School of Engineering and Applied Science (SEAS)
Ahmedabad University

BTech(ICT) Semester V: Wireless Communication (ECE311)

Laboratory Assignment-1

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1. Task: Simulated plot under AWGN channel with QPSK modulation.

   (a) Matlab Script:

```
% *************** Comparision of BER v/s SNR for BPSK and QPSK modulation over
    AWGN noise *********%

% ******************** Initialization ***********************************%
clc;
clear all;
close all;

loop=1; % Monte Carlo
M=1000000;  % Frame length (x_1 x_2 ... x_M)
SNRdB=-10:10; % SNR in dB
SNR=10.^(SNRdB/10);
Rate= zeros(1, length(SNRdB)); %

% ******************** Transmitter ************************************%

for dB= 1: length(SNRdB) % start looping by SNR
    dB
    for lp= 1: loop, % start looping of frame data

% ******************** QPSK signal generation **************************%
  x_inp_I=sign(rand(M,1)- 0.5); % 1 or -1 for inphase signal
    x_inp_Q=sign(rand(M,1)- 0.5); % 1 or -1 for guadrature signal
    x_inp=x_inp_I+i*x_inp_Q; %  1+j=00, -1+j=01, -1-j=10, 1-j=11
    x_inp=(1/sqrt(2))*x_inp; % normalization


% ******************** Channel ****************************************%
  N0=1./SNR(dB);
    sigma(dB)=sqrt(N0/2);
    noise=(1/sqrt(2))*(sigma(dB)*randn(M,1)+i*sigma(dB)*randn(M,1));
    y_channel=x_inp+noise; % Additive White Guassiann Noise (AWGN)



% ******************** Receiver ***************************************%
    y=y_channel;
    x_out_I= sign(real(y)); %
    x_out_Q= sign(imag(y)); %
    x_out=x_out_I+i*x_out_Q;

% ******************** Bit Error Rate (BER) calulation *****************%
    [err, rate]= symerr([x_inp_I;x_inp_Q], [x_out_I;x_out_Q]);
    Rate(dB)= Rate(dB) + rate;
    end % end for loop
    Rate(dB)= Rate(dB)/loop; % Average value over Monte Carlo simulation
                             % loop
end % end Monte Carlo

% ******************** Plot the simulation result **********************%
```

```
50
51      f1 = figure(1);
52      set(f1,'color',[1 1 1]);
53
54      semilogy(SNRdB,Rate, 'b')
55      hold on;
56
57
58
59      BER_th=(1/2)*erfc(sqrt(SNR)); % theoritical calculation for BER
60      semilogy(SNRdB,BER_th,'r-o');
61
62      hold on;
63      axis([1 10 0.000001  1.2]);
64      xlabel( 'Signal-to-Noise Ratio (SNR)')
65      ylabel( 'Bit Error Rate (BER)')
66      title('Simulation QPSK transmission over noise');
67      legend('BER simulation','BER calculation')
68      grid on;
69
70
```

(b) Simulation Output:

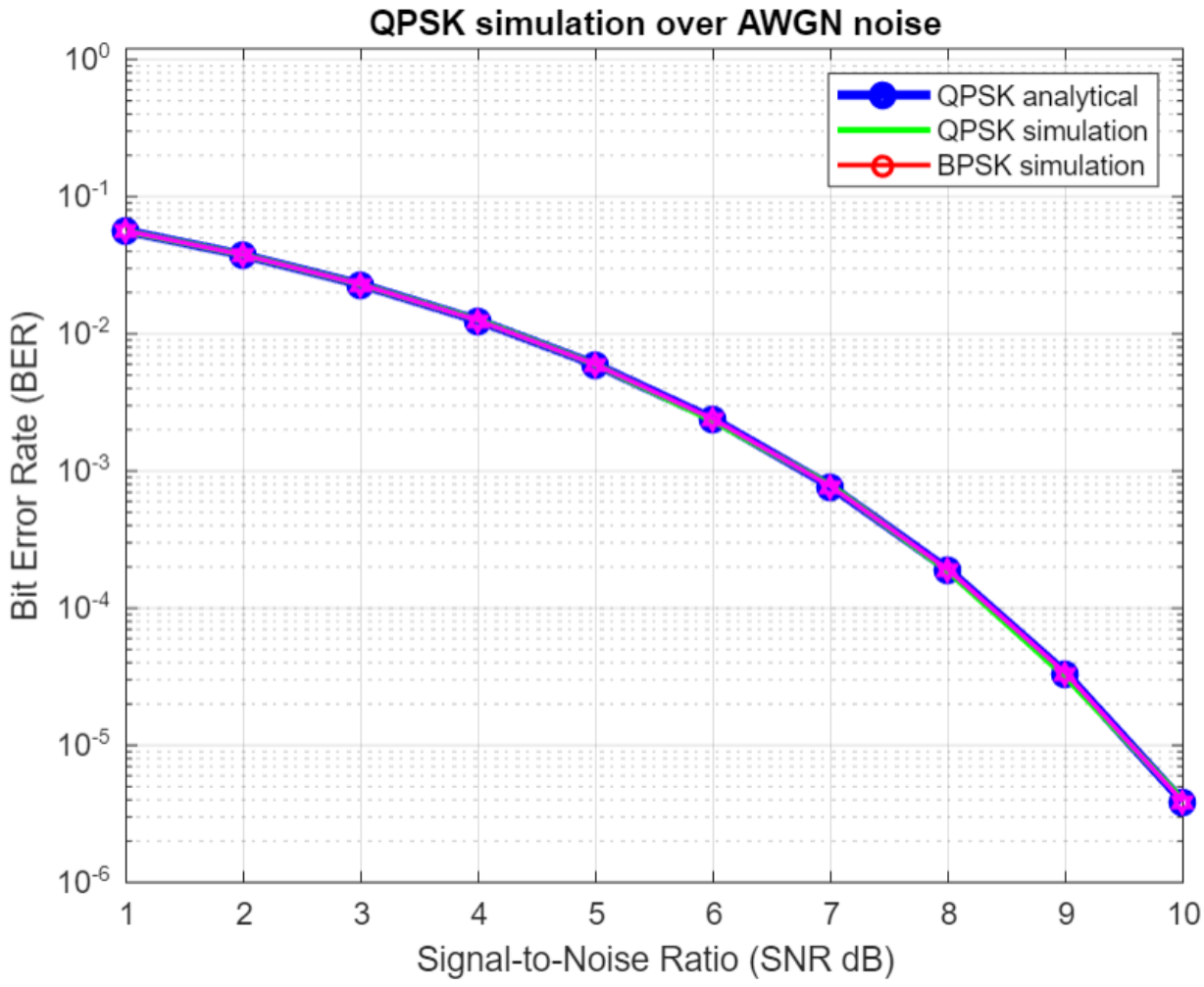

Figure 1: Simulated plot under AWGN channel with BPSK and QPSK modulation.

(c) **Inference 1:** Since the bit error rate for BPSK and QPSK is similar thus it by using QPSK we can transmit twice amount of data on the same channel with the same bandwidth. If we extend the modulation using 4 QPSK, 8QPSK then we can achieve higher data rate on little increase in Bit error rate as compare to BPSK. The above comparison graph represents the statement in pictorial form.

(d) **Inference 2:** BER is the key parameter for indicating the system performance of any data link. The BER vs SNR plot for BPSK and QPSK modulation techniques shows that for higher order modulation schemes the BER increases with increasing SNR. On the other hand, the lower order modulation schemes (BPSK and QPSK) experience less BER at receiver thus lower order modulations improve the system performance in terms of BER and SNR.

2. Solution Problem-2

(a) Matlab Script:

```
% *************** SER v/s SNR of BPSK and QPSK modulation over AWGN noise
    *********%
% with using Monte Carlo simulation

% ********************* Initialization ***********************************%
clc;
clear all;
close all;
r=randi(1,10000);
for i=1:10000
    if r(i)==0
        s(i)=-1;
    else
        s(i)=1;
    end
end
k=1;
for snrdb=1:1:10;
    v=1/(10^(snrdb/10));
x=awgn(s,snrdb,'measured');
%n1=sqrt(v/2)*randn(1,10000);
%n2=sqrt(1/2)*randn(1,10000);
%n=sqrt(n1.*n1+n2.*n2);
y=x;
for j=1:10000
    if y(j)>0
        z(j)=1;
    else
        z(j)=0;
    end
end
error=length(find(z~=r));
ber(k)=error/10000;
ser_qpsk(k)=error/5000;
k=k+1;
end
snrdb=1:1:10;

snrlin=10.^(snrdb./10);
tber=0.5.*erfc(sqrt(snrlin));

semilogy(snrdb,ser_qpsk,'-ro');
grid on
semilogy(snrdb,ber,'-bo');
hold on;
xlabel('SNR(dB)');
ylabel('SER');
legend('QPSK', 'BPSK')

```

(b) Simulation Output:

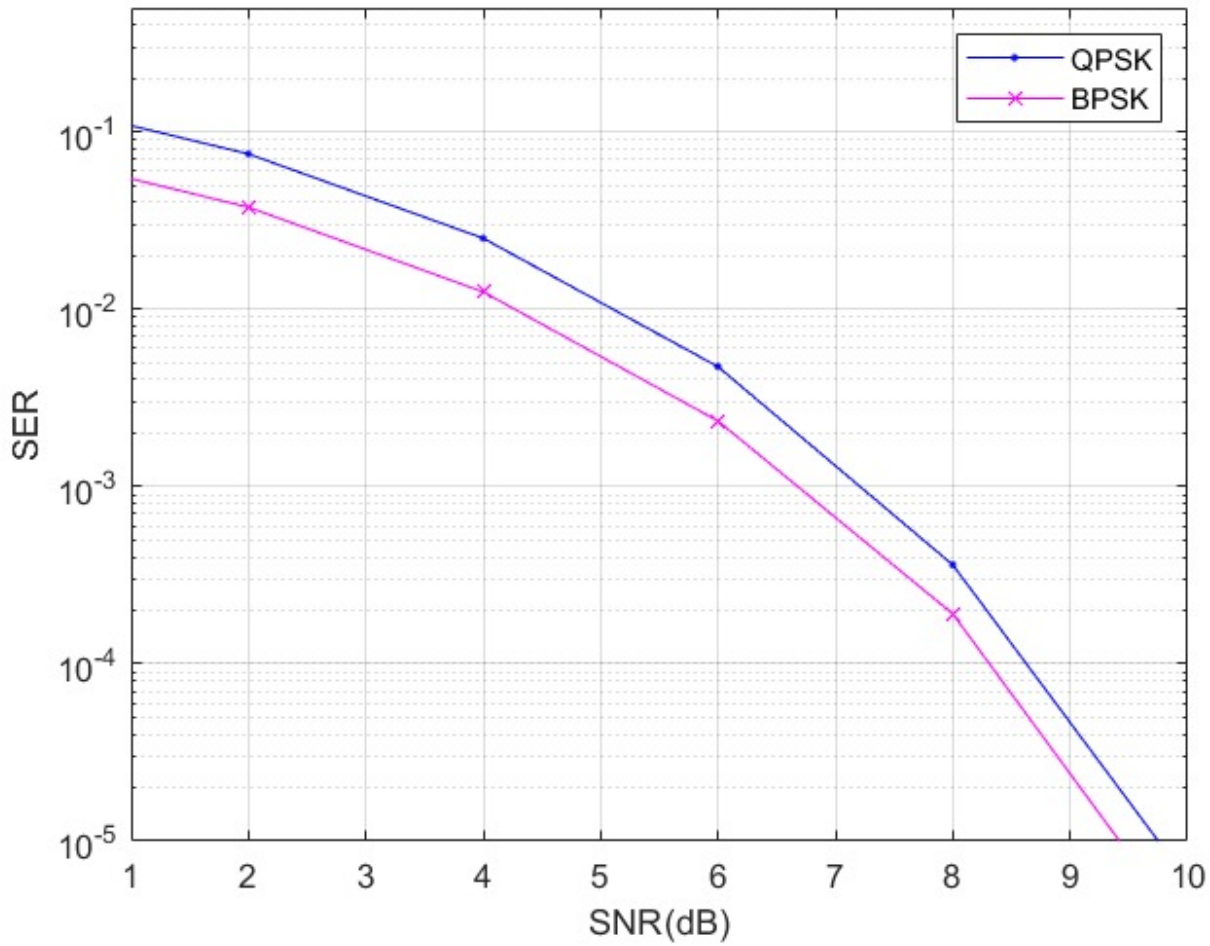

Figure 2: Simulated plot under AWGN channel with BPSK and QPSK modulation.

3. **Inference:** SER for QPSK is almost double the SER for BPSK. In QPSK, two bits can be represented per symbol unlike BPSK, which can only represent one bit per symbol. QPSK is more likely sensitive to noise than BPSK modulation, since noise can produce with higher probability an additive phase value. Hence, QPSK has more symbol error rate since it has more number of symbols than BPSK.