ELP311
Communication Engineering Laboratory

Experiment 7
Modulation and Demodulation of SSB-SC Signal

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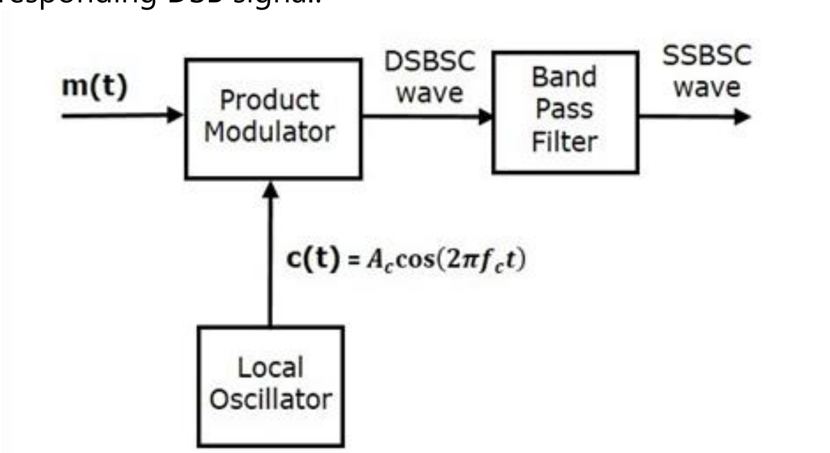
Objective

To model a SSB-SC signal using MATLAB.

Theory

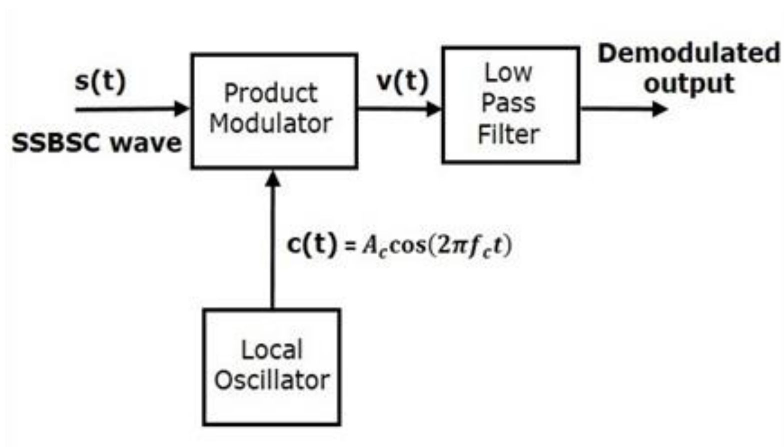
The process of suppressing one of the sidebands along with the carrier and transmitting a single sideband is called as Single Sideband Suppressed Carrier system or simply SSBSC.

An SSB signal is produced by passing the DSB signal through a highly selective bandpass filter. This filter selects either the upper or the lower sideband. Thus, the bandwidth of the SSB is half of the bandwidth of the corresponding DSB signal.



SSB Modulation Block Diagram

To retrieve the message signal, SSB-SC signal is multiplied with the carrier signal followed by lowpass filter.



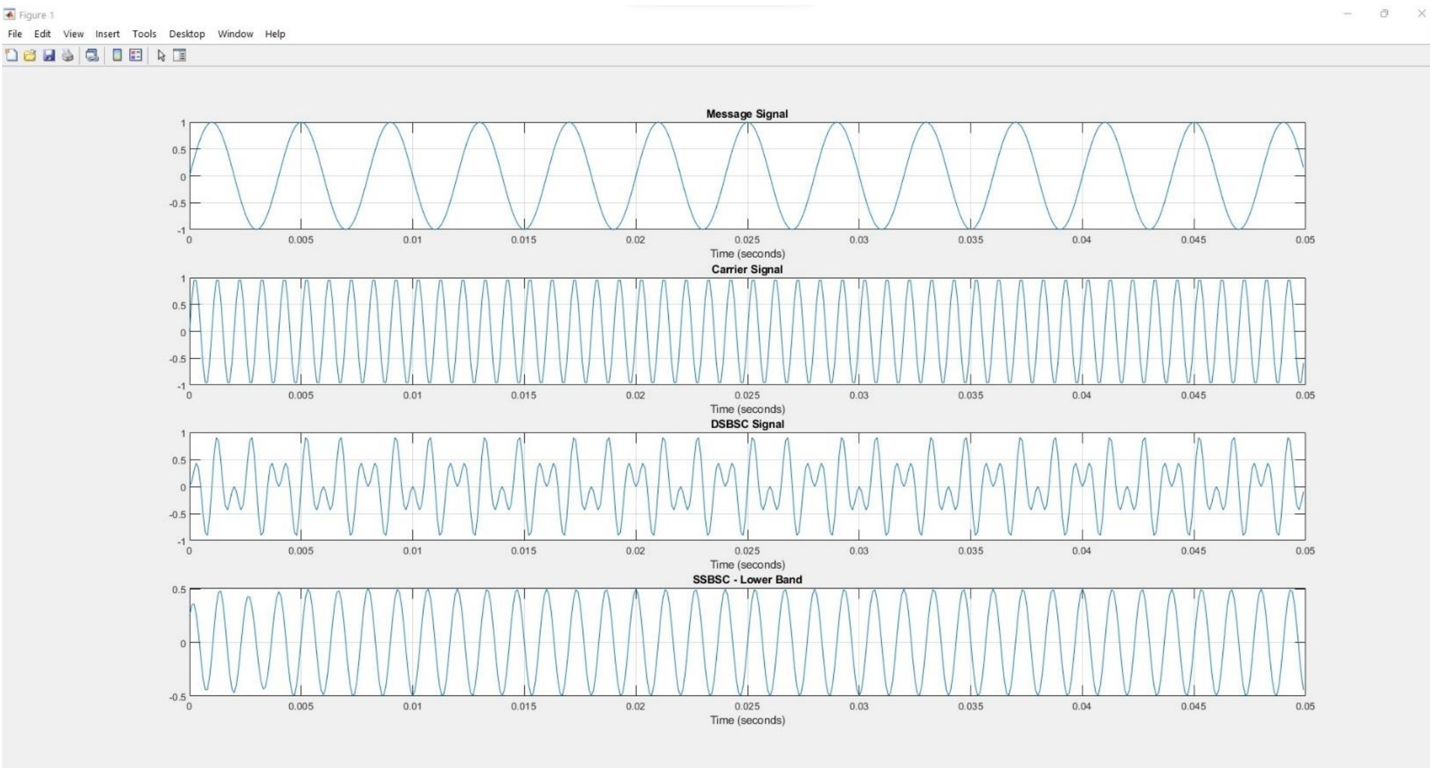
SSB Demodulation Block Diagram

MATLAB code

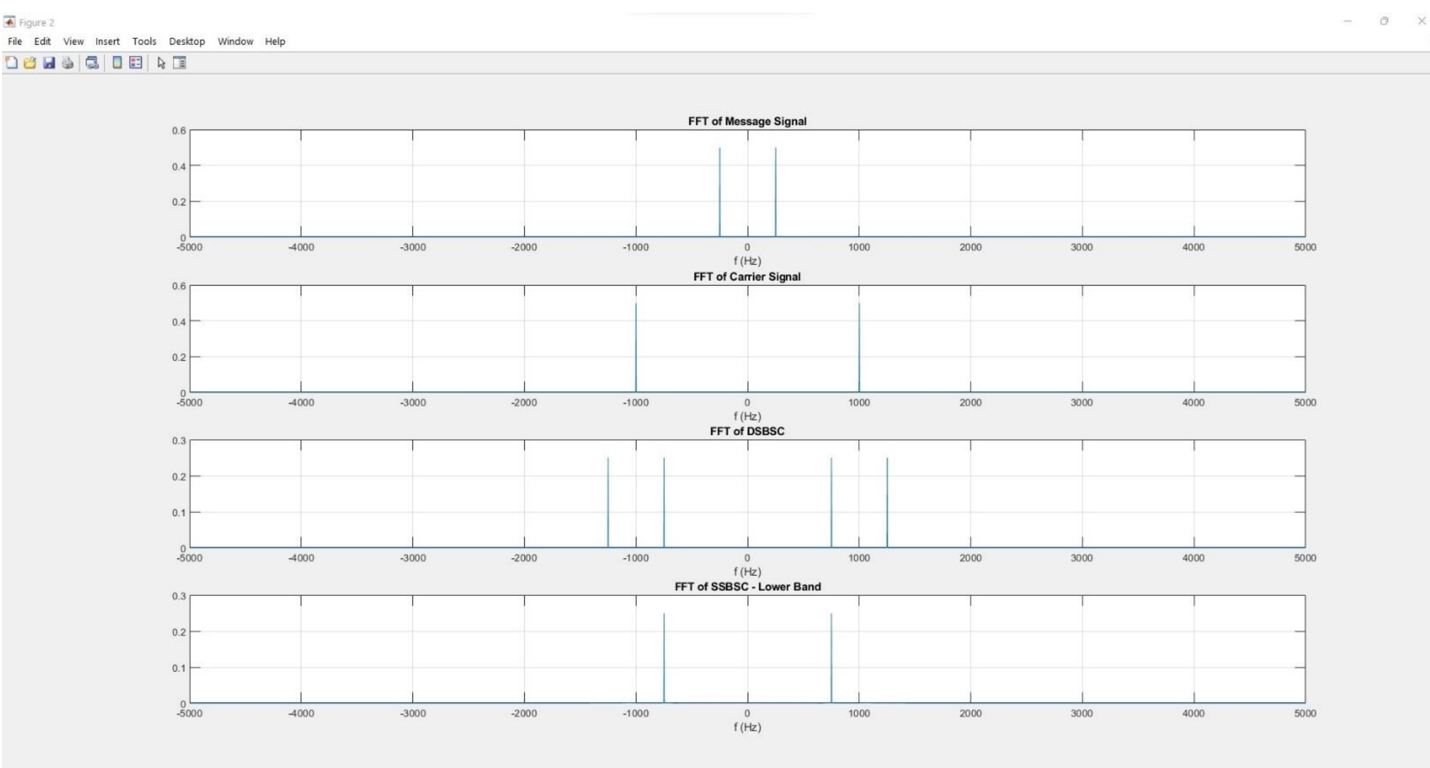
```
close all;
startplot = 1;
endplot = 500;

fc = 1000;   % Carrier frequency
fm = 250;    % Modulating frequency
fs = 10000; % Sample frequency
N = 5000;    % Number of samples

Ts = 1/fs;
t = (0:Ts:N*Ts-Ts);

Am = 1;
Ac = 1;

message = Am.*sin(2*pi*fm*t);
carrier = Ac.*sin(2*pi*fc*t);

figure (1);
subplot(4,1,1);
plot(t(startplot:endplot), message(startplot:endplot));
title('Message Signal');
xlabel('Time (seconds)');
grid;

figure (1);
subplot(4,1,2);
plot(t(startplot:endplot), carrier(startplot:endplot));
title('Carrier Signal');
xlabel('Time (seconds)');
grid;

dsbsc = message.*carrier;
ssbsc = bandpass(dsbsc, [fc-fm fc], fs);

figure (1);
subplot(4,1,3);
plot(t(startplot:endplot), dsbsc(startplot:endplot));
title('DSBSC Signal');
xlabel('Time (seconds)');
grid;

figure (1);
subplot(4,1,4);
plot(t(startplot:endplot), ssbsc(startplot:endplot));
title('SSBSC - Lower Band');
xlabel('Time (seconds)');
grid;

lm = length(message);
f = linspace(-fs/2,fs/2,lm);
msg_fourier = abs(fftshift(fft(message,lm)))/lm;

figure (2);
subplot(4,1,1);
plot(f,msg_fourier)
title('FFT of Message Signal');
xlabel('f (Hz)');
grid;

lm = length(carrier);
f = linspace(-fs/2,fs/2,lm);
carrier_fourier = abs(fftshift(fft(carrier,lm)))/lm;
```

```
figure (2);
subplot(4,1,2);
plot(f,carrier_fourier)
title('FFT of Carrier Signal');
xlabel('f (Hz)');
grid;

lm = length(dsbsc);
f = linspace(-fs/2,fs/2,lm);
dsbsc_fourier = abs(fftshift(fft(dsbsc,lm)))/lm;

figure (2);
subplot(4,1,3);
plot(f,dsbsc_fourier)
title('FFT of DSBSC');
xlabel('f (Hz)');
grid;

lm = length(ssbsc);
f = linspace(-fs/2,fs/2,lm);
ssbsc_fourier = abs(fftshift(fft(ssbsc,lm)))/lm;

figure(2);
subplot(4,1,4);
plot(f,ssbsc_fourier)
title('FFT of SSBSC - Lower Band');
xlabel('f (Hz)');
grid;

product = carrier.*ssbsc;
demodulated = lowpass(product, fm, fs);

figure (3);
subplot(4,1,1);
plot(t(startplot:endplot), product(startplot:endplot));
title('Product of Carrier and SSBSC');
xlabel('Time (seconds)');
grid;

lm = length(product);
f = linspace(-fs/2,fs/2,lm);
product_fourier = abs(fftshift(fft(product,lm)))/lm;

figure (3);
subplot(4,1,2);
plot(f,product_fourier)
title('FFT of Product');
xlabel('f (Hz)');
grid;

figure (3);
subplot(4,1,3);
plot(t(startplot:endplot), demodulated(startplot:endplot));
title('Demodulated Signal');
xlabel('Time (seconds)');
grid;

lm = length(demodulated);
f = linspace(-fs/2,fs/2,lm);
demodulated_fourier = abs(fftshift(fft(demodulated,lm)))/lm;

figure (3);
subplot(4,1,4);
plot(f,demodulated_fourier)
title('FFT of Demodulated Signal');
xlabel('f (Hz)');
grid;
```

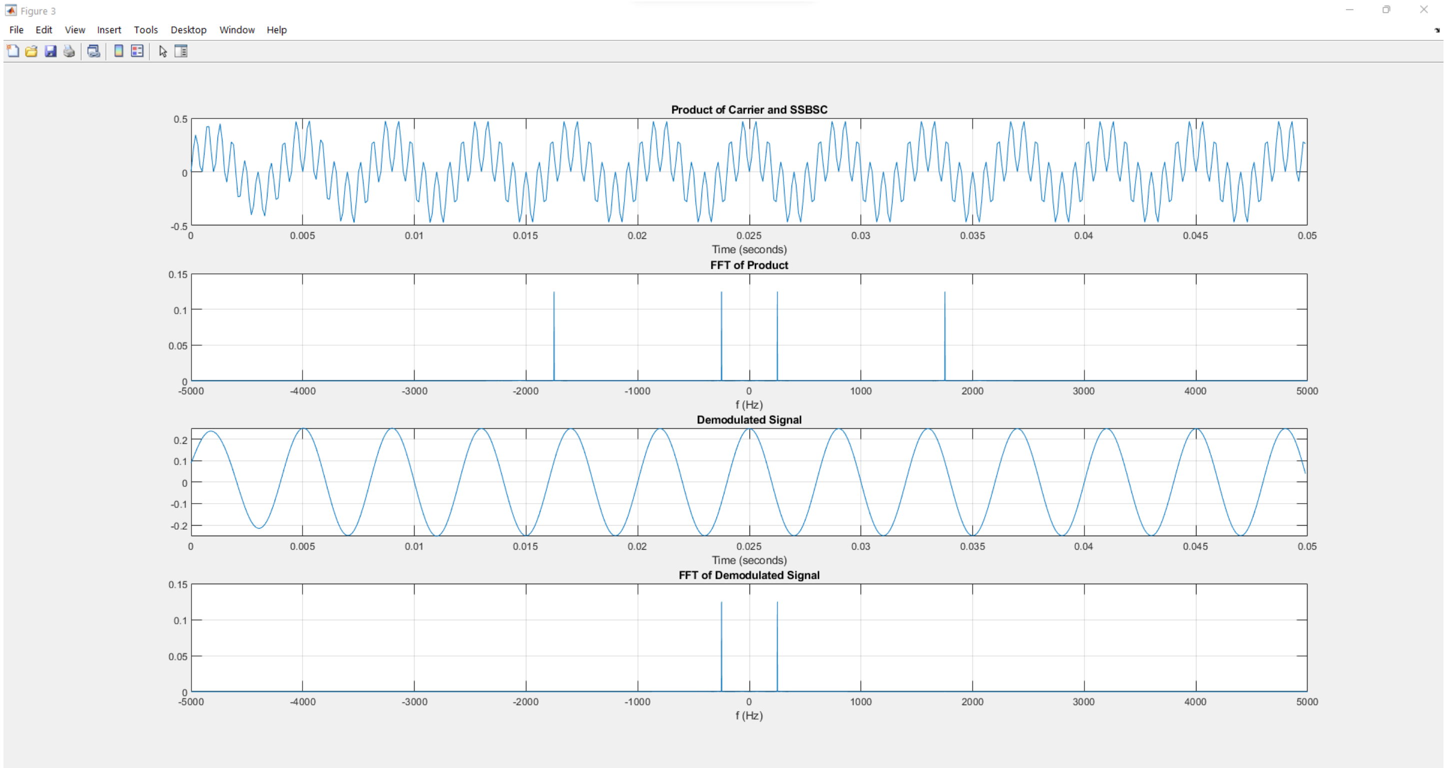
Plots



Waveforms of message, carrier, DSBSC, and SSBSC-Lower Band signals



FFT of message, carrier, DSBSC, and SSBSC-Lower Band signals

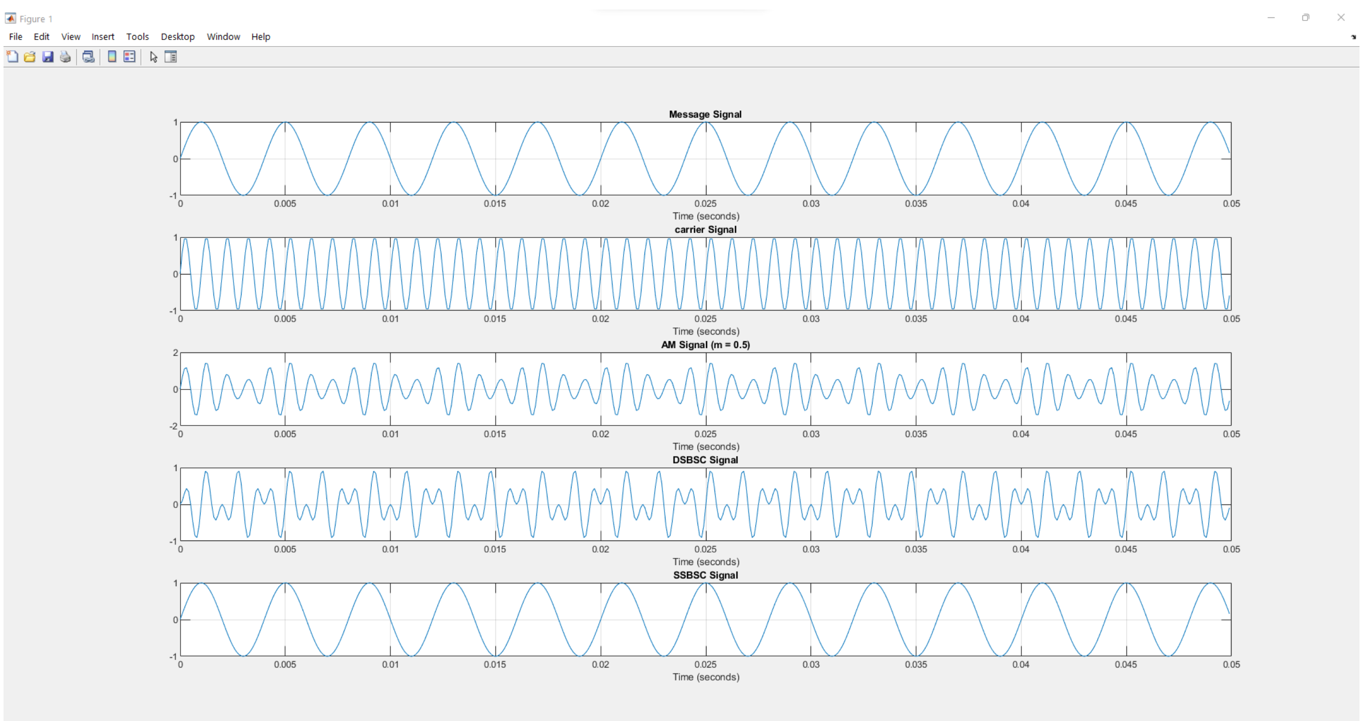


Waveform and FFT of product (of Carrier and SSBSC) and demodulated signals

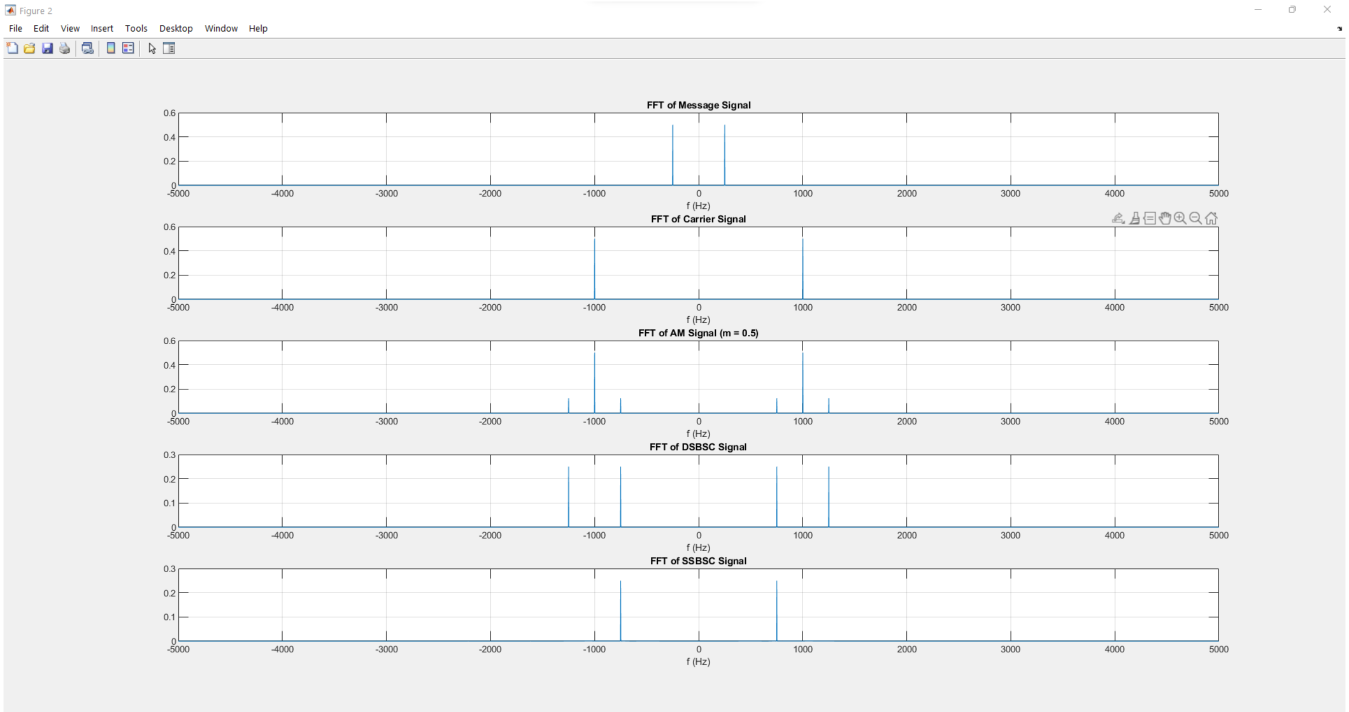
Tutorial Questions

1. Plot the SSB-SC, DSBSC and AM signal for same message signal and compare the output waveforms.

Ans.



Waveforms of message, carrier, AM, DSBSC, and SSBSC-Lower Band signals

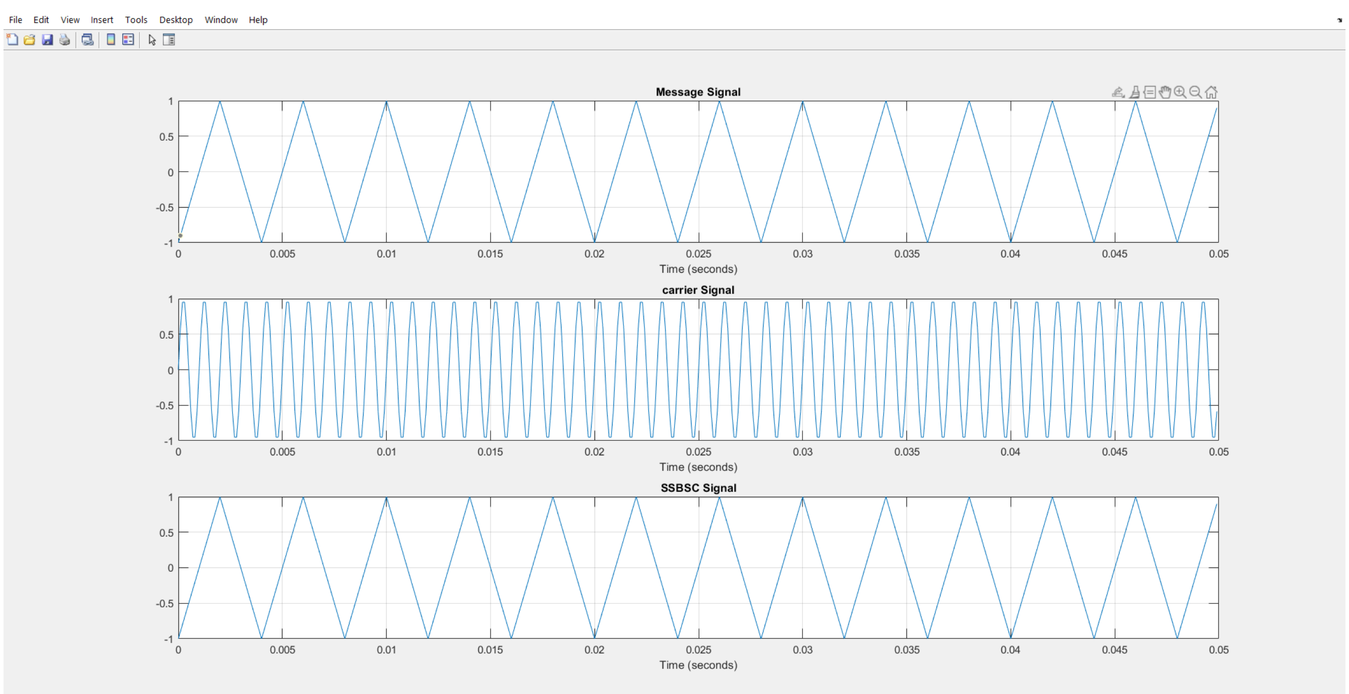


FFT of message, carrier, AM, DSBSC, and SSBSC-Lower Band signals

In amplitude modulation scheme, carrier is not suppressed. This is evident since in the FFT plot of AM signal, there are peaks at carrier frequencies. These peaks are not observed in suppressed carrier schemes. Further, the bandwidth of SSBSC is half the bandwidth of DSBSC or AM signal. This is because in SSBSC, only single side band is transmitted.

2. Plot the SSB-SC signal for triangular waveform.

Ans.



3. **Write the MATLAB Code for plotting SSB-SC signal using Hilbert transformation of message signal.**

Ans.

```
close all;

fc = 1000;      % Carrier frequency
fm = 250;       % Modulating frequency
fs = 10000;     % Sample frequency
N = 5000;       % Number of samples

Ts = 1/fs;
t = (0:Ts:N*Ts-Ts);

message = sin(2*pi*fm*t);       % message signal
hilbert_msg = imag(hilbert(msg))  % imaginary part of Hilbert transform of message signal

% SSB-SC signal
ssbc = message.*cos(2*pi*fc*t) - hilbert_msg.*sin(2*pi*fc*t)
```

4. **What percentage of power is saved in SSB as compared to DSB-SC and AM.**

Ans. The maximum power efficiency of AM is 33 %. For DSBSC scheme, power efficiency is 50 %, while for SSBSC scheme, the power efficiency is 100 %. Therefore, as compared to DSBSC, 50 % power is saved in SSBSC, whereas as compared to AM, a minimum of 67 % power is saved in SSBSC.

5. **What is bandwidth of SSB-SC signal?**

Ans. The bandwidth of the SSB-SC signal is same as that of the message signal.

6. **What are the drawbacks of frequency discrimination technique used in generation of SSB signal? What are the possible solutions?**

Ans. The frequency discrimination technique requires a bandpass filter with a very sharp cut-off, which is not practically possible. This implies that there will always be some vestigial parts of the cut-out sideband after filtering, which makes frequency discrimination technique unsuitable for video signals.

One way to overcome the drawbacks of frequency discrimination technique is to generate SSB-SC signals using Hibert transform (method mentioned above).

7. **Can you generate multitone SSB signal using phase discrimination method? Why or why not?**

Ans. Yes, phase discrimination can used to generate a multitone SSB signal from a multitone message signal. This is because phase discrimination system is a linear system, and it will treat the message signal as a summation of individual single tone signals and generate the desired output.

8. **Why SSB is used for voice signals?**

Ans. SSB is used for voice signals because voice signals have zero amplitude around zero frequency. Therefore, even if we don’t have sharp cut-off bandpass filter, the vestigial parts of the cut-out signal will have very low amplitude. Thus, the frequency discrimination method will work in this case.

Conclusion

SSB-SC modulation and demodulation were simulated in MATLAB, and it can be observed that the simulations agree with the theoretical results.
