Smart Ladder

Individual Progress Report

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1. Introduction

Our group has been working on a smart ladder which implements four load cells, an accelerometer, amplifiers, a microcontroller and switches on each rung in order to provide both visual and audio feedback on the safety of the ladder currently in use. There are three main components to our design: the feedback from the load cells, accelerometer, and switches is one main component. The coding of the microcontroller to analyze the data and communicate with the LED, speaker, and digital display is another main component. The third component is the power supply and managements system, and the voltage regulation to be applied.

My individual responsibilities as outlined in the design review are to test and design the sensor circuitry, begin implementing the microcontroller, and to build as well as test the power management and voltage regulation. The role in the greater project for this is to be able to accurately determine the center of mass from the sensor data; the accelerometer determines the angle, the switches the height and the load cells determine weight applied to be analyzed in the safety equations. Everything must also be powered both correctly and safely.

2. Individual Design Work

2.1. Design Changes

The changes we have made since the design review are mainly with how the ladder itself will be designed. In order to account for the weight of the person either breaking the switches or not activating the switches, each rung of the ladder will be encased in rubber in order to distribute the force applied on the switch to the entire rung for better accuracy. The load cells must also be encased in rubber after they are screwed into the base of the ladder because it would not be safe to have the metal load cells make direct contact with the ground (the ladder we will use already has rubber at the base, so we would remove it, add the load cell, and then encase it again).

The wiring for all the components will also be fed through the ladder by drilling holes so that they are not a potential tripping hazard or exposed to the weather. The display and speakers will be mounted on the PCB at the top of the ladder (along with the accelerometer and voltage regulators), and the switches will have their own PCBs as well. The diagram below outlines these changes that are to be made.

2.2. Diagrams

2.2.1. New Ladder Setup

The ladder will be set up as follows with large arrows indicating three possible fall directions:

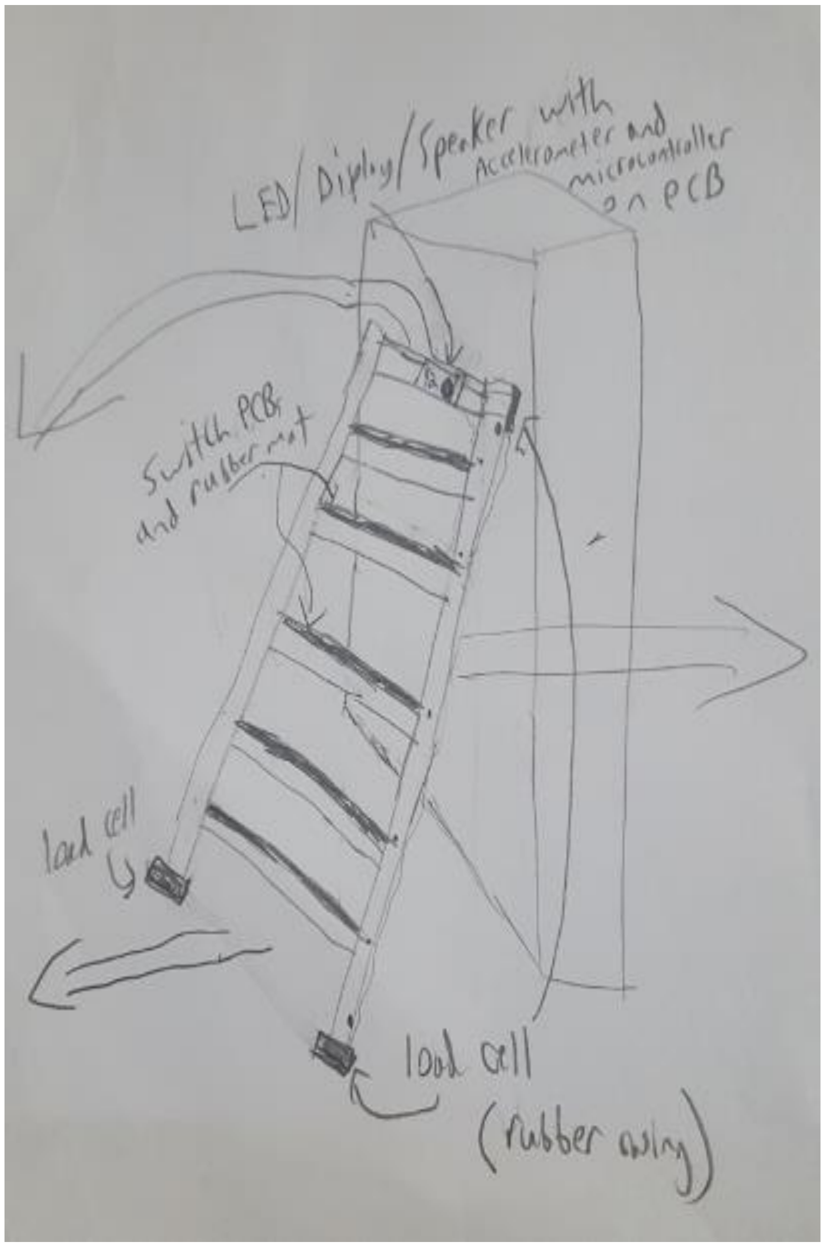

Figure 1: Changes since design review on ladder set up.

2.2.2. New Circuit Schematic for Main PCB

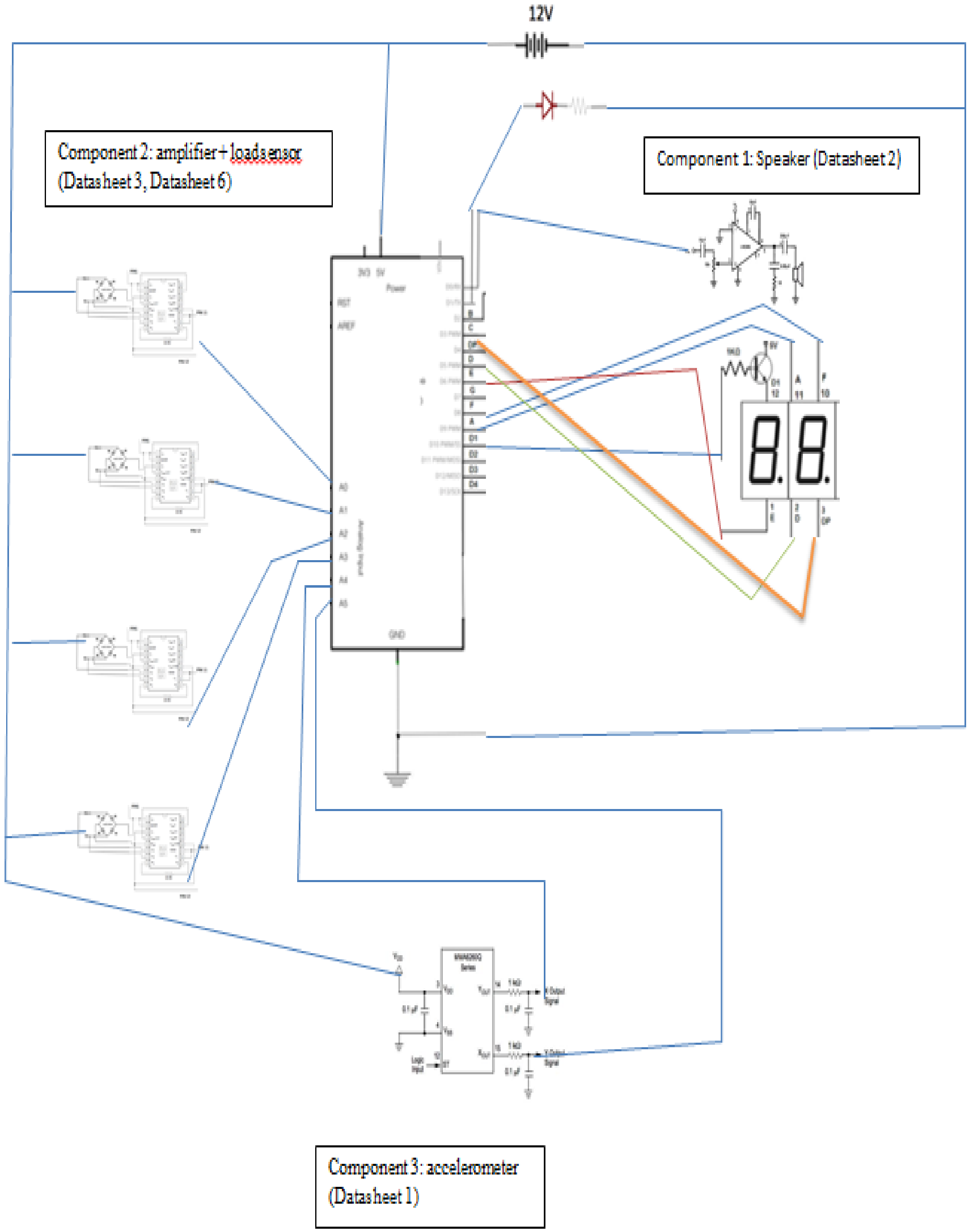

Figure 2: Main PCB Schematic

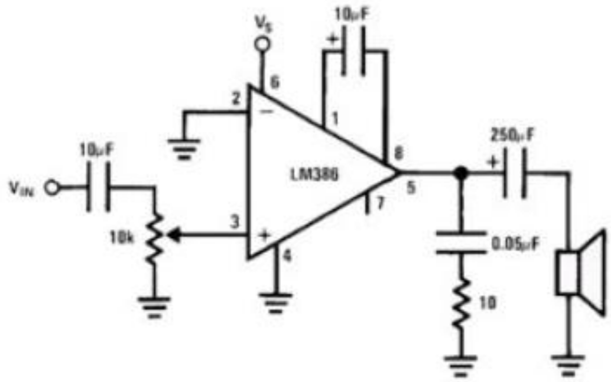

Figure 3: Component 1 on previous page

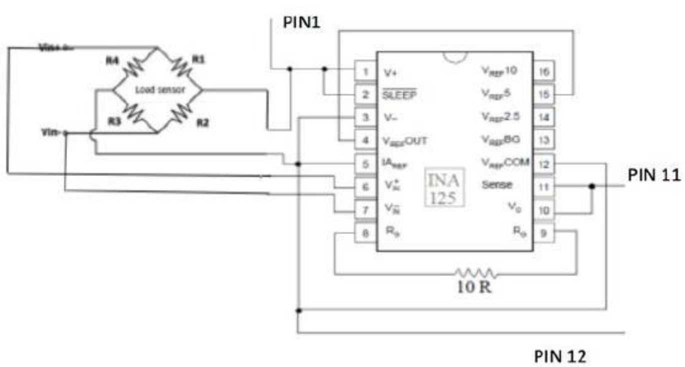

Figure 4: Component 2 on previous page

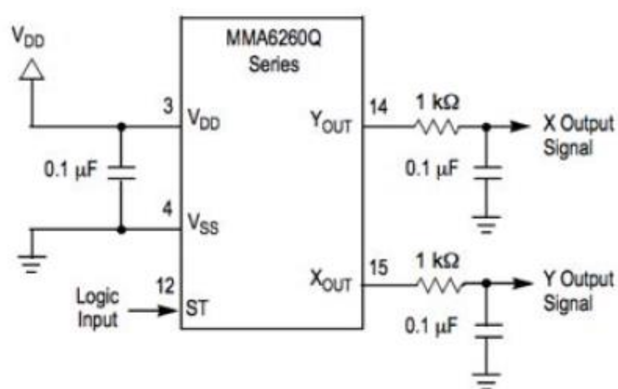

Figure 5: Component 3 on previous page

2.3. Testing and Verification

The plans for testing are to use a force gauge on the load cells in order to measure the change in current due to the added resistance by using a ammeter or multimeter, ensuring the load cells work as intended, and with little noise; in order to test the output with the code and microcontroller the output must be fed through an amplifier as well as an analog to digital converter. The accelerometer must also be tested to insure the sensor output values are theoretically correct by rotating the sensor about a single axis and noting how the values on one both sides of the axis change. The testing will be done within the next week as all the components have just arrived.

The power source and management will be tested before anything in the circuit is connected to guarantee the voltage is being regulated properly so that nothing is damaged or unsafe. To test the power source, the input voltage should be sweep from a lower to a higher DC value depending on the component; the load cells require 300mW to 800mW of power, the accelerometer and amplifier require 3mW to 5mW, the speaker, LED, and microcontroller need around 200 mW to 400 mW, and the digital display requires 500 mW. The voltage inputs to achieve the power is as follows: the LED, accelerometer, amplifier, and speaker require 3.3VDC, the microcontroller and digital display require 5VDC, and the load cells require 8VDC. To ensure the battery lasts at least an 8 hour work day, we would power everything in a worst case scenario and note when everything turns off; the power source will also be tested this week. The LEDs, digital displays, and speaker will be tested last, towards the end, because they should work when receiving the proper signal from the microcontroller.

Our plans for failed tests are as follows: if accelerometer does not properly compute the angle required for the calculations, a three axis instead of a two axis will be used. There are currently no plans if the load cells do not work as intended, as they were difficult to obtain. Everything else is an easy fix as extra/different components would simply have to bought and tried from the ECE store or around campus. We will be unable to test the ladder itself until the PCB is obtained and everything is attached to the ladder.

3. Conclusion

The individual workload vs the total workload for the project is about even, mainly because we are working on at least some of all the three main components discussed earlier together due to there being two of us. The project is currently behind schedule as it has taken a very long time to obtain all the parts. The coding for the microcontroller has been started in the meantime, but it must still be finished. The plans for the works that remains is to be able to finish all the testing and get everything ready to be attached to the ladder within two weeks, which should be possible. The PCB is also a little behind schedule currently, but should be ready on time. There is still a lot of work remaining, but I am ambitious to finish the project before the break, in about three weeks, but possible setbacks would require additional work to be done over the break as well.

4. Citations

1. Datasheets for accelerometer:
   http://www.nxp.com/files/sensors/doc/data_sheet/MMA6260Q.pdf
   http://www.nxp.com/files/sensors/doc/app_note/AN3107.pdf

2. Datasheet for digital display:
   http://www.mouser.com/ds/2/737/adafruit-led-backpack-932846.pdf

3. Datasheet information for load cells:
   https://www.aliexpress.com/item/Durable-in-use-1PCX-200kg-electronic-platform-scale-load-cell-pressure-balanced-cantilever-load-weight-sensor/32704104726.html?spm=2114.40010208.4.14.Tkktqy

4. Datasheet for microcontroller:
   https://cdn-learn.adafruit.com/downloads/pdf/introducing-trinket.pdf

5. Datasheet for battery:
   http://www.batteryclerk.com/assets/documents/BatteryClerk-AJC-Battery-D5S.pdf

6. Datasheet for amplifier:
   http://www.ti.com/lit/ds/symlink/ina125.pdf

7. Datasheet for switches:
   https://www.sparkfun.com/datasheets/Components/Buttons/SMD-Button.pdf

8. Datasheet for speaker:
   http://www.mouser.com/ds/2/334/AS05008PR-2-R-68516.pdf