SWIMMING DATA TRACKER

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Abstract

Swimming trackers are expensive and are difficult to calibrate quickly. The University Laboratory High School swim coach approached us to design a simple and effective timer for training purposes. The tracker uses a computer program to initiate the start of training and allow the user to set desired values for rest times or lap times. Our swimming data tracker utilizes 4 buttons that are simply pushed after the swimmer has finished his set lap. The internal counter will then display the user's set rest time or the remainder of the user's set lap time. Once the lap is complete, each separate time will be sent to the laptop and arranged in an excel sheet. This will give the user a simple and easy to read list of each swimmers time. This hands free device will allow the user to focus on other tasks and track increases/decreases in the swimmers pace.

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1. Introduction

1.1 Purpose and Usefulness

This project was selected because there is a need for easier swim time tracking during practice. We have been given specifications by Illini swim coach Howard Schein who we will work with throughout our project. We are convinced that this product will be marketable since it is easy to set up for swim training in public pools. We are looking forward to improving the process of swim training by giving the coach “hands-free” lap timing, minimizing set-up time, and gathering data easier. Our final product will be a battery powered, poolside module that can track incoming swimmers and wirelessly relay their data to a computer where it can be transferred and observed on a user friendly interface such as Microsoft Excel.

The following sections will elaborate on the design of the project and include simulations and a detailed description. We will cover the requirements and the tests need to verify them. The cost of this project is one of the most important aspects and the list of products including costs will be displayed and further commented on. To finish off the report, we will discuss the accomplishments and uncertainties of the project and also future ideas of our project.

1.2 Functions

The functions of this project are very simple and that is why our project will be a success. Our project will give the user a simple and hands free method of recording swimmers lap times during practice. Our project can record up to four swimmer’s lap time in a single lane. Our software also is designed to incorporate more button boxes for different lanes and therefore giving the user the ability to track as many swimmers as he needs. This function will be useful for big swim teams or events.

One of the main functions required for our project to be successful is the function of being able to view trends in the swimmer’s lap times. The user will be able to visually see if a swimmer is becoming slower or faster than previous sessions by pulling up a simple excel document. The excel document makes it easier on the user to view the times and since it is always updating, the times are communicated immediately. This immediate response will give the user same time information and that is needed during training sessions.

1.3 Blocks

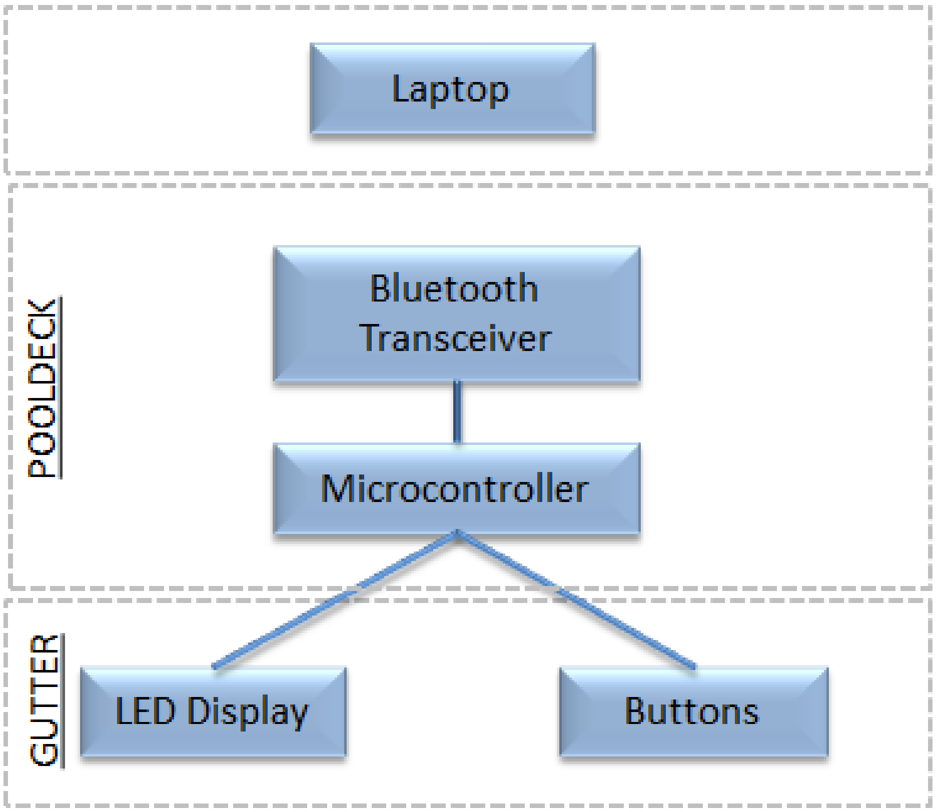

Figure 1 – Block Diagram

1.4 Block Descriptions

1. Power Supply

   The power supply will be a bank of removable batteries installed inside the waterproof enclosure. We will need 3 – 6 V to power a Bluetooth transmitter and microcontroller. Therefore we will use a 6V battery to power the electronics in the waterproof enclosure. We will have a rechargeable battery that you can plug into the wall while you are not using it. It will be only able to charge when the power switch is off.

2. Laptop

   The computer will be provided by the user so the system must be universal in the sense that there are many options that the user could bring. Almost all laptop computers now have Bluetooth capabilities so it will be assumed that it connect with the Bluetooth modem attached to the microcontroller. The computer will send the microcontroller a signal that will then tell the swimmers to begin their laps. When the swimmer reaches and activates the sensor, the microcontroller will then send back a time as well as identification unique to that sensor. Initially, this data will be logged in a simple .txt or .csv file. When the user notifies the computer that the swimmers have finished, the .txt or .csv file will close and then be opened in Excel where the data can be logged in a user friendly way and perhaps linked to past information to help track athlete progress.

3. Microcontroller

The microcontroller will be an ATmega328. This chip is low powered and it will not drain the battery quickly. It also provides a safety net if dropped into the water. However, it does have the processing power that we will need to provide communications and calculations between the swimmers and ultimately the computer. Serial ports (up to 115,200 baud rate) will allow the microcontroller to send dense amounts of data via Bluetooth transmission to the computer where it can then be processed and organized in a reader friendly manor. Digital outputs will allow to control the LED's and pass information to the swimmers such as when their next lap will start. The chip also includes 35Kb of memory that will hold the program as well as temporarily hold data to ensure that the computer has received it. ATmega328 will run by an external 16MHz crystal which will provide ample speed for the products functionality.

4. Buttons

There will be a block of four buttons located in the box on the gutter. Each button will be designated for a single swimmer. Once the coach initiates the program and swimmers return and press the button, it will stop the timer and trigger the rest period. Once all the rest periods have taken place, the last time the swimmer presses their button it will stop the timer.

5. LED signals and 7-Segment

In the housing there will be a 7-segment display and an array of four green LED's. These will inform the swimmers on the status of their program. Once the program has been turned on, the 7-segment display will countdown for the first swimmer when there is nine seconds left of rest time. When the countdown reaches zero the green LED array will turn on. The next 7-segment display will be providing countdown for the next swimmer starting at the designated interval. Once each swimmer has returned to the poolside and activates their sensor, their corresponding green LED turns off to inform them that their time has been logged.

6. Bluetooth Transceiver

To wirelessly communicate between the microcontroller and the computer, the product will take advantage of the JY-MCU Bluetooth Modem. The modem operates at standard 2.4GHz with a maximum baud rate of 115,200, the same as the ATmega328. The unit will be tested to provide communication over 50+ feet. The modem will be physically connected to the microcontroller via PCB and sit in a waterproof container. From there, signals from the microcontroller will be sent to and from the computer holding data about the swimmers, their times, and the practice program the coach has selected.

2 Design

2.1 Schematics

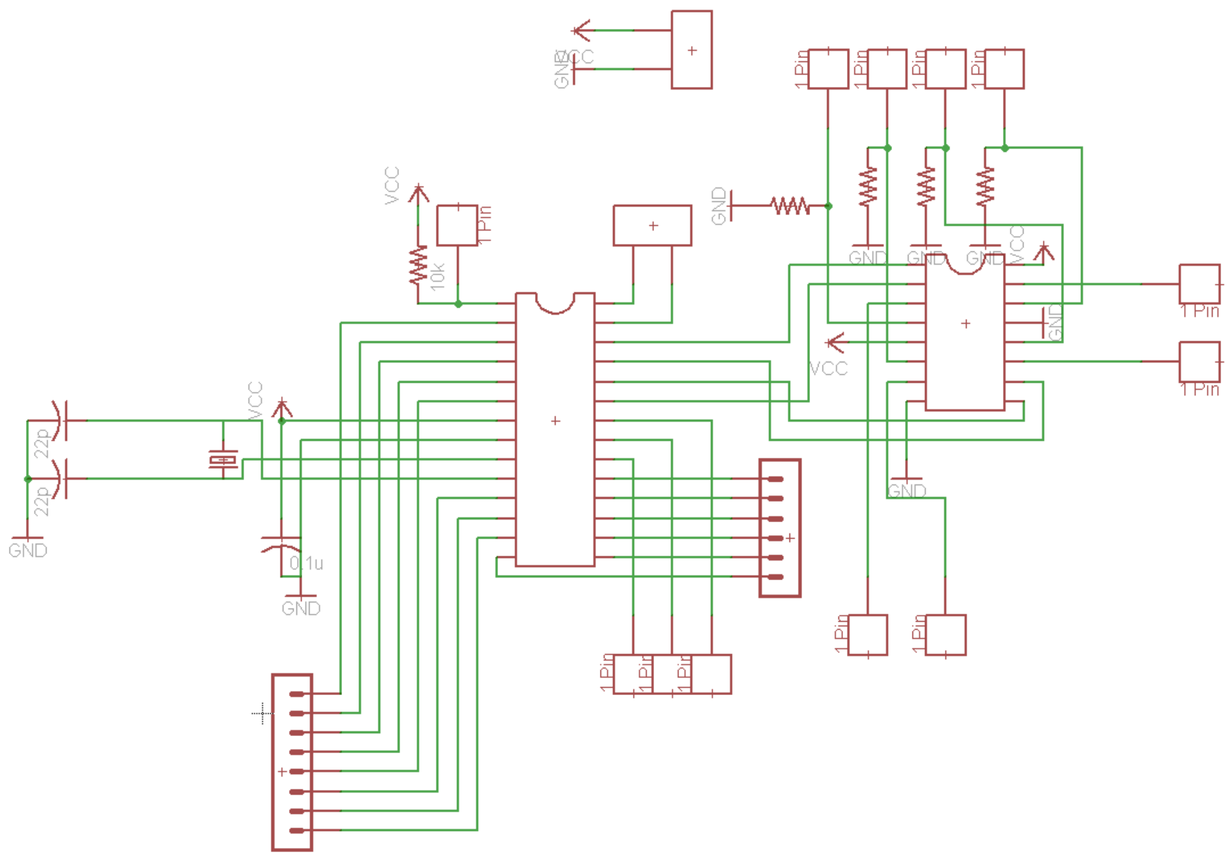

Figure 1. Microcontroller schematic with a debouncing circuit

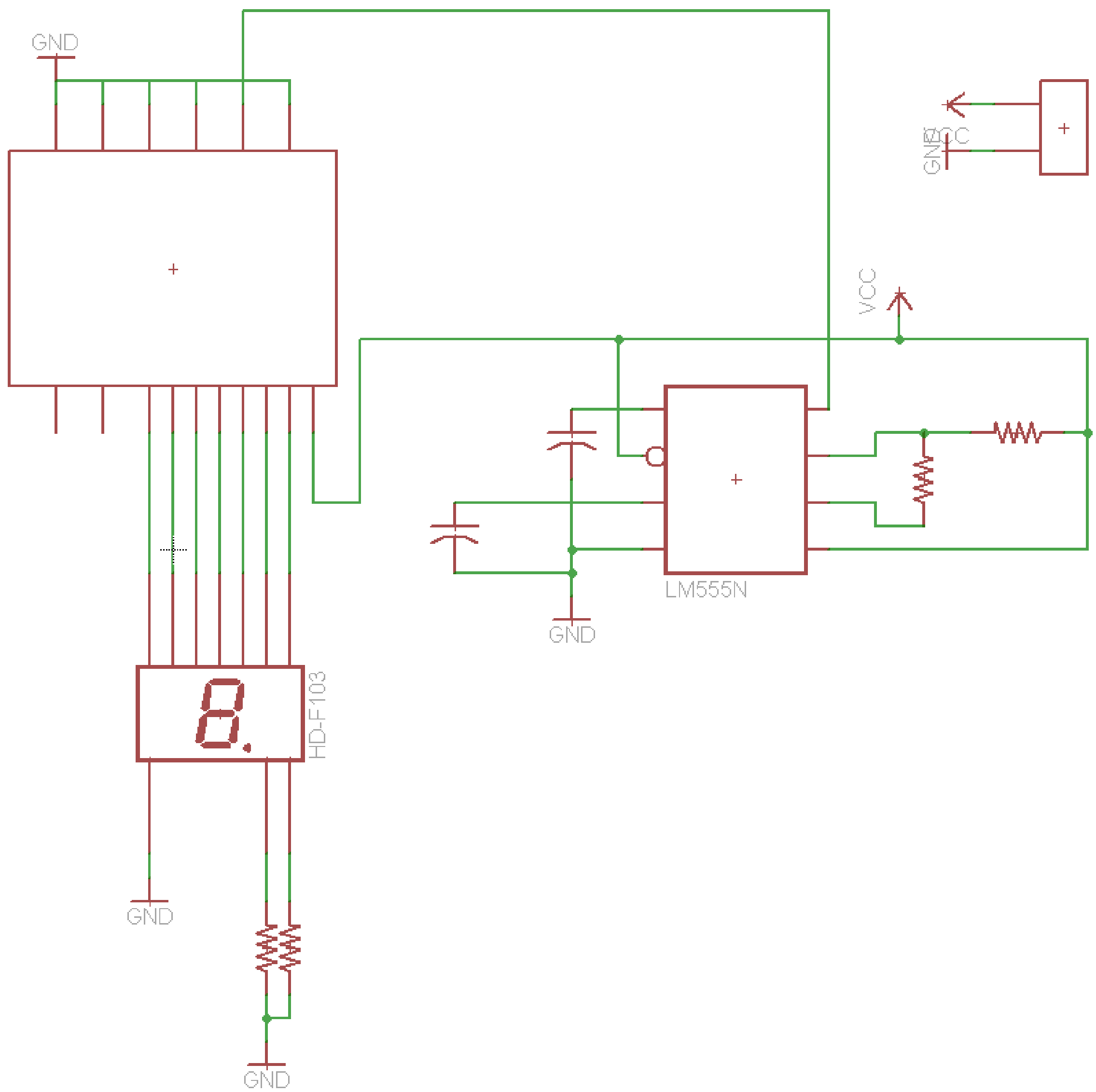

Figure 2. Display schematic

2.2 Simulations

Below is our simulation of engaging our button. It shows that there is no "bouncing" in our button. However, we will create a debouncing system for our buttons to make sure there is no chance of any "bouncing".

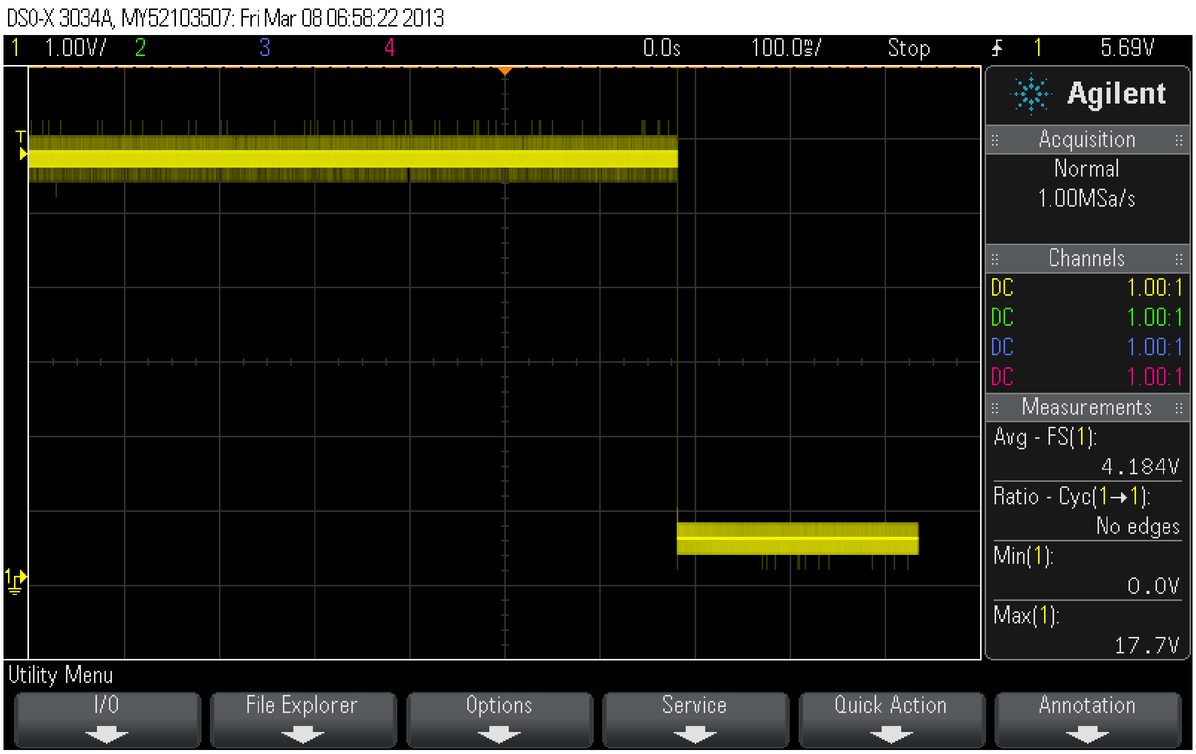

Figure 3. Debouncing check simulation

The first bluetooth simulation was at a distance of 3 feet. 300 random binary bits were uploaded to an Arduino. These bits were then sent via Bluetooth to a computer located 3 feet from the Arduino's Bluetooth module. Figure 4 shows the outputted data. The data received will be compared to the data sent in section 3.2.

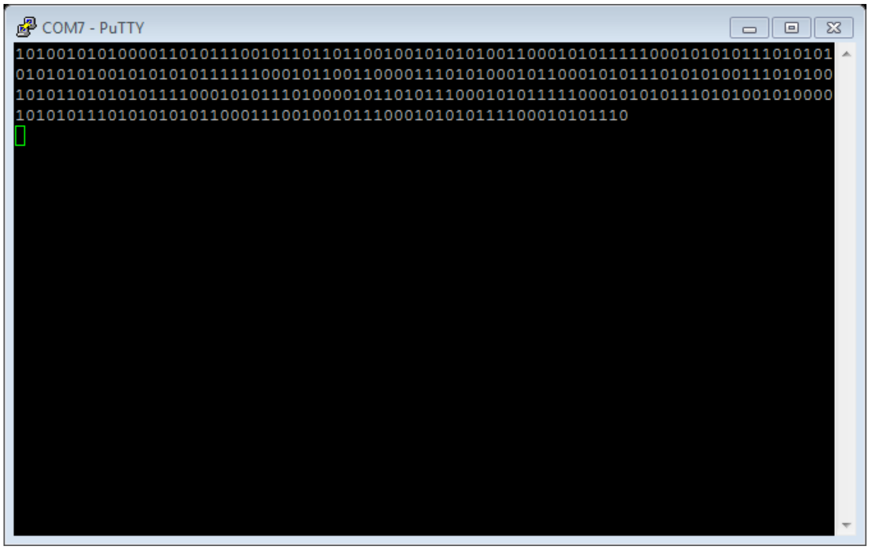

Figure 4. Bluetooth Transmitted Data 3 Feet

The second Bluetooth simulation was at a distance of 51 feet. 300 random binary bits were uploaded to an Arduino. These bits were then sent via Bluetooth to a computer located 51 feet from the Arduino's Bluetooth module. Figure 5 shows the outputted data. The data received will be compared to the data sent in section 3.2.

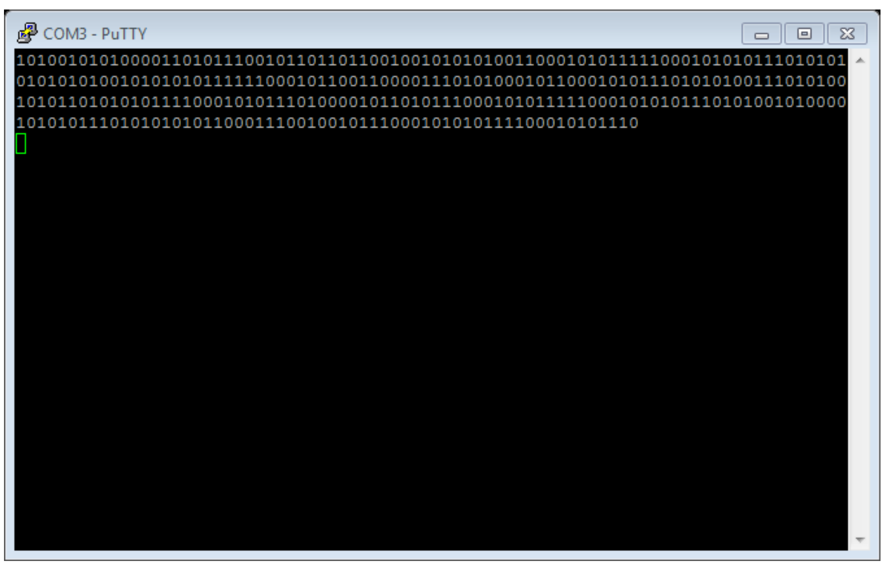

Figure 5. Bluetooth transmitted at 51 Feet

2.3 Results

Figure 6 shows the results of both the Bluetooth transceiver requirements and requirement 4 of the microcontroller.

Sent Data

10100101010000110101110010110110110010010101010011000101011111000101010111010101010
1010100101010101111111000101100110000111010100010110001010111010101001110101001010 11
010101011111000101011101000010110101110001010111110001010101110101001010000101010111
01010101011000111001001011100010101011110001010110

Received Data at 3 Feet

10100101010000110101110010110110110010010101010011000101011111000101010111010101010
1010100101010101111111000101100110000111010100010110001010111010101001110101001010 11
010101011111000101011101000010110101110001010111110001010101110101001010000101010111
01010101011000111001001011100010101011110001010110

Received Data at 51 Feet

10100101010000110101110010110110110010010101010011000101011111000101010111010101010
1010100101010101111111000101100110000111010100010110001010111010101001110101001010 11
010101011111000101011101000010110101110001010111110001010101110101001010000101010111
01010101011000111001001011100010101011110001010110

Figure 6. Data Transmitted Compared to Original Data

Figure 6 shows that all the bits were transmitted correctly. This gives a 0% transmit error which is in the limit of the originally stated 2% transmit error.

2.4 GUI

The following figure shows the graphical user interface that the user will interact with. The GUI is easy to use and allows for multiple swimming modes to be used. The GUI also incorporates the future use of multiple swimming data tracker products in multiple lanes. The GUI was built using Processing IDE. (1)

Figure 7. Graphical User Interface

3. Design Verification

Verifying our project didn't really take place until all of our components were connected together. Since our components relied on each other then we needed to have it running to verify each part.

3.1 Power supply

Our power supply went from a 12V battery to a 6V battery due to the Bluetooth maximum operating voltage. We measured the voltage of the battery and found it to be 5.849V (-2.52%) which is within our limit of +/- 5% Volts. Our current battery is not able to be recharged through the wall and due to our power study; our system will need to be powered by a rechargeable battery. Our battery is able to output 12 A-hrs and 5.849V. Our system at 5.98V will consume .9A. Therefore, we multiply our systems voltage and amperage and we get 5.382W of power to our system. By taking our original battery data, we find that it outputs (5.849*12) = 70.188W/hrs. Therefore, there is (70.188/5.382) ≈ 13 hours of operation time.

3.2 Buttons

The buttons were the easiest verification testing we had to do. We simply applied a signal to one pin, pressed the button, and viewed the signal on the opposite pin. You can see our testing in Figure 3 where the button was engaged and released.

3.3 LED Signals

The LED's were fully visually verified. We connected a source to the LED's and visually verified they would light up. The 7-segment display is also visually verified since we knew how long our rest time was going to last, we counted down until the 7-segment display would trigger. The display triggered correctly with our coordinating time.

3.4 Microcontroller

Testing the microcontroller was the most time consuming. We tested that the timing mechanism was triggered and correct by manually timing each set lap time that we had. We also verified that the timing mechanism was triggered due to the turning on/off of the LED on the PCB's. By checking our excel sheet, we can tell that four times have been recorded by the microcontroller and sent via Bluetooth to the laptop. The GUI will allow us to vary the lap/rest times and therefore we can manually time the change in times from the box.

3.5 Bluetooth Transceiver

During the start-up process, we sent 300 bits via the Bluetooth component to the laptop and back shown in Figure 4, 5, and 6. We had no faults in this message and therefore we hooked up the Bluetooth to the actual project and tested. (2) The Bluetooth sent correct data with times from the microcontroller to the laptop where we visually verified on the excel sheet.

3.6 Laptop

Testing the laptop was partially done by testing the Bluetooth and by testing the rest/lap times manually with a stopwatch. The main testing of the laptop consisted of verifying correct data being sent and displayed in an excel sheet. This was done through code and verified visually by seeing correct data in the sheet.

3.7 Enclosure

Testing the enclosure was done by simply pouring water directly on top of the enclosure and visually checking the inside to see if water has leaked into the box. The buttons, connectors, and switch were all waterproof and held the water outside of the box. Also, before the box was given to us by the machine shop, Glenn poured water into the enclosure and made sure that no water would leak out. Therefore, our enclosure has been tested inside and out.

4. Costs

4.1 Labor

Table 1. Labor Costs

Name	Hourly Rate	Total Hours Worked	Total = Hourly Rate x 2.5 x Total Hours Worked
Phil Niemerg	$35.00	200	$17500.00
Lin Stacey	$35.00	200	$17500.00
Ryan Turner	$35.00	200	$17500.00
Total	$105.00	600	$52500.00

4.2 Parts

Table 2. Parts Costs

Item	Part Number	Quantity	Retail Cost ($)	Bulk Purchase Cost ($)	Actual Cost ($)
Button's		4	$60.00	$50.00	$200.00
ATmega328	COM-09061	1	$4.30	$4.30	$4.30
Crystal 16MHz	COM-00536	1	$0.95	$0.95	$0.95
10 KΩ Resistor	COM-08374	4	$0.25	$0.25	$1.00
1 KΩ Resistor	COM-08980	4	$0.25	$0.25	$1.00
22pF Ceramic Capacitor	COM-08571	4	$.50	$.50	$2.00
.1μF Ceramic Capacitor	COM-08375	4	$0.75	$0.75	$3.00
5mm Red LED	COM-09590	2	$0.70	$0.70	$1.40
5mm Yellow LED	COM-09594	4	$1.40	$1.40	$5.60

Item	Part Number	Quantity	Retail Cost ($)	Bulk Purchase Cost ($)	Actual Cost ($)
5mm Green LED	COM-09592	4	$1.40	$1.40	$5.60
Bluetooth Modem - BlueSMiRF RP-SMA	WRL-00158	1	$65.00	$65.00	$65.00
Waterproof Wire Connectors		2	$5.00	$5.00	$10.00
PCB		1	$20.00	$20.00	$20.00
6V Battery		1	$25.00	$25.00	$25.00
Waterproof Enclosure		1	$50.00	$50.00	$50.00
TOTAL COST					**394.85**

4.3 Grand Total

Table 3. Grand Total Costs

Labor ($)	Parts ($)	Grand Total ($)
52500.00	394.85	52894.85

5. Conclusion

5.1 Accomplishments

Being a senior in electrical engineering at the University of Illinois, this was our first project we designed and built from scratch. This whole project was an accomplishment to all of us. We have met every deadline and even beat deadlines by a few days. We were organized in the design and planning to where everyone knew what to do and when to do it. Our organization and planning are the biggest accomplishments of this project.

To actually feel fully accomplished with this project, everything had to and needed to work. Our PCB designs failed for our first try but our second requested PCBs worked perfectly. This accomplishment was the key to a working project. Waterproofing the box was another issue of our project. Since the box will be located next to water, we need to have a sealed box where no moisture will enter the box. After testing our box for waterproofness by pouring water over it, it was a great relief and a feel of accomplishment to see our box is waterproof. Our group accomplished a functional design that was a success and very intriguing to Howard which was our major focus.

5.2 Uncertainties

Our project is designed be user friendly and "plug-and-play". This user friendly feature relies on everything working and no uncertainties. One of the biggest uncertainties is the use of a non-rechargeable 6V battery. Since our rechargeable battery was not reliable, at the last second, we replaced it with a 6v non-rechargeable battery. We believe that our system will not use a great amount of power and the non-rechargeable battery will be sufficient to power our system for an extended period of time.

More uncertainties come to us when we think of marketability and cost. There are a handful of swimming timers but they are very expensive and take time to set up. Our project is a great design but will people want to buy it for the set price of $300 after mass production? Another uncertainty is the lifetime of our project. How long will our project last under the certain conditions? If our project were to be sent to market, these questions would need to be answered.

5.3 Ethical considerations

Ethics is a very important issue when it comes to an engineering project that must be taken into consideration. This project has a couple of ethical issues that need to be addressed and considered. The following issues are from the IEEE code of Ethics, the numbers correspond to the ethical issue number.

1. *to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment*

Since the project will be near the location rule one of the IEEE Code of ethics needs to be address. This rule must be addressed because of the use of electrical hardware next to a swimming pool. The hardware will be enclosed in a waterproof box however this must be addressed in case the electrical components would be exposure to water. If this were to occur, for example the box falling into the pool or a broken box, the water would short the hardware and not cause damage to the patrons. Only 12-volts will be used causing no harm to come to the patrons. However, there will be a broken nonfunctional hardware.

3. *to be honest and realistic in stating claims or estimates based on available data*

This rule is important because the project will be sending information wirelessly by Bluetooth to a computer. It is important and ethical to deliver appropriate claims about how far the data can be sent. The computer will need to be within range to receive the data being sent.

9. *to avoid injuring others, their property, reputation, or employment by false or malicious action*

Due to this project being used in public pools, it is important that the project does not damage the property of the pool. It is also very important that the project does not injure any patrons.

5.4 Future work

The main objective left to be completed for the project is an easy to use user manual. Howard Schein will be using this project in his pool and it is necessary that he has documentation that will step him through how to use the product. It must easily illustrate how to operate the product so that anyone can use it. The user manual will explain how to set up Bluetooth communication, how to use the GUI, and how to transfer the files into Excel.

After talking to Howard another future task would be adding a LCD display to each display PCB to display the swimmers current time. This is definitely possible however a new designed display PCB would be needed. A new microcontroller with more output/input pins may be needed as well. This would lead to a redesigned microcontroller PCB.

References

[1] Fry, Ben, and Casey Reas. "Getting Started. Welcome to Processing!." *Processing*. N.p., n.d. Web. 1 May 2013. <http://www.processing.org/learning/gettingstarted/>.

[2] "User Guide for: Blue Radios Bluetooth Intelligent Serial Module AT Command Set." *Blue Radios*. Blue Radios,Inc, n.d. Web. 23 Feb 2013

Appendix A

Requirement and Verification Table

Requirements	Verification
Power Supply: 1. The battery unit should contain a full-charge voltage. 2. The battery should be rechargeable via wall outlet. 3. The battery should be able to recharge in 20 hours. 4. The battery should have a discharge rate of 12 hours.	1. Probe battery terminals with multimeter, voltage should be 6 V +/- 5%. 2. Probe battery terminals with multimeter before charging. Plug battery into wall and let charge for 1 hour. After charging probe battery terminals again, the voltage should increase. 3. Drain battery to 0 Volts. After connecting the terminals to a charger, plug battery into wall and let charge for 20 hours. Probe the battery terminals with a multimeter, voltage should read 6 V +/- 5%. 4. Connect battery terminals to a load requiring 7Ah. Using a multimeter take measurements every 1-2 hours. Voltage should be 0 volts in 12 hours.
Buttons: 1. Signal is grounded when button is open. 2. When pushed the buttons must transmit a signal.	1. Probe button terminals with multimeter. 2. Probe button terminals with multimeter, check that 90% of load is transmitted.
LED signals: 1. LED's must light up when a 2mA source is connected to them. 2. 7-Segment display will countdown with 10 seconds left of the rest swim stage. 3. Green LED must turn on with go swim stage.	1. Connect the LED terminals to a 2mA source. 2. During rest stage 7-segment display will count down/be illuminated. 3. During go stage green LED will be illuminated.
Microcontroller: 1. The microcontroller must time and record 4 time periods. 2. The buttons must trigger the microcontrollers timing mechanism. 3. The microcontroller must record correct swimming times. 4. The microcontroller must send data to the Bluetooth. 5. The microcontroller must be able to store 4 different time recordings. 6. The microcontroller must be able to vary the rest times via the laptop.	1. Output recorded times to text file. 2. Output time when button is pushed along with every ten seconds until button is pushed again. 3. Output time, compare with manual stopwatch. 4. Transmit a 300 bit binary code with max 2% error. 5. Directly access the microcontroller's data and output time records from corresponding outputs. 6. Vary the rest times via laptop and run different lap time tests and output the rest times used in the tests.
Bluetooth Transceiver: 1. The Bluetooth transceiver must	1. Transmit a 300 bit binary code with max 2%

communicate with the laptop. 2. The Bluetooth transceiver must transmit data to the laptop up to a 50+ ft radius.	error. 2. Transmit a 300 bit binary code with max 2% error at a range of 50+ feet.
Laptop: 1. The laptop must be able to communicate with Bluetooth transceiver. 2. The laptop must be able to adjust the rest periods for each of the four swimmers. 3. The laptop must run a program to transfer data received from the Bluetooth transceiver to a data sheet.	1. Transmit a 300 bit binary code with max 2% error. 2. Vary the rest times via laptop and run different lap time tests and output the rest times used in the test. 3. Run different lap time tests and output times in a text file (Excel Sheet Form).
Box: 1. Pool gutter box must be waterproof. 2. 7-segment display must work in wet conditions. 3. Green LED must work in wet conditions. 4. Buttons must work in wet condition.	1. Pour 5-gallon bucket of water directly on top of the box. 2. 7-segment display counts down in rest period. 3. Green LED lights up during go period. 4. Swim times are outputted to computer.