Amplitude Modulation and DSB-SC Modulation

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Introduction

Amplitude modulation (AM) is a popular technique used to transmit information signals over a carrier signal. In AM, the amplitude of the carrier signal is varied in accordance with the message signal. This lab assignment aims to explore the properties of AM and Double-sideband suppressed carrier (DSB-SC) modulation.

Theory

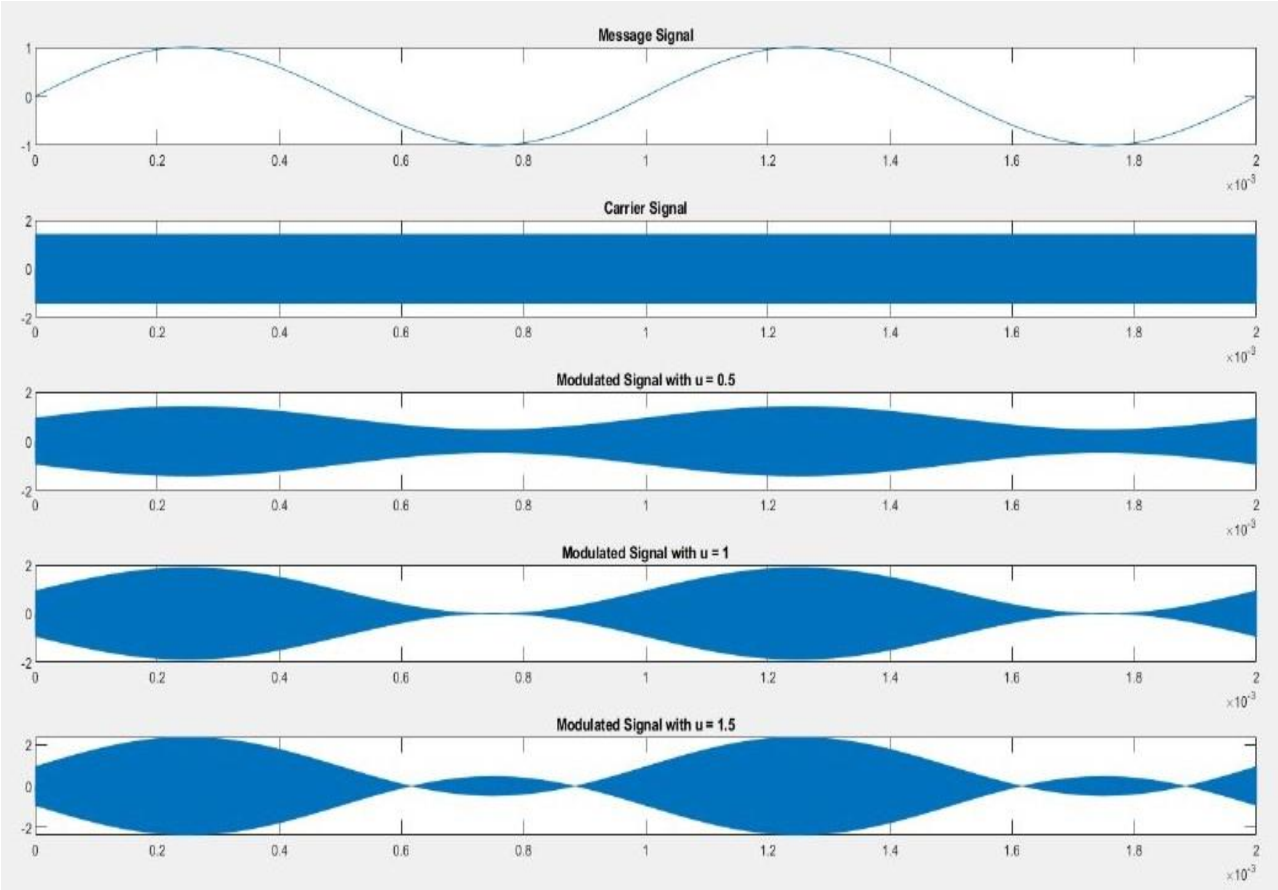
The message signal is given by $m(t) = mp \times \sin(2\pi \times 1000 \times t)$, where mp is the amplitude of the message signal, and fc is the frequency of the carrier signal. The modulated signal can be written as: $\phi AM (t) = (Ac + m(t)) \sin(2\pi fct)$ where Ac is the amplitude of the carrier signal. The modulation index, μ, is defined as $\mu = mp/Ac$.

In DSB-SC modulation, both the upper and lower sidebands are transmitted while the carrier frequency is suppressed. The modulated signal in DSB-SC modulation is given by: $\phi DSB\text{-}SC(t) = Ac\,[m(t)\cos(2\pi fct)]$.

Plots And Observations

The message signal $m(t) = mp \times \sin(2\pi \times 1000 \times t)$ modulated by a sinusoid carrier of frequency fc = 100 Mhz, given as $\phi AM (t) = (Ac + m(t)) \sin(2\pi fct)$.

(a) A figure containing the message signal with mp = 1 Volt, carrier signal, and modulated signal with μ = mp Ac = {0.5, 1, 1.5} in the time domain. Limit the range of x-axis to two cycles of the message signal.
Plot -

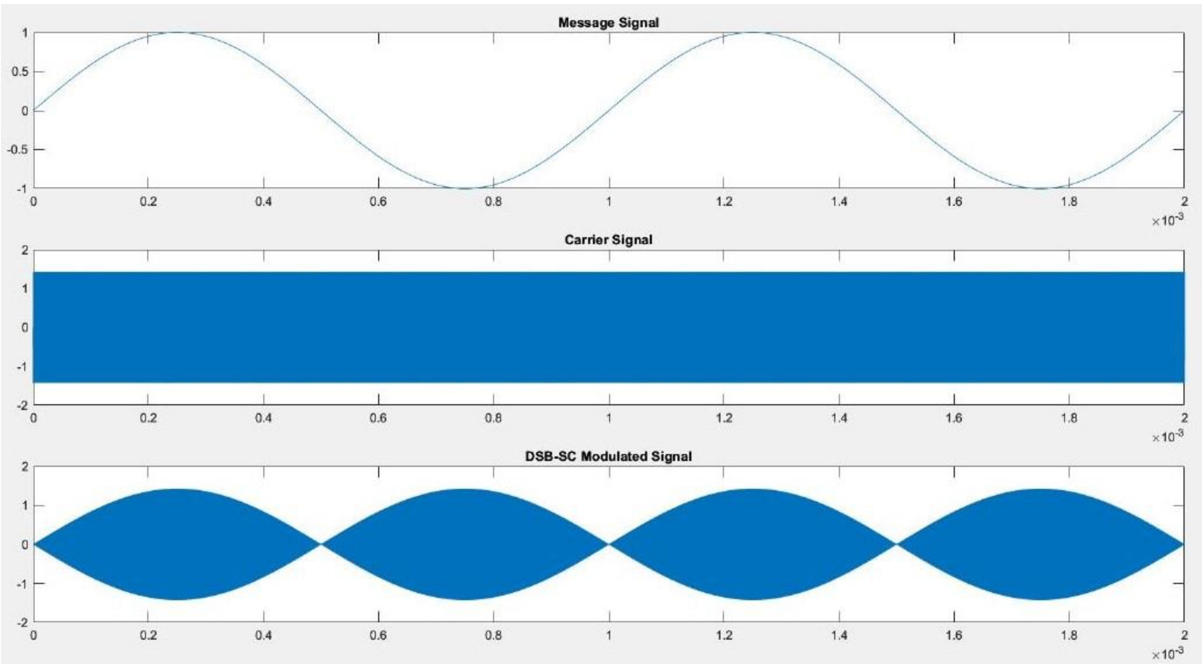

Message Signal
Carrier Signal
Modulated Signal with u = 0.5
Modulated Signal with u = 1
Modulated Signal with u = 1.5

Code -

```
%% Equations

t = 0:1/(10*fc):2/fm;

mt = mp*sin(2*pi*fm*t);
ct = Ac*u*sin(2*pi*fc*t);

s1 = Ac*(1+ 0.5*sin(2*pi*fm*t)).*sin(2*pi*fc*t);
s2 = Ac*(1+ sin(2*pi*fm*t)).*sin(2*pi*fc*t);
s3 = Ac*(1+ 1.5*sin(2*pi*fm*t)).*sin(2*pi*fc*t);

d = mt .* ct;

%% subplot - 1

subplot(5,1,1);
plot(t,mt);
title("Message Signal");

subplot(5,1,2);
plot(t,ct);
title("Carrier Signal");

subplot(5,1,3);
plot(t,s1);
title("Modulated Signal with u = 0.5");

subplot(5,1,4);
plot(t,s2);
title("Modulated Signal with u = 1");

subplot(5,1,5);
plot(t,s3);
title("Modulated Signal with u = 1.5");
```

(b) A figure containing the message signal with mp = 2 Volts, carrier signal with Ac = 2 Volts, and modulated signal for the equivalent DSB-SC modulation in the time domain.

Plot -



Code –

```
Ac = 1;
fm = 1000;
fc = 100*10^6;
T = 2/fc;
u = 1.5;

%% Equations

t = 0:1/(10*fc):2/fm;
f = linspace(-fm,fm,length(t));

mt = mp*sin(2*pi*fm*t);
mf = fftshift(fft(mt));

ct = Ac*u*sin(2*pi*fc*t);
cf = fftshift(fft(ct));

d = mt .* ct;
df = mf .* cf;

%% subplot - 2

subplot(3,1,1);
plot(t,mt);
title("Message Signal");

subplot(3,1,2);
plot(t,ct);
title("Carrier Signal");

subplot(3,1,3);
plot(t,d);
title("DSB-SC Modulated Signal");
```

In this scenario, the message signal is given as m(t) = 2*sin(2π × 1000 × t)

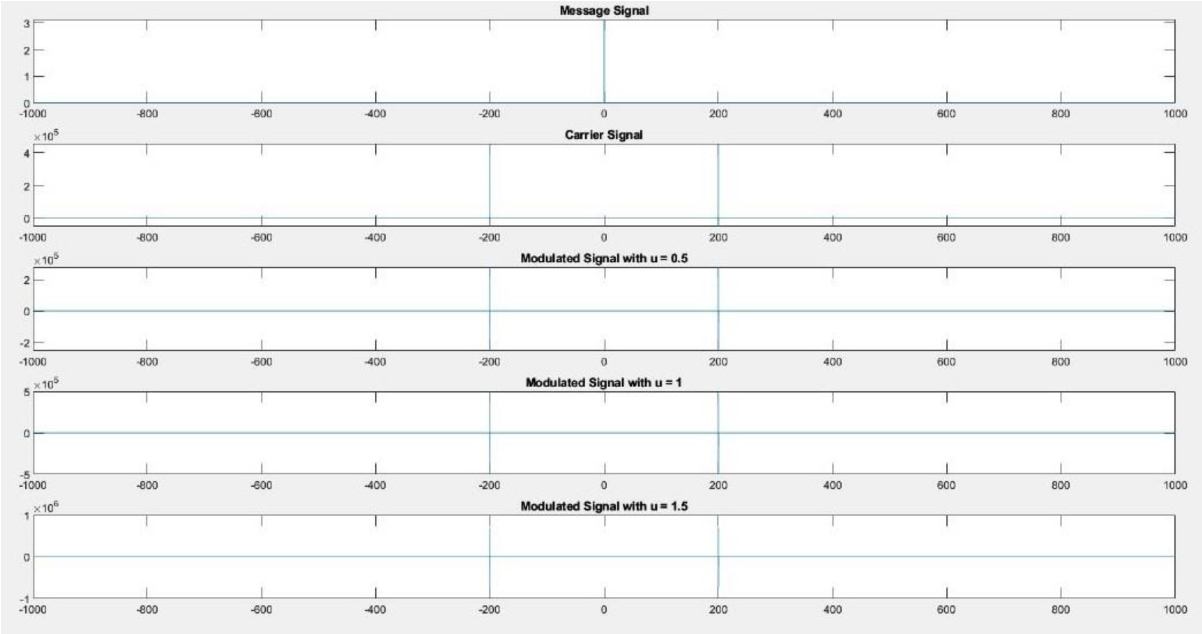
The carrier signal is given as c(t) = 2*sin(2π × 100,000,000 × t)

The DSB-SC modulated signal can be obtained using ϕDSB-SC (t) = 2*m(t)*cos(2π × 100,000,000 × t).

As we can see from the plot, the modulated signal for the DSB-SC modulation is similar to the modulated signal for the AM modulation with μ = 1. The only difference is that the DSB-SC modulated signal does not contain the carrier frequency

(c) A figure containing the message signal with mp = 1 Volt, carrier signal, and modulated signal with μ = mp Ac = {0.5, 1, 1.5} in the frequency domain.

Plot -

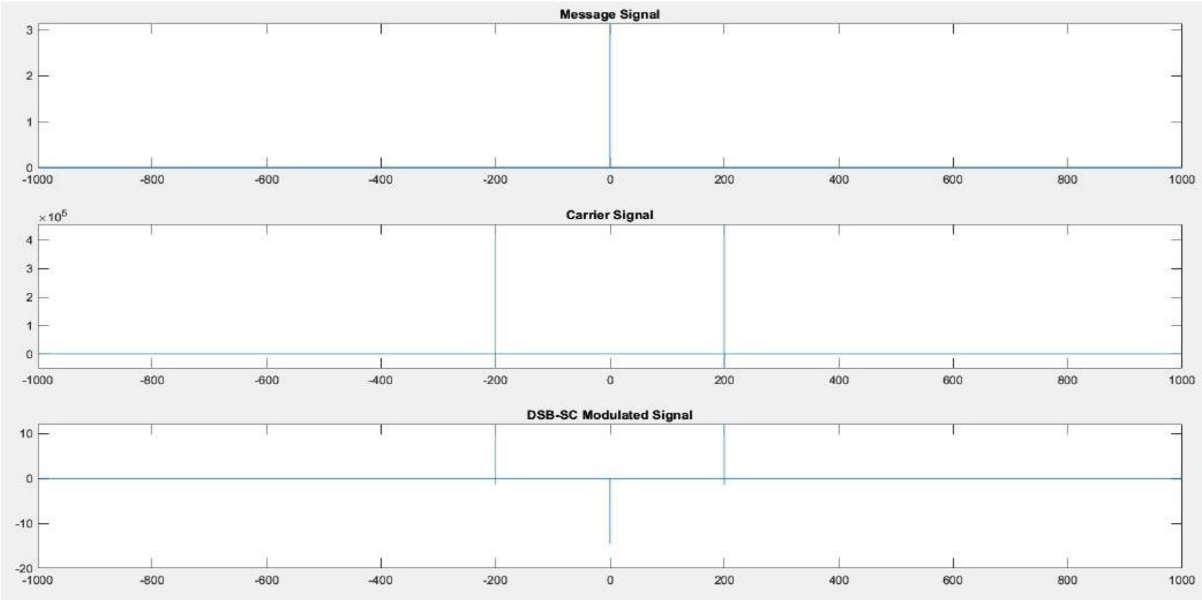


Code -

```
cf = fftshift(fft(ct));

s1 = Ac*(1+ 0.5*sin(2*pi*fm*t)).*sin(2*pi*fc*t);
s1f = fftshift(fft(s1));

s2 = Ac*(1+ sin(2*pi*fm*t)).*sin(2*pi*fc*t);
s2f = fftshift(fft(s2));

s3 = Ac*(1+ 1.5*sin(2*pi*fm*t)).*sin(2*pi*fc*t);
s3f = fftshift(fft(s3));

d = mt .* ct;

%% subplot - 1

subplot(5,1,1);
plot(f,mf);
title("Message Signal");

subplot(5,1,2);
plot(f,cf);
title("Carrier Signal");

subplot(5,1,3);
plot(f,s1f);
title("Modulated Signal with u = 0.5");

subplot(5,1,4);
plot(f,s2f);
title("Modulated Signal with u = 1");

subplot(5,1,5);
plot(f,s3f);
title("Modulated Signal with u = 1.5");
```

(d) A figure containing the message signal with mp = 2 Volts, carrier signal with Ac = 4 Volts, and modulated signal for the equivalent DSB-SC modulation in the frequency domain. State the equivalent DSB-SC equation. Is this scenario similar to a scenario in part (c)?

Plot –



Code -

```
Ac = 1;
fm = 1000;
fc = 100*10^6;
T = 2/fc;
u = 1.5;

%% Equations

t = 0:1/(10*fc):2/fm;
f = linspace(-fm,fm,length(t));

mt = mp*sin(2*pi*fm*t);
mf = fftshift(fft(mt));

ct = Ac*u*sin(2*pi*fc*t);
cf = fftshift(fft(ct));

d = mt .* ct;
df = mf .* cf;

%% subplot - 2

subplot(3,1,1);
plot(f,mf);
title("Message Signal");

subplot(3,1,2);
plot(f,cf);
title("Carrier Signal");

subplot(3,1,3);
plot(f,df);
title("DSB-SC Modulated Signal");
```

The equivalent DSB-SC (double-sideband suppressed carrier) equation for a message signal m(t) and carrier signal c(t) is given by:
$\phi DSB\text{-}SC(t) = m(t) * c(t) * \cos(2\pi fct)$

This scenario is similar to part (c) of the question in that both parts involve modulating a message signal with a carrier signal. However, in part (c), we are using an AM (amplitude modulation) method to modulate the message signal, while in part (d) we are using a DSB-SC method to modulate the message signal.

Conclusion

In this lab assignment, we explored the properties of amplitude modulation and double-sideband suppressed carrier modulation. The modulation index plays a crucial role in determining the properties of the modulated signal. When the modulation index is less than one, we get under-modulated signals, while over-modulation leads to distortion.

Overall, this lab assignment helped us understand the properties of amplitude modulation and double-sideband suppressed carrier modulation and how the modulation index affects the modulated signal's properties.