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BER of BPSK in Rayleigh fading

AIM:
To perform an experiment to simulate BER of BPSK in Rayleigh fading.

With BPSK:

$$P_e \mid h = Q\left(\sqrt{2 \mid h \mid^2 SNR}\right)$$

The channel gain h varies with time. With $h \sim \mathcal{CN}(0,1)$,

$$P_e = \mathrm{E}_h\left[Q\left(\sqrt{2 \mid h \mid^2 SNR}\right)\right] = \frac{1}{2}\left(1 - \sqrt{\frac{SNR}{1+SNR}}\right)$$

Task

- **Write matlab/octave code to plot the BER of BPSK symbols in Rayleigh fading as a function of Eb/N0 in dB**
  - Plot the theoretical BER of BPSK in Rayleigh fading as a function of Eb/ No in dB (use semilogy)
  - Plot the theoretical BER of BPSK in AWGN as a function of Eb/ No in dB (use semilogy)

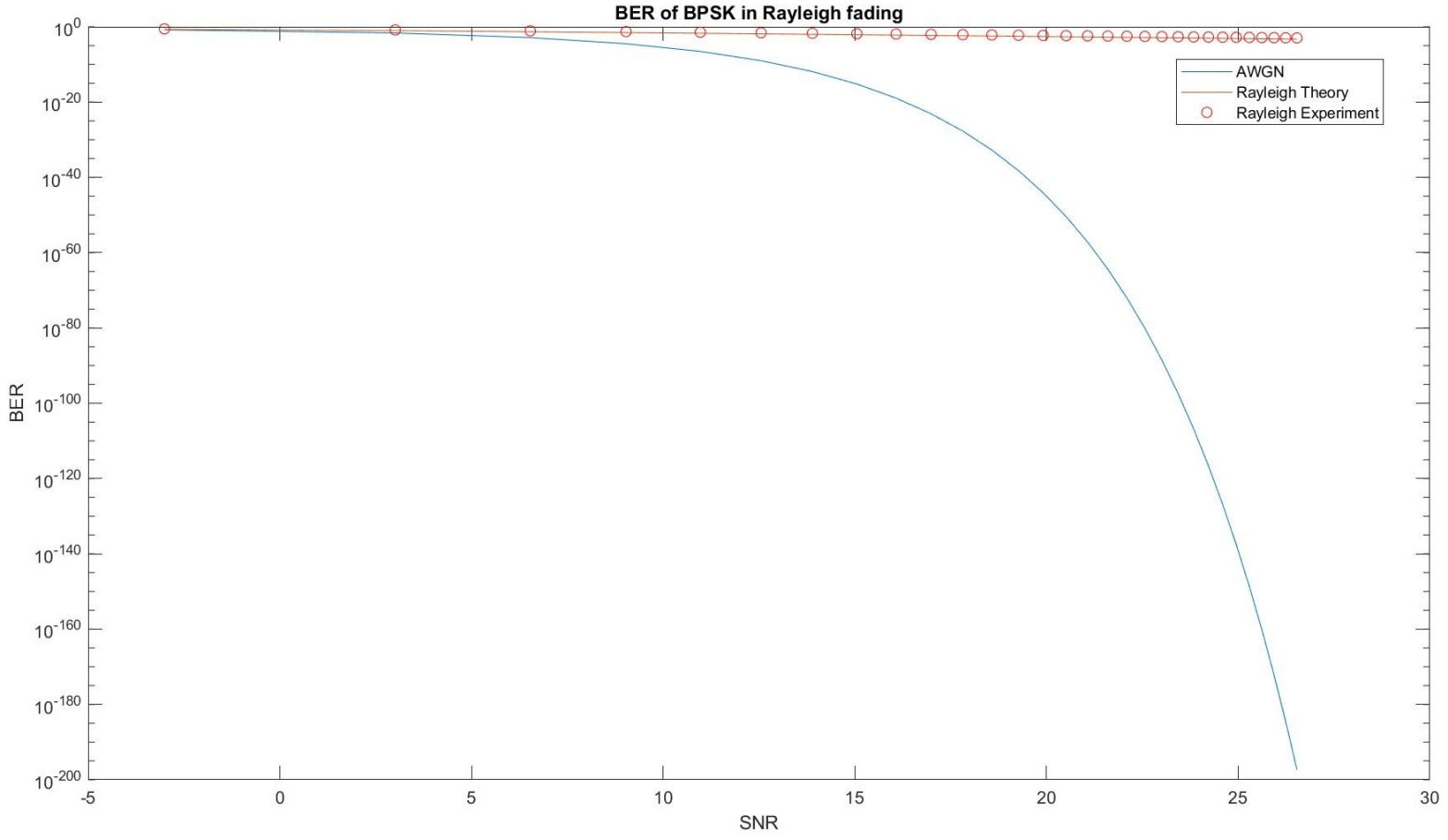
Working Code

```
%BER of BPSK in Rayleigh fading
clear all; close all; clc; % Clear all data
%  Different sample of Amplitude of 1 bit
a1 = 0:0.5:15;
%  Different sample of Amplitude of 0 bit
a2 = -a1;
BER = zeros(1,length(a1));      %initialise BER count to zero
% mean of Random Variable
mu = 0;
% variance of Random Variable
sigma = 0.5;
% Number of sample
N = 1000000;
%snr ->signal to noise ratio
snr=(a1.^2)./sigma;
snrdb = 10*log10(snr);
%AWGN Theory
q=(a1-a2)./(2*sigma); % For computation of Qfunc from ERFC
PEawgn = 1/2 .* erfc(q./sqrt(2));
%plot for AWGN Theory
semilogy(snrdb,PEawgn);
%Rayleigh Theory
PEray = 0.5.*(1-sqrt((snr./(1+snr))));
%plot snr vs ber
```

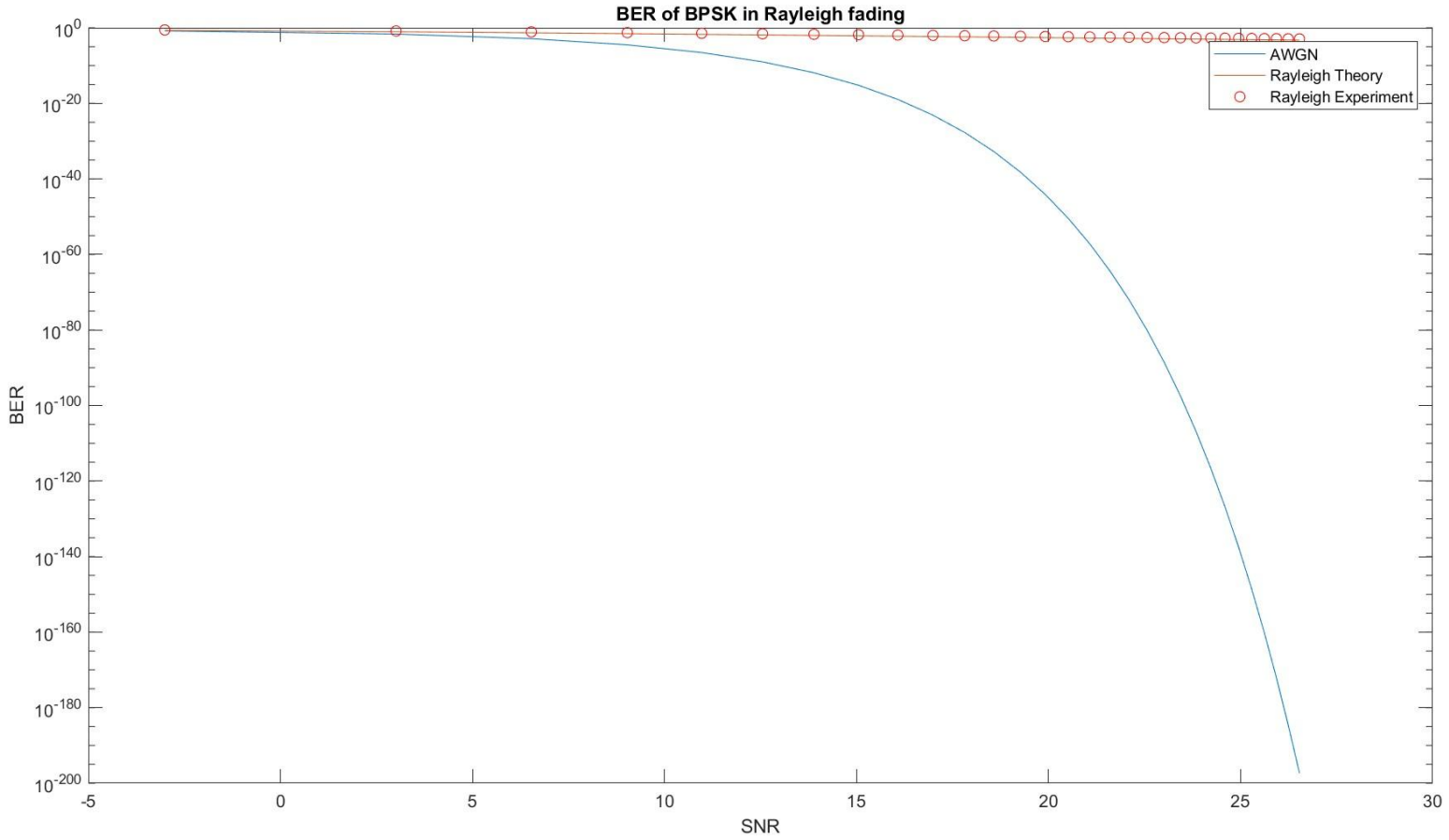
```
hold on;
semilogy(snrdb,PEray);
hold off
% Generation of Gaussian random variable samples for real part
Hr = normrnd(mu,sigma ,1,N);
% Generation of Gaussian random variable samples for imaginary part
Hi = normrnd(mu,sigma ,1,N);
% Generation of Rayleigh complex random variable
H = Hr+1j*Hi;
% Generation of Gaussian random variable samples for real part
Zr = normrnd(mu,sigma ,1,N);
% Generation of Gaussian random variable samples for imaginary part
Zi = normrnd(mu,sigma ,1,N);
% Generation of Rayleigh complex random variable
Z = Zr+1j*Zi;
x = randi([0 1],1,N);
s = zeros(1,N);%input signal
Y = zeros(1,N);%input signal
Ytil = zeros(1,N);%input signal
for i = 1:length(a1)     %sample of amplitude
      BER(i)    = 0;    %BER initialization
      txcount = 0;     % Number of symbol transmitted counter
      recvcorrect = 0;% Number of symbol received correct counter
  for j = 1:N
      if x(j)==1
          s(j) = a1(i);        % symbol with bit 1
      else
          s(j) = a2(i);        % symbol with bit 0
      end
  end
  Y = s.*H +  Z ;        % addition of gaussian noise
  Ytil = real((Y.*(conj(H)./abs(H))));
  bound = (a1(i)+a2(i))/2;    % boundary
  for j = 1:N
      if(s(j) == a1(i))
          txcount = txcount+1;
          % Number of symbol transmitted counter
          if Ytil(j) >= bound
              recvcorrect = recvcorrect+1;
              % Number of symbol received correct counter
          end
      else
           txcount = txcount+1;
           % Number of symbol transmitted counter
           if Ytil(j) < bound
              recvcorrect = recvcorrect+1;
              % Number of symbol received correct counter
          end
      end
  end
  BER(i)  = (1- (recvcorrect/txcount)); %calculation of BER
end
%plot snr vs ber
```

```
hold on;
semilogy(snrdb,BER,"ro");
hold off
xlabel('SNR');  % label x axis
ylabel('BER');  % label y axis
title('BER of BPSK in Rayleigh fading');% Title
legend('AWGN','Rayleigh Theory','Rayleigh Experiment');% Legend
```

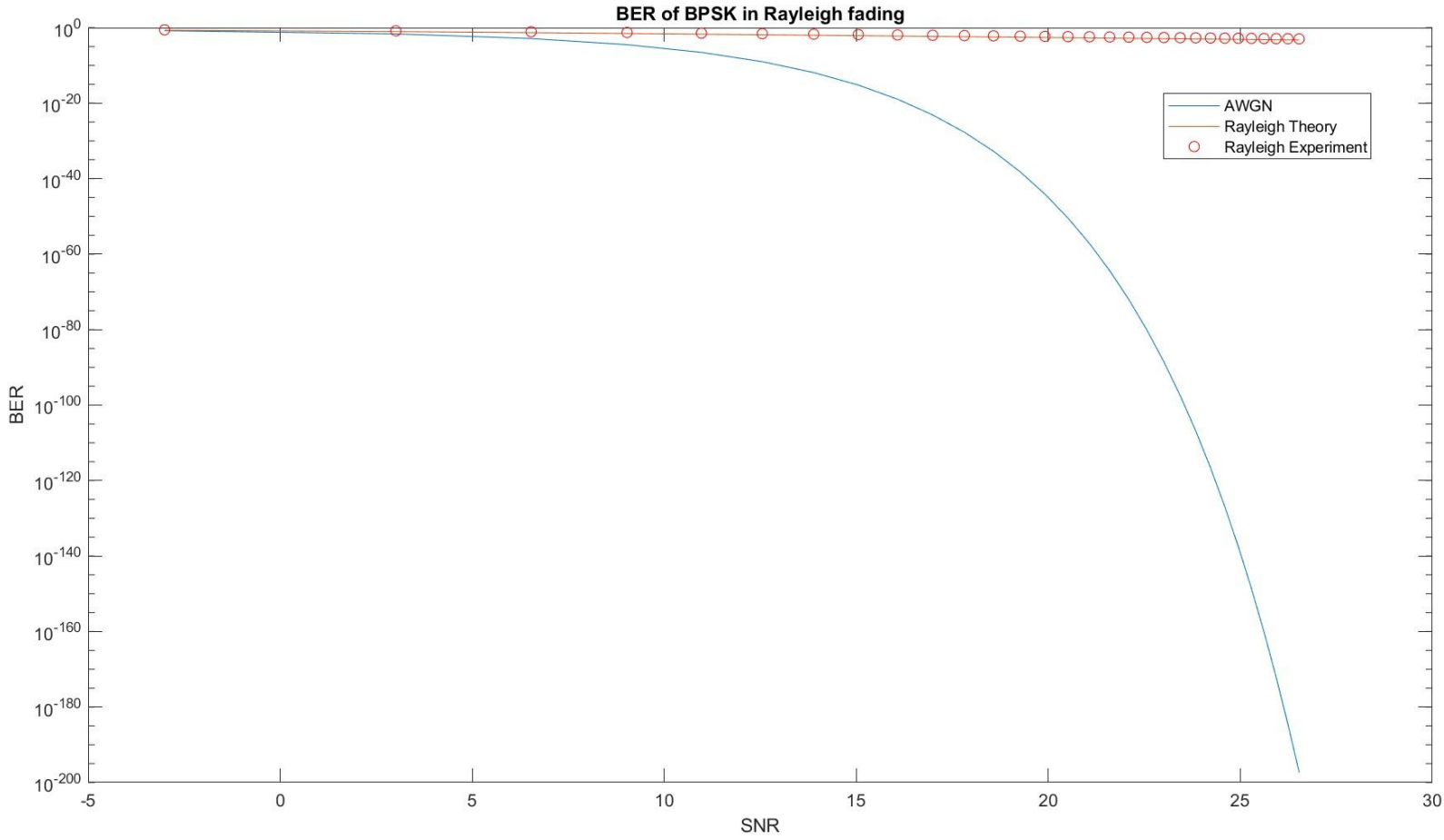
Plot
Simulation 1



Simulation 2



Simulation 3



Observation :

- **Experiment to simulate BER of BPSK in Rayleigh fading.**
- **Plot for AWGN Theory, Rayleigh Theory and Experimental Rayleigh have been plotted and verified.**