

# Jawaharlal Nehru Engineering College

*Laboratory Manual*

## **DIGITAL COMMUNICATION**

For

Third Year Students

Manual made by  
Prof.P.B.Murmude

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**MGM'S**

## **Jawaharlal Nehru Engineering College**

**N-6, CIDCO, Aurangabad**

### **Department of Electronics & Telecommunication**

#### **Vision of the Department:**

To develop **GREAT** technocrats and to establish centre of excellence in the field of **Electronics and Telecommunications**.

- ▶ *Global technocrats with human values*
- ▶ *Research and lifelong learning attitude,*
- ▶ *Excellent ability to tackle challenges*
- ▶ *Awareness of the needs of society*
- ▶ *Technical expertise*

#### **Mission of the Department:**

1. To provide good technical education and enhance technical competency by providing good infrastructure, resources, effective teaching learning process and competent, caring and committed faculty.
2. To provide various platforms to students for cultivating professional attitude and ethical values.
3. Creating a strong foundation among students which will enable them to pursue their career choice.

# Jawaharlal Nehru Engineering College

## Technical Document

This technical document is a series of Laboratory manuals of Electronics & Telecommunication and is a certified document of Jawaharlal Nehru Engineering College. The care has been taken to make the document error free but still if any error is found kindly bring it to the notice of subject teacher and HOD.

Recommended by,

HOD

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## **FOREWORD**

It is my great pleasure to present this laboratory manual for Third year engineering students for the subject of DIGITAL COMMUNICATION to understand and visualize the basic concepts of various digital communication systems with waveforms. DIGITAL COMMUNICATION covers basic concepts of communication devices.

This lab manual provides a platform to the students for understanding the basic concepts of DIGITAL COMMUNICATION. This practical background will help students to gain confidence in qualitative and quantitative approach through MATLAB.

Good Luck for your Enjoyable Laboratory Sessions.

Prof.P.B.Murmude

## LABORATORY MANUAL CONTENTS

This manual is intended for the third year students of Electronics subject of Digital Communication. This manual typically contains Practical/Lab Sessions related to Digital Communication covering various aspects related the subject to enhance understanding of the subject.

Students are advised to thoroughly go through this manual rather than only topics mentioned in the syllabus, as practical aspects are the key to understanding conceptual visualization of theoretical aspects covered in the books.

Good Luck for your Enjoyable Laboratory Sessions.

Prof.P.B.Murmude

## SUBJECT INDEX:

1. Do's & Don'ts in Laboratory.
2. Lab Exercises
  1. Noisy signal generation and analysis.
  2. Verification of sampling theorem using flat top sampling
  3. Study of ASK generation and detection
  4. Study of PSK generation and detection
  5. Study of FSK generation and detection
  6. Study of DPSK generation and detection
  7. Study of QPSK generation and detection
  8. Study of PCM generation and detection
  9. Study of Delta Modulation.
3. Quiz
4. Conduction of viva voice examination
5. Evaluation & marking scheme

## **1 Do's and Don'ts in Laboratory:-**

1. Refer Help to run the program.
2. Study waveforms before going to run the program.
3. Go through Demos of Signal Processing tool box.
4. Strictly observe the instructions given by the Teacher/ Lab Instructor.
5. Switch of systems before leaving the Labs.

## **2 Instructions for Laboratory Teachers:**

1. Lab work completed during prior session should be corrected during the next lab session.
2. Students should be guided and helped whenever they face difficulties.
3. The promptness of submission should be encouraged by way of marking and evaluation patterns that will benefit the sincere students.

## Exercise No.1

**Aim** :- Noisy signal generation and analysis.

**Software**:- MATLAB 7.10

**Theory** :-

In electronics, **noise** is a random fluctuation in an electrical signal, a characteristic of all electronic circuit. Noise generated by electronic devices varies greatly, as it can be produced by several different effects. Thermal noise is unavoidable at non-zero temperature, while other types depend mostly on device type (such as shot noise, which needs steep potential barrier) or manufacturing quality and semiconductor defects, such as conductance fluctuations, including  $1/f$  noise.

In communication systems, noise is an error or undesired random disturbance of a useful information signal in a communication channel. The noise is a summation of unwanted or disturbing energy from natural and sometimes man-made sources. Noise is, however, typically distinguished from interference, (e.g. cross-talk, deliberate jamming or other unwanted electromagnetic interference from specific transmitters), for example in the signal-to-noise ratio (SNR), signal-to-interference ratio (SIR) and signal-to-noise plus interference ratio (SNIR) measures. Noise is also typically distinguished from distortion, which is an unwanted systematic alteration of the signal waveform by the communication equipment, for example in the signal-to-noise and distortion ratio (SINAD). In a carrier-modulated passband analog communication system, a certain carrier-to-noise ratio (CNR) at the radio receiver input would result in a certain signal-to-noise ratio in the detected message signal. In a digital communications system, a certain  $E_b/N_0$  (normalized signal-to-noise ratio) would result in a certain bit error rate (BER).

While noise is generally unwanted, it can serve a useful purpose in some applications, such as random number generation or dithering.

Noise Types:

1.1) Thermal noise 1.2) Shot noise 1.3) Flicker noise 1.4) Burst noise 1.5) Transit-time noise

**Algorithm**:-

- 1) To generate sine waveform.
- 2) To generate random signal.
- 3) To generate AWGN signal.
- 4) To plot sine + random signal.
- 5) To plot sine + AWGN signal.
- 6) To plot FFT of both noisy signal.

**Program**:-

```
# NOISY SIGNAL GENERATION AND ANALYSIS. #  
close all;  
clear all;
```



```

t=(0:0.0001:0.1); % time scale

s=4*sin(2*pi*100*t); % input sine signal
subplot(4,2,1); % subplot for first position
axis([0 10 -4 4]); % to define x & y axis range
plot(t,s); % to plot sine wave
title('sine wave'); % title

subplot(4,2,2) % subplot for 2 nd position
axis([0 10 -4 4]); % to define x & y axis range
plot(t,s); % to plot sine wave
title('sine wave'); % title

subplot(4,2,4); % subplot for 4th position
axis([0 10 -4 4]); % to define x & y axis range
snr=15; % declration of signal to noise ratio
n= awgn(s,snr); % syntax for additive white gaussian noise
plot(t,n); % plot awgn
xlabel('time'); % label to x axis
ylabel('amplitude'); % label to Y axis
title(' awgn noisy signal 1') % title

subplot(4,2,6); % subplot for 6th position
axis([0 10 -4 4]); % to define x & y axis range
z=s+n; % to add sinewave & awgn noise signal
plot(t,z); % to plot awgn + sinewave
xlabel('time'); % label to x axis
ylabel('amplitude'); % label to y axis
title('awgn + sine'); % title

subplot(4,2,8); % subplot for 8th position
axis([0 20 -4 4]); % to define x & y axis range
y=fft(z); %taking fast fourier transform
plot(t,y); % plot fourier transform of awgn Noise + input signal
title('fft of awgn') % Title

subplot(4,2,3); % subplot for 3rd position
axis([0 10 -4 4]); % To define x & y axis range
p=0.1*randn(size(t)); % syntax for random noise
snr=20; % declration of signal to noise ratio
plot(t,p); % To plot random niose signal
xlabel('time'); % label to x axis
ylabel('amplitude'); % label to y axis
title('rand noisy signal 2') % Title

subplot(4,2,5); % subplot for 5th position

```

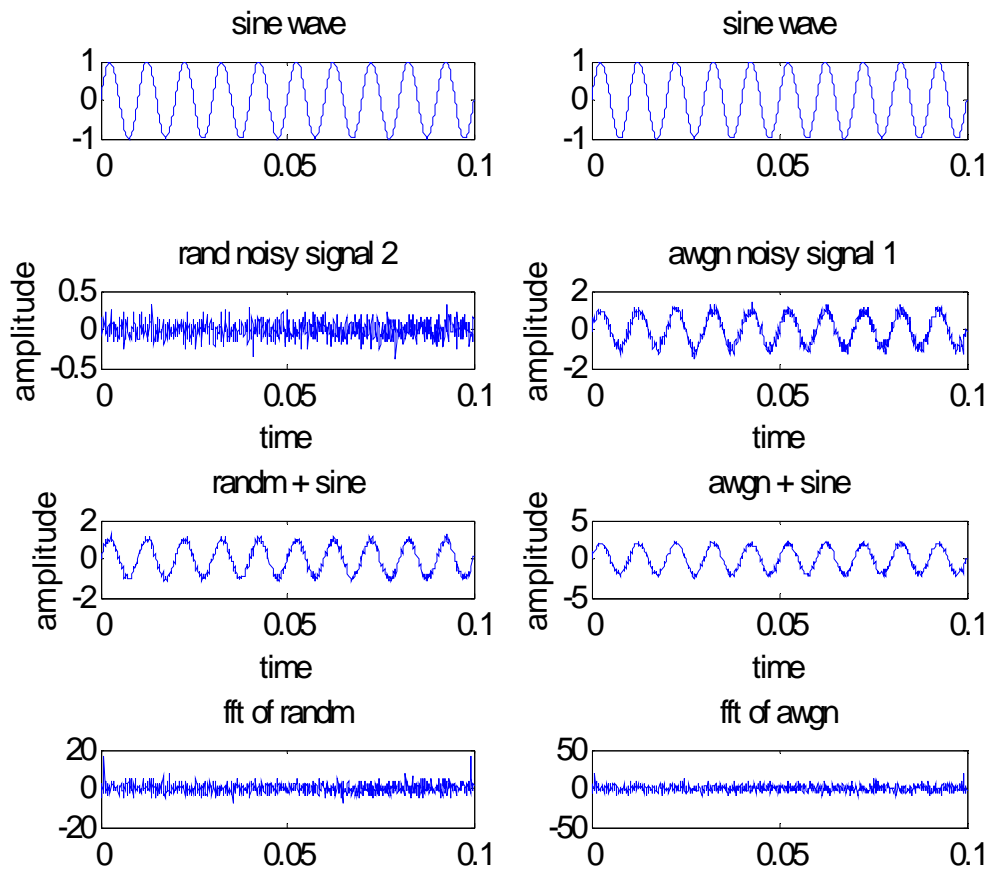
```

axis([0 10 -4 4]);           % To define x & y axis range
e=s+p;                       % to add sinewave & random noise signal
plot(t,e);                   % plot random noise signal
xlabel('time');              % label to x axis
ylabel('amplitude');         % label to y axis
title('randm + sine')        % Title

subplot(4,2,7);              % subplot for 5th position
axis([0 20 -4 4]);           % To define x & y axis range
w=fft(e);                    % taking fast fourier transform
plot(t,w);                   % plot fourier transform of random noise + input signal
title('fft of randm')        % Title

```

**Output Waveform :-**



**Conclusion:-** Thus we have studied Noisy signal generation and analysis.

## Exercise No.2

**Aim** :- Verification of sampling theorem using flat top sampling.

**Software**:- MATLAB 7.10

### **Theory** :-

In signal processing, **sampling** is the reduction of a continuous signal to a discrete signal. A common example is the conversion of a sound wave (a continuous signal) to a sequence of samples (a discrete-time signal).

A **sample** is a value or set of values at a point in time and/or space.

A **sampler** is a subsystem or operation that extracts samples from a continuous signal.

A theoretical **ideal sampler** produces samples equivalent to the instantaneous value of the continuous signal at the desired points.

Sampling can be done for functions varying in space, time, or any other dimension, and similar results are obtained in two or more dimensions.

For functions that vary with time, let  $s(t)$  be a continuous function (or "signal") to be sampled, and let sampling be performed by measuring the value of the continuous function every  $T$  seconds, which is called the **sampling interval**. Then the sampled function is given by the sequence:

$s(nT)$ , for integer values of  $n$ .

The **sampling frequency** or **sampling rate**, **fs**, is the average number of samples obtained in one second (*samples per second*), thus **fs = 1/T**.

### **Algorithm**:-

- 1) To declare and plot modulating frequency.
- 2) To declare three sampling frequencies according to  $fs > 2f_m$ ,  $fs = 2f_m$ ,  $fs < 2f_m$ . And plot respective graphs.
- 3) To plot graph showing aliasing effect also.

### **Program**:-

```
# SAMPLING #
clear all ;
close all ;
t=-10:0.01:10 ;           % range of given input signal.
T=8 ;                    % sampling period.
fm=1/T ;                 % modulating frequency.
```

```

x=cos(2*pi*fm*t);           % given input signal.
fs1=1.2*fm ;                % first sampling frequency.
fs2=2*fm ;                  % second sampling frequency.
fs3=8*fm ;                  % third sampling frequency.
n1=-4:1:4 ;                  % range of signal for 1st case=(fs<2fm).
xn1=cos(2*pi*n1*fm/fs1) ;   % given signal with 1st sampling frequency.
subplot(2,2,1) ;
stem(t,x) ;
xlabel('time in second') ;   % labelling x-axis.
ylabel(' x(t) ');           % labelling y axis.
title('continuous time signal') ; % labelling 1st block.
subplot(2,2,2) ;
stem(n1,xn1) ;
hold on ;
plot(n1,xn1) ;
xlabel('n') ;                % labelling x-axis.
ylabel('x(n)') ;            % labelling y-axis.
title('DTS with fs<2fm') ;   % labelling 2nd block.
n2=-5:1:5 ;                  % range of signal for 2nd case=(fs=2fm)
xn2=cos(2*pi*n2*fm/fs2) ;   % given signal with 2nd sampling frequency.
subplot(2,2,3) ;
stem(n2,xn2) ;
hold on ;
plot(n2,xn2) ;
xlabel('n') ;                % labelling x-axis.
ylabel('x(n)') ;            % labelling y-axis.
title('DTS with fs=2fm') ;   % labelling 3rd block.
n3=-20:1:20 ;                % range of signal for 3rd case.=(fs>2fm).
xn3=cos(2*pi*n3*fm/fs3) ;   % given signal with 3rd sampling frequency.
subplot(2,2,4) ;
stem(n3,xn3) ;
hold on ;
plot(n3,xn3) ;
xlabel('n') ;                % labelling x-axis.
ylabel('x(n)');             % labelling y-axis.
title('DTS with fs>2fm') ;   % labelling 4th block.

```

Plotting the sampled signals with a different sampling period using the subplot command in MATLAB, how could we identify the aliasing in a sampled signal?  
 Here is the example code that plotted two signals, one at the Nyquist rate while the other less than the Nyquist rate:

```

A = 2;           % Amplitude
Fmax = 10;       % Maximum frequency
Fs = 2*Fmax;     % Declaring Fs
n = 0:1/Fs:1;    % Assigning value to n

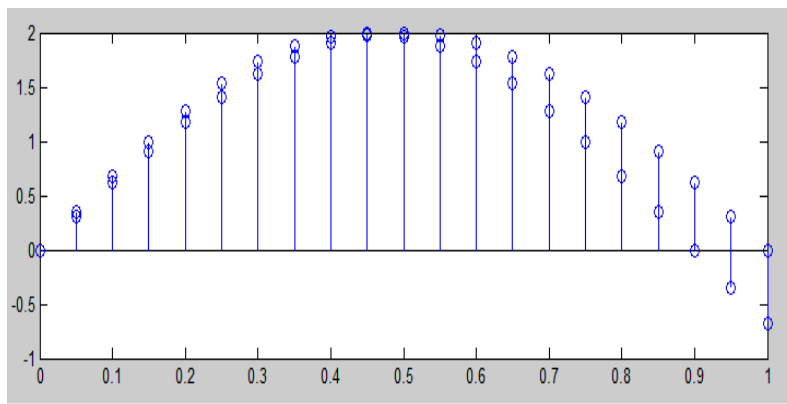
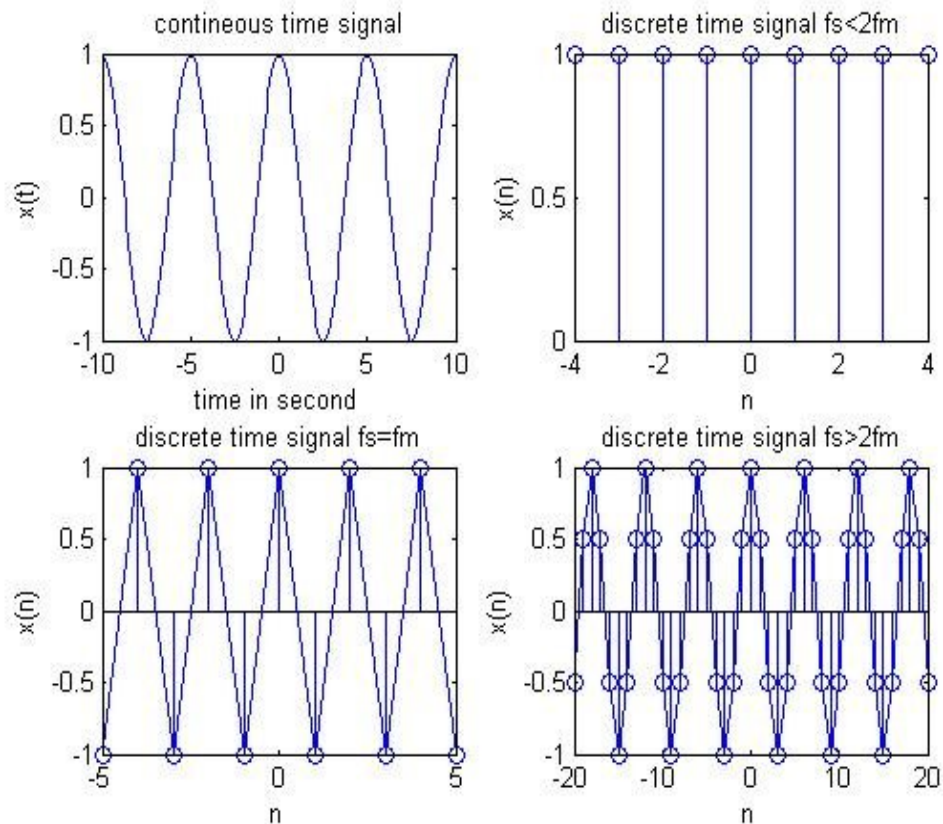
```

```

Cont = A*sin(2*pi*(Fmax/Fs)*n); %sine function declaration
Cont1 = A*sin(2*pi*(Fmax/18)*n);
subplot(2,1,1)
stem(n,Cont)
hold on
stem(n,Cont1)

```

**Output Waveform :**



**Conclusion:-** Thus we have studied Verification of sampling theorem using flat top sampling.

## Exercise No.3

### AMPLITUDE SHIFT KEYING

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

**Software:-** MATLAB 7.10

**Theory:-**

#### **Generation of ASK**

Amplitude shift keying - ASK - is a modulation process, which imparts to a sinusoid two or more discrete amplitude levels. These are related to the number of levels adopted by the digital message.

For a binary message sequence there are two levels, one of which is typically zero. The data rate is

a sub-multiple of the carrier frequency. Thus the modulated waveform consists of bursts of a sinusoid. One of the disadvantages of ASK, compared with FSK and PSK, for example, is that it has not got a constant envelope. This makes its processing (eg, power amplification) more difficult, since linearity becomes an important factor. However, it does make for ease of demodulation with an envelope detector.

#### **Demodulation**

ASK signal has a well defined envelope. Thus it is amenable to demodulation by an envelope detector. Some sort of decision-making circuitry is necessary for detecting the message. The signal

is recovered by using a correlator and decision making circuitry is used to recover the binary sequence.

**Algorithm:-**

Initialization commands

#### **ASK modulation**

1. Generate carrier signal.
2. Generate message signal
3. Generate ASK modulated signal.
4. Plot message signal and ASK modulated signal.
5. Plot the data and carrier.

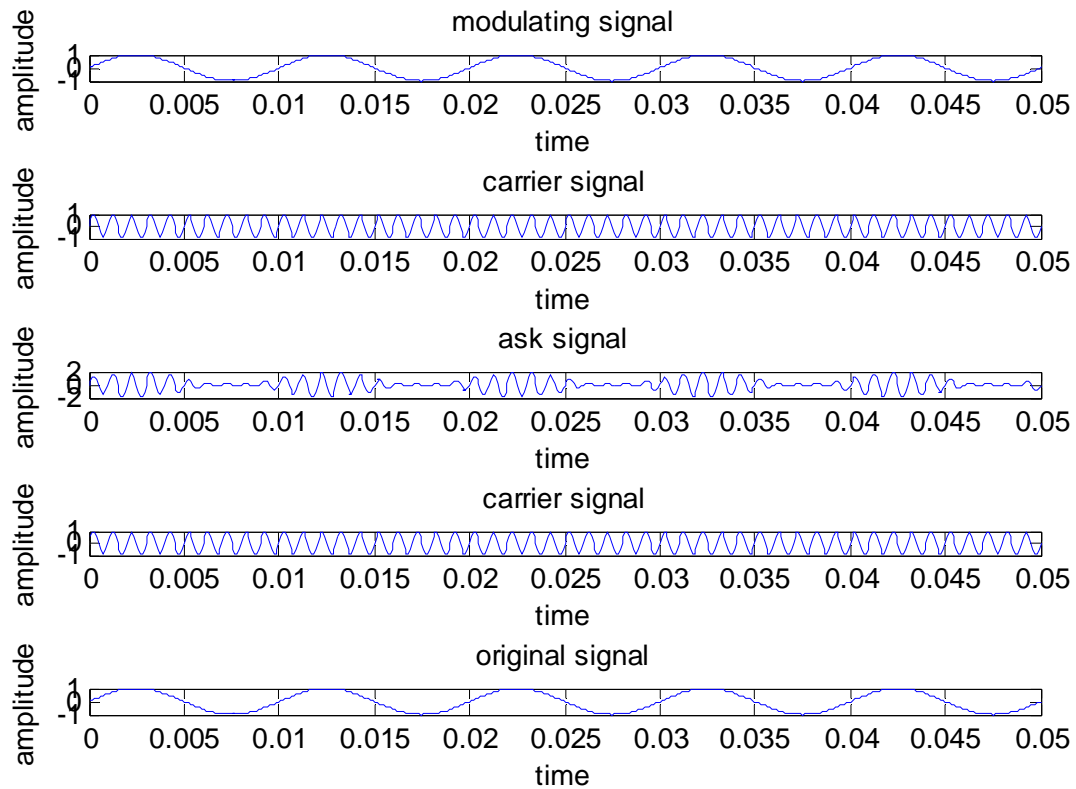
#### **ASK demodulation**

1. Perform correlation of ASK signal with carrier to get decision variable
2. Make decision to get demodulated binary data.
3. Plot the demodulated binary data.

## **Program:-**

```
clc;
close all;
clear all;
t=0:0.0001:0.05;      % declaration of time scale
x=sin(2*pi*100*t);    % declaration of sine function.
Subplot(5,1,1);      % declaration of position in subplot.
plot(t,x);           % plotting of signal
xlabel('time');      % labelling of X axes
ylabel('amplitude'); % labelling of Y axes
title('modulating signal'); % declaration of title of waveform
y=sin(2*pi*1000*t);  % declaration of sine with different frequency
subplot(5,1,2);      % declaration of position in subplot.
plot(t,y);           % plotting of signal
xlabel('time');      % labelling of X axes
ylabel('amplitude'); % labelling of Y axes
title('carrier signal'); % declaration of title of waveform
z=x.*y;              % multiplication of two signals
a=z+y;               % addition of two signals
subplot(5,1,3);
plot(t,a);
xlabel('time');
ylabel('amplitude');
title('ask signal'); % plottig of ASK modulated signal
a=z./x;
subplot(5,1,4);
plot(t,a);
xlabel('time');
ylabel('amplitude');
title('carrier signal'); % demodulation of carrier
q=(z./y);
subplot(5,1,5);
plot(t,q);
xlabel('time');
ylabel('amplitude');
title('original signal');      % demodulation of ASK means original signal back
```

## Output Waveform:-



**Conclusion:-**The program for ASK modulation and demodulation has been simulated in MATLAB and necessary graphs are plotted. Study of ASK generation and detection is done.



## Exercise No.4

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

**Software:-** MATLAB 7.10

**Theory :-**

### Generation of PSK signal

PSK is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave). PSK uses a finite number of phases, each assigned a unique pattern of binary digits. Usually, each phase encodes an equal number of bits. Each pattern of bits

forms the symbol that is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal

and maps it back to the symbol it represents, thus recovering the original data.

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

$$S_1(t) = \sqrt{2E_b/T_b} \cos 2\pi f_c t$$

$$S_2(t) = \sqrt{2E_b/T_b} (2\pi f_c t + \pi) = -\sqrt{2E_b/T_b} \cos 2\pi f_c t \text{ where } 0 \leq t < T_b \text{ and}$$

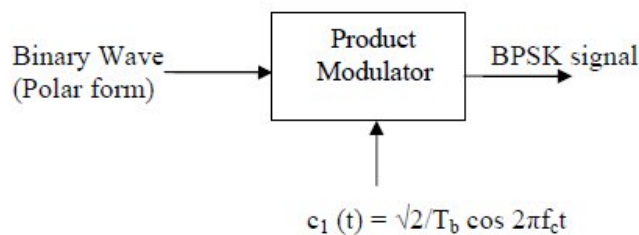
$E_b$  = Transmitted signed energy for bit

The carrier frequency  $f_c = n/T_b$  for some fixed integer  $n$ .

### Antipodal Signal:

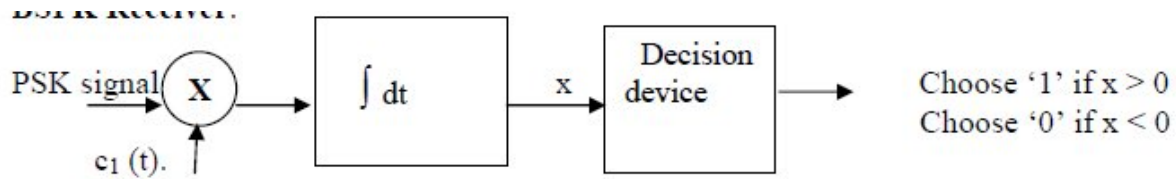
The pair of sinusoidal waves that differ only in a relative phase shift of  $180^\circ$  are called antipodal signals.

### BPSK Transmitter



The input binary symbols are represented in polar form with symbols 1 & 0 represented by constant amplitude levels  $\sqrt{E_b}$  &  $-\sqrt{E_b}$ . This binary wave is multiplied by a sinusoidal carrier in a product modulator. The result is a BPSK signal.

### BSPK Receiver:



The received BPSK signal is applied to a correlator which is also supplied with a locally generated reference signal  $c_1(t)$ . The correlated o/p is compared with a threshold of zero volts. If  $x > 0$ , the receiver decides in favour of symbol 1. If  $x < 0$ , it decides in favour of symbol 0.

### **Algorithm:-**

Initialization commands

#### **PSK modulation**

1. Generate carrier signal.
2. Generate binary data, message signal in polar form
3. Generate PSK modulated signal.
4. Plot message signal and PSK modulated signal.
5. Plot the binary data and carrier.

#### **PSK demodulation**

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

### **Program:-**

```

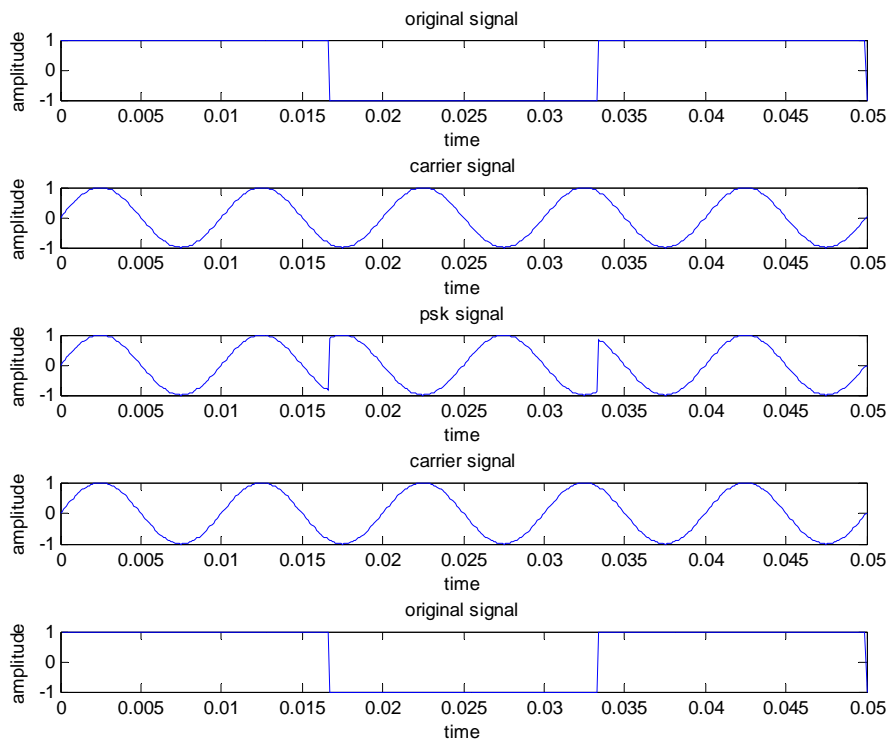
p=square(2*pi*30*t);           % declaration of square function
subplot(5,1,1);
plot(t,p);
xlabel('time');
ylabel('amplitude');
title('original signal');
s=sin(2*pi*100*t);           % declaration of square function
subplot(5,1,2);
plot(t,s);
xlabel('time');
ylabel('amplitude');
title('carrier signal');
e=p.*s;                       % multiplication of two signal to plot psk signal
subplot(5,1,3);
plot(t,e);
xlabel('time');
ylabel('amplitude');
  
```

```

title('psk signal');
i=e./p;          % division of two signals to separate carrier
subplot(5,1,4);
plot(t,i);
xlabel('time');
ylabel('amplitude');
title('carrier signal');
x2=e./s;
subplot(5,1,5);
plot(t,x2);
xlabel('time');
ylabel('amplitude');
title('original signal');% demodulated psk means original signal back

```

### Output Waveform:-



**Conclusion:-** Study of PSK generation and detection is done. The program for PSK modulation and demodulation has been simulated in MATLAB and necessary graphs are plotted

## Exercise No.5

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

**Software:-** MATLAB 7.10

**Theory:-**

### Generation of FSK

Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave. The simplest FSK is binary FSK

(BFSK). BFSK uses a pair of discrete frequencies to transmit binary (0s and 1s) information. With

this scheme, the "1" is called the mark frequency and the "0" is called the space frequency.

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

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

0 elsewhere

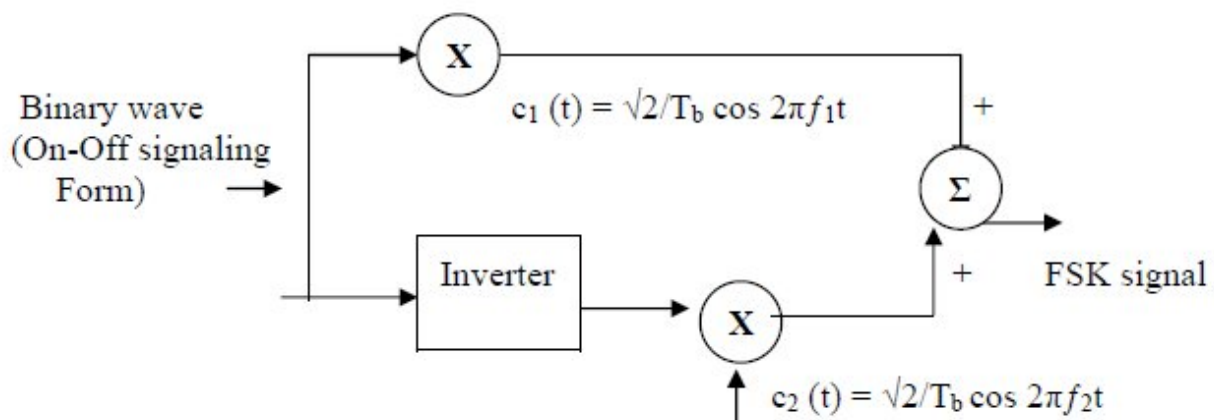
Where  $i=1, 2$  &  $E_b$ =Transmitted energy/bit

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

Symbol 1 is represented by  $S_1(t)$

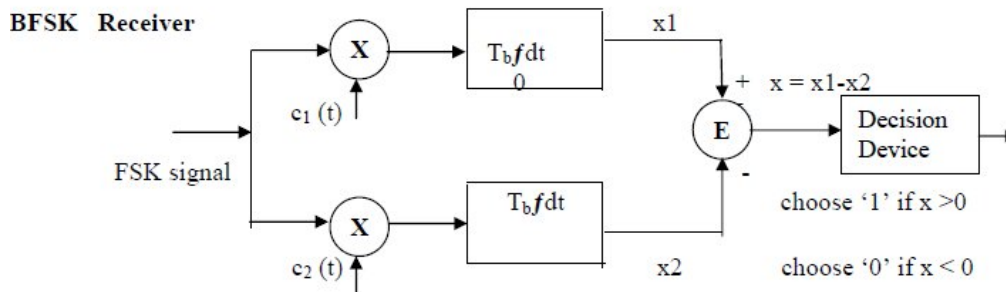
Symbol 0 is represented by  $S_0(t)$

### BFSK Transmitter



**The input binary sequence is represented in its ON-OFF form, with symbol 1** represented by constant amplitude of  $\sqrt{E_b}$  with & symbol 0 represented by zero volts. By using inverter in the lower channel, we in effect make sure that when symbol 1 is at the input, The two frequency  $f_1$  &  $f_2$  are chosen to be equal integer multiples of the bit rate  $1/T_b$ . By summing the upper & lower channel outputs, we get BFSK signal.

### **BFSK Receiver**



**The receiver consists of two correlators with common inputs which are supplied with** locally generated coherent reference signals  $c_1(t)$  and  $c_2(t)$ .

The correlator outputs are then subtracted one from the other, and the resulting difference  $x$  is compared with a threshold of zero volts. If  $x > 0$ , the receiver decides in favour of symbol 1 and if  $x < 0$ , the receiver decides in favour of symbol 0.

### **Algorithm:-**

Initialization commands

#### **FSK modulation**

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

#### **FSK demodulation**

1. Start FOR loop
2. Perform correlation of FSK modulated signal with carrier 1 and carrier 2 to get two decision variables  $x_1$  and  $x_2$ .
3. Make decision on  $x = x_1 - x_2$  to get demodulated binary data. If  $x > 0$ , choose '1' else choose '0'.
4. Plot the demodulated binary data.

### **Program:-**

```
clc;
close all;
clear all;
fc1=10;
fc2=30;
fp=5;
amp1=4;
amp=amp1/2;

t=0:0.001:1;
c1=amp.*sin(2*pi*fc1*t);% For Generating 1st Carrier Sine wave
c2=amp.*sin(2*pi*fc2*t);% For Generating 2nd Carrier Sine wave

subplot(5,1,2); %For Plotting The Carrier wave
plot(t,c1);
xlabel('Time');
ylabel('Amplitude');
title('Carrier 1 Wave');

subplot(5,1,3); %For Plotting The Carrier wave
plot(t,c2);
xlabel('Time');
ylabel('Amplitude');
title('Carrier 2 Wave');

m=amp.*square(2*pi*fp*t)+amp;%For Generating Square wave message
subplot(5,1,1); %For Plotting The Square Binary Pulse (Message)
plot(t,m);
xlabel('Time');
ylabel('Amplitude');
title('input binary mod pulse');

for i=0:1000 %here we are generating the modulated wave
    if m(i+1)==0
        m(i+1)=c1(i+1);
    else
        m(i+1)=c2(i+1);
    end
end

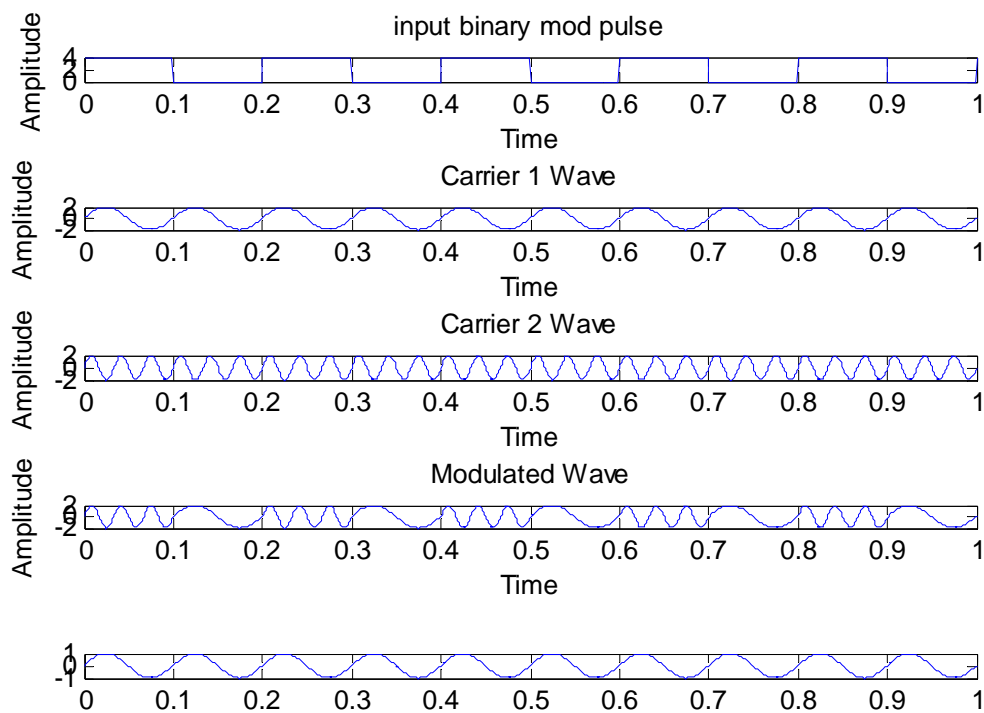
subplot(5,1,4); %For Plotting The Modulated wave
plot(t,m);
xlabel('Time');
```

```
ylabel('Amplitude');  
title('Modulated Wave');
```

```
m1=c1./amp;  
subplot(5,1,5);  
plot(t,m1);
```

```
m3=c2./amp;  
subplot(5,1,6);  
plot(t,m3);
```

### **Output waveform:-**



**Conclusion:-** Study of BFSK generation and detection is done. The program for FSK modulation and demodulation has been simulated in MATLAB and necessary graphs are plotted

## Exercise No.6

**Aim** :- Study of DPSK generation and detection

**Software**:- MATLAB 7.10

**Theory** :-

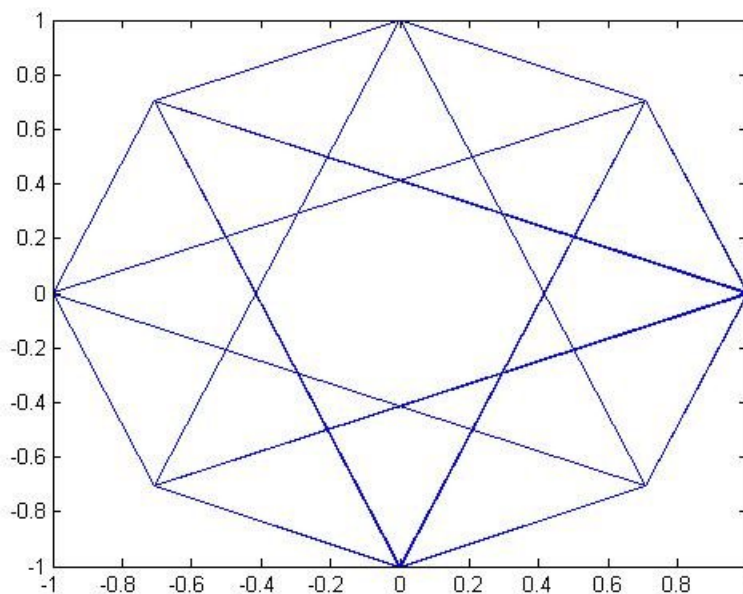
1. Draw and explain generation and detection of DPSK.
2. Write program for DPSK.

**Program**:-

# DPSK #

```
M=4 ; % use dpsk in this example.so M=4.
x=randint(300,1,M,13) ; % random data.
y=dpskmod(x,M,pi/4) ; % modulation using non-zero initial phase.
plot(y) ; % plot all the points(use lines to connect them).
```

**Output Waveform** :-



**Conclusion**:-Study of DPSK generation and detection is done.



## Exercise No.7

**Aim:** To generate and demodulate quadrature phase shifted (QPSK) signal using MATLAB

**Software:-** MATLAB 7.10

### **Theory:**

#### **Generation of Quadrature phase shift keyed (QPSK) signal**

QPSK is also known as quaternary PSK, quadriphase PSK, 4-PSK, or 4-QAM. It is a phase modulation technique that transmits two bits in four modulation states.

Phase of the carrier takes on one of four equally spaced values such as  $\pi/4$ ,  $3\pi/4$ ,  $5\pi/4$  and  $7\pi/4$ .

$$S_i(t) = \sqrt{2E/T} \cos \{2\pi fct + (2i - 1)\pi/4\}, 0 \leq t \leq T$$

0, elsewhere

Where  $i = 1, 2, 3, 4$ , &  $E = T_x$  signal energy per symbol

$T =$  symbol duration

Each of the possible value of phase corresponds to a pair of bits called dibits.

Thus the gray encoded set of dibits: 10, 00, 01, 11

$$S_i(t) = \sqrt{2E/T} \cos [(2i - 1)\pi/4] \cos (2\pi fct) - \sqrt{2E/T} \sin [(2i - 1)\pi/4] \sin (2\pi fct), 0 \leq t \leq T_b$$

0, else where

There are two orthonormal basis functions

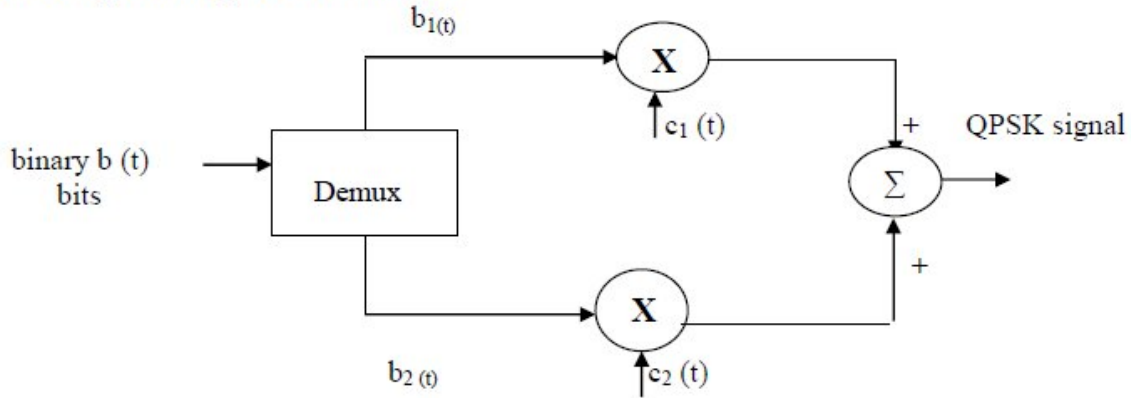
$$c_1(t) = \sqrt{2/T} \cos 2\pi fct, 0 \leq t \leq T_b$$

$$c_2(t) = \sqrt{2/T} \sin 2\pi fct, 0 \leq t \leq T_b$$

Input dibits	Phase of QPSK signal	Co-ordinates of message signals	
		S1	S2
10	$\pi/4$	$\sqrt{E/2}$	$-\sqrt{E/2}$
00	$3\pi/4$	$-\sqrt{E/2}$	$-\sqrt{E/2}$
01	$5\pi/4$	$-\sqrt{E/2}$	$+\sqrt{E/2}$
11	$7\pi/4$	$+\sqrt{E/2}$	$+\sqrt{E/2}$

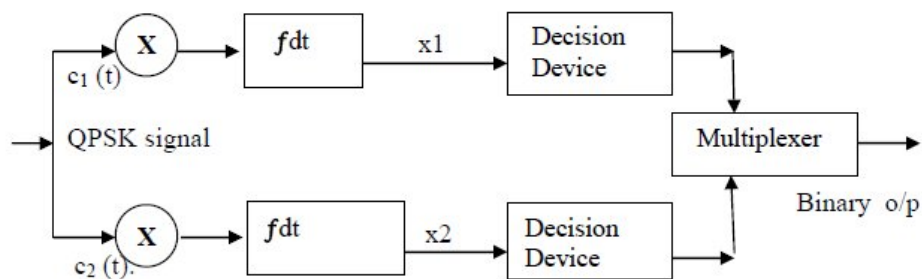
There are four message points

### Block diagram of QPSK Transmitter



The I/p binary sequence  $b(t)$  is represented in polar form with symbols 1 & 0 represented as  $+\sqrt{E}/2$  and  $-\sqrt{E}/2$ . This binary wave is demultiplexed into two separate binary waves consisting of odd & even numbered I/P bits denoted by  $b_1(t)$  &  $b_2(t)$ .  $b_1(t)$  &  $b_2(t)$  are used to modulate a pair of quadrature carrier. The result is two PSK waves. These two binary PSK waves are added to produce the desired QPSK signal

### QPSK Receiver:



QPSK receiver consists of a pair of correlators with common I/P & supplied with locally generated signal  $c_1(t)$  &  $c_2(t)$ . The correlator output,  $x_1$ , &  $x_2$  are each compared with a threshold of zero volts. If  $x_1 > 0$ , decision is made in favour of symbol '1' for upper channel and if  $x_1 < 0$ , decision is made in favour of symbol 0. Parallely if  $x_2 > 0$ , decision is made in favour of symbol 1 for lower channel & if  $x_2 < 0$ , decision is made in favour of symbol 0. These two channels are combined in a multiplexer to get the original binary output.

**Algorithm:-**

Initialization commands

**QPSK modulation**

1. Generate quadrature carriers.
2. Start FOR loop
3. Generate binary data, message signal(bipolar form)
4. Multiply carrier 1 with odd bits of message signal and carrier 2 with even bits of message signal
5. Perform addition of odd and even modulated signals to get the QPSK modulated signal
6. Plot QPSK modulated signal.
7. End FOR loop.
8. Plot the binary data and carriers.

**QPSK demodulation**

1. Start FOR loop
2. Perform correlation of QPSK modulated signal with quadrature carriers to get two decision variables  $x_1$  and  $x_2$ .
3. Make decision on  $x_1$  and  $x_2$  and multiplex to get demodulated binary data.  
If  $x_1 > 0$  and  $x_2 > 0$ , choose '11'. If  $x_1 > 0$  and  $x_2 < 0$ , choose '10'. If  $x_1 < 0$  and  $x_2 > 0$ , choose '01'. If  $x_1 < 0$  and  $x_2 < 0$ , choose '00'.
4. End FOR loop
5. Plot demodulated data

**Program:-**

```
% QPSK Modulation
clc;
clear all;
close all;
%GENERATE QUADRATURE CARRIER SIGNAL
Tb=1;t=0:(Tb/100):Tb;fc=1;
c1=sqrt(2/Tb)*cos(2*pi*fc*t);
c2=sqrt(2/Tb)*sin(2*pi*fc*t);
%generate message signal
N=8;m=rand(1,N);
t1=0;t2=Tb
for i=1:2:(N-1)
t=[t1:(Tb/100):t2]
if m(i)>0.5
m(i)=1;
m_s=ones(1,length(t));
else
m(i)=0;
m_s=-1*ones(1,length(t));
end
%odd bits modulated signal
```

```

odd_sig(i,:)=c1.*m_s;
if m(i+1)>0.5
    18
    m(i+1)=1;
    m_s=ones(1,length(t));
else
    m(i+1)=0;
    m_s=-1*ones(1,length(t));
end
%even bits modulated signal
even_sig(i,:)=c2.*m_s;
%qpsk signal
qpsk=odd_sig+even_sig;
%Plot the QPSK modulated signal
subplot(3,2,4);plot(t,qpsk(i,:));
title('QPSK signal');xlabel('t---->');ylabel('s(t)');grid on; hold on;
t1=t1+(Tb+.01); t2=t2+(Tb+.01);
end
hold off
%Plot the binary data bits and carrier signal
subplot(3,2,1);stem(m);
title('binary data bits');xlabel('n---->');ylabel('b(n)');grid on;
subplot(3,2,2);plot(t,c1);
title('carrier signal-1');xlabel('t---->');ylabel('c1(t)');grid on;
subplot(3,2,3);plot(t,c2);
title('carrier signal-2');xlabel('t---->');ylabel('c2(t)');grid on;
% QPSK Demodulation
t1=0;t2=Tb
for i=1:N-1
    t=[t1:(Tb/100):t2]
    %correlator
    x1=sum(c1.*qpsk(i,:));
    x2=sum(c2.*qpsk(i,:));
    %decision device
    if (x1>0&&x2>0)
        demod(i)=1;
        demod(i+1)=1;
    elseif (x1>0&&x2<0)
        demod(i)=1;
        demod(i+1)=0;
    elseif (x1<0&&x2<0)
        demod(i)=0;
        demod(i+1)=0;
    elseif (x1<0&&x2>0)
        demod(i)=0;
        demod(i+1)=1;
    end
end

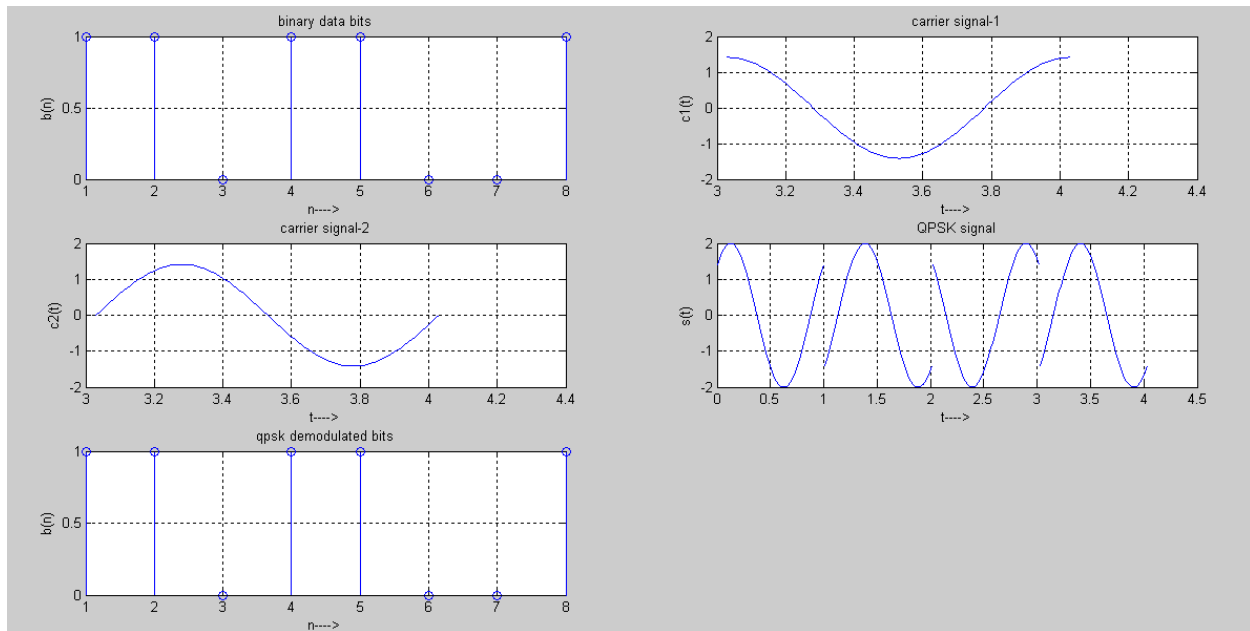
```

```

end
t1=t1+(Tb+.01); t2=t2+(Tb+.01);
end
subplot(3,2,5);stem(demod);
title('qpsk demodulated bits');xlabel('n---->');ylabel('b(n)');grid on;

```

**Output waveform:**



**Conclusion:-** Thus we have studied QPSK generation and detection. The program for QPSK modulation and demodulation has been simulated in MATLAB and necessary graphs are plotted.

## Exercise No.8

**Aim** :- Study of PCM generation and detection

**Software** :- MATLAB 7.10

**Theory** :-

1. Draw and explain generation and detection of PCM .

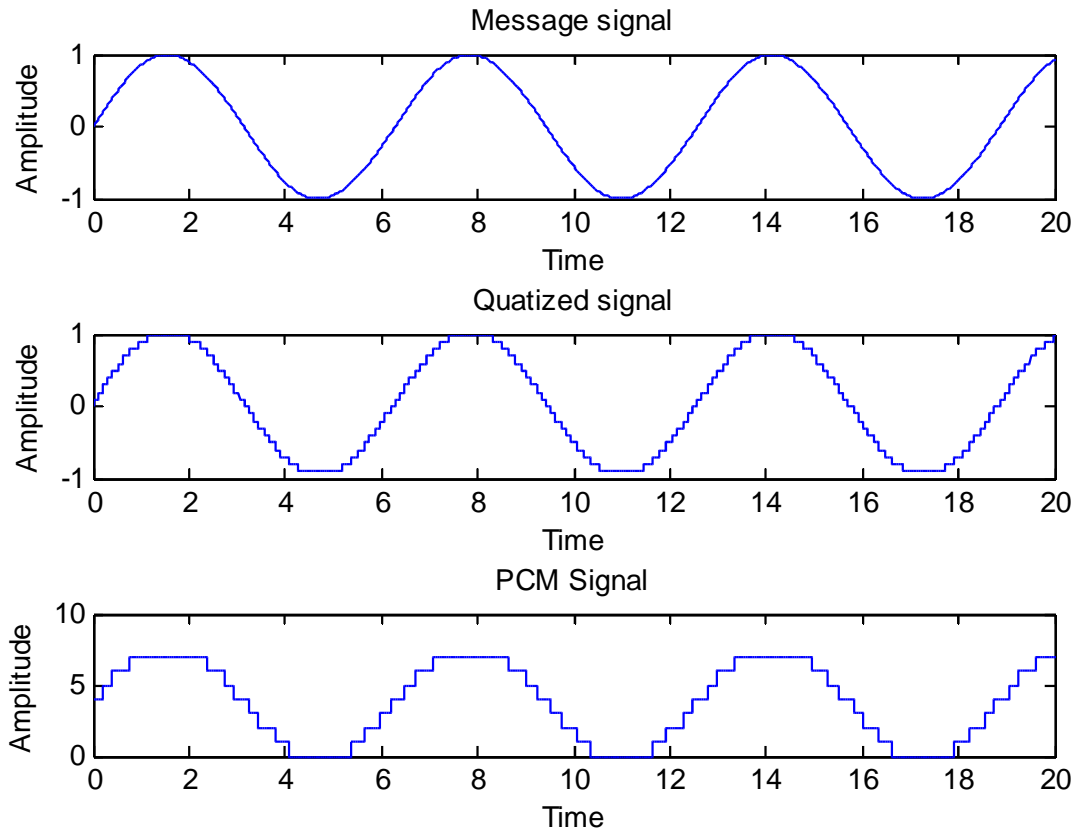
**Algorithm**:-

- 1) Declare Range of Given signal.
- 2) Declare of partition levels and Quantization.
- 3) Declare of codebook with an increment of 1 interval.
- 4) On sin waveform apply quantization and declare of Quantization process.
- 5) Encoding of above gives PCM signal.

**Program**:-

```
clc;
clear all;
close all;
t=0:0.0005:20;      % Range of Given signal.
partition=-1:0.1:1; % Declaration of partition levels and Quantization.
codebook=-1:0.1:1.1; % Declaration of codebook with an increment of 1 interval.
x=sin(t);          % Input Sine Wave.
[index,quants]=quantiz(x,partition,codebook); % Declaration of Quantization process
subplot(3,1,1);
plot(t,x);         % Plot 1st sine wave input.
title('Message signal'); % Labelling 1st Block.
xlabel('Time');    % Labelling x axis.
ylabel('Amplitude'); % Labelling y axis.
subplot(3,1,2);
plot(t,quants);   % Plot quantized signal.
title('Quantized signal'); % Labelling 2nd block.
xlabel('Time');   % Labelling x axis.
ylabel('Amplitude'); % Labelling y axis.
y=uencode(quants,3);
subplot(3,1,3);
plot(t,y);        % Plot encoding signal.
title('PCM Signal'); % Labelling 3rd block.
xlabel('Time');   % Labelling x axis.
ylabel('Amplitude'); % Labelling y axis.
```

**Output Waveform :-**



**Conclusion:-** Thus we have studied PCM generation and detection.

## **Exercise No.9:**

**Aim** :- Study of Delta Modulation

**Theory** :-

1. Draw and explain generation and detection of DM.

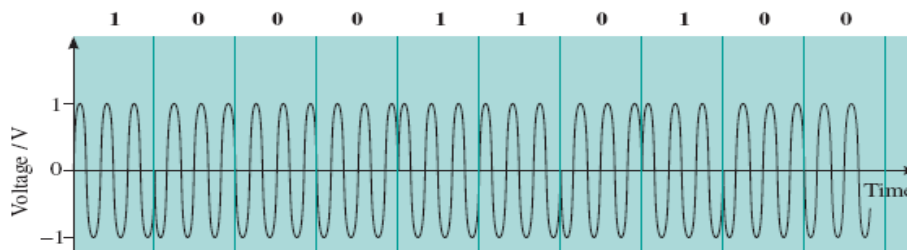
**Conclusion**:-Study of Delta Modulation is done.



### 3. Quiz on the subject:

Quiz should be conducted on tips in the laboratory, recent trends and subject knowledge of the subject. The quiz questions should be formulated such that questions are normally from the scope outside of the books. However twisted questions and self formulated questions by the faculty can be asked but correctness of it is necessarily to be thoroughly checked before the conduction of the quiz.

1. Given the following binary modulation scheme shown below:



The above modulation scheme is an example of \_\_\_\_\_.

- phase shift keying
  - frequency shift keying
  - amplitude shift keying
  - continuous-phase frequency shift keying
2. In a linear system, if an input  $x_1(t)$  produces an output  $y_1(t)$ , and an input  $x_2(t)$  produces an output  $y_2(t)$ , then an input  $x_1(t) + x_2(t)$  produces an output  $y_1(t) + y_2(t)$ . This property of the linear system obeys \_\_\_\_\_.
- frequency preservation property
  - orthogonal property
  - principle of superposition
  - amplification property
3. On-off keying is the modulation scheme used for the majority of optical-fiber communication systems. This scheme is an example of \_\_\_\_\_.
- binary frequency shift keying
  - binary phase shift keying
  - binary continuous-phase frequency shift keying
  - binary amplitude shift keying
4. Light is an electromagnetic wave similar to a radio signal with a frequency \_\_\_\_\_.
- very much slower than frequency of a radio signal
  - very much higher than frequency of a radio signal
  - identical to the frequency of a radio signal
  - very similar to the frequency of a radio signal

5. An important impairment to digital signals in a communication system is the irregularities in timing caused by imperfections in clock extraction and waveform regeneration. This effect is known as \_\_\_\_\_.
- a. jitter
  - b. aliasing
  - c. fading
  - d. attenuation
6. A useful spectral model of many types of noise encountered in communication systems is White noise. An important property of a White noise is that it has \_\_\_\_\_.
- a. a decreasing power density for all frequencies
  - b. an increasing power density for all frequencies
  - c. a constant power density for all frequencies
  - d. an increasing power density for high frequencies only
7. The exact format of frame in case of synchronous transmission depends on whether transmission scheme is
- a. digital
  - b. analog
  - c. either character oriented or bit oriented
  - d. none of these above
8. Coaxial cables are widely used on
- a. telephone networks
  - b. cable TV networks
  - c. broadband networks
  - d. none of these above
9. For carrying digital data over long distance using either analog signal or digital signal at approximately spaced points, we must have
- a. amplifiers
  - b. repeater
  - c. switch
  - d. either amplifier or repeater
10. The effective bandwidth of a signal is the
- a. width of the spectrum
  - b. width of range of frequencies
  - c. band of frequencies containing most of the energy in the signal
  - d. width of the channel

11. Telephone companies normally provide a voltage of \_\_\_\_\_ to power telephones.
- +24 volts DC
  - 24 volts DC
  - +48 volts DC
  - 48 volts DC.
12. The situation when both transmitter and receiver have to work in tandem is referred to as
- parallel
  - serial
  - synchronous
  - asynchronous
13. Which transmission mode is used for data communication along telephone lines?
- Parallel
  - Serial
  - Synchronous
  - Asynchronous
14. A large numbers of computers in a wide geographical area can be efficiently connected using
- twisted pair lines
  - coaxial cables
  - Communication satellites
  - all of the above
15. A sample rate of \_\_\_\_\_ is required for a good quality representation of telephone conversation.
- 4500 times per second.
  - 700 integer sample points per minute.
  - 50 times per second per mile of distance travelled.
  - 8000 times per second.

(Key- 1-a, 2-c, 3-d, 4-b, 5-a, 6-c, 7-c, 8-b, 9-d, 10-c, 11-d, 12-c, 13-b, 14-d, 15-c)

#### **4. Conduction of Viva-Voce Examinations:**

Teacher should conduct oral exams of the students with full preparation. Normally, the objective questions with guess should be avoided. To make it meaningful, the questions should be such that depth of the students in the subject is tested. Oral examinations are to be conducted in cordial environment amongst the teachers taking the examination. Teachers taking such examinations should not have ill thoughts about each other and courtesies should be offered to each other. Difference of opinion, if any, should be critically suppressed in front of the students.

#### **5. Evaluation and marking system:**

Basic honesty in the evaluation and marking system is absolutely essential and in the process impartial nature of the evaluator is required in the examination. It is a wrong approach to award the students by way of easy marking to get cheap popularity among the students, which they do not deserve. It is a primary responsibility of the teacher to see that right students who are really putting up lot of hard work with right kind of intelligence are correctly awarded. The marking patterns should be justifiable to the students without any ambiguity and teacher should see that students are faced with just circumstances.