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BER for binary signals in AWGN channel

AIM:

To perform Monte Carlo simulation using matlab for finding BER of a binary signal in AWGN channel and verify the same by Theoretical BER .

Signal tx and rx

$$z = \begin{cases} a_1 + n_0 & \text{if } s_1(t) \text{ (bit } = \text{ '1') is transmitted,} \\ a_2 + n_0 & \text{if } s_2(t) \text{ (bit } = \text{ '0') is transmitted,} \end{cases}$$

Theoretical BER

1. Consider the antipodal signalling, that is, a2 =−a1.
2. Let a1 =[0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.5, 3, 3.5].
3. Noise variance =1.
4. Using matlab function erfc, calculate theoretical BER for each value of a1.
5. Plot the theoretical BER as a function of SNR. While plotting use loglog function instead of plot

   BER expression

$$p_b = Q\left(\frac{a_1 - a_2}{2\sigma_0}\right)$$

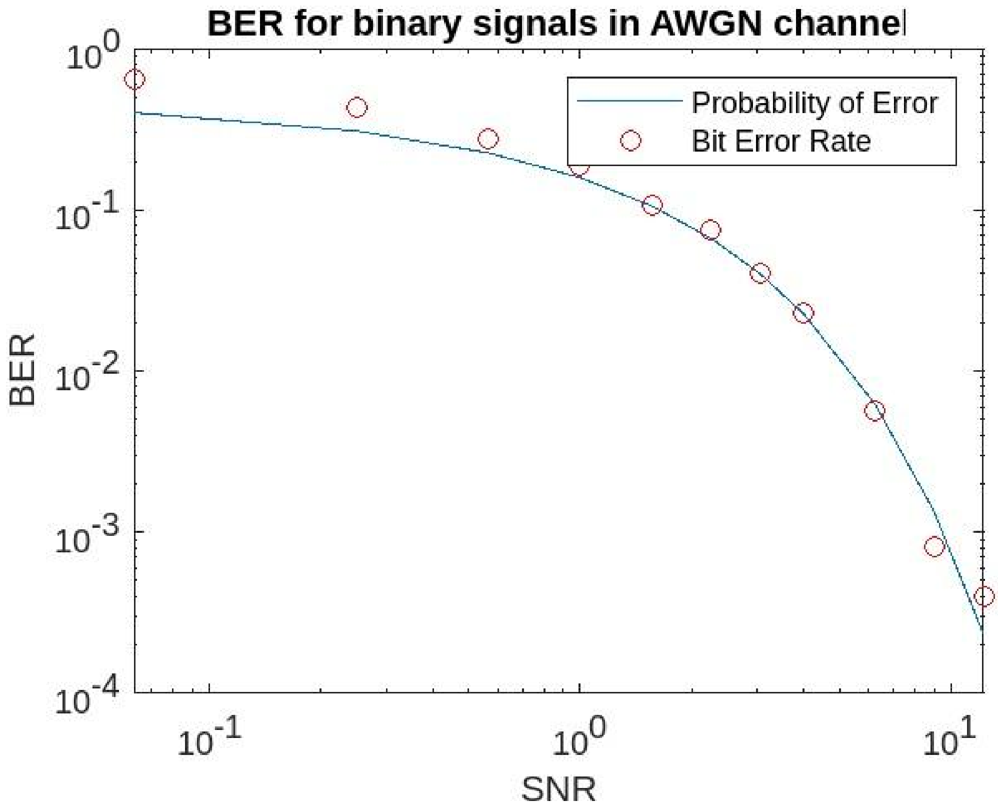
Monte carlo simulation

1. Consider a1=- a2
2. Generate a signal randomly from [a1, a2]. USe rand or randi matlab function
3. Generate noise using the randn function.
4. Generate z using signal a and noise.
5. If z> (a1+a2)/2, declare the received signal as bit 1 else as bit 0.
6. Repeat the above process 10000 times. The count number of times bit 1 is tx. count number of times
7. z = bit 1.
8. Sim BER = 1-(z=bit 1)/(#times bit 1 tx)

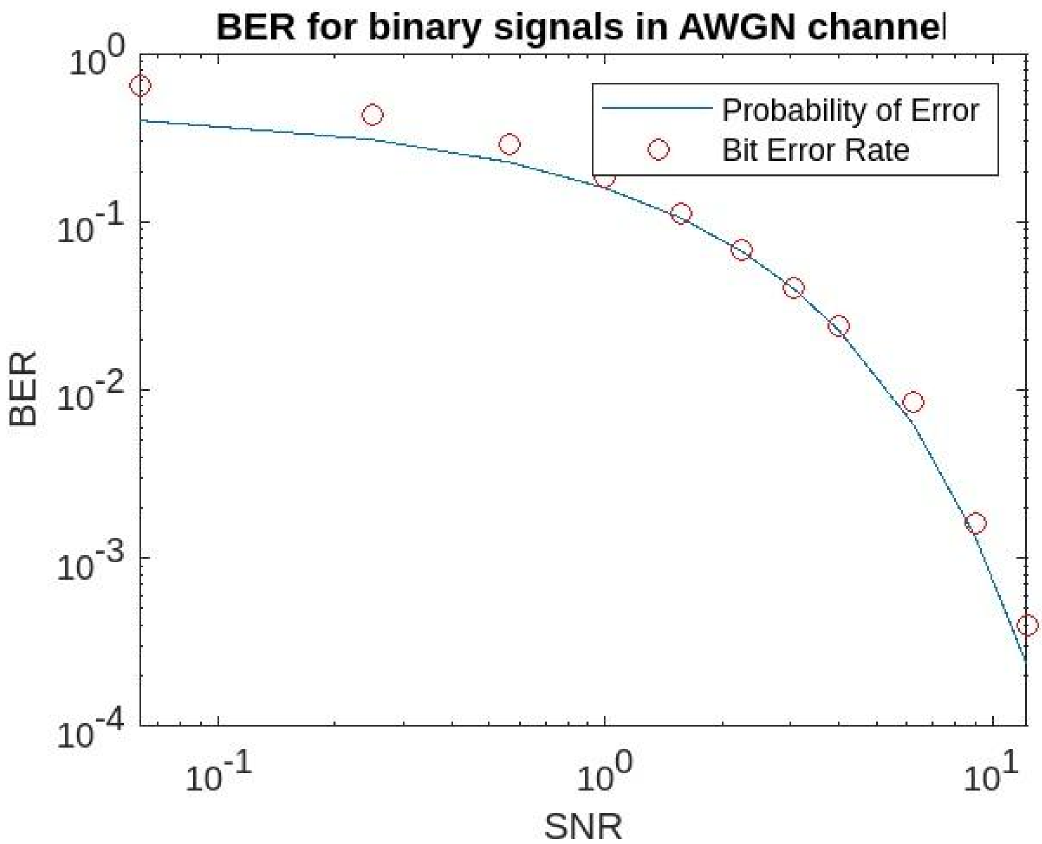
Working Code

```
%BER for binary signals in AWGN channel
clear all; close all; clc; % Clear all data
%Task 1: Theoretical BER
a1 =[0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.5, 3, 3.5];
%  Different sample of Amplitude of 1 bit
a2 = -a1;  %  Different sample of Amplitude of 0 bit
NoiseVariance = 1;%Noise variance =1.
% Number of sample
numsamp =5000;
%pb -> probability of error(BER)
q=(a1-a2)./(2); %% For computation of Qfunc from ERFC
pb = 1/2 .* erfc(q./sqrt(2));
%snr ->signal to noise ratio
snr=(a1.^2)./NoiseVariance;
%plot snr vs probability of error
loglog(snr,pb);
%Monte carlo simulation
ber = zeros(1,length(a1));%initialise BER count to zero
for i = 1:length(a1)    %sample of amplitude
       ber(i) =0;
       tx1count =0;
       rx1count =0;
   for j = 1:numsamp
       x = randi([0 1]);
       if x==1
           s=a1(i);
       else
           s = a2(i);
       end
       n0 = randn();%Generate  AWGN
       z = s +  n0 ;        % addition of gaussian noise
       bound = (a1(i)+a2(i))/2;    % boundary
        if z >= bound
           rx1count = rx1count+1;% Num of 1 bit received for a(i)Amp
           if(s == a1(i))
               tx1count = tx1count+1;% Num of 1 bit received for a(i)Amp
           end
       end
   end
 ber(i) = abs(1- (rx1count/tx1count)); %calculation of BER
end
%plot snr vs ber
hold on;
loglog(snr,ber,"ro");
hold off
xlabel('SNR');  % label x axis
ylabel('BER');  % label y axis
title('BER for binary signals in AWGN channel');% Title
legend('Probability of Error','Bit Error Rate');% Legend
```

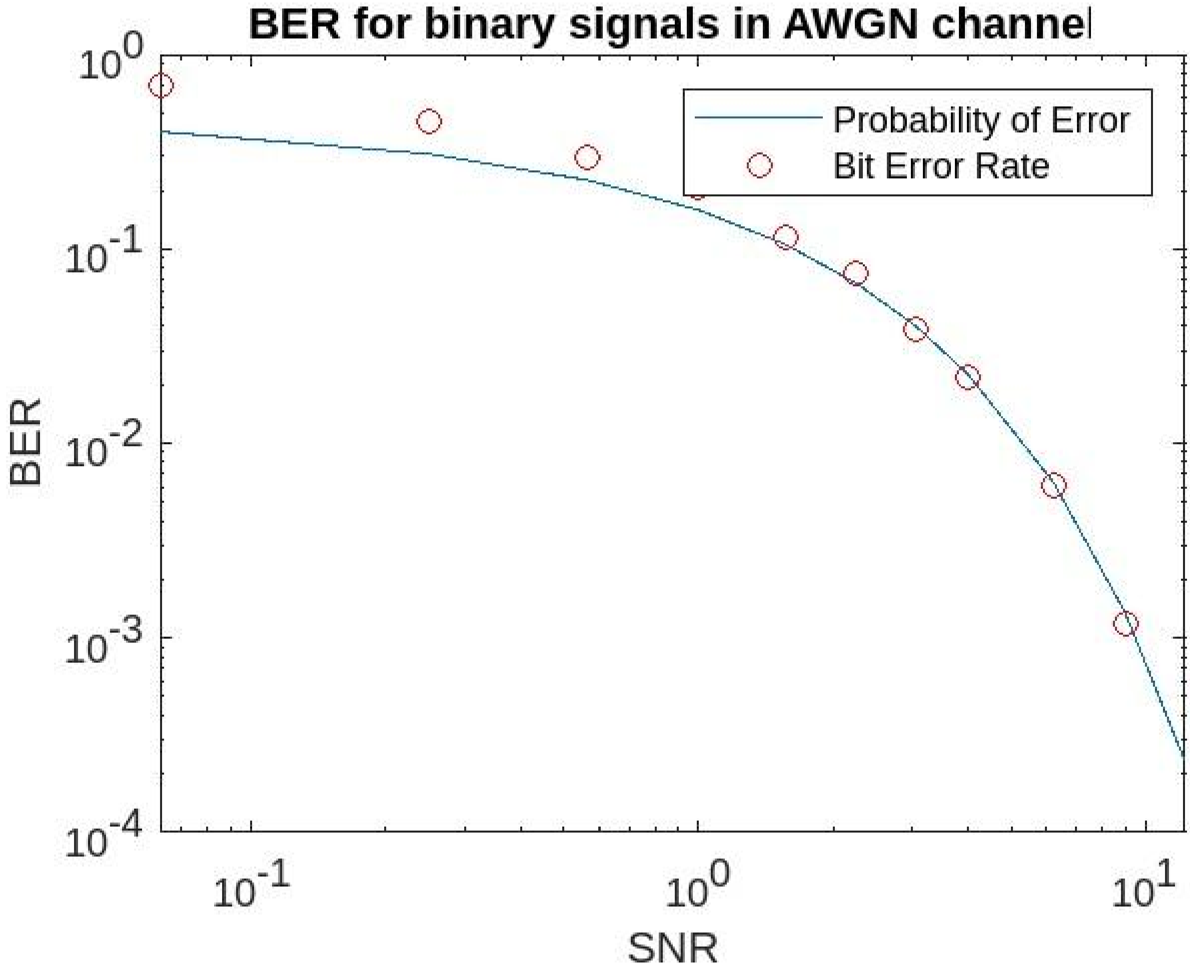
Simulation 1



Simulation 2



Simulation 3:



Observation :

- **The Monte Carlo simulation is performed for finding BER of a binary signal in AWGN and verified with the Theoretical BER.**
- **The simulated BER is within the range of Theoretical BER.**
- **The BER decreases exponentially with the increase in SNR.**