Car Locator Project

EE198B: Senior Design Project II
San Jose State University
Fall2004

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Abstract

The purpose of this report is to discuss the purpose, design, testing, and conclusion of the Car Locator device. A Car Locator devise is a device used to identify the direction of a parked automobile. This device was designed conceptually, actualized by several circuits that performed specific tasks, tested, debugged, and a working prototype was produced.

Introduction

We all live in a time compressed society. Nearly every minute of the day is used for critical tasks, and few can afford to waste those minutes on trivial issues. Yet, trivial issues seem to present themselves and require us to divert our attention to less important things. One of those trivial issues is when a person spends time searching for their automobile when they have forgotten where they have parked it.

As more and more automobiles are manufactured every year, and there are less and less classes of cars, more of those automobiles are beginning to be less distinctive. Furthermore, as more "strip" malls are being erected, parking lots are becoming expansive. This creates a common problem that many people have experienced. Many people have exited from a structure, into a large parking lot, and realizing they have forgotten where they parked their car, spent valuable time, walking through row after row, searching for their automobile.

Therefore, a device that can indicate to a user the direction of his or her parked vehicle would be an excellent solution to this common problem. With this in mind, the Car Locator device was designed, constructed, and tested.

Background

Currently, there are no devices on the market that perform the specific task of identifying to a user, the direction of his or her vehicle. With some modifications, some GPS systems can be utilized for this purpose. However, GPS systems require monthly subscriptions for their services. Due to the subscription fees, it is impractical for most people to purchase such a device and as a result, there are no products out on the market that use GPS to perform this task.

Some automobiles come standard with anti theft devices. One of the features of these anti theft devices is to produce a beeping sound when the user presses the key fob on their key chain. Some people use this feature as a means to identify where their car is parked. However, in a noisy environment, this feature is of no use. Furthermore, not all vehicles come standard with such anti theft devices. The purchase price of such an anti theft device ranges from $200 to $800. Few people would be willing to pay this fee just to be able to identify the location of their parked car.

Theory

The main feature of the Car Locator is to identify to the user, the direction the car is parked. In order to accomplish this task, RF principles were used. The car would have a transmitter placed on the vehicle. This transmitter would emit an RF (radio frequency) signal. The Car Locator device would be a hand held unit that receives the RF signal. The user would then sweep the Car Locator device in an arc (refer to Illustration 1) and when the directional antenna in the hand held unit detects the RF signal, the user would be notified via a lit LED that the direction he or she is pointing the hand held unit in, is the direction the car is parked.

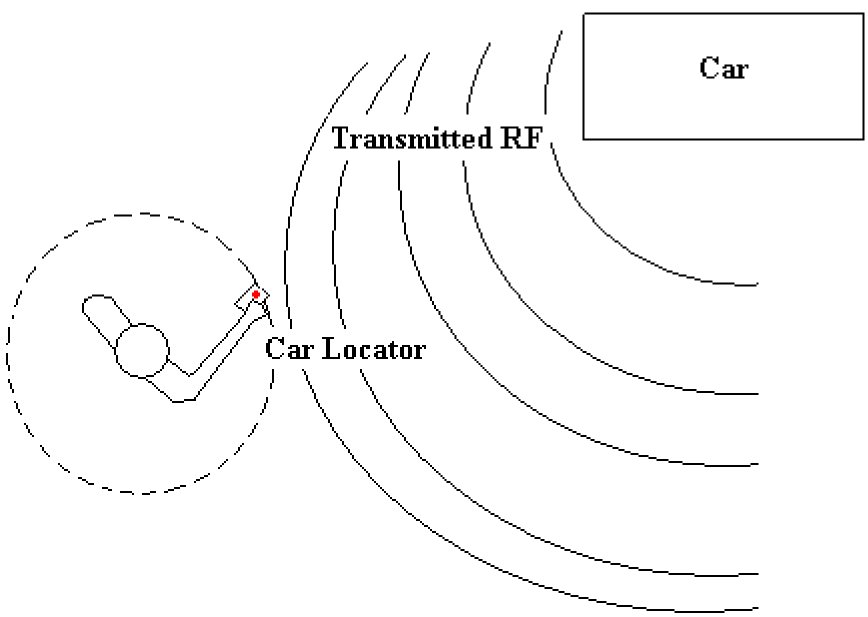

Illustration 1. User with hand held Car Locator sweeping the unit in an arc.

Conceptual Design

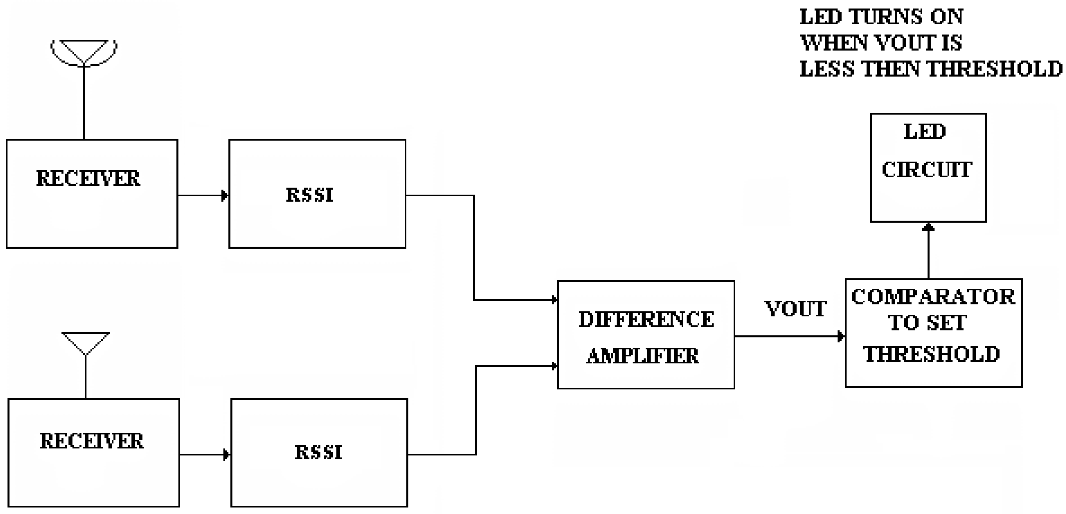

Figure 1. Block diagram of Car Locator

As Figure 1 illustrates, the Car Locator is comprised of a directional antenna, an omni-directional antenna, two RF receivers, each with RSSI (Received Signal Strength Indicator) capability a difference amplifier, comparator circuit, and an LED circuit.

The directional antenna provides a higher dB output when it is pointed in the direction the RF signal is being emitted from.

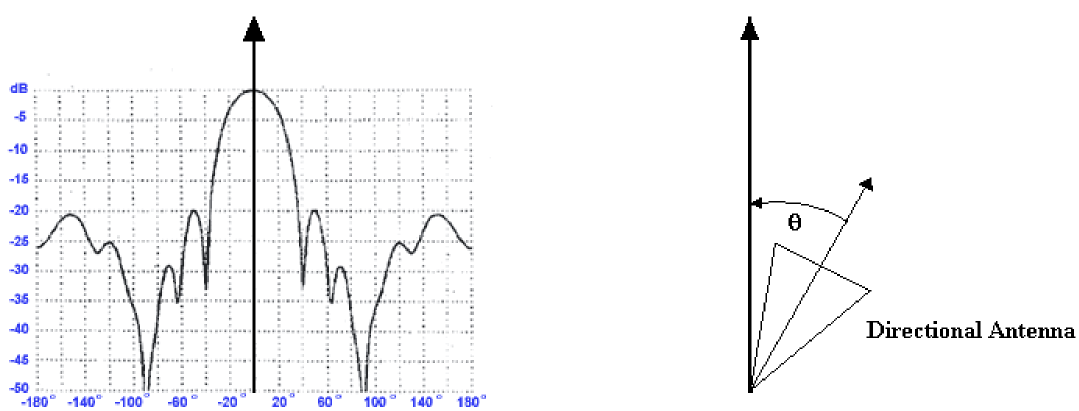

Figure 2. Typical radiation pattern of a Yagi Directional antenna.

The receiver detects the RF signal, and the RSSI provides an output in the form of a voltage. Since the RSSI chip detects the intensity of a transmitted signal, the closer the user is to the transmitter, the higher the output of the RSSI chip. If a directional antenna is fed into the RSSI chip, then the output of the RSSI chip will be a function of the angle the directional antenna is pointing towards with respect to the transmitter.

An omni-directional antenna is also used in the Car Locator device. This antenna, when attached to the RSSI chip will give an output as a function of distance. The closer the antenna is to the transmitter, the larger the output of the RSSI chip. Conversely, the farther the antenna is to the transmitter the lower the output of the RSSI chip will be.

The difference amplifier takes the difference of two input voltages and provides the difference as an output. The comparator takes the input and compares the input value to a set threshold. The LED circuit turns the LED on when a positive voltage is supplied in the input.

The hand held unit is physically laid out as per Figure 3 below.

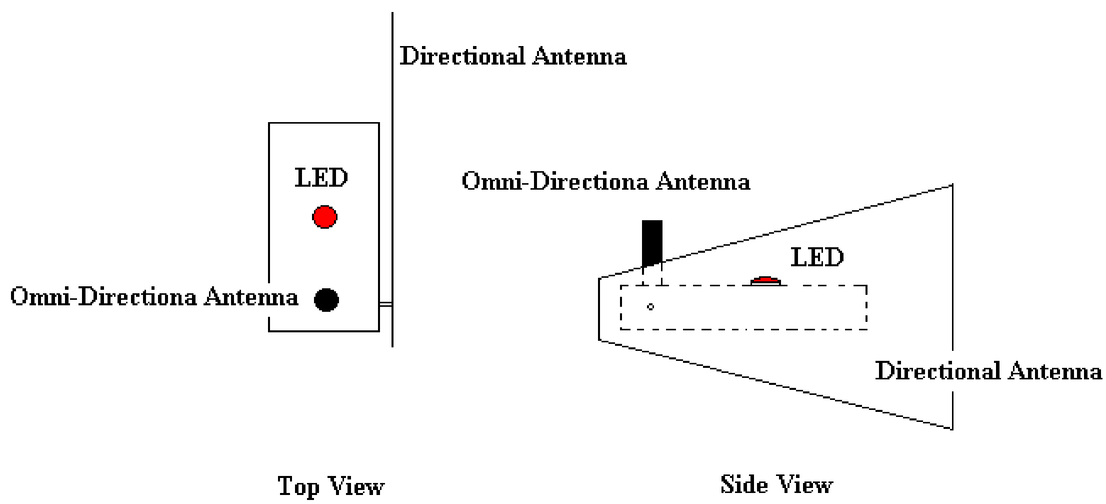

Figure 3. Top and Side Views of the Car Locator Device.

As a user walks out onto the parking lot, the vehicle could be positioned in any arbitrary location with respect to the user. The user then takes out the device and starts to sweep it in an arc as previously discussed. The user would stand at a fixed distance from the car. The omni-directional antenna would receive the signal and the RSSI chip would output a voltage with respect to that distance. If the user is pointing the unit in a direction not aligned with the car, the output of the RSSI chip from the directional antenna would be less than the output of the RSSI chip from the omni-directional antenna. The difference of these two voltages would be taken and compared to a set threshold. If that voltage is not smaller than the set threshold, the LED will remain off. As the user sweeps the unit in the arc, and as the directional antenna is eventually pointed in the right direction, the output of the two RSSI chips would be very similar. The difference again is taken, and compared to the threshold. At this point, the difference would be smaller than the threshold voltage, and the LED circuit will turn on. Thus the user is able to identify the direction of his or her car.

RF signals are prone to reflection. RF detection devices therefore have issues with multi-path signals.

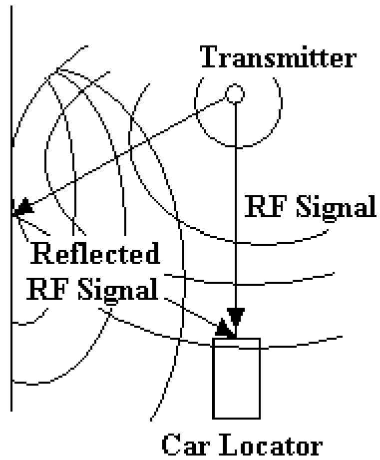

Figure 4. Illustration of multi-path.

In the situation illustrated above, if the user was pointing the Car Locator in the direction of the Reflected RF signal, the directional antenna would detect this signal. However, because the omni-directional antenna is present, the output of the RSSI chip would output a voltage that is the greater of the two signals due to the fact that the reflected signal would be attenuated. The output of the RSSI chip from the omni-directional antenna would be large, and the output of the RSSI chip from the directional antenna would be smaller. Thus, when the difference is taken, there would be a difference between the two outputs, and the comparator would not allow the LED circuit to turn on. Therefore, when the Car Locator is pointed in the direction of the reflected signal, the LED will not turn on.

Actualized Design

The symbolic/schematic diagram of the actualized circuit is illustrated below in Figure 5.

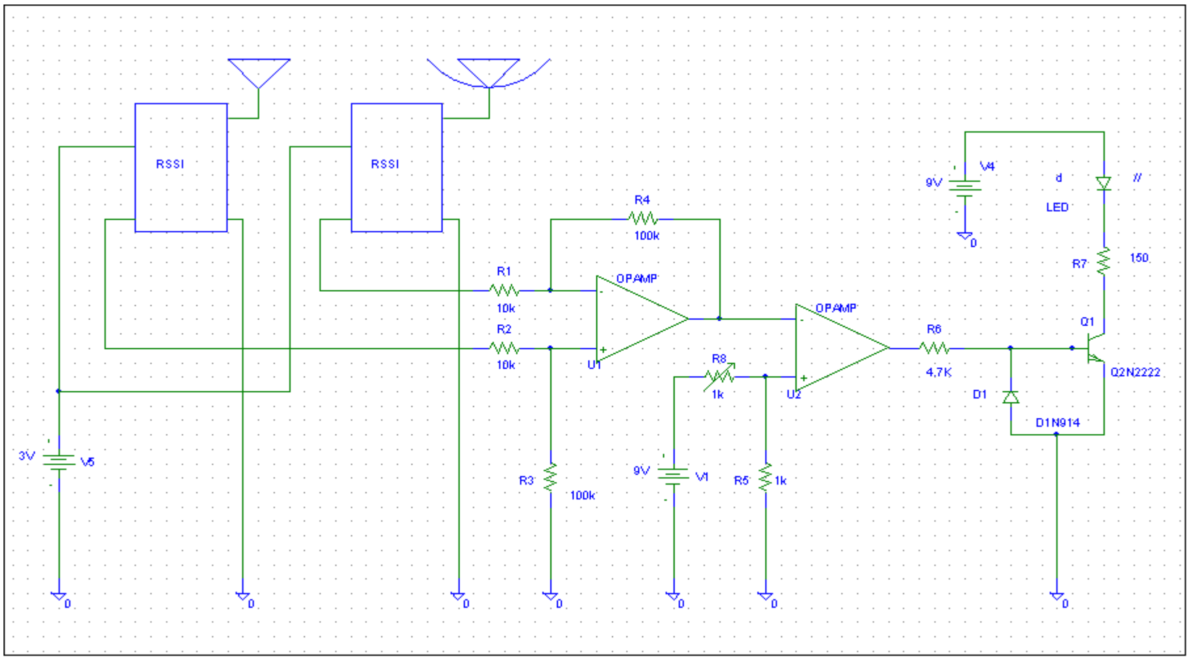

Figure 5. Symbolic/schematic of the actual design.

The RF signal transmitted from the transmitter is a 433 MHz signal. 433 MHz was selected for several reasons. First, 433 MHz is a frequency that requires no special FCC approvals for its use. Second, a lower frequency signal would require a larger directional antenna. The device is to be hand held, and therefore, a large directional antenna is not a good option. Third, although a higher frequency would provide for a smaller directional antenna, it also would have a greater amount of problems due to reflection and transmission.

The directional antenna is a mini-Yagi antenna that is currently sold on the market. The omni-directional antenna is also currently sold on the market.

The RF receiver was purchased off the shelf. It came with the RSSI capability. The difference amplifier and the comparators were realized with 741 op amps and resistors. The LED circuit was constructed using a single BJT, a diode, resistors and an LED.

Component Analysis

Directional Antenna

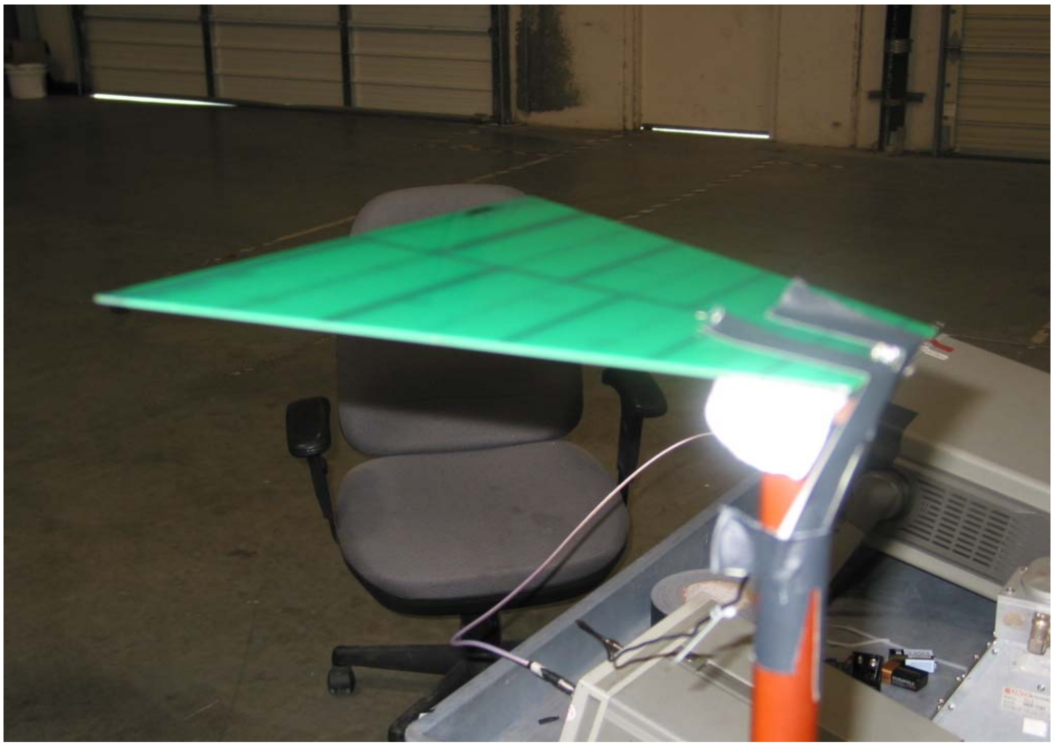

Illustration 2. The directional antenna.

The directivity of the directional antenna was tested at Elliot Labs. The directional antenna was placed 25 feet from the transmitter. The direction of the antenna was varied as in 30 degree increments. The antenna was attached to the receiver and the RSSI output was read as the antennas angle was varied. The data is presented below in Table 1.

Angle	Distance	RSSI Output
0	25 Ft	1.84
30	25 Ft	1.79
60	25 Ft	1.74
90	25 Ft	1.69
120	25 Ft	1.59
150	25 Ft	1.51
180	25 Ft	1.41
210	25 Ft	1.52
240	25 Ft	1.58
270	25 Ft	1.69
300	25 Ft	1.74
330	25 Ft	1.79
360	25 Ft	1.82

Table 1. RSSI output with respect to the angle of the directional antenna.

As expected the RSSI output was greatest when the directional antenna was pointed directly at the transmitter. As the angle was varied in increments of 30 degrees, the RSSI output decreased.

Omni-directional antenna

The omni-directional antenna was attached to the receiver and was placed at various distances from the transmitter in increments of 5 ft up to 25 ft. The RSSI output data was taken. The data is presented below in Table 2.

Distance	RSSI Output
1 Ft	1.82
5 Ft	1.76
10 Ft	1.73
15 Ft	1.68
20 Ft	1.58
25 Ft	1.52

Table 2. RSSI output with respect to distance.

The data presented in Table 2 demonstrates that the RSSI output decreased as the distance the omni-directional antenna is from the transmitter is increased.

Receiver with RSSI capability

The receiver chip was purchased from Linx Technologies. It operates at 433 MHz. The data provided with the chip states that the RSSI output ranges from 1.4 volts to 1.8 volts. This was verified from the data obtained in Table 1 and Table 2.

Difference Amplifier

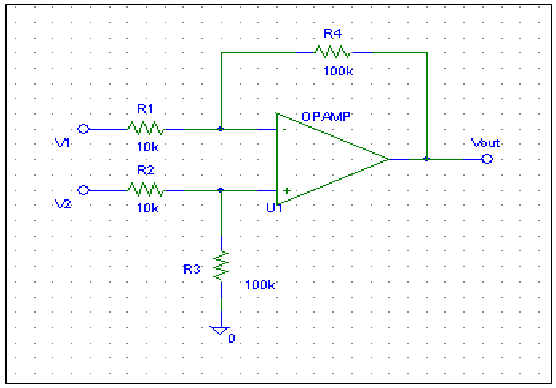

Figure 6. The schematic of the difference amplifier.

The difference amplifier was constructed using a standard 741 op amp. Vout can be expressed by equation 1.

$$Vout = (V_2 - V_1)\frac{R_4}{R_1} \tag{1}$$

By selecting R_4 to be 100 kΩ and R_1 to be 10 kΩ, a gain of 10 was obtained. The purpose of this gain was to amplify the relatively small differences between the two RSSI chip outputs. Table 3 below demonstrates the data, as V1 was held constant at 2 volts, and V2 was varied, and then as V2 was held constant at 2 volts and V2 was varied. Table 3 illustrates the functionality of the difference amplifier.

V1	V2	Vout
2	1	-7.92
2	1.1	-7.93
2	1.2	-7.93
2	1.3	-7.73
2	1.4	-6.71
2	1.5	-5.73
2	1.6	-4.54
2	1.7	-3.63
2	1.8	-2.62
2	1.9	-1.56
2	2	-0.23

V1	V2	Vout
1	2	7.82
1.1	2	7.82
1.2	2	7.83
1.3	2	7.81
1.4	2	7.11
1.5	2	5.92
1.6	2	4.97
1.7	2	4.01
1.8	2	2.93
1.9	2	1.98
2	2	0.89

Table 3. Output data of the difference amplifier

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Comparator Circuit

The comparator circuit was constructed using a standard 741 op-amp. The comparator circuit takes the output of the difference amplifier and compares it to the set threshold voltage. A positive comparator output is produced when the input voltage is less than the threshold voltage. In the same manner, a negative comparator output is produced when the input voltage is higher then the threshold voltage. The schematic of the comparator circuit used in the design of Car Locator device is shown below in Figure 7.

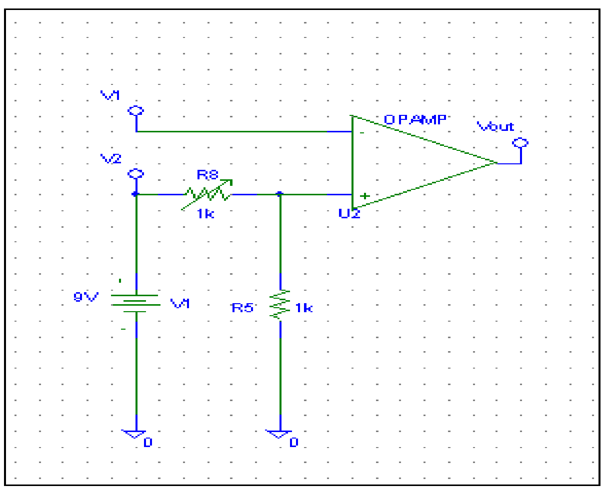

Figure 7. Schematic of the comparator circuit.

As illustrated in Figure 7, a 9V battery was used supply the threshold voltage. This separate power supply is important to make the threshold voltage very stable to prevent oscillation. Table 4 demonstrates the comparator data obtained by setting the threshold voltage to 0.3V.

V1	V2	Vout
0	0.3	7.69
0.1	0.3	7.69
0.2	0.3	7.7
0.3	0.3	-7.69
0.4	0.3	-7.68
0.5	0.3	-7.85
0.6	0.3	-7.82
0.7	0.3	-7.81
0.8	0.3	-7.82
0.9	0.3	-7.61
1	0.3	-7.92

Table 4. The output data of the comparator circuit.

When V_1 is less than the threshold voltage (0.3V), the output of the comparator is positive. When V_1 is greater than the threshold voltage, the output of the comparator is negative.

The LED Circuit

A basic LED circuit was constructed to let the user know when the Car Locator device is being pointed in the direction of the transmitter. The LED circuit is designed to turn on the LED at 0.7V or greater. The LED circuit schematic is provided below in Figure 8.

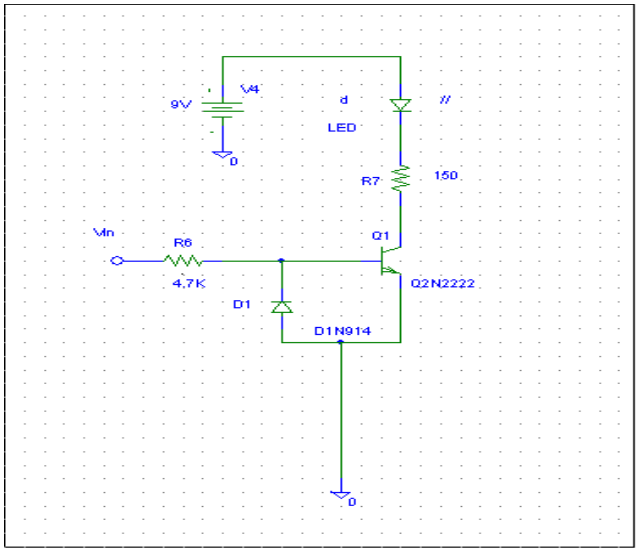

Figure 8. Schematic for the LED circuit.

The LED circuit was tested by applying a set of voltages to the input and observing the LED. Table 5 below illustrates the test data.

V	LED
0	OFF
0.1	OFF
0.2	OFF
0.3	OFF
0.4	OFF
0.5	OFF
0.6	OFF
0.7	ON
0.8	ON
0.9	ON
1	ON

Table 5. Test data for the LED circuit.

As the test data illustrates, the LED circuit functioned as it was supposed to. The LED turned on when a voltage of 0.7 volts was applied to the input.

Discussion

The final version of the Car Locator that was constructed functioned as it was designed to. However, several issues presented themselves which require some minor level of improvement.

If the user places his or her hand too close to the directional antenna and thus blocks the RF signal from reaching the antenna, the output of the RSSI chip goes decreases, and as a result, the difference between the two also decreases beyond the threshold value, thus causing the LED to turn on. In such a case, the Car Locator would seem to indicate to the user an incorrect direction. A solution to this problem is to place the omni-directional antenna in a position less apt to be in contact or near the user's hand.

A second issue that requires improvement is that the comparator causes some flickering of the LED because it switches from rail to rail as the output of the difference amplifier gets closer to the threshold value of 0.3 volts. A solution to this problem is to purchase a comparator that has built in hysterisis. The hysteresis feature would allow the comparator to switch to the appropriate value when the input is close to the threshold, but then would not jump to the opposite rail should the value of the difference amplifier shift slightly above 0.3 volts.

Conclusion

In conclusion, the Car Locator project was a successful project in that it produced a device that can effectively identify to the user the direction of his or her parked vehicle. The Car Locator was fist designed conceptually. Then components were designed to complete specific tasks. The components were then assembled and tested separately. Finally, a complete prototype was constructed and tested. The device was then rigorously tested and debugged.

Acknowledgements

We would like to express our gratitude to the following for their support and guidance.

Professor David Waitt

Elliot Labs

Professor Ray Kwok