Amplitude Modulation – A Simple Demonstration Experiment

Harjinderpal Singh Kalsi and Poonam Agarwal

Department of Physics,
Guru Nanak Khalsa College of Arts, Science & Commerce (Autonomous),
Matunga, Mumbai, India
kalsi.hs@gnkhalsa.edu.in
poonam.agarwal@gnkhalsa.edu.in

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Abstract

This article describes a very simple demonstration experiment of understanding Amplitude Modulation. Even though ICs are available for amplitude modulation, but this article shows that how one can understand the concept of amplitude modulation by using basic components and instruments available in any Undergraduate Physics laboratory.

1 Introduction

In Radio transmission, the audio signal (20 Hz to 20 kHz) is to be transmitted from a broadcasting station over a great distance to a receiver. However, the audio signal cannot be sent directly over the air for appreciable distance, even if the audio signal is converted into electrical signal, it cannot be sent very far without employing large amount of power. As, the radiation of electrical energy is practicable only at high frequencies, high frequency signals can be sent thousands of miles with small power. [1, 2]. Therefore, if an audio signal is to be transmitted to a longer distance, some methods must be devised which will allow transmission to occur at high frequencies and at the same time also carry the audio signal along with it. This is achieved by superimposing the low frequency electrical audio signal on a high frequency wave. The high frequency wave is called as the “Carrier” as it carries the low frequency audio signal. The resultant waves are known as modulated waves or radio waves and the process is called modulation as shown in Figure 1 [3, 4].

Modulation is the process of changing some characteristics (for example amplitude, frequency, phase) of the high frequency (carrier) wave in accordance with

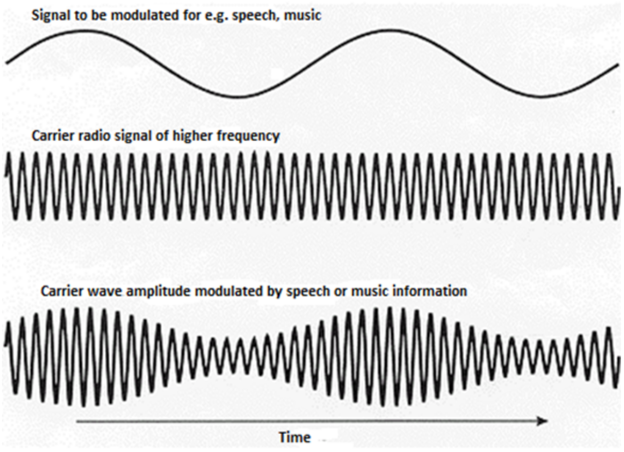

Figure 1: Modulation (Amplitude Modulation)

the intensity of the audio signal. Basically, there are three types of modulation:

- Amplitude modulation
- Frequency modulation
- Phase modulation

When the amplitude of high frequency carrier wave is changed in accordance with the intensity of the audio signal, it is called amplitude modulation as shown in Figure 1. Referring to Figure 1, in Amplitude Modulation only the amplitude of the high frequency carrier wave changes in accordance with the intensity of the audio signal, but the frequency of the modulated wave remains as that of the carrier waveform.

Whereas, when the frequency of the carrier wave is changed in accordance with the intensity of the audio signal, it is called Frequency Modulation (FM) as shown in Figure 2. In FM only the frequency of carrier wave is changed in accordance with the audio signal, however the amplitude of the carrier wave remains the same.

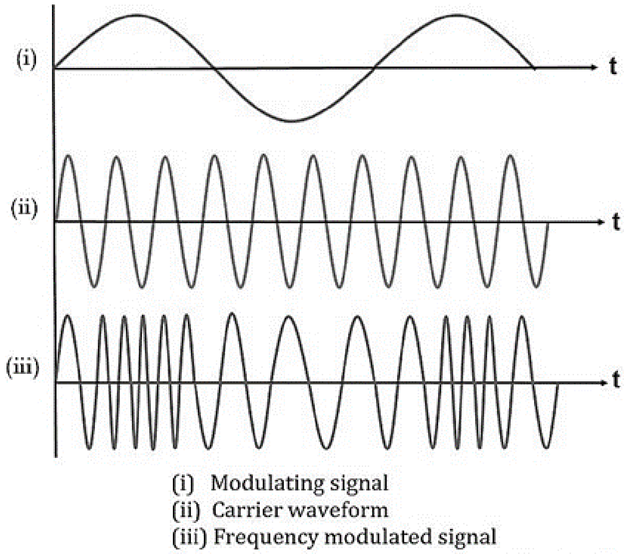

Figure 2: Frequency Modulation

2 The experimental set-up

In order to design a simple amplitude modulator circuit, we first design a basic Common Emitter Amplifier circuit having a certain voltage gain (Av) as shown in Figure 3. In the circuit, R_1 and R_2 are used as potential divider to apply a smaller ac input voltage to the amplifier. The input applied has a voltage of 50mV and frequency, f = 7.6kHz. The output observed is 180° out of phase with respect to the input signal as shown in Figure 4.

Now, we shall introduce another ac signal which is to be transmitted, to the emitter of the transistor as shown in Figure

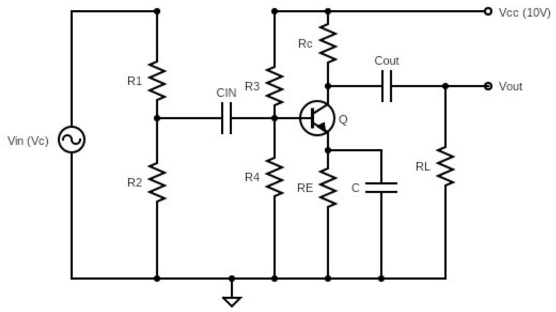

Figure 3: Common Emitter Amplifier (R_1= 10 kΩ, $R_2 = 1$ kΩ, R_3 = 22 kΩ, $R_4 = 10$ kΩ, R_C =15 kΩ, R_E =10 kΩ, $C_{in} = 0.1$ μF, $C_{out} = 0.01\mu$F, C = 1μF, Q = BC147).

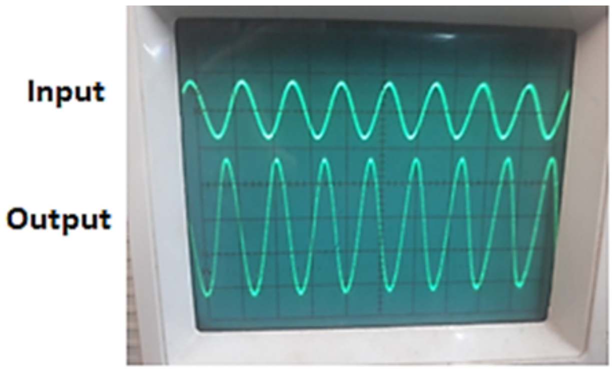

Figure 4: Input Output Waveform of CE Amplifier

5. This ac signal should be of low frequency. In this set-up we have kept 100Hz. Since this low frequency signal is now a part of the biasing circuit, hence it produces low frequency voltage variations in the emitter circuit.

As the voltage at the emitter varies, the Gain 'Av' of the amplifier also varies. Hence the amplitude of the amplified output varies in accordance with the intensity of the low frequency signal as shown in Figure 6a and

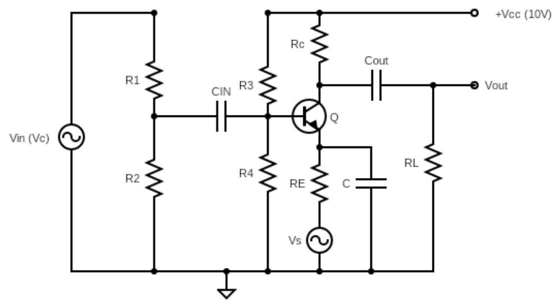

Figure 5: Low Frequency Signal applied to Emitter

6b. The output waveform observed at the Common Emitter amplifier looks like an amplitude modulated waveform, whereas the input signal applied to the input of the CE amplifier is the Carrier Waveform and the low frequency signal applied to the emitter of the transistor is the audio or modulating signal. So, when the amplitude of high frequency carrier wave is changed in accordance with the intensity of the audio signal it is called amplitude modulation. The frequency of the modulated signal is same as that of the Carrier frequency as shown in Figure 7.

One can also study the Modulation factor, which describes the depth of modulation i.e., the extent to which the amplitude of the carrier wave is changed by the audio signal. This can be done by varying the amplitude of the low frequency modulating signal. When the amplitude of the modulating signal (low frequency signal) is less than the amplitude of the high frequency carrier signal then it results in 'Under Modulation'.

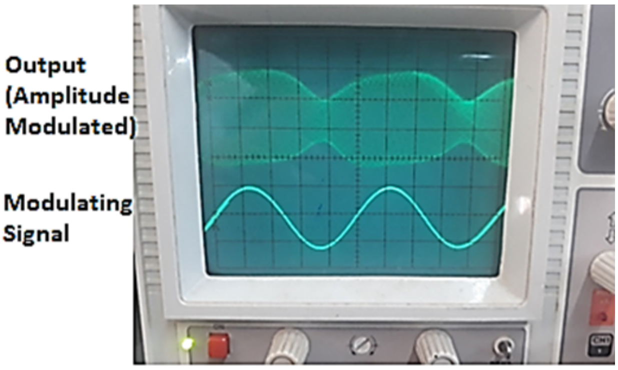

Figure 6a: Modulated Waveform and Modulating Signal

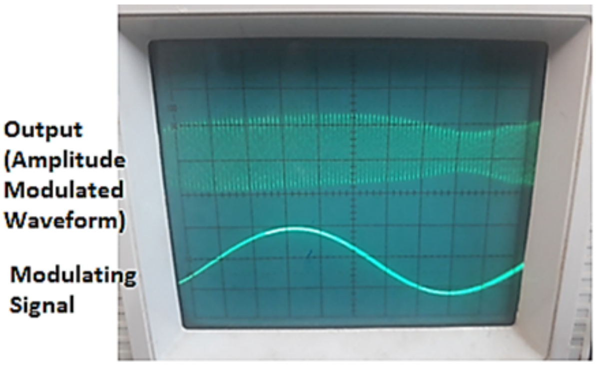

Figure 6b: Modulated Waveform and Modulating Signal

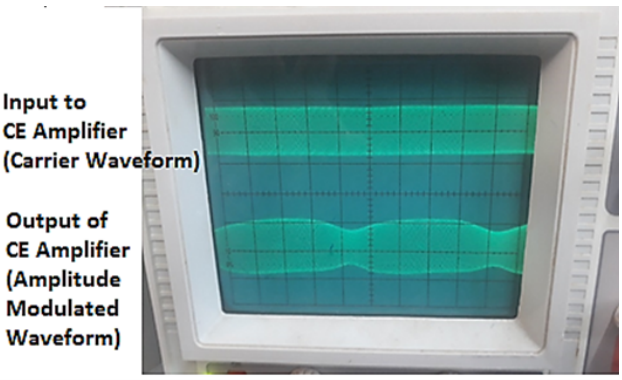

Figure 7: Frequency of Modulated Waveform same as Carrier Waveform

When the amplitude of the modulating signal (low frequency signal) is more than the amplitude of the high frequency carrier signal then it results in 'Over Modulation' as shown in Figure 8. The entire experimental set-up is shown in Figure 9.

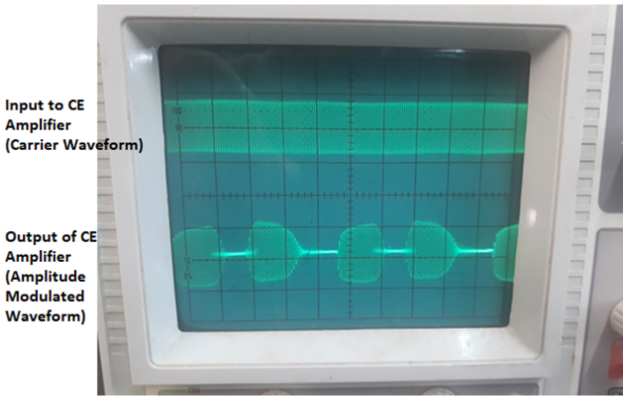

Figure 8: Over- Modulation

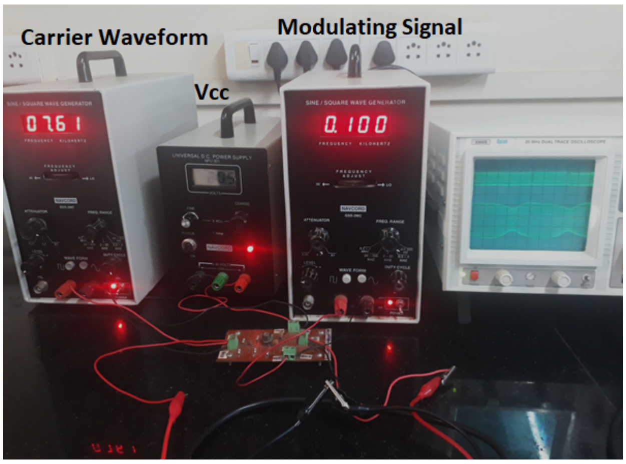

Figure 9: Entire Experimental Set-up

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