Proposal:

Application of IR-Transmitter as IR Tripwire

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Abstract

An infrared tripwire is proposed as a novel and useful application for the transmitter and receiver modules of the Optical Uplink project. The importance of efficient and non-intrusive trip wire sensors for both defense and retail applications is outlined, in addition, the background theory for infrared sensors is described. Preliminary measured results of the Optical Uplink are provided as well as their ramifications on the tripwire sensor are discussed. Relevant qualifications of all team members is described and sufficient experience is with required technology is shown. Finally, a cost analysis for design and production of the proposed tripwire is performed.

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Contents

List of Figures

List of Tables

1 Introduction

This proposal is written in reply to a call for proposals for novel applications of the transmitter module of the Optical Uplink project. The overall block diagram of the Optical Uplink can be seen in Figure 1.

Figure 1: Block diagram for optical uplink

The Optical Uplink project was finalized with the implementation of an LED signal transmitter with a separate receiver/amplifier module. The entire device acts as a rudimentary wireless communication device capable of transmission over tens of meters.

An infrared sensor, widely known as a tripwire, is a popular device that has many applications, notably in both military and retail. In this proposal, the use of IR as trigger method for IR will be considered, and the importance of tripwire sensors in retail will be discussed.

2 Background

In both the defense and retail fields, tracking the movement of people or groups of people is paramount. Being able to effectively detect, monitor, and measure the number of people crossing and do so a non intrusive manner is of extreme importance in gaining a fundamental understanding of a dynamic system that can't be predicted with 100 percent accuracy, but can track patterns over time.

Literature review of both craftspersons websites and scientific journals have aided in the development of this IR transmitter application. Journal articles [1] and [2] demonstrate the feasibility for the tripwire in defense applications. One application was for the protection of defensive perimeters, while the other was a novel approach, using IR sensors to detect anti-personnel mines. Both are vital in the modern climate of war on terror, where reconstruction and defense of destabilized countries is the current modus operandi.

Other applications in a less lethal environment were explored in journal [3], which establishes a body of work using the tripwire as a sensor to measure foot traffic. The measuring of foot traffic in retail can not be understated. This provides retailers with way of developing metrics to determine total foot traffic through any given part of a store. This would allow retailers to determine sales per aisle per person and be able determine the most cost effective way of product throughput. This results in an increase in sales and increasing profits.

3 Proposed Work

The base level schematic or block diagram is shown below in Figure 2.

The optical uplink has the transmitter and receiver already constructed. The transmitter and receiver will transmit information to the microcontroller, which will count the amount of foot traffic in retail stores.

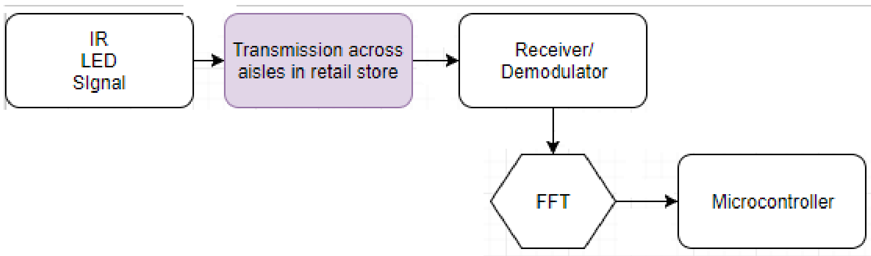

Figure 2: System level schematic of foot-traffic sensor

The actual sensor will require a pair of parallel beams, placed at waist height at the entrance and exit of each aisle. The reasoning for the parallel beams is that it would enable the microcontroller to calculate which direction foot traffic flows, entering or exiting the aisles. There are limitations with regards to density of traffic, where the beams may be blocked for a longer duration, counting only one person when there are multiple in reality. Algorithms will take this into account within the microcontroller as to not negatively impact the data. The circuit will be powered by a 9V source, and will output a constant infrared during store hours. As a person moves through the parallel beams, the microcontroller will process the lack of the beams, detecting which was interrupted first, then save the data to the DRAM.

4 Preliminary Results

The IR-tripwire used to detect foot traffic has two parts. One is the microcontroller/receiver, and the second is the transmitter. The transmitter has been previously contructedin the Optical Uplink transmitter modules. This circuit is made up of CMOS astable multivibrator circuit which provides the driving signal for the LED. A schematic of the transmitter is shown below in Figure 3

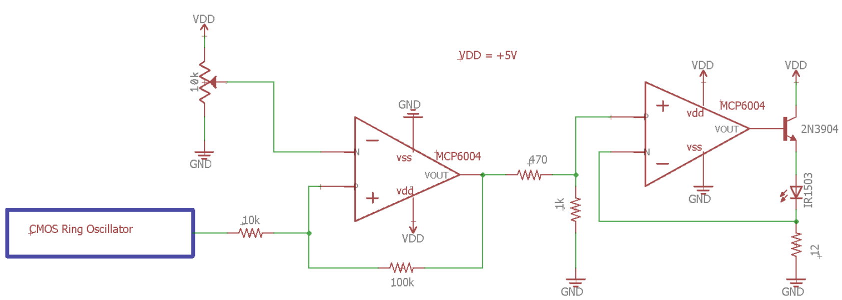

Figure 3: Circuit schematic of transmitter

The astable multivibrator is constructed on a signal CD4007 MOS DIP, which consists of three CMOS circuits. The waveform is then conditioned with a Schmitt trigger and then passed through a amplifier, both constructed on an MCP6004 quad-op-amp. This, in turn, drives an 2N3904 BJT, which controls the current through the IR1503 LED. The resulting current is seen in Figure 4.

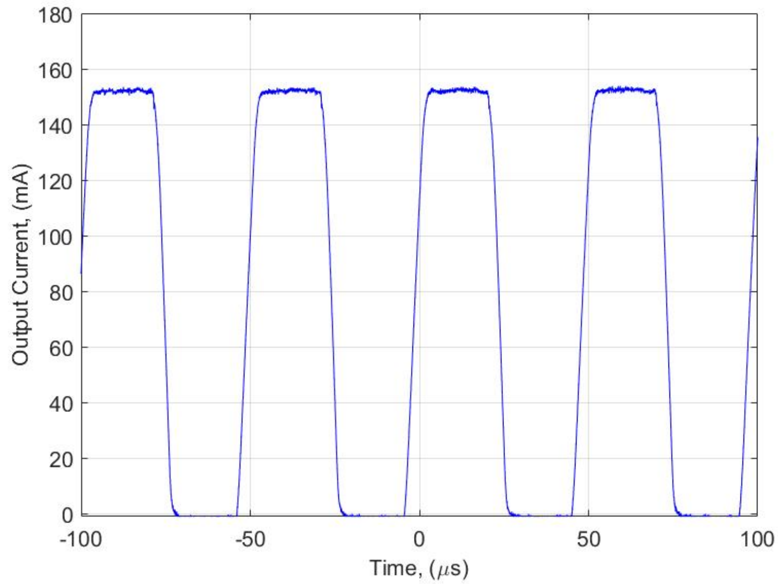

Figure 4: Current through LED

The maximum current was found to be 150mA, with a duty-cycle of 50%. This current for the LED is important for energy conservation regions and to not overheat the IR LED. The LED will not overheat in this manner, which will also prevent parasitic effects of temperature change from affecting it. This results in steady operation of the system as a whole, which will in turn provide accurate results of foot traffic in stores.

5 Team Qualifications

Ryan, Phil and Joseph have completed, at the time of this proposal, five semesters in the electical and computer engineering discipline. The most relevant skillsets for the purposes of this proposal is from the electronics course, ECE 342, which an optical uplink was simulated and designed by this team. This course focused primarily on microelecronic circuits and in-depth study of MOSFET's, BJT's and their implementation in circuits with operational amplifiers.

Ryan is double majoring in Computer and Electrical engineering at the University of Maine. Relevant skills from coursework include Microcomputer Architecture and Design, ECE 473, which implements Verilog in design of Microprocessors, which is of use when designing hardware for the tripwire. Skills in microelectronics from Electronics I, EC 342, is also of use for designing IR sensor circuits.

Phil is double majoring in Computer and Electrical engineering at the University of Maine. Relevant skills from coursework includes Microcomputer Architecture and Design, ECE 473, which implements Verilog in design of Microprocessors, which is of use when designing hardware for the tripwire. Skills in microelectronics from Electronics I, EC 342, is also of use for designing IR sensor circuits.

Joseph is an undergraduate majoring in electrical engineering at the University of Maine. Experience includes Electronics I, ECE 342, which is used in the development of the IR circuits used in this design.

6 Cost Analysis

The selling price of the device can be seen below in Table 5.

Figure 5: Cost Analysis Table

Table 4: Determining Selling Price	
NRE Costs	$6,552.00
Manufacturing Costs	$7,465.43
Sales/Marketing	$2,803.49
Profit Margin	52%
TOTAL SELLING PRICE	**$25,567.79**
PRICE PER CIRCUIT	**$25.57**

While selling at a 52 % profit margin the final price is a little less than $26. This provides a competitive edge compared to similar products already on the market. The component value breakdown as well as non renewable engineering cost breakdown can be found in the appendix.

7 Conclusion

The IR tripwire for retail foot traffic was proposed as a novel and useful application for the transmitter module of the Optical Uplink project. The components and function of th IR tripwire sensor were described, including benefits. Preliminary measurements of the Optical Uplink transmitter/reciever were provided. A discussion was provided on the impact on tripwire functionality. Relevant qualifications of all team members were stated, and a cost analysis of the design and production of the device were performed.

References

[1] Doug Richardson. (2002) ”Sensors, Sentry Owls and smart dust: since the summer of 2002, Sentry Owls have been helping guard US units operating in overseas locations close to Afghanistan.” Business Insights: Essentials.

[2] A. A. Faust, et Al. (2005) ”Canadian teleoperated landmine detection systems.” Avalable: Internation Journal of System Sciences.

[3] Vicaire, Pascal, et Al. (2009) ”Acheiving Long-term Surveillance in VigilNet.” Available: ACM Trans. Sen. Netw.

Appendices

Figure 6

Table 1: NRE Costs	
NRE Factors	Price per Hour
Salary	$35.00
Health Cost	$8.00
Social Security/Medicaid	$3.00
Sick Leave/Holidays	$4.00
401k Contribution	$5.00
Overhead	$66.00
Total per Hour	$121.00
# Hours Worked on Project	26
# Employees on Project	2
TOTAL NRE COSTS	**$6,292.00**

Figure 7

Table 3: Assembly Costs				
Component	# of Connections	Cost per Component	Quantity/ Circuit	Cost per Component to Connect
2N7000FS-ND MOSFET	3	$0.00990	3	$0.02970
LF351DT MOSFET	6	$0.01980	3	$0.05940
OP999 PHOTODIODE	2	$0.00660	1	$0.00660
CERAMIC CAPACITOR 470PF	2	$0.00660	6	$0.03960
CERAMIC CAPACITOR 10NF	2	$0.00660	2	$0.01320
CERAMIC CAPACITOR 2UF	2	$0.00660	2	$0.01320
CERAMIC CAPACITOR 10UF	2	$0.00660	1	$0.00660
LF347 OP AMP	2	$0.00660	6	$0.03960
2.7K OHM 1/4W RESISTOR	2	$0.00660	1	$0.00660
4.3K OHM 1/4W RESISTOR	2	$0.00660	2	$0.01320
160K OHM 1/4W RESISTOR	2	$0.00660	1	$0.00660
20K OHM 1/4W RESISTOR	2	$0.00660	1	$0.00660
100K OHM 1/4W RESISTOR	2	$0.00660	1	$0.00660
170K OHM 1/4W RESISTOR	2	$0.00660	2	$0.01320
0	2	$0.00660	0	$0.00000
Total Connection Costs	$0.2607			
Cost to Test per Circuit	$0.20			
TOTAL ASSEMBLY COSTS	**$460.70**			

Figure 8

Table 2: Cost to Purchase Components			
Component	**Price/Unit**	**Quantity/ Circuit**	**Price for 1000 Circuits**
2N7000FS-ND MOSFET	$0.06100	3	$183.00
LF351DT MOSFET	$0.26390	3	$791.70
OP999 PHOTODIODE	$0.62000	1	$620.00
CERAMIC CAPACITOR 470PF	$0.00610	6	$36.60
CERAMIC CAPACITOR 10NF	$0.00390	2	$7.80
CERAMIC CAPACITOR 2UF	$0.06800	2	$136.00
CERAMIC CAPACITOR 10UF	$0.06200	1	$62.00
LF347 OP AMP	$0.76000	6	$4,560.00
2.7K OHM 1/4W RESISTOR	$0.00480	1	$4.80
4.3K OHM 1/4W RESISTOR	$0.22000	2	$440.00
160K OHM 1/4W RESISTOR	$0.11000	1	$110.00
20K OHM 1/4W RESISTOR	$0.00480	1	$4.80
100K OHM 1/4W RESISTOR	$0.03300	1	$33.00
170K OHM 1/4W RESISTOR	$0.05100	2	$102.00
PCB BOARD (3"x4")	$4.00000	1	$4,000.00
Cost of Components	$11.0917		
Shipping Cost	$0.0147		
Sales Tax	$0.6100		
Total Cost per Circuit	$11.7164		
Number of Circuits to be Built	1000		
TOTAL COMPONENT PURCHASING COSTS	**$11,716.4900**		