# Formi

# A New Age in Music Listening

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Senior Design Project Proposal

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# 1) Introduction:

**Objective:**

With Americans spending on average 4.5 hours per day listening to music, it is no doubt that we love music. In fact, it has been used as a stress reliever for hundreds of years yet each modern speaker, headphone, etc optimizes for a limited range of music dictated by its sound signature. Sound signature emanates from two elements:

1) Programmed equalization into the DACs (Digital to Analog Converters)
2) Circuit Components.

Our solution targets both of these elements by optimizing circuit components for adaptability and utilizing a baseline neutral DAC equalization. Building on this, we will create a computer/phone (with Bluetooth connectivity) application that dynamically augments equalization based on the music itself.

**Background:**

As avid music listeners, we recognized a common problem that many musicians and music lovers alike have faced. In order to enjoy a wide and varied range of music genres, people have to buy multiple high-end headphones. With every headphone having different sound signatures, each one works best for a specific genre or use case and may even cause fatigue when mismatched. This is especially troubling if you love multitudes of music genres, compose or record music. Concurrently, modern pop music is incorporating multiple genres into itself. With artists like Lil NasX, Billy Eilish, and Twenty One Pilots all in one genre, the difference in sound can be quite extreme.

With the wide adoption of wireless headphones, there is an opportunity to further enhance the music listening experience and tackle the aforementioned issue. While the physical design influences the sound signatures, companies spend thousands of hours to fine-tune and hard code equalization settings into DACs to establish brand sound signature (Beats -> Bass Heavy). Our approach is different! We want to leverage the adaptability of DACs with Machine Learning to create a dynamic EQ that enhances the music listening experience.

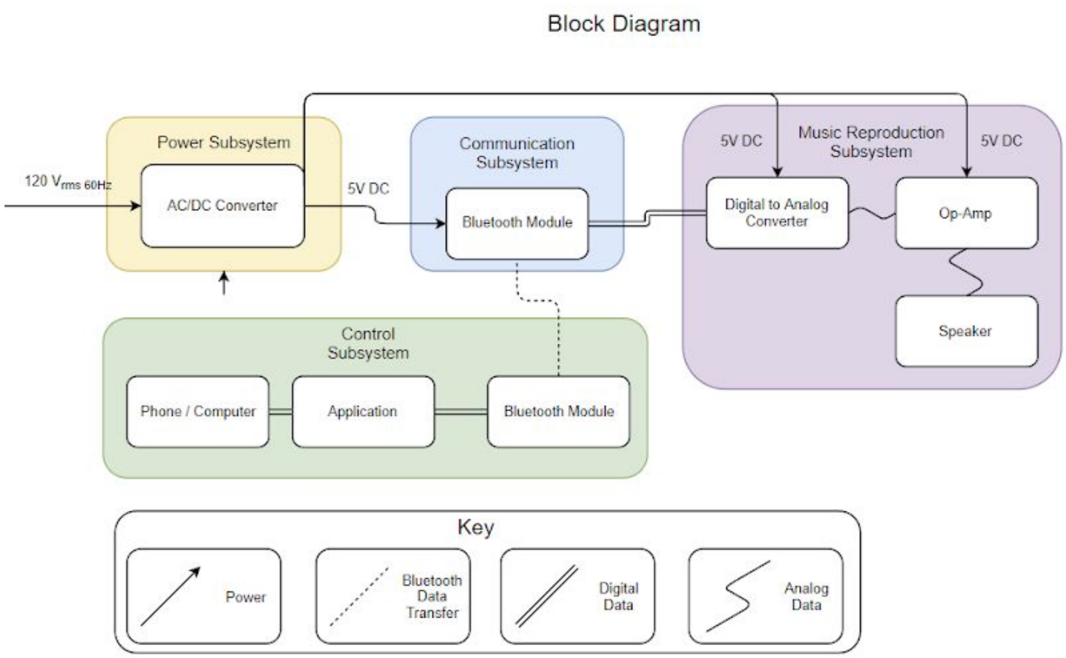
**High-Level Requirements List:**

NOTE: “Genre” in the following text may refer to differences such as pop versus country but can also refer to differences such as country(high pitch singer) versus country(low pitch singer)

- The equalization, or change in decibels over frequency, must exhibit a change from genre to genre. (We will have specific EQ numbers at future date)
- The power subsystem must be able to convert 120 Vrms at 60hz to 5V DC (+-0.5V)
- The Machine Learning program must be 70% accurate in determining the correct genre. (Note: 70% is used as an estimate to account for songs that may be socially accepted as one genre but musical elements may differ)

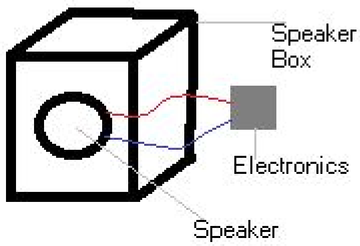
# 2) Design:

**Block Diagram:**




Above, we can see that wall power is sent to the AC-DC converter (power subsystem) effectively ensuring that our second high-level requirement is being met. After conversion, Power is sent to all other PCB components (including Communication and Music Reproduction Subsystem(sans Speaker which will be connected to terminals on the PCB)). The first and third requirements are incorporated by the application where the equalization is chosen by the ML derived genre. The song is augmented with chosen EQ and sent digitally to the Bluetooth module, converted to an analog signal in the DAC, and finally sent to the Op-Amp/Speaker.

**Physical Design:**




To ensure we do not have to fine-tune the physical speaker design, we will use a pre-existing speaker and speaker box setup with pre-tuned acoustics which will connect to our PCB (Printed Circuit Board). Our PCB will be connected to wall power to optimize current for powering the speaker and long testing cycles when finetuning EQs. Since the Bluetooth communication to the control subsystem is a preexisting digital device, i.e. phone or computer, we have not included it in our physical design.

**Functional Overview:**

The power from a wall outlet is sent into the AC-DC converter and 5V DC is sent to the Bluetooth module, DAC and the Op-Amp. Through communication with the Bluetooth module, the phone/computer can modify the equalization of songs and send the augmented data to the module which sends the digital data to the DAC. The DAC converts the digital data to low-level analog data. This low-level analog data is sent to the op-amp to increase the power of the signal to power the speaker which converts the high-level analog data to sound waves.

**Block Requirements:**

AC-DC converter:

This converter must successfully take in 120 Vrms at 60 hz and turn it into 5V DC. There can be a small voltage ripple, but we would like to limit the error in the output signal to +-.5V. This way we can successfully power all our components.

Bluetooth module:

The only hard requirement for this block is that the data transfer must be done in a quick manner meaning delay from computer/application must be under 1 second. As well, this module must be powered by 5V +- .5V DC.

Digital to Analog converter (DAC):

The DAC will convert I2S digital data from the Bluetooth module to an analog line-level signal. The DAC output line-level max voltage will be 900mv.

Op-Amp:

The Op-amp will amplify the line-level analog signal to a high-power analog signal that can power a speaker. Must be capable of supporting power up to 10 mW.

Application:

There needs to be a constraint on the latency of the program so that it processes the song prior to playing or it cannot exceed 10 seconds of live-processing before the data is sent.

*We are not building the speaker*

**Risk Analysis:**

The application that will change equalization based on genre and using machine learning is the greatest risk for failure. This is due to the massive amount of data points that machine learning needs to increase its productivity and efficiency. As well, the complexity of the code needed in the program is rather advanced and will demand more time and energy in order to ensure its successful operation.

# 3) Ethics and Safety:

**Ethics:**

[ACM 1.1, 1.2, 2.1, 3.1] Since we have personally experienced fatigue or even nausea when listening to music with mismatched sound signature/EQ, we must be cognizant of the risks involved when matching EQs to songs. Accordingly, we should try not to create EQs that drastically augment songs to distortion or other uncomfortable experiences.

## Safety:

[ACM 2.6 and IEEE 7.8.7] There is some risk involved with using wall power since the voltage coming from the wall is 120Vrms. The best way to ensure safe practice is to ensure that someone else is always around in the laboratory when utilizing wall power as well as having a TA check the circuit before plugging it in or powering the circuit. Also, the one hand rule can be useful in ensuring that the person working on the circuit is never the quickest path to ground.

[ACM 1.2] As well, there is the potential of the over raising the decibel levels so high that clipping can occur in the DAC. This is a potential fire hazard and this can be stifled by putting hard upper limits on the decibel levels in the code for the equalization. As well, in case of emergency, a protocol for the laboratory fire emergency must be followed.

[ACM 1.2] The possibility of listening to loud music for long periods can damage eardrums. This can be mitigated either by using ear protection and limiting long periods of music listening.

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