Frequency Modulation

Team Members:

1. Adham Saad 202100163
2. Mohamed Morshedy 202100372
3. Mohamed Ezzat 20200543

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I. Introduction

This report is the documentation for the final project for course CIE-227: Signals & Systems.

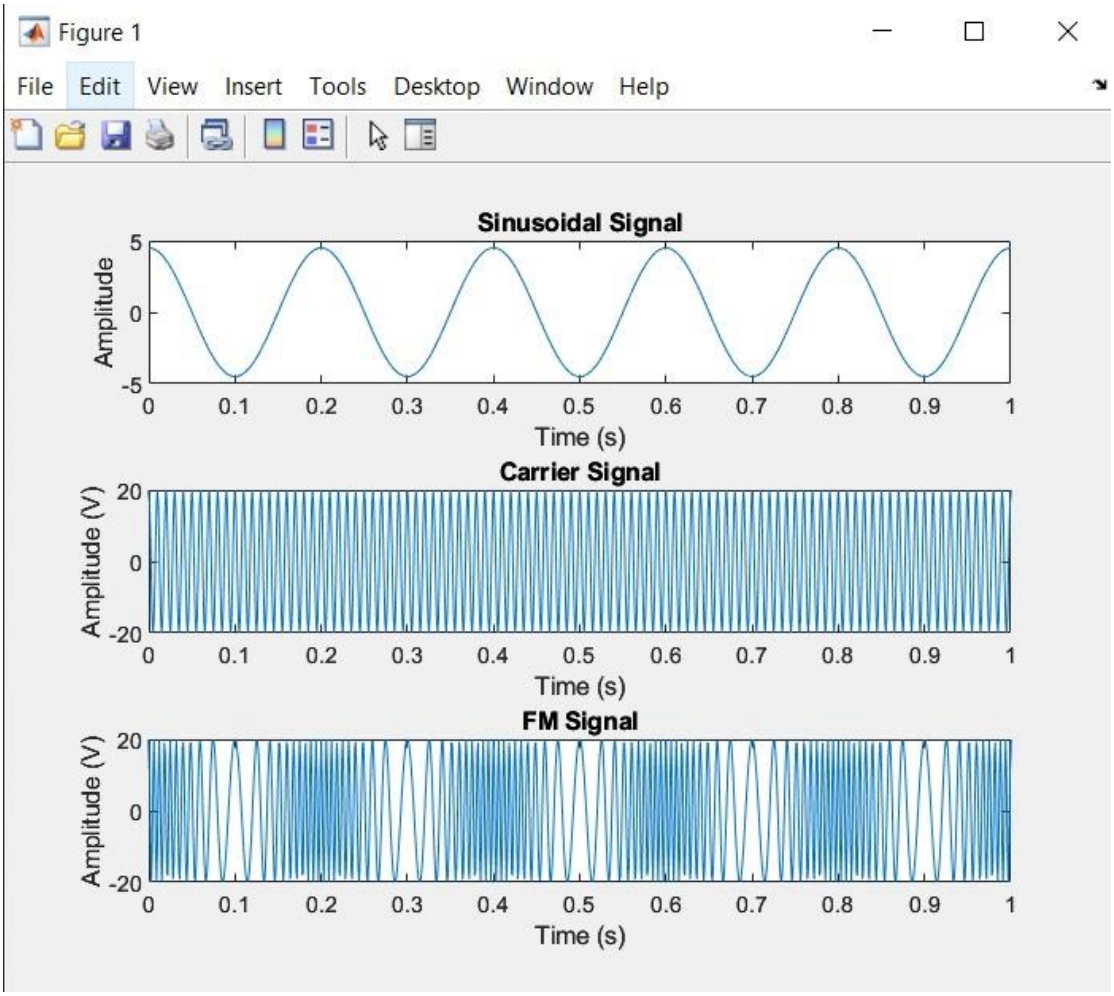
- Frequency modulation (FM) is a widely used modulation technique in telecommunications and broadcasting. In FM, the frequency of a carrier signal is varied according to the amplitude of a message signal, resulting in a modulated signal with a varying frequency but constant amplitude.

- In this project, we explore the principles of FM modulation and demodulation through a series of tasks. Our goal is to generate and analyze FM signals with different modulation indices, and to understand how the modulation index affects the signal bandwidth and power. We also aim to demodulate the FM signal and compare it to the original message signal. Through these tasks, we hope to gain a deeper understanding of the properties and applications of FM modulation.

- The tasks include generating a sinusoidal signal and a carrier signal with specific frequencies and amplitudes, modulating the carrier signal with the sinusoidal signal using FM with a specific modulation index, and plotting the results in both time and frequency domains. We will also vary the modulation index and observe the changes in the signal bandwidth and power. Finally, we will demodulate the FM signal and compare it to the original message signal.

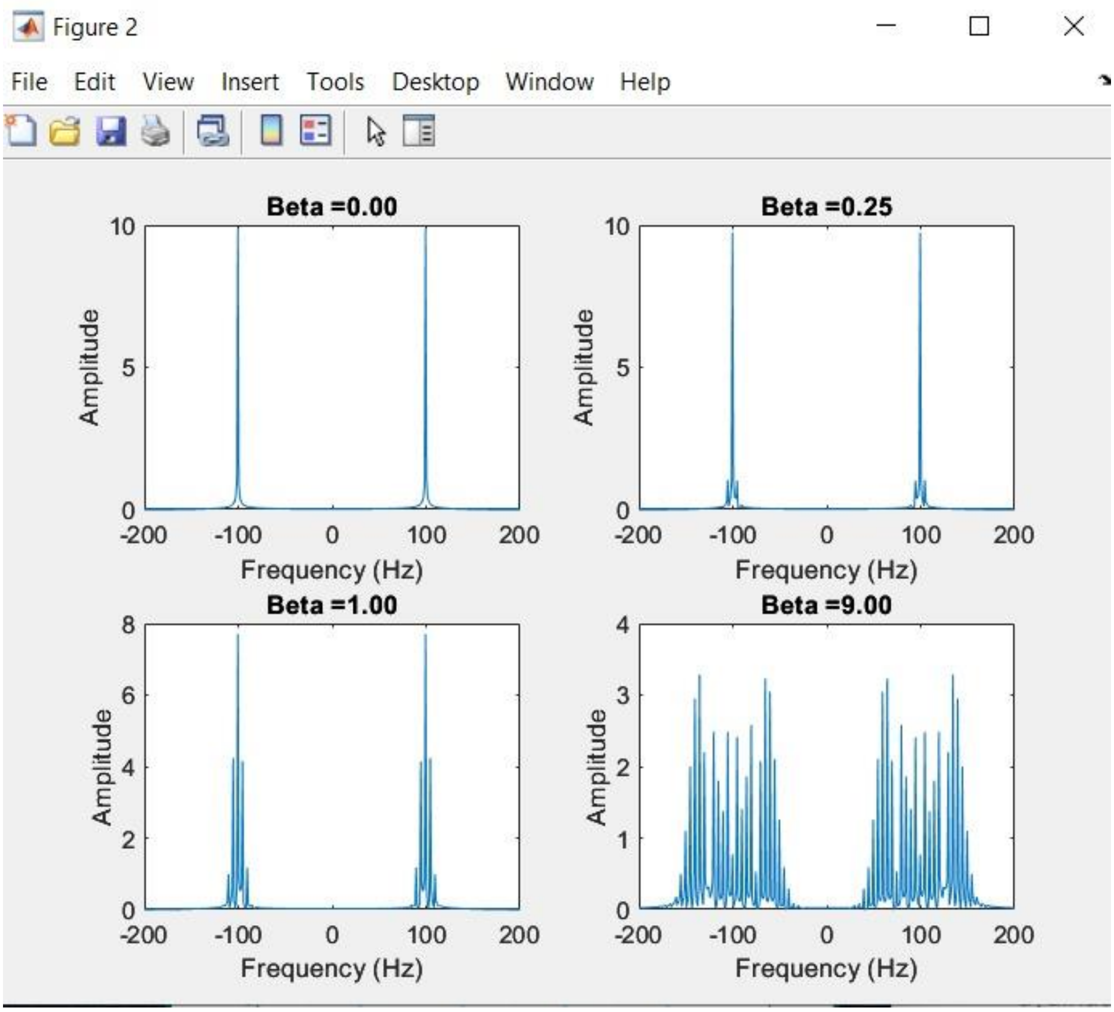
- By completing these tasks, we aim to demonstrate our understanding of FM modulation and demodulation, and to gain practical experience with signal processing techniques. This report outlines our methodology, results, and conclusions.

II. Results & Discussions



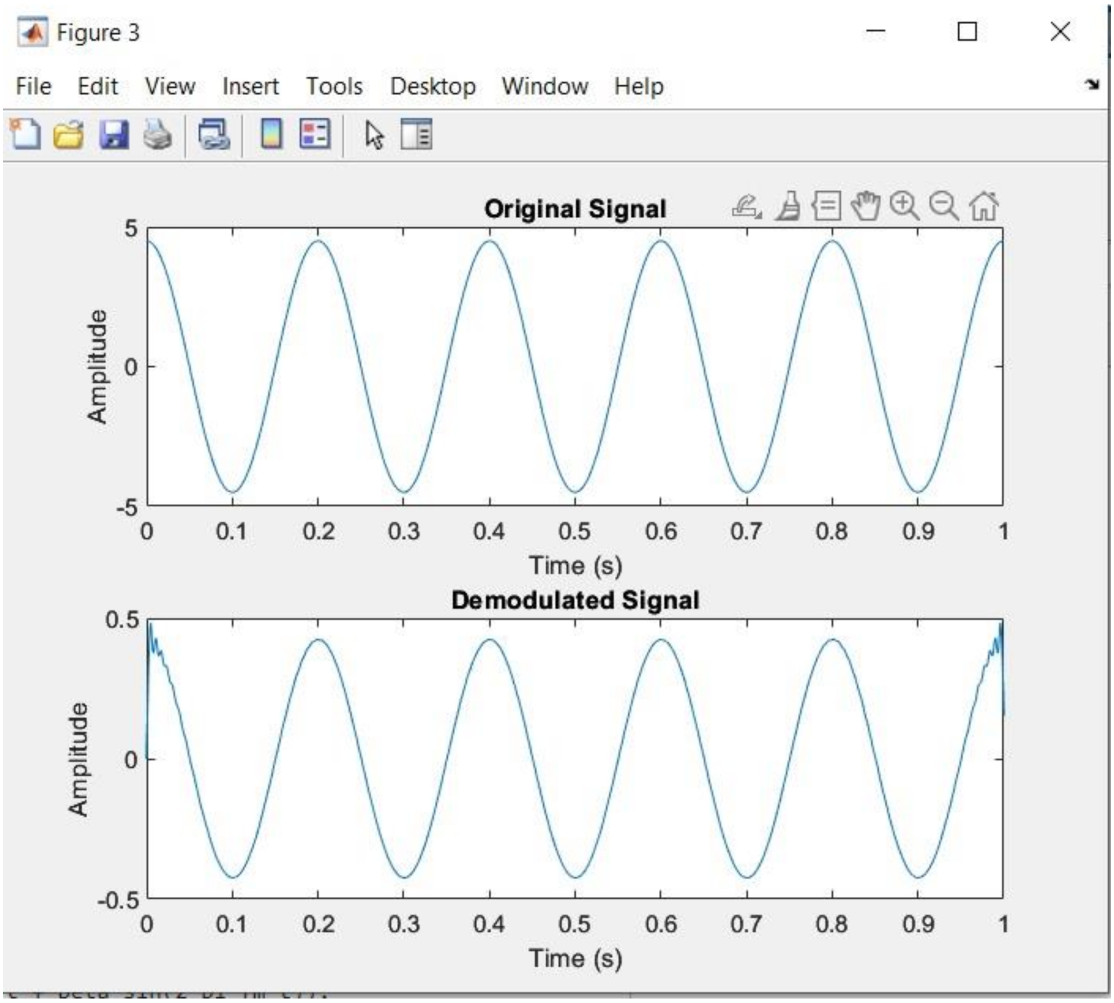
- Figure 1: This figure shows the sinusoidal signal, carrier signal, and FM signal in the time domain. The sinusoidal signal is a modulating signal with a frequency of 5 Hz and a mixture of three cosine waves. The carrier signal is a 100 Hz sine wave with an amplitude of 20V. The FM signal is the result of modulating the carrier signal with the modulating signal using FM with a peak frequency deviation of 1.5 kHz. The figure shows **how the frequency of the FM signal varies with the modulating signal**.

- Figure 1: The results show that the FM signal has a varying frequency with respect to the modulating signal, while the amplitude of the signal remains constant. The carrier signal acts as a carrier for the modulating signal, resulting in the **generation of an FM signal with a frequency deviation proportional to the amplitude of the modulating signal**.



- Figure 2: This figure shows the FFT of the FM signal for different modulation indices. The modulation indices tested are 0, 0.083, 0.333, and 3. The figure shows **how the bandwidth of the FM signal changes with the modulation index**. As the modulation index increases, the bandwidth also increases, resulting in the generation of more sidebands.

- Figure 2: The results show that the bandwidth of the FM signal increases as the modulation index increases. This is due to the generation of more sidebands around the carrier frequency. The figure demonstrates the **importance of choosing an appropriate modulation index** to ensure efficient use of bandwidth.



- Figure 3: This figure shows the original modulating signal and the demodulated signal in the time domain. The demodulated signal is obtained by demodulating the FM signal using an FM demodulator with a carrier frequency of 100 Hz. The figure shows how **the demodulated signal closely matches the original modulating signal, indicating successful demodulation**.

- Figure 3: The results show that the demodulated signal closely matches the original modulating signal, indicating **successful demodulation of the FM signal**. This highlights the practical applications of FM modulation and demodulation in telecommunication systems.

- All in all, these figures demonstrate the principles of FM modulation and demodulation and showcase how the modulation index affects the bandwidth of the FM signal. They also show how FM signals can be demodulated to obtain the original modulating signal, highlighting the practical applications of this modulation technique.

III. Conclusion

- In this project, we explored the principles of FM modulation and demodulation. We generated a sinusoidal modulating signal and a carrier signal with specific frequencies and amplitudes and modulated the carrier signal using FM with a range of modulation indices. We analyzed the resulting FM signals in both the time and frequency domains, and observed how the modulation index affected the bandwidth of the FM signal. We also successfully demodulated the FM signal to obtain the original modulating signal.

- Our findings show that FM modulation is a powerful technique for transmitting signals over long distances with better quality than AM modulation. FM signals are less susceptible to noise and interference and have a wider bandwidth due to the generation of sidebands. The modulation index plays an important role in determining the bandwidth and efficiency of the FM signal and must be carefully chosen to ensure optimal performance.

- Overall, this project provided us with a practical understanding of FM modulation and demodulation, and the tools to analyze and design FM signals for a variety of applications. By completing these tasks, we gained valuable experience in signal processing and expanded our knowledge of signals and systems.

IV. References

[1] A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals and Systems*. Harlow: Pearson Education Limited, 2014. s

[2] J. MacClellan, R. Schafer, and M. Yoder, *DSP First*. Harlow: Pearson, 2017.

[3] “fmmod Function,” MATLAB, https://www.mathworks.com/help/comm/ref/fmmod.html (accessed May 8, 2023).

[4] “Frequency Modulation,” MathWorks, https://www.mathworks.com/help/comm/ug/frequency-modulation.html (accessed May 8, 2023).

[5] R. W. S. James H. McClellan, “DSP first,” DSP First,

https://dspfirst.gatech.edu/ (accessed May 8, 2023).