MINI PROJECT REPORT

ON

"Audio Amplifier Using Basic Components"

EC - 594 (DESIGN-I LAB.)

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Introduction to the Audio Amplifier Project

The **Audio Amplifier** project focuses on the design and construction of an efficient and reliable amplifier circuit capable of driving speakers with a substantial power rating, specifically tailored for high-fidelity audio applications. Audio amplifiers are fundamental components in various audio systems, ranging from home theater setups, public address systems, to professional sound equipment. Their primary function is to amplify low-level audio signals, typically originating from a source such as a microphone, radio, or music player, and transform them into signals that can drive speakers to produce sound at desired volumes.

In this project, a **high-power audio amplifier** is being developed using discrete components such as **transistors**, **capacitors**, **diodes**, **resistors**, and **potentiometers** to create a fully functional audio amplifier system. The amplifier is designed to handle substantial power levels, specifically aimed at amplifying audio signals to drive speakers of up to **150W** power rating, making it suitable for both **domestic and semi-professional** audio setups.

The core of the amplifier circuit is built around **power transistors**, such as the **2SC5200**, **BD139**, and **BD140**. These transistors are chosen for their high power handling capabilities and efficient amplification performance. The circuit design incorporates the use of passive components like **resistors**, **capacitors**, and **potentiometers** to fine-tune and regulate the audio signal, ensuring smooth frequency response, bass/treble adjustments, and volume control.

Need and Importance of Audio Amplifiers

Audio amplifiers are essential for applications that require the amplification of low-level audio signals, ensuring that the sound output is clear, loud, and free of distortion. These amplifiers are typically used in:

- **Home Audio Systems**: Enhancing music or movie soundtracks by delivering better sound clarity and increased volume.
- **Public Address Systems**: Amplifying the voice for large audiences in venues such as auditoriums, conference halls, and stadiums.
- **Musical Instrument Amplifiers**: Providing the necessary sound amplification for instruments like electric guitars and keyboards in live performances and practice sessions.
- **Professional Audio Systems**: Used in studios, live concerts, and broadcasting for clear and loud audio transmission.

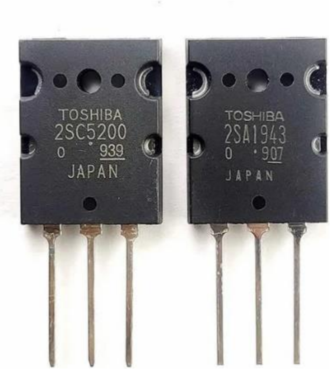
The development of high-quality audio amplifiers is critical to improving the overall listening experience, whether for music, speeches, or any other audio-driven content. A high-fidelity amplifier ensures minimal distortion, clear audio reproduction, and sufficient volume to suit various acoustic environments.

COMPONENTS

1. Transistors:

a) 2SC5200 (NPN Power Transistor) - x2:

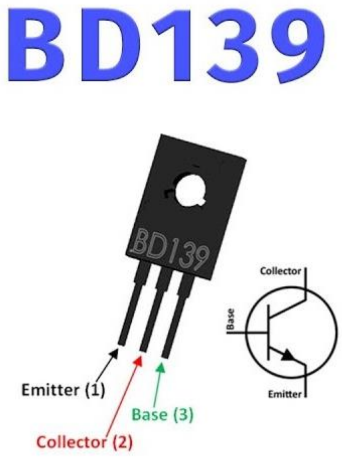
- **Purpose**: The 2SC5200 is a high-power NPN transistor designed for audio power amplification. It's used in the output stage of audio amplifiers to provide high current and voltage gain, driving the speaker.
- **Specifications**:



  - **Max Collector-Emitter Voltage (Vce)**: 230V
  - **Max Collector Current (Ic)**: 15A
  - **Power Dissipation (Ptot)**: 150W
  - **Gain (hFE)**: 30 to 120
  - **Application**: Commonly used in high-power audio amplifiers, subwoofer amplifiers, and other high-fidelity audio systems.
  - **Key Feature**: Capable of handling large currents and voltages, making it ideal for powering speakers with high wattage needs.

b) BD139 (NPN Transistor) - x2:

- **Purpose**: The BD139 is a medium-power transistor, used here as a driver stage transistor for controlling the power transistors (2SC5200). It amplifies the current from the input signal to drive the larger power transistors efficiently.
- **Specifications**:



  - **Max Collector-Emitter Voltage (Vce)**: 80V
  - **Max Collector Current (Ic)**: 1.5A
  - **Power Dissipation (Ptot)**: 30W
  - **Gain (hFE)**: 40 to 320
  - **Application**: Typically used in low to medium power amplifiers, switch-mode power supplies, and linear regulators.
  - **Key Feature**: Good current gain and robust performance in driving output transistors.

c) BD 140 (PNP Transistor) - x1:

- **Purpose**: The BD140 is a complementary transistor to the BD139. It is used in the push-pull configuration, ensuring that both halves of the output waveform are properly amplified. This configuration reduces distortion and provides better efficiency and linearity.
- **Specifications**:
  - **Max Collector-Emitter Voltage (Vce)**: 80V
  - **Max Collector Current (Ic)**: 1.5A
  - **Power Dissipation (Ptot)**: 30W
  - **Gain (hFE)**: 40 to 320
  - **Application**: Used in audio amplifier output stages to improve signal amplification with a complementary NPN transistor.
  - **Key Feature**: Essential for the push-pull design, ensuring smooth, distortion-free output.

2. Resistors:

a) 120k Ohm Resistor:

- **Purpose**: This resistor is likely part of the biasing network for the base of the transistor, setting the operating point of the transistors.
- **Specifications**:
  - **Power Rating**: Generally, low-power rating (e.g., 0.25W)
  - **Tolerances**: 5% tolerance is common
  - **Application**: Used in biasing circuits to ensure the transistors operate within their optimal range.

b) 1k Ohm Resisstor:

- **Purpose**: A larger resistor used in the emitter or collector circuits of the transistors. The 2-watt rating ensures that it can handle the power dissipation in the current-limiting or feedback paths.

- **Specifications**:
    - **Power Rating**: 2W, allowing it to handle higher power dissipation without overheating.
    - **Tolerance**: Usually ±5% or better.
    - **Application**: Limits current to prevent overdriving the transistors or used in feedback paths for stability.

b) 470 Ohm Resistor:

- **Purpose**: This resistor helps in controlling the current in specific parts of the circuit, potentially in the feedback loop, emitter biasing, or base resistors to provide stability.

- **Specifications**:
    - **Power Rating**: Low (0.25W typical)
    - **Tolerance**: ±5% tolerance
    - **Application**: Used in biasing circuits or as part of a feedback network to stabilize the circuit's response.

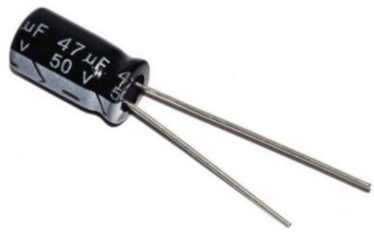
3. Capacitors:

a) 2200uF / 50V Capacitor:

- **Purpose**: This is an electrolytic capacitor, typically used for power supply filtering to smooth out ripples in the DC supply voltage. It helps to prevent power supply noise from interfering with the audio signal.
- **Specifications**:
    - **Capacitance**: 2200uF
    - **Voltage Rating**: 50 V (higher than the expected supply voltage to handle any voltage spikes)
    - **Application**: Smoothing the DC output from the power supply, preventing hum or noise in the audio output.

b) 47µF / 50V Capacitor:

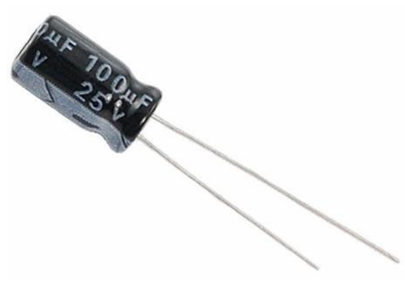
- **Purpose**: Used to filter out low-frequency voltage ripples and stabilize the output voltage in power supplies. It helps in smoothing the DC output from rectifiers to maintain steady voltage levels.
- **Specifications**:



  - **Capacitance**: 47uF
  - **Voltage Rating**: 50V (adequate for typical audio signal paths)
  - **Application**: To filter and smooth out voltage fluctuations in power supplies.

c) 100uF / 25V Capacitor (*2):

- **Purpose**: Primarily used for decoupling and filtering applications, it smoothens voltage fluctuations in power supplies and minimizes noise in analog or audio circuits. It stores and releases charge to stabilize the voltage.
- **Specifications**:



  - **Capacitance**: 100uF
  - **Voltage Rating**: 25 V (higher than the expected supply voltage to handle any voltage spikes)
  - **Application**: To store and release energy, stabilizing voltage and reducing noise in circuits.

d) 10uF / 10V Capacitor:

- **Purpose**: Typically employed in bypass and decoupling applications to remove high-frequency noise and interference from the power supply. It also helps in maintaining stable voltage in sensitive circuits like microcontrollers and analog devices.
- **Specifications**:

  - **Capacitance**: 10 uF
  - **Voltage Rating**: 10 V (higher than the expected supply voltage to handle any voltage spikes)
  - **Application**: To bypass high-frequency noise and smooth power supply in sensitive electronics.

4. Diodes:

a) 1N4007 Diode (x2):

- **Purpose**: These are general-purpose diodes used to protect the circuit from reverse voltage (reverse polarity) and to prevent damage to components when the power supply is connected incorrectly.
- **Specifications**:

  - **Max Reverse Voltage**: 1000V
  - **Max Forward Current**: 1A
  - **Application**: Protection diodes, ensuring that the circuit remains safe when connected to a power supply with incorrect polarity.
  - **Key Feature**: Robust and inexpensive, commonly used in low-power applications.

b) IN5408 Diode:

- **Purpose:** The IN5408 is a **high-power, general-purpose rectifier diode** used in applications requiring the rectification of alternating current (AC) into direct current (DC).
- **Specifications:**

  - **Max Reverse Voltage**: **1000V**
  - **Max Forward Current**: **3A**
  - **Application:** Commonly used in **power supply circuits**, **voltage rectification**, **DC motor circuits**, and **battery charging applications**.
  - **Key Feature: High Surge Current Capability**- Can handle **surge currents up to 200A** (for short durations), making it suitable for applications with high inrush currents.

5. Potentiometer:

a) 100k Ohm Potentiometer(*3)

- **Purpose**: The potentiometer acts as a volume control. By adjusting the resistance, it modifies the input signal's amplitude, thereby controlling the output volume.

- **Specifications**:
  - **Resistance**: 100k Ohm
  - **Power Rating**: Typically 0.5W to 1W
  - **Type**: Linear or logarithmic (depending on the design, often logarithmic for audio applications)

Application:

- **Volume Control**: Adjusts the overall audio output level.
- **Treble Control**: Adjusts the high-frequency response, allowing you to boost or cut the treble frequencies.
- **Bass Control**: Adjusts the low-frequency response, providing control over bass levels.

6. Speaker:

a) Above 150W Rated Speaker:

- **Purpose**: The speaker is the load for the amplifier. It converts the amplified electrical signal back into sound waves, producing the audio output.
- **Specifications**:
  - **Power Rating**: Typically rated for continuous power handling of at least 60W.
  - **Impedance**: Usually 4 ohms or 8 ohms (ensure this matches the amplifier's design).
  - **Application**: High-power speakers are required to handle the output of the amplifier without distortion or damage.

7. Power Supply:

a) DC Above 24 V Power Supply:

- **Purpose**: This power supply provides the necessary voltage to the amplifier circuit. The power rating (24V) is chosen to ensure that the transistors operate within their optimal voltage range while delivering sufficient power for the speaker.

- **Specifications**:
  - **Voltage**: Above 24 V DC, which is sufficient to drive the amplifier's output stage.
  - **Current**: Typically, a power supply rated for at least 5-6A is required to handle the current draw of the amplifier without sagging voltage.

b) About IN BUILT Power Supply:

1. Integrated Design:

- An **in-built power supply** in an audio amplifier combines the power supply and amplifier circuitry into a single unit. This simplifies the overall design and reduces the need for external power sources.

2. AC to DC Conversion:

- The power supply typically includes a **transformer** to step down the AC voltage from the mains power supply (e.g., 120V/240V) to a lower AC voltage. This AC voltage is then rectified into DC using **diodes** and smoothed using **capacitors** to provide a stable DC voltage for the amplifier's operation.

3. Power Rating:

- The power supply is designed to handle the **total power requirement** of the amplifier. For example, a 150W amplifier needs a power supply capable of providing sufficient DC voltage and current to handle the peak power output, typically at **±35V to ±45V** for a standard 150W amplifier.

4. Voltage Regulation:

- An in-built power supply often includes **voltage regulators** to ensure a consistent output voltage, regardless of fluctuations in the input AC voltage. This helps maintain stable performance and prevents distortion caused by varying supply voltage.

8. 12-0-12 Transformer

Specifications:

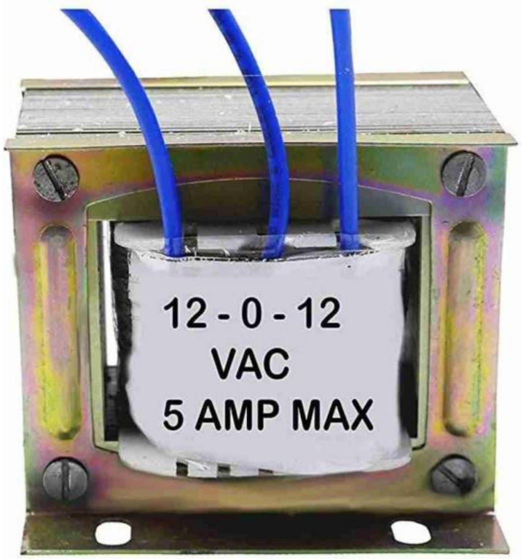
- **Primary Voltage:** 240V (AC)
- **Secondary Voltage:** 12V - 0V - 12V (AC)
- **Power Rating:** Typically between 1VA to 500VA (depending on the specific model and manufacturer)
- **Frequency:** 50Hz or 60Hz (depends on the region's grid frequency)
- **Current Rating:** Varies based on power rating (e.g., for a 12V 1A output, the transformer will handle up to 12W of power)
- **Insulation Class:** Usually Class A, B, or F (depending on the transformer’s heat tolerance)
- **Core Material:** Typically iron or ferrite core for standard models
- **Size:** Varies depending on the power rating

Purpose:

- The **12-0-12 transformer** is designed to step down high AC voltage (240V) to a lower, safer AC voltage of 12V, with a center tap at 0V. This center-tapped configuration is commonly used for creating dual polarity power supplies, providing both positive and negative 12V outputs from a single transformer.

Applications:

- **Audio Amplifiers:** Commonly used in audio amplifier circuits to power the pre-amp and power stages, providing dual voltage rails (+12V, -12V).
- **DC Power Supply Circuits:** Used in power supply circuits that require both positive and negative DC voltages for powering analog or digital circuits, like op-amps, sensors, and audio circuits.
- **Signal Processing:** Can be used in signal processing equipment that needs a balanced power supply for optimal operation.
- **Radios and Home Appliances:** Often found in low-power appliances and radios that require 12V AC power for operation.
- **Battery Charging:** Used in some battery chargers that need dual polarity to charge specific types of batteries.



Working Principle of the Audio Amplifier Circuit

The audio amplifier circuit is based on the **Class AB push-pull configuration**, which is a common design for high-efficiency, low-distortion audio amplifiers. Below is a detailed explanation of how this amplifier works step-by-step:

1. Input Stage: Signal Processing

- **Signal Source**: The audio signal (e.g., from a smartphone, computer, or audio player) is input through an auxiliary (aux) cable into the amplifier circuit.
- **Coupling Capacitor**: At the input of the amplifier, a **220µF capacitor** (or similar) is used to **block any DC voltage** and allow only the AC audio signal to pass into the amplifier stage. This ensures that any potential DC bias from the source does not affect the circuit or the speaker.
- **Input Resistor & Potentiometer**: The signal then goes through a **100k potentiometer**, which is typically used as a **volume control**. This allows the user to adjust the amplitude (volume) of the incoming signal. In some designs, a resistor network could further condition the signal, but here the potentiometer does most of the work.

2. Pre-Amplification Stage: Biasing and Amplification

- **BD139 & BD140 Transistors**: These transistors are part of the **driver stage** and work in a **push-pull configuration**. The BD139 (NPN) and BD140 (PNP) transistors are complementary pairs, meaning they handle both the positive and negative halves of the signal, which is critical for minimizing distortion.
  - **Base Biasing**: The base of each transistor receives biasing from a network of resistors (like the 120k resistor). The goal here is to keep the transistors in their active region (not saturated or cut-off), allowing for linear amplification.
  - **Voltage Gain**: The transistors amplify the small input signal to a higher voltage, but they cannot yet supply sufficient current to drive the speaker. This is where the power transistors (2SC5200) come in.
  - **Operation in Push-Pull**: When the audio signal is positive, the BD139 (NPN) turns on, and when the signal is negative, the BD140 (PNP) turns on. This allows both positive and negative portions of the audio waveform to be amplified, which is essential for producing a **clean, undistorted signal**.

3. Power Amplification Stage: Driving the Speaker

- **2SC5200 Power Transistors**: These high-power transistors handle the high current required to drive the speaker. The 2SC5200 transistors are configured in **parallel** to handle the higher current demands of driving the speaker, which is necessary for louder volume levels without clipping.

- **Signal Amplification**: The amplified voltage signal from the BD139/BD140 transistors is fed into the base of the 2SC5200 power transistors. These power transistors act as **current amplifiers**, providing the necessary current to drive the connected speaker.
- **Operation**: The signal enters the base of the 2SC5200, which causes current to flow through the transistor from the collector to the emitter. The amplified current flows through the **collector-emitter path** and is then fed to the speaker, producing a corresponding sound.
- **Push-Pull Output**: Just like the BD139/BD140 pair, the 2SC5200 transistors also operate in a **push-pull configuration**, ensuring that both the positive and negative halves of the audio waveform are faithfully amplified. This ensures high efficiency and low distortion.

4. Feedback Network: Stabilization

- **Feedback Resistors**: The feedback network, which may involve resistors (such as the **470 Ohm** resistor and others), plays a critical role in controlling the overall gain of the amplifier and stabilizing the output signal. The resistors provide **negative feedback**, which reduces distortion and improves linearity, ensuring the output is a faithful reproduction of the input.
- **Stabilization**: In high-power amplifiers, a lack of feedback can result in **oscillations or instability**. The feedback from the output stage (after the speaker) is sent back to the input stage to ensure that the amplifier remains stable across all frequencies and volume levels.

5. Protection and Biasing Circuit: Ensuring Safe Operation

- **Diodes (1N4007)**: These diodes are placed across the transistors to protect against **reverse polarity** and **voltage spikes** that can occur, particularly during power-up or power-down. The diodes help to **clamp the voltage** and prevent damage to the sensitive components.
    - **Reverse Polarity Protection**: If the power supply is connected incorrectly, the diodes prevent reverse voltage from reaching the transistors, which would otherwise cause damage.
    - **Voltage Spikes**: The diodes can also protect against voltage spikes that may occur when switching the amplifier on/off or during load fluctuations (like speaker impedance changes).

6. Capacitors: Smoothing and Signal Coupling

- **2200µF Capacitor**: This **filtering capacitor** is typically placed at the **power supply input** to smooth out any ripple from the power supply. Without this capacitor, the power supply might cause fluctuations or noise in the audio signal, resulting in hum or distortion. This large capacitor ensures that the amplifier receives clean, stable DC power for optimal performance.
- **Coupling Capacitors**: Smaller capacitors (like the **220µF** one) are used in the signal path to **block DC** while allowing the AC audio signal to pass through. These capacitors ensure that there is no DC bias between stages, which could distort the audio output.

7. Output Stage: Driving the Speaker

- **Speaker Connection**: The final step involves the **audio signal driving the speaker**. The 2SC5200 power transistors deliver the amplified current to the speaker, causing it to vibrate and produce sound.
  - **Speaker Impedance**: The speaker typically has an impedance of **4 or 8 ohms**. The amplifier must be able to handle the current required by the speaker, and the 2SC5200 transistors are designed for high current capability.
  - **Power Output**: Given that the speaker is rated for 60W, the amplifier must be able to deliver sufficient current to generate the corresponding voltage that will result in the required power. The voltage output from the 2SC5200 transistors is proportional to the input audio signal, and the current is determined by the speaker impedance.

8. Power Supply: DC Voltage Input

- **Voltage Requirements**: The amplifier requires a **DC voltage of 20-24V**, which powers the entire circuit, including the transistors and capacitors. The supply voltage must be stable and able to provide enough current for the power transistors to drive the speaker.
- **Current Draw**: The total current drawn by the amplifier will depend on the output power. For a 60W speaker, at 8 ohms, the amplifier will need to provide about **3.5A** (assuming an ideal 100% efficiency, which is not the case in practice). Therefore, a **5A or higher** power supply would be ideal for this setup.

The overall working principle of this amplifier revolves around **signal amplification**, where the input audio signal is amplified at various stages—first by small transistors (BD139/BD140), and then by large power transistors (2SC5200). The push-pull configuration of the transistors ensures **high fidelity** and **low distortion** across the entire frequency range of the audio signal. Capacitors and diodes protect the circuit, smooth the power supply, and ensure proper signal flow. Finally, the **speaker** receives the amplified signal and converts it into audible sound.

Safety Features

Here are the key safety features commonly found in in-built power supplies in audio amplifiers:

1. Overcurrent Protection:

- Purpose: Protects the amplifier and power supply from damage caused by excessive current flow.
- How it works: If the current exceeds a predefined limit, the power supply either shuts down or limits the current to prevent overheating and potential component failure.

2. Overvoltage Protection:

- Purpose: Prevents damage to the amplifier circuitry due to voltage spikes or surges.
- How it works: A voltage clamping mechanism (such as zener diodes) or a crowbar circuit may be used to cut off the supply or divert the excess voltage to ground if the voltage exceeds the safe limit.

3. Thermal Protection:

- Purpose: Protects against overheating, which can degrade the performance of the amplifier and cause permanent damage.
- How it works: A thermal sensor or temperature-sensing circuit monitors the temperature of critical components (like the transformer or power transistors). If the temperature exceeds a safe threshold, the amplifier is either shut down or derated (operates at reduced power) to cool down.

4. Short-Circuit Protection:

- Purpose: Protects the amplifier and power supply from the potential damage caused by short circuits.
- How it works: If a short circuit is detected (e.g., by monitoring the output or feedback loop), the system either disconnects or limits the current to prevent components from being damaged by the excess current.

5. Fuse Protection:

- Purpose: Provides a simple and cost-effective safety feature to disconnect the power in case of overcurrent conditions.
- How it works: A fuse is placed in series with the power supply input. When excessive current flows through it (due to a short circuit or fault), the fuse blows, effectively disconnecting the power supply from the circuit and preventing further damage.

6. Surge Protection:

- Purpose: Safeguards the amplifier and power supply from sudden voltage spikes caused by external factors such as lightning strikes or power grid fluctuations.
- How it works: Surge protectors or varistors (voltage-dependent resistors) are included to clamp transient voltages, diverting them safely to ground or absorbing the excess energy.

7. Grounding:

- Purpose: Ensures safety for both the user and the components by providing a safe path for electrical faults.
- How it works: The amplifier is grounded to prevent any accidental electrical shock in case of a fault in the internal circuitry. This is typically achieved via a three-prong power plug that connects the amplifier's chassis to earth ground.

8. Overload Protection:

- Purpose: Protects the amplifier from damage due to excessive power demands.
- How it works: The power supply monitors the load placed on the amplifier. If the load exceeds the rated capacity (e.g., due to impedance mismatch or improper speaker connection), the supply may automatically reduce output or shut down.

9. DC Offset Protection:

- Purpose: Prevents damage to the speaker caused by unwanted DC voltage at the amplifier's output.
- How it works: A capacitor or relay is often placed in series with the output to block any DC voltage that might otherwise be delivered to the speaker, protecting it from damage.

10. Soft-Start Circuit:

- Purpose: Reduces the inrush current during power-up, protecting the power supply components from sudden stress.
- How it works: A soft-start circuit gradually ramps up the current when the amplifier is powered on, preventing large inrush currents that could damage internal components like capacitors and transformers.

11. Reverse Polarity Protection:

- Purpose: Prevents damage if the power supply is connected with incorrect polarity.
- How it works: A diode or relay is placed in the power input stage, allowing current to flow only when the polarity is correct. If the polarity is reversed, the diode will block current or the relay will prevent the circuit from powering on.

12. Capacitor Safety:

- Purpose: Ensures that electrolytic capacitors, which are used for filtering, do not fail due to voltage spikes or excessive ripple.
- How it works: Capacitors are selected based on their voltage rating and temperature tolerance to ensure they can handle the power demands without failure. Some amplifiers also use capacitor discharge circuits to safely release charge when powered off.

13. Isolation:

- Purpose: Provides electrical separation between the audio signal and power supply, ensuring that any failure in the power supply does not affect the audio output.
- How it works: Isolation transformers or optical isolators are used to isolate the high-voltage power circuits from the low-voltage audio circuits.

14. EMI/RFI Filtering:

- Purpose: Protects the amplifier and connected devices from electromagnetic interference (EMI) and radio-frequency interference (RFI).
- How it works: EMI/RFI filters are used at the power supply input to prevent noise from the power line from entering the amplifier and to prevent the amplifier's high-frequency signals from affecting other equipment.

These safety features help to ensure that the amplifier operates efficiently, safely, and without damaging the components or creating hazards for the user.

Conclusion

The successful completion of this **Audio Amplifier Project** marks a significant milestone in understanding and applying the principles of electronics and circuit design. Through this project, we have built a functional high-power audio amplifier capable of delivering high-quality sound with low distortion, making it suitable for driving speakers of up to 150W power rating.

The project provided a comprehensive learning experience, encompassing the selection of appropriate components, circuit design, assembly, and troubleshooting. The use of transistors such as **2SC5200**, **BD139**, and **BD140**, along with passive components like resistors, capacitors, and potentiometers, allowed for the creation of a robust and efficient amplifier. Additionally, incorporating safety features such as overcurrent protection, voltage regulation, and thermal management ensured the reliability and durability of the system.

This project has also helped in developing practical skills such as soldering, circuit analysis, and testing, which are essential for any electronics engineer. By understanding the nuances of power supply filtering, audio signal amplification, and user-friendly control integration, we have gained valuable insights into the real-world applications of electronic circuits.

In conclusion, this project has not only deepened our theoretical understanding of audio amplifier circuits but also provided a hands-on approach to solving design and implementation challenges. It serves as a testament to the importance of teamwork, perseverance, and continuous learning in achieving technological advancements.

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   - **Datasheet for BD139 Transistor** – Datasheet Link
   - **Datasheet for BD140 Transistor** – Datasheet Link