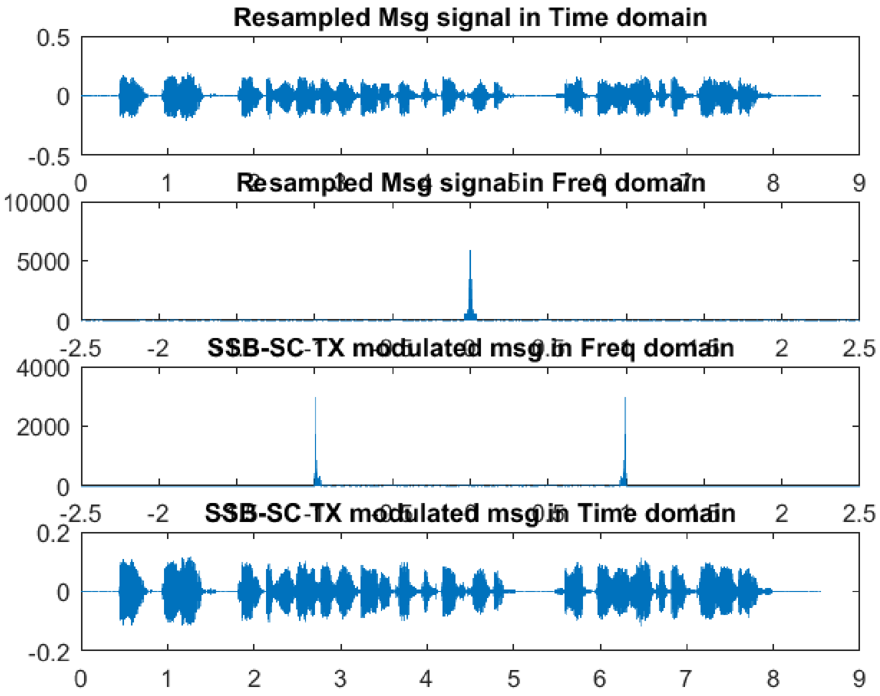
```
clear;
clc;
% orignal sound
[xin ,fs] = audioread('eric.wav');
audio_length= length(xin)./fs;
t=linspace(0,audio_length,length(xin));

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')
```

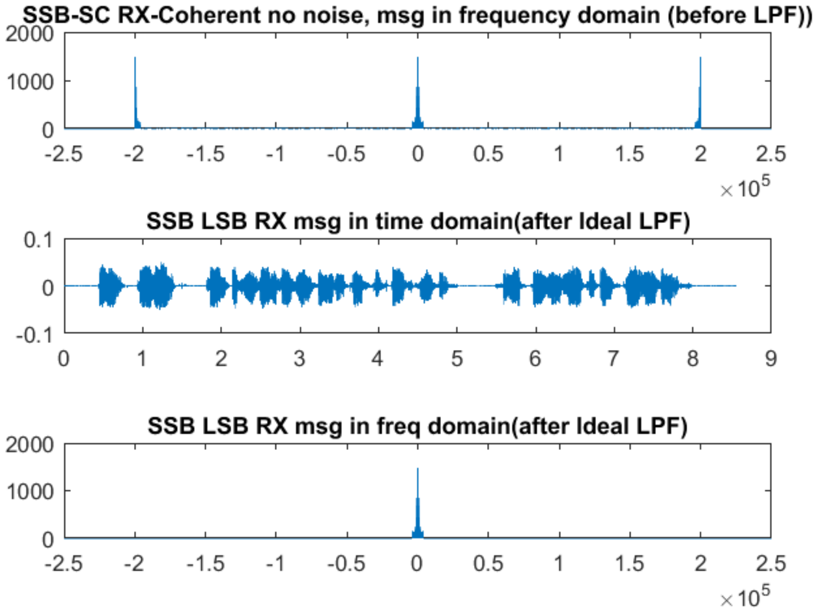
```
subplot(4,1,4)
plot(t,transmitted_m)
title('SSB-SC TX modulated msg in Time domain')
```



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)
```



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

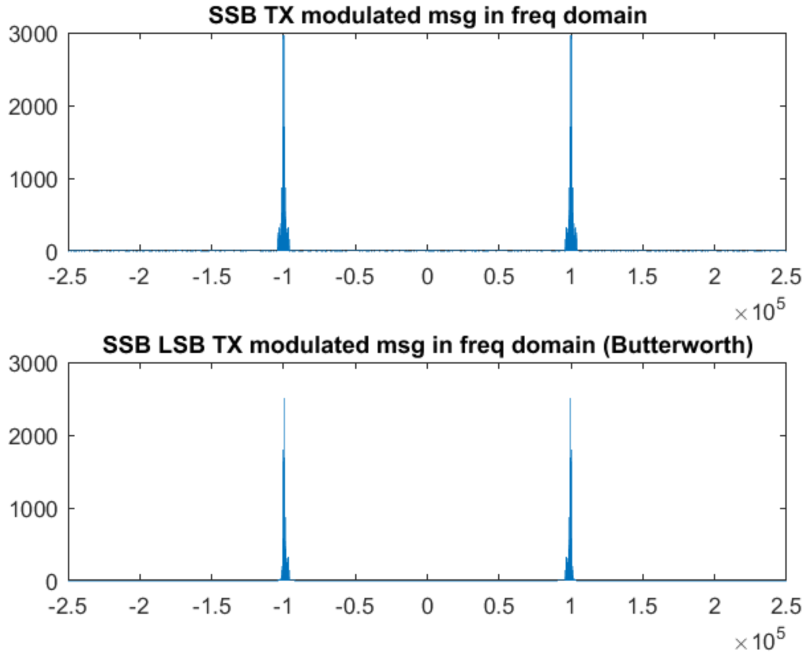
SSB LSB RX msg in time domain(after Ideal LPF)

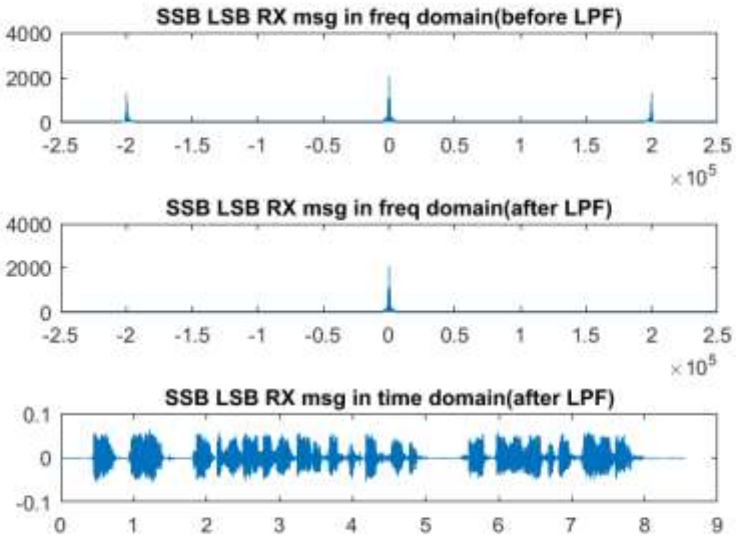
SSB LSB RX msg in freq domain(after Ideal LPF)

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%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)
```

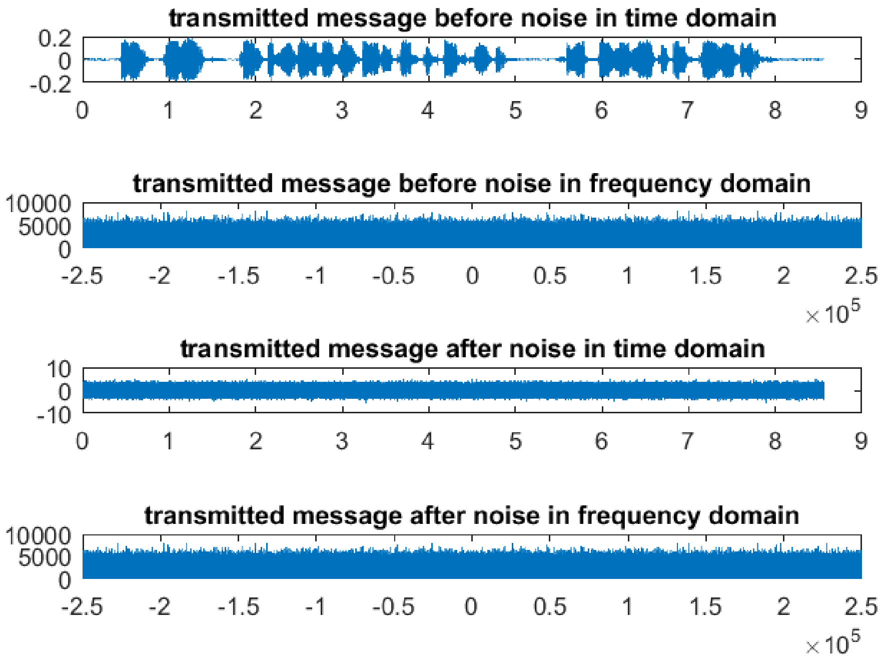


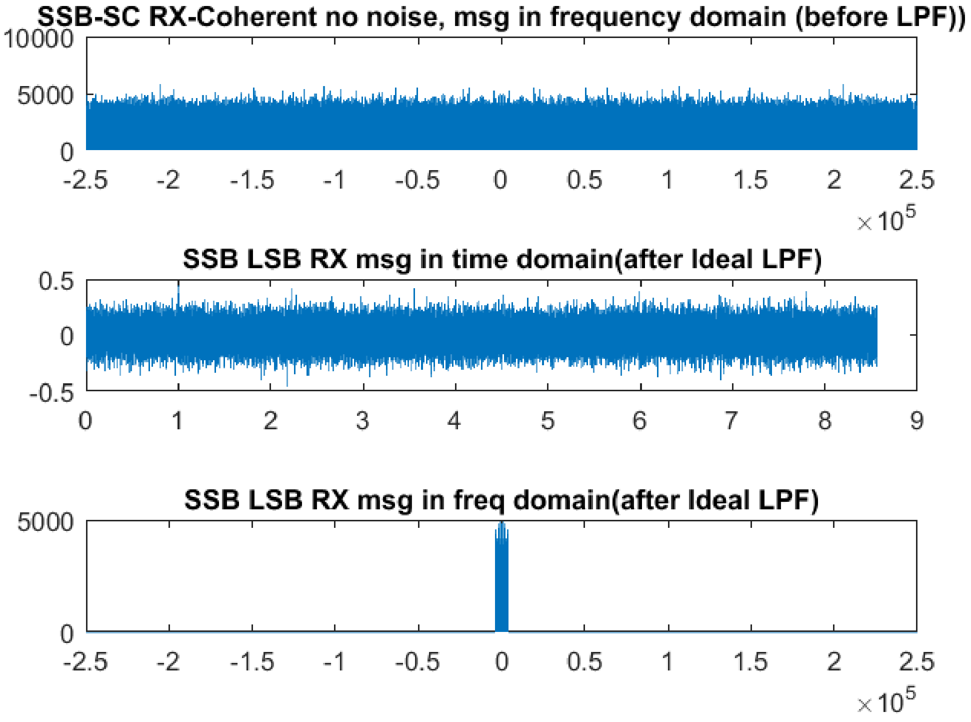


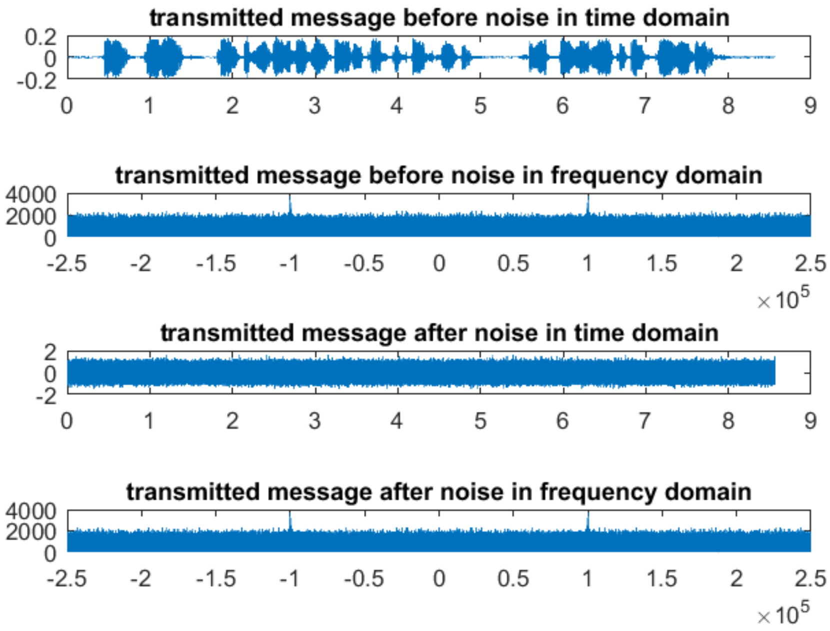
noise

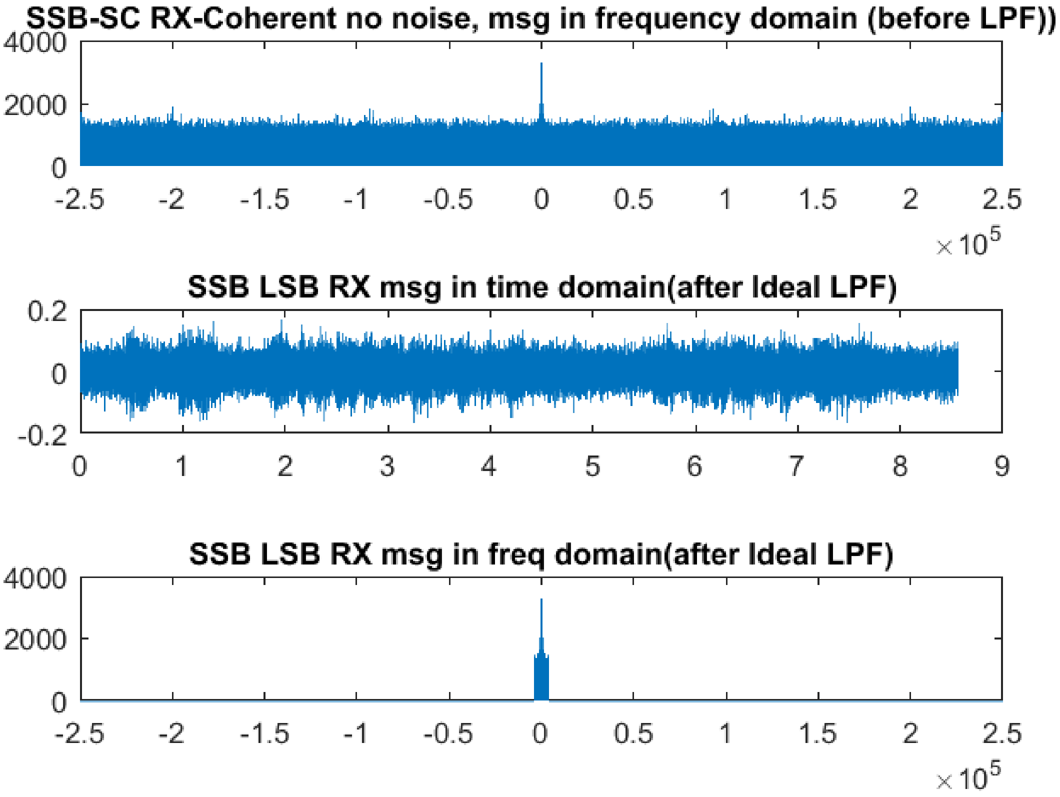
```
n_snr=0;
add_noise(transmitted_m,t,f_vec,n_snr);
message_noise= awgn(transmitted_m, n_snr);
ideal_rx(message_noise,t,f_vec,fs_new,fs);

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)
```

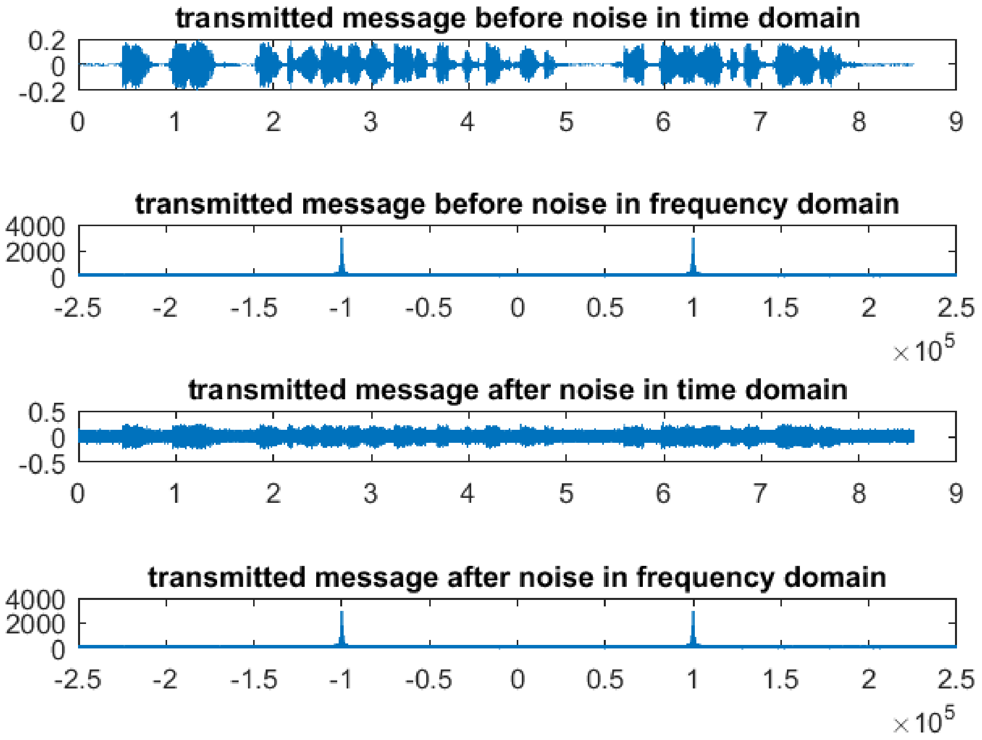
```
plot(t,transmitted_m)
title('transmitted message before noise in time domain')

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')
```

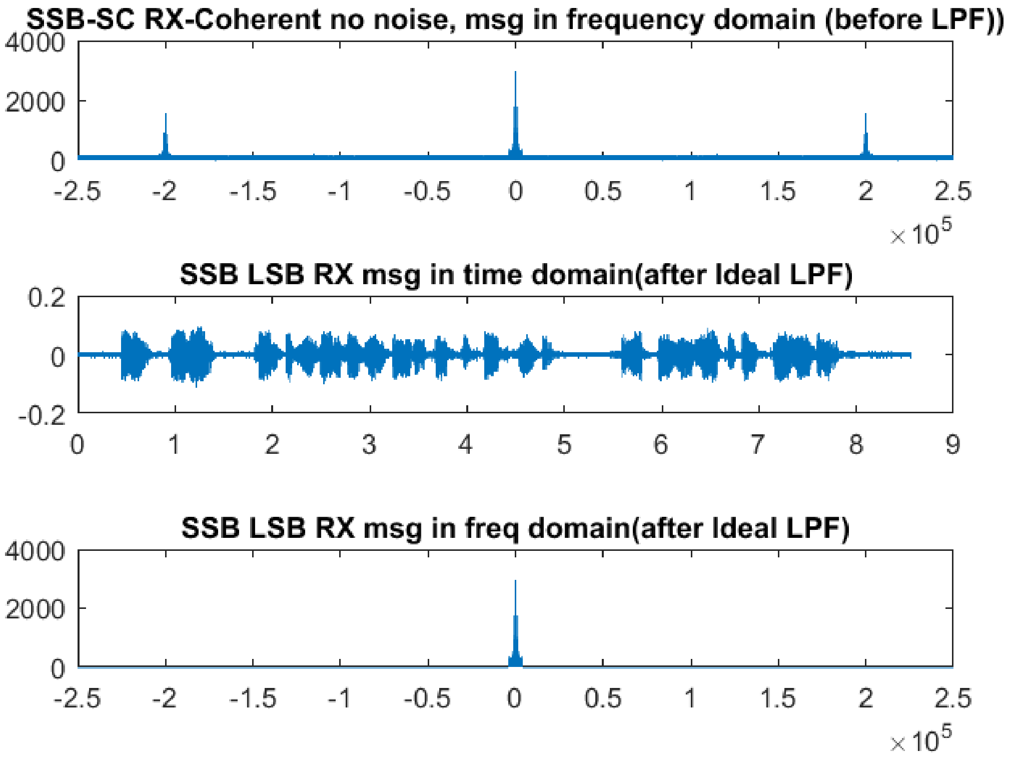

transmitted message before noise in time domain
0.2
0
-0.2
0
1
2
3
4
5
6
7
8
9
transmitted message before noise in frequency domain
10000
5000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
$\times 10^5$
transmitted message after noise in time domain
10
0
-10
0
1
2
3
4
5
6
7
8
9
transmitted message after noise in frequency domain
10000
5000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
$\times 10^5$


SSB-SC RX-Coherent no noise, msg in frequency domain (before LPF))
10000
5000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
$\times 10^5$
SSB LSB RX msg in time domain(after Ideal LPF)
0.5
0
-0.5
0
1
2
3
4
5
6
7
8
9
SSB LSB RX msg in freq domain(after Ideal LPF)
5000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
$\times 10^5$


transmitted message before noise in time domain
0.2
0
-0.2
0
1
2
3
4
5
6
7
8
9
transmitted message before noise in frequency domain
4000
2000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
× 10^5
transmitted message after noise in time domain
2
0
-2
0
1
2
3
4
5
6
7
8
9
transmitted message after noise in frequency domain
4000
2000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
× 10^5


SSB-SC RX-Coherent no noise, msg in frequency domain (before LPF))
4000
2000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
× 10^5
SSB LSB RX msg in time domain(after Ideal LPF)
0.2
0
-0.2
0
1
2
3
4
5
6
7
8
9
SSB LSB RX msg in freq domain(after Ideal LPF)
4000
2000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
× 10^5


transmitted message before noise in time domain
0.2
0
-0.2
0
1
2
3
4
5
6
7
8
9
transmitted message before noise in frequency domain
4000
2000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
× 10^5
transmitted message after noise in time domain
0.5
0
-0.5
0
1
2
3
4
5
6
7
8
9
transmitted message after noise in frequency domain
4000
2000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
× 10^5


SSB-SC RX-Coherent no noise, msg in frequency domain (before LPF))
4000
2000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
× 10^5
SSB LSB RX msg in time domain(after Ideal LPF)
0.2
0
-0.2
0
1
2
3
4
5
6
7
8
9
SSB LSB RX msg in freq domain(after Ideal LPF)
4000
2000
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
× 10^5

9) SSB-TC:

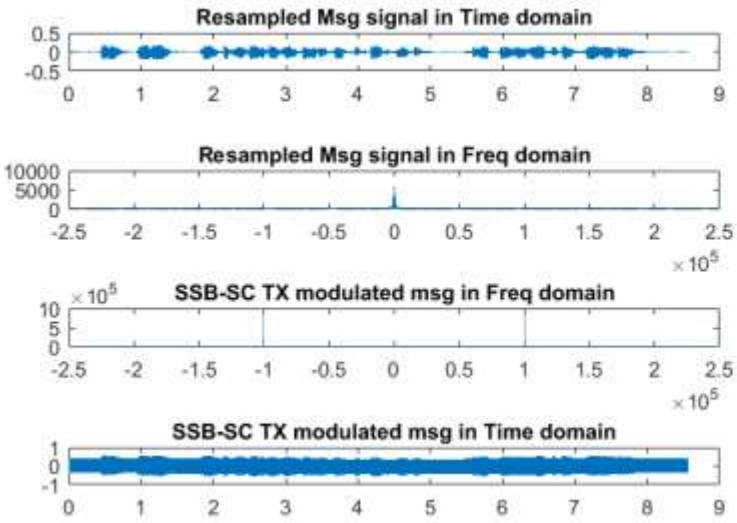
```
clear;
clc;
[xin ,fs] = audioread('eric.wav');
audio_length= length(xin)./fs;
t=linspace(0,audio_length,length(xin));



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

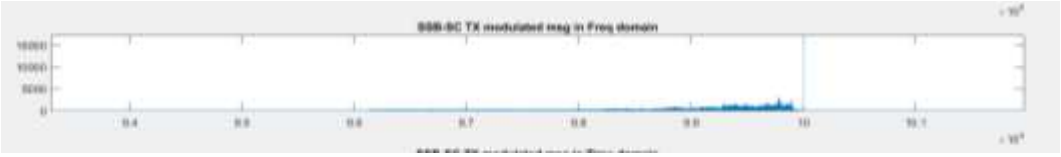
```
fc = 100000;
```

```
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')
```



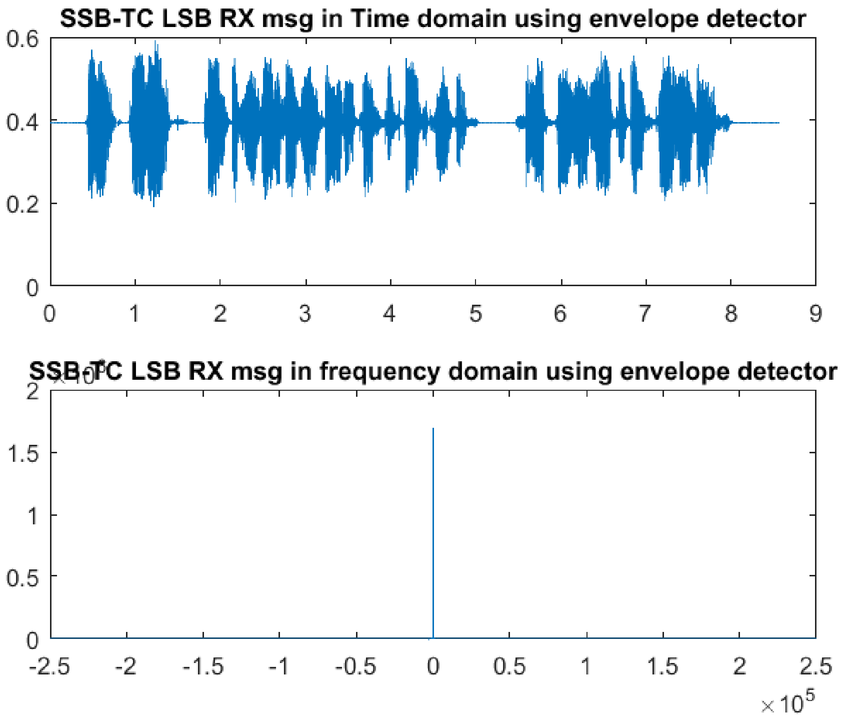
Zoomed version of the SSB-SC in frequency domain



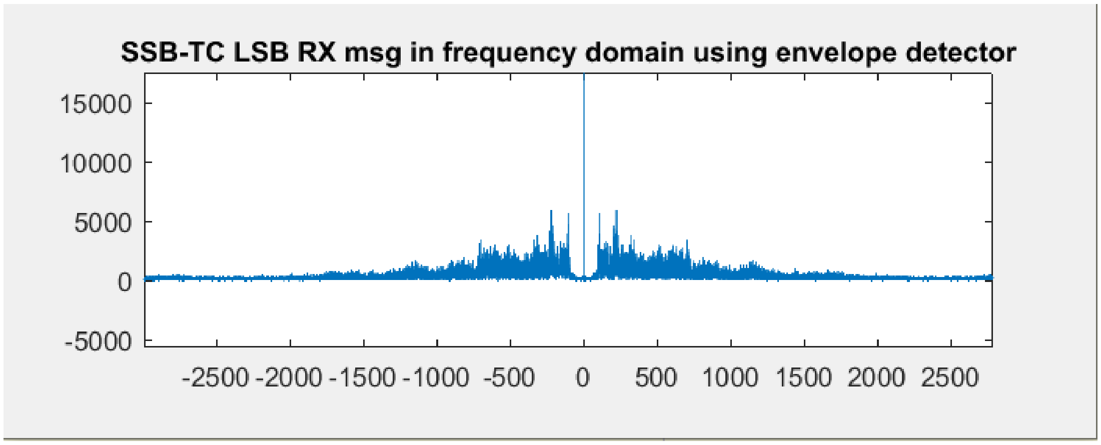
receiver

```
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


SSB-TC LSB RX msg in frequency domain using envelope detector