Bluetooth Splitter

ECE 445: Design Document

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Table of Contents

1 Introduction

1.1 Objective

Problem:

Wireless headphone sales have been increasing year after year, increasing the use of Bluetooth. Over 54% of dollar sales of headphones are wireless headphone sales [1]. Bluetooth headphones have become so overwhelmingly popular that Apple decided to remove the audio port from their devices. With the rise of Bluetooth solutions, comes the rise of devices to allow for advanced listening options. Users want a better experience with Bluetooth headphones and speakers than they do with wired headphones. However, currently, there is less functionality with Bluetooth than wired. Two people, with different wireless headphones or speakers, cannot listen to the same device concurrently. In order to share in a listening experience, two people would need to either play the audio out loud, perhaps disturbing others in a public place, or acquire two pairs of wired headphones and an eighth inch cord splitter. Stereo systems with speakers from different platforms cannot be connected together.

Solution:

Our solution is to create a bluetooth splitter. The idea is very similar to the auxiliary cord splitter most people have used before. We will have one bluetooth receiver and two bluetooth transmitters. We could connect a device, like a laptop or phone, to two different bluetooth devices, two bluetooth speakers or headphones, and have both devices receive the same audio simultaneously, regardless of the company that created the devices.

1.2 Background

As of right now a device exactly the same as ours does not exist. We have seen an implementation similar in headphones or speakers of the same brand. For instance, it is possible to connect multiple pairs of AirPods or Beats bluetooth headphones together since they are produced by Apple [2]. Other companies have smartphone applications that will connect multiple of their speakers or headphones together, but they are all dependent on buying multiple products from the same company. There is also an app, AmpMe, meant to create a surround sound system and will broadcast the same music to multiple phones [3]. However, AmpMe only connects multiple smartphones, but our device relies on only one “smart” device (phone or a laptop). There are devices that have the capability to support dual streaming, but these devices, like the AluraTek Audio Transmitter, require that the device playing the audio be connected to the device is connected via a wire [4]. Our solution will be both brand agnostic and wireless. However, Bluetooth has seen a value in this so in Bluetooth 5 there is a dual audio mode

[5]. The release of Bluetooth 5 has not actually made this two to one connection widely available. The Bluetooth 5 chip was released in 2016 [6], and made into the market on the iPhone 8 and Samsung Galaxy S8 in 2017. However, there is currently no way to use this feature on the iPhone, and Samsung only recently, January 13, 2020, has released support for this feature [7].

1.3 High-Level Requirements

- The device must pair to a single laptop or phone as a source of audio.
- The device must pair to two speakers or headphones simultaneously as an output for audio.
- The device must send data or music at a minimum rate of 24 kbit/s [8] from source to output.

2 Design

2.1 Block Diagram

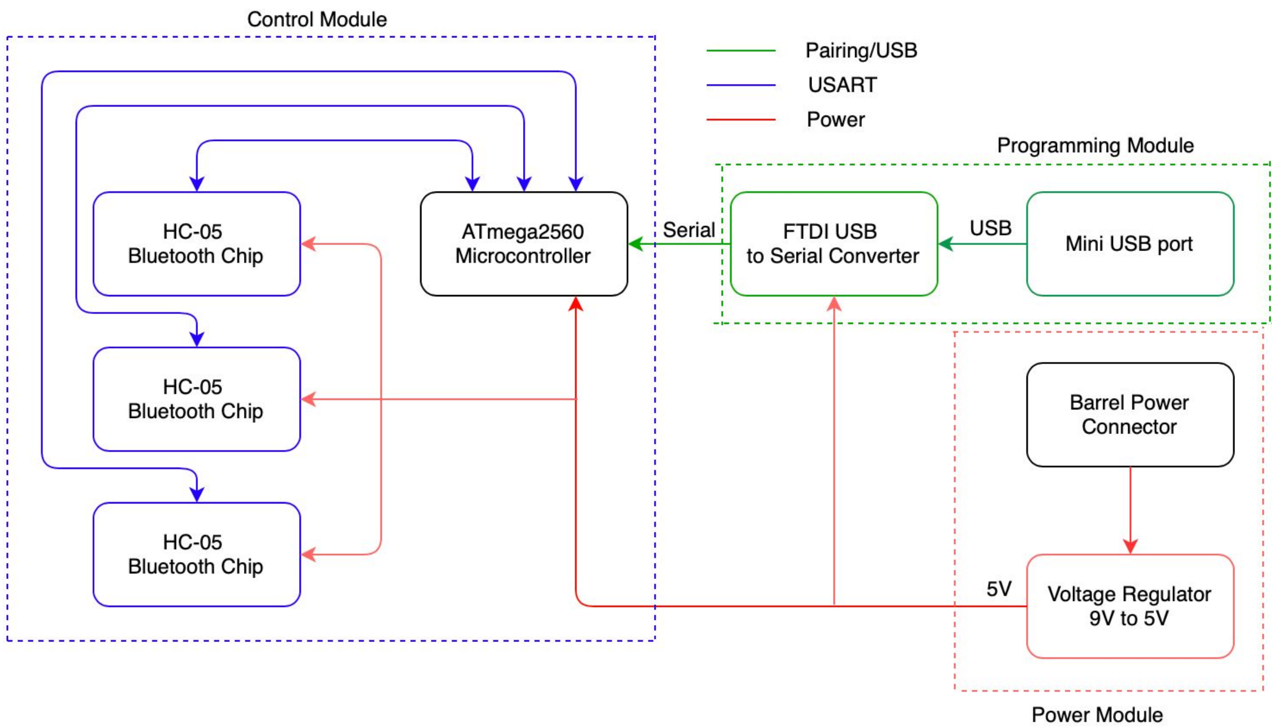

Figure 1: Block Diagram

2.2 Requirements & Verification Tables

Control Module

The control of the bluetooth connections and transportation of the audio data will be handled through the data module, consisting of the ATmega2560 microcontroller and three Bluetooth Chips. The microcontroller will assist in pairing, allowing the user to program the device with the MAC addresses of the devices they wish to connect. More importantly, the microcontroller will transfer the audio data across to the two bluetooth transmitters. For good audio quality it is usually recommended to use 64-128kbps[8]. According to the datasheet for the HC-05 chips, we need to run a voltage divider from the TX pin on the microcontroller to the chips' RX pins, in order to maintain 3.3V as a logical 1 on the chips. This can be seen in our circuit schematic in Figure 5.

We will be using the USART pins (RX/TX) on the AT2560 to communicate with our Bluetooth Module. This will allow us to run multiple streams of serial communication simultaneously. This is done through USART and TTL communication protocols. We chose the AT2560 for its 4 RX/TX pins, allowing us to have simultaneous communication.

Requirement	Verification
Microcontroller can read and send data between the chips simultaneously	AT-Commands (AT+NAME) can be sent to chips from Serial Monitor on the Microcontroller
Microcontoller can pair chips with various Bluetooth devices	Pairing is successful
Data can be sent reliably and quickly enough to play music to speakers	A small series of tones can be played from laptop and heard on headphones/speaker

Figure 2: R&V for the Control Module

Power Module

The main power source will be through a barrel male connector. This will go through a voltage regulator to supply power to our microcontroller, FTDI chip, and three Bluetooth chips. Using a USB port will allow for the device to be easily powered through battery packs, while allowing for mobility. The current and voltage requirements come from the draw from each chip. The microcontroller draws a max of 14 milliamps, the chips draw up to 40mA each while pairing, and the FTDI chip draws 15mA. The regulator itself draws minimal current. The voltage regulator will be used to clean and transmit 5V to our microcontroller and FTDI chip and the HC-05 chips. We choose to use a 9V battery and barrel connector as our goal is run our device for an hour, and with our current draw, a 9V battery can run our device for a little more than 3, fitting our requirements.

Voltage Regulator 1 (9V to 5V): L7805CV

Supplies up to 1.5A

Efficiency: 5/9 = 55.56%

Max Total Possible Current = 14 + 40(3) + 15 = 149mA - ~156.45 mA (5% error from max current)

Voltages: 5V

Battery Capacity: 500mAh

156.45 mA for 3.205 hours

Requirement	Verification
Our battery must supply at least 156.45 mA for five minutes.	Connect a load and the battery, measuring current with an multimeter based on our calculations above.
Our voltage regulator must provide 5V and at least 29mA to microcontroller and FTDI chip for five minutes	Connect input of regulator to the battery and output to a load. Discharge battery and check voltage at load with a multimeter.
The voltage regulator must provide at least 120mA to Bluetooth chips for five minutes	Connect input of regulator to the battery and output to a load.

Figure 3: R&V for Power Module

Programming Module

The programming of the AT2560 chip will only need to be done a couple times and will be conducted through the Mini USB Port and FTDI Chip. We will need to first program the chip with the software, and then need to use the programming module when pairing the HC-05 chips the first time.

Requirement	Verification
Send data and code from laptop via Mini USB to AT2560	Compile and upload simple DigitalReadSignal program to microcontroller using Arduino program. Connect one pin to 5V and read the value at pin.

Figure 4: R&V for Programming Module

2.3 Tolerance

The biggest concern for our project will be the speed at which data can be sent from any Bluetooth chip through the AT2560 to another Bluetooth chip. Any sort of tones or music needs to play at certain frequencies and speeds in order to have a proper listening experience. The minimum rate that music needs to transmit at is at least 24 kbps, meaning the AT2560 needs to be able to serially communicate at 24 kbps [8]. The max serial communication rate on the mega is 115200 bps, therefore giving us a 380% error margin. The typical rate is 96 kbps [8], giving us a 20% error.

The AT2560 has a clock speed of 16 MHz, divided between the three chips to be 5.3MHz per chip. This means that the processing speed on the AT2560 is greater than the transmission rate, allowing us to not store data on the microcontroller itself.

The battery, a 9V battery, can supply 156.45 mA for 3.205 hours, as it has a capacity of 500mA hours [13]. This means that our goal to run our device for an hour can be achieved by this battery, with a 220% margin.

$(3.205 - 1)/1 = 2.205 * 100 = 220.5\%$

The voltage regulator that converts our 12V to 5V supplies up to 1.5A and has a 2% output voltage tolerance. This means that the output voltage can range from 4.9 to 5.1V, which would still supply enough to the Arduino, FTDI chips, and HC-05 chips. The FTDI chip has a lower tolerance at 3.3 to 5.2V.

2.4 Circuit Schematics

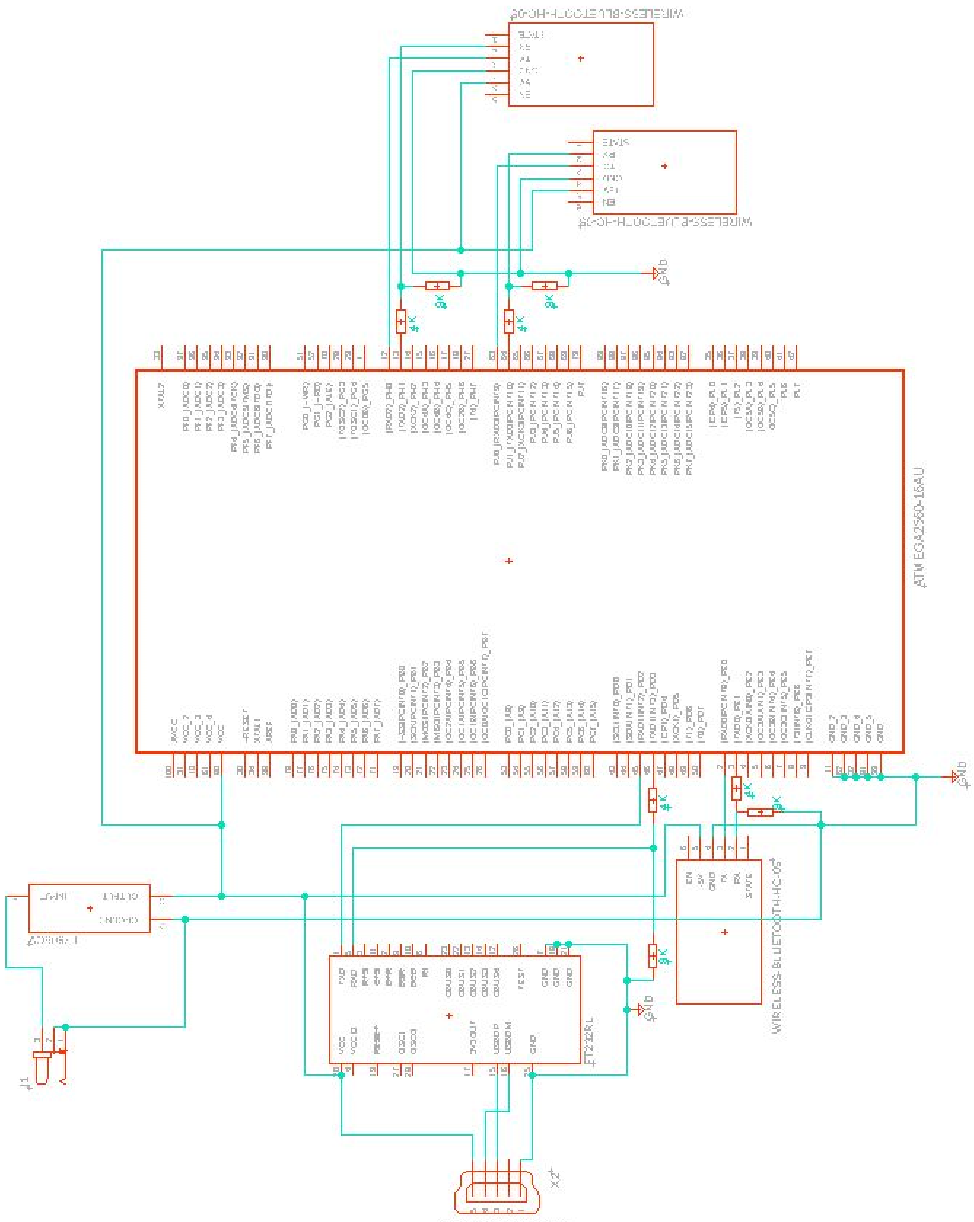

Figure 5: Circuit Schematic

3 Cost and Schedule

3.1 Cost Analysis

The total project costs are split between the labor needed to build the project and the parts that will go into the project. The labor analysis is as follows: 10hrs/(week/person) * 16weeks * $50/hour * 3 people = $24,000.

Item	**Part # / Manufacturer**	**Quantity**	**Total Price**
Microcontroller	ATMEGA2560-16AU	1	$11.85
Bluetooth chips	HC-05	3	$25.98
FTDI chip	FT232R	1	$4.50
Voltage Regulator (12V-5V)	L7805CV	1	$0.50
DC Barrel Power Jack	SPC4077	1	$1.25
USB - Mini B USB 2.0 Receptacle Connector	UX60-MB-5ST	1	$0.99
9 Volt Alkaline Battery	NA	1	$4.24
Sum			$49.31

Figure 6: Cost of Parts Table

The total cost for this project, excluding PCB manufacturing, will be $24,000 + $45.07 = $24,045.07.

3.2 Schedule

Date	**Niharika**	**Katie**	**Nathan**

February 25, 2020	Design Document draft Finalize design specs	Design Document draft Finalize design specs	Design Document draft Finalize design specs
March 3, 2020	Design Review - finished Design Document Start PCB design	Design Review - finished Design Document Start PCB design	Design Review - finished Design Document Start PCB design
March 10, 2020	Finalize battery and method for powering the device	Finish PCB design	Buy required parts including backups
March 17, 2020	Verify and test devices individually	Order PCB and aid in testing	Start microcontroller programming
March 24, 2020	Work on Integration	Work on microcontroller code	Work on Microcontroller code
March 31, 2020	Finish up Program	Solder PCB and work on verifying	Finish up Program
April 7, 2020	Work on integration, testing, final demo, final presentation, and final report	Work on integration, testing, final demo, final presentation, and final report	Work on integration, testing, final demo, final presentation, and final report
April 14, 2020	Work on integration, testing, final demo, final presentation, and final report	Work on integration, testing, final demo, final presentation, and final report	Work on integration, testing, final demo, final presentation, and final report
April 21, 2020	Mock demo, final demo, final presentation, and final report	Mock demo, final demo, final presentation, and final report	Mock demo, final demo, final presentation, and final report
April 28, 2020	Final demo, final presentation, and final report	Final demo, final presentation, and final report	Final demo, final presentation, and final report

Figure 7: Planned Schedule

4 Safety & Ethics

One of the large ethical concerns that was initially brought up with this project was avoiding harm which is part of the ACM code of ethics [9]. The point of avoiding harm is to make sure that all devices that are built cannot be used to hurt other people.

Since we are building a device that transmits data wirelessly, it is important to check that we are not building a device that can interfere with other important signals such as WiFi. When looking into the interference issue, it is clear that both Bluetooth and WiFi can transmit near the same frequency, it is rare that they actually interfere with each other [10]. This is due to frequency hopping which is inherent to the Bluetooth protocol. One of the ways to make sure that we do not run into any of these issues is by limiting the output power of the devices. The chips that we will be using in this project will be having a limited output, but we will ensure that we do not over power the devices. In order for this device to be able to work on aircraft, we must be sure to follow the guidelines set forth by the FAA [11]. However, this will be something that we can look into after building a prototype but before any mass production.

When looking at the safety concerns, we want to make sure that we do not overpower the device. This could cause problems like overheating or malfunctioning of the device. We will use voltage regulators in an attempt to mitigate these issues. We believe that these concerns will be addressed by the regulators.

As mentioned in other sections, there are wired devices that currently perform these functions. Since this is the most comparable device that we are building , we believe that our product will not have extra ethical implications. This product will not be violating any patentable technology and we are therefore respecting the original designers of several technologies in this area.

We will strive to abide by both the IEEE and ACM code of ethics. We will keep the safety of the consumers as our highest priority, and we will make sure that we will treat all people fairly and accept criticism of others of our project [12].

5 Citations

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