Faculty of Engineering & Technology

Electrical & Computer Engineering Department

COMMUNICATIONS LAB

ENEE4113

Experiment No. 2

DSB-SC Experiment

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1.Abstract:

This experiment aims to understand the double-sideband suppressed carrier (DSBsc) from a theoretical and practical perspective. In theory, DSBsc is learned from all aspects and its knowledge is delved into deeper, while in practice it is learned how to create a DSBsc, demodulate it, and study this aspect on the surface. DSBsc, and checked if there is an impact of non-coherent problems on the practical implementation of these methods

2.Theory:

2.1. double-sideband suppressed carrier:

DSB-SC stands for Double Sideband Suppressed Carrier, a technology used in communications systems that produces two identical sidebands, the carrier being suppressed or completely removed. Because it does not contain any useful information and sending it causes a loss of power, so they resort to sending sidebands that contain only information. In order to save energy. There are many benefits to DSB-sc, including: Its carrier cancellation reduces power consumption, making it more energy efficient compared to other types of modulation. Furthermore, by only using the primary sidebands, DSB-sc contributes to a more efficient use of the channel. Connection. On the other hand, there are drawbacks resulting from this type of modulation, including: demodulation of DSB-SC signals requires simultaneous detection, which requires careful coordination between the receiver and the transmitter. Moreover, demodulating DSB-SC signals can be relatively expensive.[1]

2.1.1. Modulation of the DSB-SC:

In the process of Amplitude Modulation, we form a blended signal that includes a carrier wave and two sidebands. Sidebands can be likened to frequency bands, akin to the lower and higher companions of the primary carrier wave.[2]

Mathematical Expressions:

Carrier signal: $c(t)=A_c\cos(2\pi f_c t)$ ------------Modulating signal: $m(t)=A_m\cos(2\pi f_m t)$

Modulated signal: $s(t)=m(t)c(t) \Rightarrow s(t)=A_m A_c\cos(2\pi f_m t)\cos(2\pi f_c t)$

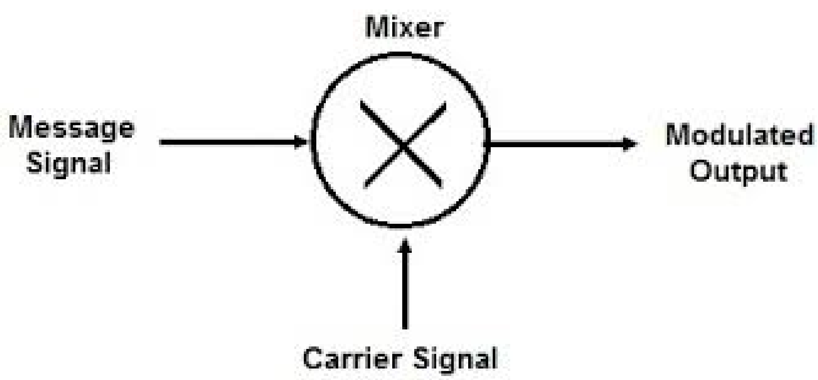


Figure 1.Modulation of the DSB-SC

2.1.2.Demodulation of the DSB-SC:

It is the process of extracting the original message signal from a modulated waveform by DSB-SC.

2.1.2.1.Coherent Demodulation of DSB-SC:

Coherent demodulation is a technique that relies on maintaining synchronization or coherence between the local oscillator of the receiver and the carrier frequency of the incoming signal. This technique is done by multiplying the DSB-SC signal with the carrier signal, the resulting signal is then passed through a low-pass filter as shown in the following image.

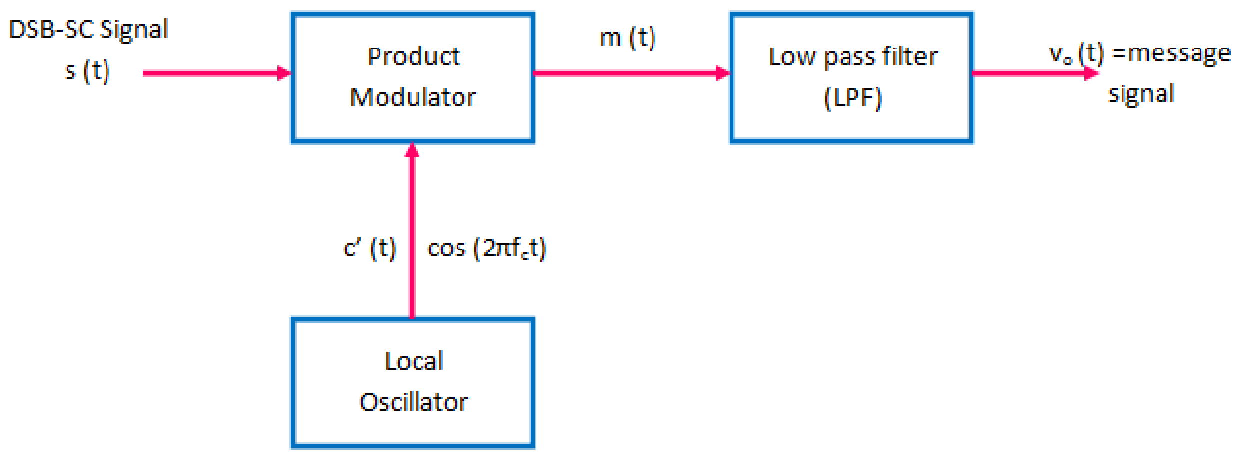


Figure 2.Coherent Demodulation of DSB-SC

2.1.2.2. Non- Coherent Demodulation of DSB-SC

Noncoherent demodulation means the receiver doesn't have to perfectly sync with the carrier frequency. It works well for signals with a full carrier, except for independent sideband signals. For those, we need coherent demodulation. But for other signals like single sideband, double sideband, noncoherent demodulation works just fine.[3]

3. Procedure, Data analysis and Discussion:

3.1. DSB-SC modulation in the time and frequency domains

We created a Double Sideband Suppressed Carrier (DSB-SC) signal represented by s(t)=Acm(t)cos(2πf c t). The goal of this step was to analyze the signal in the time and frequency domains and observe the change that occurs in the signal by changing the values. Parameters (fm, fc, Am, Ac).We began by creating the message signal m(t)=Amcos(2πfmt),followed by making the carrier signal c(t)=Accos(2πfct)c(t)=Accos(2πfct),After that, we generated the DSB-SC signal s(t)=Acm(t)cos(2πfct) in both the time and frequency domains.

3.1.1.case1:Am=1 ,fm=1000 ,Ac=1 ,fc=10000

In time domain :

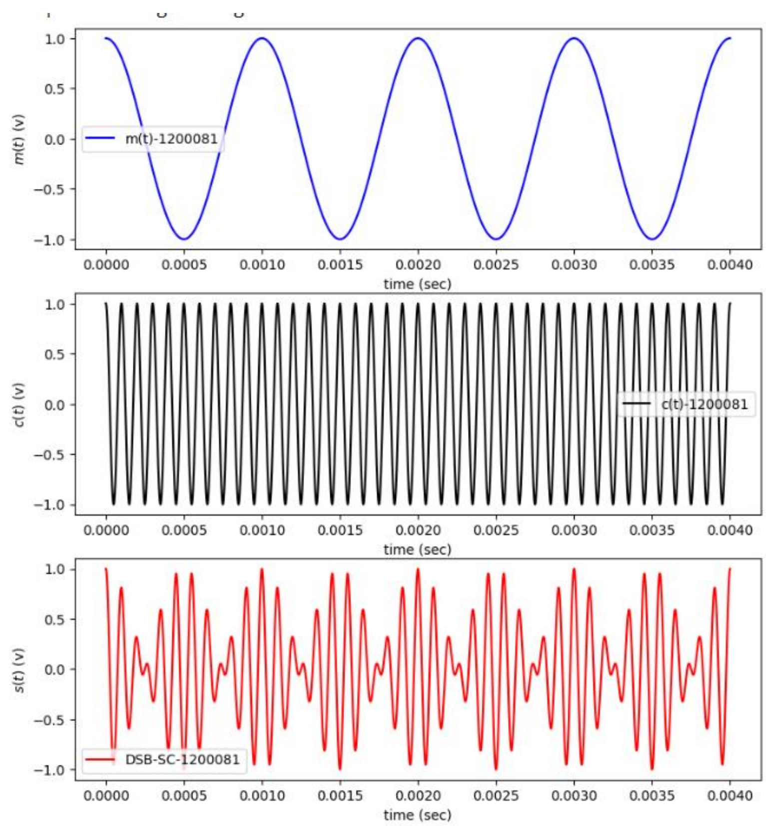


Figure 3.M(t),C(t),S(t) in time domain case1

From the diagrams we notice that the amplitude of the message signal is 1, and the amplitude of the carrier signal is 1, which is similar to the amplitude It is found in the coefficients that were previously entered in case 1. Also, when s (t) is obtained, as in the following equation $s(t) = m(t) * c(t)$, it results that the signal amplitude is equal to 1, and this is what is observed from the diagram $s\ (t)$

In frequency domain:

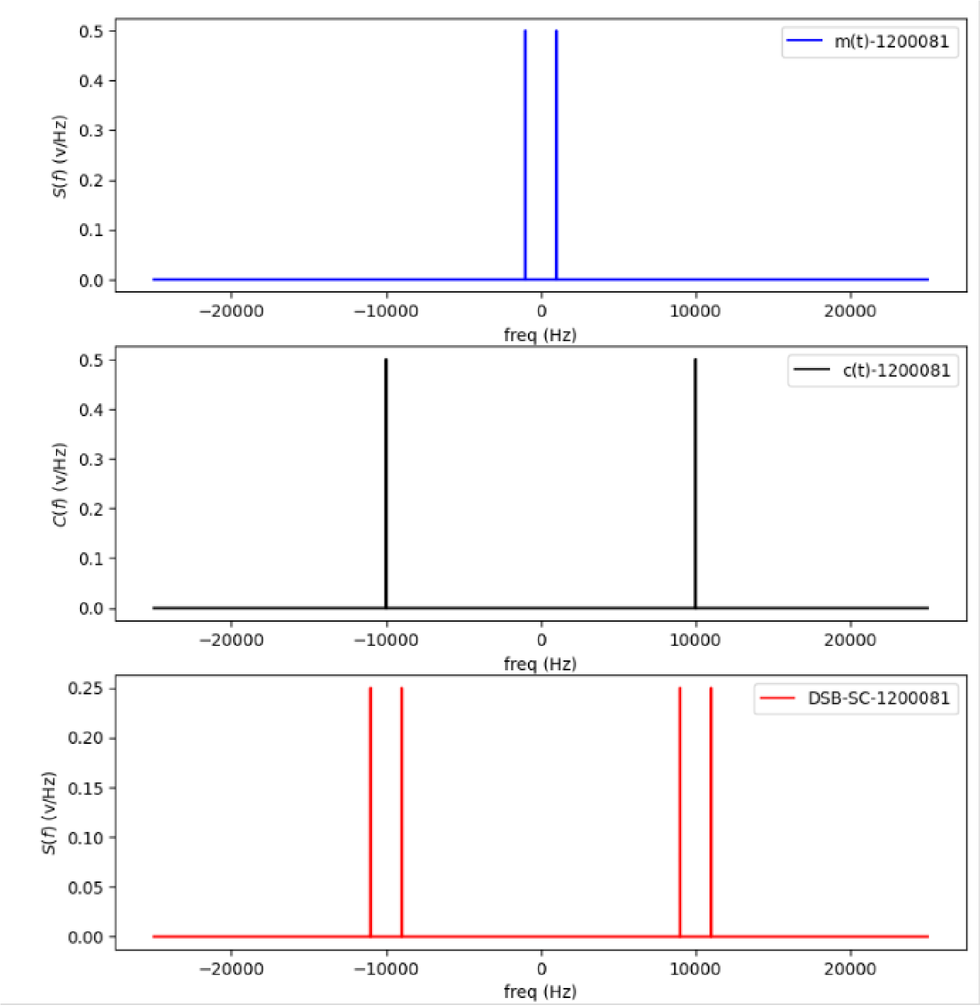


Figure 4.M(t),C(t),S(t) in frequency domain case1

We note from the plot that the frequency of the message signal is 1 kHz, and the frequency of the carrier signal is 10 kHz, as we set in case 1.And from the drawing of s (t), we notice that it has two deltas, the first at t fc+fm=11000, and the second at fc.-fm=9000 and has amplitude =0.25.

3.1.2.case2:Am=2,fm=1500 ,Ac=2 ,fc=15000

in time domain:

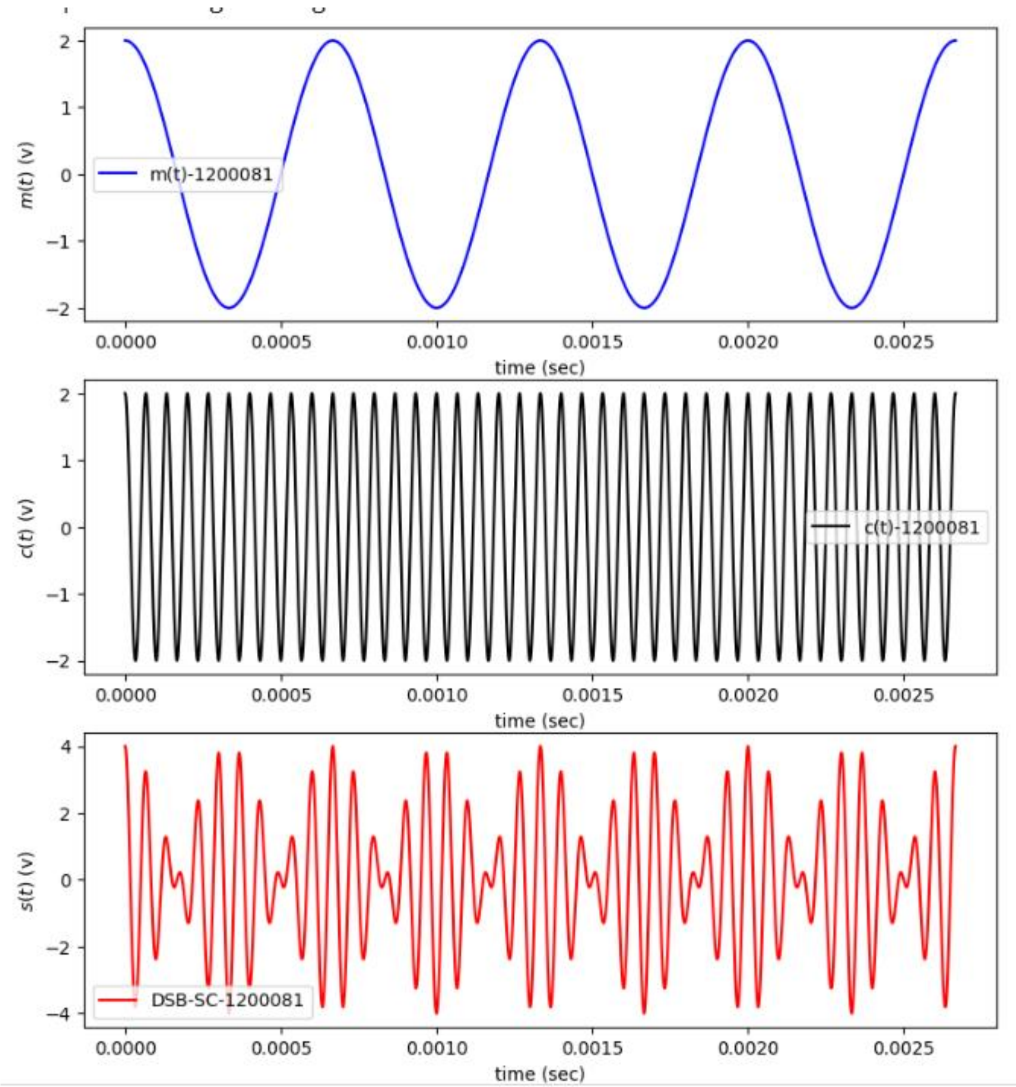


Figure 5.M(t),C(t),S(t) in time domain case2

From the diagrams we notice that the amplitude of the message signal is 2, and the amplitude of the carrier signal is 2, which is similar to the amplitude It is found in the coefficients that were previously entered in case 1. Also, when s (t) is obtained, as in the following equation $s(t) = m(t) * c(t)$, it results that the signal amplitude is equal to 4, and this is what is observed from the diagram $s\ (t)$

In frequency domain:

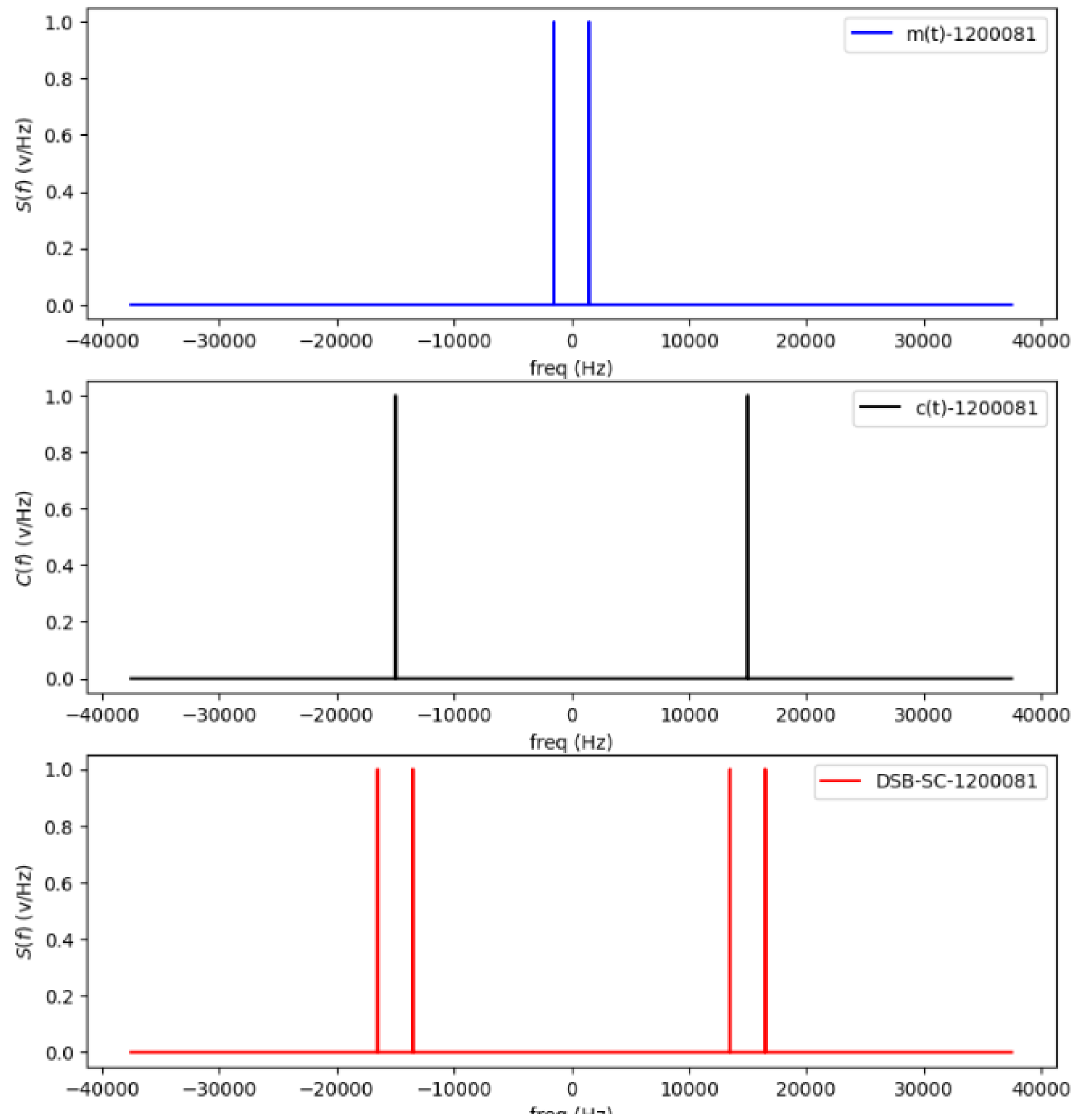


Figure 6.M(t),C(t),S(t) in frequency domain case2

We note from the plot that the frequency of the message signal is 1.5 kHz, and the frequency of the carrier signal is 15 kHz, as we set in case 1.And from the drawing of s (t), we notice that it has two deltas, the first at t fc+fm=16.5k, and the second at fc.-fm=13.5 and has amplitude =1, and this corresponds to the values of the second case

3.2. DSB-SC modulation of a message signal with multiple harmonics:

Computed and plotted the signal and spectrum of x(t)=Am1 cos(2πf m1 t)+A m2 cos(2πf m2 t)+A m3cos(2πf m3t).

3.2.1.case1:

```
.Am1=3,fm1=1000,Am2=2,fm2=2000,Am3=1,fm3=3000,Ac=1,fc=10000,fm1_3=[fm1,fm2,fm3]
```

Time domain:

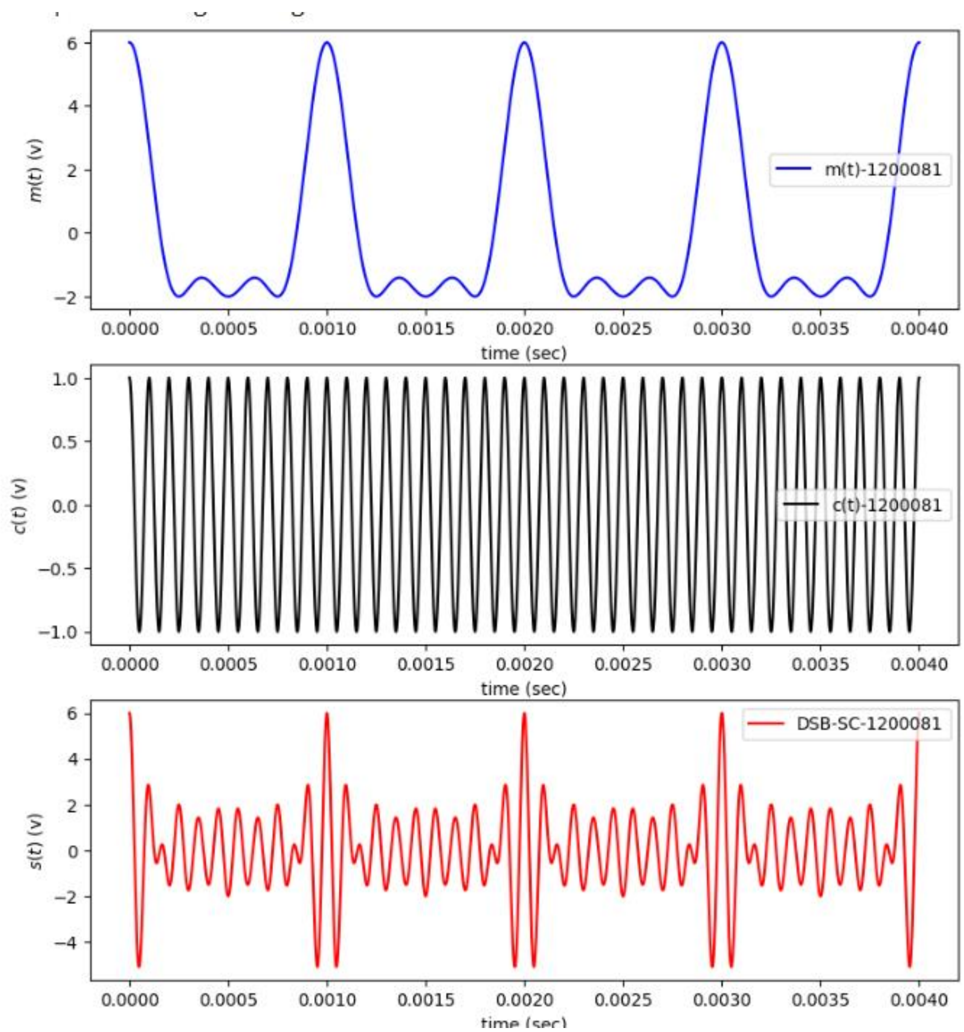


Figure 7.DSB-SC modulation of a message signal with multiple harmonics in time domain case1

mathematical equations for this case :

m1(t)=3cos(2pi1000t), m2(t)=2cos(2pi2000t), m1(t)= cos(2pi3000t) so the Amplitude for Massage signal = 6 and this is what we got in the drawing.

C(t)=cos(2pi10000t) so the Amplitude for Massage signal = 1 and this is what we got in the drawing.

s(t)=(3cos(2π×1000×t)+2cos(2π×2000×t)+cos(2π×3000×t))cos(2pi10000t) ,and we got the amplitude =6

Frequency domain:

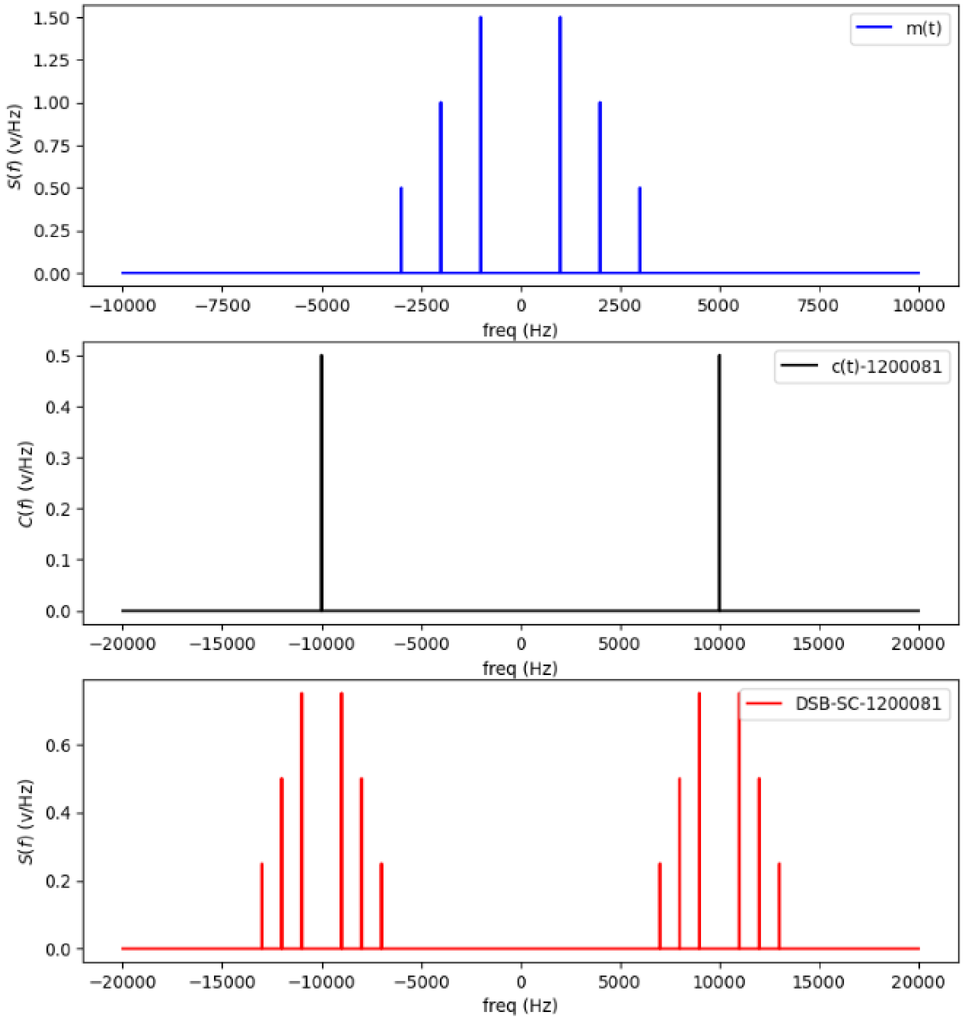


Figure 8.DSB-SC modulation of a message signal with multiple harmonics in frequency domain case1

$M(f)=Am1/2(\delta(f-fm1)+\delta(f+fm1))+Am2/2(\delta(f-fm2)+\delta(f+fm2))+Am3/3(\delta(f-fm3)+\delta(f+fm3))$

$M(f)=3/2(\delta(f-1000)+\delta(f+1000))+ (\delta(f-2000)+\delta(f+2000))+1/2(\delta(f-3000)+\delta(f+3000))$

$C(f)= C(f)=1/2(\delta(f-10000)+\delta(f+10000))$

$s(f)=3/4\delta(f-9000)+\delta(f+9000))+3/4(\delta(f-11000)+\delta(f+11000))+1/2(\delta(f-8000)+\delta(f+8000))+1/2(\delta(f-12000)+\delta(f+12000))+1/4(\delta(f-7000)+\delta(f+7000))+1/4(\delta(f-13000)+\delta(f+13000))$

from the plot we observe the following:

M(f) represents the modulation signal with frequencies at 1000, 2000, and 3000 and an amplitude 1.5,1,0.5

C(f) is the carrier signal with a frequency of 10000, and an amplitude of 1/2.

s(f) is the modulated signal, which is a combination of delta functions at frequencies 7000, 8000, 9000, 11000, 12000, and 13000. and an amplitude of ¾,1/2,1/4

3.2.2.case2:

```
.Am1=2,fm1=500,Am2=1,fm2=1000,Am3=0.5,fm3=2000,Ac=1,fc=9000,fm1_3=[fm1,fm2
,fm3]
```

Time domain:

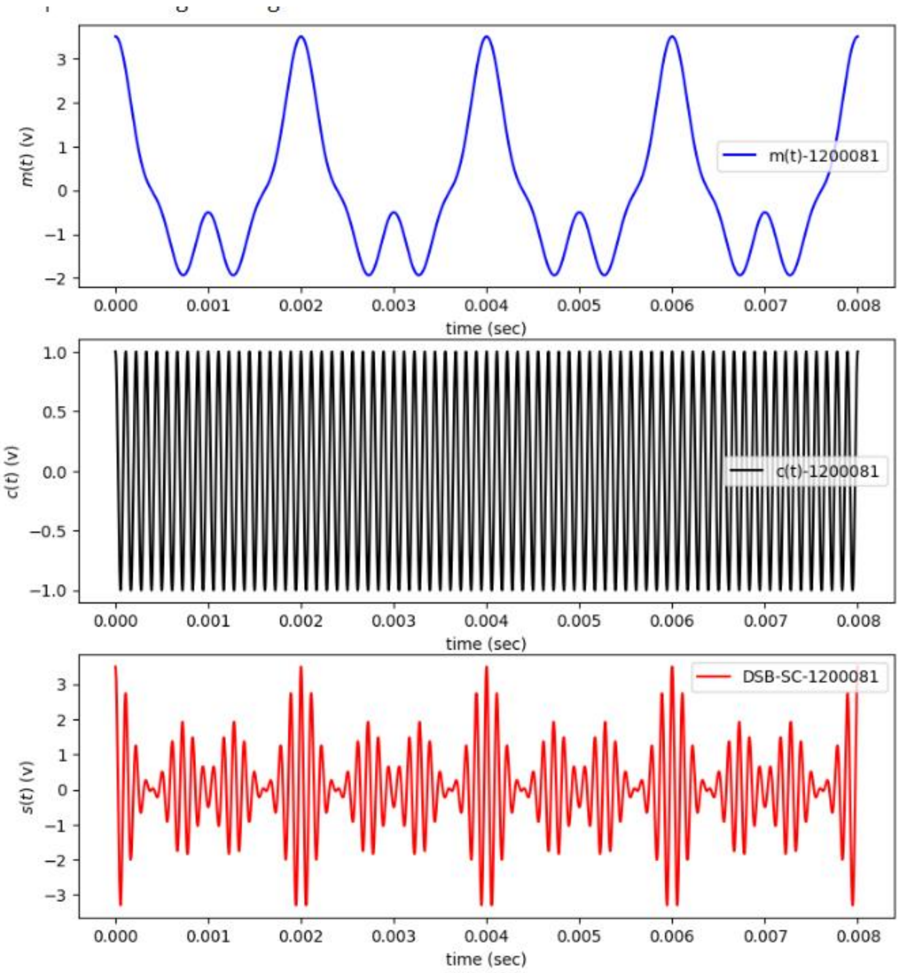


Figure 9DSB-SC modulation of a message signal with multiple harmonics in time domain case2

mathematical equations for this case :

m1(t)=2cos(2pi500t), m2(t)=cos(2pi1000t), m3(t)=0.5 cos(2pi2000t) so the Amplitude for Massage signal = 3.5 and this is what we got in the drawing.

C(t)=cos(2pi9000t) so the Amplitude for Massage signal = 1 and this is what we got in the drawing.

s(t)=(2cos(2pi×500×t)+cos(2pi×1000×t)+cos(2π×2000×t))cos(2pi9000t) ,and we got the amplitude =3.5

Frequency domain:

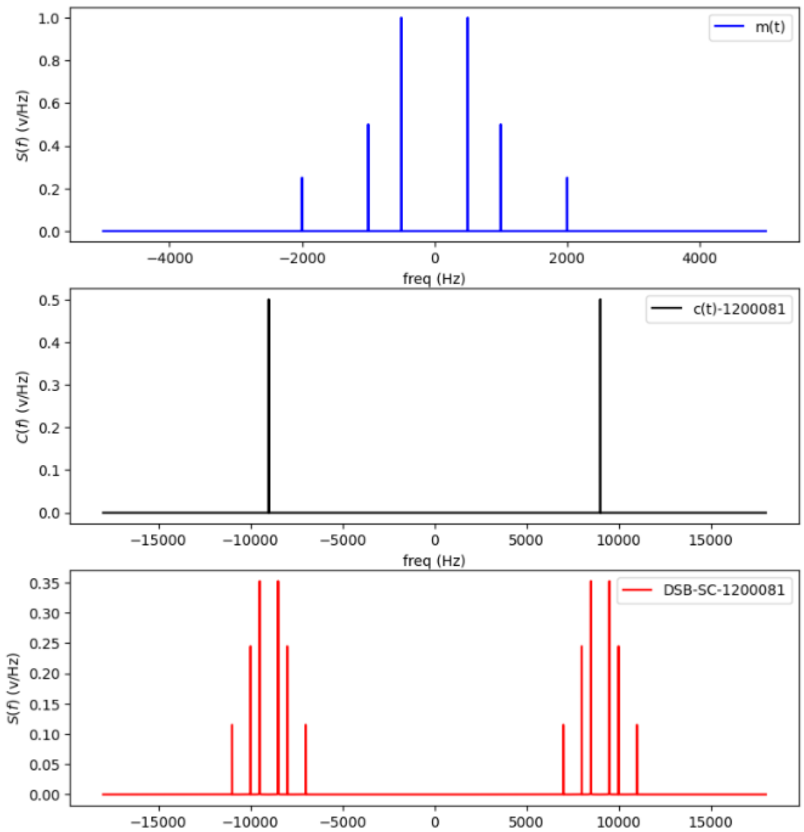


Figure 10.Figure 8.DSB-SC modulation of a message signal with multiple harmonics in frequency domain case2

M(f)=Am1/2(δ(f−fm1)+δ(f+fm1))+Am2/2(δ(f−fm2)+δ(f+fm2))+Am3/3(δ(f−fm3)+δ(f+fm3))

M(f)=3/2(δ(f−1000)+δ(f+1000))+ (δ(f−2000)+δ(f+2000))+1/2(δ(f−3000)+δ(f+3000))

C(f)= C(f)=1/2(δ(f−10000)+δ(f+10000))

s(f)=3/4δ(f−9000)+δ(f+9000))+3/4(δ(f−11000)+δ(f+11000))+1/2(δ(f−8000)+δ(f+8000))+1/2(δ(f −12000)+δ(f+12000))+1/4(δ(f−7000)+δ(f+7000))+1/4(δ(f−13000)+δ(f+13000))

from the plot we observe the following:

M(f) represents the modulation signal with frequencies at 1000, 2000, and 3000 and an amplitude 1.5,1,0.5

3.3. Demodulation of DSB-SC modulation using coherent demodulation

we demodulated a DSB-SC signal using coherent demodulation.first we multiplied the DSB-SC signal by the carrier signal r(t)=c(t)s(t)=c(t)m(t)c(t)=A c2m(t)cos 2(2πf ct). Following this, we applied a Low-Pass Filter (LPF) to retrieve the original message signal

in time domain:

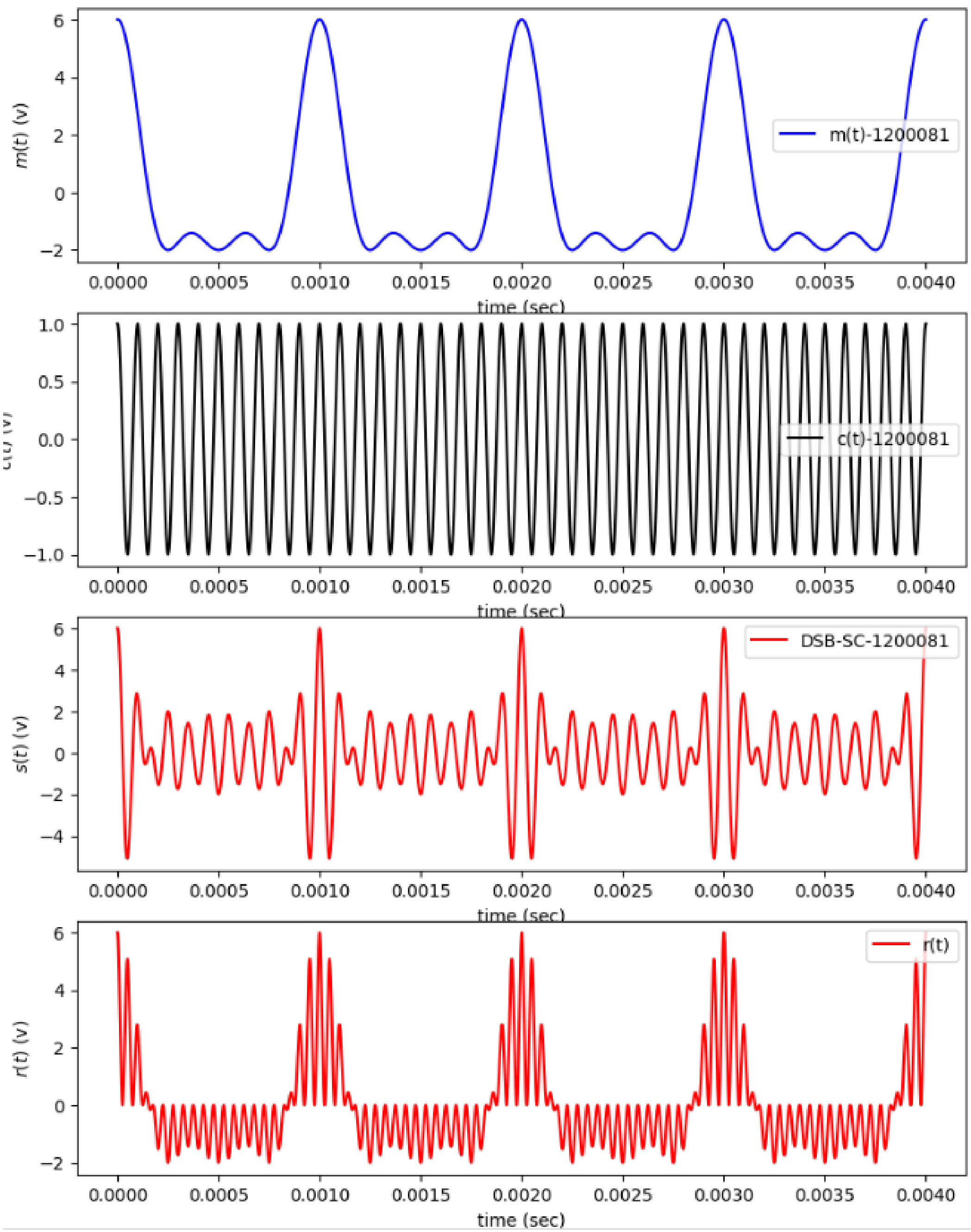


Figure 11.Demodulation of DSB-SC modulation using coherent demodulationin time domain

In frequency domain:

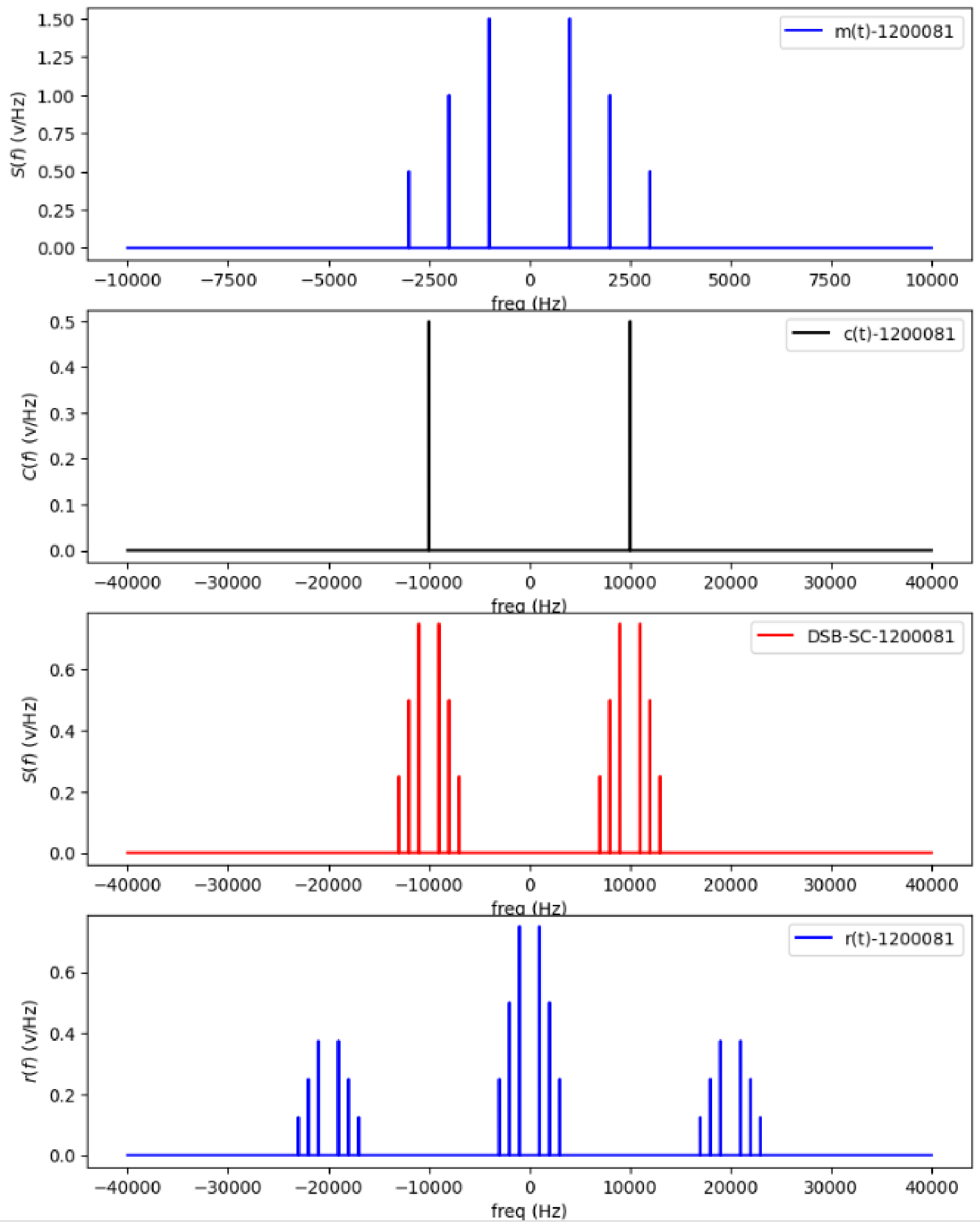


Figure 12.Demodulation of DSB-SC modulation using coherent demodulation in frequency domain

As can be observed from the amplitude spectrum of R(t), a Low pass filter (LPF) is needed to recover the modulated signal $m\hat{}(t)$ and remove the high freqiency components at $2f_c$ and $-2f_c$.

Here the the plot of frequency response of the LPF

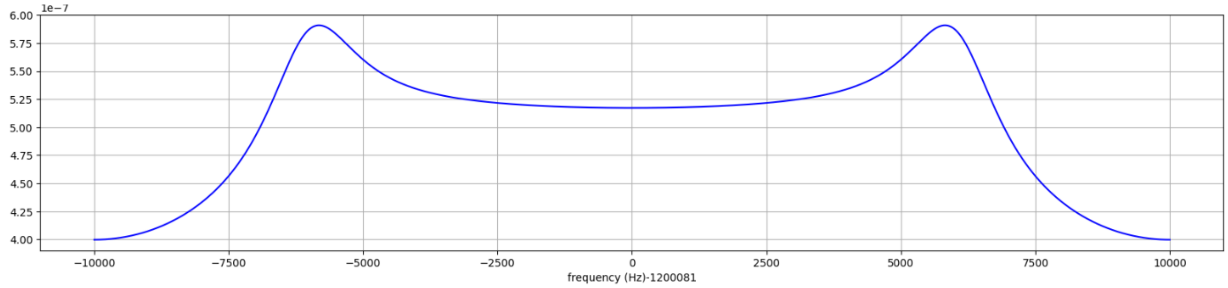
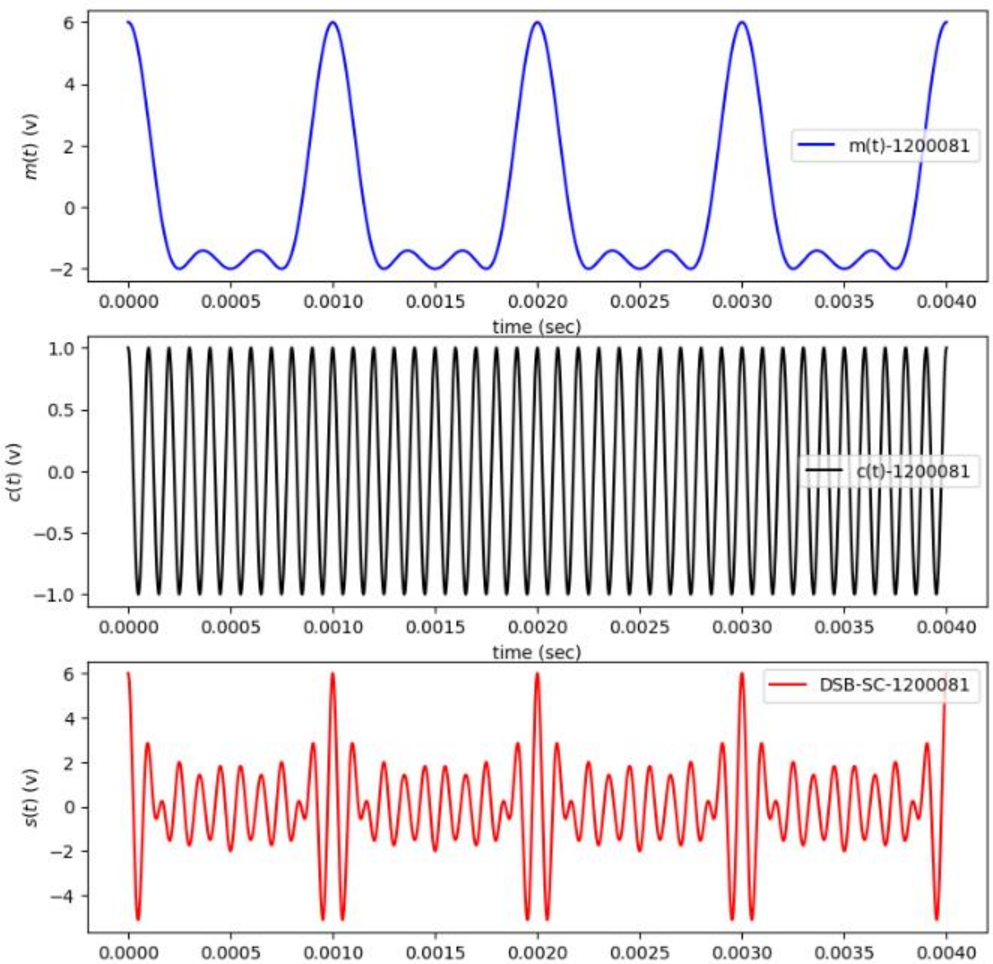


Figure 13.frequency response of the LPF

Now We applied the filter with f 3dB =BW and observed the output. BW represented the bandwidth of m(t).

```
Am1=3,fm1=1000,Am2=2,fm2=2000,Am3=1,fm3=3000,Ac=1,fc=10000,fm1_3=[fm1,fm2,
fm3],f3db = 6000forder=5
```

Time domain :



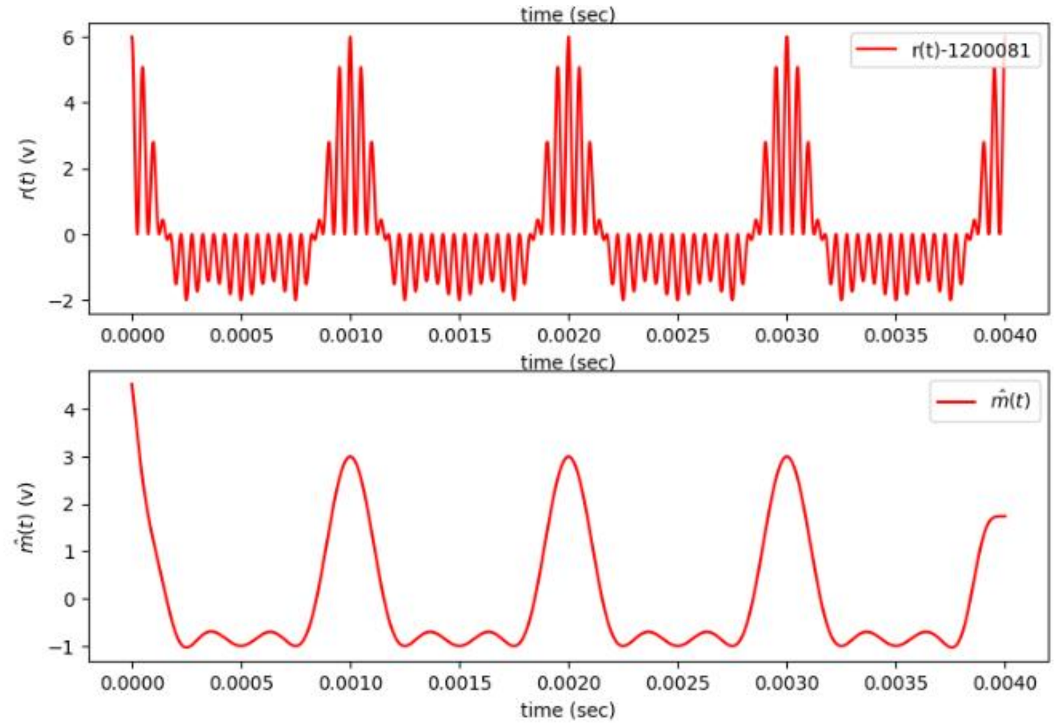


Figure 14 r(t),m^(t) in time domain case 1

The previous diagrams show the demodulation process. The diagram shows the processes of modulation and demodulation, and displays the original message signal, the carrier signal, the modulated signal, and the demodulated signal before and after passing through the low-pass filter. From here we notice that the demodulated signal contains noise, and after it passes through the filter, the filter removes the noise. However, we notice that there is a slight difference between the amplitude of the signal resulting from the filter and the amplitude of the original message signal. The reason for this difference can be attributed to the presence of noise in the received signal, and perhaps the defect is caused by the software program.

In frequency domain :

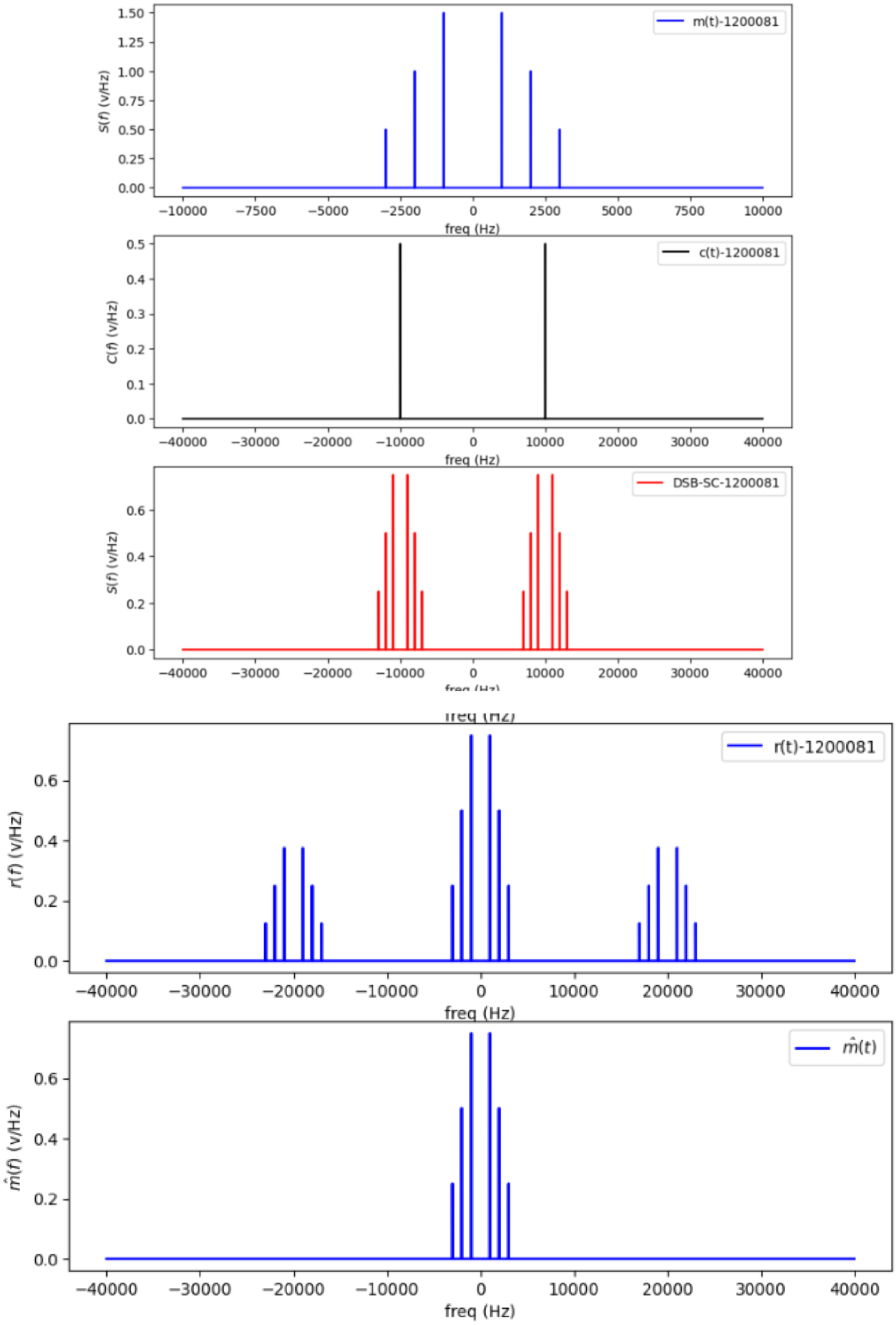
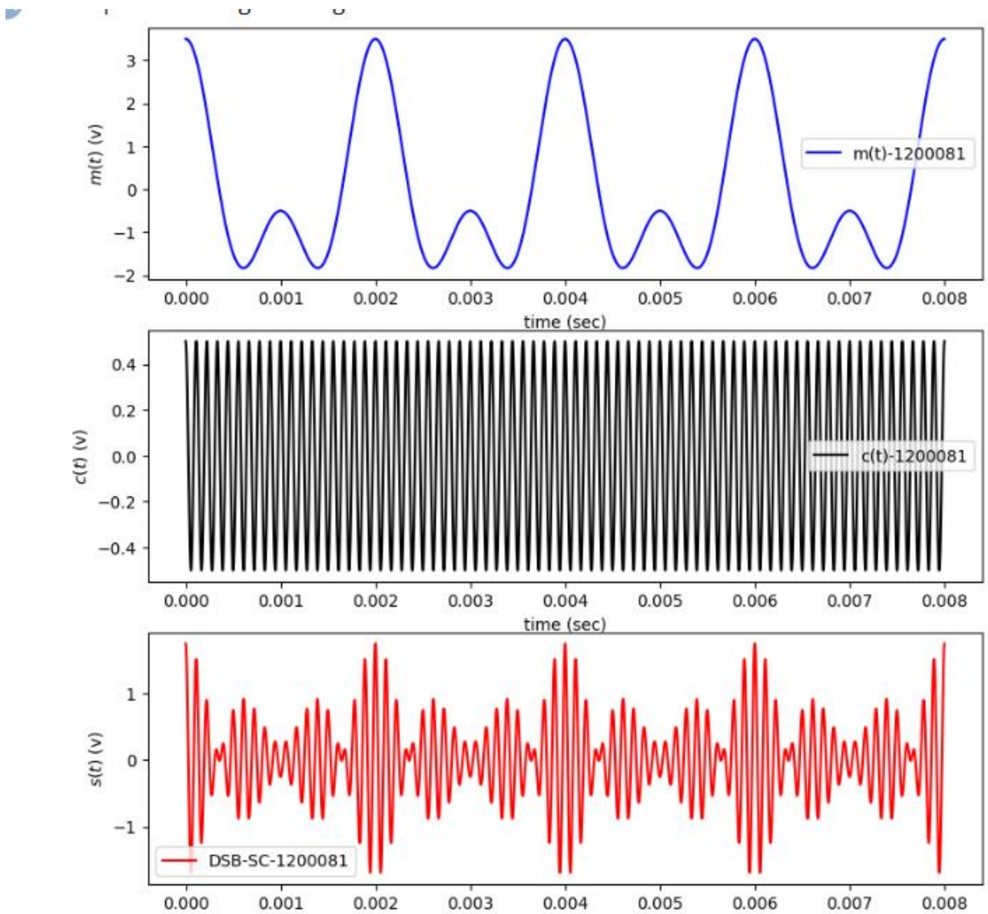


Figure 15. r(t),m^(t) in frequency domain case 1

The previous images show the demodulation process in the frequency domain. These images show the accompanying frequency domain plots of the original message signal, the carrier signal, and the demodulated signal before and after low-pass filtering. It can be seen in the images that R(t) contains noise, After passing through the filter, the filter effectively reduces the attenuation of these high-frequency components, and remove the high frequency components at 2fc and −2fc, and it turns out that there is a difference in amplitude between the filtered signal and the original message signal. This difference can be attributed to noise in the received signal, or Possible software-related problems.

```
Am1=2,fm1=500,Am2=1,fm2=1000,Am3=0.5,fm3=2000,Ac=0.5,fc=9000,fm1_3=[fm1,fm2,fm3],f3db = 4000forder=3
```

In time domain :



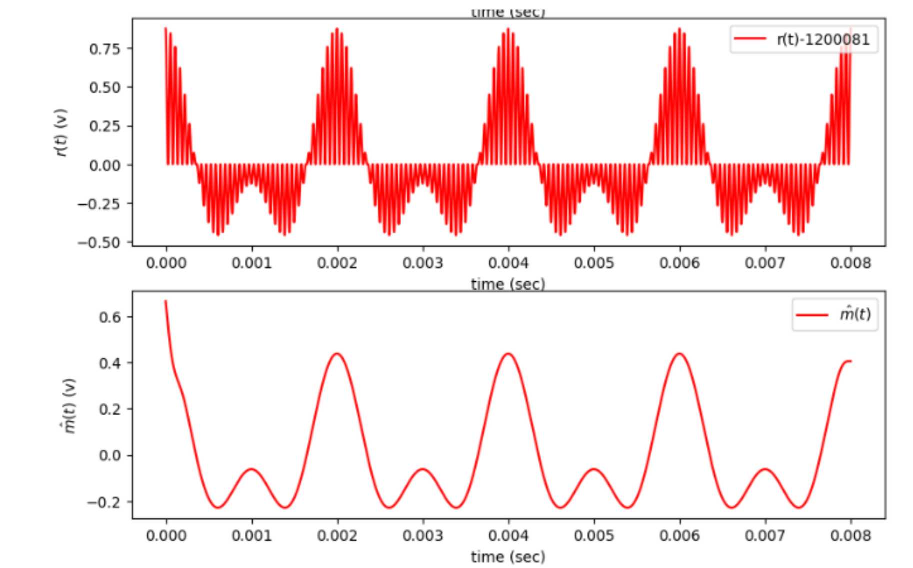
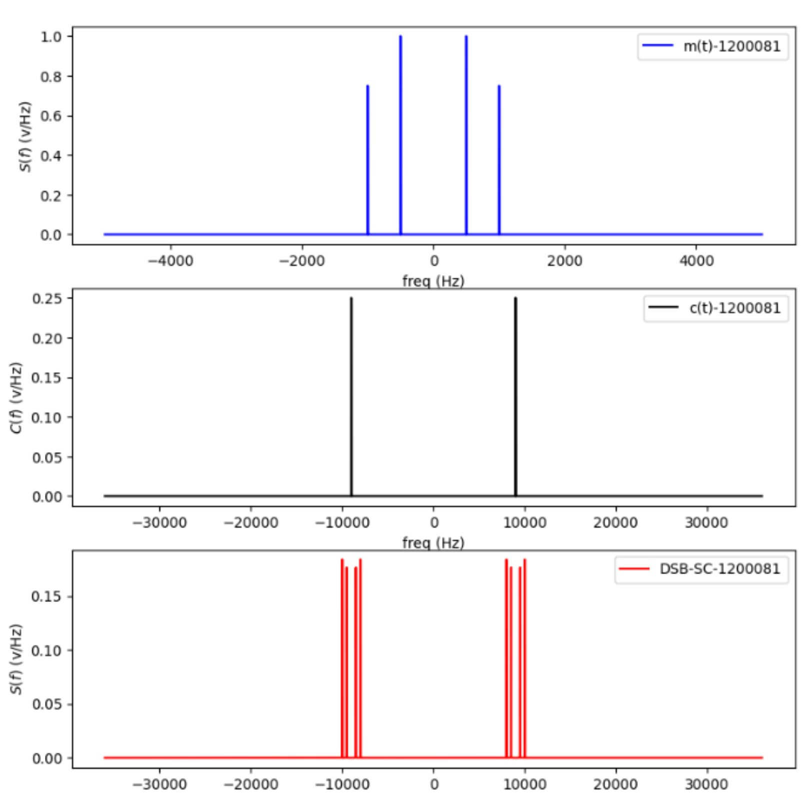


Figure 16. r(t),m^(t) in time domain case 2

We notice that after reducing the values, the noise in r(t) increased, but it disappeared after passing through the filter, and we obtained a message signal that is very close to the original.

Frequency domain:



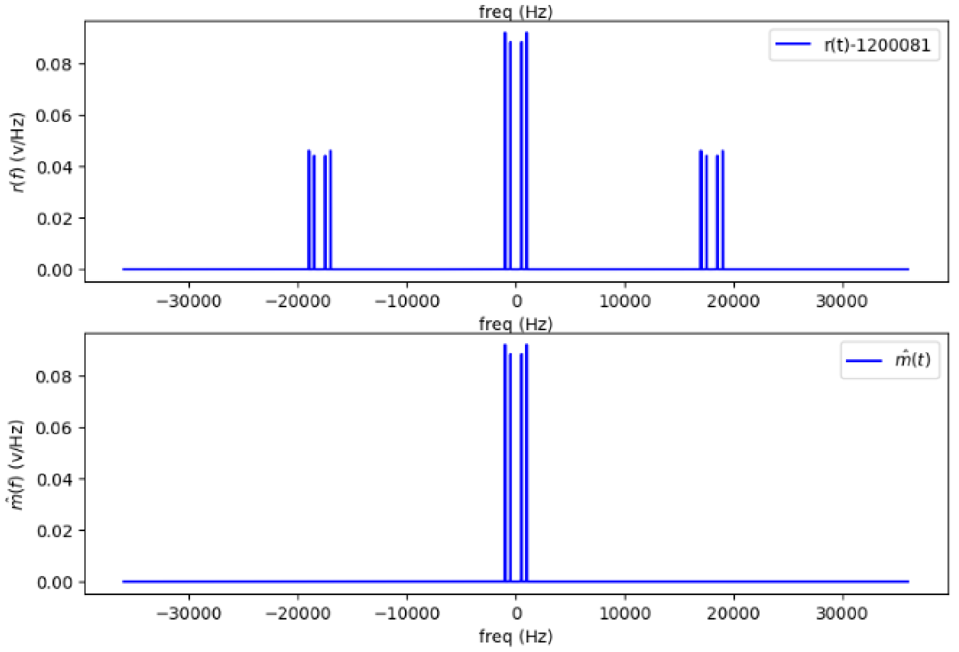
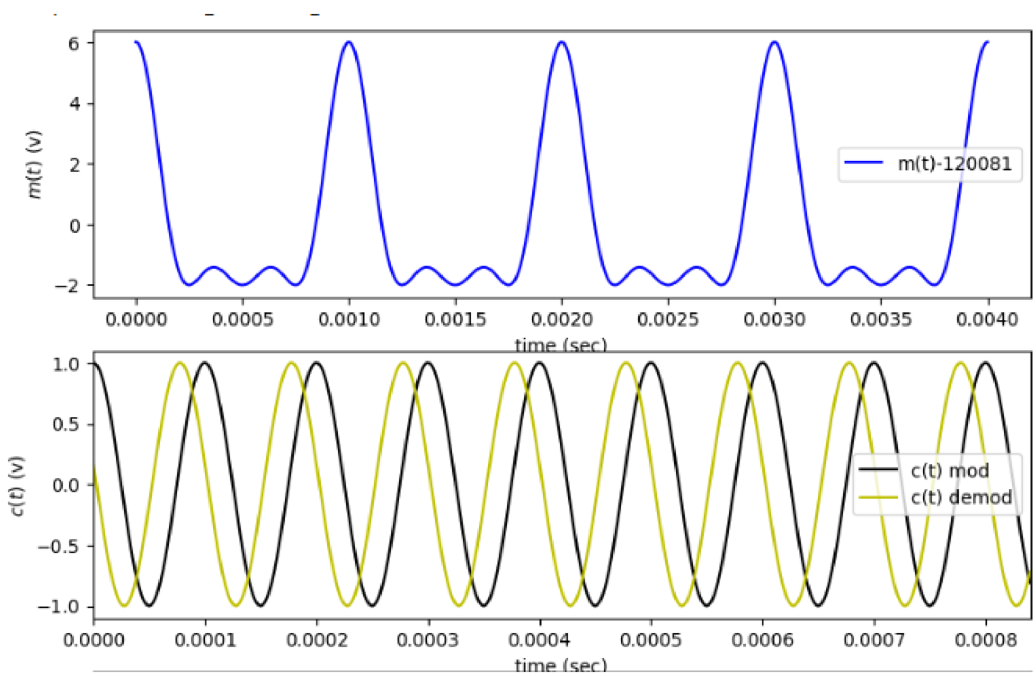


Figure 17. r(t),m^(t) in frequency domain case 2

3.4.DSB-SC modulation/demodulation: effect of carrier noncoherence in phase on demodulated signal

3.4.1.Phi=80

Time domain :



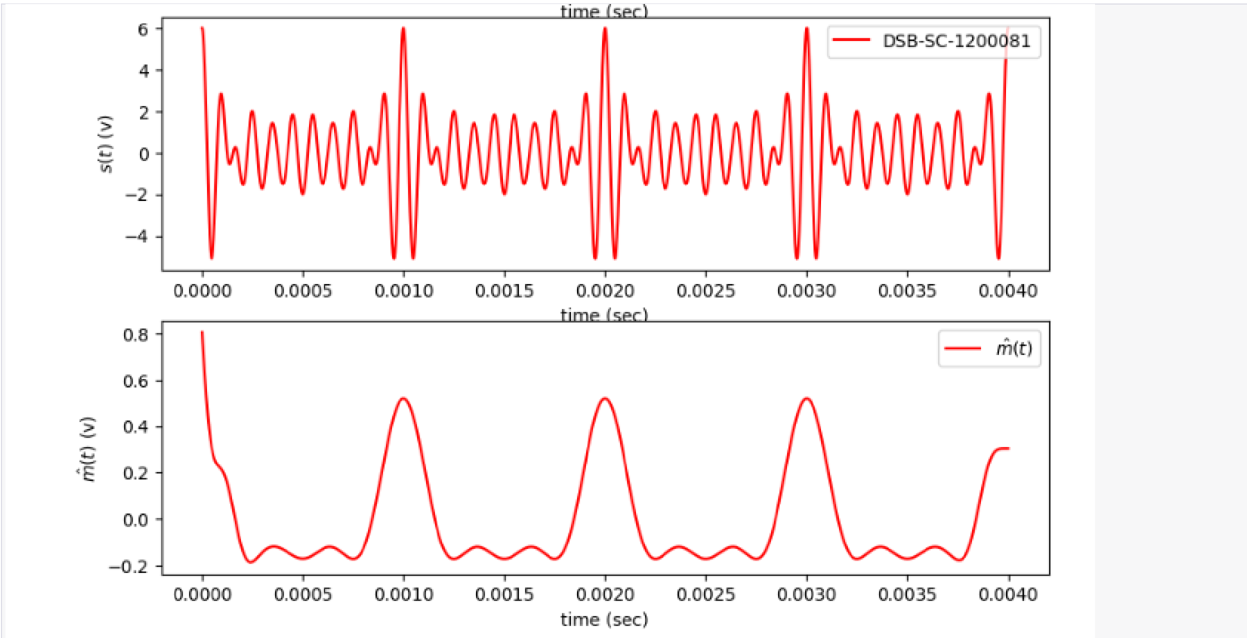
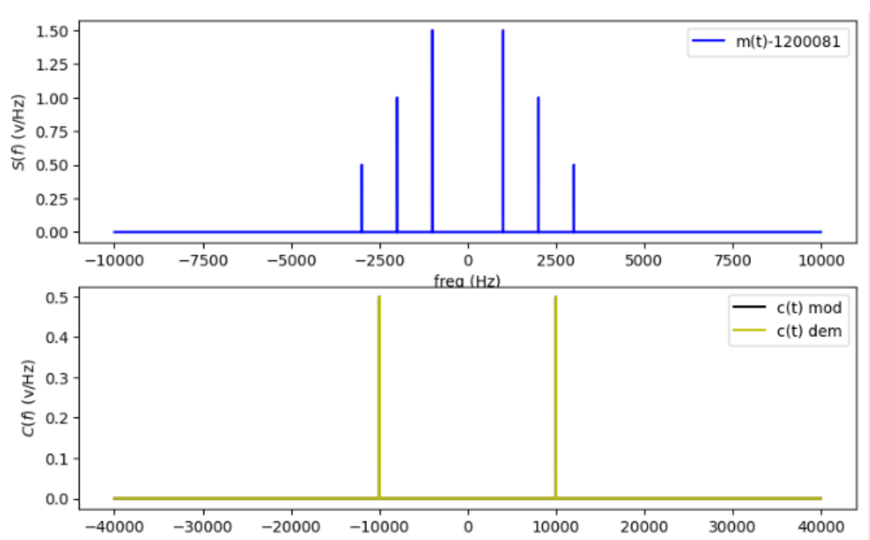


Figure 18 .s(t),m^(t) Φ=80

The incoherence of the phase of the carrier signal introduces differences in the phase relationship between the modified signal and the local oscillator during demodulation. We notice from the images that when the message signal was recovered, there was a significant difference between it and the original signal in terms of amplitude and shape, in which some distortions occurred.

Frequency domain:



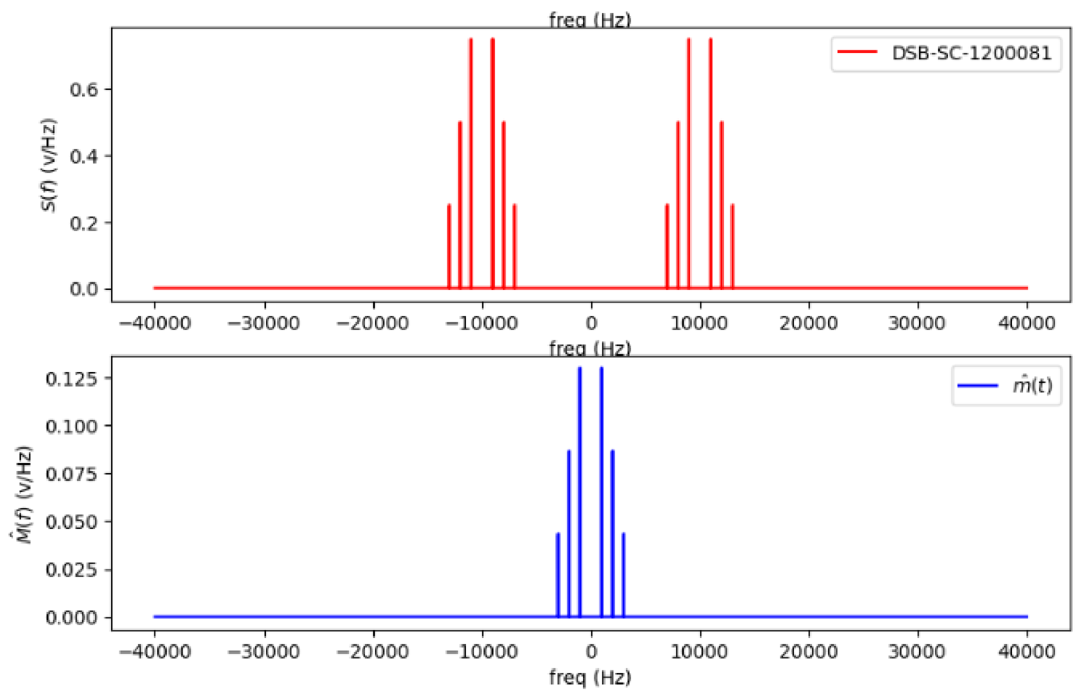
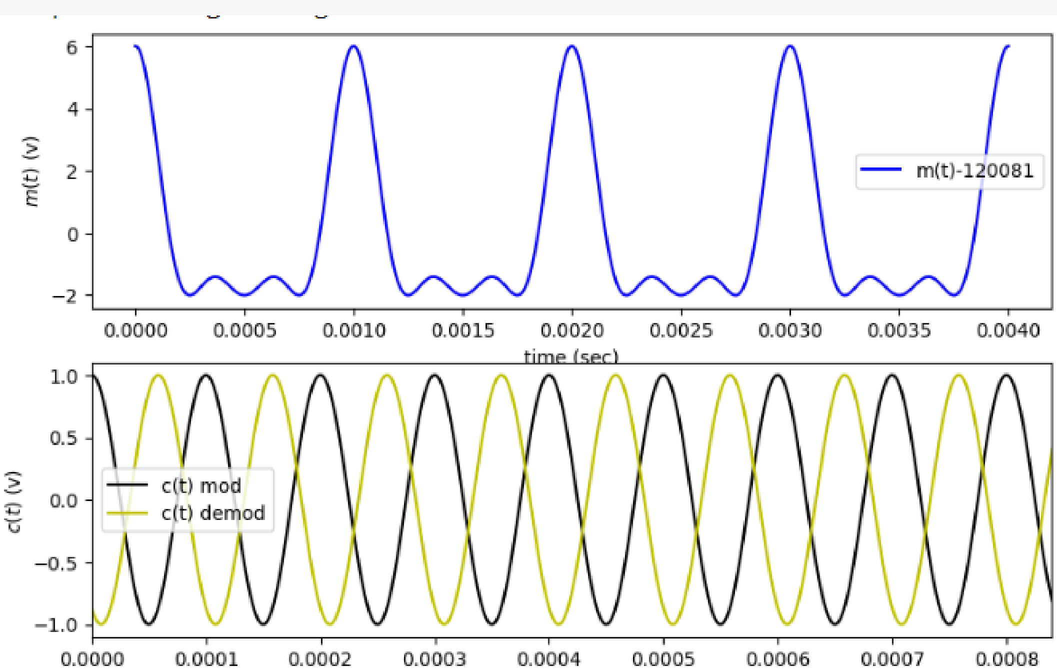


Figure 19.s(f),m^(f) Φ=80

3.4.2.Phi=150

```
Time domain:
```



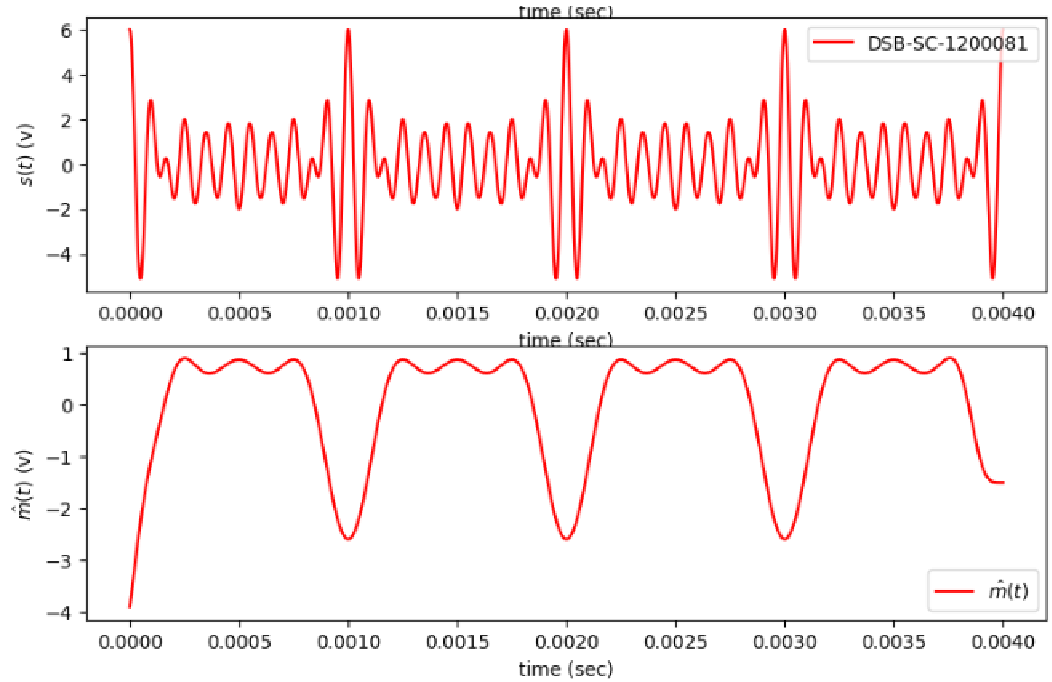
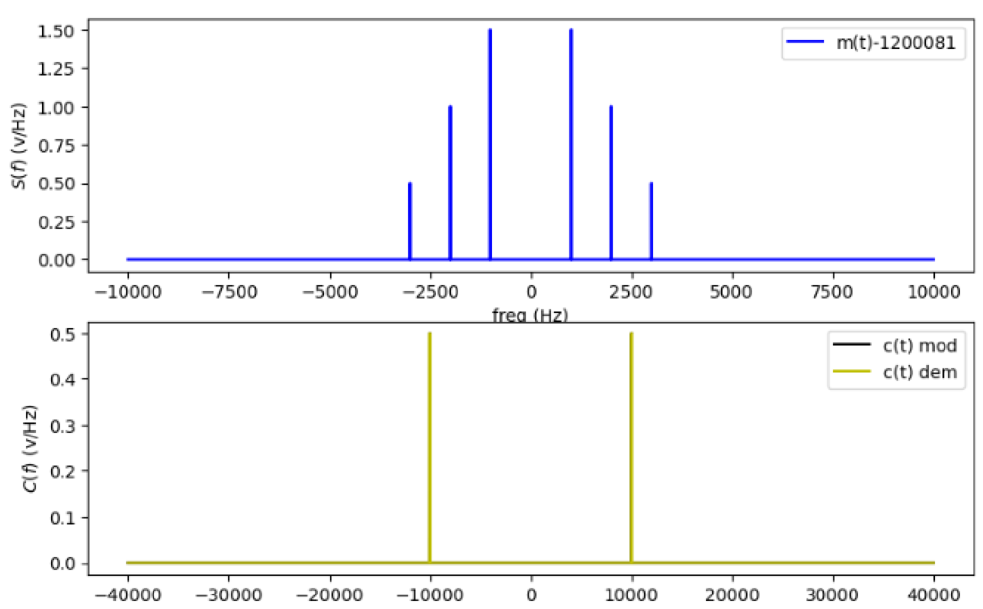


Figure 20 .s(t),m^(t) Φ=150

The degree of distortion is affected by the extent of phase incoherence. We notice when we increased Φ to 150, the distortions increased significantly, causing the recovered signal to be inverted and the opposite of the original signal. From here we conclude the importance of maintaining phase coherence in the demodulation process for DSB-SC modulation. And that coherence in the demodulation process is better at obtaining a recovered signal that is close to the original signal

Frequency domain:



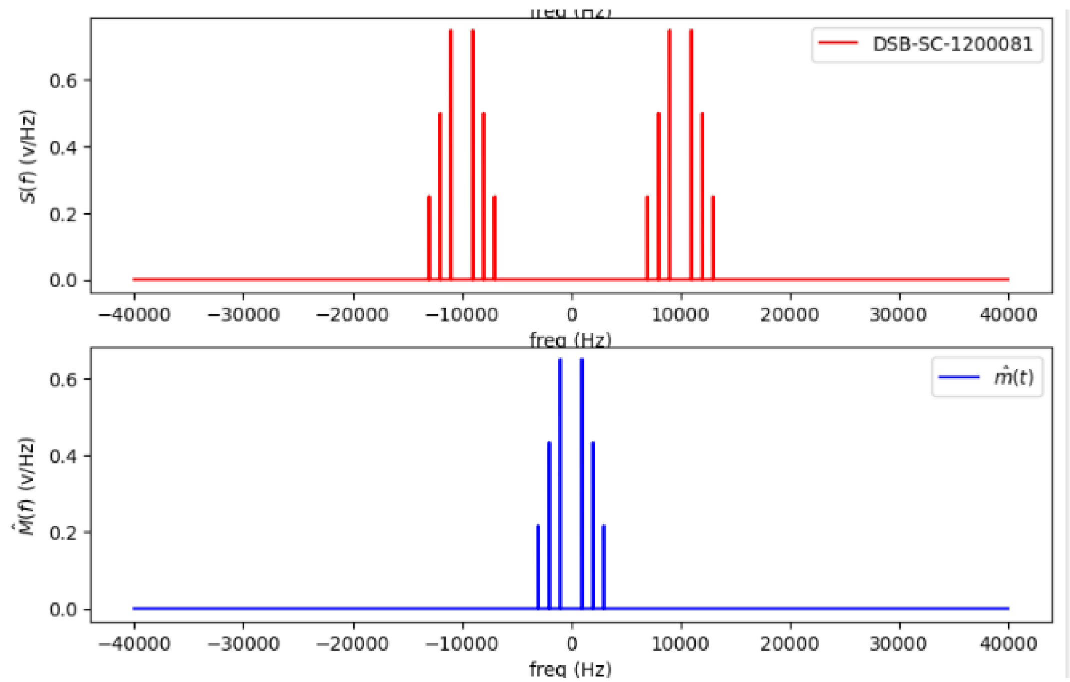


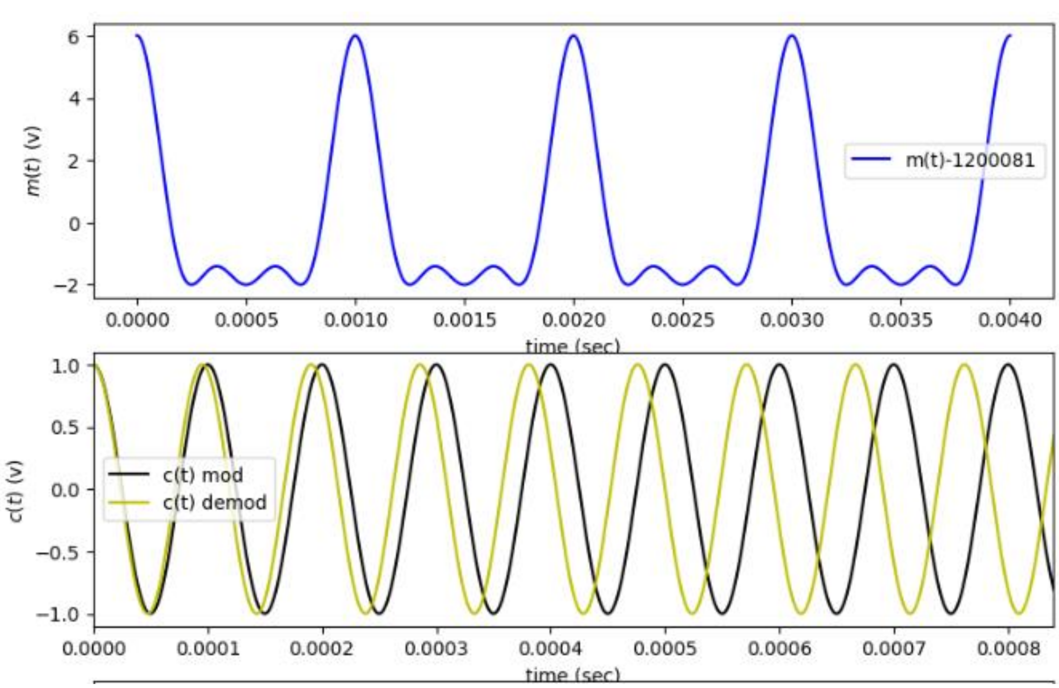
Figure 21.s(f),m^(f) Φ=150

3.5. DSB-SC modulation/demodulation: effect of carrier noncoherence in frequency on demodulated signal

3.5.1.case1:

```
df=500 #carrier noncoherence in frequency
```

time domain:



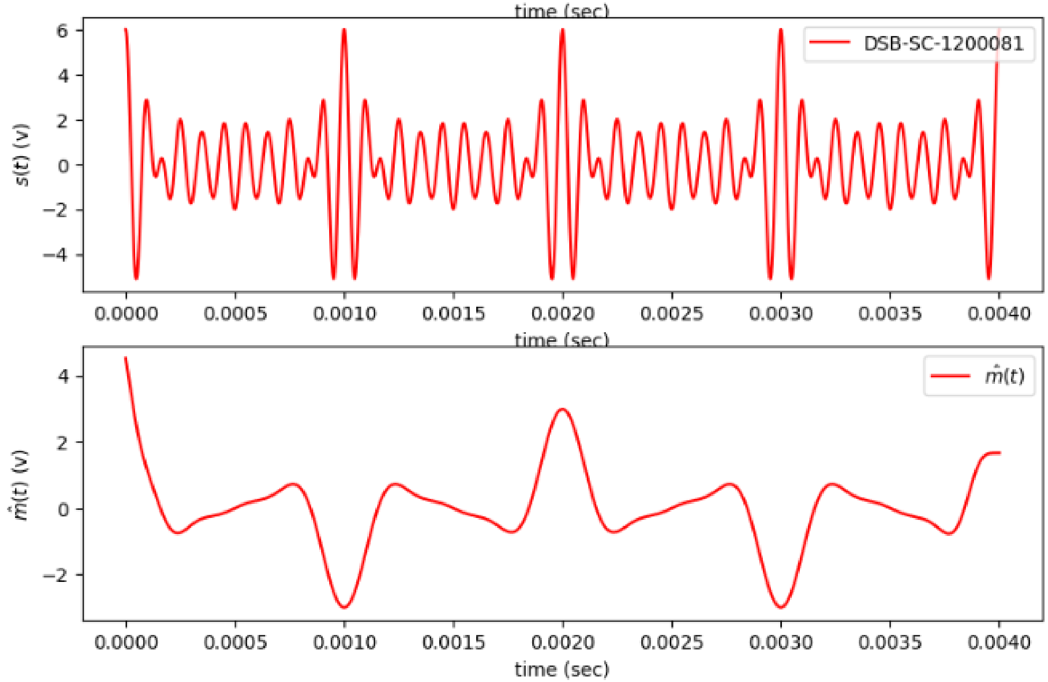
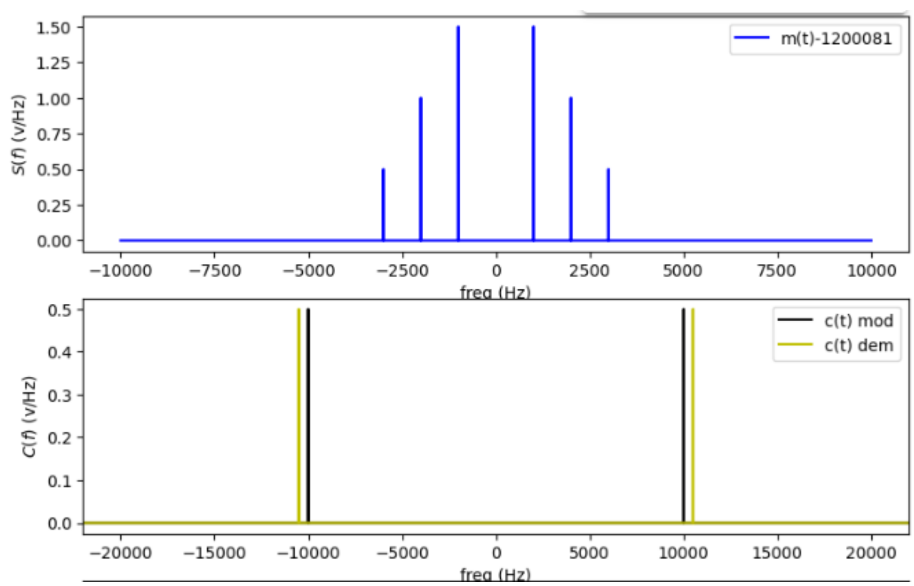


Figure 22.s(t),m^(t)at df=500

When (df = 500 Hz), this means that the carrier frequency does not remain exactly where it is supposed to be. This makes the presence of fluctuation and lack of clarity in the returned message signal and difficulty in understanding it.

Frequency domain:



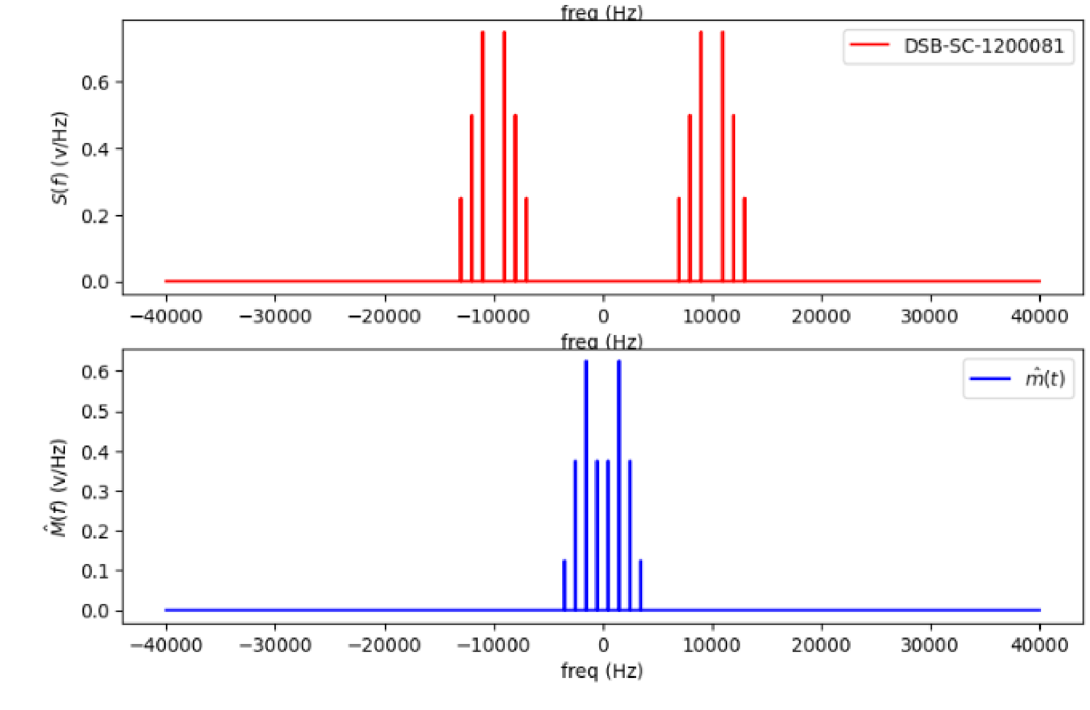
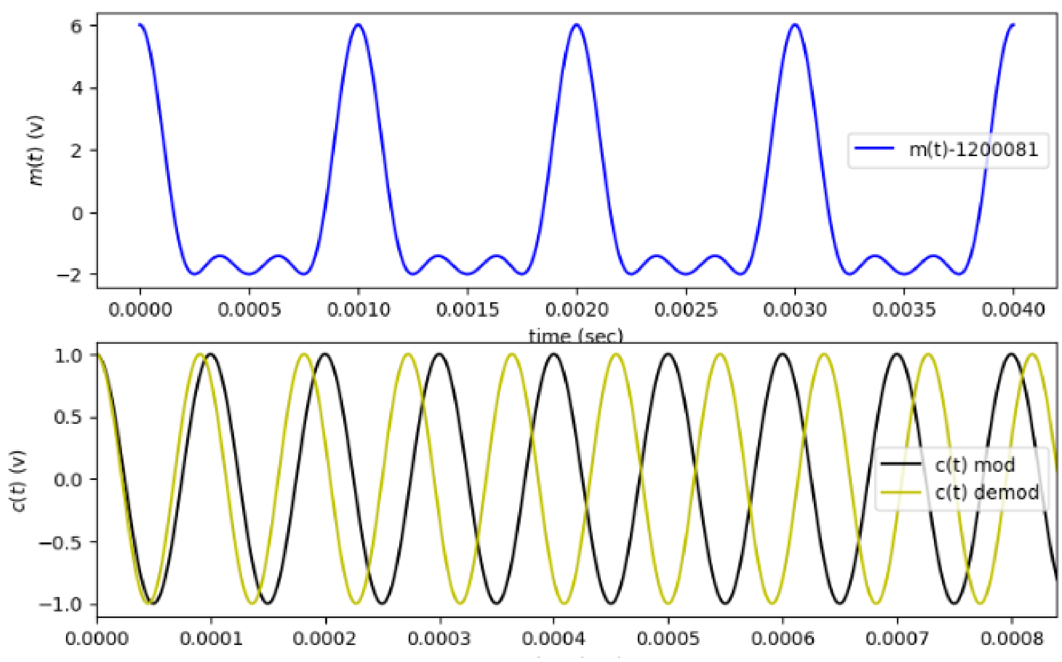


Figure 23.s(f),m^(f)at df=500

With df set to 500 Hz, the previous image shows that. Deviations from the carrier frequency are present, which contribute to the overall spectrum of the recovered signal.

3.5.2.case2:

```
df=1000 #carrier noncoherence in frequency
in time domain:
```



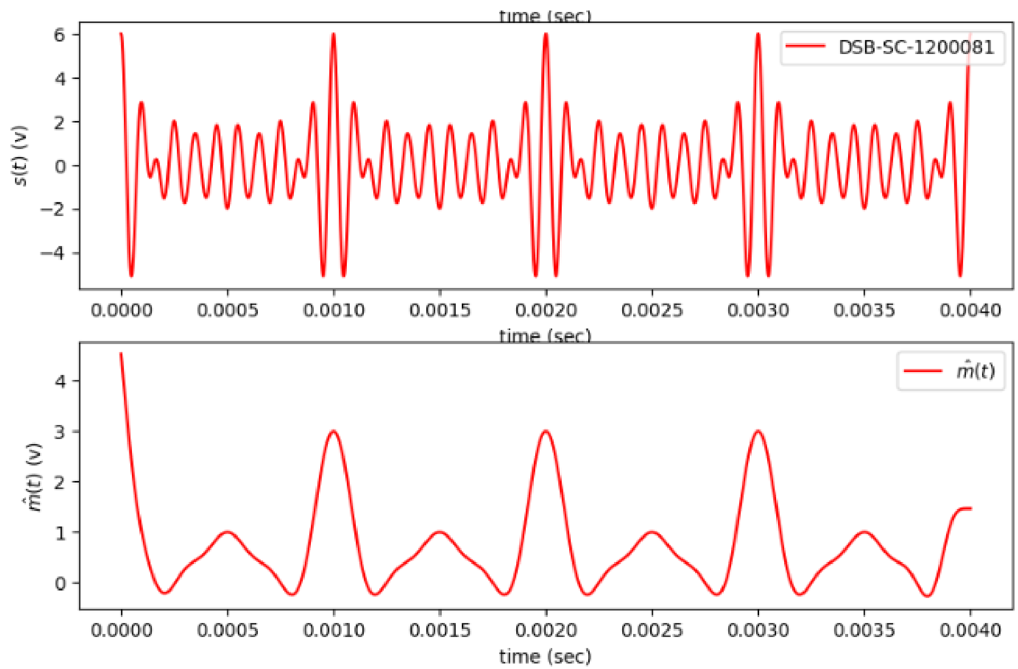
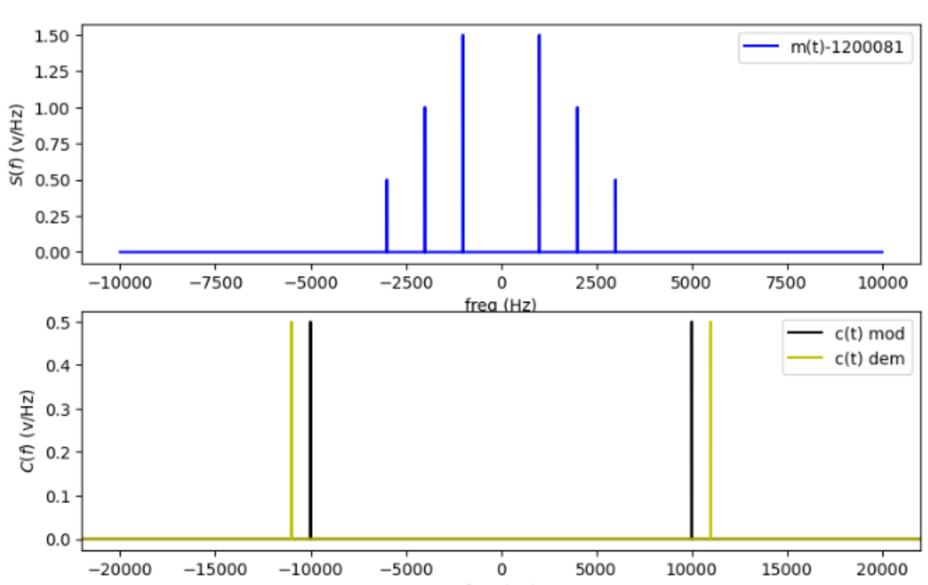


Figure 24.s(t),m^(t)at df=1000

Note that when the df value increased to 1000, the fluctuations in the recovered message signal decreased and became somewhat clearer, but there is still a difference between it and the original signal.

Frequency domain:



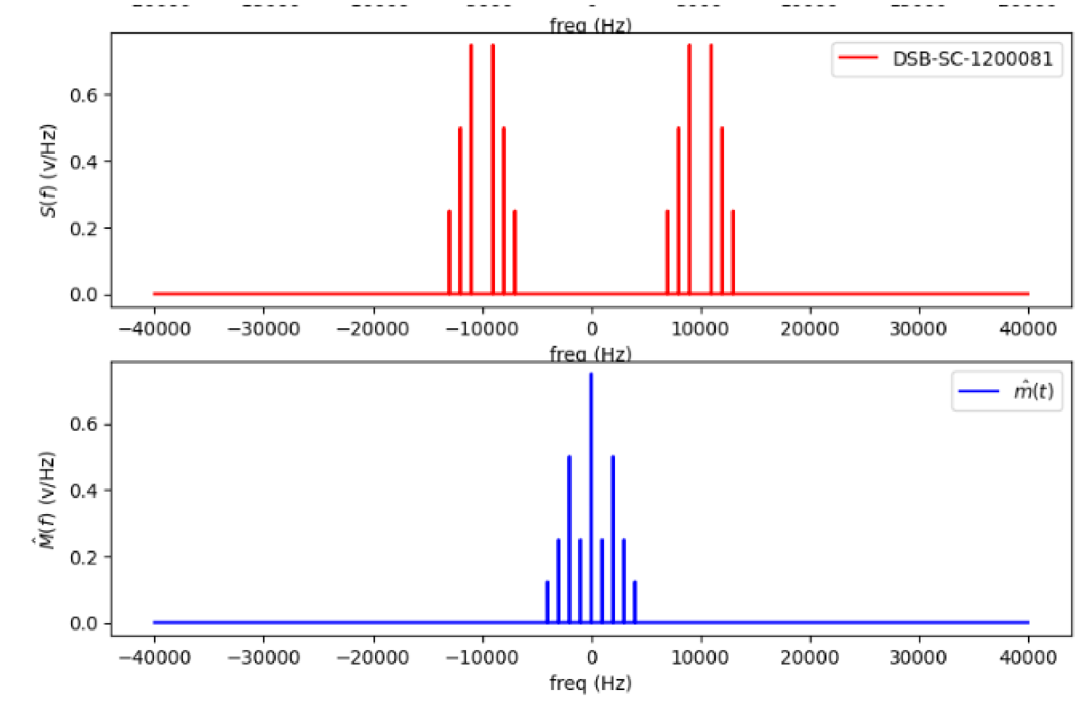


Figure 25.s(f),m^(f)at df=1000

4. Conclusion:

This experiment was successful and the practical results were close to the theoretical results. We have learned a new type of amplitude modulation technique, dual-band suppressed carrier (DSB-SC). The theoretical and practical aspects of this modulation technique are explored, enhancing our understanding of duplex modulation and demodulation processes.

5.References:

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