AMPLITUDE MODULATOR

Course code and Name:

2EC402 Analog Circuits

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AIM: Amplitude Modulator using 741 IC (op amp)

OBJECTIVE:

- Learn about modulation process and its theory.
- See how modulation index affects AM signals.
- Learn about op amp and its application in amplitude modulation.

COMPONENTS AND ITS DETAIL:

- Operational Amplifier
  - → IC 741
  - → Used as a mixer to produce am signal by adding and subtracting as needed
  - → Number of IC's used: 2
- Resistors
  - → 1.2kΩ, 4.9kΩ, 100kΩ, 33kΩ, 9.2kΩ, 95kΩ, 12kΩ
  - → Used to set gain, bias input of op-amp, attenuate carrier signal, adjust amplitude of am signal, filter output
- Capacitors
  - → 2.2nF
  - → Number of capacitors used: 2
- PN Junction Diode
  - → Used to limit amplitude of am signal
- BJT Transistor
  - → NPN transistor
  - → Used to amplify am signal
- Potentiometer
  - → 22kΩ
  - → Used to adjust the amplitude of modulating signal

THEORY:

Modulation: It is defined as the process of superimposing a low-frequency signal on a high-frequency carrier signal.

There are mainly three types of modulation:

(1) Amplitude Modulation, (2) Frequency Modulation, (3) Phase Modulation.

Here, we are going to learn about Amplitude Modulation.

Amplitude Modulation: The modulation process in which the peak amplitude of the carrier wave is varied in proportion to the message signal.

Here, the phase and frequency are kept constant.

m(t) = message signal

c(t) = carrier signal

s(t) = amplitude modulated signal

We can write the above signals as,

$m(t) = A_m \cos(2\pi f_m t + \phi)$

$c(t) = A_c \sin(2\pi f_c t)$

Therefore, we can put the values of m(t) and c(t) in s(t) as given below

$s(t) = [1 + k_a m(t)]\ c(t)$; where k_a = amplitude sensitivity ;$0<k_a<1$

$s(t) = [1 + k_a m(t)]\ A_c \sin(2\pi f_c t)$

$s(t) = A_c \sin(2\pi f_c t) + A_c k_a m(t) \sin(2\pi f_c t)$

Taking the Fourier transform of the above equation,

$s(f) = \int_{-\infty}^{\infty} s(t) e^{-j\omega t}\, dt$

$|s(f)| = \frac{A_c}{2} [\delta(f - f_c) - \delta(f + f_c) + \frac{A_c k_a}{2} [M(f - f_c) - M(f + f_c)]$

In the equation of s(t), max $|k_a m(t)| = \mu$ is called the modulation index.

If,

$\mu<1$ → under modulation

$\mu=1$ → perfect modulation

$\mu>1$ → over modulation

$$\mu = \frac{A_m}{A_c} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$

where,

A_m = peak amplitude of message signal

A_c = peak amplitude of carrier wave

WORKING:

The modulating signal is an audio signal that carries the desired information, such as speech or music. The carrier signal is a high-frequency signal that is used to transmit the modulated signal over a distance. The AM circuit works as follows:

1. <u>Modulation stage:</u>

   The modulating signal is applied to the inverting input of the op-amp through the potentiometer. The non-inverting input of the op-amp is grounded. The op-amp amplifies the modulating signal.

2. <u>Clipping and biasing stage:</u>

   The output signal from the op-amp is then clipped and biased by the diode. The clipping diode limits the amplitude of the modulated signal to prevent it from exceeding the maximum allowable voltage levels. And sets the DC bias level of the modulated signal.

3. <u>Filtering stage:</u>

   The clipped and biased modulated signal is then filtered by a low-pass filter that is composed of two resistors and a capacitor. The low-pass filter removes any high-frequency components that may have passed through the clipping stage, leaving only the modulating signal to be applied to the load.

4. <u>Amplification stage:</u>

   The filtered modulated signal is then amplified by the BJT, which is configured as a class A amplifier. The amplified modulated signal is produced across the load resistor and can be used to drive a speaker or other load.

Advantages Of Amplitude Modulation:

- It is simple to implement.
- Demodulation of AM signals can be done using simple circuits consisting of diodes.
- AM transmitters are less complex.
- AM receivers are very cheap as no specialized components are needed.
- AM waves can travel a longer distance.
- AM waves have low bandwidth

Disadvantages of Amplitude Modulation:

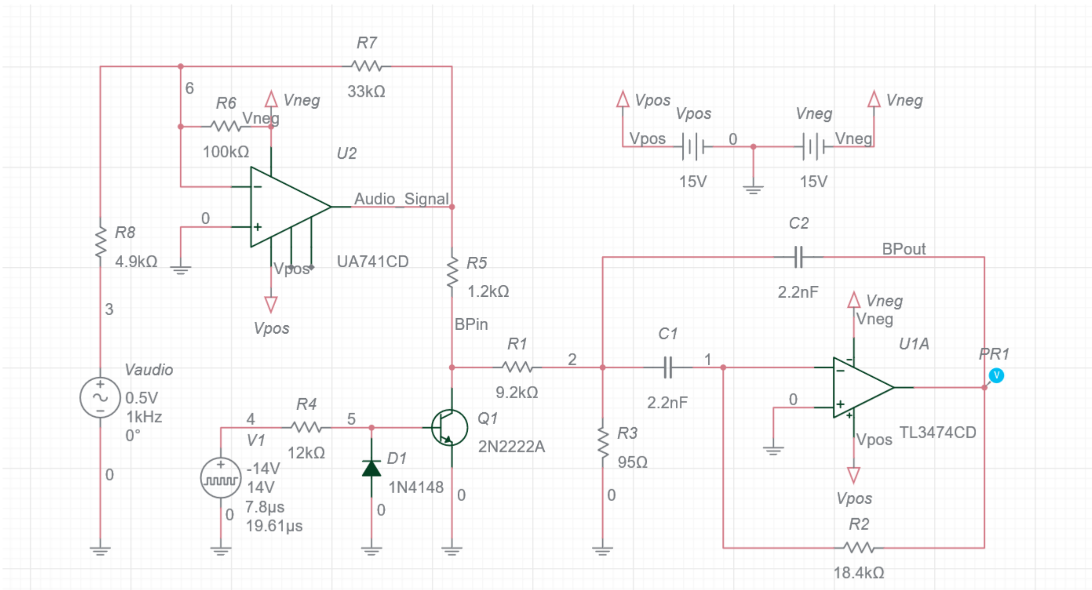
- An amplitude modulation signal is not efficient in terms of its power usage.
- It is not efficient in terms of its use of bandwidth. It requires a bandwidth equal to twice that of the highest audio frequency. In amplitude modulation sidebands contain the signal. The power in sidebands is the only useful power. For 100 % modulation, the power carried by AM waves is 33.3 %. The power carried by the AM wave decreases with the decrease in the extent of modulation.
- AM detectors are sensitive to noise hence an amplitude modulation signal is prone to high levels of noise.

Application of Amplitude Modulation:

- **Communication between Aircraft:** AM is more commonly utilized for pilot-to-ground control communications than other approaches like FM because it can receive numerous signals on the same channel.
- **Broadcast Transmission:** Long, medium, and short-wave bands, are still served by AM. Equipment is less expensive even though it is simple to demodulate and has a low production cost.
- **Quadrature Amplitude Modulation:** Two carriers are combined throughout this approach and are 90° out of phase. They are commonly employed in relatively brief wireless communication networks such as WIFI and cellular networks.

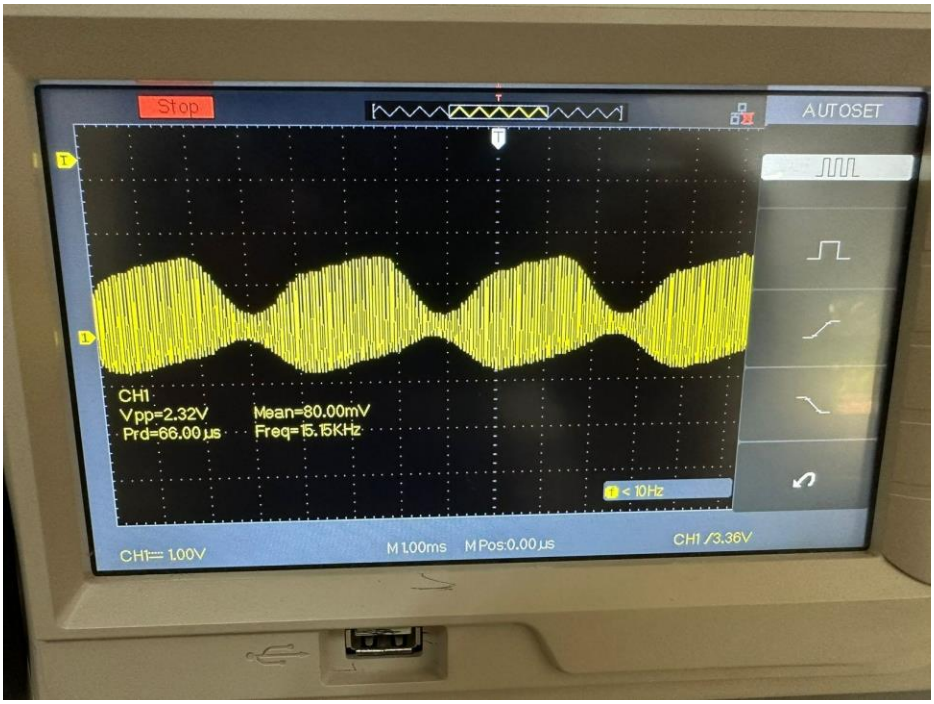
- **<u>Single sideband:</u>** Regarding high-frequency radio connections, a singular sideband of amplitude modulation waves has always been employed. Lower bandwidth is also employed, allowing for more effective use of transmitted power. This is still utilized for many high-frequency point-to-point links.

CIRCUIT:

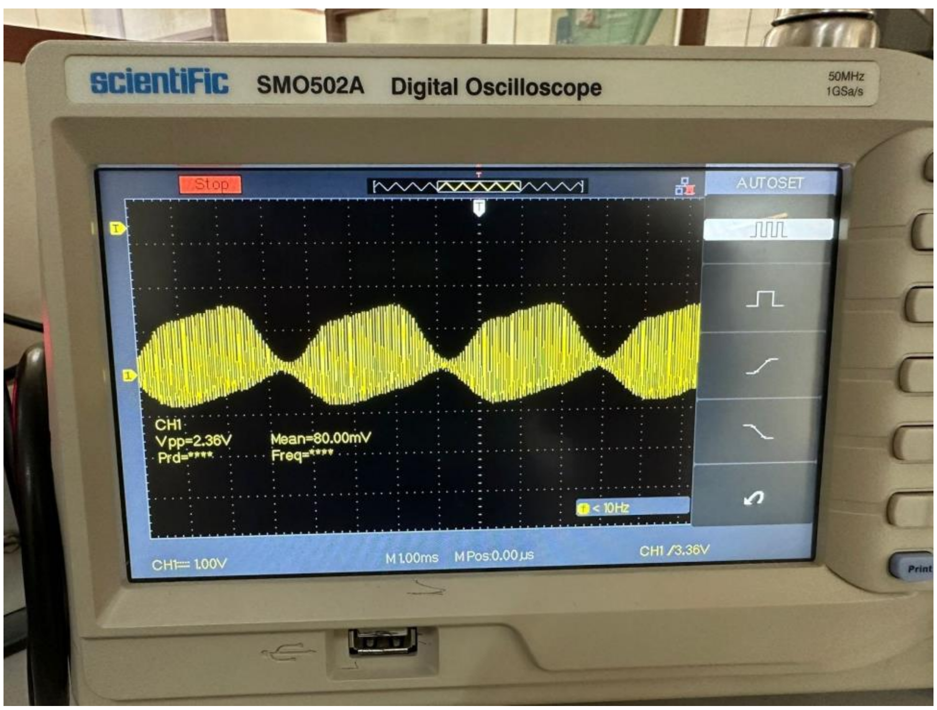


OUTPUT:

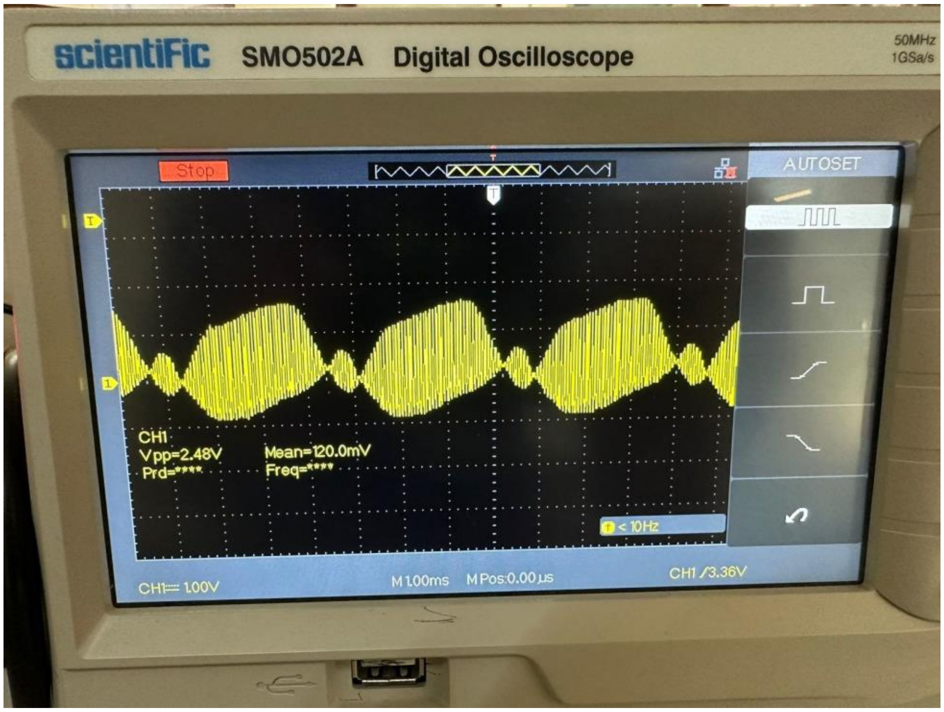
- <u>Under Modulation:</u>



- <u>Perfect Modulation:</u>



- <u>Over Modulation:</u>



CONCLUSION:

From the above, we conclude that amplitude modulation is achieved by multiplying carrier and message signals. Also, we learnt to implement a circuit of amplitude modulation using IC 741. This technique is used in many areas of communication, such as in portable two-way radios, citizens band radios, VHF aircraft radios and in modems for computers.