Upgrading an Audio Amplifier from BJT to MOSFET

Introduction:

- The original audio amplifier was a simple DIY design consisting of 7 common, inexpensive components.
- It performed well but was not suitable for modern devices as wired headphones and audio jacks have become obsolete.
- The goal was to improve the design to drive louder speakers and replace the BJT with a MOSFET for higher efficiency and power handling.

The Problem with the Old Audio Amplifier:

- The original amplifier used a **Bipolar Junction Transistor (BJT)**, but it could not supply enough power for a loud speaker.
- **Current Limitation:** The amp could only supply about 23mA to the speaker, but to drive a loud speaker, 500mA was needed.
- **Solution:** The idea was to allow more current to flow through the collector path to boost the volume.

Darlington Transistor as a Solution:

- Replacing the BJT with a **TIP142 Darlington Transistor** (10A rating) initially seemed like a good idea.
- **Problems with Darlington Transistor:**
    - The minimum voltage drop across the Darlington transistor was about 1-2V, which limited the available voltage for the audio waveform at a 5V supply.
    - Increasing the supply voltage to 12V helped, but it also caused resistors to overheat, and they required recalculation for proper power handling.

Calculating New Resistor Values:

- **Resistor Selection:**
    - The goal was to provide a 12V bias and allow 500mA current.

- The correct resistor values calculated were 12Ω for the collector resistor and 2.4Ω for the emitter resistor.
- Incorrect power ratings led to resistor failure, and proper power dissipation was factored into the new design.

Improving Power Handling:

- After recalculating and installing new resistors, the amplifier powered up and provided a small boost in volume.
- **Problem with Heating:** The Darlington transistor still heated up, requiring the addition of a heatsink for better cooling.

MOSFET Amplifier Approach:

- **Choosing a MOSFET:** A **IRFZ44N MOSFET** was selected for its ability to handle large current with lower resistance and less power loss.
- **Powering Up the MOSFET:** The MOSFET provided more current flow than the BJT due to its smaller voltage drop.
- **Biasing with MOSFET:** The MOSFET works with voltage control rather than current, so different biasing techniques had to be used.

Fine-Tuning the MOSFET Amplifier:

- **Adjusting the Offset Voltage:**
  - The MOSFET needed a **threshold voltage** between 2-4V to turn on. This threshold was adjusted using a potentiometer for optimal audio signal input.
- **Final Setup:** The final MOSFET design, including a heatsink and appropriate resistors, worked well and produced a loud audio output.

Comparison of Darlington Transistor vs MOSFET Amplifier:

- **Advantages of the MOSFET Amplifier:**
  - The MOSFET amplifier was simpler and louder due to its lower voltage drop.

    - However, MOSFETs usually have a **lower gain** than BJTs or Darlington transistors.
- **Disadvantages of the MOSFET Amplifier:**
    - **Non-Linear Amplification:** MOSFETs often produce less linear amplification, leading to **distortion** in the output signal.
    - **Harmonic Distortion:** The MOSFET amplifier showed a noticeable increase in **Total Harmonic Distortion (THD)**, which was visible in the FFT of the audio output.
    - The **Darlington transistor** amplifier performed much better in terms of maintaining the original waveform with low distortion.

Verdict:

- **BJTs (Darlington Transistors)** are generally **better** for audio amplification, providing **lower distortion** and **more linear behavior**.
- Despite the MOSFET amplifier being simpler and louder, it showed greater **distortion** and was less suitable for high-quality audio amplification.
- While the MOSFET amplifier may be viable in some applications, **BJTs remain the better choice** for audio projects due to their linear amplification and lower distortion.

Conclusion:

- The project demonstrated the trade-offs between different transistor types in audio amplification.
- Both the **Darlington transistor** and **MOSFET** designs had their merits, but **BJTs** are preferred for more efficient and distortion-free audio amplification.
- The MOSFET approach, while more modern, presented challenges related to **biasing**, **non-linearity**, and **distortion**.