# Initial Project Proposal (Spring 2020)

**Project Name:** AudioBeamer
**Creation Date:** November 3, 2019
**Last Modified:** January 5th, 2019

**Team Members (#1 is Team Leader):**
**Member 1:** Carson Tabachka **Email:** ctabachk@purdue.edu
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## 1.0 Description of Problem:

Playing an electric guitar with an amplifier can be such a hassle when there are electric cords everywhere. Needing to constantly untangle and untie cords when all you want to do is jam is such a bummer. People who play guitar should be able to pick up and play their instrument seamlessly and effortlessly. Wireless technology is everywhere nowadays, so why is it not mainstream for guitar players to have wireless audio transmission between their guitars and amplifiers? There are about 16 million guitar players just in the United States [1] and all of them could potentially run into this issue when using an amplifier.
In addition to the proposed guitar application, we plan to make our system universal. It should be compatible with any electronic music instrument that outputs sound using a 3.5mm or 6.3mm audio port. (DJ Controllers, Digital synthesizer etc.)

## 2.0 Proposed Solution:

Our solution to the issue of wires is a wireless audio transmission system. This would include a transmitter device and a receiver device. The transmitter device will only be responsible for transmitting the audio signal produced from the guitar. The transmitter will take an input from the guitar to a microcontroller, send the information to a radio FSK modulator, then transmit the data using an antenna. The receiver will be responsible for receiving the modulated signal via an antenna, de-modulating the signal, processing the signal, interfacing with the app, and outputting to the amplifier. These devices would have a 3.5mm audio jack, which would be usable as a 6.3mm audio jack using a 3.5mm to 6.3mm converter. The choice to use a 3.5mm audio jack rather than a 6.3mm audio jack allows for compatibility with a larger variety of devices.
Both the receiver and the transmitter will be battery powered to meet the goal of truly wireless devices. Our goal is to be powered on for at least two hours using an external battery. Radio waves used with FSK modulation are chosen as a means of wireless audio communication due to low latency & high quality when compared to other audio transmission protocols (Bluetooth).
Additionally, we will also implement & develop an Android smartphone app to control certain aspects of the audio processing via Bluetooth, which will be processed on the microcontroller using Digital Signal Processing. This app allows the user to customize audio filters controlling bass, middle, highs as well as provide additional audio processing options such as distortion etc. This app will communicate with the receiving device using Bluetooth, telling the microcontroller

**Commented [WTA1]:** Approved. Please see comment below.

**Commented [WTA2]:** Nowhere in your proposal do I see a target battery life. I would consider this necessary.

**Commented [WTA3]:** This statement is unclear. What radio protocol are you planning to use for the audio transmission?

**Commented [WTA4]:** How do you plan to do your audio processing?

**Commented [CT5R4]:** IF we decide to change from DSP, edit this

how to process the incoming audio signal. This is an example of a 3.5 mm to 6.3 mm converter [3]:

**3.0 ECE477 Course Requirements Satisfaction**

**3.1 Expected Microcontroller Responsibilities**

The microcontroller responsibilities are divided between the receiver and transmitter since our project requires a microcontroller in both.

The microcontroller in the transmitter needs to be able to do the following:

1. Receive an audio signal from an electric guitar
2. Communicate with peripherals responsible for FSK modulation and transmission

Commented [WA6]: What does RF mean here? I think you should at least have a protocol in mind.

The microcontroller in the receiver needs to be able to do the following:

1. Communicate with an Android app via Bluetooth
2. Communicate with peripherals responsible for FSK demodulation
3. Handle audio processing using Digital Signal Processing at a sampling rate of preferably 44.1kHz

Commented [WTA7]: You should be aware that there are other options.

A potential microcontroller we were considering is Atmel AVR-UC3 which is a low powered microcontroller with some dedicated audio processing functionality. It can be programmed in C/C++. Another factor worth considering is that the microcontroller on the transmitter has a significantly reduced processing responsibility and should use a cheaper microcontroller if we have to save costs.

**3.2 Expected Printed Circuit Board Responsibilities**

For our proposed project we plan to use two PCBs in two separate enclosures:
The first PCB is going to be the transmitter PCB. It is expected to incorporate an audio FSK modulated radio transmitter to transmit analog audio from an electric guitar source, a microcontroller to interface with the FSK modulator & transmitter, an appropriate antenna, and voltage regulation circuitry. The only responsibility of the Transmitter circuit is to modulate and transmit the received audio signal from an electric guitar using FSK modulation.

The second PCB is the receiver PCB. It is meant to receive the modulated audio FSK signal, demodulate it, process it & output the audio signal. We plan to incorporate an FSK demodulator, an appropriate antenna, a microcontroller suitable for audio DSP (bass, middle, treble, distortion), a BLE receiver to communicate with an Android cell phone app, audio amplification circuitry & voltage regulation circuitry. The microcontroller processes the demodulated FSK audio. This is outputted using the microcontroller DAC to suitable audio amplification circuitry. This is the output of the receiver PCB.

Each PCB will be powered by an external battery whose voltage and capacity will be decided further down the design process. Voltage regulation will be required due to the dynamic load of the circuit. We will include resistors as necessary. We would need to be careful with resistance to not provide too much current into our microcontroller and other devices. To account for dynamic load conditions, we will use inductors and capacitors to account for any jumps in current to make sure they are not too severe enough to damage the circuit. Voltage and current requirements of our power electronics will be decided based on efficiency calculations further down the design process.

**Commented [WA8]:** Yes it will. You should read more about AAA batteries and how they operate under dynamic load conditions.

**4.0 Market Analysis:**

Those who are learning to play guitar or are currently playing guitars would be the potential users of this product, specifically those who use an electric guitar and an amp. There are 16 million musicians who this product is likely marketable to [1]. Additionally, we believe that this product may have a high appeal with professional musicians. Professional musicians often use numerous hardware attachments, processors, & pedals with their instruments during live performances resulting in a large mess of cables. This also means that the musician's movement on stage would be restricted by the length of the wire, & also create a tripping hazard on stage. This product would therefore help a lot of people save the hassle of cables but providing them with a high-quality wireless equivalent.

**5.0 Competitive Analysis:**

In most situations, there is a high likelihood that there are already patents, products, or projects similar (in all ways or only in some) to what you intend to do for your project. Even if this is not the case, there are presumably current approaches and methods to partially address the problem in part 1. This section is where you analyze competing ideas and evaluate the strengths and weaknesses of those ideas. Through competitive analysis you may glean insight into approaches to solving the problem you hadn't previously considered, as well as features to potentially incorporate into your design. Cite every competitor that you find. Diligence is valuable here: the more sources of inspiration and prior art you can find, the better.

**5.1 Preliminary Patent Analysis:**

**5.1.1 Wireless transmitter suitable for electric guitar CN205140505U:**
**Patent Title:** Wireless transmitter suitable for electric guitar
**Patent Holder:** IP Right Grant
**Patent Filing Date:** 2015-11-20

This patent [9] is similar to our device because it involves a wireless transmission device attached to an electric guitar. This has an antenna and a folding plug connector that adjusts up to 135 degrees from its original angle. This device differs from ours because our intended design does not have a protruding antenna and our design does not have a plug connector that can fold. The advantage to this patent's approach is that the folding plug will make the shape of the device slightly adjustable, however the disadvantage of this design is that it is more prone to accidental readjustments when bumping into it.

**5.1.2 Cordless guitar transmitter US5025704A:**
**Patent Title:** Cordless guitar transmitter
**Patent Holder:** AERIELLE GROUP INTERNATIONAL Inc FERNANDEZ ED, Airjack Wireless Systems Inc
**Patent Filing Date:** 1989-04-14

This device [4] is similar to our desired device. This device is a radio transmitter for electric string instruments designed to function wirelesses. The transmission is sent through FM radio and received by any radio receiver. Two 6V batteries in series power this device. No chips are used here, capacitor values are chosen for the desired FM frequency. The patent for this has recently expired.

**5.1.3 High-Frequency Transmitter, Wireless Microphone and Guitar Transmitter or Pocket Transmitter US20150303886A1:**
**Patent Title:** High-Frequency Transmitter, Wireless Microphone and Guitar Transmitter or Pocket Transmitter
**Patent Holder:** Sennheiser Electronic GmbH and Co KG
**Patent Filing Date:** 2012-02-28

This device [9] detects signals for microphones and guitars only at high-frequency signals and amplifies them. This is like our design because it helps transmit signals from electric guitars. This device differs from our design because our design does intend to amplify signals. Our device is also intended to work at all reasonable frequencies for an electric guitar, not just the high frequencies. Lastly, our device is not intended to work with microphones, unlike this device. The advantage of this patent design's approach is that it is very useful for its intended use (wirelessly amplifying high-frequency signals for guitars and microphones), however the disadvantage of this approach is that it does not work at lower frequencies.

**5.2 Commercial Product Analysis:**

**5.2.1 Xvive U2 Guitar Wireless System:**

This product [5] includes a transmitter, receiver and power cable, and some information is listed below:

- 70 feet range (Line-0-site outdoors) (2.4 GHz)
- 6ms Latency, on four channels
- Only supports passive electric guitar pickup and piezo-electric Acoustic guitar pickup not with microphone system pickup
- 20Hz - 20kHz frequency response
- 4 to 5 hours of battery life (Rechargeable Lithium Battery)
- Comes with transmitter, receiver and power cable

Cons:

This product does not seem to be compatible with all 3.5 mm devices, but our project aims to achieve this.

**5.2.2 Donner Rechargeable Wireless System:**

- 2.5ms latency, plug and play
- Uncompressed wireless transmitting, 100 feet range

- Rechargeable lithium battery, 6 hour battery life
- Supports 4 sets of devices working at the same time (one-to-one, one-to-two or one-to-three transmission)
- 180 degree Rotatable 1/4" Plug

Pros:

This product [6] supports multiple devices working simultaneously and our current proposed product does not, this is something we need to consider.

Cons:

This product does not seem to be compatible with all 3.5 mm devices, but our project aims to achieve this.

**5.2.3 Getaria 2.4GHZ Wireless Guitar System:**


Wireless transmitter & receiver set designed for electronic music instruments like guitar, bass, etc. Some information about this product is listed below:

- 2.4 GHz uncompressed wireless signal transmission (claims low latency)
- Effective range of 30 meters.
- Supports 6 sets of devices working at the same time
- Built-in rechargeable lithium battery, supports USB recharging
- 280 degree rotatable 1/4" plug

Pros:

This products [7] supports a rotatable form factor which could be convenient while in use with a guitar, this is something we can look into for our design.

Cons:

This product does not seem to be compatible with all 3.5 mm devices, but our project aims to achieve this.

**5.3 Open Source Project Analysis:**

**5.3.1 FM-based Wireless Electric Guitar!:**

This project [10] implements a wireless sender/receiver system similar to what we hope to achieve. In this example, two Arduino microcontrollers are used, and audio is transmitted with

an SPI-based protocol. The code for the Arduino microcontrollers is given. The creator hopes to receive input from enthusiasts. In this case, the final product had no encasing, which the author lists as a desired item.

**Pros:**

- Accomplishes wireless audio transmission
- SPI transmission protocol meets low latency requirement
- Battery powered

**Cons:**

- Requires two microcontrollers
- No casing/not a polished final product
- Provides no filtering

#### 5.3.2 Beetle Mk III:

This project [11] takes in a signal from a guitar, radio, or tape-recorder and produces a radio frequency. This signal is sent through a buffer and amplifier before being outcasted via an antenna. It can also be used with a microphone (however it will likely not work as well). The website that describes this project also list parts and values for things like resistors. This project implements error checking via LED lights.

**Pros:**

- LED lights are used to indicate if the connection is stable.
- The website describing the design is very detailed, including a circuit design.
- It uses radio waves to communicate.
- Battery powered.

**Cons:**

- The radio frequencies must be adjusted manually
- Apparently, it is not extremely reliable

#### 5.3.3 DIY wireless guitar system using NRF24L01:

This project [12] involves using two NRF24L01 boards for a cost of around $30. These devices transmit over 2.4G. It uses 2 transceivers to communicate between the guitar and amp, similar to our intended project. The project creator uses 2 AA batteries to power each device.

Pros:

- Wireless
- Battery Powered
- 100m range

Cons:

- No casing/not a polished final product
- No filtering provided
- 2.4G may have high latency

## 7.0 Roles & Responsibilities:

1. Team Leader – Carson Tabachka
    - Carson has great interpersonal communication skills. He coordinated his environmental engineering team to best delegate tasks and ensure timely

completion. He has interest in software design especially with respect to networking and security.

2. Systems Engineer – Aditya Thagarthi Arun
    - Aditya T A has interest in software development. He will also understand the PCB design in full in order to serve the role as a systems engineer in this team. He has personal interest in audio and has a prior experience with working on audio related projects. He will be responsible with tying the hardware and software components of this project.
3. Hardware Engineer – Aditya Biala
    - Aditya B. has experience with Audio Hardware Development during projects with his internship with the audio team at Amazon. Additionally, he has completed numerous audio projects involving PCB design and embedded software both personally and as part of coursework. He has a lot of interest in audio hardware, and therefore he will be responsible for reliable, robust hardware design of this project.
4. Software Engineer – Calvin Walter Heintzelman
    - Calvin has a personal interest in software engineering and has taken specialized classes regarding the topic, including a class in software for embedded systems. He has done personal projects and has developed websites, apps, and neural networks. He will therefore be primarily responsible for the proper functionality and quality of software/code.

**7.1 Homework Assignment Responsibilities:**

| ***Design Component Homework*** | | ***Professional Component Homework*** | |
|---|---|---|---|
| 3-Software Overview | A.T.A | 9-Legal Analysis | C.W.H. |
| 5-Electrical Overview | A.B. | 10-Reliability and Safety Analysis | A.B. |
| 7-Mechanical Overview | C.T. | 11-Ethical/Environmental Analysis | C.T. |
| 8-Software Formalization | C.W.H. | 12-User Manual | A.T.A. |

Carson Tabachka - C.T.
Aditya Thagarthi Arun - A.T.A.
Aditya Biala - A.B.
Calvin Walter Heintzelman - C.W.H.

**8.0 Estimated Budget:**

| **Item** | **Estimated Price** |
|---|---|

| | |
|---|---|
| ***Electrical*** | |
| Microcontrollers | $30 |
| 3.5 mm to 6.35 mm converter https://www.amazon.com/UGREEN-6-35mm-Female-Stereo-Adapter/dp/B01D82XXGO/ref=pd_sbs_23_t_2/137-6701114-4457541?_encoding=UTF8&pd_rd_i=B01D82XXGO&pd_rd_r=e76ad8c3-dae4-492f-815b-e11492849946&pd_rd_w=k05EY&pd_rd_wg=OGMYx&pf_rd_p=5cfcfe89-300f-47d2-b1ad-a4e27203a02a&pf_rd_r=N0FZA16TWV22VMTRXKMK&psc=1&refRID=N0FZA16TWV22VMTRXKMK | $8 |
| NRF24L01 Transceiver | $10 |
| Batteries | $20 |
| PCB | $70 |
| Miscellaneous Electrical components (resistors, wires, LEDs, etc) | $10 |
| ***Non-Electrical*** | |
| 3D printing material | $25 |
| Shipping Costs | $50 |
| **Total** | $223 |

**9.0 Project Specific Success Criteria:**

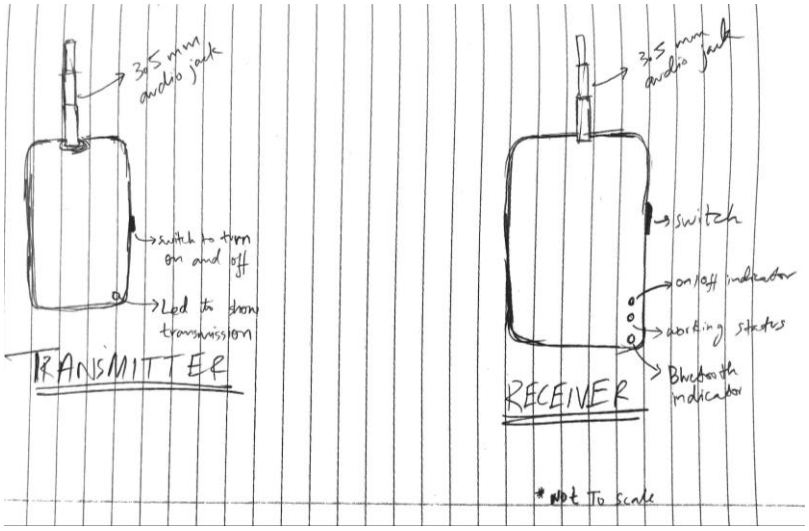
1. The ability to use an audio signal from an electric guitar to transmit & receive the signal using audio FSK modulation
2. The ability to use Bluetooth data received from an Android cell phone to control audio equalization on the Receiver PCB
3. The ability to be powered on for at least 2 hours running on an external battery
4. The ability to use an LED based UI to show battery and connectivity status of the transmitter and receiver
5. The ability to use a developed Android app to pass user-customizable audio equalization data to the receiver MCU using inbuilt cell phone Bluetooth

**10.0 Sources Cited:**

[1] "Guitar Players in The United States." Answers.Google.com. http://answers.google.com/answers/threadview/id/720968.html (accessed Nov. 7, 2019).

[2] "900 MHz vs 433 MHz for Urban Environments." Electronics.StackExchange.com. https://electronics.stackexchange.com/questions/115429/900-mhz-vs-433-mhz-for-urban-environments (accessed Nov. 7, 2019).
[3] "ARISTA 16-097 3.5mm (Mini) to 6.3mm (1/4") Headphone Adapter." Amazon.com. https://www.amazon.com/ARISTA-16-097-3-5mm-Headphone-Adapter/dp/B00009UVPN (accessed Nov. 7, 2019).
[4] R. Davis. "Cordless Guitar Transmitter." Patents.Google.com. https://patents.google.com/patent/US5025704?oq=wireless+audio+transmitter+and+receiver+guitar (accessed Nov. 7, 2019).
[5] "Xvive U2 Guitar Wireless System with Rechargeable 2.4GHz Digital Guitar Transmitter and Receiver for Electric Guitar, Bass, Violin." Amazon.com. https://www.amazon.com/Xvive-Wireless-Rechargeable-Transmitter-Receiver/dp/B01N4DSQBR?ref_=fsclp_pl_dp_1&th=1 (accessed Nov. 7, 2019).
[6] "Donner New Version Rechargeable Wireless System DWS-3 Digital Guitar Bass Audio Transmitter and Receiver." Amazon.com. https://www.amazon.com/Donner-Rechargeable-Wireless-Transmitter-Receiver/dp/B07DHLCRKD?ref_=fsclp_pl_dp_6 (accessed Nov. 7, 2019).
[7] "Getaria 2.4GHZ Wireless Guitar System Built-in Rechargeable Lithium Battery Digital Transmitter Receiver for Electric Guitar Bass (Black)." Amazon.com. https://www.amazon.com/Getaria-Wireless-Rechargeable-Transmitter-Receiver/dp/B07L5B64RG/ref=sxin_3_ac_d_pm?ac_md=2-0-VW5kZXIgJDUw-ac_d_pm&crid=2GDW7CD75H14M&keywords=wireless%2Bguitar%2Btransmitter%2Breceiver&pd_rd_i=B07L5B64RG&pd_rd_r=d45ef3f4-4691-40ad-bc9b-dda170ba6bc9&pd_rd_w=GXplv&pd_rd_wg=Fq9FG&pf_rd_p=24d053a8-30a1-4822-a2ff-4d1ab2b984fc&pf_rd_r=JC41M1CEC09B1RX30W7N&qid=1573167971&s=musical-instruments&sprefix=wireless%2Bguitar%2B%2Cmi%2C166&th=1 (accessed Nov. 7, 2019).
[8] 胡宇鹏. "Wireless Transmitter Suitable for Electric Guitar." Patents.Google.com. https://patents.google.com/patent/CN205140505U/en?oq=guitar+transmitter (accessed Nov. 7, 2019).
[9] M. Kleinsorge and C. Budnik. "High-Frequency Transmitter, Wireless Microphone and Guitar Transmitter or Pocket Transmitter." Patents.Google.com. https://patents.google.com/patent/US20150303886?oq=guitar+transmitter (accessed Nov. 7, 2019).
[10] "FM-Based Wireless Electric Guitar!" Instructables.com. https://www.instructables.com/id/FM-based-Wireless-Electric-Guitar/ (accessed Nov. 7, 2019).
[11] "Beetle Mk III: Connect your Guitar to the Airwaves." TalkingElectronics.com. http://www.talkingelectronics.com/projects/BeetleMklll/BeetleMkIII.html (accessed Nov. 7, 2019).
[12] M. Caldeira. "DIY Wireless Guitar System Using NRF24L01." YouTube.com. https://www.youtube.com/watch?v=66lN1GD_TN4 (accessed Nov. 7, 2019).

**Appendix 1: Concept Sketch**


3.5 mm audio jack
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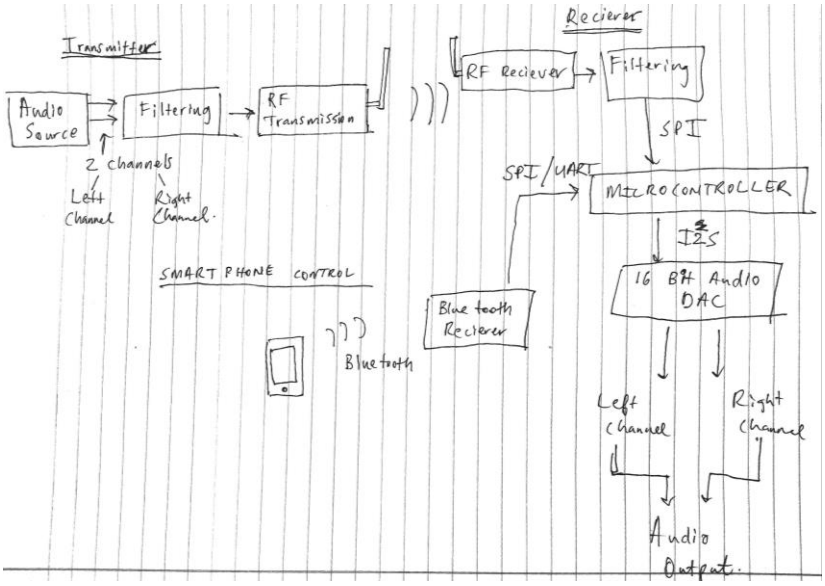
Led to show transmission
TRANSMITTER
3.5 mm audio jack
switch
on/off indicator
pairing status
Bluetooth indicator
RECEIVER
*not To scale


Transmitter
Audio Source
Filtering
RF Transmission
2 channels
Left Channel
Right Channel
SMART PHONE CONTROL
Bluetooth
Reciever
RF Reciever
Filtering
SPI
SPI/UART
MICROCONTROLLER
I2S
16 BIT Audio DAC
Blue tooth Reciever
Left Channel
Right Channel
Audio Output.