Wireless Bluetooth Music Player

ECE 445 Design Document

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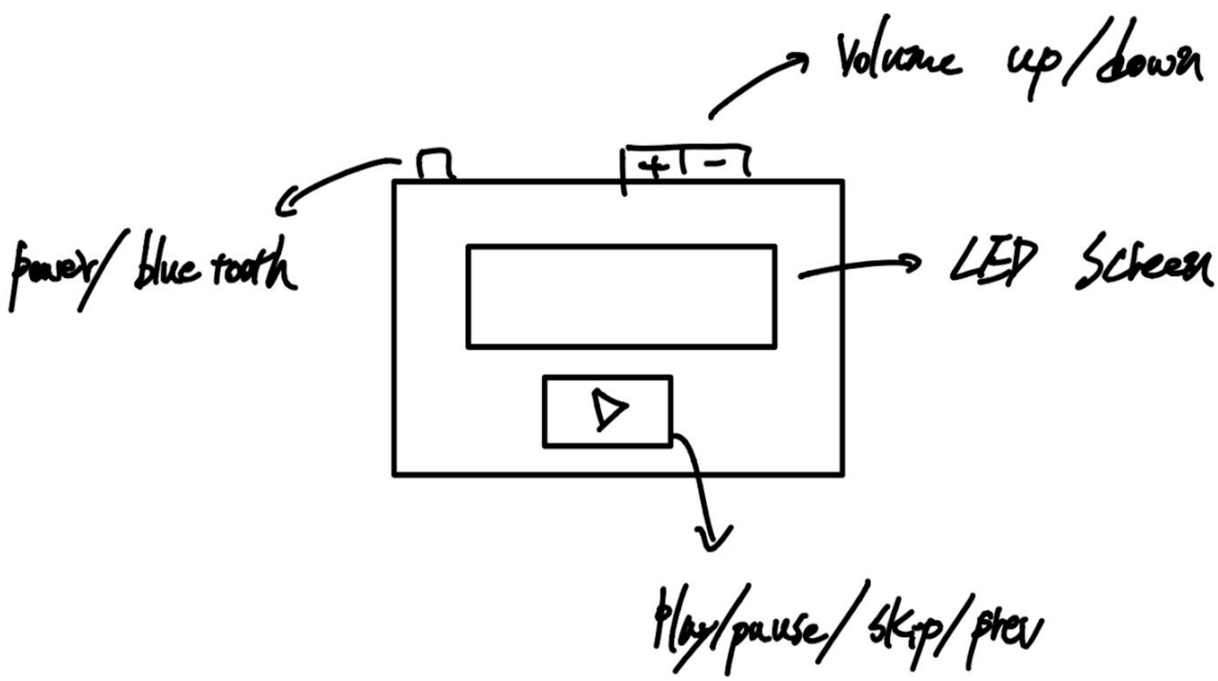
1. Introduction

1.1 Problem and Solution

Current music playback devices are increasing in size to meet the demand for larger and larger screen sizes. Phones are now averaging with a screen size of 5.5 inch and increasing each year[1]. The weight of these devices is rather large, the result of using metals and glass to give users a 'premium feel' and increasing battery size to maximize the charge life of the device. These factors are integral to making good smart devices; however, they also lead to bulky/inconvenient device profiles for physical activity, especially for exercises like running and rock climbing.

Our proposed solution is a clip-on wireless music player that is capable of storing and playing the user's music through wireless headphones via bluetooth. It will be lightweight and convenient to wear while exercising (clipped onto shirts or joggers). Our device will be simple and affordable. It will store audio files on the device and play them back via bluetooth.

1.2 Visual Aid



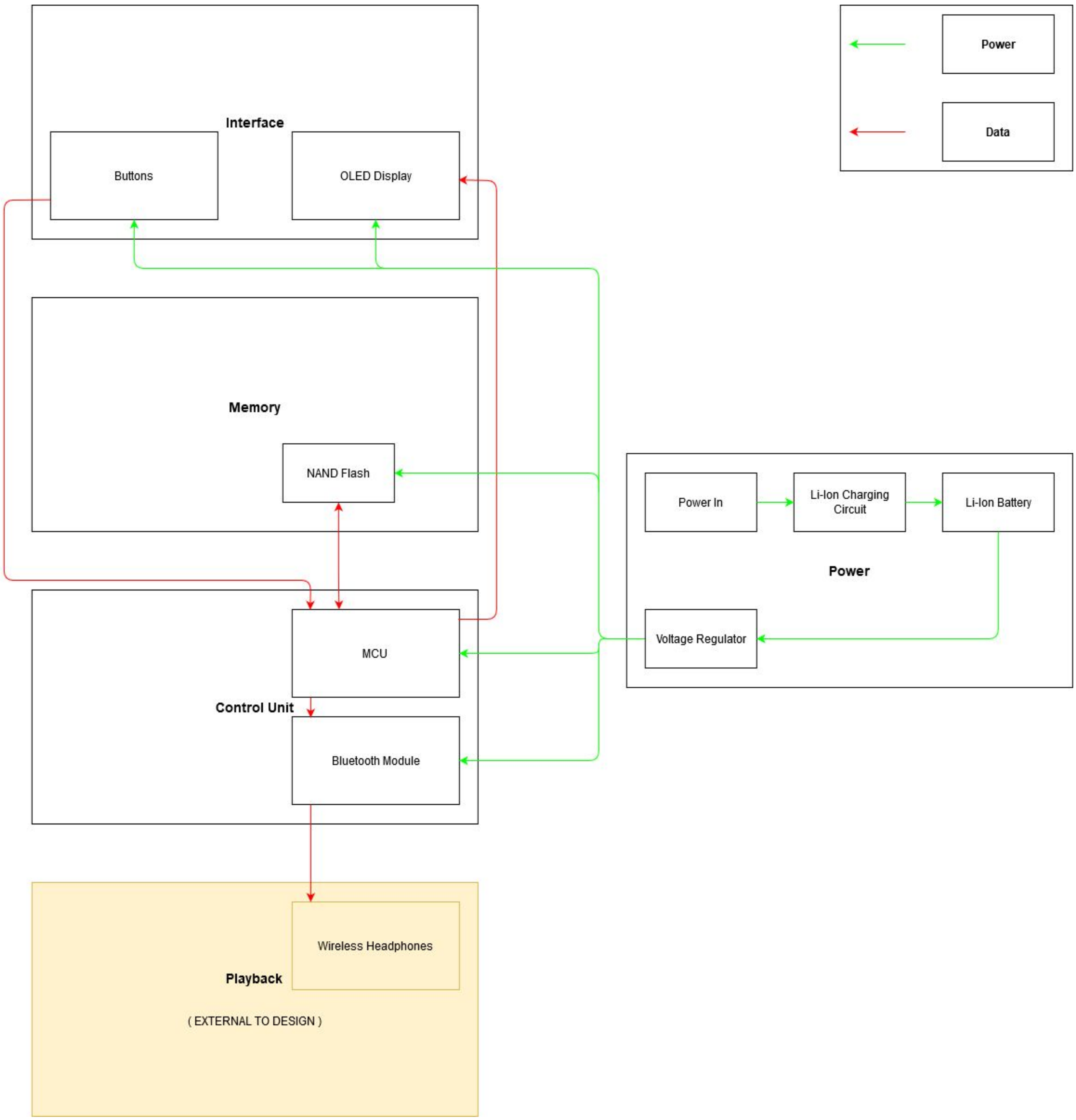
1.3 High-level requirements list

- The device must be able to play as many songs users can listen to in a workout or run session.
- The device must have enough battery life to last a workout or run.

- The device must be light enough so it will not interfere with workouts or runs, and small enough so the user can carry it without annoyance.

2. Design

2.1 Block Diagram



2.2 Block Descriptions

2.2.1 Power

Block Requirement: The power block is responsible for supplying power to all the components in the device, must last at least 3 hours and prevent overcharging.

Lithium Ion Charging Circuit:
The lithium ion charging circuit will receive power from the USB input to the device, and manage the charging process of the battery to prevent damage to the battery, and ensure longevity of the device's charge life.

Battery:
We will be powering our device with a Lithium Ion Polymer Battery as they are the established standard for safety and size. There are some safety considerations, which we will cover in the Safety section, but Lithium Ion batteries are the best option available to us. The option we are currently considering is rated at 3.7V at 500mAh, a reasonable amount of power for a system as small as ours. This option is expected to easily meet the power demands of our device for more than the duration of average use.

Voltage Regulator:
This module takes in the battery voltage, and supplies 3.3V to all components on the board.

2.3 Requirements and Verification Table

2.3.1 Power Supply Unit

Requirements	**Verifications**
Lithium Ion Battery 1) Supply 3.7V at 300mAh draw on the PCB	Verification Process: 1) Hook up to an oscilloscope to ensure voltage and currents are steady at specified values
Voltage Regulator 1) Handle up to 4.0V battery voltage 2) Supply up to 200 mA current draw	Verification Process: 1) Use a multimeter to measure the potential difference and ensure it is within range 2) Use the oscilloscope or multimeter to measure the current is close to our specified value

2.4 Tolerance Analysis

The flash memory is the biggest risk to the completion of the project. Without any storage, the device does not have any music to play and is therefore unable to operate. It is also the hardest component to get working, as we do not have as much experience working with memory as we do with the other subsystems. Managing the data storage will be a significant part of the challenge, as flash memory has unique quirks that make it challenging to work with at times. Part of the addressing of this problem should be addressed by utilizing a pre-packaged file system capable of reading from memory, such as FATFS.

A large concern for the device functionality is the throughput of the flash to the MCU, as audio output requires real-time access to the data. The device operating in asynchronous mode is capable of up to 50 MT/s, which equates to a maximum data rate of 50 MB/s, as the flash has a 8-bit data bus width. Any rate near this theoretical maximum should be more than sufficient to allow for the MCU to receive the audio data at a sufficient rate such that the processing and transferring of the data can fill even the maximum available bandwidth for the A2DP Bluetooth profile. This A2DP profile will use the SBC audio codec, which has a maximum data bandwidth of 320 kbit/s, after processing the audio data by the MCU. The fast transfer speeds from the flash memory will minimize the overhead of loading the data from memory, and allow for more time other processes required for audio playback.

Bluetooth communication could potentially be a blockade for our project. The aim is to have a standalone Bluetooth module that interacts with the MCU over either the I^2C or UART standard. Although the internal design sounds straightforward, it requires further research in communication between the MCU and Bluetooth module.

Also, the pairing process between the Bluetooth standalone device and our BLE could potentially be complicated. We could either program it while the MCU is connected to the computer or using the device’s interface (screen and buttons) to select the device we wish to pair it with. Additionally, we have two modes to communicate with our BLE Device: command and data transfer. Both modes could operate up to 10m of distance that could be explained with figure 2.4.1.

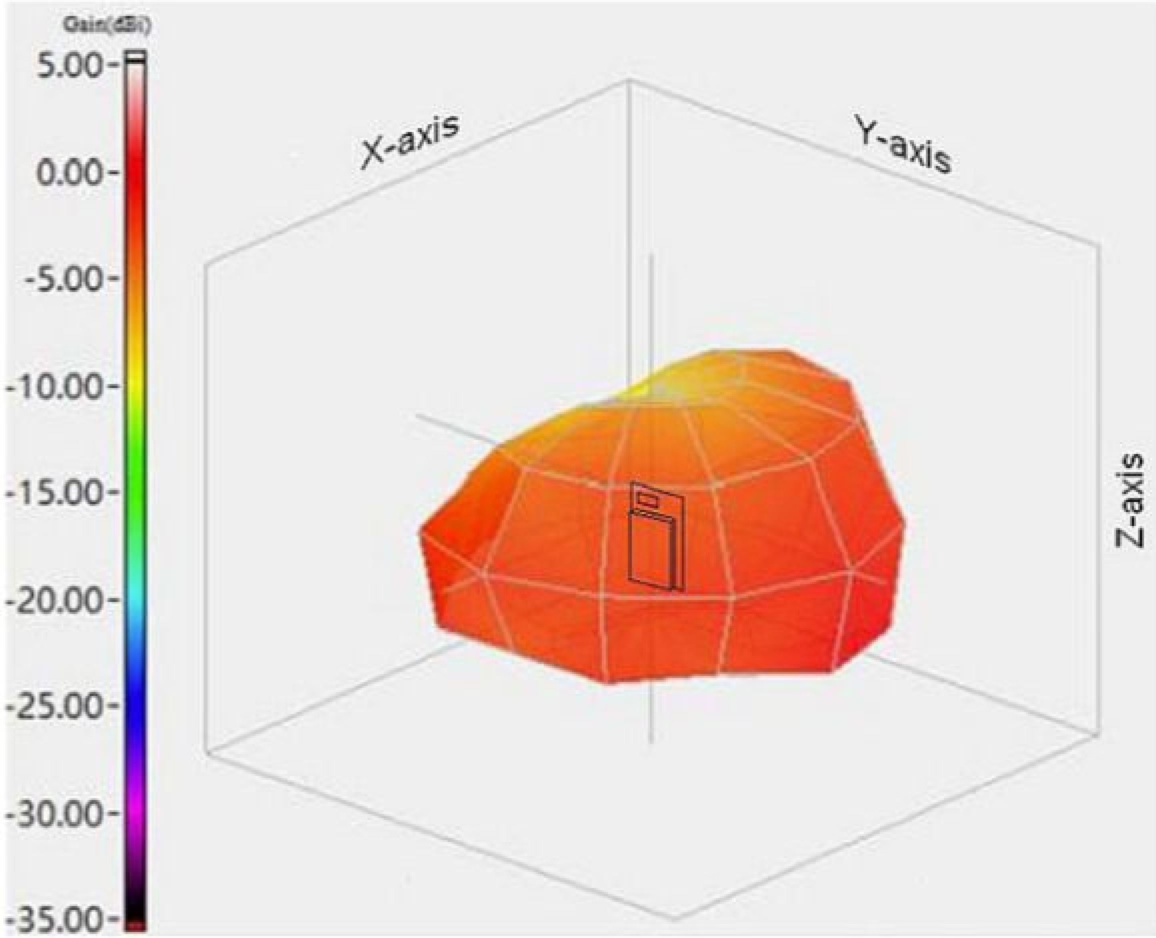


Figure 2.4.1 RN4871 Antenna Performance [5]

3. Cost and Schedule

3.1 Cost Analysis

3.1.1 Labor

To calculate the labor cost for this project, we will use the following equation to estimate:

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Labor Cost = Salary * Total Work Time * Number of Members
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According to the Engineering Career Center in UIUC, the average starting salary for a BS graduate is $78,159 per year in 2017-2018 report [2]. Converting to hours, it will be $37.58 per hour per person. As for the total work time, according to the Office of Provost in UIUC, we are expected to put three times the amount of work time in the number of credit hours we receive per week [3]. That is 12 hours of work time per week for Senior Design. Lastly, we have a total of 3 engineers in this group. The total labor cost will sum up to be $21,646.08 for a semester.

3.1.2 Cost

Part #	Qty	Mft	Vendor	Desc	Price/Unit	Total
K32L2B31VLH0A	1	NXP	Amazon	MCU with USB 2.0	$4.60	$4.60
RN4871	1	Microchip	Digi-Key	Bluetooth 5.0 Module	$7.06	$7.06
MT29F32G08C BADBBWP	1	Micron	Mauser	4Gx8 nand flash chip	$6.70	$6.70
LP-401230	1	Adafruit	Adafruit	3.7-4.2V and 100mAh	$5.95	$5.95
LP2953	1	TI	Digi-Key	Micropower voltage regulator	$5.86	$5.86
B0761LV1SD	1	MakerFocus	Amazon	I2C OLED, res: 128x32	$5.50	$5.50
FSM6JH	2	Tyco Electronics	Tyco Electronics	6mm tact switch	$0.16	$0.32

After adding up all of the components, the device itself will cost $35.99. This is assuming we are only making one device. If we order parts in bulks, the cost of components will be a lot less.

3.1.3 Sum of Grand Total

Summing up the grand total, we estimate the device's development cost is $21,682.07.

3.2 Schedule

Week of	Task
2/17	Finalize Parts/ Assign Development Roles/Sent first part request
2/24	Finish Design Doc/ Begin Board Development
3/2	Complete initial PCB Development
3/9	Review Development and Pass Audit
3/16	Assembly of board
3/23	Initial unit testing for individual components/ think of integration test ideas

3/30	Debug unit test/ early stage integration
4/6	Complete bulk of integration tests on board
4/13	Debug system(s)/Begin final verifications
4/20	Final verifications/presentations/Begin final paper
4/27	Demo and Presentation
5/4	Submit finalized documents

4. Discussion of Ethics and Safety

There are some safety concerns present in our device. Lithium-ion batteries have the potential to explode and cause fires under certain conditions like puncturing and overheating. In 2015, lithium batteries in hoverboards caused so many house fires that Amazon suspended their sales; e-cigarette batteries have combusted even when not in use; and the fire suppression system on airplanes is often inadequate at extinguishing lithium battery fires so captains must make emergency landings [4]. To prevent batteries from being exposed to these dangerous conditions, we will warn the user of the potential hazards and encase the battery and the device components in a puncture resistant housing. We could also monitor temperatures and suspend operation beyond a certain temperature threshold. Another common cause of lithium battery fires is overcharging. To prevent such a situation, we will ensure the device cannot charge beyond a certain voltage threshold. In order to prevent moisture from entering the device and causing short circuits, the casing will also have to adhere to IP67 guidelines.

When the user is operating the device while running, it is possible that he or she is not paying attention to his or her surroundings. When running on the streets, there is a possibility that the user is unable to hear incoming vehicles if the device is operating at a high enough volume. Although the runner is using the device to facilitate this situation, we believe the responsibility in this scenario lies with the user. This is a potential issue with every device with audio capabilities, but in the end, users do have a degree of responsibility when using any product. It is common practice to monitor one's situation while listening to music in order to avoid accidents or injury.

5. Citations

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