Wireless Modular Mixer

Project Proposal

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1 Introduction

1.1 Objective

Sometimes, it can an inconvenience for amateur musicians to gather for a jam session. You have to worry about where to play. Musicians must consider the noise level of their instruments and its effect on their immediate environment. Necessary equipment such as cables and amplifiers can be a hassle to carry around.

The premise of this project is to provide an affordable and portable way for bands with electric instruments to be able to practice or “jam” without causing distraction to their peers and neighbors. For electric instruments, setting up to play involves bringing their instrument, an amplifier, and the necessary cables to their gathering. This in itself can be a burden. Our mixer will allow musicians to “jam” with others without being tethered to a cord. It will also allow for “quiet” playing because everything will be heard through wireless headphones.

1.2 Background

As consuming music has become increasingly more wireless, it is surprising that producing music has not moved forward at the same rate. The market for wireless mixers is both small and expensive. Our initial searches have found other wireless analog mixers with MSRPs starting at $280 [1]. It also seems that even though these mixers are wireless, a cord must still be used to connect an electric instrument directly. On the instrument side, electric guitar transmitters start at around $100 [2]]. With our solution, everything will be completely wireless, and will come with the equipment (i.e. instrument transmitter) necessary for playing. This will cut down on the price of buying transmitters on their own.

The concern for noise is becoming more relevant as people have started choosing apartments for their housing. For example, on the University’s campus it can be difficult for students to find a suitable location to play music without causing concern of a noise complaint. The campus facilities are not always available when needed. For people in areas without access to facilities like this, coordinating a good time or place can be cumbersome.

1.3 High-Level Requirements List

- Slave modules must be able to connect to the Master
- Mixer must be able to mix audio signals from the Master Mixer modules and Slave Mixer modules
- Mixer must be able to send the outputted, mixed signal back to each Bluetooth-connected device.
- The instrument module must be able to connect to their paired Base modules and transmit audio from their instrument.

2 Design

The design will consist of four sections: a power supply, a base mixer module, two slave mixer modules (identical and flipped), and an instrument module. The master and slave modules will be powered by a 12 V outlet. Each base will contain bluetooth receivers for connecting to instruments for a maximum of two instruments per mixer module. Each base will also contain two equalizers for customization and two more bluetooth modules for transmitting the mixed audio signal to wireless headphones. Finally, the instrument modules will be powered by AA batteries. It will contain a bluetooth module for connecting to the base, and it will connect directly to each electronic instrument via an audio jack.

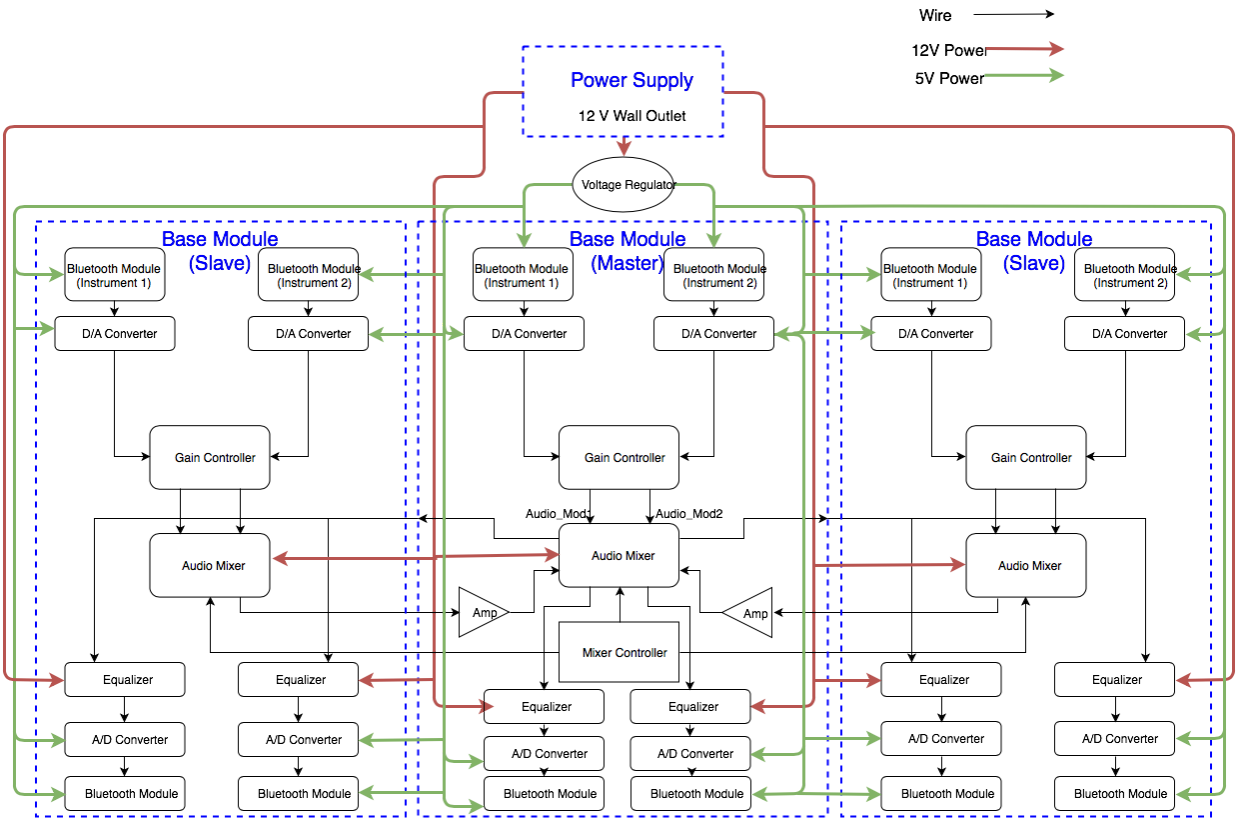

Figure 1: Modular Mixer Block Diagram

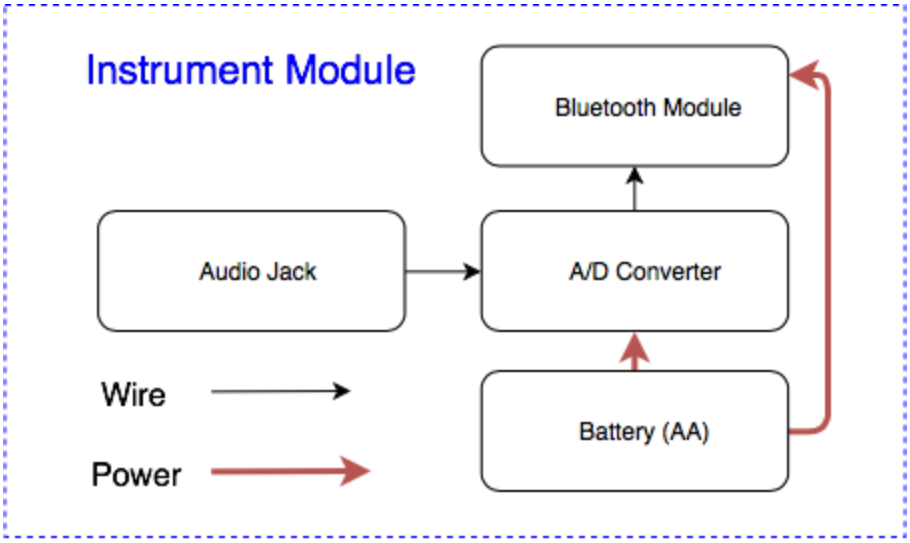

Figure 2: Instrument Block Diagram

2.1 Power Supply

A significant power supply is necessary in order for the mixer to work. In order to accomplish this, the mixer will draw power from a wall outlet, utilizing a 12 V DC power supply plug.

Requirement: The power supply must provide a voltage in the range of 11.5-12.5 V

2.1.1 Voltage Regulator

Because some modules will need lower voltage to power them, a voltage regulator will be used to step down the voltage.

Requirement: Must be able to step voltage down to 3.1 V +/- 5%

2.2 Base Module (Master)

2.2.1 Bluetooth Receiver

This block will consist of a bluetooth transceiver that will utilize the aptX low latency codec. This codec will help reduce the delay associated with bluetooth using the standard A2DP profile. Reducing latency is vital to the musicians ability to play in-time with the rest of the band. Voltage Requirement: 3.3-5 V

Requirement: Must have high speed communication capabilities near 1 Mbps.

2.2.2 Gain Controller

Knobs will control the potentiometers attached the output of each channel's op-amp in the audio mixer block. This will allow the users to adjust each instrument's placement in the sound field.

Requirements:

- Must have a dynamic range of 80 dB.
- Must be able to adjust the levels for each instrument individually.

2.2.3 Audio Mixer

This will be an Active Dual-Gate MOSFET mixer. It will take in two audio signals, mix them, and output a mixed signal. Because our mixer will have the option of mixing up to 6 instruments, each Slave base module will have a Dual-Gate MOSFET mixer PCB. These mixers will send an mixed audio signal to the Master base module. The Master base module will need a mixer PCB consisting of three mixers. One will take in signals from two instruments while the other will take in each Slave mixed audio signal. The final mixer PCB will take in the outputs of the other two and output a mixed audio signal of up to six instruments. The final output will be sent to the different equalizer modules for further customization. Voltage Requirements: 11.5-12.5 V

Requirements:

- Output must have a balanced volume level of all elements mixed
- Output must have all audible frequencies properly represented

2.2.5 Equalizer

Each equalizer will be designed to be able to customize what each person connected wants to hear. The equalizer will be designed to be a 5-band equalizer. It will consist of a band-pass filter to accommodate for each frequency band. Each band will allow for a specific range of frequencies: 50-60 Hz, 100-200 Hz, 200-500 Hz, 500-1000 Hz, and 2000 Hz. The output of each equalizer will go to a bluetooth module for transmitting the final audio signal. Voltage Requirements: 11.5-12.5 V

Requirement: The equalizer must be able to boost or cut the specified frequency for each band

2.2.6 Bluetooth Transmitter

Two Bluetooth transmitter modules will be used to transmit the mixed audio signal to two seperate bluetooth headphones. Voltage Requirement: 3.3-5 V

Requirements:

- Must support A2DP profile or aptX
- Must have a data rate near 1 Mbps
- Must be able to operate at a distance of at least 10 meters.

2.3 Base Module (Slave)

2.3.1 Receiver

This block will consist of a bluetooth transceiver that will utilize the aptX low latency codec. This codec will help reduce the delay associated with bluetooth using the standard A2DP profile. Reducing latency is vital to the musicians ability to play in-time with the rest of the band. Voltage Requirement: 3.3-5 V

Requirement: Must have high speed communication capabilities near 1 Mbps.

2.3.2 Gain Controller

Will control the potentiometers attached the output of each channel's op-amp in the audio mixer block. This will allow the users to adjust each instrument's placement in the sound field.

Requirement: Must have a dynamic range of 80 dB

2.3.3 Audio Mixer

This will be an Active Dual-Gate MOSFET mixer. It will take in two audio signals, mix them, and output a mixed signal. Because our mixer will have the option of mixing up to 6 instruments, each Slave base module will have a Dual-Gate MOSFET mixer PCB. These mixers will send an mixed audio signal to the Master base module. The Master base module will need a mixer PCB consisting of three mixers. One will take in signals from two instruments while the other will take in each Slave mixed audio signal. The final mixer PCB will take in the outputs of the other two and output a mixed audio signal of up to six instruments. The final output will be sent to the different equalizer modules for further customization. Voltage Requirement: 11.5-12.5 V

Requirements:

- Output must have a balanced volume level of all elements mixed
- Output must have all audible frequencies properly represented

2.3.4 Equalizer

Each equalizer will be designed to be able to customize what each person connected wants to hear. The equalizer will be designed to be a 5-band equalizer. It will consist of a band-pass filter to accommodate for each band. Each band will be centered on a frequency to allow for a specific range: 60 Hz, 250 Hz, 1000 Hz, 4000 Hz, and 16 kHz. The output of each equalizer will go to a bluetooth module for transmitting the final audio signal. Voltage Requirement: 11.5-12.5 V

Requirement: The equalizer must be able to boost or cut the specified frequency for each band

2.3.5 Bluetooth Transmitter

Two Bluetooth transmitters will be used to transmit the mixed audio signal to two seperate bluetooth headphones. Voltage Requirement: 3.3-5 V

Requirements:

- Must support A2DP profile or aptX
- Must have a data rate near 1 Mbps
- Must be able to operate at a distance of at least 10 meters.

2.4 Instrument Module

2.4.1 Gain Controller

Physical knob used on the instrument module to adjust the gain for the user's instrument. This knob will be implemented by a 10k potentiometer.

Requirement: The gain knob must be able to provide the user the ability to adjust the gain to at least ten distinct levels.

2.4.2 Audio Jack

Physical interface to the instrument. A ¼" mono plug will be used in order to be universal with electric instruments.

Requirements:

- Must be in a location that is easy to plug into an instrument.

- Must be able to move or rotate separately from the rest of the module.

2.4.3 Analog to Digital Converter

Converting the analog input from the instrument to a digital signal for use by the bluetooth transmitter module. Voltage Requirement: 2.5-3.3 V

Requirements:

- Convert the analog sound to a 16-bit 192 kbps digital signal.
- Must communicate to the Bluetooth transmitter with a serial SPI output.

2.4.4 Bluetooth Transmitter

This block will consist of a bluetooth transceiver that will utilize the aptX low latency codec. This codec will help reduce the delay associated with bluetooth using the standard A2DP profile. Reducing latency is vital to the musicians ability to play in-time with the rest of the band. Voltage Requirement: 3.3-5 V

Requirements:

- The transmitter must operate within the same band as the receiver on the base modules.
- The transmitter must be omnidirectional.
- The transmitter must have a range of at least 10 meters.

2.4.5 Battery Module

The batteries will be used to supply power for instrument module. This module also contains a voltage regulator to supply the correct voltage for the transmitter and ADC.

Requirements:

- Must provide appropriate voltage for the transmitter and Analog-to-Digital converter (estimated to be 3.3V).
- Must be placed in a physical spot that is easy to access and change.

2.5 Risk Analysis

The Bluetooth connection between the instrument unit and the audio mixer will be vital to the success of the project. It is the sole connection for sending data to the mixer. The success of the project will be determined by the accurate transmission of the audio

signal from the instrument to the mixer. The largest factors in the success of the project will be latency and sound quality.

Latency is a limiting factor to the success of the project due to the real-time nature of musical performance. Having long delays between when a musician plays a tone and to when they hear it would be detrimental to their performance. Small amounts of latency is to be expected compared to a wired system, but too much would mean the product is sluggish and frustrating to use.

3 Ethics and Safety

Batteries can potentially be dangerous and must be implemented in a way such that extended overheating and fires are not a concern for the instrument module. 9-V batteries are particularly prone to shorts because the terminals are close together, which could potentially cause a fire. The mixer's voltage regulator must also supply proper voltages to the various modules in order to avoid overheating and electrical failures.

Proper listening volume is a concern for the end user. Users must take care to avoid listening to music with their headphones at maximum volumes (about 100 dBa) for over 15 minutes to avoid permanent hearing damage [2]. This information will be disclosed to the end user in accordance to the IEEE Code of Ethics [3].

References

[1] Sweetwater.com. Peavy PV 6 BT Mixer with Bluetooth and Effects. [Online]. Available at: https://www.sweetwater.com/store/detail/PV6BT--peavey-pv-6-bt-mixer-with-bluetooth-and-effects [Accessed 9/20/2018].

[2] Guitarcenter.com. Line 6 Relay G10T Wireless Guitar Transmitter. [Online]. Available at: https://www.guitarcenter.com/Line-6/Relay-G10T-Wireless-Guitar-Transmitter.gc [Accessed 9/20/18]

[3] "Noise Induced Hearing Loss (NIHL)" *Dangerous Decibels.* [Online]. Available at: http://dangerousdecibels.org/education/information-center/noise-induced-hearing-loss/ [Accessed 9/19/2018].

[4] IEEE.org. IEEE Code of Ethics. [Online]. Available at: https://www.ieee.org/about/corporate/governance/p7-8.html [Accessed 9/18/2018].

[5] Austin Harney and Grzegorz Wawrzola Download PDF. "Power Management Design for PLLs." Two Ways to Measure Temperature Using Thermocouples Feature Simplicity, Accuracy, and Flexibility | Analog Devices, www.analog.com/en/analog-dialogue/articles/power-management-design-for-plls.html. [Accessed 9/17/18]

[6] "FET Mixer." *Op Amp Gain | Operational Amplifier Calculation Equations* [Online]. Available at: www.radio-electronics.com/info/rf-technology-design/mixers/fet-mixers.php. [Accessed 9/17/18]

[7] "Bluetooth Goes Ultra-Low-Power." *Digi-Key Electronics.* [Online]. Available at: https://www.digikey.com/en/articles/techzone/2011/dec/bluetooth-goes-ultra-low-power [Accessed 9/18/18]

[8] "aptX Bluetooth Codec." *An explanation of the aptX Bluetooth codec and aptX vs SBC. Lifewire.* [Online]. Available at: https://www.lifewire.com/aptx-bluetooth-codec-4151667. [Accessed 9/18/18]