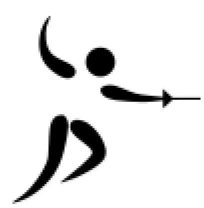
EEL 4924 Electrical Engineering Design
(Senior Design)

Final Report

26 April 2012

Remote Fencing Scoreboard
Gator FenceBox



<u>Team Members</u>: Adrian Montero and Alexander Quintero

Project Abstract:

The scope of this project is to build a sophisticated fencing scoring machine that can be remotely controlled using a Smartphone. In the sport of fencing, there are three main weapons: Epee, Foil, and Saber. Each weapon works differently and has unique timing rules that must be programmed into a microcontroller. Four sets of LED blocks will be designed to notify in real-time the sensing of electric contact between fencers. Additionally, the scoring machine will have seven 7-segment LEDs to implement a remotely controlled programmable clock and scoring board. A Bluetooth IC will be interfaced with the microcontroller to receive commands from a remote Smartphone application. Some of the commands will include the selection of weapons, clock programming, score updating control, and a soft reset.

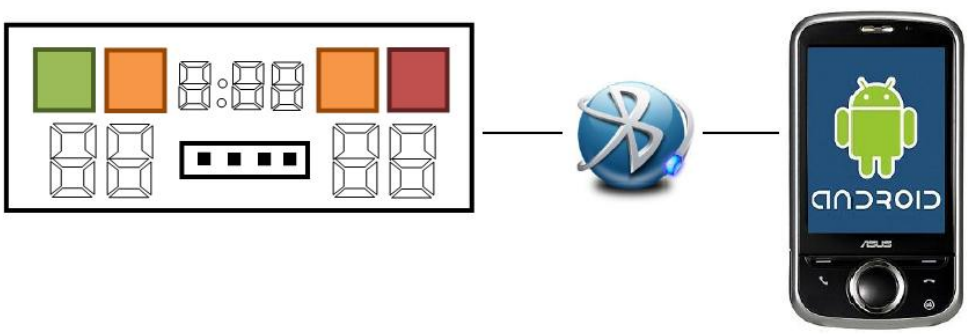


Figure 1 - Basic overview of the Gator FenceBox

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Introduction:

Scoreboards are a major part of any type of sport, regardless of whether they are digital or not. Their function is generally very basic, but also very useful: to keep score of a present event, game, or match. However, in the sport of fencing, the scoreboard is actually an integral part of any match. Here, the scoreboard, or scoring box, is interwoven into every match as each fencer is physically connected to the scoring box through reels of wire which will be used throughout a match for contact detection between two fencers. Upon contact, the scoring box will either turn on the corresponding light block of the player that made valid contact, or remain idle if the contact was not valid. It is then up to the referee to update the score which is also displayed on the scoring box. This is the basic operation of a fencing scoring box.

The complex, yet intricate electrical functionality of a fencing scoring box was very appealing to us and was a factor in our selecting to do this project. We were also motivated to build this project because of the lack of scoring equipment in the University of Florida Fencing Team. A scoring system of this complexity ranges commercially from the price of $500 to $1000; however we believed that we could build such a system for roughly less than that price range. The novelty of our design is the use of a Smartphone to interface with the scoring box and control the scoring system, instead of building a remote control, which is the current standard. The increased use of the Smartphone in today's society makes this system very appealing and easy to use.

Hardware:

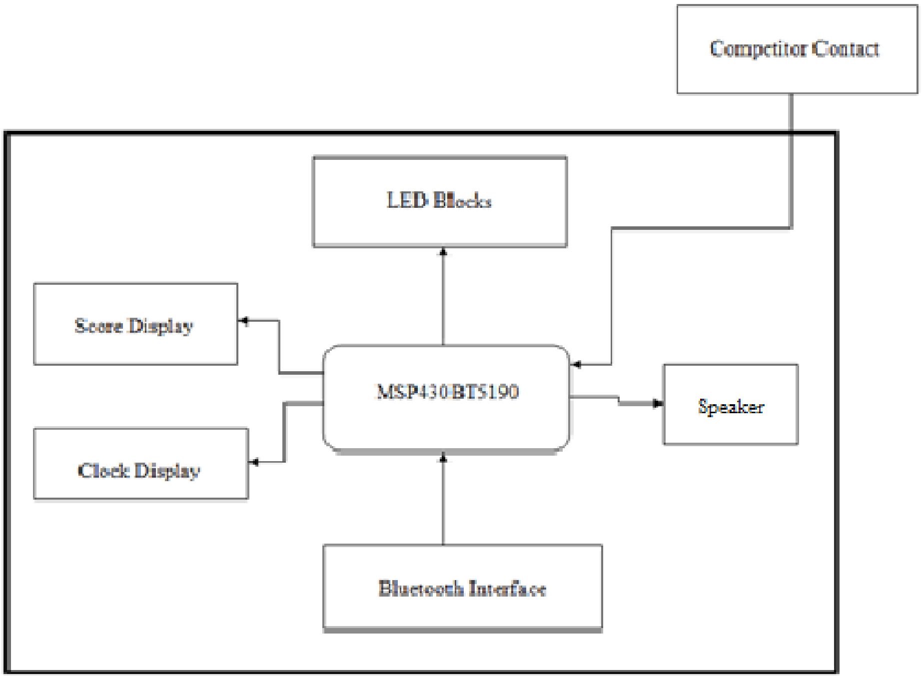

Figure 2 - Basic block diagram

I. Developmental Tools

One of the first steps in starting our project was agreeing on the necessary developmental tools to use for a prototype. Since our project revolves around the use of Bluetooth for information transfer, finding a microcontroller that could interface with a Bluetooth IC was key. We decided to use the **MSP430F5438 Experimenter Board**. It is a Development board with sufficient I/O ports and the necessary peripherals to implement, test, and debug our design. We also decided to use the **PAN1323ETU**, a Bluetooth development module that is compatible with the MSP430F5438 experimenter board and was used for the purpose of interfacing a Smartphone with the microcontroller for scoreboard operation.

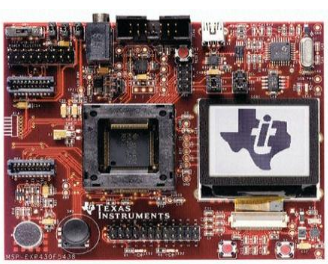

Figure 3 - MSP430F5438 Experimenter Board and PAN1323ETU Bluetooth development module

II. Hardware Components

The overall scoring box will contain 4 LED blocks for indicating contact and proper weapon connection; a 7-segment LED block that will contain 2-7segments for each fencer and 4 7-segments for the clock; an audio block that contains a D/A converter, an audio amplifier, and a speaker for event notification; and finally, the Bluetooth block that will contain the Bluetooth development module that will interface the Smartphone to the scoring box. The following block diagram illustrates the connectivity and interaction of these components:

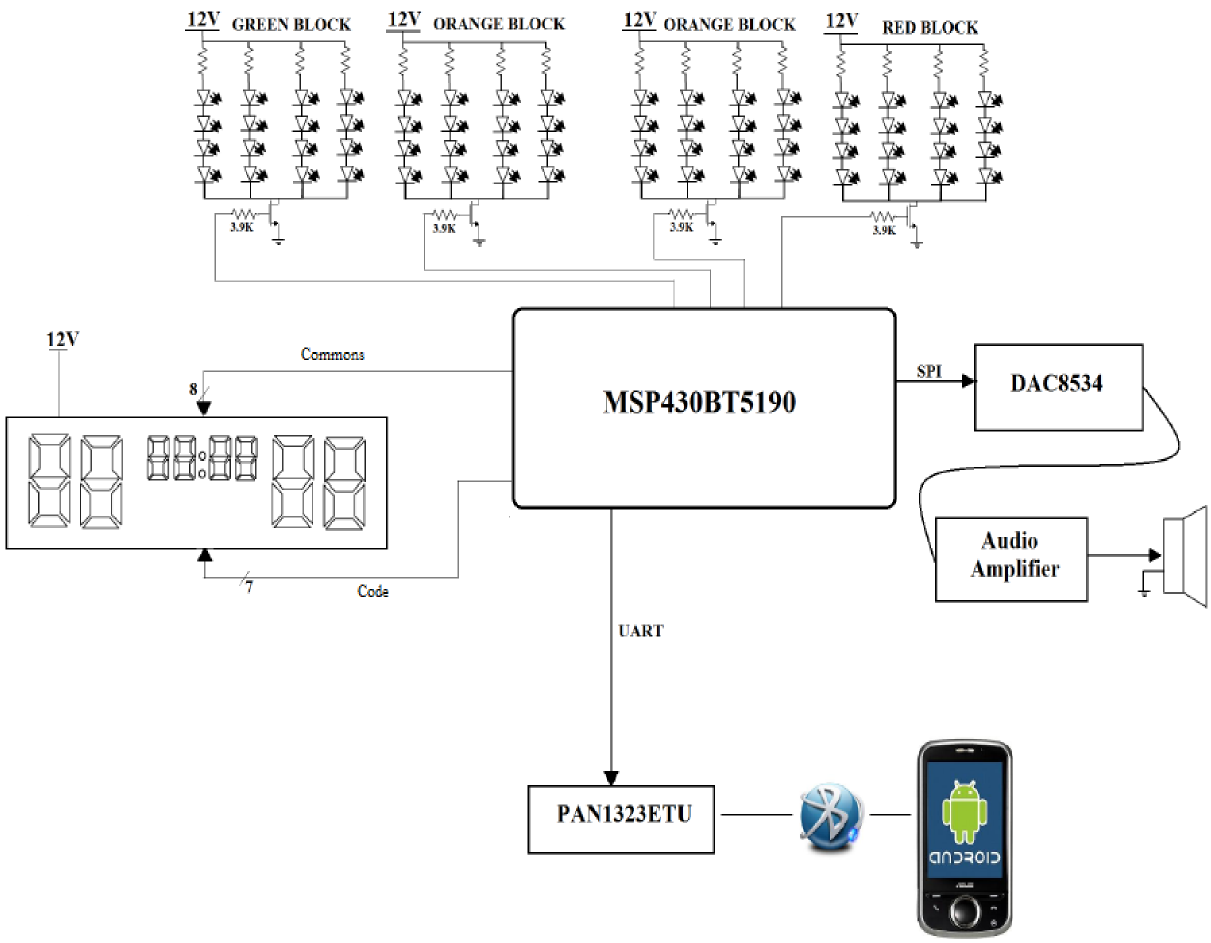

Figure 4 - Detailed block diagram of project sections and their interaction

In the LED blocks section, there are 4 blocks: A green and an orange block for player 1 and a red and an orange block for player 2. Each block consists of 4 columns of 4 LEDs connected in parallel and being supplied by 12V. Each block is grounded through an NPN transistor which acts as a switch that is controlled by the microcontroller. When valid contact is made between the fencers, the microcontroller will send out a control signal to the NPN transistor of the corresponding LED block which will cause the block to light up.

The board is powered by 12V/2A source which is further regulated by a **TI UA78M33** 3.3V voltage regulator. The 7-segment LED section of the scoreboard contains a total of 8 7-segment LEDs: 2 for each player and 4 for the clock. The 7-segment LEDs we are using are common anode, so they will only light up when the anode is connected to 12V. To handle this functionality, we used PNP transistors between the power source and each 7-segment LED so that the 7-segments would remain on at all times as long as power is being supplied to the box. The 7-segments will turn off when the microcontroller sends out a control signal to the PNP for a software 'Power Off' event. Each individual LED on each 7-segment is controlled in a similar fashion using NPN transistors and code on the microcontroller in order to display the desired number.

The audio section consists of a **TI DAC8534** D/A converter, an LM386 audio power amplifier, and an 8Ω speaker. The microcontroller sends out a sine wave of different frequencies, depending on the event. The DAC8534 is a 16-bit, serial input D/A converter that interfaces with the microcontroller through SPI; it takes in the data stream and outputs voltages to the LM386 power amplifier. The LM386 is supplied by 3.3V and amplifies the signal from the D/A converter before passing the signal out to the speaker. The speaker currently outputs two different sounds: a sound for when the score is updated on the scoreboard and a higher frequency sound for when valid contact is made between two fencers. The code for audio is therefore set to work in conjunction with the code that controls the valid point LED blocks and the updating of the 7-segments that display the score.

Finally, the Bluetooth section consists of the PAN1323ETU Bluetooth module, which interfaces directly with the **TI MSP430BT5190** microcontroller for communication with a Smartphone. This module is run using the FreeRTOS multitasking real time operating system.

III. PCB Designs

The Gator FenceBox is composed of 5 different PCBs that are all connected together. The first 2 PCBs each contain the 2 LED blocks and the 2 7-segment LEDs to display the score for each player. The 2 LED blocks will be either green and orange or red and orange, depending on the player. The orange LED blocks are used for determining if the fencing weapons are properly connected to the fencing box and will stay on if there is a faulty connection. The third PCB contains the 7-segment clock display, which can be updated, set to count down, stopped, and reset. The fourth PCB contains the MSP430BT5190 microcontroller, a circuit for the JTAG programmer, the circuit for interfacing the PAN1323ETU Bluetooth module, and all audio circuitry. The final PCB contains the socket connectors for the weapons. Each weapon has three wires that need to be connected to their corresponding socket on the scoring box.

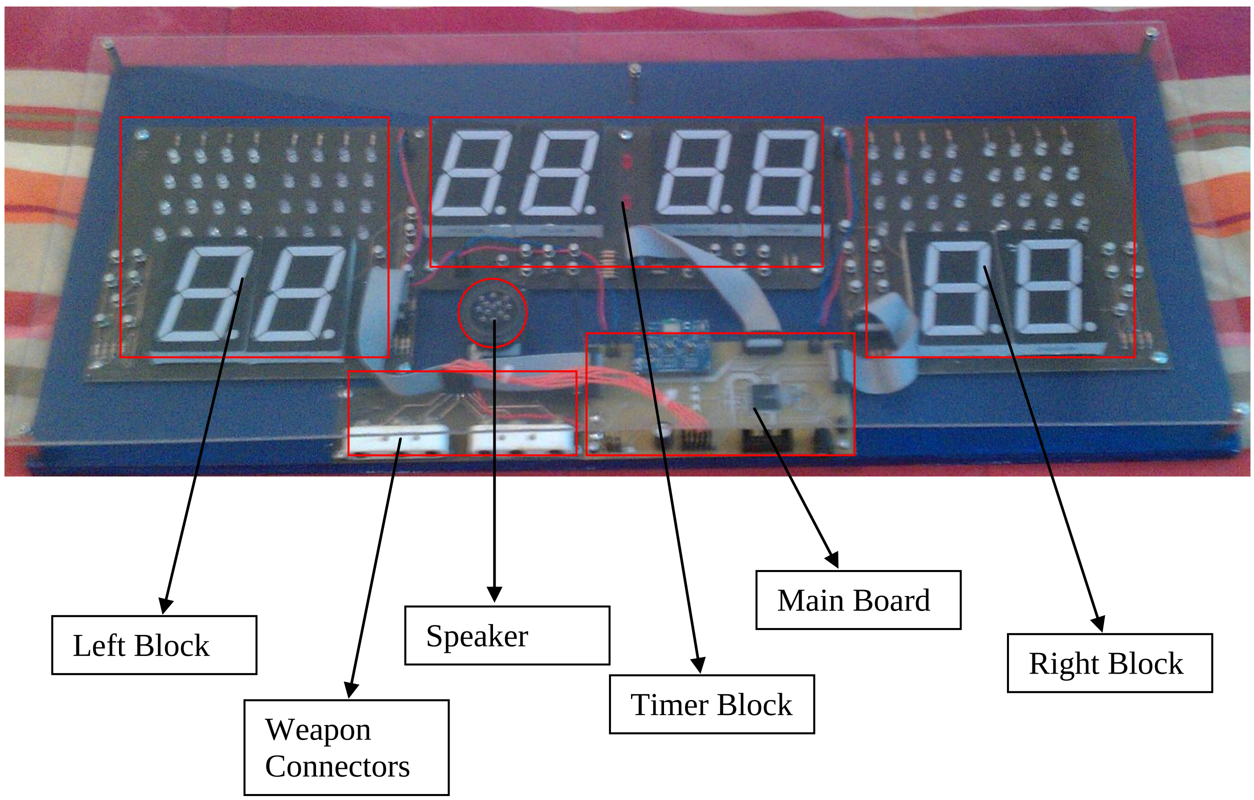

Figure 5 – Modular PCB design

Software:

In this project we are using a real-time operating system (FreeRTOS) to manage four separate tasks:

1. Idle Task
2. Write Task
3. Read Task
4. User Task

The idle task is automatically created by the real-time operating system scheduler. Inside this task we have added the initialization code for the Bluetooth stack. Idle task has the lowest priority on the task queue. The write task handles the receiving of Bluetooth data while the read task handles the sending of Bluetooth data. These two tasks have the highest priority on the queue. The user task, on the other hand, handles the logic of all three weapons. This task is suspended initially or whenever the system is turned off.

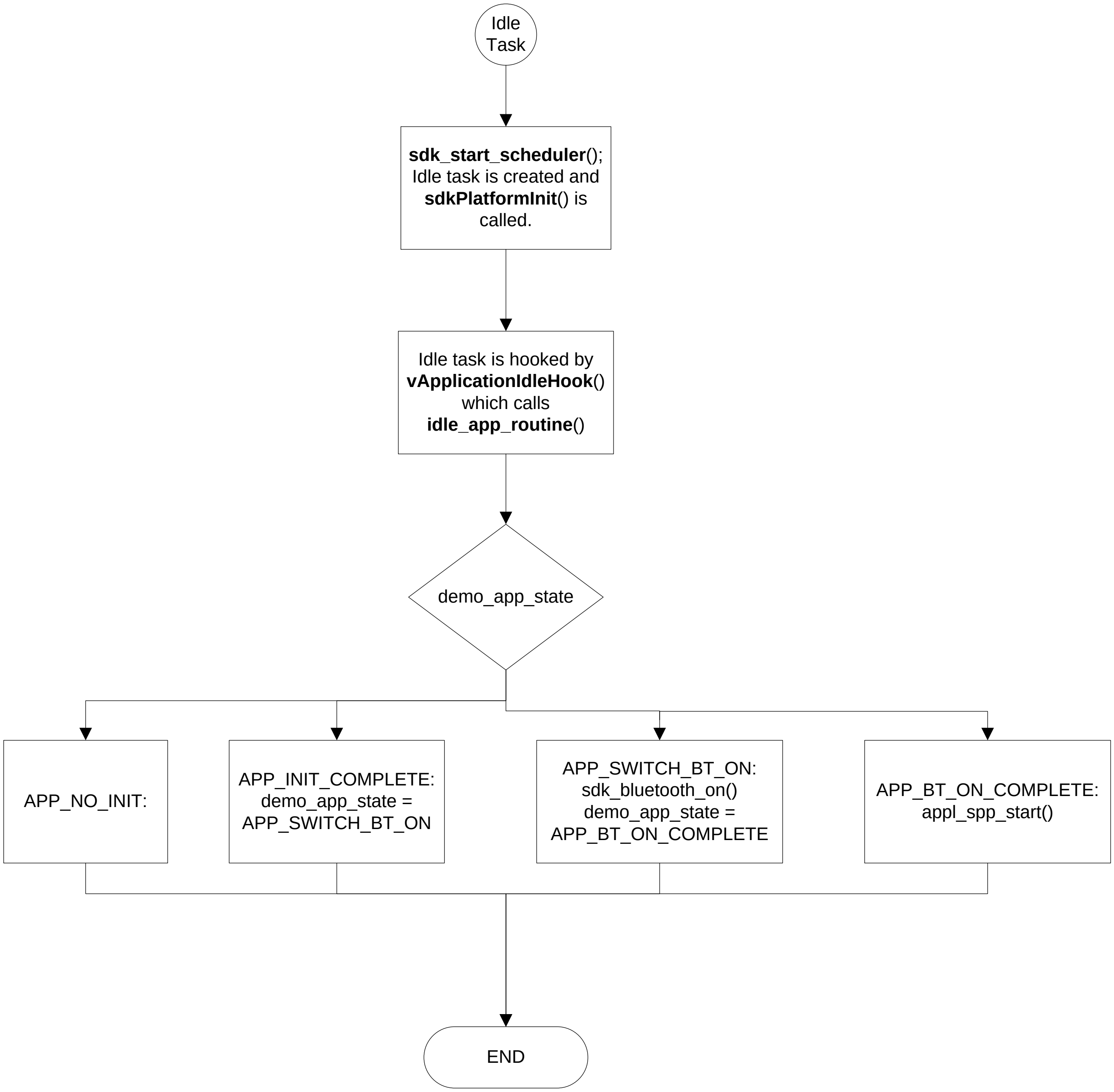

Figure 6 – Bluetooth initialization

Gator FenceBox

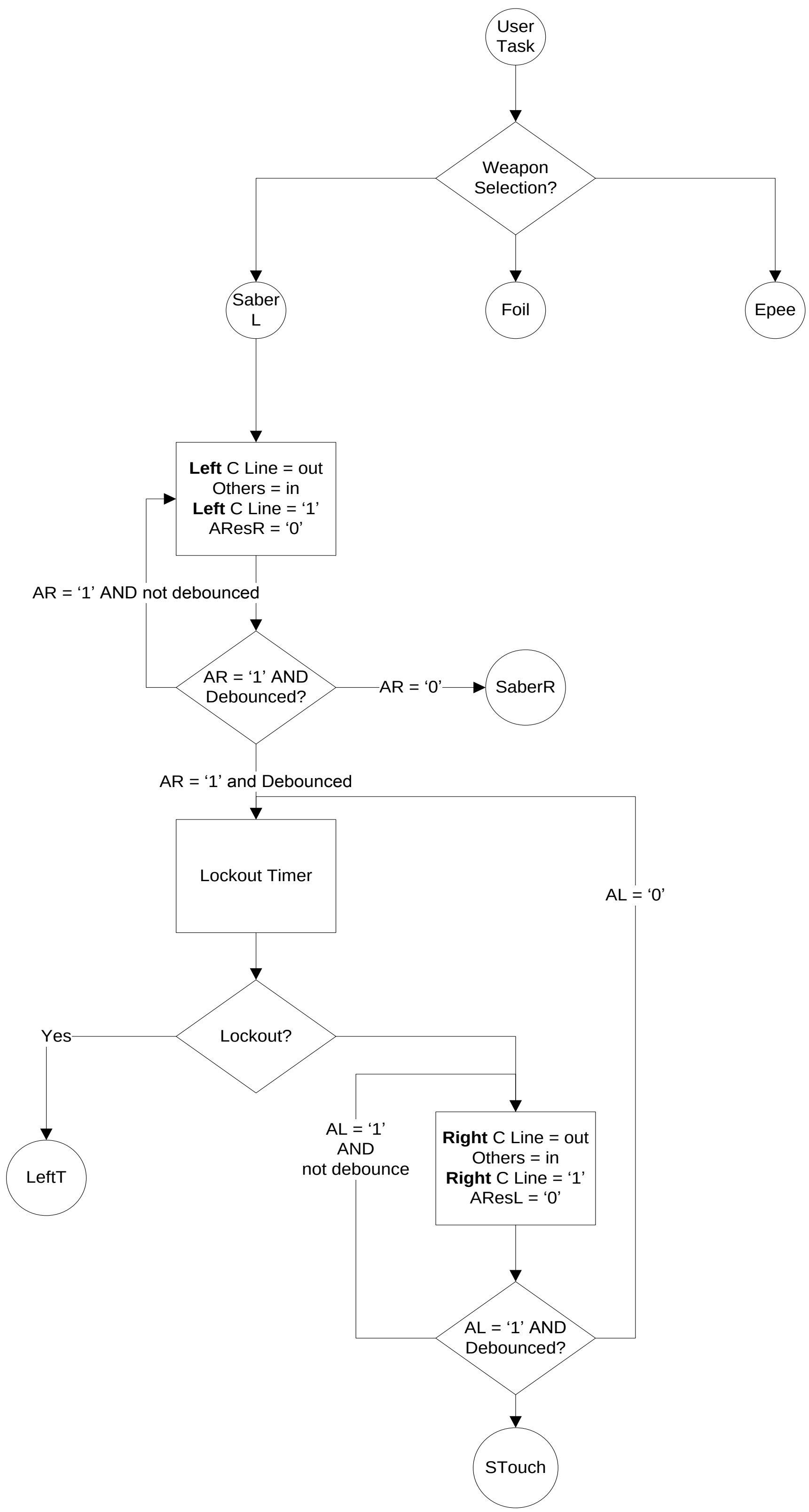

Figure 7 – User task and Saber left logic

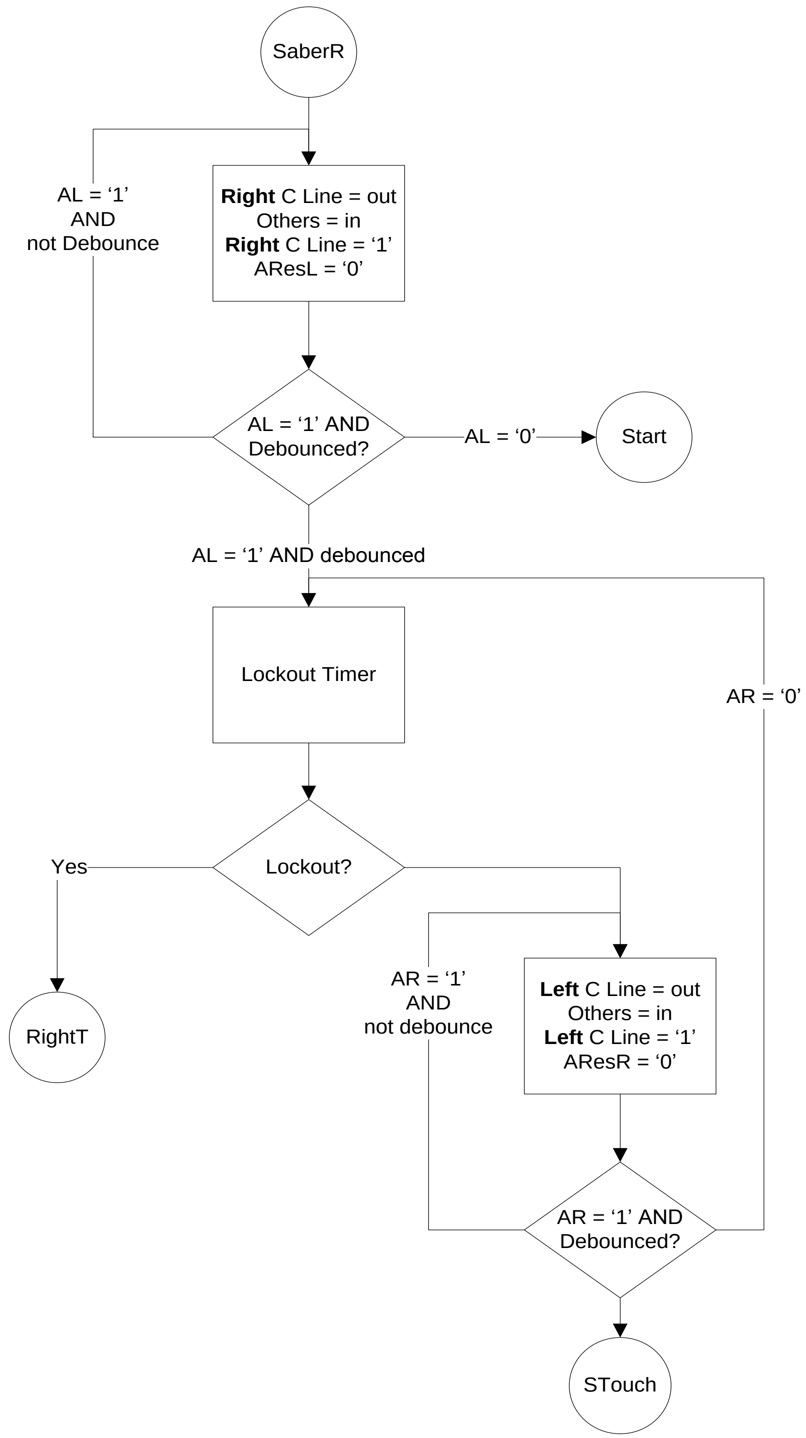

Figure 8 – Saber right logic

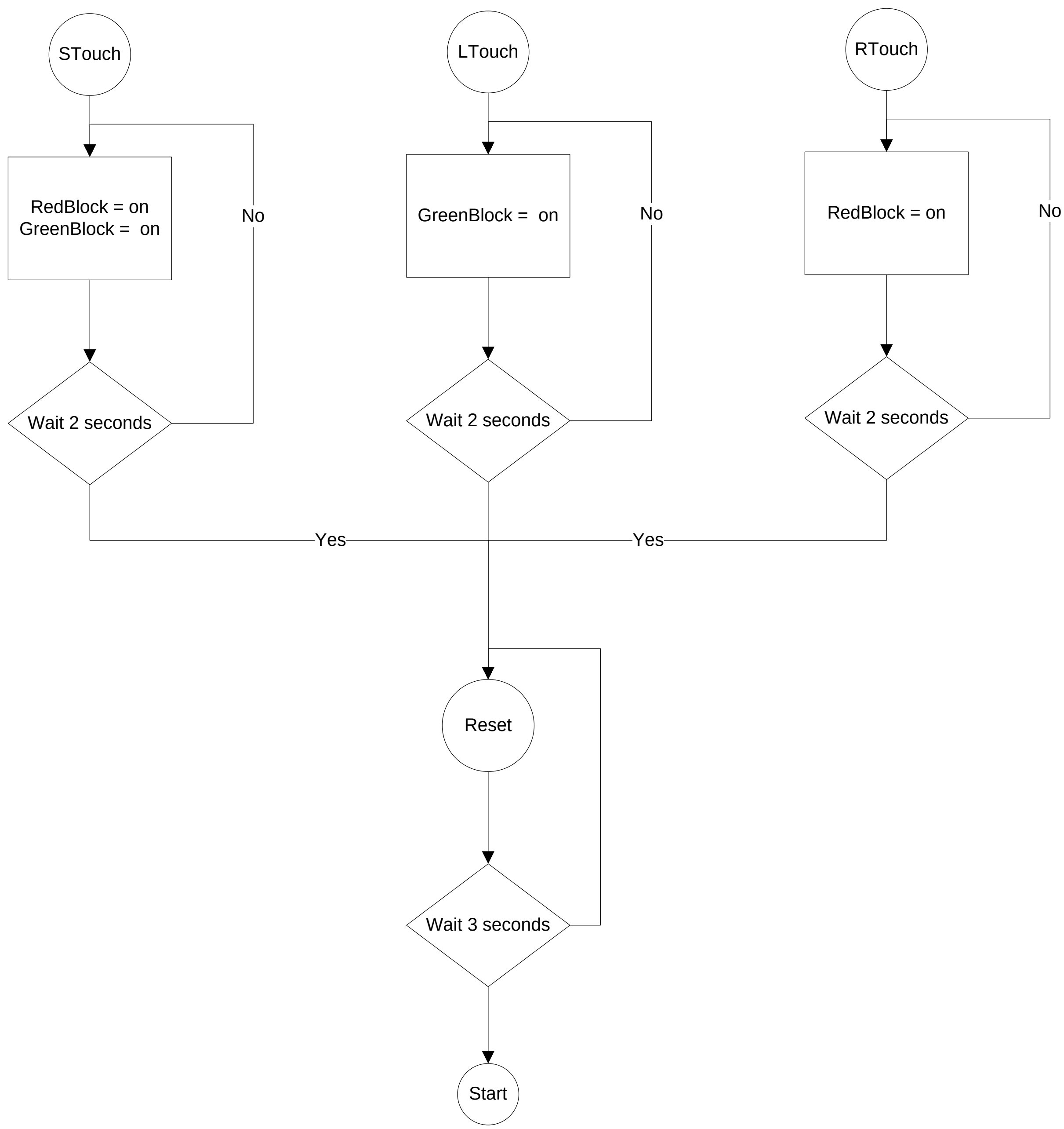

Figure 7 – Weapon wait and reset times

Conclusion:

For completion of this project, we were able to achieve a number of tasks and overcome quite a few obstacles. Ultimately, we were able to establish a successful interface between the Smartphone and scoreboard by learning how to operate and connect with Bluetooth; we learned to use a real-time operating system for multitasking; we created an Android Smartphone application specifically for the purpose of scoreboard control; accommodate all scoreboard components with a 12V/2A power supply; successfully integrate audio with LED blocks and 7-segment score displays for indication of an event; and we managed to implement full functionality for all three fencing weapons: epee, foil, and saber. In short, a fully functional fencing box has been created that can be used in an actual fencing match for a fully immersive fencing experience

Future Work:

With a project of this scope, a number of things can be added to make the fencing scoring box much more user friendly. Possible future enhancements may include the addition of an LCD screen for real-time status updates regarding current weapon choice, winner of the current match, victory count, etc. Bi-directional communication between the scoring box and the Smartphone would also be a great functionality to add for a more interactive Smartphone application. We would also like to eliminate wires between the scoring box and fencers for an all-wireless communication. One strange issue we had during communication with the board through Bluetooth as the introduction of noise on the speaker upon Bluetooth start-up; we would like to aim for removing this problem in the future. Finally, we would like to add an implementation of complete logic functionality for the epee and foil weapons so that the piste (copper floor fencing strip) is incorporated in the fencing experience.

References:

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