Report on Upper and Lower Sideband Modulation

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1 Introduction

In the field of signal processing and communication, modulation techniques play a crucial role in transmitting information efficiently over communication channels. One such modulation technique is sideband modulation, where the message signal is modulated onto a carrier wave, resulting in the generation of upper and lower sidebands. This report presents an analysis of upper and lower sideband modulation using MATLAB simulations.

2 Methodology

2.1 Message Signal Generation

A message signal, $m(t)$, is generated using the formula:

$$m(t) = \frac{\sin(\pi B t)}{\pi t}$$

where $B = 1$ and t ranges from -5 to 5 milliseconds.

2.2 Modulation

The message signal is modulated onto a carrier wave with a frequency of $f_c = 5$ Hz and an amplitude of $A_c = 2$. Both upper and lower sidebands are generated using the Hilbert transform to produce in-phase and quadrature components. The upper and lower sidebands are represented as y_{up} and y_{low} respectively.

2.3 Spectral Analysis

The Fourier transform is applied to both upper and lower sideband signals to analyze their frequency spectra. The power spectral density is computed to examine the power distribution across different frequencies.

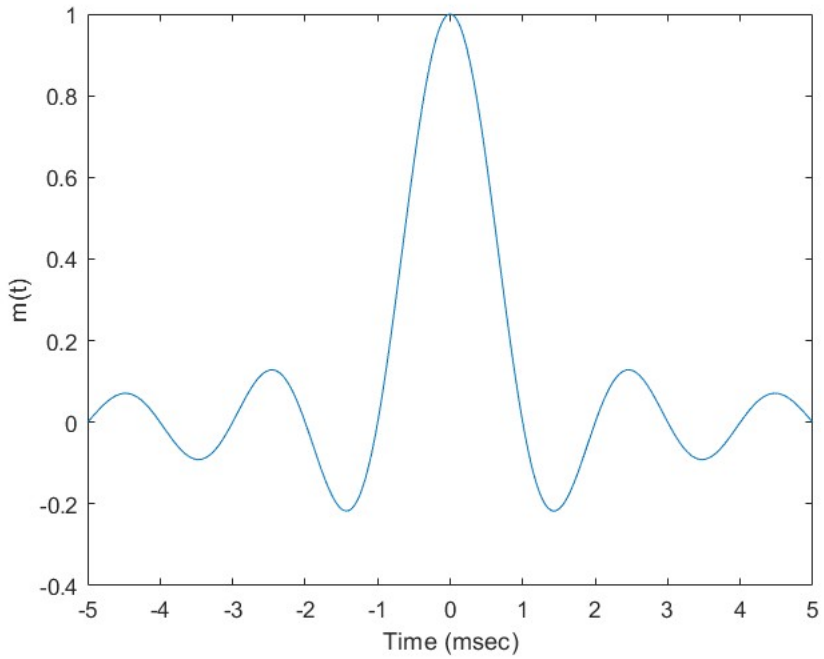
2.4 Demodulation

A demodulation process is performed on the signal y by multiplying it with cosine of the same frequency and then using a low-pass filter to recover the original message signal.

3 Results

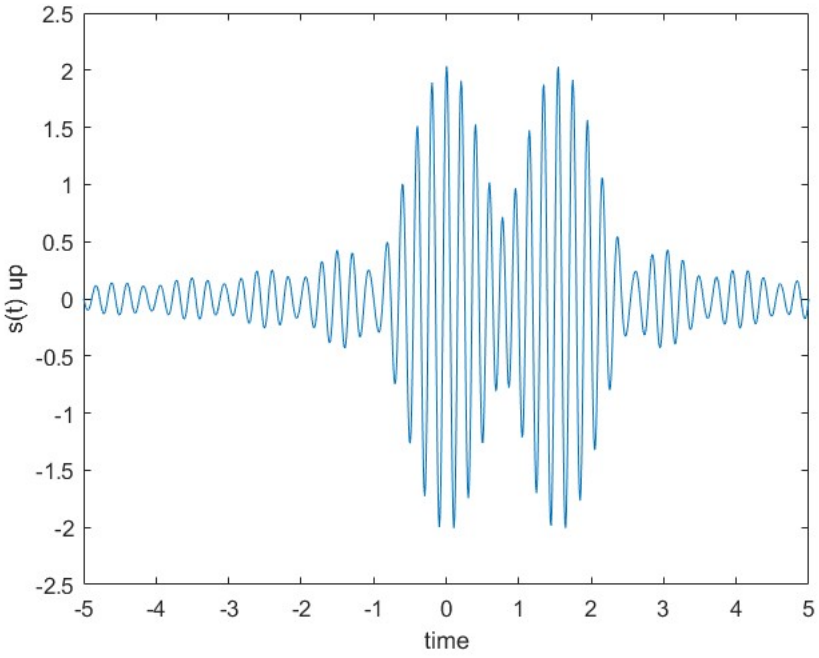
3.1 Message Signal

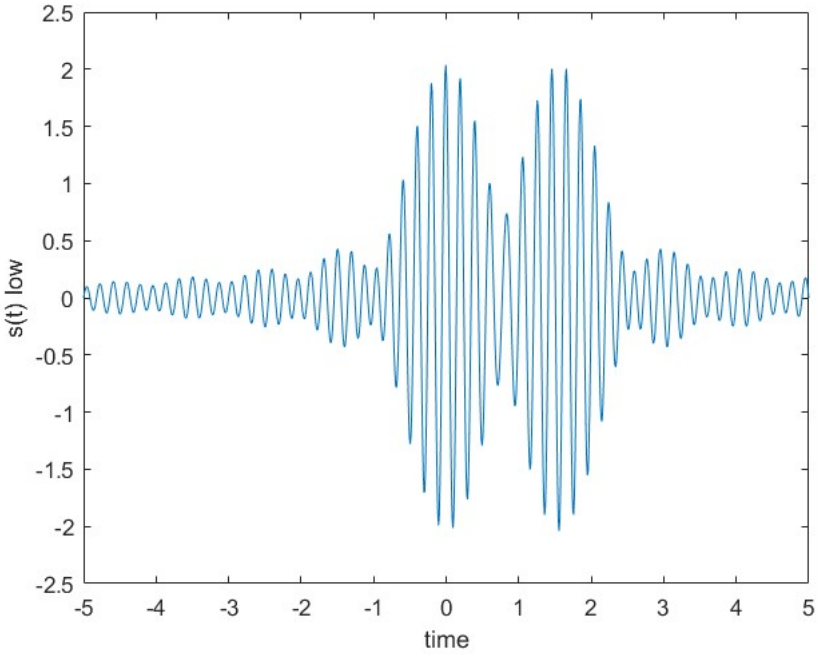
The generated message signal $m(t)$ exhibits a sinc-like shape, which is characteristic of band-limited signals.



3.2 Upper and Lower Sideband Signals

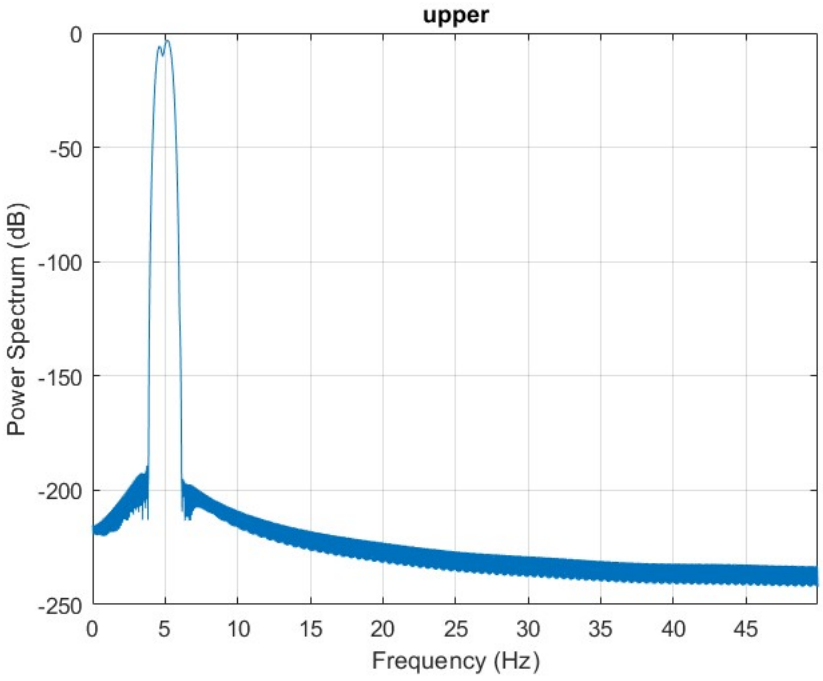
The upper and lower sideband signals, y_{up} and y_{low}, are plotted over time. Both signals demonstrate the modulation of the message signal onto the carrier wave, resulting in the formation of sidebands.

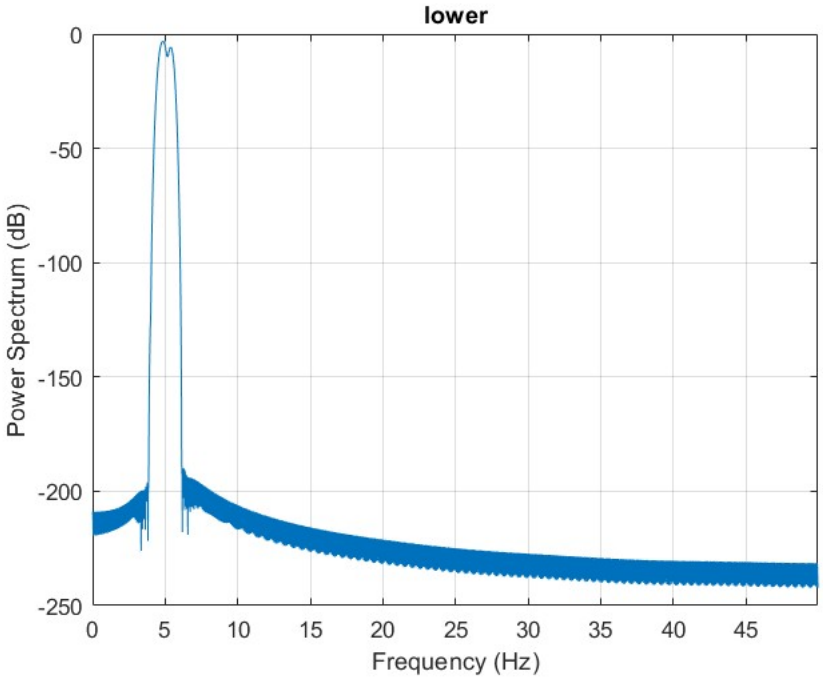

s(t) up
time
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-5
-4
-3
-2
-1
0
1
2
3
4
5


s(t) low
time
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-5
-4
-3
-2
-1
0
1
2
3
4
5

3.3 Spectral Analysis

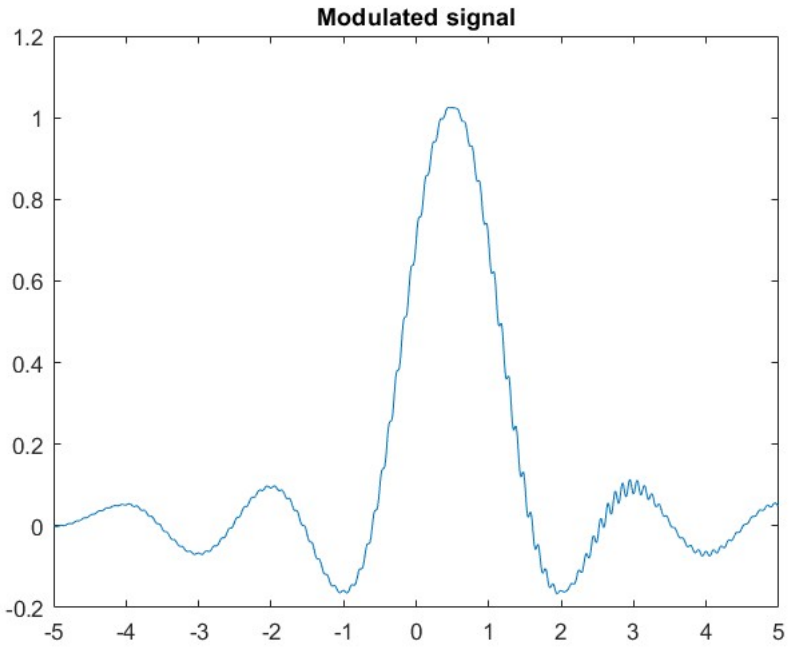
The power spectral density of the upper and lower sideband signals reveals the distribution of power across different frequencies. The upper sideband is centered around the carrier frequency f_c, while the lower sideband is a mirror image around the negative carrier frequency.

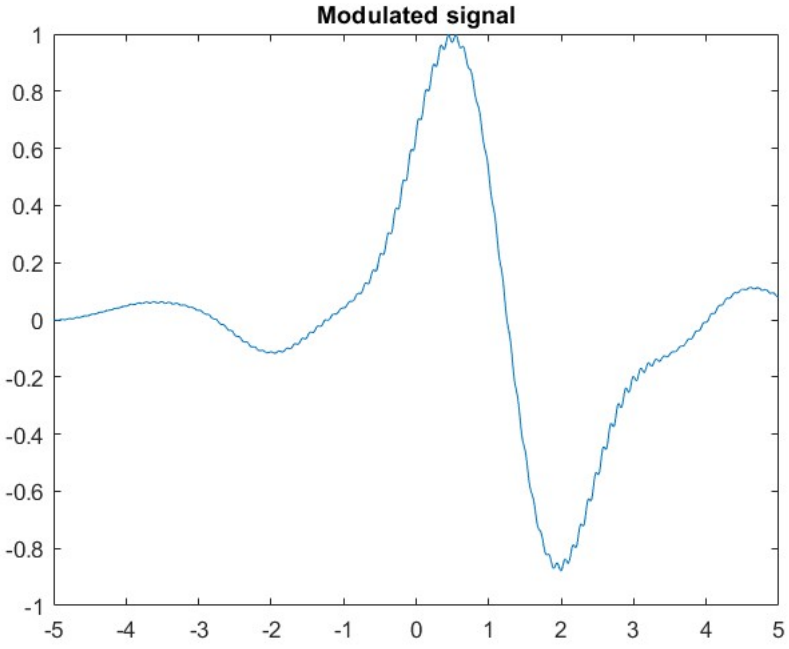


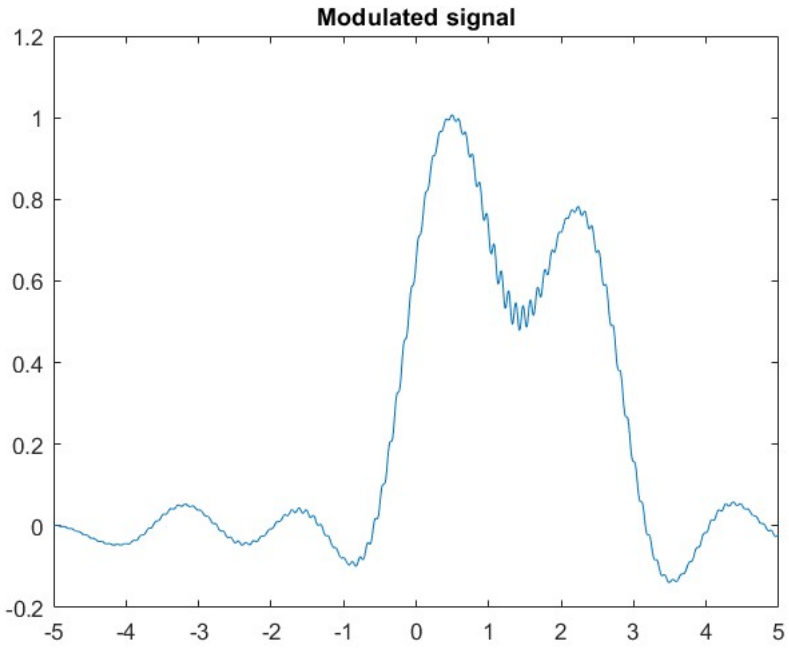


3.4 Demodulation

Demodulation of the upper sideband signal successfully recovers the original message signal, as demonstrated by the modulated signal plotted over time.


Modulated signal
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-5
-4
-3
-2
-1
0
1
2
3
4
5


Modulated signal
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-5
-4
-3
-2
-1
0
1
2
3
4
5



4 Conclusion

The analysis presented in this report illustrates the principles of upper and lower sideband modulation. Through MATLAB simulations, we have explored the generation of sidebands, their frequency spectra, and the demodulation process. Sideband modulation techniques are widely used in various communication systems, and understanding their operation is essential for efficient signal transmission.