IVEND – INFRARED DETECTION

Team Dec15-10

with Dr. Wang and Fawn Engineering

Tyler Westerberg
Tim Howell
Jacob Olstad
Steve Dorenkamp
Seth Schmidt

Contents

Introduction

Fawn Engineering Co. currently uses iVend Product Detection to indicate when products have been successfully dispensed in one of their machines. Currently, the system is experiencing intermittent times iVend fails to operate as required, resulting in the machine vending an additional product. Some of Fawn Engineering's designs are currently used with high cost items, which have resulted in significant losses for their customers.

Problem Statement

Working with Dr. Zhengdao Wang and the engineers at Fawn Engineering, we are to redesign the iVend system and will ensure that our newly designed system functions as described. Our final deliverable is the completed board that does not allow any items to fall into the delivery bin undetected by the iVend. The device developed by our team will save their clients money and will hopefully result in return customers.

System Level Design

System Requirements

- The system must be able to fit in space that the current boards occupy.
- The system must be able to plug into the existing connectors, and run off of the existing supplied power. The existing power is 24 V DC power at 200 mA.
- The system shall be that of two boards, one on either side of the tray, matching that of the current system.
- The system shall be able to detect an error during startup.
- The system must detect when a product has gone through the IR field.
- The system shall be capable of detecting an object as small as a standard zip tie.
- The system shall have a visual indication of when an object is detected.
- The system shall use a voting method to detect an item.
- The system shall be capable of communicating the event an item is vended.
- The system must be able to re-vend a product if an item was purchased and the IR curtain was never broken.

Functional Requirements

- The system shall communicate that an object has been detected by holding communications line low for at least 150ms.
- The system must be effective when the emitter and detector bars are spaced from a minimum distance of 9.824" to a maximum distance of 34.652".
- The system should be able to operate in an environment of ambient light with levels up to indirect sunlight.
- The system should be able to operate in temperatures of -30 F to 185 F.
- There should be no vibration or shock constraints for the system.
- The new system design should have a cost relative to that of the current one.

System Analysis

The system we are dealing with in this project has two parts, one composed of hardware, and the second composed of software. The hardware element is our PCB (see appendix B) boards. These boards are responsible for detecting when a product is vended and passes through the IR field. Once this is detected, our software element needs recognize this and not vend an additional product. After a new design is implemented, it must be able to detect an item roughly the size of a zip tie, falling through the IR field at any point.

Hardware:

The boards that we develop for the new systems must have several key components. They must have IR emitters and sensors for detecting a product and they must have an LED (see appendix B) light for notifying when a product has been detected. The IR emitters will create a light curtain that will be detected by the sensors. Emitters for these boards should be chosen so that they are capable of sending IR streams to each sensor, but that they are narrow enough to cut down the reflection from the tray. When the sensors do not detect an IR stream for a given amount of time, they will pull the output signal to active to indicate a product has been vended. When the output signal is pulled active, the LED will switch to the off position, indicating that the IR curtain has been broken. This light will remain off until the IR curtain is no longer blocked. The amount of emitters and sensors, as well as the configuration, will be decided based upon that which will achieve the greatest results.

Software:

The software should be notified when a product is vended, and therefore given a window of time in which the IR curtain should be broken. If a vend is expected, and an output is given from the IR sensors within the set time frame, the system has operated correctly. If a vend is expected, and an output is not received, the system shall vend an additional product. The system shall use a voting method to determine if the curtain was broken for a long enough time period.

Hardware

Block Diagram

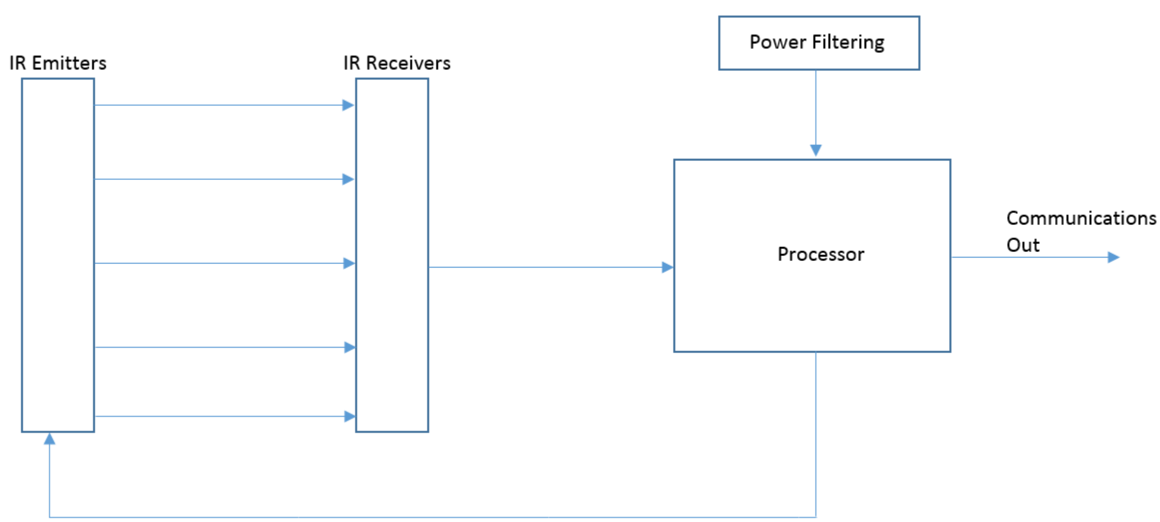

Figure 1 Block Diagram of the System

Schematic

See appendix A.

PCB Boards

There will be two, two layer PCB boards. One will be a detector board. This board will hold the IR detectors the processor and the communication back to the main vending machine system. It will also hold a visual indicator of when an object is detected. The second board will hold the IR LEDs.

MSP430

The MSP430 will be the main processing unit for or project. I will be responsible for modulating the IR LEDs and determining when an object has passed through the IR mesh based on sensor feedback. The 430 will also need to blink an LED and pull a signal line low when an object is detected.

Figure 2 MSP430F1121

IR LEDs

The IR LEDs will be modulated at 38KHz and will be responsible for creating an IR mesh that an object will break when falling through. They will sit on the opposite end of the bin as the detectors and only one will be switched on at a time.

Figure 3 IR LED

RED LED

A single red LED will be present on the detection board so that operators can have a visual indication of when an object is detected. This LED will need to be prominelty displayed so the operator can easily see it.

Detectors

The detectors will be digital and designed to filter for the 38KHz signal the IR LEDs are modulated at. We will be using the TSOP4038 from Vishay to accomplish this as they are designed to do exactly that.

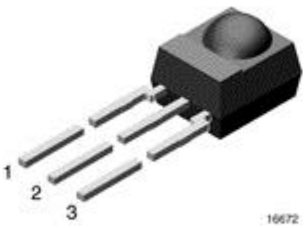

Figure 4 TSOP4038

Analog Detector

A single analog detector will be present so the firmware can calibrate the intensity of each LED on startup. The analog sensors output will be run into the MSP430's ADC so the hardware can perform the needed measurement to determine LED intensity.

Spacing

The detectors and emitters will be spaced such as to reduce the area that an item would fall out of line of sight between an emitter detector pair. This will be calculated and modeled in order to find an ideal number of emitter detector pairs and their ideal spacing.

Input/Output

The hardware shall provide two open collector signal output ports. One port shall be the reverse of the opposite and firmware shall only have access to a single port. The only input to the board shall be an unfiltered full wave rectified 24V power source.

Firmware

Block Diagram

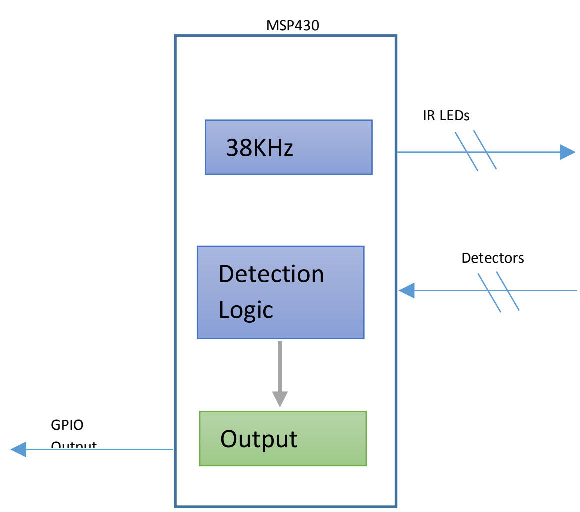

Figure 5 Firmware Block Diagram

Interface

The only human interface that will be available is a single red LED that will be kept on during normal operation and turned off if either an object is detected or a fault condition has occurred.

Signal Output

The firmware shall turn on a single GPIO port that will be used to signal when an object is detected or a fault has occurred. If an object is detected the line shall be on for 150ms and then turned low again.

LED Modulation

The firmware will be responsible of modulating the IR LEDs at a frequency of 38KHz in order to filter our other IR interference. The LEDs should be turned on one at a time in order to make sure that each detector can see each LED. This will be accomplished by setting the the PWM up to modulate each of the GPIO (see appendix B) pins that are connected to the LEDs. Each pin shall than be switched in and out when needed.

Calibration

The firmware will go through an initial calibration during startup. This will be done by changing the duty ratio on each LED while measuring the output of an analog IR detector. The firmware will vary the duty cycle until the analog sensor output matches a predefined value acquiring the correct intensity for each LED.

Object Detection

The firmware will be required to processing the signals from the IR detectors in order to determine when an object is or is not blocking the path. This will be accomplished by measuring the output signal of each detector and comparing it to a known value.

Detection

The firmware will take the output of each TSOP4038 and decide whether an object has crossed the mesh depending on how long and how many of the detectors have been low. This will be accomplished by counting each time a detector is tripped during a full cycle of the LEDs if this count ends up above a predetermined average during testing then the firmware will indicate an object has been detected.

Fault Detection

On startup the firmware will be responsible of ensuring that all LEDs can be seen by each detector. If for any reason the firmware cannot accomplish this it will keep the output line low to signal that a fault has been detected.

Detailed Description

Simulations and Modeling

Much of the schematics of the infrared matrix can be simulated with PSpice or an equivalent program. This can be used to make sure the circuits for prototypes are correctly constructed. The mechanics of the infrared matrix inside the delivery bin can be modeled with two breadboards, one board representing the emitter side, and the other board representing the sensors. Components can easily be swapped accordingly while testing for conditions.

Implementation Issues and Challenges

Key challenges:

1.) Fully understanding what the source of error is for the current infrared matrix.
2.) Implementing a prototype within a reasonable amount of time to guarantee the success of the project.
3.) Satisfying all of the conditions that Fawn Engineering wishes to achieve with this project.

Testing, Procedures, and Specifications

The testing phase of this project is expected to be rigorous. Our aim is to make the infrared matrix work with 100 percent success rate. Since it could take up to a few hundred product deliveries before an error occurs, much time and consideration must be put into testing.

This testing will include:

1.) Finding out what components work best at detecting objects
2.) Reflection inside the delivery bin
3.) Making sure the firmware code is properly checking vended items
4.) Examining outside light sources and testing whether certain lights interfere with the infrared matrix

Diagrams of our testing boards are shown below. We will use these boards to be able to test 360 unique points in the IR array for holes.

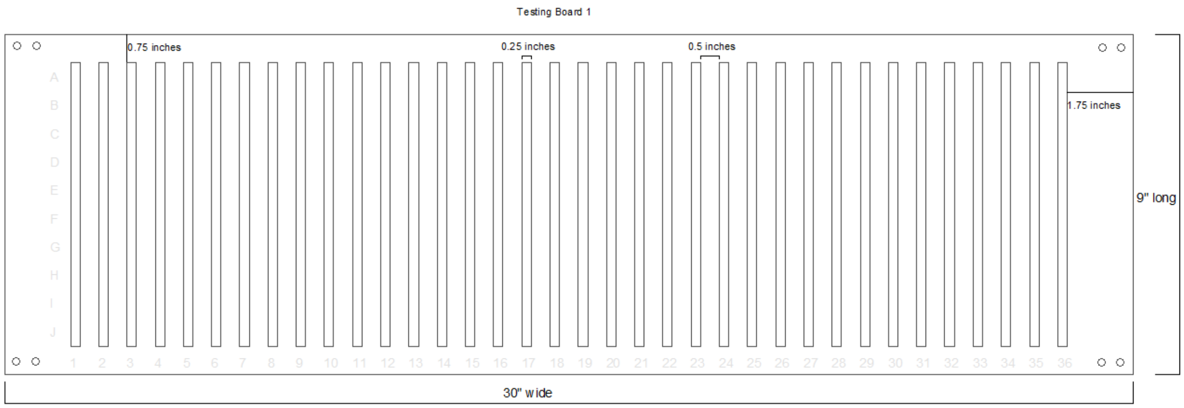

Figure 6 Testing Board 1

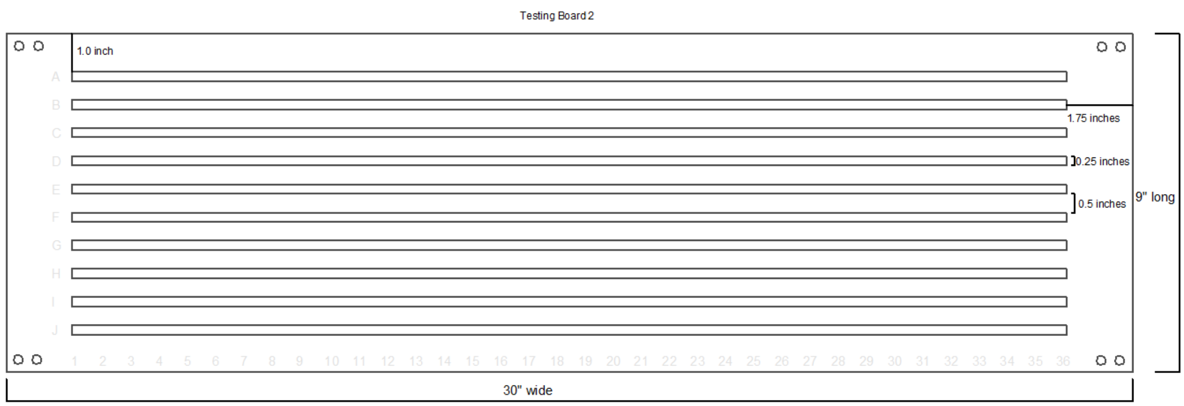

Figure 7 Testing Board 2

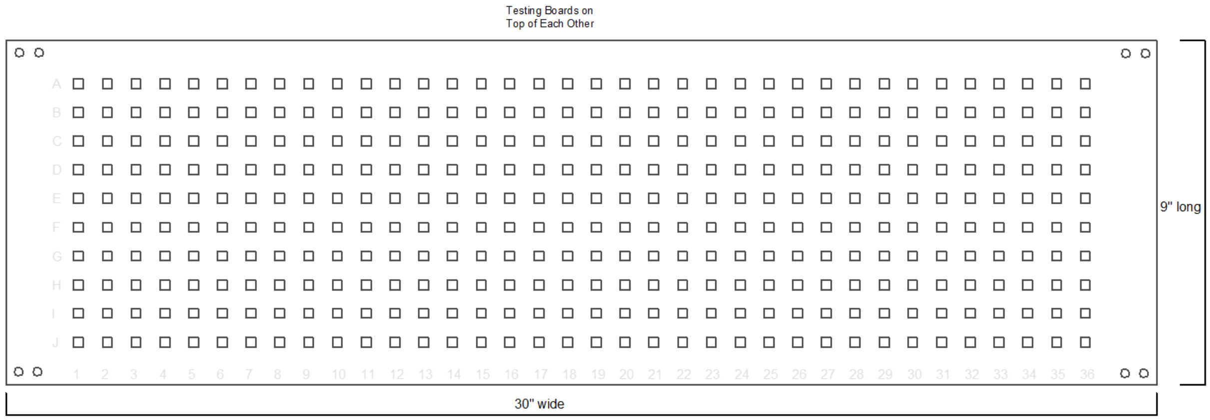

Figure 8 Testing Boards Together

Conclusion

We are confident that with our testing system and our knowledge of electronics and programming, that we will be able to create a product that works exactly as the client desires. With our testing we were able to determine the errors of the current iVend and have a good plan on how to go about fixing it.

Appendix A – Schematics

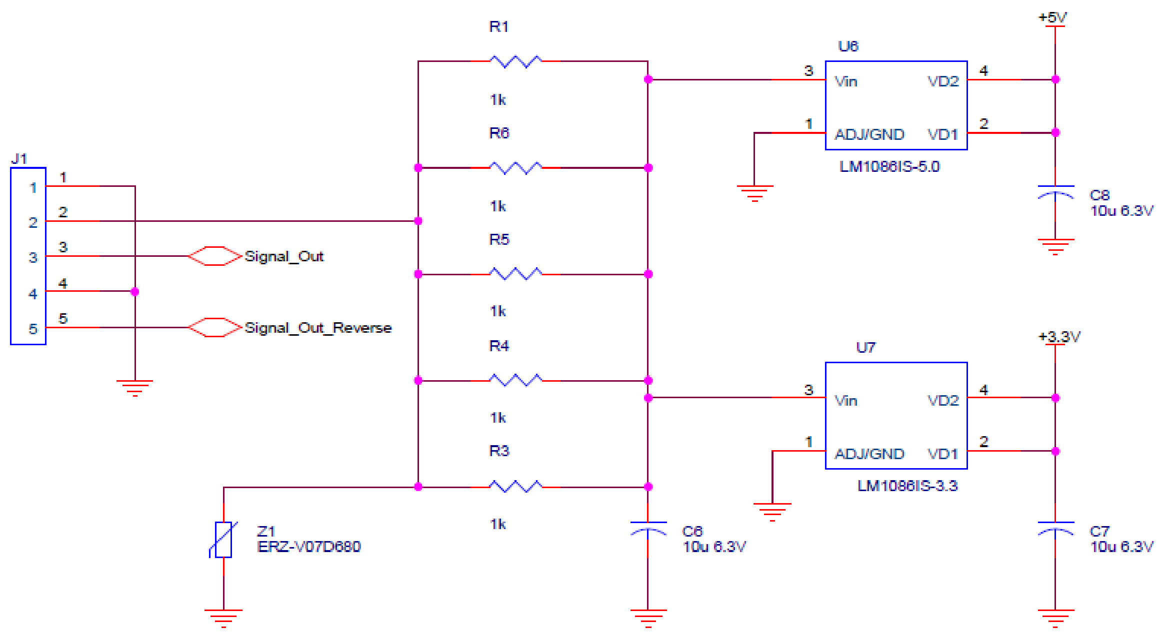

Figure 9 Schematic of Current Detectors

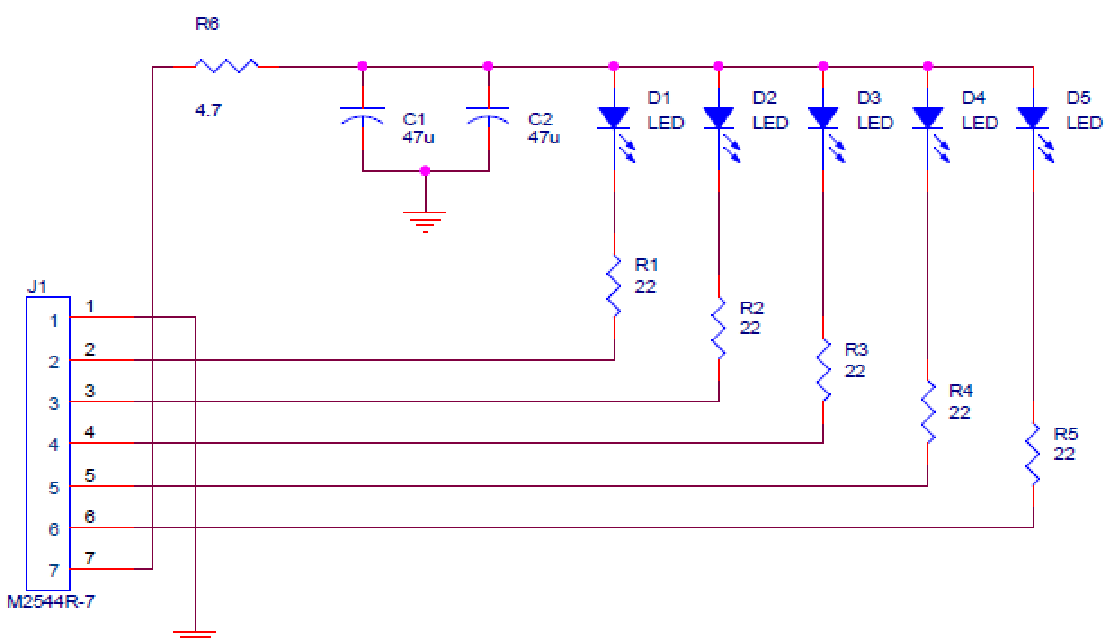

Figure 10 Schematic of Current Emitters

Appendix B – Glossary of Abbreviations

Abbreviation	Meaning
IR	Infrared
PCB	Printed Circuit Board
LED	Light Emitting Diode
GPIO	General Purpose Input/Output