WIRELESS COMMUNICATION

PRACTICAL FILE

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IT- BATCH 2
41310403117(38)

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PRACTICAL 1

Aim: Various types of plots using matlab.

Additive white Gaussian noise

A basic and generally accepted model for thermal noise in communication channels, is the set of assumptions that

- ● The noise is additive, i.e., the received signal equals the transmit signal plus some noise, where the noise is statistically independent of the signal.

- ● The noise is white, i.e, the power spectral density is flat, so the autocorrelation of the noise in the time domain is zero for any non-zero time offset.

- ● The noise samples have a Gaussian distribution. Mostly it is also assumed that the channel is Linear and Time Invariant. The most basic results further assume that it is also frequency non-selective.

Plot-1:
Eb/No:-0.18 dB
Channel type: AWGN
Modulation type: PSK
Modulation order:

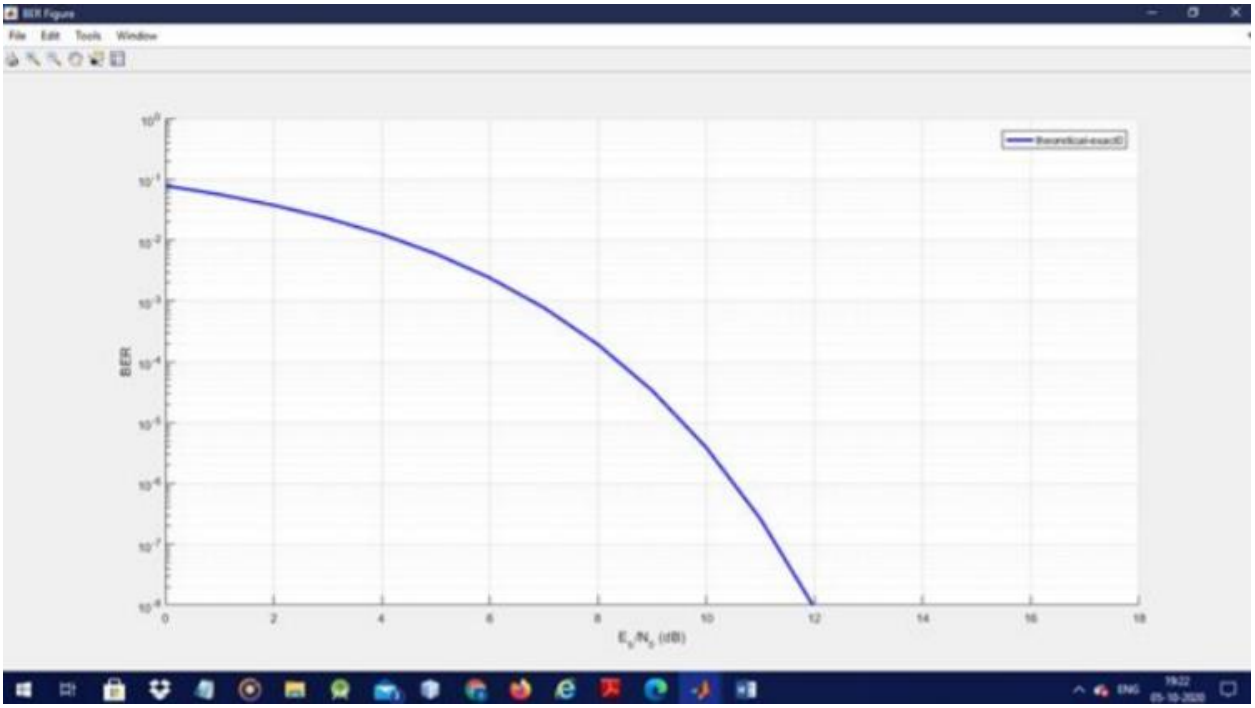


Fig. Additive White Gaussian Noise Plot 1

Plot-2:

Eb/No:-0.18

dB Channel type: AWGN

Modulation type: DPSK

Modulation order: 2

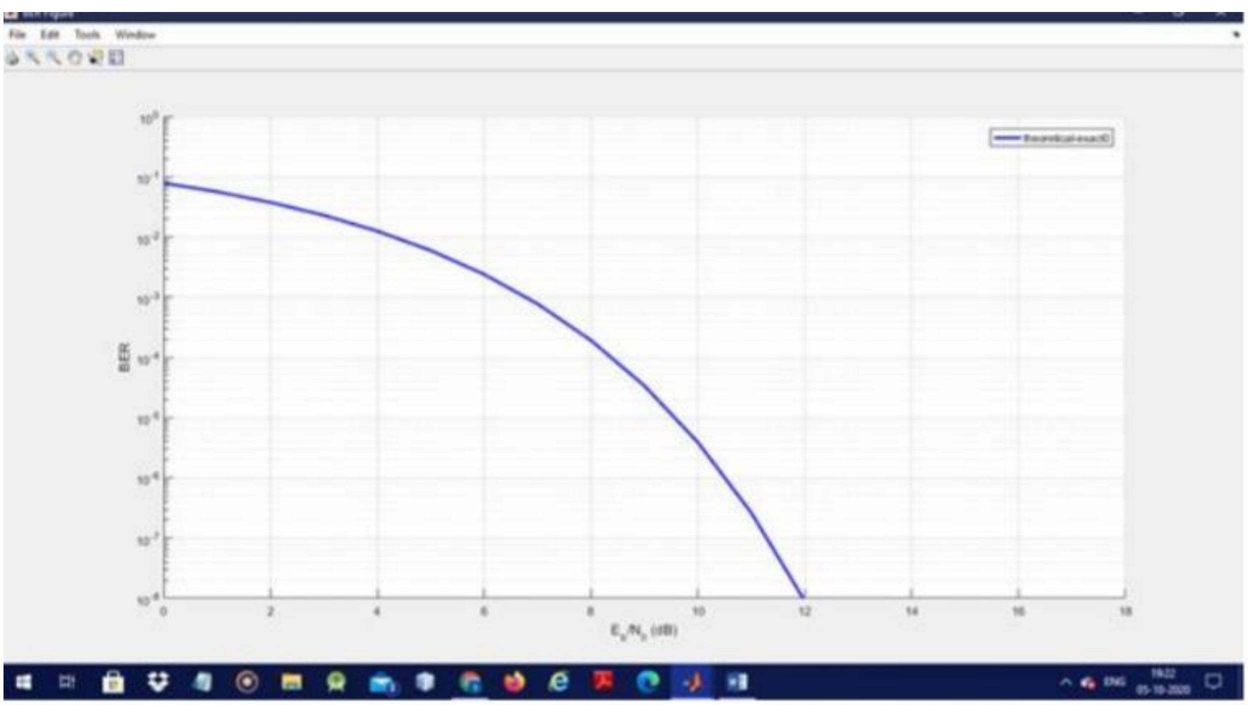


Fig. Additive White Gaussian Noise Plot 2

Rayleigh

The Rayleigh fading model uses a statistical approach to analyse the propagation, and can be used in a number of environments.

The Rayleigh fading model is ideally suited to situations where there are large numbers of signal paths and reflections. Typical scenarios include cellular telecommunications where there are large number of reflections from buildings and the like and also HF ionospheric communications where the uneven nature of the ionosphere means that the overall signal can arrive having taken many different paths.

The Rayleigh fading model is also appropriate for tropospheric radio propagation because, again there are many reflection points and the signal may follow a variety of different paths.
The Rayleigh fading model may be defined as follow:

· **Rayleigh fading model:** Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium (also called a communications channel) will vary randomly, or fade, according to a Rayleigh distribution — the radial component of the sum of two uncorrelated Gaussian random variables.

Plot-3:
Eb/No:-0.18 dB
Channel type: Rayleigh
Diversity order: 1
Modulation type: PSK
Modulation order: 2

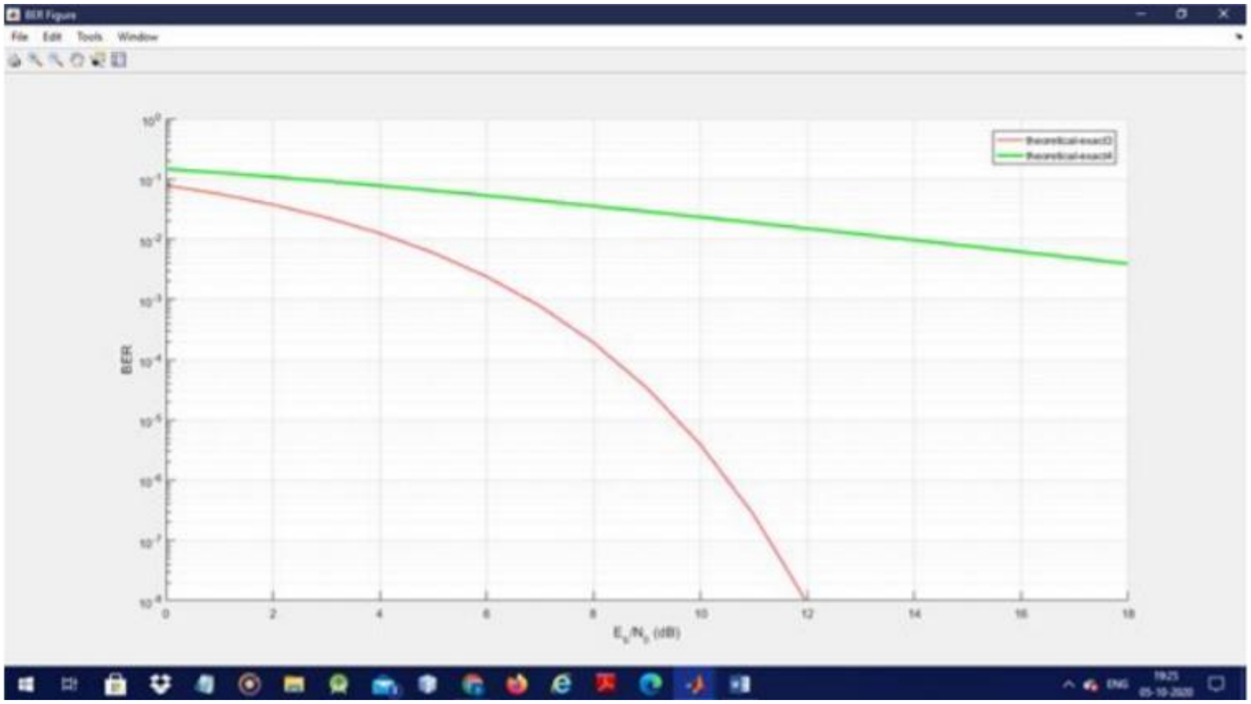


Fig. Rayleigh Plot 3

Plot-4:

Eb/No:-0.18 dB

Channel type: Rayleigh

Diversity order: 2

Modulation type: PSK

Modulation order: 2

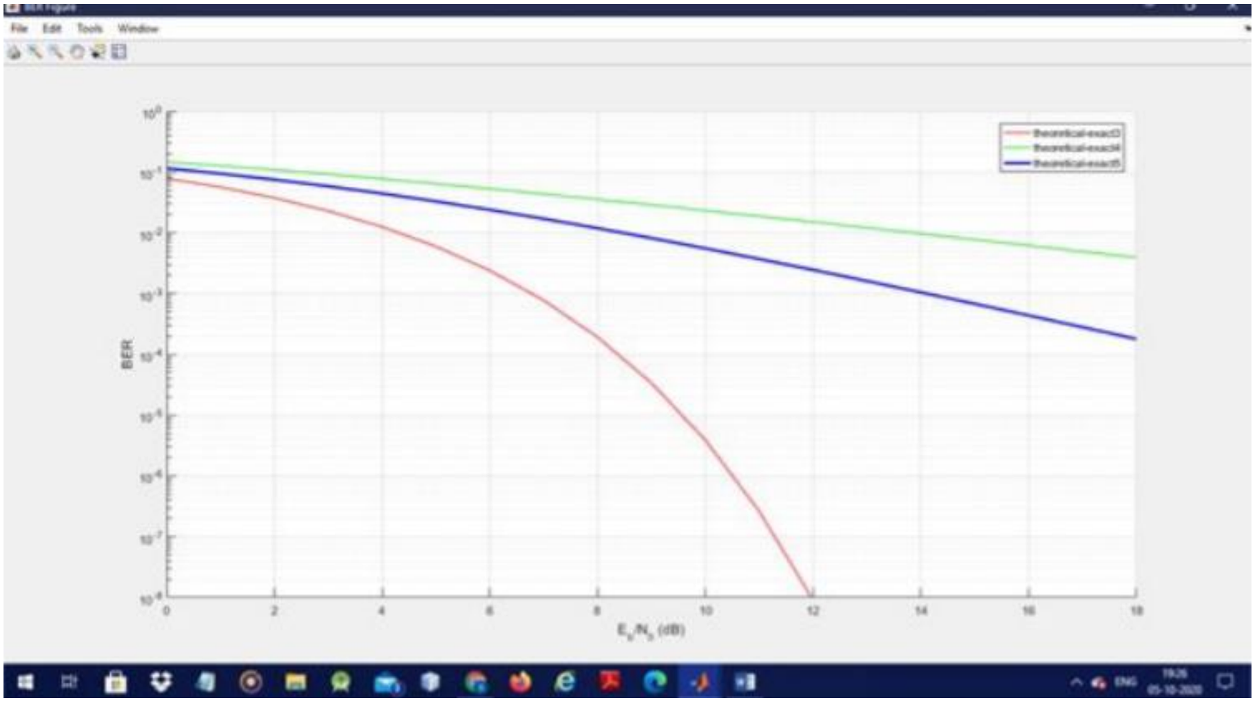


Fig. Rayleigh Plot 4

Rician fading

The model behind Rician fading is similar to that for Rayleigh fading, except that in Rician fading a strong dominant component is present. This dominant component can for instance be the line-of-sight wave. Refined Rician models also consider that

- That the dominant wave can be a phasor sum of two or more dominant signals, e.g. the line-of-sight, plus a ground reflection. This combined signal is then mostly treated as a deterministic (fully predictable) process, and that
- The dominant wave can also be subject to shadow attenuation. This is a popular assumption in the modelling of satellite channels.

Besides the dominant component, the mobile antenna receives a large number of reflected and scattered waves.

Plot-5:

Eb/No:-0.18 dB
Channel type: Rician
Diversity order: 2
K-factor: 0
Modulation type: PSK
Modulation order: 2

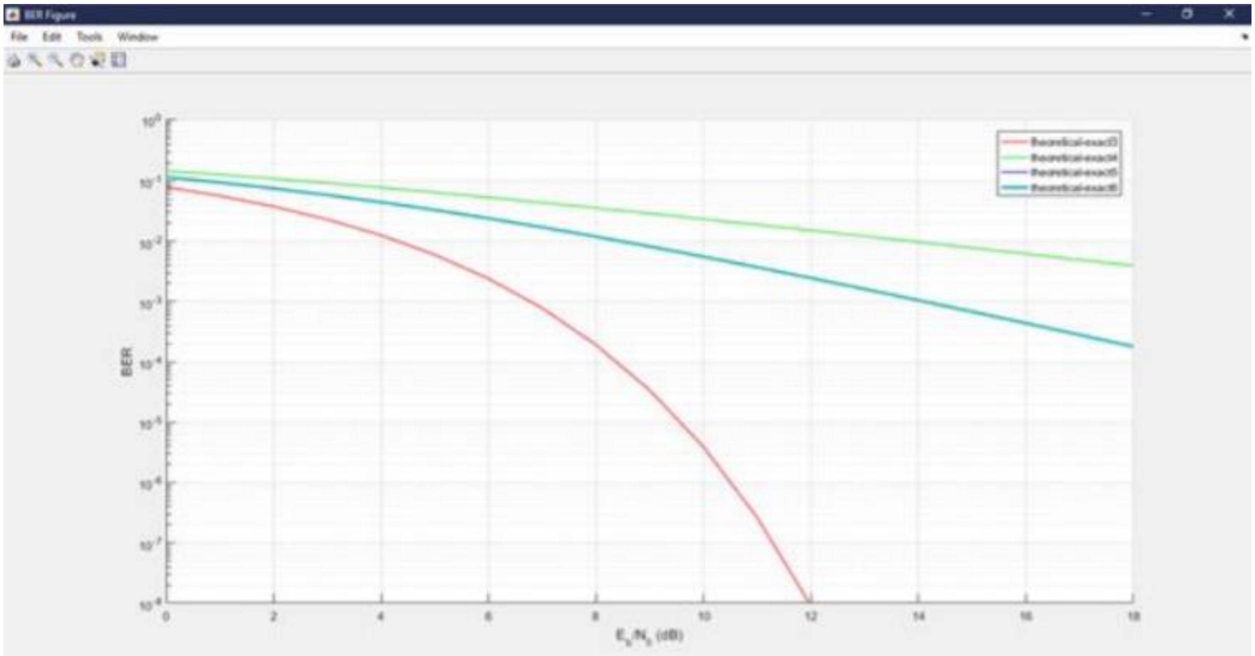


Fig. Rayleigh Plot 5

Plot-6:

Eb/No:-0.18 dB

Channel type: Rician

Diversity order: 2

K-factor: 1

Modulation type: PSK

Modulation order: 2

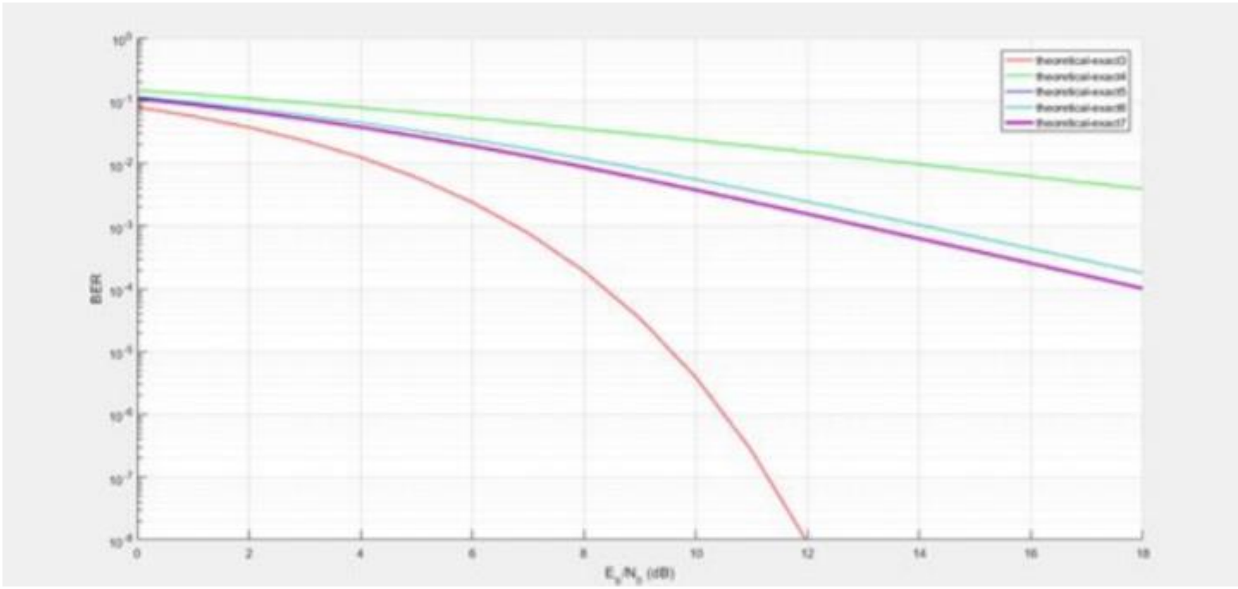


Fig. Rayleigh Plot 6

PRACTICAL 2

AIM: Generation of CDMA

Code Division Multiple Access (CDMA) is a sort of multiplexing that facilitates various signals to occupy a single transmission channel. It optimizes the use of available bandwidth. The technology is commonly used in ultra-high-frequency (UHF) cellular telephone systems, bands ranging between the 800-MHz and 1.9-GHz.

CDMA Overview

Code Division Multiple Access system is very different from time and frequency multiplexing. In this system, a user has access to the whole bandwidth for the entire duration. The basic principle is that different CDMA codes are used to distinguish among the different users.
Techniques generally used are direct sequence spread spectrum modulation (DS-CDMA), frequency hopping or mixed CDMA detection (JDCDMA). Here, a signal is generated which extends over a wide bandwidth. A code called spreading code is used to perform this action. Using a group of codes, which are orthogonal to each other, it is possible to select a signal with a given code in the presence of many other signals with different orthogonal codes.

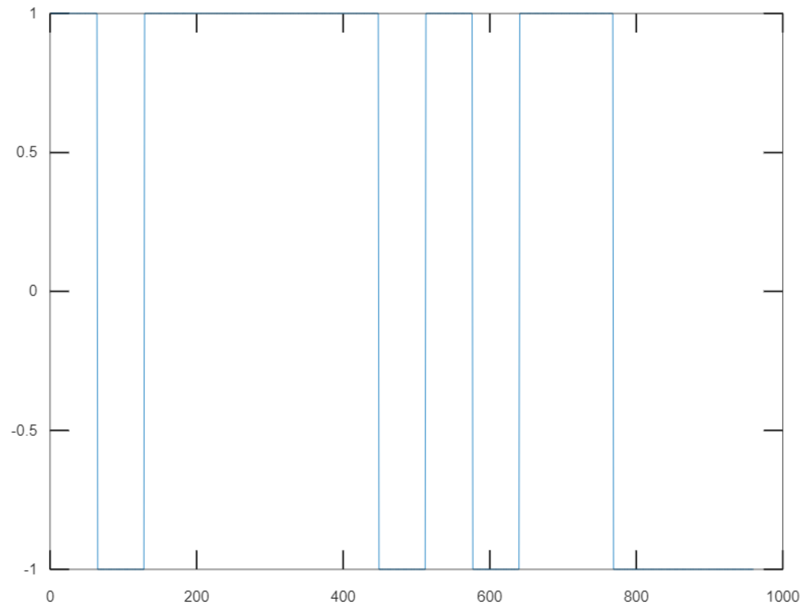
How Does CDMA Work?

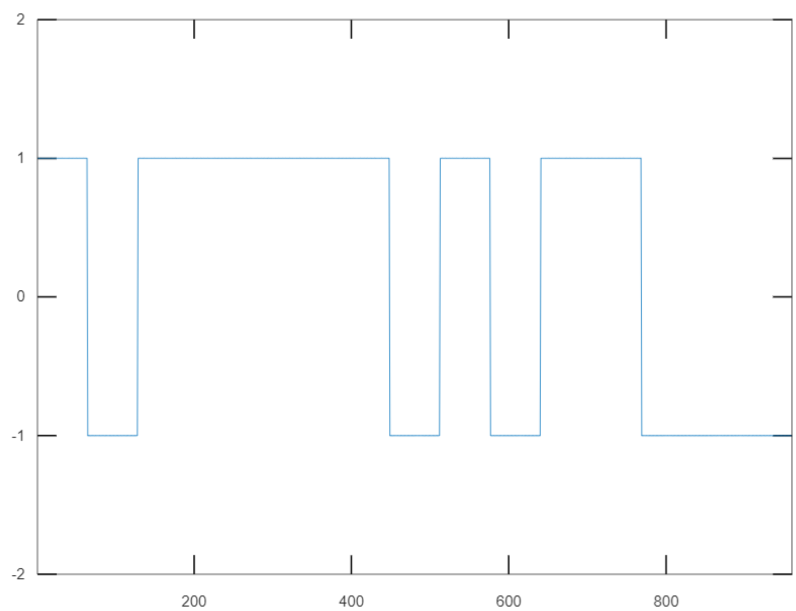
CDMA allows up to 61 concurrent users in a 1.2288 MHz channel by processing each voice packet with two PN codes. There are 64 Walsh codes available to differentiate between calls and theoretical limits. Operational limits and quality issues will reduce the maximum number of calls somewhat lower than this value.
In fact, many different "signals" baseband with different spreading codes can be modulated on the same carrier to allow many different users to be supported. Using different orthogonal codes, interference between the signals is minimal. Conversely, when signals are received from several mobile stations, the base station is capable of isolating each as they have different orthogonal spreading codes.
The following figure shows the technicality of the CDMA system. During the propagation, we mixed the signals of all users, but by that you use the same code as the code that was used at the time of sending the receiving side. You can take out only the signal of each user.

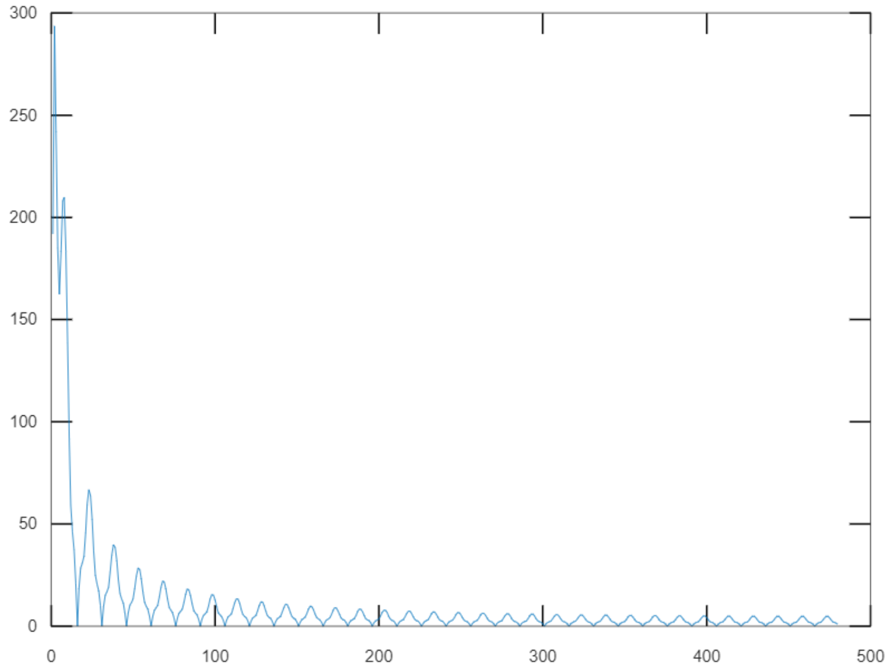
```
%Firstly we generate a small random sequence of binary data, that we represent as a
%sampled waveform with 64 samples per bit.
% CDMA example
clear all
data = randi([0,1],1,15);
count = 0;
```

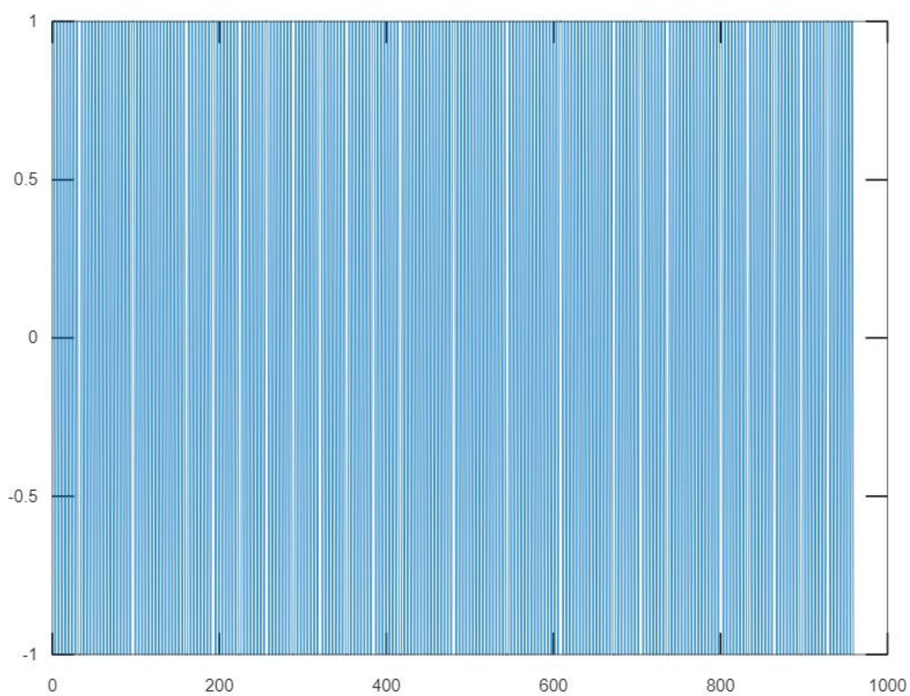
```
for i = 1:15
   for j = 1:64
      count = count + 1;
      data_exp(count) = data(i);
   end
end
data_exp = 2*data_exp - 1;
figure(1)
plot(data_exp)
axis([1,15*64,-2,2])

%Then we generate the spectrum of this signal, to illustrate that it is a fairly narrowband
%signal.
% generate spectrum
data_f = fft(data_exp);
figure(11)
plot(abs(data_f(1:(15*32))))
title('data spectrum')
pause

%Then we select one of the Walsh codes, and use it to spread our data. The spreading
%process simply involves multiplying the data line code by the higher rate spreading
%code (the spreading code here is at 64 times the data rate. That is, chip rate = 64 * data
%rate). The resultant signal is at a much higher data rate – the same as the chip rate.
% generate a spreading code for a user
codes = hadamard(64);
user_code = codes(:,35);
spread = zeros(1,15*64);
count = 0;
for i = 1:15,
   spread((count+1):(count+64))=data_exp((count+1):(count+64)).*(user_code');
   count = count + 64;
end
figure(2)
plot(spread)
axis([1,15*64,-2,2])
pause

% The resultant spectrum is much wider in bandwidth than the spectrum of the data
% signal. Note that the code below doesn't give an accurate rendition of the spectrum of
% the spread signal. Why?
spread_f = fft(spread);
figure(12)
plot(abs(spread_f(1:(15*32))))
title('spread spectrum')
pause
```

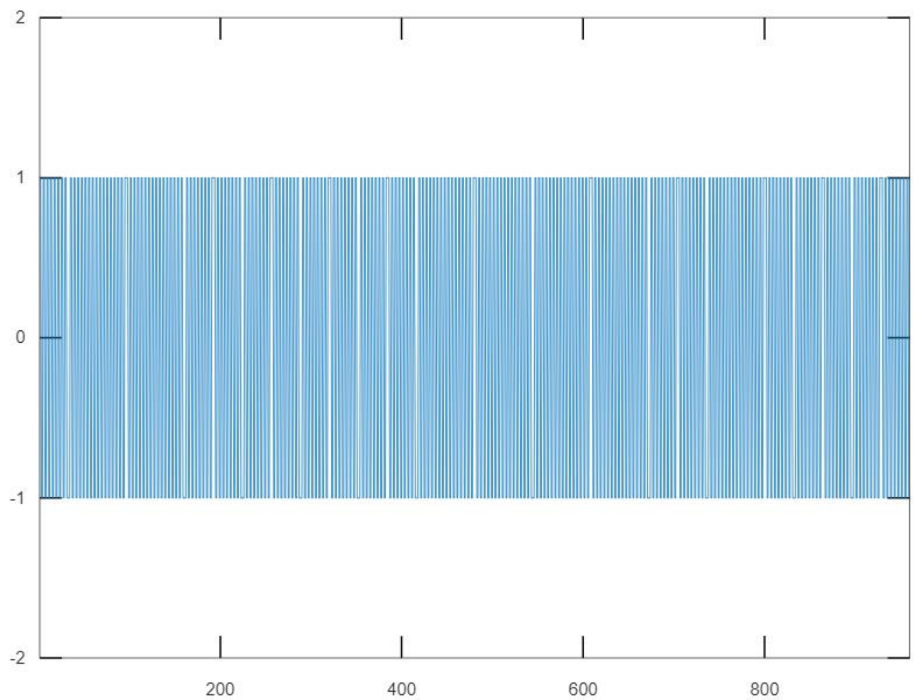
```
% We can then recover the data from the spread signal by multiplying by the code
% waveform and summing every 64 chips (since 1*1 = 1 and -1*-1 = 1, the effect of
% multiplying by the code twice is to recover the original data sequence. Obviously
% synchronisation is an issue – how do we match the code sequence at the transmitter
% and the receiver?
% recover user data
count = 0;
for i = 1:15,
  data_desp((count+1):(count+64)) = spread((count+1):(count+64)).*(user_code');
  count = count + 64;
end
time_base = 1:(15*64);
count = 0;
for i = 1:15,
  data_rec(i) = sum(data_desp((count+1):(count+64)))/64;
  count = count+64;
end
count = 0;
for i = 1:15,
  for j = 1:64,
    count = count + 1;
    data_rec_exp(count) = data_rec(i);
  end
end
figure(3)
plot(time_base,data_rec_exp,time_base,data_exp)
axis([1,15*64,-2,2])
pause
% We can add noise to the CDMA spread signal to such an extent that the signal is
% indistinguishable below the ‘noise floor’.
% now let's add some noise
noise = 5*randn(1,15*64);
noisy_cdma = spread + noise;
figure(4)
plot(noisy_cdma)
axis([1,15*64,-12,12])
pause
```


1
0.5
0
-0.5
-1
0
200
400
600
800
1000

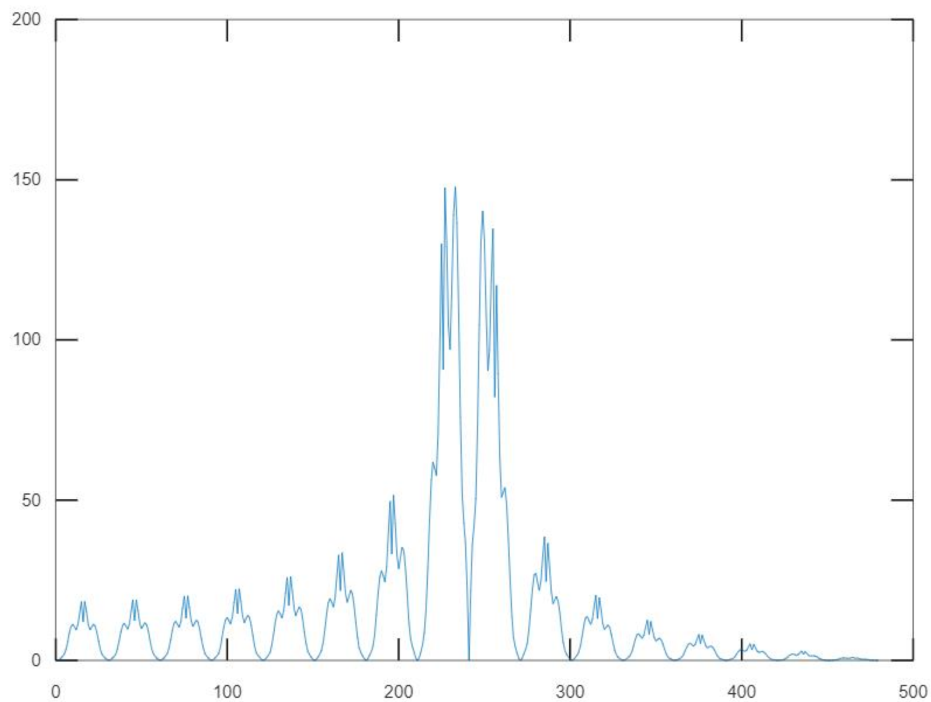

2
1
0
-1
-2
200
400
600
800


300
250
200
150
100
50
0
0
100
200
300
400
500

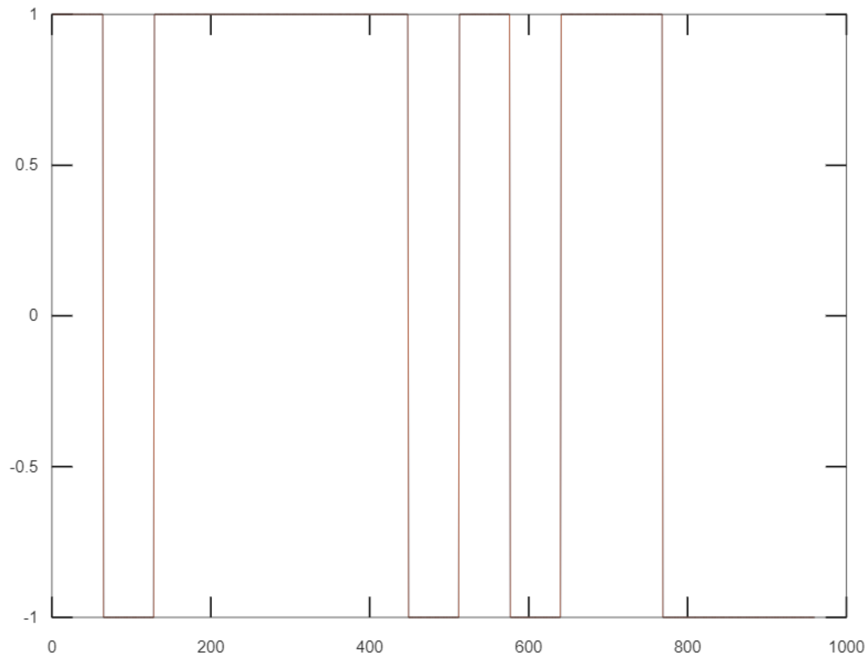

1
0.5
0
-0.5
-1
0
200
400
600
800
1000

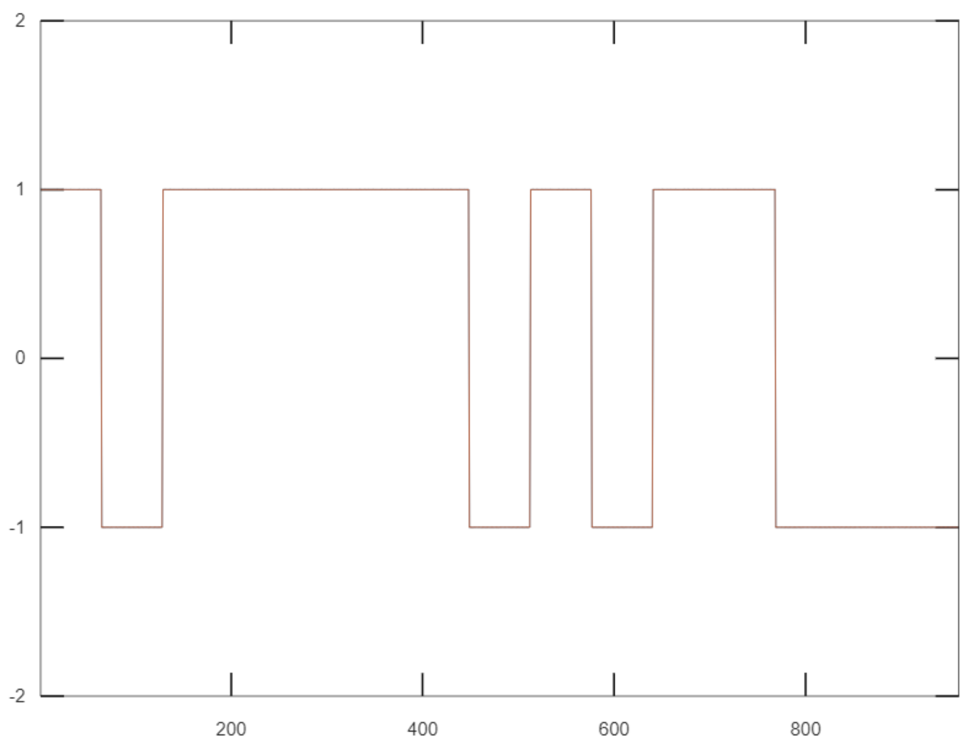


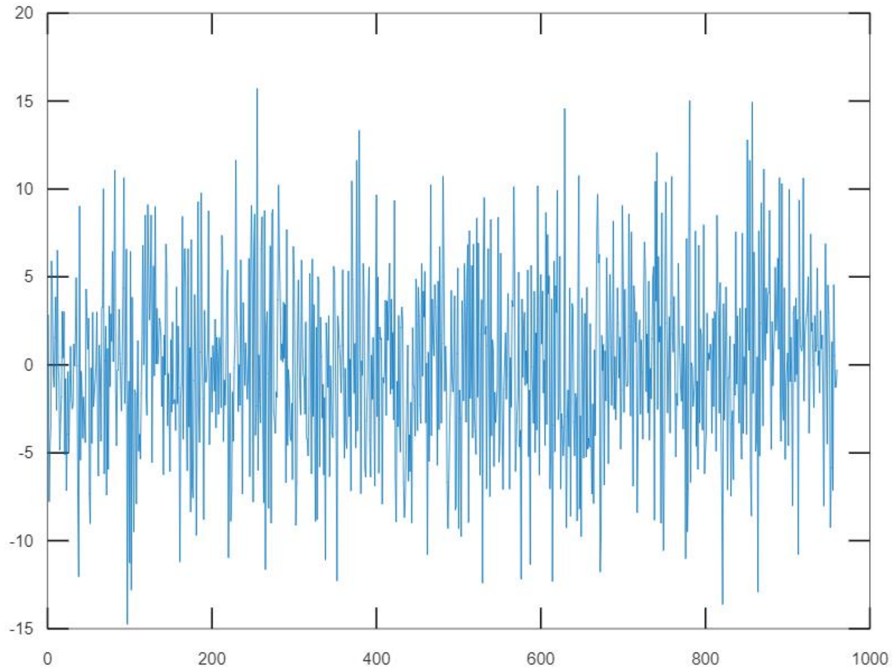
2
1
0
-1
-2
200
400
600
800



200
150
100
50
0
0
100
200
300
400
500


1
0.5
0
-0.5
-1
0
200
400
600
800
1000


2
1
0
-1
-2
200
400
600
800


20
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000

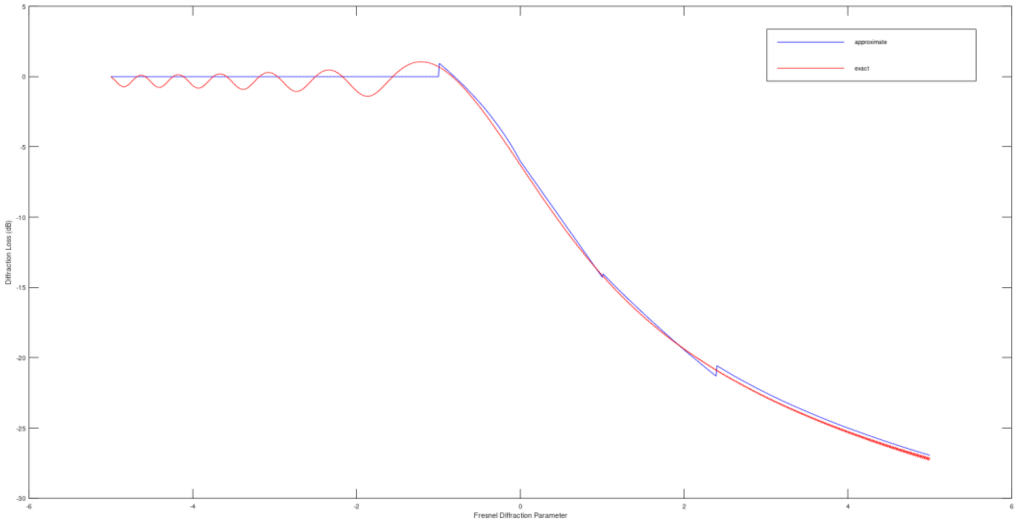
PRACTICAL 3

Knife Edge Diffraction Model

AIM:

Calculation of the path loss based on the value of Fresnel Diffraction Parameter as proposed by Lee W C Y Mobile Communications Engineering 1985

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Exact calculation of the path loss (in dB)
% based on Fresnel Diffraction Parameter (v)
% T S Rappaport Wireless Communications P&P
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

clear all
close all
v=-5:0.01:5;
for n=1:length(v)
   if v(n) <= -1
      G(n)=0;
   elseif v(n) <= 0
      G(n)=20*log10(0.5-0.62*v(n));
   elseif v(n) <= 1
      G(n)=20*log10(0.5*exp(-0.95*v(n)));
   elseif v(n) <= 2.4
      G(n)=20*log10(0.4-sqrt(0.1184-(0.38-0.1*v(n))^2));
   else
      G(n)=20*log10(0.225/v(n));
   end
  end
plot(v, G, 'b');hold on;

for n=1:length(v)
     v_vector=v(n):0.01:v(n)+100;
   F(n)=((1+1i)/2)*sum(exp((-1i*pi*(v_vector).^2)/2));
end
F=abs(F)/(abs(F(1)));
plot(v, 20*log10(F),'r'); hold on;
legend('approximate','exact');
xlabel('Fresnel Diffraction Parameter')
ylabel('Diffraction Loss (dB)')
```

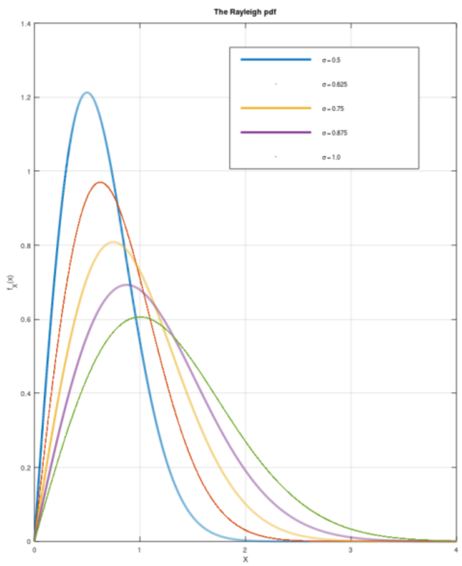

approximate
exact
Diffraction Loss (dB)
Fresnel Diffraction Parameter
5
0
-5
-10
-15
-20
-25
-30
-6
-4
-2
0
2
4
6

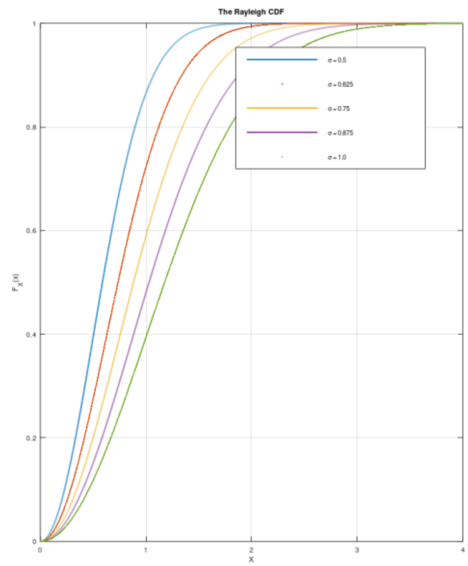
PRACTICAL 4

PROBABILITY DISTRIBUTIONS

<u>RAYLEIGH</u>

```
%%% MATLAB script to generate and
% plot Rayleigh  pdf and CDF..
close all; clear all; clf;
sig=linspace(0.5,1,5);
clr=['-o-','-.-','-+-','--','-x-'];
x=[0:.001:4];
for i=1:length(sig)
fX=x/sig(i)^2.*exp(-x.^2/(2*sig(i)^2));
subplot(121),plot(x,fX,clr(i),'LineWidth',3);
grid on; hold on;
end;
xlabel('X'); ylabel('f_{X}(x)');
title('The Rayleigh pdf');
legend('\sigma = 0.5','\sigma = 0.625',...
   '\sigma = 0.75','\sigma = 0.875',...
   '\sigma = 1.0');
for i=1:length(sig)
FX=1-exp(-x.^2/(2*sig(i)^2));
subplot(122),plot(x,FX,clr(i),'LineWidth',2);
grid on; hold on;
end;
xlabel('X'); ylabel('F_{X}(x)');
title('The Rayleigh CDF');
legend('\sigma = 0.5','\sigma = 0.625',...
   '\sigma = 0.75','\sigma = 0.875',...
   '\sigma = 1.0');
hold off;
%%% end of rayleigh.m
```

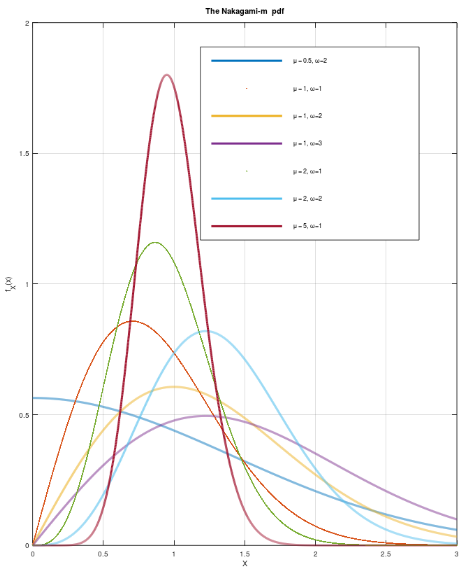


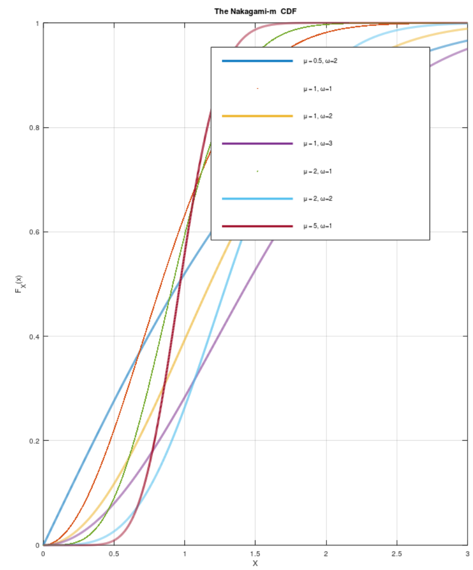


Nakagami-m

```
%%% MATLAB script to generate and
% plot Nakagami-m  pdf and CDF..
%%% MATLAB script to generate and
% plot Nakagami-m  pdf and CDF..
close all; clear all; clf;
m=[0.5,1,1,1,2,2,5];
o=[2,1,2,3,1,2,1];
x=[0:.001:3];
clr=['-.-','-.-','-+-','-x-','..','+-'];
for i=1:length(m)
fX= 2*m(i)^m(i)/(gamma(m(i))*o(i)^m(i))...
   *x.^(2*m(i)-1).*exp(-(m(i)/o(i))*x.^2);
subplot(121),plot(x,fX,clr(i),'LineWidth',3);
grid on;hold on;
end;
xlabel('X'); ylabel('f_{X}(x)');
title('The Nakagami-m  pdf');
legend('\mu = 0.5, \omega=2', '\mu = 1, \omega=1',...
   '\mu = 1, \omega=2','\mu = 1, \omega=3',...
   '\mu = 2, \omega=1','\mu = 2, \omega=2',...
   '\mu = 5, \omega=1');
for i=1:length(m)
FX= gammainc((m(i)/o(i))*x.^2,m(i));
subplot(122),plot(x,FX,clr(i),'LineWidth',3);
grid on; hold on;
 end;
xlabel('X'); ylabel('F_{X}(x)');
```

```
title('The Nakagami-m  CDF');
legend('\mu = 0.5, \omega=2', '\mu = 1, \omega=1',...
   '\mu = 1, \omega=2','\mu = 1, \omega=3',...
   '\mu = 2, \omega=1','\mu = 2, \omega=2',...
   '\mu = 5, \omega=1');
 hold off;
%%% end of nakagamim.m
```

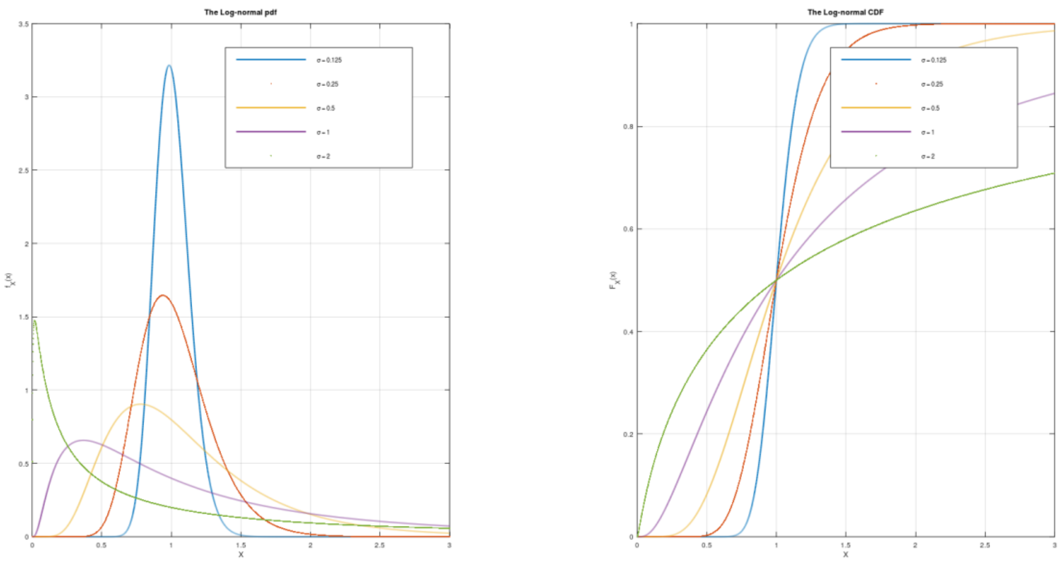




<u>Log-normal</u>

```
%%% MATLAB script to generate and
% plot Log-normal   pdf and CDF..
close all; clear all; clf;
mu=0;
sig=[0.125, 0.25, 0.5, 1, 2];
x=[0:.001:3];
clr=['-o-','-.-','-+-','--','-*-'];
for i=1:length(sig)
fX= 1./(x*sig(i)*sqrt(2*pi)).*exp(-(log(x)...
   -mu^2).^2/(2*sig(i)^2));
subplot(121),plot(x,fX,clr(i),'LineWidth',2);
grid on;hold on;
end;
xlabel('X'); ylabel('f_{X}(x)');
title('The Log-normal pdf');
legend('\sigma = 0.125', '\sigma = 0.25',...
   '\sigma = 0.5', '\sigma = 1','\sigma = 2');
for i=1:length(sig)
```

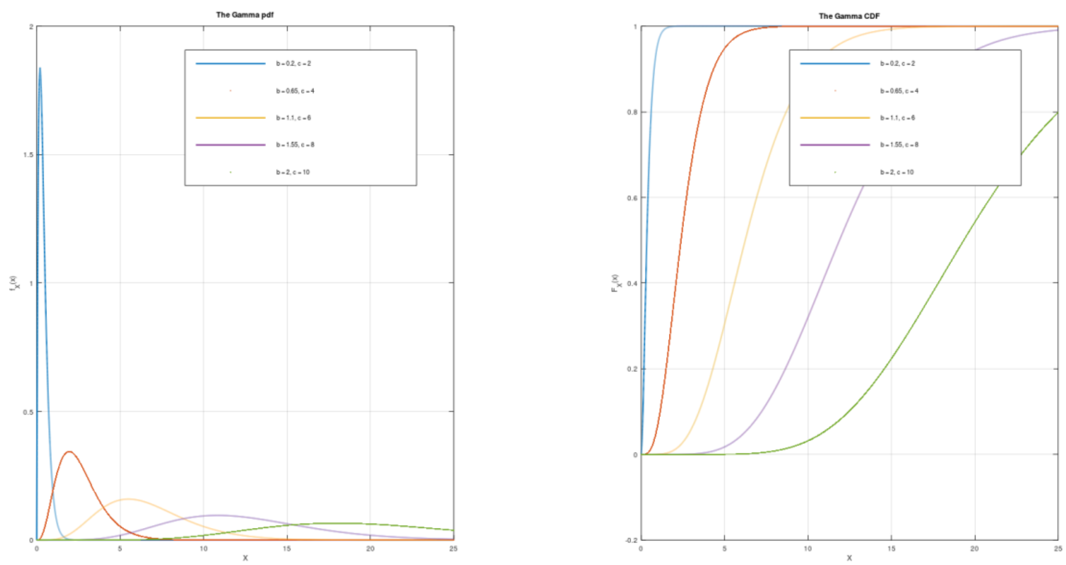
```
FX=0.5+0.5*erf( (log(x)-mu)/(sig(i)*sqrt(2)));
subplot(122),plot(x,FX,clr(i),'LineWidth',2);
grid on;hold on;
 end;
xlabel('X'); ylabel('F_{X}(x)');
title('The Log-normal CDF');
legend('\sigma = 0.125', '\sigma = 0.25',...
   '\sigma = 0.5', '\sigma = 1','\sigma = 2');
hold off;
%%% end of lognormal.m
```



Gamma

```
%%% MATLAB script to generate and
% plot Gamma   pdf and CDF..
close all; clear all; clf;
b=linspace(0.2,2,5);
c=linspace(2,10,5);
x=[0:.001:25];
clr=['-o-','-.-','-+-','--','-x-'];
for i=1:length(b)
fX=  (x/b(i)).^(c(i)-1).*exp(-x/b(i))/...
   (b(i)*gamma(c(i)));
subplot(121),plot(x,fX,clr(i),'LineWidth',2);
grid on;hold on;
end;
xlabel('X'); ylabel('f_{X}(x)');
title('The Gamma pdf');
legend('b = 0.2, c = 2', 'b = 0.65, c = 4',...
   'b = 1.1, c = 6', 'b = 1.55, c = 8', ...
   'b = 2, c = 10');
```

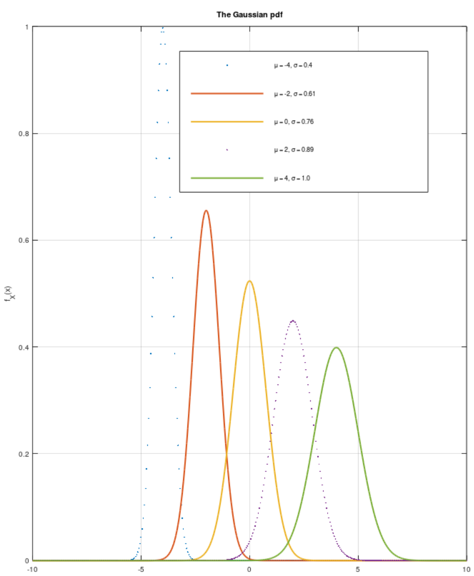
```
for i=1:length(b)
FX= gammainc(x/b(i),c(i));
subplot(122),plot(x,FX,clr(i),'LineWidth',2);
grid on;hold on;
 end;
xlabel('X'); ylabel('F_{X}(x)');
title('The Gamma CDF');
legend('b = 0.2, c = 2', 'b = 0.65, c = 4',...
   'b = 1.1, c = 6', 'b = 1.55, c = 8', ...
   'b = 2, c = 10');
hold off;
%%% end of gammapdf.m
```



<u>Gaussian</u>

```
%%% MATLAB script to generate and
% plot Gaussian pdf and CDF..
close all; clear all; clf;
sig=sqrt(linspace(0.16,1,5));
m=linspace(-4,4,5);
clr=['.-','-.-','+-','-o','-*'];
x=[-10:.05:10];
for i=1:length(sig)
fX=1/(sqrt(2*pi*sig(i)^2))*exp(-(x-m(i)).^2/(2*sig(i)^2));
subplot(121),plot(x,fX,clr(i),'LineWidth',2);
grid on;hold on;
end;
xlabel('X'); ylabel('f_{X}(x)');
title('The Gaussian pdf');
```

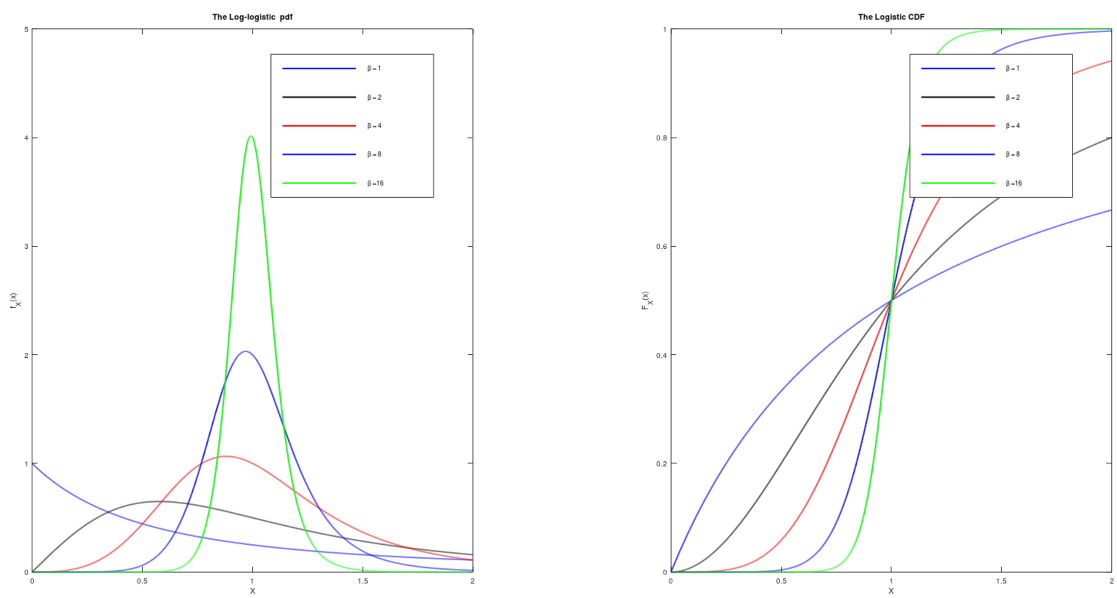
```
legend('\mu = -4, \sigma = 0.4','\mu = -2, \sigma = 0.61',...
   '\mu = 0, \sigma = 0.76','\mu = 2, \sigma = 0.89',...
   '\mu = 4, \sigma = 1.0');
for i=1:length(sig)
% FX=0.5*erfc(-x/sqrt(2));
FX=normcdf(x,m(i),sig(i));
% The normcdf(.) is available only in
% Statistics Toolbox of MATLAB....
subplot(122),plot(x,FX,clr(i), 'LineWidth',2);
grid on; hold on;
end;
xlabel('X'); ylabel('F_{X}(x)');
title('The Gaussian CDF');
legend('\mu = -4, \sigma = 0.4','\mu = -2, \sigma = 0.61',...
   '\mu = 0, \sigma = 0.76','\mu = 2, \sigma = 0.89',...
   '\mu = 4, \sigma = 1.0');
hold off;
%%% end of gausspdf.m
```



<u>Logistic</u>

```
%%% MATLAB script to generate and
% plot Logistic pdf and CDF..
close all; clear all; clf;
a=1;
b=[1,2,4,8,16];
x=[0:.001:2];
clr=['bk','r','b','g','m'];
for i=1:length(b)
fX=  b(i)*x.^(b(i)-1)./(1+x.^b(i)).^2;
```

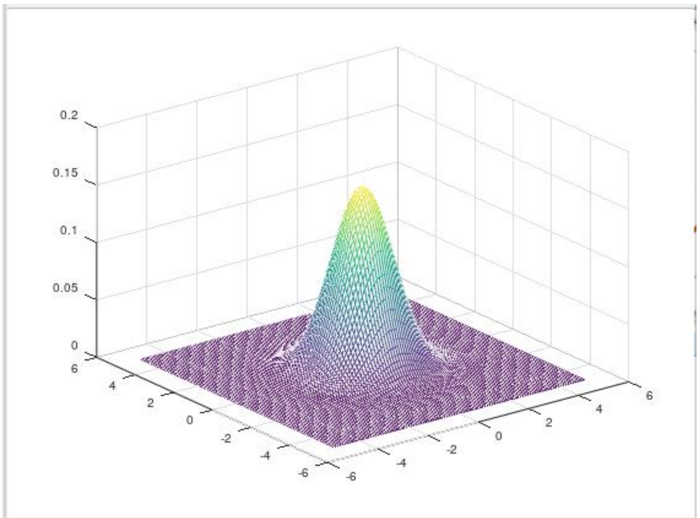
```
subplot(121),plot(x,fX,clr(i),'LineWidth',2);
hold on;
end;
xlabel('X'); ylabel('f_{X}(x)');
title('The Log-logistic  pdf');
legend('\beta = 1','\beta = 2','\beta = 4',...
   '\beta = 8','\beta =16');
for i=1:length(b)
FX= x.^b(i)./(1+x.^(b(i)));
subplot(122),plot(x,FX,clr(i),'LineWidth',2);
hold on;
 end;
xlabel('X'); ylabel('F_{X}(x)');
title('The Logistic CDF');
legend('\beta = 1','\beta = 2','\beta = 4',...
   '\beta = 8','\beta =16');
hold off;
```



<u>Gaussian (Normal)</u>

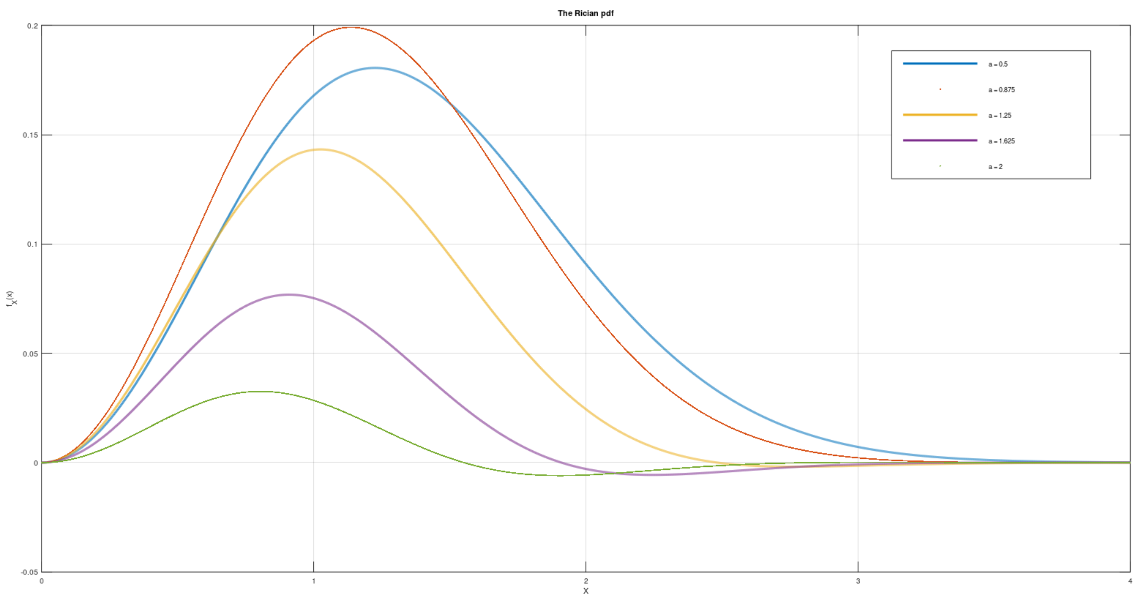
```
%%% MATLAB m-file to generate and plot
%%% a jointly Gaussian (Normal) pdf..
close all, clear all; clf;
sigx=1; sigy=1;
mux=0; muy=0;
rho=0;
x=linspace(-5,5,100);
y=x;
[x,y]=meshgrid(x,y);
fxy=1/(2*pi)*exp(-(x.^2+y.^2)/2);
```

```
% surfc(x,y,fxy);
mesh(x,y,fxy);
%%% end of jgausspdf.m
```



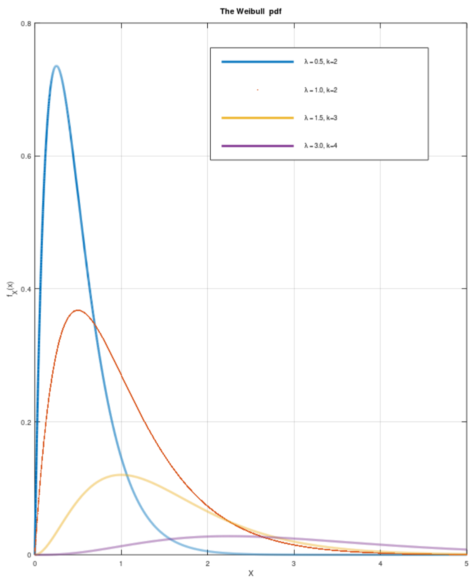
<u>Rician</u>

```
%%% MATLAB script to generate and
% plot Rician  pdf...
close all; clear all; clf;
sig=0.9;
a=linspace(0.5,2,5);
x=[0:.001:4];
clr=['-o-','-.-','-+-','--','-x-'];
for i=1:length(a)
   fX=x/sig^2.*exp(-(x.^2+a(i)^2)/...
      (2*sig^2)).*besselj(1,a(i)*x/sig^2);
plot(x,fX,clr(i),'LineWidth',3);
grid on; hold on;
end;
xlabel('X'); ylabel('f_{X}(x)');
title('The Rician pdf');
legend('a = 0.5', 'a = 0.875',...
   'a = 1.25', 'a = 1.625', 'a = 2');
hold off;
%%% end of rician.m
```

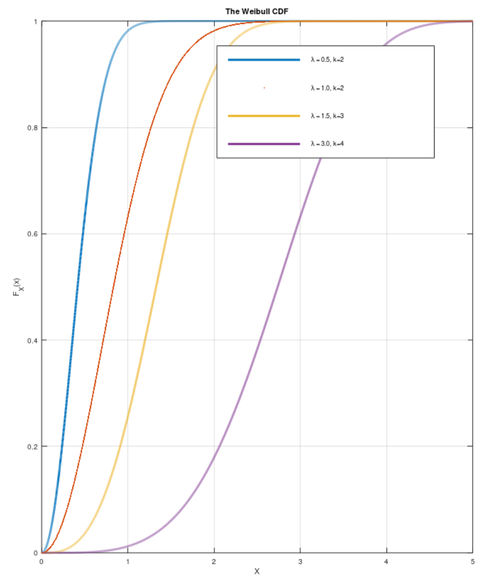


<u>Weibull</u>

```
%%% MATLAB script to generate and
% plot Weibull  pdf and CDF..
close all; clear all; clf;
lam=[0.5,1,1.5,3];
k=[2,2,3,4];
x=[0:.001:5];
clr=['-.-','-.-','-+-','-x-'];
for i=1:length(k)
fX=k(i)/lam(i)*(x/lam(i)).^(k(i)-1).*exp(-(x/lam(i))).^k(i);
subplot(121),plot(x,fX,clr(i),'LineWidth',3);
grid on;hold on;
end;
xlabel('X'); ylabel('f_{X}(x)');
title('The Weibull  pdf');
legend('\lambda = 0.5, k=2', '\lambda = 1.0, k=2', ...
   '\lambda = 1.5, k=3', '\lambda = 3.0, k=4');
for i=1:length(k)
FX=1-exp(-(x/lam(i)).^k(i));
subplot(122),plot(x,FX,clr(i),'LineWidth',3);
grid on;hold on;
 end;
xlabel('X'); ylabel('F_{X}(x)');
title('The Weibull CDF');
legend('\lambda = 0.5, k=2', '\lambda = 1.0, k=2', ...
   '\lambda = 1.5, k=3', '\lambda = 3.0, k=4');
hold off;
%%% end of weibull.m
```



The Weibull pdf
λ = 0.5, k=2
λ = 1.0, k=2
λ = 1.5, k=3
λ = 3.0, k=4
f_X(x)
X



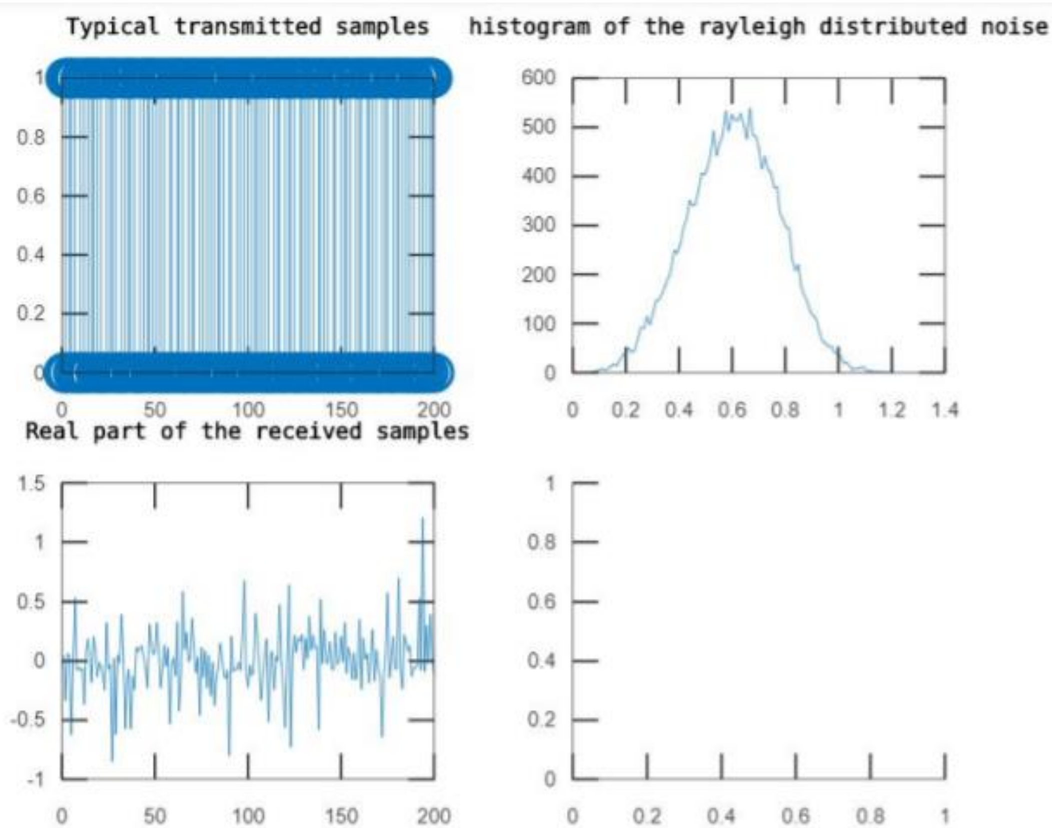
The Weibull CDF
λ = 0.5, k=2
λ = 1.0, k=2
λ = 1.5, k=3
λ = 3.0, k=4
F_X(x)
X

PRACTICAL 5

Aim: Plotting Rayleigh Model

```
%rayleighdemo.m
DATA=round(rand(1,10000));
TX=[];
a=1;
%Let the bandwidth of the complex base band signal be W/2
W=2;
N0=0.01;
N0W=(N0/2)*W;
for i=1:1:length(DATA)
if(DATA(i)==0)
TX=[TX a 0];
else
TX=[TX 0 a];
end
end
%Gaussian noise with variance 0.01
g=sqrt(N0W)*randn(1,20000)+j*sqrt(N0W)*randn(1,20000);
%Flat-fading rayleigh channel with impulse response r
r=sqrt(0.1)*randn(1,20000)+j*sqrt(0.1)*randn(1,20000);
RX=r.*TX+g;
figure
subplot(2,2,1)
stem(TX(1:1:200))
title('Typical transmitted samples')
subplot(2,2,2)
[a,b]=hist(sqrt(abs(r)),100)
plot(b,a)
title('histogram of the rayleigh distributed noise')
subplot(2,2,3)
plot(real(RX(1:1:200)))
title('Real part of the received samples')
subplot(2,2,4)
plot(imag(RX(1:1:200)))
title('Imaginary part of the received samples')
%detection
DETDATA=[];
for i=1:2:200
```

```
temp=[RX(i) RX(i+1)];
O=abs(temp(1))-abs(temp(2));
if(O>0)
DETDATA=[DETDATA 0];
else
DETDATA=[DETDATA 1];
end
end
figure
subplot(2,1,1)
stem(DATA(1:1:100))
title('Transmitted data')
subplot(2,1,2)
stem(DETDATA,'r')
title('Corresponding detected data')
```



EXPERIMENT 6

Aim: Study of Rician channel model using MATLAB

Apparatus: MATLAB S/W

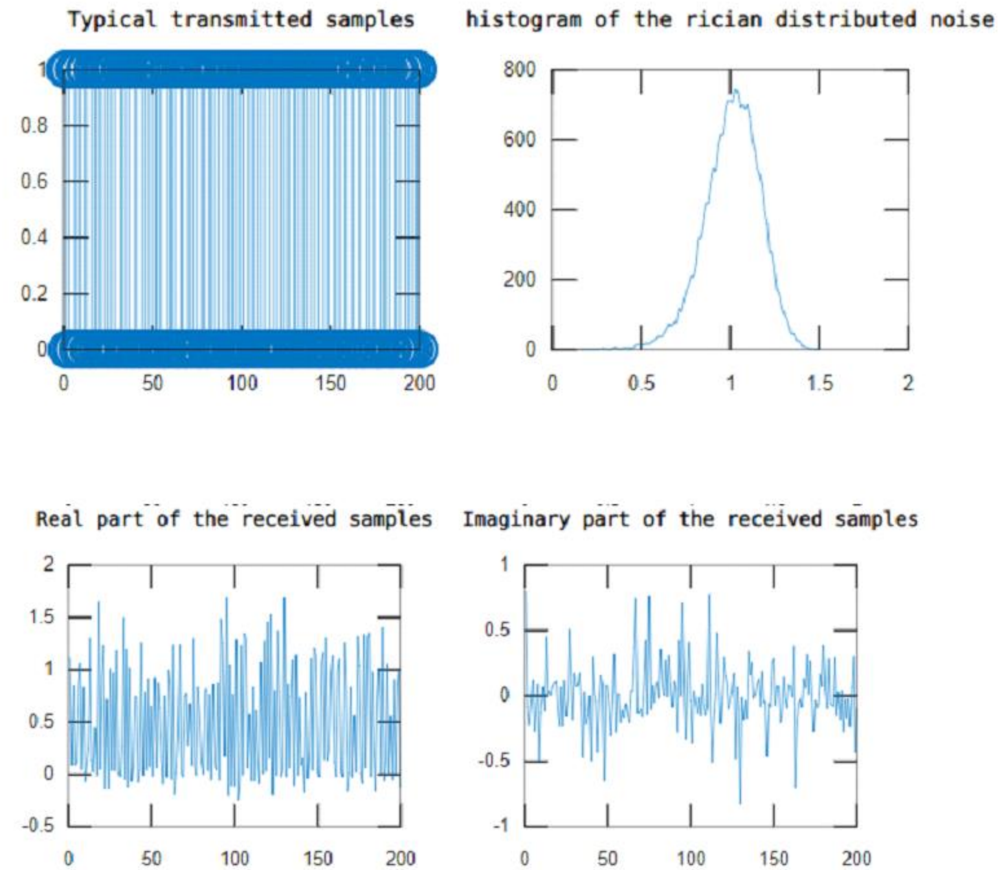
Theory:

Matlab Code:

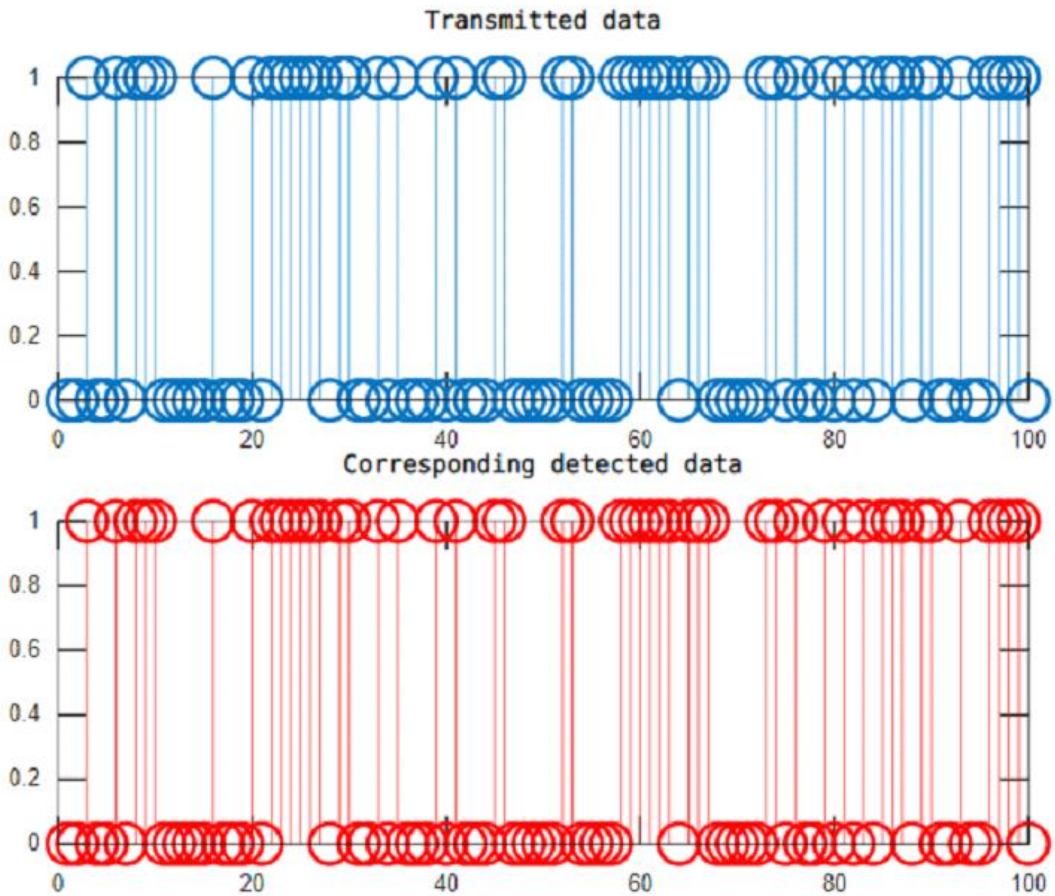
```
riciandemo.m
DATA=round(rand(1,10000));
TX=[];
a=%1;
%Let the bandwidth of the complex base band signal be W/2
W=2;
N0=0.01;
N0W=(N0/2)*W;
for i=1:1:length(DATA)
if(DATA(i)==0)
TX=[TX a 0];
else
TX=[TX 0 a];
end
end
m=1;
%Gaussian noise with variance 0.01
g=sqrt(N0W)*randn(1,20000)+j*sqrt(N0W)*randn(1,20000);
%Flat-fading rician channel with impulse response r
r=sqrt(0.1)*randn(1,20000)+1+j*sqrt(0.1)*randn(1,20000);
RX=r.*TX+g;
figure
subplot(2,2,1)
stem(TX(1:1:200))
title('Typical transmitted samples')
subplot(2,2,2)
[a,b]=hist(sqrt(abs(r)),100)
plot(b,a)
title('histogram of the rician distributed noise')
subplot(2,2,3)
plot(real(RX(1:1:200)))
```

```
title('Real part of the received samples')
subplot(2,2,4)
plot(imag(RX(1:1:200)))
title('Imaginary part of the received samples')
%detection
DETDATA=[];
for i=1:2:200
temp=[RX(i) RX(i+1)];
O=abs(temp(1))-abs(temp(2));
if(O>0)
DETDATA=[DETDATA 0];
else
DETDATA=[DETDATA 1];
end
end
figure
subplot(2,1,1)
stem(DATA(1:1:100))
title('Transmitted data')
subplot(2,1,2)
stem(DETDATA,'r')
title('Corresponding detected data')
```

OUTPUT:



Typical transmitted samples
histogram of the rician distributed noise
Real part of the received samples
Imaginary part of the received samples


Transmitted data
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
Corresponding detected data
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100

PRACTICAL 7

AIM: To study CDMA Transmitter

CDMA

Code Division Multiple Access (CDMA) [3] is a spread spectrum technique that uses neither frequency channels nor time slots. With CDMA, the narrow band message (typically digitized voice data) is multiplied by a large bandwidth signal that is a pseudo random noise code (PN code). All users in a CDMA system use the same frequency band and transmit simultaneously. The transmitted signal is recovered by correlating the received signal with the PN code used by the transmitter.

SPREAD SPECTRUM TECHNIQUES

- Frequency hopping spread spectrum
- Direct sequence spread spectrum

1. Frequency Hopping Spread Spectrum

The signal is broadcasted over a random series of radio frequencies, hopping from one frequency to another frequency at fixed intervals a receiver, hopping between frequencies in synchronization with the transmitter picks up the message

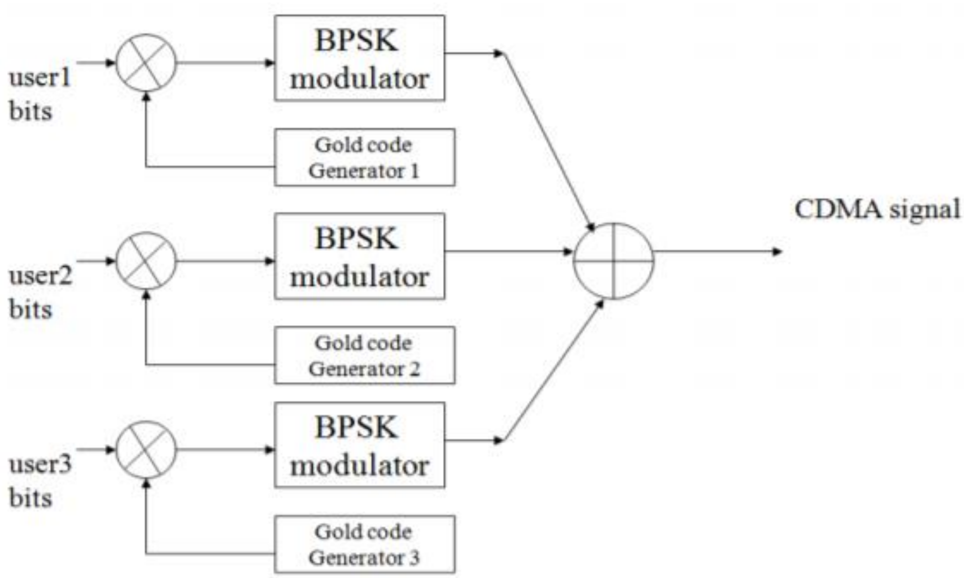
2. Direct Sequence Spread Spectrum

Each bit in the original signal is represented by multiple bits in the transmitted signal, using a spreading code . The spreading code spreads the signal across a wider frequency band in direct proportion to the number of bits used

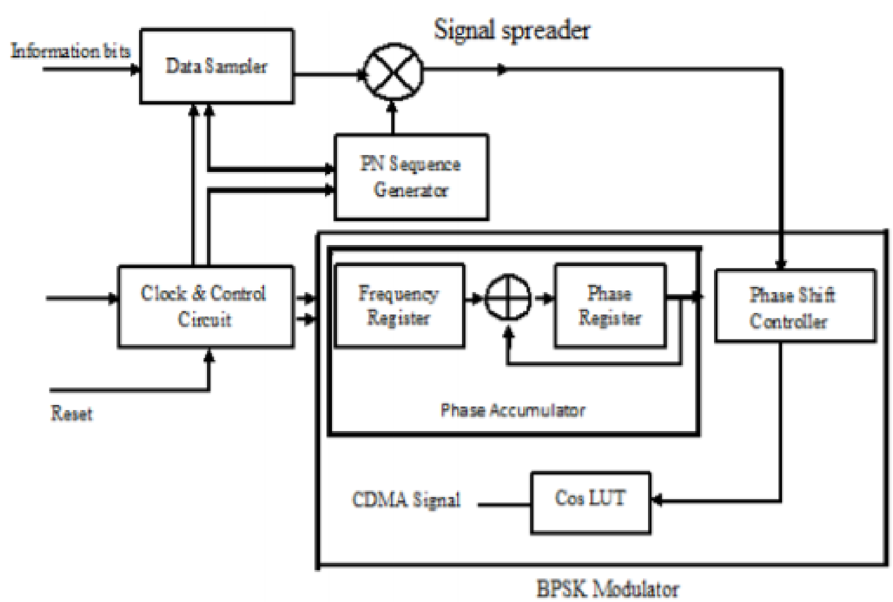
Techniques generally used are direct sequence spread spectrum modulation (DS-CDMA), frequency hopping or mixed CDMA detection (JDCDMA). Here, a signal is generated which extends over a wide bandwidth. A code called spreading code is used to perform this action. Using a group of codes, which are orthogonal to each other, it is possible to select a signal with a given code in the presence of many other signals with different orthogonal codes.

CDMA TRANSMITTER

In CDMA transmission user data is spreaded by a PN sequence and then modulated using BPSK modulation where in the carrier is generated using digital frequency synthesizer principle .Then the modulated signals from different users are combined and transmitted.



Block Diagram of multiple users CDMA Transmitter



Block Diagram of CDMA Transmitter

The main blocks of the CDMA transmitter are listed below.

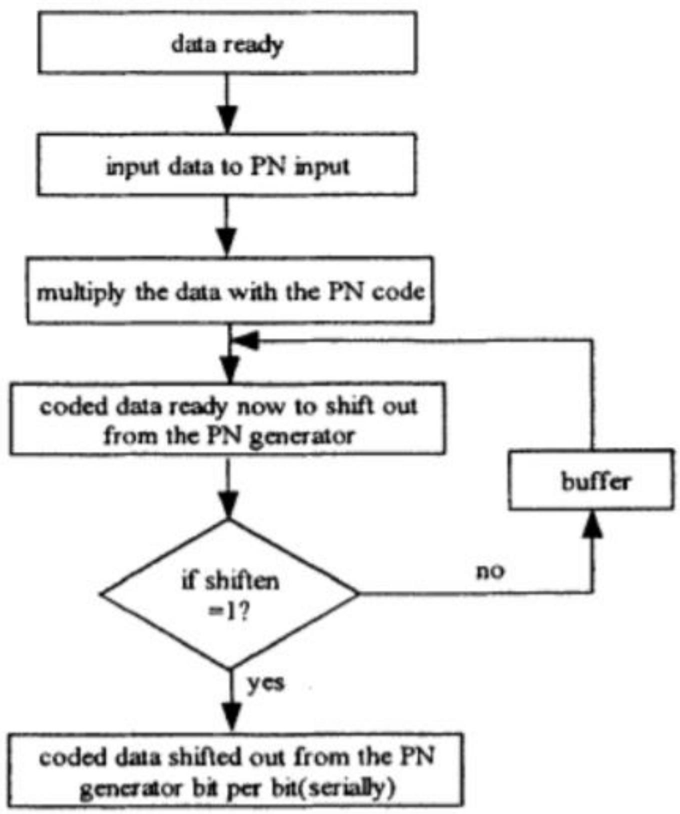
- Clock distributor
- PN sequence generator
- Signal spreader
- BPSK modulator

A. Clock Distributor

The clock distributor of CDMA transmitter derives different clock signals from master clock, which are required for Spread spectrum signal generation.

B. PN Sequence Generation

The important block of DS-CDMA communication system is the PN sequence generator. The PN sequence generator can be implemented using LFSR‟s to generate several types of PN sequences. Two types of PN sequence generators implemented in this project. They are ML sequences and gold codes



Flow Chart of PN Generator

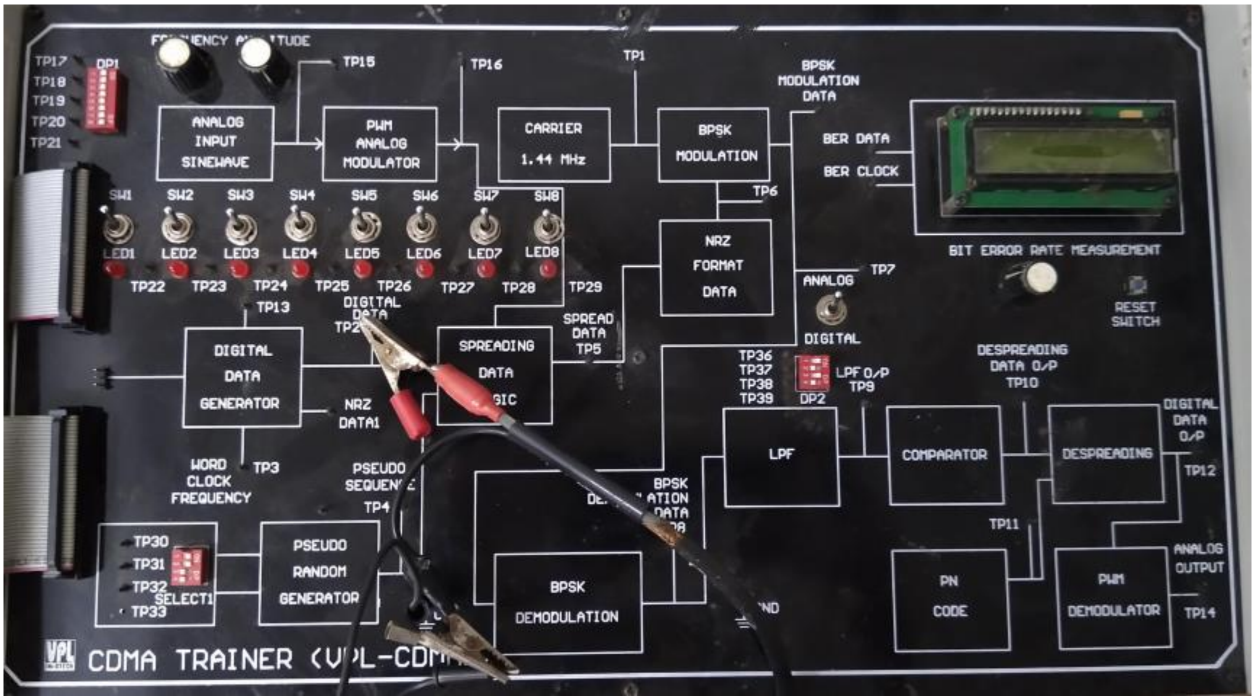
C. Signal Spreader

The function of signal spreader is to generate PN sequence when the information bit is '1' and generate the complement of the PN sequence if the information bit is '0'. The digital implementation of signal spreader is achieved by using XOR gate controlled inverter action. The spreaded chip signal is used for modulation by BPSK modulator.

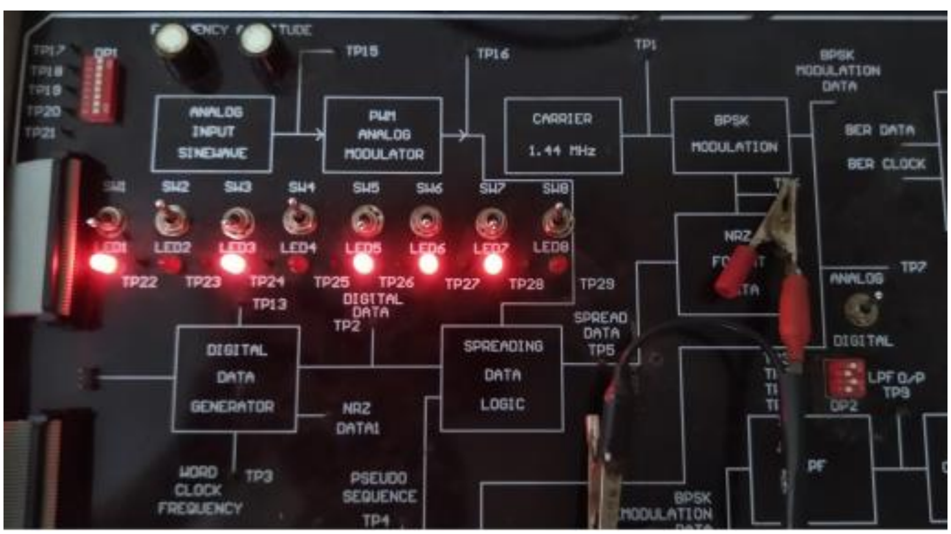
D. BPSK Modulator

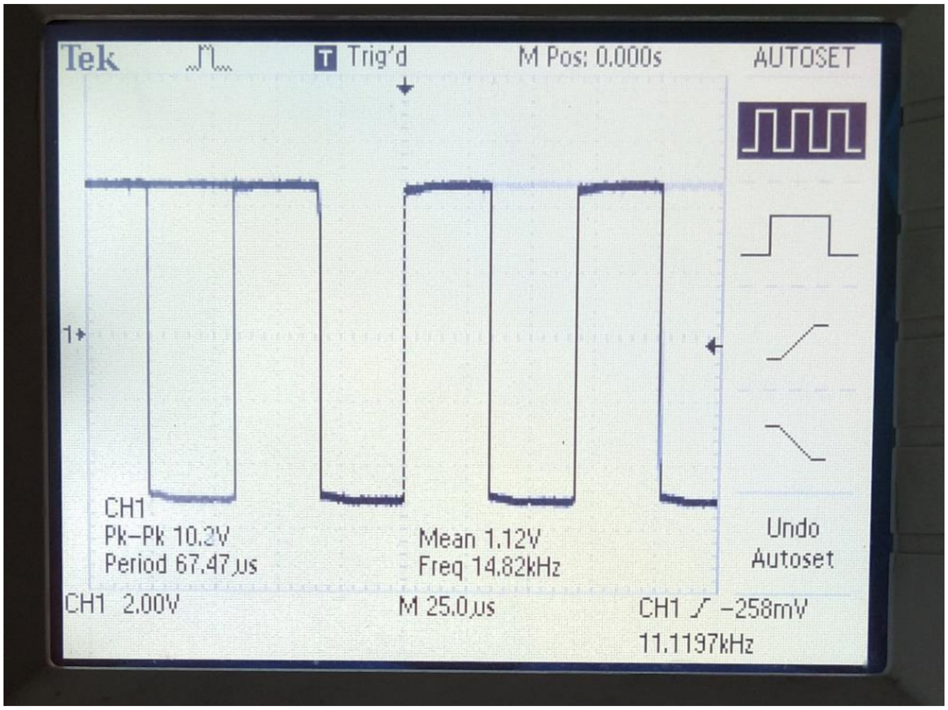
The BPSK modulator produces the band pass spread spectrum signal which is suitable for transmission from the spreaded signal. The BPSK modulator is implemented using pure digital architecture. The Direct Digital Frequency Synthesis (DDFS) technique with phase shifting provision is used for the signal generation.

CDMA BLOCKS:



DATA : 10101110

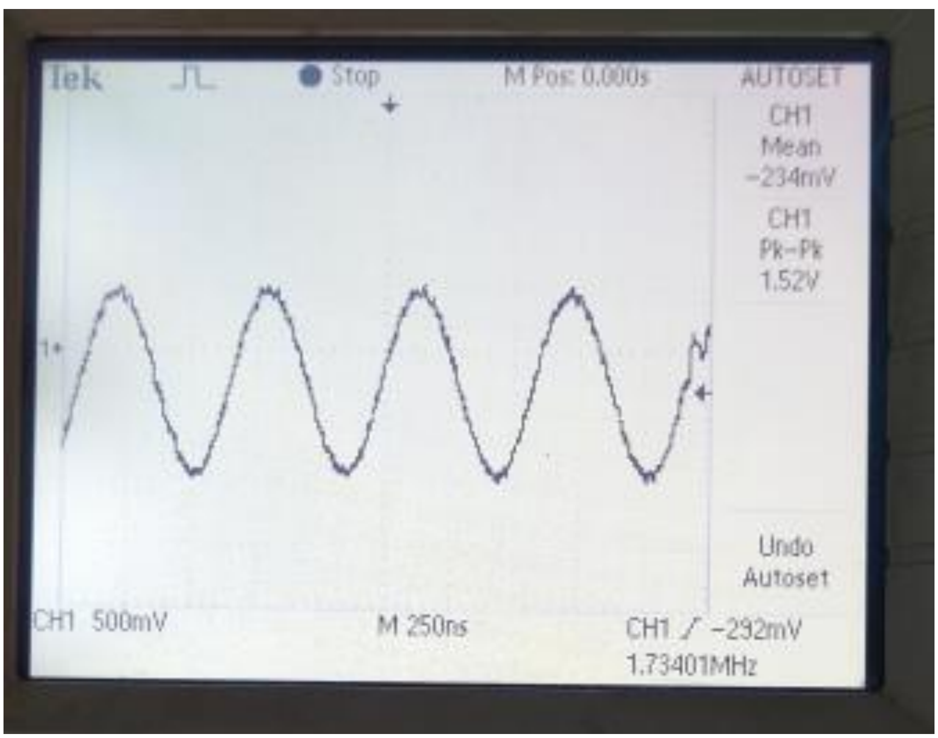




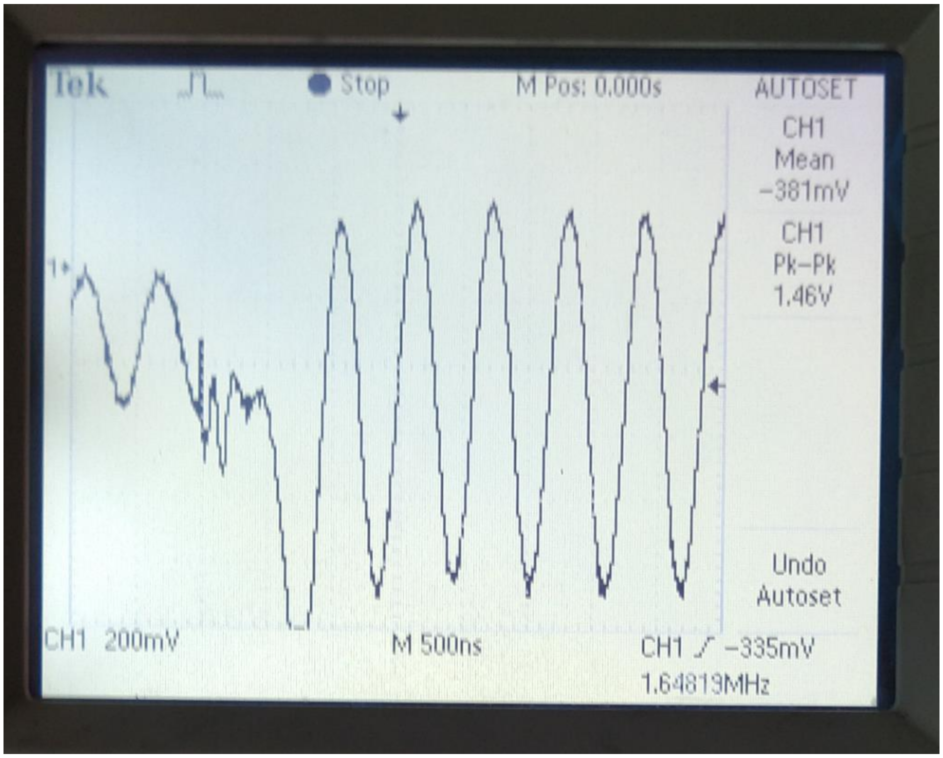
PN SEQUENCE:

SPREAD SIGNAL:

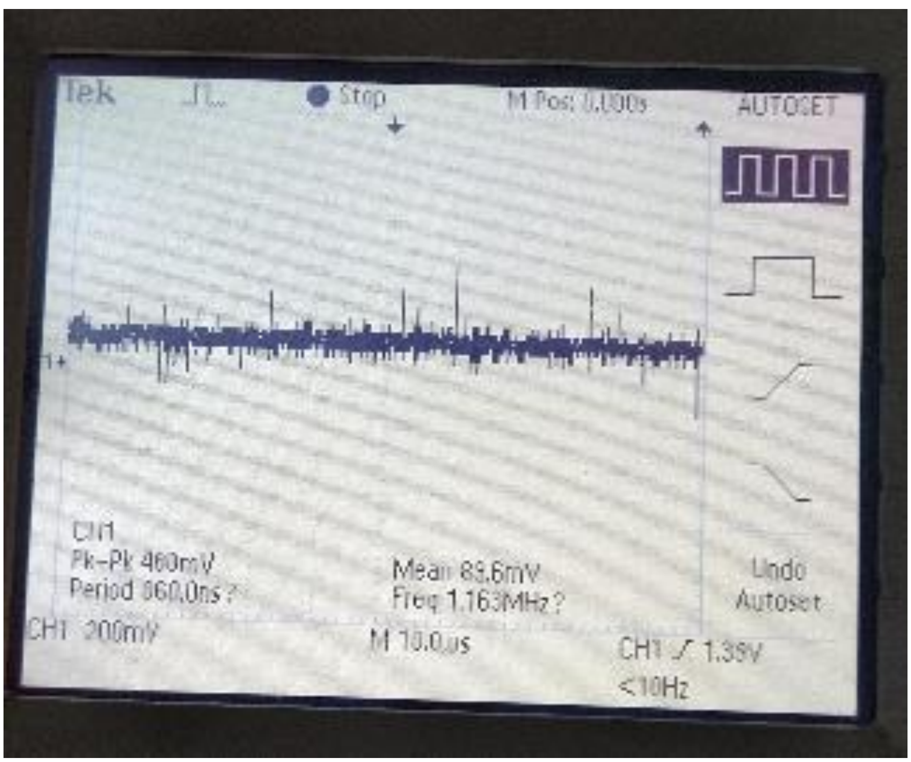
CARRIER SIGNAL FOR BPSK MODULATION:



BPSK MODULATED SIGNAL:



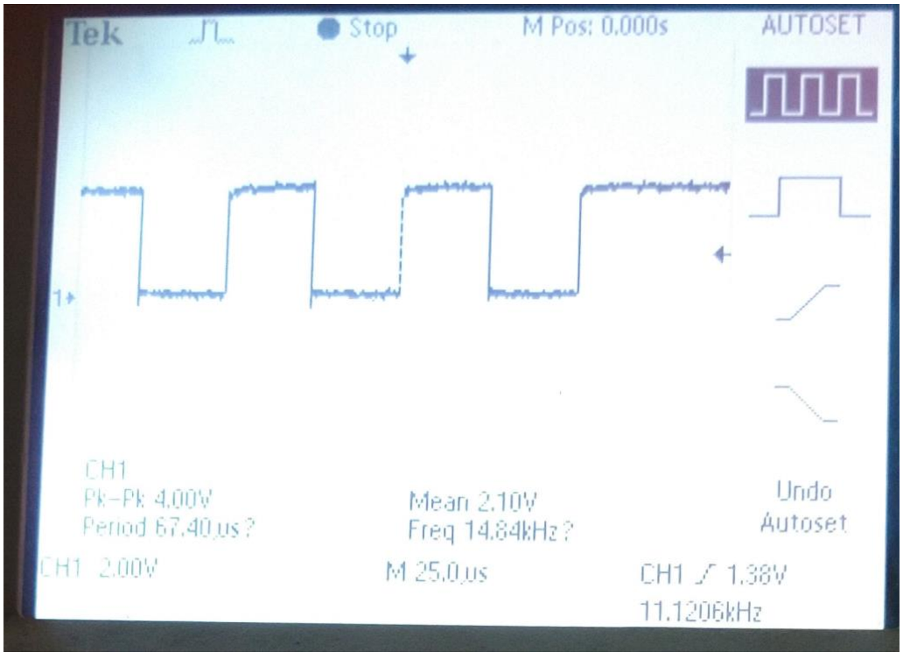
BPSK DEMODULATED SIGNAL:



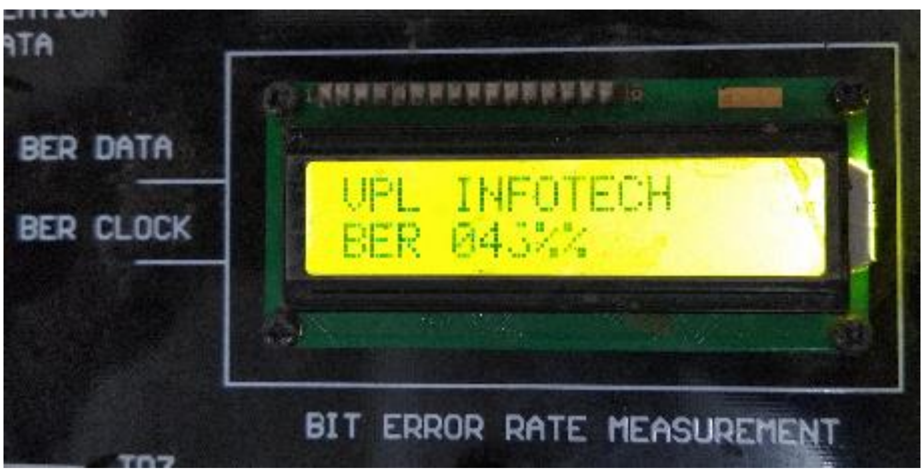
DECODED SPREAD-SIGNAL:

PN SEQUENCE AT RECEIVER:

RECONSTRUCTED DATA:



BER MEASUREMENT:

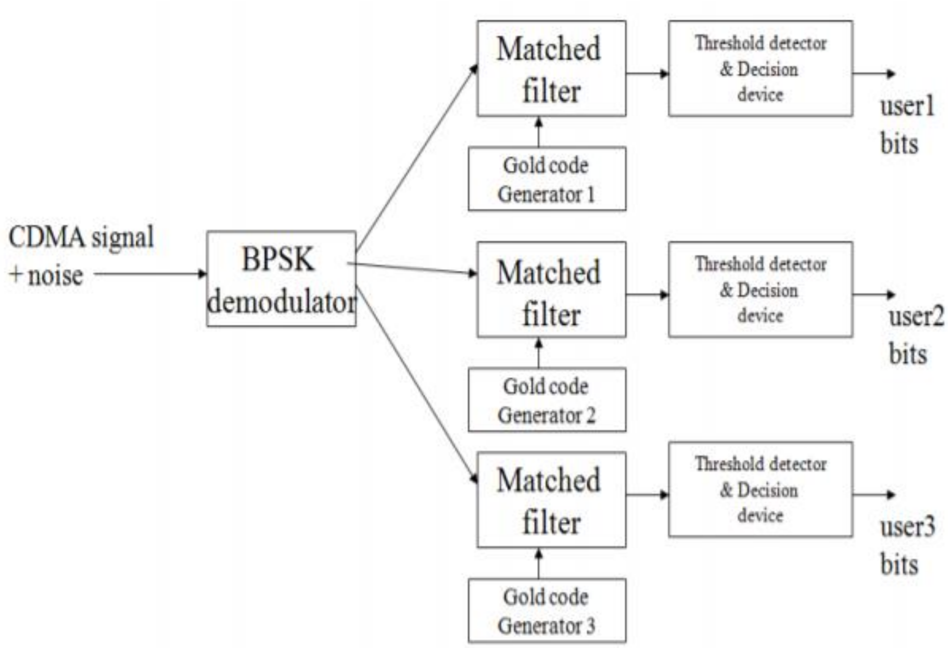


PRACTICAL 8

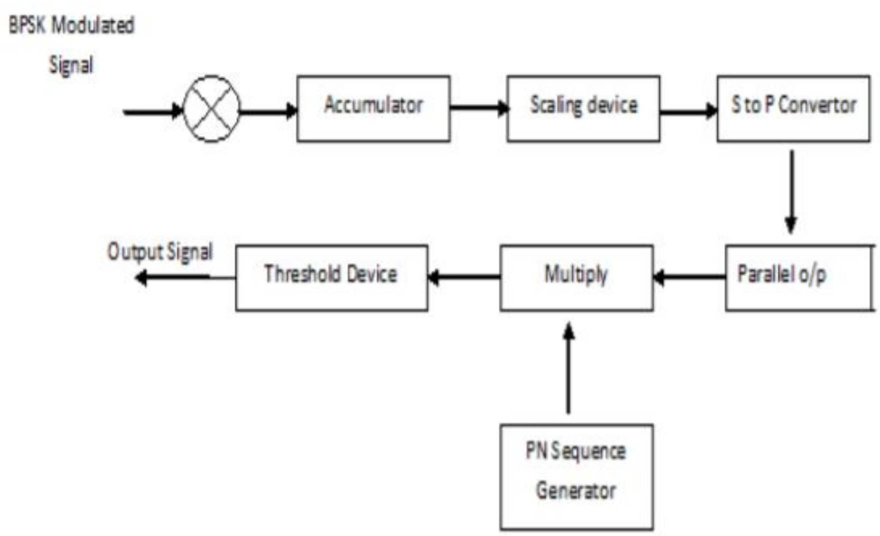
AIM: To study CDMA Receiver

CDMA RECEIVER

The CDMA receiver gets its input from the transmitter section and recovers the data using matched filter. The matched filter can distinguish the PN sequence and the passes the data to the respective user.



Block diagram of multiple users CDMA Receiver



Block Diagram of CDMA Receiver

The receiver performs the following steps to extract the Information:
Demodulation
Accumulation
Scaling
Serial to parallel conversion
Multiplying and dispreading
Threshold device

A. BPSK Demodulator

BPSK demodulator principle is used in this project for receiving the DS-CDMA signals. The BPSK demodulator produce 15 (-7 to 7) digital words, unlike in conventional BPSK demodulator which produces only two symbols (‘1’ and ‘0’). This is necessary due to the low power spectral density of DS-CDMA signals and it is only possible to detect the information bits after correlation.

B. Multiplier

A signed multiplier is used to multiply the incoming signal with the LO output. The multiplication is performed in 2’s complement and the 15 bit result is given to the accumulator.

C. Local oscillator

The Local oscillator produces 6 bit signed bits representing the COS signal. The same principle DDFS which is used in transmitter is used in the receiver.

D. Accumulator

The accumulator in the receiver corresponds to the integrator in the analog equivalent. The accumulator accumulates the outputs of multiplier for one symbol duration and outputs at the beginning of next symbol.

E. Scaling device

The scaling device accepts the output of accumulator and scales its value to 4 bit signed number range, i.e., -7 to +7. This is done in order to reduce the complexity at the correlator and even at the hardware implementation level.

F. Serial to parallel converter

The serial to parallel converter accepts the outputs of the BPSK demodulator and produces parallel vector with an array of 128 words. This parallel 128 words constitute the most recent 128 outputs of the BPSK demodulator. This becomes input to the correlator.

G. PN sequence generator

The PN sequence generator is same as the one cussed in transmitter, except in the output type. In the transmitter side the output of PN sequence generator continuously produces PN sequence on one bit output. But in the receiver side, since the complete PN sequence is required every time for correlating with the outputs of BPSK demodulator it is provided as a parallel vector. Another difference is the ‘1’ of PN sequence is provided as +1 and ‘0’ is provided as -1, which is the required form for correlator.

H. Matched filter

Matched filter based correlator is used in this project for receiving the DS-CDMA signals. The correlator accepts the 128 demodulator outputs and multiplies with 128 length PN sequence which is a sequence of +1 and -1. The outputs of multipliers are accumulated to produce the correlator output. The magnitude of the correlator output peaks whenever exact match occurs between the PN sequence and BPSK demodulator outputs. The output of the matched filter is given to the threshold detector, for detecting the information bits.

I. Threshold detector

The threshold detector compares the magnitude of the correlator output with the threshold value. If the magnitude of the correlator output is higher than the threshold value, then it raises a flag indicating that one bit is detected. If the sign of the correlator output is positive, then it will be interpreted as ‘1’. Otherwise it will be declared as ‘0’. This is the detected information bit.

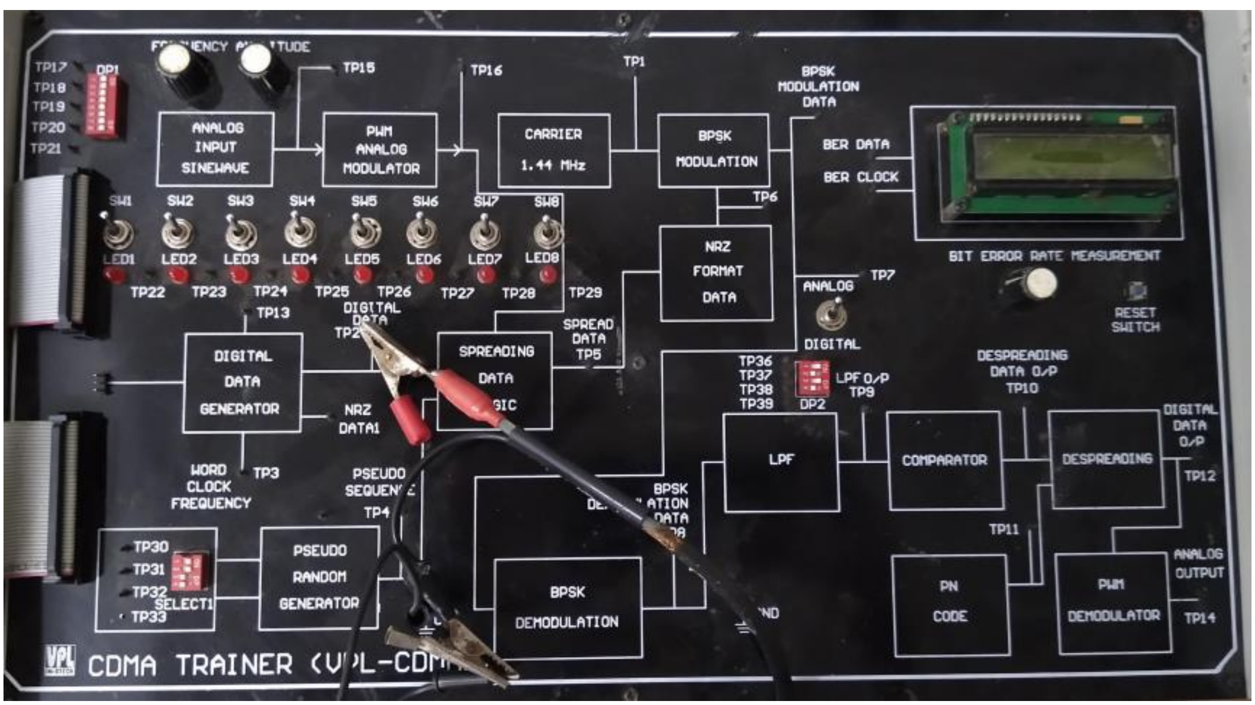


Fig. CDMA Blocks

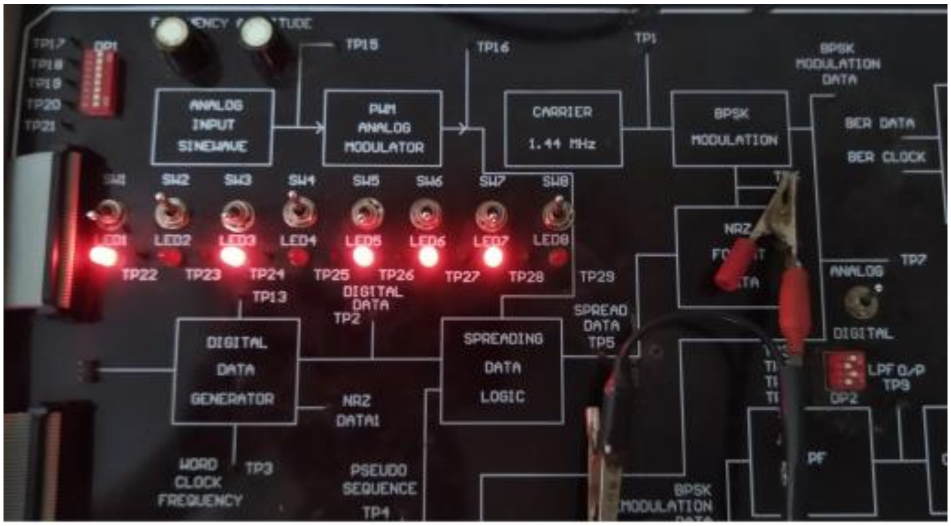


Fig. data : 10101110

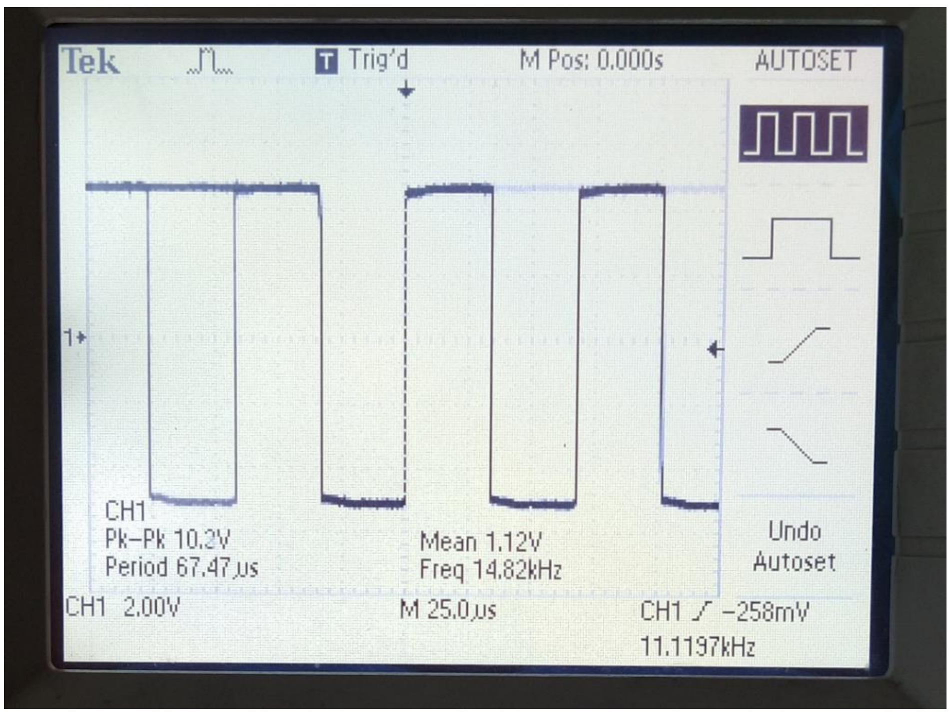
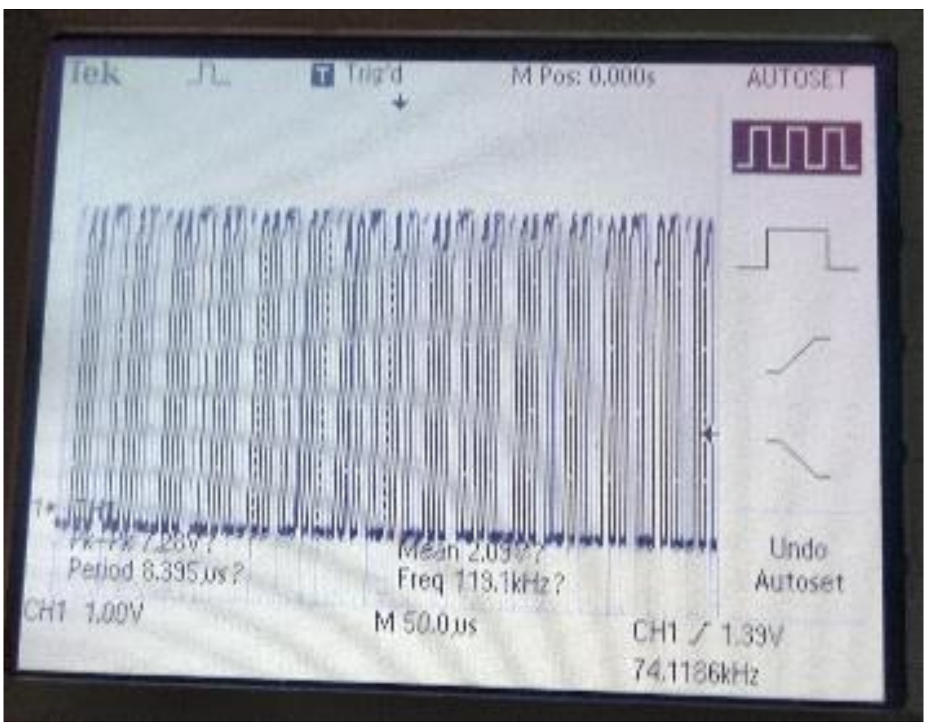
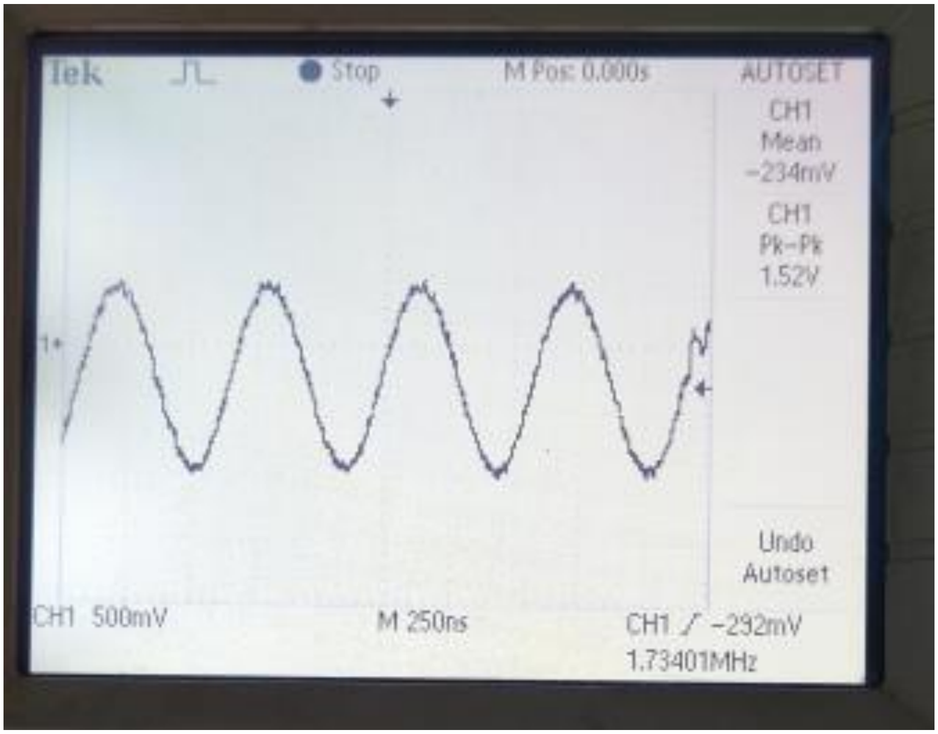


Fig. PN Sequence

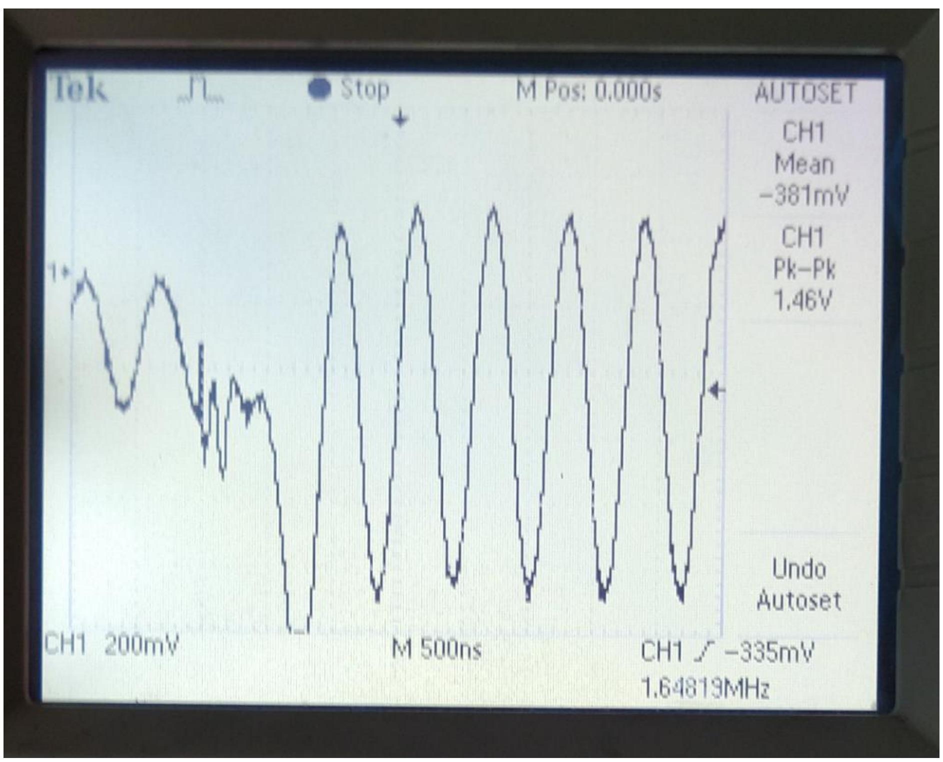
SPREAD SIGNAL:



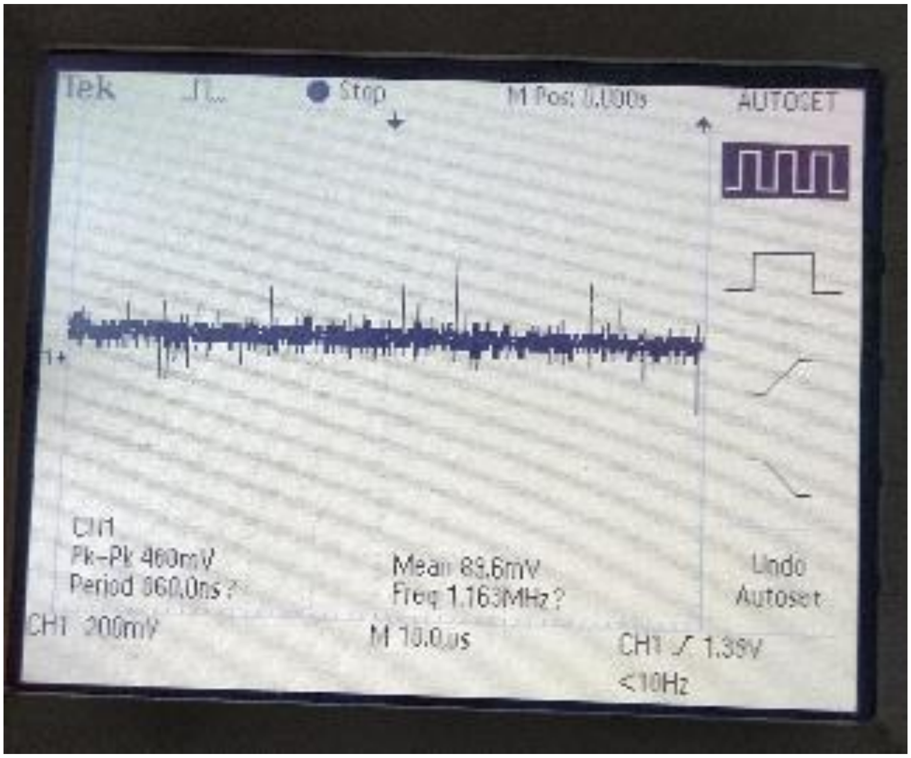
CARRIER SIGNAL FOR BPSK MODULATION:



BPSK MODULATED SIGNAL:



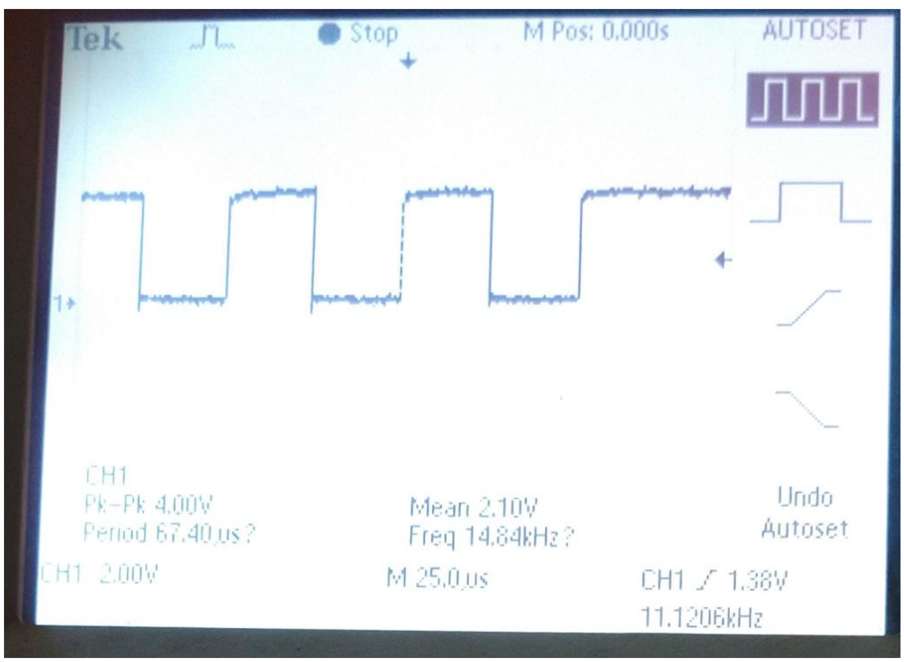
BPSK DEMODULATED SIGNAL:



DECODED SPREAD-SIGNAL:

PN SEQUENCE AT RECEIVER:

RECONSTRUCTED DATA:



BER MEASUREMENT:


BER DATA
BER CLOCK
VPL INFOTECH
BIT ERROR RATE MEASUREMENT

PRACTICAL 9

AIM: Introduction to GSM trainer kit

Apparatus: GSM kit, power supply, connecting probes.

Theory

GSM Trainer is the training system enabling users to study GSM/GPRS communication protocol and to experience the overall knowledge about mobile communication through GSM module control. To control the GSM module, there is an advanced set of AT Commands according to GSM ETSI (European Telecommunications Standard Institutes). GSM Trainer has full training contents of Command Level Study on AT Commands.GSM Trainer is based upon GSM cellular phone and allows for connection to PC for operation and programming.This trainer is designed to instruct the students System operation, Theory, Programming, Servicing, Problem diagnosis of GSM cellular mobile systems. GSM Trainer is mainly used for students to learn fundamentals in mobile communication systems such as mobile station network entry, calling process, network signals, AT Commands, Audio communication, Short message services,,,etc.

The training covers the command level study with AT Commands, GPRS Internet Connection, Multiplexer Protocol training and Hardware test experiments, Introduction of Embedded OS system and GUI programming on GSM-5000 through the provided source codes.

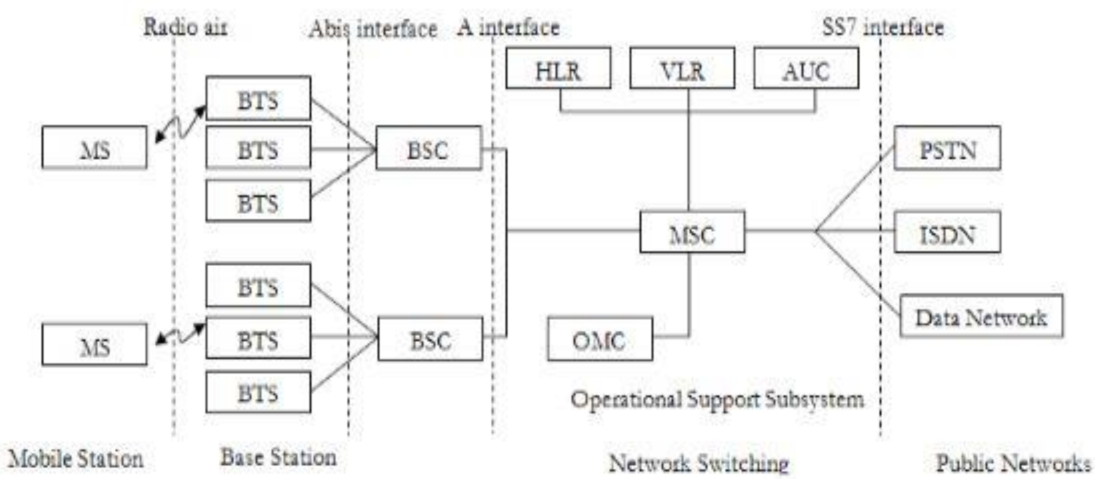


Fig: GSM Architecture

The GSM network architecture provided a simple and yet effective architecture to provide the services needed for a 2G cellular or mobile communications system.

There were four main elements to the overall GSM network architecture and these could often be further split. Elements like the base station controller, MSC, AuC, HLR, VLR and the like are brought together to form the overall system.

The 2G GSM network architecture, although now superseded, gives an excellent introduction into some of the basic capabilities required to set up a mobile communications phone network and how all the entities operate together.

In order that the GSM system operates together as a complete system, the overall network architecture brings together a series of data network identities, each with several elements.

The GSM network architecture is defined in the GSM specifications and it can be grouped into four main areas:

- Network and Switching Subsystem (NSS)
- Base-Station Subsystem (BSS)
- Mobile station (MS)
- Operation and Support Subsystem (OSS)

The different elements of the GSM network operate together and the user is not aware of the different entities within the system.

As the GSM network is defined but the specifications and standards, it enables the system to operate reliably together regardless of the supplier of the different elements.

User Equipment (UE)—These are the users .Number of users are controlled by one BTS

1. The mobile stations (MS) communicate with the base station subsystem over the radio the radio interface.

2. The BSS called as radio the subsystem, provides and manages the radio transmission path between the mobile stations and the Mobile Switching Centre(MSC).It also manages radio interface between the mobile stations and other subsystems of GSM.

3. Each BSS comprises many Base Station Controllers(BSC) that connect the mobile station to the network and switching subsystem (NSS) through the mobile switching center

4. The NSS controls the switching functions of the GSM system.It allows the mobile switching center to communicate with networks like PSTN, ISDN, CSPDN, PSPDN and other data networks.

5. The operation support system (OSS) allows the operation and maintenance of the GSM system. It allows the system engineers to diagnose,troubleshoot and observe the parameters of the GSM systems.The OSS subsystem interacts with the other subsystems and is provided for the GSM operating company staff that provides service facilities for the network.

Base station(BSS)-- The following stations subsystem comprises of two parts:

1. Base Transceiver Station (BTS).

2. Base Station Controller(BSC).

The BSS consists of many BSC that connect to a single MSC. Each BSC controls up to several hundred BTS.

Base Transceiver Station(BTS)-BTS

It has a radio transceiver that defines a cell and are capable of handling radio link protocols with MS.

Functions of BTS are

1. Handling radio link protocols

2. Providing FD communication to MS.

3. Interleaving and de- interliving.

Base station controller(BSC) IT manages radio resources for one or more BTS.It controls several hundred BTS all are connected to single MSC.

Functions of BTS are

• To control BTS.

• Radio resource management

• Handoff management and control

• Radio channel setup and frequency hoping

Network subsystem(NSS)

1.It handels the switching of GSM calls between external networks and indoor BSC

2.It includes three different data bases for mobility management as

A .HLR (Home Location Register)

B .VLR (Visitor Location Register)

C. AUC (Authentication center)

Mobile switching center (MSC)--

It connects fix networks like ISDN ,PSTN etc.

Following are the functions of MSC

1. Call setup, supervision and relies

2. COLLECTION OF BILLING INFORMATION

3. Call handling / routing

4. Management of signalling protocol

5. Record of VLR and HLR

HLR (Home Location Register) - Call roaming and call routing capabilities of GSM are handeled.It stores all the administrative information of subscriber registered in the networks.IT maintenance unique international mobile subscriber identity.(IMSI).

VLR (Visitor Location Register) - It is a temporary data base.It stores the IMSC number and customer information for each roaming customer visiting specific MSC.

Authentication center - It is protected database .It maintenance authentication keys and algorithms.It contain s a register called as Equipment Identity Register.

Operation subsystem(OSS) - IT manages all mobile equipment in the system 1)management for charging and billing procedure 2)To maintain all hardware and network operations

Smart Card (SIM Card) pinout

Pin	Name	Description
C1	VCC	+5 VDC power supply input (optional use by the card)
C2	RESET	Reset signal, used to reset the card's communications. Either used itself (reset signal supplied from the interface device) or in combination with an interal reset control circuit (optional use by the card). If internal reset is implemented, the voltage supply on Vcc is mandatory
C3	CLOCK	Provides the card with a clock signal, from which data communications timing is derived
C4	RESERVED	AUX1, optionally used for USB interfaces and other uses.
C5	GND	Ground (reference voltage)
C6	Vpp	Programing voltage input (optional). This contact may be used to supply the voltage required to program or to erase the internal non-volatile memory. ISO/IEC 7816-3:1997 designated this as a programming voltage: an input for a higher voltage to program persistent memory (e.g., EEPROM). ISO/IEC 7816-3:2006 designates it SPU, for either standard or proprietary use, as input and/or output.
C7	I/O	Input or Output for serial data (half-duplex) to the integrated circuit inside the card.
C8	RESERVED	AUX2, optionally used for USB interfaces and other uses.

Hardware consists of:
1. Main board
2. Module board

Operation:
1. Reset GSM trainer kit to the command prompt
2. Enter various AT commands
3. Press any key except <Enter> key to recieve more than one line
4. Press <Enter> key to abort the command

Fig. Trainer kit

Result : GSM trainer is studied and functions understood

PRACTICAL 10

AIM: To execute various AT commands on GSM trainer kit

Apparatus required: GSM trainer kit

Fig. Trainer kit

These commands are classified into four types namely Test, Read, Set and Execution.

Test Command

The test AT command is mainly used for checking the command's compatibility using a modem. The SYNTAX for this command is AT < name of the command>. The best example of this command is AD =?

Read Command

The Read command is mainly used for changing the settings of mobile phone otherwise modem required for operations. The SYNTAX for this command is AT < name of the command>. The best example of this command is AT+CBC =?

Set Command

The Set command is mainly used for making modifications in the settings of mobile phone otherwise modem required for operations. The SYNTAX for this command is AT < name of the command> = Value 1, Value 2….Value N. The best example of this is AT+CBC =”+923140”, 110

Execution Command

The Execution command is mainly used for executing the said operation. The SYNTAX for this command is AT < name of the command> = parameter-1, parameter-2… parameter-N. The best example of this is AT+CBC = 2,”+ 4867512120”, 210.

AT Commands List

The list of AT commands is discussed below.

For Testing

AT command is used to check the communication among the computer as well as module

For Controlling Call

The commands used for controlling call mainly include the following.

- ATA command is an answer command
- ATH is used to hang up call

- ATD is a dial command
- ATM command is used to check speaker mode
- ATT command is used to fix tone dial like the default
- ATL command is used to check speaker loudness
- AT+CSTA command is used to select an address type
- ATP command is used to fix pulse dial like the default
- ATO is a Go on-line command
- AT+CRC command is used for cellular result codes

For Data Card Control

The commands used for data call control mainly include the following.

- ATI command is used for identification
- AT&F command is used to reinstate factory settings
- ATZ command is used to remind stored profile
- AT&W command is used to store parameters within the specified profile
- AT+CSTA command is used to select an address type
- AT+GMM command is used to identify request model
- AT&V command is used to examine the active configuration
- AT+CLCK command is used for facility lock
- AT+GCAP command is used to complete request of a capabilities list
- AT&Y command is used to choose power-up option
- AT+GMR command is used to identify request revision
- AT+COLP is a connected line recognition presentation
- AT+GMI is a request manufacturer identification command
- AT+GSN command is used to request product IMEI number.

For Phone Control

The commands used for phone control mainly include the following.

- AT+CBC command is used to charge the battery
- AT+CGMR command is used to identify request revision
- AT+CGSN command is used to request product serial number
- AT+CMEE command is used to report the error of mobile equipment
- AT+CPBF command is used to find the entries of the phone book
- AT+CPBR command is used to read entries of the phone book
- AT+CPBS command is used to choose the storage of phone book memory
- AT+CSCS command is used to select TE character set
- AT+CPBW command is used to write phone book entry
- AT+CGMM command is used to identify request model
- AT+CGMI command is used to identify request manufacturer
- AT+CSQ is a signal quality command
- AT+CPAS command is used to check the status of phone activity

Computer Data Interface

The commands used for computer data interface mainly include the following.

ATE is an Echo command

- ATQ command results code suppression
- ATX command is used to select response rang
- AT+ICF command is used to framing the character of DTE-DCE

- AT&Q command is used to identify an option for communications mode
- AT&C command is used to identify the usage of DCD
- AT&D command is used to identify the usage of DTR
- ATV command is a define response format
- AT+IFC command is used to control local flow for DTE-DCE
- AT&K command is used to choose flow control
- AT&S command is used to identify an option for DSR
- AT+IPR command is used to set DTE rate

For Service

The commands used for service mainly include the following.

- AT+CLIP command is used for calling line recognition presentation
- AT+ILRR command is used for reporting DTE-DCE
- AT+CR command is used to control service reporting
- AT+DR command is used for reporting data compression

For Network Communication Parameter

The commands used for network communication parameter mainly include the following.

- ATB command is an option for a communications standard
- AT+DS command is used to compress the data
- AT+CEER command is used to extend error report
- AT+CBST command is used to choose the type of bearer service
- AT+CRLP command is a radio link protocol

For Miscellaneous

The commands used for miscellaneous mainly include the following.

- A/ command is used to the re-execute command line
- AT*C command is used to start SMS interpreter
- AT? is used to command help
- AT*V command is used to activate V.25bis mode
- AT*T command is used to enter SMS block mode protocol
- AT+CESP command is used to enter SMS block mode protocol
- AT*NOKIATEST command is used to test command

For SMS Text Mode

The commands used for SMS text mode mainly include the following.

- AT+CSMS command is used to select message service
- AT+CSMP command is used to fix text mode parameters
- AT+CMGF command is used to format message
- AT+CPMS command is used to choose message storage
- AT+CRES command is used to restore settings
- AT+CNMI command is used to indicate a new message to TE
- AT+CSCA command is used for service center address
- AT+CSCB command is used to choose types of cell broadcast message
- AT+CMGR command is used to read the message
- AT+CSDH command is used to illustrate text mode parameters
- AT+CSAS command is used to save settings

- AT+CMSS command is used to send a message from storage
- AT+CMGD command is used to delete the message
- AT+CMGL command is used to list messages
- AT+CMGS command is used to send message
- AT+CMGW command is used to write a message to memory

SMS PDU Mode

The commands used for SMS PDU mode mainly include the following.

- AT+CMGL command is used to list messages
- AT+CMGW command is used to write a message to memory
- AT+CMGS command is used to send message
- AT+CMGR command is used to read the message

ESP8266 AT Commands

The ESP8266 Commands mainly include the following.

- AT+RST command is used to restart the module
- AT+CWQAP command is used to quit the AP
- AT+ CIPSTATUS command is used to obtain the connection status
- AT+CWJAP command is used to join the AP
- AT+CWMODE command is used to wi-fi mode
- AT+CWLAP command is used to list the AP
- AT+CIPSTART command is used to set up the connection for TCP otherwise UDP
- AT+CIPCLOSE command is used to close the connection for TCP otherwise UDP

- AT+ CIPMUX command is used to fix multiple connections
- AT+ CWSAP command is used to fix the parameters of AP
- AT+ CIPSERVER command is used to set as serve
- AT+CIPSEND command is used to send data
- AT+CIFSR command is used to obtain an IP address
- IPD command is used to receive data

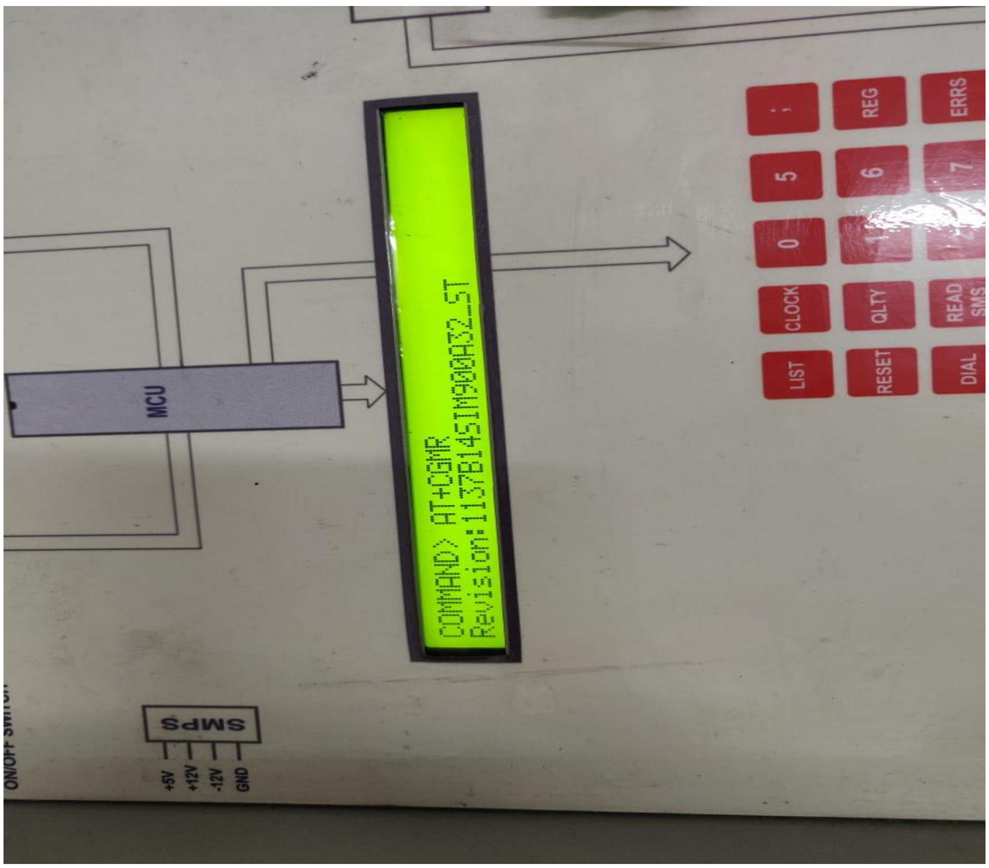


Fig. AT + CGMR command

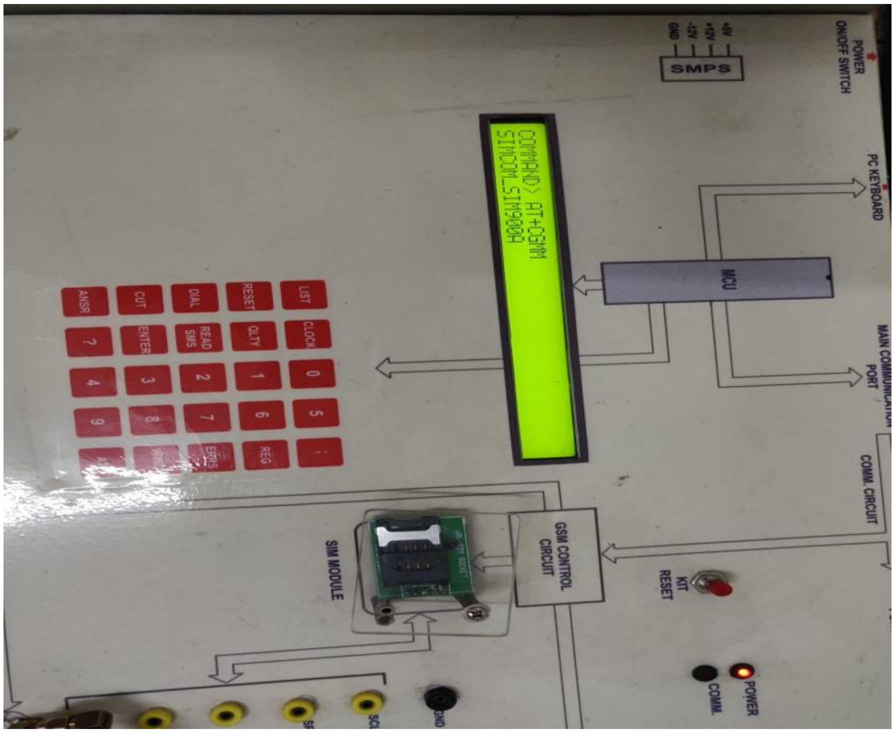


Fig. AT + CGMM command

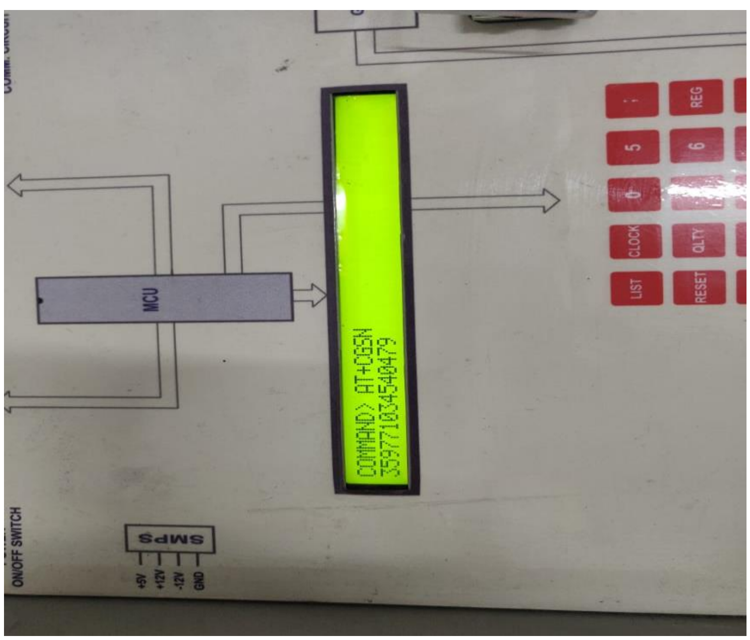


Fig. AT + CGSN command

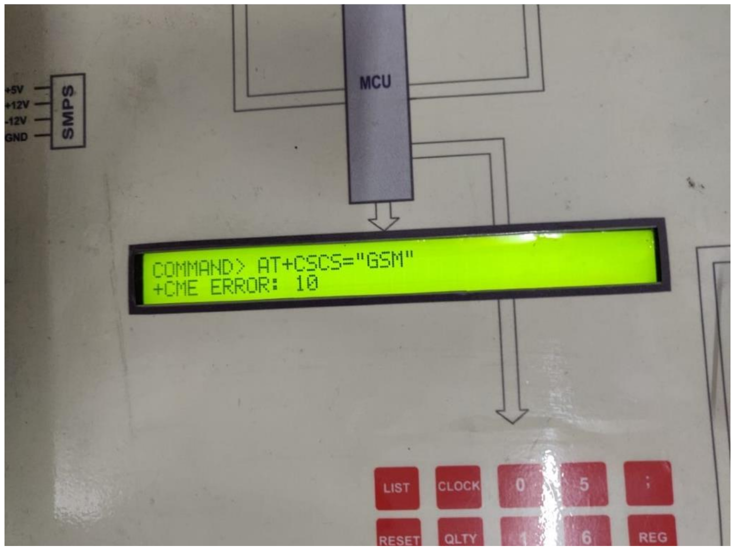


Fig. AT + CSCS command

Result: GSM AT commands are studied.

PRACTICAL 11

Aim– To study Orthogonal frequency division multiplexing (OFDM) through carrier generation

Apparatus – MATLAB S/W

Theory – OFDM, Orthogonal Frequency Division Multiplexing is a form of signal waveform or modulation that provides some significant advantages for data links.

Accordingly, OFDM, Orthogonal Frequency Division Multiplexing is used for many of the latest wide bandwidth and high data rate wireless systems including Wi-Fi, cellular telecommunications and many more.

The fact that OFDM uses a large number of carriers, each carrying low bit rate data, means that it is very resilient to selective fading, interference, and multipath effects, as well providing a high degree of spectral efficiency.

Early systems using OFDM found the processing required for the signal format was relatively high, but with advances in technology, OFDM presents few problems in terms of the processing required.

OFDM is a form of multicarrier modulation. An OFDM signal consists of a number of closely spaced modulated carriers. When modulation of any form - voice, data, etc. is applied to a carrier, then sidebands spread out either side. It is necessary for a receiver to be able to receive the whole signal to be able to successfully demodulate the data. As a result when signals are transmitted close to one another they must be spaced so that the receiver can separate them using a filter and there must be a guard band between them. This is not the case with OFDM. Although the sidebands from each carrier overlap, they can still be received without the interference that might be expected because they are orthogonal to each another. This is achieved by having the carrier spacing equal to the reciprocal of the symbol period.

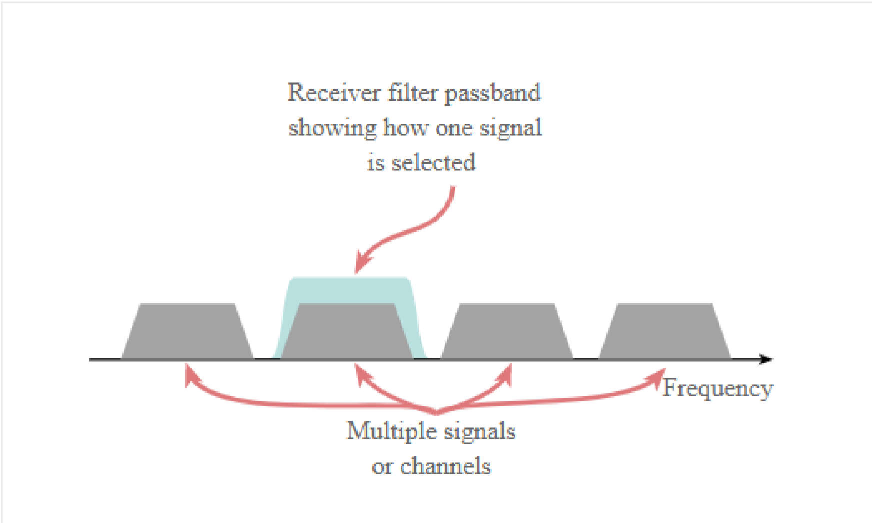


Fig. Traditional-selection of signals on different channels

To see how OFDM works, it is necessary to look at the receiver. This acts as a bank of demodulators, translating each carrier down to DC. The resulting signal is integrated over the symbol period to regenerate the data from that carrier. The same demodulator also demodulates the other carriers. As the carrier spacing equal to the reciprocal of the symbol period means that they will have a whole number of cycles in the symbol period and their contribution will sum to zero - in other words there is no interference contribution.

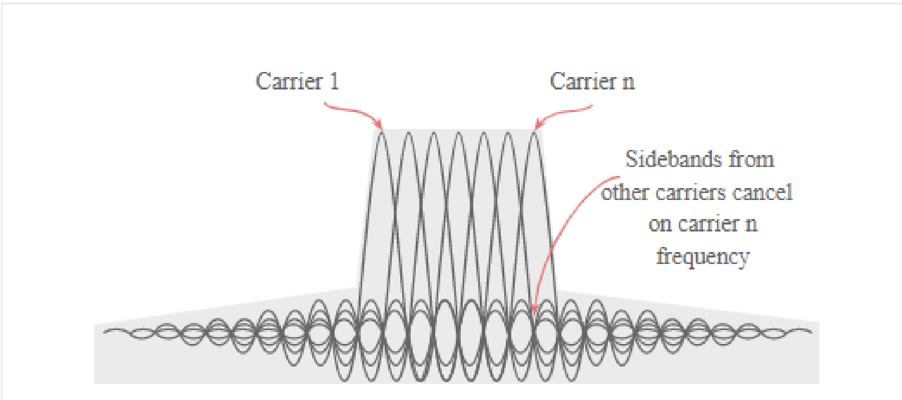
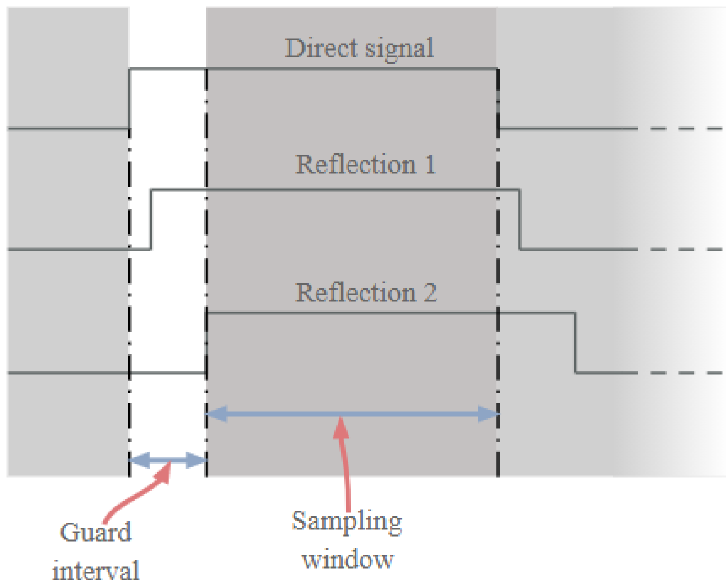


Fig. Basic Concept of OFDM, Orthogonal Frequency Division Multiplexing

One requirement of the OFDM transmitting and receiving systems is that they must be linear. Any non-linearity will cause interference between the carriers as a result of inter-modulation distortion. This will introduce unwanted signals that would cause interference and impair the orthogonality of the transmission.

In terms of the equipment to be used the high peak to average ratio of multi-carrier systems such as OFDM requires the RF final amplifier on the output of the transmitter to be able to handle the peaks whilst the average power is much lower and this leads to inefficiency. In some systems the peaks are limited. Although this introduces distortion that results in a higher level of data errors, the system can rely on the error correction to remove them.



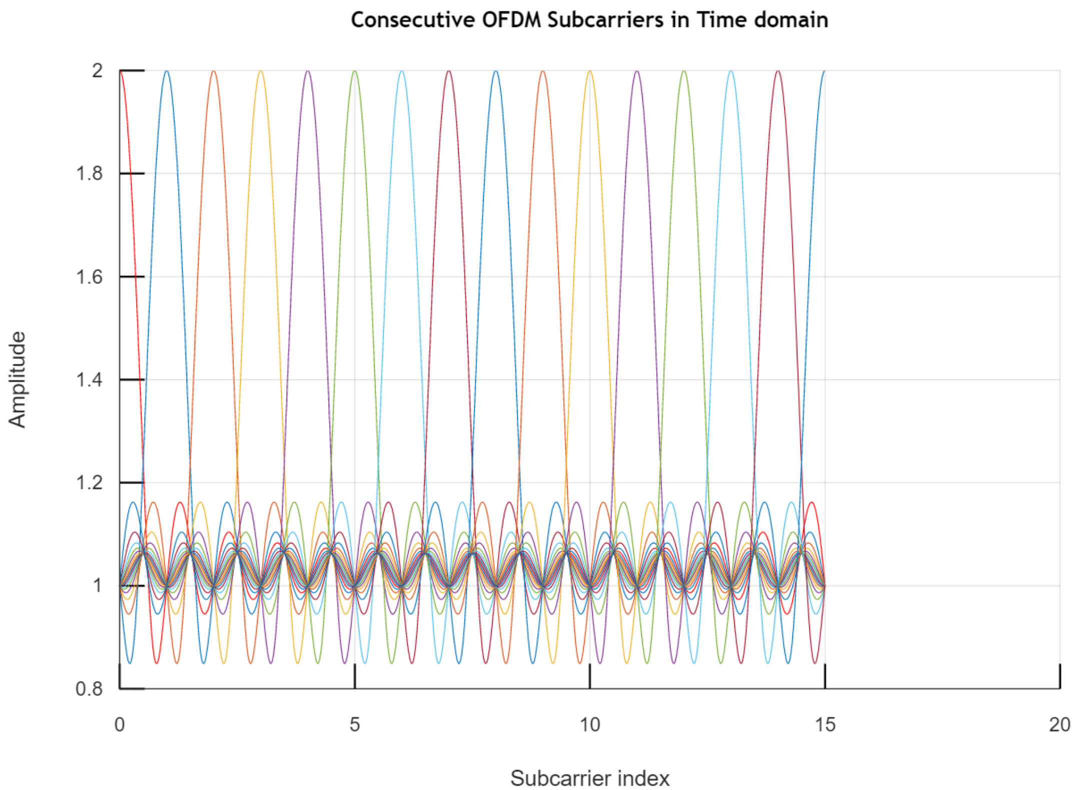
Guard interval on OFDM signals

MATLAB CODE:

```
%% This program plots sensitivity of OFDM subcarriers with Carrier frequency offset(CFO)
clc
clear all
e = 0;        % Normalized CFO
N = 16;       % Total Subcarriers
Indx = 0.01;   % Over sampling index
vi = 1;        % counter index
for k = 0:Indx:N-1
   hi = 1;    % counter index
   for l = 0:N-1
     % this function calculates effect of CFO. Bias 1 is deliberately
     % added in order to evaluate function at zero CFO.
     f(vi,hi) = 1 +(sin(pi*(l+e-k))*exp(1i*pi*(N-1)*(l+e-k)/N))...
            /(N*sin(pi*(l+e-k)/N));
     hi = hi+1;
   end
   vi = vi+1;
end
plot([0:Indx:N-1],abs(f(:,1)),'r');
hold on; grid on;
title('Consecutive OFDM Subcarriers in Time domain');
xlabel('Subcarrier index');ylabel('Amplitude');
```

```
for n = 1:N-1
   plot([0:Indx:N-1],abs(f(:,n+1)));
end
```

OUTPUT



RESULT : OFDM carrier generation is studied through simulation