School of Engineering and Applied Science (SEAS)
Ahmedabad University

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

Laboratory Assignment-2

Enrollment No: AU1841029 **Name: Kalki Bhavsar**

1. Task: Simulated plot over Wireless channel with QPSK modulation..

   (a) Matlab Script:

```
  %%%%%%%%Simulated plot over Wireless channel with QPSK modulation.%%%%%%%%%
close all;
clear all;
clc;

%********************** Initialization ***********************************%
N = 10^6;
SNRdB = [0:40]; %SNR in dB
ipHat = zeros(1,N);


% ***************************************************************************%
% ***************************** AWGN CHANNEL ********************************%
% ***************************************************************************%

% ********************* Transmitter ***************************************%
for ii = 1:length(SNRdB)

% ********************* QPSK signal generation ****************************%
    x_AWGN = (2*(rand(1,N)>0.5)-1) + 1i*(2*(rand(1,N)>0.5)-1);
    x_AWGN_normal = (1/sqrt(2))*x_AWGN; % Normalization of Energy to 1

% ********************* Channel *******************************************%
    n_WGN = 1/sqrt(2)*[randn(1,N) + j*randn(1,N)];
    % White Guassian Noise with 0dB variance
    y_AWGN = x_AWGN_normal + 10^(-SNRdB(ii)/20)*n_WGN;
    % Additive White Gaussian Noise

% ********************* Receiver ******************************************%
    y_AWGN_real = real(y_AWGN);% real part of recieved signal
    y_AWGN_img = imag(y_AWGN); % imaginary part of recieved signal


    ipHat(find(y_AWGN_real >= 0 & y_AWGN_img > 0)) = 1 + 1*j;
    ipHat(find(y_AWGN_real < 0 & y_AWGN_img < 0)) = -1 + -1*j;
    ipHat(find(y_AWGN_real >= 0 & y_AWGN_img < 0)) = 1 - 1*j;
    ipHat(find(y_AWGN_real < 0 & y_AWGN_img >= 0)) = -1 + 1*j;

% ********************* Bit Error Rate (BER) calulation *******************%
    total_error_bits(ii) = size(find([x_AWGN- ipHat]), 2);
    % Counting the total number of errors by comparing
    % the transmitted and recieved signal
end

%Y-axis vector, BER for AWGN channel model
BER_AWGN = total_error_bits/N;
```

```
51
52 % ************************************************************************%
53 % ******************RAYLEIGH FADING CHANNEL*****************************%
54 % ************************************************************************%
55
56 % ******************** Transmitter ***************************************%
57 for i = 1:length(SNRdB)
58     x_Ray = (2*(rand(1,N)>0.5)-1) + j*(2*(rand(1,N)>0.5)-1);
59     x_Ray_normal = (1/sqrt(2))*x_Ray; % Normalization of energy to 1
60
61 % ******************** Channel *******************************************%
62     n_Ray = 1/sqrt(2)*[randn(1,N) + j*randn(1,N)];
63     % White Gaussian Noise with 0dB variance
64     h_Ray = 1/sqrt(2)*[randn(1,N) + j*randn(1,N)];
65     % h
66     y = x_Ray_normal.*h_Ray + 10^(-SNRdB(i)/20)*n_Ray;
67     % Addition of Additive White Gaussian Noise and tranmitted signal
68
69 % ******************** Receiver ******************************************%
70     y_AWGN_real = real(y./h_Ray); % real part of recieved signal
71     y_AWGN_img = imag(y./h_Ray);  % imaginary part of recieved signal
72     iphat(find(y_AWGN_real < 0 & y_AWGN_img < 0)) = -1 + -1*j;
73     iphat(find(y_AWGN_real >= 0 & y_AWGN_img > 0)) = 1 + 1*j;
74     iphat(find(y_AWGN_real < 0 & y_AWGN_img >= 0)) = -1 + 1*j;
75     iphat(find(y_AWGN_real >= 0 & y_AWGN_img < 0)) = 1 - 1*j;
76
77 % ******************** Bit Error Rate (BER) calulation *******************%
78     total_error_bits(i) = size(find([x_Ray- iphat]),2);
79     % Counting the total number of errors by comparing
80     % the transmitted and recieved signal
81 end
82 BER_Rayleigh = total_error_bits/N;
83
84 % ******************** Plot the simulation result ************************%
85 figure
86 % *********  Plot BER v/s SNRdb over Rayleigh Fading Channel *************%
87 semilogy(SNRdB, BER_Rayleigh, 'b-o', 'linewidth', 2);% Rayliegh
88 hold on
89 % *************** Plot BER v/s SNRdb over AWGN Channel ******************%
90 semilogy(SNRdB, BER_AWGN,'r->', 'linewidth', 2);% AWGN
91 grid on;
92 xlabel('Signal to Noise Ratio (SNR dB)');
93 ylabel('Bit Error Rate - BER');
94 title('BER for QPSK modulation over Rayleigh Channel');
95 legend('QPSK over Rayleigh Fading Channel Simulation', 'QPSK over AWGN channel
       Simulation');
96
97
98
```

(b) Simulation Output:

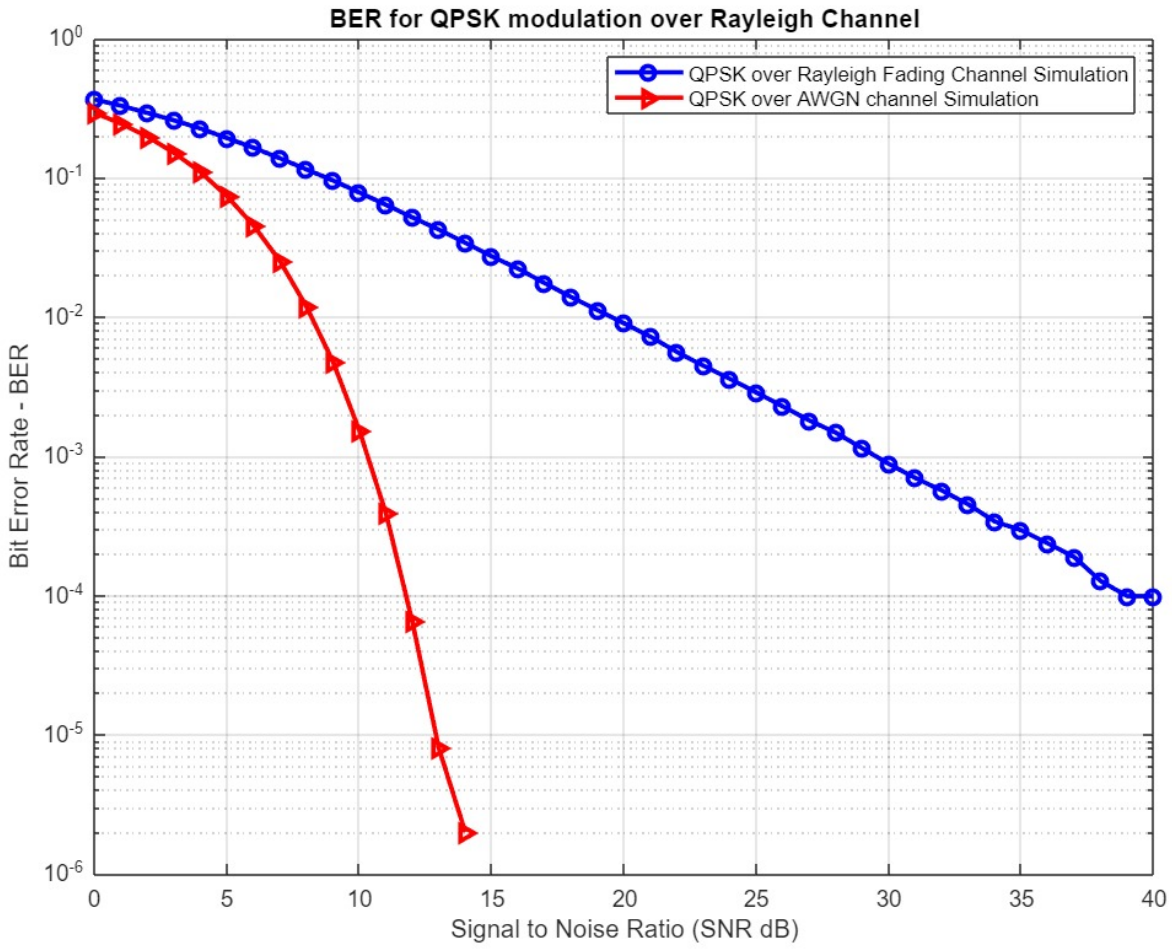

Figure 1: Simulated plot under under Rayleigh channel and AWGN channel with QPSK modulation.

(c) **Inference 1: Energy comparision**
In BPSK as compared to the AWGN case, there is around 25 dB degradation of SNR.
The amount of energy required for transmission over AWGN channel is lesser than the energy required for transmission over Rayleigh channel.

(d) **Inference 2: BER comparision**
The BER for transmission over AWGN channel is lesser than that for Rayleigh channel. Hence BER performance is better in AWGN channel as compared to Rayleigh channel over noisy environment. So if the transmission enviroment is noisy, AWGN channel performance is better.

(e) **Inference 3: QPSK or BPSK?**
Since, QPSK offers acceptable BER while transmitting signals of relatively low energy, QPSK modulation is preferred in cases where we need to consider small amounts of transmitting energy. Hence, QPSK modulation technique gives better BER performance in AWGN and lower bit error rate probability as compared to Rayleigh channel.

(f) **Inference 4: AWGN or Rayleigh channel?**
In AWGN channel, for minimizing the error, required value of SNR is less hence less energy is required for bits in symbols. While in Rayleigh channel, for reducing the error, required value of SNR is high. Hence more energy is required for each bits in symbols.

(g) **Inference 5: SNR required for 3G/ 4G standards**
The SNR for QPSK under AWGN channel is approximately 10dB for 3G standards and 11.5dB for 4G standards.