Minnesota State University, Mankato

Electrical and Computer Engineering Department

Lab Assignment 7 – USB & LSB SSB Modulation

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USB & LSB SSB Modulation

*Abstract*

This lab focuses on the modulation and spectral analysis of Single Sideband (SSB) signals using Fourier Transform techniques. The experiment involves defining a baseband signal, computing its Fourier Transform, applying the Hilbert Transform for analytic signal generation, and performing Upper Sideband (USB) and Lower Sideband (LSB) modulation. The spectral properties of the SSB signals are analyzed to verify the effectiveness of the modulation and demodulation process.

*Materials*

**Equipment Needed                                        Quantity.**

Laptop (Visual Studio Code)                                 1

**Methods (Procedure, Data Collection, and Analysis)**

**Part A: USB & LSB SSB Modulation**

1. **Define the Baseband Signal m(t)m(t)m(t)**

* The given baseband signal is:



* Set T=0.01s and generate the time vector t from 0 to 10T.
* Implement the **unit step function** to ensure the signal exists only within the specified range.

1. **Compute and Plot the Baseband Signal**

* Use matplotlib to **visualize the baseband signal** over time.

1. **Compute and Plot the Baseband Spectrum**

* Use the **Fast Fourier Transform (FFT)** to obtain the **frequency spectrum** of m(t)m(t)m(t).
* Define the frequency axis using np.fft.fftfreq() and plot the **magnitude and phase spectrum**.

1. **Compute the Hilbert Transform Using IDFT**

* The **Hilbert Transform** is used to obtain the **analytic signal** m^(t).
* Apply the **frequency-domain transformation**:

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* Perform **Inverse FFT (IDFT)** to retrieve m^(t)\hat{m}(t)m^(t) in the time domain.

1. **Generate the USB-SSB and LSB-SSB Modulated Signals**

* Compute the **Upper Sideband (USB) signal**:



* Compute the **Lower Sideband (LSB) signal**:

s

* Use numpy to apply the equations and **plot the time-domain signals**.

1. **Compute and Plot the Spectrum of USB-SSB and LSB-SSB**

* Apply **FFT** to the modulated signals to obtain their spectra.
* Use np.fft.fftshift() to center the **frequency domain representation**.
* Plot the **USB-SSB and LSB-SSB spectra** for analysis.

*Results*

A screenshot of a graph

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*Conclusion*

In this lab, we successfully implemented **Upper Sideband (USB) and Lower Sideband (LSB) modulation** using Fourier Transform-based spectral analysis. We started by defining and visualizing the baseband signal m(t), then computed its **Fourier Transform** to analyze its spectral properties. The **Hilbert Transform** was applied to obtain the analytic signal, which enabled the generation of **SSB signals** by suppressing one sideband.

The **USB and LSB modulated signals** were successfully generated by mixing the baseband signal with a carrier and adjusting phase shifts accordingly. The frequency-domain analysis confirmed that the **USB-SSB spectrum retained only the positive frequency components**, while the **LSB-SSB spectrum contained only the negative frequencies**, validating the expected behavior of **SSB modulation**.

Overall, this experiment demonstrated the efficiency of **SSB modulation in reducing bandwidth usage**, which is widely used in applications like **radio communications and speech transmission**. The results aligned well with theoretical expectations, reinforcing the importance of Fourier Transform techniques in **signal processing and communication systems**.

*Appendices*

A screen shot of a computer program

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A computer screen shot of text

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*References*

1. <https://rodzah.files.wordpress.com/2011/07/how-to-write-lab-report.pdf>
2. EE343- LAB Assignment 7.pdf