Bangladesh University of Engineering and Technology

Department of Electrical and Electronic Engineering

Project Title:

AMPLITUDE MODULATION AND DEMODULATION

Submitted to:

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Academic Honesty Statement:

"In signing this statement, We hereby certify that the work on this project is our own and that we have not copied the work of any other students (past or present), and cited all relevant sources while completing this project. We understand that if we fail to honor this agreement, We will each receive a score of ZERO for this project and be subject to failure of this course."

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1. Abstract:

The amplitude modulation and demodulation project aims to explore the principles, applications, and implications of this fundamental communication technique. Firstly, amplitude modulation was done by a simple switching modulator circuit. The resulting amplitude-modulated waveform was then demodulated using two techniques named envelope detector and coherent detection techniques. The circuit was at first simulated on Proteus software and then hardware implementations were made. Practical implementation involves the design and construction of a hardware circuit for amplitude modulation, complemented by demodulation techniques. The project considers safety, societal, and environmental aspects, ensuring a well-rounded evaluation. Ultimately, this endeavor contributes to a deeper understanding of amplitude modulation, its real-world applications, and its broader impact on technology and society.

2. Introduction:

Modulation is the process of varying a carrier signal's properties, such as its amplitude, frequency, or phase, in accordance with an input signal. The purpose of modulation is to encode information onto a carrier signal for transmission over a communication channel. Modulation is necessary for the efficient utilization of frequency spectrum by which the multiple messages can be sent simultaneously. Modulation is performed to fulfill the channel requirement and broaden the operating range and it decreases the antenna range too.

In our project, we delve into the core principles of AM modulation, where the amplitude of a carrier signal is varied in accordance with the instantaneous amplitude of the modulating signal. This process enables us to embed information onto the carrier signal, effectively encoding the desired data for transmission. Subsequently, our project extends to the demodulation stage, where the original modulating signal is extracted from the modulated carrier, facilitating the retrieval of the transmitted information. The significance of our project lies in its practical applications across various domains, including radio broadcasting, telecommunications, and wireless networking. By developing a comprehensive understanding of AM modulation and demodulation techniques, we aim to explore the intricacies of signal processing, circuit design, and communication theory.

Our project report encompasses a detailed analysis of the circuit design, simulation results, experimental findings, and comparative studies with theoretical predictions. By documenting our methodologies, observations, and conclusions, we aim to contribute to the collective knowledge base in the field of analog communication systems.

3. Design:

3.1 Problem Formulation

We wish to design both diode detector and coherent detector circuits. For the diode detection circuit, we have to do with carrier modulation. Because without carrier we cannot detect the envelop. To overcome this challenge, we proposed to do switching modulator as it can do with carrier modulation. Diode detectors are sensitive to variations in amplitude, making them well-suited for demodulating AM signals. Switching modulators can provide a clean and well-defined amplitude modulation, which enhances the sensitivity and accuracy of the demodulation process. For coherent detection, we don't have to do the DSB-WC modulation. So, we have implemented bridge modulator for DSB-SC modulation. For demodulation, we have used the same bridge modulation circuit to do coherent detection.

3.2 Design Method:

For coherent detector circuit, our carrier frequency is 1MHz. So, we have to design a bandpass filter about 1MHz frequency. Our design has lower cutoff of 996kHz and higher cutoff of 1.4MHz. For detector circuit, we have to design a low pass filter around 3.2kHz.

We chose, R = 2.6kΩ, L = 120μH and C = 150pF

For Bandpass filter in bridge circuit,

$$\omega_o = \frac{1}{\sqrt{LC}} = 7.45 \times 10^6\ rad/s$$
$$f_o = 1.18 \times 10^6\ Hz$$

Cutoff Frequency,

$$\omega_1 = -\frac{1}{2\mathrm{RC}} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \frac{1}{LC}} = 6.28 \times 10^6\ \ rad/s$$
$$f_1 = 9.996 \times 10^5\ Hz$$

And,

$$\omega_2 = \frac{1}{2RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \frac{1}{LC}} = 8.84 \times 10^6\ \ \mathrm{rad/s}$$
$$f_2 = 1.4 \times 10^6\ Hz$$

For Low Pass filter in demodulator circuit,

$$f_c = 3.2\mathrm{k}Hz$$

Now,

$$\omega_o = 20.16 \times 10^3\ \mathrm{rad/s}$$

Therefore, C = 33nF
R = 1.5kΩ

Circuit Diagram:

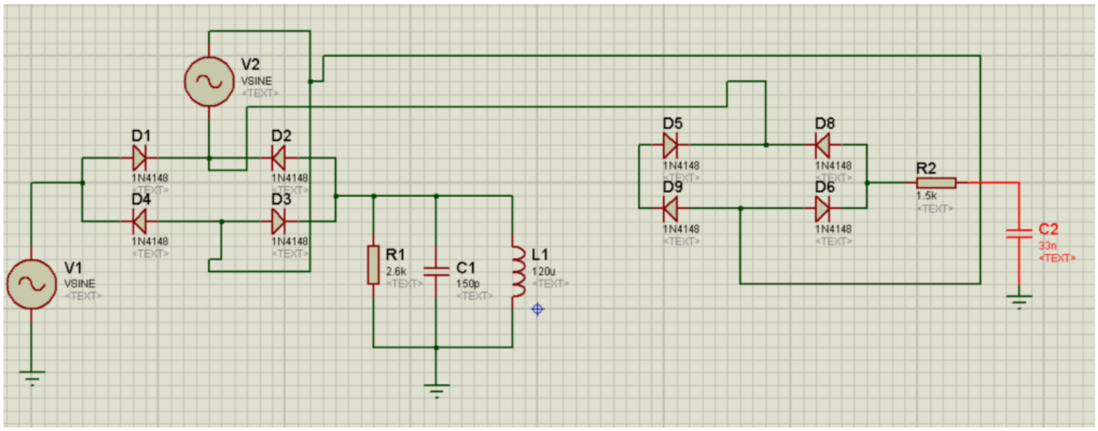


Figure 1: Schematic for product detector circuit.

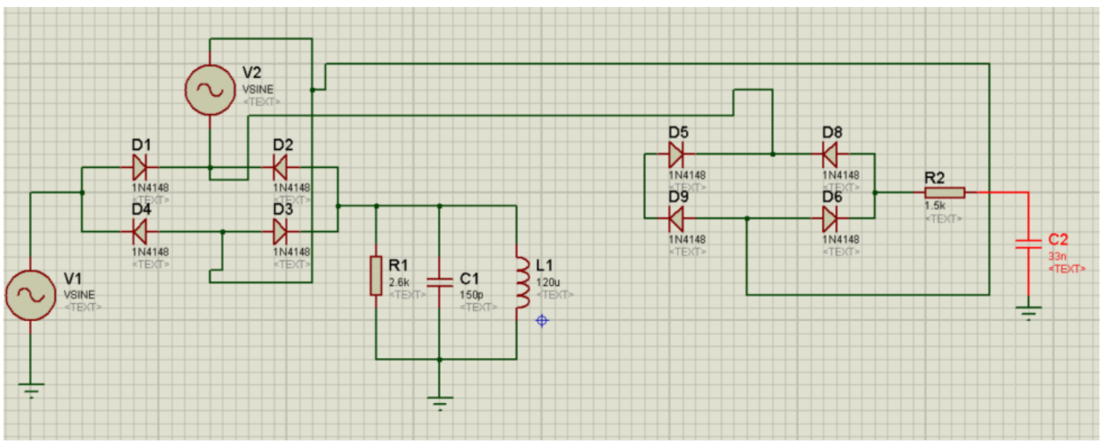


Figure 2: Schematic for envelope detector circuit

Simulation Model:

We have used Proteus software for simulation.

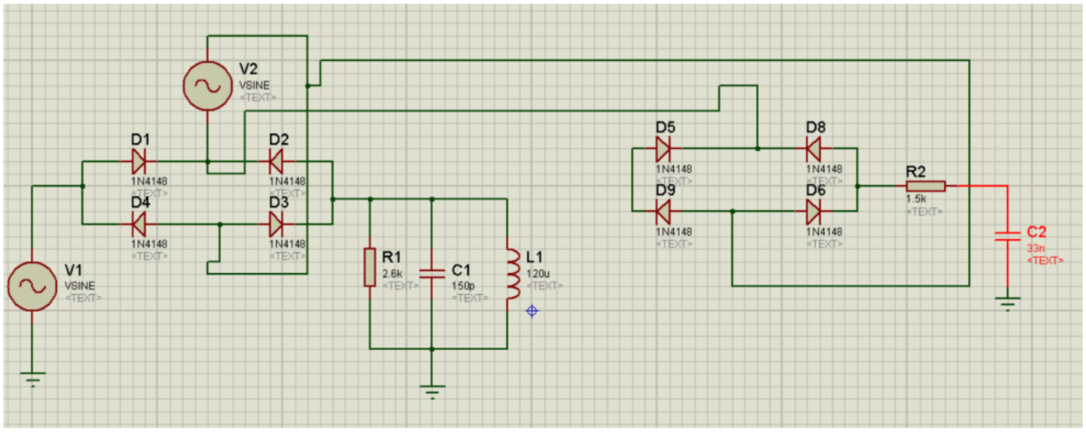


Figure 3: Schematics for coherent detector circuit

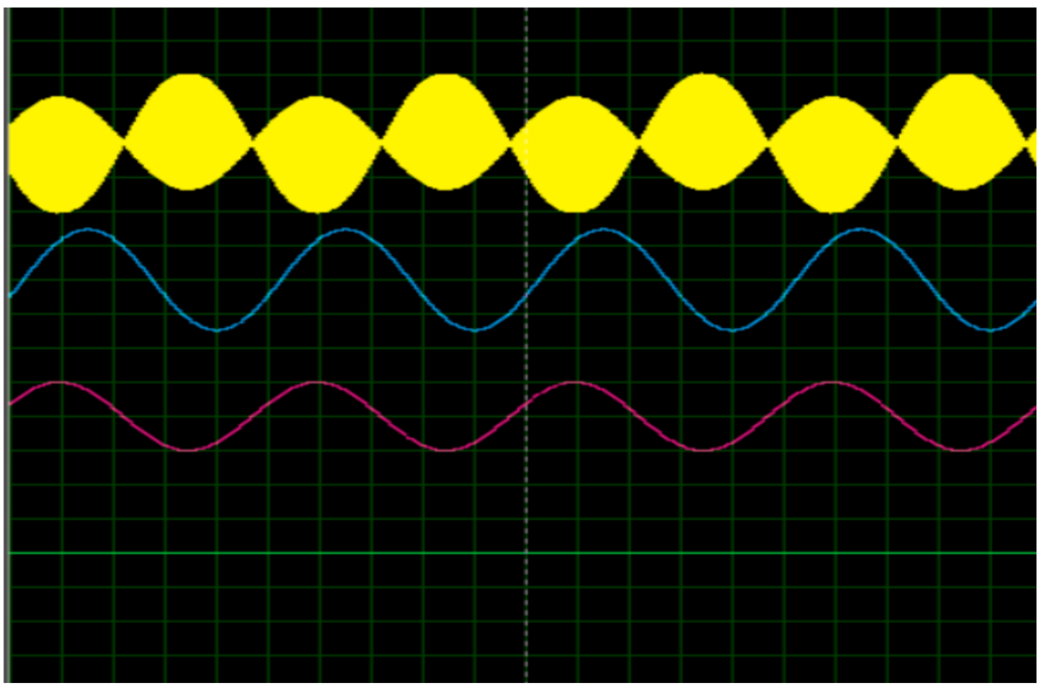
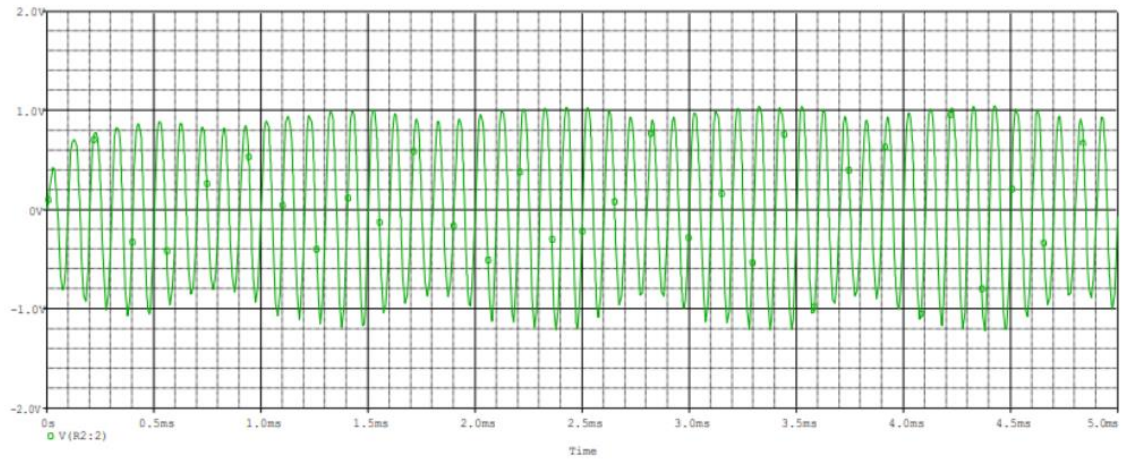


Figure 4: Output of product detector circuit

In the above figure, yellow wave is the modulated signal. Red signal is the message signal and the blue signal is demodulated signal.

Modulated signal:



Demodulated Signal:

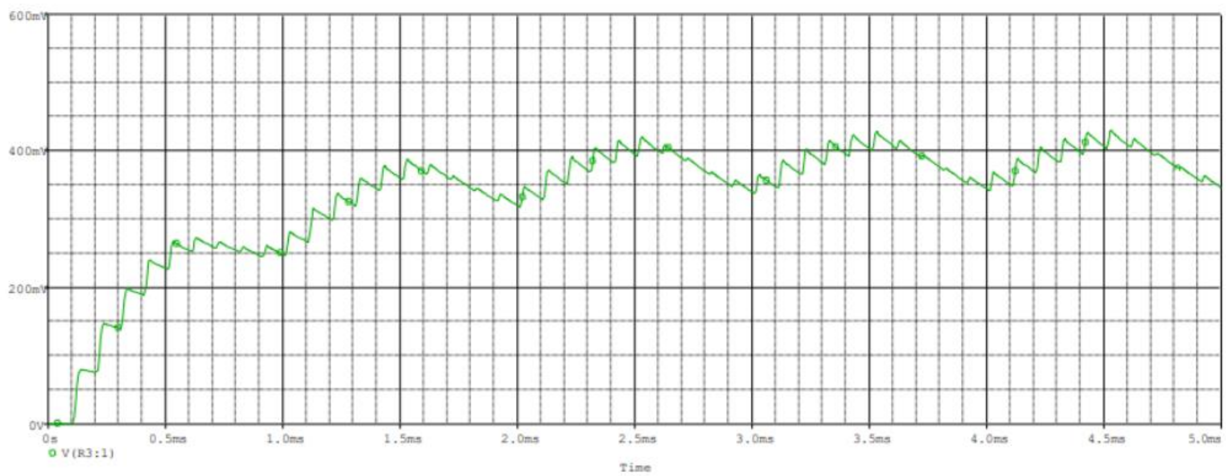


Figure 4&5: Modulated and Demodulated simulated output for envelope detector circuit.

Hardware Design:

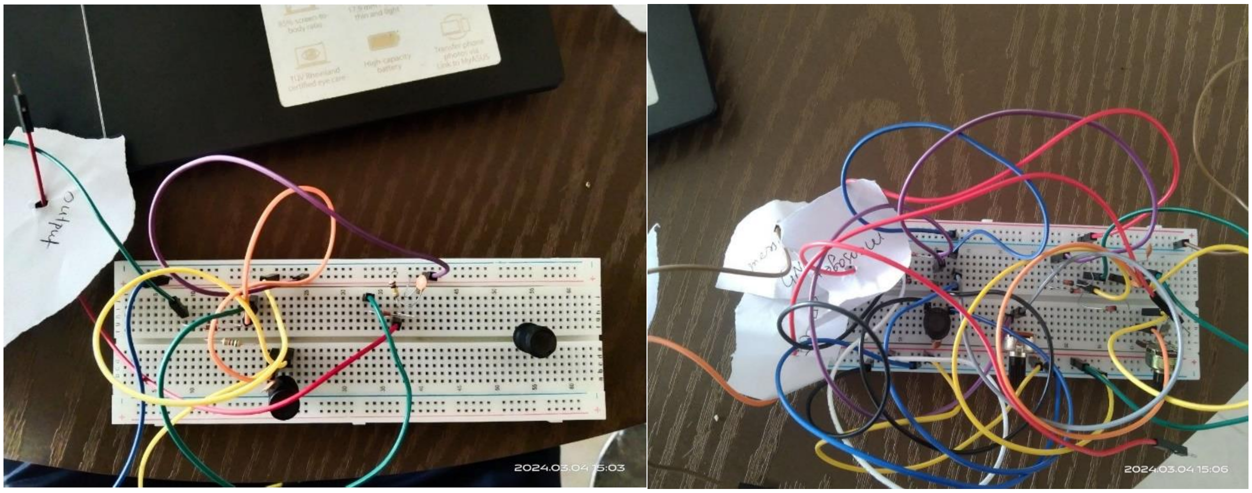


Figure 6: Circuit of diode & coherent detector in breadboard

4.1 Implementation:

For amplitude modulation and demodulation, we utilized a series diode bridge switching modulator circuit. The carrier signal is applied across two diagonally opposite terminals of the diode bridge, typically being a high-frequency sinusoidal signal. The modulating signal, representing the information to be transmitted, is connected across the other two diagonally opposite terminals of the diode bridge. This modulating signal varies in amplitude accordingly. When the modulating signal is positive, the connected diodes conduct, permitting the carrier signal to pass through the bridge. Conversely, when the modulating signal is negative, the diodes are reverse biased, blocking the carrier signal. The output of the diode bridge modulator circuit is obtained from the diodes' junction, resulting in an amplitude-modulated signal where the carrier signal's amplitude fluctuates in accordance with the modulating signal. This output undergoes filtration with a bandpass filter, set at the carrier frequency cutoff

4.2 Experiment and Data Collection:

For Diode Detector:

Carrier Signal:

Type: Sinusoidal

Amplitude: 4 V (p-p)

Frequency: 500 kHz

Message signal:

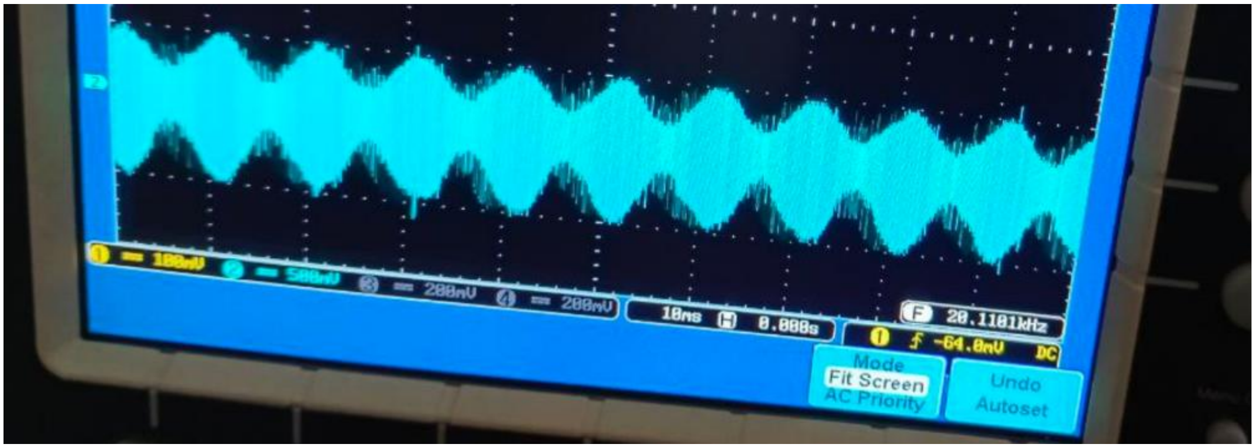
Type: Sinusoidal

Amplitude: 1V(p-p)

Frequency: 100 Hz

Modulated Signal:

We obtained the modulated signal for both the envelope detector circuit and the



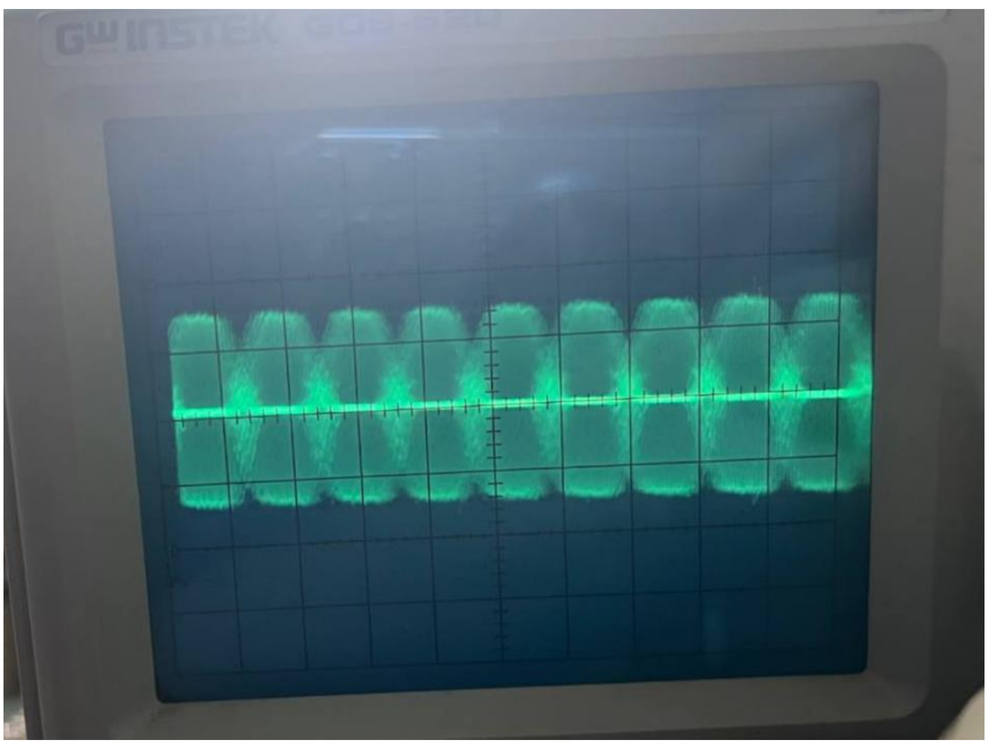


Fig. Modulated signal output:

Demodulated Output:

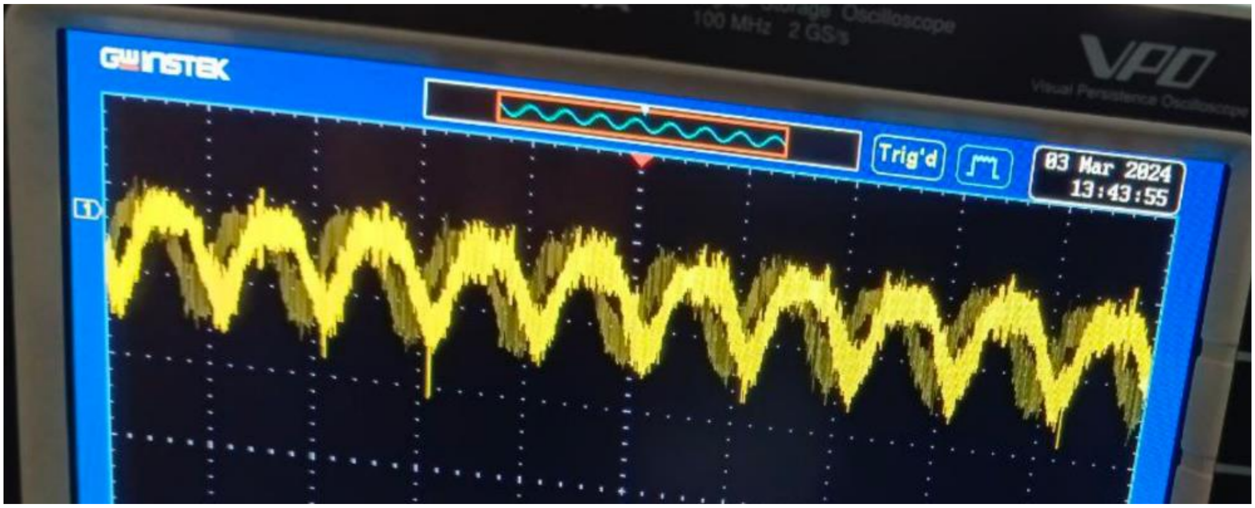


Fig: Demodulated signal output

Type: Sinusoidal (little bit distorted and noisy)

Frequency: 100Hz

Product Detector:

For Product Detector:

Carrier Signal:

Type: Sinusoidal

Frequency: 600 kHz

Message signal:

Type: Sinusoidal

Frequency: 1.3426 kHz

Modulated Signal:

We obtained the modulated signal for both the envelope detector circuit and the

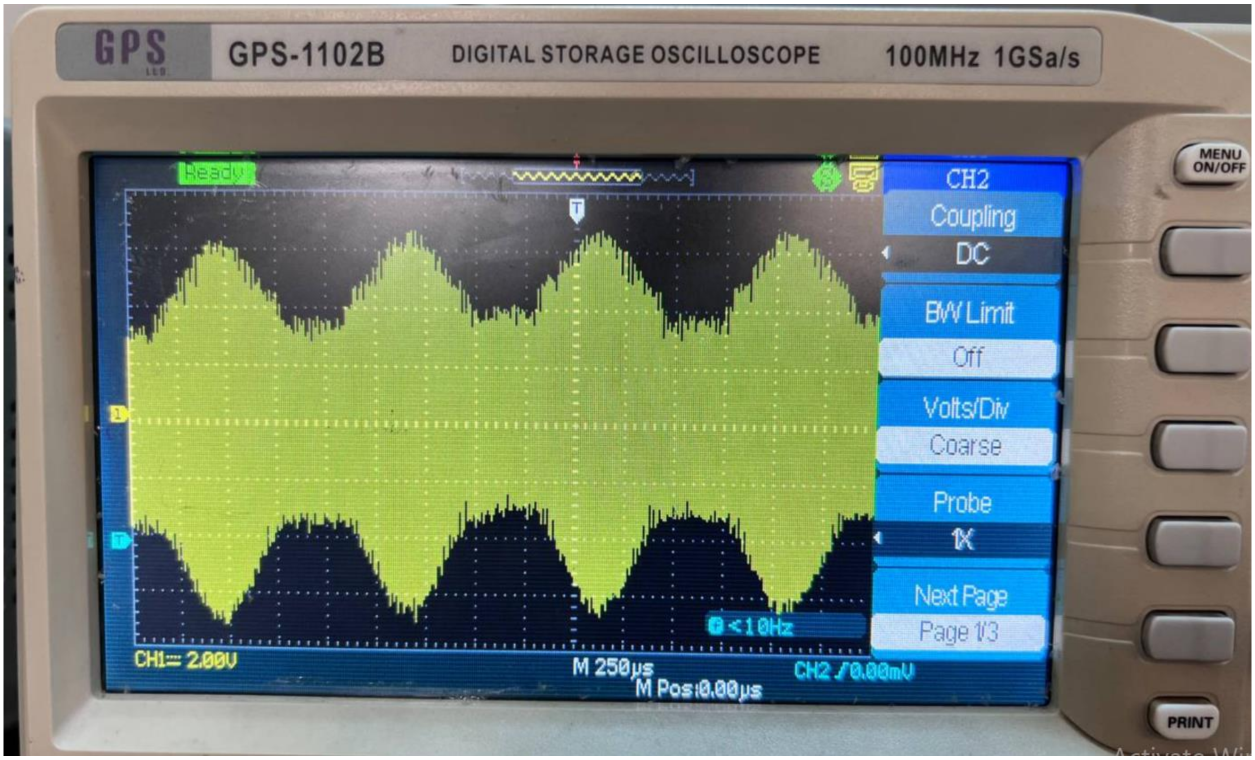


Fig. Modulated signal output:

Demodulated Output:

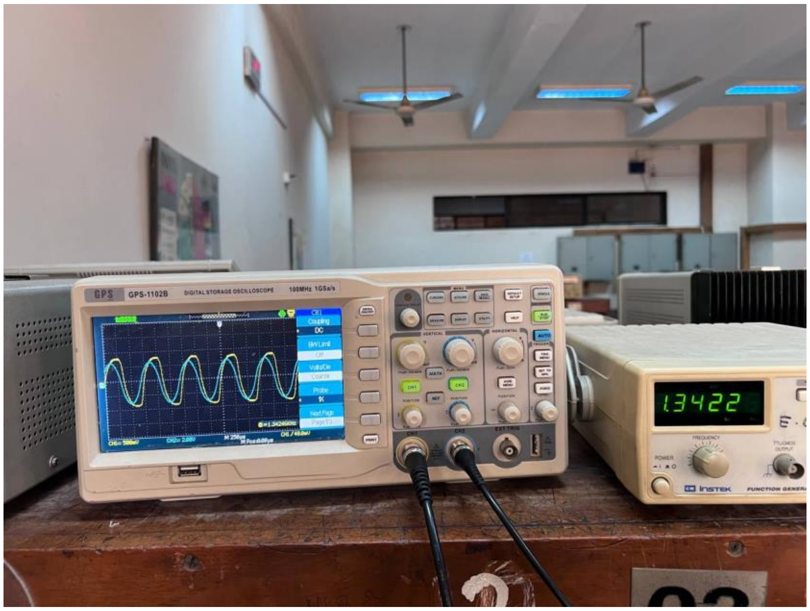


Fig: Demodulated signal output(blue message, yellow output)

Type: Sinusoidal (little bit distorted and noisy)

Frequency: 1.3425kHz

Data Analysis:

The carrier frequency significantly exceeds that of the message signal. Additionally, the amplitude of the message signal surpasses that of the message itself to ensure effective switching of diodes. Adequate design of the bandpass filter in the modulation and the low-pass filter in the demodulation circuit ensures that their cutoff frequencies align with the carrier signal frequency.

Result:

The frequency of the input message signal and the demodulated signal is equal. So the message signal is successfully demodulated.

5. Design Analysis and Evaluation

5.1 Novelty

Our group has successfully conducted Amplitude Modulation (AM) utilizing a Switching Modulator, alongside demodulation employing an Envelope Detector and Synchronous Detector circuit. This project was facilitated through a straightforward breadboard setup, making it exceedingly user-friendly and comprehensible, particularly for those new to electronics. It serves to elucidate the fundamental principles underlying modulation and demodulation processes crucial for contemporary communication purposes. Additionally, our project prioritizes cost-effectiveness by utilizing readily available components. While we couldn't pursue PCB design due to time constraints, it remains a viable avenue for future development

5.2 Design Considerations (PO(C))

5.2.1 Considerations to Public Health and Safety:

We have to consider some health hazards during this project. They are given below:

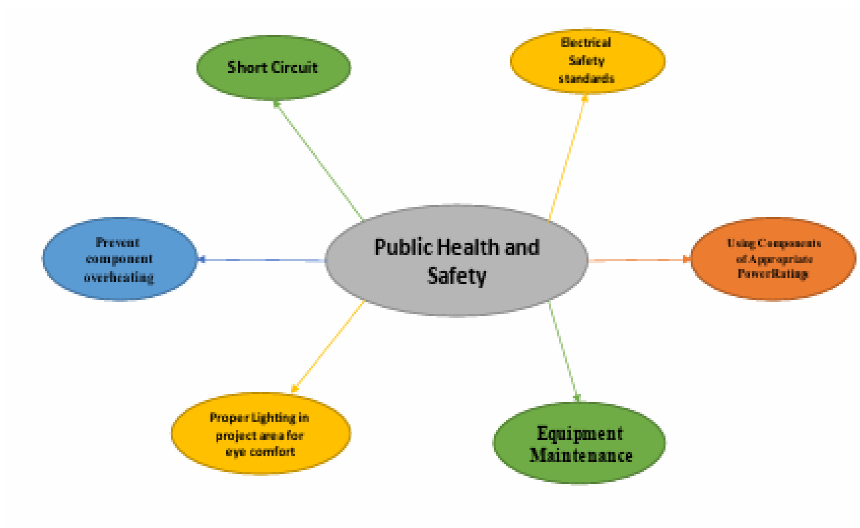


Figure 20: Health considerations

5.2.2 Considerations of Environment:

We have to focus on public health and safety issues as well as environmental impacts. We have used simple breadboard, jumper wires, resistors, capacitors diodes but no chemicals or anything. Again we use multimeters, oscilloscope, and function generators to test the circuits. So no considerable impacts on the environment. But we can consider some of the steps given below for better safety:

- Some of the jumper wires have been damaged during the project. We didn't through the jumper wires here and there. We collected them and ensured proper waste management.
- We properly used the equipment provided in the laboratory and cleaned the table after our work was finished.
- We tried our best to use a minimum no of electrical components and carefully used those components so minimal waste (damaged electrical components) was produced.

5.2.3 Considerations to cultural and societal needs

Amplitude modulation and demodulation processes have a great impact on our society. Some of the points are given below:

- AM radio broadcasting

Amplitude modulation is used in AM radio broadcasting. Radio frequencies are employed in this communication medium to transmit audio material such as music and news.

- Telecommunications:

Amplitude modulation techniques are historically used telecommunications, particularly in transmitting voice signals.

- Aviation Communication:

Amplitude modulation is used in aviation communication systems to transmit signals between aircraft and air traffic control (ATC) facilities.

- Industrial applications:

AM modulation allows for the efficient transmission of control signals and data over varying distances, making it suitable for industrial applications to remote control systems and telemetry.

- Low-cost communication:

AM is cost-effective, making it suitable for applications where simplicity is valued.

- VHF Airband communication:

AM modulation is used in very high-frequency (VHF) Airband communication.

- Transmission of analog signals:

AM is used for transmitting analog signals in communication systems. Considering the abovementioned points, we take the project of amplitude modulation project to have a clear idea about it to apply it in the future in a wide range for the betterment of society.

5.3 Investigations (PO(d)):

5.3.1 Literature Review:

Amplitude modulation is a technique used in electronic communication quarter of the 20th century beginning with Roberto Landell de Moura and Reginald Fessenden's radiotelephone experiments in 1900. It was first transmitted in 1901 by Canadian engineer Reginald Fessenden.

A number of studies have been performed on amplitude modulation and demodulation techniques. Robert Barsanti and Jason S. Skinner prepare a project on amplitude modulation and demodulation for use in undergraduate studies communication courses for Electrical Engineering Students. They use switching modulators for amplitude modulation and envelope detector circuits as demodulation techniques. According to the authors, presentation style in undergraduate courses leaves undergraduate students with the challenge of relating these theories to real-world circuit implementations. Firstly, they simulated their circuit in Pspice and then implemented that circuit in the breadboard for better understanding.Our project is also similar to this study. We tried to implement the switching modulator and envelope detector as a demodulator. In addition to this, we use a synchronous detector for the demodulation process for a better understanding of the theory courses.

5.4 Limitations of Tools (PO(e))

We faced a lot of problems regarding tools. We have implemented the circuit in breadboard. But to test the circuit we needed function generators, oscilloscopes, multimeters. We collected those instruments and tested the circuit in our communication laboratory. We perfectly observed modulation in our communication laboratory for two circuits (Envelope detector circuit and synchronous detector circuit). We were unable to observe the demodulation process in the communication laboratory. Then we went to our Level-1 term 2 hardware laboratory and were able to observe the demodulation process for synchronous detectors

5.5 Impact assessment (PO(f))

5.5.1 Assessment of Health and Safety Issues :

❖ Identification of potential electrical hazards during the project.

❖ Verification of the ratings of all the electrical components used during the project

❖ Ensuring the proper management of damaged electrical components.

5.5.2 Assessment of Legal Issues :

➢ We followed academic rules to implement this project.

➢ Proper collaboration was done among group members to ensure participation of every group member in this project.

5.6 Sustainability and Environmental Impact Evaluation (PO(h))

➢ Design the project with energy efficiency in mind, ensuring that components and devices operate with minimal energy consumption.

➢ Ensure compliance with environmental regulations and standards applicable to electronic projects and communication systems.

5.7. Ethical Issues (PO(h))

➢ We clearly defined who contributed to this project and how much contribution was made by each member.

➢ We ensure proper citations to avoid plagiarism in our project.

6. Reflection on Individual and Team work

6.1Individual Contribution of Each Member

- 2006112- Project proposal, purchasing parts, Simulation of circuit-I, testing of circuit-I, testing of circuit-II, Simulation of circuit-II, making report.
- 2006114- Project proposal, Simulation of circuit-I, testing of circuit-I, Simulation of circuit-II, purchasing parts, Demodulator Circuit Assembly, testing of circuit-II.
- 2006124- Simulation of circuit-I, purchasing parts, testing of circuit-I, testing of circuit-II, making report.
- 2006129- Project proposal, Purchasing parts, Modulator Circuit Assembly, testing of circuit-I, testing of circuit-II, Demodulator Circuit Assembly, testing of circuit-II, making report.

6.2 Mode of Team Work

Each team member brought unique abilities, perspectives, and experiences to the project. We were dedicated to a common objective, collaborated closely, shared responsibilities, and actively contributed towards achieving our goals.

6.3 Diversity Statement of Team

We recognize diversity as a catalyst for innovation and success. We ensure equal access to opportunities and resources for all team members. Tasks were assigned based on skills, and team members collaborated closely to accomplish project objectives.

6.4 Log Book of Project Implementation

Date	Description
22 Feb, 2024	Our task was to construct a circuit for amplitude modulation and demodulation
25 Feb, 2024	The resistor, inductor, and capacitor values were obtained from the simulation of modulator circuit
26 Feb, 2024	Bought components of the desired values
26 Feb, 2024	Constructed the modulator circuit
27 Feb, 2024	Tested the modulator circuit
28 Feb, 2024	The resistor, inductor, and capacitor values were obtained from the simulation of demodulator circuit
28 Feb, 2024	Bought components of the desired values
2 March, 2024	Constructed the demodulator circuit
3 March, 2024	Tested the demodulator circuit
3 March, 2024	Wrote a report on the procedure
4 March, 2024	Demonstration of the circuit

7. Communication

7.1 Executive Summary:

Our project focuses on exploring two modulation and demodulation methods in communication technology, highlighting the practical applications of amplitude modulation through envelope detection and coherent detection techniques. This hands-on experimentation not only enhances understanding of modulation principles but also provides insights into real-world telecommunications and broadcasting, demonstrating the versatility and relevance of amplitude modulation in modern communication systems.

7.2 User Manual:

Step-by-step Guide:

- **Modulation Setup:**

- Connect the function generator to the modulator circuit.

- Adjust input signal levels for optimal modulation.
- Power up the function generator and verify functionality.
  - **2. Demodulation Setup - Envelope Detection:**
- Connect the modulated signal output to the envelope detector circuit.
- Fine-tune envelope detector parameters for efficient demodulation.
- Monitor output signals to observe the retrieved message signal.

- **3. Demodulation Setup - Coherent Detection:**
- Connect the modulated signal output to the coherent detector circuit.
- Align the local oscillator frequency with the carrier frequency.
- Adjust phase and amplitude of the reference signal for coherent detection.
- Monitor output to observe the demodulated message signal.
  - **4. Performance Evaluation:**
- Compare signal qualities obtained from both demodulation methods.
- Analyze factors impacting signal fidelity, such as noise and distortion.
- Document observations and evaluate the efficacy of each demodulation technique.
  - **5 Shutdown Procedure**:
- Power off all circuits and disconnect input/output connections.
- Store equipment and components safely.

8. Project Management and Cost Analysis

8.1 Bill of Materials

Costs in different sectors of our project is given below:

Description	Quantity	Unit Price	Total Price
Bread Board	3	90	270
Jumper Set	3	50	150
Inductor coil	5	10	50
Diode (IN4148)	10	1	10
Resistor(560,1k)	30	1.5	45
Capacitor(33nF)	5	1	5
Capacitor(150pF)	5	1	5
Ceramic Capacitor(10x)	10	1	10
Variable resistor pot 5K	1	15	15
Variable resistor pot 2K	1	5	5
Inductor (120 µH)	3	6	18
Transportation	-	-	450

	Total		1,033

9. Future Work:

- Investigate advanced modulation techniques like frequency modulation (FM) and Phase Modulation (PM) to gain a deeper understanding of communication systems.
- Examine how channel characteristics affect modulation and demodulation, especially in environments with high levels of noise.
- Deploy digital modulation schemes and assess their effectiveness in contemporary digital communication setups.

10. Reference:

1) https://peer.asee.org/amplitude-modulation-circuit-implementation-for-use-in-a communication-course-for-electrical-engineering-students.pdf