Smart Ladder

Design Review

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1. **Introduction:**

1.1 Statement of Purpose

Improper use of ladders often causes them to fall and this is a safety hazard in both the workplace and around the home. Falls are one of the leading causes of injury mortality, and according to the CDC 43% of all fatal falls involve a ladder; there are around 30,000 injuries per year from falling ladders based on numbers from previous years. Our ladder solves this problem by analyzing all the forces applied on the ladder and then displaying how close the ladder is to slide or rotate by using digital display. The user would also be warned if certain conditions for using the ladder are not ideal such as weight surpassing the ladder rating and improper usage. Currently there is no way for someone to know how stable the ladder they are using is or if they are pushing the ladder too far.

1.2. Objectives

1.2.1. Goals and Benefits

1. Prevent ladder related injuries due to falls from improper use
2. Increased work efficiency from stability assurances
3. Prevent users from using the ladder if the conditions are unsafe before use
4. A user would be able to safely use the ladder if placed on two legs

1.2.2. Functions and Features

1. Determine center of gravity relative to the base stability of the ladder
2. Calculate and display a percent margin of stability
3. Audibly warn the user if the margin of stability is below 50%
4. Sound override button to disable the warning
5. Detect the user's weight and active a LED if too much weight is being applied
6. If the user climbs too high a switch will trigger to warn them not to continue
7. Power management system
8. The ladder will be 6 ft tall on two legs.
9. If the angle between the ladder and the surface it is leaning against is greater than 75.5° then the ladder is unsafe based on OSHA regulations and the warning will activate.

2. Design

2.1. Block Diagram and Block Descriptions:

2.1.1. Block diagram

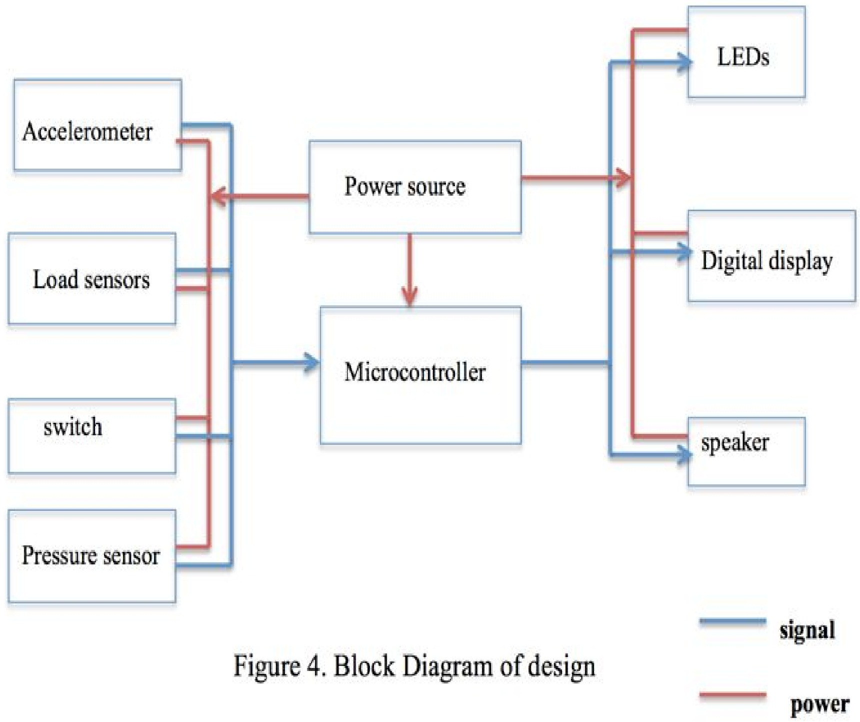


Figure 4. Block Diagram of design

2.2. Description of Blocks

2.2.1. Microcontroller

Inputs: Regulated 8VDC +/-10% from power source, 3-axis acceleration data, switch data, analog data from load cells.

Outputs: Sends information to the LED, Digital Display, and Speaker.

The microcontroller is responsible for collecting data from the sensors and controlling all the feedback devices in the system. The accelerometer and load sensors will be connected to microcontroller; then it will analyze the data, determining whether the ladder is safe or not, and send a signal to LED, Digital Display and speaker. This part is important because it will analyse the data collected by all of the sensors and determine the degree of safety of the ladder.

The data will be analyzed and the information will be used 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. If the user reaches out in any direction, the amount of force this creates will be compared to the forces acting on the ladder to determine if the ladder will fall to the right or left as well. This module analyzes the accelerometer and switch data in order to know the user's position and the angle that the ladder is set at. It must also reduce the safety margin by 8% to account for the tolerance error of the load sensors. i.e. The ladder will never read 100% safe; 92% would be the maximum value displayed.

2.2.2. Power Source

Inputs: None
Outputs: 12VDC, to microcontroller, to load cells, to accelerometer, to switches, to LED, to digital display, to speaker

We will use resistors to regulate the voltage going to different components. The power source will have a switch which will be controlled by a signal sent by microcontroller. If the switch is on, the LED, digital display and speaker will show their behaviors respectively. For example, the red LED will be turned on if there is too much weight on the ladder, the digital display will show the safety and the speaker will be activated if the condition is considered as unsafe.

2.2.3. Load Sensors

Inputs: Regulated 8VDC +/-10% from power source, Force applied to sensor from the user
Outputs: Analog change in resistance corresponding to forces sent to voltage amplifier

We will place load sensors at the base of the ladder in order to detect the directions of the all the forces being applied, including gravity. This information will be used to detect the center of gravity of the ladder relative to the base of stability and will be sent to the microcontroller. The load sensors will also determine if the ladder can handle the weight of the person and whatever they might be carrying. These sensors are connected to the voltage amplifier.

2.2.4. Digital Display

Inputs: Regulated 5VDC +/- 10% from power source, data to display from microcontroller
Outputs: Visual % of how close the ladder is to falling

This module will receive a signal from the microcontroller to display to the user how safe and stable the ladder currently is. If the center of mass of the ladder is completely stable, a 92% reading would be displayed; if the ladder is falling 0% to 8% would be displayed. Since the tolerance and noise of the load cells and accelerometer will affect the accuracy of the safety margin, a percentage of 8% is being reduced and added to the total above. This is shown in the tolerance and noise calculations. One 330Ω resistor must be placed in series with each segment (seven total) to control the current.

2.2.5. LED

Inputs: Regulated 3.3VDC +/- 10% from power source, signal from microcontroller
Outputs: Lights up for user

There will be one LEDs and it would only be on if there is too much weight being applied on the ladder’s first step than it would theoretically be able to handle. The LED receives its signal from the microcontroller.

2.2.6. Speaker

Inputs: Regulated 3.3VDC +/- 10% from power source, signal from microcontroller
Outputs: Audio warning to the user

This module will receive a signal from the microcontroller if the ladder is reaching a point of about 50% its safety margins where it would be close to falling. It will then play a warning to the user to caution them that the ladder will fall if they continue.

2.2.7. Accelerometer

Inputs: Regulated 3.3VDC +/- 10% from power source, physical orientation of ladder
Outputs: Output voltage data to microcontroller

This module is used to determine the gravity vector of the ladder. It is also used to determine if the angle the ladder makes with the wall is within OSHA regulations of 75.5° by measuring the static acceleration due to gravity. The accelerometer measures the acceleration that is being experienced by the chip on the x, y, and z axes in space. The natural acceleration of gravity allows this sensor to give a measurement of the ladder's orientation with respect to the ground.

2.2.8. Switches

Inputs: 12VDC +/- 10% from power source, input from user
Outputs: Signal to microcontroller to note position

This module determines which rung of the ladder the user is currently on in order to determine the height of the center of gravity and then sends this information to the microcontroller. There will be a switch on each rung, and a signal will be sent when the switch is triggered.

2.2.9. Amplifier

Inputs: 5VDC +/- 10% from power source, analog data from the load cells.
Outputs: Signal sent to microcontroller

This module amplifies the data received from the load cells in order for the microcontroller to read the data more clearly.

2.3. Circuit Schematic

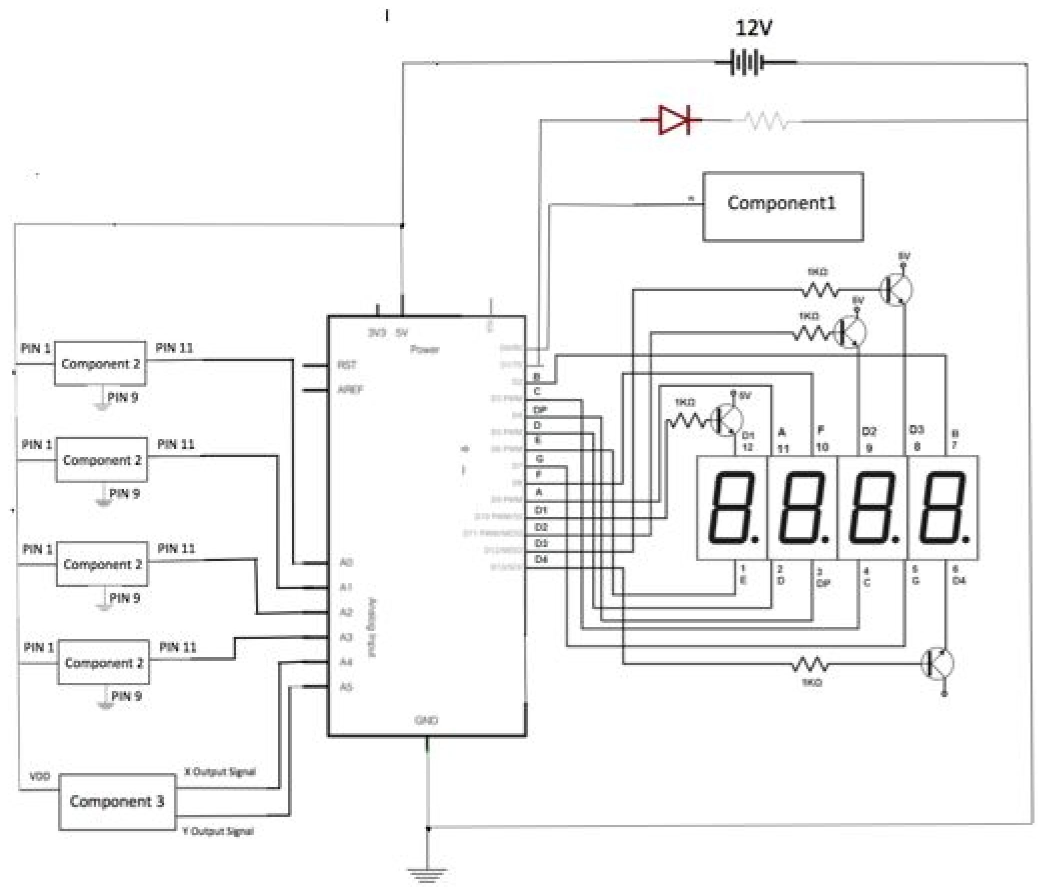
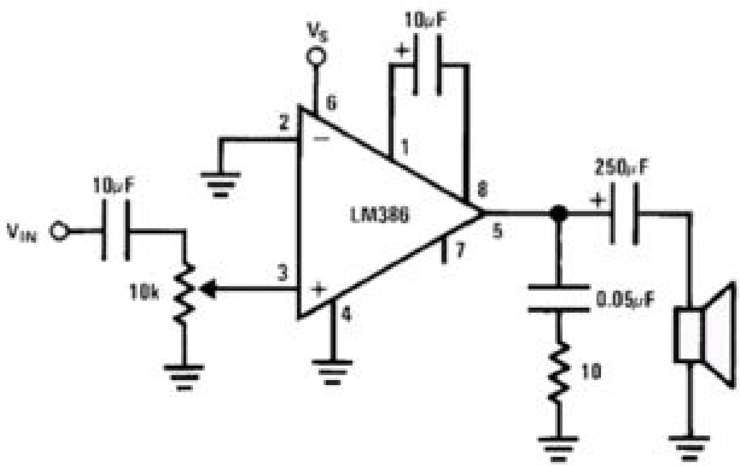
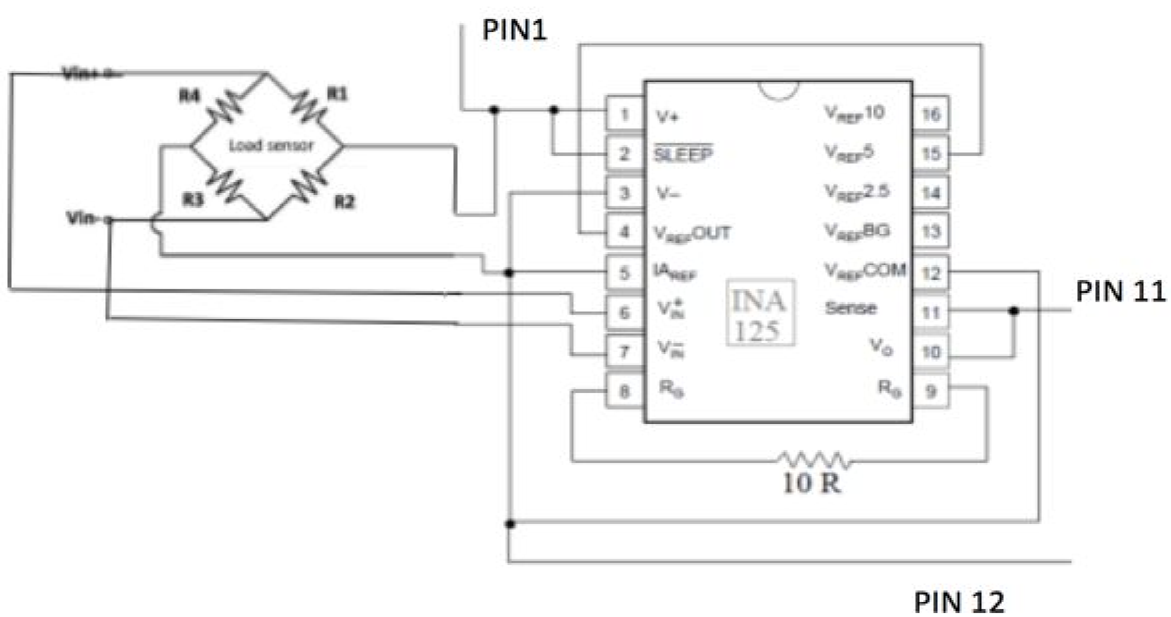


Figure 0: Circuit diagram

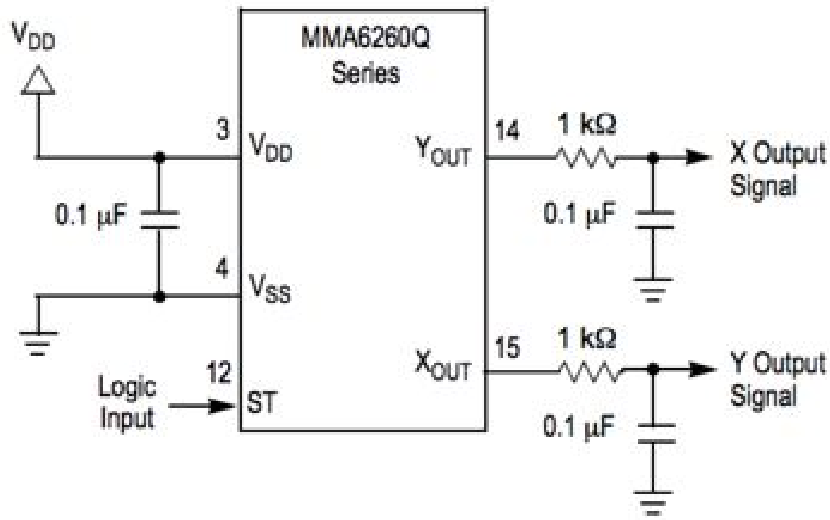
Component1: speaker (Datasheet 2)



Component2: amplifier + load sensor (Datasheet 3, Datasheet 6)



Component3: accelerometer (Datasheet 1)



3. Tolerance Analysis and Calculations

3.1. Power Consumption Calculations

Devices (More detail in parts section below)	**Worst power consumption(unit: mWatts)**	**Average power consumption(unit: mWatts)**
Load sensors	711	316
Speaker	200	200
LED	297	82.5
Microcontroller	360	360
Accelerometer	4.95	3.96
Switches	1600	1600
Digital Display	530.3	530.3

Amplifier	2.3	2.63
Total	3705.55	3095.39

The capacity rating of the battery is 5Ah and the consumption is from 3.70555W/12V = 0.309 A, which would give 5/0.309 = 16.2 hours of use.

3.2 Noise and Tolerance of Accelerometer

The tilt angle that the ladder makes with the ground can be found from the equation below. The values of 1650mV and 800mV/g are found on the MMA6260Q datasheet. The tolerance on the datasheet is +/- 5% in regards to the output voltage, and the typical noise is 1.8mV.

$$\theta = \arcsin\left(\frac{V_{OUT} - V_{OFFSET}}{\frac{\Delta V}{\Delta g}}\right) \qquad \theta = \arcsin\left(\frac{V_{OUT} - 1650\text{mV}}{800\text{mV}/\text{g}}\right)$$

If Vout is 2V, then

$$\theta = \arcsin\left(\frac{2000\text{mV} + 1.8\text{mV} + (2000\text{mV} * 1\%) - 1650\text{mV})}{\frac{800\text{mV}}{\text{g}}}\right)\theta = 27.69°$$

$$\theta = \arcsin\left(\frac{2000\text{mV} + 1.8\text{mV} - (2000\text{mV} * 1\%) - 1650\text{mV})}{\frac{800\text{mV}}{\text{g}}}\right)\theta = 24.5°$$

$$\theta = \arcsin\left(\frac{2000\text{mV} - 1650\text{mV})}{\frac{800\text{mV}}{\text{g}}}\right)\theta = 25.94°$$

Therefore, the margin of error is $(27.69 - 25.94)/25.94 * 100$ = **+6.75%** and $(24.5 - 25.94)/25.94 * 100$ = **-5.55%**. The angle measurement must take into account a +7% maximum error and a -6% minimum error.

The angle the ladder makes with the wall is (90° - tilt angle), which is the angle used in the formula (1.1) calculation. For the sake of determining the tolerance effect, M1= 70 kg, θ = 14.5° (based on the angle with the base being 75.5°, which is the maximum angle allowed for safety), a = 0.73 (based on the maximum height the person of this weight can theoretically climb before the ladder will slip and fall based on the total force acting on the base which would be around **162.68 N** if the friction coefficient is 0.2: Ffr = (g(M1+M2) * μ). Using formula 1.1, The total **F = 145.98 N**. The percent safety margin for this specific scenario would be **10.27%** safe with no tolerance. Since the accelerometer we are using has an angular error of **+7%** and **-6%**,, the angle that the ladder makes with the wall would be either **15.52°** or **13.63°**. Plugging in 15.52° instead of 14.5° in the equations with all other parameters the same yields **F = 156.76 N**; the safety margin would now read **3.64%** safe. The difference between the two safety margin values is about **6.63%**. Plugging in 13.63° instead of 14.5° in the equations with all other parameters the same yields **F = 136.875 N**; the safety margin would now read **15.86%** safe. The difference between the two safety margin values is about **5.60%**, and therefore our tolerance for the accelerometer would be **+/- 7%** from using the worst case angle above.

3.3 Tolerance and Noise of Load Cells

The force of the ladder against the wall must be greater than the force of the ladder against the base or the ladder will slip and fall. We would use load cells at the base of the ladder to determine the total force acting on the base. This value is then compared with formula 1.1 below; M is the mass of the user which is determined by a load cell placed on the first rung of the ladder; ‘a’ is the fraction of the ladder height the user is currently located which is determined by switches placed on each rung of the ladder (if the user is on two rungs at one an average is taken); θ is the angle the top of the ladder shares with the wall; m is the mass of the ladder which is equal to 10 kg for the ladder we plan on using and 3 kg more for all the sensors and components added on; g is gravity and equal to 9.8 m/sec^2.

For the sake of determining the tolerance effect, M= 70 kg, θ = 14.5° (based on the angle with the base being 75.5°, which is the maximum angle allowed for safety), a = 0.73 (based on the maximum height the person of this weight can theoretically climb before the ladder will slip and fall based on the total force acting on the base which would be around **162.68 N** if the friction coefficient is 0.2: Ffr = g(M1+M2) * μ). The total F = **145.98 N**. The percent safety margin for this specific scenario would be **10.266%** safe with no tolerance. Since the load cells we are using have a maximum error of 0.05%, the mass of the person would be detected as 70 kg +/- 0.035 kg. Plugging in 70.035 kg instead of 70 kg in the above equations with all other parameters the same yields **F = 146.05 N** and **Ffr = 162.75 N**; the safety margin would now read **10.261%** safe. The difference between the two safety margin values is about 0.005%, and therefore our tolerance would be **+/- 0.005%**;

The total effect that noise has on the output of the load cells is 0.02% from the information provided. This is a very miniscule effect, even less than the load cell tolerance error, because the load cells provide very precise values. The equation that factors in noise is as follows: $f(x) = f(xo) + df/dx\ (n - xo)$, where $df/dx(n - xo)$ is from the noise component, and the total term would be f(x) = f(xo) + 0.0002*f(xo), where f(xo) is the signal from the load cell without any noise. Since we are only sampling one point a second, the noise will be averaged out to the above equation. Using the same method as above, the 0.02% error will cause an effect of about **+/- 0.002%** on the total safety margin.

This value is extrapolated to a tolerance of **+/- 1%** which will cover all possible unaccounted for sources of error; the load cells are very precise, which is why they cost the most out of all our components.

The total tolerance would be from the angular component and the load cell component, therefore 1% + 7%= , and -1% + -7% = **+/- 8%** is our total safety margin tolerance.

3.4. Ladder safety calculation

3.4.1. Scenario1:

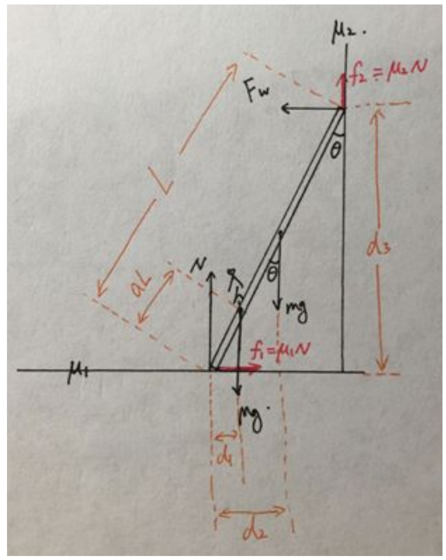


Figure 1.1: slipping analysis of the ladder

$$\sum\tau = 0 = \sum r \times \vec{F} = M * g * d_1 + m * g * d_2 - F_w * d_3 - f_2 * d_4$$

Therefore,

$$F_w = \frac{M*g*d_1 + m*g*d_2 - f_2 * d_4}{d_3}$$

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

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

$$= (M * g * (a-1) + 0.5 * m * g + N) * tan(\theta) \quad \textbf{(1.1)}$$

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

The smaller F_w is, the safer the ladder is.

Safety Analysis:

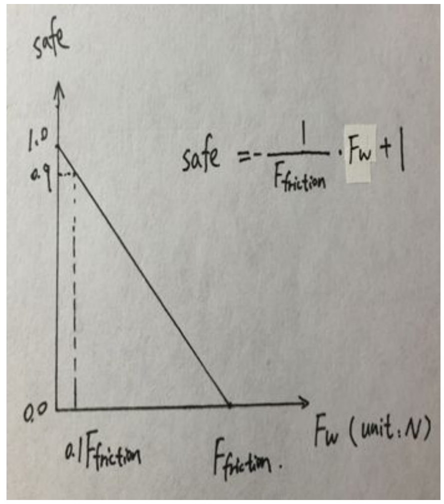


Figure 1.2: Setup for safety margin plot

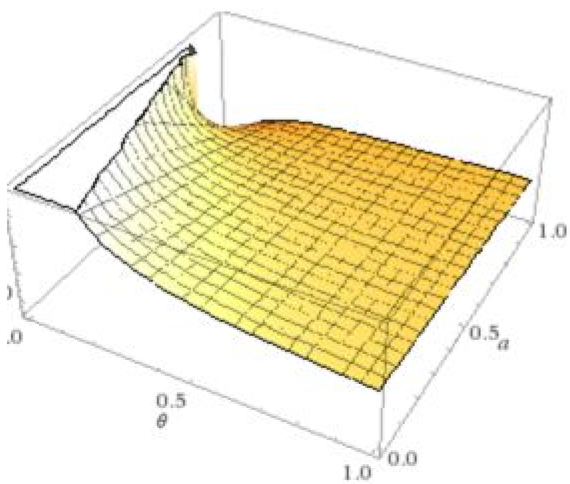


Figure 1.3: 3D plot of safety margin

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

$$\text{safe}(a,\ \theta) = -\frac{1}{F_{friction,max}} * (M * g * (a-1) + 0.5 * m * g + N) * tan(\theta) + 1 \qquad \textbf{(1.2)}$$

suppose M = 60kg, m = 10kg, g=9.8m/s^2, $F_{friction,max}$ is constant

3.4.2. Scenario 2:

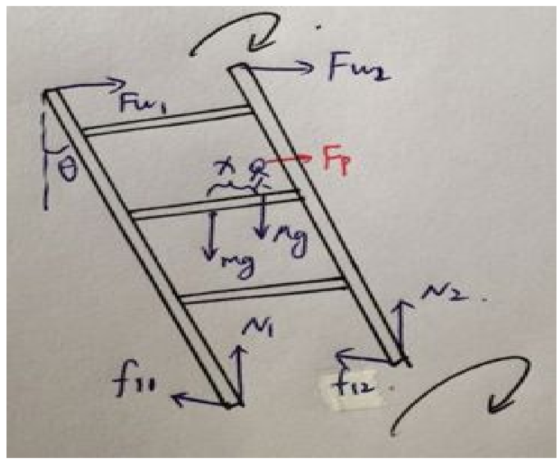


Figure2.1: rotation analysis of the ladder

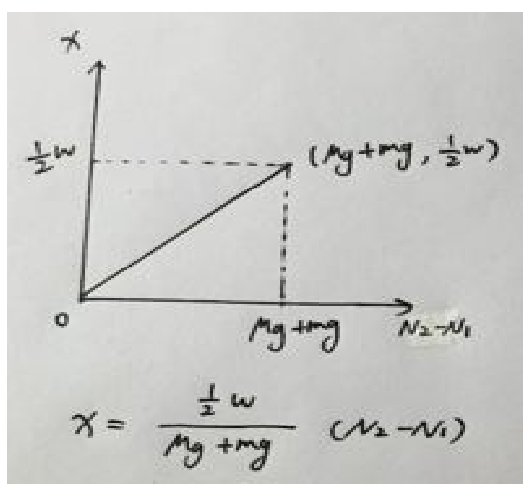


Figure2.2: plot for x

x is the distance between the position of user and the center of the ladder

treat N1 - N2 as a variable

x=0, N1 = N2 = 0.5*(M*g+m*g), N2-N1=0

x=0.5w, N1=0, N2=M*g+m*g, N2-N1=M*g+m*g

$\sum \tau = 0 = \sum r \times \vec{F} = -M * g * (0.5 * w - x) * sin(\theta) - m * g * (0.5 * w) * sin(\theta) - f_{11} * w * cos(\theta) + F_{w1} * w * cos(\theta) + N1 * w * sin(\theta) + F_p * (0.5 * w - x)$

$$F_p = -\frac{-M * g * (0.5 * w - x) * sin(\theta) - m * g * (0.5 * w) * sin(\theta) - f_{11} * w * cos(\theta) + F_{w1} * w * cos(\theta) + N1 * w * sin(\theta)}{0.5 * w - x}$$

(2.1)

If $F_p \leq f_{11,max} + f_{12,max} - F_{w1} - F_{w2}$, the ladder is consider safe, otherwise, not safe. The smaller F_p is, the safer the ladder is.

Safety Analysis:

$$\text{safe} = -\frac{1}{f_{11,max} + f_{12,max} - F_{w1} - F_{w2}} * F_p + 1$$

$$\text{safe}(a, \theta) = -\frac{1}{f_{11,max} + f_{12,max} - F_{w1} - F_{w2}} * -\frac{-M * g * (0.5 * w - x) * sin(\theta) - m * g * (0.5 * w) * sin(\theta) - f_{11} * w * cos(\theta) + F_{w1} * w * cos(\theta) + N1 * w * sin(\theta)}{0.5 * w - x} + 1 \quad \textbf{(2.2)}$$

3.4.3. Scenario 3:

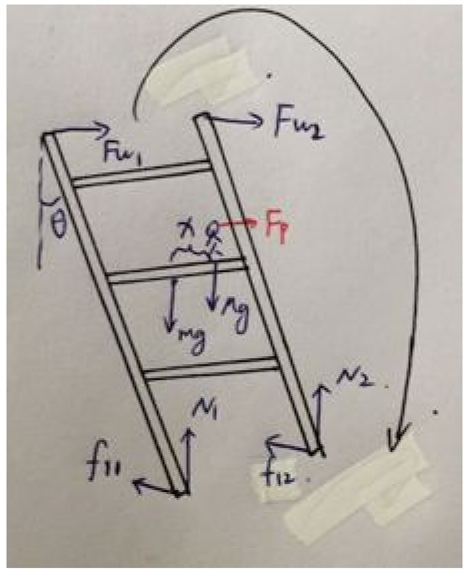


Figure3.1: rotation analysis of the ladder

$\sum\tau = 0 = \sum r\times\vec{F} = -M*g*a*L*sin(\theta) - m*g*(0.5*L)*sin(\theta) + (F_{w1}+F_{w2})*L*cos(\theta) + F_p*a*L*\sin(\theta)$

$$F_p = \frac{M*g*a*L*sin(\theta) + m*g*(0.5*L)*sin(\theta) - (F_{w1}+F_{w2})*L*cos(\theta)}{a*L*\sin(\theta)} \qquad \textbf{(3.1)}$$

If $F_p \le f_{11,max} + f_{12,max}$, the ladder is consider safe, otherwise, not safe. The smaller F_p is, the safer the ladder is.

Safety Analysis:

$$\text{safe} = -\frac{1}{f_{11,max} + f_{12,max}} * F_{\text{p}} + 1$$

$$\text{safe}(\text{a},\ \theta) = -\frac{1}{f_{11,max} + f_{12,max}} * \frac{M*g*a*L*sin(\theta) + m*g*(0.5*L)*sin(\theta) - (F_{W1}+F_{W2})*L*cos(\theta)}{a*\text{L}*\sin(\theta)} + 1 \qquad \textbf{(3.2)}$$

Program size and Software speed: Our program will use the data measured by sensors as input and output the safety percentage that will be displayed on digital display. The time complex is linear and space complex is constant.

3.5. Flowchart:

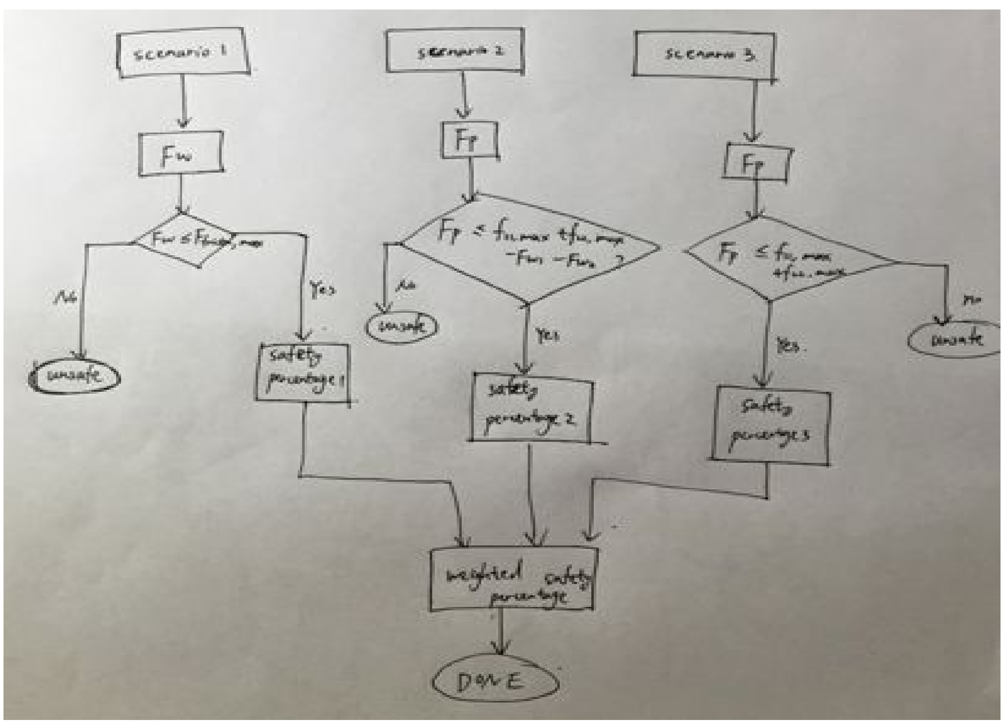


Figure4: flowchart for calculating safety percentage

3.6. Pseudocode:

$F_{w1} \leftarrow value\ from\ load\ sensor1$

$F_{w2} \leftarrow value\ from\ load\ sensor2$

$N1 \leftarrow value\ from\ load\ sensor3$

N2 $\leftarrow value\ from\ load\ sensor4$

$\theta \leftarrow value\ from$ accelerometer

a $\leftarrow value\ based\ on\ which\ switch\ is\ pushed$

m $\leftarrow weight\ of\ the\ ladder$

M $\leftarrow weight\ of\ user$

L $\leftarrow length\ of\ the\ ladder$

N $\leftarrow N1 + N2$

f $\leftarrow \mu_1 *$ N

$f_{11,max} \leftarrow \mu_1 *$ N1

$f_{12,max} \leftarrow \mu_1 *$ N2

safe_scenario1 ← formula(1.2)

safe_scenario1 ← formula(2.2)

safe_scenario1 ← formula(3.2)

total_safety $\leftarrow \frac{safe\_scenario1 + safe\_scenario2 + safe\_scenario3}{3}$

4. Requirements and Verifications:

4.1. Requirements and Verifications Table

Requirements	Verification	Points
1. Load Sensors: a. Must be able to determine the value and direction of the perpendicular forces acting on the base of the ladder from a range of 1kg to 200kg. The tolerance is within 1kg +/- 0.0005 kg. b. Power consumption must be between 300mW and 800mW. c. The output voltage signal must be amplified before being processed by the microcontroller.	Load Sensors: a. 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. b. Attach the sensor input to a DC power supply, and sweep the voltages from 4.0 VDC to 13.0 VDC. Check that the device is active within the specified range and that there isn't too much current being supplied. c. Make sure the voltage increased by a gain of 4 from the amplifier by using a multimeter across the output of the amplifier.	10
4. Data analyzer: Must analyze the data collected from microcontroller, calculate how close the ladder is to falling	Data analyzer: Theoretically work out the safety margin percentage based on the current stability of the ladder and insure the value that the data	30

with the center of gravity relative to the base of stability, and then provide an appropriate percentage within +/- 1% to send back to microcontroller. It also must reduce the safety margin by 8% to account for the tolerance error of the load sensors. i.e. The ladder will never read 100% safe; 92% would be the maximum value displayed.	analyzer calculates is within the required tolerance. The center of gravity would be calculated theoretically as well by finding the balance point of the ladder and we would insure that the center of gravity we measure is within a reasonable distance from the theoretical value.	
5. Microcontroller: must send appropriate threshold voltages to activate the loads such as LEDs, digital displays and speakers. Power to the circuit board elements is controlled through transistor gates.	Program the microcontroller to send a HIGH to turn on LEDs, digital displays and the speaker.	20
6. Power Source: a. Must be able to provide a 12VDC +/- 1.2VDC output and produce about 4 watts of power b. Voltage regulated to 3.3VDC +/- 0.3VDC output for the LED, accelerometer, and speaker c. Voltage regulated to 8VDC +/- 0.8 VDC	Power Source: a. Measure the voltage across the battery using a multimeter and verify that it is within the correct tolerance. b. Connect voltage regulator input voltage to power supply and sweep the input voltage from 5 VDC to 10 VDC. Use a multimeter to verify that the voltage stays within 3.3VDC +/- 10% c. Connect voltage regulator input voltage to power supply and sweep the input voltage from 6 VDC to 12 VDC. Use a	30

output for the load cells and microcontroller d. Voltage regulated to 5VDC +/- 0.5 VDC output for the digital display. e. Must be able to last an 8 hour workday before needing to be recharged.	multimeter to verify that the voltage stays within 8VDC +/- 10% d. Connect voltage regulator input voltage to DC power supply and sweep the input voltage from 6 VDC to 10 VDC. Use a multimeter to verify that the voltage stays within 5VDC +/- 10% e. Power Source: Turn on all the devices at once and insure that the battery last over 8 hours.	
8. Accelerometer: a. The accelerometer must sense an acceleration of 1g +/- 1% on a single axis when completely flat	a. Connect the output of the accelerometer to the microcontroller. Observe the sensor output values. When the sensor is flat, the microcontroller should indicate high values on one side (+1g +/- 1%) and values close to zero for the other sides (1g +/- 0.01g). As the sensor is rotated about a single axis, the values of one axis should increase and another axis should decrease. b. Attach the accelerometer input supply to a DC power supply and sweep the voltages from 1.0 V to 4.0 V. Check that the	10

b. Power consumption must be between 3mW and 5mW. c. Must be able to determine tilt angle with horizontal within +7% and -6% error.	device is active within the specified range and that there isn't too much current being supplied. c. Measure the output voltage and insure that the angle measured is within the bounds of the theoretical value from the tilt angle calculation.	
9. Speaker, Digital Display and LED: Must all turn on at the appropriate time. i.e at 50% safety, if too much weight is applied on the ladder (200 to 375 pounds depending on ladder rating), or show the percentage of safety.	Speaker and LEDs: Measure the theoretical values and compare to the value displayed and see if the signal should or should not be sent.	0
10. Switches on Rungs: Must be able to determine if the user is currently on which rung of the ladder.	Switches on Rungs: If a person steps on a rung, a high signal should be sent to the microcontroller to determine the user's position on the ladder.	0

5. Cost and Schedule

5.1. Cost Analysis

5.1.1 Labor Costs

Name	Hourly Rate	Total Hours Invested	Total Labor Costs (Hourly Rate * 2.5 * Total Hours Invested)
Brad	30.00 $/hour	225	$16,875.00
Lingying	30.00 $/hour	225	$16,875.00
Total		450	$33,750.00

5.1.2. Parts

Item	Quantity	Total Cost
665-AS05008PR2R Speaker	1	$3.69
Adafruit 878 LED 7-Segment Digital Display	1	$9.95
1PCX 200 kg Load Cell	2	$29.74
HLMP1340 Red LED	1	$0.12
INA-125 Amplifier	1	$6.12
1528-1021-ND Microcontroller	1	$9.95
MMA6260Q Accelerometer	1	$8.42
CoCOM-08720 ROHS Switches	6	$18.00
PS-1250 12V 5AH Battery	1	$11.99
Total		$97.98

5.1.3. Grand Total

Section	Total
Labor	$33,750.00
Parts	$97.98
Grand Total	$33,847.98

6. Weekly Schedule

Week	Task	Responsibility
Sep 12	Finish Project Proposal	Brad
	Finish Project Proposal	Lingying
Sep 19	Order sensors, devices, and ladder	Brad
	analyze the data(figure out formula)	Lingying
Sep 26	Run tests on sensors	Brad
	Begin programming data analyzer	Lingying
Oct 3	Finish Designing circuitry	Brad
	Finish Designing circuitry	Lingying
Oct 10	Begin programming microcontroller	Brad
	Begin programming microcontroller	Lingying
Oct 17	Implement and test power source and external devices (speaker, display, LED)	Brad

	Design the data analyzer and program microcontroller	Lingying
Oct 24	Assemble Prototype Circuitry	Brad
	Test Prototype Circuitry	Lingying
Oct 31	Solder modules together	Brad
	Solder modules together	Lingying
Nov 7	Prepare for/finalize mock demo and R&V table	Brad
	Prepare for/finalize mock demo and R&V table	Lingying
Nov 14	Run tests on final project	Brad
	Finalize software changes	Lingying
Nov 21	Solve Final Issues	Brad
	Solve Final Issues	Lingying
Nov 28	Final Demos and Presentation	Brad
	Final Demos and Presentation	Lingying
Dec 5	Final report	Brad
	Final report	Lingying

7. Discussion of Ethics and Safety:

7.1. IEEE Code of Ethics

Here are some specific IEEE codes of Ethics that must be considered:

1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;

This point is important because of the safety issues that come with using a ladder. It is crucial that we thoroughly instruct the users on how to properly operate the ladder in order to avoid injury. Improper use of the device from poor documentation will likely lead to injuries.

3. to be honest and realistic in stating claims or estimates based on available data;

If we make false claims on how well the ladder can evaluate a user's safety on the ladder, it could lead to improper usage and incorrect feedback to the user. It is our responsibility to thoroughly test our ladder and insure that our safety claims are backed by data.

7.2. Safety

There are many ways to improperly use a ladder that our ladder would not be able to detect and may tell the user that they are safe when in reality they are not; We would place a sticker showing the correct way to use the ladder for the safety readings to be accurate, and it would also warn the user that they might not be safe if the ladder isn't properly set up. According to OSHA regulations, ladders must be placed at an angle of from the vertical wall; we would make this clear on the sticker as well and the angle will be taken into account in the calculations for safety.

8. 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