

# Modular Headphones Add On For Noise Cancelling

Team 19

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## 1.1 Introduction

### Objective:

**Problem Statement:** There is a burgeoning market for wireless, active-noise cancelling headphones, however, currently, headphones that have these features are very expensive. Many people have wired headphones without active-noise cancellation.

**Solution:** We will make an add-on to headphones, attached to the line-in, that modifies a headphone to be noise-cancelling. We will also attach an amplifier and an app alongside the hardware for noise-cancelling variability, frequency adjustment, volume control. By doing this, it will not only be user-customizable, but also cost-efficient. Our goal is a modular device that is capable of removing 50% of background noise, while maintaining 30% of the cost of popular noise cancelling headsets. We understand that headphones are made differently, so we'll also make an application that syncs frequency levels and noise-cancelling levels with the headphone.

### Background Information:

Currently the headphone market is divided into two distinct segments: general consumer grade headphones that cost than or equal to \$150, and high end "audiophile" headphones that include the latest features and cost \$200 and upwards (some headphones, such as the Sennheiser HD 800 model, can cost \$1200 dollars!). Due to the recent removal of the 3.5mm headphones connection as a commodity in mobile devices, bluetooth audio has gone from being a luxury product to being priced with regular consumer headphones. Noise canceling technology, however, has remained at the upper range of the market and is still considered a luxury feature. In fact, simply adding noise cancelling to headsets can raise the price by \$100, for example:

- [https://www.amazon.com/Bose-SoundLink-around-ear-wireless-headphones/dp/B0117RGG8E/ref=sr\\_1\\_6?s=aht&ie=UTF8&qid=1504991769&sr=1-6](https://www.amazon.com/Bose-SoundLink-around-ear-wireless-headphones/dp/B0117RGG8E/ref=sr_1_6?s=aht&ie=UTF8&qid=1504991769&sr=1-6) (\$230)
- [https://www.amazon.com/Bose-QuietComfort-Wireless-Headphones-Cancelling/dp/B01E3SNO1G/ref=sr\\_1\\_1?s=aht&ie=UTF8&qid=1504991769&sr=1-1](https://www.amazon.com/Bose-QuietComfort-Wireless-Headphones-Cancelling/dp/B01E3SNO1G/ref=sr_1_1?s=aht&ie=UTF8&qid=1504991769&sr=1-1) (\$330)

In fact, this is quite a modest gain, as some headphones simply double in price with the addition of just one feature. This then creates a void in the market for low cost, yet good performance noise cancelling headsets.

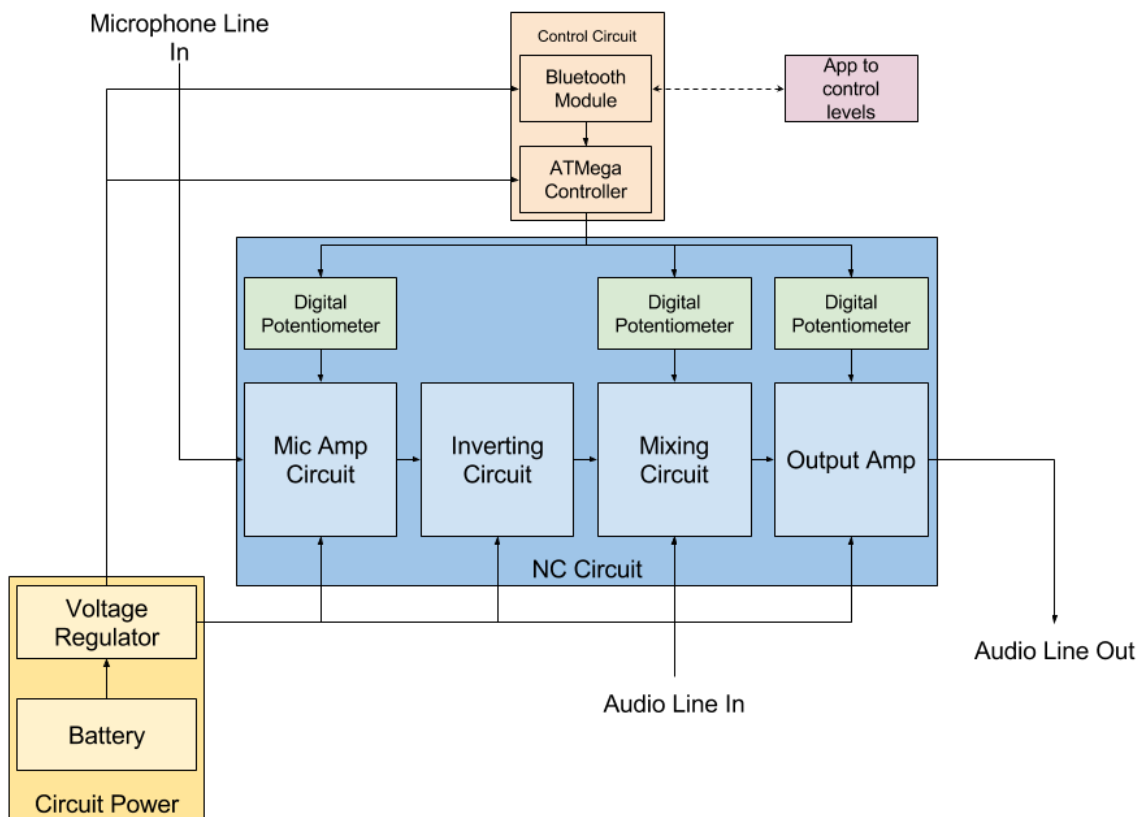
### High-Level Requirements:

- One characteristic our final project must have is the ability to reduce external sound levels by a significant amount of at least 20% noise reduction.
- Another requirement the project must satisfy is the ability to make a pair of headphones bluetooth, allowing a wireless connection between the audio device to the headphones.

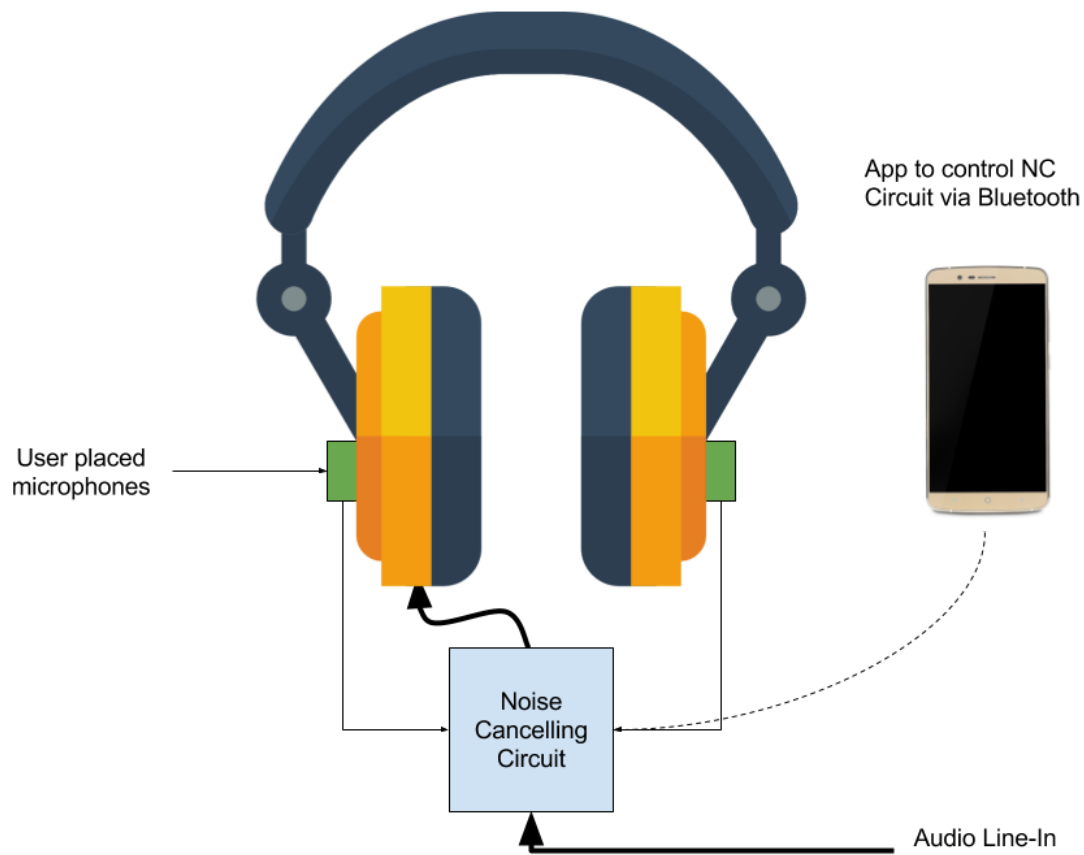
- A third requirement would be the modular aspect of the project in the sense that if a user decides to not use the features, then they must have the ability to remove our project, and use the headphones perfectly with our addition removed.

## 1.2 Design and Requirement

Block diagram:



## Physical design:



## Functional Overview:

- Control Circuit
  - The control circuit is made up of 2 components, the bluetooth module and the ATmega control, which work together to give wireless control of the noise cancelling circuit via an app that runs on a smartphone. The Bluetooth module communicates with the smartphone running the app so that parameters such as “microphone level”, “microphone mix level”, and “output amp level” can be controlled, allowing for fine-tuning of the NC circuit by the user based on the location/environment they are in. However, the bluetooth module is useless without the ATmega controller, which is used to convert the packets received by the bluetooth controller into actions taken by the NC circuit, effectively acting as a translator between the bluetooth module and the circuit itself.

*Requirement: The ATmega controller and bluetooth module must be able to communicate quickly at speeds of at least 4 Mbps*

- Noise Cancelling (NC) Circuit:

- The noise cancelling circuit is made up of four distinct components that act in a pipeline fashion to produce an output that is noise cancelled audio playing through the user's headphones. The first component is the microphone amp circuit, which takes in the signal from the microphones mounted on the sides of the headphones and amplifies said signal. This is done because the signal from the microphone may not be strong enough to be mixed into the incoming audio signal from the user's audio source. The second component is the Inverting circuit. This circuit takes input from the microphones attached to the headphones and inverts the signal. This contributes to the noise-cancelling attribute of the headphones as this step is crucial in cancelling external sound waves. The third stage in the pipeline is the mixing circuit. The mixing circuit takes the inverted microphone signal and adds the user's input audio signal to it. This effectively creates a noise cancelled version of the user's audio. In addition, if there is no audio coming from the user, then the circuit simply acts as a active noise cancelling headset, still providing silence to the user. The final stage in the pipeline is the output amp. This outputs an amplified version of the noise cancelled signal so that the user can control the output volume from the module itself. The digital potentiometers exist to allow for a control interface between the control circuit and the NC circuit. This allows for wireless control of the NC circuit.

*Requirement: circuit must keep the maximum current to around 65 mA in order to protect the headphones*

- Circuit Power:

- The NC module is made to be powered by a battery, so it can be portable and operate anywhere. This means that two things are required. Firstly, a battery is required to provide power to the entire circuit when it is portable, ideally for extended periods of time. Secondly, a voltage regulation circuit is needed. This circuit will play a twofold role. First, it will regulate voltage between the battery and the NC and control circuits to acceptable levels. Second, it will act as the charging circuit for the battery and will prevent back current to the NC and control circuits while also regulating the charging of the battery.

*Requirement: The power supply must provide around 8-9V to provide power to the noise cancelling circuit, and must be capable of around 30mA*

- Smartphone App

- The smartphone app will be used to control and fine tune the noise canceling of the headphones. This is done by connecting the headphones to the app via bluetooth and then being able to regulate the NC circuit via sliders in the app. The fine tuning of the NC circuit is required because a modular NC unit cannot automatically acclimate to the requirements of the user, the environment the NC

module is being used in, and also the placement of the microphones on the headset itself.

*Requirement: App must be able to communicate with bluetooth module over at least Bluetooth 4.0*

## Risk Analysis:

The component that poses the greatest risk to the successful completion of the project is that of the mixer circuit, as it is crucial for full functionality of the headphones. This interface is the most complex as it must mix the inverted input from the microphones with the input from the audio device. If this module is not completed or fully functional, the project itself would not function.

## 1.3 Ethics and Safety

There is one critical component that should raise safety concerns in this project: the battery and charging circuit. Since the battery is of a Lithium-Ion type, it poses dangers such as explosion, and the charging circuit poses dangers such as shock hazards. There are precautions being taken towards each of these. For the battery, there is a two fold plan. Firstly, the charging circuit is being designed to monitor the battery charge level such that the battery cannot be overcharged or overheated, preventing explosion issues on that front. Secondly, the battery is being placed in a reinforced portion of the casing of our NC module, while also being placed in its own plastic sheath internally, so it should be protected from bumps and drops. The charging circuit poses a shock hazard to the user due to the fact that it handles the current to the battery, and thus could cause electrical harm to the user through the casing. This, however, is being prevented through the design of the case itself, which is made of a non conductive material. Secondly, the charging circuit will be monitored by our ATmega controller, on both current and temperature metrics, so that if unacceptable levels are reached, the charging may be paused, or stopped altogether until safe levels are reached. Such safe levels are defined for usage by the user without them noticing the device operating outside defined limits. The other components will be shielded through non-conductive material, such as a protective epoxy, such that internal arcing may not occur. In addition, the other components in our design do not pose a risk to the user as they are all low-power systems and operate at low temperatures.

Because of the bluetooth wireless communication used in our project, it may infract upon with the IEEE Code of Ethics, #1: "To accept responsibility..." [11]. There are definitely risks with the open communication. However, we believe that the although there are these risks involved, the benefits of having the ability to have open wireless connection drastically outweigh the negative possibilities included.