Package Anti-Theft System

ECE 445 Mock Design Review Document

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1 Introduction

1.1 Objective

In the past twenty years, the emergence and subsequent boom in online shopping has changed the way consumers shop and buy goods. According to a recent survey conducted by the Pew Research Center, 79% of Americans shop online, and 15% buy online on a weekly basis [1]. Consumers now have access to thousands of products with a tremendous degree of selection, all at the convenience of a few clicks and a standard shipping and handling fee. However, the spike in online shopping has created a scenario where millions of packages are left unattended on porches and doorsteps. This ubiquity in unattended packages has led to a ubiquity in package theft. According to a survey done by Xfinity Home, Comcast's home security service, more than 50% of people across the United States know someone who has had a package stolen, and about 30% of people have had it happen themselves [2]. Clearly, this is a very pervasive problem.

Our goal is to design and construct a device that stymies package theft through a weight, alarm, and camera-based security system. We will use pressure sensors to precisely measure the weight of a package or set of packages, and an alarm system that is triggered when the weight of the package decreases within a certain threshold. Each time the alarm system is triggered, a camera takes a picture of the criminal and sends the picture to the user's cell phone via Wi-Fi and a proprietary Android application. The user can disable the alarm via the app over Wi-Fi or through an RFID tag. We believe that these measures will provide both deterrence and protection of the user's package.

2 Diagrams

2.1 Block Diagram

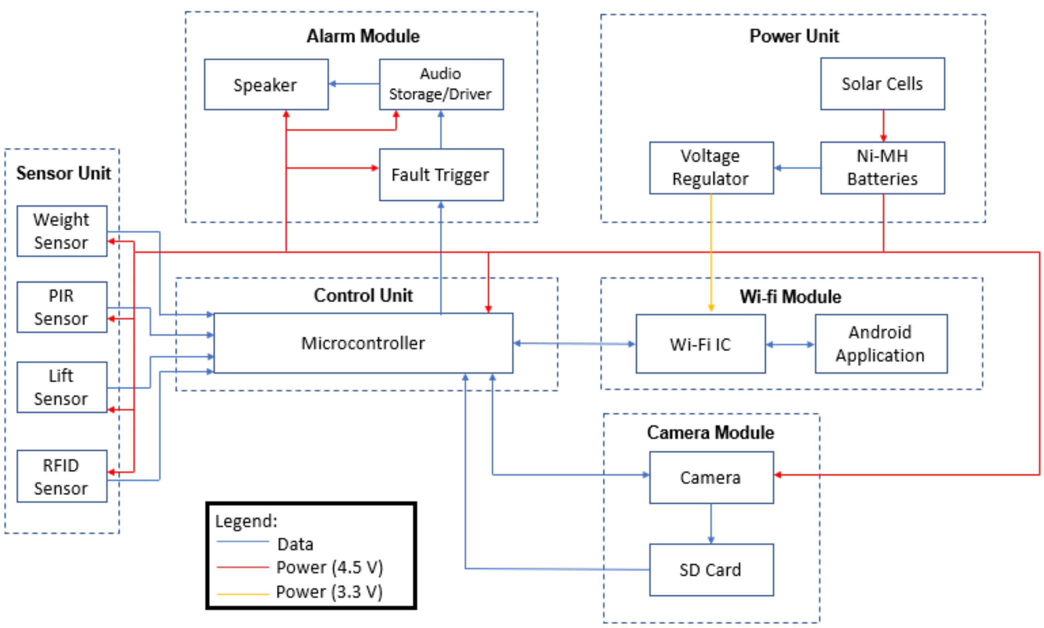

Figure 2.1: Block Diagram

2.2 Physical Design

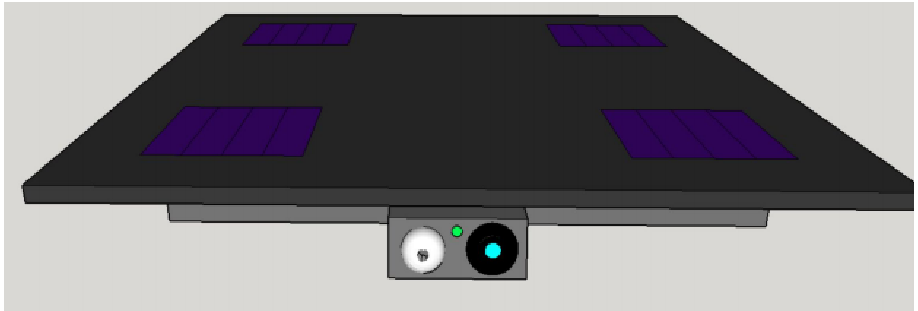

Figure 2.2: Top angle view showing solar cells, camera, and PIR sensor

3 Circuit schematics

3.1 Alarm Module

The circuit schematic in Figure 3.1 below details the alarm and verbal warning parts of our theft deterrence system. The four parts of this are the voice-playback circuit, siren circuit, channel selector, and adjustable-gain audio amp. This circuit is capable of switching between two signal channels—a siren and a voice, which is fed into an amplifier circuit and speaker that produces the desired noise. Also included in this design is an inverter that causes the alarm to go off if it fails to receive a signal from the controller, the ability to select between alarm signals (such as a police siren, fire truck siren, and security alarm), and an adjustable voice sampling rate. Not shown is the separate audio input module needed to record a message on the onboard chip.

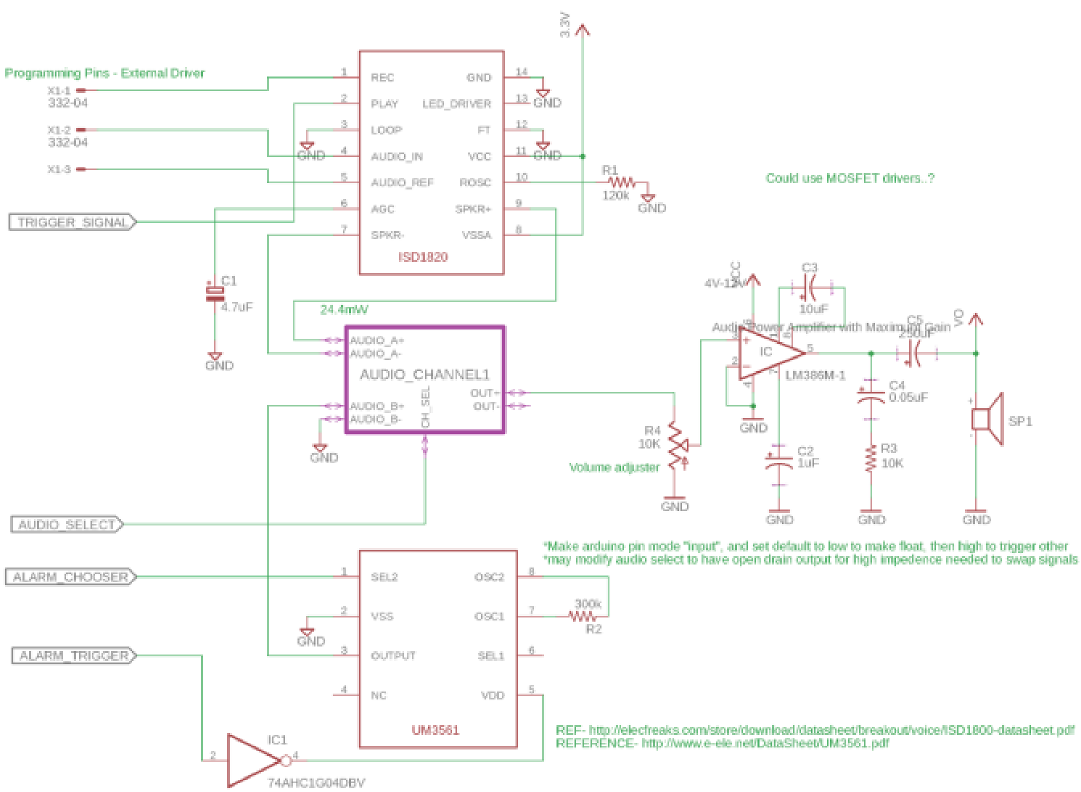

Figure 3.1: Audio Circuit Schematic

4 Calculations

4.1 Load Cell Accuracy Calculations

One of the most crucial aspects of our project is being able to precisely measure differences in package weights. An option for doing this is the use of load cells. In order to estimate the possible accuracy of the load cells, and thus minimum package weight they can carry, we use equation (1), where ε is the total error, ε_C is the combined error, $\varepsilon_z/\varepsilon_s$ is the temperature effects on zero and span, L is the rated load capacity, N is the number of load cells, W is the maximum load and t is the operating temperature range.

$$\varepsilon > \sqrt{\varepsilon_C^2 + \left(\frac{\varepsilon_Z \times L \times N}{W_1} \times t\right)^2 + (\varepsilon_S \times t)^2} \quad (1)$$

From this, we can estimate that given a scale using three common 10kg load cells, operating at maximum load of 30kg at a worst-case temperature variation from -20°C to 40°C (-13°F to 104°F), we can expect a load cell error of less than 50 grams, which is reasonable.

5 Plots

5.1 Force Sensing Resistor Response

Another option for weight sensing in this project is the use of a force-sensing resistor (FSR). In order to use this, we must use an empirical resistance-force curve for the device, shown below. This was given by the product guide [3]. Using these resistance values, as well as the resolution of our microcontroller's analog input voltage, we can determine the optimum operating points of this cell as well as its best possible accuracy.

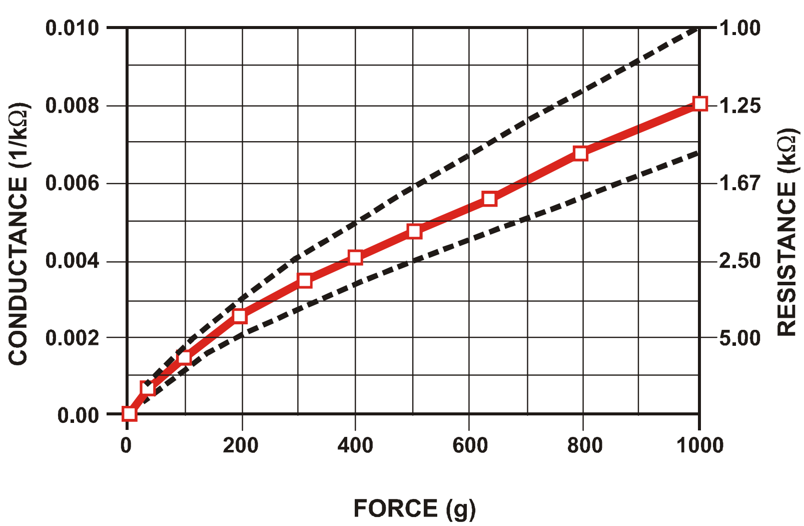

Figure 5.1: Empirical Force-Resistance curve of our chosen FSR

6 Requirements and Verification Plans

6.1 Power

Voltage Regulator: Regulates the voltage output at 3.3V to elements that require less than 4.5V and delivers over-load safety features.

- Supporting Documents:

  Part Information: Texas Instruments' LD1117 Low Dropout Voltage Regulator

  Reason for selection:

  - Low dropout voltage
  - Provides a steady 3.3V output
  - Can provide a maximum output of 800mA

Requirements	Verification
1) Outputs 3.3V ± 5% with an input of 4.5V 2) Provides an output current of 800mA to ensure maximum load conditions	1) Check with voltmeter to ensure voltage output is within specifications 2) Use the regulator with a known load (i.e. power resistors with a known value) to ensure the maximum current capability

7 Safety & Ethics Statements

We must be cognizant of several potential safety hazards while constructing this device. First, and perhaps most obviously, we must ensure that our alarm system and speaker does not exceed the limit of a safe noise level exposure for the public. Hearing loss has become more prevalent in the United States, having increased from 13.2 million (6.3% of the US population) in 1971 to 48 million (15.3%) in 2011 [4]. We do not want our device to contribute to that statistic, so we will keep our alarm under 85 dB. This device will be displayed outdoors, and outdoor electronics present a risk, especially in wet conditions. We intend to waterproof the protective layer for the electronics by adhering to IP68 guidelines [5], which keeps the equipment suitable for continuous immersion in water. This means that we will most likely keep our internals hermetically sealed.

From an ethical standpoint, we must design our device to deter crime in such a way to scare away criminals from stealing packages, but not make people fear for their lives. An alarm system that is so loud that is causes permanent hearing loss, or so jarring that it causes heart palpitations is not in accordance with IEEE Code of Ethics #1, "to hold paramount the safety, health, and welfare of the public" [6]. Furthermore, we must consider the health and safety of the neighbors and of people passing by. Especially in urban neighborhoods where houses are clustered close together, a loud and jarring alarm system could be detrimental to the health of the public. Another ethical consideration is to test the limits of our device and avoid making claims that exceed the limits. We will quote realistic and accurate claims, pursuant to IEEE Code of Ethics #3, "to be honest and realistic in stating claims or estimates based on available data" [6].

8 Citations

[1] Smith, Aaron, and Monica Anderson. “Online shopping and purchasing preferences.” Pew Research Center: Internet and Technology, 19 Dec. 2016.

[2] Weise, Elizabeth. Package theft hits nearly one-Third of Americans. Is video surveillance the answer? USA Today, 20 Nov. 2017.

[3] “Force Sensing Resistor Integration Guide and Evaluation Parts Catalog.” SparkFun Electronics, https://www.sparkfun.com/datasheets/Sensors/Pressure/fsrguide.pdf

[4] Lin FR, Niparko JK, Ferrucci L. Hearing loss prevalence in the United States. Arch Intern Med. 2011;171(20):1851–1852

[5] “IP Rating Chart.” DSMT.com, www.dsmt.com/resources/ip-rating-chart/.

[6] “IEEE Code of Ethics.” IEEE - IEEE Code of Ethics, www.ieee.org/about/corporate/governance/p7-8.html.