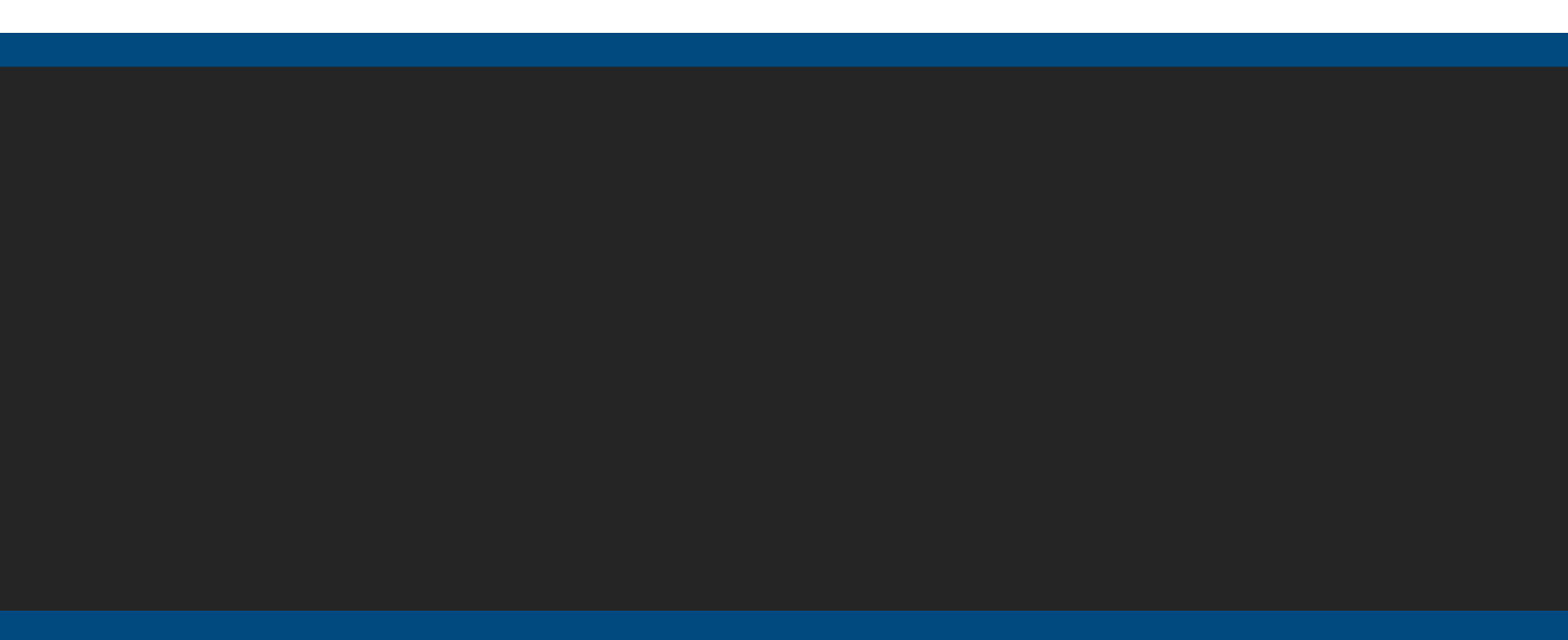


Communication Project



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1. Our Work Explanation:

Firstly, we read three signals with different sounds and same sampling frequencies then, we choose the first channel for our messages and find the length of each one along with max length in-order to be able to sum all modulated signal of each input. We make all audios have the same length by adjusting all of them by adding zero to make have same length. Secondly got time and frequencies intervals. Then we calculated omega **(ω1, ω2)** by **ω=2\*pi\*const** in frequency domain. Then we got carrier in cos and sin domain

**Carrier Signal One=cos (2\*pi\* ω1)**

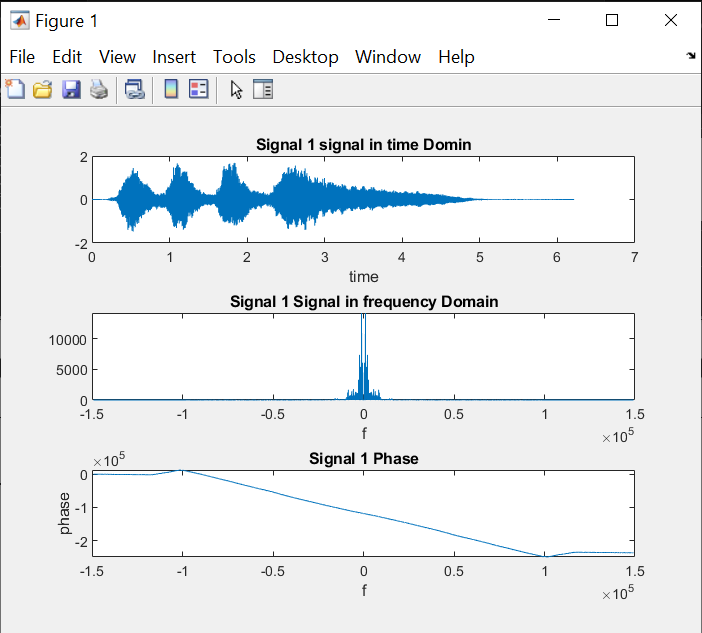
**Carrier Signal Two=sin (2\*pi\* ω2)**

Modulation:

1. Calculate modulated signal by multiplying signal and carrier
2. Calculate Fourier transform of modulated signal returned from step 1
3. Calculate phase of modulated signal returned from step 1
4. Sum all modulated signals of all audios
5. FFT to summation of modulated signals
6. Calculate phase of modulated signals
7. Calculate frequency band pass which is used in de-modulation

De-modulation:

1. Calculate demodulated signal by multiplying carrier and modulation signal
2. Calculate low pass filter used frequency sampling.
3. Perform demodulation three times with phase shifts of 10, 30, 90 degrees for both carriers **note** **(before each phase shift calculate carrier phase)**.
4. perform demodulation two times with a local carrier frequency that is different by 2 Hz and 10 Hz from its carrier frequency.
5. Required results and answers to questions:
6. Required figures:



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Chart

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A picture containing diagram

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Graphical user interface

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1. Codes:

%% Read Voice

[signal\_1, frequency\_sampling1] = audioread('signals/esoo.wav');

[signal\_2, frequency\_sampling2] = audioread('signals/ziad.wav');

[signal\_3, frequency\_sampling3] = audioread('signals/mohey.wav');

%% Sum first and second channel

signal\_1 = signal\_1(:, 1)+signal\_1(:, 2);

signal\_2 = signal\_2(:, 1)+ signal\_2(:, 2);

signal\_3 = signal\_3(:, 1)+signal\_3(:, 2);

%% frequency Sampling

frequency\_sampling = frequency\_sampling1;

%% set maxuim length between 3 signals

length\_1 = length(signal\_1);

length\_2 = length(signal\_2);

length\_3 = length(signal\_3);

N = max([length\_1, length\_2, length\_3]);

%% make 3 signals be same

signal\_1 = [signal\_1;zeros(N-length\_1, 1)];

signal\_2 = [signal\_2;zeros(N-length\_2, 1)];

signal\_3 = [signal\_3;zeros(N-length\_3, 1)];

%% get time and frequencyuency interval

t = linspace(0, N/frequency\_sampling, N);

frequency\_d = frequency\_sampling/2;

frequency = -frequency\_d : frequency\_sampling/N: frequency\_d - frequency\_sampling/N;

%% frequencyuency Domin

signal\_1\_fft = fftshift(fft(signal\_1));

signal\_2\_fft = fftshift(fft(signal\_2));

signal\_3\_fft = fftshift(fft(signal\_3));

phase\_signal\_1 = unwrap(angle(signal\_1\_fft));

phase\_signal\_2 = unwrap(angle(signal\_2\_fft));

phase\_signal\_3 = unwrap(angle(signal\_3\_fft));

%% Carrie in frequencyuency Domin

Carrier\_frequencyuency\_1 = 5000;

Carrier\_frequencyuency\_2 = 3\*5000;

WC\_1 = 2\*pi \* Carrier\_frequencyuency\_1;

WC\_2 = 2\*pi \* Carrier\_frequencyuency\_2;

%% Carrier in time Domain

carrier\_signal\_1 = cos(WC\_1 \* t);

carrier\_signal\_2 = cos(WC\_2 \* t);

carrier\_signal\_3 = sin(WC\_2 \* t);

phase\_carrier\_signal\_1 = unwrap(angle(fftshift(fft(carrier\_signal\_1))));

phase\_carrier\_signal\_2 = unwrap(angle(fftshift(fft(carrier\_signal\_2))));

phase\_carrier\_signal\_3 = unwrap(angle(fftshift(fft(carrier\_signal\_3))));

%% Modulation

modulatedSignal\_t1 = signal\_1' .\* carrier\_signal\_1;

modulatedSignal\_t2 = signal\_2' .\* carrier\_signal\_2;

modulatedSignal\_t3 = signal\_3' .\* carrier\_signal\_3;

modulated\_signal\_f1 = fftshift(fft(modulatedSignal\_t1));

modulated\_signal\_f2 = fftshift(fft(modulatedSignal\_t2));

modulated\_signal\_f3 = fftshift(fft(modulatedSignal\_t3));

phase\_modulation\_1 = unwrap(angle(modulated\_signal\_f1));

phase\_modulation\_2 = unwrap(angle(modulated\_signal\_f2));

phase\_modulation\_3 = unwrap(angle(modulated\_signal\_f3));

%% Add modulated signals

Modulated\_Signal = modulatedSignal\_t1 + modulatedSignal\_t2 + modulatedSignal\_t3;

Modulated\_Signal\_f = fftshift(fft(Modulated\_Signal));

phase\_mod = unwrap(angle(Modulated\_Signal\_f));

frequncy\_BandPass = Carrier\_frequencyuency\_1;

%% Synchronous Modulation for 3 signals

FileNames=["Out\_1" "Out\_2" "Out\_3"];

Carries=[carrier\_signal\_1 ;carrier\_signal\_2; carrier\_signal\_3];

for i = 1:3

LowPass=demodulation(Modulated\_Signal,frequncy\_BandPass,FileNames(i), Carries(i,:,:), frequency\_sampling);

fftSignal = fftshift(fft(LowPass));

N=(length(fftSignal)/2);

frequency = (-1\*N:N-1);

phase=unwrap(angle(fftSignal));

plot\_signal(t, frequency.',phase,LowPass, abs(fftSignal),i+6, strcat('Deodulated Signal ',num2str(i,' %2d')));

end

%%

% Phase Shift: 10

Carries\_phase\_10 = CarriersPhase(Carrier\_frequencyuency\_1, Carrier\_frequencyuency\_2, 10,t);

FileNames\_phases\_10=["Out\_1\_phase\_10" "Out\_2\_phase\_10" "Out\_3\_phase\_10"];

for i = 1:3

demodulation(Modulated\_Signal,frequncy\_BandPass,FileNames\_phases\_10(i), Carries\_phase\_10(i,:,:), frequency\_sampling);

end

% Phase Shift: 30

Carries\_phase\_30 = CarriersPhase(Carrier\_frequencyuency\_1, Carrier\_frequencyuency\_2, 30,t);

FileNames\_phases\_30=["Out\_1\_phase\_30" "Out\_2\_phase\_30" "Out\_3\_phase\_30"];

for i = 1:3

demodulation(Modulated\_Signal,frequncy\_BandPass,FileNames\_phases\_30(i), Carries\_phase\_30(i,:,:), frequency\_sampling);

end

% Phase Shift: 90

Carries\_phase\_90 = CarriersPhase(Carrier\_frequencyuency\_1, Carrier\_frequencyuency\_2, 90,t);

FileNames\_phases\_90=["Out\_1\_phase\_90" "Out\_2\_phase\_90" "Out\_3\_phase\_90"];

for i = 1:3

demodulation(Modulated\_Signal,frequncy\_BandPass,FileNames\_phases\_90(i), Carries\_phase\_90(i,:,:), frequency\_sampling);

end

%%

% local carrier frequencyuency different than Fc by 2 Hz in Demodulation

Carries\_shift\_2 = CarriersDifferentFc(Carrier\_frequencyuency\_1, Carrier\_frequencyuency\_2, 2,t);

FileNames\_shift\_2=["Out\_1\_shift\_2" "Out\_2\_shift\_2" "Out\_3\_shift\_2"];

for i = 1:3

demodulation(Modulated\_Signal,frequncy\_BandPass,FileNames\_shift\_2(i), Carries\_shift\_2(i,:,:), frequency\_sampling);

end

% local carrier frequencyuency different than Fc by 10 Hz in Demodulation

Carries\_shift\_10 = CarriersDifferentFc(Carrier\_frequencyuency\_1, Carrier\_frequencyuency\_2, 10,t);

FileNames\_shift\_10=["Out\_2\_shift\_10" "Out\_2\_shift\_10" "Out\_3\_shift\_10"];

for i = 1:3

demodulation(Modulated\_Signal,frequncy\_BandPass,FileNames\_shift\_10(i), Carries\_shift\_10(i,:,:), frequency\_sampling);

end

% Ploting Signals

plot\_signal(t, frequency.', phase\_signal\_1,signal\_1, abs(signal\_1\_fft),1, 'Signal 1');

plot\_signal(t, frequency.', phase\_signal\_2,signal\_2, abs(signal\_2\_fft),2, 'Signal 2');

plot\_signal(t, frequency.', phase\_signal\_3,signal\_3, abs(signal\_3\_fft),3, 'Signal 3');

% Ploting Modulated Signals

plot\_signal(t, frequency.',phase\_modulation\_1,modulatedSignal\_t1, abs(modulated\_signal\_f1),4, 'Modulated Signal 1');

plot\_signal(t, frequency.', phase\_modulation\_2,modulatedSignal\_t2, abs(modulated\_signal\_f2),5, 'Modulated Signal 2');

plot\_signal(t, frequency.', phase\_modulation\_3,modulatedSignal\_t3, abs(modulated\_signal\_f3),6, 'Modulated Signal 3');

function plot\_signal(length\_t, f,angle, time, freq,counter, Time)

figure(counter)

subplot(3, 1, 1)

plot(length\_t, time)

xlabel('time')

%title of time Domain

title(strcat(Time, ' signal in time Domin'))

subplot(3, 1, 2)

plot(f, freq)

xlabel('f')

%title of frequency Domain

title(strcat(Time, ' Signal in frequency Domain'))

subplot(3, 1, 3)

plot(f, angle)

ylabel('phase')

xlabel('f')

%title of phase

title(strcat(Time, ' Phase'))

end

function lpf=demodulation(signal\_modulation, frequncy\_BandPass, out\_name, carrier\_signal, frequency\_signal\_sampling)

demodulationdSignal = 2 \* (signal\_modulation .\* carrier\_signal);

lpf = lowpass(demodulationdSignal, frequncy\_BandPass, frequency\_signal\_sampling);

audiowrite(strcat("Output\_signals/", out\_name, '.wav'), lpf, frequency\_signal\_sampling);

end

function Array\_of\_carries = CarriersPhase(Carrier\_frequencyuency\_1, Carrier\_frequencyuency\_2, deg,time)

carry\_1 = cos((2\*pi \* Carrier\_frequencyuency\_1 \* time) + ((deg \* pi) / 180));

carry\_2 = cos((2\*pi \* Carrier\_frequencyuency\_2 \* time) + ((deg \* pi) / 180));

carry\_3 = sin((2\*pi \* Carrier\_frequencyuency\_2 \* time) + ((deg \* pi) / 180));

Array\_of\_carries=[carry\_1; carry\_2; carry\_3];

end

function Array\_of\_carries = CarriersDifferentFc(Carrier\_frequencyuency\_1, Carrier\_frequencyuency\_2, frequency\_dc,t)

carry\_1 = cos(2\*pi \* (Carrier\_frequencyuency\_1 + frequency\_dc) \* t);

carry\_2 = cos(2\*pi \* (Carrier\_frequencyuency\_2 + frequency\_dc) \* t);

carry\_3 = sin(2\*pi \* (Carrier\_frequencyuency\_2 + frequency\_dc) \* t);

Array\_of\_carries=[carry\_1; carry\_2; carry\_3];

end