WCOM LAB ASSIGNMENT 7

Name - Kushagra Garg
Roll Number - 23UCC564

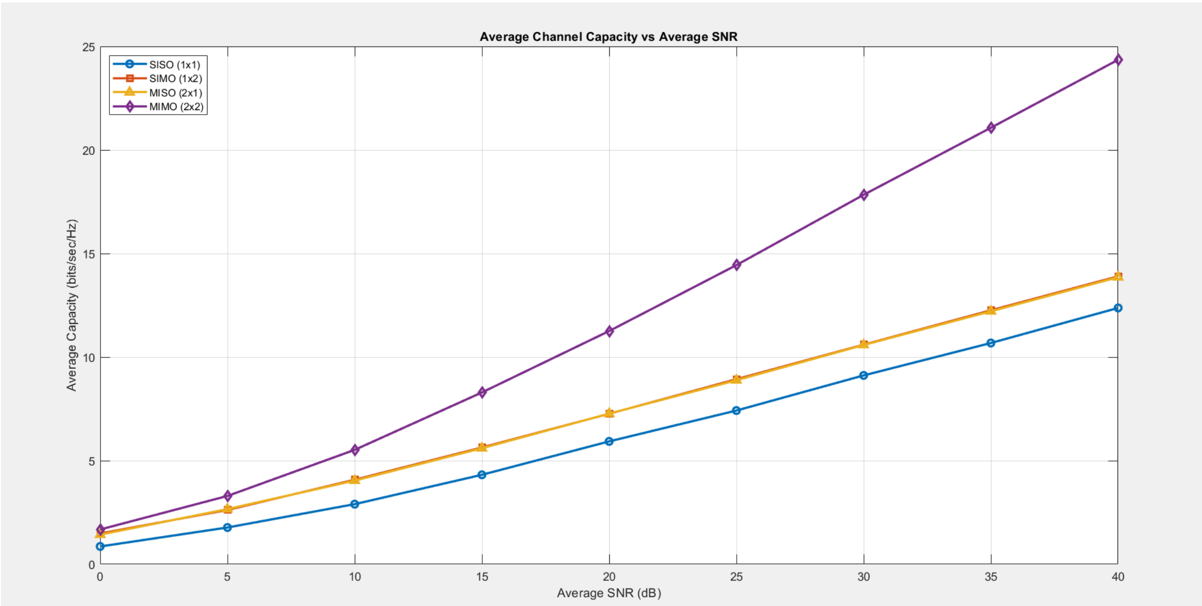
Task 1 : Calculate the Channel Capacity for SISO , SIMO , MISO , MIMO

Matlab Code -

```
clc; clear; close all;
SNR_dB = 0:5:40;
SNR_linear = 10.^(SNR_dB/10);
numRealizations = 1000;
Nt_SISO = 1;  Nr_SISO = 1;
Nt_SIMO = 1;  Nr_SIMO = 2;
Nt_MISO = 2;  Nr_MISO = 1;
Nt_MIMO = 2;  Nr_MIMO = 2;
C_SISO = zeros(size(SNR_linear));
C_SIMO = zeros(size(SNR_linear));
C_MISO = zeros(size(SNR_linear));
C_MIMO = zeros(size(SNR_linear));
for i = 1:length(SNR_linear)
  snr = SNR_linear(i);

  temp_siso = 0;
  temp_simo = 0;
  temp_miso = 0;
  temp_mimo = 0;

  for k = 1:numRealizations

     H = (1/sqrt(2))*(randn(Nr_SISO,Nt_SISO)+1i*randn(Nr_SISO,Nt_SISO));
     temp_siso = temp_siso + log2(1 + snr * abs(H)^2);

     H = (1/sqrt(2))*(randn(Nr_SIMO,Nt_SIMO)+1i*randn(Nr_SIMO,Nt_SIMO));
     temp_simo = temp_simo + log2(1 + snr * norm(H)^2);

     H = (1/sqrt(2))*(randn(Nr_MISO,Nt_MISO)+1i*randn(Nr_MISO,Nt_MISO));
     temp_miso = temp_miso + log2(1 + snr * norm(H)^2);
     H = (1/sqrt(2))*(randn(Nr_MIMO,Nt_MIMO)+1i*randn(Nr_MIMO,Nt_MIMO));
     temp_mimo = temp_mimo + real(log2(det(eye(Nr_MIMO) + (snr/Nt_MIMO)*(H*H'))));
  end

  C_SISO(i) = temp_siso / numRealizations;
  C_SIMO(i) = temp_simo / numRealizations;
  C_MISO(i) = temp_miso / numRealizations;
  C_MIMO(i) = temp_mimo / numRealizations;
end
```

```
figure;
plot(SNR_dB, C_SISO, '-o','LineWidth',2); hold on;
plot(SNR_dB, C_SIMO, '-s','LineWidth',2);
plot(SNR_dB, C_MISO, '-^','LineWidth',2);
plot(SNR_dB, C_MIMO, '-d','LineWidth',2);
grid on;
xlabel('Average SNR (dB)');
ylabel('Average Capacity (bits/sec/Hz)');
title('Average Channel Capacity vs Average SNR');
legend( sprintf('SISO (%dx%d)', Nt_SISO, Nr_SISO), ...
    sprintf('SIMO (%dx%d)', Nt_SIMO, Nr_SIMO), ...
    sprintf('MISO (%dx%d)', Nt_MISO, Nr_MISO), ...
    sprintf('MIMO (%dx%d)', Nt_MIMO, Nr_MIMO), ...
    'Location', 'NorthWest');
```

Result Obtained -

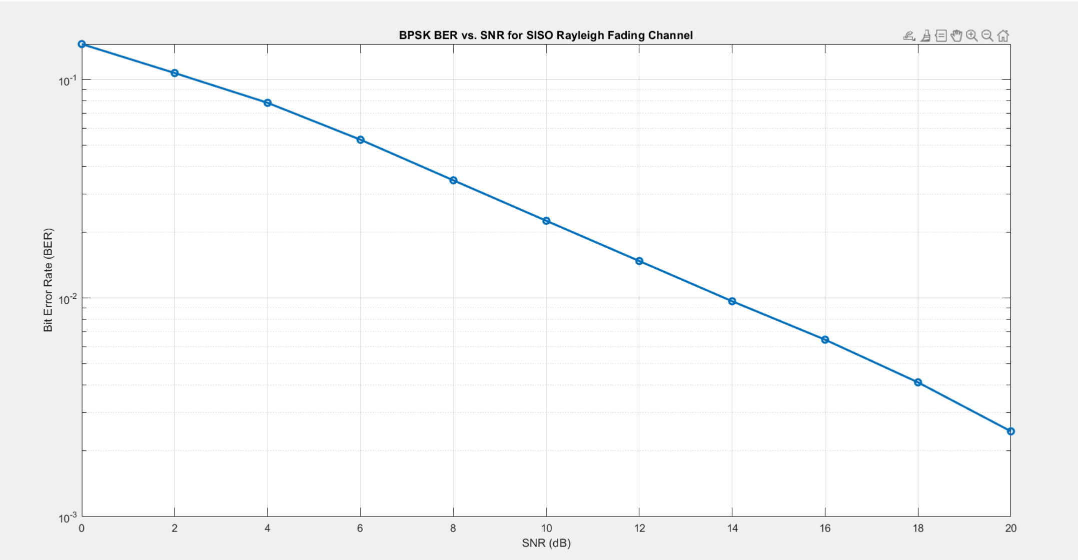


Task 2 : BER VS SNR of SISO

Matlab Code -

```
clc;
clear;
close all;

N = 1e5;
snr_dB = 0:2:20;
snr = 10.^(snr_dB/10);

bits = randi([0 1],1,N);
bpskSymbols = 2*bits - 1;

ber_sim = zeros(size(snr_dB));

for k = 1:length(snr_dB)
    snr_linear = snr(k);
    h = (randn(1,N) + 1i*randn(1,N))/sqrt(2);
    noise = (randn(1,N) + 1i*randn(1,N))/sqrt(2) * sqrt(1/snr_linear);
    r = h .* bpskSymbols + noise;
    r_eq = r ./ h;
    bits_hat = real(r_eq) > 0;
    ber_sim(k) = sum(bits ~= bits_hat)/N;
end

semilogy(snr_dB, ber_sim,'-o','LineWidth',2);
xlabel('SNR (dB)');
ylabel('Bit Error Rate (BER)');
title('BPSK BER vs. SNR for SISO Rayleigh Fading Channel');
grid on;
```

Results Obtained -



Task 1: Calculate the Channel Capacity for SISO, SIMO, MISO, MIMO

Observations and Results:

The MATLAB code calculates and plots the average channel capacity (bits/sec/Hz) against the average Signal-to-Noise Ratio (SNR) in dB for four different MIMO configurations: SISO (1x1), SIMO (1x2), MISO (2x1), and MIMO (2x2).

- **SISO (Single-Input Single-Output):** As expected, SISO has the lowest channel capacity among the four configurations. The capacity increases with SNR, but at a slower rate compared to the other systems.
- **SIMO (Single-Input Multiple-Output):** SIMO shows improved capacity over SISO. With two receive antennas, it benefits from diversity gain, leading to a higher capacity for the same SNR.
- **MISO (Multiple-Input Single-Output):** MISO also demonstrates better capacity than SISO. With two transmit antennas, it leverages transmit diversity, resulting in increased capacity.
- **MIMO (Multiple-Input Multiple-Output):** MIMO (2x2) exhibits the highest channel capacity. With both multiple transmit and receive antennas, it benefits from both diversity and spatial multiplexing gains, leading to a significant increase in capacity, especially at higher SNRs. The capacity increases most rapidly with SNR for the MIMO system.

In general, the results show that increasing the number of antennas (either at the transmitter or receiver, or both) significantly enhances the channel capacity, with MIMO offering the most substantial gains due to its ability to exploit spatial resources more effectively.

Task 2: BER VS SNR of SISO

Observations and Results:

The MATLAB code simulates the Bit Error Rate (BER) versus SNR for a Binary Phase Shift Keying (BPSK) modulation scheme over a SISO (Single-Input Single-Output) Rayleigh fading channel.

- **BER vs. SNR:** The plot shows a clear inverse relationship between BER and SNR. As the SNR increases (from 0 dB to 20 dB), the BER decreases significantly. This is a fundamental characteristic of digital communication systems: higher signal power relative to noise leads to fewer errors in bit detection.
- **Rayleigh Fading:** The simulation accounts for Rayleigh fading, which introduces random fluctuations in the signal strength. This makes the BER performance worse compared to an Additive White Gaussian Noise (AWGN) channel without fading, as the signal can experience deep fades, leading to more errors.

- **BPSK Modulation:** BPSK is a simple and robust modulation scheme. The simulated BER curve is typical for BPSK in a fading channel, showing a gradual improvement in error performance as the SNR improves.

The results obtained from the simulation are consistent with theoretical expectations for BPSK over a SISO Rayleigh fading channel, demonstrating that increasing the transmit power (and thus SNR) is crucial for achieving reliable communication in such environments.