DEPARTMENT OF ELECTRICAL ENGINEERING & TECHNOLOGY, UET TAXILA

PROJECT REPORT

Communication Systems Lab (CS)

(Section: C-2)

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Date: 07-2-2023

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1. Abstract:

Amplitude modulation is a process by which the wave signal is transmitted by modulating the amplitude of the signal. In general, amplitude modulation definition is given as a type of modulation where the amplitude of the carrier wave is varied in some proportion with respect to the modulating data or the signal. It is often called AM and is commonly used in transmitting a piece of information through a radio carrier wave. Amplitude modulation is mostly used in the form of electronic communication

Currently, this technique is used in many areas of communication such as in portable two-way radios, citizens band radio, VHF aircraft radio and in modems for computers. Amplitude modulation is also used to mention the mediumwave AM radio broadcasting.

Types of Amplitude Modulation

There are three main types of amplitude modulation. They are.

- Double sideband-suppressed carrier modulation (DSB-SC).
- Single Sideband Modulation (SSB).
- Vestigial Sideband Modulation (VSB).

2. Objective:

General objective:

The general objective of this project is to Implement component-based Amplitude modulation and demodulation technique. (Use Transistors, resistors etc.) We are using proteus Software.

Description:

This experiment is in two parts, an AM modulator, and an AM demodulator. The circuit is designed to Carry out Conventional Amplitude Modulation.

3. Background Knowledge:

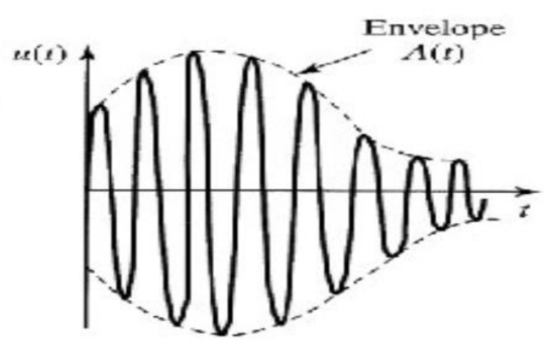
<u>AMPLITUDE MODULATION (AM):</u>

In amplitude modulation, the message signal m(t) is impressed on the amplitude of the carrier signal c(t) = Ac*Cos(2pi*fc*t)

This results in a sinusoidal signal whose amplitude is a function of the message signal m(t). There are several different ways of amplitude modulating the carrier signal by m(t) but for this project we are using conventional Amplitude modulation described below:

<u>CONVENTIONAL AMPLITUDE MODULATION:</u>

A conventional AM signal consists of a large carrier component, in addition to the double-sideband AM modulated signal.



- The transmitted signal is expressed mathematically as:

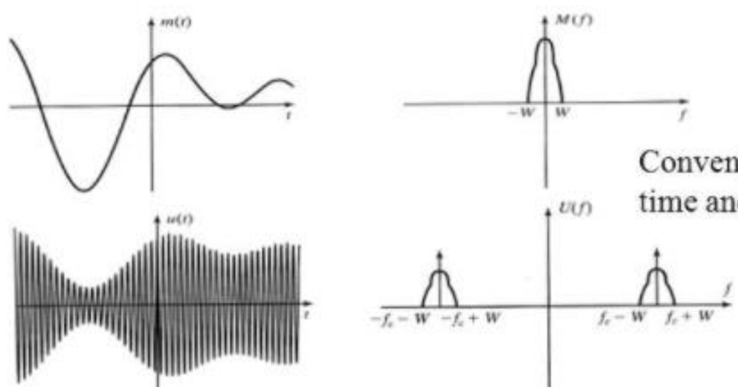
- The message waveform is constrained to satisfy the condition that |m(t)|<=1
- We observe that Ac*m(t) Cos(2*pi*fc*t) is a double sideband AM signal and Ac*cos(2*pi*fc*t) is the carrier component.
- Conventional Amplitude Modulation As long as |m(t)| <=1, the amplitude Ac[1 + m(t)] is always positive. This is the desired condition for conventional DSB AM that makes it easy to demodulate.
- On the other hand, if m(t) < -1 for some t, the AM signal is **overmodulated** and its demodulation is rendered more complex
- The scale factor a is called the **modulation index,** which is generally a constant less than 1.

SPECTRUM OF CONVENTIONAL AM SIGNAL:

If m(t) is a message signal with Fourier transform (spectrum) M(f), the spectrum of the amplitude-modulated signal u(t).

$$U(f) = F[A_c a m_n(t)\cos(2\pi f_c t)] + F[A_c \cos(2\pi f_c t)]$$
$$= \frac{A_c a}{2}[M_n(f-f_c)+M_n(f+f_c)] + \frac{A_c}{2}[\delta(f-f_c)+\delta(f+f_c)]$$

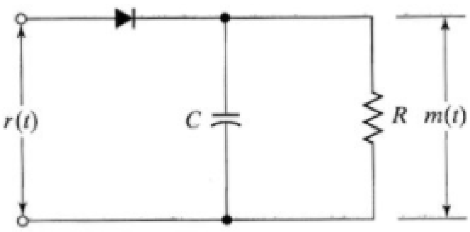
A message signal m(t), its spectrum M(f), the corresponding modulated signal u(t), and its spectrum U(f) are shown:



Conventional AM in both the time and frequency domain.

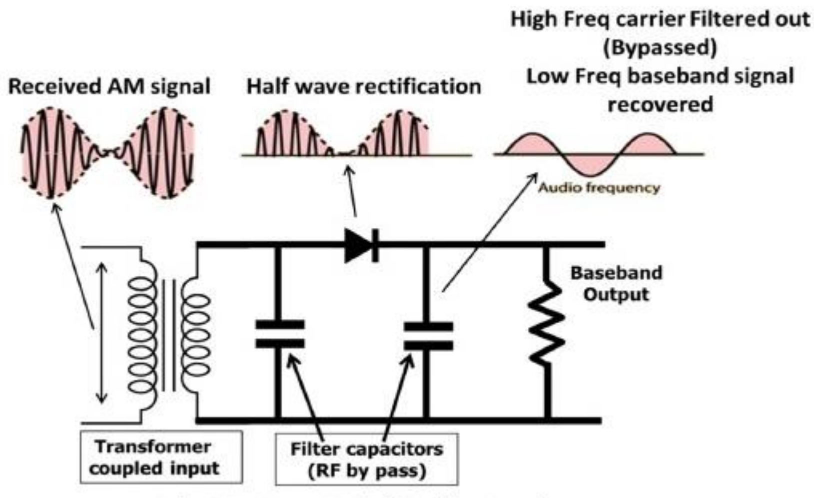
ENVELOPE DETECTOR:

Conventional DSB-AM signals are easily demodulated by an envelope detector A circuit diagram for an envelope detector is shown:



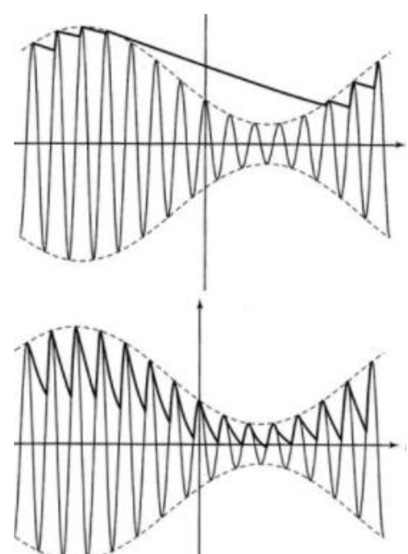
An envelope detector.

It consists of a diode and an RC circuit, which is basically a simple lowpass filter. During the positive half-cycle of the input signal, the diode conducts, and the capacitor charges up to the peak value of the input signal. When the input falls below the voltage on the capacitor, the diode becomes reverse-biased and the input disconnects from the output during this period, the capacitor discharges slowly through the load resistor R.



Envelop Detector

The detector consists of a simple half-wave rectifier which rectifies the received AM signal. This is followed by a low pass filter which removes (bypasses) the high-frequency carrier waveform the received signal. The resultant output of the low pass filter will be the original input (modulating) signal.



Effect of (a) large and (b) small RC values on the performance of the envelope detector.

The time constant RC must be selected to follow the variations in the envelope of the modulated signal:

- If RC is too large, then the discharge of the capacitor is too slow and again the output will not follow the envelope.
- If RC is too small, then the output of the filter falls very rapidly after each peak and will not follow the envelope closely

For good performance of the envelope detector,

$$\frac{1}{f_c} << RC << \frac{1}{W}$$

DEMODULATION OF CONVENTIONAL AM SIGNAL:

Demodulation is a key process in the reception of any amplitude modulated signals whether used for broadcast or two-way radio communication systems. Demodulation is the process by which the **original information bearing signal**, i.e., the modulation is extracted from the incoming overall received signal.

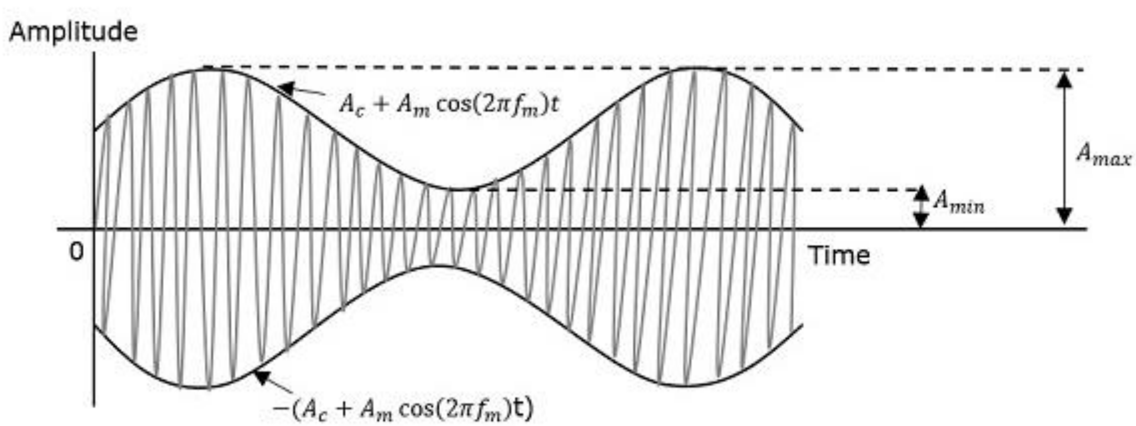
Ideally, the output of the envelope detector is of the form d(t) = g1+g2*m(t)

where g1 represents a DC component and g 2 is a gain factor due to the signal demodulator. The DC component can be eliminated by passing d(t) through a transformer, whose output is g 2 m(t).

The simplicity of the demodulator has made conventional DSB-AM a practical choice for AM-radio broadcasting Since there are literally billions of radio receivers, an inexpensive implementation of the demodulator is extremely important ¨ The power inefficiency of conventional AM is justified by the fact that there are few broadcast transmitters relative to the number of receivers ¨ n Consequently, it is cost-effective to construct powerful transmitters and sacrifice power efficiency in order to simplify the signal demodulation at the receivers.

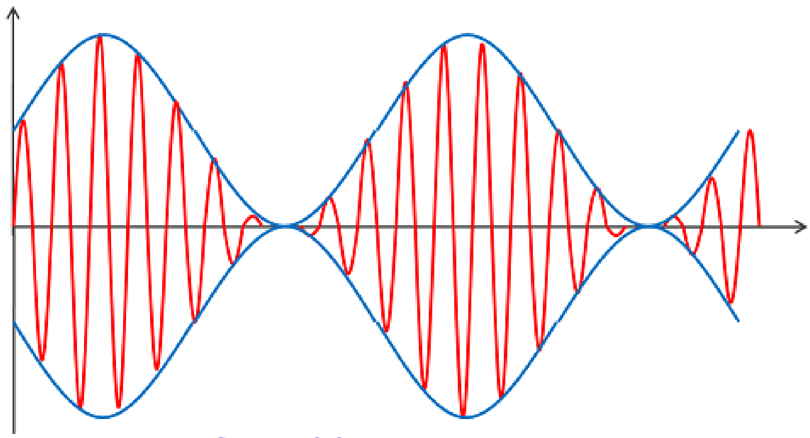
MODULATION INDEX:

A carrier wave, after being modulated, if the modulated level is calculated, then such an attempt is called as **Modulation Index** or **Modulation Depth**. It states the level of modulation that a carrier wave undergoes.



For a **perfect modulation,** the value of modulation index should be 1, which means the modulation depth should be 100%.

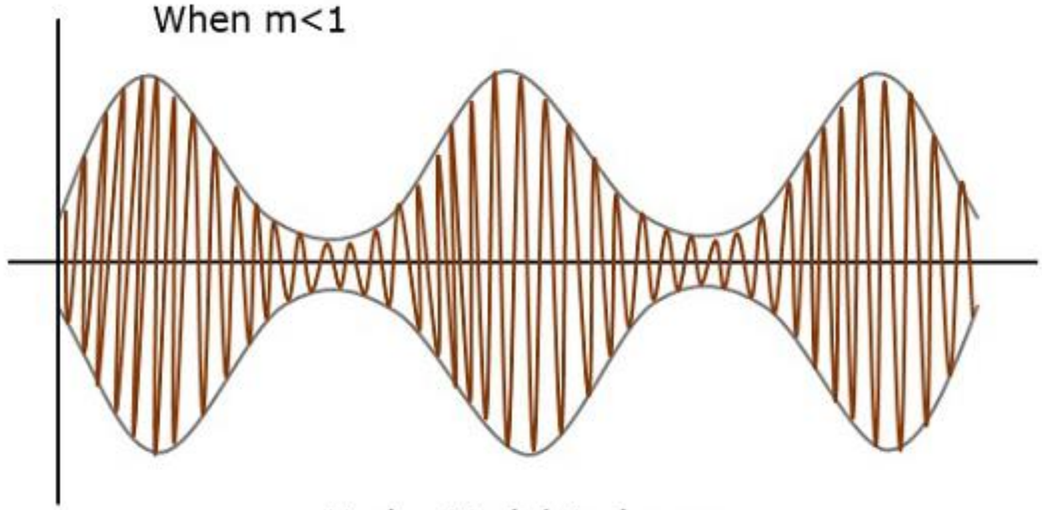
When $M_i = 1$



Perfect Modulation

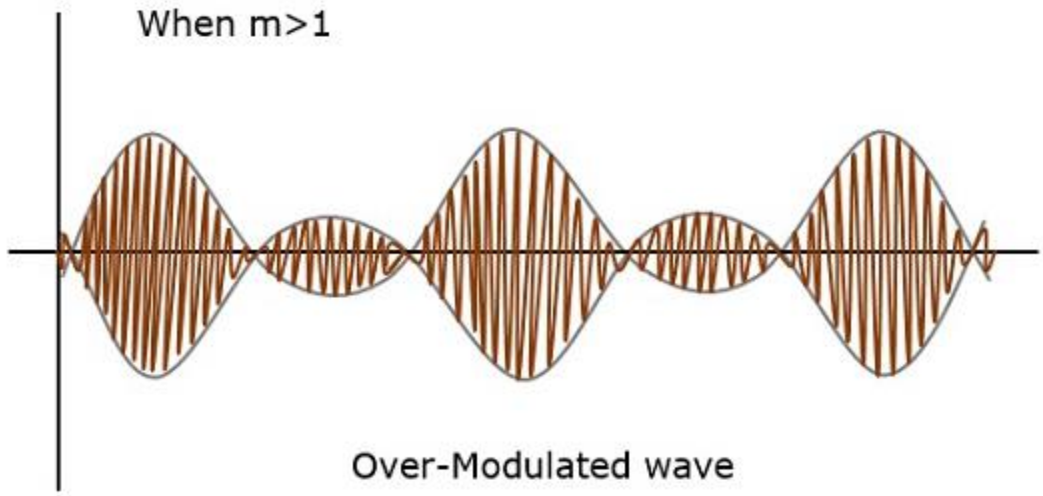
For instance, if this value is less than 1, i.e., the modulation index is 0.5, then the modulated output would look like the following figure. It is called as Under-modulation. Such a wave is called as an **under-modulated wave**.

When m<1



Under-Modulated wave

If the value of the modulation index is greater than 1, i.e., 1.5 or so, then the wave will be an **over-modulated wave**. It would look like the following figure.



BANDWIDTH OF AMPLITUDE MODULATION:

The bandwidth is the difference between lowest and highest frequencies of the signal.

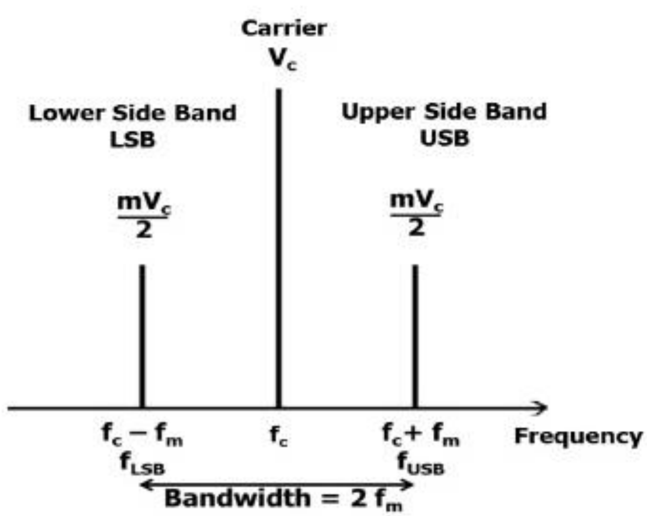
For amplitude modulated wave, the bandwidth is given by

BW = f{USB}-f{LSB}

=(fc + fm)-(fc - fm)

BW = 2fm

Hence, we got to know that the bandwidth required for the amplitude modulated wave is twice the frequency of the modulating signal.



On the next cycle of the carrier, the diode again conducts when the input signal exceeds the voltage across the capacitor n The capacitor again charges up to the peak value of the input signal and the process is repeated.

ADVANTAGES OF AMPLITUDE MODULATION:

Advantages	Disadvantages
Amplitude Modulation is easier to implement.	When it comes to power usage it is not efficient.
Demodulation can be done using few components and a circuit.	It requires a very high bandwidth that is equivalent to that of the highest audio frequency.
The receiver used for AM is very cheap.	Noise interference is highly noticeable.

APPLICATIONS OF AMPLITUDE MODULATION:

While amplitude modulation use has decreased over the years it is still present and has several applications in certain transmission areas. We will look at them below.

- **Broadcast Transmissions:** AM is used in broadcasting transmission over the short, medium, and long wavebands. Since AM is easy to demodulate radio receivers for amplitude modulation are therefore easier and cheaper to manufacture.

4. List of Components & Tools:

i. Connecting Wires

ii. Oscilloscope

iii. Inductors

iv. Resistors

v. Generic Electrolytic and non-Electric Capacitors

vi. Signal Generators

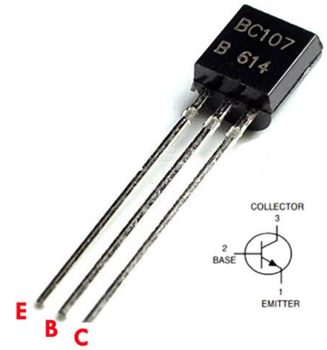
vii. NPN bipolar Transistor

viii. Battery

ix. Terminal Blocks

Transistor (BC 107 BP)

The BC107 is a small single NPN Transistor available in TO-18 metal can package. These transistors are age old and have been used in low noise and low signal designs. Today a lot new transistors have come as replacement for BC107, but still the transistor can be found in market for its legacy.



Resistors

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.

Terminal block

A terminal block is a modular, insulated block that secures two or more wires together. Factories use terminal blocks to secure and/or terminate wires. In their most basic form, terminal blocks consist of several individual terminals which are arranged in a long strip.

Connecting wires

Wires are used for establishing electrical conductivity between two devices of an electrical circuit. They possess negligible resistance to the passage of current.

Vero Board

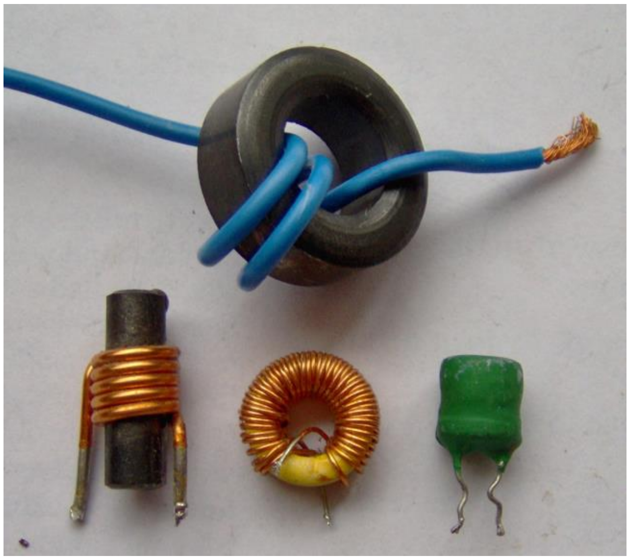
Veroboard is a brand of stripboard, a pre-formed circuit board material of copper strips on an insulating bonded paper board which was originated and developed in the early 1960s by the Electronics Department of Vero Precision Engineering Ltd (VPE). It was introduced as a general-purpose material for use in constructing electronic circuits - differing from purpose-designed printed circuit boards (PCBs) in that a variety of electronics circuits may be constructed using a standard wiring board.

Capacitors

A capacitor is a device that is used to store charges in an electrical circuit. A capacitor works on the principle that the capacitance of a conductor increases appreciably when an earthed conductor is brought near it. Hence, a capacitor has two plates separated by a distance having equal and opposite charges.

Inductors

An inductor, also called a coil, choke, or reactor, is a passive two-terminal electrical component that stores energy in a magnetic field when electric current flows through it.[1] An inductor typically consists of an insulated wire wound into a coil.



5. Working of Amplitude Modulation and Demodulation:

We used proteus software to construct the Amplitude Modulation circuit. Here we are using VSM Signal generator to Create Message and Carrier Signals as the inputs. (The VSM Signal Generator is supplied as standard with both ProSPICE Professional. It models a simple audio functional generator with the following features:

- Square, saw-tooth, triangle, and sine output waveforms.
- Output frequency range from 0-12MHz in 8 ranges
- Output amplitude from 0-12V in 4 ranges.
- Amplitude and frequency modulation inputs.

As we specify the values for V-p-p and frequency in each of the Signal generators.

For Message Signal:

- Frequency – 120 Hz or (Audio Signal)
- Amplitude – 1V

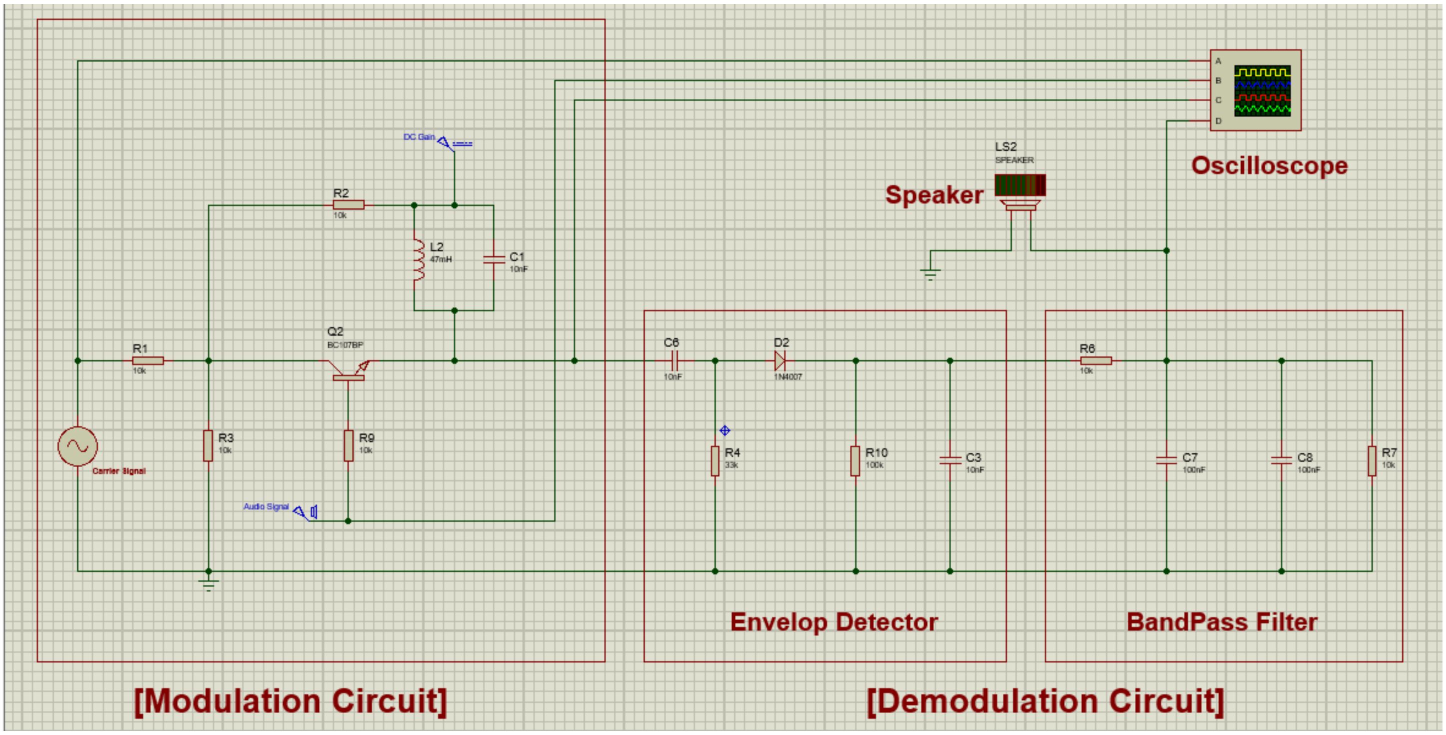
For Carrier Signal:

- Frequency -10kHz
- Amplitude – 5V

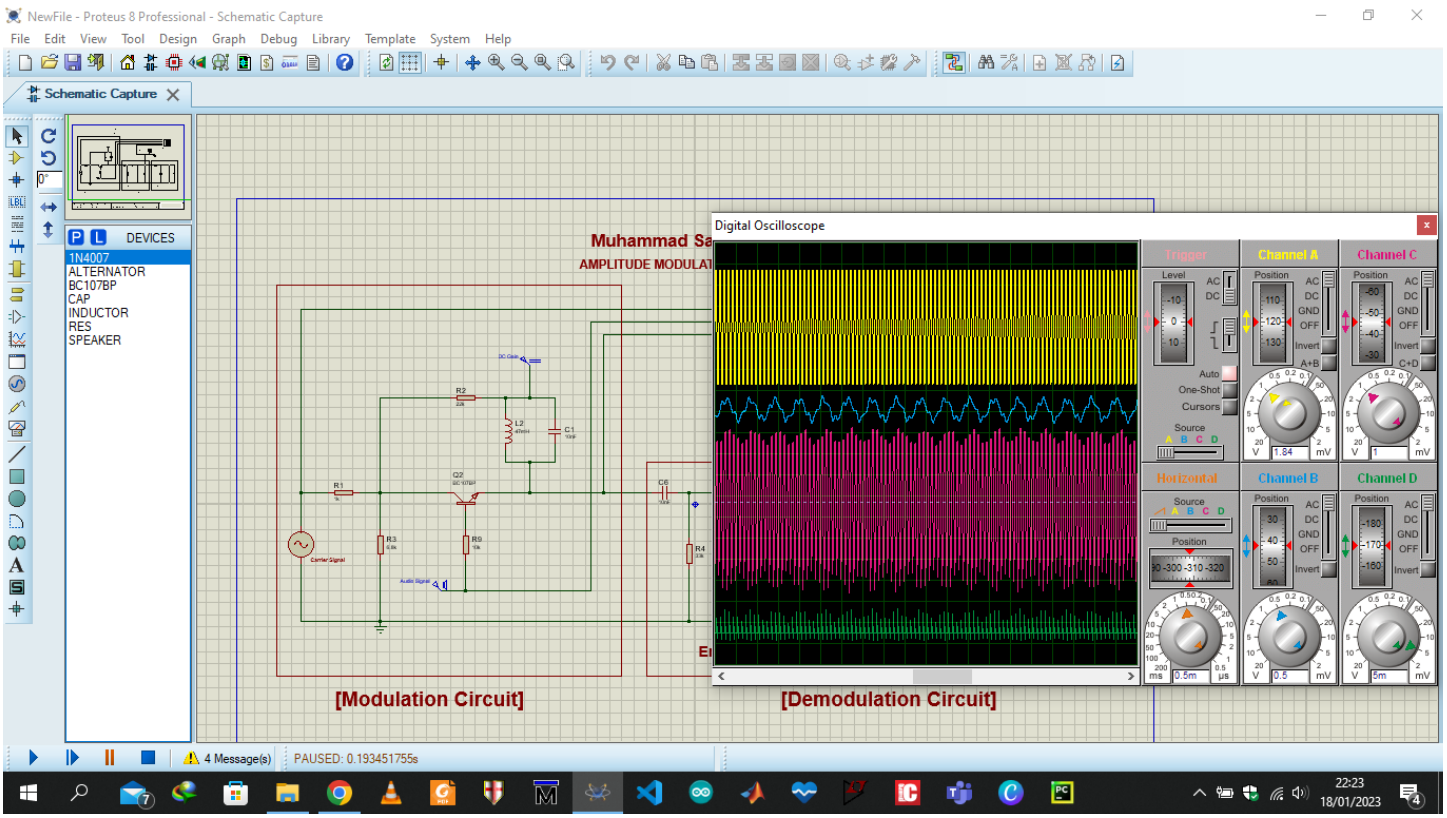
For Envelope Detector (Demodulation Part) we build an envelope detector that consists of diode and an RC circuit, which is basically a simple lowpass filter.

The detector consists of a simple half-wave rectifier which rectifies the received AM signal. This is followed by a low pass filter which removes (bypasses) the high-frequency carrier waveform the received signal. The resultant output of the low pass filter will be the original input (modulating) signal. This demodulated AM signal output is connected to input D of the oscilloscope.

6. Proteus Circuit:



OUTPUT: (DEMODULATED SIGNAL)



8. Conclusion:

In this Project, the basic principle of amplitude modulation is learned with real life circuit designing to implement the concepts as through procedures carried out. With respect to lab, we got practical learning on the concept of Amplitude Modulation. For this project we Choose to do Amplitude modulation with conventional method, As the Message signal is modulated with the Carrier signal, without suppressing it, and thus this Modulated Signal is later, demodulated to get the message signal, Using the Envelope Detector Method.

9. References:

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