University of Engineering and Technology, Taxila

Lab Project Report

Communication Systems

Project Title:

Amplitude Modulation and Demodulation

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Besides our teachers, our respected parents always stood beside us to motivate us, encourage us, which meant a lot to us. We would like to admit that we owe all our achievements to our parents and family members whose love and prayers have always been a constant source of inspiration for us.

Abstract

A message signal m(t) is transmitted using Amplitude Modulation and is demodulated at the receiver's end using an Envelope Detector. Message signal can be any audio signal from any source like microphone. Modulating (speech) signal frequency is approximately 500 Hz and carrier signal frequency is 15KHz. Also Based on different variations in proteus we understand the amplitude modulated and demodulated signal waveforms that we also did.

Part- 01

Theoretically Knowledge

Introduction

The AM modulation is a kind of modulation technique which is in use since the very early days of wireless data transmission amplitude modulation is the simplest modulation technique among the wide verity of modulation techniques in use. In a radio transmission system, there is a relation between the ranges of frequencies which can be transmitted wirelessly with the length of the transmitting antenna. The relation is inversely proportional to one another, means as the frequency of the signal to be transmitted increases the length of the antenna can be reduced and as the frequency of the signal to be transmitted decreases the length of the transmitting antenna should be increased accordingly. Using an antenna of few meters the frequencies in the range of MHz can be easily transmitted to a distance.

Modulation is used in efficient radiation of signals. This way, the antenna size can be made small as well as more than one signals can be transmitted through a single channel by transmitting modulating signals at different frequency bands. Amplitude modulation implies variation in the amplitude of the carrier signal according to the amplitude of the modulating signal. Special circuits are required in the receiver to reduce the effects of communication channel and demodulate the modulated signal to receive the message signal. Further, to improve the power of the message signal, MOSFET amplifier is used to amplify the voltage level etc.

Project Objective:

The main objectives of this project are:

- To design and implement amplitude modulation and demodulation circuit (on Veroboard).
- To understand the amplitude modulated and demodulated signal waveforms based on different variations in Proteus.

Theoretical Background

Signal Modulation:

A message carrying signal has to get transmitted over a distance and for it to establish a reliable communication; it needs to take the help of a high frequency signal which should not affect the original characteristics of the message signal.

The characteristics of the message signal, if changed, the message contained in it also alters. Hence it is a must to take care of the message signal. A high frequency signal can travel up to a longer distance, without getting affected by external disturbances. We take the help of such high frequency signal which is called as a carrier signal to transmit our message signal. Such a process is simply called as Modulation.

Modulation is the process of changing the parameters of the carrier signal, in accordance with the instantaneous values of the modulating signal.

Need for Modulation:

The baseband signals are incompatible for direct transmission. For such a signal, to travel longer distances, its strength must be increased by modulating with a high frequency carrier wave, which doesn’t affect the parameters of the modulating signal.

Advantages of Modulation:

The antenna used for transmission, had to be very large, if modulation was not introduced. The range of communication gets limited as the wave cannot travel to a distance without getting distorted.

Following are some of the advantages for implementing modulation in the communication systems.

- Antenna size gets reduced.
- No signal mixing occurs.

- Communication range increases.
- Multiplexing of signals occur.
- Adjustments in the bandwidth are allowed.
- Reception quality improves.
- Signals in the Modulation Process
- Following are the three types of signals in the modulation process.

Message or Modulating Signal:

The signal which contains a message to be transmitted is called as a message signal. It is a baseband signal, which has to undergo the process of modulation, to get transmitted.

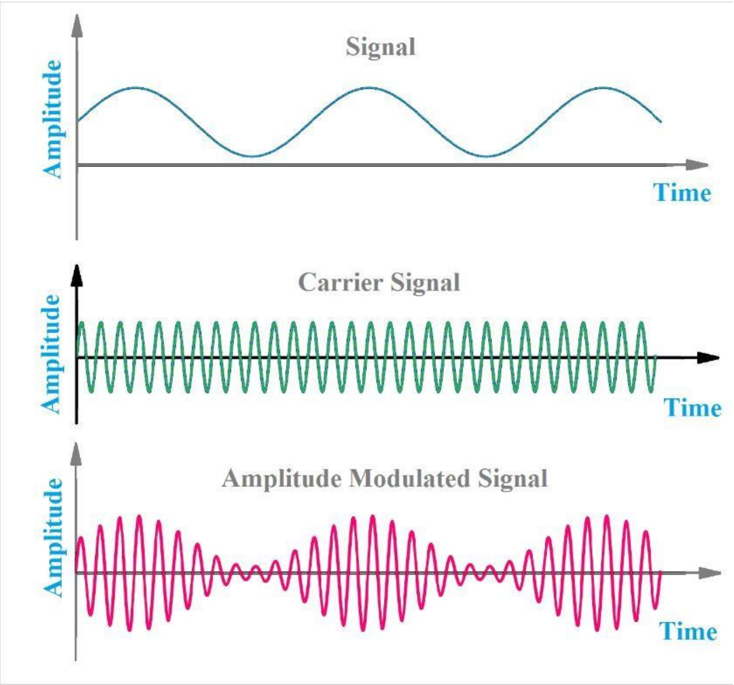
Hence, it is also called as the modulating signal.

Carrier Signal:

The high frequency signal which has a certain phase, frequency, and amplitude but contains no information is called a carrier signal. It is an empty signal. It is just used to carry the signal to the receiver after modulation.

Modulated Signal:

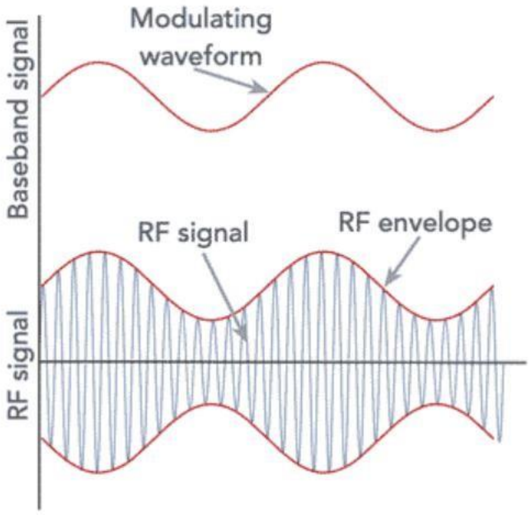
The resultant signal after the process of modulation is called as the modulated signal. This signal is a combination of the modulating signal and the carrier signal.



Amplitude Modulation:

Amplitude modulation or AM as it is often called is a form of modulation used for radio transmissions for broadcasting and two-way radio communication applications. Although one of the earliest used forms of modulation it is still used today, mainly for long, medium, and short-wave broadcasting and for some aeronautical point to point communications. One of the key reasons for the use of amplitude modulation was its ease of use. The system simply required the carrier amplitude to be modulated, but more usefully the detector required in the receiver could be a simple diode based circuit. This meant that AM radios did not need complicated demodulators and costs were reduced - a key requirement for widespread use of radio technology, especially in the early days of radio when ICs were not available. In order that a radio signal can carry audio or other information for broadcasting or for two-way radio communication, it must be modulated or changed in some way. Although there are several ways in which a radio signal may be modulated, one of the easiest is to change its amplitude in line with variations of the sound.

In this way the amplitude of the radio frequency signal varies in line with the instantaneous value of the intensity of the modulation. This means that the radio frequency signal has a representation of the sound wave superimposed in it. In view of the way the basic signal "carries" the sound or modulation, the radio frequency signal is often termed the “carrier". Different waveforms of amplitude modulation are shown in below figure. From the below figure, it can be seen that the envelope of the signal follows the contours of the modulating signal.



Amplitude Modulation Applications:

Amplitude modulation is used in a variety of applications. Even though it is not as widely used as it was in previous years in its basic format it can nevertheless still be found.

- **Broadcast transmissions:** AM is still widely used for broadcasting on the long, medium and short wave bands. It is simple to demodulate and this means that radio receivers capable of demodulating amplitude modulation are cheap and simple to manufacture. Nevertheless, many people are moving to high quality forms of transmission like frequency modulation, FM or digital transmissions.
- **Air band radio:** VHF transmissions for many airborne applications still use AM. It is used for ground to air radio communications as well as two-way radio links for ground staff as well.
- **Single sideband:** Amplitude modulation in the form of single sideband is still used for HF radio links. Using a lower bandwidth and providing more effective use of the transmitted power this form of modulation is still used for many points to point HF links.
- **Quadrature amplitude modulation:** AM is widely used for the transmission of data in everything from short range wireless links such as Wi-Fi to cellular telecommunications and much more. Effectively it is formed by having two carriers 90° out of phase.

These form some of the main uses of amplitude modulation. However, in its basic form, this form of modulation is being used less as a result of its inefficient use of both spectrum and power.

AM Demodulation (Amplitude Modulation Detection):

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. The process of demodulation for signals using amplitude modulation can be achieved in a number of different techniques, each of which has its own advantage. The demodulator is the circuit, or for software defined radio, the software that is used to recover the information content from the overall incoming modulated signal. AM demodulators are found in many items of radio equipment: broadcast receivers, professional radio communication equipment, walkie talkies - AM is still used for air-band radio communications.

Detection or Demodulation:

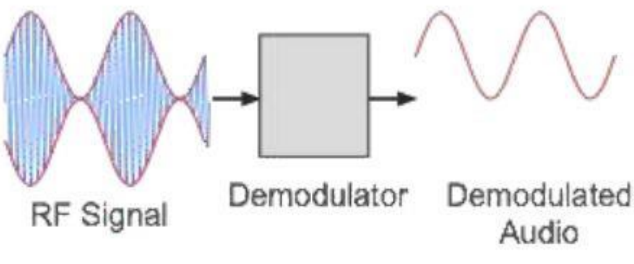
The terms detection and demodulation are often used when referring to the overall demodulation process. Essentially the terms describe the same process, and the same circuits.

As the name indicates the demodulation process is the opposite of modulation, where a signal such as an audio signal is applied to a carrier.

In the demodulation process the audio or other signal carried by amplitude variations on the carrier is extracted from the overall signal to appear at the output.

As the most common use for amplitude modulation is for audio applications, the most common output is the audio. This may be broadcast entertainment for broadcast reception, and for two way radio communications, it is often used for land communications for aeronautical associated applications - often within walkie talkies.

Terms like diode detector, synchronous detector and product detector are widely used. But the term demodulation tends to be used more widely when referring to the process of extracting the modulation from the signal.



The term detection is the older term dating back to the early days of radio. The term demodulation is probably more accurate in that it refers to the process of demodulation,

i.e. extracting the modulation from the signal.

AM Demodulation Techniques:

There are a number of techniques that can be used to demodulate AM signals. Different types are used in different applications to suit their performance and cost.

Diode Rectifier Envelope Detector:

This form of detector is the simplest form, only requiring a single diode and a couple of other low cost components. The performance is adequate for low cost AM broadcast radios, but it does not meet the standards of other forms of demodulation. It has a high level of distortion, and performs badly under conditions of selective fading such as those experienced on the medium and short wave bands. That said the diode detector has been in use for many years. It was widely used for domestic and professional valve or tube radios, and when semiconductors replaced valves, simple diode detectors were very easy to implement.

AM demodulators are used within any piece of radio equipment that is used for AM broadcast reception or radio communications systems that use amplitude modulation. Although amplitude modulation is not as widely used as it was many years ago, it is still used for broadcasting on the Long, Medium and Short Wave bands.

Possibly its greatest use for professional radio communications is for aeronautical radio communications. Here it is widely used for ground communications and walkie talkies are widely used. each of these different forms of radio communication will require for their to be an AM demodulator.

Advantages & Disadvantages of Amplitude Modulation:

As with any technology there are advantages and disadvantages to be considered. The summary below gives a highlight of the basic pro's and cons of AM modulation.

- **Advantages**
  - It is simple to implement.
  - It can be demodulated using a circuit consisting of very few components. o AM receivers are very cheap as no specialized components are needed.
- **Disadvantages**
  - It is not efficient in terms of its power usage.
  - It is not efficient in terms of its use of bandwidth, requiring a bandwidth equal to twice that of the highest audio frequency.
  - It is prone to high levels of noise because most noise is amplitude based and obviously AM detectors are sensitive to it.

Part-02

Electronics Circuit Base Knowledge

Amplitude Modulators:

Amplitude modulators are generally one of two types: low level or high level. Low-level modulators generate AM with small signals and thus must be amplified considerably if they are to be transmitted. High-level modulators produce AM at high power levels, usually in the final amplifier stage of a transmitter. Here we will discuss the lower level modulator.

Diode Modulator:

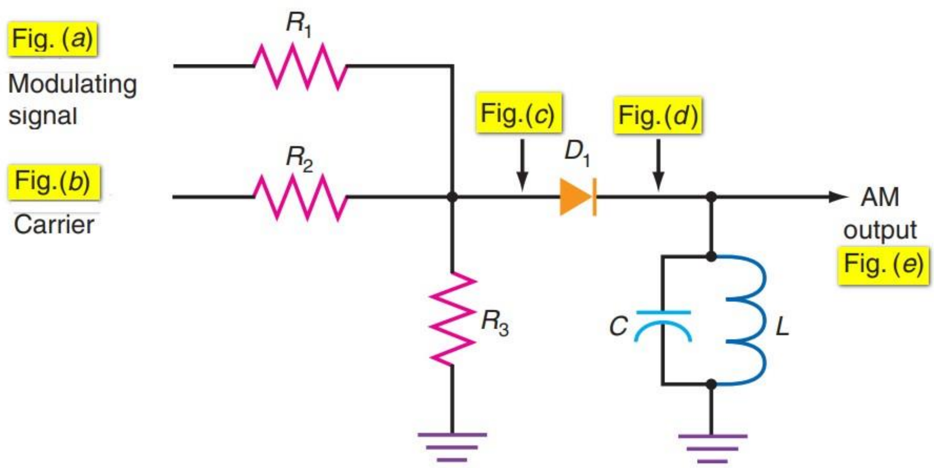
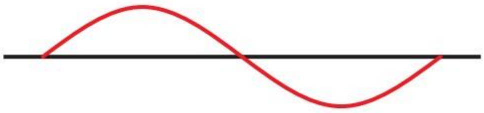


Figure 1-1

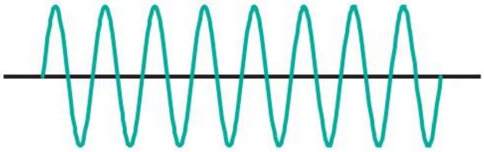
One of the simplest amplitude modulators is the diode modulator described in this Sec. The practical implementation above shown in Fig.1-1 consists of a resistive mixing network, a diode

rectifier, and an LC tuned circuit. The carrier (Fig.b) is applied to one input resistor and the modulating signal

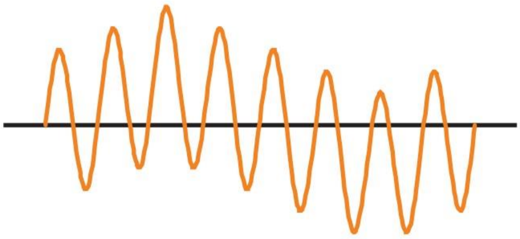
(Fig. a) to the other. The mixed signals appear across R3. This network causes the two signals to be linearly mixed, i.e., algebraically added. If both the carrier and the modulating signal are sine waves, the waveform resulting at the junction of the two resistors will be like that shown in Fig. 1-2 (c), where the carrier wave is riding on the modulating signal.



(a)

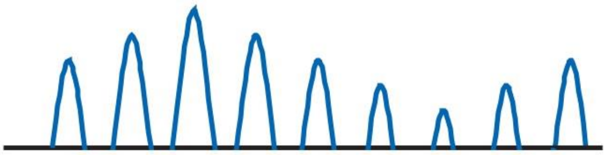


(b)



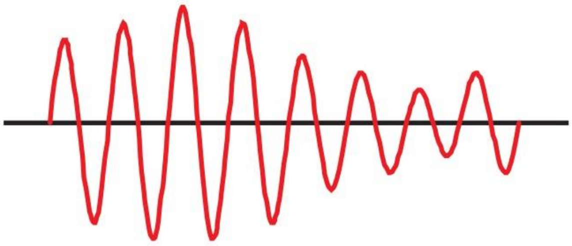
(c)

This signal is not AM. Modulation is a multiplication process, not an addition process. The composite waveform is applied to a diode rectifier. The diode is connected so that it is forwardbiased by the positive-going half-cycles of the input wave. During the negative portions of the wave, the diode is cut off and no signal passes. The current through the diode is a series of positive-going pulses whose amplitude varies in proportion to the amplitude of the modulating signal [see Fig. 1-2 (d)].



(d)

These positive-going pulses are applied to the parallel-tuned circuit made up of L and C, which are resonant at the carrier frequency. Each time the diode conducts, a pulse of current lows through the tuned circuit. The coil and capacitor repeatedly exchange energy, causing an oscillation, or “ringing,” at the resonant frequency. The oscillation of the tuned circuit creates one negative half-cycle for every positive input pulse. High amplitude positive pulses cause the tuned circuit to produce high- amplitude negative pulses. Low-amplitude positive pulses produce corresponding low-amplitude negative pulses. The resulting waveform across the tuned circuit is an AM signal, as Fig. (e) illustrates.



(e)

The Q of the tuned circuit should be high enough to eliminate the harmonics and produce a clean sine wave and to filter out the modulating signal, and low enough that its bandwidth accommodates the sidebands generated.

This signal produces high-quality AM, but the amplitudes of the signals are critical to proper operation. Because the nonlinear portion of the diode's characteristic curve occurs only at low voltage levels, signal levels must be low, less than a volt, to produce AM. At higher voltages, the diode current response is nearly linear. The circuit works best with millivolt-level signals.

Transistor Modulator:

An improved version of the circuit just described is shown in Fig. 1-2. Because it uses a transistor instead of the diode, the circuit has gain. The emitter-base junction is a diode and a nonlinear device. Modulation occurs as described previously, except that the base current controls a larger collector current, and therefore the circuit amplifies. Rectification occurs because of the emitter-base junction. This causes larger half-sine pulses of current in the tuned circuit. The tuned circuit oscillates (rings) to generate the missing half-cycle. The output is a classic AM wave.

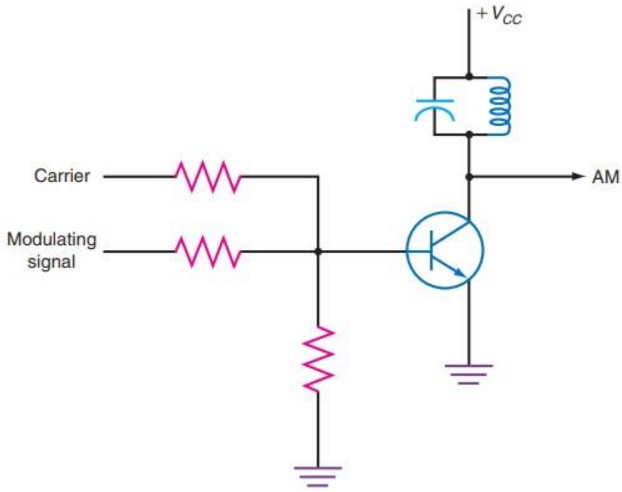


Figure 1- 2

Amplitude Demodulators:

Demodulators, or detectors, are circuits that accept modulated signals and recover the original modulating information. The demodulator circuit is the key circuit in any radio receiver. In fact, demodulator circuits can be used alone as simple radio receivers.

Diode Detectors:

The simplest and most widely used amplitude demodulator is the diode detector (see Fig. 1-3). As shown, the AM signal is usually transformer-coupled and applied to a basic half wave rectifier circuit consisting of D1 and R1. The diode conducts when the positive half-cycles of the AM signals occur. During the negative half-cycles, the diode is reverse-biased and no current l flows through it. As a result, the voltage across R1 is a series of positive pulses whose amplitude varies with the modulating signal. A capacitor C1 is connected across resistor R1, effectively filtering out the carrier and thus recovering the original modulating signal. One way to look at the operation of a diode detector is to analyze its operation in the time domain. The waveforms in Fig. 1-4 illustrate this. On each positive alternation of the AM signal, the capacitor charges quickly to the peak value of the pulses passed

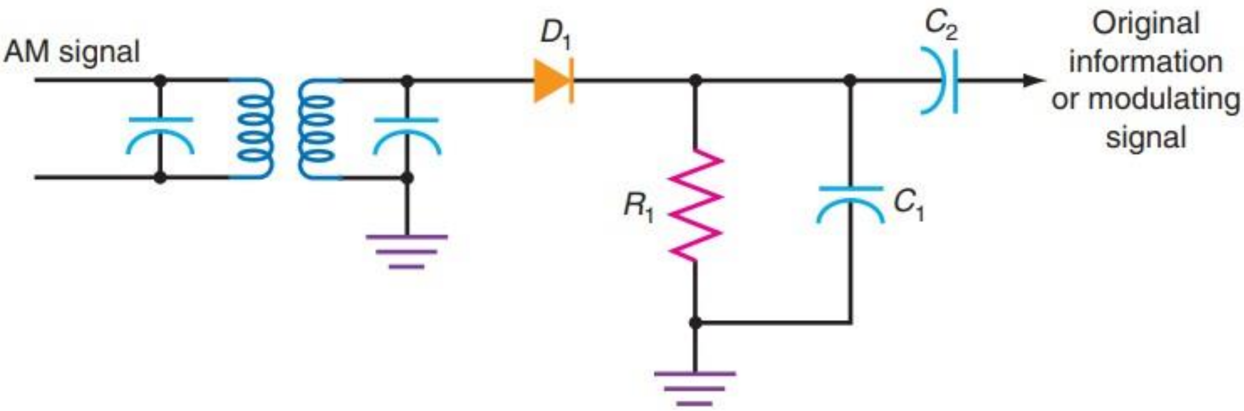


Figure 1-3

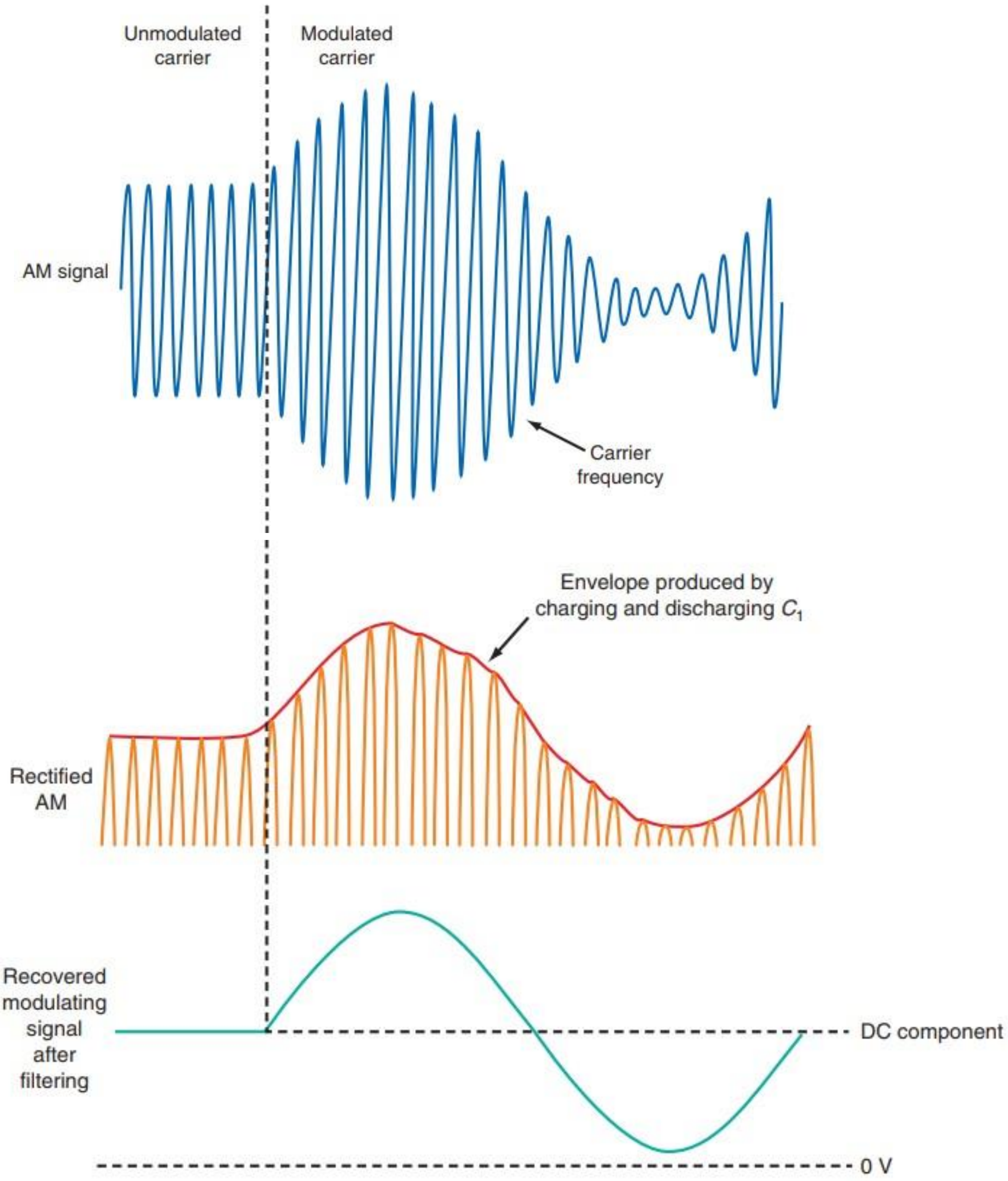


Figure 1-4

by the diode. When the pulse voltage drops to zero, the capacitor discharges into resistor R1. The time constant of C1 and R1 is chosen to be long compared to the period of the carrier. As a result, the capacitor discharges only slightly during the time that the diode is not conducting. When the next pulse comes along, the capacitor again charges to its peak value. When the diode cuts off, the capacitor again discharges a small amount into the resistor. The resulting waveform across the capacitor is a close approximation to the original modulating signal.

Because the capacitor charges and discharges, the recovered signal has a small amount of ripple

on it, causing distortion of the modulating signal. However, because the carrier frequency is usually many times higher than the modulating frequency, these ripple variations are barely noticeable. Because the diode detector recovers the envelope of the AM signal, which is the original modulating signal, the circuit is sometimes referred to as an envelope detector. Distortion of the original signal can occur if the time constant of the load resistor R1 and the shunt filter capacitor C1 is too long or too short. If the time constant is too long, the capacitor discharge will be too slow to follow the faster changes in the modulating signal. This is referred to as diagonal distortion. If the time constant is too short, the capacitor will discharge too fast and the carrier will not be sufficiently filtered out. The dc component in the output is removed with a series coupling or blocking capacitor, C2 in Fig. 1-4, which is connected to an amplifier. Another way to view the operation of the diode detector is in the frequency domain. In this case, the diode is regarded as a nonlinear device to which are applied multiple signals where modulation will take place. The multiple signals are the carrier and sidebands, which make up the input AM signal to be demodulated. The components of the AM signal are the carrier fc, the upper sideband fc + fm, and the lower sideband fc - fm. The diode detector circuit combines these signals, creating the sum and difference signals:

$$
\begin{aligned}
f_c + (f_c + f_m) &= 2f_c + f_m \\
f_c - (f_c + f_m) &= -f_m \\
f_c + (f_c - f_m) &= 2f_c - f_m \\
f_c - (f_c - f_m) &= f_m
\end{aligned}
$$

All these components appear in the output. Since the carrier frequency is very much higher than that of the modulating signal, the carrier signal can easily be iltered out with a simple low-pass filter. In a diode detector, this low-pass filter is just capacitor C1 across load resistor R1. Removing the carrier leaves only the original modulating signal. The frequency spectrum of a diode detector is illustrated in Fig. 1-5. The low-pass ilter, C1 in Fig. 1-3, removes all but the desired original modulating signal.

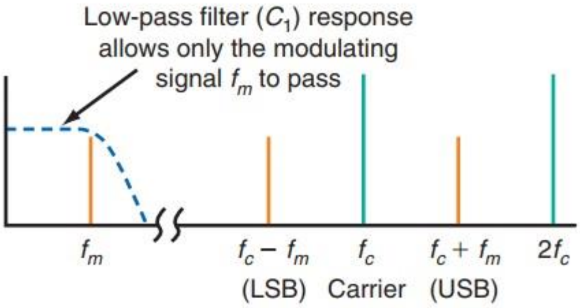


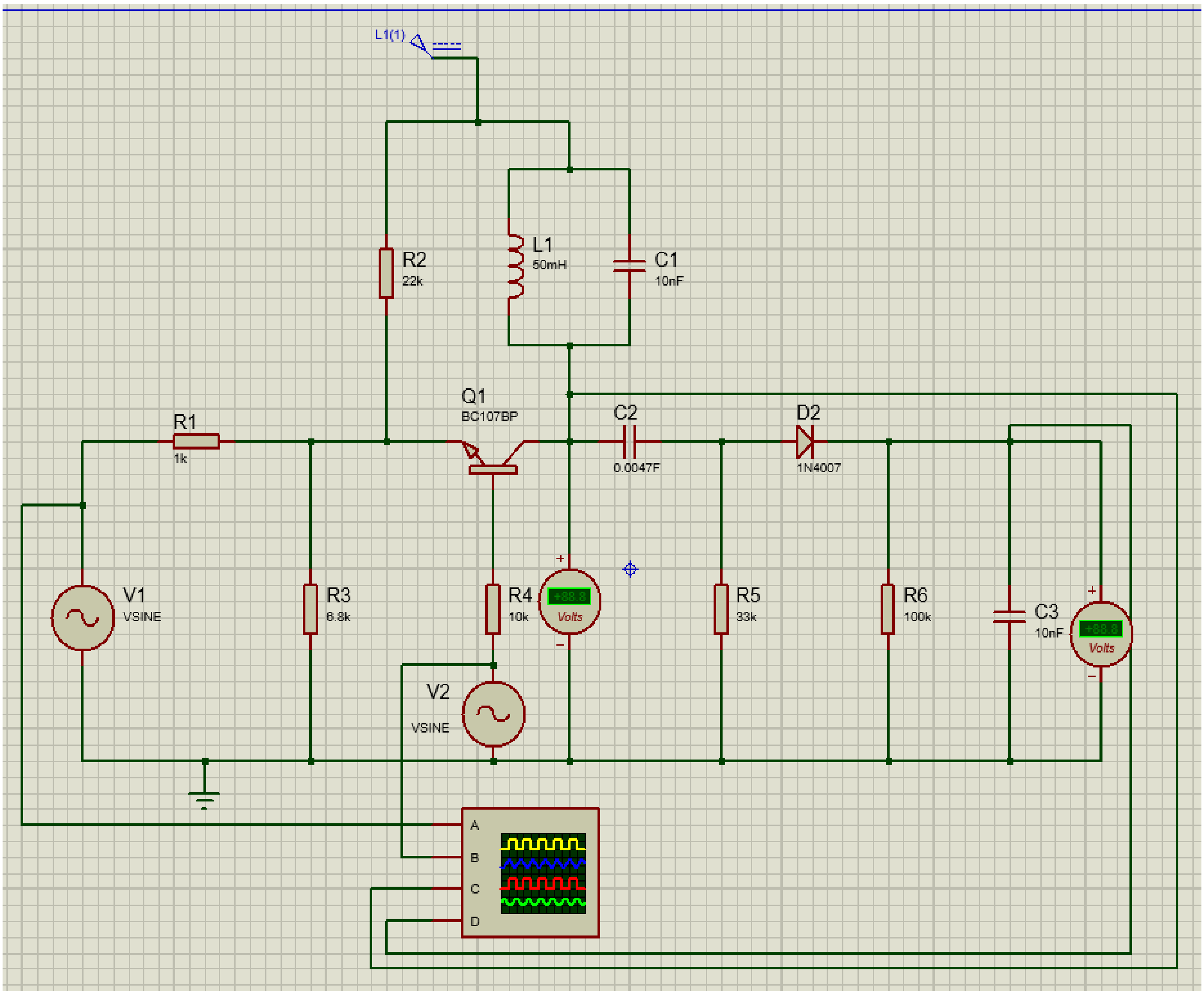
Figure 1-5

Part- 03

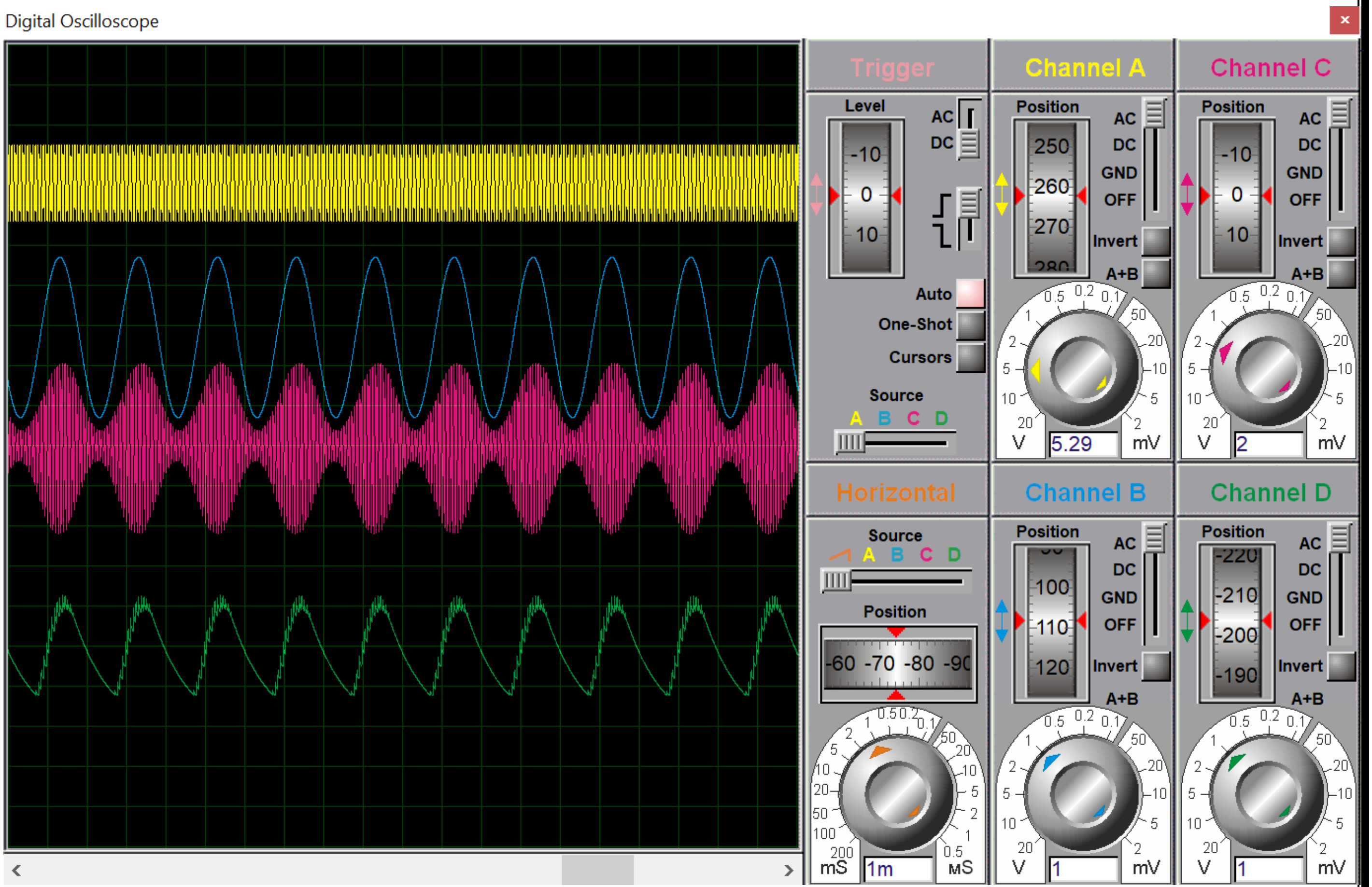
Simulation Base

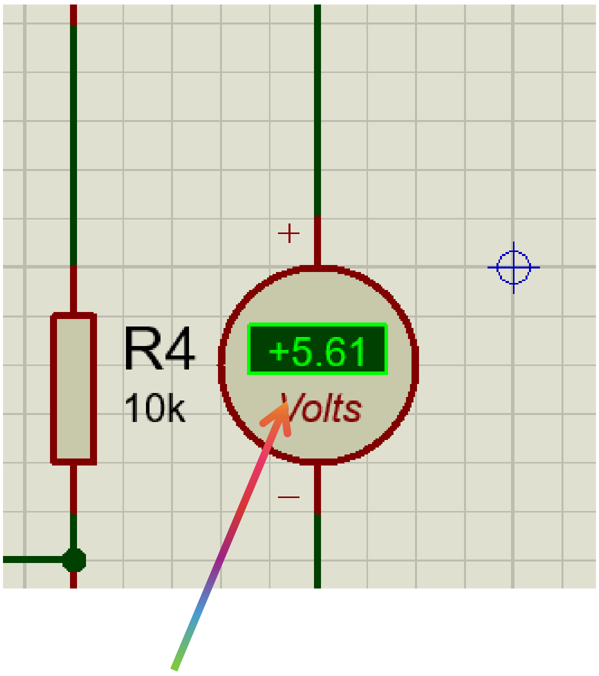
In this section we are analyzing the circuit by using a simulation software which is proteus.

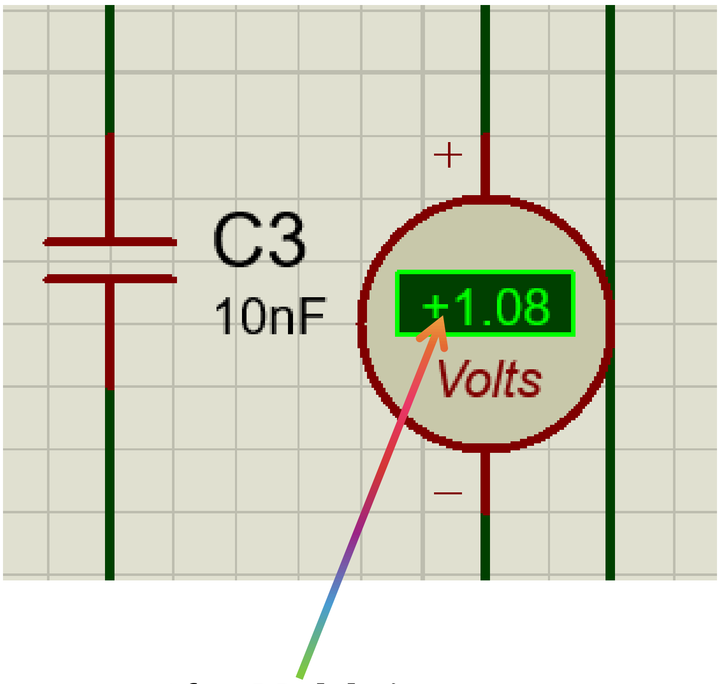
Circuit Diagram:



Graphical Output:

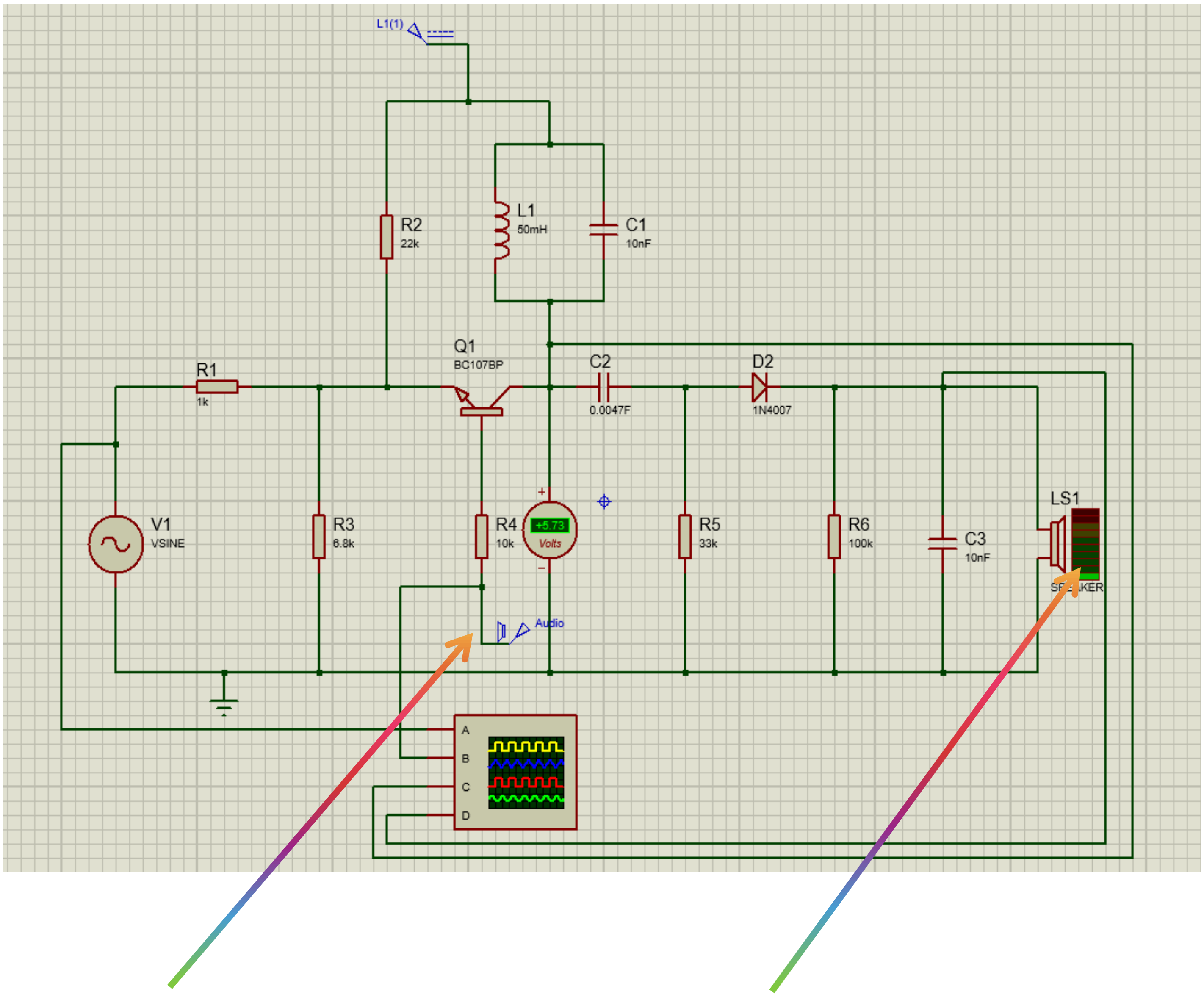






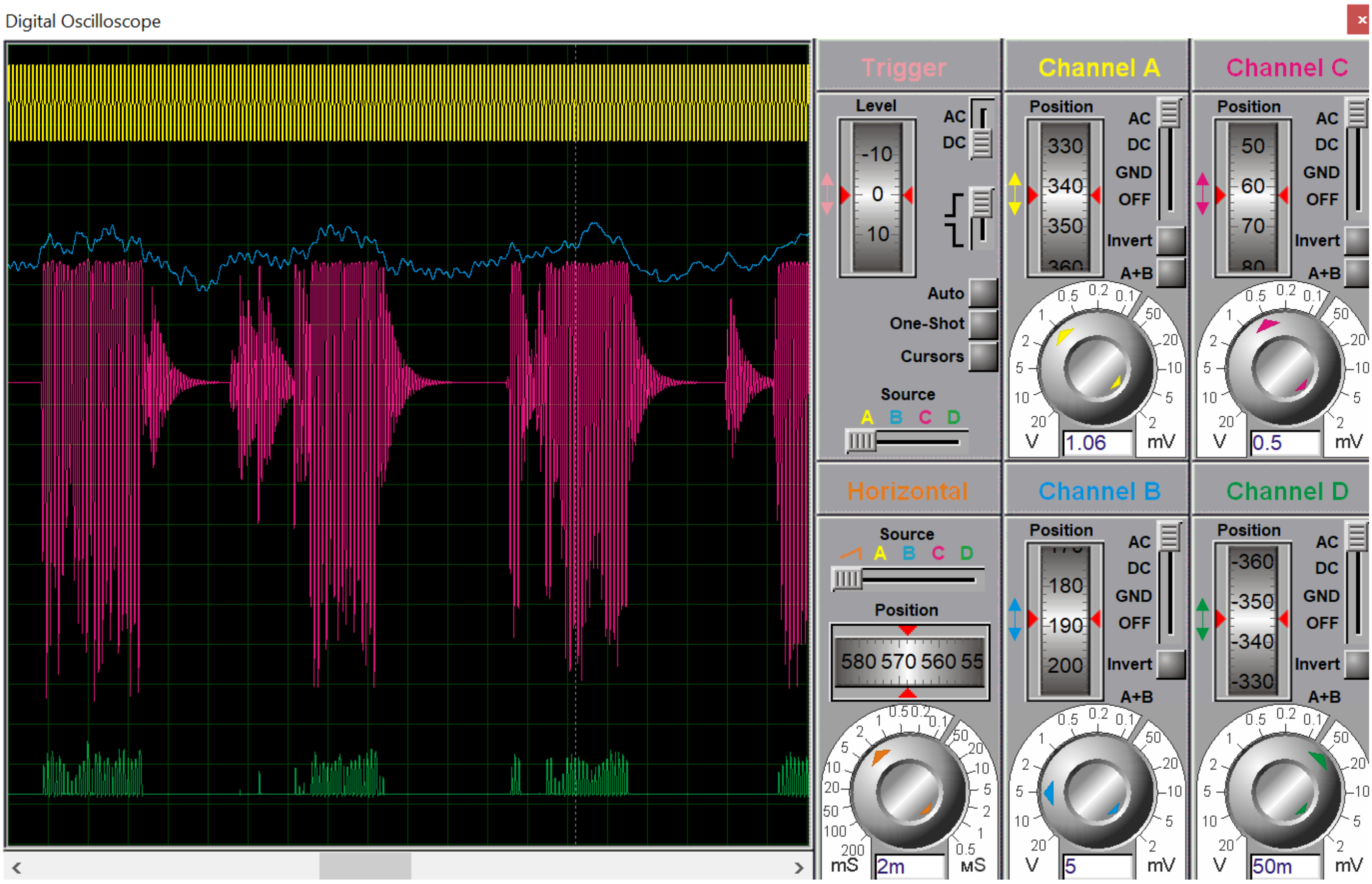
Before Modulation **After Modulation**

Circuit Diagram using Audio File:



Audio File Source **Speaker Output**

Graphical Output using Audio File:



Part- 04
Practically Circuit on Veroboard

Equipments:

Resistor 1k ohm	(1 No)
Resistor 6.8k ohm	(1 No)
Resistor 10k ohm	(1 No)
Resistor 22k ohm	(1 No)
Resistor 33k ohm	(1 No)
Resistor 100k ohm	(1 No)
Capacitor 10nf	(1 No)
Capacitor 4.7nf	(1 No)
Inductor 51mH	(1 No)
Transistor BC107BP	(1 No)
1N4007 Diode	(1 No)
Battery	(1 No)
Veroboard	(1 No)
Connection terminals	(2 No)
Microphone	(2 No)
Spst switch	(1 No)

4.7nf / 0.0047uf

Microphone

Bnanna Cable

SPST switch

Jack female port

Connection Terminal

Speaker

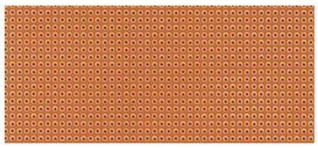
50mH Inductor

BC107BP transistor

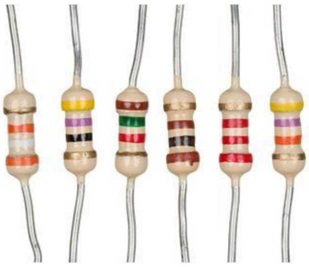
Soldering iron

Solder wire

Veroboard



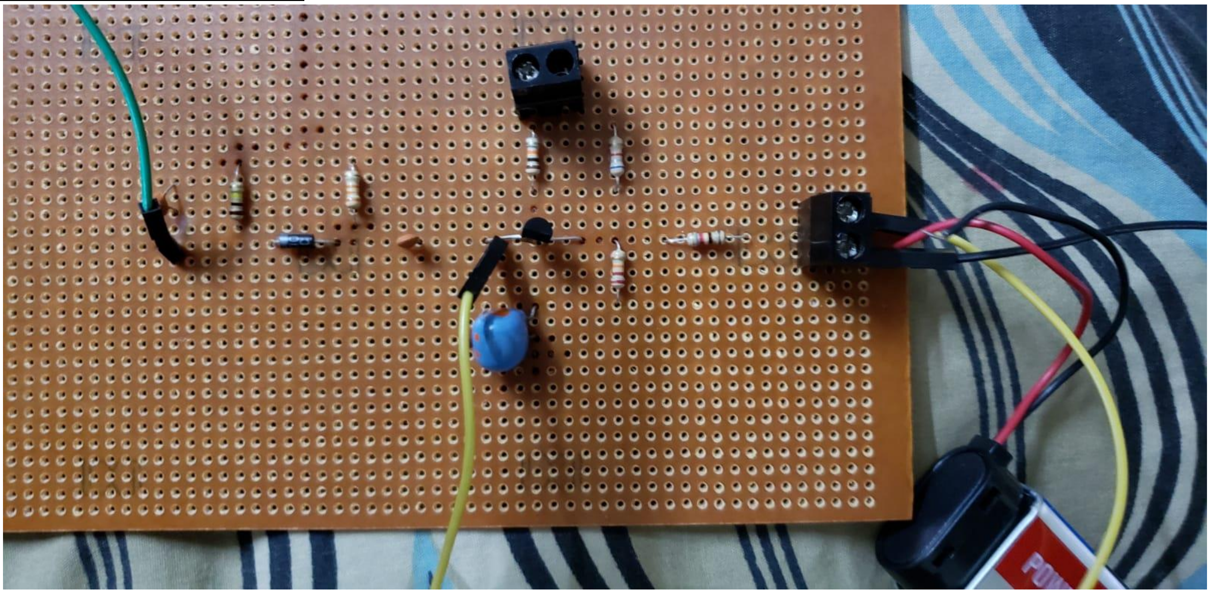
Resistors

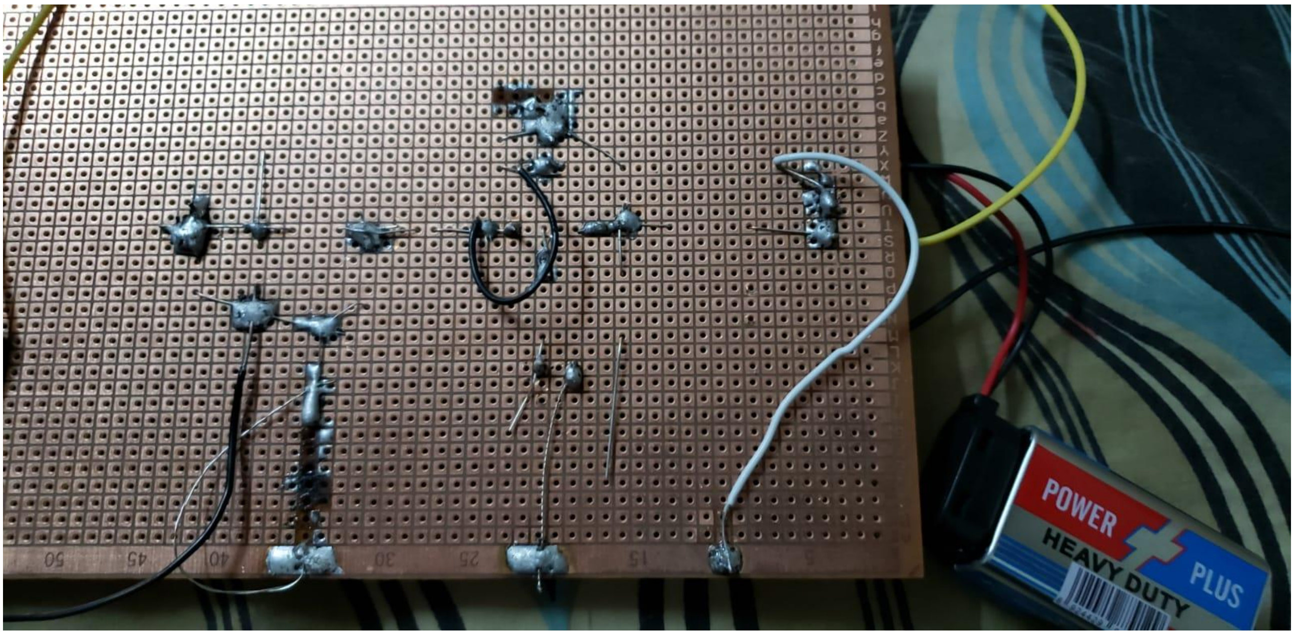


Diode 1N4007

9V Battery

Circuit on Veroboard:





Calculations and Conclusions:

In this project, we implemented AM modulation and demodulation using Function generator, speech signal, Diode enveloper detector for demodulation. For the message signal of 1KHz and 10KHz for carrier signal, which is within the range of AM. By the changing the amplitude of carrier signal or message signal modulation goes in three modes under, exact or over modulation. All work was done by using a simulation model, a Proteus platform in which the model was implemented for the modulation and demodulation of the signal. Hence the objective of this project is achieved, in proteus, we also designed and implemented the circuit of amplitude modulation and demodulation circuit on the Veroboard. Also, based on different variations in Proteus, we understand the amplitude modulated and demodulated signal waveforms.

References

[1] S. Haskin Communication Systems, 4th Edition. Toronto: John Wiley & Sons, Inc., 2001.

[2] https://www.electronics-tutorials.ws/oscillator/wien_bridge.html

[3] https://www.slideshare.net/sovan005/am-modulation-and-demodulation-with-circuitand-output-61978890

Project Rubrics

PLOs	Decision Criterion	Exemplary 5	Satisfactory 4	Developing 3	Unsatisfactory 2	Unacceptable 0-1
PLO-3 (C3)	Q1: Proposed Project Solution (Report)	Has proposed an effective design solution that addresses all the project specifications with complete implementation	Has proposed a design solution that is closely relevant to the project specifications with almost complete implementation	Has proposed a design solution that is mostly relevant to the project specifications with partially complete implementation	Has proposed a design solution that is marginally relevant and addresses very few project specifications with incomplete implementation	Has not proposed any relevant design solution to meet project specifications with implementation

PLOs	Decision Criterion	Exemplary 5	Satisfactory 4	Developing 3	Unsatisfactory 2	Unacceptable 0-1
PLO-4 (P4)	Q2: Implementation of the Proposed Project Solution (Hardware)	Project is implemented according to the defined scope mentioned in report. Successfully developed a solution that meets all and exceeds some operational specifications. The achievement level is >90%.	Project is almost implemented according to the defined scope mentioned in report. Successfully developed a solution that meets most of the operational specifications. The achievement level is >75%.	Some of the project sections are not properly implemented according to the defined scope mentioned in report. Developed a solution that meets some of the operational specifications. The achievement level is >50%.	Majority of the project sections are not implemented. Developed a partially working solution that meets very few of the operational specifications. The achievement level is >25%.	Majority of the project sections are not implemented that does not meet the operational specifications. The achievement level is <25%.
PLO-4 (P4)	Q3: Results Interpretation and Investigation (Demonstation / Presentation)	The results are fully interpreted and are in line with problem specification. The limitations and weaknesses are discussed/ presented/ demonstrated and suggestions are made as to how to limit or eliminate them.	The results are interpreted and are in line with problem specification, but not as fully as they might be. The limitations and weaknesses are reasonably discussed/ presented/ demonstrated, but few suggestions are made as to how to limit or eliminate them.	The results are partially interpreted in a logical way or in line with problem specification. The limitations and weaknesses are somehow discussed/ presented/ demonstrated and little suggestions are made as to how to limit or eliminate them.	The results are not interpreted in a logical way or in line with problem specification. The limitations and weaknesses are not discussed/ presented/ demonstrated, nor are suggestions made as to how to limit or eliminate them.	The results are not interpreted or discussed/ presented/ demonstrated at all.

PLOs	Decision Criterion	Exemplary 5	Satisfactory 4	Developing 3	Unsatisfactory 2	Unacceptable 0-1
PLO-10 (A2)	**Q4:Organization / Structure (Report)**	The final report follows the prescribed format. All the components of the solution are addressed in detail. All necessary diagrams, equations, and graphs are correctly labeled. The procedure and results are described clearly and in an organized fashion.	The final report follows the format. Almost all the components of the solution are addressed in detail. Almost all the necessary diagrams, equations and graphs are included. The procedure and results are mostly described clearly and in an organized fashion.	The final report follows the format, but each section may not have been completely addressed. Some of the necessary diagrams, equations and graphs are missing. Student may have understood the connection between the initial problem and the outcome, but this understanding is not expressed in the report.	The final report follows the format, but there may have been several omissions. Most of the necessary diagrams, equations and graphs are missing. Students do not understand the connection between the initial problem and the outcome.	The report do not address the problem mentioned in Project. All the relevant diagrams, equations and graphs are missing. The report has no logical linkage, or paragraphs are irrelevantly linked together.