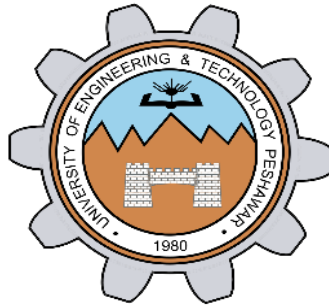


# **DIGITAL SIGNAL PROCESSING LAB**

**Fall 2024, 5<sup>th</sup> Semester**

## **Lab Report 9**



**Submitted by: Hassan Zaib Jadoon**

**Registration Number: 22PWCSE2144**

**Section: A**

"On my honor, as a student at the University of Engineering and Technology Peshawar, I have neither given nor received unauthorized assistance on this academic work."

**Signature:**

**Submitted To: Dr. Yasir Saleem Afridi**

**Department of Computer Systems Engineering**

**University of Engineering and Technology Peshawar**

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**CSE 402L: Digital Signal Processing**


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| <b>Demonstration of Concepts</b> | <b>Poor (Does not meet expectation (1))</b>                                                                                                                                                                          | <b>Fair (Meet Expectation (2-3))</b>                                                                                                                                                                                  | <b>Good (Exceeds Expectation (4-5))</b>                                                                                                                                                                         | <b>Score</b> |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
|                                  | The student failed to demonstrate a clear understanding of the assignment concepts                                                                                                                                   | The student demonstrated a clear understanding of some of the assignment concepts                                                                                                                                     | The student demonstrated a clear understanding of the assignment concepts                                                                                                                                       | <b>30%</b>   |
| <b>Accuracy</b>                  | The student completed ( <50%) tasks and provided MATLAB code and/or Simulink models with errors. Outputs shown are not correct in form of graphs (no labels) and/or tables along with incorrect analysis or remarks. | The student completed partial tasks (50% - <90%) with accurate MATLAB code and/or Simulink models. Correct outputs are shown in form of graphs (without labels) and/or tables along with correct analysis or remarks. | The student completed all required tasks (90%-100%) with accurate MATLAB code and/or Simulink models. Correct outputs are shown in form of labeled graphs and/or tables along with correct analysis or remarks. | <b>30%</b>   |
| <b>Following Directions</b>      | The student clearly failed to follow the verbal and written instructions to successfully complete the lab                                                                                                            | The student failed to follow the some of the verbal and written instructions to successfully complete all requirements of the lab                                                                                     | The student followed the verbal and written instructions to successfully complete requirements of the lab                                                                                                       | <b>20%</b>   |
| <b>Time Utilization</b>          | The student failed to complete even part of the lab in the allotted amount of time                                                                                                                                   | The student failed to complete the entire lab in the allotted amount of time                                                                                                                                          | The student completed the lab in its entirety in the allotted amount of time                                                                                                                                    | <b>20%</b>   |

# Lab Report: Frequency Division Multiplexing and De-multiplexing

## Step 1: Load and Play Voice Signals

```

%% Load and play voice signals
[sig1, fs1] = audioread('beep-02.wav');
[sig2, fs2] = audioread('beep-07a.wav');
[sig3, fs3] = audioread('beep-10.wav');

%% Resample signals to a common sampling rate
common_fs = 44100; % Define a common sampling rate
sig1 = resample(sig1, common_fs, fs1);
sig2 = resample(sig2, common_fs, fs2);
sig3 = resample(sig3, common_fs, fs3);

fs1 = common_fs; fs2 = common_fs; fs3 = common_fs;

%% Ensure all signals have the same length
min_length = min([length(sig1), length(sig2), length(sig3)]);
sig1 = sig1(1:min_length);
sig2 = sig2(1:min_length);
sig3 = sig3(1:min_length);

%% playback
sound(sig1, fs1); pause(2);

%%
sound(sig2, fs2); pause(2);

%%
sound(sig3, fs3); pause(2);

```

Remarks:

Step II: Plot the spectra of the signals as they arrive (Use fft and dsp.SpectrumAnalyzer for comparison)

Code:

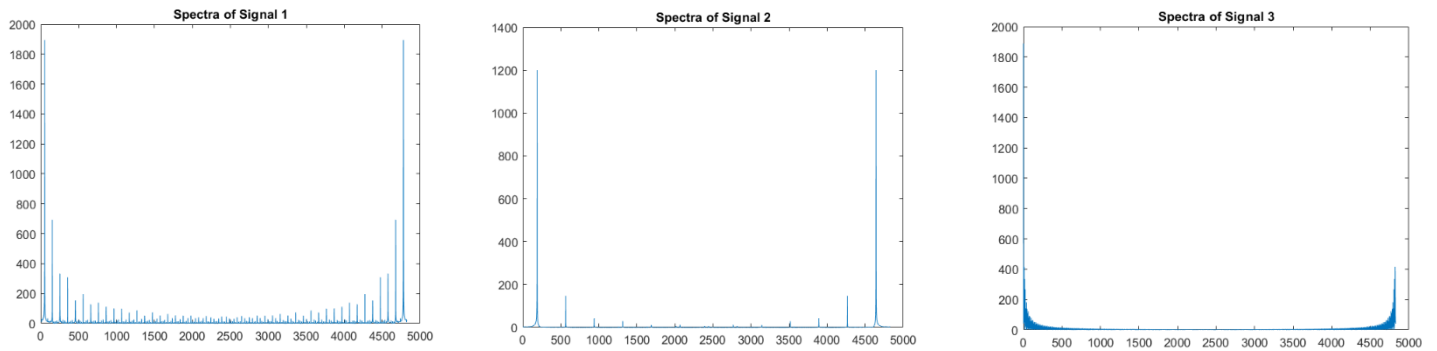
```

%% Spectral analysis
fft_sig1 = abs(fft(sig1));
fft_sig2 = abs(fft(sig2));
fft_sig3 = abs(fft(sig3));

%% plot spectrum
figure; plot(fft_sig1); title('Spectra of Signal 1');
figure; plot(fft_sig2); title('Spectra of Signal 2');
figure; plot(fft_sig3); title('Spectra of Signal 3');

```

Output:



Remarks:

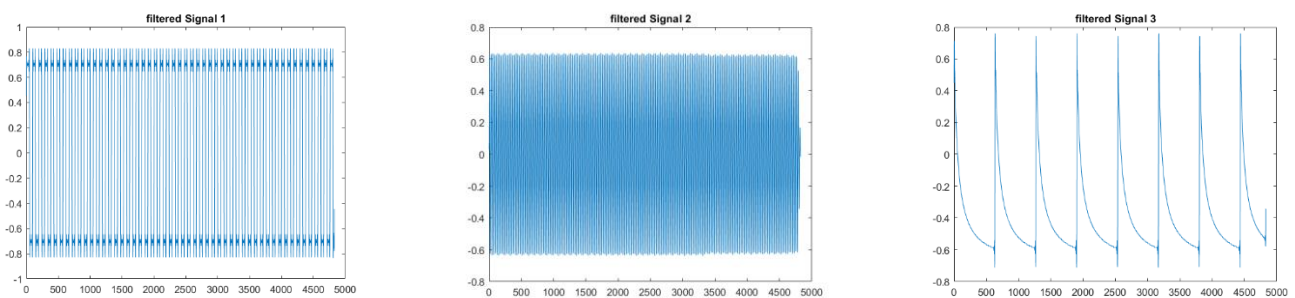
Step III: the signals are passed through a low pass filter and plotted

---

```
%% Low Pass Filtering
fc = 5000; % Cutoff frequency (Hz)
sig1_filt = lowpass(sig1, fc, fs1);
sig2_filt = lowpass(sig2, fc, fs2);
sig3_filt = lowpass(sig3, fc, fs3);
%% filtered plot
figure; plot(sig1_filt); title('filtered Signal 1');
figure; plot(sig2_filt); title('filtered Signal 2');
figure; plot(sig3_filt); title('filtered Signal 3');
```

---

Output:



Remarks:

STEP IV: Reproduce the signals after passing them through the filter.

---

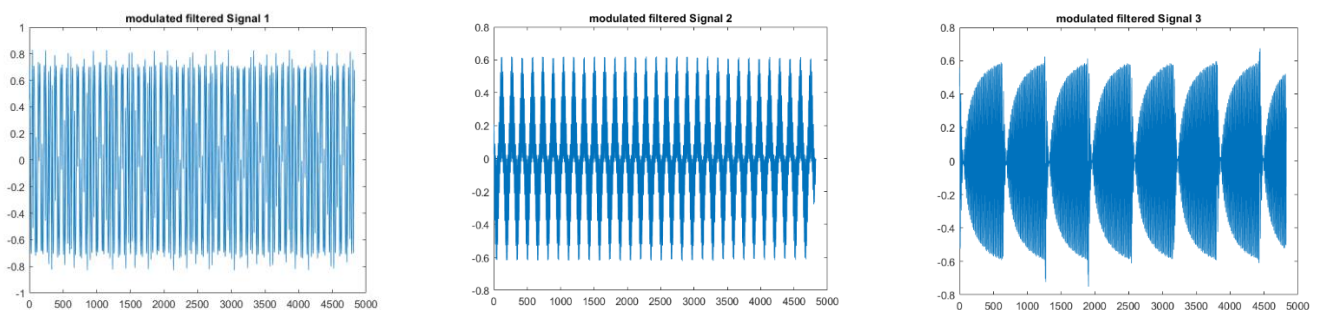
```
%% Modulation
t = (0:length(sig1_filt)-1) / fs1; % Time vector
carrier1 = cos(2*pi*1000*t)';
carrier2 = cos(2*pi*2000*t)';
carrier3 = cos(2*pi*3000*t)';

mod_sig1 = sig1_filt .* carrier1;
mod_sig2 = sig2_filt .* carrier2;
mod_sig3 = sig3_filt .* carrier3;
```

---

```
%% modulated plot
figure; plot(mod_sig1); title('modulated filtered Signal 1');
figure; plot(mod_sig2); title('modulated filtered Signal 2');
figure; plot(mod_sig3); title('modulated filtered Signal 3');
```

Output:



Remarks:

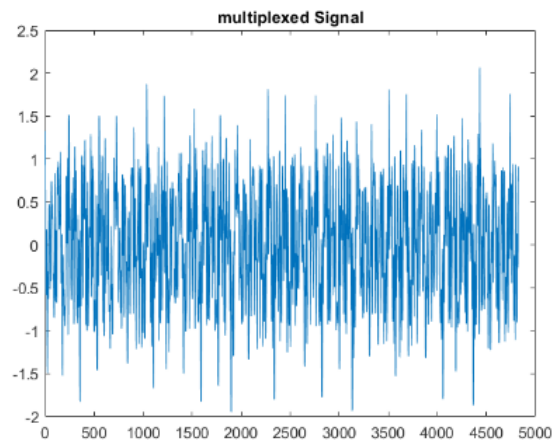
STEP 6: The modulated signals are filtered in the given band and added together

---

```
%% Multiplexing
mux_sig = mod_sig1 + mod_sig2 + mod_sig3;

figure; plot(mux_sig); title('multiplexed Signal');
```

Output:

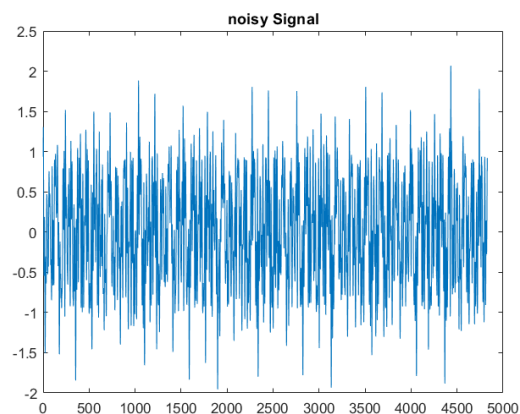


Remarks:

STEP 7, some noise is added to the transmitted signal

```
%% Adding noise
noise = 0.01 * randn(size(mux_sig));
noisy_sig = mux_sig + noise;
figure; plot(noisy_sig); title('noisy Signal');
```

Output:



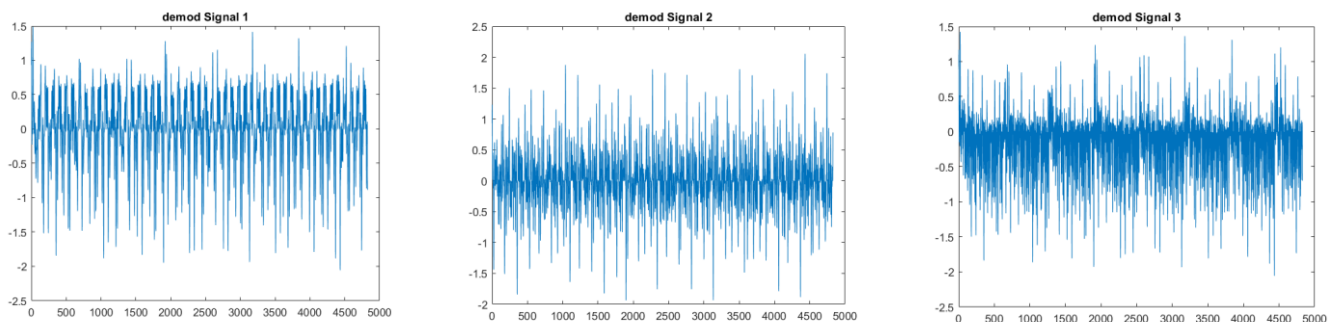
Remarks:

STEP 8, upon arrival each band is filtered

```
%% Demultiplexing and demodulation
demod_sig1 = noisy_sig .* carrier1;
demod_sig2 = noisy_sig .* carrier2;
demod_sig3 = noisy_sig .* carrier3;

%% plot
figure; plot(demod_sig1); title('demod Signal 1');
figure; plot(demod_sig2); title('demod Signal 2');
figure; plot(demod_sig3); title('demod Signal 3');
```

Output:



Remarks:

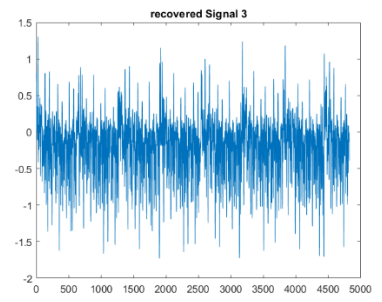
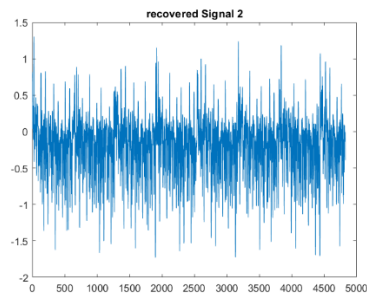
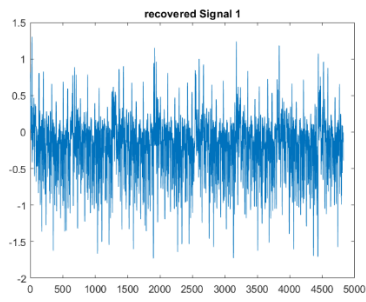
STEP 9, each recovered band is demodulated to return the signal at the indicated frequency

```
%% Recovered signals
% 1
sound(demod_sig1, fs1); pause(2);
figure; plot(demod_sig3); title('recovered Signal 1');

%% 2
sound(demod_sig2, fs2); pause(2);
figure; plot(demod_sig3); title('recovered Signal 2');

%% 3
sound(demod_sig3, fs3); pause(2);
figure; plot(demod_sig3); title('recovered Signal 3');
```

Output:



Remarks: