Smart Ladder

Mock Design Review

TA: Luke Wendt

Bradden Pesce : bpesce2
Lingying Cai : lcai12

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1. Block diagram

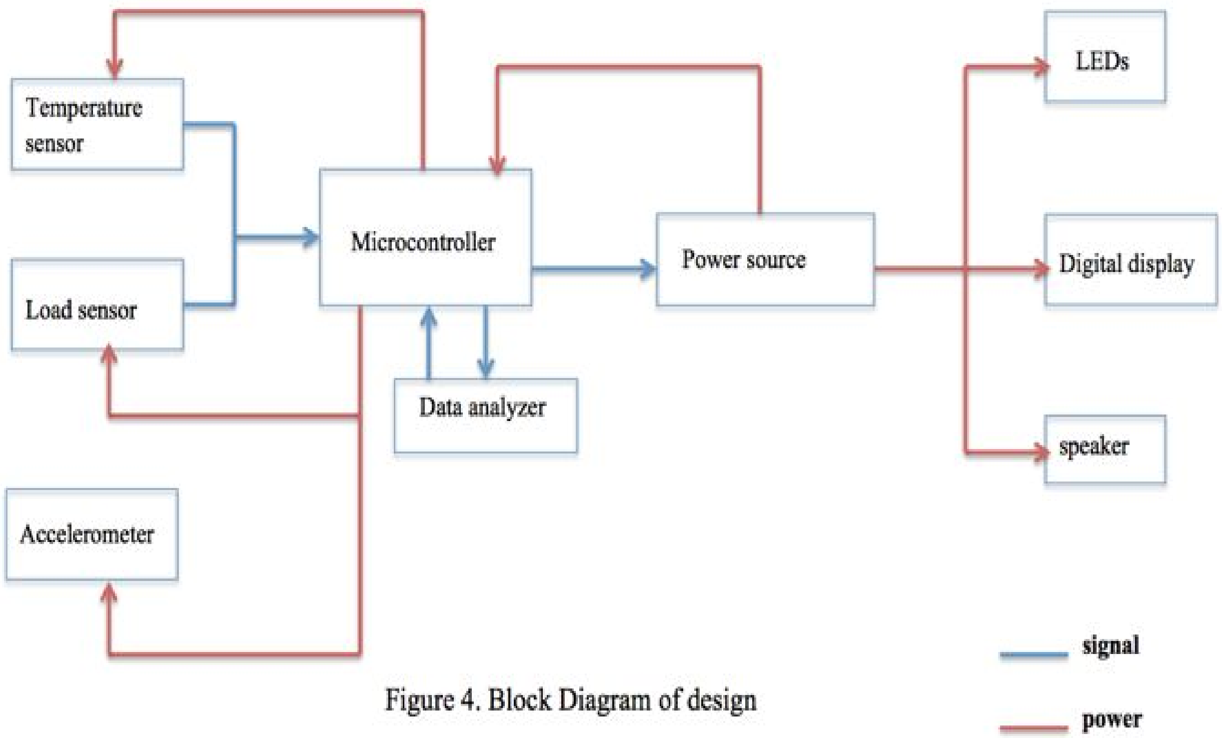
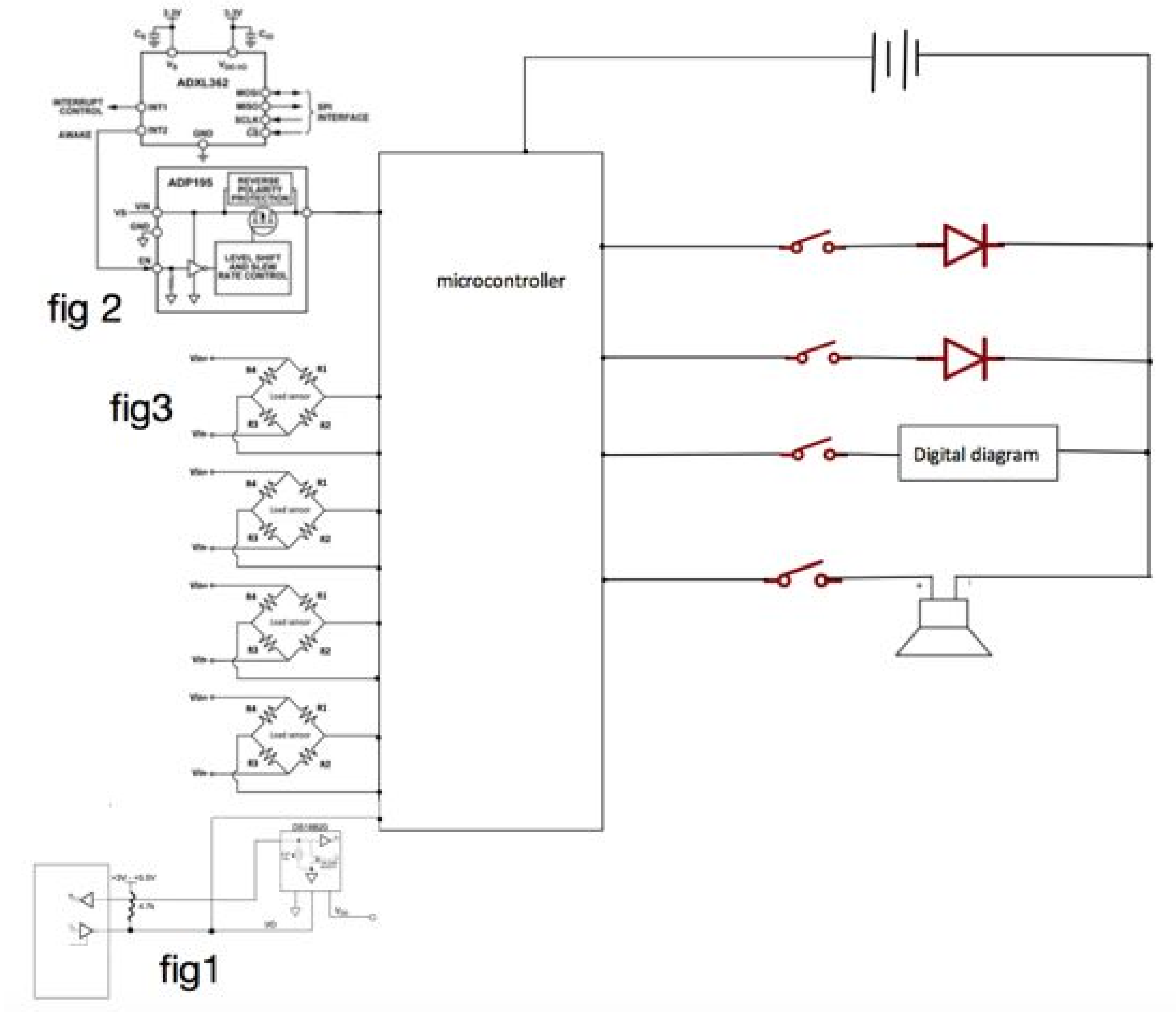


Figure 4. Block Diagram of design

2. One circuit schematic



3. One calculation

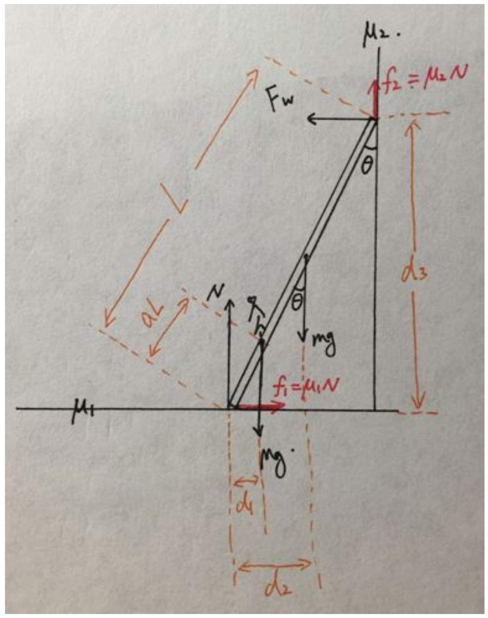


Figure 5: Calculation for ladder on two legs

$$\sum \tau = 0 = \sum r \times \vec{F} = M^*g^*d_1 + m^*g^*d_2 - F_w{}^*d_3$$

Therefore,

$$F_w = \frac{M^*g^*d_1 + m^*g^*d_2}{d_3}$$

$$= \frac{M^*g^*a^*L^*sin(\theta) + m^*g^*\frac{L}{2}{}^*sin(\theta)}{L^*cos(\theta)}$$

$$= \frac{M^*g^*a^*sin(\theta) + m^*g^*\frac{1}{2}{}^*sin(\theta)}{cos(\theta)}$$

if $F_w \leq F_{friction}$, the ladder is consider safe, otherwise, not safe. The smaller F_w is, the safer the ladder is.

4. One plot (simulation or experiment)

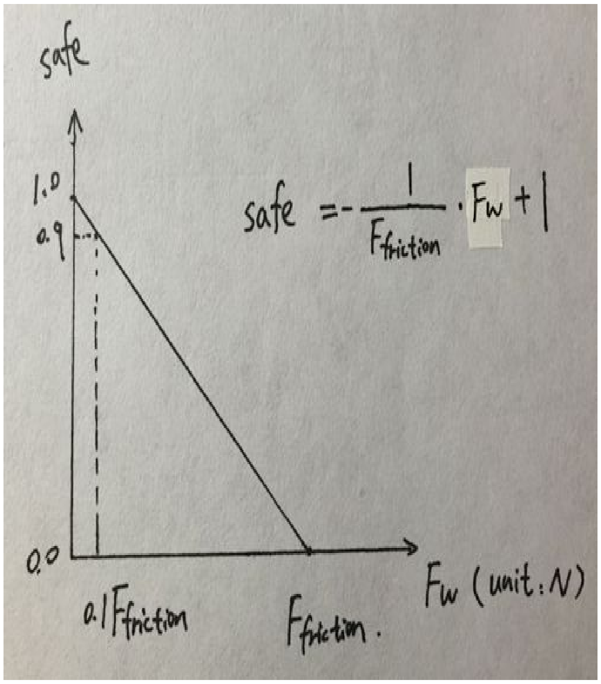


Figure 6: Setup for safety margin plot

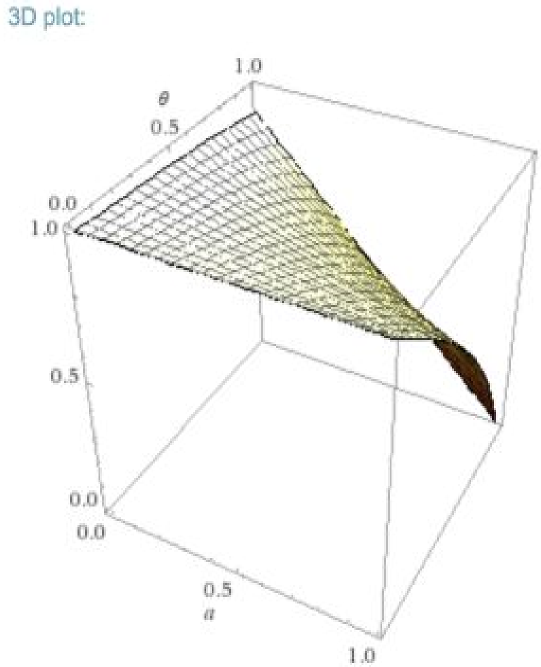


Figure 7: 3D plot of safety margin

$$\text{safe} = -\frac{1}{F_{friction}} * F_w + 1$$

$$\text{safe}(a,\ \theta) = -\frac{1}{F_{friction}} * \frac{M*g*a*sin(\theta) + m*g*\frac{1}{2}*sin(\theta)}{cos(\theta)} + 1$$

5. One block description

Data Analyzer

This module receives and stores data from the microcontroller and uses the information in computing the center of gravity of the ladder relative to the base stability by comparing all the forces acting on the base of the ladder; the safety margin of the ladder is computed based on how close the ladder is to slipping by first finding the forced applied from the user on the ladder and comparing that value to the friction force the ladder makes with the ground. If the force applied is greater than friction then it is not safe and the signal goes back to the microcontroller. This module also analyzes the accelerometer and temperature sensor data and sends a corresponding signal to the microcontroller. It must also reduce the safety margin by 1% to account for the tolerance error of the load sensors. i.e. The ladder will never read 100% safe; 99% would be the maximum value displayed.

6. Requirements and verifications

Requirement	**Verification**
Load Sensors: Must be able to determine the value and direction of all the forces acting on the base of the ladder and on the first step of the ladder. The tolerance is within +/ 0.035 kg.	Load Sensors: Use a force gauge to determine an applied force and compare it to the value measured from the load sensor by measuring the current change due to added resistance by using a ammeter.

7. Safety statement

In order to account for error in the load sensors, the display will only ever reach 99% safe as a maximum value. 1% error is reasonable because it is both small and the load sensors have a resolution of +/- 0.035 kg which only has an effect of 0.03% on the safety margin.

8. Works Cited

Figure 1:

"DIGITAL TEMPERATURE SENSOR." *All Electronics Corp.* N.p., n.d. Web. 19 Sept. 2016.

Figure 2:

"Analog Devices." *ADXL362 Datasheet and Product Info*. N.p., n.d. Web. 19 Sept. 2016.

Figure 3:

"Load Cell Electrical Circuit. | Utilcell." *Load Cell Electrical Circuit.* | *Utilcell*. N.p., n.d. Web. 19 Sept. 2016.