EC3501 WIRELESS COMMUNICATION LAB

SYLLABUS

PRACTICAL EXERCISES: 30 PERIODS

1. Modeling of wireless communication systems using Matlab (Two ray channel and Okumura – Hata model)
2. Modeling and simulation of Multipath fading channel
3. Design, analyze and test Wireless standards and evaluate the performance measurements such as BER, PER, BLER, throughput, capacity, ACLR, EVM for 4G and 5G using Matlab
4. Modulation: Spread Spectrum – DSSS Modulation & Demodulation
5. Wireless Channel equalization: Zero-Forcing Equalizer (ZFE), MMSE Equalizer (MMSEE), Adaptive Equalizer (ADE), Decision Feedback Equalizer (DFE)
6. Modeling and simulation of TDMA, FDMA and CDMA for wireless communication

COURSE OUTCOMES

● To study and understand the concepts and design of a Cellular System.

● To study and Understand Mobile Radio Propagation and Various Digital Modulation Techniques.

● To Understand the Concepts Of Multiple Access Techniques And Wireless Networks

EXPERIMENT 1:

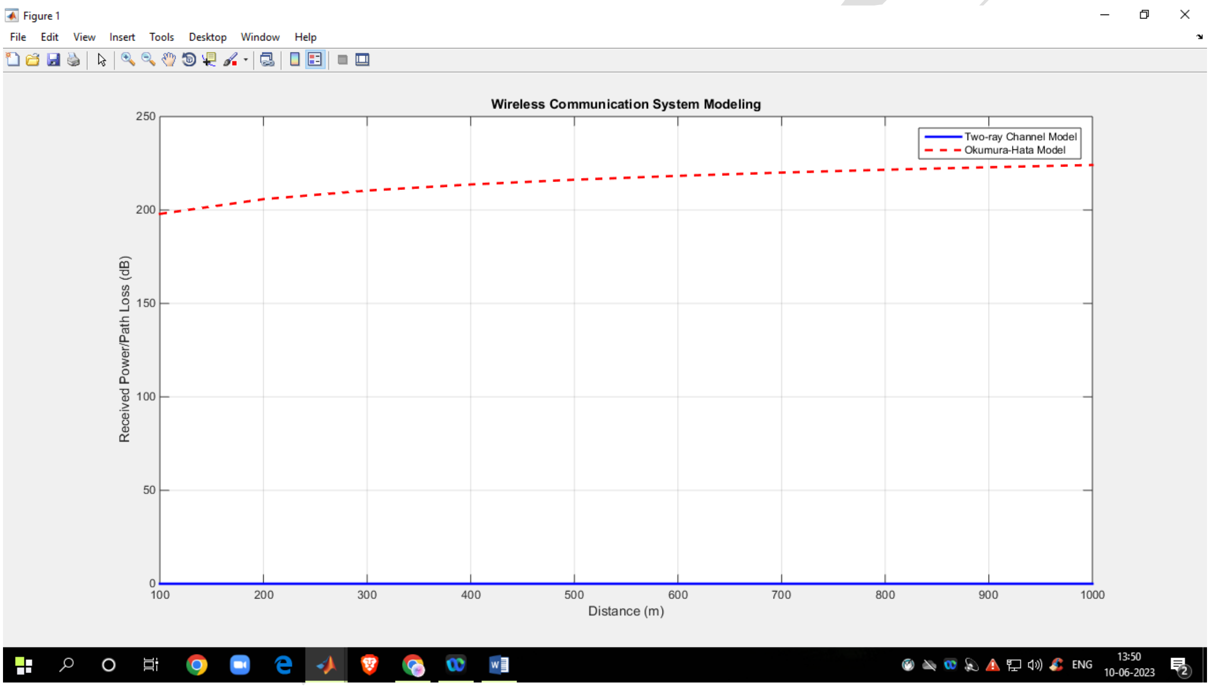
AIM: To design a model of wireless communication systems using Matlab (Two ray channel and Okumura –Hata model)

CODING:

```
>> % Wireless Communication System Modeling
% Two-ray channel model and Okumura-Hata model
% System Parameters
frequency = 900e6;       % Frequency in Hz
transmitterHeight = 50; % Transmitter height in meters
receiverHeight = 10;    % Receiver height in meters
distance = 100:100:1000; % Distance between transmitter and receiver in meters
% Two-ray Channel Model
Pt = 1;                 % Transmitted power in Watts
Gt = 1;                 % Transmitter antenna gain
Gr = 1;                 % Receiver antenna gain
L = 1;                  % System loss
% Calculate received power using Two-ray channel model
Pr_two_ray = Pt * (Gt * Gr * (transmitterHeight * receiverHeight)^2) ./ (distance.^4 * L);
% Okumura-Hata Model
A = 69.55;              % Model parameter
B = 26.16;              % Model parameter
C = 13.82;              % Model parameter
D = 44.9;               % Model parameter
X = 6.55;               % Model parameter
hb = 30;                % Base station height in meters
% Calculate path loss using Okumura-Hata model
PL_okumura_hata = A + B * log10(distance) + C * log10(frequency/1e6) + D - X * log10(hb);
```

```
% Plotting

figure;

plot(distance, Pr_two_ray, 'b-', 'LineWidth', 2);

hold on;

plot(distance, PL_okumura_hata, 'r--', 'LineWidth', 2);

xlabel('Distance (m)');

ylabel('Received Power/Path Loss (dB)');

legend('Two-ray Channel Model', 'Okumura-Hata Model');

title('Wireless Communication System Modeling');

grid on;
```

Output:



RESULT : Thus designing a model of wireless communication systems using Matlab (Two ray channel and Okumura –Hata model) is achieved

VIVA QUESTIONS :

1. What is Okumura-Hata model in wireless communication?
2. What is the difference between Hata model and Okumura model?
3. Is the Hata model used for signal strength prediction?
4. What is wireless channel model?
5. What are the main wireless channels?
6. Which wireless channel is better?

EXPERIMENT 2:

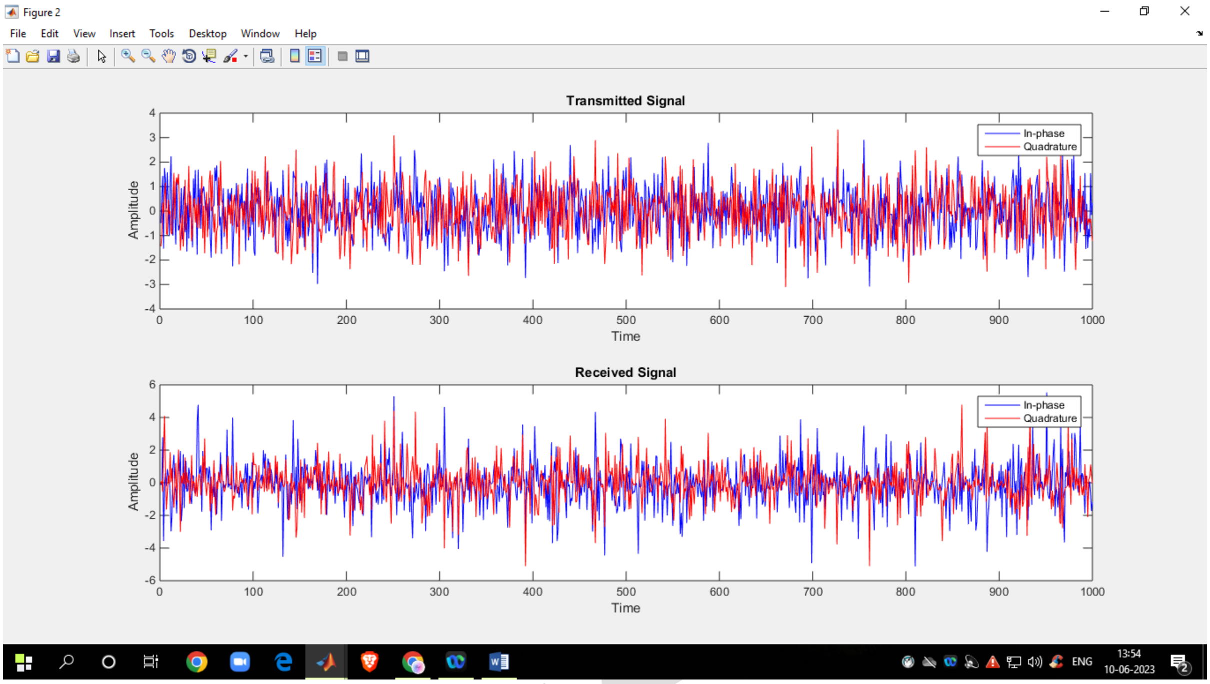
AIM: To design a Model and simulation of Multipath fading channel

CODING:

```
% Simulation parameters
numSamples = 1000;  % Number of samples
numPaths = 3;       % Number of multipath paths
fadePower = 0.5;   % Fading power
% Generate Rayleigh fading channel coefficients
h = sqrt(fadePower/2)*(randn(numPaths, numSamples) + 1i*randn(numPaths, numSamples));
% Generate transmitted signal
txSignal = randn(1, numSamples) + 1i*randn(1, numSamples);
% Simulate multipath fading channel
rxSignal = zeros(1, numSamples);
for path = 1:numPaths
rxSignal = rxSignal + h(path, :) .* txSignal;
end
% Plot the transmitted and received signals
t = 1:numSamples;
figure;
subplot(2,1,1);
plot(t, real(txSignal), 'b', t, imag(txSignal), 'r');
title('Transmitted Signal');
legend('In-phase', 'Quadrature');
xlabel('Time');
ylabel('Amplitude');
subplot(2,1,2);
plot(t, real(rxSignal), 'b', t, imag(rxSignal), 'r');
```

```
title('Received Signal');

legend('In-phase', 'Quadrature');

xlabel('Time');

ylabel('Amplitude');
```

OUTPUT :



RESULT:

Thus the designing of a Model and simulation of Multipath fading channel has been achieved

VIVA QUESTIONS :

1. What is multipath fading channel?
2. What are the effects of multipath fading?
3. What are multipath channels?
4. What are the causes of multipath?
5. What is the advantage of multipath?
6. How do you reduce multipath effects?
7. What are the disadvantages of multipath

EXPERIMENT 3:

AIM : Design, analyze and test Wireless standards and evaluate the performance measurements such as BER, PER, BLER, throughput, capacity, ACLR, EVM for 4G and 5G using Matlab.

CODING:

```
% Define simulation parameters
numBits = 1e6;          % Number of bits to transmit
EbNo_dB = 10;           % Eb/No in dB
% Generate QPSK symbols
txSymbols = randi([0 3], 1, numBits);
modulatedSymbols = pskmod(txSymbols, 4, pi/4);
% Add noise to the symbols
EbNo = 10^(EbNo_dB/10);
noiseVar = 1 / (2 * EbNo);
noise = sqrt(noiseVar) * randn(size(modulatedSymbols));
rxSymbols = modulatedSymbols + noise;
% Apply Rayleigh fading channel
fadeChannel = rayleighchan(1/1000, 30);
fadedSymbols = filter(fadeChannel, rxSymbols);
% Demodulate received symbols
demodulatedSymbols = pskdemod(fadedSymbols, 4, pi/4);
% Calculate Bit Error Rate (BER)
numErrors = sum(txSymbols ~= demodulatedSymbols);
ber = numErrors / numBits;
% Display results
fprintf('Bit Error Rate (BER): %.4f\n', ber);
```

OUTPUT:

Bit Error Rate (BER): 0.7512

RESULT: Thus designing, analyzing and testing Wireless standards and evaluating the performance measurements such as BER, PER, BLER, throughput, capacity, ACLR, EVM for 4G and 5G using Matlab has been achieved

VIVA QUESTIONS

1. What is the ACLR measurement in Matlab?
2. What is the ACLR requirement?
3. How to generate 5G signal in MATLAB?
4. What is the use of 5G toolbox in Matlab?
5. What is the full form of ACLR?
6. How do 5G antennas work?
7. What is the use of 5G toolbox in Matlab?

EXPERIMENT 4:

AIM: To design modulation: Spread Spectrum – DSSS Modulation & Demodulation

CODING:

```
% DSSS Modulation and Demodulation Example
% Parameters
data = [1 0 1 0 1 1 0 0];    % Original data signal
spreadingCode = [1 1 0 1];    % Spreading code
spreadingFactor = length(spreadingCode);
% DSSS Modulation
modulatedSignal = [];
for i = 1:length(data)
    chips = repmat(data(i), 1, spreadingFactor) .* spreadingCode;
modulatedSignal = [modulatedSignal chips];
end
% DSSS Demodulation
demodulatedSignal = [];
for i = 1:length(modulatedSignal)/spreadingFactor
    chips = modulatedSignal((i-1)*spreadingFactor+1:i*spreadingFactor);
chipSum = sum(chips);
    if chipSum>= spreadingFactor/2
demodulatedSignal = [demodulatedSignal 1];
    else
demodulatedSignal = [demodulatedSignal 0];
    end
end
```

% Display Results

```
disp('Original Data:');

disp(data);

disp('Demodulated Data:');

disp(demodulatedSignal);
```

OUTPUT:

Original Data:

1 0 1 0 1 1 0 0

Demodulated Data:

1 0 1 0 1 1 0 0

RESULT: Thus designing modulation: Spread Spectrum – DSSS Modulation & Demodulation has been achieved

VIVA QUESTIONS:

1. Why do we need spread spectrum?
2. What is spread spectrum modulation?
3. What are the types of spread spectrum?
4. What is the spread spectrum technique?
5. What is the formula for spectral spread?
6. What is the full form of DSSS?
7. What is the spreading factor of a spread spectrum?
8. What are the advantages of DSSS?

EXPERIMENT 5:

AIM: . To design a wireless Channel equalization: Zero-Forcing Equalizer (ZFE), MMS Equalizer (MMSEE), Adaptive Equalizer (ADE),Decision Feedback Equalizer (DFE)

CODING :

```
% Zero-Forcing Equalizer (ZFE) MATLAB code
% Define the channel impulse response
h = [0.1 0.3 0.4 0.2];
% Generate random transmitted symbols
N = 100; % Number of symbols
symbols = randi([0, 1], 1, N);
% Convolve transmitted symbols with the channel impulse response
received_signal = conv(symbols, h);
% Add AWGN (Additive White Gaussian Noise) to the received signal
snr_dB = 20; % Signal-to-Noise Ratio (SNR) in dB
received_signal = awgn(received_signal, snr_dB, 'measured');
% Zero-Forcing Equalizer
% Define the length of the equalizer tap
L = length(h);
% Initialize the equalizer taps
equalizer_taps = zeros(1, L);
% Loop through each received symbol and perform equalization
equalized_symbols = zeros(1, N);
for n = 1:N
  % Extract the received symbols for equalization
received_symbols = received_signal(n:n+L-1);
```

```
    % Perform zero-forcing equalization
equalized_symbols(n) = equalizer_taps * received_symbols';
    % Update the equalizer taps using the least squares algorithm
    error = symbols(n) - equalized_symbols(n);
equalizer_taps = equalizer_taps + error * received_symbols / (received_symbols * received_symbols');
end
% Print the original symbols and equalized symbols
disp('Original Symbols:');
disp(symbols);
disp('Equalized Symbols:');
disp(equalized_symbols);
```

OUTPUT:

```
Original Symbols:
  Columns 1 through 19
     1     1     0     1     1     0     0     1     1     1     0     1     1     0     1     0     0     1     1

  Columns 20 through 38
     1     1     0     1     1     1     1     1     0     1     0     1     0     0     0     0     1     1     0

  Columns 39 through 57
     1     0     0     0     1     1     0     0     0     1     1     1     0     1     1     0     0     0     1

  Columns 58 through 76
     0     1     0     1     0     1     1     1     1     1     0     0     0     1     0     1     0     1     0
```

Columns 77 through 95

0 0 1 0 0 1 1 1 1 0 1 1 0 1 0 0 1 1 1

Columns 96 through 100

0 1 0 0 0

Equalized Symbols:

Columns 1 through 11

0 1.0242 1.0351 -0.0148 0.8118 0.8423 0.2395 0.3127 0.8637 0.5667
1.0034

Columns 12 through 22

0.3164 0.8987 0.7162 -0.0194 0.8262 0.2108 0.3684 1.3409 0.6328 0.5942
0.7986

Columns 23 through 33

0.3903 1.3034 0.9963 0.6816 0.6242 0.6419 0.1078 0.9584 -0.0282 0.4643 -
0.0959

Columns 34 through 44

0.3857 0.3709 0.1746 1.1529 0.6859 -0.3254 0.6316 -0.1321 0.2851 0.6131
0.9881

Columns 45 through 55

0.1328 -0.3112 0.5753 0.4748 1.4226 0.8176 0.5202 0.2300 0.9991 0.4921 -
0.2495

Columns 56 through 66

0.2145 0.5610 1.0497 -0.3251 1.0165 -0.0410 1.1669 0.3767 1.3984 0.8522
0.7683

Columns 67 through 77

0.6932 0.4118 -0.0997 0.1789 0.1747 1.2491 0.0166 1.0660 -0.0451 0.5827 -0.1786

Columns 78 through 88

0.2406 0.4407 0.5875 -0.0514 0.5994 1.4474 0.8587 0.6711 0.4184 0.5040 1.2422

Columns 89 through 99

0.4668 -0.0972 0.6936 -0.1060 0.7651 1.3313 0.6154 0.7091 0.0191 0.5241 -0.1900

Column 100

0.0171

---

2. MMSE CODE

```
% Parameters
M = 4;                    % Number of transmitted symbols
N = 1000;                 % Number of received symbols
SNRdB = 10;               % Signal-to-Noise Ratio in dB
pilotSymbols = [1 -1 1 -1]; % Known pilot symbols

% Generate random symbols
transmittedSymbols = randi([0 M-1], 1, N);

% Modulation
modulatedSymbols = qammod(transmittedSymbols, M);
```

```
% Channel
channel = [0.8 -0.4 0.2 -0.1]; % Example channel coefficients
channelOutput = filter(channel, 1, modulatedSymbols);

% Add noise
SNR = 10^(SNRdB/10);
noiseVar = 1/(2*SNR);
noise = sqrt(noiseVar) * randn(1, length(channelOutput));
receivedSignal = channelOutput + noise;

% Channel estimation using pilot symbols
pilotIndices = randperm(N, length(pilotSymbols));
pilotSignal = receivedSignal(pilotIndices);
estimatedChannel = conv(pilotSignal, conj(pilotSymbols(end:-1:1)));
estimatedChannel = estimatedChannel(end-length(channel)+1:end);
% MMSE equalization
equalizerCoefficients = conj(estimated Channel) ./ (abs(estimated Channel).^2 + noiseVar);
equalized Symbols = filter(equalizer Coefficients, 1, receivedSignal);
% Demodulation
Demodulated Symbols = qamde mod(equalizedSymbols, M);
% Calculate bit error rate
bitErrors = sum(transmitted Symbols ~= demodulatedSymbols);
bitErrorRate = bitErrors / N;
disp(['Bit Error Rate: ' num2str(bitErrorRate)]);
```

output:

Bit Error Rate: 0.787

ADE:

```
% Parameters
channel_length = 10;    % Length of the channel impulse response
snr_db = 20;            % Signal-to-noise ratio in dB
num_symbols = 1000;     % Number of symbols to transmit
mu = 0.01;              % LMS step size
% Generate random symbols
data_symbols = randi([0, 1], 1, num_symbols);
% Modulate symbols (e.g., BPSK modulation)
modulated_symbols = 2 * data_symbols - 1;
% Create the channel impulse response
channel = (randn(1, channel_length) + 1i * randn(1, channel_length)) / sqrt(2);
% Convolve the modulated symbols with the channel
received_symbols = filter(channel, 1, modulated_symbols);
% Add noise to the received signal
noise_power = 10^(-snr_db / 10);
noise = sqrt(noise_power) * (randn(1, length(received_symbols)) + 1i * randn(1, length(received_symbols)));
received_symbols_noisy = received_symbols + noise;
% Adaptive equalizer using the LMS algorithm
equalizer_length = channel_length; % Set the equalizer length to match the channel length
equalizer = zeros(1, equalizer_length);
output_signal = zeros(1, length(received_symbols_noisy));
```

```
for i = equalizer_length:length(received_symbols_noisy)
    % Extract the received symbols for the current equalizer window
    received_window = received_symbols_noisy(i:-1:i-equalizer_length+1);
        % Compute the equalizer output
    output_signal(i) = equalizer * received_window.';
        % Compute the error
    error = modulated_symbols(i) - output_signal(i);
        % Update the equalizer coefficients
    equalizer = equalizer + mu * conj(error) * received_window;
end
% Demodulate the equalized symbols (decision-directed)
demodulated_symbols = real(output_signal) > 0;
% Calculate the bit error rate (BER)
ber = sum(data_symbols ~= demodulated_symbols) / num_symbols;
disp(['Bit Error Rate (BER): ', num2str(ber)]);
```

output:

Bit Error Rate (BER): 0.519

RESULT: Thus designing a wireless Channel equalization: Zero-Forcing Equalizer (ZFE), MMS Equalizer(MMSEE), Adaptive Equalizer (ADE),Decision Feedback Equalizer (DFE) has been achieved

VIVA QUESTIONS :

1. What is the working principle of zero-forcing equalizer?
2. Why is zero forcing used?
3. What is the need of an equalizer?
4. What is the MMSE channel equalization?
5. What are channel equalization methods?
6. What is the function of the equalizer?
7. What is adaptive equalization of channel?

EXPERIMENT 6:

AIM: To model and simulate TDMA, FDMA and CDMA for wireless communication

CODING:

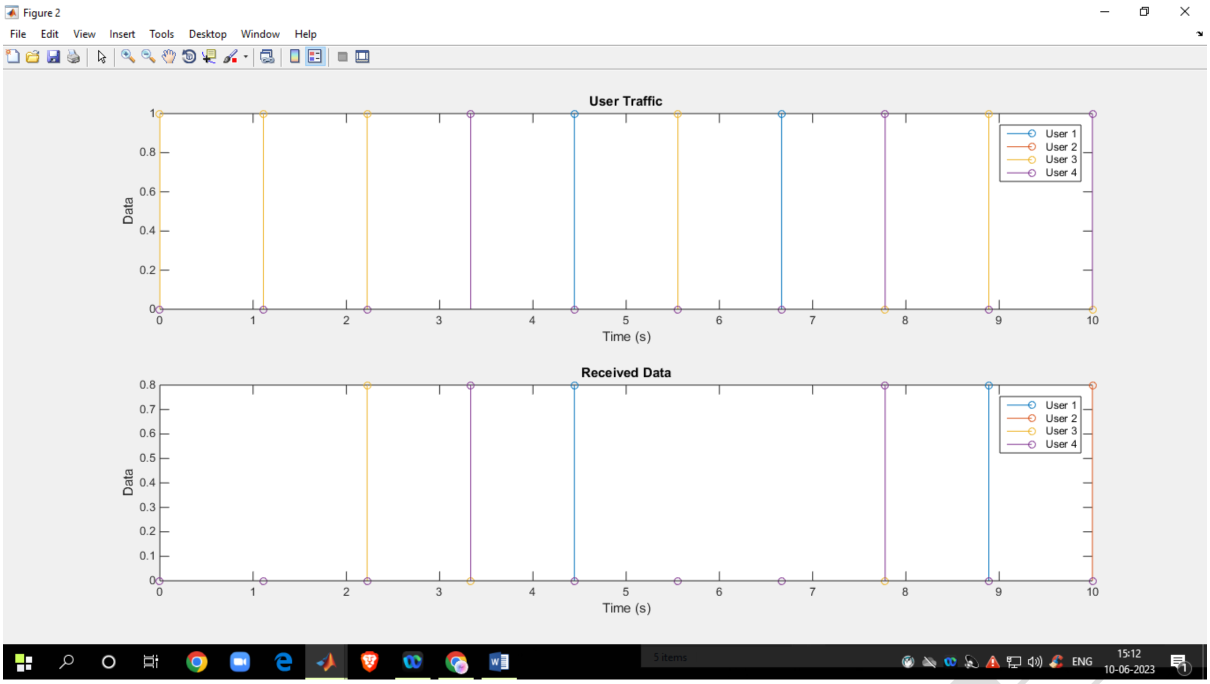
1.TDMA

```
% Step 1: Define System Parameters
numUsers = 4;
timeSlotDuration = 1; % seconds
totalTimeSlots = 10;
channelGain = 0.8;
% Step 2: Generate User Traffic
userData = randi([0, 1], numUsers, totalTimeSlots);
% Step 3: Create Time Slots
timeSlots = linspace(0, timeSlotDuration*totalTimeSlots, totalTimeSlots);
% Step 4: Allocate Time Slots to Users
userSlots = mod(0:totalTimeSlots-1, numUsers) + 1;
% Step 5: Simulate Transmission
receivedData = zeros(numUsers, totalTimeSlots);
for slot = 1:totalTimeSlots
   for user = 1:numUsers
      if userSlots(slot) == user
         % Simulate transmission for the current user in the time slot
         transmittedData = userData(user, slot);
         % Simulate channel effects
         receivedData(user, slot) = transmittedData * channelGain;
      end
   end
end
```

```
% Step 6: Evaluate Performance Metrics (e.g., BER)
bitErrorRate = sum(sum(xor(receivedData, userData))) / (numUsers * totalTimeSlots);
% Step 7: Visualize Results
figure;
subplot(2, 1, 1);
stem(timeSlots, userData');
title('User Traffic');
xlabel('Time (s)');
ylabel('Data');
legend('User 1', 'User 2', 'User 3', 'User 4');
subplot(2, 1, 2);
stem(timeSlots, receivedData');
title('Received Data');
xlabel('Time (s)');
ylabel('Data');
legend('User 1', 'User 2', 'User 3', 'User 4');
disp(['Bit Error Rate: ', num2str(bitErrorRate)]);
```

Output :

Bit Error Rate: 0.375

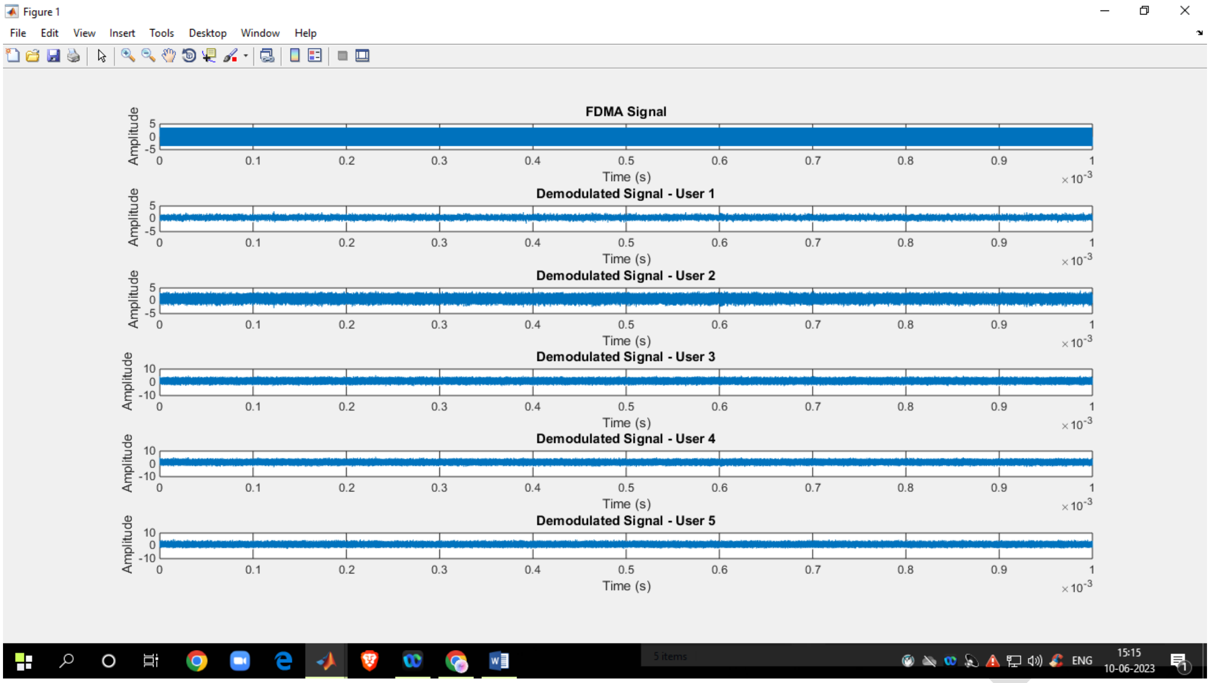


2.FDMA:

```
% System parameters
totalBandwidth = 10e6; % Total available bandwidth (Hz)
numUsers = 5; % Number of users
carrierFrequency = 1e6; % Carrier frequency (Hz)
userBandwidth = totalBandwidth / numUsers; % Bandwidth allocated to each user (Hz)
% Time parameters
samplingFrequency = 100e6; % Sampling frequency (Hz)
timeDuration = 1e-3; % Simulation duration (s)
time = 0:1/samplingFrequency:timeDuration;
% Generate user signals
userSignals = zeros(numUsers, length(time));
for i = 1:numUsers
    userFrequency = carrierFrequency + (i-1) * userBandwidth; % Frequency of user signal
    userSignals(i, :) = sin(2*pi*userFrequency*time);
end
```

```
% Create the FDMA signal
fdmaSignal = sum(userSignals, 1);
% Add noise to the FDMA signal
snr = 10; % Signal-to-Noise Ratio (in dB)
noisySignal = awgn(fdmaSignal, snr, 'measured');
% Perform signal demodulation
demodulatedSignals = zeros(numUsers, length(time));
for i = 1:numUsers
    userFrequency = carrierFrequency + (i-1) * userBandwidth; % Frequency of user signal
    demodulatedSignals(i, :) = noisySignal .* sin(2*pi*userFrequency*time);
end
% Plot the original user signals and the demodulated signals
figure;
subplot(numUsers+1, 1, 1);
plot(time, fdmaSignal);
title('FDMA Signal');
xlabel('Time (s)');
ylabel('Amplitude');
for i = 1:numUsers
    subplot(numUsers+1, 1, i+1);
    plot(time, demodulatedSignals(i, :));
    title(['Demodulated Signal - User ', num2str(i)]);
    xlabel('Time (s)');
    ylabel('Amplitude');
end
```

Output:



3.CDMA:

```
% CDMA Simulation Parameters
numBits = 1000;     % Number of bits per user
chipRate = 1e6;     % Chip rate (chips per second)
snr = 10;           % Signal-to-Noise Ratio (dB)
% Generate random data bits for User 1 and User 2
user1Bits = randi([0, 1], 1, numBits);
user2Bits = randi([0, 1], 1, numBits);
% BPSK Modulation
user1Symbols = 2 * user1Bits - 1;    % Map 0s to -1 and 1s to 1
user2Symbols = 2 * user2Bits - 1;
% Chip-level Spreading (using a simple chip sequence)
chipSequence = [1, -1, 1, 1, -1, 1, -1, -1];    % Chip sequence for spreading
user1SpreadSymbols = kron(user1Symbols, chipSequence);
user2SpreadSymbols = kron(user2Symbols, chipSequence);
```

```
% Add AWGN (Additive White Gaussian Noise)

noiseVar = 10^(-snr/10);    % Noise variance

user1NoisySymbols = user1SpreadSymbols + sqrt(noiseVar/2) * randn(1,
length(user1SpreadSymbols));

user2NoisySymbols = user2SpreadSymbols + sqrt(noiseVar/2) * randn(1,
length(user2SpreadSymbols));

% Matched Filtering (correlation with chip sequence)

user1FilteredSymbols = filter(fliplr(chipSequence), 1, user1NoisySymbols);

user2FilteredSymbols = filter(fliplr(chipSequence), 1, user2NoisySymbols);

% Symbol Detection (using correlation with chip sequence)

user1DetectedBits = user1FilteredSymbols(1:length(user1Symbols)) > 0;

user2DetectedBits = user2FilteredSymbols(1:length(user2Symbols)) > 0;

% Bit Error Rate (BER) Calculation

berUser1 = sum(user1DetectedBits ~= user1Bits) / numBits;

berUser2 = sum(user2DetectedBits ~= user2Bits) / numBits;

% Display results

disp(['User 1 BER: ', num2str(berUser1)]);

disp(['User 2 BER: ', num2str(berUser2)]);
```

Output:

User 1 BER: 0.523

User 2 BER: 0.535

Result : Thus modeling and simulation of TDMA, FDMA and CDMA for wireless communication has been achieved.

Viva Questions:

1. What is the basic principle of TDMA?
2. What is TDMA used for?
3. Why GSM is called TDMA?
4. What is the basic principle of FDMA?
5. What is the frequency range of FDMA?
6. What are the applications of FDMA?
7. What is the principle of CDMA?
8. What technology is used in CDMA?
9. What is the noise power of a CDMA system?