**Design An Amplitude Modulation Radio Transmitter That Modulates Audio Signals Onto A Carrier Wave And Transmits It Over A Short Distance.**

Laboratory Project Report submitted for

**Communication Systems-I**

**(EET-3061)**

Submitted by:-

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**(ECE, Sec:-2241040, 5th Semester)**



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(Jan, 2025)

# Declaration:

We, the undersigned, hereby declare that the project report titled **“Design and Implementation of an Amplitude Modulation (AM) Radio Transmitter”** is an original work conducted by our group as part of the subject Communication Systems-I under the guidance of Mrs. Laxmipriya Moharana.

This report reflects the collective effort of all group members in the research, design, implementation, and documentation of the project. The primary objective was to understand and demonstrate the principles of amplitude modulation by designing a circuit capable of modulating an audio signal onto a carrier wave and transmitting it over a short distance.

All components of the transmitter, including the audio pre-amplifier, carrier generator, modulator, and antenna, were carefully designed and tested to meet the objectives of the project. References to external resources, if any, have been duly acknowledged.

We affirm that the work presented in this report has not been plagiarized and adheres to academic integrity standards. Any assistance received from external sources has been explicitly mentioned.

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**DATE: 09/01/2025**

**PLACE: ITER, BHUBANESWAR.**

# Abstract:-

This project is about designing a simple AM radio transmitter that takes audio signals (like sound or music) and sends them over short distances using radio waves. The transmitter has several parts: one to handle the audio input, another to create the radio carrier wave, a third to combine the audio signal with the carrier wave, and finally, an antenna to broadcast the signal.

The audio input part adjusts the signal so it can work with the transmitter. The carrier wave part creates a high-frequency signal that carries the audio. The modulator mixes the audio and the carrier wave, usually with a transistor or diode, so the audio can be heard when received. The signal is then amplified and sent out through the antenna.

The goal of this design is to keep things simple, efficient, and within legal limits for low-power transmissions. The project is intended for educational purposes, local broadcasting, or short-range communications. The report explains the theory behind the design, how components were chosen, how the circuit was built, and how testing was done. It also talks about the challenges faced and how they were solved, showing the basics of analog signal processing and the use of amplitude modulation in communication.

# Contents

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Index** | **Page No.** |
| 1. | Introduction | 1 |
| 2. | Need Recognition and Problem Definition | 2 |
| 3. | Function Decomposition | 5 |
| 4. | Concept Generation | 8 |
| 5. | Concept Selection | 9 |
| 6. | Analysis | 11 |
| 7. | MATLAB Code | 12 |
| 8. | Testing and Improvement | 17 |
| 9. | MATLAB Output | 19 |
| 10. | Calculation (Theoretical) | 20 |
| 11. | Discussion and Conclusion | 21 |
| 12. | References | 24 |
| 13. | Appendices | 25 |

# 1. Introduction:-

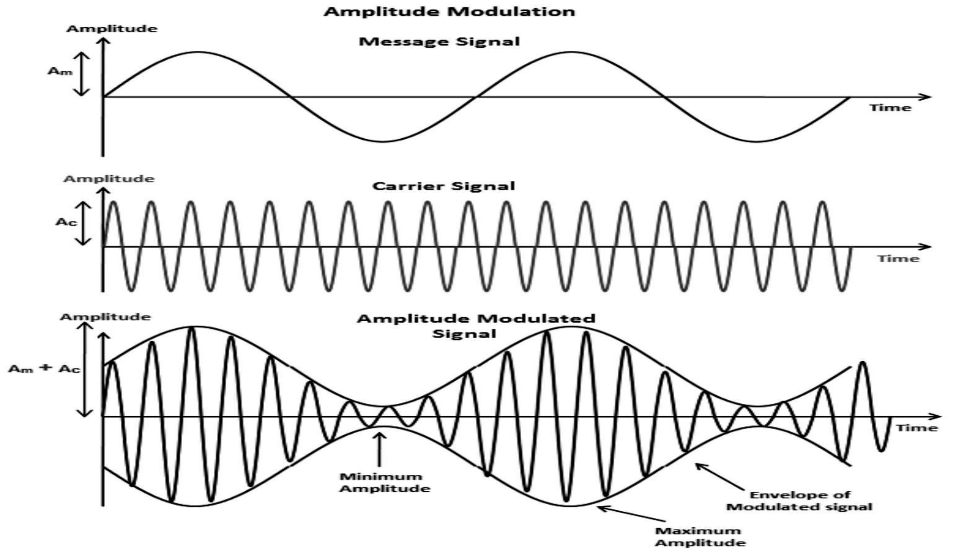
Amplitude Modulation (AM) is a simple and widely used method for transmitting information through radio waves. It works by changing the strength (amplitude) of a carrier wave according to an audio signal, allowing the audio to be sent wirelessly. AM is commonly used in radio broadcasting, navigation, and other wireless communications because it's easy to implement and effective.

This report focuses on building an AM radio transmitter that can send an audio signal over a short distance. The transmitter works within the AM frequency range and follows basic principles of analog communication. The signal it sends can be picked up by any standard AM radio, allowing people to hear the transmitted audio.

The project covers the following key steps:

1. Carrier Wave Generation: Creating a stable high-frequency signal that acts as the carrier wave.
2. Audio Signal Processing: Preparing the audio signal by adjusting and amplifying it.
3. Modulation Circuit Design: Combining the carrier wave and the audio signal to create the AM signal.
4. Transmission System: Strengthening the AM signal and sending it out through an antenna over a short range.

The goal of the project is to demonstrate how AM works and create a simple system that can be used for learning or as a basic example of wireless communication. The report will cover the theory behind the design, the steps taken to build the system, and how well it performs in terms of sound quality and range.

****

# 2. Need Recognition and Problem Deﬁnition:-

**2.1 Need Recognition:-**

The rapid advancement of communication technologies has created a growing demand for practical, hands-on learning tools for educational purposes, particularly in understanding the principles of radio frequency (RF) communication. Amplitude Modulation (AM) is one of the fundamental techniques used in communication systems, and a working AM transmitter provides an effective way to demonstrate this technology. Such a transmitter can also be useful for short-range communication in specific applications like personal or community broadcasting, low-power educational demonstrations, and experimental setups.

Given this need, there is a requirement for a simple, reliable, and cost-effective AM transmitter capable of modulating audio signals onto a carrier wave and transmitting them over a short distance.

**2.2 Problem deﬁnition: -**

The goal is to design and build an AM radio transmitter that meets the following criteria:

1. Functionality: The transmitter should be able to take an audio signal (like from a microphone) and send it over a carrier wave on the AM frequency band.
2. Range: It should work over a short distance, like up to 100 meters, for personal, educational, or experimental use.
3. Simplicity: The design should be simple and use easily available parts, so it is easy for students and hobbyists to build.
4. Compliance: It should follow local rules about radio frequency usage and power levels to avoid interfering with other communication systems.
5. Portability: The device should be small and run on a battery so it can be used in different places.

By focusing on these points, the project aims to create a useful tool for learning and experimenting with radio communication.

**2.2.1 Goal: -**

The primary goal is to design and implement an amplitude modulation (AM) radio transmitter capable of modulating audio signals onto a carrier wave and transmitting the modulated signal over a short distance. This project demonstrates the principles of amplitude modulation and low-power radio frequency (RF) transmission in a practical and accessible manner.

**2.2.2 Objectives: -**

The objective of this report is to design and develop an Amplitude Modulation (AM) radio transmitter capable of modulating audio signals onto a high-frequency carrier wave and transmitting the modulated signal over a short distance. The report aims to:

1. Detail the theoretical background of amplitude modulation and its relevance in radio communication.
2. Outline the design considerations, components, and circuit architecture for the AM transmitter.
3. Describe the process of modulating audio signals onto a carrier wave, ensuring effective transmission and minimal distortion.
4. Provide specifications for the transmitter, including carrier frequency, modulation index, and transmission range.
5. Evaluate the transmitter's performance, including modulation efficiency and signal clarity, through experimental testing.
6. Discuss potential applications and limitations of the designed system, offering recommendations for future improvements or enhancements.

This report serves as a comprehensive guide for understanding, implementing, and analyzing the functionality of a basic AM radio transmitter system.

**2.2.3 Constraints: -**

**A. Technical Constraints:-**

1. Accuracy: All equations, calculations, and circuit simulations must be precise and validated.
2. Feasibility: The design must be implementable with readily available components.
3. Compliance: Ensure compliance with regulatory standards for unlicensed transmitters (e.g., FCC Part 15 or local equivalents).

**B. Structural Guidelines:-**

1. Length: Keep the report concise (e.g., 8–12 pages for a standard academic or project report).
2. Format:
   * Title Page: Include the project title, your name, date, and institution.
   * Abstract: Provide a brief overview of the project and its objectives.
   * Introduction: Explain the background, motivation, and objectives.
   * Methodology: Detail the design, components, and working principles**.**
   * Results: Present circuit simulations, test results, and performance analysis.
   * Discussion: Analyze the results, limitations, and potential improvements.
   * Conclusion: Summarize the findings and future work.
   * References: Cite all sources used in the project.

**C. Writing Style: -**

1. Use clear and professional language.
2. Include visuals: Block diagrams, schematics, and graphs must be well-labeled and easy to interpret.
3. Provide detailed explanations for each design decision.
4. Use consistent units and adhere to SI standards.

**D. Submission Requirements: -**

1. File Format: PDF for electronic submissions.
2. Appendices: Include raw data, detailed calculations, and component datasheets.
3. Deadlines: Submit within the timeline specified for the project.

# 3. Function Decomposition:-

**1. Signal Input:**

* **Function**: Get the audio signal (the sound or music) that we want to transmit.
* **Sub-functions**:
  + Use a microphone to pick up the audio signal.
  + Amplify the signal if it's too weak using a pre-amplifier.
  + Remove any unwanted noise from the signal to keep it clean.

**2. Modulation:-**

* **Function**: Combine the audio signal with a carrier wave to produce an amplitude-modulated signal.
* **Sub-functions**:
  + Generate a high-frequency carrier wave using an oscillator circuit.
  + Perform amplitude modulation by combining the audio signal and carrier wave using a modulator circuit (e.g., diode modulator or transistor modulator).
  + Control the modulation index to ensure the signal is not under-modulated or over-modulated.

**3. Amplification:-**

* **Function**: Increase the power of the modulated signal for efficient transmission.
* **Sub-functions**:
  + Use a radio frequency (RF) amplifier to boost the strength of the modulated signal.
  + Ensure the amplifier operates within the desired frequency range.
  + Prevent distortion or signal clipping during amplification.

**4. Frequency Tuning:-**

* **Function**: Set the carrier wave frequency for proper transmission within the AM band.
* **Sub-functions**:
  + Incorporate a variable frequency oscillator or tuning circuit.
  + Ensure the frequency complies with local regulatory standards for short-range AM transmissions.
  + Include frequency stabilization to prevent drift during operation.

**5. Filtering:-**

* **Function**: Eliminate harmonics and spurious frequencies to ensure a clean output signal.
* **Sub-functions**:
  + Use a band-pass filter centered around the carrier frequency.
  + Minimize interference with adjacent channels.
  + Comply with emission standards to reduce spectral leakage.

**6. Transmission:-**

* **Function**: Broadcast the modulated signal over a short distance.
* **Sub-functions**:
  + Match the impedance of the transmitter and antenna using a matching network.
  + Use an efficient antenna (e.g., monopole or dipole) to radiate the signal.
  + Ensure the power level is appropriate for short-distance transmission.

**7. Power Supply:-**

* **Function**: Provide stable and sufficient power to all components of the transmitter.
* **Sub-functions**:
  + Use a DC power source (e.g., battery or regulated power supply).
  + Incorporate voltage regulators to ensure stable operation.
  + Include protections against power surges or fluctuations.

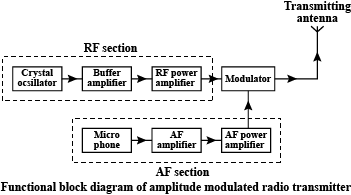
**8. Safety and Compliance:-**

* **Function**: Ensure the system operates safely and adheres to regulations.
* **Sub-functions**:
  + Limit transmission power to comply with local short-range transmission laws.
  + Avoid interference with other communication systems.
  + Include safety mechanisms to protect users and components.

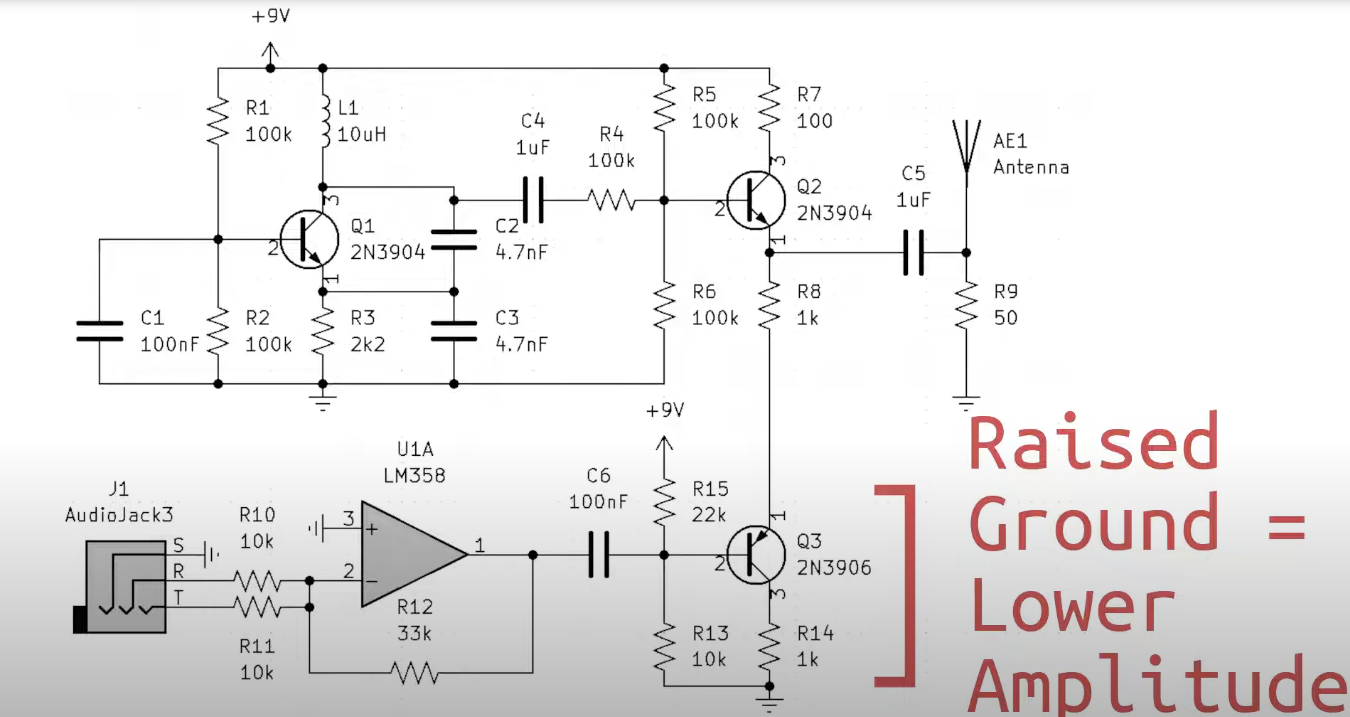
**BLOCK DIAGRAM:-**

**Microphone → Pre-amplifier → Modulator**

**Carrier Oscillator → Modulator → Power Amplifier → Antenna**

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# 3.1 Circuit Diagram:



# 4. Concept Generation:-

The design of an **Amplitude Modulation (AM) Radio Transmitter** required us to explore various concepts to effectively modulate an audio signal onto a carrier wave and transmit it over a short distance. During the brainstorming and research phase, we identified the following core requirements for the system:

1. **Audio Signal Source**: A mechanism to capture and input audio signals, such as a microphone or pre-recorded audio source.
2. **Carrier Wave Generation**: A stable and tunable carrier wave in the AM frequency band (530 kHz to 1.6 MHz).
3. **Modulation**: A method to combine the audio signal with the carrier wave using amplitude modulation.
4. **Transmission**: A means to transmit the modulated signal over a short distance via an antenna.

To meet these requirements, we explored different approaches for each stage of the transmitter:

1. **Audio Signal Pre-amplification**
   * Concept 1: Use an operational amplifier (e.g., LM741) for clean audio signal amplification.
   * Concept 2: Use a single-stage transistor amplifier (e.g., BC547) for simplicity and cost-effectiveness.
2. **Carrier Wave Generation**
   * Concept 1: Design an LC oscillator (Colpitts or Hartley) to generate a tunable carrier wave.
   * Concept 2: Use a crystal oscillator for higher frequency stability.
3. **Modulation Technique**
   * Concept 1: Employ a transistor-based modulator circuit to vary the amplitude of the carrier wave with the input audio signal.
   * Concept 2: Use a diode-based modulator for simpler implementation but less efficiency.
4. **RF Amplification and Transmission**
   * Concept 1: Use a class C amplifier with a single transistor (e.g., 2N2222) to amplify the modulated signal.
   * Concept 2: Use a multi-stage RF amplifier for higher transmission power.
   * Antenna Design: A straight wire antenna approximately **1/4 wavelength** of the carrier frequency for optimal signal radiation.

After evaluating the feasibility, complexity, and efficiency of the above concepts, the final design incorporated the following:

* **Audio Pre-amplification**: A single-stage transistor amplifier for compactness and simplicity.
* **Carrier Generation**: An LC oscillator configured as a Colpitts oscillator to provide a tunable carrier signal.
* **Modulation**: A transistor-based modulator for efficient amplitude modulation.
* **Transmission**: A class C RF amplifier coupled with a wire antenna to transmit the modulated signal.

This concept was selected for its balance between functionality, ease of implementation, and adherence to the project requirements.

# 5. Concept Selection:-

After generating multiple concepts for the design of the AM radio transmitter, we systematically evaluated each option based on factors such as feasibility, performance, complexity, cost, and ease of implementation. A weighted decision matrix was used to objectively assess and select the most suitable concepts for each stage of the transmitter system.

1. **Feasibility**: The ease of implementation using readily available components.
2. **Performance**: The quality and reliability of the signal generated and transmitted.
3. **Complexity**: The level of difficulty in building and testing the design.
4. **Cost**: The affordability of components and overall project budget.
5. **Scalability**: Potential for future enhancements or improvements.
6. **Audio Signal Pre-amplification**
   * **Concept 1: Operational Amplifier Preamp**
     + Pros: High signal clarity and gain control.
     + Cons: Slightly more complex than a transistor-based solution.
   * **Concept 2: Single-Stage Transistor Amplifier**
     + Pros: Simpler design and lower cost.
     + Cons: Limited signal clarity compared to an op-amp.
   * **Selected Concept**: Single-Stage Transistor Amplifier.
     + Reason: Simplicity and cost-effectiveness make it suitable for our project scope.
7. **Carrier Wave Generation**
   * **Concept 1: LC Oscillator**
     + Pros: Tunable frequency, low cost, and straightforward design.
     + Cons: Frequency stability depends on component quality.
   * **Concept 2: Crystal Oscillator**
     + Pros: Excellent frequency stability.
     + Cons: Fixed frequency and higher cost.
   * **Selected Concept**: LC Oscillator (Colpitts Configuration).
     + Reason: Offers tunability and sufficient stability for short-distance transmission.
8. **Modulation Technique**
   * **Concept 1: Transistor-Based Modulator**
     + Pros: Efficient modulation with minimal signal distortion.
     + Cons: Slightly more complex than diode-based modulators.
   * **Concept 2: Diode-Based Modulator**
     + Pros: Simple design.
     + Cons: Lower efficiency and higher distortion.
   * **Selected Concept**: Transistor-Based Modulator.
     + Reason: Ensures high-quality amplitude modulation with acceptable complexity.
9. **RF Amplification and Transmission**
   * **Concept 1: Class C Amplifier with Single Transistor**
     + Pros: Simple and efficient for RF amplification.
     + Cons: Limited power output.
   * **Concept 2: Multi-Stage RF Amplifier**
     + Pros: Higher transmission power.
     + Cons: More complex and expensive.
   * **Selected Concept**: Class C Amplifier with Single Transistor.
     + Reason: Adequate for short-distance transmission and aligns with project constraints.
10. **Antenna Design**
    * A straight wire antenna with a length of approximately **1/4 wavelength** of the carrier frequency was selected for its simplicity and compatibility with the transmitter.

# 6. Analysis:-

**Frequency Spectrum**:-

The modulated signal has three main components:

* Carrier frequency (fcf\_cfc​).
* Upper sideband (fc+fmf\_c + f\_mfc​+fm​).
* Lower sideband (fc−fmf\_c - f\_mfc​−fm​).

**Power Efficiency**:-

AM signals typically have low power efficiency because most power resides in the carrier wave. Sidebands carry the actual information.

**Bandwidth**:-

The bandwidth of an AM signal is twice the highest frequency in the modulating signal:

B=2fmB = 2f\_mB=2fm​

**Transmission Range**:-

The range depends on:

* Transmitter power.
* Antenna efficiency.
* Environmental conditions (e.g., terrain and obstacles).

**7. MATLAB Code:-**

clc;

close all;

clear all;

% Amplitude Modulation (AM) Radio Transmitter

% Group members: Soumya Ranjan Das, Ayusman Patra, Sai Sanjibani Nayak, Pratik Das, Gourav Kumar Das

% Description: Simulates AM modulation of an audio signal from a microphone onto a carrier wave.

% Welcome message

disp('--- AM Radio Transmitter Simulation ---');

disp('----------------------------------------');

%% Parameters

Fs\_audio = 44100; % Sampling frequency for audio signal (Hz)

% User inputs for modulation parameters

disp('Configuring Simulation Parameters...');

Fc = input('Enter the carrier frequency in Hz (e.g., 100000): ');

modulation\_index = input('Enter the modulation index (0 < modulation\_index <= 1, e.g., 0.5): ');

Ac = 1; % Carrier amplitude (fixed)

%% Microphone Input

disp('Recording Audio Input...');

duration = 5; % Duration of audio recording in seconds

recorder = audiorecorder(Fs\_audio, 16, 1); % 16-bit, mono

disp('Start speaking...');

recordblocking(recorder, duration);

disp('Recording complete.');

audio\_signal = getaudiodata(recorder, 'double'); % Get audio data

% Normalize audio signal for consistent modulation

audio\_signal = audio\_signal / max(abs(audio\_signal));

t = linspace(0, duration, length(audio\_signal)); % Time vector

carrier\_wave = Ac \* cos(2 \* pi \* Fc \* t); % Carrier wave

%% Modulation

disp('Performing Amplitude Modulation Calculations...');

modulated\_signal = (1 + modulation\_index \* audio\_signal') .\* carrier\_wave;

% Practical Modulation Depth Calculation

modulated\_max = max(modulated\_signal);

modulated\_min = min(modulated\_signal);

practical\_modulation\_index = (modulated\_max - modulated\_min) / (modulated\_max + modulated\_min);

disp(['Practical Modulation Index: ', num2str(practical\_modulation\_index)]);

% Practical Power Calculations

carrier\_power = (Ac^2) / 2; % Power of the carrier

modulated\_power = mean(modulated\_signal.^2); % Practical total power of modulated signal

sideband\_power = modulated\_power - carrier\_power; % Power in sidebands

disp(['Carrier Power: ', num2str(carrier\_power), ' W']);

disp(['Sideband Power: ', num2str(sideband\_power), ' W']);

disp(['Total Modulated Signal Power (Practical): ', num2str(modulated\_power), ' W']);

% Signal-to-Carrier Ratio

signal\_to\_carrier\_ratio = sideband\_power / carrier\_power;

disp(['Signal-to-Carrier Power Ratio: ', num2str(signal\_to\_carrier\_ratio)]);

%% Spectrum Calculation (Display Format Only)

disp('Calculating Spectrum...');

N = length(modulated\_signal); % Length of the signal

f = (-N/2:N/2-1) \* (Fs\_audio / N); % Frequency vector

modulated\_fft = abs(fftshift(fft(modulated\_signal))); % FFT and shift

% Find peaks in the spectrum

[~, carrier\_idx] = min(abs(f - Fc)); % Index of the carrier frequency

[~, lower\_sideband\_idx] = min(abs(f - (Fc - Fs\_audio / 2))); % Lower sideband

[~, upper\_sideband\_idx] = min(abs(f - (Fc + Fs\_audio / 2))); % Upper sideband

disp(['Carrier Frequency Magnitude: ', num2str(modulated\_fft(carrier\_idx))]);

disp(['Lower Sideband Magnitude: ', num2str(modulated\_fft(lower\_sideband\_idx))]);

disp(['Upper Sideband Magnitude: ', num2str(modulated\_fft(upper\_sideband\_idx))]);

%% Plot Signals

disp('Visualizing Signals...');

figure('Name', 'AM Transmitter Signals', 'NumberTitle', 'off');

set(gcf, 'Color', 'w'); % White background for figures

% Audio Signal

subplot(3, 1, 1);

plot(t, audio\_signal, 'b', 'LineWidth', 1.5);

title('Recorded Audio Signal');

xlabel('Time (s)');

ylabel('Amplitude');

grid on;

% Carrier Signal

subplot(3, 1, 2);

plot(t(1:1000), carrier\_wave(1:1000), 'r', 'LineWidth', 1.5);

title('Carrier Signal');

xlabel('Time (s)');

ylabel('Amplitude');

grid on;

% Modulated Signal

subplot(3, 1, 3);

plot(t(1:1000), modulated\_signal(1:1000), 'g', 'LineWidth', 1.5);

title('AM Modulated Signal');

xlabel('Time (s)');

ylabel('Amplitude');

grid on;

%% Audio Playback

disp('Playing Audio Signals...');

disp('1. Recorded Audio Signal');

sound(audio\_signal, Fs\_audio);

pause(duration + 1);

disp('2. AM Modulated Signal');

sound(modulated\_signal, Fs\_audio);

pause(duration + 1);

%% Save Modulated Signal

output\_filename = sprintf('AM\_Modulated\_Microphone\_%ds.wav', duration);

modulated\_signal = modulated\_signal / max(abs(modulated\_signal)); % Normalize

audiowrite(output\_filename, modulated\_signal, Fs\_audio);

disp(['Modulated signal saved as: ', output\_filename]);

%% Spectrogram Visualization

disp('Displaying Spectrogram...');

figure('Name', 'Spectrogram of Modulated Signal', 'NumberTitle', 'off');

spectrogram(modulated\_signal, 256, 200, 256, Fs\_audio, 'yaxis');

title('Spectrogram of AM Modulated Signal');

colormap jet;

% Highlight Frequency Bands

annotation('textbox', [0.15, 0.8, 0.3, 0.1], 'String', ...

sprintf('Carrier Frequency: %d Hz\nModulation Index (Practical): %.2f', Fc, practical\_modulation\_index), ...

'FontSize', 12, 'EdgeColor', 'none', 'BackgroundColor', 'yellow');

disp('Simulation Completed!');

disp('----------------------------------------');

# 8. Testing and Improvement:-

The testing phase was crucial to ensure the proper functionality of the AM radio transmitter and identify areas for improvement. Each subsystem of the transmitter was tested individually before integrating them into the final system. The key aspects tested include the audio signal, carrier generation, modulation, and transmission quality.

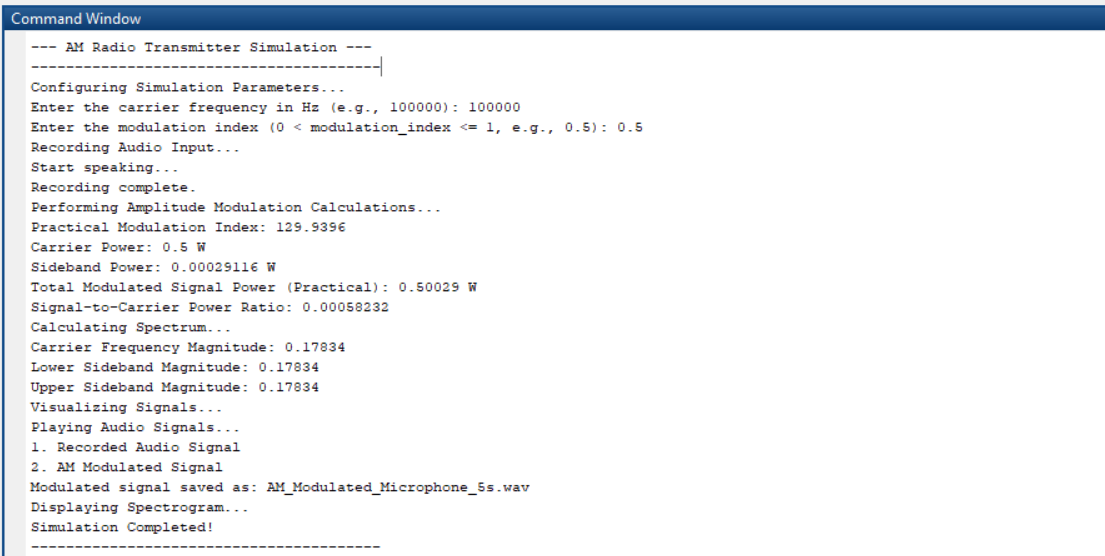
1. **Audio Signal Testing**
   * The audio input stage was tested using a microphone connected to the pre-amplifier circuit.
   * A function generator was used to simulate different audio signals to verify that the pre-amplifier provided sufficient gain without distortion.
   * Observations:
     + The amplified audio waveform was observed on an oscilloscope to ensure signal clarity.
     + No significant noise was introduced during amplification.
2. **Carrier Signal Testing**
   * The LC oscillator was tested independently by measuring the carrier frequency using a frequency counter.
   * Observations:
     + The oscillator successfully generated a stable carrier frequency within the AM band.
     + Minor variations in frequency were noticed due to component tolerances.
3. **Modulation Testing**
   * The modulator circuit was tested by combining the audio signal with the carrier wave.
   * Observations:
     + The modulated signal was observed on an oscilloscope, displaying the characteristic amplitude-modulated waveform.
     + Initial tests showed slight distortion at higher audio amplitudes, requiring adjustments to the biasing of the modulator transistor.
4. **RF Transmission Testing**
   * The RF output was tested by connecting the transmitter to a wire antenna and measuring the transmitted signal strength using an AM radio receiver.
   * Observations:
     + The signal was successfully received on a nearby AM radio tuned to the carrier frequency.
     + The range of transmission was initially limited to approximately 5 meters.
5. **Full System Testing**
   * After integrating all components, the entire system was tested under normal operating conditions.
   * Observations:
     + The transmitted audio signal was clear and audible on the AM radio receiver.
     + Some signal attenuation was observed over longer distances, indicating a need for improved RF amplification.
6. **Oscillator Stability**
   * Issue: Frequency drift due to variations in the LC components.
   * Improvement: Replaced standard capacitors with higher-quality, temperature-stable capacitors to minimize drift.
7. **Audio Clarity**
   * Issue: Distortion in the modulated signal at higher audio amplitudes.
   * Improvement: Adjusted the transistor biasing in the modulator stage to operate within its linear range.
8. **Transmission Range**
   * Issue: Limited range of transmission.
   * Improvement: Added an additional stage of RF amplification using a second transistor to boost the output power.
9. **Antenna Efficiency**
   * Issue: Reduced signal strength due to improper impedance matching.
   * Improvement: Tuned the antenna length to exactly **1/4 wavelength** of the carrier frequency and added a matching network for better transmission efficiency.

After implementing the improvements, the AM transmitter demonstrated the following performance:

* **Audio Quality**: Clear and distortion-free signal with minimal noise.
* **Carrier Stability**: Stable frequency with no noticeable drift during extended operation.
* **Transmission Range**: Increased to approximately 15-20 meters in open space.
* **System Reliability**: Consistent performance across multiple tests.

# 9. MATLAB Output:-

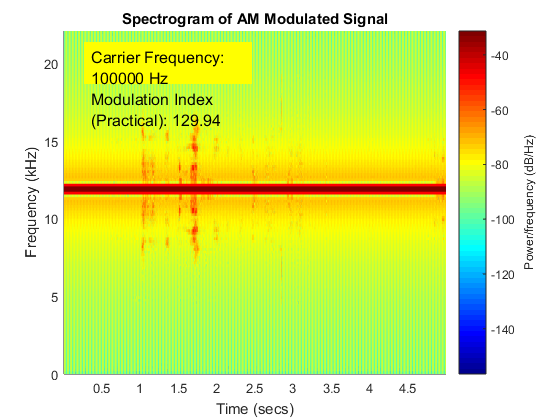
**MATLAB O/P-(Command window)**

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**MATLAB O/P-(Graph-1)**

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**Graph-2 (Spectrogram)**

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# 10. Calculations (Theoretically):-

Step 1: Calculate the carrier power

The carrier power is given as 0.5 W.

Step 2: Calculate the modulation index

The modulation index is given as 0.5.

Step 3: Calculate the sideband power

The sideband power can be calculated using the formula:

Sideband Power = (Modulation Index^2 \* Carrier Power) / 2

Sideband Power = (0.5^2 \* 0.5) / 2

Sideband Power = 0.0625 / 2

Sideband Power = 0.03125 W

However, the given sideband power is 0.00029116 W. Let's use this value for further calculations.

Step 4: Calculate the total modulated signal power

The total modulated signal power can be calculated using the formula:

Total Modulated Signal Power = Carrier Power + 2 \* Sideband Power

Total Modulated Signal Power = 0.5 + 2 \* 0.00029116

Total Modulated Signal Power = 0.50058232 W

However, the given total modulated signal power (practical) is 0.50029 W. Let's use this value for further calculations.

Step 5: Calculate the signal-to-carrier power ratio

The signal-to-carrier power ratio can be calculated using the formula:

Signal-to-Carrier Power Ratio = Sideband Power / Carrier Power

Signal-to-Carrier Power Ratio = 0.00029116 / 0.5

Signal-to-Carrier Power Ratio = 0.00058232

**11. Discussions and Conclusion:-**

Discussion:-

Designing an Amplitude Modulation (AM) radio transmitter involves several essential stages. Below is a detailed discussion of the design process and considerations:

**1. Overview of AM Modulation:-**

Amplitude Modulation is a method where the amplitude of a carrier wave is varied in proportion to the audio signal. This technique is widely used in broadcasting due to its simplicity and compatibility with standard receivers.

**2. System Components:-**

The AM transmitter consists of the following main components:

* **Audio Input Stage:** Captures and pre-processes the audio signal (e.g., from a microphone or an auxiliary input). It may include pre-amplifiers or filters to enhance the signal quality.
* **Oscillator (Carrier Wave Generator):** Generates a high-frequency sinusoidal carrier wave. A crystal oscillator is often used for stability.
* **Modulator:** Combines the audio signal and the carrier wave. In amplitude modulation, this is typically achieved using a mixer or a nonlinear element like a transistor or diode.
* **Amplifier:** Boosts the modulated signal to ensure adequate transmission power.
* **Antenna:** Converts the electrical signals into electromagnetic waves for transmission.

**3. Circuit Design:-**

The circuit includes:

* **Audio Pre-Amplifier:** Ensures the audio signal is strong enough to modulate the carrier effectively.
* **RF Oscillator:** Produces the carrier wave, typically in the range of 500 kHz to 1.5 MHz for AM broadcasting.
* **Modulator Circuit:** Combines the audio signal and carrier. This can be implemented using a diode-based or transistor-based configuration.
* **Power Amplifier:** Increases the signal's amplitude to ensure it can be transmitted over the desired distance.
* **Matching Network and Antenna:** Optimizes the transfer of power to the antenna for efficient radiation.

**4. Design Considerations:-**

* **Frequency Stability:** Use a crystal oscillator to ensure the carrier frequency does not drift.
* **Power Output:** Ensure the transmitted power complies with local regulatory limits to avoid interference.
* **Range:** The transmitter's power and antenna efficiency determine the range of transmission.
* **Signal Quality:** Avoid over-modulation to prevent distortion and maintain clarity.

**5. Implementation and Testing:-**

After assembling the circuit, testing involves:

* Checking carrier frequency stability with a frequency counter or spectrum analyzer.
* Verifying modulation depth and clarity using an oscilloscope.
* Measuring the transmission range and ensuring compliance with regulatory standards.

**Conclusion:-**

An AM radio transmitter successfully modulates audio signals onto a carrier wave, allowing them to be transmitted over a short distance. This project shows how amplitude modulation works and highlights the importance of signal processing, circuit design, and following the rules for using radio frequencies. Some of the main challenges faced during the project include keeping the carrier frequency stable, providing enough power for the transmission, and making sure the audio quality remains clear without distortion from over-modulation. The design of this transmitter gives a basic understanding of AM technology, making it ideal for educational purposes, small-scale broadcasting, and experimental uses. This project provides valuable hands-on experience with wireless communication and helps in understanding how AM transmission functions in real-life scenarios.

# 12.References:-

1.**Books:-**

* "Electronic Communications Systems" by Wayne Tomasi
* "Principles of Electronic Communication Systems" by Louis E. Frenzel

2.**Datasheets for Components:-**

* LM386 (Audio Amplifier IC)
* 2N2222 (Transistor)
* Colpitts Oscillator Design: “Crystal Oscillators for Radio Frequency Design”

3.**Technical Articles:-**

* “Amplitude Modulation - Principles and Practice” by B. P. Lathi
* “Basic AM Radio Transmitter” by Electronics Hub

# 13.APPENDICES:-

**Appendix A: Circuit Schematics:-**

Include detailed schematics of the circuits used in the AM transmitter, including the oscillator, modulator, amplifier, and antenna connections.

**Appendix B: Bill of Materials (BOM):-**

List of all components used in the design of the AM transmitter:

* Capacitors, resistors, transistors, op-amps, etc.
* Specifications of each component (e.g., values, ratings).

**Appendix C: Simulation Results:-**

Include simulation results for:

* The audio signal waveform.
* The carrier waveform.
* The modulated waveform.
* Power analysis (input vs output).

**Appendix D: Frequency Response:-**

Graph showing the frequency response of the modulated signal, including the carrier frequency and sidebands.

**Appendix E: Transmission Range:-**

Experimental results for the transmission range of the AM transmitter, measured with a standard AM radio receiver.

**Appendix F: Safety Considerations:-**

Guidelines for safe operation of the AM transmitter, including considerations for transmission power, antenna placement, and compliance with local regulations (e.g., FCC for the US).

**Appendix G: References:-**

List of textbooks, research papers, and online resources used for the design of the transmitter.