School of Engineering and Applied Science (SEAS)
Ahmedabad University

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

Laboratory Assignment-3

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1. Task: Simulated and Analytical plot of (1*2) and (1*4) SIMO wireless system.

   (a) Matlab Script:

```
clear all;
close all;
clc;

%*** Initialization ******%
SNRdB = 1:1:35;
N = 1000000;
x= rand(1,N)>0.5;
s=2*x-1;
SNR_linear = 10.^(SNRdB./10);
BER_1x1_theory = (1/2).*(1-(sqrt(SNR_linear./(SNR_linear+1))));


% ********%
% **** 1*1 Simulation ****%
% ********%

% *** Transmitter ******%

for i = 1:length(SNRdB)
    SNR_linear = 10.^(SNRdB(i)/10);
    total_error_bits=0;

% *** BPSK signal generation ***%
    h = (1/sqrt(2)).*(randn(1,N)+ 1i*randn(1,N));
    n = (1/sqrt(2*SNR_linear)).*(randn(1,N)+ 1i.*randn(1,N));

% *** Reciever ******%
    y = (h.*s) + n;

    for k = 1:N
        d(k) = (conj(h(k))*y(k));
        if real(d(k))>=0
            data(k)=1;
        else
           data(k)=0;
        end
    end

% *** Bit error Rate (BER) calulation **%
    for k = 1:N
        error_bits=xor(x(k),data(k));
        total_error_bits = total_error_bits + error_bits;
    end
    BER_1x1_simulation(i) = total_error_bits/N;
end
```

```matlab

% ********%
% ****   1*2 Theory   ****%
% ********%
SNR_linear = 10.^(SNRdB/10);
u = sqrt(SNR_linear./(SNR_linear+1));
BER_1x2_theory = (1/4)*(2-(3*u)+ (u.^3));

% ********%
% **** 1*2 Simulation ****%
% ********%

for i = 1:length(SNRdB)
    SNR_linear = 10.^(SNRdB(i)/10);
    total_error_bits=0;
    h1 = (1/sqrt(2)).*(randn(1,N)+ 1i*randn(1,N));
    h2 = (1/sqrt(2)).*(randn(1,N)+ 1i*randn(1,N));
    n1 = (1/sqrt(2*SNR_linear)).*(randn(1,N)+ 1i.*randn(1,N));
    n2 = (1/sqrt(2*SNR_linear))*(randn(1,N)+ 1i.*randn(1,N));

    y1 = (h1.*s) + n1;
    y2 = (h2.*s) + n2;

    for k = 1:N

        d(k) = (conj(h1(k))*y1(k))+(conj(h2(k))*y2(k));
        if real(d(k))>=0
            data(k)=1;
        else
           data(k)=0;
        end
    end

    for k = 1:N
        error_bits = xor(x(k),data(k));
        total_error_bits = total_error_bits + error_bits;
    end
    BER_1x2_simulation(i) = total_error_bits/N;

end

% ********%
% **** 1*4 Simulation ****%
% ********%

for i = 1:length(SNRdB)
    SNR_linear = 10.^(SNRdB(i)./10);
    total_error_bits=0;
    h1 = (1/sqrt(2)).*(randn(1,N)+ 1i*randn(1,N));
    h2 = (1/sqrt(2)).*(randn(1,N)+ 1i*randn(1,N));
    n1 = (1/sqrt(2*SNR_linear)).*(randn(1,N)+ 1i.*randn(1,N));
    n2 = (1/sqrt(2*SNR_linear)).*(randn(1,N)+ 1i.*randn(1,N));
    h3 = (1/sqrt(2)).*(randn(1,N)+ 1i*randn(1,N));
    h4 = (1/sqrt(2)).*(randn(1,N)+ 1i*randn(1,N));
    n3 = (1/sqrt(2*SNR_linear)).*(randn(1,N)+ 1i.*randn(1,N));
    n4 = (1/sqrt(2*SNR_linear)).*(randn(1,N)+ 1i.*randn(1,N));
    y1 = (h1.*s) + n1;
    y2 = (h2.*s) + n2;
    y3 = (h3.*s) + n3;
    y4 = (h4.*s) + n4;

    for k = 1:N

        d(k) = (conj(h1(k))*y1(k))+(conj(h2(k))*y2(k)) + (conj(h3(k))*y3(k))+(conj(h4(k))*y4(k));
        if real(d(k))>=0
            data(k)=1;
        else
           data(k)=0;
        end
```

```
    end

    for k = 1:N
        error_bits  = xor(x(k),data(k));
        total_error_bits = total_error_bits + error_bits;
    end

    BER_1x4_simulation(i) = total_error_bits/N;
end


% *** Plot the simulation result ***%
figure

semilogy(SNRdB, BER_1x1_simulation, 'g-o', 'linewidth', 2);
hold on;
semilogy(SNRdB, BER_1x1_theory, 'y-o', 'linewidth', 2);
hold on;
semilogy(SNRdB, BER_1x2_theory, 'r-o', 'linewidth', 2);
hold on;
semilogy(SNRdB, BER_1x2_simulation, 'c-o', 'linewidth', 2);
hold on;
semilogy(SNRdB, BER_1x4_simulation,  'b-o', 'linewidth', 2);

title('Simulated and Analytical BER plot of (1*2) and (1*4) SIMO wireless system.');
legend ("nRx=1 Analytical","nRx=1 Simulation","nRx=2 Analytical","nRx=2 Simulation", "nRx=4 Simulation");
xlabel("Signal To Noise Ratio (SNRdB)");
ylabel("Bit Error Rate (BER)");
axis([1 30 10^-5 10^0]);
hold off
grid on


% ********%
```

(b) Simulation Output:

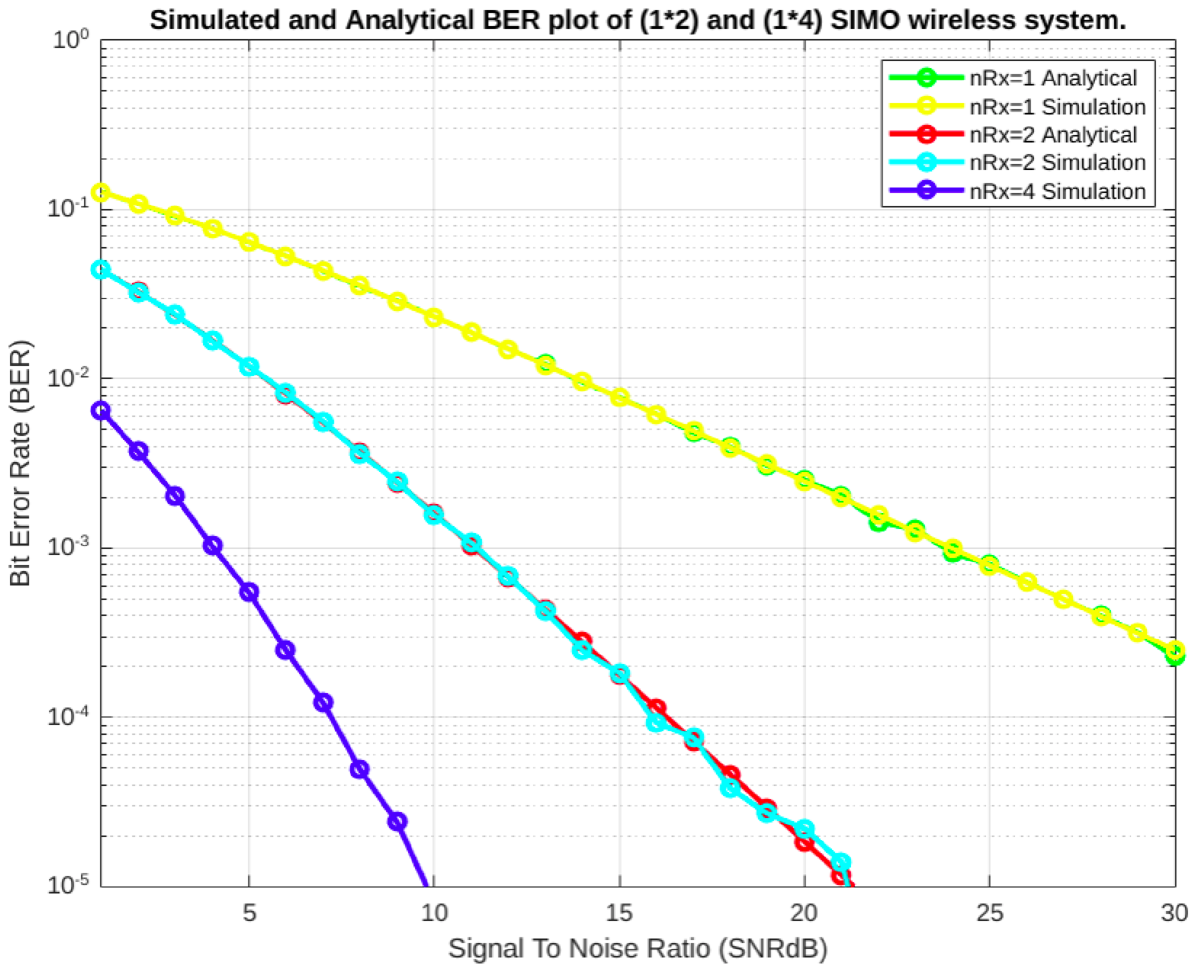

Figure 1: Simulated and Analytical BER plot of (1*2) and (1*4) SIMO wireless system.

(c) **Inference 1:** Rayleigh fading channel which is a more realistic representation of a wireless communication channel. In fact, for rayleigh fading, the plot has a steady slope in BER curve for SISO(1*1) channel model. With increasing the signal power, the bit error in received signal reduces steadily.

(d) **Inference 2:** In SIMO, the multiple receivers are receiving data with high data rate. That implies reduction of errors which delimits the BER value to give the best performance of the system with less noise. Therefore, it is necessary to choose better channel that has better BER performance when building the transceiver in order to produce less noise and high performance. In SIMO (1*2), if at one Rx, signal is in deep fading then the second Rx can receive the signal. This way, we can improve performance the over SISO(1, 1).

(e) **Inference 3:** For SIMO (1*4) BER is small as compared to SIMO(1*2) and SISO(1*1). In SIMO(1*2), if at one Rx, signal is in deep fading then the second Rx can receive the signal and we can improve performance over SISO(1*1). But if the more than one Rx, signal is in deep fading then third or fourth Rx can receive the signal and we can improve performance over SIMO(1, 2). Hence the SIMO (1, 4) is more efficient for fading channels.

(f) **Inference 4:**
The SNR for nRx=4 simulation is less than the SNR of nRx=2 simulation.
The SNR for nRx=4 in BER v/s SNRdB is around 4.7dB for 3G and around 7.2dB for 4G.
The SNR for nRx=2 in BER v/s SNRdB is around 11dB for 3G and around 16.5dB for 4G.