MATLAB based research for Different Type's Digital Modulation on BER & AWGN Channels

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Contents

1 Abstract

The MATLAB software with relevant toolboxes for the development of the Simulink model is used for system simulation. This report introduces basic three types of the digital modulation techniques, followed by an evaluation of the receiver's bit rate performance characteristics using the MATLAB Simulink Model for FSK, PSK and QAM modulation techniques. There are different types of channels used in wireless communication. The AWGN channel is used in this report between the transmitter and the receiver. We focuses on the characterization and design of analog signal waveforms which carry digital information and compare their output on an AWGN channel.

2 Introduction

The performance of the transmitting and receiving systems is very important in recent times for fast growing wireless technologies. A tremendous technological development over the past two decades has provided potential growth in the field of digital communication and for some reasons a lot of the latest applications and technologies are coming up every day. By increasing the capacity, speed and quality of the wireless network, digital modulation schemes contribute to the evolution of mobile communications. Digital modulation schemes provide more capacity to carry information, better communication quality, data security and the sharing of RF spectrum to accommodate more services. So we need to analyze the channel parameters, components, and structures.

The bit error rate is therefore the main performance parameter of the digital communication system. Channel performance can be evaluated from the bit error rate (BER) versus the signal-to-noise ratio (SNR) curve. Noise means energy which is not needed. At any point in the communication system, noise can interfere with the signal, which will affect when the signal is weak. The ideal additive white Gaussian noise (AWGN) channel in the study of communication systems, with statistically independent Gaussian noise samples corrupting data samples free of inter-symbol interference (ISI), is the usual point of departure for understanding basic performance relations. Thermal noise generated in the receiver is the primary source of performance degradation. The thermal noise usually has a spectral density of flat power over the signal band and a probability density function of zero-mean Gaussian voltage.

2.1 AWGN Channel

For any type of communication system, channel is the most important issue. The performance of the communication channels depends on the noise. Additive white Gaussian Noise originates from many natural sources such as conductor vibration of atoms, shot noise, earth and other warm object radiation, and from celestial sources such as the Sun. There are different sorts of channels of communication. AWGN channel is a channel's simplest model, and is well suited for wired communication. This channel is (LTI) linear and time-invariant.

As signal passes through it, AWGN channel adds white Gaussian noise to the signal. The amplitude frequency response of this channel is flat, and phase response for all frequencies is linear. It moves through the modulated signals without any loss of amplitude or phase distortion. So, in such a case, there is no fading but the AWGN introduces the only distortion that exists. The signal (received) is simplified to:

$$r(t)=x(t)+n(t)$$

Where n(t) represents the noise, Gaussian distribution has the mean and variance of 0 as the transmitted signal is defined by the noise power and x(t).

2.2 Bit Error Rate

In a digital transmission basically, BER is the number of bits with errors divided by the total number of bits transmitted, received or processed over a given time period. That is:

$$BER = \frac{No.of\ bits\ with\ errors}{Total\ number\ of\ bits\ sent}$$

Bit error rate is a key parameter used to assess the performance of the systems which transmits digital data from one location to another. There is a probability that errors can be introduced into the network as data is transmitted over a data link. As a result, the performance of the system needs to be assessed, and BER provides an ideal way to achieve that.

2.3 Digital Modulation

There are three main modulation methods for digital signal transmission. The methods are based on three a sinusoidal signal, amplitude, frequency, and phase attributes. The corresponding modulation methods for digital modulation are: amplitude shift keying (ASK), frequency shift keying (FSK), and phase shift keying (PSK).

2.3.1 Amplitude shift keying

Easy and simple type of digital modulation is Amplitude Shift Keying (ASK). The digital input is NRZ unipolar. Amplitude in ASK carrier is multiplied by high amplitude for binary "1," or low amplitude for binary "0."

However, if the low amplitude is 0 for the binary "0" then the ASK is called the On-Off keying. The modulated carrier signal can be written in OOK as:

$$(t)=A\sin(2\pi fct)$$

Where, fc is the frequency of the carrier and A is a variable of the data bit. Depending on the state of the digital input signal, the value of A may be "1" or "0.

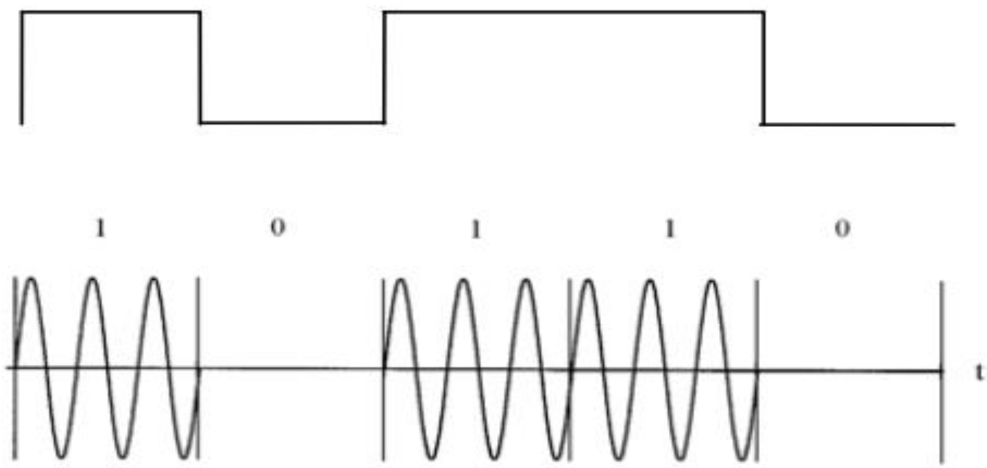


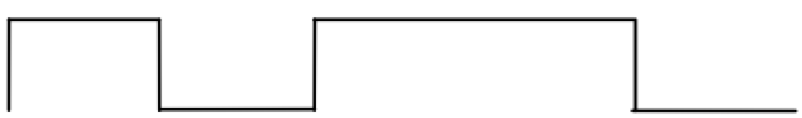
Figure: Amplitude shift keying (ASK)

2.3.2 Frequency shift keying

In frequency shift keying (FSK), the carrier frequency is shifted between two discrete values, one representing binary "1" and representing binary "0," but the amplitude of the carrier does not change. FSK in its simple form is BFSK. The FSK signal's instantaneous vale is given by:

$$(t)=A\sin(2\pi f_1)+\bar{A}\sin(2\pi f_2 t)$$

Where, f1 and f2 are the frequencies that correspond to binary "1" and "0," and f1 > f2 respectively. It is clear from the above equation that the FSK signal can be deemed to consist of two ASK signals with carrier frequencies f1 and f2



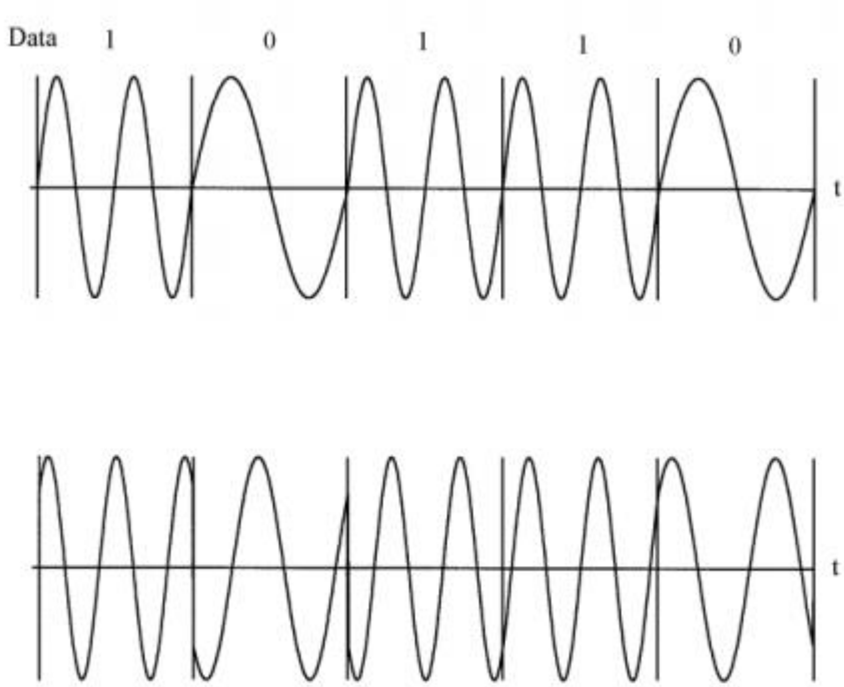


Figure: FSK with continuous and discontinuous phase

2.3.3 Phase shift keying

In phase shift keying (PSK), the carrier phase is modulated in order to represent the binary values. The carrier phase shifts via the optical bipolar signal between 0 and ÿ. The Binary states "1" and "0" are represented by the digital signal's positive and negative polarity. The digital signal's instant-value can be written as:

$$(t)=A\sin(2\pi fct)$$

Where, $A=\pm1$; $A=1$ for binary state "1" and $A=-1$ for binary state "0".

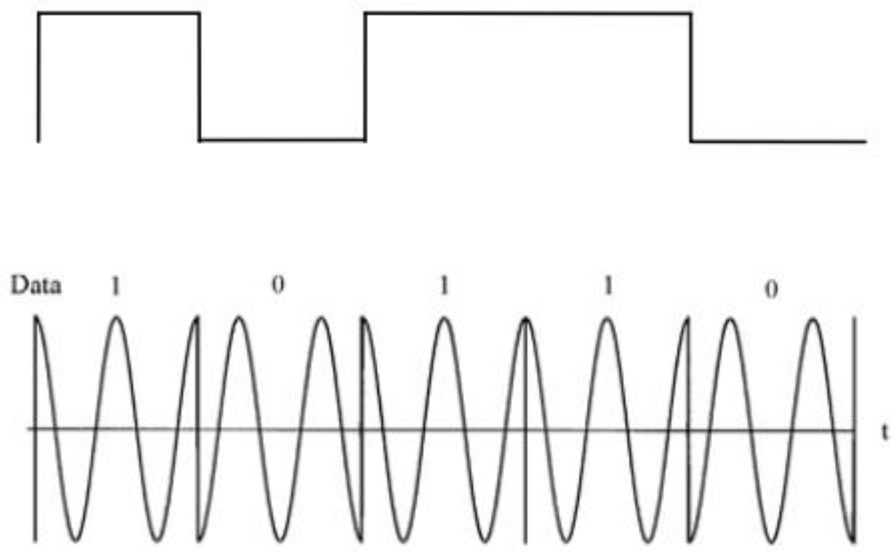


Figure: Phase shift keying (PSK)

3 Performance Analysis using MATLAB

3.1 Simulation Models:

The simulation model for MATLAB consists of the transmitter, channel, and receiver. Between transmitter and receiver the AWGN channel is used. Data are generated by Bernoulli data generator at the transmitter end. Data generator Bernoulli produces data with a probability of zero 0.5 and a sampling time of one second. The bit error rate (BER) of various types of digital modulation can be calculated using MATLAB Simulink file using Monte Carlo simulations.

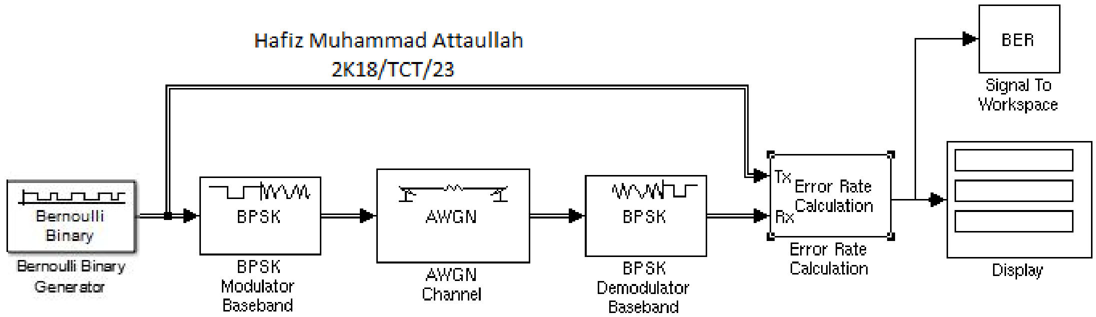


Figure: Screen-shoot of Simulink Model for BPSK

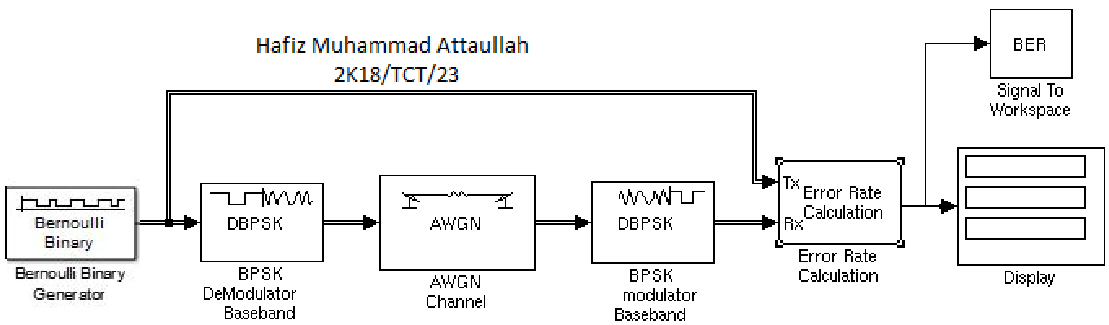


Figure: Screen-shoot of Simulink Model for DBPSK

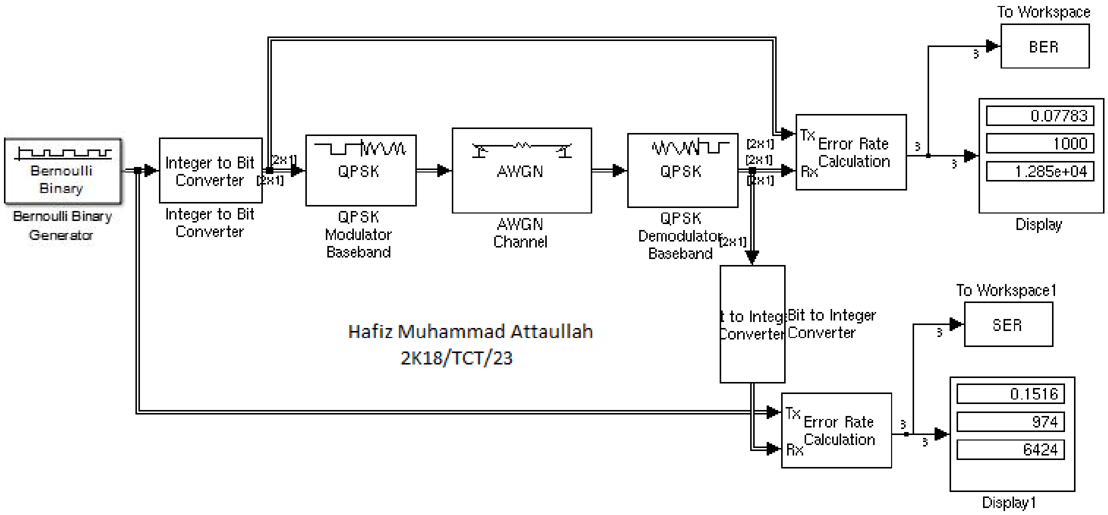


Figure: Screen-shoot of QPSK Modulation and Demodulation Simulink Model

3.2 Coding:[1]

3.2.1 BPSK modulation and de-modulation

```
% ********************* BPSK modulation and de-modulation ****************%
clc;
clear all;
% ********************* Define transmitted signal *************************
N=10;           % 10 is Number of bits
x_inp = randint(1,N);  % binary signal 0 or 1 % transmitted message
Tb = 0.0001; % bit period (per second)
% ********************* Represent input signal as digital signal ****
x_bit=[];
nb=100; % bbit/bit
for n=1:1:N   %
    if x_inp(n)==1;  %
       x_bitt=ones(1,nb);
```

[1] All coding is done with the help of various sources specially mathworks community.

```
    else x_inp(n)==0;
        x_bitt=zeros(1,nb);
    end
     x_bit=[x_bit x_bitt];
end
t1=Tb/nb:Tb/nb:nb*N*(Tb/nb); % time of the signal
f1 = figure(1);
set(f1,'color',[1 1 1]);
subplot(3,1,1);
plot(t1,x_bit,'lineWidth',2);grid on;
axis([ 0 Tb*N -0.5 1.5]);
ylabel('Tmplitude(volt)');
xlabel(' Time(sec)');
title('Input signal as digital signal');
% ********************* Define BFSK Modulation ****************************
Ac=5;  % Amplitude of carrier signal
mc=4;  % fc>>fs fc=mc*fs fs=1/Tb
fc=mc*(1/Tb); % carrier frequency for bit 1
fi1=0; % carrier phase for bit 1
fi2=pi; % carrier phase for bit 0
t2=Tb/nb:Tb/nb:Tb;
t2L=length(t2);
x_mod=[];
for (i=1:1:N)
    if (x_inp(i)==1)
        x_mod0=Ac*cos(2*pi*fc*t2+fi1);%modulation signal with carrier signal 1
    else
        x_mod0=Ac*cos(2*pi*fc*t2+fi2);%modulation signal with carrier signal 2
    end
    x_mod=[x_mod x_mod0];
end
t3=Tb/nb:Tb/nb:Tb*N;
subplot(3,1,2);
plot(t3,x_mod);
xlabel('Time(sec)');
ylabel('Amplitude(volt)');
title('Signal of  BASK modulation ');
```

```
% ******************** Transmitted signal x *****************************
x=x_mod;
% ******************** Channel model h and w ****************************
h=1; % Fading
w=0; % Noise
% ******************** Received signal y ********************************
y=h.*x+w;
% ******************** Define BPSK Demodulation *************************
y_dem=[];
for n=t2L:t2L:length(y)
  t=Tb/nb:Tb/nb:Tb;
  c=cos(2*pi*fc*t); % carrier siignal
  y_dem0=c.*y((n-(t2L-1)):n);
  t4=Tb/nb:Tb/nb:Tb;
  z=trapz(t4,y_dem0); % intregation
  A_dem=round((2*z/Tb));
  if(A_dem>Ac/2) % logic level = Ac/2
    A=1;
  else
    A=0;
  end
  y_dem=[y_dem A];
end
x_out=y_dem; % output signal;
% *************** Represent output signal as digital signal ***************
xx_bit=[];
for n=1:length(x_out);
    if x_out(n)==1;
       xx_bitt=ones(1,nb);
    else x_out(n)==0;
        xx_bitt=zeros(1,nb);
    end
     xx_bit=[xx_bit xx_bitt];
end
t4=Tb/nb:Tb/nb:nb*length(x_out)*(Tb/nb);
subplot(3,1,3)
plot(t4,xx_bit,'LineWidth',2);grid on;
```

```
axis([ 0 Tb*length(x_out) -0.5 1.5]);
ylabel('Amplitude(volt)');
xlabel(' Time(sec)');
title('Output signal as digital signal');
% **************************** end of program *****************************
```

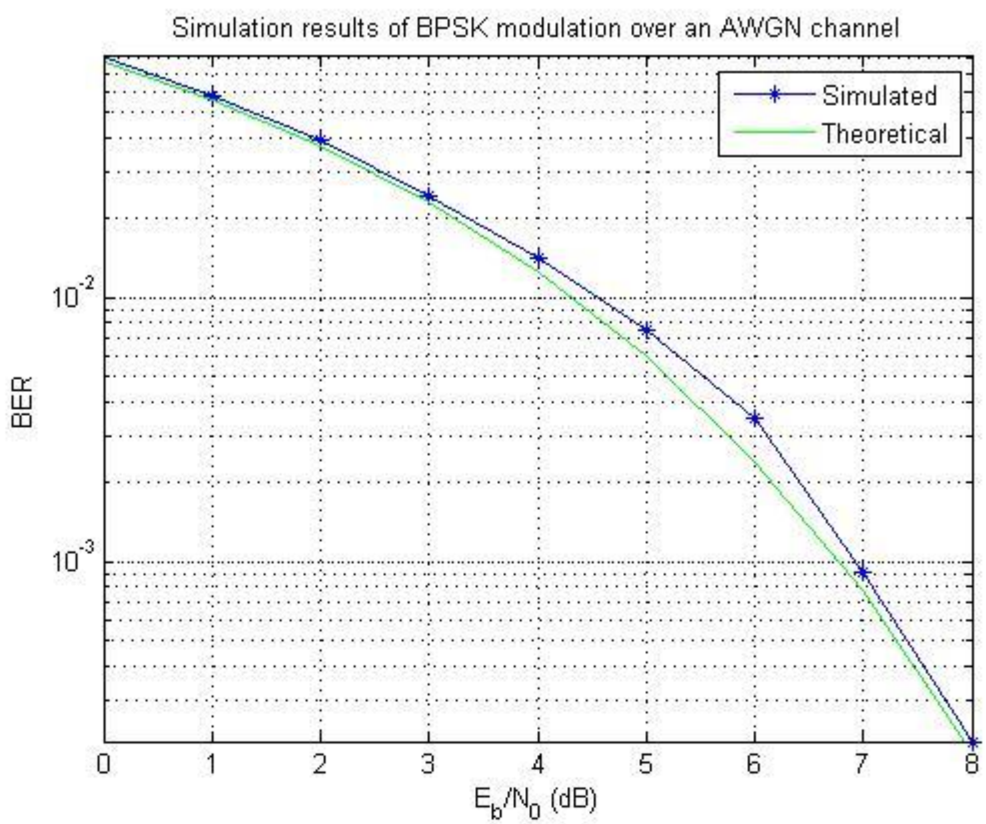
3.2.2 QPSK Modulation and Demodulation

```
%**** QPSK Modulation and Demodulation****
clc;
clear all;
close all;
data=[0  1 0 1 1 1 0 0 1 1]; % information
%Number_of_bit=1024;
%data=randint(Number_of_bit,1);
figure(1)
stem(data, 'linewidth',3), grid on;
title('  Information before Transmiting ');
axis([ 0 11 0 1.5]);
data_NZR=2*data-1; % Data Represented at NZR form for QPSK modulation
s_p_data=reshape(data_NZR,2,length(data)/2);  % S/P convertion of data
br=10.^6; %Let us transmission bit rate  1000000
f=br; % minimum carrier frequency
T=1/br; % bit duration
t=T/99:T/99:T; % Time vector for one bit information
% **************** QPSK modulatio  ****************
y=[];
y_in=[];
y_qd=[];
for(i=1:length(data)/2)
    y1=s_p_data(1,i)*cos(2*pi*f*t); % inphase component
    y2=s_p_data(2,i)*sin(2*pi*f*t) ;% Quadrature component
    y_in=[y_in y1]; % inphase signal vector
    y_qd=[y_qd y2]; %quadrature signal vector
    y=[y y1+y2]; % modulated signal vector
end
```

```
Tx_sig=y; % transmitting signal after modulation
tt=T/99:T/99:(T*length(data))/2;
figure(2)
subplot(3,1,1);
plot(tt,y_in,'linewidth',3), grid on;
title(' wave form for inphase component in QPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude(volt0');
subplot(3,1,2);
plot(tt,y_qd,'linewidth',3), grid on;
title(' wave form for Quadrature component in QPSK modulation ');
xlabel('time(sec)');
ylabel(' amplitude(volt0');
subplot(3,1,3);
plot(tt,Tx_sig,'r','linewidth',3), grid on;
title('QPSK modulated signal (sum of inphase and Quadrature phase signal)');
xlabel('time(sec)');
ylabel(' amplitude(volt0');
% **************** QPSK demodulation ****************
Rx_data=[];
Rx_sig=Tx_sig; % Received signal
for(i=1:1:length(data)/2)
    %**************** inphase coherent dector ****************
    Z_in=Rx_sig((i-1)*length(t)+1:i*length(t)).*cos(2*pi*f*t);
    % above line indicat multiplication of received & inphase carred signal

    Z_in_intg=(trapz(t,Z_in))*(2/T);% integration using trapizodial rull
    if(Z_in_intg>0) % Decession Maker
        Rx_in_data=1;
    else
       Rx_in_data=0;
    end

    %**************** Quadrature coherent dector ****************
    Z_qd=Rx_sig((i-1)*length(t)+1:i*length(t)).*sin(2*pi*f*t);
    %above line indicat multiplication ofreceived & Quadphase carred signal
```

```
    Z_qd_intg=(trapz(t,Z_qd))*(2/T);%integration using trapizodial rull
        if (Z_qd_intg>0)% Decession Maker
        Rx_qd_data=1;
        else
       Rx_qd_data=0;
        end


        Rx_data=[Rx_data  Rx_in_data  Rx_qd_data]; % Received Data vector
end
figure(3)
stem(Rx_data,'linewidth',3)
title('Information after Receiveing ');
axis([ 0 11 0 1.5]), grid on;
% ****************    end of program    ****************
```

4 Result:



Signal Scope:

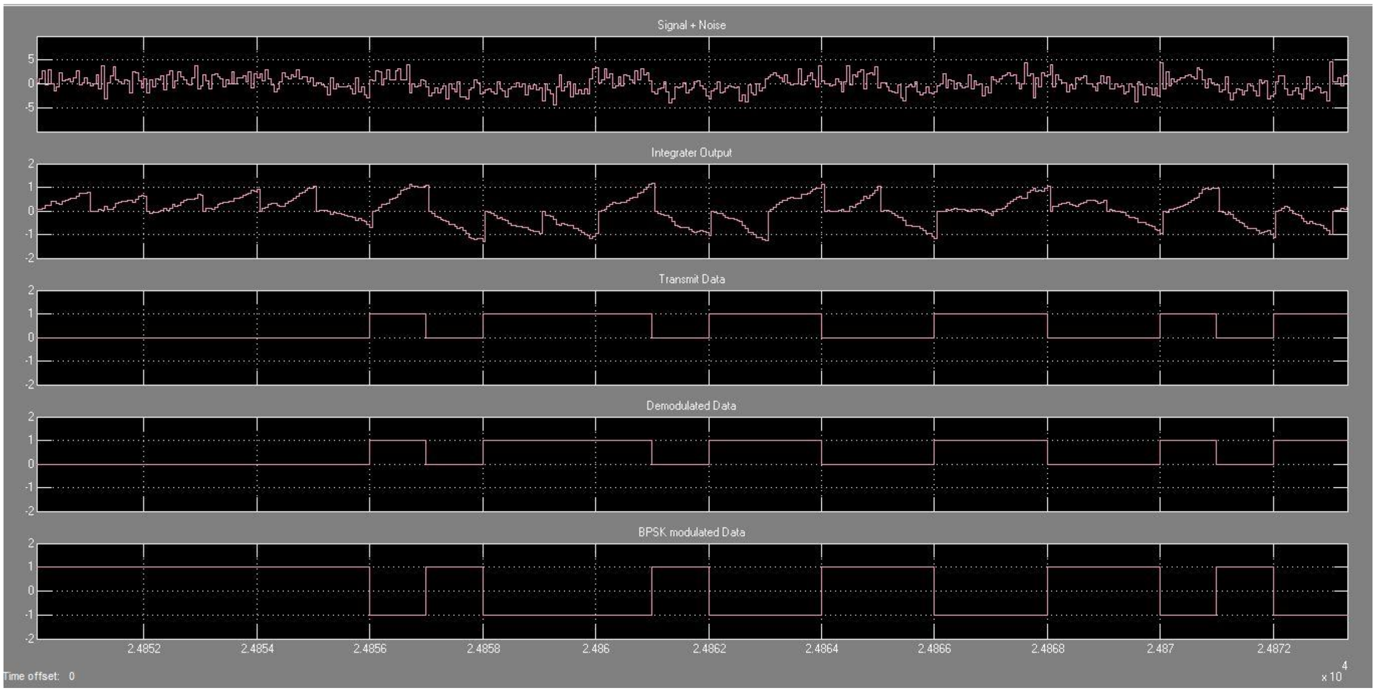


Table: Bit Error Rate for 100000 bits transmission.

E_b/N_0	BPSK	DBPSK	QPSK
1	0.05663	0.14090	0.24230
2	0.03834	0.10130	0.19630
3	0.02345	0.06752	0.15030
4	0.01279	0.04123	0.10940
5	0.00626	0.02156	0.07373
6	0.00236	0.00914	0.04519
7	0.00072	0.00341	0.02433
8	0.00024	0.00096	0.01149

5 Conclusion

In this report; it addressed three basic modulation types. For the purposes of MATLAB simulation a variety of modulation schemes such as BPSK, QPSK, DBPSK, and QAM were considered.

Their BER was analyzed using MATLAB Monte Carlo simulation tool for the white Gaussian noise channel additive and some MATLAB coding as well. From the above figures, we concluded that BPSK is the most effective modulation schemes in a practical communication system, depending on the rate of bit errors.

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