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Project Report

on

Amplitude Modulation and Demodulation Module

<u>Submitted by</u>: **Group One (Team "Kinetic-Vision")**

Name	**ID**	**Intake/Section**
Md. Mehedi Hasan	20212208019	32/01
Md. Sabbir Hasan	20212208020	32/01
Soyod Rahabar A Islam	20212208022	32/01
Mamun Or Rashid	20212208025	32/01
Maruf Hasan	20212208031	32/01
Minhazul Uddin	19202208077	29/02

<u>Submitted to:</u>

Nafis Shahriar Munir

Lecturer

Department of EEE, BUBT

Dedicated to

Our Parents

and

Honorable Teacher

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Abstract

Amplitude Modulation (AM) is a fundamental technique in telecommunications for encoding information onto a carrier wave. This modulation process involves varying the amplitude of the carrier wave in accordance with the instantaneous amplitude of the message signal. In this abstract, we explore the principles of AM modulation and demodulation. The modulation process begins with a baseband signal, representing the information to be transmitted, and a high-frequency carrier signal. The modulator combines these signals, adjusting the amplitude of the carrier wave based on the variations in the message signal. The resulting modulated signal is then transmitted through the communication channel.

Demodulation, the reverse process of modulation, is essential for extracting the original message signal from the received modulated signal. Various demodulation techniques exist, with one common method being the envelope detector. This detector rectifies and smoothens the received signal to recover the envelope, which closely resembles the original message signal. A subsequent low-pass filter helps isolate the message signal from unwanted high-frequency components.

Understanding AM modulation and demodulation is crucial for many communication systems, including broadcast radio. This abstract provides a concise overview of the principles involved in AM modulation and demodulation, emphasizing their role in transmitting and retrieving information in telecommunications.

Chapter-01

Introduction

1.1 Description

Amplitude Modulation (AM) is a key modulation technique that has played a pivotal role in the development of telecommunications. It provides a means of encoding information onto a carrier wave by varying its amplitude, enabling the transmission of signals over long distances. This modulation technique, accompanied by its counterpart, demodulation, forms the backbone of numerous communication systems, including broadcast radio.

The primary objective of AM modulation is to efficiently transmit analog signals, such as voice or music, over a communication channel. This is achieved by superimposing the message signal onto a higher frequency carrier signal. The modulation process involves manipulating the amplitude of the carrier wave in real-time, mirroring the changes in the original signal. This modulation allows the efficient use of the frequency spectrum, making it possible to broadcast multiple signals simultaneously[1].

Conversely, demodulation is the process of retrieving the original information from the modulated carrier wave. Without an effective demodulation process, the transmitted signal would be indecipherable at the receiving end. Demodulation is thus a critical component in communication systems, ensuring the faithful reconstruction of the original message signal.

In this exploration of AM modulation and demodulation, we delve into the underlying principles that govern these processes. We will examine how AM facilitates the efficient transmission of information and explore the techniques employed in demodulation to recover the original signal faithfully. From broadcast radio to various other applications, a comprehensive understanding of AM modulation and demodulation is essential for anyone involved in the field of telecommunications[2].

1.2 Objectives

- To know about the AM modulation and demodulation
- To know about the hardware connection of this modulation and demodulation
- To know about how the AM signal characteristics and how it works
- To know about the envelope detector
- To know about how the signal transmitting and receiving

Chapter-02

Background

2.1 Description

Amplitude Modulation (AM) is a fundamental technique in the field of analog communication, widely used for transmitting information through radio waves. It involves varying the amplitude of a high-frequency carrier signal in proportion to the instantaneous amplitude of a modulating signal, typically an audio or voice signal. This modulation process allows the transmission of the modulating signal over long distances through the carrier wave. And demodulation is a crucial process in the field of analog communication, where the original information, encoded within the amplitude variations of a carrier signal, needs to be extracted[3]. The demodulation process is essential for recovering the transmitted message signal from the modulated carrier wave.

2.2 Motivation

In the vast landscape of telecommunications, where the seamless transfer of information is paramount, modulation techniques stand as crucial mechanisms for encoding and transmitting signals. Among these, Amplitude Modulation (AM) holds a significant place, offering a straightforward yet effective means of impressing information onto a carrier wave. The foundation of AM modulation lies in the alteration of the carrier wave's amplitude to reflect the variations in an input signal, often referred to as the message signal. This process allows the transmission of analog information, such as audio signals, over communication channels. By superimposing the message signal onto the carrier wave, AM enables the propagation of signals over long distances, making it a cornerstone in radio broadcasting and various other communication systems.

As much as modulation is integral for sending information, its counterpart, demodulation, is equally critical for extracting the original signal at the receiving end. Demodulation serves to unravel the modulated carrier wave, separating the information from the carrier and ensuring the fidelity of the transmitted data. This exploration into AM modulation and demodulation aims to unravel the intricacies of these processes. From understanding the principles that govern the modulation of a carrier wave to the techniques employed in demodulation for signal recovery, this journey seeks to illuminate the fundamentals that underpin effective communication systems. Whether in the realm of broadcast radio or broader applications of telecommunications, a grasp of AM modulation and demodulation is foundational for engineers, researchers, and enthusiasts alike.

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Required Equipment

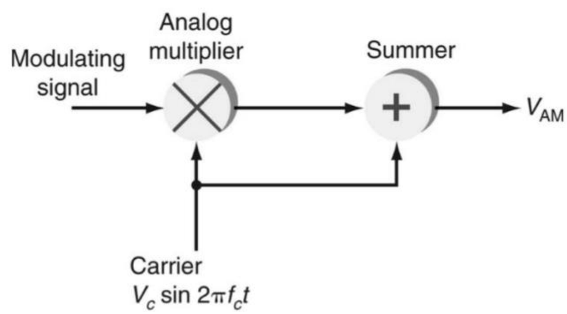
- Breadboard
- Transistor-BC107BP or 2N5551 (NPN, Bipolar)
- Transistor 2N3904 (NPN, Bipolar)
- Capacitors-10nF,0.22µF,1µF,1nF
- Inductor-50mH
- Resistors- 1KΩ, 22KΩ, 6.8KΩ, 10 KΩ, 100 KΩ, 20 KΩ, 1.5 KΩ.
- Diode-1N914
- Amplifier-UA741
- Jumper wire
- Function Generator
- Oscilloscope

Chapter-04

Literature Review

4.1 AM Modulation

A continuous-wave goes on continuously without any intervals and it is the baseband message signal, which contains the information. This wave has to be modulated. According to the standard definition, “The amplitude of the carrier signal varies in accordance with the instantaneous amplitude of the modulating signal[4].” Which means, the amplitude of the carrier signal containing no information varies as per the amplitude of the signal containing information, at each instant. This can be well explained by the following figures.



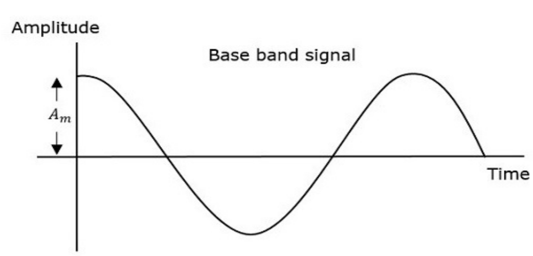
Block diagram of AM modulation

The first figure shows the modulating wave, which is the message signal. The next one is the carrier wave, which is a high frequency signal and contains no information. While, the last one is the resultant modulated wave. It can be observed that the positive and negative peaks of the carrier wave, are interconnected with an imaginary line. This line helps recreating the exact shape of the modulating signal. This imaginary line on the carrier wave is called as Envelope. It is the same as that of the message signal.

Mathematical Expressions:

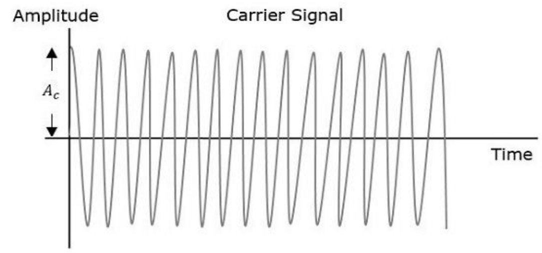
Following are the mathematical expressions with Time-domain Representation for these waves.

Let the modulating signal be,



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

and the carrier signal be,

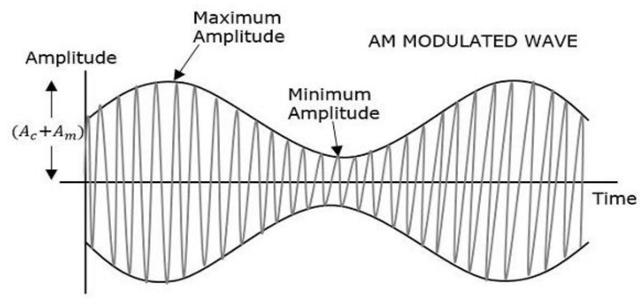


$$c(t) = A_c \cos(2\pi f_c t)$$

Where, A_m and A_c are the amplitude of the modulating signal and the carrier signal respectively.

f_m and f_c are the frequency of the modulating signal and the carrier signal respectively.

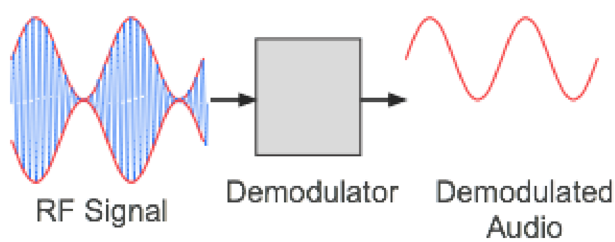
Then, the equation of Amplitude Modulated wave will be,



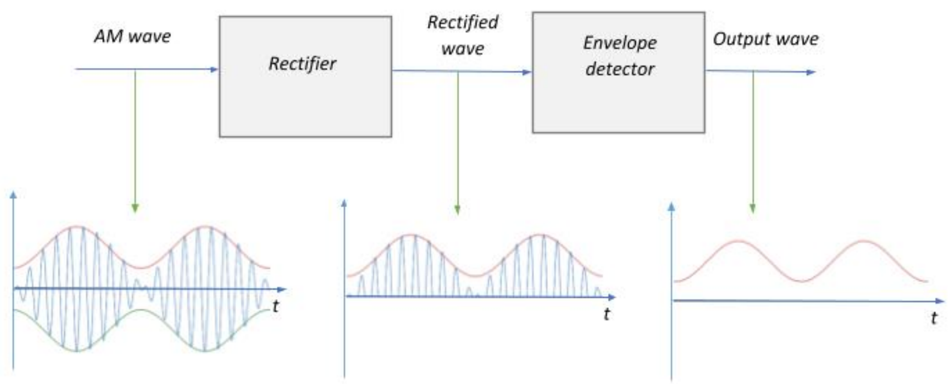
$$s(t) = [\, A_c + A_m \cos(2\pi f_m t)]\, \cos(2\pi f_c t)]$$

4.2 AM Demodulation

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, 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[5]. The demodulator is the circuit, or for a software defined radio, the software that is used to recover the information content from the overall incoming modulated signal.



Detection or Demodulation:



Block diagram of AM modulation

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 circuit. 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[6]. 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.

Chapter-05

Methodology

5.1 Modulation

We have taken 10V sinusoidal signal with 500Hz frequency as message signal and we have connected the oscilloscope to see the message signal. Then we have taken 15V sinusoidal signal with 10kHz frequency as carrier signal. We are doing AM modulation that's why the amplitude will vary but the phase sequence and the frequency will stay constant. We have used BJT diagram to solve this. For modulation, we have used transistor 2N5551 and we have used a capacitor and an inductor. So, here we have connected the oscilloscope and it is showing the modulated signal.

5.2 Demodulation

We have used the output signal of modulation part as the input of the demodulation part. We have used diode 1N914 and Transistor 2N3904. After demodulation we will get back the message signal as demodulation output but there will be some noise with that message signal. To remove those noise, we have used a low pass filter. Now we will get the accurate message signal. When we will connect the oscilloscope, it will show the message signal as the output of the demodulator. But the amplitude is totally in inverse position, to solve this problem we have used an inverting amplifier. So now if we connect the oscilloscope, it will show the amplitude correctly. For using the amplifier, there will some noise, to remove those noise we have used a low pass filter again. So, now if we connect the oscilloscope, it will show the accurate message signal which is as same as the input message signal of this project.

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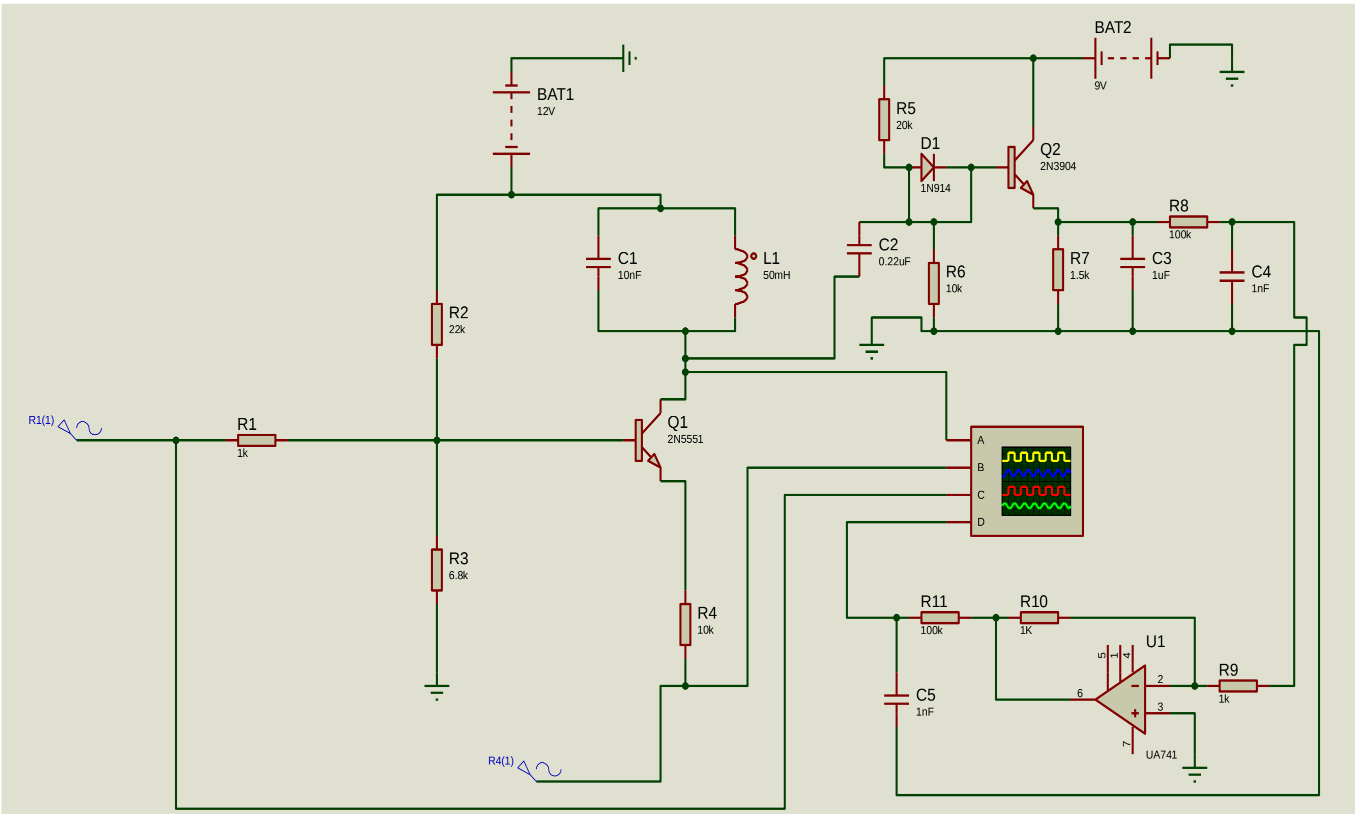
Circuit Diagram



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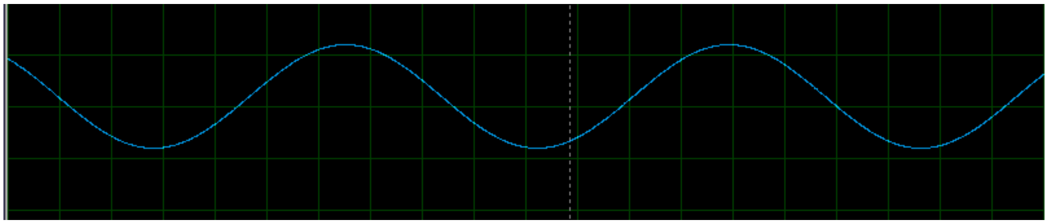
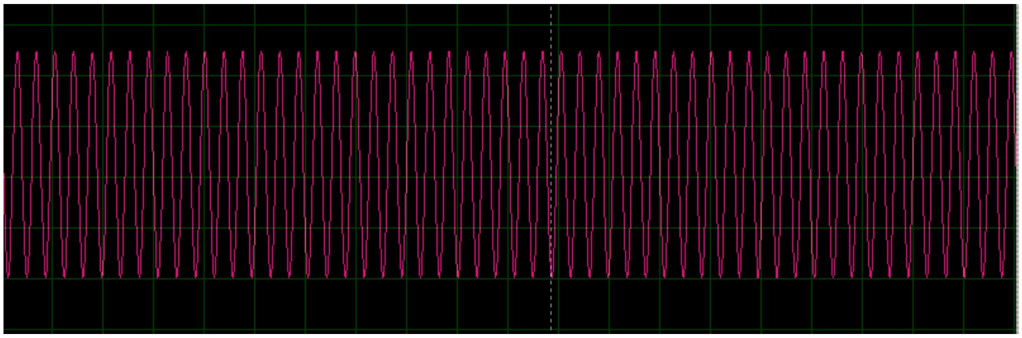
Result

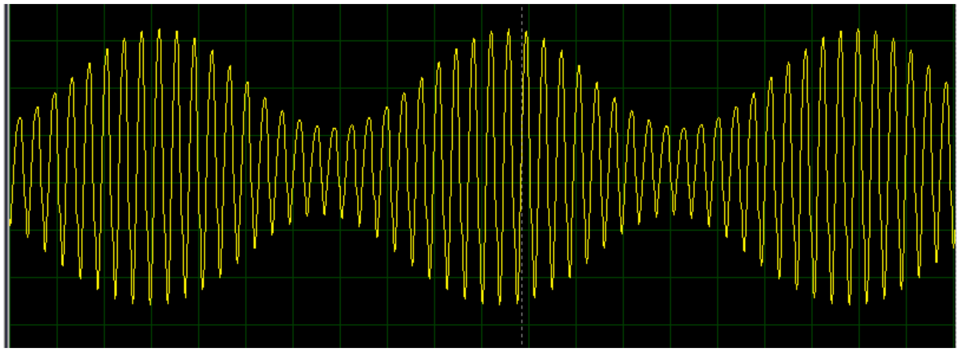
7.1 Message Signal



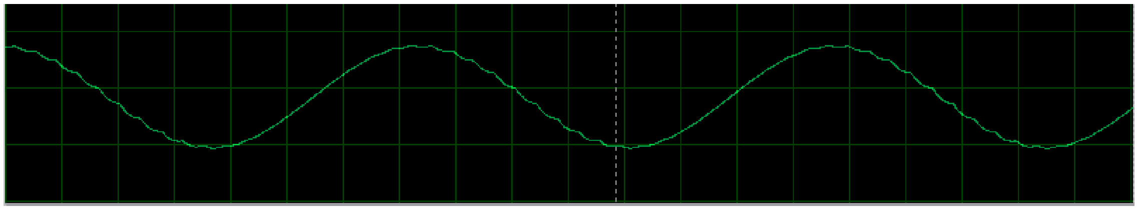
7.2 Carrier Signal



7.3 Amplitude Modulated Signal



7.4 Amplitude Demodulated Modulated Signal



Chapter-08

Socio Economy Impact

8.1 Advantages

Amplitude Modulation (AM) and its associated demodulation processes offer several advantages, contributing to their widespread use in various communication systems. Here are some key advantages:

8.1.1 Advantages of AM Modulation:

Simple Implementation: AM modulation being relatively simple to implement compared to other modulation techniques, making it cost-effective and accessible.

Compatibility with Analog Signals: AM is well-suited for analog signals, such as voice and music. It preserves the original waveform, allowing for the faithful reproduction of the input signal.

Efficient Use of Spectrum: AM is bandwidth-efficient, as the sidebands contain the essential information. This enables multiple AM signals to be transmitted simultaneously without excessive bandwidth requirements[7].

Ease of Demodulation: AM signals are straightforward to demodulate, especially using envelope detection methods. This simplicity in demodulation contributes to the overall efficiency of the system.

Resilience to Interference: AM signals can withstand some degree of noise and interference. In certain applications, this resilience is advantageous, especially in conditions where a robust signal is necessary.

8.1.2 Advantages of AM Demodulation:

Simplicity in Demodulation: Demodulating an AM signal, especially using envelope detection, is a relatively simple process. This simplicity aids in the design of cost-effective demodulation circuits.

Cost-Effectiveness: The demodulation circuitry required for AM is often less complex and less expensive compared to demodulation techniques for other modulation schemes.

Compatibility with Analog Systems: The simplicity of AM demodulation makes it compatible with analog systems, allowing for the extraction of the original message signal without significant distortion.

Ease of Integration: Demodulated AM signals can be easily integrated into various analog systems, contributing to the versatility of AM in applications like broadcast radio.

Amplitude Versatility: The amplitude variations in AM signals allow for the encoding of information, making it versatile for applications where amplitude variations are essential for conveying data.

8.2 Disadvantages

While Amplitude Modulation (AM) and its associated demodulation processes have their advantages, they also come with certain disadvantages, which have led to the development and adoption of more advanced modulation techniques in certain applications. Here are some of the key disadvantages of AM modulation and demodulation:

8.2.1 Disadvantages of AM Modulation:

Inefficient Use of Bandwidth: AM uses a considerable amount of bandwidth to transmit information. The bandwidth is often twice the maximum frequency of the original message signal, leading to less efficient use of the available spectrum.

Vulnerability to Interference: AM signals are susceptible to various types of interference, including atmospheric noise and electrical interference. This vulnerability can result in degraded signal quality and decreased range[8].

Low Power Efficiency: AM transmission requires more power compared to other modulation techniques. The power is distributed between the carrier and the sidebands, but only the information in the sidebands is useful. This leads to inefficiency in power utilization.

Limited Transmission Range: AM signals may suffer from limited transmission range, especially in long-distance communication, due to susceptibility to noise and interference. This limitation makes AM less suitable for certain applications.

8.2.2 Disadvantages of AM Demodulation:

Sensitivity to Variations in Amplitude: AM demodulation techniques, particularly envelope detection, are sensitive to variations in signal amplitude. This sensitivity can lead to distortion in the demodulated signal.

Difficulty in Recovering the Original Carrier: In situations where the carrier signal is not easily recoverable, demodulating the original signal accurately becomes challenging.

Inaccurate Demodulation in the Presence of Noise: AM demodulation is more susceptible to noise and interference compared to some other demodulation techniques. This susceptibility can result in a lower signal-to-noise ratio, affecting the quality of the recovered signal[9].

Not Suitable for High-Frequency Signals: AM is typically used for lower-frequency signals. It is not as suitable for high-frequency applications where more efficient modulation schemes, like Frequency Modulation (FM) or Phase Modulation (PM), are preferred.

While AM modulation and demodulation are still widely used in applications like broadcast radio, their limitations have led to the development and adoption of more advanced modulation techniques in certain contexts where efficiency, robustness, and improved signal quality are critical.

8.3 Limitations of our project

Amplitude Modulation (AM) has been widely used for transmitting audio signals over radio frequency carriers. However, it has some limitations that have led to the development and adoption of other modulation techniques. Here are some of the limitations of AM modulation and demodulation:

8.3.1 Low Efficiency: AM is not a power-efficient modulation technique. The power in the carrier signal is constant, but only a portion of it carries useful information (the sidebands). The rest of the power is wasted in transmitting the carrier, which does not contribute to the information being sent.

8.3.2 Bandwidth Utilization: AM uses a relatively wide bandwidth compared to other modulation schemes. This limits the number of channels that can be accommodated within a given frequency range. This inefficiency in bandwidth utilization has been addressed by more advanced modulation techniques like Frequency Modulation (FM) and Phase Modulation (PM).

8.3.3 Susceptibility to Noise: AM signals are susceptible to noise interference, which can result in a degradation of signal quality. Noise can introduce unwanted variations in the amplitude of the received signal, affecting the demodulated audio quality.

8.3.4 Limited Signal-to-Noise Ratio (SNR): The SNR of an AM signal is limited, especially in comparison to other modulation techniques. This can result in a lower quality of signal reception, particularly in environments with high levels of interference or noise.

8.3.5 Lack of Security: AM signals can be easily intercepted and demodulated by unauthorized receivers. This lack of security makes AM unsuitable for certain applications where secure communication is essential.

8.3.6 Non-linear Distortion: The demodulation of AM signals is sensitive to non-linearities in the demodulation process. This can result in distortions and affect the fidelity of the recovered signal.

8.3.7 Complexity of Demodulation: The demodulation process for AM signals can be more complex compared to other modulation techniques. In certain cases, synchronous detection or coherent demodulation is required, adding complexity to the receiver design.

Despite these limitations, AM modulation is still used in various applications, especially for broadcasting purposes, where the ease of implementation and widespread availability of receivers make it a practical choice. However, in many modern communication systems, more advanced modulation techniques with better spectral efficiency and noise resilience are preferred.

Chapter-09

Future Plan

AM modulation is surpassed by digital modulation system but we can also work to develop this modulation and demodulation. We can work in those section which are given below:

9.1 Improved Spectral Efficiency:

Research and development efforts may focus on enhancing the spectral efficiency of AM modulation. Strategies to reduce the bandwidth requirements while maintaining signal quality could make AM more competitive in crowded frequency spectra.

9.2 Hybrid Modulation Techniques:

Hybrid modulation schemes that combine elements of AM with other modulation techniques might be explored. This could involve integrating digital modulation methods to enhance noise resilience and overall system efficiency.

9.3 Adaptations for Niche Applications:

While AM has seen a decline in widespread use, it might find new applications in niche scenarios. Researchers may explore specific contexts where the simplicity of AM and its compatibility could offer advantages, such as in low-power or specialized communication systems.

9.4 Integration with Digital Technologies:

The integration of AM with digital signal processing techniques could lead to novel approaches. Hybrid systems that leverage the simplicity of AM for transmission but incorporate digital methods for improved demodulation and error correction might be developed.

9.5 Exploration in IoT and Low-Power Devices:

As the Internet of Things (IoT) expands, there may be considerations for using AM modulation in low-power and energy-efficient communication for small, resource-constrained devices. AM's simplicity could be an asset in scenarios where power consumption is a critical factor.

9.6 Revival in Specialized Broadcasting:

AM modulation might experience a revival in specialized broadcasting applications, where its specific characteristics, such as long-range propagation, could be advantageous. This could be explored in contexts like emergency broadcasting or specific rural communication needs[10].

While the future of AM modulation may not involve widespread use in mainstream communication, its simplicity, historical significance, and specific advantages could inspire continued exploration and adaptation for specialized applications. Future plans might involve finding innovative ways to integrate AM into modern communication landscapes or leveraging its characteristics in specific scenarios where it offers unique benefits.

Chapter-10

Conclusion

Amplitude Modulation (AM) has played a crucial role in the history of wireless communication, particularly in the realm of broadcasting. Its simplicity and compatibility made it a widely adopted modulation technique, especially for transmitting audio signals over radio frequencies. However, the inherent vulnerabilities to noise and inefficiencies in spectrum usage have led to the rise of more advanced modulation schemes in modern communication systems. Besides, amplitude Modulation (AM) demodulation is a critical process in extracting the original message signal from an AM-modulated carrier wave. Various demodulation techniques, such as envelope detection and synchronous detection, have been employed to recover the transmitted information. Despite its historical significance and simplicity, AM demodulation faces challenges, particularly in dealing with noise and interference.

In contemporary communication systems, the prevalence of digital modulation techniques has surpassed traditional analog methods like AM modulation and demodulation. Digital approaches offer enhanced signal quality, improved noise resilience, and more efficient use of the available spectrum. However, AM modulation and demodulation still find applications in specific scenarios, such as AM radio broadcasting.

Chapter-11

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