Laplace transform" without qualification, the unilateral or one-sided transform is normally intended. The Laplace transform can be alternatively defined as the bilateral Laplace transform or two-sided Laplace transform by extending the limits of integration to be the entire real axis. If that is done the common unilateral transform, simply becomes a special case of the bilateral transform where the definition of the function being transformed is multiplied by the Heaviside step function.

$$\begin{aligned}
 \mathcal{L}\{f(t)\} &= \int_{0^-}^{\infty} e^{-st} f(t) dt \\
 &= \left[ \frac{f(t)e^{-st}}{-s} \right]_{0^-}^{\infty} - \int_{0^-}^{\infty} \frac{e^{-st}}{-s} f'(t) dt \quad (\text{by parts}) \\
 &= \left[ -\frac{f(0^+)}{s} \right] + \frac{1}{s} \mathcal{L}\{f'(t)\},
 \end{aligned}$$

**Inverse Laplace transform**

The inverse Laplace transform is given by the following complex integral, which is known by various names (the Bromwich integral, the Fourier-Mellin integral, and Mellin's inverse formula):

$$f(t) = \frac{1}{2\pi j} \int_{\alpha-j\infty}^{\alpha+j\infty} F(s)e^{st} ds$$

**Example:**

Let  $y(t)=u(t)$ . We have

$$\begin{aligned}
 u(t) &= 1 && \text{for } t \geq 0 \\
 &= 0 && \text{for } t < 0 \\
 L\{u(t)\} &= \int_0^{\infty} u(t) \cdot e^{-st} dt = \int_0^{\infty} 1 \cdot e^{-st} dt = \left[ \frac{e^{-st}}{-s} \right]_0^{\infty} \\
 &= \left[ \frac{e^{-\infty}}{-s} - \frac{e^0}{-s} \right] && \text{as } e^{-\infty} = 0 \\
 L\{u(t)\} &= \frac{1}{s}
 \end{aligned}$$

The integral converges if  $s > 1$ . The functions  $\exp(t)$  and  $1/(s-1)$  are partner functions.

**PROCEDURE: -**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM:-**

```
%Laplace Transform%
clc
clear all;close all;syms t;
x=exp(-2*t)*heaviside(t);y=laplace(x);
disp('Laplace Transform of input
signal');y
z=ilaplace(y);
disp('Inverse Laplace Transform of input signal');z
```

**OUTPUT: -****Laplace Transform**

```
Laplace Transform of input
signalY=
1/(s+2)
Inverse Laplace Transform of input
signalZ=
1/exp(2*t)
```

**RESULT: -**

Laplace and inverse laplace transforms were verified using MATLAB functions.

**VIVA QUESTIONS: -**

1. Define Laplace-Transform?
2. What is the Condition for Convergence of the L.T?
3. What is the Region of Convergence(ROC)?
4. State the Shifting property of L.T?
5. State convolution Property of L.T?6. Define Scaling Property of L.T?
7. Explain Time Convolution Property of L.T?
8. Explain Frequency Convolution Property of L.T?
9. Explain the linearity property of L.T?10. Describe the advantages of L.T?

## EXERCISE PROGRAMS

1. Write a MATLAB program to find L.T of the causal signal  $x(t)=t^2$
2. Write a MATLAB program to find L.T of the causal signal  $x(t)=t$
3. Write a MATLAB program to find L.T of the causal signal  $x(t)=e^{-at}$
4. Write a MATLAB program to find L.T of the causal signal  $x(t)=e^{at}$
5. Write a MATLAB program to find L.T of the causal signal  $x(t)=te^{at}$
6. Write a MATLAB program to find L.T of the causal signal  $x(t)=te^{-at}$
7. Write a MATLAB program to find L.T of the causal signal  $x(t)=\cos t$
8. Write a MATLAB program to find L.T of the causal signal  $x(t)=\sin t$
9. Write a MATLAB program to find L.T of the causal signal  $x(t)=e^{at}\cos t$
10. Write a MATLAB program to find L.T of the causal signal  $x(t)=e^{at}\sin t$
11. Write a MATLAB program to find the cross correlation using DFT.
12. Write a MATLAB program to find L.T of the causal signal  $x(t)=at$
13. Write a MATLAB program to find L.T of the causal signal  $x(t)=10e^{-at}$
14. Write a MATLAB program to find L.T of the signal  $x(t)=1$
15. Write a MATLAB program to find L.T of the causal signal  $x(t)=\text{impulse function}$
16. Write a MATLAB program to find L.T of the causal signal  $x(t)=\text{Delta function}$
17. Write a MATLAB program to find L.T of the causal signal  $x(t)=\cos(at)$
18. Write a MATLAB program to find L.T of the causal signal  $x(t)=\sin(at)$
19. Write a MATLAB program to find L.T of the causal signal  $x(t)=e^{at}\cos(at)$
20. Write a MATLAB program to find L.T of the causal signal  $x(t)=e^{at}\sin(at)$
21. Write a MATLAB program to find the auto correlation using L.T.
22. Write a MATLAB program to find L.T of the causal signal  $x(t)=5t$
23. Write a MATLAB program to find L.T of the causal signal  $x(t)=5e^{-at}$
24. Write a MATLAB program to find L.T of the causal signal  $x(t)=5e^{at}$
25. Write a MATLAB program to find L.T of the causal signal  $x(t)=5te^{at}$
26. Write a MATLAB program to find L.T of the causal signal  $x(t)=e^{4t}$
27. Write a MATLAB program to find L.T of the causal signal  $x(t)=te^{5t}$
28. Write a MATLAB program to find L.T of the causal signal  $x(t)=te^{-4t}$
29. Write a MATLAB program to find L.T of the causal signal  $x(t)=7\cos t$
30. Write a MATLAB program to find L.T of the causal signal  $x(t)=5\sin t$

### Real Time Applications:

Laplace transforms having following

- ☐ applications Analysis of differential equations
- ☐ Laplace transform
- ☐ spectroscopy Quantum mechanics
- ☐ Signal processing applications etc

**EXPERIMENT NO:12****GAUSSIAN NOISE****AIM: -**

To Generate Gaussian Noise and to Compute its Mean, M.S. Values, Skew, kurtosis, PS and PDF.

**SOFTWARE REQUIRED: -**

1. MATLAB R2010a.
2. Windows XP SP2.

**THEORY:-**

**Gaussian noise** is statistical noise that has a probability density function (abbreviated pdf) of the normal distribution (also known as Gaussian distribution). In other words, the values that the noise can take on are Gaussian-distributed. It is most commonly used as additive white noise to yield additive white Gaussian noise (AWGN). Gaussian noise is properly defined as the noise with a Gaussian amplitude distribution. It says nothing of the correlation of the noise in time or of the spectral density of the noise. Labeling Gaussian noise as 'white' describes the correlation of the noise. It is necessary to use the term "white Gaussian noise" to be correct. Gaussian noise is sometimes misunderstood to be white Gaussian noise, but this is not the case.

**PROCEDURE:-**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window \ Figure window

**PROGRAM:-**

%Gaussian noise%

```
clc; close all;
clear all;
N=input ('enter no of samples');
R1=rand(1,N);
M=mean(R1);
v=var(R1); x=psd(R1); subplot(2,2,1);plot(R1);
xlabel('sample numbers');ylabel('amplitude');
title('normal distributed random
signal');subplot(2,2,2);
hist(R1);
xlabel('sample numbers');ylabel('total');
title('histogram of a random signal');subplot(2,2,[3,4]);
plot(x);
xlabel('sample numbers');ylabel('amplitude');
title('psd of a normal random signal');
```

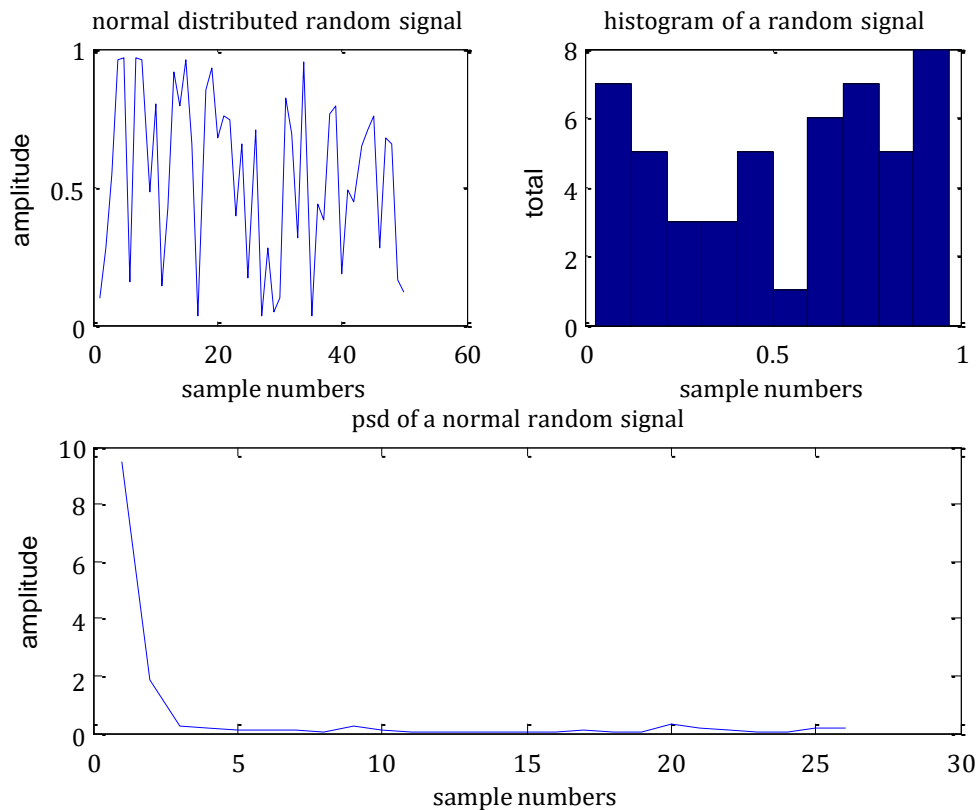
**OUTPUT:-**

Gaussian noise

enter no of samples50



## Basic Simulation Lab Manual

**RESULT: -**

Additive White Gaussian noise was generated and its PSD and PDF were plotted and its Mean, Standard Deviation, Kurtosis, Skew were Computed using MATLAB functions.

**VIVA QUESTIONS: -**

1. What is a noise and how many types of noises are there?
2. What is gaussian noise?
3. What is Auto-correlation ?
4. State Parseval's energy theorem for a periodic signal?
5. What is Signum function?
6. How many types of correlation are there?
7. State Parseval's Power theorem for a periodic signal?
8. What is Cross-correlation ?
9. Define ESD? Explain the relation between ESD and Auto-correlation ?
10. Define PSD? Explain the relation between PSD and Auto-correlation ?

**EXERCISE PROGRAMS**

1. Write a MATLAB program to plot the co-sinusoidal signal.
2. Write a MATLAB program to subtract two sinusoidal signals.
3. Write a MATLAB program to subtract and multiply two sinusoidal signals.
4. Write a MATLAB program to right shift the signal to 5 times of the original signal.
5. Write a MATLAB program to left shift the signal to 8 times of the original signal.
6. Write a MATLAB program to add two different signals with  $2 < t < 5$
7. Write a MATLAB program to shift a positive time line signal to negative timeline signal.
8. Write a MATLAB program to subtract co-sinusoidal signals.
9. Write a MATLAB program to subtract two sinusoidal signals
10. Write a MATLAB program to division and multiply two co-sinusoidal signals.
11. Write a MATLAB program to generate time scaling of a sequence.
12. Write a MATLAB program to generate time shifting of a sequence.
13. Write a MATLAB program to generate time folding of a sequence.
14. Write a MATLAB program to generate amplitude scaling of a sequence with amplitude 5.
15. Write a MATLAB program to generate time scaling of a sequence with time 2sec.
16. Write a MATLAB program to add two different signals with  $4 < t < 8$
17. Write a MATLAB program to shift a negative time line signal to positive timeline signal.
18. Write a MATLAB program to subtract sinusoidal signals.
19. Write a MATLAB program to subtract and divide two sinusoidal signals
20. Write a MATLAB program to add and multiply two co-sinusoidal signals.
21. Write a MATLAB program to generate time scaling of a signal.
22. Write a MATLAB program to generate time shifting of a signal.
23. Write a MATLAB program to generate time folding of a signal.
24. Write a MATLAB program to generate amplitude scaling of a sequence with amplitude 10.
25. Write a MATLAB program to generate time scaling of a sequence with time 5sec.
26. Write a MATLAB program to compute auto correlation between  

$$x = \sin(4\pi \cdot 2 \cdot t), y = \sin(4\pi \cdot 20 \cdot t).$$
and see how matlab reacts to it.
27. Write a MATLAB program to compute cross correlation between  $x = \sin(3\pi \cdot 2 \cdot t)$ ,  $y = \cos(5\pi \cdot 5 \cdot t)$ . and see how matlab reacts to it.
28. Write a MATLAB program to compute auto correlation between two signals  $x = 4 \cdot \cos(2\pi \cdot 10 \cdot t)$ ,  $y = 6 \cdot \cos(6\pi \cdot 10 \cdot t)$ .
29. Write a MATLAB program to compute cross correlation between two Sequences  
 $[2 \ 6 \ 4 \ 8 \ 5]$  &  $[8 \ 9 \ 6 \ 7 \ 5]$ .
30. Write a MATLAB program to compute auto correlation between two signals  
 $x = 5 \cdot \cos(8\pi \cdot 10 \cdot t)$ ,  $y = 6 \cdot \cos(7\pi \cdot 10 \cdot t)$ .

**Real Time Applications:**

- Stream processing
- Vector processing
- Digital processing applications

**EXPERIMENT NO:13****SAMPLING THEOREM****AIM: -**

To Demonstrate Sampling Theorem and aliasing effect using MATLAB.

**SOFTWARE REQUIRED: -**

1. MATLAB R2010a.
2. Windows XP SP2.

**THEORY: -****Sampling Theorem:**

The theorem shows that a band limited analog signal that has been sampled can be perfectly reconstructed from an infinite sequence of samples if the sampling rate exceeds  $2B$  samples per second, where  $B$  is the highest frequency in the original signal.

If a signal contains a component at exactly  $B$  hertz, then samples spaced at exactly  $1/(2B)$  seconds do not completely determine the signal, Shannon's statement notwithstanding.

**Proof:** Let  $g(t)$  be a bandlimited signal whose bandwidth is  $f_m$  ( $\omega_m = 2\pi f_m$ ).

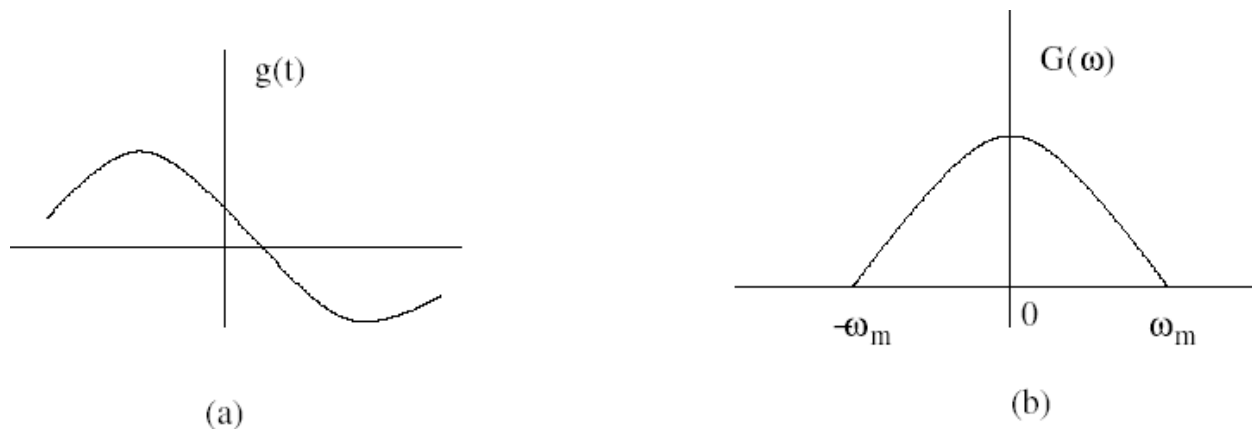


Figure 2: (a) Original signal  $g(t)$  (b) Spectrum  $G(\omega)$   
 $\delta(t)$  is the sampling signal with  $f_s = 1/T > 2f_m$ .

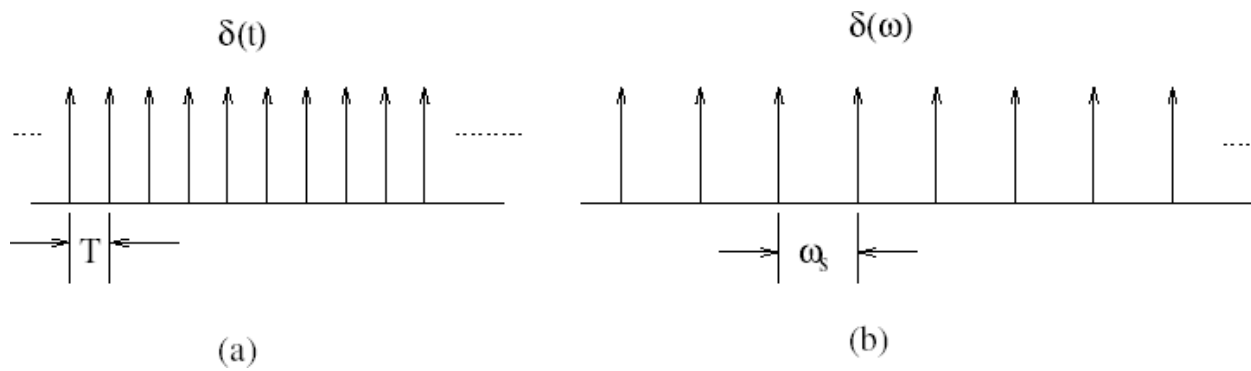


Figure 3: (a) sampling signal  $\delta(t)$  (b) Spectrum  $\delta(\omega)$

Let  $g_s(t)$  be the sampled signal. Its Fourier Transform  $G_s(\omega)$  is given by

$$\begin{aligned}
 \mathcal{F}(g_s(t)) &= \mathcal{F}[g(t)\delta_T(t)] \\
 &= \mathcal{F}\left[g(t) \sum_{n=-\infty}^{+\infty} \delta(t - nT)\right] \\
 &= \frac{1}{2\pi} \left[ G(\omega) * \omega_0 \sum_{n=-\infty}^{+\infty} \delta(\omega - n\omega_0) \right] \\
 G_s(\omega) &= \frac{1}{T} \sum_{n=-\infty}^{+\infty} G(\omega) * \delta(\omega - n\omega_0) \\
 G_s(\omega) &= \mathcal{F}[g(t) + 2g(t) \cos(\omega_0 t) + 2g(t) \cos(2\omega_0 t) + \dots] \\
 G_s(\omega) &= \frac{1}{T} \sum_{n=-\infty}^{+\infty} G(\omega - n\omega_0)
 \end{aligned}$$

## Basic Simulation Lab Manual

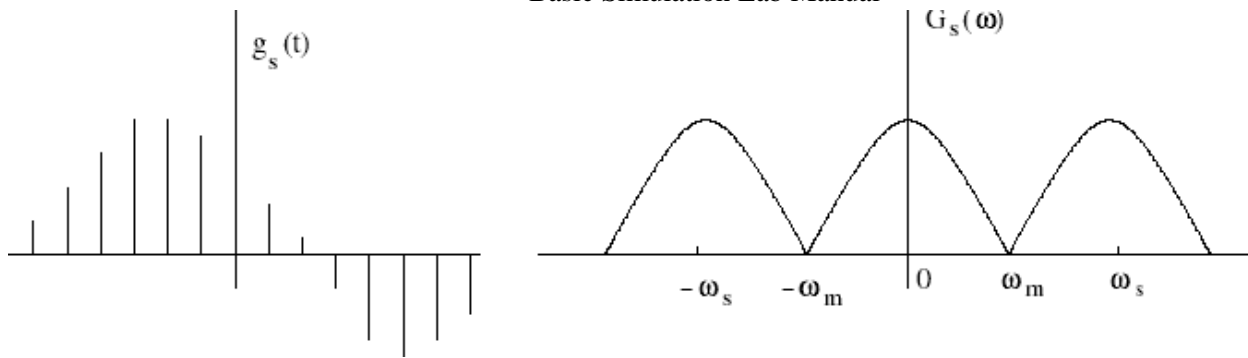


Figure 4: (a) sampled signal  $g_s(t)$  (b) Spectrum  $G_s(\omega)$

If  $\omega_s = 2\omega_m$ , i.e.,  $T = 1/2f_m$ . Therefore,  $G_s(\omega)$  is given by

$$G_s(\omega) = \frac{1}{T} \sum_{n=-\infty}^{+\infty} G(\omega - n\omega_m)$$

To recover the original signal  $G(\omega)$ :

1. Filter with a Gate function,  $H_{2\omega_m}(\omega)$  of width  $2\omega_m$
2. Scale it by  $T$ .

$$G(\omega) = T G_s(\omega) H_{2\omega_m}(\omega).$$

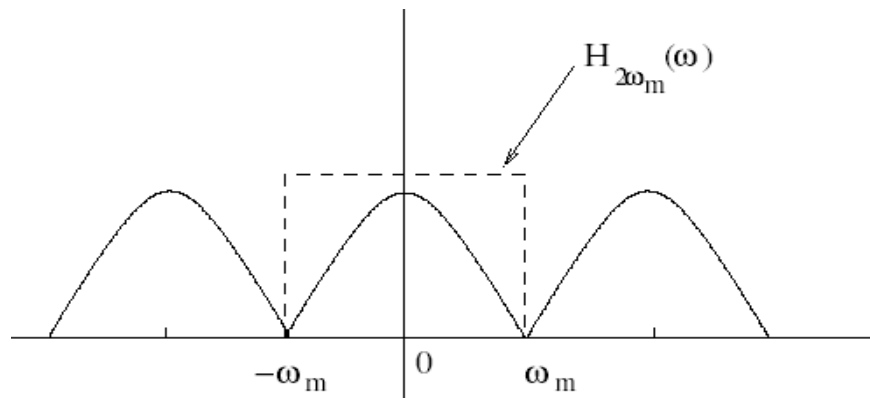


Figure 5: Recovery of signal by filtering with a filter of width  $2\omega_m$

## Aliasing

{ Aliasing is a phenomenon where the high frequency components of the sampled signal interfere with each other because of inadequate sampling  $\omega_s < 2\omega_m$ .

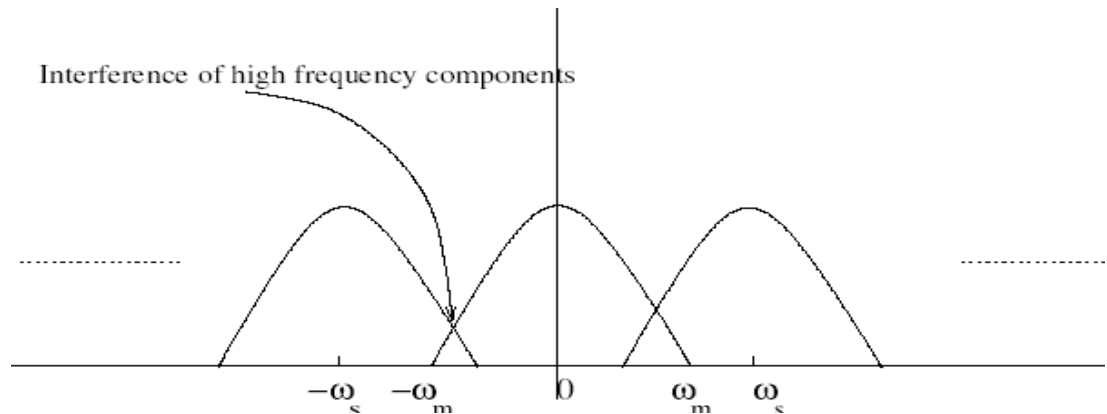


Figure 6: Aliasing due to inadequate sampling

Aliasing leads to distortion in recovered signal. This is the reason why sampling frequency should be at least twice the bandwidth of the signal.

### PROCEDURE:-

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM:-**

```
%sampling theorem%
clc;
clear all; close all;
t=0:0.001:1;f=5;
x=cos(2*pi*f*t);
plot(t,x);

%when fs>2fm%

fs1=3*f; ts1=1/fs1;
n1=0:ts1:1;
xs1=cos(2*pi*f*n1);
figure;
plot(n1,xs1,'r');
hold on;
plot(t,x);
hold off;

%when fs=2fm%

fs2=2*f;
ts2=1/fs2;
n2=0:ts2:1;
xs2=cos(2*pi*f*n2);
figure; plot(n2,xs2,'r');
hold on;
plot(t,x);
hold off;

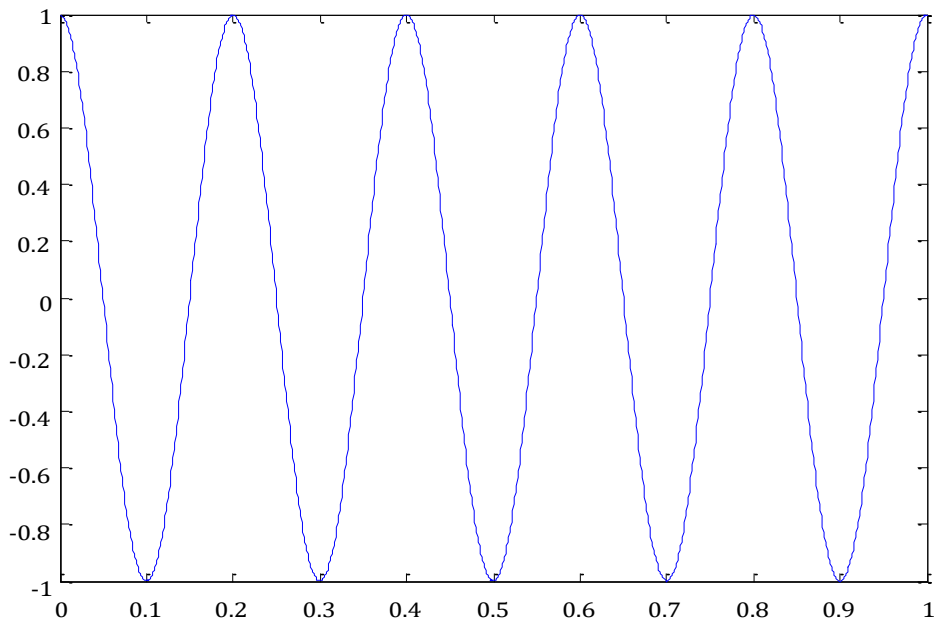
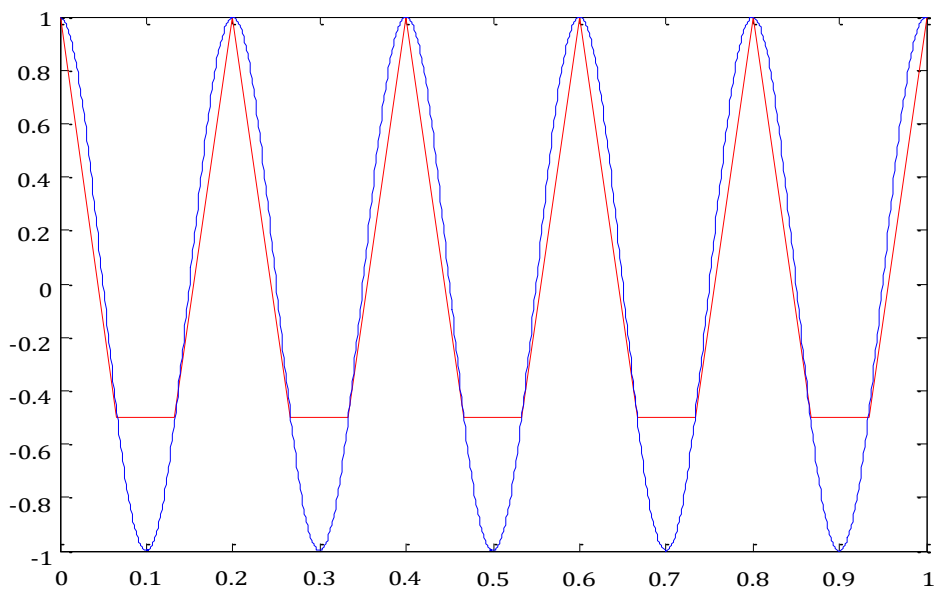
%when fs<2fm%

fs3=1.5*f;
ts3=1/fs3;
n3=0:ts3:1;
xs3=cos(2*pi*f*n3);
figure;
plot(n3,xs3,'r');
hold on;
plot(t,x);
hold off;
```



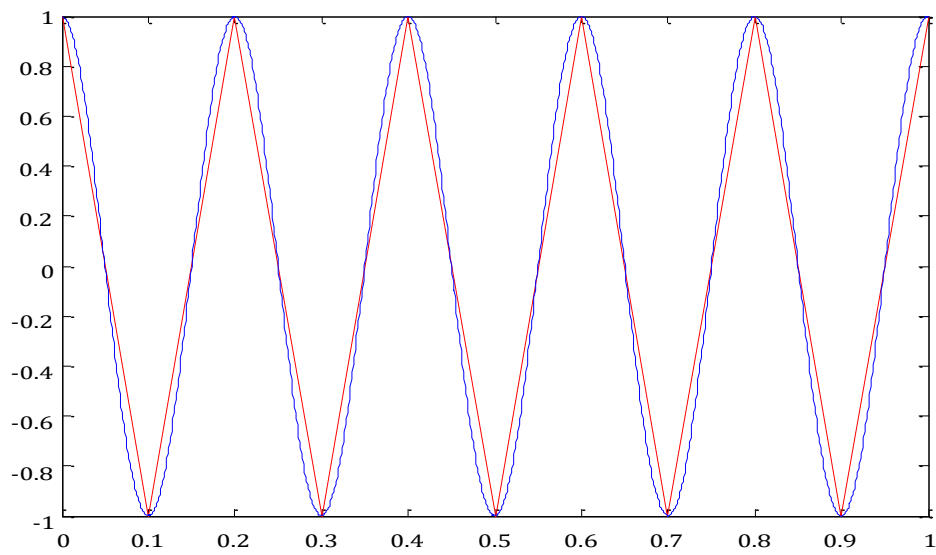
**OUTPUT:-**

sampling theorem

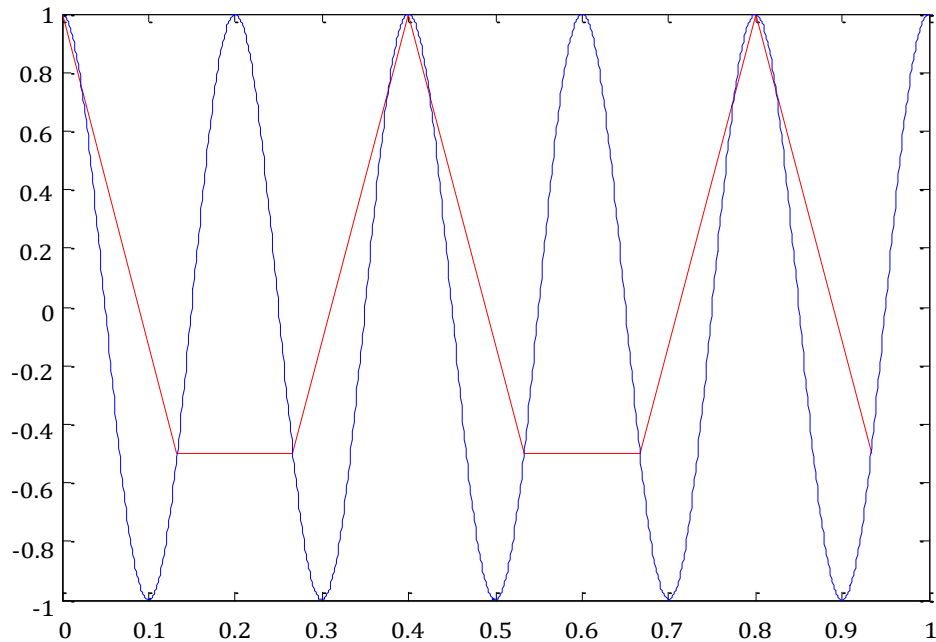
when  $f_s > 2f_m$ 

## Basic Simulation Lab Manual

when  $f_s = 2f_m$



when  $f_s < 2f_m$



**RESULT: -**

In this experiment the sampling theorem have been verified using MATLAB.

**VIVA QUESTIONS: -**

- 1.State Parseval's energy theorem for a periodic signal?
2. Define sampling Theorem?
3. What is Aliasing Effect?
4. what is Under sampling?
5. What is Over sampling?
- 6.Give the importance of Natural Sampling? 7.Give the importance of Flat-top Sampling? 8.Give the importance of ideal Sampling?
9. What is Anti-Aliasing Effect? 10.Define Stability of LTI system?

**EXERCISE PROGRAM: -**

1. Write a MATLAB program to find the effect of up sampling in frequency domain.
2. Write a matlab program to get the above output where  $t_0 = 2$
3. Write a MATLAB program to find the effect of up sampling in frequency domain for 20kHz.
4. Write a program to get the following output  $t = -$   
 $1: -5$  5. Write mat lab program to get the above output  
 $X(t) = 1; (0 < t < 2)$   
 $= 10; (2 < t < 15)$  Note: Add ramp and unit
6. Write a matlab program to generate a sine wave with amplitude = 3, frequency 20Hz. 7. Write a matlab program to generate a cos wave with amplitude = 3, frequency 20Hz. 8. Write a matlab program to generate a triangular wave with amplitude = 8, frequency 10Hz.
9. Write a matlab program to generate a square wave with amplitude = 2, frequency 10kHz.
10. Write a matlab program to generate the signum function.
11. Write a matlab program to generate exponential growing signal.
12. Write a matlab program to generate exponential decaying signal.
13. Write a matlab program to generate a triangular wave with amplitude = 6, frequency 1Hz.
14. Write a matlab program to generate a square wave with amplitude = 5, frequency 5kHz.
15. Write a matlab program to generate a sawtooth wave with amplitude = 8, frequency 5Khz.
16. Write a matlab program to generate a sine wave with amplitude = 5, frequency 5Hz.
17. Write a matlab program to generate a cos wave with amplitude = 4, frequency 10Hz.
18. Write a matlab program to generate a triangular wave with amplitude = 5, frequency 4Hz.

## Basic Simulation Lab Manual

19. Write a matlab program to generate a square wave with amplitude = 1, frequency 20kHz.
20. Write a matlab program to generate the signum function.
21. Write a matlab program to generate a square wave with amplitude = 4, frequency 5kHz.
22. Write a matlab program to generate a triangular wave with amplitude = 6, frequency 6Hz.
23. Write a matlab program to generate a triangular wave with amplitude = 8, frequency 2Hz.
24. Write a matlab program to generate a square wave with amplitude = 7, frequency 5kHz.
25. Write a matlab program to generate a sawtooth wave with amplitude = 10, frequency 10Khz.
26. Write a matlab program to generate the step function.
27. Write a matlab program to generate exponential growing signal of amplitude = 5.
28. Write a matlab program to generate exponential decaying signal of amplitude = 7..
29. Write a matlab program to generate a triangular wave with amplitude = 7, frequency 1Hz.
30. Write a matlab program to generate a square wave with amplitude = 7, frequency 10kHz.

**Real Time Applications:**

- Industrial control and automation (Control the velocity or position of an object)
- Examples: Controlling the position of a valve or shaft of a motor
- Examples: Digital processing applications
- TV reception
- RADAR
- SONAR

**EXPERIMENT NO:14****REMOVAL OF NOISE BY AUTO CORRELATION/CROSSCORRELATION****AIM: -**

removal of noise by auto correlation/cross correlation.

**SOFTWARE REQUIRED: -**

- 1.MATLAB R2010a.
- 2.Windows XP SP2.

**THEORY: -**

Detection of a periodic signal masked by random noise is of great importance. The noise signal encountered in practice is a signal with random amplitude variations. A signal is uncorrelated with any periodic signal. If  $s(t)$  is a periodic signal and  $n(t)$  is a noise signal then

$$\lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} S(t)n(t-T) dt = 0 \text{ for all } T$$

$Q_{sn}(T)$  = cross correlation function of  $s(t)$  and  $n(t)$  Then

$Q_{sn}(T) = 0$  Detection by Auto-Correlation:

$S(t)$  = Periodic Signal mixed with a noise signal  $n(t)$ . Then  $f(t)$  is  $[s(t) + n(t)]$  Let  $Q_{ff}(T)$  = Auto Correlation Function of  $f(t)$

$Q_{ss}(t)$  = Auto Correlation Function of

$S(t)$   $Q_{nn}(T)$  = Auto Correlation Function

of  $n(t)$

$$Q_{ff}(T) = \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} f(t)f(t-T) dt$$

$$= \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} [s(t)+n(t)][s(t-T)+n(t-T)] dt$$

$$= Q_{ss}(T) + Q_{nn}(T) + Q_{sn}(T) + Q_{ns}(T)$$

The periodic signal  $s(t)$  and noise signal  $n(t)$  are

uncorrelated  $Q_{sn}(t) = Q_{ns}(t) = 0$ ; Then

$$Q_{ff}(t) = Q_{ss}(t) + Q_{nn}(t)$$

The Auto correlation function of a periodic signal is periodic of the same frequency and the Auto correlation function of a non periodic signal is tends to zero for large value of  $T$  since  $s(t)$  is a periodic signal and  $n(t)$  is non periodic signal so  $Q_{ss}(T)$  is a periodic where

as  $Q_{nn}(T)$  becomes small for large values of  $T$  Therefore for sufficiently large values of  $T$   $Q_{ff}(T)$  is equal to  $Q_{ss}(T)$ .

### Detection by Cross Correlation:

$$f(t) = s(t) + n(t)$$

$c(t)$  = Locally generated signal with same frequency as that of

$$\begin{aligned} Q_{fc}(t) &= \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-T/2}^{T/2} [s(t) + n(t)] [c(t-T)] dt \\ &= Q_{sc}(T) + Q_{nc}(T) \end{aligned}$$

$C(t)$  is periodic function and uncorrelated with the random noise signal  $n(t)$ .  
Hence  $Q_{nc}(T) = 0$  Therefore  $Q_{fc}(T) = Q_{sc}(T)$

### PROCEDURE:-

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM:-**

```
%auto
correlation%clc;
clear all; close all; t=0:0.1:pi*4;
s=sin(t); k=2;
subplot(6,1,1) plot(s);
title('signal s');xlabel('t');
ylabel('amplitude');n = randn([1 126]);
f=s+n; subplot(6,1,2) plot(f);
title('signal f=s+n');
xlabel('t');
ylabel('amplitude');
as=xcorr(s,s);
subplot(6,1,3);
plot(as);
title('auto correlation of s');
xlabel('t');
ylabel('amplitude'); an=xcorr(n,n);
subplot(6,1,4)
plot(an);
title('auto correlation of n');xlabel('t');
ylabel('amplitude');
cff=xcorr(f,f);
subplot(6,1,5);
plot(cff);
title('auto correlation of f');
xlabel('t');
ylabel('amplitude');
hh=as+an;
subplot(6,1,6);
plot(hh);
title('addition of as+an');
xlabel('t');
ylabel('amplitude');
```

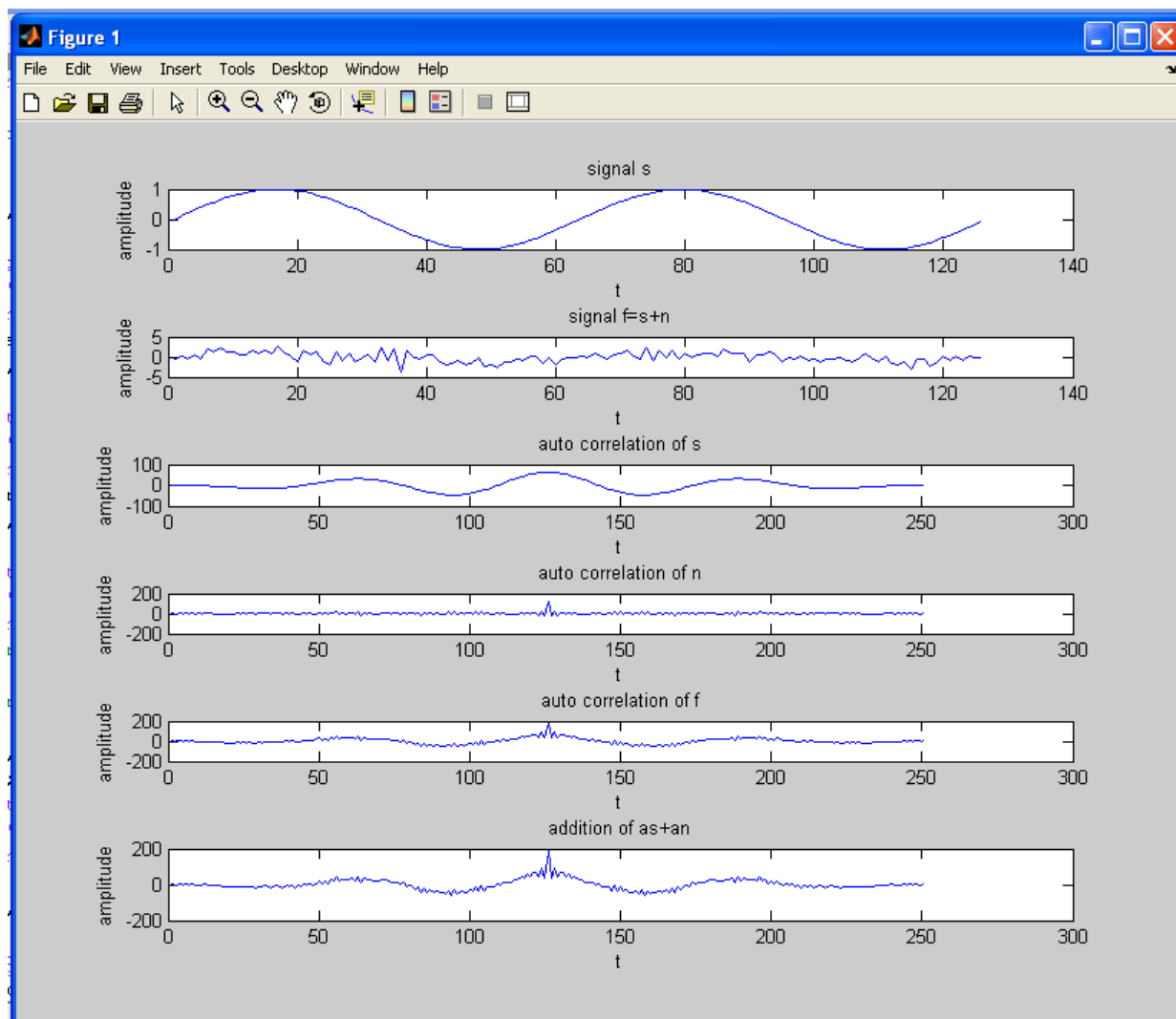
```
%CROSS CORRELATION %
```

```
clc; clear all; close all;
t=0:0.1:pi*4;
s=sin(t); k=2;
%sk=sin(t+k); subplot(7,1,1) ;
plot(s); title('signal s');
xlabel('t'); ylabel('amplitude'); c=cos(t);
subplot(7,1,2) plot(c); title('signal c'); xlabel('t');
ylabel('amplitude'); n = randn([1 126]);
f=s+n; subplot(7,1,3) plot(f);
title('signal f=s+n'); xlabel('t');
ylabel('amplitude');
asc=xcorr(s,c);
subplot(7,1,4);
plot(asc);
title('auto correlation of s and c');
xlabel('t'); ylabel('amplitude'); anc=xcorr(n,c);
subplot(7,1,5) plot(anc);
title('auto correlation of n and c'); xlabel('t');
ylabel('amplitude'); cfc=xcorr(f,c);
subplot(7,1,6);
plot(cfc);
title('auto correlation of f and c');
xlabel('t'); ylabel('amplitude');
hh=asc+anc;
subplot(7,1,7);
plot(hh);
title('addition of asc+anc'); xlabel('t');
ylabel('amplitude');
```

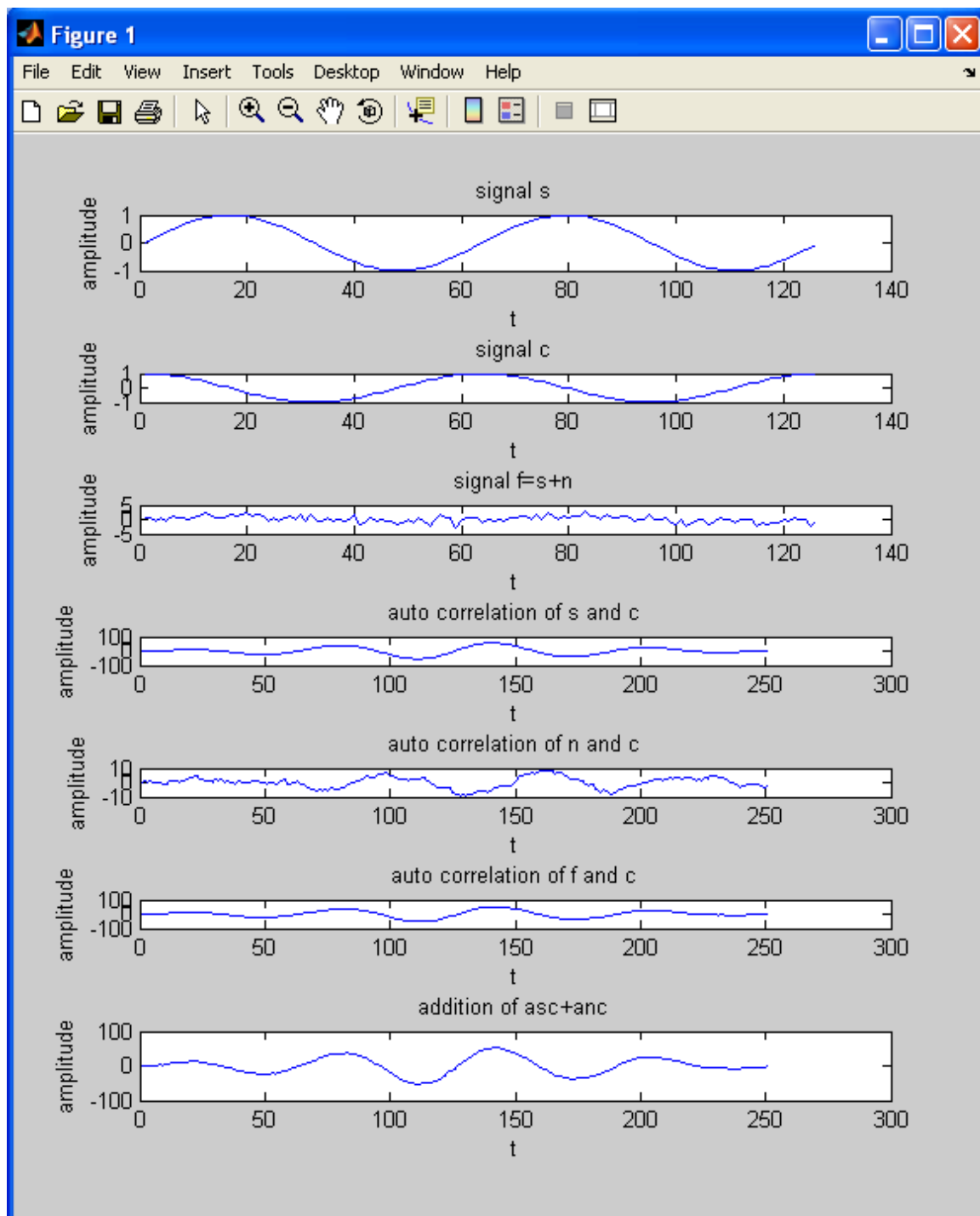


**OUTPUT: -**

auto correlation



CROSS CORRELATION



**RESULT:-**

In this experiment the removal of noise by autocorrelation/cross correlation have been verified using MATLAB.

**VIVA QUESTIONS:-**

1. What is Causal Signal?
2. What are the Different types of Systems?
3. What is Linear System?
4. What is Signum function?
5. What is Static and Dynamic System?
6. Define Linear Convolution?
7. Define Properties of Convolution in time domain?
8. What is the Difference Between Linear Convolution & Circular Correlation?
9. What are Dirichlet Conditions for Fourier Transform?
10. What is Full Wave Symmetry?

**EXERCISE PROGRAMS**

1. Write a MATLAB program to find the cross correlation using FFT.
2. Write a mat lab program to perform the cross correlation between sinusoidal and ramp function and see how mat lab reacts to it.
3. Write a MATLAB program to perform cross correlation between square and step signal and see how mat lab reacts to it.
4. Write a MATLAB program to perform cross correlation between sinusoidal and ramp signal and see how mat lab reacts to it.
5. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 2 \ 3 \ 5]$  and  $y(n) = [-1 \ -2]$  and see how matlab reacts to it.
6. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ -3 \ 5]$  and  $y(n) = [1 \ 2 \ 3 \ 4]$  and see how matlab reacts to it.
7. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 0 \ 1 \ 1]$  and  $y(n) = [1 \ 0 \ 0 \ 0 \ 0]$  and see how matlab reacts to it.
8. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0]$  and  $y(n) = [1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
9. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 1 \ 0 \ 0]$  and  $y(n) = [1 \ 1 \ 1 \ 1]$  and see how matlab reacts to it.
10. Write a MATLAB program to perform the cross correlation between  $X(n) = [6 \ 7 \ 8 \ 9 \ 10]$  and  $y(n) = [5 \ 4 \ 3 \ 2 \ 1]$  and see how matlab reacts to it.
11. Write the MATLAB program to perform cross correlation between the following sequences  $X(n) = [2 \ -2 \ 3 \ 2]$ ,  $h(n) = [-2 \ 4 \ -5 \ 2]$ .

12. Write a mat lab program to perform the convolution between step and ramp function and see how mat lab reacts to it.
13. Write a MATLAB program to perform convolution between square and step signal and see how mat lab reacts to it.
14. Write a MATLAB program to perform convolution between sinusoidal and square signal and see how mat lab reacts to it.
15. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 3 \ 4 \ 5]$  and  $y(n) = [-2 \ -4]$  and see how matlab reacts to it.
16. Write a MATLAB program to perform the convolution between  $X(n) = [3 \ -4 \ 6]$  and  $y(n) = [2 \ 6 \ 8 \ 6]$  and see how matlab reacts to it.
17. Write a MATLAB program to perform the convolution between  $X(n) = [3 \ 1 \ 2 \ 0]$  and  $y(n) = [2 \ 4 \ 3 \ 4 \ 5]$  and see how matlab reacts to it.
18. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 2 \ 1 \ 0 \ 2 \ 1 \ 1 \ 0]$  and  $y(n) = [1 \ 1 \ 1 \ 2 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
19. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 1 \ 2 \ 1]$  and  $y(n) = [1 \ 2 \ 1 \ 2]$  and see how matlab reacts to it.
20. Write a MATLAB program to perform the convolution between  $X(n) = [5 \ 6 \ 9 \ 8 \ 7]$  and  $y(n) = [1 \ 2 \ 3 \ 2 \ 1]$  and see how matlab reacts to it.
21. Write the MATLAB program to perform cross correlation between the following sequences  $X(n) = [4 \ -6 \ 5 \ 1]$ ,  $h(n) = [-1 \ 3 \ -4 \ 3]$ .
22. Write a mat lab program to perform the cross correlation between ramp and step function and see how mat lab reacts to it.
23. Write a MATLAB program to perform cross correlation between square and step signal and see how mat lab reacts to it.
24. Write a MATLAB program to perform cross correlation between sinusoidal and step signal and see how mat lab reacts to it.
25. Write a MATLAB program to perform the convolution between  $X(n) = [1 \ 5 \ 6 \ 5]$  and  $y(n) = [-3 \ -6]$  and see how matlab reacts to it.
26. Write a MATLAB program to plot the co-sinusoidal signal.
27. Write a MATLAB program to subtract two sinusoidal signals.
28. Write a MATLAB program to subtract and multiply two sinusoidal signals.
29. Write a MATLAB program to right shift the signal to 5 times of the original signal.
30. Write a MATLAB program to left shift the signal to 8 times of the original signal.

### **Real Time Applications:**

- The cross correlation is to determine the response  $y[n]$  of a system of a known impulse response  $h[n]$  for a given input signal  $x[n]$  to obtain  $y[n]$ . Digital signal processing applications etc...

**EXPERIMENT NO:15****EXTRACTION OF PERIODIC SIGNAL MASKED BY NOISE USING CORRELATION****AIM: -**

To generate a periodic sequence, corrupt it with zero mean White noise and extract the sequence using periodic circular cross correlation.

**SOFTWARE REQUIRED:-**

- 1.MATLAB R2010a.
- 2.Windows XP SP2.

**THEORY: -**

Removal of noise by Filtering is not the solution because noise contains power at all frequencies. Hence we use correlation techniques.

The theorem is useful for analyzing linear time-invariant systems, LTI systems, when the inputs and outputs are not square integrable, so their Fourier transforms do not exist. A corollary is that the Fourier transform of the autocorrelation function of the output of an LTI system is equal to the product of the Fourier transform of the autocorrelation function of the input of the system times the squared magnitude of the Fourier transform of the system impulse response. This works even when the Fourier transforms of the input and output signals do not exist because these signals are not square integrable, so the system inputs and outputs cannot be directly related by the Fourier transform of the impulse response. Since the Fourier transform of the autocorrelation function of a signal is the power spectrum of the signal, this corollary is equivalent to saying that the power spectrum of the output is equal to the power spectrum of the input times the power transfer function. This corollary is used in the parametric method for power spectrum estimation.

**PROCEDURE:-**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

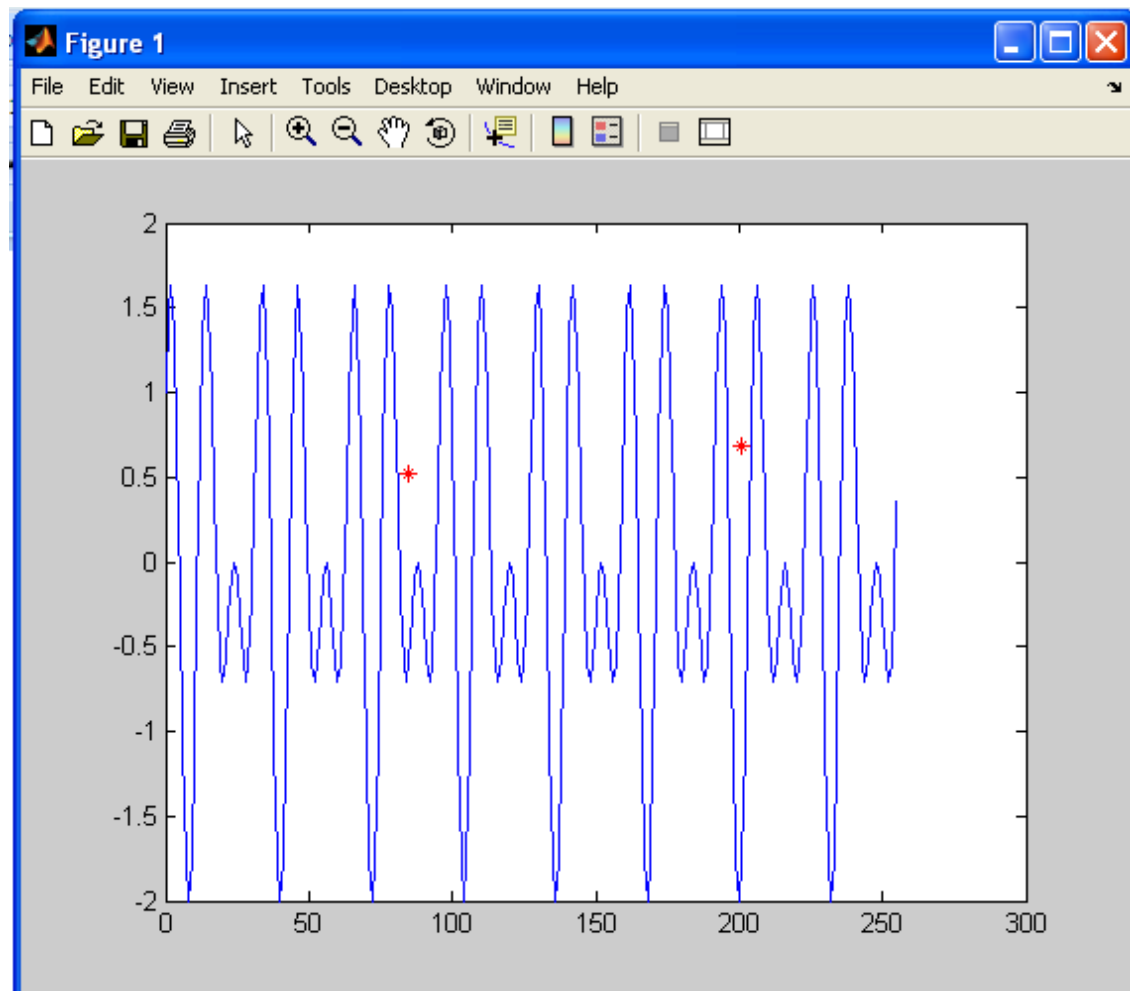
**PROGRAM:-**

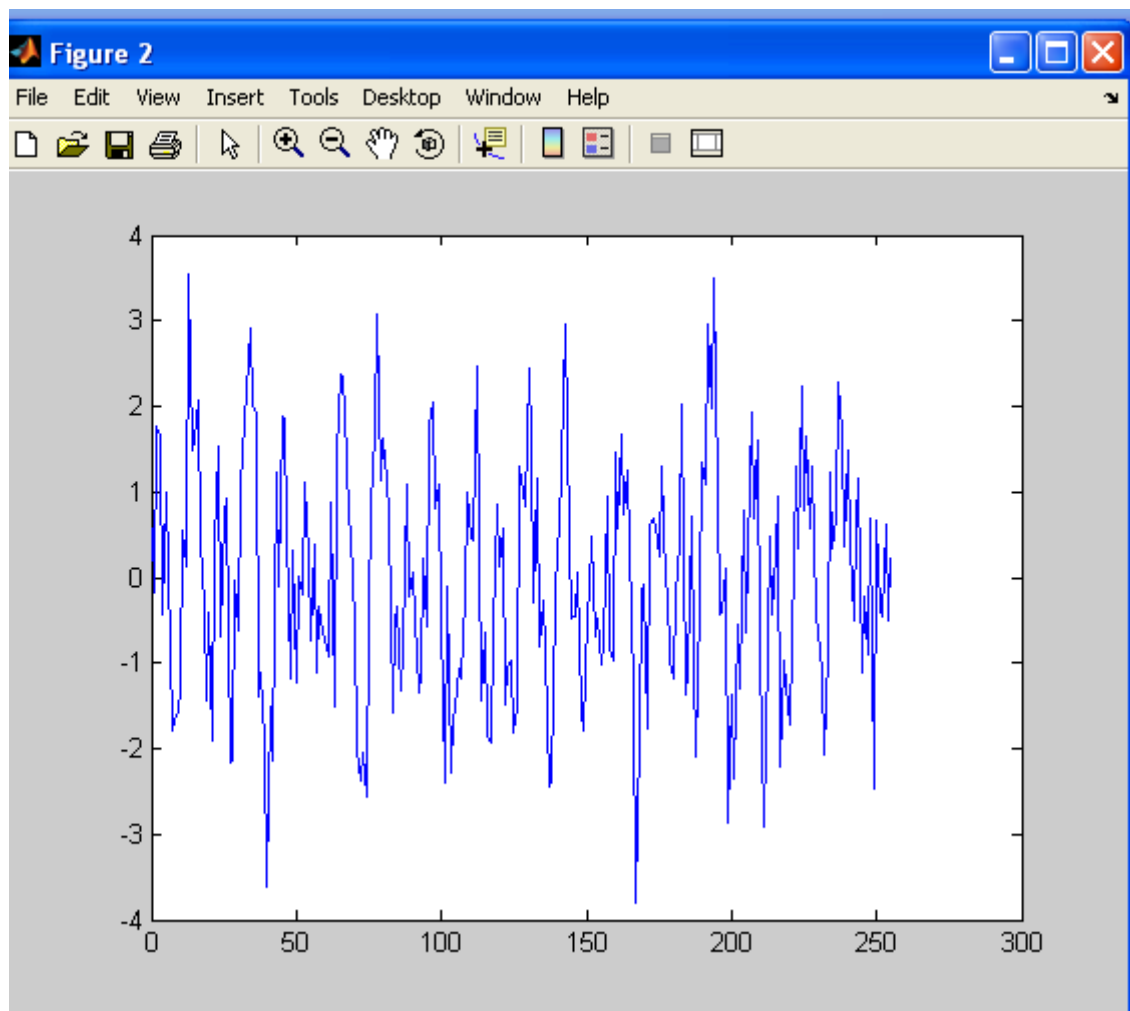
```

clc;
clear
all;close
all;
n=256;
k1=0:n-1;
x=cos(32*pi*k1/n)+sin(48*pi*k1/n);
plot(k1,x);
%Module to find period of input
signalk=2;
xm=zeros(k,1);ym=zeros(k,1);hold on;
for i=1:k
[xm(i) ym(i)]=ginput(1);
plot(xm(i),
ym(i),'r*');end;
period=abs(xm(2)-xm(1));
rounded_p=round(period); m=rounded p;
% Adding noise and plotting noisy
signaly=x+randn(1,n);
figure; plot(k1,y);
% To generate impulse train with the period as that of input
signal%d=zeros(1,n);
for i=1:n
if (rem(i-1,m)==0)d(i)=1;
end; end;
% correlating noisy signal and impulse
traincir=cxcorr1(y,d);
%plotting the original and reconstructed
signalm1=0:n/4;
figure
plot(m1,x(m1+1),'r',m1,m*cir(m1+1));

```

**OUTPUT:-**



**RESULT:-**

Using Cross- correlation the periodic signal from noise was estimated using MATLAB.



**VIVA QUESTIONS: -**

1. State the relationship between PSD and ACF?
2. What is the integration of ramp signal?
3. Difference between vectors and signals?
4. What is the important of dot product over cross product in signals?
5. Define Hilbert transforms?
6. What is Hilbert transform of  $\sin(t)$ ?
7. What is Hilbert transform of  $\cos(t)$ ?
8. What is difference between Hilbert transforms and Fourier Transforms?
9. What is difference between Hilbert transforms and Laplace Transforms?
10. Explain LTI and LTV systems?

**EXERCISE PROGRAM:-**

1. Simulate a matlab program on autocorrelation and PSD if  $x = [1 \ 2 \ 3 \ 4 \ 5]$ .
2. Write a mat lab program to perform the cross correlation between sinusoidal and rampfunction and see how mat lab reacts to it.
3. Write a MATLAB program to perform cross correlation between square and step signal andsee how mat lab reacts to it.
4. Write a MATLAB program to perform cross correlation between sinusoidal and ramp signaland see how mat lab reacts to it.
5. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 2 \ 3 \ 5]$  and  $y(n) = [-1 \ -2]$  and see how matlab reacts to it.
6. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ -3 \ 5]$  and  $y(n) = [1 \ 2 \ 3 \ 4]$  and see how matlab reacts to it.
7. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 0 \ 1 \ 1]$  and  $y(n) = [1 \ 0 \ 0 \ 0 \ 0]$  and see how matlab reacts to it.
8. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0]$  and  $y(n) = [1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
9. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 1 \ 0 \ 0]$  and  $y(n) = [1 \ 1 \ 1 \ 1]$  and see how matlab reacts to it.
10. Write a MATLAB program to perform the cross correlation between  $X(n) = [6 \ 7 \ 8 \ 9 \ 10]$  and  $y(n) = [5 \ 4 \ 3 \ 2 \ 1]$  and see how matlab reacts to it.
11. Write the MATLAB program to perform cross correlation between the following sequences  $X(n)=[2 \ -2 \ 3 \ 2]$ ,  $h(n) = [-2 \ 4 \ -5 \ 2]$ .
12. Write a mat lab program to perform the convolution between step and ramp function and seehow mat lab reacts to it.
13. Write a MATLAB program to perform convolution between square and step signal and seehow mat lab reacts to it.
14. Write a MATLAB program to perform convolution between sinusoidal and square signal andsee how mat lab reacts to it.
15. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 3 \ 4 \ 5]$  and  $y(n) = [-2 \ -4]$  and see how matlab reacts to it.
16. Write a MATLAB program to perform the convolution between  $X(n) = [3 \ -4 \ 6]$  and  $y(n) = [2 \ 6 \ 8 \ 6]$  and see how matlab reacts to it.

## Basic Simulation Lab Manual

17. Write a MATLAB program to perform the convolution between  $X(n) = [3 \ 1 \ 2 \ 0]$  and  $y(n) = [2 \ 4 \ 3 \ 4 \ 5]$  and see how matlab reacts to it.
18. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 2 \ 1 \ 0 \ 2 \ 1 \ 1 \ 0]$  and  $y(n) = [1 \ 1 \ 1 \ 2 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
19. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 1 \ 2 \ 1]$  and  $y(n) = [1 \ 2 \ 1 \ 2]$  and see how matlab reacts to it.
20. Write a MATLAB program to perform the convolution between  $X(n) = [5 \ 6 \ 9 \ 8 \ 7]$  and  $y(n) = [1 \ 2 \ 3 \ 2 \ 1]$  and see how matlab reacts to it.
21. Write the MATLAB program to perform cross correlation between the following sequences  $X(n) = [4 \ -6 \ 5 \ 1]$ ,  $h(n) = [-1 \ 3 \ -4 \ 3]$ .
22. Write a matlab program to perform the cross correlation between ramp and step function and see how matlab reacts to it.
23. Write a MATLAB program to perform cross correlation between square and step signal and see how matlab reacts to it.
24. Write a MATLAB program to perform cross correlation between sinusoidal and step signal and see how matlab reacts to it.
25. Write a MATLAB program to perform the convolution between  $X(n) = [1 \ 5 \ 6 \ 5]$  and  $y(n) = [-3 \ -6]$  and see how matlab reacts to it.
26. Write a MATLAB program to find Hilbert transforms of the causal signal  $x(t) = t^2$
27. Write a MATLAB program to find Hilbert transforms of the causal signal  $x(t) = t$
28. Write a MATLAB program to find Hilbert transforms of the causal signal  $x(t) = e^{-at}$
29. Write a MATLAB program to find Hilbert transforms of the causal signal  $x(t) = e^{at}$
30. Write a MATLAB program to find Hilbert transforms of the causal signal  $x(t) = te^{at}$

**Real Time Applications:**

- The cross correlation is to determine the response  $y[n]$  of a system of a known impulse response  $h[n]$  for a given input signal  $x[n]$  to obtain  $y[n]$ .
- Digital signal processing applications etc...
- TV reception.

**EXPERIMENT NO:16****VERIFICATION OF WIENER-KHINCHIN RELATION****AIM: -**

Verification of wiener-khinchine relation.

**SOFTWARE REQUIRED: -**

- 1.MATLAB R2010a.
- 2.Windows XP SP2.

**THEORY:-**

The Wiener-Khinchin theorem (also known as the Wiener-Khintchine theorem and sometimes as the Wiener-Khinchin-Einstein theorem or the Khinchin-Kolmogorov theorem) states that the power spectral density of a wide-sense-stationary random process is the Fourier transform of the corresponding autocorrelation function.

Continuous case:

$$S_{xx}(f) = \int_{-\infty}^{\infty} r_{xx}(\tau) e^{-j2\pi f\tau} d\tau$$

**Where**

$$r_{xx}(\tau) = E[x(t)x^*(t - \tau)]$$

is the autocorrelation function defined in terms of statistical [expectation](#), and where is the power spectral density of the function. Note that the autocorrelation function is defined in terms of the expected value of a product, and that the Fourier transform of does not exist in general, because stationary random functions are not square integrable.

The asterisk denotes complex conjugate, and can be omitted if the random process is real valued.

**Discrete case:**

$$S_{xx}(f) = \sum_{k=-\infty}^{\infty} r_{xx}[k] e^{-j2\pi kf}$$

where

$$r_{xx}[k] = E[x[n]x^*[n-k]]$$

and where is the power spectral density of the function with discrete values. Being asampled and discrete-time sequence, the spectral density is periodic in the frequencydomain.

#### PROCEDURE:-

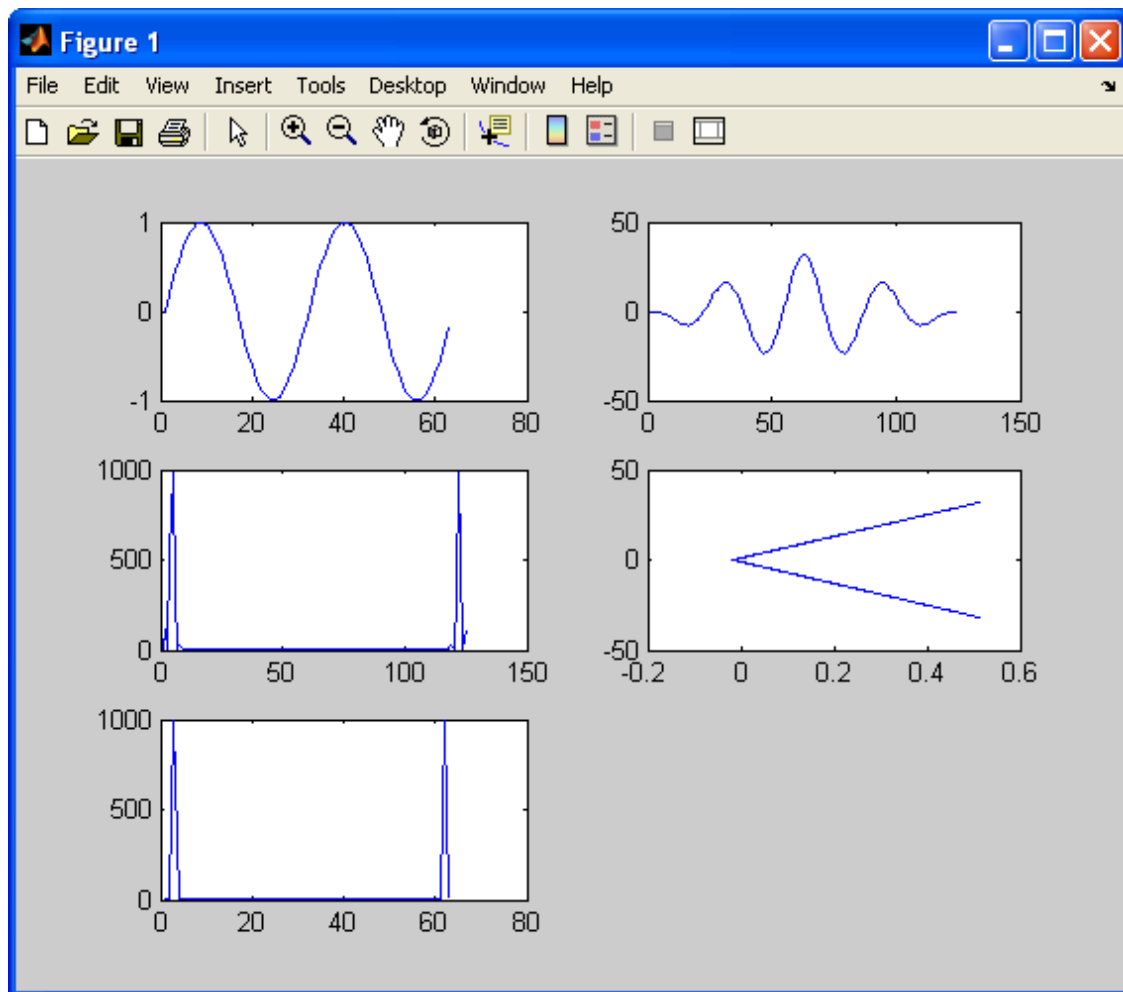
- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

#### PROGRAM:-

```
% wiener-khinchine relation%
clc;
clear all; t=0:0.1:2*pi; x=sin(2*t); subplot(3,2,1);
plot(x); au=xcorr(x,x);
subplot(3,2,2);
plot(au);
v=fft(au); subplot(3,2,3);
plot(abs(v)); fw=fft(x);
subplot(3,2,4); plot(fw);
fw2=(abs(fw)).^2;
subplot(3,2,5);
plot(fw2);
```

**OUTPUT:-**

wiener-khinchine relation



**RESULT:-**

Calculation of Auto-correlation function using Weiner-Khinchin theorem was verified using MATLAB.

**VIVA QUESTIONS: -**

1. What is mean wiener–khinchine relation?
2. Define fourier transform and its inverse?
3. What is the difference b/w convolution and correlation?
4. What is the importance of power spectrum?
5. What is the importance of correlation?
6. Write the relation between Step and Impulse signals?
7. Write the relation between Ramp and impulse signals?
8. Write the relation between Ramp and Step signals?
9. Define Standerd signals?
10. Give examples of Standerd signals?

**EXERCISE PROGRAMS**

1. Write a MATLAB program to illustrate the effect of anti-aliasing filter.
2. Write a MATLAB program to subtract two sinusoidal signals.
3. Write a MATLAB program to subtract and multiply two sinusoidal signals.
4. Write a MATLAB program to right shift the signal to 5 times of the original signal.
5. Write a MATLAB program to left shift the signal to 8 times of the original signal.
6. Write a MATLAB program to add two different signals with  $2 < t < 5$
7. Write a MATLAB program to shift a positive time line signal to negative timeline signal.
8. Write a MATLAB program to subtract co-sinusoidal signals.
9. Write a MATLAB program to subtract two sinusoidal signals
10. Write a MATLAB program to division and multiply two co-sinusoidal signals.
11. Write a MATLAB program to generate time scaling of a sequence.
12. Write a MATLAB program to generate time shifting of a sequence.
13. Write a MATLAB program to generate time folding of a sequence.
14. Write a MATLAB program to generate amplitude scaling of a sequence with amplitude 5.
15. Write a MATLAB program to generate time scaling of a sequence with time 2sec.
16. Write a MATLAB program to add two different signals with  $4 < t < 8$
17. Write a MATLAB program to shift a negative time line signal to positive timeline signal.
18. Write a MATLAB program to subtract sinusoidal signals.

## Basic Simulation Lab Manual

19. Write a MATLAB program to subtract and divide two sinusoidal signals
20. Write a MATLAB program to add and multiply two co-sinusoidal signals.
21. Write a MATLAB program to generate time scaling of a signal.
22. Write a MATLAB program to generate time shifting of a signal.
23. Write a MATLAB program to generate time folding of a signal.
24. Write a MATLAB program to generate amplitude scaling of a sequence with amplitude 10.
25. Write a MATLAB program to generate time scaling of a sequence with time 5sec.
26. Find the addition of null matrix and unity matrix of order 4x4.
27. Write a MATLAB program to find rank of the  
matrixA= [6 4 9 3 5; 6 2 4 8 5; 6 3 1 7 9].
28. Write a MATLAB program to find Eigen of the  
matrixA= [2 5 0 3 4; 5 4 3 7 8; 9 1 6 5 4].
29. Write a MATLAB program to find inverse of the  
matrixA= [1 5 9 8 5; 4 3 5 8 4; 5 6 3 5 0]
30. Write a MATLAB program to find determinant of the  
matrixA= [1 6 9 8 5; 9 3 5 6 4; 1 6 3 5 6].

**Real Time Applications:**

- Stream processing applications
- Block processing applications
- Vector processing applications
- Signal processing applications

**EXPERIMENT NO:17****CHECKING A RANDOM PROCESS FOR STATIONARITY IN WIDE SENSE.**

**AIM:** - Checking a random process for stationarity in wide sense.

**SOFTWARE REQUIRED:-**

- 1.MATLAB R2010a.
- 2.Windows XP SP2.

**THEORY:-**

A stationary process (or strict(ly) stationary process or strong(ly) stationary process) is a stochastic process whose joint probability distribution does not change when shifted in time or space. As a result, parameters such as the mean and variance, if they exist, also do not change over time or position. A weaker form of stationary commonly employed in signal processing is known as weak-sense stationary, wide-sense stationarity (WSS) or covariance stationarity. WSS random processes only require that 1st and 2nd moments do not vary with respect to time.

$$\mathbb{E}\{x(t)\} = m_x(t) = m_x(t + \tau) \quad \forall \tau \in \mathbb{R}$$

and autocorrelation function

$$\mathbb{E}\{x(t_1)x(t_2)\} = R_x(t_1, t_2) = R_x(t_1 + \tau, t_2 + \tau) = R_x(t_1 - t_2, 0) \quad \forall \tau \in \mathbb{R}.$$

The first property implies that the mean function  $m_x(t)$  must be constant. The second property implies that the correlation function depends only on the difference between  $t_1$  and  $t_2$  and only needs to be indexed by one variable rather than two variables. Thus, instead of writing,

$R_x(t_1 - t_2, 0)$  we usually abbreviate the notation and write

$$R_x(\tau) \text{ where } \tau = t_1 - t_2.$$

This also implies that the auto covariance depends only on  $\tau = t_1 - t_2$ , since

$$C_x(t_1, t_2) = C_x(t_1 - t_2, 0) = C_x(\tau).$$

**Stationary and Non Stationary Random Process:**

A random  $X(t)$  is stationary if its statistical properties are unchanged by a time shift in the time



## Basic Simulation Lab Manual

origin. When the auto-Correlation function  $R_x(t, t+T)$  of the random  $X(t)$  varies with

time difference  $T$  and the mean value of the random variable  $X(t)$  is independent of the choice of  $t$ , then  $X(t)$  is said to be stationary in the wide sense or wide-sense stationary. So a continuous-time random process  $X(t)$  which is WSS has the following properties

$$1) E[X(t)] = \mu_X(t) = \mu_X(t+T)$$

2) The Autocorrelation function is written as a function of  $T$   
that is  $R_X(t, t+T) = R_X(T)$

If the statistical properties like mean value or moments depend on time then the random process is said to be non-stationary.

When dealing with two random processes  $X(t)$  and  $Y(t)$ , we say that they are jointly wide-sense stationary if each process is stationary in the wide-sense.

$$R_{xy}(t, t+T) = E[X(t)Y(t+T)] = R_{xy}(T).$$

**PROCEDURE:-**

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window \ Figure window

**PROGRAM:-**

```

Clc; Close all;
clear all
y = randn([1 40]) my=round(mean(y));
z=randn([1 40]) mz=round(mean(z));
vy=round(var(y));
vz=round(var(z));
t = sym('t','real');h0=3;
x=y.*sin(h0*t)+z.*cos(h0*t);
mx=round(mean(x));
k=2;
xk=y.*sin(h0*(t+k))+z.*cos(h0*(t+k));x1=sin(h0*t)*sin(h0*(t+k)); x2=cos(h0*t)*cos(h0*(t+k));
c=vy*x1+vz*x2;

```

**OUTPUT:**

```
%if we solve "c=2*sin(3*t)*sin(3*t+6)" we get c=2*cos(6)
%which is a constant does not depend on variable 't'
% so it is wide sense stationary.
```

**RESULT:-**

Checking a random process for stationarity in wide sense by using MATLAB .

**VIVA QUESTIONS:-**

1. what is the condition for WSS random process?
2. Define random variable with examples?
3. Define random process with examples?
4. Difference between ACF and CCF?
5. what are the different noises?
6. Explain two Properties of Auto-Correlation?
7. Explain two Properties of Cross-Correlation?
8. What is the difference b/w Auto-correlation and Cross-Correlation?
9. Define ESD?
10. Define PSD?

**EXERCISE PROGRAMS**

1. Write a program to simulate parseval's relation
2. Write a mat lab program to perform the cross correlation between sinusoidal and ramp function and see how mat lab reacts to it.
3. Write a MATLAB program to perform cross correlation between square and step signal and see how mat lab reacts to it.
4. Write a MATLAB program to perform cross correlation between sinusoidal and ramp signal and see how mat lab reacts to it.
5. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 2 \ 3 \ 5]$  and  $y(n) = [-1 \ -2]$  and see how matlab reacts to it.
6. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ -3 \ 5]$  and  $y(n) = [1 \ 2 \ 3 \ 4]$  and see how matlab reacts to it.
7. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 0 \ 1 \ 1]$  and  $y(n) = [1 \ 0 \ 0 \ 0 \ 0]$  and see how matlab reacts to it.
8. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0]$  and  $y(n) = [1 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
9. Write a MATLAB program to perform the cross correlation between  $X(n) = [1 \ 1 \ 0 \ 0]$  and  $y(n) = [1 \ 1 \ 1 \ 1]$  and see how matlab reacts to it.
10. Write a MATLAB program to perform the cross correlation between  $X(n) = [6 \ 7 \ 8 \ 9 \ 10]$

and  $y(n) = [5 \ 4 \ 3 \ 2 \ 1]$  and see how matlab reacts to it.

11. Write the MATLAB program to perform cross correlation between the following sequences  $X(n) = [2 \ -2 \ 3 \ 2]$ ,  $h(n) = [-2 \ 4 \ -5 \ 2]$ .
12. Write a mat lab program to perform the convolution between step and ramp function and see how mat lab reacts to it.
13. Write a MATLAB program to perform convolution between square and step signal and see how mat lab reacts to it.
14. Write a MATLAB program to perform convolution between sinusoidal and square signal and see how mat lab reacts to it.
15. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 3 \ 4 \ 5]$  and  $y(n) = [-2 \ -4]$  and see how matlab reacts to it.
16. Write a MATLAB program to perform the convolution between  $X(n) = [3 \ -4 \ 6]$  and  $y(n) = [2 \ 6 \ 8 \ 6]$  and see how matlab reacts to it.
17. Write a MATLAB program to perform the convolution between  $X(n) = [3 \ 1 \ 2 \ 0]$  and  $y(n) = [2 \ 4 \ 3 \ 4 \ 5]$  and see how matlab reacts to it.
18. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 2 \ 1 \ 0 \ 2 \ 1 \ 1 \ 0]$  and  $y(n) = [1 \ 1 \ 1 \ 2 \ 1 \ 0 \ 1 \ 0]$  and see how matlab reacts to it.
19. Write a MATLAB program to perform the convolution between  $X(n) = [2 \ 1 \ 2 \ 1]$  and  $y(n) = [1 \ 2 \ 1 \ 2]$  and see how matlab reacts to it.
20. Write a MATLAB program to perform the convolution between  $X(n) = [5 \ 6 \ 9 \ 8 \ 7]$  and  $y(n) = [1 \ 2 \ 3 \ 2 \ 1]$  and see how matlab reacts to it.
21. Write the MATLAB program to perform cross correlation between the following sequences  $X(n) = [4 \ -6 \ 5 \ 1]$ ,  $h(n) = [-1 \ 3 \ -4 \ 3]$ .
22. Write a mat lab program to perform the cross correlation between ramp and step function and see how mat lab reacts to it.
23. Write a MATLAB program to perform cross correlation between square and step signal and see how mat lab reacts to it.
24. Write a MATLAB program to perform cross correlation between sinusoidal and step signal and see how mat lab reacts to it.
25. Write a MATLAB program to perform the convolution between  $X(n) = [1 \ 5 \ 6 \ 5]$  and  $y(n) = [-3 \ -6]$  and see how matlab reacts to it.
26. Write a MATLAB program to illustrate the effect of anti-aliasing filter.
27. Write a MATLAB program to subtract two sinusoidal signals.
28. Write a MATLAB program to subtract and multiply two sinusoidal signals.
29. Write a MATLAB program to right shift the signal to 2 times of the original signal.
30. Write a MATLAB program to left shift the signal to 5 times of the original signal.

### **Real Time Applications:**

- Parseval's theorem for energy signals
- Parseval's theorem for power signals
- Digital signal processing applications etc...

Basic Simulation Lab Manual  
**EXPERIMENT NO:18 (Beyond Syllabus)**

**LOCATING THE ZEROS AND POLES AND PLOTTING THE POLE  
 ZERO MAPS IN S-PLANE AND Z-PLANE FOR THE GIVEN TRANSFER  
 FUNCTION.**

**AIM: -**

To locating the zeros and poles and plotting the pole zero maps in s-plane and z-plane for the given transfer function.

**SOFTWARE REQUIRED: -**

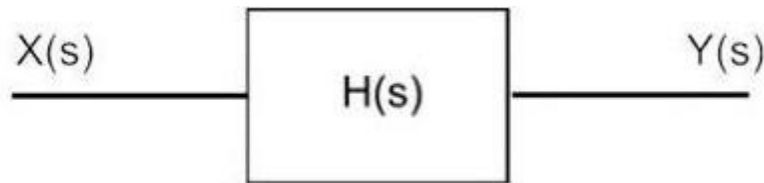
1. MATLAB R2010a.
2. Windows XP SP2.

**THEORY:-**

A Transfer Function is the ratio of the output of a system to the input of a system, in the Laplace domain considering its initial conditions to be zero. If we have an input function of  $X(s)$ , and an output function  $Y(s)$ , we define the transfer function  $H(s)$  to be:

$$H(s) = \frac{Y(s)}{X(s)}$$

transfer function is the Laplace transform of a system's impulse response.



Given a continuous-time transfer function in the Laplace domain,  $H(s)$  or a discrete-time one in the Z-domain,  $H(z)$ , a zero is any value of  $s$  or  $z$  such that the transfer function is zero, and a pole is any value of  $s$  or  $z$  such that the transfer function is infinite.

**Zeros:** 1. The value(s) for  $z$  where the *numerator* of the transfer function equals zero 2. The complex frequencies that make the overall gain of the filter transfer function zero.

**Poles:** 1. The value(s) for  $z$  where the *denominator* of the transfer function equals zero 2. The complex frequencies that make the overall gain of the filter transfer function infinite.

## Z-transforms

The Z-transform converts a discrete time-domain signal, which is a sequence of real or complex numbers, into a complex frequency-domain representation. The Z-transform, like many other integral transforms, can be defined as either a one-sided or two-sided transform.

### Bilateral Z-transform

The bilateral or two-sided Z-transform of a discrete-time signal  $x[n]$  is the function  $X(z)$  defined as

$$X(z) = \mathcal{Z}\{x[n]\} = \sum_{n=-\infty}^{\infty} x[n]z^{-n}$$

### Unilateral Z-transform

Alternatively, in cases where  $x[n]$  is defined only for  $n \geq 0$ , the single-sided or unilateral Z-transform is defined as

$$X(z) = \mathcal{Z}\{x[n]\} = \sum_{n=0}^{\infty} x[n]z^{-n}$$

In signal processing, this definition is used when the signal is causal.

where  $z = r.e^{j\omega}$

$$X(z) = \frac{P(z)}{Q(z)}$$

The roots of the equation  $P(z) = 0$  correspond to the 'zeros' of  $X(z)$ . The roots of the equation  $Q(z) = 0$  correspond to the 'poles' of  $X(z)$ .

### PROCEDURE:-

- Open MATLAB
- Open new M-file
- Type the program
- Save in current directory
- Compile and Run the program
- For the output see command window\ Figure window

**PROGRAM:-**

%locating poles of zero on s-plane%

```
clc;
clear all;
close all;
num=input('enter numerator co-efficients');
den=input('enter denominator co-efficients');h=tf(num,den);
poles=roots(den); zeros=roots(num);sgrid;
pzmap(h);
grid on;
title('locating poles of zeros on s-plane');
```

%locating poles &zeros on z-  
plane%

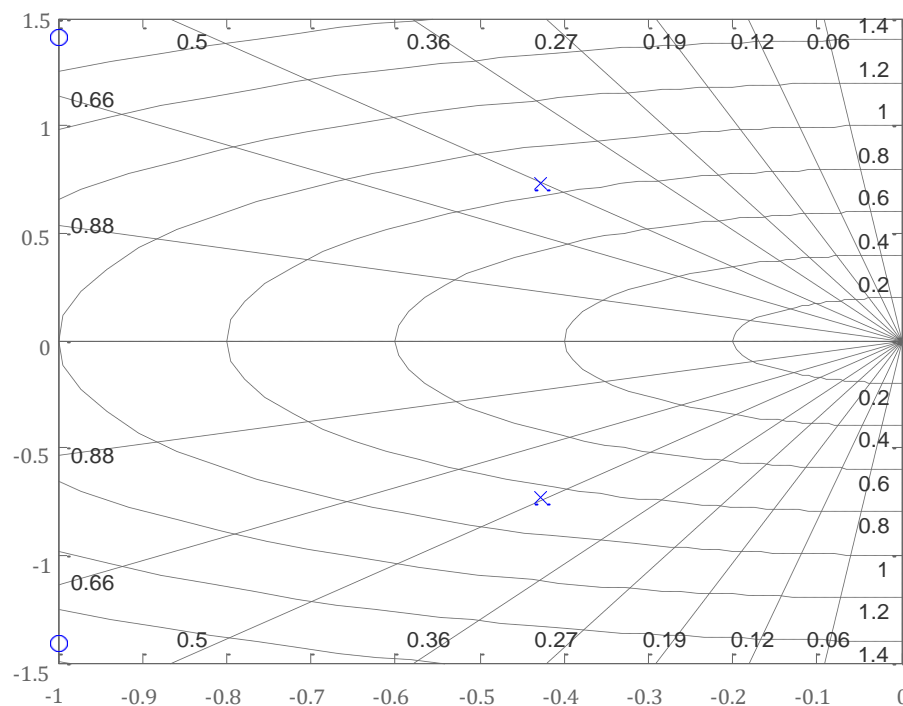
```
clc;
clear all;close all;
num=input('enter numerator coefficient'); den=input('enter denominator coefficient');
p=roots(den);
z=roots(num);zplane(p,z); grid;
title('locating poles and zeros on s-plane');
```

**OUTPUT: -**

locating poles of zero on s-plane

enter numerator coefficient[1 2 3]

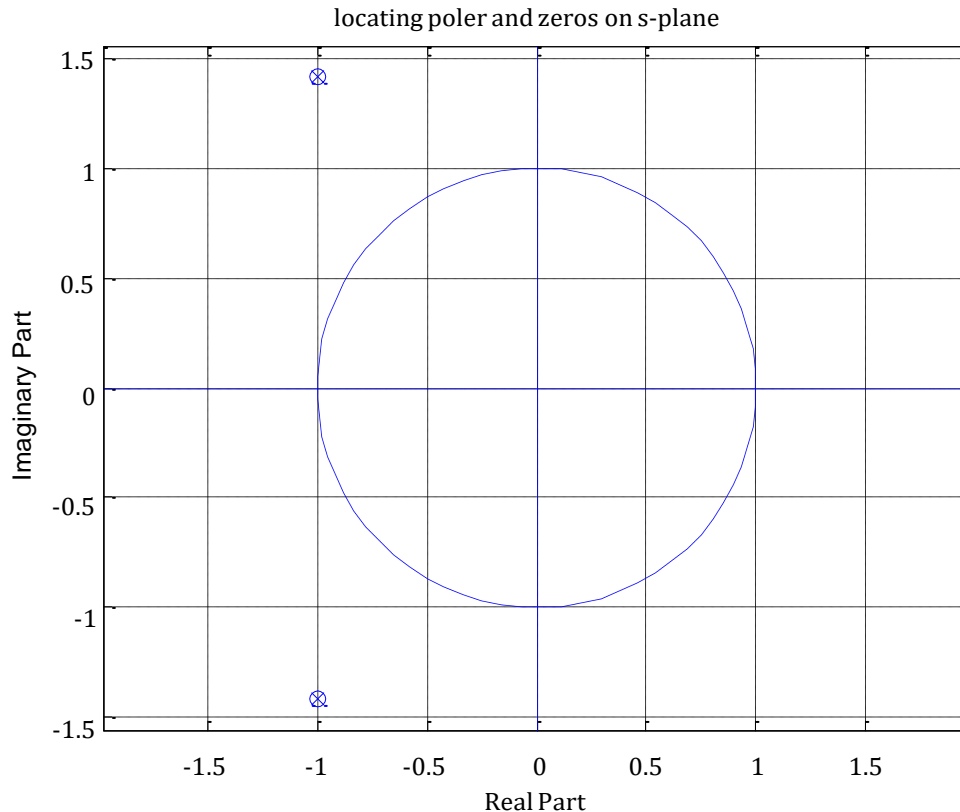
enter denominator coefficient[7 6 5]



locating poles & zeros on z-plane

enter numerator coefficient [1 2 3]

enter denominator coefficient [1 2 3]

**RESULT: -**

In this experiment the zeros and poles and plotting the pole zero maps in s-plane and z-plane for the given transfer function using MATLAB.

**VIVA QUESTIONS: -**

1. Study the details of `ztrans()` and `iztrans()` functions?
2. What are poles and zeros?
3. How you specify the stability based on poles and zeros?
4. Define S-plane and Z-plane?
5. What is the difference b/w S-plane and Z-plane?
6. Define Scaling Property of Z-plane?
7. Explain Time Convolution Property of Z-plane?
8. Explain Frequency Convolution Property of Z-plane?
9. Explain the linearity property of Z-plane?
10. Describe the advantages of Z-plane?



**EXERCISE PROGRAMS**

1. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n) - 5y(n-1) + 4y(n-2) = x(n) - 2x(n-1)$ .
2. Write a MATLAB program to find the impulse response of the following difference equation  $6y(n) - 9y(n-1) - 4y(n-2) = x(n) - 5x(n-1)$ .
3. Write a MATLAB program to find the impulse response of the following difference equation  $8y(n) - 6y(n-1) + 4y(n-2) = x(n) + 2x(n-1)$ .
4. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n) + 5y(n-1) + 9y(n-2) = x(n) - 9x(n-1)$ .
5. Write a MATLAB program to find the impulse response of the following difference equation  $6y(n) - 5y(n-1) + 4y(n-2) = x(n) - 2x(n-1)$ .
6. Write a MATLAB program to find the impulse response of the following difference equation  $7y(n) - 5y(n-1) + 4y(n-2) = x(n) - 9x(n-1)$ .
7. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n) - 5y(n-1) + 4y(n-2) = x(n) - 6x(n-1)$ .
8. Write a MATLAB program to find the impulse response of the following difference equation  $5y(n) - 5y(n-1) + 5y(n-2) = x(n) - 2x(n-1)$ .
9. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n) - 6y(n-1) + 4y(n-2) = x(n) - 7x(n-1)$ .
10. Write a MATLAB program to find the impulse response of the following difference equation  $2y(n) - 5y(n-1) + 4y(n-2) = x(n) - 2x(n-1)$ .
11. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n) - 5y(n-1) + 4y(n-2) = 5x(n) - 6x(n-1)$ .
12. Write a MATLAB program to find the impulse response of the following difference equation  $6y(n) - 8y(n-1) - 4y(n-2) = 7x(n) - 5x(n-1)$ .
13. Write a MATLAB program to find the impulse response of the following difference equation  $8y(n) - 8y(n-1) + 9y(n-2) = x(n) + 5x(n-1)$ .
14. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n) + 9y(n-1) + 9y(n-2) = 9x(n) - 5x(n-1)$ .
15. Write a MATLAB program to find the impulse response of the following difference equation  $6y(n) - 5y(n-1) + 4y(n-2) = 7x(n) - 2x(n-1)$ .
16. Write a MATLAB program to find the impulse response of the following difference equation  $7y(n) - 5y(n-1) + 4y(n-2) = x(n) - 7x(n-1)$ .
17. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n) - 5y(n-1) + 4y(n-2) = x(n) - 6x(n-1)$ .
18. Write a MATLAB program to find the impulse response of the following difference equation  $5y(n) - 5y(n-1) + 5y(n-2) = 7x(n) - 2x(n-1)$ .
19. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n) - 6y(n-1) + 4y(n-2) = 4x(n) - x(n-1)$ .
20. Write a MATLAB program to find the impulse response of the following difference equation  $2y(n) - 5y(n-1) + 4y(n-2) = x(n) - 2x(n-1)$ .
21. Write a MATLAB program to find the impulse response of the following difference equation

$$7y(n)-5y(n-1)+y(n-2)=x(n)-7x(n-1).$$

22. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n)-5y(n-1)+4y(n-2)=x(n)-6x(n-1)+u(n)$
23. Write a MATLAB program to find the impulse response of the following difference equation  $5y(n)-5y(n-1)+5y(n-2)=7x(n)-2x(n-1)+u(n)$ .
24. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n)-6y(n-1)+4y(n-2)=4x(n)-x(n-1)+u(n)$ .
25. Write a MATLAB program to find the impulse response of the following difference equation  $2y(n)-5y(n-1)+4y(n-2)=x(n)-2x(n-1)+u(n)$ .
26. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n)-5y(n-1)+4y(n-2)=4x(n)-12x(n-1)$ .
27. Write a MATLAB program to find the impulse response of the following difference equation  $6y(n)-9y(n-1)-4y(n-2)=6x(n)-15x(n-1)$ .
28. Write a MATLAB program to find the impulse response of the following difference equation  $8y(n)-6y(n-1)+4y(n-2)=8x(n)+2x(n-1)$ .
29. Write a MATLAB program to find the impulse response of the following difference equation  $3y(n)+5y(n-1)+9y(n-2)=5x(n)-9x(n-1)$ .
30. Write a MATLAB program to find the impulse response of the following difference equation  $6y(n)-5y(n-1)+4y(n-2)=x(n)-6x(n-1)$ .

### **Real Time Applications:**

Z- Transforms having following

- ☐ applications
- ☐ Analysis of differential equations
- ☐ Z- transform
- ☐ spectroscopy
- ☐ Quantum mechanics
- Signal processing applications etc
- Conversion of analog signals to digital signals etc