Adjustable Smart Filtering Hearing Aid

EECS 3611 Analog Electronics Project

Quardin Lyttle 215957889
Menachem Guttmann 218776021
Sourav Saini 219220540

Project background

Hearing impairment affects millions of people worldwide, and traditional hearing aids often lack advanced features that adapt to dynamic sound environments and are very expensive. For our analog electronics course project, we aim to develop a hearing aid amplifier that not only amplifies sound from a microphone to a speaker but also incorporates modern features to enhance user experience. These features include:

- An adjustable volume control using a variable resistor.
- A custom program to filter out unwanted ambient noise, potentially increasing the clarity of speech and reducing background interference.

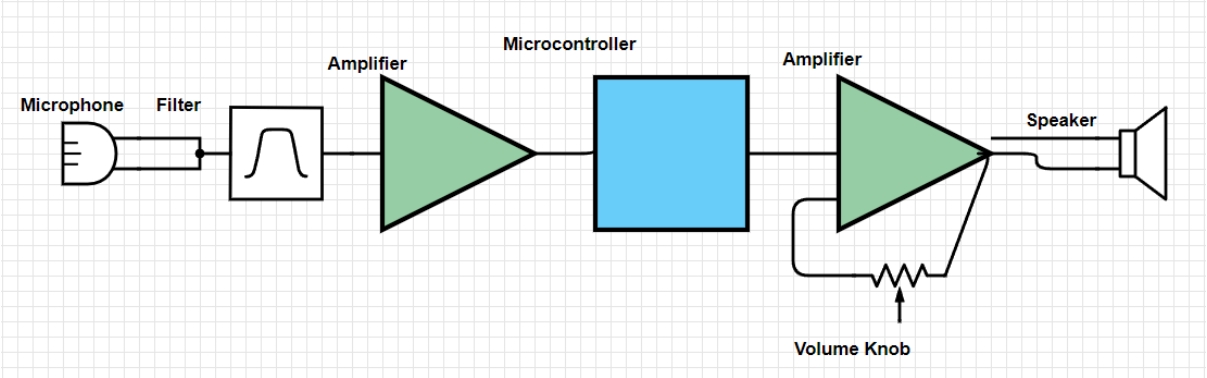
This project bridges classical analog circuit design with modern digital signal processing techniques, offering an exciting interdisciplinary challenge.

Objective

Primary Objective: Develop a reliable hearing aid amplifier using transistors and operational amplifiers (op-amps) that efficiently amplifies audio input for clear output through a speaker.
Secondary Objectives:

- Integrate a variable resistor to provide users with adjustable volume control.
- Research and implement an audio processing algorithm to filter and reduce unwanted noise.
- Analyze power requirements and ensure the circuit operates efficiently.
- Explore additional filtering techniques to boost specific frequencies as needed.

Technical Approach & Methodology



Audio Input & Amplification

- **Circuit Design:**
  - **Input Stage:** Design a front-end circuit to receive audio signals from a microphone.
  - **Amplification Stage:** Utilize transistors and op-amps to boost the incoming signal.
  - **Power Analysis:** Conduct an analysis to ensure the circuit operates within safe power limits and determine optimal power supply specifications.
  - **Filtering:** Develop and incorporate basic analog filters (low-pass, high-pass, or band-pass) to reduce interference and noise before amplification.

Volume Adjustment

- **Variable Resistor Integration:**
  - Incorporate a variable resistor (potentiometer) within the amplification circuit to allow real-time volume control.
  - Calibrate the system to ensure smooth transitions and avoid abrupt changes in output volume.

Audio Processing & Noise Cancellation

- **Digital Signal Processing (DSP):**
  - Investigate and select an appropriate microcontroller or DSP platform to interface with the analog circuit.
  - Implement a noise filtering algorithm capable of distinguishing between speech and background noise.
  - **Research Component:**
    - Review existing literature on noise cancellation and frequency boosting techniques.
    - Experiment with different algorithms to achieve optimal performance in various environmental conditions.
  - **Integration:** Seamlessly integrate the digital processing stage with the analog front-end to form a cohesive system.

Testing & Validation

- **Prototype Development:** Assemble the circuit on a breadboard for initial testing.
- **Performance Testing:**
    - Measure amplification levels, signal-to-noise ratio, and power consumption.
    - Test the variable resistor for accurate and responsive volume control.
    - Evaluate the Computer-Assisted-based noise filtering module under different audio conditions.
- **Iterative Improvement:** Based on test results, refine both the analog and digital components of the system.

Expected Outcomes

- A fully functional prototype of a hearing aid amplifier that effectively amplifies audio signals.
- A user-adjustable volume control feature that allows for personalized audio output.
- A digital and physical noise cancellation system using computer processing and a bandpass filter to filter out unwanted background sounds, thereby enhancing speech clarity.
- Comprehensive documentation covering circuit design, testing procedures, and algorithm performance, which could be useful for further research or development.

Work Breakdown

Quardin

- Output signal integrity
- Second amplifier with potentiometer
- Speaker
- Circuit testing and analysis

Menachem

- Input signal integrity
- First amplifier and bandpass filter
- Microphone
- Circuit testing and analysis

Sourav

- Microcontroller instrumentation
- Audio-level-adjusting potentiometer
- Digital Sound Processing (DSP)