March 10, 2010

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Project Design Specifications for a Blind Spot Safety System

Dear Dr. Rawicz,

The attached document contains the design specification of our project iChecked blind spot detection system for ENSC 440. The aim of our project is to implement a blind spot safety system for automobile drivers.

The attached design specifications concisely describe how we plan to implement the hardware, circuitry, and other components of our product, and include our strict rationale for design and component selection. We also outline a test plan to ensure our product functions correctly and reliably.

Ensuring the success of our project is a team of five enthusiastic and talented individuals from the School of Engineering Science: Aron McKinnon, Elyas Sepasi, Barry Li, and Victor Chan. We believe this team is capable of accomplishing the proposed task in a timely fashion.

If you have any questions or concerns, please do not hesitate to contact us via email at blindspot-440@sfu.ca.

Sincerely,

Aron McKinnon
Chief Executive Officer
iChecked Inc.

Enclosure: Design Specification for iChecked Inc. Blind Spot Safety System

Design Specification for

Blind Spot Safety System

iChecked Inc.

Project Team:

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Submitted to: Dr. Andrew Rawicz – ENSC 440
Mr. Steve Whitmore – ENSC 305
School of Engineering Science
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Issued Date: March 10, 2010

Abstract

The purpose of this document is to specify the design for the proof-of-concept prototype of the iChecked Blind Spot Detection System. The design specifications will correspond to the functionalities outlined in the functional specifications document indicated as phases I and II. [1] The development of this product consists of the design of an exterior warning indicator system and a car module.

The design of this product includes solving many engineering problems. The most feasible solution based on the time-line and budget constraints is selected. In this document, a summary of numerous amounts of experiments which were conducted to verify the feasibility of the design is also included. Furthermore, a system test plan that will ensure functional and performance requirements during its development has also been included in the document. The system test plan will also ensure the iChecked Blind Spot Detection System will be able to perform like an end product.

The document provides an in-depth description of important background information necessary to understand the design in more details. With the current pace of the development cycle, we are confident that we will accomplish the targeted milestones and complete the development of the proof of concept prototype by the target date April 15, 2010.

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Glossary

DC: Direct Current

LED: Light Emitting Diode

1. Introduction

Blind spot safety system is a driver assistant, it will safeguard you when switch lanes and carelessly missed the hazard in your blind spot. Although shoulder check is mandatory in North America, some still ignore or forget to do so, in some country should check is not required. Certain vehicles have interior designs which limit vision and even with a shoulder check changing lanes can still be dangerous and uncertain for the driver. Therefore such system will help the drive avoid hitting other road users when they switch lanes.

The Blind Spot Detection system would consist of a sensors, signal processor, and warning system. The sensor of the blind spot of the system detects cars on the side of the vehicle. The signal is passed by wires to a processor circuit which will process the data and determine if a vehicle is in the blind spot area. If so, warning signal consists of LED and buzzer will alert the driver of neighboring traffic.

1.1 Scope

This document outlines the design requirements that will be met by iChecked Inc. and how the design relates to the functional specifications outlined in Functional Specification for iChecked Blind Spot Detection System. It provides information on system parameters, components and ratings. These set of requirements fully describe the proof of concept prototype and production procedures. Since experience will be gained while developing this device, only a partial set of functional requirements is supplied for the production device. Given that the project is currently under development, the final functional specifications may vary slightly from those provided in this document.

1.2 Intended Audience

The functional specification is intended for use by all members of iChecked Inc. The team manager should use the functional requirements as a concrete measure of progress throughout the development phase. Design engineers should use this to follow the design goal and implantation. Test engineers should use this document to assist in testing the similarity of function in the actual system with the functionality described in this document. Marketing personnel can use this document to develop advertising materials.

1.3 Key Definition

Blind spot

Even in a time that the mirrors are properly adjusted, there are large areas around a vehicle that drivers are not able to see their mirrors. These spaces are called blind spots. Blind spots are in the sides of the car and at the back of the car and also, below driver's field of vision to the front. The most dangerous blind spots are to the sides of the car. Those are the spots that drivers are supposed to check by doing shoulder check. Depend on the design of each car, small objects like bicycles can be ignored if they are in these spaces around the car.

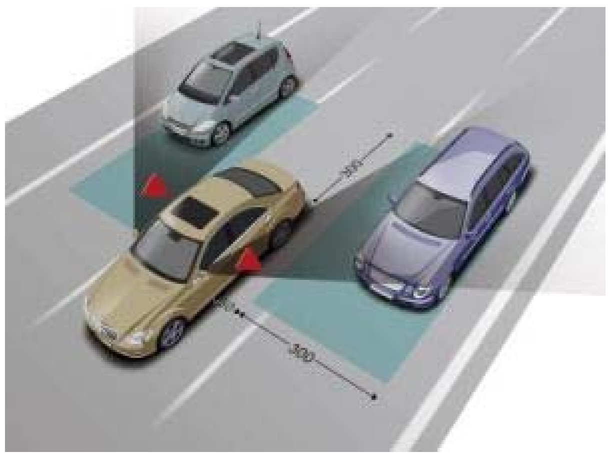

Figure 1-1: Typical Blind Spot of a car

Usually cars have smaller blind spots at the front and at the back and two large blind spots on the sides. The sizes of the blind spots are depended on the size of cars. Therefore, there is no specific range for these spaces around each car. However, with good approximation it can be said that the side blind spots are from 20^{o}C to 90^{o}C from side of the car [2]. Also, it starts from the blind spot of the driver's eyes and go toward the back of the car; blind spot of the driver's eyes is the area that eyes are covering without turning the head around which for a normal eyes is usually from 0^{o}C to 180^{o}C from left to right. To have some approximation about the distance of other cars around the car, it can be say that the closest distance which a car will be in blind spot is around 0.5 meter and the furthest distance from the car is around 3 meters [2]. By furthest distance it is implied the closest- furthest distance since we can go as far as we want and stay in the blind spot. However, after 3 meters it is not a dangerous zone any more.

2. System Overview

After a vehicle is located in the blind spot, it is recommended to avoid lane changes until the vehicle has passed. The blind spot safety system is a driving assisting system. It will provide more vision and safety than regular mirrors have provided. The intended users are drivers from compact car to truck, and the system would be designed differently for car sizes [3].

The overall system is consisting of three stages in the block diagram Figure 2-1.

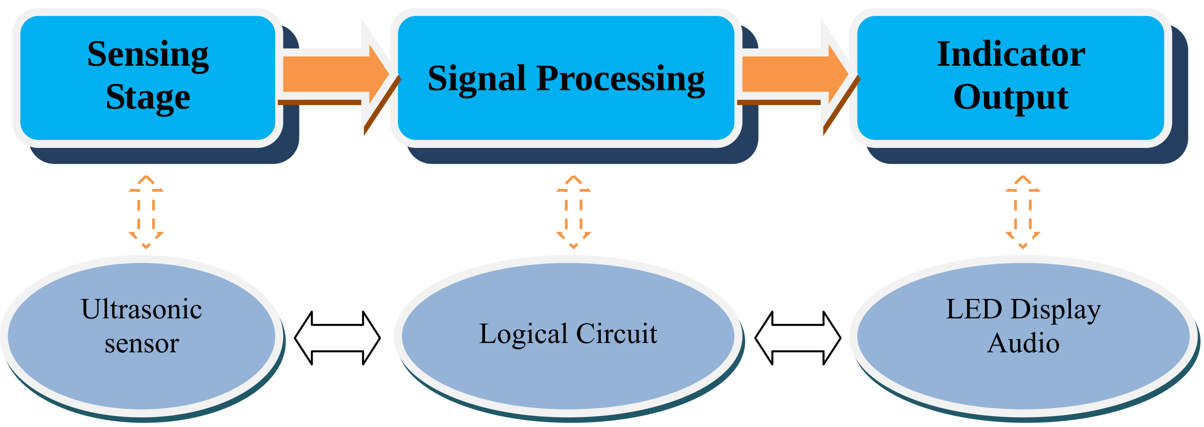

Figure 2-1: Overall Block Diagram

Though our target goal is to have a working prototype by the second week of April 2010, we are not limited to think ahead on our actually production goal. Figure 2-2 shows what we have envisioned the installation of our system on an actual vehicle. This design is a reflection of nearly 2 months of contemplation and constructive debate, and it best represents our design.

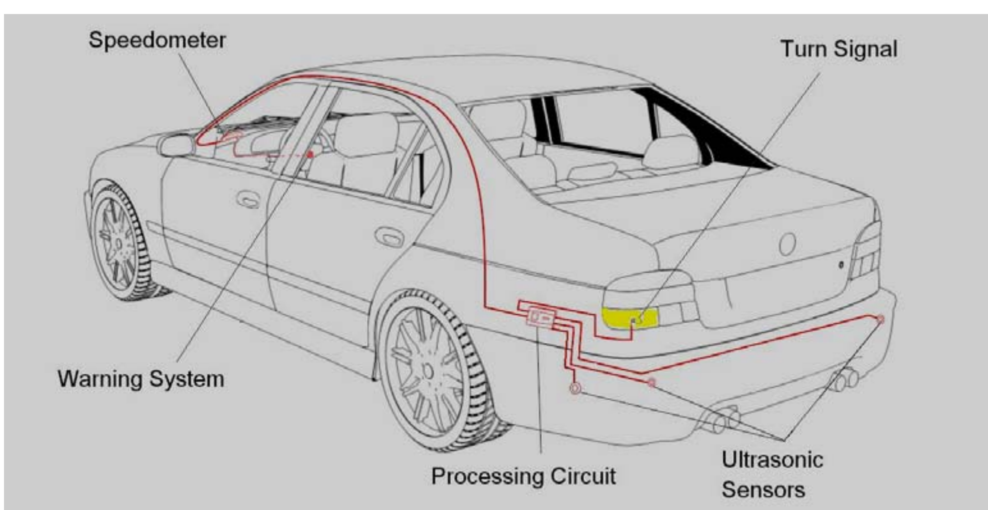

Figure 2-2: See-Through Sample of our product

3. Input Signals

3.1 Sensor Selection

The intended sensor detection region shown in the figure 3-1 shows that the system requires a short range sensor with a wide area spectrum. This is important so that we do not give a warning indication to the driver if a vehicle is 2 lanes over.

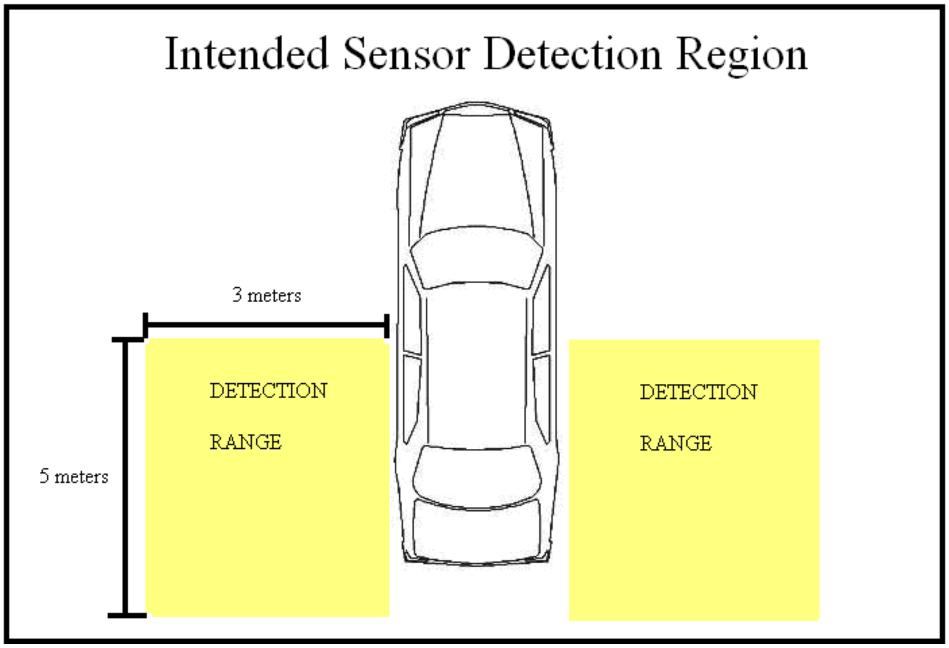

Figure 3-1: Intended Sensor Detection Region

The Sensor Criteria is as follows:

- Should be a wide angle detector (40 degree angle or greater)
- Should not detect past 3m (do not want to sense vehicles 2 lanes over)
- Should be fairly inexpensive

A few types of technologies that could be used for the sensors were investigated:

- Laser detection (range issue could be a problem as well as angle, basically a point source)
- Infrared (Sensors were shown to be very costly)
- Ultrasonic (found to be the best suited to wide angle with range restrictions)

Ultrasonic sensors were investigated from a number of different sources:

- •Local electronic suppliers Digikey (basic ping ultrasound, not wide angle)
- •Industrial /Automation Suppliers (Very Expensive > $150)
- •Taking from other products that use ultrasound sensors (Parking Detector Systems)
- •Meet our criteria (Wide angle +/- 40 degree, short range 3m, low cost)

We choose the sensors from an existing product called Automotive Parking Sensors from AutoSonar [4]. These ultrasonic sensors are Table 3-1 lists the technical specifications of these sensors. [5]

Table 3-1: technical specifications of Automotive Parking Sensors

Parameter	Specification
Working Voltage	10.5-16V DC.
Working Temperature	- 30C to + 80C
Sensor Dimensions	22mm x 18mm
Sensor Detection Angles	Horizontal: 80 degrees; Vertical: 80 degrees
Sensor Detection Range	0.4m - 1.5m

3.2 Sensor Placement

Two sets of sensors will be placed, one on the back wheel well and one behind the driver's window. This will allow for the best coverage of the intended sensor detection area.

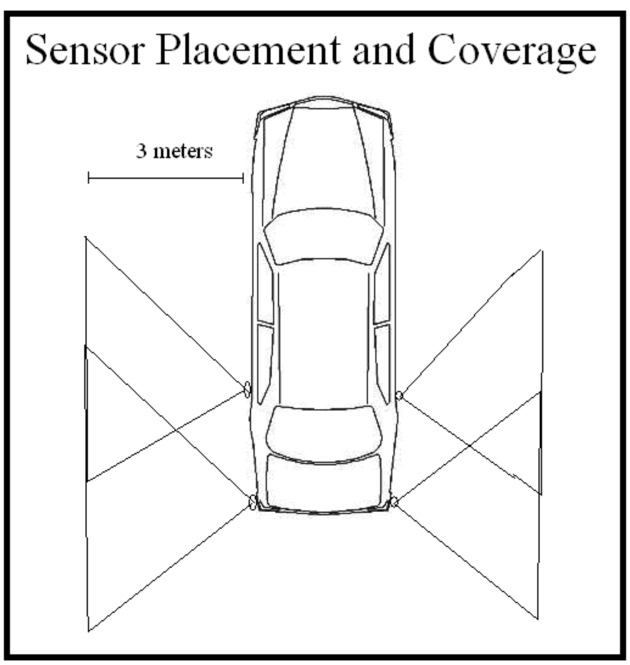

Figure 3-2: Sensor Placement and Coverage Region

4. Signal Control Unit

4.1 Processing Circuit

Assuming the output of the sensors is unstable, we first need to stabilize the signal first. We choose to use another circuit to adjust the sensor output from 0V to 5V, it will be used later to compare with other voltages. With other signals are also from 0V to 5V, all the signal coming into the logical circuit become high-low signals. From the diagram below signal will be processed by numbers of logic gates. These gates are simple and trustful, unlike microcontroller requires higher power and costs.

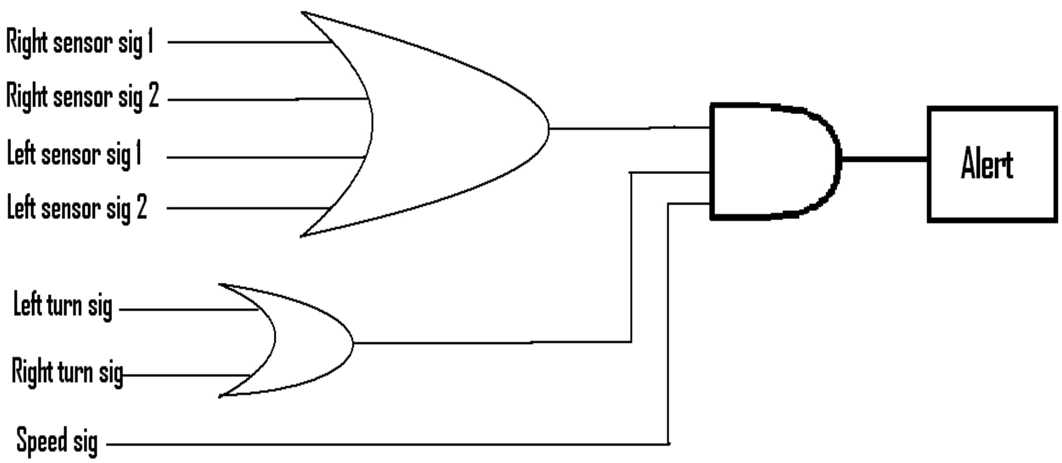

Figure 4-1: Logic diagram of the processing stage

The processor takes in seven signals from sensors and car output, they are four sensors and two turn signals and one tachometer signal. Wiring section will explain more on how to acquire those three signals from the car. After receiving all seven signals, we use three logic gates to achieve safe detection.

After the oral presentation we had with the professors and teaching assistant, we have modified the idea a bit. Originally we thought the system would activate only when the driver use the turn signal and the speed is over 30 Kilometer per hour.

The OR gates we choose to use is the model of MM74HC32 [6]. The AND gates we will use is from the model of MM74HC08 [7]. The key features of these ICs are listed in table 4-1 below.

Table 4-1: Key Features of MM74HC08 and MM74HC32

Parameter	MM74HC08	MM74HC32
Supply Voltage (V_{cc})	-0.5 to +7.0 V	-0.5 to +7.0 V
DC Input Voltage	-1.5 to V_{cc}+1.5V	-1.5 to V_{cc}+1.5V
DC Output Voltage	-0.5 to V_{cc}+0.5V	-0.5 to V_{cc}+0.5V
Operating Temperature	-40 to +85^{o}C	-40 to +85^{o}C
Input Rise/Fall Time When V_{cc} = 4.5V	500 ns	500 ns

4.2 Physical Design

Since our circuit can be quite compact, we do have the capacity to place our core circuit on a PCB. We decide to build the circuit onto the breadboard for lab testing, for the finishing prototype then we will solder the component onto a standalone PCB build into a plastic box, see Figure4-2. The plastic box should have nine connectors available, seven for the inputs and one for output and one for common ground. The type of connection will be discussed in wiring section.

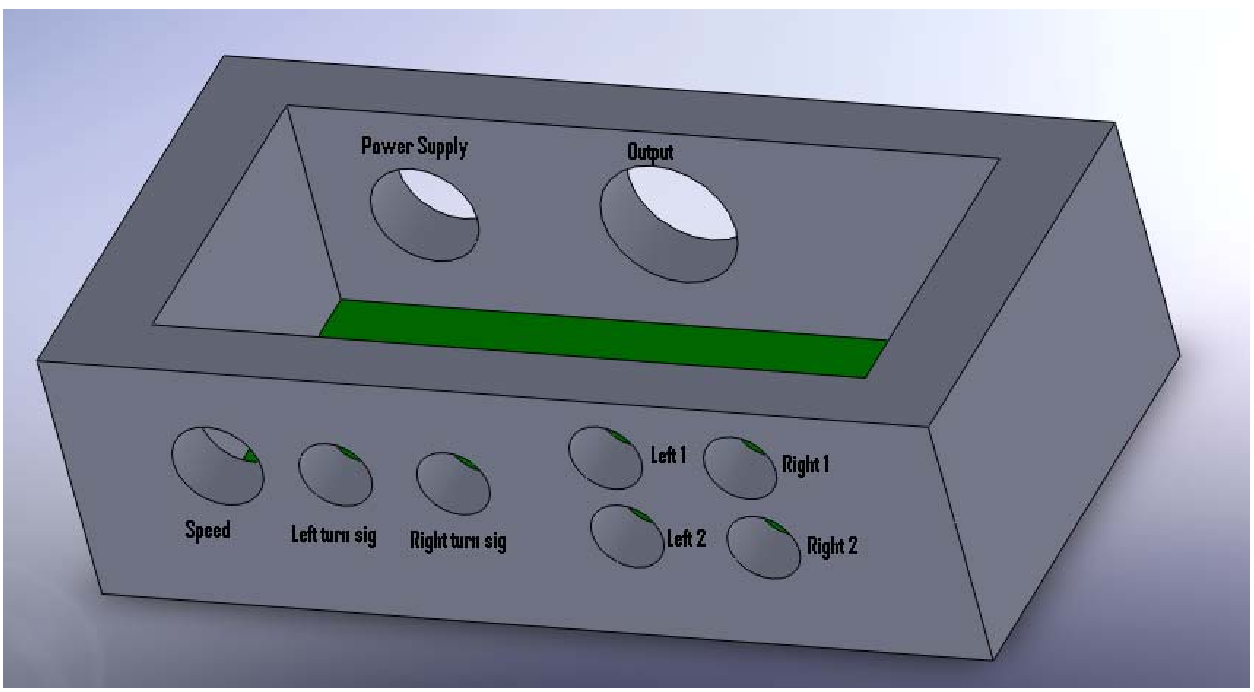

Figure 4-2: Design of the container box

5. Signal Processing Unit

The purpose of the blind spot detector that we are designing is to increase the safety of the driving. Therefore, the warning system proposed in our design includes two subsections: auditory and visual in order to use both sight and hearing senses.

5.1 Indicator

The results of the processing of the signals of sensors in the processing circuit indicate that whether there is any obstacle in the blind spot of the vehicle or not. In cases that results show an obstacle in the area of blind spot, the processing circuit sends relative signals to the warning system. There are two signals to the warning system; one turns on an LED while the other makes an alarm buzz.

Consequently, the probability that the driver receives the alarm signals is satisfactory. For instance, when, due to the combination of lights outside and inside the car, the driver misses the light indicator, there is a sound alarm as a back up to warn the driver. On the other hand, if the environment is too noisy (loud music or noise of traffic) and the driver cannot hear the alarm sound, there is a visual alarm to inform the driver. Having explained that the purpose of the blind spot detector is to increase the safety of roads, by using this technique (having visual and auditory) we increase the probability that drivers receive the corresponding alarm in the time that they are putting themselves and other drivers or riders in a danger of accident.

One of the purposes of iChecked is to design a blind spot detector, which is introduced as an aftermarket product. For the purpose of our design we want to have the warning system as a package. A package that is easy to install, compatible with different models of vehicles, and hidden so it does not deteriorate the beauty of vehicles, outside and inside. Therefore, to satisfy these criteria, the small package, which includes the light and sound alarms, is mounted behind the steering wheel. There are some benefits to install this kit behind the steering wheel; first of all, we do not change the exterior appearance of the car as well as the interior one, which otherwise the costumers would not be happy with this feature. Secondly, the design of the steering wheel for almost all the vehicles is same therefore, independent form the kind and model of the car, owners have this opportunity to buy the iChecked and have it installed on their cars. Thirdly, installation of such kit is straight forward enough to capable most of the costumer to install the kit by their own.

5.2 Visual

For this part of the warning system we are using some LEDs, as you will see in Figure 5-1 to 5-3. These kinds of LEDs have the fairly bright color. Hence, their effect is obvious even in day time. Because the light is bright and relatively strong, LEDs are implemented in such a way that they do not shine directly to the drivers' eyes for safety purposes. The LEDs are behind the steering wheel pointing toward the dashboard. Therefore, they light up the dashboard and attract drivers' attention.

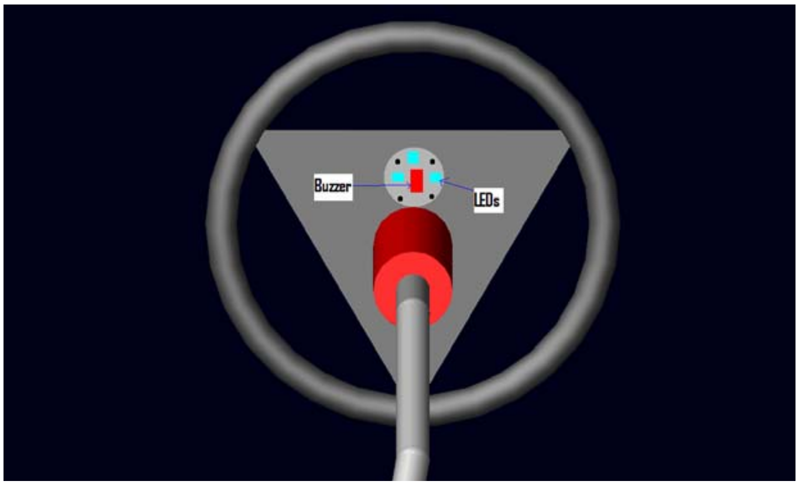

Figure 5-1: Behind the Wheel

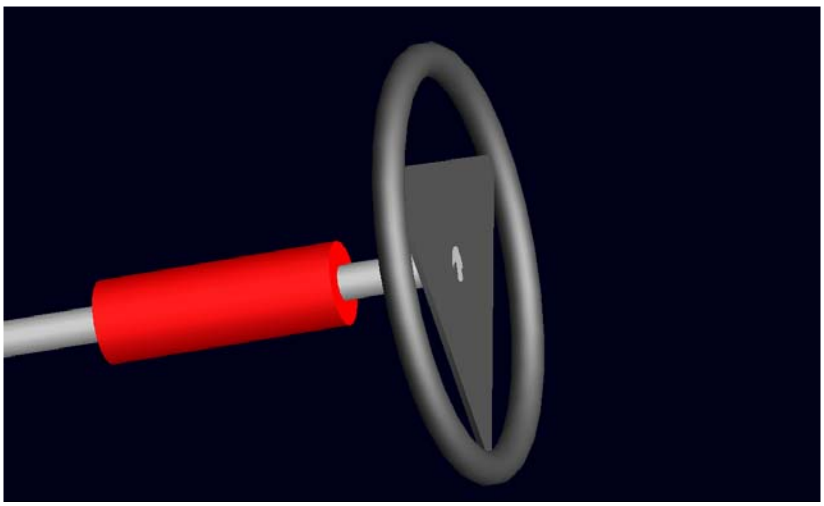

Figure 5-2: Side View of the Wheel

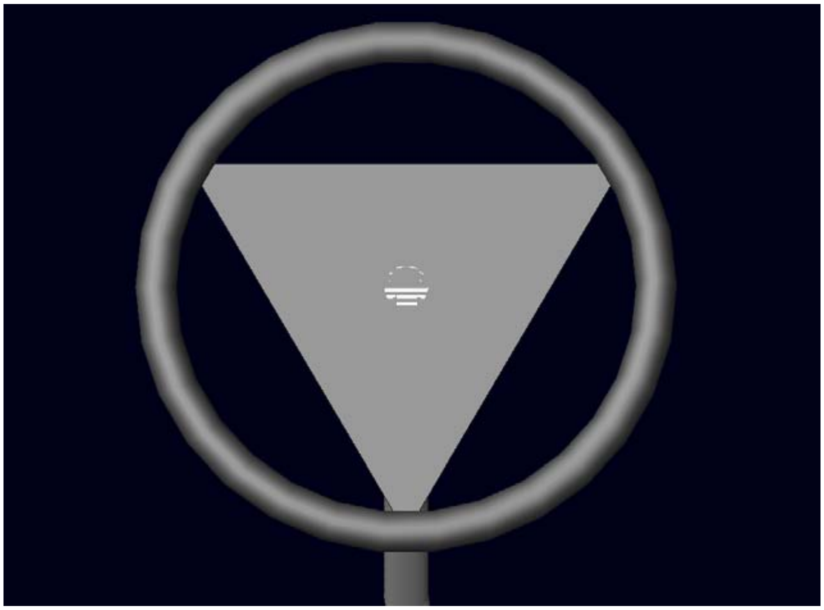

Figure 5-3: Front Side of the Wheel

5.3 Audio

This part of the warning system is responsible to make alert sound in order to warn drivers. A buzzer is installed on the board of the warning system, which is placed behind the steering wheel. The proposed location of the installation makes the buzzer really close to drivers. Therefore, the chance that the drivers hear the alarm is high.

5.4 Warning System

Indicating in figure 5-4, the signal received from the processing circuit is going to an amplifier in order to have the desire current for LEDs and the buzzer. The signal sent form the processing circuit has 5 V voltages which is enough for both LEDs and the buzzer on the warning system. As it has been motioned before, the warning system includes two parts; figure 5-1 illustrates the concept. For the visual section, we have decided to imply an MR-D0040-20T Pre-Mounted Rebel Red LEDs [8]. This model has three LEDs on a 20mm by 20mm Tri-Star Base, 90 lumens of Red light at 350mA and 195 lumens at 700mA. The Max current 1000 mA can be applied for current 350 mA it required 8.7 V. The type of LED used is LXML-PD01-0030 and it has the wavelength of 626 nm with weight of 1.2 g and it works in wild range of temperature between -20^{o}C to 80^{o}C.

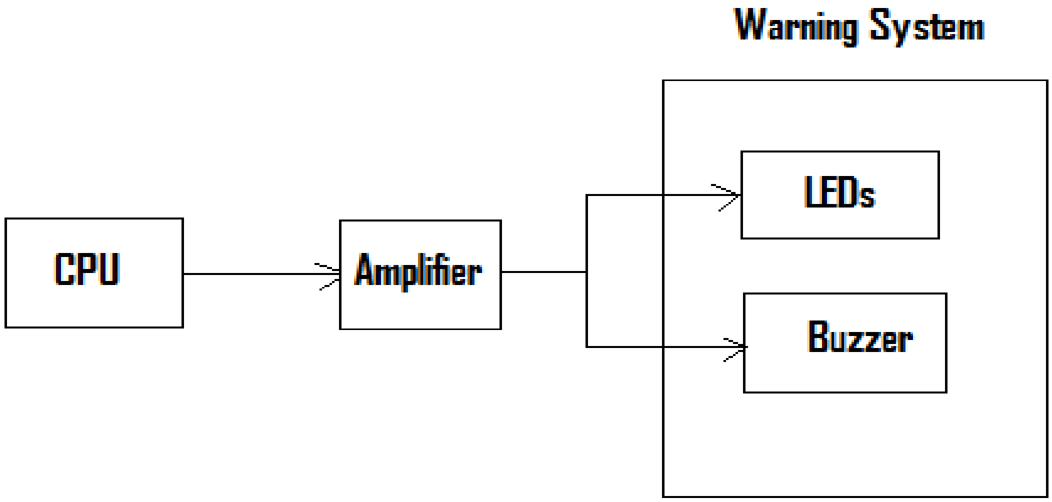

Figure 5-4: Warning System Block Diagram

Also, as you can see in the figure 5-1, there are some holes on the base which makes it easier to mount it on the steering wheel. The applied LEDs are similar to the LEDs used in the headlights of some cars. The brightness of such LEDs is enough to attract the derivers' attention without distracting them. Since the purpose of this system is to inform the drivers about the dangerous position of other cars relative to his or her car, it makes sense to apply red color LEDs on the system. Also, for auditory part we plan to use the Mechanical Buzzer FBMMB2618 [9]. The advantages of this model are that not only it is small and consequently easy to be hidden behind the steering wheel but also there are some holes on it to help mounting it on the steering wheel. This model of buzzer has the low pitch tone, low current consumption 21, 25 and 33 mA. Also voltages required for it are 6, 12 and 24 V and it provides 70 dBA/100 cm with frequency of 400 +/- 100 Hz. This buzzer same as LED works in wild range of temperature; between -20℃ to 70℃ and its weight is around 17 g.

6. System Test Plan

6.1 Objective of Test Plan

To ensure that iChecked Blind Spot Detection System is as accurate and reliable a device as possible, we will need to conduct testing in several different key areas. Many of these test cases are important even for the proof of concept to ensure accurate functionalities, whereas the rest are required for the production design, before the manufacturing process to ensure a trustworthy, stable, reliable final product. This test plan is not intended to be completely comprehensive nor to restrict further testing, but to ensure our prototype to perform its functions as we have specified.

6.2 Approach

The subsystems are tested individually through unit tests. The system is then integrated, and tested as a whole. As the result of these tests, our goal is to ensure that iChecked will effectively detect vehicles once they are present in the blind spot areas, and give warning signals accordingly.

Integration testing will be performed after all unit tests have passed and the subsystems have been integrated into a complete system. All members will contribute to integration testing so that their insight into each subsystem can be leveraged for troubleshooting any problems that may arise.

Acceptance testing will be performed last; after all other tests have passed. All iChecked Inc.'s team members, and well as some of their friends and family will participate in the acceptance testing. Acceptance testing will primarily involve using an iChecked Blind Spot Detection equipped minivan for short trips. At that time, any deficiencies or possible improvements on the system can be communicated back to iChecked Inc. for our consideration. During the acceptance testing, the tester will not have detailed knowledge of our system's structure. This will ensure the feedback can be solicited unbiased user comments after using this product.

6.3 Unit Test

6.3.1 Warning System

Connect the warning system to a 5V DC source from the power supply in the lab. The LED indicators should be illuminated, and the audio buzzer should give away sound.
If either the LED or the buzzer does not function, test each individually.

6.3.2 Circuit Components

Test AND gate by supply 5V DC source from the power supply in the lab to its AB pin pair. The resulting DC output voltage at the corresponding Y pin should be measured to satisfy the MM74HC08 data sheet.

Test OR gate by supply 5V DC source from the power supply in the lab to either one input pins of AB pin pair. The resulting DC output voltage at the corresponding Y pin should be measured to satisfy the MM74HC32 data sheet.

6.3.3 Sensors

Prepare a 50cmX50cm flat surfaced card box coated with aluminum foil on one side. This object will be used to imitate an automobile. Connect the sensors, one at a time, to a 12V DC source from the power supply in the lab. Connect the output pin of the sensor to a voltmeter on a DC dial. Move the test object from ranges of 0.5m to 2m directly away from the sensor. The output pin should read a steady 5V DC when the test object is in range.

6.4 Integration Test

Connect all parts together
Combine the testing methods listed above, place the object in the sensor's detection range, and simulate a left turn signal voltage and speedometer voltage from the power supply. The warning system should light up both the LED and sound the buzzer.

At this point, we will have achieved our goal of prototyping the system in the laboratory environment.

6.5 Acceptance Test

After the prototype product is assembled onto the 1996 Dodge minivan, the testers will take the car onto the open road, and test the system.

7. Conclusion

The proposed design specifications for iChecked Blind Spot Detection System are presented in this document to address all the design challenges in our project. The Design Specification should be consistent with the functions listed in Functional Specification for iChecked Blind Spot Detection System. By following the design specifications, most of the functional requirements will be met.

Now that the iChecked has a complete Design Specification, development can commence. Once development of our proof-of-concept device implementing the design discussed is complete, we can begin further planning and marketing in hopes of continuing on to complete a full prototype of the iChecked Blind Spot Detection System.

8. References

[1] iChecked Inc, “Functional Specifications for iChecked Blind Spot Detections System” February 08, 2010.

[2] www.darylstrickland.com, “Blind-spots,” 2009. Available: http://strick4life.files.wordpress.com/2009/10/blindspot.jpg?w=300&h=222 [accessed: Jan 23, 2010]

[3] International Harmonized Research Activities, “Statement of Principles on the Design of High-Priority Warning Signals for In-Vehicle Intelligent Transport Systems – Draft” 2008. Available: http://www.unece.org/trans/doc/2009/wp29/ITS-17-03e.pdf [accessed: Jan 15, 2010]

[4] Engineering Performance Innovations Corp, “Auto Sonar Installation Manual”, 2007. Available: http://www.autosonar.com/Download/Installation_Manual.pdf [accessed: Feb 23, 2010]

[5] Engineering Performance Innovations Corp, “Auto Sonar User Manual”, 2007. Available: http://www.autosonar.com/Download/User_Manual.pdf [accessed: Feb 23, 2010]

[6] FairChild Semiconductor, “MM74HC32 OR Gate Data Sheet”, 2008. Available: http://www.fairchildsemi.com/ds/MM%2FMM74HC32.pdf [accessed: Feb 16, 2010]

[7] FairChild Semiconductor, “MM74HC08 AND Gate Data Sheet”, 2008. Available: http://www.fairchildsemi.com/ds/MM%2FMM74HC08.pdf [accessed: Feb 16, 2010]

[8] Luxeon Star LEDs, “Pre-Mounted Rebel Red LEDs” , 2010. Available: http://www.luxeonstar.com/premounted-rebel-red-leds-on-a-20mm-tristar-base-195-lm-p-630.php?zenid=mg8hk9m458eh4276v3s3ght3f0 [accessed: March 02, 2010]

[9] Fbele Acustic, “Mechanical Buzzer FBMMB2618”,2009. Available: http://www.fbelebuzzer.com/FBMMB2618-A-B-C-D-E-F--China-Mechanical-buzzer -manufacturer-FBMMB2618-A-B-C-D-E-F---FBELE-Brand.htm [accessed: March 05, 2010]