

Turn and Brake Signal System for a Bicycle

A Senior Project

presented to

the Faculty of the Electrical Engineering Department  
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Bachelor of Science

by

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## **Abstract**

The common motorist views bicyclists as unpredictable on city streets and often lack experience sharing the road with motorists. The key to integrating bicyclists and motor vehicles on the same road with both parties feeling comfortable around one another lies in a common means of communication. Bicycles lack a signaling system based on lights, like that of a motor vehicle, which other motorists easily read and interpret. The proposed system integrates Cypress Semiconductor's Programmable System on Chip 5 (PSoC 5) and an array of sensors to detect key changes in the bikes behavior. The PSoC 5 analyzes the data from the sensors and lights the correct turn light or brake light depending on the cyclists turning, slowing down, or braking.

## 1.01 – Introduction

According to the League of American Bicyclists, in 2007, 698 cyclists sustained fatal injuries, and 43,000 cyclists received injuries in accidents involving motor vehicles [1]. The Bureau of Transportation Statistics held a survey asking cyclists how safe they felt. Only 50% of the cyclists felt safe, while less than a quarter of the overall responses felt completely safe while bicycling [2]. Misunderstandings between cyclists and motorists, as well as an unawareness of cyclists by motorists, account for the largest causes of accidents. This project aims to increase the safety of both cyclists and motor vehicles and lower the number of bicyclists injured or killed while riding.

To accomplish this, the project implements turn signal indicators and brake lights on bicycles, similar to those found on motor vehicles. The average driver has become accustomed to recognizing turn indicators and brake lights from other vehicles; by adding these same indicators to bicycles, they become easier to recognize and understand. Though the law dictates that drivers must recognize the arm movements cyclists use for turning, some drivers do not. Or, due to adverse weather or light conditions, drivers cannot perceive cyclists. Moreover, often times road conditions make it unsafe and/or impossible for bicyclists to remove their hand from the handlebars in order to make an appropriate arm signal. By using the same turn signals found on vehicles, cyclists communicate more efficiently with motor vehicles when turning and braking. The systems that exist on the market today consist mainly of do-it-yourself kits, or devices that companies no longer produce.

## 2.01 – Requirements and Specifications

The device consists of a set of brake lights and turn signal indicators that attach to an existing bicycle to provide the same safety lights as a motor vehicle. The user can turn on the blinking turn signals using capacitive touch sensors, or the accelerometer onboard the PSoC senses a the lean of the bike and turn on the appropriate turn signal, should the user forget. Using an accelerometer, the brake lights illuminate when decelerating. To ensure safety, the LED lighting needs to work under foggy weather, wet weather, and poor lighting conditions.

A simple instruction manual demonstrates the attachment procedure and functionality of the system. The system attaches to various types of bicycles with relative ease. To keep from weighing down the bicycle and impeding user performance, the requirement for a small, compact system becomes imperative. A small, replaceable or rechargeable battery provides the system power. With brake and turn signal capacitive touch sensors integrated onto the handlebars, both hands of the user remain on the handlebars at all times, making signaling safer. Since Cypress Semiconductor commissioned the project, the system relies on the PSoC 5 development board. Table 1 and 2 provide the details of the project team and the requirements and specifications of the project.

Difficulties lie in sensing the difference between braking and deceleration due to a hill. Difficulties also lie in detecting how vertical the bike remains while riding in normal conditions. Extensive testing of the device ensures the accelerometer can compensate for these issues.

**Table 1**

Project Name, Team, and Advisor

<b>Turn and Brake Signal System for a Bicycle</b>	
<b>Christian Orsi</b> <b>Steven Hamilton</b> <b>EE 460-01</b>	<b>Bryan Mealy</b> <b>1. I agree to supervise this senior project.</b> ____bm____ <b>2. The specifications consist of [3]-[4]:</b> <input checked="" type="checkbox"/> Abstract—Describes what project should do, not how. <input checked="" type="checkbox"/> Bounded—Identify project boundaries, scope, and context <input checked="" type="checkbox"/> Complete—Include all the requirements identified by the customer, as well as those needed to define the project. <input checked="" type="checkbox"/> Unambiguous—Concisely state one clear meaning. <input checked="" type="checkbox"/> Verifiable—A test can prove if system meets specification. <input checked="" type="checkbox"/> Traceable—Each engineering specification serves at least one marketing requirement.
<b>ADVISORS:</b> Please initial above, if you agree to supervise this senior project. Also, please check applicable boxes above. Comment below, if requirements or specifications require revision.	

**Table 2****Turn and Brake Signal System for a Bicycle Requirements and Specifications**

<b>Marketing Requirements</b>	<b>Engineering Specifications</b>	<b>Justification</b>
1	The turn signal indicators and brake lights maintain 300 lumens each when lit.	Motorists can see 300 lumens during the day and in foggy weather, while remaining within the brightness requirements in North America.
1	The turn signals illuminate amber colored and the brake lights illuminate red.	Car designers established these colors as the safest colors for use.
2	The device consists of a main housing, two turn signal indicators, brake lights, and controls that attach to the bicycle using Velcro straps.	The device adapts to the shape of the bike while remaining simple to attach.
2	The project includes a manual diagramming how to install the device.	The manual depicts all steps necessary to attach the device to a bicycle in clear, simple order.
2, 4	A replaceable or rechargeable battery powers the device.	The necessity for portability and size make a rechargeable or replaceable battery the ideal power source.
3, 6	The user can turn on the blinkers using a capacitive touch module built into the PSoC5.	The user can turn on the blinkers before making a turn.
3, 6	When the device senses an active turn signal and the bicycle has remained vertical for five seconds, the turn signal automatically turns off.	The device senses that the cyclist has completed their turn and turns off the turn signal.
3	The brake lights illuminate when the cyclists uses the brakes or the bike slows down more than 5mph without braking.	The brake lights come on when the user brakes or, if riding in rough terrain or uphill and not braking, the device senses the cyclist slowing and illuminates the brake lights as well.
4	The entire system weighs less than 4.5 pounds.	By ensuring the device remains below 15% of the average adult bicycle weight (30lbs), the performance of the rider remains unaffected.

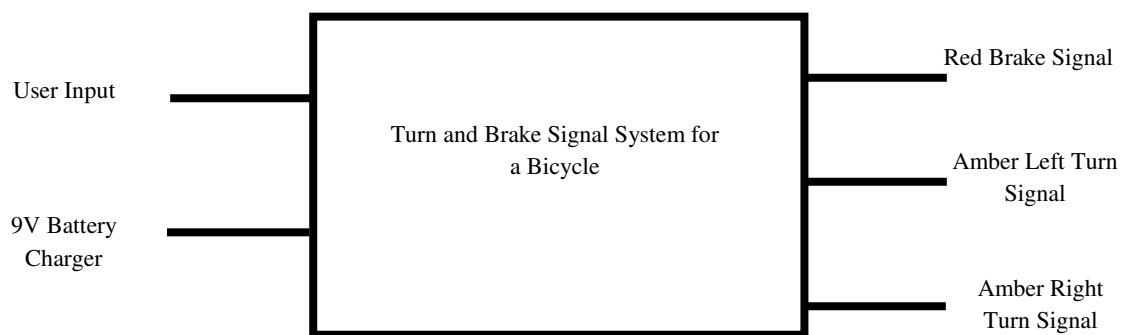
Marketing Requirements	Engineering Specifications	Justification
4	The main housing, brake lights, and turn indicators each fit within a 3.5"x2.5"x1.5" rectangle volume.	No single component takes up a large amount of space on the bike.
5	The housing of the device can repel water up to 5 ATM, and can handle temperatures from 32 degrees to 130 degrees Fahrenheit.	The device can handle rain and shallow pools of water as well as extreme temperatures. This complies with the NEMA 4 rating.
6	The device runs off of a PSoC5 development board	Cypress commissioned this project so the PSoC5 development board provides the backbone for the device.
<b>Marketing Requirements</b> <ol style="list-style-type: none"> <li>1. Visible at all times</li> <li>2. Simple enough for uneducated users to use</li> <li>3. Activate turn and brake signals at appropriate times</li> <li>4. System does not impede the rider</li> <li>5. Suitable for most weather conditions</li> <li>6. Uses the PSoC5 Development Board</li> </ol>		



## 3.01 – Block Diagram

### 3.11 – Level 0 Decomposition [5]

The user touch interface and a 9V battery charger provide the basic inputs of the level 0 system. Employing a rechargeable battery implies a 9V battery charger as an input to the system. The brake and turn signals activate upon the combination of user input and accelerometer data. Figure 1 and Table 3 shows a system functional decomposition for level 0.



**Figure 1**

Level 0 Block Diagram for the Turn and Brake Signal System for a Bicycle

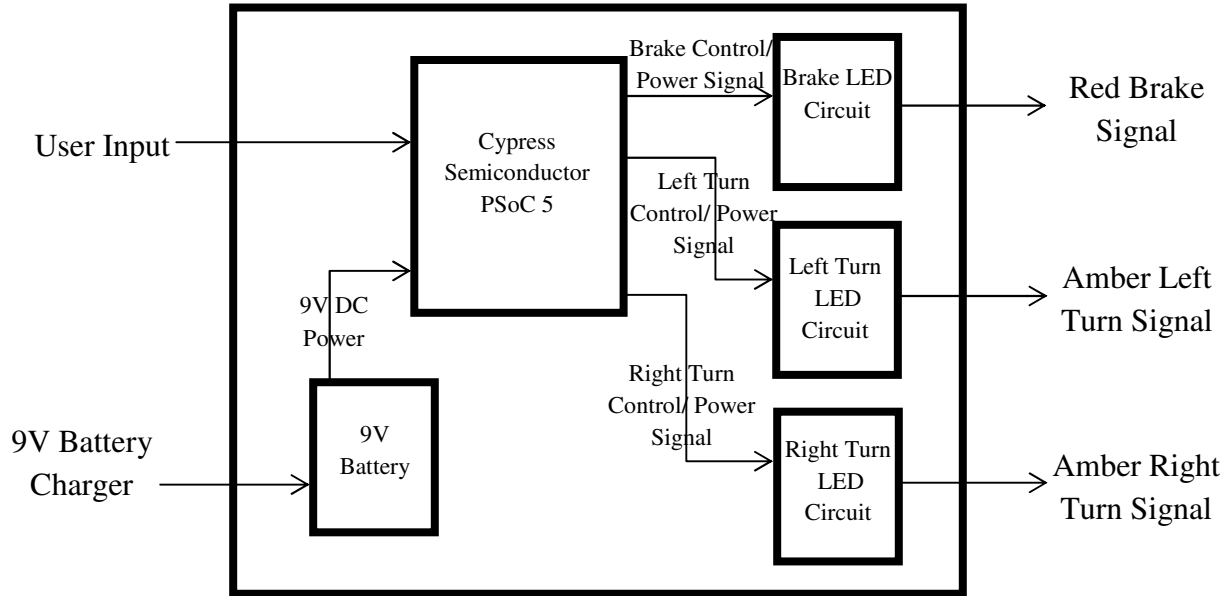
**Table 3**

Level 0 Functional Requirements

<i>Module</i>	Turn Signal System for a Bicycle
<i>Inputs</i>	<ul style="list-style-type: none"><li>• User input, in the form of velocity and acceleration and touch</li><li>• 9V battery charger</li></ul>
<i>Outputs</i>	<ul style="list-style-type: none"><li>• Successful activation of the appropriate amber turn signal or red brake light at a maximum light level of 300 lumens</li></ul>
<i>Functionality</i>	Activate the turn signals based on user input and accelerometer output. De-assert the turn signal after the bicycle has completed the turn. Apply the brake signal light when decelerating. Create a safer system for signaling on the bicycle. The ability to recharge the internal battery creates a sustainable system.

### 3.21 – Level 1 Decomposition

Figure 2 demonstrates the level 1 system decomposition. The system decomposes into five functional components: a 9V battery, the PSoC 5, and three LED circuits for the brake and turn signals.



**Figure 2**

Level 1 Block Diagram for the Turn and Brake Signal System for a Bicycle

### 3.22 – 9V Battery

A 9V battery provides power to the PSoC 5 and charges via a 9V battery charger. The PSoC 5 requires a 9V DC power source. The component requirements summarized in Table 4 provide further explanation.

**Table 4**

Level 1 Functional Requirements for the 9V Battery

Module	9V Battery
Inputs	<ul style="list-style-type: none"><li>9V battery charger</li></ul>
Outputs	<ul style="list-style-type: none"><li>9V DC power</li></ul>
Functionality	To provide steady 9V power to the PSoC. The 9V battery charger replenishes the depleted battery cell.

### 3.23 – Cypress Semiconductor PSoC 5 [6]-[7]

The platform the system relies on the PSoC 5, which provides the sensors and the ability to analyze the data taken from those sensors [8]-[10]. The user provides input in the form of touch sensors and tilt of the bicycle. The PSoC 5 analyzes the data provided, and delivers three

separate control and power signals to each of the turn and brake LED circuits. The data contained in the control signal depends on the input to the PSoC 5, but amounts to a simple ON/OFF control for the LED circuits. The component requirements summarized in Table 5 provide further explanation.

**Table 5**  
Level 1 Functional Requirements for the PSoC5

<i>Module</i>	Cypress Semiconductor PSoC 5
<i>Inputs</i>	<ul style="list-style-type: none"> <li>• User input, in the form of velocity and acceleration and touch.</li> <li>• 9V DC power</li> </ul>
<i>Outputs</i>	<ul style="list-style-type: none"> <li>• Brake control/power signal at 9V DC</li> <li>• Left turn control/power signal at 9V DC</li> <li>• Right turn control/power signal at 9V DC</li> </ul>
<i>Functionality</i>	The acceleration and tilt of the bicycle and touch inputs provided by the user determine which signals assert a high and low control. The platform power provided by the 9V battery ensures a stable power source.

### 3.24 – Brake LED Circuit

The brake LED circuit takes an input of a control/power signal from the PSoC and outputs a red brake light. The PSoC provides power to this circuit. The light levels output when the input signal remains high and remain between 200 and 300 lumens. The component requirements summarized in Table 6 provide further explanation.

**Table 6**  
Level 1 Functional Requirements for the Brake LED Circuit

<i>Module</i>	Brake LED Circuit
<i>Inputs</i>	<ul style="list-style-type: none"> <li>• Brake control/power signal at 9V DC</li> </ul>
<i>Outputs</i>	<ul style="list-style-type: none"> <li>• Successful activation of the red brake light at a maximum light level of 300 lumens</li> </ul>
<i>Functionality</i>	The circuit receives power from the PSoC 5 when the brake control signal remains active and stops when the PSoC 5 brake control signal remains de-asserted.

### 3.25 – Left Turn LED Circuit

The left turn LED circuit takes an input of a control/power signal from the PSoC and outputs an amber brake light. The PSoC provides power to this circuit. The light levels output when the

input signal remains high and remain between 200 and 300 lumens. The light blinks like the turn signal on an automobile while active. The component requirements summarized in Table 7 provide further explanation.

**Table 7**

Level 1 Functional Requirements for the Left Turn LED Circuit

<i>Module</i>	Left Turn LED Circuit
<i>Inputs</i>	<ul style="list-style-type: none"> <li>Left turn control/power signal at 9V DC</li> </ul>
<i>Outputs</i>	<ul style="list-style-type: none"> <li>Successful activation of the left amber turn light at a maximum light level of 300 lumens.</li> </ul>
<i>Functionality</i>	The circuit receives power from the PSoC 5 when the left turn control signal remains active and stops when the PSoC 5 left turn control signal remains de-asserted.

### 3.26 – Right Turn LED Circuit

The right turn LED circuit takes an input of a control/power signal from the PSoC and outputs an amber brake light. The PSoC provides power to this circuit. The light levels output when the input signal remains high and remain between 200 and 300 lumens. The light blinks like the turn signal on an automobile while active. The component requirements summarized in Table 8 provide further explanation.

**Table 8**

Level 1 Functional Requirements for the Right Turn LED Circuit

<i>Module</i>	Right Turn LED Circuit
<i>Inputs</i>	<ul style="list-style-type: none"> <li>Right turn control/power signal at 9V DC</li> </ul>
<i>Outputs</i>	<ul style="list-style-type: none"> <li>Successful activation of the right amber turn light at a maximum light level of 300 lumens.</li> </ul>
<i>Functionality</i>	The circuit receives power from the PSoC 5 when the right turn control signal remains active and stops when the PSoC 5 right turn control signal remains de-asserted.

## 4.01 – Initial Implementation

### 4.11 –Turn and Brake Signal Design

To start, the LED turn signals were constructed. The materials used for the initial design of the LED turn signals are as follows:

- 18 3mm Orange LEDs
- 16 3mm Red LEDs
- 2 Electroluminescent (EL) Triangle Panels (2" x 2.31")
- 1 EL Rectangle Panel (2" x 3")
- 1 Clear Acrylic Back Plate
- 1 Miscellaneous 22 AWG Wires
- 1 9V Battery
- 1 9V Battery Housing
- 1 Epoxy Mix
- 2 Hose Clamp

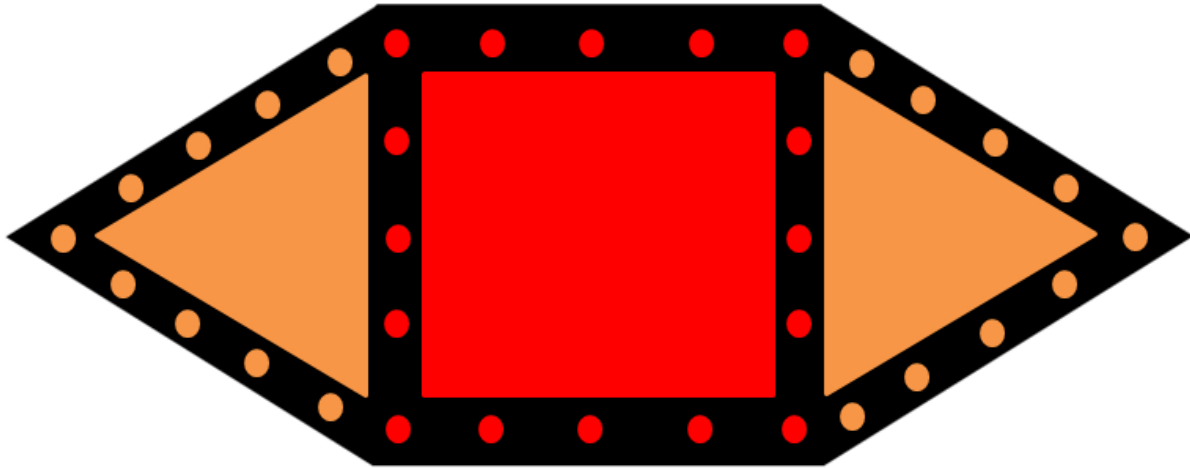
We start by creating the general shapes of the signals we want to illuminate out of EL panels. We cut out two triangle shapes for the left and right signals, and a square panel for the brake light. Next, we create a back plate to house the paneling, as well as the LEDs. We construct the plate out of clear acrylic and shape it to hold the EL panels in the desired configuration, the turn signals pointing out on both sides, with the square panel in the middle. Using a small amount of epoxy, we affix the EL panels to the acrylic plate.

Around the EL panels, we drill holes to provide access to the LED leads from the back of the panel. The LEDs provide additional visibility during the day, since the EL panels are barely visible in direct sunlight.

To maximize battery usage, we only want the EL panels to illuminate when they are visible. A photocell and additional code in the PSoC ensure the correct implementation of the bi-level lighting.

Figure 3 shows the resulting back plate diagram.

**Figure 3**  
Back Plate Design and LED/EL Panel Mounting Diagram



With the back plate complete, and the EL panels fixed in place, we insert our LEDs and begin wiring them. We wire each group of LEDs in parallel, separating them between left, right, and brake, creating three separate LED circuits. With the wiring complete, we check the continuity of each circuit to ensure functionality, before we create our silicone mold.

We use the mold to help encase the already constructed lighting circuitry in more epoxy. By surrounding the circuitry in epoxy, the circuit is waterproof and everything is held in place, removing any chance of wires shaking loose, or water ruining the panels. We design the mold in the same shape as Figure 4, allowing room for the circuits and a layer of epoxy around the entire shape.

With the mold created, we lay down a base layer of epoxy for the backside of the case. On top of this layer, we place the circuitry with its back plate of epoxy pressed against the base layer of epoxy, taking care to pull the wires out of the mold. Finally, we add more epoxy over the entire circuit to fill the mold, giving us a fully encased lighting circuit with a smooth layer of epoxy on all sides.

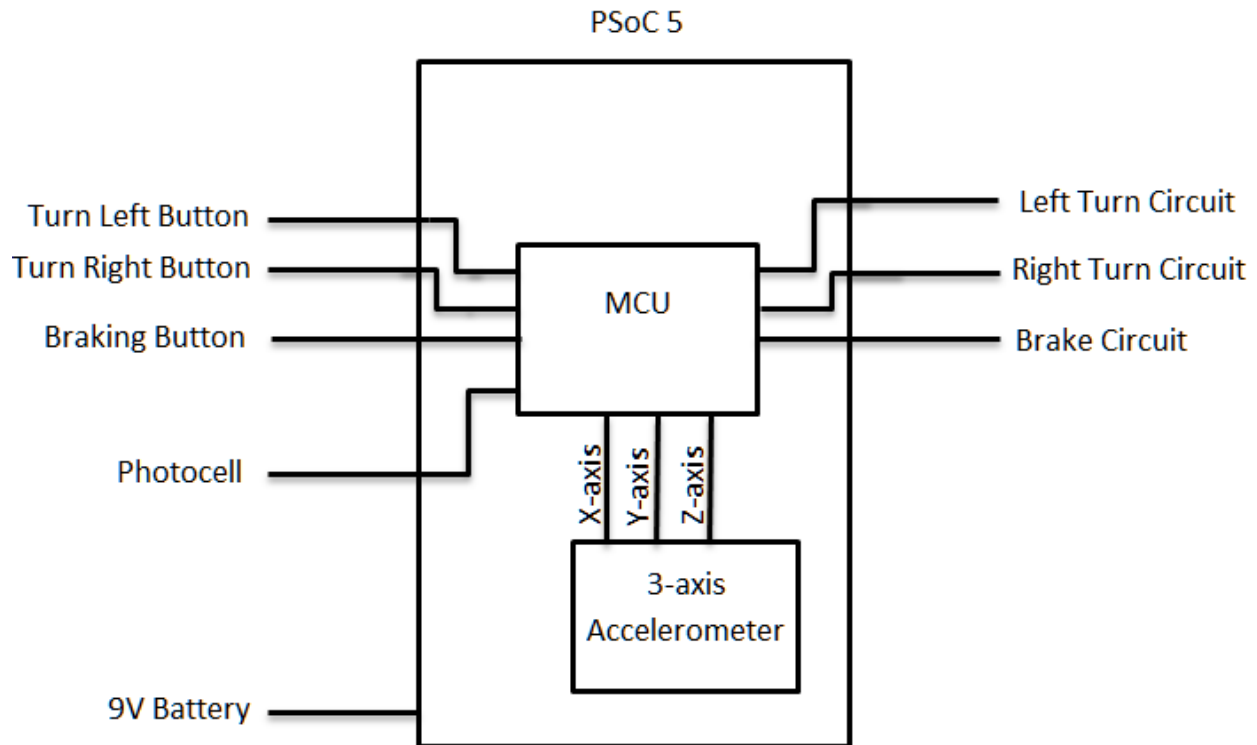
After waiting for the epoxy to dry, we sand down the entire assembly with a belt sander to create flat edges and surfaces. We continue doing this until the entire unit is shaped to how we desire and smooth on all sides. On the front side, we sand the face above the LEDs and EL panels with increasingly finer grit sandpaper, creating a clear face for the light to shine through.

With the overall light circuitry and case completed, we attach a hose clamp to the case for mounting. Using epoxy, we mount the hose clamp to the back of the circuit allowing us to mount the case to the seat post of a bicycle. To ensure the entire system works, we connect each LED and EL panel circuit with power and push buttons and ensure they light up correctly.

#### 4.21 – PSoC 5 Accelerometer Implementation

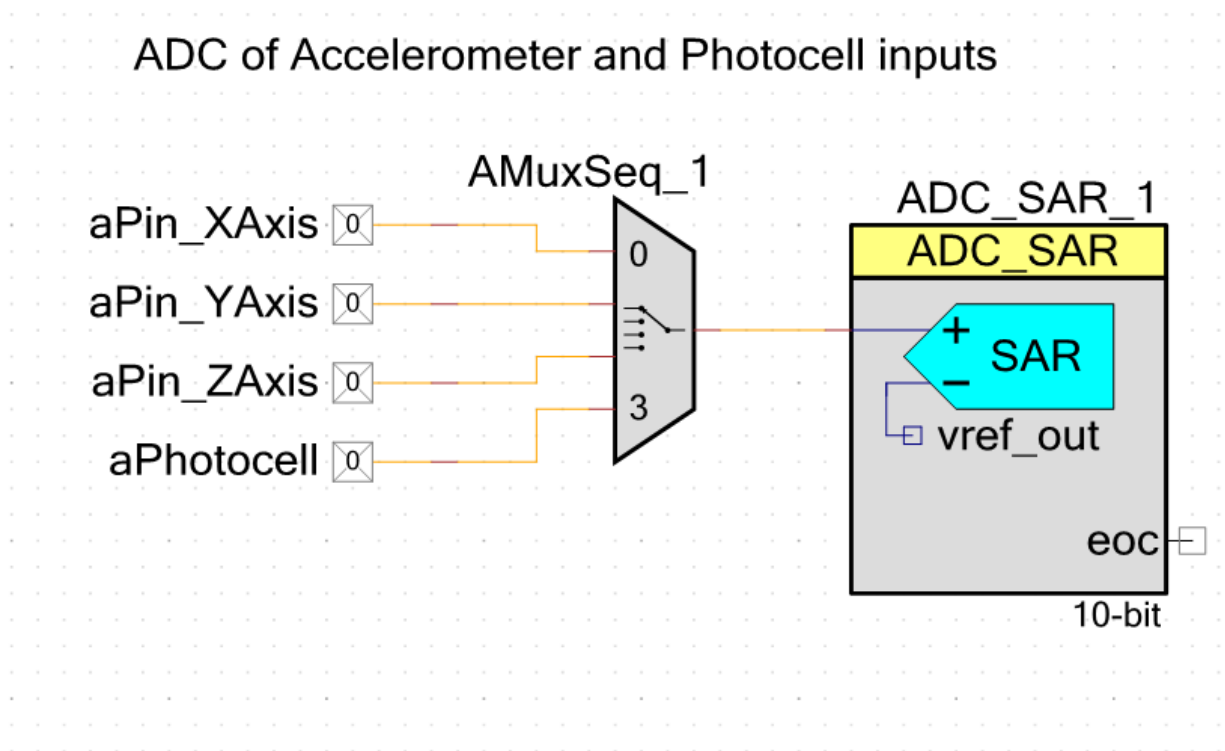
The PSoC board has a built-in, onboard, triple-axis accelerometer which removes the need for an external accelerometer. This also removes several inputs and outputs needed to build the control circuitry, minimizing our inputs to only three buttons and a photocell. The inputs and outputs of the board are shown in Figure 4.

**Figure 4**  
PSoC 5 Wiring Diagram



The programming and wiring of the control circuitry is rather straightforward thanks to the built-in functions of the board. The program uses a successive approximation ADC, provided by the PSoC itself to convert the voltages received from the accelerometer. This eliminates the need for an off-board ADC. However, four inputs make use of the same ADC which makes a MUX necessary. To cycle successively through the four inputs, completing one conversion for each input, we initially used a single MUX and C code to cycle through the inputs. However, Creator already has a component in the library that accomplishes this task, called an Analog MUX Sequencer. We utilize this component with the successive approximation ADC to convert and store each of the four inputs. The schematic view of this is shown in Figure 5.

**Figure 5**  
Conversion Hardware in PSoC Creator



With the analog inputs converted, we employ case statements to decide the proper outputs from the board. The user has three digital inputs they can control: the left button, right button, and the brake button. When the user presses a turn signal button, the turn signal activates, and stays lit until the bike tilts far enough on the X-axis and returns to horizontal, registering a complete turn. With a turn completed, the turn signal turns off. If the user does not activate the turn signal but the accelerometer registers a tilt on the X-axis, the appropriate turn signal activates until the bike levels.

Deceleration is harder to register with an accelerometer, particularly when climbing hills. To correct for this, the user must activate the brake light prior to decelerating. The brake light stays active during the entire deceleration and only deactivates when a large acceleration is registered. This prevents the light from activating unnecessarily.

Due to the cost and sensitivity of the PSoC, we encase the control circuitry differently than we do the lighting circuitry. To enclose the board, we use a clear, watertight box, which we attach to the bicycle frame in the same manner as the lighting board. We drill a hole through the case to feed wires that lead to the lighting circuitry and fill the hole with hot glue to keep the system isolated and watertight.



#### 4.31 – Test

The system responds well to field tests when attached to a bicycle. Motorists are able to see the intentions of the cyclist clearly in daylight and at night. Initial tests show the brake signaling sensitivity is too high, meaning sensitivity on the Y-axis is too high on the accelerometer. By reducing the sensitivity, or raising the value the acceleration needs to achieve before the lights turns off, we achieve much better results in final tests.

#### 4.41 – Cost

The final cost of the system is shown in Table 9.

**Table 9**  
Final Project Cost

<b>CHRISTIAN ORSI, STEVEN HAMILTON EE 464-01</b>				
<b>COST FOR</b>				
<b>TURN AND BRAKE SIGNAL SYSTEM FOR A BICYCLE</b>				
Item	Unit	No. Of Units	Unit Price	Extended Price
PSoC 5 First Touch Starter Kit	EA.	1	\$49.00	\$49.00
Acrylic Panel	EA.	2	\$5.99	\$11.98
Housing for PSoC	EA.	1	\$11.99	\$11.99
Tactile Buttons	EA.	3	\$0.25	\$0.75
Assorted 3mm LEDs	EA.	34	\$0.75	\$25.50
Epoxy Resin	EA.	1	\$24.97	\$24.97
Triangle EL Panel	EA.	2	\$17.99	\$34.98
Rectangular EL Panel	EA.	1	\$22.99	\$22.99
Photocell	EA.	1	\$1.00	\$1.00
22 AWG Wire	L.F.	15	\$0.12	\$1.80
Battery Case	EA.	2	\$3.95	\$7.90
9V Battery	EA.	2	\$3.00	\$6.00
Hose Clamp	EA.	3	\$0.75	\$2.25
Shipping	EA.	2	\$5.00	\$10.00
Labor	Hr.	175	\$14.00	\$2,450.00
Subtotal:				\$2,613.11
Tax (8.25%):				\$215.58
Total:				\$2,828.69
Note: All costs in 2013 dollars				

## 5.01 – References

- [1] Omnibus Bureau of Transportation and Statistics, “Bicyclist Safety Satisfaction,” *United States Department of Transportation*, para. 3, Sept. 13, 2003. [Online]. Available: [http://www.rita.dot.gov/bts/programs/omnibus\\_surveys/household\\_survey/](http://www.rita.dot.gov/bts/programs/omnibus_surveys/household_survey/). [Accessed: Jan. 31, 2013].

This site gives many statistics with regard to all forms of transportation. The US Department of Transportation commissioned the survey, enforcing the credibility of the survey. This helps to set the tone of why a turn signal system would improve safety on a bicycle.

- [2] League of American Bicyclists, “Facts & Figures,” *bikeleague.org*, para. 7, 2012. [Online]. Available: <http://www.bikeleague.org/media/facts/#crash>. [Accessed: Jan. 31, 2013].

This site provides many facts and advocates bicycle riding in the US. This helps to set the tone of why a turn signal system would improve safety on a bicycle. The League consists of many strong advocates of bicyclists in the US, and the site aims to educate riders on the laws and statistics of cycling in the US.

- [3] R. Ford and C. Coulston, *Design for Electrical and Computer Engineers*, McGraw-Hill, 2007, p. 37

This remains the book used for EE460, assuming the department and professor teach ideals to aspiring engineers, this book has strong credibility. This helps to set the requirements and specifications to appropriate bounds.

- [4] IEEE Std 1233, 1998 Edition, p. 4 (10/36), DOI: 10.1109/IEEESTD.1998.88826

IEEE embodies the largest professional organization in the world and all standards have gone through thorough peer reviewing. This helps to set the requirements and specifications to appropriate bounds.

- [5] R. Ford and C. Coulston, *Design for Electrical and Computer Engineers*, McGraw-Hill, 2007, p. 92

This remains the book used for EE460, assuming the department and professor teach ideals to aspiring engineers, this book has strong credibility. This helps to provide a basis for the functional decomposition of the system proposed in this project.

- [6] R. Ashby, *Designer’s Guide to the Cypress PSoC*. Oxford, UK: Elsevier, 2005.

This book describes the basic operations of the Cypress Semiconductor PSoC. This helps teach the basics of interfacing with the PSoC in a streamlined manner. Well known, the publisher, Elsevier, embodies the world-leading provider of scientific and technical information.

- [7] Cypress Semiconductor, “Programmable System-on-Chip (PSoC),” CY8C38 datasheet, Sept. 3, 2012.

The datasheet for the PSoC 3 describes in detail all the caveats of the platform. The datasheet consists of incredibly helpful information on details on interfacing and programming the PSoC. The credibility of this source lies in the credibility of Cypress Semiconductor who has published and made many revisions to ensure the accurate information on the platform.

- [8] J. Dorogusker, “Systems and methods for integrating a portable electronic device with a bicycle,” U.S. Patent 8,364,389, issued Jan. 29, 2013.

This US patent exists for created for Apple Inc. The patent describes methods for mounting electronic devices on a bicycle, a direct application to this project. A business as large as Apple would not waste efforts on meaningless patents, ensuring credibility.

- [9] F. Reverter, "Interfacing Differential Capacitive Sensors to Microcontrollers: A Direct Approach," *IEEE Transactions on Instrumentation and Measurement*, vol. 59, pp. 2736-2769, Oct. 2010.

This journal details how to interface capacitive sensors to microcontrollers in the most efficient way possible. This pertains to this project due to a need for several capacitive sensors in the project. A trusted source, the paper has endured peer-reviewing by other members of the IEEE community.

- [10] T. Peng, "Touch-sensor with shared capacitive sensors," U.S. Patent 8,040,321, issued Oct. 18, 2011.

This patent, created for Cypress Semiconductor, details how to interface several capacitive and touch sensors for the same application. This useful information in integrating several sensors for the same application pertains directly to this project. The credibility of this source lies in the credibility of Cypress Semiconductor, a major semiconductor company

- [11] J. deBoisblanc, "pimpMyBike," *jdeboi.com*, para. 1, Nov. 15, 2012. [Online]. Available: <http://jdeboi.com/pimpmybike/>. [Accessed: Jan. 31, 2013].

This tutorial details how to install brake and turn signals on a bike. This exhibits a direct application to what this project wishes to achieve only using an accelerometer internal to the PSoC. The credibility of this tutorial comes from Ms. DeBoisblanc, who teaches courses on the Arduino platform via Skillshare.

- [12] M. Fenwick, "Homemade Bicycle Turn Signals," *mikefenwick.com*, para. 1, Dec. 2009, 2009. [Online]. Available: <http://mikefenwick.com/projects/bicycle-turn-signals/>. [Accessed: Jan. 31, 2013].

This project webpage consists of a tutorial on installing brake and turn signal lights. Applications pertain directly to this project, although modifications make it a perfect fit. Mr. Fenwick graduated from the University of Arizona State in 2009 with a degree in Physics and has remained a hobbyist in electronic applications since.

# Appendix A: Analysis of Senior Project Design

## 1. Summary of Functional Requirements

The device consists of a set of brake lights and turn signal indicators that attach to an existing bicycle to provide the same safety lights as a motor vehicle. The user can turn on the blinking turn signals using capacitive touch sensors, or the accelerometer onboard the PSoC senses a the lean of the bike and turn on the appropriate turn signal, should the user forget to signal. The brake lights illuminate when detecting deceleration by the accelerometer. To ensure safety, the LED lighting needs to work under foggy weather and poor lighting conditions.

## 2. Primary Constraints

Difficulties lie in sensing the difference between braking and deceleration due to a hill. Detecting how vertical the bike remains while riding contains difficulties as well. Through extensive testing and averaging, the accelerometer compensates for these issues.

A simple instruction manual demonstrates the attaching the device and the functionality of the system. The system easily attaches to various types of bicycles with relative ease. To refrain from impeding the user performance, the requirement for a small, compact system becomes imperative. A small, replaceable or rechargeable battery provides the power for the system. With brake and turn signal capacitive touch sensors integrated onto the handlebars, both hands of the user remain on the handlebars at all times, making signaling safer. Since Cypress Semiconductor commissioned the project, the PSoC 5 development board provides the platform on which the rest of the system relies on.

## 3. Economic

Two undergraduate engineers work on this project, preparing it for use by the general public. They remain in contact with an engineer with Cypress Semiconductor who guides them and provides input on the progress of our project. A senior project advisor also provides feedback and helps along the way with the project. Cypress Semiconductor also provides the PSoC 5 First Touch Kit. Finance for the project consists of a combination of donations and personal funds. They plan on utilizing minimal amounts of components so as to not exhaust the natural resources of the planet. However, their system may save a few hundred bicyclist lives a year, which may impact the bio-capacity of the Earth. However, the estimated impact of the system on the bio-capacity of the Earth has a minimal to negligible effect.

Table 5 below shows the fixed cost of the system in detail. Figure 3 through 7.show the Gantt Chart of the project. Red highlights pertain to written reports.

**Table 10**

Preliminary Project Cost Estimates [11]-[12]

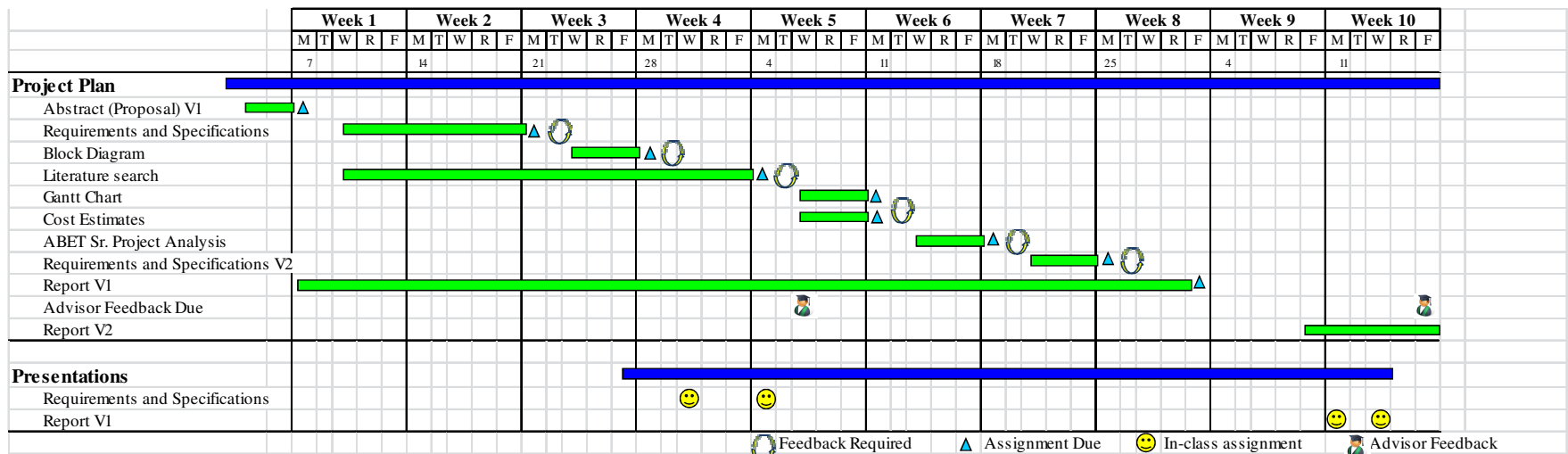
<b>CHRISTIAN ORSI, STEVEN HAMILTON EE 460-01 W13</b>				
<b>COST ESTIMATE FOR</b>				
<b>TURN AND BRAKE SIGNAL SYSTEM FOR A BICYCLE</b>				
Item	Unit	No. Of Units	Unit Price	Extended Price
PSoC 5 First Touch Starter Kit	EA.	1	\$49.00	\$49.00
Soldering Board	EA.	3	\$5.00	\$15.00
Housing for Lighting	EA.	3	\$10.00	\$30.00
Capacitive Sensors	EA.	4	\$3.00	\$12.00
Assorted 5mm LEDs	EA.	50	\$0.75	\$37.50
Assorted Resistors	EA.	20	\$0.02	\$0.33
24 AWG Wire	L.F.	10	\$0.12	\$1.20
Battery Case	EA.	2	\$3.95	\$7.90
9V Battery	EA.	2	\$3.00	\$6.00
Mounting Hardware	EA.	1	\$20.00	\$20.00
Shipping	EA.	8	\$7.00	\$56.00
Labor	Hr.	250	\$14.00	\$3,500.00
Subtotal:				\$3,734.93
Tax (8.25%):				\$308.13
Total:				\$4,043.06
Note: All costs in 2013 dollars				

\*The PSoC 5 First Touch Starter Kit comes equipped with a three axis accelerometer and a light sensor.

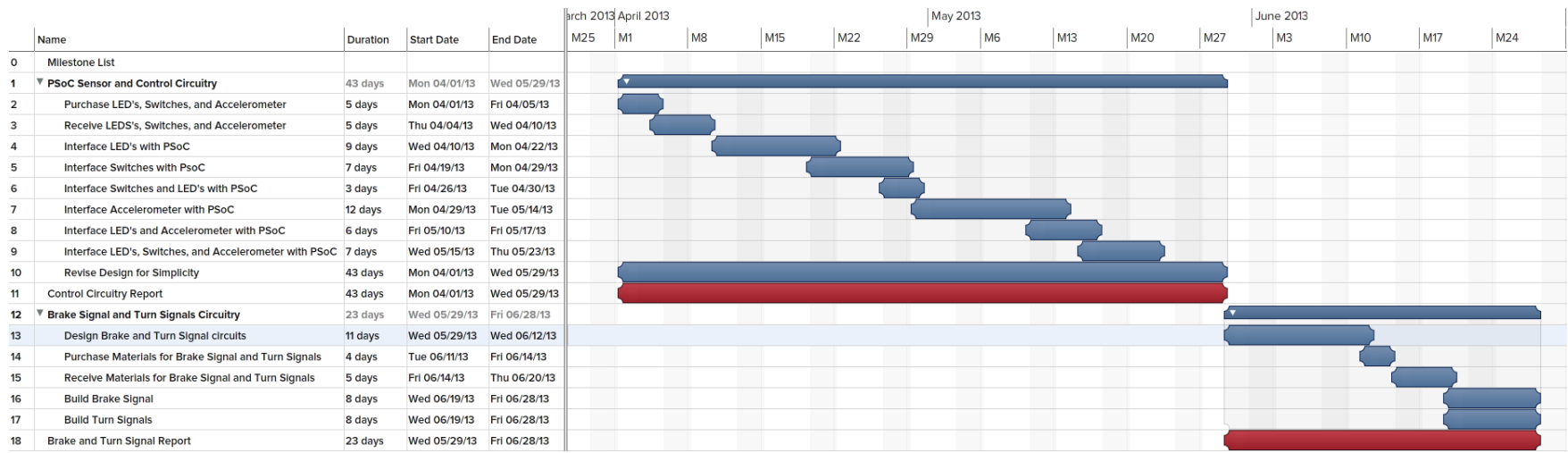
The necessary components required to construct and mount the LED turn signals and brake light onto the bicycle consist of: soldering boards, LEDs, resistors, wire, housing for lighting, and mounting hardware. Additional capacitive sensors enable the rider to interface with the system. The battery case and 9V batteries power the mobile platform. Shipping and tax costs make up a significant amount. Labor estimated at \$14/hour, or a base salary of \$30,000 a year.

The equation from Ford and Coulston estimates the price of each line item as follows:

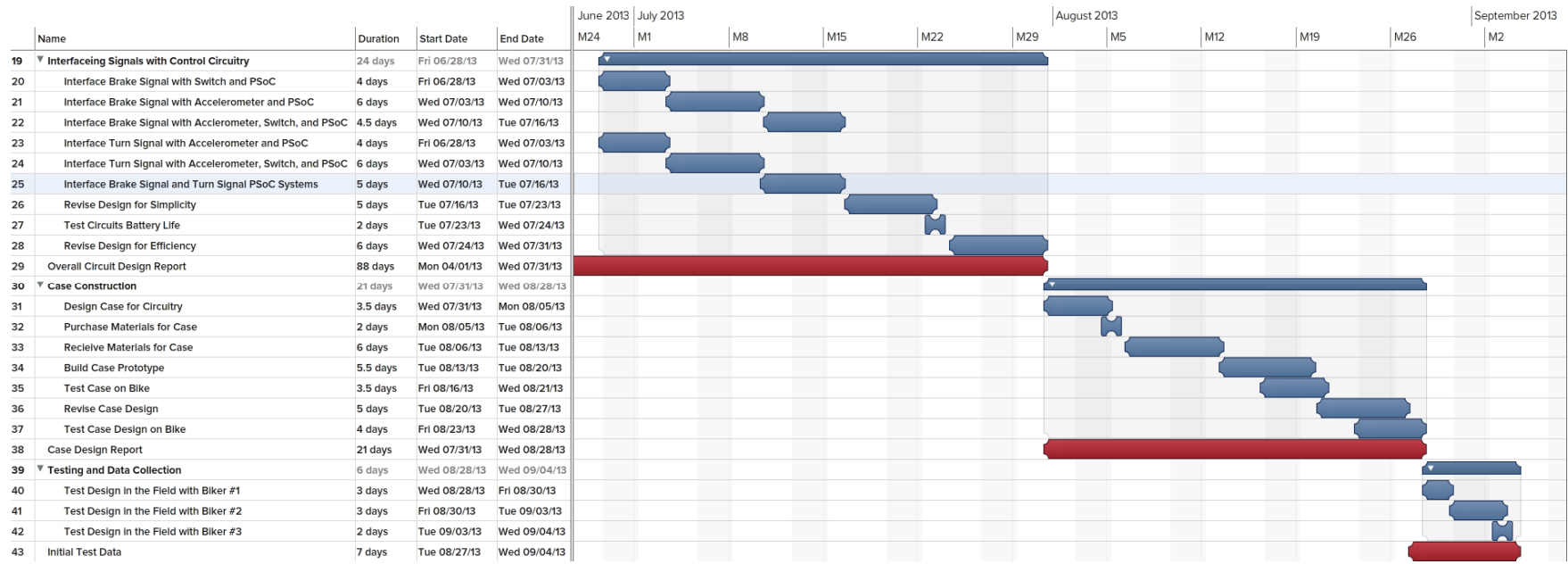
$$Cost = \frac{cost_a + 4cost_m + cost_b}{6}$$



**Figure 6**  
Winter 2013 Gantt Chart

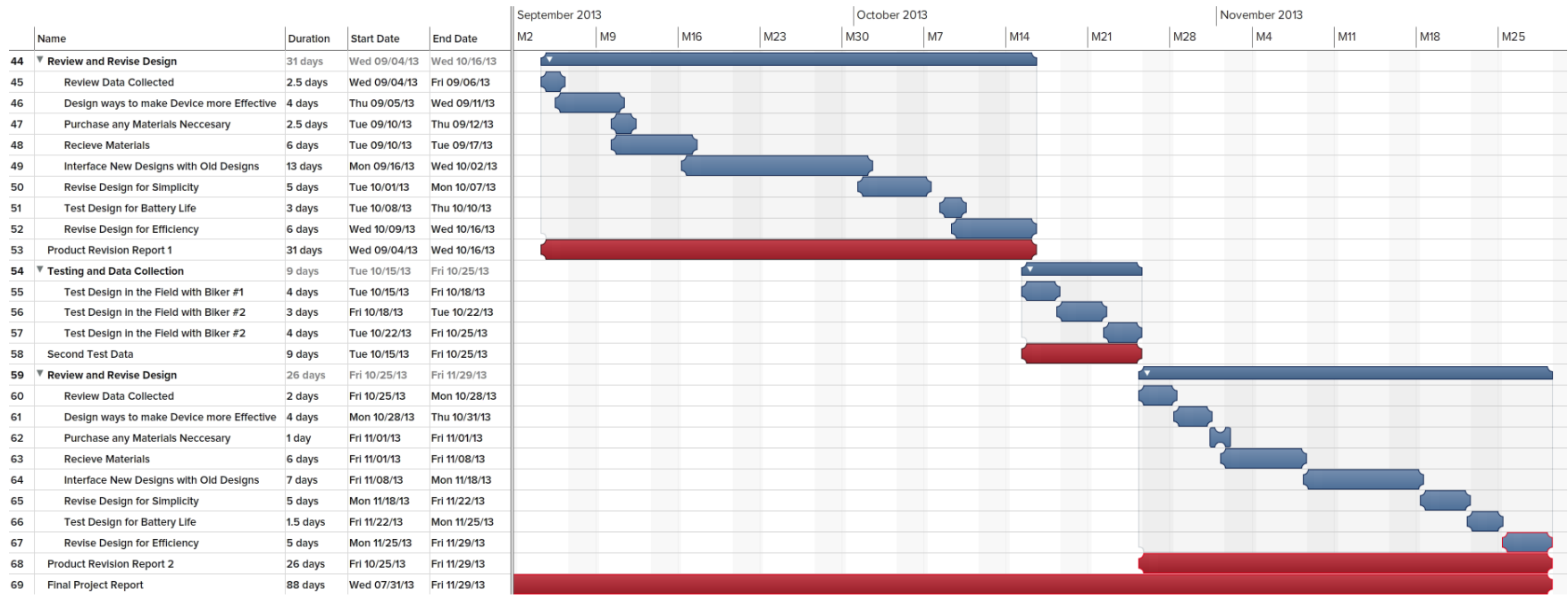


**Figure 7**  
Spring 2013 Gantt Chart

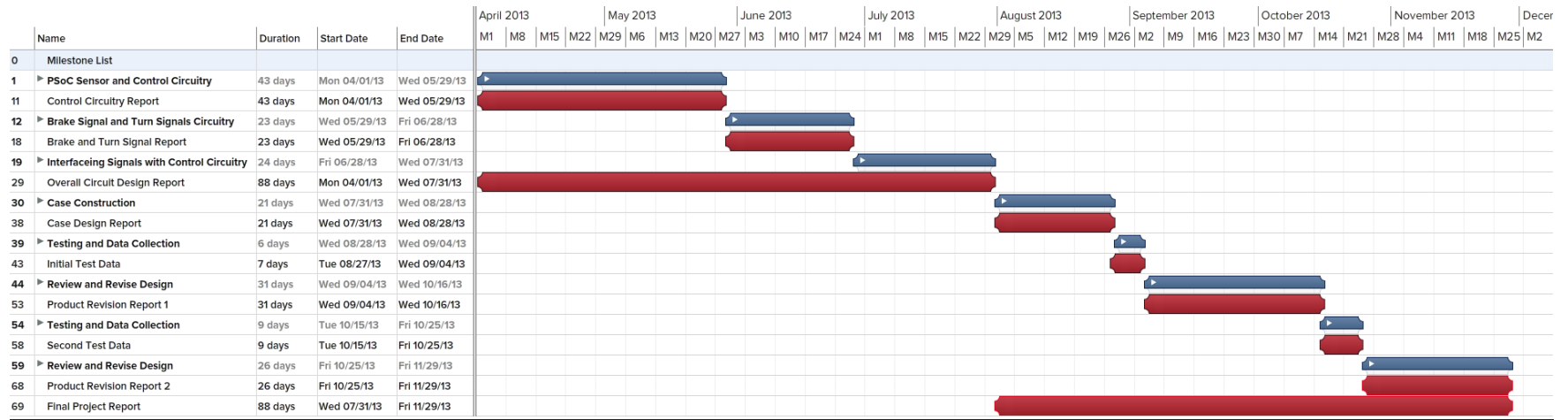


**Figure 8**  
Summer 2013 Gantt Chart





**Figure 9**  
Fall 2013 Gantt Chart



**Figure 10**  
Project Report Overview Gantt Chart

#### **4. Commercial Manufacturability**

The fixed costs of the system sum to \$4,044. The estimated purchase price of the system amounts to \$100 per unit. The manufacturing costs equal roughly \$80 if parts cost bulk price. Therefore, at least 203 units need to sell to break even. Anticipating around 1,000 units sold a year, the estimated profit per year, after the break-even point, sums to \$20,000. The operations and maintenance costs consist only of replacing the 9V battery, not charging a rechargeable battery. If the user utilized the device constantly, batteries would need replacing every two weeks. If the user bought two 9V batteries a month, this equates to an O&M cost of \$50 a year.

#### **5. Environmental**

The product casing consists preferably of recycled plastic to lower its environmental impact. Depending on the effectiveness of a rechargeable battery, using it in the device lowers the amount of waste produced by the device, in this case, dead batteries. Though, because the device needs charging, this has an environmental impact through the use of electricity, but no more than a typical LED flashlight. The project also consists of basic components like LEDs, resistors, etc., so the reusability of the device in its modular state amounts to roughly 50%. This device may impact other species through the increase of ambient light at night. The turn signal indicators and brake lights may bother night creatures like owls, bats, raccoons, etc., but these indicators also make the biker easier to see and scare away animals that may otherwise collide with the bicyclist.

#### **6. Manufacturability**

The major issue facing manufacturability pertains to the development of a system that could universally fit on any bicycle. The best thing to remedy this consists of making adaptors available for those that need them to fit the system to their bicycles. The PSoC platform creates a large overhead cost and makes up over 60% of the cost of the system. Perhaps a bulk deal made with Cypress Semiconductor could lower the price. The processes of assembling the system should become entirely automated. This decreases labor costs to practically zero, but increases the fixed costs dramatically. As far as end of life issues, we predict the usefulness of this technology spanning at least 20 years. At the end of the useful life, the user can harvest useful components from the system, such as the PSoC and other various components. The system can easily avoid the landfill through reuse of components.

#### **7. Sustainability**

The only sustainability challenge that the device suffers from once complete pertains to the battery situation. If using a typical battery, then this battery needs replacing constantly throughout the devices lifetime. This affects both the overall cost for the user, and the impact on the environment. If the device uses a rechargeable battery, then the lifetime of the rechargeable battery after multiple charges affects the lifetime of the device. Many consumers also toss the device once the rechargeable battery wears down, instead of replacing the battery. This also

effects the environment by creating more waste. The ideal situation relies on making the device use a small enough amount of energy so that the waste created by buying batteries reduces to a minimal amount or the lifetime of a rechargeable battery outlasts that of the consumer. The minimum power requirements of the PSoC and the various indicators make this difficult to achieve.

## **8. Ethical**

Under the IEEE Code of Ethics, this system meets all ten points. In order to create this system, we must expand our knowledge and seek honest criticism of our technical work, meeting points 5, 6, and 7. Our system serves people of all backgrounds, reduces injuries, and satisfies the claims of the makers, meeting points 2, 3, 8, and 9. We accept full responsibility for the system, reject all forms of bribery, and assist each other in the development of the system, meeting the remaining points 1, 4, and 10.

Under the Utilitarian ethical framework, this system meets the main points. The system meets the quantitative measurement of utility in that it benefits most cyclists should they choose to implement the system on their bicycle. It reduces injuries, and even lives if implemented.

## **9. Health and Safety**

A single 9V battery provides the voltage source to power the circuit, enough to provide a shock, though hardly noticeable. The lights and signals consist of LEDs, which degrades in lumen levels by 10% for every 5,000 hours of usage. This means that if a consumer utilizes the product, the light level output does not change drastically over the life of the product, making LEDs safer than implementing some other type of bulb. The system may impact the number of cyclists in a positive manner, reducing the number of cars on the road, reducing the emissions by cars. This creates cleaner air for everyone to enjoy. The health and safety of the general public not utilizing the system remains the same.

## **10. Social and Political**

This project makes riding bicycles safer. This would lead to an increase in cyclists, leading to an increase in members of cycling clubs perhaps. This would also mean fewer people driving cars in the city to work, leading to fewer emissions. Fewer emissions could ease up on legislation surrounding emissions from vehicles. The system would also likely increase the legislation regulating bicycles, perhaps inspiring a helmet law for all riders. This would amount to an adverse effect on the cycling community since people ride a bike less if they have to wear a helmet. As stated earlier, the number of accidents decreases significantly since drivers identify the cyclist's intentions with relative ease thanks to the common signal system. The system complies with the California DMV Equipment and Requirements V C Section 21201.

## **11. Development**

We must learn to use the PSoC Creator software, as well as all aspects of the PSoC, in order to interface with the PSoC board successfully. We must learn how to interface an accelerometer with the PSoC and how to design and build a plastic housing compartment mounts for vital aspects of the project. Performing a literature search helped to narrow our goals and utilize the basic designs of the existing DIY systems out there.