# Requirements and Verification

## Physical Control Design Requirements

| Requirements | Verification |
|---|---|
| 1. When a 10kg load is applied to the top of the physical design foot pad, at least a .05 mV difference is measured. | Equipment: Multimeter<br>Test Procedure:<br>1. Attach the load cell wires to appropriate locations according to schematic on a breadboard<br>2. Use a multimeter to measure the change in voltage<br>3. Record the average value output by the ATMega328 over 30 seconds with no weight on the foot pad<br>4. Place the 1kg weight onto the foot pad and record the average value output by the ATMega328 over 30 seconds<br>5. Repeat steps 1-4 with all load cells.<br>Presentation of Results:<br>- The results will be presented in a table which shows the difference in average values with and without the weight.<br>Point Value: 5 |
| 2. After standing on top of the board for 30 minutes, a user does not feel more uncomfortable than if they were standing on plain carpet. | Method: Ask roommates and friends to test<br>Test Procedure:<br>1. Survey testers on scale of 1-10<br>2. Aggregate scores should average 7 or higher, with 6 being explicitly stated as the comfortability of carpet.<br>Point Value: 2 |
| 3. When a person of average American weight (+/- 20 kgs) steps onto the foot pads, they are able to stay standing on them without sliding or falling off for 10 minutes. | Method: Asked testers about comfortability<br>Test Procedure:<br>1. Survey testers on scale of 1-10 at 10 minute mark<br>2. Aggregate scores should average 8 or higher<br>Point Value: 3 |

## Electronics Requirements

| Requirements | Verification |
|---|---|
| 1. The signals on the PCB arrive at the correct locations. | Equipment: Breadboard<br>Test Procedure:<br>1. Wire up the breadboard according to the PCB schematic.<br>2. Confirm functionality of other requirements and expected outputs to PC<br>3. Rebuild schematic on PCB<br>4. Confirm that the functionality from the PCB matches the expected response from the breadboard<br>Presentation of Results:<br>- A binary confirmation from the product tester<br>Point Value: 5 |
| 2. The time from when a user applies pressure to the load cell to when the signal is received by the computer must be at or below 60ms. | Equipment: ATMega328, AD7705, Load Cell<br>Test Procedure:<br>1. Connect the USB-to-Serial to computer<br>2. Restart the ATMega328 to begin polling<br>3. Use the ArduinoIDE and timestamps to count the number of average responses a second<br>4. Multiply that response time by 4, one for each analog-to-digital converter<br>Presentation of Results:<br>- The results will be presented as a chart of average timings<br>Solution:<br>- It slows down when we swap channels, so using 4 chips and 1 channel per would significantly decrease the latency. To further decrease latency, instead of using the polling protocol, an interrupt protocol |

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| | can be used using the D_Ready pin on each chip.<br>Point Value: 5 |
| 3. Outputs from the microcontroller have an error rate of less than 1% | Equipment: ATMega328, AD7705, Load Cells<br>Test Procedure:<br>1. Wire the ATMega328 and AD7705 according to schematic<br>2. Connect the circuit to the computer via USB<br>3. Let the ATMega328 run for 5 minutes with no weight on the load cells<br>4. Check that 99%+ of the outputs fluctuates between a range of +/- 0.05 mv from the baseline voltage<br>5. Apply a 10 kg weight to the attached load cell and record the new baseline voltage<br>6. Check that 99%+ of the outputs fluctuates between a range of +/- 0.05 mv from the baseline voltage<br>Presentation of Results:<br>- The results will be presented as an average voltage with its standard deviation<br>Provisional Result:<br>- Initially failed because of ceramic oscillators on the ATMega328. Succeeded when swapped to crystal oscillator<br>Point Value: 5 |

**Software Requirements**

| **Requirements** | **Verifications** |
|---|---|
| The ATMega328 polls the analog to digital converters correctly and passes that data along to the PC. | Equipment:PC<br>Test Procedure:<br>1. Connect USB-to-Serial to PC<br>2. Press down on foot pad<br>3. Use ArduinoIDE to find voltage values of all inputs |

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| | 4. Record data<br>5. Press down again with a different level of force and record data<br>6. Repeat for each pad<br><br>Presentation of Results: Graph that show each sensor being pressed with varying levels of force. Each line represents voltage. X represents time. Y represents voltage level.<br>Point Value: 20 |
| The software properly sends an input signal (key press) to the PC once a load cell has exceeded a set threshold (a.k.a the user steps on the pad) | Equipment: PC<br>Test Procedure:<br>1. Plug in USB-to-Serial converter<br>2. Restart ATMega328<br>3. Open word processor<br>4. Step on foot pad<br>5. Record if a key was output to word processor<br>6. Repeat for each foot pad<br>Presentation of Results:<br>- Table comparing input values to output values and expected output values<br>Point Value: 5 |

# Verification Data

| Weight (kg) | Voltage (V) | Load Cell |
|---|---|---|
| 0 | 2.305 | 1 |
| 0 | 2.307 | 2 |
| 0 | 2.306 | 3 |
| 0 | 2.306 | 4 |
| 10 | 2.298 | 1 |
| 10 | 2.301 | 2 |
| 10 | 2.301 | 3 |
| 10 | 2.301 | 4 |

Physical Control Design Requirements: Load Cell Sensitivity

| Tester Number | Comfort (1-10) | Comments: |
|---|---|---|
| 1 | 7 | N/A |
| 2 | 8 | Not bad |
| 3 | 9 | N/A |
| 4 | 7 | Slightly better than carpet |
| 5 | 8 | N/A |
| 6 | 7 | N/A |
| 7 | 7 | Could use more cushion |
| 8 | 7 | N/A |
| 9 | 6 | Felt pretty hard |
| 10 | 8 | N/A |
| Average Value: | 7.4 | |

Physical Control Design Requirements: Comfortability

| Tester Number | Stability(1-10) | Comments: |
|---|---|---|
| 1 | 8 | N/A |
| 2 | 9 | N/A |
| 3 | 8 | N/A |
| 4 | 7 | Felt wobbly at times |
| 5 | 8 | N/A |
| 6 | 8 | N/A |
| 7 | 9 | Pretty good. |
| 8 | 9 | N/A |
| 9 | 10 | N/A |
| 10 | 9 | N/A |
| Average Value: | 8.5 | |

Physical Control Design Requirements: Stability

Does the PCB circuit have the same outputs as the breadboard circuit?: **Yes** / No

Electronic Requirements: PCB wiring data

| | Second 1 | Second 2 | Second 3 | Second 4 | Second 5 | |
|---|---|---|---|---|---|---|
| Number of inputs | 60 | 64 | 60 | 60 | 60 | |
| Latency | 66ms | 63 ms | 66 ms | 66 ms | 66 ms | |
| Average Latency | _____ | _____ | _____ | _____ | _____ | 65.4 ms |

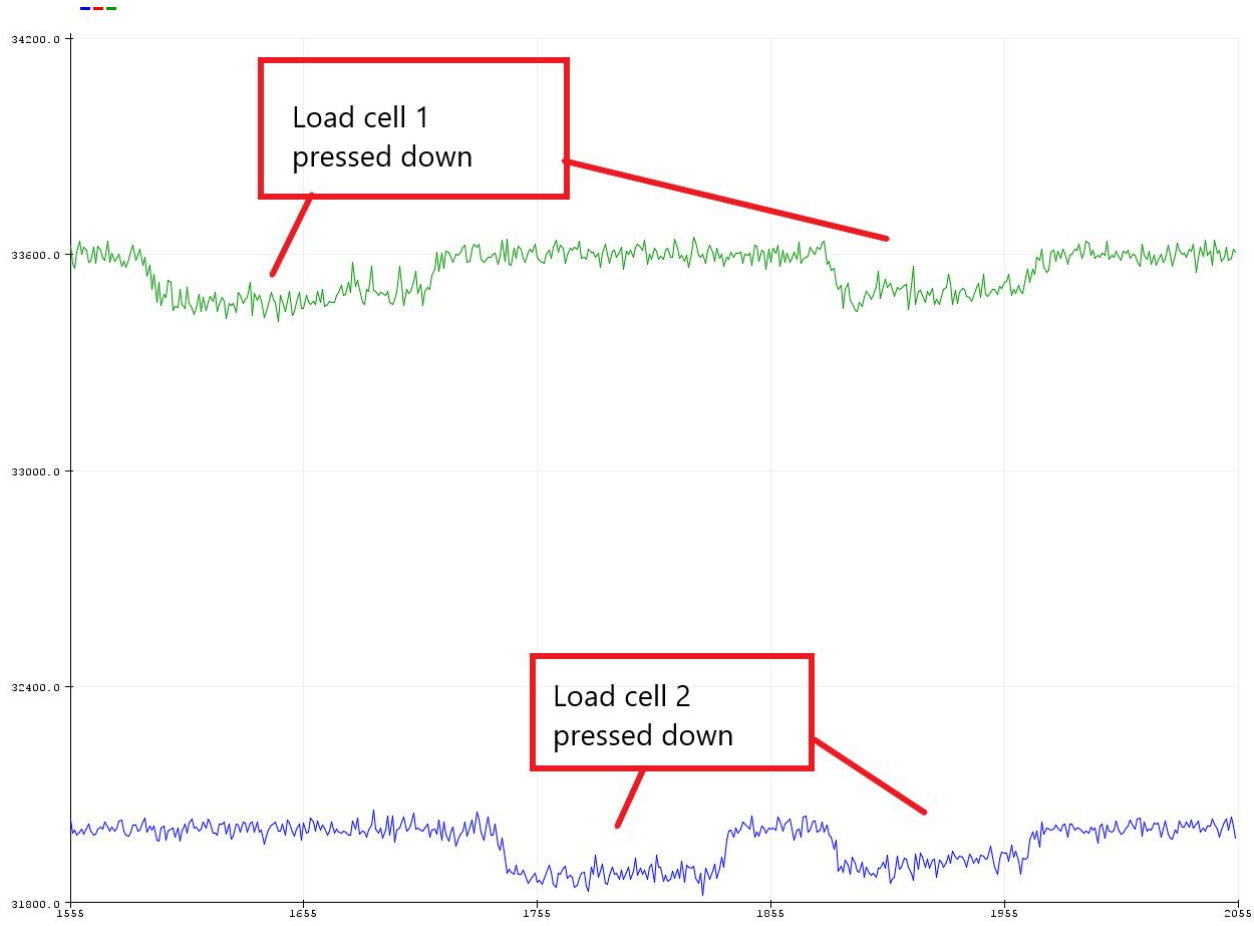
Electronic Requirements: Latency Data

Average Voltage (no weight): 2.306 V
Std. Voltage Deviation (no weight): +/- .007 V
Average Voltage (10kg weight): 2.301 V
Std. Voltage Deviation (10kg weight): +/- .008 V

Electronic Requirements: Measurement Accuracy Data

| Input Location | Expected Output | Actual Output |
|---|---|---|
| Left Back | C | C |
| Left Front | A | A |
| Right Back | D | D |
| Right Front | B | B |

Software Requirements: Input Signals




Software Requirements: Data Conversion