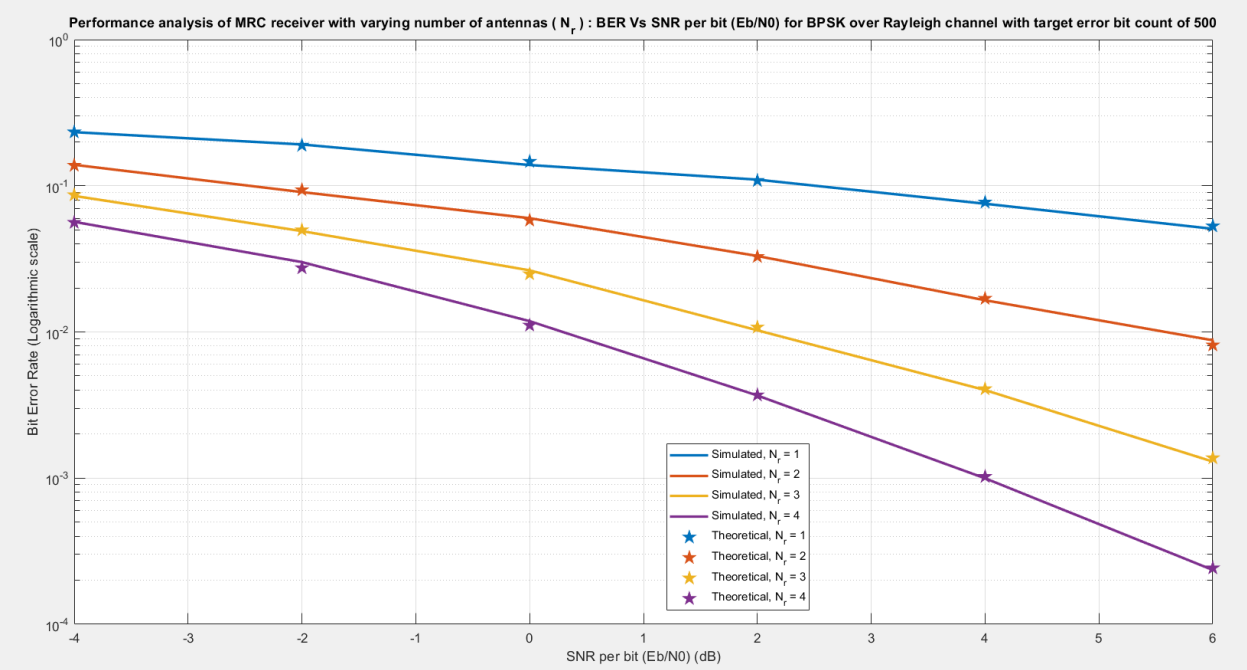
# BER vs Eb/N0 for BPSK Modulation over Rayleigh Channel

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% BER vs Eb/N0 for BPSK Modulation over Rayleigh Channel
clc;
clear all;
close all;
%---------Target Number of Errors----------------------
errorTarget = 500;
%----------Number of Receive Antennas-----------------
Nr_antennas = 1:4;
%-------------------------------------------------------------
M=2; %Number of Constellation points M=2^k for BPSK k=1
Rm=log2(M); %Rm=log2(M) for BPSK M=2
EbN0dB=-4:2:6; %Range of Eb/N0 values
simBER_mrc=zeros(length(Nr_antennas),length(EbN0dB));
theoretical_mrc=zeros(length(Nr_antennas),length(EbN0dB));
for iNr = 1:length(Nr_antennas)
Nr = Nr_antennas(iNr);
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i_EbN0=1;
for k=EbN0dB
EbN0 = 10.^(k/10); %Converting Eb/N0 dB value to linear scale
nVar = (1./(2*Rm*EbN0)); %Noise variance according to the
required Eb/N0
clc;
fprintf('Simulation running for Nr = %d and Eb/N0 (dB) =
%d\n',Nr,k);
errorCount_mrc = 0;
N = 0;
while errorCount_mrc < errorTarget
d=rand(1,1)>0.5; %binary data
x=2*d-1; %BPSK symbols 0 -> -1, 1 -> 1
%Channel and Noise effect
n=sqrt(nVar)*(randn(Nr,1)+1i*randn(Nr,1)); %AWGN noise with
mean=0
h=1/sqrt(2)*(randn(Nr,1)+1i*randn(Nr,1)); %Rayleigh Flat Fading
factor- single tap
%received signal through Rayleigh channel
y=h*x+n; %Received Vector
%MRC Receiver for Rayleigh Channel
w_opt = h./(norm(h));
y_mrc=w_opt'*y; %Assuming that h is known at the signal
accurately
est_Bits=real(y_mrc)>0; %received symbols = 1 if real part > 0
or else it is 0
%Counting errors
errorCount_mrc = errorCount_mrc + xor(d,est_Bits);
N = N + 1;
end
%Calculating bit error rate
simBER_mrc(iNr,i_EbN0)=errorCount_mrc/N;
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%-------------------------------------------------------------
%Theoretical BER calculation
p=0.5*(1-sqrt(EbN0./(1+EbN0))); % Eavg = 1 and Eb = 1, Eavg =
2*Eb.
sum_tmp=0;
for kk=0:Nr-1
sum_tmp = sum_tmp + nchoosek(Nr-1+kk,kk)*(1-p)^kk;
end
theoretical_mrc(iNr,i_EbN0) = p^(Nr)*sum_tmp;
%-------------------------------------------------------------
i_EbN0 = i_EbN0 + 1;
end %End of EbN0 loop
end %End of Nr antennas loop
%------------------------------Plots---------------------------
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col = lines(length(Nr_antennas)); %ColorMap for plots
h1 = zeros(length(Nr_antennas),1); %Handles for Legend
h2 = zeros(length(Nr_antennas),1);
for i = 1:length(Nr_antennas)
Nr = Nr_antennas(i);
h1(i)=semilogy(EbN0dB,simBER_mrc(i,:),'color',col(i,:),'LineWidt
h',2,'DisplayName',['Simulated, N_r = ',num2str(Nr)]);hold on;
grid on;%Ploting with y-axis in logarithmic scale
h2(i)=semilogy(EbN0dB,theoretical_mrc(i,:),'p','color',col(i,:),
'LineWidth',2,'DisplayName',['Theoretical, N_r =
',num2str(Nr)]); hold on;grid on; %Ploting with y-axis in
logarithmic scale
end
legend([h1;h2],'location','best');
title(['Performance analysis of MRC receiver with varying number
of antennas ( N_r ) : BER Vs SNR per bit (Eb/N0) for BPSK over
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```
Rayleigh channel with target error bit count of
',num2str(errorTarget)]);
xlabel('SNR per bit (Eb/N0) (dB)');
ylabel('Bit Error Rate (Logarithmic scale)');
```