## Project Summary

Who is the customer and how is EMG useful?

Electromyography is a measurement of electrical activity in the muscle during movement. Electromyography as it is used now, sends muscle data signals to a host, where the information is later analyzed by a professional. There is currently a very high demand for EMG, especially to help athletes analyze their movement. The appeal of EMG is that the data is not immediate obvious, like it is for velocity-based training or force analysis. Electromyography gives athletes an even closer look at their movement by reading muscle signals to educate and help their routines. For example, EMG is used for athletes in analyzing squatting to determine whether an athlete's core was the limiting factor in the amount of weight they could lift. With this same research, we hope to design the Muscle Guide to help upper-body athletes, specifically weight lifters better understand their movement and determine places for improvement. Medical professionals are now able to interpret EMG signals to better the performance of athletes. In other words, EMG signals give athletes and trainers a glimpse of what is happening within the muscles when participating in a sport, and how to improve the muscle(s) to better prepare themselves for their sport.

Wearable box or phone application?

The Muscle Guide will include contact or surface electrodes to measure muscle activity of the user. The device will measure EMG signal(s) and send the signal(s) to a computer where it will be properly filtered and amplified for the data to be readable. Once sent to the computer, it will be displayed and analyzed later by the athlete or their trainer. In other words, all electronics needed to measure and filter the signals will be housed in a light-weight and small enough container to attach to the user's body during usage without hindering performance. We believe that the least amount of hindrance during performance can be achieved by using straps over the shoulders and around the neck.

## Engineering Analyses

1. **Data Rate Analysis:**

    1.1. Throughput Calculation

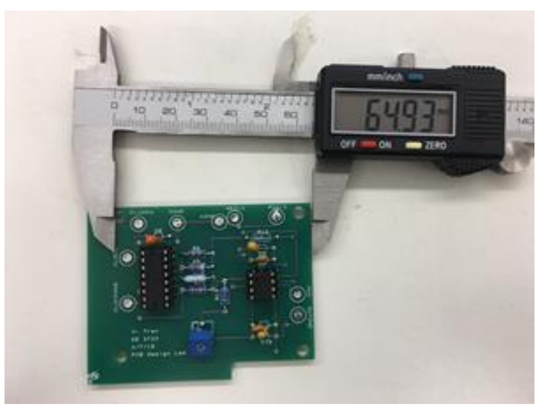
$$\text{Throughput} = \frac{payload\ size\ (bytes)}{transaction\ time\ (seconds)}$$

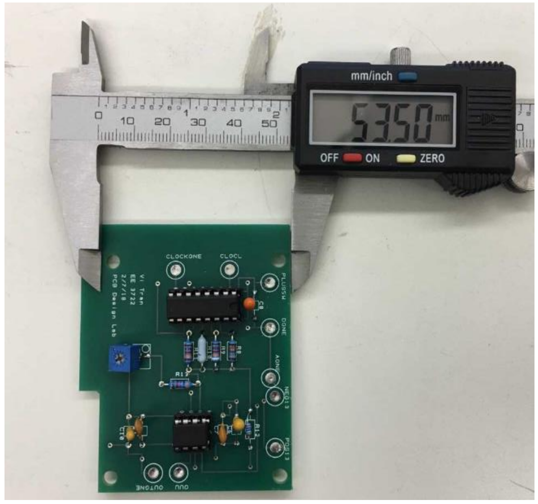
The payload size (bytes) of the muscle signal is 16 bytes. A test plan has been developed to determine the data rate for our device, and this plan will be executed during winter quarter once the muscle signal is successfully transmitted via Bluetooth. To meet Bluetooth standard 4.2 and qualify as a Bluetooth Low Energy (BLE) device the maximum theoretical throughput must be 739.2 kbps.

2. **Size and Weight Analysis:**

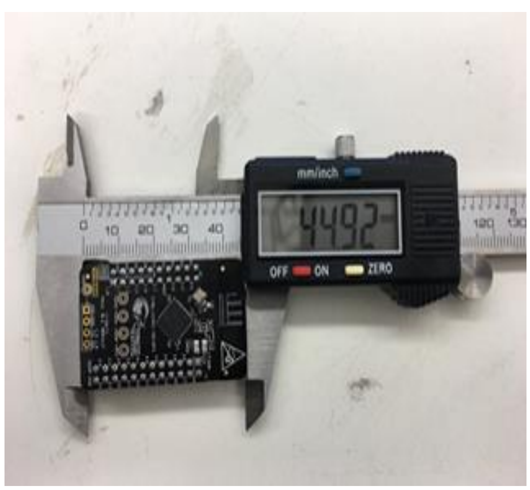
    2.1. Size

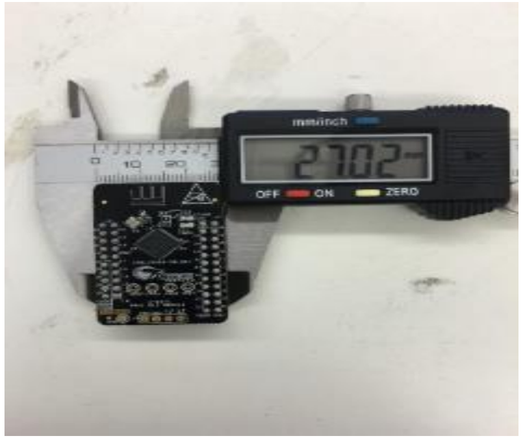
    2.1.1. PCB of Signal Conditioning Unit (SCU) Circuit





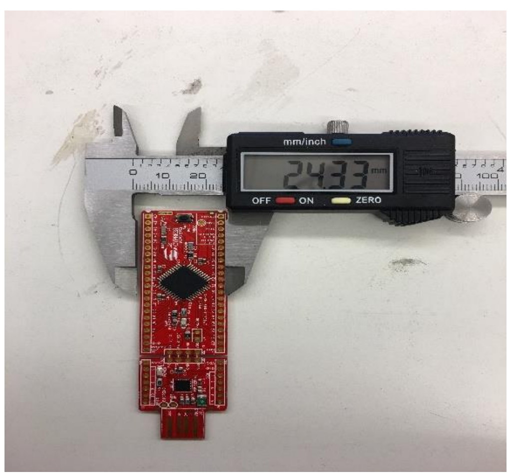

2.1.2. BLE Module

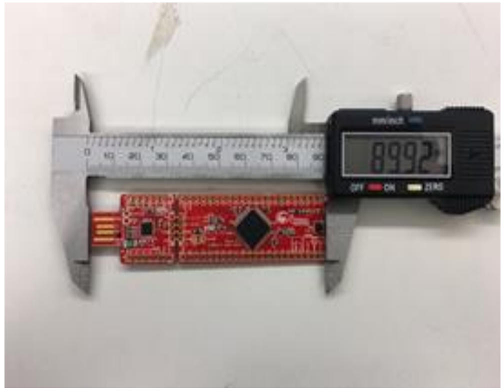


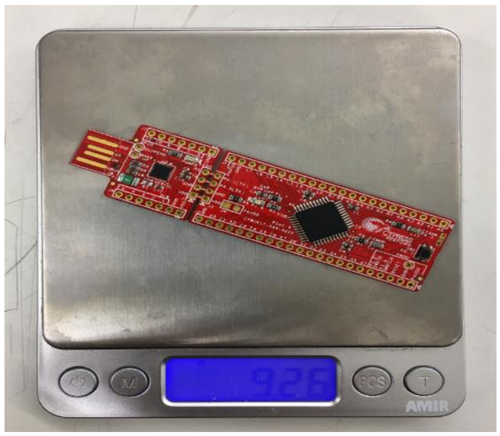




2.1.3. Breakaway board







2.1.4. Coin cell battery

2.1.5 Electrodes and Cables (Data found from datasheet)

## 2.2. Weight

The following general components listed below will be included in the final design.

| Components: | Weight: |
| --- | --- |
| Breakaway Board | 9.26 g |
| BLE module | 11.50 g |

| | |
|---|---|
| SCU PCB | 19.34 g |
| EMG electrodes & cables | 20.0 g |
| Coin cell battery | 3.0 g |
| Two (2) 9-Volt Batteries | 90.0 g |
| | Total: 153.1 g |

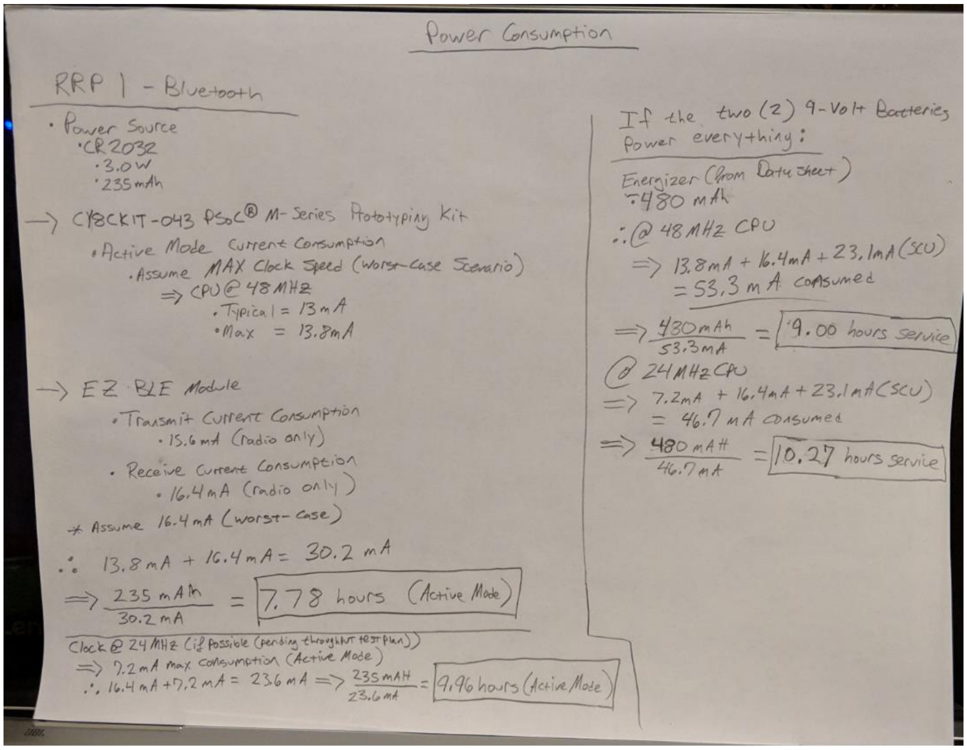
In conclusion of the size and weight analysis, there are many factors that contribute into the final design of the Muscle Guide. For Notorious EMG, weight and size has always played a significant role in the design process. We now feel comfortable that we can keep the final design weight under two pounds. This was achieved by getting rid of the PSOC4 kit and replacing it with the Breakaway Board. This reduced our weight by approximately 13%. This reduced weight also produced the capability to arrange our three major components in a tighter, more condensed configuration than what was achieved in our prior design. The new design will enable us to configure our housing unit by arranging the Breakaway Board and BLE module directly above the Signal Conditioning Unit (SCU) PCB. The new alignment of components means that the final design size will be reduced by approximately 14% its original size. This is not as impactful as our weight reduction, but with the appropriate PCB design we feel confident that the design may potentially exceed reductions up to 20%.

## 3. Data Storage Analysis:

The size of the BLE program is currently 11 kb. For our final product, we intend to use the PSoC 4 M-Series prototyping kit. The kit includes a break-away programmer/debugger on a USB connector, and this is desirable to minimize size. This kit includes 16 kb of SRAM which means there is approximately 32% of memory remaining should the program size increase.

## 4. Power Analysis:

### 4.1. Calculations




4.2. Conclusions

If we use the CR2032 coin cell to power the breakaway board and BLE module then we can expect a service life of **7.78 hours** in active mode at 48 MHz CPU. Once the test plan for the data rate has been executed, we will be able to determine if the CPU speed can be decreased. If so, a speed of 24 MHz consumes nearly half the current at 7.2 mA, and this offers a service life of 9.96 hours in active mode.

If the two (2) 9V batteries are to be used to power everything (including the signal conditioning unit (SCU)) then the datasheet indicates a capacity of 480 mAh at approximately 50 mA consumed. At 48 MHz CPU a service life of **9 hours** is expected in active mode, and at 24 MHz a service life of **10.3 hours** is expected in active mode. This option is not suitable at the moment since a transformer would need to be selected and installed to transform voltage down to a usable level for the prototype board. Further, a size and weight analysis would need to be completed on the transformer which would significantly increase the mass. Finally, this power analysis would need to be re-accomplished to analyze the transformer loss. This will then require further heat analysis, and, for these reasons and with the allotted time, the best design choice is to use the CR2032 to power the prototype board and BLE module, and the two 9 V batteries will be used to power the SCU.

It remains that, if the two (2) 9V batteries are to only power the SCU, a service life of >> 8.75 hours is expected at 23.1 mA consumed. Note that the datasheet reports that at 50 mA of constant current a service life of 8.75 hours can be expected.