Wireless RF Audio System

FINAL DESIGN DOCUMENT

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Contents

1 Introduction
- 1.1 Project statement
- 1.2 Purpose
- 1.3 Goals

2 Deliverables

3 Design
- 3.1 System specifications
  - 3.1.1 Non-functional
  - 3.1.2 Functional
- 3.2 Proposed Design/Method

4 Testing/Development
- 4.1 Interface specifications
- 4.2 Hardware/Software Implementations
- 4.3 Testing Process

5 Results

6 Conclusions

7 Appendices
- 7.1 Appendix I: Operation Manual
- 7.2 Appendix II: Alternatives/Initial Version
- 7.3 Appendix III: Other Considerations

1 Introduction

1.1 Project statement

The goal for this project is building a wireless speaker system that will produce an optimal sound output. The speaker system should give an optimal sound clarity in a large room, especially places like a convention facility and lecture halls.

1.2 Purpose

It has been common to find at a number of facilities that the speaker systems produce less than optimal sound clarity. This poor sound output quality makes it so that the audience can't hear what the person with the microphone is saying, and these issues can be compounded with audience members with lowered hearing abilities. Sometimes, this is due to the poor speaker placement, but we want to tackle the problem on a more technical side and look at the actual hardware being used. The usage of speakers is a very common way to convey messages to large audiences, whether that be indoors or out. Hopefully, the project will help to make these messages clearer and more easily understood.

1.3 Goals

Goals for this project include:

- Stand alone speaker system
- Scalable system in order to fit the needs of different sized rooms
- Easy to use, will not distract from the presentation

2 Deliverables

For this project, the deliverable will be a multiple speaker system that is able to be connected to via radio frequency, that is able to produce an optimal sound clarity, and is able to be connected to with standard microphone options.

3 Design

3.1 System specifications

The project will be divided into two sections, the transmitter and the receiver. The transmitter will consist of an RF antenna module, Arduino Uno microcontroller and microphone. The microcontroller should be able to create a network for the receiver to connect to and should be able to transmit audio through the created network. The microphone will capture the analog audio signal and convert it to a digital signal which will then be transmitted. The receiver consists of the speakers and the receiver wireless module that will be connected to them. The module will establish a connection with the network that the transmitter had created.

3.1.1 Non-functional

- **Reliability:** The speaker system should have a very reliable wireless connection. This means that the connection between the transmitter and receiver should have zero interference from other signals, and zero connection errors.

- **Usability:** The speaker system should be user friendly for anyone who uses it, which means that the process of establishing and connecting the network between the microphone and the speakers should be straightforward and easy to do for all of the speakers in the system.

- **Scalability:** The speaker system should has a flexible range of scalability in terms of amplifying the audio output while maintain the desired level of audio clarity.

3.1.2 Functional

- The system must send and receive a stream of audio data and signals.
- The system must be able to convert the the analog data received and convert the digital data back to an analog signal.
- The system must have certain filters that are able to change the audio signals for clarity purposes.

3.2 Proposed Design/Method

The system will comprise of two parts, which is the transmitter and receiver. For the transmitter part, an Arduino will be used in communicating with the microphone and transmitting the data. The Arduino should be able to receive the audio data from the microphone and able to transmit the data via radio signal with the RF antenna module installed on the microcontroller. For the receiver, another Arduino will be used and programmed to connect and receive the data transmitted from the radio signal. Then, the speakers connected to the receiver microcontroller will play the received audio signal.

4 Testing/Development

4.1 Interface specifications

In our project, the hardware and software will need to interface with each other. The radio will largely be run via software, which will then need to work with an antenna to connect to our other speakers and transmit the speaker's message.

4.2 Hardware/Software Implementations

We are currently working with two main parts in doing testing for this project. The first is the Arduino Uno, a microcontroller that we are using due to it being cheaper and easy to use in terms of coding and modules. Then we are using the Arduino units and their software packages to develop the radio operations via software.

4.3 Testing Process

For the testing process, we are using a full FM Band to test the ability for the transmitter and receiver to make connections at each of the frequencies. Before making connection, the optimum frequency will be determined by measuring the signal strength at each frequency by analyzing the channel noise and the traffic levels. This is achieved by running a frequency sweep across the FM Band. Besides that, the range are also tested by analyzing the connection of the transmitter and receiver at various frequencies at different range.

For the input testing, we analyzed the input voltages from the microphone in different levels of background noise to ensure clear transmission. Then, for the output testing, we tested the speaker output has no feedback and sufficiently amplified. To achieve this, calibration measurements can be made by using different amplifiers.

5 Results

The current design is the result of a lot of trial and error in what we think we can create in a realistic amount of time and at a realistic cost.

We managed to create a working system in which the receiver and transmitter managed to establish a connection. We are also able to transmit the audio data from the microphone through the transmitter and receiver, then to the speaker to produce the audio output.

6 Conclusions

The final design formed through several meetings with Professor Tuttle led to our current testing phase. Once we finished our current testing phase we got a good idea of the physical design of our product. The communication intermediaries between each component will be decided once we have the capability to send and receive signals.

After some more research, and meeting with Professor Tuttle we began to look into software radio and building a simple FM antenna and receiver. We have now split the project into two groups with Nick and Quinn focusing on the software, and Arifi and Andrew working on designing a receiver.

7 Appendices

7.1 Appendix I: Operation Manual

Operating this system is done in two parts, setup and execution. The setup process was made almost entirely autonomous with the exception of a single button press. The process begins by having the transmitter search through the frequency spectrum for the channel that has the most open air waves. During this time, the receivers will be in an idle state until the transmitter begins communication. The transmitter will select the three best frequencies it finds and stores them into memory. Following this, the transmitter will wait for user to press a button to begin the radio data service transmission. The transmitter will set its buffer to the frequencies it detected one at a time. Changing only when the user is ready to switch to the next one by pressing a button. The LCD display will tell the user which frequency is being sent. On the receiver end, when the first frequency is transmitted this will begin the synchronization. The receiver will read that first frequency and store it. An LED will illuminate telling the user once each frequency has been detected and stored. This allows for syncing without having to have all receivers in close proximity. This step will repeat three times when the user sends all three frequencies. The final step in the process asks the user if they want to use one frequency or three. This will affect the execution process. Once all three LEDs are lit and the user chooses which mode, the setup will be complete and the execution will commence.

For Single Frequency Mode:

The transmitter will begin transmitting the input data from the microphone at the specified “best frequency.” The only changes that can be made on the transmitter end at this point is the microphone. It can be changed to three states using a three mode switch. This will alter the gain of the microphone by pulling up or pulling down on the gain. It can also be switched of with a dual mode switch when the user wants to mute themselves. The receiver at this point will only use the first frequency in which it received. The user will see the frequency and volume on the LCD display. The volume can be changed with two push buttons. The range is from 0 (mute) to 15.

For Three Frequency Mode:

The user interaction will be exactly the same for both the transmitter and receiver. However, the transmitter and receiver will begin frequency hopping every minute between the three frequencies. This will display the current FM frequency on both. The purpose for this is to mitigate outside listeners tuning into the FM frequency. This creates a network between our devices.

7.2 Appendix II: Alternatives/Initial Version

<u>GNU Radio:</u>

We moved away from our initial plan, which was using GNU Radio, because of it’s large library of dependencies. There was also issues with the latency during the audio data transmission. These constraints would become a major problem in our implementation of the project.

TI Launchpad:

Initially, we were planning to use the TI launchpad controller as the medium for connection between the transmitter and receiver. The largest issue faced was compatability with the radio component modules we were using. Because of this, we changed to using the Arduino Uno, because it has better compatibility and implementation with these modules.

7.3 Appendix III: Other Considerations

Initially we were basing most of our design on bluetooth communication. Dr. Banitt was worried about using radio frequencies, and had presented possibly using another technology such as infrared. After coming to our first design we met with Professor Tuttle who helped push us into something that would be a bit more realistic for us. We decided to go with radio frequencies, as they are the perfect medium for transferring data without distance and connection reliability becoming an issue, especially when compared with WiFi and Bluetooth.

We also wanted to use a Raspberry Pi and a bluetooth transmitter to sync with some simple bluetooth speakers. The cost of a single Raspberry Pi with a bluetooth antenna would not allow us to scale the project realistically. Not to mention each additional speaker would have to come at market cost which isn't very realistic.