IR Navigational Beacon

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Overview

Figure 1a below shows a breakdown of the sensor systems of the mobile robot platform:

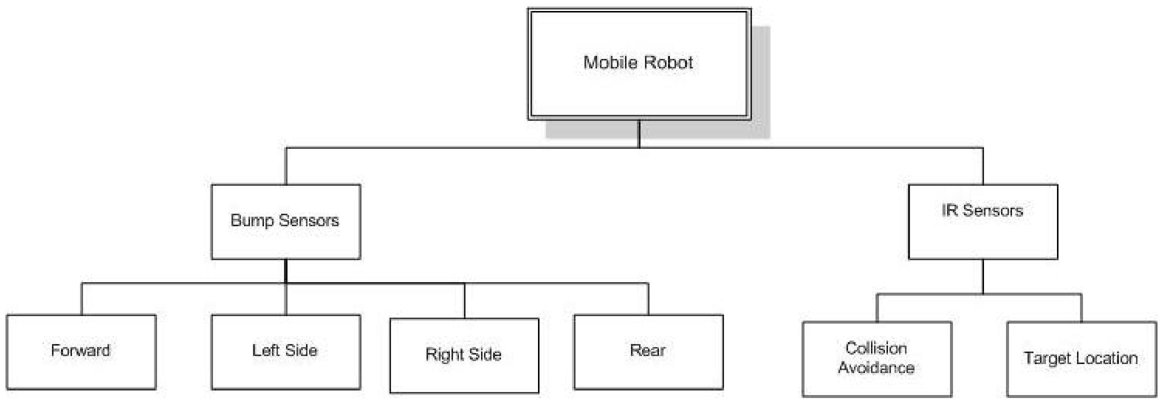

Figure 1a

Figure 1b below shows a breakdown of the sensor systems of the target platform:

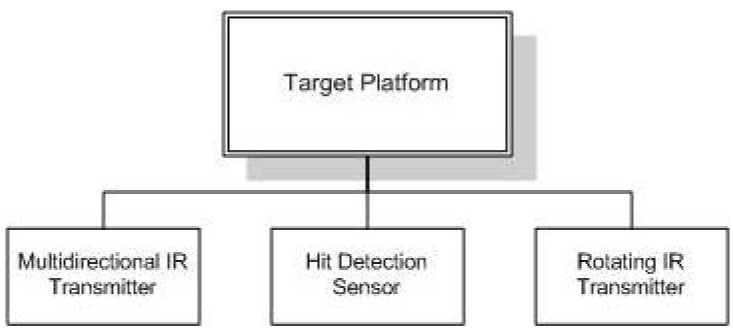

Figure 1b

This report will focus on the design, theory, and implementation of the target platform's IR transmission systems, and will touch briefly upon the mobile robot platform's IR reception system.

Although the 32kHz receiver for the single direction IR is not technically part of the focus of this report it does bear special mention as it is required to receive the output of the emitter, and thus required for testing. To construct this receiver I used a Max266 programmable filter(see fig 3). The input to this filter is provided by an IR phototransistor placed in series with a current limiting resistor. The voltage across the current limiting resistor is then fed into the filter as its input. The output of the filter unit is a DC value of about 1V with a ripple of about .2V.

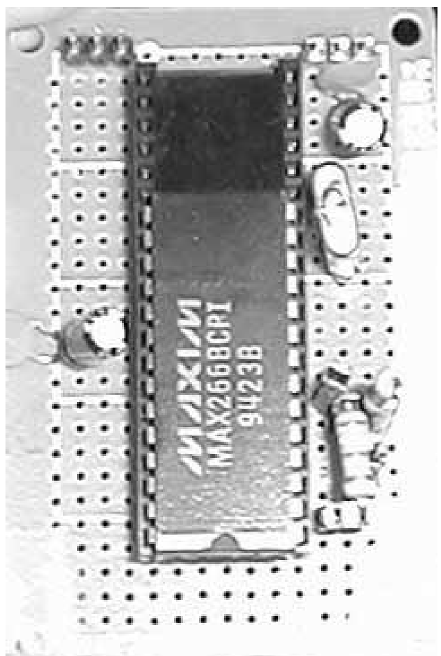

Figure 2: Filter Unit

Relevant Design Theory

The goal of the sensors discussed in this report is to enable the mobile robot to navigate to a known position relative to that of the target platform. The system will accomplish this by using a form of differential GPS. The target platform will utilize two IR emitters. One will consist of a single IR emitter rotating at a constant speed and constantly broadcasting. The other will consist of many IR emitters facing in all directions which will only be activated when the rotating emitter passes by a specific point. The point at which the multidirectional IR system will activate will be denoted as 0°. By measuring the difference in time between when the rotating IR signal is detected, and when the multidirectional system's IR is detected the mobile platform's position can be determined relative to the 0° point. This can be accomplished because the rotation speed of the IR emitter is known. For example, the single direction IR emitter is rotating at a speed of 1° per second. The multidirectional signal is detected at t=5, and the single direction(rotating) signal is detected at t=30. Therefore the mobile platform is located at a position of (30-5)=25° from the 0° position of the target platform.

Sensor Design

Target Platform

As you can see from figure 1b, the target platform will require a total of three control systems. The first will control the rotation of the directed IR beam. The second will control the IR frequency of the single direction emitter. The third will control the IR frequency of the multi direction emitter.

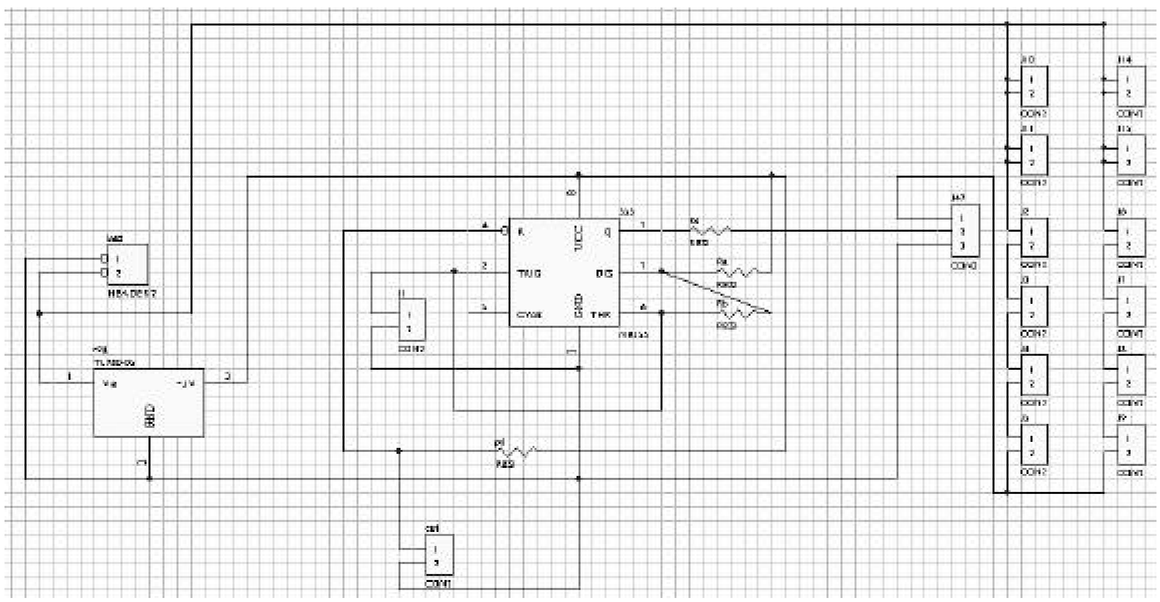

Fig. 3

In order to generate the control signals a series of 555 timer chips will be used. Figure 3 above shows the basic layout of the multidirectional IR system. The signal output from the timer chip is fed through a current limiting resistor into the base of a Darlington transistor which switches the IR emitters on and off. The power source for the board will consist of a standard 9v battery connected to the +5vdc regulator shown in the lower left hand corner of figure 3. The connector at the bottom of the figure is an photointerrupter diode. This diode will short the two terminals normally, however, when an object passes through the photointerrupter, the two terminals will be opened. When the two terminal are open, the reset line will be pulled high, and the timer chip will be turned on. When the two terminals are shorted, the reset line will be pulled low, and the chip will shut off. The end result of this is that the rotating emitter will have on it an object that will pass through the center of the photointerrupter when it reaches the 0° point. This will cause the multidirectional emitter(Fig. 3) to turn on for a brief moment, emitting a pulse, and then turn off.

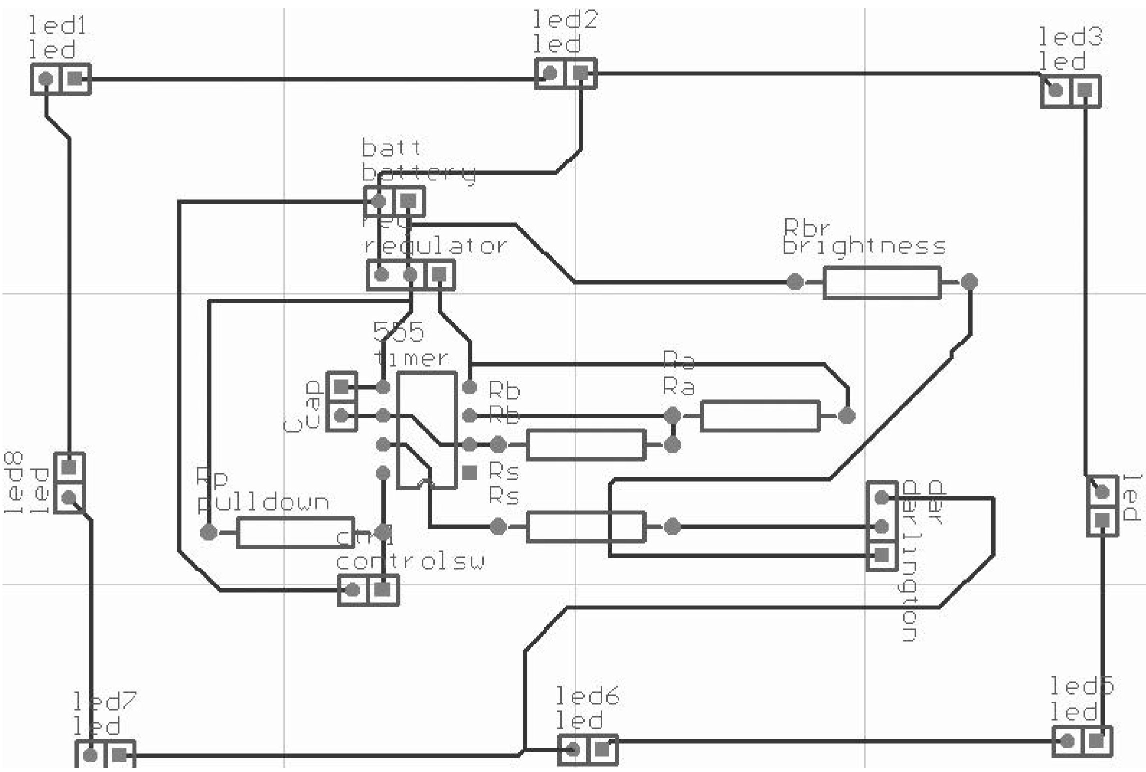

Fig 4a Multidirectional IR transmitter layout

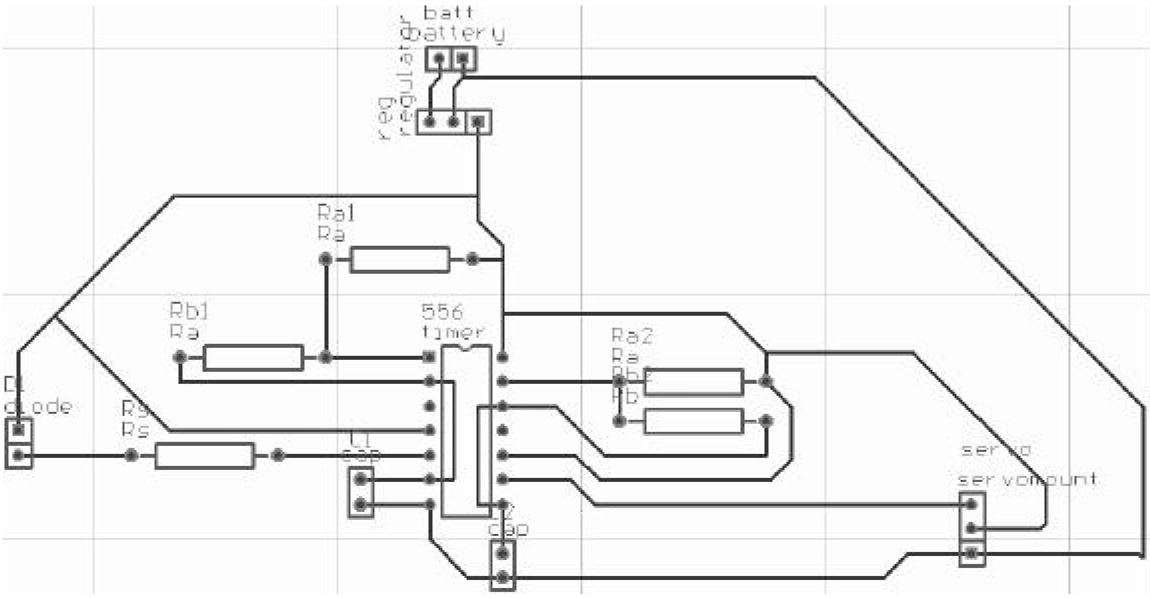

Fig 4b single direction IR transmitter and servo control layout

Figures 4a and 4b above show the Protel™ design files for the board layouts of the rotating and stationary emitters as well as the control for the servo that will rotate the single direction emitter. It is important to note that the layout file for the multidirectional emitter has an error in it. The pull-up resistor connected to photointerrupter header is connected to ground, and the other terminal of the header is connected to the positive terminal of the battery. These two connections should be reversed. The error arose from the fact that I was forced to route the board manually in Protel™ due to a bug in the program. While doing this I inadvertently switched the two connections. In the final design this was corrected by drilling out the affected traces, and then jumpering the terminals to their correct destinations with small segments of wire.

The assembled platform is shown below in figures5a-e.

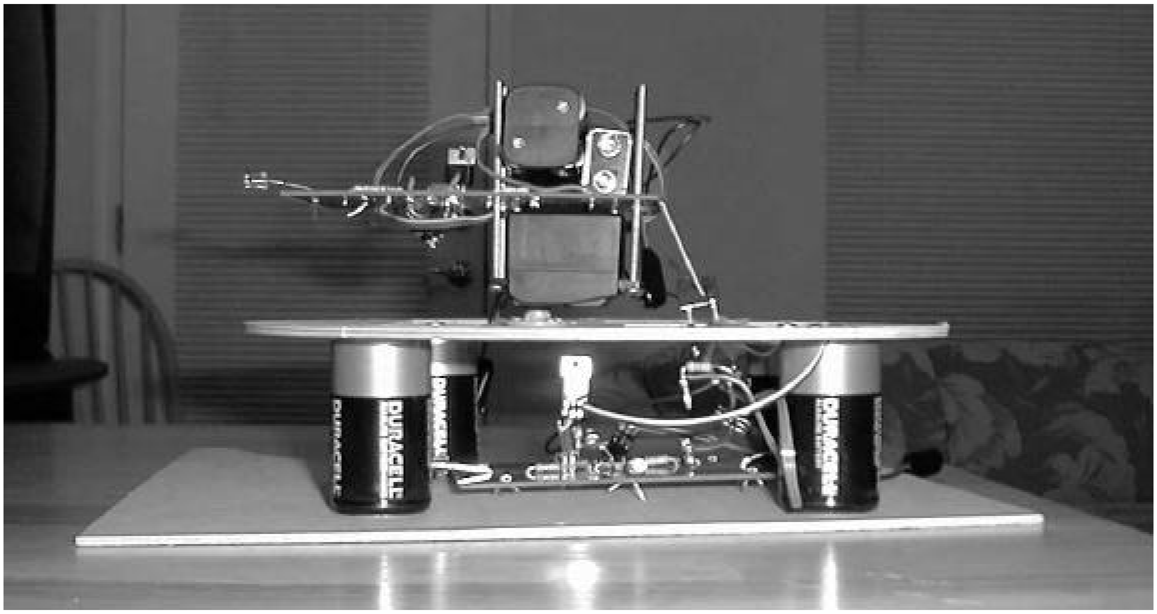

Fig 5a assembled sensor platform

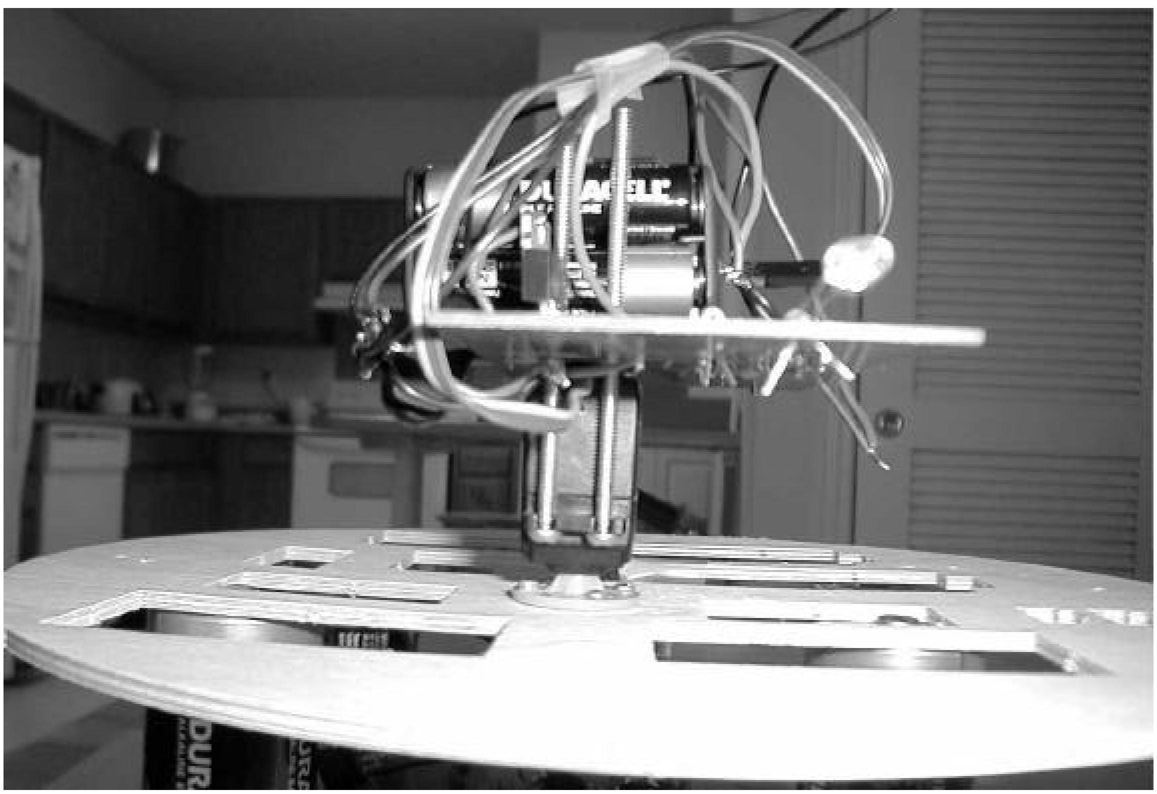

Fig 5b close-up view of servo mount

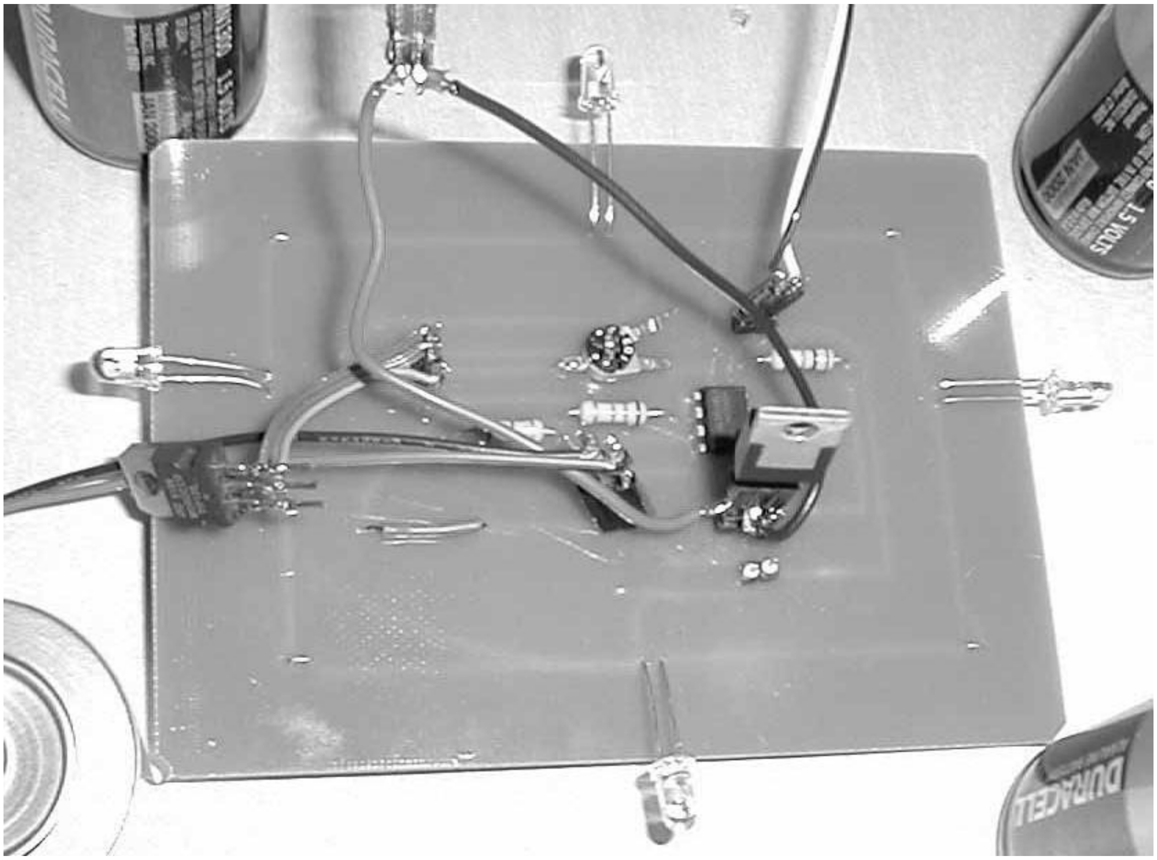

Fig5c overhead view of multidirectional IR board

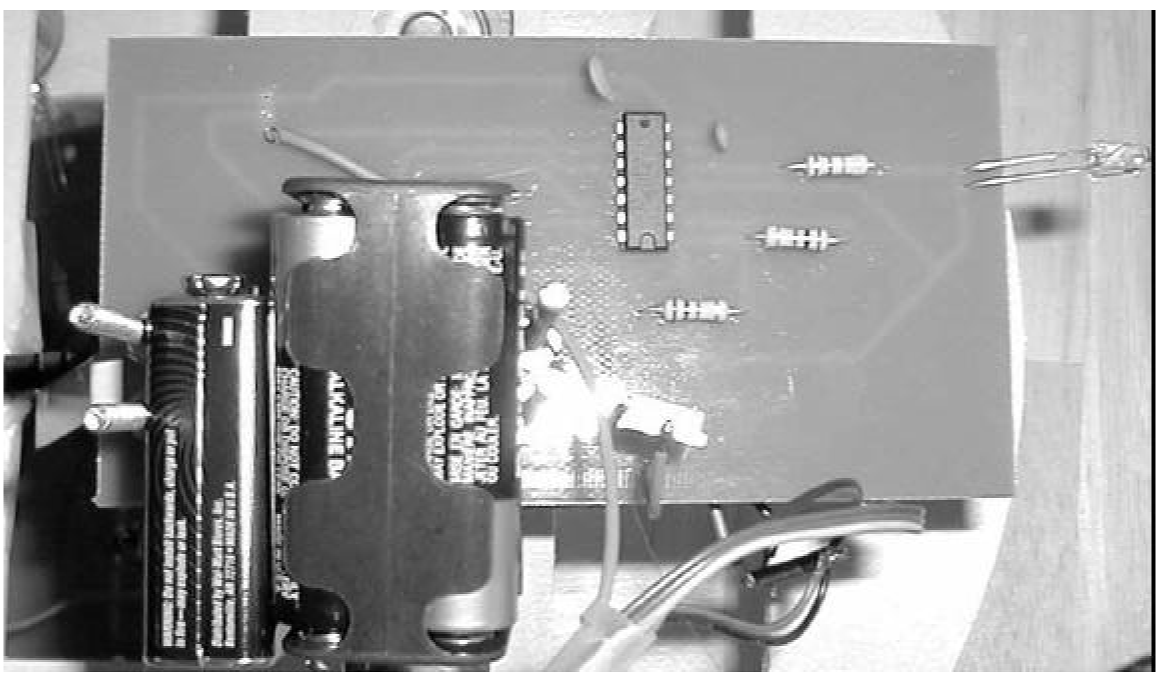

Fig5d overhead view of single direction IR board

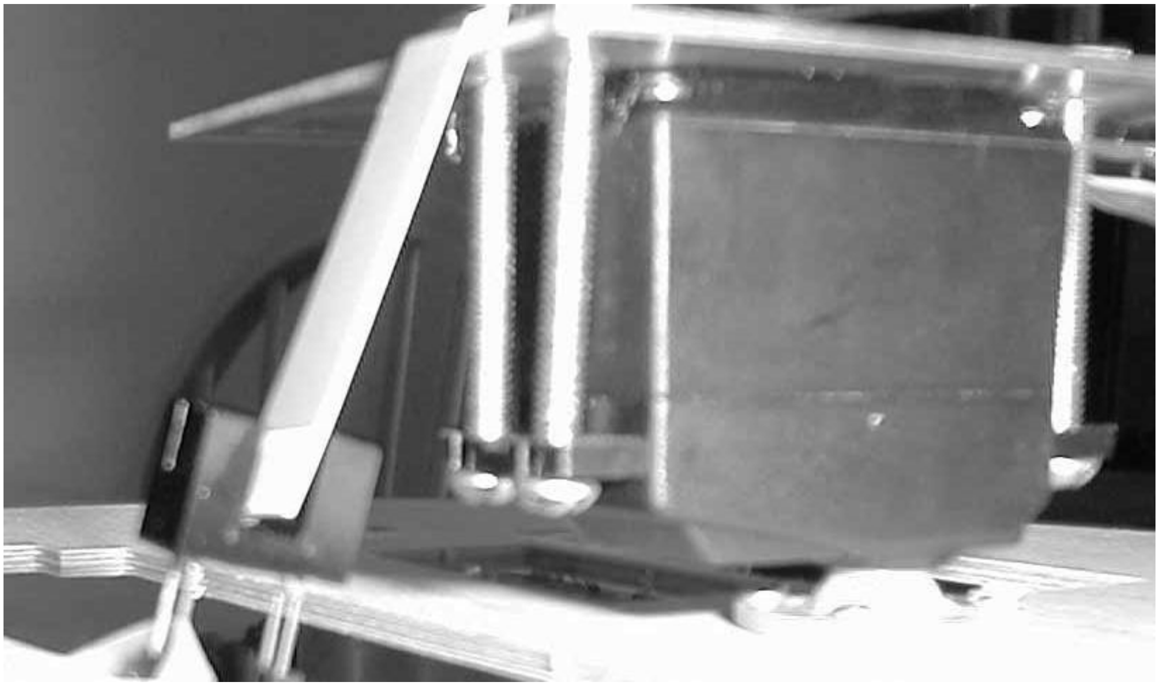

Fig5e close-up view of photointerrupter

Appendix A

Sources of parts

Part: High current IR LEDs models HSDL-4220 and HSDL-4230

Company: Agilent

Cost: Free

Source: Arrow Electronics

Comments: Great LEDs, unfortunately they put out 880nm IR. On the plus size, they glow red when on, and Sharp cans have no problem seeing them. Unfortunately, the Radio Shack IR receivers seem to have difficulty detecting them.

Part: Photointerrupter model LTH301-07

Company: Lite-On Optoelectronics

Cost: Free

Source: Arrow Electronics

Comments: Avoid Lite-On like the plague. Their collection of online datasheets is incomplete, and the datasheets that they do have up are often missing important data. Their US website is a joke, and I was forced to go to the European website(http://www.liteon.com.tw) to find the datasheet for this part. I have a collection of about 30 different parts from them, and according to Lite-On's websites only about half of these parts have valid part numbers.

Part: 5V regulator model TL780-05CKC

Company: TI

Cost: Free

Source: TI

Comments: All parts were sent UPS next-day air. Website is easy to navigate, and always gave the required info.

Part: Adjustable regulator models LM317KC and LM337KC

Company: TI

Cost: Free

Source: TI

Comments: Datasheets for these parts did not contain very much useful application information.

Part: Photodiode model QSC112 and photodarlington model QSC133

Company: Fairchild

Cost: Free

Source: Fairchild

Comments: This company has an extremely odd sample program, it took 2 weeks for the parts to arrive because they were airmailed from Hong Kong. I could not get the photodarlington to activate no matter how much IR I projected onto it. The photodiode has a very small detection angle, but gives decent response.

Part: Adjustable filter model Max266

Company: Maxim

Cost: Free

Source: Maxim

Comments: Perfumed adequately. The development software will not run on my system (Windows ME).

Part: Electric foam disc launcher

Company: Kids Only™

Cost: $5

Source: Wal-Mart

Comments: A decently accurate gun(out to about 20') with a light trigger pull. I did have a bit of a problem with the trigger dragging on the left hand side of the gun.