Experiment 8: Simulation of Rayleigh and Rician Fading Channels using MATLAB

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Aim:

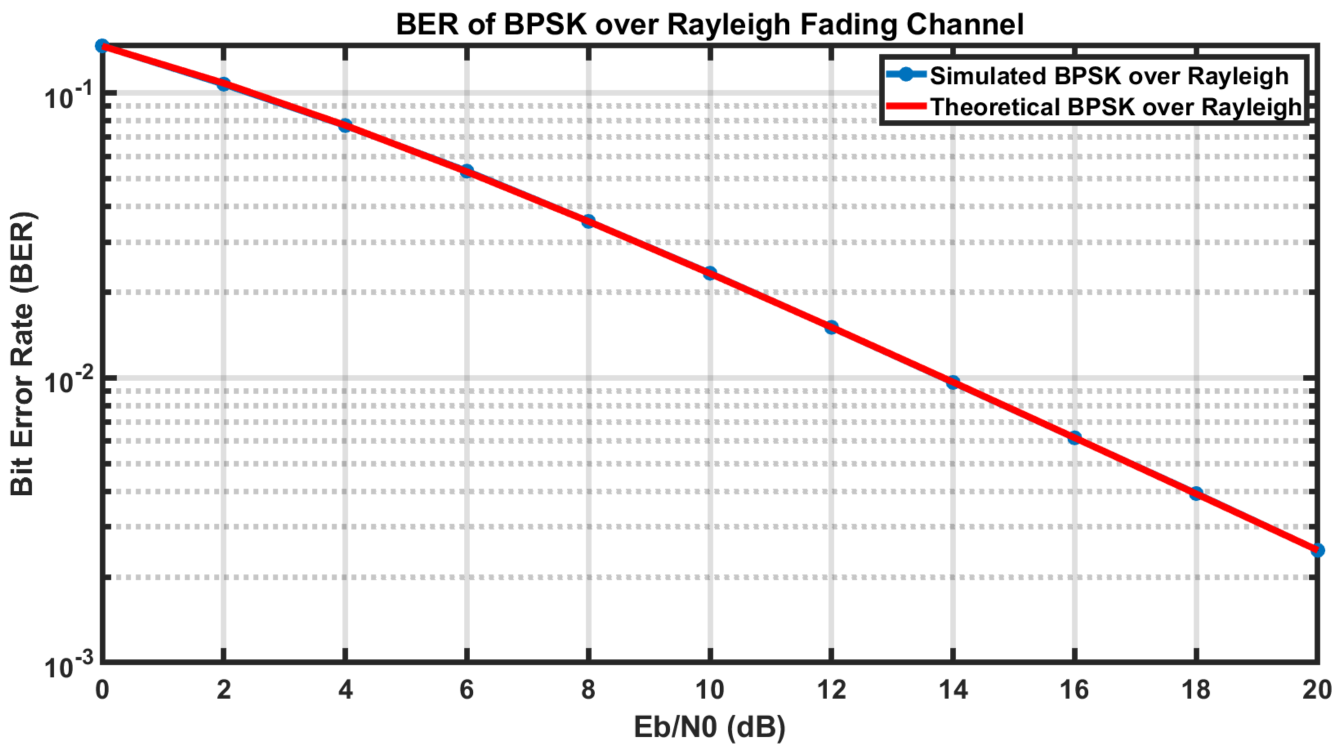
To study and Compare the BER of BPSK over Rayleigh and Rician Fading Channel.

Code (Rayleigh):

```
clc;
clear;
close all;

% Simulation parameters
N = 1e6; % Number of symbols
EbN0_dB = 0:2:20; % SNR range in dB

% Generate random binary data   `1q
data = randi([0 1], 1, N);

% BPSK Modulation
bpsk_symbols = 2*data - 1; % BPSK: 0 -> -1, 1 -> 1

% Initialize BER arrays
ber_bpsk = zeros(1, length(EbN0_dB));

for i = 1:length(EbN0_dB)
    % Convert SNR from dB to linear scale
    EbN0 = 10^(EbN0_dB(i)/10);
    noise_variance = 1 / (2 * EbN0);

    % Rayleigh fading (envelope)
    rayleigh_fading = (randn(1, N) + 1i*randn(1, N)) / sqrt(2);

    % Received signal with Rayleigh fading and AWGN
    received_signal = rayleigh_fading .* bpsk_symbols + sqrt(noise_variance) *
(randn(1, N) + 1i*randn(1, N));

    % Equalization (coherent detection)
    equalized_signal = real(received_signal ./ rayleigh_fading);

    % BPSK Demodulation
    detected_data = equalized_signal > 0;
```

```
    % BER Calculation
    ber_bpsk(i) = sum(detected_data ~= data) / N;
end

% Theoretical BER for BPSK over Rayleigh fading
EbN0_linear = 10.^(EbN0_dB/10);
ber_bpsk_theory = 0.5 .* (1 - sqrt(EbN0_linear ./ (EbN0_linear + 1)));

% Plotting
figure;
semilogy(EbN0_dB, ber_bpsk, 'o-', 'LineWidth', 5);
hold on;
semilogy(EbN0_dB, ber_bpsk_theory, 'r-', 'LineWidth', 5);
xlabel('Eb/N0 (dB)');
ylabel('Bit Error Rate (BER)');
title('BER of BPSK over Rayleigh Fading Channel');
legend('Simulated BPSK over Rayleigh', 'Theoretical BPSK over Rayleigh');
set(gca,'FontSize',20,'LineWidth',4,'FontWeight','bold');
grid on;
```

Output:



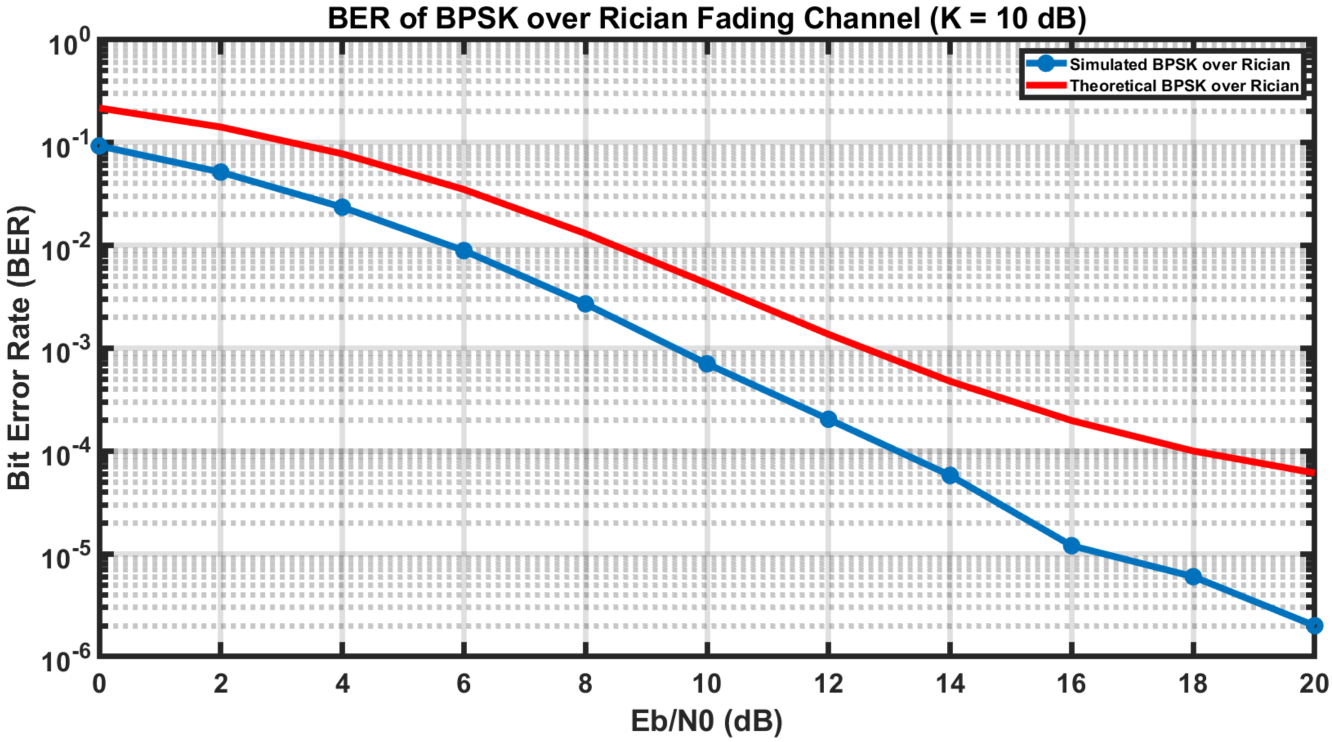
Inference:

The BER of BPSK over a Rayleigh Channel decreases with increase in SNR

Code (Rician):

```
clc;
clear;
close all;
N = 1e6;
EbN0_dB = 0:2:20;
K_dB = 10;
K = 10^(K_dB/10);
data = randi([0 1], 1, N);
bpsk_symbols = 2*data - 1;
ber_rician = zeros(1, length(EbN0_dB));
for i = 1:length(EbN0_dB)
EbN0 = 10^(EbN0_dB(i)/10);
noise_variance = 1 / (2 * EbN0);
rician_fading = sqrt(K / (K + 1)) + sqrt(1 / (K + 1)) * (randn(1, N) + 1i *
randn(1, N)) / sqrt(2);
received_signal = rician_fading .* bpsk_symbols + sqrt(noise_variance) * (randn(1,
N) + 1i * randn(1, N));
equalized_signal = real(received_signal ./ rician_fading);
detected_data = equalized_signal > 0;
ber_rician(i) = sum(detected_data ~= data) / N;
end
EbN0_linear = 10.^(EbN0_dB/10);
ber_rician_theory = 0.5 * exp(-K * EbN0_linear ./ (EbN0_linear + K + 1));
figure;
semilogy(EbN0_dB, ber_rician, 'o-', 'LineWidth', 5, 'MarkerSize', 8);
hold on;
semilogy(EbN0_dB, ber_rician_theory, 'r-', 'LineWidth', 5);
set(gca, 'FontSize', 14, 'FontWeight', 'bold');
xlabel('Eb/N0 (dB)', 'FontSize', 14, 'FontWeight', 'bold');
ylabel('Bit Error Rate (BER)', 'FontSize', 14, 'FontWeight', 'bold');
title(['BER of BPSK over Rician Fading Channel (K = ', num2str(K_dB), ' dB)'],
'FontSize', 14, 'FontWeight', 'bold');
legend({'Simulated BPSK over Rician', 'Theoretical BPSK over Rician'}, 'Location',
'NorthEast', 'FontSize', 12, 'FontWeight', 'bold');
set(gca,'FontSize',20,'LineWidth',4,'FontWeight','bold');
grid on;
```

Output:



Inference:

The BER of BPSK over a Rician Channel decreases with increase in SNR

Observation and Result:

- Rician fading is less severe than Rayleigh fading due to the presence of the LOS component. Hence its BER reaches lower magnitudes compared to Rayleigh fading.
- The K-factor in Rician fading plays a crucial role in determining the BER performance.

Hence, the graphs of SNR Vs BER were plotted and observed BPSK modulation over Rayleigh and Rician Fading channels.