School of Engineering and Applied Science (SEAS)
Ahmedabad University

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

Laboratory Assignment-4

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1. Solution Problem-1

   (a) Matlab Script:

```
close all;
clear all;
clc;

%bpsk
%step1: Analytical plot
%define SNR
Eb_No_db= [0:20] ;

%convert into linear
Eb_No_Lin=10.^ (Eb_No_db/10);
rho = 0.8 ;

%mu for theoretical part
mu=sqrt(Eb_No_Lin ./ (Eb_No_Lin + 1 ));

theoryBer_siso=0.5.*(1-sqrt(Eb_No_Lin./(Eb_No_Lin+1)));

theoryBer_simo=0.25*(2 - (3.* mu) + (mu.^(3)));

theoryBer_icsi_siso = 0.5 * (1 -  rho .* sqrt(Eb_No_Lin./(Eb_No_Lin+1)));

theoryBer_icsi_simo= 0.25 * (2 - (3 .* rho .* mu ) + ((rho .^ 3) .* (mu .^ 3)));

%step2 :simulation
N=1500000;
ip = rand(1,N)>0.5;              % generating 0,1 with equal probability
s = 2*ip-1;                      % BPSK modulation 0 -> -1; 1 -> 1

index=1;
for ii = 1:length(Eb_No_db)

   n1= 1/sqrt(2)*[randn(1,N) + j*randn(1,N)]; %white gaussian noise, 0dB variance
   h1=1/sqrt(2)*[randn(1,N) + j*randn(1,N)];  %rayleigh channel
   % Noise addition
   y1 = h1.* s + 10^(-Eb_No_db(ii)/20) *n1 ;  %additive white gaussian noise

   n2= 1/sqrt(2)*[randn(1,N) + j*randn(1,N)]; %white gaussian noise, 0dB variance
   h2=1/sqrt(2)*[randn(1,N) + j*randn(1,N)];  %rayleigh channel
   % Noise addition
   y2 = h2.* s + 10^(-Eb_No_db(ii)/20)*n2 ;   %additive white gaussian noise

   %siso perfect CSI
   for jj=1:N
   d0(jj)=conj(h2(jj)) * y2(jj) ;
     if (real(d0(jj))>0)
       dataDetect0(jj)=1;
     else
       dataDetect0(jj)=0;
     end
```

```
    end

    error0=xor(ip,dataDetect0);
    bers0(index)=sum(error0)/N;
    snr0(index)=ii;
    [snr0(index) bers0(index)]

    %simo perfect CSI
    for kk=1:N
    d(kk)=conj(h1(kk)) * y1(kk) + conj (h2 (kk)) * y2(kk);
      if (real(d(kk))>0)
        dataDetect(kk)=1;
      else
        dataDetect(kk)=0;
      end
    end


    error=xor(ip,dataDetect);
    bers(index)=sum(error)/N;
    snr(index)=ii;
    [snr(index) bers(index)]

    h3= rho .* h1 + sqrt(1- rho.^2) .*randn(1,N);
    y3 = h3.* s + 10^(-Eb_No_db(ii)/20) *n1 ;

    h4= rho .* h2 + sqrt(1- rho.^2) .*randn(1,N);
    y4 = h4 .* s + 10^(-Eb_No_db(ii)/20) * n2;

    %siso imperfect CSI
    for mm=1:N
    d1(mm)=conj(h1(mm)) * y3(mm);
      if (real(d1(mm))>0)
        dataDetect1(mm)=1;
      else
        dataDetect1(mm)=0;
      end
    end

    error1=xor(ip,dataDetect1);
    bers1(index)=sum(error1)/N;
    snr1(index)=ii;
    [snr1(index) bers1(index)]

    %simo imperfect CSI
    for ll=1:N
    d2(ll)=conj(h1(ll)) * y3(ll) + conj (h2 (ll)) * y4(ll);
      if (real(d2(ll))>0)
        dataDetect2(ll)=1;
      else
        dataDetect2(ll)=0;
      end
    end

    error2=xor(ip,dataDetect2);
    bers2(index)=sum(error2)/N;
    snr2(index)=ii;
    [snr2(index) bers2(index)]
    index=index+1;

end

semilogy(Eb_No_db,theoryBer,'bo-','LineWidth',3);
% simo ther csi
hold on
semilogy(Eb_No_db,bers,'dr-','LineWidth',3);
% simo sim csi
hold on
semilogy(Eb_No_db,theoryBer_icsi_simo,'k^-','LineWidth',3);
% simo ther icsi
```

```
hold on
semilogy(Eb_No_db,bers2,'co-','LineWidth',3);
% simo sim icsi
hold on
semilogy(Eb_No_db,theoryBer_icsi_siso,'y+-','LineWidth',3);
%siso ther icsi
hold on
semilogy(Eb_No_db,bers1,'mx-','LineWidth',3);
% siso sim icsi
hold on
semilogy(Eb_No_db,bers0,'bx-','LineWidth',3);
%siso sim csi
hold on
semilogy(Eb_No_db,theoryBer_siso,'+c','LineWidth',3);
% siso ther csi
axis([0 20 10^-6 0.5])
grid on
legend(' SIMO analytical \rho = 1 ','SIMO simulation \rho =1 ','SIMO  analytical \
    rho = 0.8 ','SIMO  simulation \rho = 0.8 ','SISO  analytical \rho = 0.8 ','
    SISO simulation \rho = 0.8','SISO   simulation \rho = 1 ','SISO analytical \
    rho = 1','Location','southwest');
xlabel('Eb/No, dB');
ylabel('Bit Error Rate');
title('Bit error probability curve for BPSK modulation over SIMO (1*2) Wireless');
```

(b) Simulation Output:

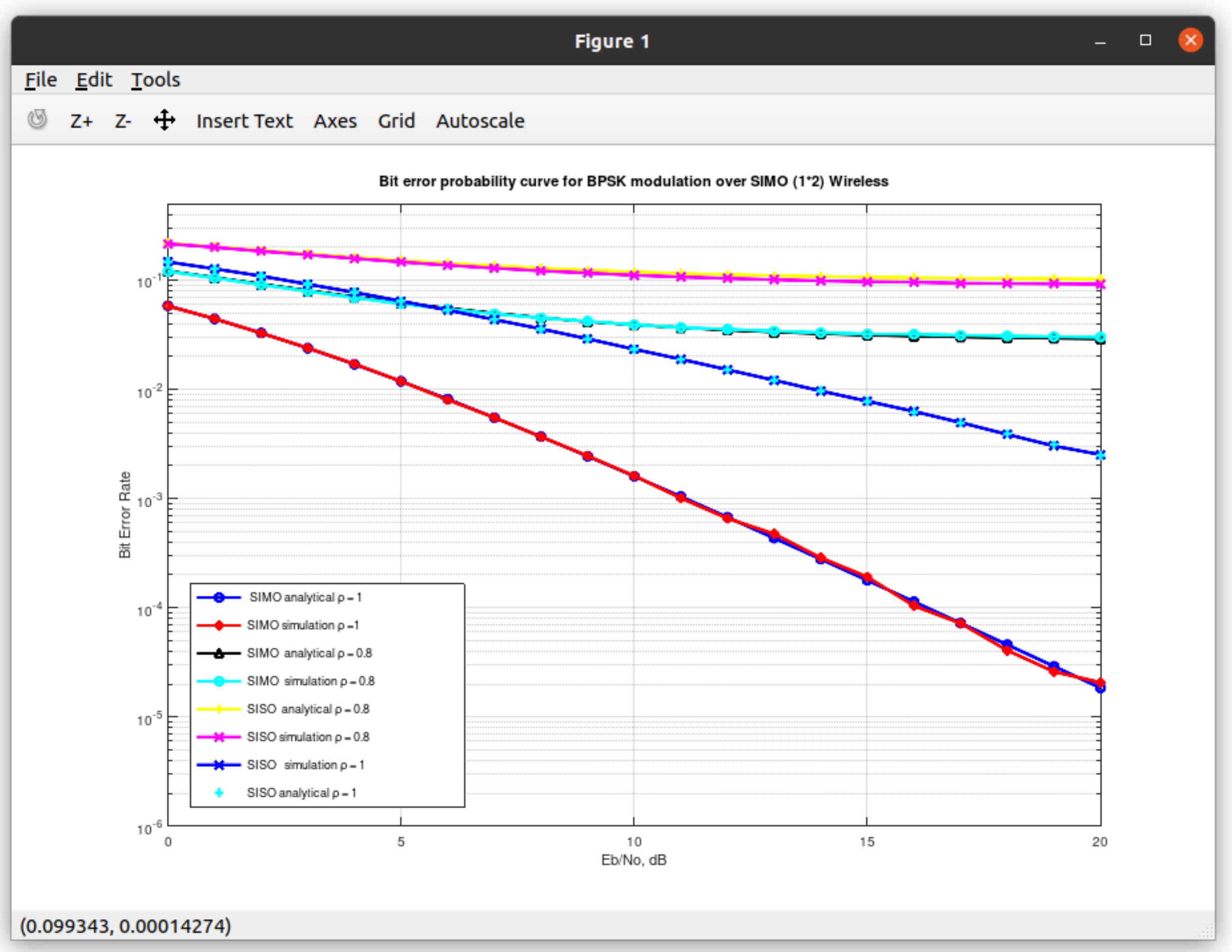

Fig 1: BPSK modulation over SIMO Imperfect CSI (1*2)

(c) Inference:

1) Imperfect channel state information (CSI) at the receiver, which is due to channel estimation error, is one of the main problems toward achieving optimum detection.single input multiple output (SIMO) systems by using maximum ratio combining (MRC) at the receiver to maximize at a targeted bit error rate (BER) via optimization.

2) In case of the availability of high SINRs(Signal to Interference Noise Ratio) with very slow moving users leading to very large channel coherence time/bandwidth, interference outperforms the other schemes even with imperfect CSI. The results draw important conclusions about the application of interference in practical systems.Here(SIMO),The receivers are receiving data with high data rate, so that necessary for reducing errors and delimit from BER value to give the best performance of the system with less noise. Therefore, necessary to choose the better channel with better BER performance when building the transceiver in order to produce less noise and high performance. In SIMO(1*2), reducing receiver diversity .

3) The confidential messages are transmitted from transmitter to the destination, while a multi-antenna eavesdropper exists. The maximal ratio combining and selection combining schemes are utilised at the receivers to improve the quality of the received signal-to-noise ratio.Imperfect CSI at reciever side never have 0 bit rate even infinite value of SNR .