Review of Amplitude Modulation and Demodulation

Lab Exercises on June 9, 2021

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1 Objective

- Review of amplitude modulation for DSB-TC, DSB-SC, SSB methods and amplitude demodulation.

2 Background Theory

2.1 Double Side Band - Transmitted Carrier (DSB-TC)

DSB-TC is a type of amplitude modulation such that full carrier representation is present in the modulated signal waveform. It is the simplest form of amplitude modulation, whose expression for modulated signal $y_{dsbtc}(t)$, message signal $m(t)$ and carrier frequency f_c is given as,

$$y_{dsbtc}(t) = (1 + \mu.m(t)) \cos(2\pi f_c t) \tag{1}$$

The modulation index μ gives the different modulating conditions as:

$$\mu < 1 \Rightarrow \text{Under modulation}$$

$$\mu = 1 \Rightarrow \text{Normal modulation}$$

$$\mu > 1 \Rightarrow \text{Over modulation}$$

2.2 Double Side Band - Suppressed Carrier (DSB-SC)

DSB-SC is a type of amplitude modulation such that carrier representation is not present in the modulated signal waveform. It is more effective than the DSB-TC modulation as the carrier is suppressed thus requiring less power and providing a higher bandwidth. For a modulated signal $y_{dsbsc}(t)$, message signal $m(t)$, carrier frequency f_c and carrier amplitude A_c, the DSB-SC expression is given as,

$$y_{dsbsc}(t) = A_c m(t) \cos(2\pi f_c t) \tag{2}$$

2.3 Single Side Band (SSB)

An unique relationship exists between the Upper Side Band (USB) and Lower Side Band (LSB) as they are symmetric about f_c, which is why only transmitting a single band is sufficient to transmit the message contained by the message signal $m(t)$, hence giving rise to SSB modulation. A general SSB signal $y_{ssb}(t)$modulated for the message signal $m(t)$, carrier frequency f_c is given as,

$$y_{ssb}(t) = m(t)\cos(2\pi f_c t) \pm \hat{m}(t)\sin(2\pi f_c t) \tag{3}$$

where, $\hat{m}(t)$ is the Hilbert Transform of the message signal given as,

$$\hat{m}(t) = m(t) * \frac{1}{\pi t} = \frac{1}{\pi}\int_{-\infty}^{\infty} \frac{m(\alpha)}{t-\alpha} d\alpha$$

2.4 Demodulation of a modulated signal

The process of separating the original information or signal from the modulated signal transmitted is called demodulation. A device called a demodulator or detector, which produces a signal corresponding to the instantaneous changes in amplitude or frequency as per the modulation scheme, is used to demodulate a signal.

For a DSB-SC modulated signal, coherent demodulation is performed by first multiplying the modulated signal with the carrier signal, and then passing this resultant signal through a low pass filter to retrieve a scaled version of the original message signal.

3 Exercises

```
fm=input('Enter message frequency :');
fc=input('Enter carrier frequency :');
fs=input('Enter sampling frequency :');
t=0:(1/fs):((4/fm)-(1/fs));
x=cos(2*pi*fm*t);
```

Listing 1: Basic setup for all exercises

Problem 1

Visualize amplitude modulation DSB-TC with different modulating conditions.

a. Under Modulation

b. Normal Modulation

c. Over Modulation

```
Ashlesh_setup;
y_under=modulate(x, fc, fs, 'amdsb-tc',
    -1/0.5);
y_normal=modulate(x, fc, fs, 'amdsb-tc',
    -1/1);
y_over=modulate(x, fc, fs, 'amdsb-tc',
    -1/2);
%Plotting signals as tiles
l=tiledlayout(2,3);
nexttile([1 , 3])
plot(t,x);
title('Message signal');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
nexttile
plot(t,y_under);
title('Under modulated signal','m<1');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
nexttile
plot(t,y_normal);
title('Normal modulated signal','m=1');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
nexttile
plot(t,y_over);
title('Over modulated signal','m>1');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
%Tiledlayout title and figure print
title(l,'AMDSB-TC modulation (PUL074BEX007)
    ');
print('dsbtc','-depsc');
```

Listing 2: Matlab script for visualization of DSB-TC modulation with different modulating conditions

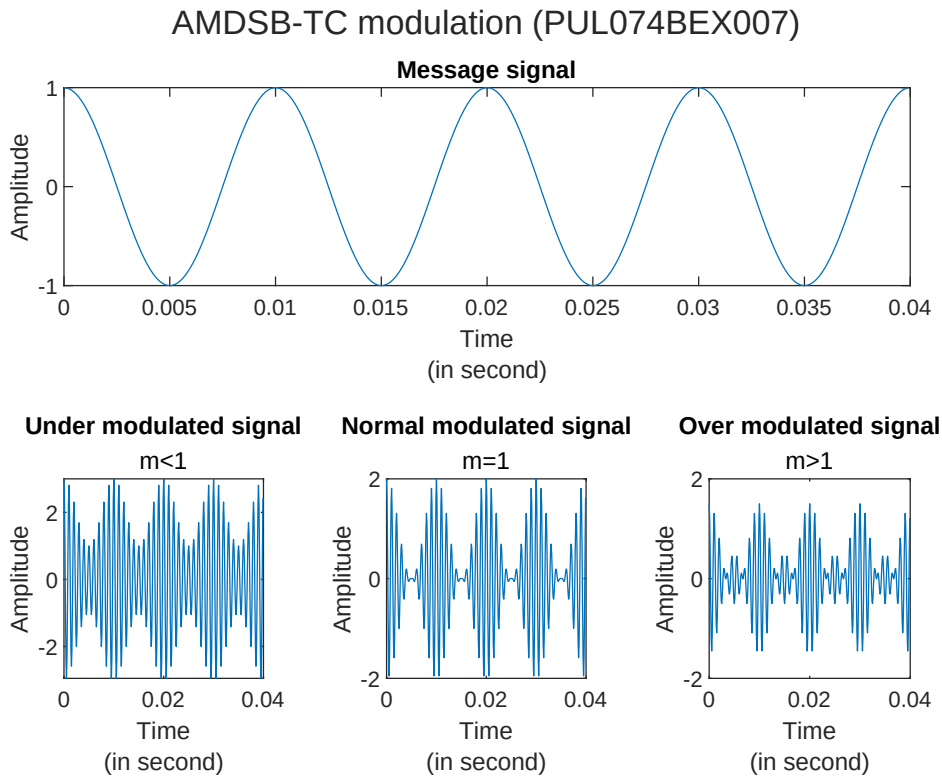

Figure 1: DSB-TC modulation with different modulating conditions

Problem 2

Visualize amplitude modulation DSB-SC with the following plots.

a. Time domain

b. Frequency domain

```
Ashlesh_setup;
y=modulate(x, fc, fs, 'amdsb-sc');
z=abs(fft(y,1024));
f= (-511*fs/1024):(fs/1024):(512*fs/1024);
%Plotting signals as tiles
l=tiledlayout(2,2);
nexttile([1 , 2])
plot(t,x);
title('Message signal');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
nexttile
plot(t,y);
title('Modulated signal','Time Domain');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
nexttile
plot(f,z);
```

```
19 title('Modulated signal','Frequency Domain'
       );
20 xlabel({'Frequency','(in Hz)'});
21 ylabel('Spectrum amplitude');
22 %Tiledlayout title and figure print
23 title(1,'AMDSB-SC modulation (PUL074BEX007)
       ')
24 print('dsbsc','-depsc');
```

Listing 3: Matlab script for visualization of DSB-SC modulation in time and frequency domain

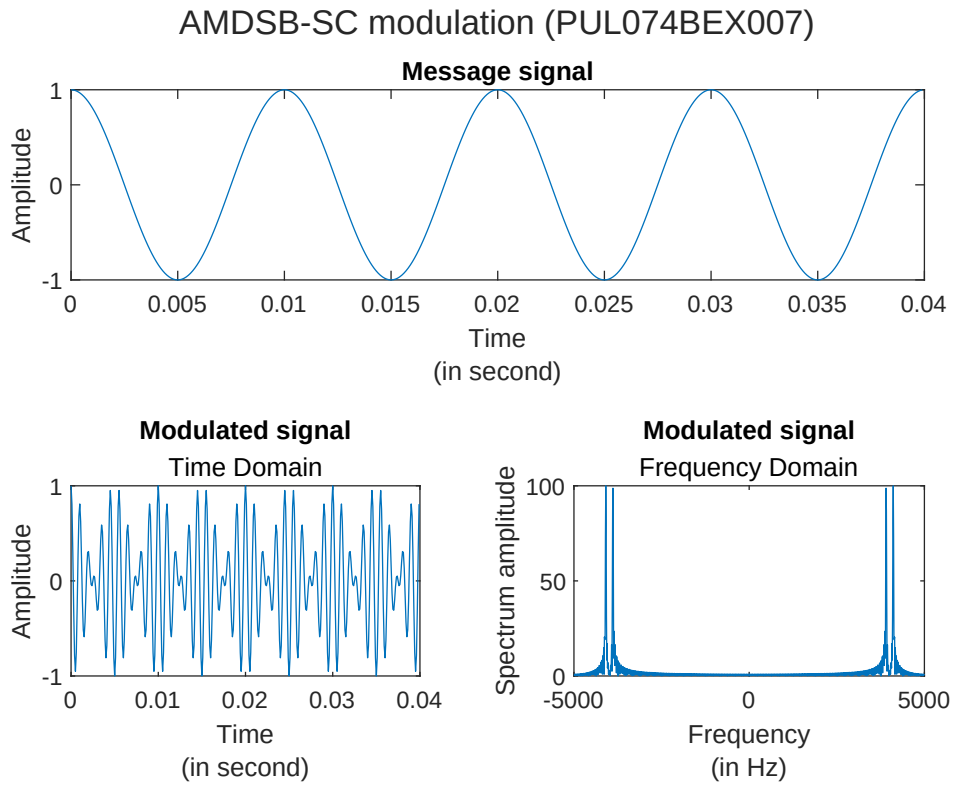

Figure 2: DSB-SC modulation with time and frequency domain plots

Problem 3

Visualize amplitude modulation SSB with the following plots.

a. Time domain

b. Frequency domain

```
Ashlesh_setup;
y=modulate(x, fc, fs, 'amssb');
z=abs(fft(y,1024));
f= (-511*fs/1024):(fs/1024):(512*fs/1024);
%Plotting signals as tiles
l=tiledlayout(2,2);
nexttile([1 , 2])
plot(t,x);
title('Message signal');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
nexttile
plot(t,y);
title('Modulated signal','Time Domain');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
nexttile
plot(f,z);
title('Modulated signal','Frequency Domain'
    );
xlabel({'Frequency','(in Hz)'});
ylabel('Spectrum amplitude');
%Tiledlayout title and figure print
title(l,'AMSSB modulation (PUL074BEX007)')
print('ssb','-depsc');
```

Listing 4: Matlab script for visualization of SSB modulation in time and frequency domain

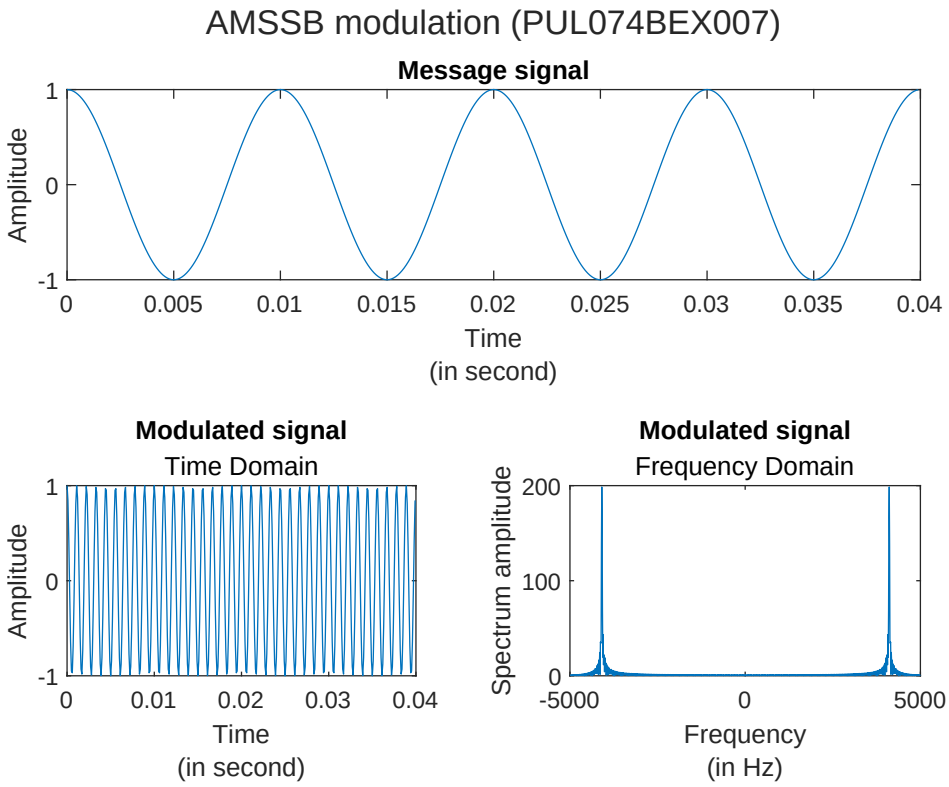

Figure 3: SSB modulation with time and frequency domain plots

Problem 4

Visualize amplitude demodulation.

```
Ashlesh_setup;
y=modulate(x, fc, fs, 'amdsb-sc');
z=demod(y,fc,fs,'amdsb-sc');
%Plotting signals as tiles
l=tiledlayout(3,1);
nexttile
plot(t,x);
title('Message signal');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
nexttile
plot(t,y);
title('Modulated signal');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
nexttile
plot(t,z);
title('Demodulated signal');
xlabel({'Time','(in second)'});
ylabel('Amplitude');
%Tiledlayout title and figure print
title(l,'DSB-SC demodulation (PUL074BEX007)
    ')
print('demod','-depsc');
```

Listing 5: Matlab script for visualization of demodulation of DSB-SC signal

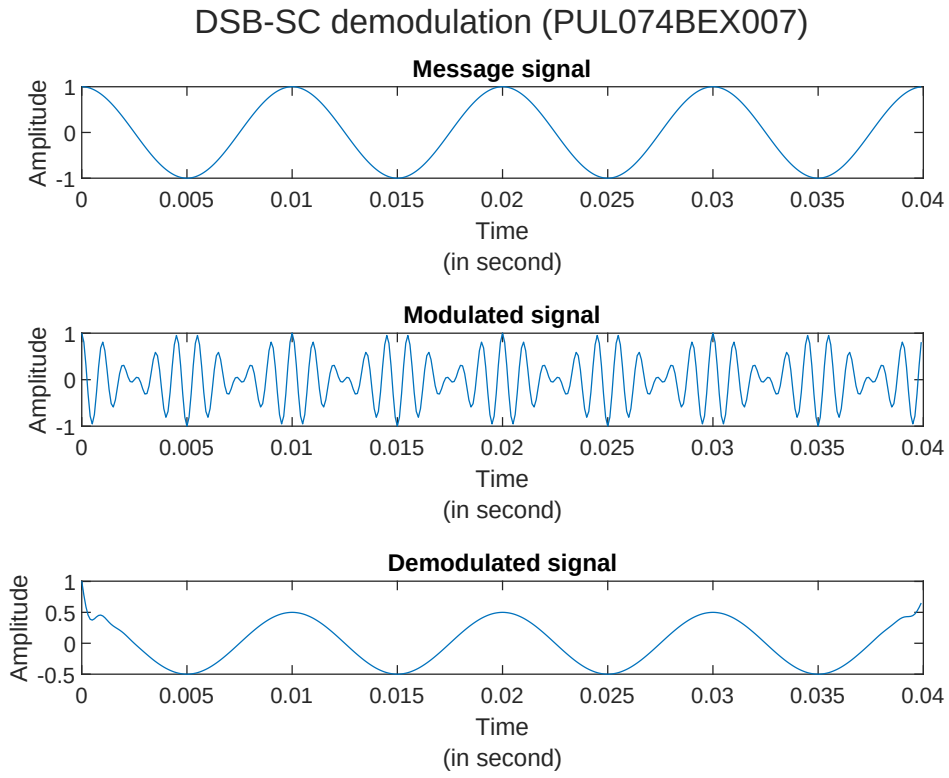

Figure 4: Demodulation of DSB-SC signal

4 Discussion and Conclusion

The lab experiment dealt with the review of amplitude modulation. Double side band transmitted carrier (DSB-TC) under three modulating conditions, viz. under, normal and over modulation was visualized. Similarly, double side band suppressed carrier (DSB-SC) and single side band (SSB) modulation were plotted in time and frequency domain. Likewise, a demodulation exercise was also performed for DSB-SC signal. The objective of the lab experiment was fulfilled.