clear;

clc;

% orignal sound

[xin ,fs] = audioread('eric.wav');

audio\_length= length(xin)./fs;

t=linspace(0,audio\_length,length(xin));

figure (1)

subplot(2,1,1)

plot(t,xin)

title('signal in Time domain')

f\_xin=fftshift(fft(xin));

f\_xin\_mg= abs(f\_xin);

N = length(xin);

f\_vec = linspace(-fs/2,fs/2,N);

subplot(2,1,2)

plot(f\_vec,f\_xin\_mg)

title(' signal in Frequency domain')

%%%%%%%%%LPF%%%%%%%%%

%filter at 4khz

n = N/fs;

right\_band = round((fs/2-4000)\*n);

left\_band = (N-right\_band+1);

f\_xin([1:right\_band left\_band:N]) = 0;

figure(2)

subplot(2,1,2)

plot(f\_vec,abs(f\_xin))

title('LPF(4khz) Signal in Frequency domain')

xin = real(ifft(ifftshift(f\_xin)));

subplot(2,1,1)

plot(t,xin)

title('LPF(4khz) Signal in Time domain')

## transmitter

fc = 100000;

fs\_new = 5\*fc;

msg\_resampled = resample(xin,fs\_new,fs);

t\_end = length(msg\_resampled)./fs\_new;

t = linspace(0,t\_end, length(msg\_resampled));

% modulation

carrier = cos(2\*pi\*fc\*t);

carrier = carrier';

transmitted\_m = msg\_resampled.\*carrier;

f\_transmitted\_m= fftshift(fft(transmitted\_m));

f\_t\_magnitude= abs(f\_transmitted\_m);

N=length(transmitted\_m);

f\_vec = linspace(-fs\_new/2,fs\_new/2,N);

% get the LSB usin LPF

N = length(msg\_resampled);

n = N/fs\_new;

right\_band = round((fs\_new/2-100000)\*n);

left\_band = (N-right\_band+1);

f\_transmitted\_m([1:right\_band left\_band:N]) = 0;

f\_t\_magnitude = abs(f\_transmitted\_m);

transmitted\_m = real(ifft(ifftshift(f\_transmitted\_m)));

t\_end = length(transmitted\_m)./fs\_new;

t = linspace(0,t\_end, length(transmitted\_m));

figure (3)

subplot(4,1,1)

plot(t,msg\_resampled)

title('Resampled Msg signal in Time domain')

f\_resampled=fftshift(fft(msg\_resampled));

f\_resampled\_mg=abs(f\_resampled);

N = length(f\_transmitted\_m);

f\_vec = linspace(-fs\_new/2,fs\_new/2,N);

subplot(4,1,2)

plot(f\_vec,f\_resampled\_mg)

title('Resampled Msg signal in Freq domain')

subplot(4,1,3)

plot(f\_vec,abs(f\_transmitted\_m))

title('SSB-SC TX modulated msg in Freq domain')

subplot(4,1,4)

plot(t,transmitted\_m)

title('SSB-SC TX modulated msg in Time domain')

## receiver

%%%%%% Ideal LPF receiver %%%%%%%%%%%%%

ideal\_rx(transmitted\_m,t,f\_vec,fs\_new,fs);

function ideal\_rx(transmitted\_m,t,f\_vec,fs\_new,fs)

received\_message = transmitted\_m.\*(cos(2\*pi\*100000\*t)');

f\_received\_message = fftshift(fft(received\_message));

received\_message\_mg = abs(f\_received\_message);

figure

subplot(3,1,1)

plot(f\_vec,received\_message\_mg)

title('SSB-SC RX-Coherent no noise, msg in frequency domain (before LPF))')

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%Ideal LPF%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%LPF to remove signal @ 2fc

left\_band = (N-right\_band+1);

f\_received\_message([1:right\_band left\_band:N]) = 0;

received\_message\_mg = abs(f\_received\_message);

received\_message = real(ifft(ifftshift(f\_received\_message)));

subplot(3,1,2)

plot(t,received\_message)

title('SSB LSB RX msg in time domain(after Ideal LPF)')

subplot(3,1,3)

plot(f\_vec,received\_message\_mg)

title('SSB LSB RX msg in freq domain(after Ideal LPF)')

original\_msg = resample(received\_message,fs,fs\_new);

%sound(original\_msg, fs)

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%Butterworth filter%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

transmitted\_m = msg\_resampled.\*carrier;

f\_transmitted\_m = fftshift(fft(transmitted\_m));

f\_transmitted\_mg = abs(f\_transmitted\_m);

N = length(transmitted\_m);

f\_vec = linspace(-fs\_new/2,fs\_new/2,N);

%plot in freq

figure(5)

subplot(2,1,1)

plot(f\_vec,f\_transmitted\_mg)

title('SSB TX modulated msg in freq domain')

% butterworth bandpass filter to filterout the USB

[b, a]= butter(4, [(fc-4000)/(fs\_new/2) fc/(fs\_new/2)], 'bandpass');

tx\_msg\_LSB = filter(b,a,transmitted\_m);

%plot in freq

figure(5)

subplot(2,1,2)

plot(f\_vec,TX\_msg\_LSB\_F\_mg)

title('SSB LSB TX modulated msg in freq domain (Butterworth)')

tr\_msg\_coh = tx\_msg\_LSB.\*carrier;

tr\_msg\_coh\_F = fftshift(fft(tr\_msg\_coh));

tr\_msg\_coh\_F\_mg = abs(tr\_msg\_coh\_F);

%plot in freq

figure(6)

subplot(3,1,1)

plot(f\_vec,tr\_msg\_coh\_F\_mg)

title('SSB LSB RX msg in freq domain(before LPF)')

%------------- LBF ---------------%

N = length(tr\_msg\_coh);

n = N/fs\_new;

right\_band = round((fs\_new/2-4000)\*n);

left\_band = (N-right\_band+1);

tr\_msg\_coh\_F([1:right\_band left\_band:N]) = 0;

tr\_msg\_coh\_F\_mg = abs(tr\_msg\_coh\_F);

tr\_msg\_coh\_LPF = real(ifft(ifftshift(tr\_msg\_coh\_F)));

%------------- LBF ---------------%

subplot(3,1,2)

plot(f\_vec,tr\_msg\_coh\_F\_mg)

title('SSB LSB RX msg in freq domain(after LPF)')

subplot(3,1,3)

plot(t,tr\_msg\_coh\_LPF)

title('SSB LSB RX msg in time domain(after LPF)')

%original\_msg = resample(tr\_msg\_coh\_LPF,fs,fs\_new);

%sound(original\_msg, fs)

## noise

n\_snr=0;

add\_noise(transmitted\_m,t,f\_vec,n\_snr);

message\_noise= awgn(transmitted\_m, n\_snr);

ideal\_rx(message\_noise,t,f\_vec,fs\_new,fs);

n\_snr=10;

add\_noise(transmitted\_m,t,f\_vec,n\_snr);

message\_noise= awgn(transmitted\_m, n\_snr);

ideal\_rx(message\_noise,t,f\_vec,fs\_new,fs);

n\_snr=30;

add\_noise(transmitted\_m,t,f\_vec,n\_snr);

message\_noise= awgn(transmitted\_m, n\_snr);

ideal\_rx(message\_noise,t,f\_vec,fs\_new,fs);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

function add\_noise(transmitted\_m,t,f\_vec, n\_snr)

message\_noise= awgn(transmitted\_m, n\_snr);

f\_transmitted\_m=abs(fftshift(fft(message\_noise)));

f\_message\_noise=fftshift(fft(message\_noise));

f\_noise\_mg=abs(f\_message\_noise);

figure

subplot(4,1,1)

plot(t,transmitted\_m)

title('transmitted message before noise in time domain')

subplot(4,1,2)

plot(f\_vec,f\_transmitted\_m)

title('transmitted message before noise in frequency domain')

subplot(4,1,3)

plot(t,message\_noise)

title('transmitted message after noise in time domain')

subplot(4,1,4)

plot(f\_vec,f\_noise\_mg)

title('transmitted message after noise in frequency domain')

**9) SSB-TC:**

clear;

clc;

[xin ,fs] = audioread('eric.wav');

audio\_length= length(xin)./fs;

t=linspace(0,audio\_length,length(xin));

f\_xin=fftshift(fft(xin));

f\_xin\_mg= abs(f\_xin);

N = length(xin);

f\_vec = linspace(-fs/2,fs/2,N);

%%%%%%%%%LPF%%%%%%%%%

%filter at 4khz

n = N/fs;

right\_band = round((fs/2-4000)\*n);

left\_band = (N-right\_band+1);

f\_xin([1:right\_band left\_band:N]) = 0;

figure(1)

subplot(2,1,2)

plot(f\_vec,abs(f\_xin))

title('LPF(4khz) Signal in Frequency domain')

xin = real(ifft(ifftshift(f\_xin)));

subplot(2,1,1)

plot(t,xin)

title('LPF(4khz) Signal in Time domain')

## transmitter

fc = 100000;

fs\_new = 5\*fc;

msg\_resampled = resample(xin,fs\_new,fs);

A=max(msg\_resampled)\*2;

t\_end = length(msg\_resampled)./fs\_new;

t = linspace(0,t\_end, length(msg\_resampled));

% modulation

carrier = cos(2\*pi\*fc\*t);

carrier = carrier';

transmitted\_m = (A+msg\_resampled).\*carrier;

f\_transmitted\_m= fftshift(fft(transmitted\_m));

f\_transmitted\_mg= abs(f\_transmitted\_m);

N=length(transmitted\_m);

f\_vec = linspace(-fs\_new/2,fs\_new/2,N);

% get the LSB usin LPF

N = length(transmitted\_m);

f\_vec = linspace(-fs\_new/2,fs\_new/2,N);

index = f\_vec>=fc+1;

f\_transmitted\_mg(index) = 0;

% remove frequencies < -fc (remove negative HSB)

index2 = f\_vec<=(-fc);

f\_transmitted\_mg(index2) = 0;

f\_transmitted\_mg = abs(f\_transmitted\_mg);

t\_end = length(transmitted\_m)./fs\_new;

t = linspace(0,t\_end, length(transmitted\_m));

figure (2)

subplot(4,1,1)

plot(t,msg\_resampled)

title('Resampled Msg signal in Time domain')

f\_resampled=fftshift(fft(msg\_resampled));

f\_resampled\_mg=abs(f\_resampled);

N = length(f\_transmitted\_mg);

f\_vec = linspace(-fs\_new/2,fs\_new/2,N);

subplot(4,1,2)

plot(f\_vec,f\_resampled\_mg)

title('Resampled Msg signal in Freq domain')

subplot(4,1,3)

plot(f\_vec,abs(f\_transmitted\_mg))

title('SSB-SC TX modulated msg in Freq domain')

subplot(4,1,4)

plot(t,transmitted\_m)

title('SSB-SC TX modulated msg in Time domain')

## Zoomed version of the SSB-SC in frequency domain

## 1

## receiver

transmitted\_m = real(ifft(ifftshift(f\_transmitted\_m)));

t\_end = length(transmitted\_m)./fs\_new;

t = linspace(0,t\_end, length(transmitted\_m));

envelope = abs(hilbert(transmitted\_m));

figure(3)

subplot(2,1,1)

plot(t,envelope)

title('SSB-TC LSB RX msg in Time domain using envelope detector')

f\_envelope= fftshift(fft(envelope));

f\_envelope\_mg= abs(f\_envelope);

subplot(2,1,2)

plot(f\_vec,f\_envelope\_mg)

title('SSB-TC LSB RX msg in frequency domain using envelope detector')

original\_msg = resample(envelope,fs,fs\_new);

sound(original\_msg, fs)

Zoomed SSB-TC after envelope detector

