Heart Racer Go-Kart

Daniel Franco, Andre Barrett, and Steve Monroy

College of Engineering and Computer Science, Dept. of Electrical and Computer, University of Central Florida, Orlando, Florida, 32816-2450

***Abstract* — A thorough combination of Electrical and Computer Engineering concepts come together in the Heart Racer Go-Kart. By attaching an array of programmable LED lights designed to perform based on results collected from a Heart Rate Monitor, along with a touch screen display to allow the user to choose the music that a set of speakers will play through their ride, this project hopes to deliver a revolutionary idea to the high speed entertainment industry. The complete system will be controlled by a pair of ATmega328 processors and powered by a set of 12V batteries to allow for portability.**

***Index Terms* — Lighting control, Microcontrollers, Displays, Signal Processing, DC-DC power converters, Wearable sensors.**

I. Introduction

Go-Karts have been a source of entertainment for the public for many years; individuals of a wide group of ages choose them when looking for a fun time. The concept of a Go-Kart, and the experience that comes with driving one, has remained unchanged since 1956 when Art Ingels invented the first one out of scrap metal and a lawn mower engine. These vehicles have not changed the way cars have over the years, the purpose of this project is to present a revolutionary idea of what a Go-Kart should look like and the options it should have. The main goal of the Heart Racer Go-Kart is to enhance the driving experience of the customer riding it by stimulating their senses and encouraging their nervous system to release more adrenaline than it regularly would with another, non-modified, Go-Kart.

A cage will be built and attached to the vehicle to go around the driver, attached to the cage will be a set of lights, in abundancy, capable of changing colors and patterns, along with a set of speakers that will play music. The steering wheel of the Go-Kart will be modified to hold a touch display, and a pulse sensor. When the driver boards the vehicle they will see the display in front of them, as well as the lights changing colors at the same pace of their heart rate.

The high speeds, combined with the effect of the music and the changing light patterns, increase the release of adrenaline by the rider; ultimately leading to a better experience on the track. To be able to control all of the components in this project, a microcontroller will be needed; this will be attached to the back of the display and will come together with the pulse monitor as well, the group of three will be one module.

II. System Components

As it was explained previously, this project will be executed by bringing several components together and allowing them to communicate with each other in order to accomplish the task described in the introduction. The separate parts that will play their specific roles in the Heart Racer Go-Kart will be described in this section; firstly as the individual hardware pieces, followed by the different modules, and ultimately by the method of communication that will allow them to interface with each other.

A. Go-Kart Frame and Engine

For the purpose of this project, choosing a Go-Kart that would meet our needs was primordial. Through thorough research, we were able to determine that we would need a racing type of vehicle. A racing Go-Kart, equipped with a Yamaha KT100 was purchased; the specific type of engine that the vehicle came with should be sufficient to meet our main requirement: to be able to travel at speeds higher than 40 mph

B. Microcontroller

For the microcontroller portion of the Heart Racer Go-Kart, the group opted to use the ATmega328 processor, commonly known as the processor that the Arduino microcontroller board uses. This piece of hardware is compatible with C language programming, which the group members are most comfortable with, has a plethora of available libraries for use, and is one of the most affordable in the market. A Printed Circuit Board designed by the group will host this component, along with others pertinent to the project in order to allow us to deliver a completed and working product.

C. Display

After analyzing our research on the display and the possibilities for us to wire it and program it, we decided to utilize the 3.5" TFT 320x480 + Touchscreen Breakout Board with MicroSD Socket. We have chosen to make use of this display for our project as it is compatible with the processor we are working with and can be programmed in the same language. It is a programmer friendly piece and presents multiple options that allow us to design our own testing methods

D. Pulse Sensor

The pulse sensor is, undeniably, one of the most crucial components to this project. This device is the one in charge of gathering data directly from the user and relaying it over to the rest of the components; ultimately allowing such information to be processed and utilized to complete different tasks such as displaying a specific pattern through the LED lights, or allowing the driver to see their current heart rate through the Screen.

We have decided to utilize the Pulse Sensor sold by Sparkfun, SEN-11574, as it is compact, easily programmable, and power efficient. This device requires a minimal power source of 5V and draws 4mA of current, which helps us in the building of our power supply allowing us to bundle it with the LEDs. The sensor is compatible with the ATmega328 processor and can be programmable in C language, which is ultimately and advantage for the members of the Heart-Racer Go-Kart project as well.

E. LED Lights

We decided to use the NeoPixel Digital RGB LED Strip with a density of 30 pixels per meter. This device consumes about 9.5 Watts of power at 5V and a maximum current draw of 2A (assuming all pixels on at full capacity, white), each pixel comes with a controller embedded onto it (allowing us to address them directly). The NeoPixel is compatible directly with the ATmega328 processor and can be programmed in the same language we have been describing through this document, C.

F. Speakers

The purpose of the speakers is a simple one: to allow the user to listen to their preference of music while riding the vehicle without overpowering the sound from the engine too much. The Pyle PLMRKT2A 2-Channel Waterproof Marine Speakers was the product chosen for this project, it is compact, and when paired with the proper amplifier, which we designed and built, is powerful enough to deliver the quality of sound we were initially pursuing.

G. *Power Supply*

In order to power all of the on-board electronics this project entails, we deemed necessary to construct a strong and reliable power source that will allow the user to enjoy the product without any interruptions. A 12V/7A lead acid battery was purchased, and along with it we had to design several DC-DC converters to be able to power our electronics due to the fact they are low voltage devices; these will come together with the processors on our Printed Circuit Board to complete our Microcontroller Board.

III. System Concept

In order to complete this project, we deemed necessary to plan out a concept on how our system would operate ad how each one of the components would communicate with each other. The following diagram (Figure 1) represents ur system design and how we envisioned our components communicating with each other:

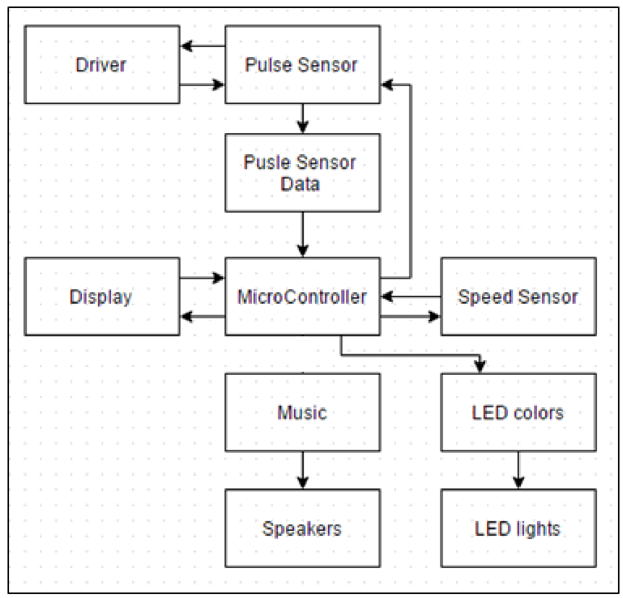

Fig.# 1 System Block Diagram for Heart Racer Go-Kart

As it is represented in the previous flowchart, this project has two main sensors that control the actions the rest of the electronics will execute and are visible by the user.

The Pulse Sensor interacts with the driver by reading their pulse. The information gathered from the driver is subsequently shared with the microcontroller, which instructs the system to execute two actions: It will display the proper information on the display (Heart Rate and Mood), and it will instruct the LED lights to follow the pattern corresponding to the gap in which the user's rate falls. We have designated six specific categories for the Heart Rate, each with their respective LED pattern and mood.

The Speed Sensor interacts with the microcontroller by keeping it updated with the current speed and displaying that information on the screen. We have decided to use a Magnetic Reed Switch in order to calculate the speed at which the driver is traveling. This type of device works by sending a signal whenever the stationary switch is enabled by the rotating magnet on the tire. By using the equation one, where RPM is Revolutions per minute measured by the switch, and r is the radius of the tire, we can easily obtain the value for Velocity (V) of the vehicle in the length unit of measurement of our choice per hour.

$$V = (RPM*60)/(2\pi r) \qquad (1)$$

The velocity calculated by the microcontroller by using the magnetic switch will then be sent to the display and updated every time it changes.

IV. Power Supply

Keeping all of our electronic devices running continuously, and simultaneously, is crucial for the success of this project. The Heart Racer Go-Kart is a prototype that contains several devices that require a reliable source of power that can deliver the proper amount of Voltage as well as Current. Most of our devices are able to operate on a voltage range between 3.3 Volts and 5 Volts. However, the amount of devices we will be utilizing; Printed Circuit Board, Microcontroller, Display, Speakers, LED Lights, and Pulse Sensor, increases the demand for power and current from the battery very drastically. It was decided we would use two 12V 7Ah Lead Acid batteries to keep our system running; one powers the Microcontroller along with the Display, Pulse Sensor, and Lights, and the other powers the speakers.

While the Lights, Pulse Sensor, and ATmega328 Processors are able to run on a 5V DC source, the display must be powered by a 3.3V DC one. For simplicity of the project, and reliability of the system, three different DC-DC converters were designed to power the individual components; two of them are identical 12V to 5V, one to power the LEDs and Pulse Sensor, and another to power the three processors we have made use of. The other converter steps the voltage down to 3.3V in order to feed the Display. The following two oscilloscope measurements (Figures 2 and 3) show the input and output of these two circuits that have been designed by the group.

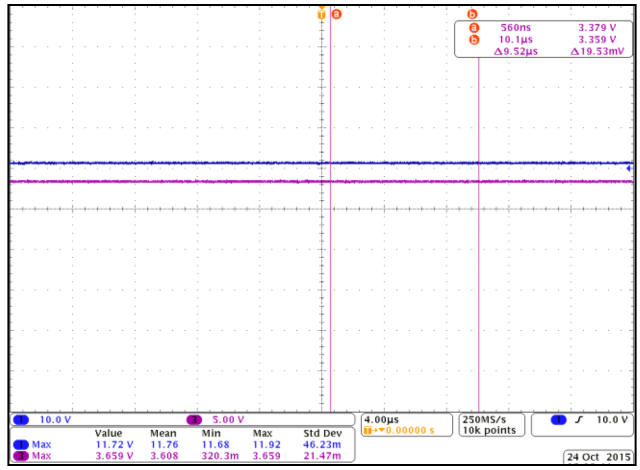

Fig.# 2 12V Dc to 3.3V DC Converter

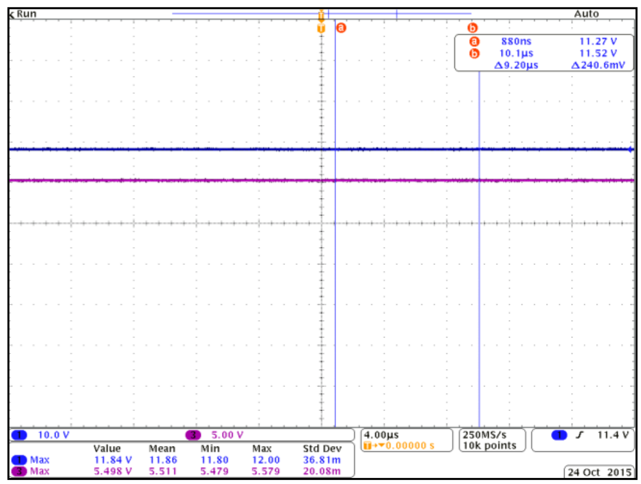

Fig.# 3 12V Dc to 5V DC Converter

V. Printed Circuit Board

The term PCB stands for "Printed Circuit Board." A PCB is a thin board made of fiberglass, composite epoxy, or other laminate material. Conductive pathways are etched or "printed" onto the board, connecting different components on the PCB, such as transistors, resistors, and integrated circuits [1], such as the ATmega328 processors the Heart Racer Go-Kart group has used in this project.

Although most of the components purchased by the group came individually assembled on a completed board, such as the microcontrollers, it was important for the group to design a one that could host all of the individual electronic pieces in one location and would allow them to interact with each other in the most space efficient manner as this is not only one of the main constraints, but also a requirement by the Accreditation Board for Engineering and Technology in order to be able to graduate.

The board designed by the Heart Racer Go-Kart group serves three purposes; to provide for the power converters that will feed the main electronic components, to host the three processors that control such pieces of equipment, and lastly, to come together with the display as one module. The board has connection points that allow for the electronics that sit away from it to plug into it.

Designing and creating a Printed Circuit Board was of crucial importance to this group in order to overcome a major barrier that came to light once we started purchasing processors and electronic components; having too many electronic pieces laying around and not in a compact location. The board helped the group conquer this challenge and allowed us to design all of our circuits and place them in one location where they will all interact with each other. A layout of the board can be seen in the following diagram (Figure 4).

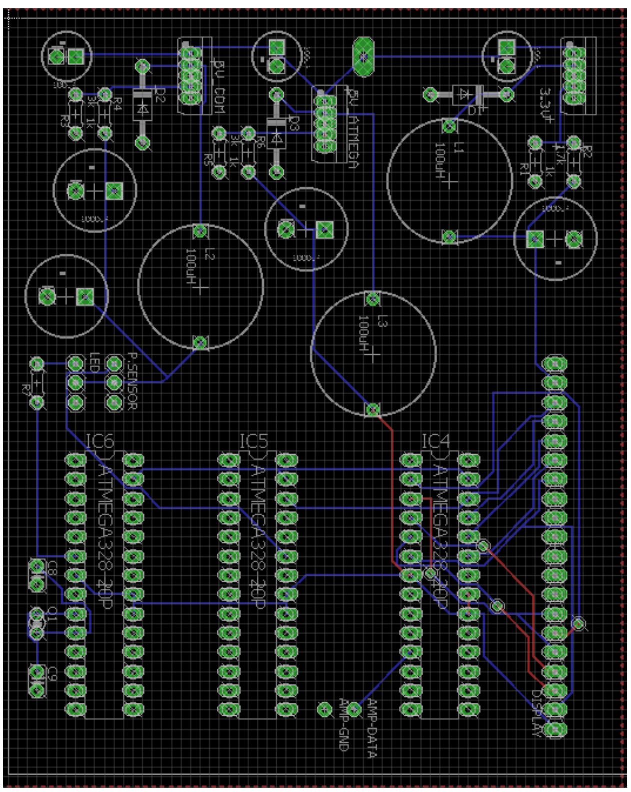

Fig.# 4 PCB Layout

VI. Circuit Schematics

In order to achieve a working prototype, we had to design several circuits that we would use to connect our devices together, as well as power them.

In the following figure (Figure 5), the circuit schematic for the NeoPixel LEDs is pictured. This was a simple circuit to build and did not require extreme planning, a 1000µf capacitor was added between Vin and Ground to prevent burning out of the component and a 470Ω resistor was added between Data in and Pin 6 of the processor to prevent any possible surges from affecting any of the LED Pixels, especially the first one.

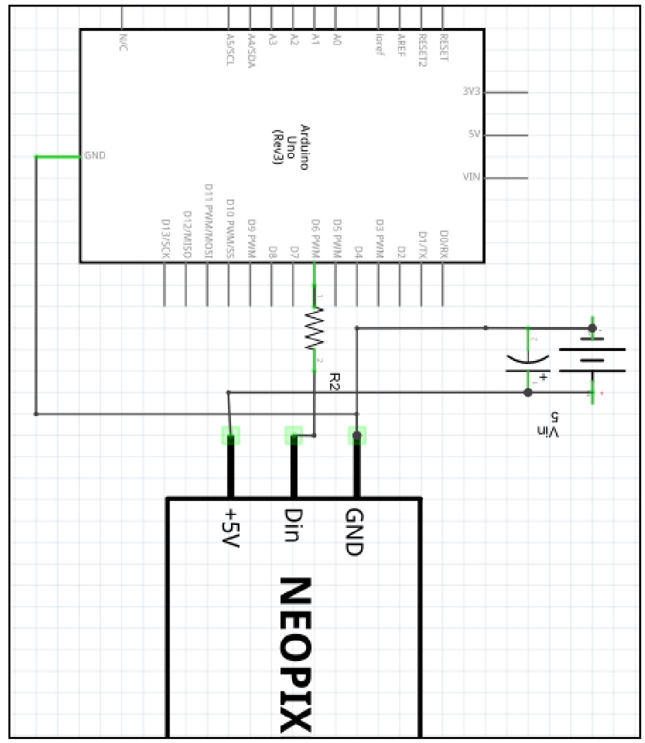

Fig.# 5 LEDs Circuit Schematic

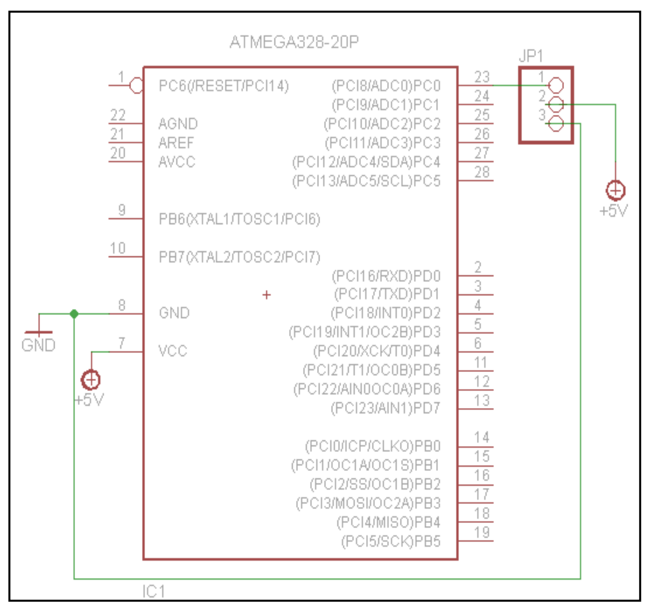

Fig.# 6 Pulse Sensor Circuit Schematic

The previous figure, figure 6, shows the schematic diagram for the procedure followed to wire the Pulse Sensor. This device was one of the simplest pieces in the Heart Racer Go-Kart project to wire due to it only needing three points of contact, one that goes directly to the voltage source that feeds it, one to ground, and a last one to interact with its respective processor, via an analog input on the ATmega328.

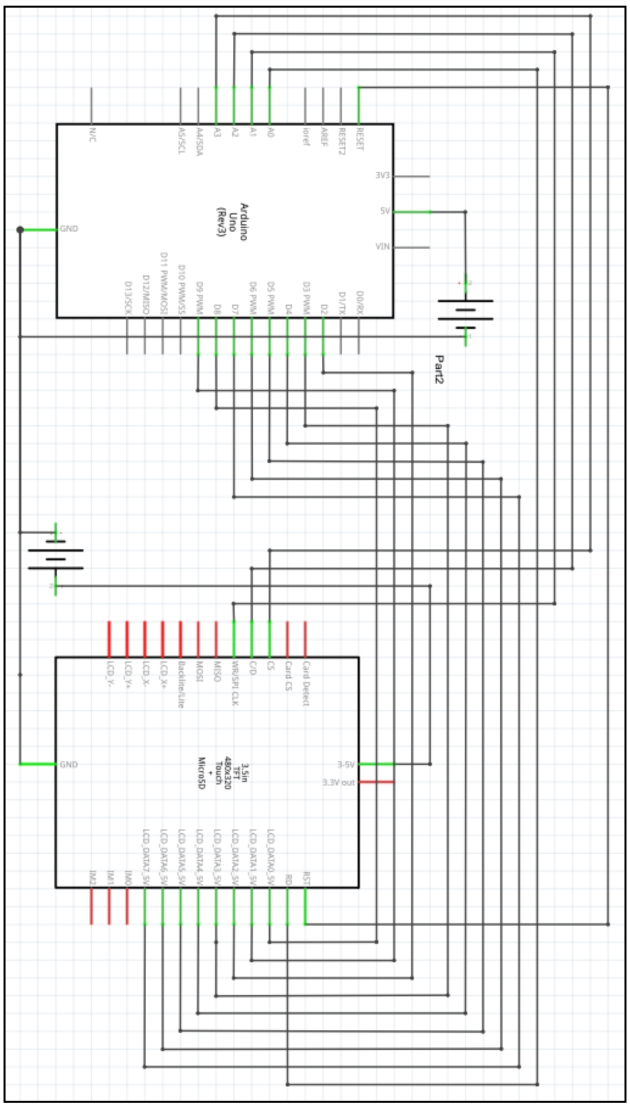

Fig.# 7 Display Circuit Schematic

In the previous circuit schematic the wiring for the display can be observed. Wiring the display was one of the most convoluted tasks the Heart Racer Go-Kart members encountered due to the fact this component possesses such a large number of input and output pins that help it communicate with the processor. In this figure (Figure 7) it is possible to see how we wired the device to the processor; the physical connections are present on the Printed Circuit Board we designed and the display was mounted as close to it as possible to minimize the amount of wires used.

In order to power the entire Printed Circuit Board, which is comprised of the individual devices that complete this project, it was necessary to design and enable three different power supplying circuits, two of which are identical but have been separated to isolate the power supply to the processors from the remaining electronics on board. The following circuits depict what was designed, Figure 8 and 9, respectively, show the 12V to 5V DC to DC converter and 12V to 3.3V one.

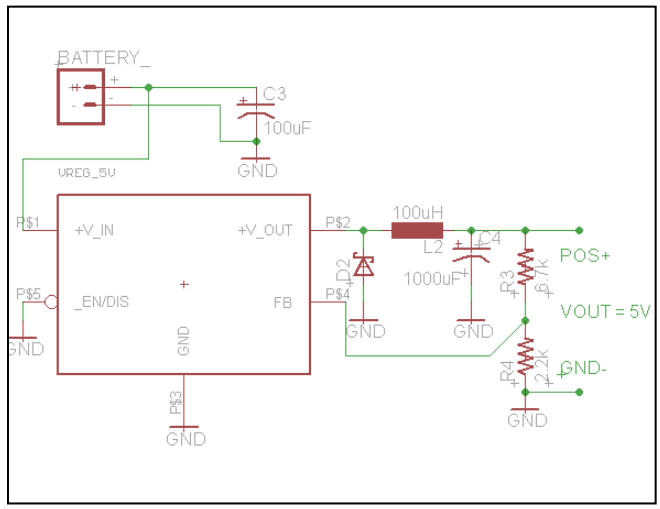

Fig.# 8 12V-5V DC-DC Circuit Schematic

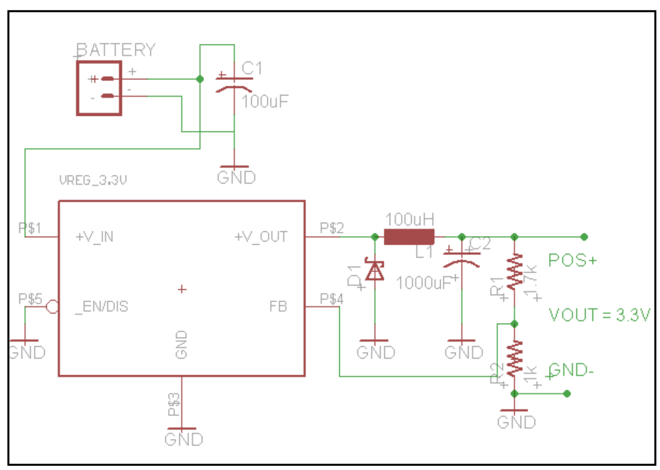

Fig.# 9 12V-3.3V DC-DC Circuit Schematic

VII. Processor Communication

One of the largest obstacles the Heart Racer Go-Kart group encountered was combining the code for the different electronic pieces into one single ATmega328 processor. It was discovered that due to the demand for separate clock signals, when the code for the individual pieces was added and combined into one processor, the tasks would begin to interrupt each other (i.e Pulse Sensor would not respect designed intervals for reading due to time delays belonging in LEDs code).

Due to being already too involved in the process of coding the individual components (in the Integrated Development Environment compatible with the processor), as well having purchased the individual pieces that were a match with the [ATmega328] type of processor the group had chosen, switching to a different processor was not an option any longer. The Heart Racer Go-Kart members came to the conclusion that adding multiple processors to the project was not only the most cost effective, but also most efficient solution to surpass this barrier.

While adding multiple processors seemed to be efficient and cost effective, this also brought another obstacle for the group to overcome; how to send information between them to be able to use the Pulse Sensor data to instruct the LEDs to set their specific patterns. Since the communication between the integrated circuits is designed to be one-way, that is strictly from one processor to the other without the need of feedback, the Inter-Integrated Circuit (or I2C [2]) method was chosen. This is a simple solution that only requires two physical connections between the Master and Slave components, as well as a simple addition in the code of each to allow for sending and receiving information. Figure 10 depicts how the two processors were connected physically in order to achieve the connection between the two that would allow for the delivery of data from the Master to the Slave processor.

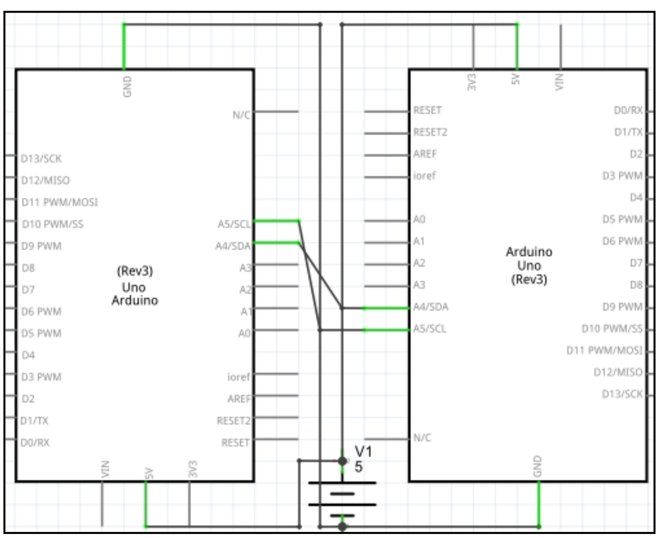

Fig.# 10 I2C Physical Wiring between Processors

Adding two physical connections to the processors on our Printed Circuit Board was not a huge challenge, and adding a few lines of code to the software design was not either. The following figures, figures 6 and 7, depict the pieces of code that were stacked next to the rest of the code in order to have successful communication between the pieces. Figure 11 shows what was added to the Master processor, while Figure 12shows what was added to the Slaves.

```
#include <Wire.h>
void setup() {
  //Start the I2C Bus as Master
  Wire.begin();
}
void loop() {
  Wire.beginTransmission(1); // transmit to device
  Wire.write(BPM);           // sends BPM
  Wire.endTransmission();    // stop transmitting
}
```

Fig.# 11 Master Processor I2C code

```
#include <Wire.h>
int x = 0;

void setup() {
  //Start the I2C Bus as Slave on address 1
  Wire.begin(1);
}
void loop() {
  Wire.onReceive(receiveEvent);
  int HR = x;
}

void receiveEvent(int bytes) {
  x = Wire.read();    // read one character from the I2C
}
```

Fig.# 12 Slave Processor I2C code

VIII. Software Design

Designing and carrying out software design in order to deliver a working project was, besides designing the circuits, the other single most important task for the success of the Heart Racer Go-Kart. Without the appropriate software to indicate the hardware pieces how to operate and complete the tasks that were designed, the group would simply have a set of electronics connected with each other that are not able to communicate or complete any tasks.

When the group members realized that a single ATmega328 processor does not have the ability to run several programs in parallel (simultaneously without blocking each other or affecting the performance of either of them), it was decided that several processors

(ATmega328s) would be needed in order to successfully carry out the originally specified goals for the project. The individual processors were assigned to different components, i.e Pulse Sensor, NeoPixel, Speedometer, and Display, with the Processor that control the Pulse Sensor and Speedometer as the Master who sends data collected, and the Display and LED lights as the slaves who receive and process the information.

The ATmega328 processor is compatible with the programming languages C and C++. Fortunately, the language the members of the Heart Racer Go-kart are most familiar with is C, reason why this one was chosen over C++, even though they are similar to each other. The only remaining piece of knowledge the members needed to familiarize themselves with was the need for libraries, which were provided by the manufacturers of each one of the pieces and were easily accessible when programming each component.

The first processor that we decided to program contained the controlling code for the Pulse Sensor and the Speedometer. The following figure, figure 13, explains the process that the code follows in order to accomplish its task. This piece of software allows the processor to update and send its information with intervals of one second to allow for accuracy.

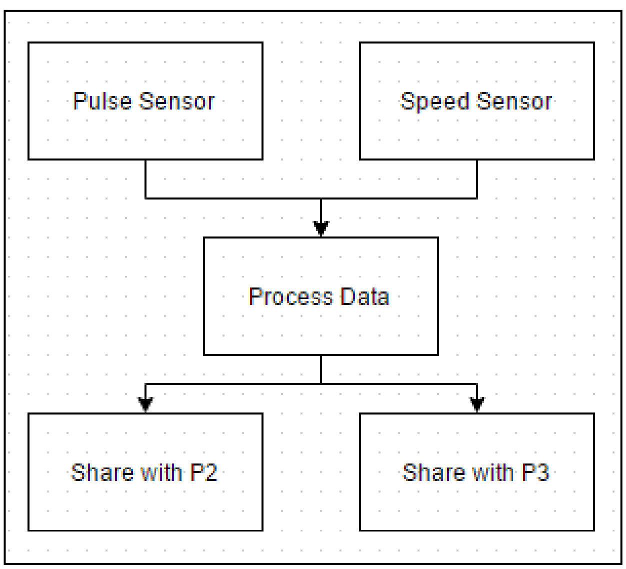

Fig.# 13 Process flow for Processor 1

The second processor, P2, contains the code for the NeoPixel LED Strip. The following figure, figure 14, explains the process that the code follows in order to accomplish its task. This piece of software receives data as it comes from the first controller and allows for the processor to update every ten seconds in order to allow for each of the light patterns to complete at least one or two of their cycles completely before possibly moving onto another one respective to a different Heart Rate bracket.

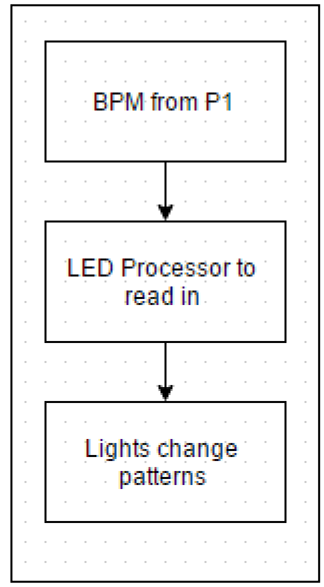

Fig.# 14 Process flow for Processor 2

The third, and last, processor that needed to be programed contained the controlling code for the LED Display. The following figure, figure 15, explains the process that the code follows in order to accomplish its task. This piece of software was, perhaps, the most difficult one to program due to the fact that we had to learn how to work around the refresh rate of the display in order to prevent it from giving us blinking screens that can be captured by the human eye every time a new set of data is received.

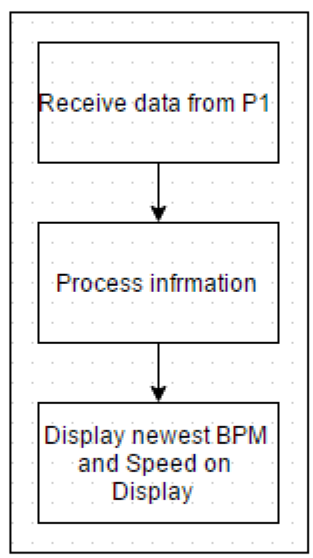

Fig.# 15 Process flow for Processor 3

IX. Conclusion

Working on this project has been a challenging experience for all of the members of the Heart Racer Go-art, especially due to the lack of experience with software programming on the part of the three members of the group. Although our solution to the idea we wanted to present was not the most efficient one, we believe we have delivered the basis for a product that could very possibly accomplish the goal we set initially; to revolutionize the Go-Kart industry. We are proud of the working product we have developed and hope it can be a source of inspiration to other students in the future.

Acknowledgement

The authors of this project wish to acknowledge the financial assistance they received from Boeing and the UCF Foundation that has helped tremendously the success of this project. It is also important to acknowledge the time and effort the professors who are part of the evaluating board have dedicated to the group in order to review this project.

The Engineers

Daniel Franco: A 23-year old senior at the University of Central Florida. Daniel will be obtaining his Bachelors of Science in Electrical Engineering in December of 2015; he currently works at Duke Energy in their Transmission Engineering, Protection and Controls department and will be pursuing a career in the same company upon his graduation. Daniel enjoys working with people and hopes to one day become a C-Level Executive at Duke Energy.

Andre Barrett: A 28-year old senior at the University of Central Florida. Andre will be obtaining his Bachelors of Science in Electrical Engineering in May of 2016. He enjoys history and day trading. Andre hopes to someday be an entrepreneur owning a business in Engineering or Financial Investments.

Steve Monroy: A 22-year old senior at the University of Central Florida. Steve will be obtaining his Bachelors of Science in Electrical Engineering in May of 2016; he currently has accepted a job offer at NextEra Energy in Power Generation upon graduation. Steve enjoys staying active by participating in team activities. He is a member of the Men's Volleyball Club Team at the University. One day he hopes to become a General Manager at NextEra Energy.

References

[1] P. Christensson, "PCB Definition." TechTerms. Sharpened Productions, Web. <http://techterms.com/definition/pcb>., Aug 2013.

[2] Instructables.com, 'I2C between Arduinos', 2015. [Online]. Available: http://www.instructables.com/id/I2C-between-Arduinos/?ALLSTEPS. [Accessed: 06- Nov- 2015]..

[3] Learn.adafruit.com, 'Adafruit NeoPixel Überguide', 2015. [Online]. Available: https://learn.adafruit.com/adafruit-neopixel-uberguide. [Accessed: 06- Nov- 2015].

[4] Y. Yang, 'Implementation of a colorful RGB-LED light source with an 8-bit microcontroller', 2010 5th IEEE Conference on Industrial Electronics and Applications, 2010.

[5] HX8357-D00/D01 320RGB x 480 dot, 16M color, with internal GRAM, TFT Mobile Single Chip Driver Data Sheet, 1st ed. Himax, 2012.

[6] WS2812B Intelligent control LED integrated light source Data Sheet, 1st ed. WorldSemi, 2014.