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# DSB-SC Modulator/Demodulator Example

This documents describes/implements the DSB-SC modulation and demodulation of a song signal.

```
Prepared for ELEC 301

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*01.04.2020*
```

# Program Initialization

```
%Clear Variables and Close All Figure Windows

% Clear all previous variables
clear
% Close all previous figure windows
close all
```

# Read Song File

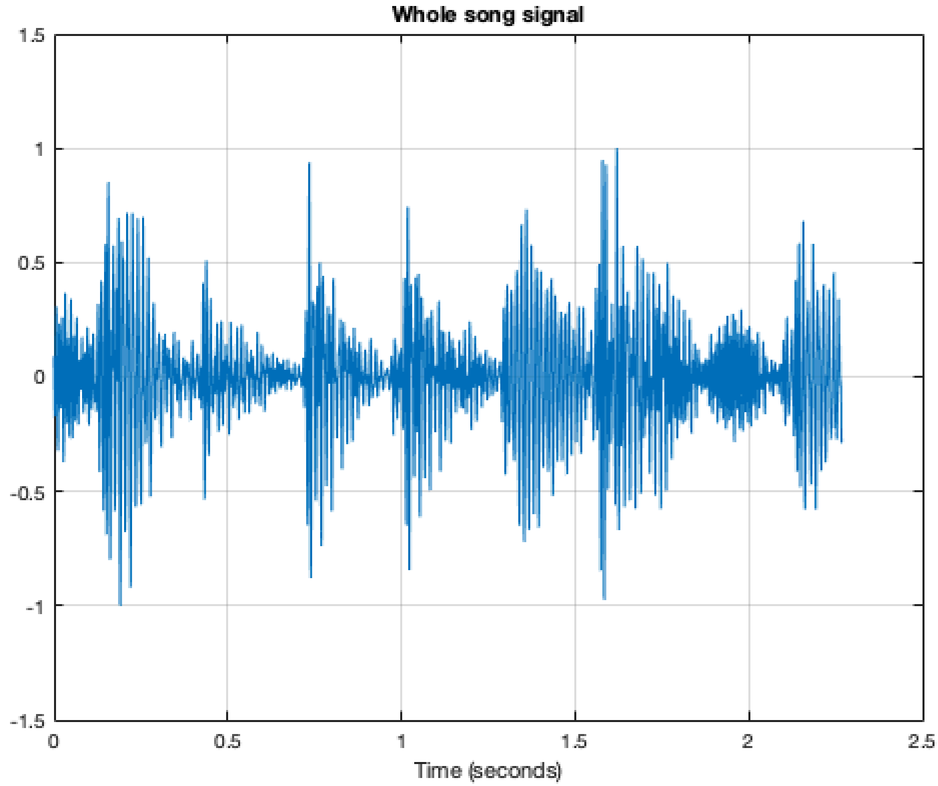
**song.mat** contains **song** variable containing Song samples and **Fs** which is the sampling frequency

```
% Load the song file
load song.mat
% song is the song samples
% Fs is the sampling frequency

% Transform the song to low rate sampling for listening (sound command
% requires sampling rate to be less than 44K
songlowrate=downsample(song,10);
% Listen to
sound(songlowrate,Fs/10);
```

```
% convert it to row array
song=reshape(song,1,length(song));
% Sampling Period
Ts=1/Fs;
% Sampling times
t=(0:1:(length(song)-1))*Ts;
```

# Display the whole song

```
% Display the whole song
figure(1)
plot(t,song);
grid
title('Whole song signal');
xlabel('Time (seconds)');
```




# Generate Modulated Signal

Generate carrier signal and multiply with the song signal to obtain DSB-SC modulated waveform

Carrier frequency:

$f_c = 60kHz$

```
fc=60e3; % 60 kHz;
```

Carrier signal: _

$c(t) = cos(2\pi f_c t)$

```
c=cos(2*pi*fc*t);
```

DSB-SC Modulated waveform

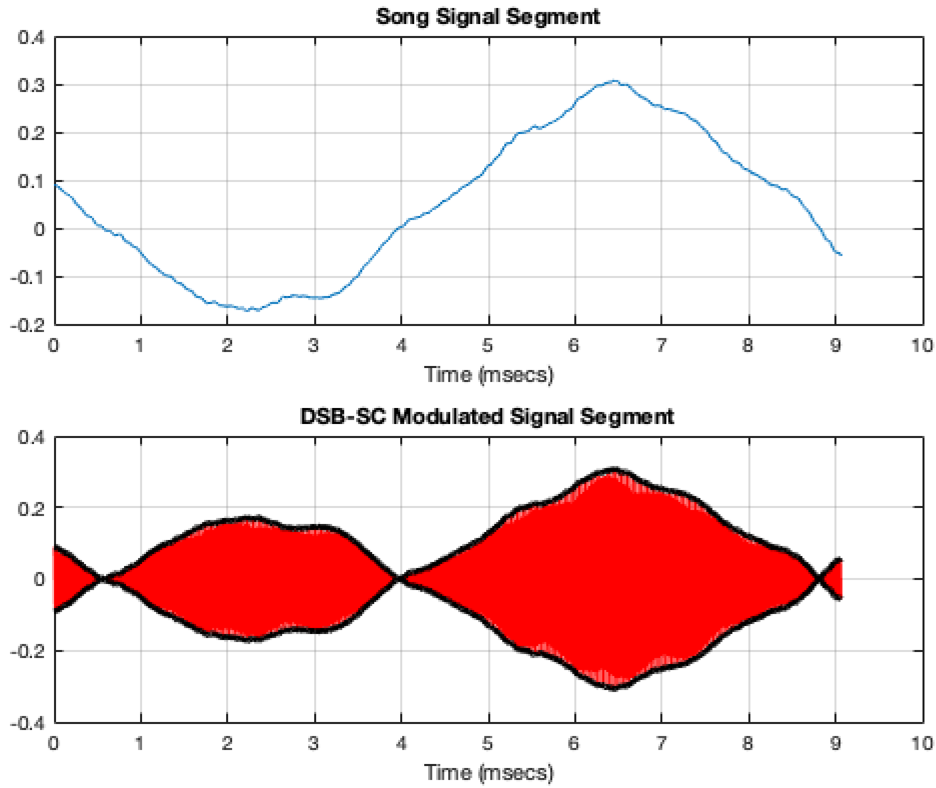
$x(t) = s(t)c(t)$

```
x=song.*c;
```

# Display the Segments of Signal and Modulated Signal

Display small section of the original signal and then the DSB-SC modulated version

```
figure(2)
% plot the song segment (for about 3000 samples)
subplot(2,1,1)
plot(t(1:3000)*1000, song(1:3000));
xlabel('Time (msecs)')
title('Song Signal Segment')
grid

subplot(2,1,2)
% plot the modulated signal
plot(t(1:3000)*1000,x(1:3000),'r');
hold on
% plot also positive and negative envelopes
p1=plot(t(1:3000)*1000,song(1:3000),'k');
p2=plot(t(1:3000)*1000,-song(1:3000),'k');
xlabel('Time (msecs)')
set(p1,'LineWidth',3)
set(p2,'LineWidth',3)
grid
title('DSB-SC Modulated Signal Segment')
```




# The DSB-SC Receiver Processing

DSB-SC Receiver operation with different receiver oscillator phases

First multiply with the receiver carrier

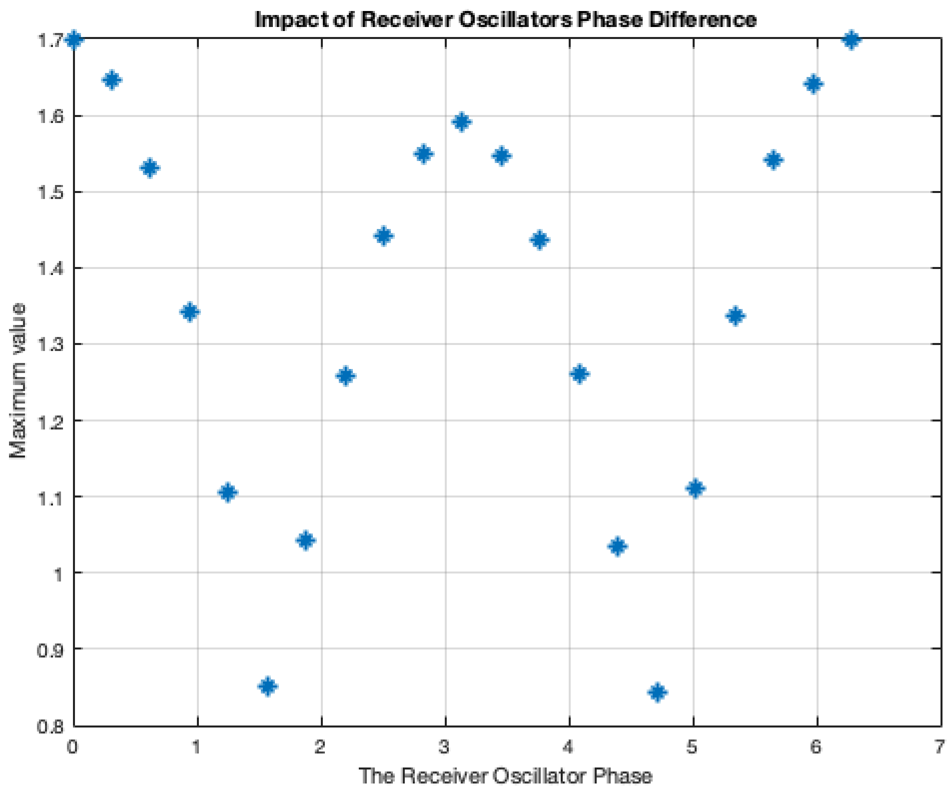
$y(t) = 2x(t)c(t + theta)$

```
theta = 0;
maxes = zeros(1,21);
thetas = zeros(1,21);

% Maxes stores the absolute maxiumum values for each phase value
% and thetas stores the different receiver oscillator phase values.

% In each loop, the value of the phase increases pi/10, and we detect
 the
% maximum value of the signal for that phase.

for i = 1:21
    theta = (i-1)*pi/10;
    thetas(i) = theta;

    c2=cos((2*pi*fc*t)+theta);
    y=2*x.*c2;
```

```
    maxes(i) = max(y(40000:60000));
end
```

# Plot the receiver oscillator phase values vs max values graph (Question 1)

```
figure(3)
plot(thetas, maxes,'*')
grid
xlabel('The Receiver Oscillator Phase')
ylabel('Maximum value')
title('Impact of Receiver Oscillators Phase Difference')
```




Then low pass filter this signal

$z(t) = y(t) * h_{LP}(t)$

```
z = lowpass(y,30e3,Fs);
```

# Fourier Transforms of Song, Modulated and Demodulated Signals

Calculate and Display the Fourier Transforms of the song,modulated and demodulated signals

Calculate the Fourier Transform of the song signal

```
[ftsong,freqs]=fouriertransform(song, Fs);
```

Calculate the Fourier Transform of the DSB-SC signal

```
[ftx,freqs]=fouriertransform(x,Fs);
```

Calculate Fourier Transform after receiver carrier multiplication

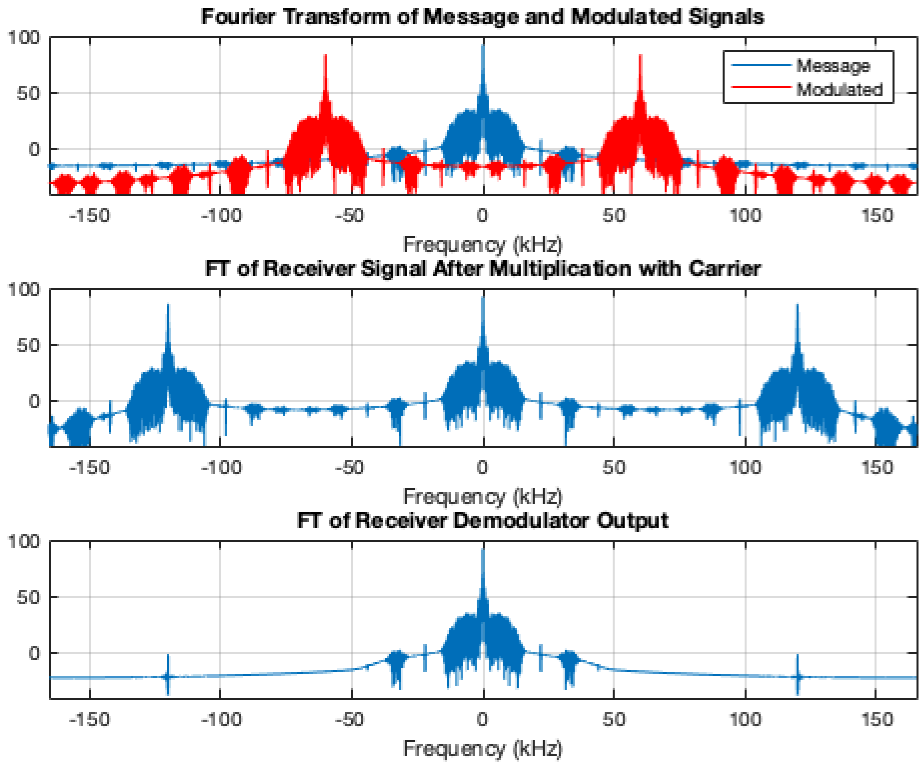
```
[fty,freqs]=fouriertransform(y,Fs);
```

Calculate Fourier Transform of the receiver output

```
[FTz,freqs]=fouriertransform(z,Fs);
```

Display these Fourier Transforms

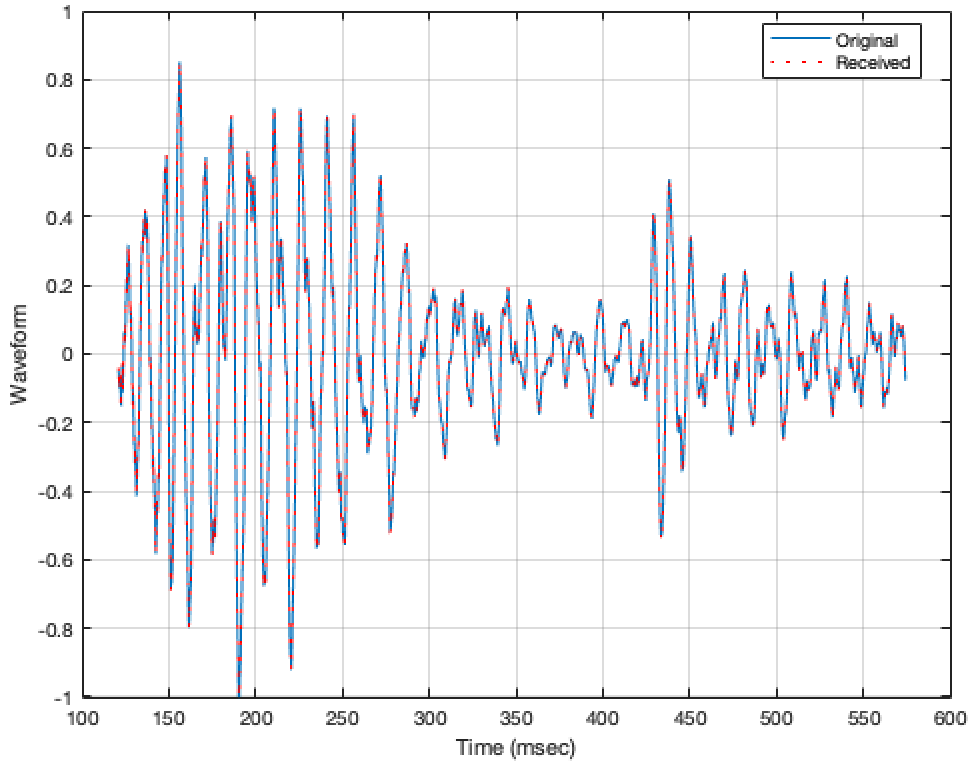
```
figure(4)
subplot(3,1,1);
plot(freqs/1000, 20*log10(abs(ftsong)));
hold on
plot(freqs/1000, 20*log10(abs(ftx)),'r');
grid
legend('Message','Modulated','Location','Best')
xlabel('Frequency (kHz)');
title('Fourier Transform of Message and Modulated Signals')
axis([-Fs/2000 Fs/2000 -40 100])
subplot(3,1,2);
plot(freqs/1000, 20*log10(abs(fty)));
axis([-Fs/2000 Fs/2000 -40 100])
grid
xlabel('Frequency (kHz)');
title('FT of Receiver Signal After Multiplication with Carrier')
subplot(3,1,3)


plot(freqs/1000, 20*log10(abs(FTz)));
axis([-Fs/2000 Fs/2000 -40 100])
grid
xlabel('Frequency (kHz)')
title('FT of Receiver Demodulator Output')
```




# Display the Original Song and the Receiver Output Segments

They are hardly distinguishable!

```
figure(5)
plot(t(40000:190000)*1000,song(40000:190000))
hold on
plot(t(40000:190000)*1000,z(40000:190000),'r:')
grid
xlabel('Time (msec)');
ylabel('Waveform');
legend('Original','Received','Location','Best');
```

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