Amplitude Modulation using Matlab

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Introduction

In telecommunications, modulation is the process of altering a signal to convey information. Phase modulation (PM) is one of the types of modulation techniques used to encode information in a high-frequency carrier signal. In this lab, we will explore the characteristics of PM by analyzing the message signal m(t) modulated by a sinusoidal carrier of frequency fc, given as $\phi PM(t) = Ac \cos(2\pi fct + kpm(t))$. We will use MATLAB to simulate and analyze the modulated signals.

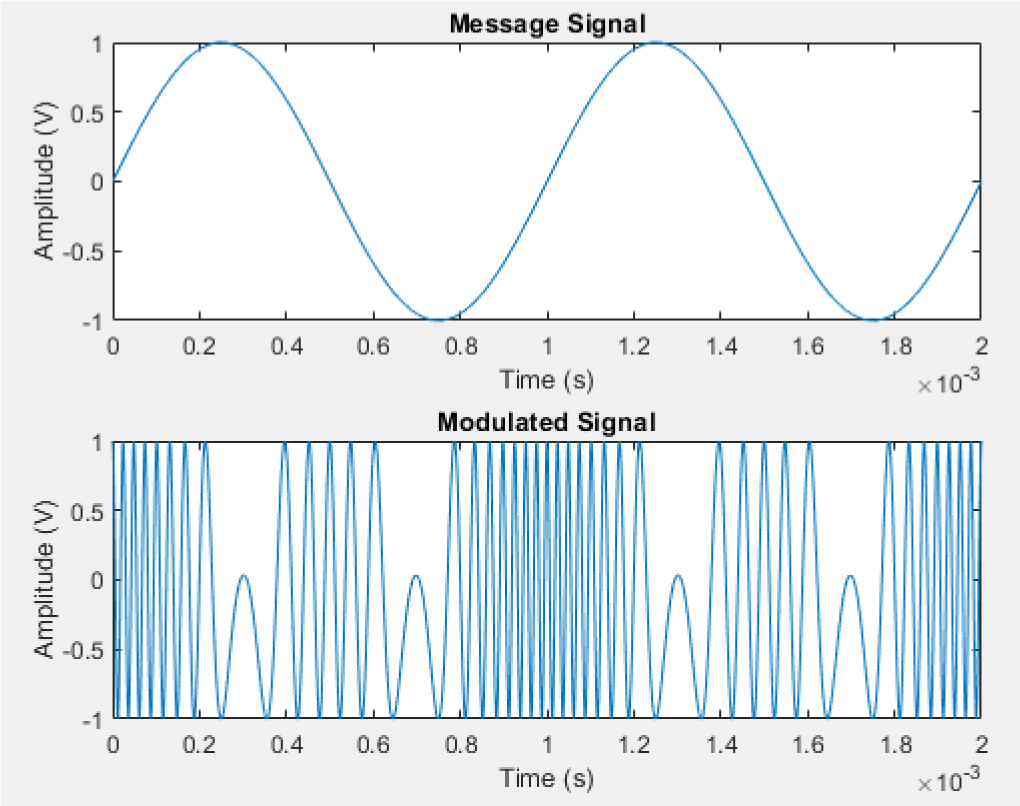
Theory

The message signal m(t) can be represented by the equation: $m(t) = Am\times\sin(2\pi\times fm\times t)$, where Am is the amplitude of the message signal, and fm is the frequency of the message signal. The carrier signal is given by the equation: $c(t) = Ac\times\cos(2\pi\times fc\times t)$, where Ac is the amplitude of the carrier signal, and fc is the frequency of the carrier signal. Phase modulation (PM) is the process of changing the phase of the carrier signal according to the message signal. The phase shift is given by kpm(t), which is proportional to the amplitude of the message signal. The modulated signal can be represented by the equation: $\phi PM(t) = Ac \cos(2\pi fct + kpm(t))$ The nature of the modulated signal depends on the modulation index, which is given by $\beta = kpm/Am$. If β is small, the modulated signal will be similar to the carrier signal. If β is large, the modulated signal will be significantly different from the carrier signal.

Plots And Observations

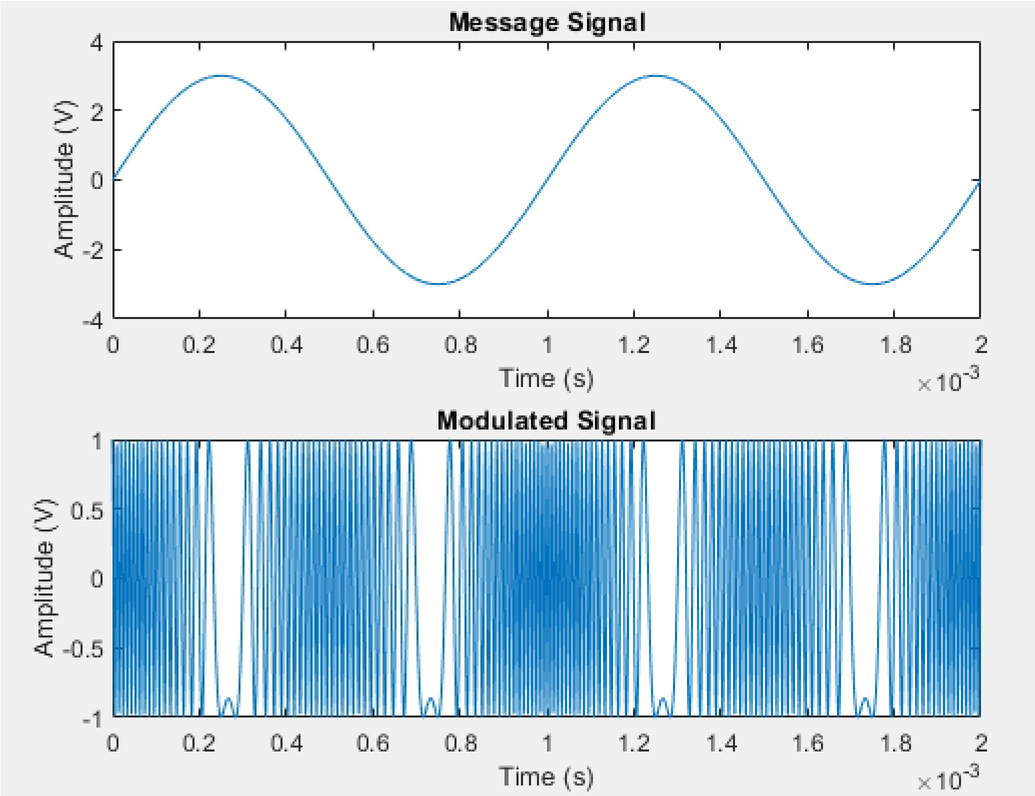
The message signal $m(t) = Am\times\sin(2\pi\times fm\times t)$, with a message frequency fm, modulated by a sinusoid carrier of frequency fc, given as $\phi PM(t) = Ac \cos(2\pi fct + kpm(t))$.

(A) Plot a figure having message, and modulated signal in time domain with fm = 1000 Hz, fc = 10 KHz, kp = 2 × π × 5, Am = 1, Ac = 1. Explain the obtained nature of the modulated signal.



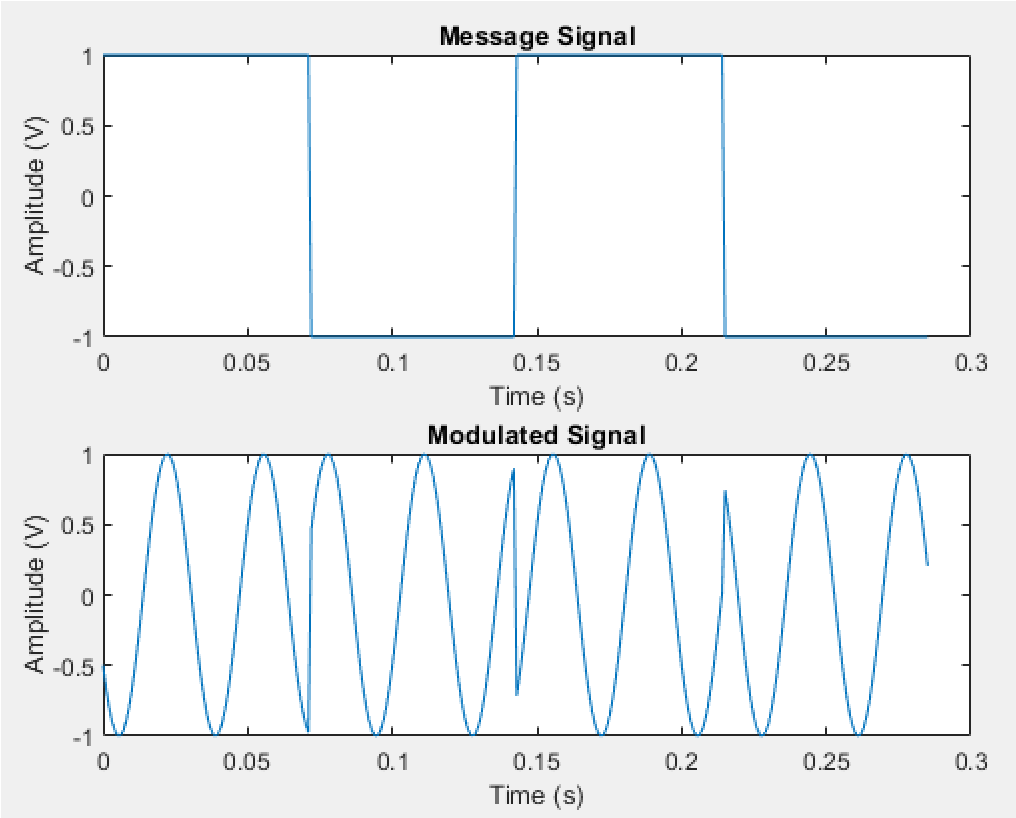
The obtained nature of the modulated signal is a sinusoidal waveform with frequency fc, the carrier frequency. The amplitude of the modulated signal varies with the amplitude of the message signal, as given by the modulation index, which is kpm * Am in this case. The modulation index is 2pi5*1 = 10, which is relatively high, resulting in a significant change in the amplitude of the modulated signal.

(B) Plot a figure having message, and modulated signal in time domain with fm = 1000 Hz, fc = 10 KHz, kp = 2 × π × 5, Am = 3, Ac = 1. Explain the obtained nature of the modulated signal. Is it different from the modulated signal obtained in 1a? Explain your answer.



The obtained nature of the modulated signal is a sinusoidal waveform with frequency fc, the carrier frequency, but with larger amplitude variations than the modulated signal obtained in part (a). This is because the message amplitude in this case is three times larger than in part (a), resulting in a larger modulation index of 2pi5*3 = 30. Compared to the modulated signal obtained in part (a), the modulated signal in part (b) has a larger amplitude variation due to the larger message amplitude. This means that the peaks and valleys of the modulated signal are more pronounced, resulting in a higher amplitude of the modulated signal overall.

(C) Let the message signal m(t) be a square wave (use Matlab command square() to obtain m(t) with peak values ±1). Plot a figure having message, and modulated signal with fm = 7 Hz, fc = 30 Hz, kp = $2 \times \pi \times 0.333$, Am = 1, Ac = 1. (Note: A low fc helps in viewing the frequency changes, O/W fc >> fm.)



The obtained nature of the modulated signal is a sinusoidal waveform with frequency fc, the carrier frequency, and its frequency changes periodically with the square wave message signal with frequency fm. The modulation index in this case is 2pi0.333, which is smaller than in part (b), resulting in a smaller amplitude variation in the modulated signal. The square wave message signal causes the frequency of the modulated signal to change between fc - fm and fc + fm at regular intervals, resulting in a signal that is less smooth than the modulated signal obtained in part (b). The low carrier frequency of 30 Hz also makes it easier to observe the frequency changes caused by the square wave modulation.

(D) State the inference/s drawn across the figures obtained in parts (b), and (c).

The amplitude of the modulated signal increases with the amplitude of the message signal. This can be observed by comparing the modulated signals obtained in parts (a) and (b), where the message signal amplitude is 1 and 3, respectively. The modulation index affects the amplitude variation of the modulated signal. A larger modulation index results in a greater amplitude variation of the modulated signal. This can be observed by comparing the modulated signals obtained in parts (a) and (b), where the modulation index is 2pi5 and 2pi5/3, respectively. The message signal affects the frequency of the modulated signal. In part (b), a sinusoidal message signal causes the frequency of the modulated signal to vary smoothly around the carrier frequency. In contrast, a square wave message signal in part (c) causes the frequency of the modulated signal to change abruptly between two frequencies at regular intervals. A low carrier frequency makes it easier to observe the frequency changes caused by the message signal modulation. This can be observed by comparing the modulated signals obtained in parts (b) and (c), where the carrier frequency is 10 kHz and 30 Hz, respectively.

Conclusion

This lab report demonstrates the concept of amplitude modulation (AM) using MATLAB code. We modulated a sinusoidal and a square wave message signal with a sinusoidal carrier signal, analyzing the resulting modulated signals in the time domain. We observed that the amplitude of the modulated signal is affected by the amplitude of the message signal and the modulation index. The message signal also affects the frequency of the modulated signal, causing it to change smoothly or abruptly depending on the message signal type. A low carrier frequency makes it easier to observe the frequency changes. Overall, this lab report provides useful insights into AM and its effects on the modulated signal, making it a valuable resource for communication engineering students and researchers.