

BME Design-Fall 2024 - NOLAN BLOMWillIS

Complete Notebook

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James Waldenberger
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Team contact Information

James Waldenberger - Dec 11, 2024, 9:30 PM CST

Last Name	First Name	Role	E-mail	Phone	Office Room/Building
Nimunkar	Amit	Advisor	ajnimunkar@wisc.edu	N/A	ECB 1226
Kutschera	Dan	Client	kutschera@att.net	N/A	N/A
BlomWillis	Nolan	Leader/Communicator	blomwillis@wisc.edu	9202871468	N/A
Schiltz	Eva	BSAC	emschiltz@wisc.edu	6125132314	N/A
Waldenberger	James	BWIG	jwaldenberger@wisc.edu	2622325907	N/A
Parsons	Jacob	BPAG	jparsons@wisc.edu	2622291557	N/A



Project description

NOLAN BLOMWillIS - Sep 19, 2024, 8:49 PM CDT

Course Number: BME 400

Project Name:

Smart Walker

Short Name:

Smart Walker

Project description/problem statement:

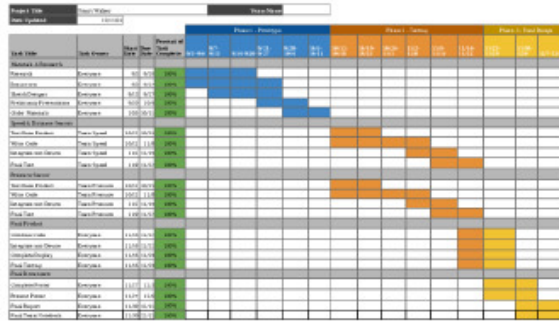
In the rehabilitation process of acute strokes or similar conditions, it is necessary for the patient to be able to walk independently so they can safely return home. Our team must design a device that works in conjunction with a standard walker that will measure the speed and distance the patient walks and the pressure applied to the walker.

About the client:

Our client is a physical therapist that works at a facility that deals with rehabilitation for acute strokes.



Jacob Parsons - Dec 11, 2024, 5:57 PM CST



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Gantt_Timeline_Semester_1_1_.xlsx (52.6 kB) Gantt Timeline for 1st Semester



2024/09/12 - 1st Client Meeting

Jacob Parsons - Sep 12, 2024, 5:32 PM CDT

Title: 1st Client Meeting

Date: 9/12/24

Content by: Jacob Parsons

Present: Whole team

Goals: Gather an understanding of the project and client expectations

Content:

- See attachment below

Conclusions/action items:

The team will make a PDS with the information provided. The team will also begin conducting research on the sensors to be used and some background information besides what the client provided for us.

Jacob Parsons - Sep 12, 2024, 5:32 PM CDT

- Your thoughts on the previous semester's project, what went well? What didn't go well?
 - Want something to use in the clinic
 - Wires weren't in the tubing, gRchy, didn't quite get the speed or distance done well
 - Focused a lot on pressure put through the walker
 - Work in neuro rehab clinic, acute stroke hospital
 - Standard walker with wheels, insurance companies are looking for a lot of objective data (progression)
 - "Gait trainer", \$5000, measures pressure, distance walked, doesn't do speed, not functional or usable for a patient
 - 2 wheel walker as an assessment tool for the patient
 - How far how reliant you are on it (pressure, gait speed (bivital sign)
 - Currently using a measuring wheel and a timer - looking for a tool that isn't \$5000 to get the objective data
 - Last group gave a realtime force in N, would like it in pounds, sent via bluetooth (not helpful?)
 - Ideally: aluminum walker with 2 wheels can the wires be put into the tubing? Could we design our own? Or use existing
 - Walker will be used every day, multiple times a day, LOTS of use
- Are there any other measurements you would like collected besides speed, distance and pressure?
 - Make sure units are converted to "understandable values", customary system
- Height adjusting?
 - Make sure to purchase a walker that is adjustable for patients of different sizes
- Weight limit?
 - Walker should be able to withstand patient, this will be point of failure
- Size limit?
 - Doesn't obstruct walking path
- Use feedback?
 - Yes
 - Display on walker for the patient? Distraction or motivation
- Budget?
 - Let him know, he can purchase the walker
 - \$200 / \$300
 - Allow for whatever is viable

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Questions_to_Ask.pdf (35.1 kB)



2024/11/7- 2nd Client Meeting

NOLAN BLOMWillIS - Nov 08, 2024, 12:05 AM CST

Title: Client Meeting

Date: 11/7/24

Content by: Nolan

Present: Nolan

Goals: Update Client on progress as well as hear from client on other tools and the importance of what we are creating

Content:

- Client says the walker only needs to read in one direction, no need to worry about speeds during a turn.
- Happy with the direction the project is going in especially with the real time display
- Appreciates the start button for each trial
- Wants to make sure the wires are not a distraction was a point again made clear
- Got to see the gait trainer, problem is it does not track speed just distance and is far from a real walker
- Long walks they will do will be roughly 100 feet is their final test
- Hopes to get the full team there for some media and testing

Conclusions/action items:

Continue to work forward on our prototype.



2024/09/13 - 1st Advisor Meeting

Jacob Parsons - Sep 13, 2024, 2:32 PM CDT

Title: 1st Advisor Meeting

Date: 9/13/24

Content by: Jacob

Present: Whole team

Goals: Catch advisor up on what we have done this week and work through plans for next week.

Content:

Client Meeting Recap

- Calculate load, distance, and speed
- Screen work will be talked about later
- Grip sensor

Jacob Recap

- Using raspberry pi would be the way to go for the display
- Check out sensors next week

Nolan Recap

- Started looking into pressure sensors and the way to go for that
- Looked at various pressure sensors, look back at 310 sensor circuits

Eva Recap

- Pressure on both sides as well as the total pressure put into the walker
- This could be put into a patent, start thinking about WARF
- 140 clinics across the country

James Recap

- Housing of the wires is the important
- Showing off the patents

Conclusions/action items:

Flush Together PDS, and layout timeline. Start looking into sensor options and brainstorming. Maybe reach out to "old" team.



2024/09/20 - 2nd Advisor Meeting

NOLAN BLOMWillIS - Sep 20, 2024, 1:01 PM CDT

Title: 2nd Advisor Meeting

Date: 9/20/24

Content by: Nolan BlomWillis

Present: Whole team

Goals: Catch advisor up on what we have done this week and work through plans for next week.

Content:

Jacob Recap

- Did work with speed and distance tracking
- Accelerometer and gyroscope research, Nimunkar asked about other applications of the device
- Looked into Hall Effect Sensor, saw someone use it as a motorcycle speedometer
- Looked into ultrasonic as well and lidar

ACTION ITEM-Look into the three different ways to go for distance and speed sensors

Nolan Recap

- Found a piezoresistive strain gauge pressure sensor pad
- Refreshed knowledge on piezoresistive sensor
- Asked about wiring and location
- Form factor and accuracy issues in regards to strain gauge pressure

ACTION ITEM: Look more into pressure sensors that can handle pressure of patient. Look into the reimbursement for the previous team.

Eva Recap

- Looked into speed sensors
- Looked into standards for PDS

ACTION ITEMS: Look into block diagram as well as get the design matrix handled

James Recap

- Looked into pressure sensor around the foot.
- Looked into movement sensors, Optical encoder sensor was unique
- Email about getting the lecture notes from Nimunkar

ACTION ITEMS: Look into cost and accuracy, also generating a block diagram, and email Nimunkar

Conclusions/action items:

Flush Together PDS, and layout timeline. Start looking into sensor options and brainstorming. Maybe reach out to "old" team.



2024/09/27 - 3rd Advisor Meeting

James Waldenberger - Dec 11, 2024, 9:14 PM CST

Title: 2nd Advisor Meeting

Date: 9/20/24

Content by: Nolan BlomWillis

Present: Whole team

Goals: Catch advisor up on what we have done this week and work through plans for next week.

Content:

Jacob Recap

- Talked about force sensor matrix and the scores behind it
- Nimunkar says there needs to be statistics behind the 5/5 numbers

ACTION ITEM: Fix sensor matrix, do some more research

Nolan Recap

- Looked into amplifiers for load cells
- Nimunkar, do we actually need an amplifier or can we build it ourself

ACTION ITEM: Work with James on circuitry

Eva Recap

- Looked at accelerometers for sensors
- Get numbers behind these sensors

ACTION ITEM: Find a specific accelerometer

James Recap

- Formulated a block diagram

ACTION ITEM: Continue work with circuitry

Conclusions/action items:

Look to have stats for why there are 5/5s, finish prelim presentation.



2024/10/11 - 4th Advisor Meeting

James Waldenberger - Dec 11, 2024, 9:17 PM CST

Title: 4th Advisor Meeting

Date: 10/11/24

Content by: Nolan BlomWillis

Present: Whole team

Goals: Catch advisor up on the preliminary report

Content:

Jacob Recap

Not Present

Nolan Recap

Met with past group for their walker

Eva Recap

Continued researching components, along with past patents and standards.

James Recap

Drew out a plan for load sensor circuit

ACTION ITEMS: Build circuitry out based on plan, get started on CAD models

Conclusions/action items:

Calibrate Load cell to get accurate measurements. Load Cells James and Nolan. Accelerometer Jacob and Eva. Eva possibly look at the display module.



2024/10/18 - 5th Advisor Meeting

NOLAN BLOMWillIS - Oct 18, 2024, 1:06 PM CDT

Title: 4th Advisor Meeting

Date: 10/11/24

Content by: Nolan BlomWillis

Present: Whole team

Goals: Catch advisor up on the preliminary report

Content:

Jacob Recap

Worked on accelerometer

I2C communication

Thonny for micro python

Got x, y, z now just needs to calibrate

Ignore Z direction

Nolan Recap

Worked on finding resistance values of the black and white wires of the load cell

Worked on obtaining the last walker

Eva Recap

Got the pico board holder started

James Recap

Had a Wheatstone bridge set up

Instrumentation amplifier set up(Look at lower value of instrumentation amplifier)

Power voltage for raspberry pico-5V

Voltage regulator needed

Conclusions/action items:

To Buy- Battery pack breakout board, Voltage regulator, display

Accelerometer should have readings by show and tell

Force output from load sensors



2024/10/24 - 6th Advisor Meeting

NOLAN BLOMWillis - Oct 25, 2024, 12:59 PM CDT

Title: 6th Advisor Meeting

Date: 10/25/24

Content by: Nolan BlomWillis

Present: Whole team

Goals: Catch advisor up on the preliminary report

Content:

Jacob Recap

Got velocity and distance readings on the accelerometer

Need to get a new micro-usb wire since last one is faulty

Start testing with accelerometer

Look at current output on the voltage regulator

Nolan Recap

Soldering the wires for James to use the load cell sensor

Eva Recap

Got designs going for holding the load cells.

James Recap

Hooked up the circuit

Output of 25mv is weird, wondering what the problem is...

Going to have jacob get eyes on the circuit

Conclusions/action items:

To Buy- Battery pack breakout board, Voltage regulator, display



2024/11/08 - 7th Advisor Meeting

NOLAN BLOMWillIS - Nov 08, 2024, 12:50 PM CST

Title: 6th Advisor Meeting

Date: 10/25/24

Content by: Nolan BlomWillis

Present: Whole team

Goals: Catch advisor up on the preliminary report

Content:

Jacob Recap

Worked on the code for the OLED display

Very touchy, looking to shift to a pico W, the Thonny is showing errors, moment code is uploaded there is an error

Is there sharing that is happening? The second line is having issues

Going to use the new raspberry pi to work towards a better setup

Nolan Recap

Met with Client to discuss progress and hear his feedback on the project

Straight line walking for patients, about 100ft

Client likes start trial button

Start fabrication work - cutting walker legs

Might want to work on some testing protocols for the other group members (load cell, accelerometer, 3D printing)

Eva Recap

Met with Jesse Darling to work on the design of the load cell holder in the leg

Two options-At the leg, or midway

Want to go with the midway design, will work on printing for the next week

James Recap

Tried to trouble shoot, thought it was circuit, was not

Did MTS testing but very small resistance change. Wheatstone bridge has the resistance maybe cancelling out.

Need to create a voltage curve. Going to test out the wires.

Conclusions/action items:

Look at individual action items



2024/11/15 - 8th Advisor Meeting

NOLAN BLOMWillis - Nov 15, 2024, 1:58 PM CST

Title: 8th Advisor Meeting

Date: 11/15/24

Content by: Nolan BlomWillis

Present: Whole team

Goals: Catch advisor up on the fabrication

Content:

Jacob Recap

No success on load cells

Going to go back and attack the problems but hopeful with the 3d print.

Nolan Recap

Give client a call about deconstruction of the walker

Nolan, do accelerometer testing protocol.

Eva Recap

Got the 3D printed design for the legs

James Recap

No success on load cells

Going to go back and attack the problems but hopeful with the 3d print.

Conclusions/action items:

Look at individual action items

Meeting Thursday at 4pm



Title: Sensor Design Matrices

Date: 9/26/2024

Content by: James Waldenberger, Jacob Parsons

Present: Group

Goals: Create design matrices for each sensor component we'll need (distance and force) to determine what type of sensor for each we'll want to go with for the final design.

Content:

Pressure Sensor

Categories	Load Cell	Piezoresistive Pad	Capacitive	Force Sensor
Accuracy (30)	5/5 30	2/5 12	4/5 24	
Ease-of-use (25)	3/5 15	4/5 20	3/5 15	
Price (20)	4/5 16	3/5 12	2/5 8	
Fabrication (15)	4/5 12	4/5 12	2/5 6	
Reusability (10)	4/5 8	2/5 4	3/5 6	
Total (100)	81	60	59	

Pressure Sensor Design Matrix Criteria

Accuracy: This design criteria scored the highest since without a device that is able to accurately measure the pressure applied by the patient on the walker, the sensor’s function is useless. The sensor must measure values within 10% accuracy and 5% precision, these metrics are suitable for the client. The load cell scored the highest in this category compared to the piezoresistive pad and the capacitive force sensor due to its ability to accurately measure and withstand higher force loads, such as a human.

Ease-of-use: There isn’t much set-up required for any of the sensors here, both in regards to the patient and the physiologist. Each of the sensors would need to be calibrated initially, to ensure that voltage readings coincide with the correct point on the calibration curve. That being said, both the load cell and capacitive force sensor would most likely need to be calibrated throughout the use of the walker (each day, perhaps), so the piezoresistive pad has the highest rating at 4/5.

Price: Sensor price often increases dramatically with improved accuracy. For this reason it was important to choose a sensor that would deliver accurate readings for a reasonable price. The piezoresistive pad was the most cost effective option giving it the highest rating of a 4/5. The capacitive force sensors tended to be priced higher to measure a similar weight range to the load cell and were therefore given the lowest rating.

Fabrication: The team has two semesters to complete the project; however, the project plan is to finalize the sensors of the device within the first semester. To do so, the sensor must be easily integrated into the device to meet this timeline. The load cell and piezoresistive pad both scored a 4/5 in this category. They scored the highest since it would be simple to integrate the sensor into the wheelchair, and the code required to gain meaning from the outputs of the sensors is easy to write and comprehend.

Reusability: Each of these options consume relatively little power, so there isn’t a big discrepancy there. However, the load cell accels in this category because of its high durability compared to the other two sensors that struggle to pick up large weight signals, therefore the load cell has the highest in this category with a 4/5, given that it still has a fairly limited weight requirement

Speed & Distance Sensor

Categories	Accelerometer	Rotary Encoder	Hall Effect
Accuracy (30)	5/5 30	5/5 24	3/5 18
Ease-of-use (25)	5/5 25	5/5 25	4/5 20
Price (20)	4/5 16	2/5 8	5/5 20
Fabrication (15)	4/5 12	3/5 9	3/5 9
Reusability (10)	4/5 8	3/5 6	3/5 6
Total (100)	91	72	73

Design Criteria:

- Accuracy (30)

This design criteria scored the highest since without a device that is able to accurately measure the distance and speed traveled by the patient on the walker, the sensor's function is useless. The sensor must measure values within 10% accuracy and 5% precision, these metrics are suitable for the client. The accelerometer and rotary encoder scored the highest in this category due to the minimum amount of error that could occur during measurement. The accelerometer measures the forces (accelerations) it endures and converts these metrics to distance and speeds. The rotary encoder evaluates the amount of rotations the wheel would undergo and derives the distance and speed traveled from the angular measurements. The hall effect and optical sensor have large sources of potential error. The specifications sheets for both of them had less than 1% error measurements.

- Ease-of-use (25)

All of the sensors will be implemented into the walker in a manner that it will require no extra effort from the client to use the device since any calibrations will occur during fabrication. The hall effect sensor requires awareness of the environment to ensure there are no objects that would affect the magnetic field, because of this both the accelerometer and rotary encoder scored a 5/5 while the hall effect scored a 4/5.

- Price (20)

The hall effect sensor will cost less than a dollar per unit, which is an unbeatable price. It will require some other electrical components; however, this pricing is minimal compared to that of the accelerometer and rotary encoder. Therefore it scores a 5/5.

- Ease-of-fabrication (15)

The team has two semesters to complete the project; however, the project plan is to finalize the sensors of the device within the first semester. To do so, the sensor must be easily integrated into the device to meet this timeline. The accelerometer scored the highest out of the sensors with a 4/5. This is due to the fact that the accelerometer can easily be placed anywhere on the device to measure the changes in acceleration, and will require minimal code to extract the values.

- Reusability (10)

Accelerometers have the smallest power consumption out of the sensor options, being on the order of micro-milli amp current to drive the device, meaning that they will be able to be used often without the need to replace batteries. There are also no concerns about durability with them, as opposed to the rotary encoder or hall effect sensor that are in contact with the moving wheels their whole lifespan

Conclusions/action items:

Moving forward with accelerometers and load cells, now research the specific devices that are on the market to see what's in the budget that fits the specs of our project, and then go ahead and order everything we need for the circuit.

 **Block Diagram**

James Waldenberger - Dec 11, 2024, 9:

Title: Block Diagram

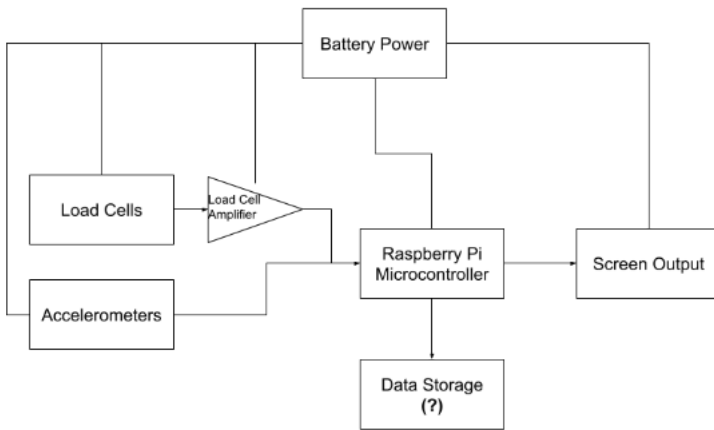
Date: 9/26/2024

Content by: James Waldenberger

Present: Group

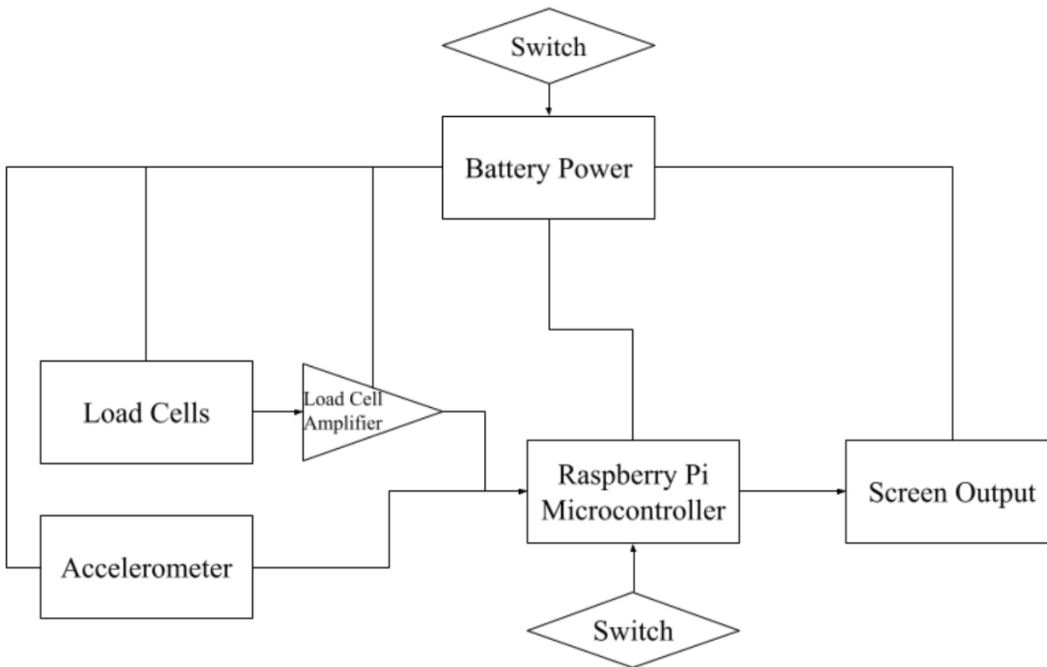
Goals: Create a block diagram to have an idea of each specific electrical component that will be used in the final circuit and how they'll all be connected together.

Content:



Update 12/11/2024 (more accurate block diagrams from the poster presentation):

Hardware:



Load cells - found in each leg of the walker, provide a voltage output with force applied to them.

Load cell amplifier - amplify this signal for the microcontroller to pick up on.

Accelerometer - provides a voltage output based on acceleration of the walker, which is sent directly to the microcontroller.

Raspberry Pi microcontroller - Gets voltage outputs from each of the different sensors in the walker, computes relevant data based on the input, and outputs it to the screen.

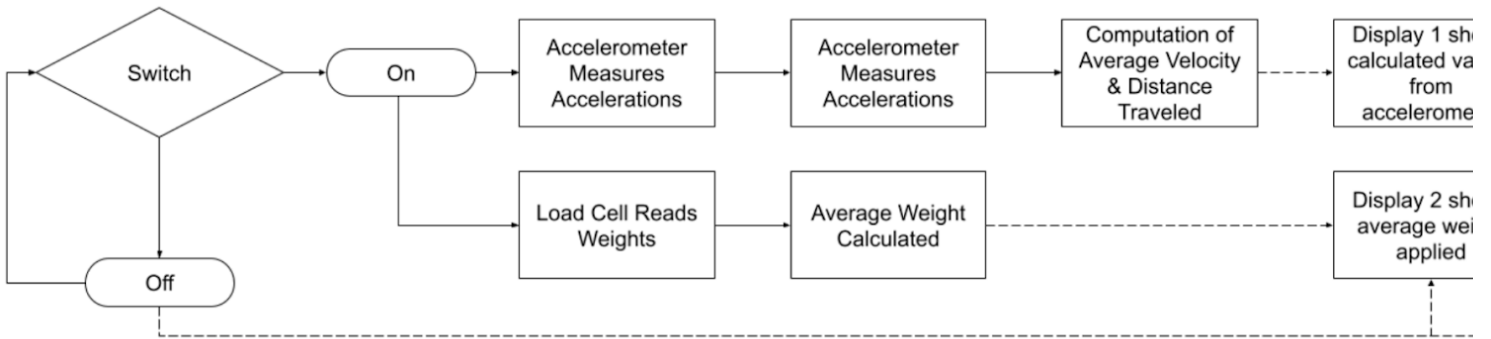
Screen output - Visible to the user of the walker, will output speed, distance traveled, and force applied to the walker.

Battery power- powers each components.

Switch to battery power - turns whole device on or off.

Switch to microcontroller - starts a trial for the walker to start picking up data.

Software:



Shows the flow of logic that will be used in the code to compute the output data.

Conclusions/action items:

Update as needed. Create each block of the diagram and connect them!



Specific Components

James Waldenberger - Dec 11, 2024, 9:49 PM CST

Title: Specific Components

Date: 12/11/2024

Content by: James Waldenberger

Present: N/A

Goals: Provide a list of specific components used based on design matrix evaluations and block diagrams.

Content:

- LT1167 instrumentation amp
- 480 ohm resistor
- 2x 10 kohm resistors
- 2x 20 kohm resistors
- TL072 op amp
- 2x 10 uF capacitors
- TC962CPA
- 4x Load sensors
- Raspberry Pi Pico microcontroller
- ADXL345 accelerometer
- 2x SSD1306 OLED display

Conclusions/action items:

Assemble all components together.



2024/10/17 - ADXL345 Set Up

Jacob Parsons - Oct 18, 2024, 12:33 PM CDT

Title: ADXL345 Set Up

Date: 10/17/24

Content by: Jacob Parsons

Present: N/A

Goals: To receive readings from the accelerometer

Content:

<https://www.raspberrypi.com/documentation/microcontrollers/pico-series.html>

<https://cdn-learn.adafruit.com/downloads/pdf/adxl345-digital-accelerometer.pdf>

Code:

```

from machine import Pin, I2C
import time
import ustruct

#Constants
ADXL345_ADDRESS = 0X53 # address for accelerometer
ADXL345_POWER_CTL = 0x2D # address for power control
ADXL345_DATA_FORMAT = 0x31 # configure data format
ADXL345_DATAX0 = 0x32 # where the x-axis data starts

#Initialize I2C
i2c = I2C(0, scl=Pin(1), sda=Pin(0))
def init_adxl345():
    i2c.writeto_mem(ADXL345_ADDRESS, ADXL345_POWER_CTL, bytearray([0x08])) # set bit 3 to 1 to enable measurement mode
    i2c.writeto_mem(ADXL345_ADDRESS, ADXL345_DATA_FORMAT, bytearray([0x00])) # Set data format to full resolution, +/- 2g

# Read acceleration data
def read_accel_data():
    data = i2c.readfrom_mem(ADXL345_ADDRESS, ADXL345_DATAX0, 6)
    x, y, z = ustruct.unpack('<3h', data)
    return x, y, z

# Main Loop
init_adxl345()
while True:
    x, y, z = read_accel_data()
    print('-----')
    print(x, y, z)
    print("X: {}, Y: {}, Z: {}".format(x*0.0039, y*0.0039, z*0.0039))
    time.sleep(0.5)

# if you do get OSError: [Errno 5] EIO, try unplug and plug
# if you do set different resolution, 0.0039 may not be the constant (check data sheet)
# look at data sheet to change line 14

```

Output:

```

Thierry - C:\Users\jacob\OneDrive\Documents\Smart Walker\Accelerometer\use_this_one_right_now.py # 26:12
File Edit View Run Tools Help
Files
This computer
C:\Users\jacob\OneDrive\Documents\Smart Walker
Accelerometer
  Adefruit_Blinka-0.49.0
  Adefruit_Python_Platform
  accel_simple_readout.py
  accel_simple_readout_sp
  accel_simple_readout_sp
  adefruit-circuitpython-ls
  adefruit-circuitpython-re
  Adefruit_Blinka-0.49.0.rp
  Adefruit_Python_Platform
  idl_nesd_helo.py
  RP2_PICO-20240602-v1.2
Raspberry Pi Pico
accel_simple_readout_spi_fixed.py - use_this_one_right_now.py
1 from machine import Pin, I2C
2 import time
3 import ustruct
4
5 #Constants
6 ADXL345_ADDRESS = 0x53 # address for accelerometer
7 ADXL345_POWER_CTL = 0x2D # address for power control
8 ADXL345_DATA_FORMAT = 0x31 # configure data format
9 ADXL345_DATA0 = 0x32 # where the x-axis data starts
10
11
12 #Initialize I2C
13 i2c = I2C(0, scl=Pin(1), sda=Pin(0))
14 def init_adxl345():
15     i2c.writeto_mem(ADXL345_ADDRESS, ADXL345_POWER_CTL, bytearray([0x08])) # set bit 3 to 1 to enable measurement mode
16     i2c.writeto_mem(ADXL345_ADDRESS, ADXL345_DATA_FORMAT, bytearray([0x00])) # Set data format to full resolution, +/- 7g
17
18 # Read acceleration data
19 def read_accel_data():
20     data = i2c.readfrom_mem(ADXL345_ADDRESS, ADXL345_DATA0, 6)
21     x, y, z = ustruct.unpack('<3h', data)
22     return x, y, z
23
24 # Main Loop
25 init_adxl345()
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```


- Implement code that will calculate speed and distance traveled



2024/10/24 - Accelerometer Velocity and Distance

Jacob Parsons - Oct 24, 2024, 2:46 PM CDT

Title: Accelerometer Velocity and Distance

Date: 10/24/24

Content by: Jacob Parsons

Present: Jacob Parsons

Goals: To have the acceleration be converted to velocity and distance traveled by the accelerometer. Then have the total time elapsed be displayed.

Content:

- The device waits for a switch to be turned on, then the device measures the acceleration and calculates the velocity and distance. Once the switch is turned off, the total time, distance traveled, and average velocity are measured.

```

from machine import Pin, I2C
import time
import ustruct

# Constants
ADXL345_ADDRESS = 0x53
ADXL345_POWER_CTL = 0x2D
ADXL345_DATA_FORMAT = 0x31
ADXL345_DATAX0 = 0x32
G_CONVERSION = 0.0039 # Adjust this based on the sensitivity setting

# Initialize I2C
i2c = I2C(0, scl=Pin(1), sda=Pin(0))

# Initialize the wire (acting as a switch)
switch = Pin(15, Pin.IN, Pin.PULL_DOWN) # Ensure this matches your GPIO setup

def init_adxl345():
    i2c.writeto_mem(ADXL345_ADDRESS, ADXL345_POWER_CTL, bytearray([0x08])) # Enable measurement mode
    i2c.writeto_mem(ADXL345_ADDRESS, ADXL345_DATA_FORMAT, bytearray([0x00])) # Set data format to full resolution, +/- 2g

def read_accel_data():
    data = i2c.readfrom_mem(ADXL345_ADDRESS, ADXL345_DATAX0, 6)
    x, y, z = ustruct.unpack('<3h', data)
    # Convert raw data to g-force using the scaling constant
    x = x * G_CONVERSION
    y = y * G_CONVERSION
    z = z * G_CONVERSION
    return x, y, z

def calculate_velocity_distance():
    velocity = 0
    distance = 0
    total_velocity = 0
    sample_count = 0
    start_time = time.ticks_ms()
    previous_time = start_time

    while switch.value(): # Keep running while the wire is connected to 3.3V
        current_time = time.ticks_ms()
        delta_time = (current_time - previous_time) / 1000 # Convert to seconds

        # Read acceleration (only x-axis for simplicity; modify if you want to use y or z)
        ax, ay, az = read_accel_data()
        print("Acceleration (G): X={}, Y={}, Z={}".format(ax, ay, az)) # Debugging print to verify values

```

```

# Update velocity: v = v0 + a * t
velocity += ax * delta_time

# Update distance: s = s0 + v * t + 0.5 * a * t^2
distance += velocity * delta_time + 0.5 * ax * (delta_time ** 2)

# Accumulate velocity for average calculation
total_velocity += abs(velocity) # Use absolute value for average
sample_count += 1

print("Velocity: {:.2f} m/s, Distance: {:.2f} m".format(velocity, distance)) # Debugging output
previous_time = current_time
time.sleep(0.1) # Sample rate

end_time = time.time()
elapsed_time = (end_time - start_time) / 1000 # Calculate total time in seconds

# Calculate the average velocity
average_velocity = total_velocity / sample_count if sample_count > 0 else 0
return average_velocity, distance, elapsed_time

# Main Program
init_adxl345()

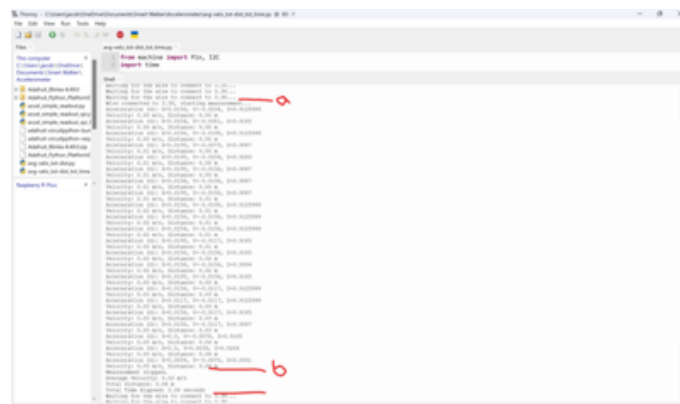
while True:
    if switch.value(): # Start measurement when the wire is connected to 3.3V
        print("Wire connected to 3.3V, starting measurement...")
        avg_velocity, total_distance, total_time = calculate_velocity_distance()
        print("Measurement stopped.")
        print("Average Velocity: {:.2f} m/s".format(avg_velocity))
        print("Total Distance: {:.2f} m".format(total_distance))
        print("Total Time Elapsed: {:.2f} seconds".format(total_time))
        time.sleep(1) # Debounce delay to avoid multiple triggers
    else:
        print("Waiting for the wire to connect to 3.3V...")
        time.sleep(0.5)

```

Conclusions/action items:

- There are faulty connections that make it very frustrating to test so if this can be done that would make the process a lot more efficient. Also I will update the code so the distance and velocity account for the x & y directions, but not the z.
- I will also conduct testing to observe how accurate the distance is.

Jacob Parsons - Oct 25, 2024, 12:10 PM CDT



[Download](#)

example_image.png (320 kB) Point a is when the "switch" was turned on and measurements began. Point b is when the switch was turned off and the final measurements and averages were displayed. Point c is when the device is waiting for the switch to be turned on again.



2024/11/25- Initial Load Cell Holder Prototype

EVA SCHILTZ - Dec 11, 2024, 7:58 PM CST

Title: Initial Load Cell Holder Prototype

Date: 11/25/24

Content by: Eva

Present: Eva and Nolan

Goals: To 3D print the initial prototype for the load cell holder and cut the walker legs.

Content:

Below is a picture of the load cell holder. It was printed with PLA at 70% infill on a Bambu Labs printer. The dimensions allow the holder to fit within the walker legs and also allow easy movement between the top and bottom pieces (not much interference from shear forces).



We cut the walker legs with a hand saw 5.5 in from the top of the nearest screw. We then assembled the load cell holder and the walker as it would look when integrated as demonstrated below.

**Conclusions/action items:**

We will need to do testing with the load cell holder to ensure friction will not affect the pressure output values. We will then need to print 4 new load cell holders out of ABS at 80% infill for the next iteration. Once those are created we can begin testing the stability of the walker with the load cell holders in place.



2024/11/15 - Load Cell Calibration Curve Testing

Jacob Parsons - Nov 22, 2024, 12:05 PM CST

Title: Load Cell Calibration Curve Testing Protocol

Date: 11/15/24

Content by: Jacob Parsons

Present: Jacob Parsons

Goals: To lay out the steps to calibrate the load cells

Content:

- See the PDF below

Conclusions/action items:

Implement the line of best fit that we created from the calibration of the load cells to the code. Then integrate the load cells into the walker and test it again and see if it is within our tolerable error.

Jacob Parsons - Dec 11, 2024, 5:14 PM CST

Load Cell Calibration

Details of Test:

1. Properly wire the load cells into a wheatstone bridge (see figures 1 and 2)
2. Properly construct the amplifier circuit as seen in figure 1
3. Place load cells within weighing shell and evenly place them as seen in figure 2
4. Observe and record the voltage output with no load applied to any of the load cells
5. Do a check out of each amplifier stage to ensure that the voltages stable check
6. Weigh a flat piece of wood or metal that can evenly distribute a load to all 4 load cells and place onto the load cells. Observe and record the voltage output here
7. Add and repeat steps 4 and 5 but with incrementally increasing loads added onto the flat object
8. The steps from 4-6 should fill in Table 1. (weight and force may vary)
9. Once complete ensure that all power supplies are turned off before deconstructing the circuit
10. Make a graph of the line of best fit of V_{out} against weight and use this to program the microcontroller to measure the force outputs.

Table 1: Blank table of the measured output voltages (V) at varying weight to forces.

Weight (lbs)	Force (N)	Avg. V_{out} (V)	Min V_{out} (V)	Max V_{out} (V)
0	0			
15	66.75			
30	133.49			
45	200.24			
60	266.99			
75	333.73			
90	400.48			
100	444.97			
125	556.22			
150	667.46			
175	778.70			
200	889.95			

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Load_Cell_Protocol_1_.pdf (428 kB)



2024/11/18 - Accelerometer Testing Protocol

Jacob Parsons - Dec 11, 2024, 5:21 PM CST

Title: Accelerometer Testing Protocol

Date: 11/18/2024

Content by: Nolan BlomWillis

Present: Myself

Goals: Set up a testing protocol for testing to be carried out

Content:

Accelerometer Testing Procedure

Details of Test:

1. Properly set up the accelerometer circuit with the ground and input voltage wired properly and the SDA and SCL pins paired with GPIO pins 0 and 1 of the Raspberry Pi Pico
2. Connect the accelerometer to a display to read output values
3. Place Accelerometer circuit on movable chair
4. Record starting point as 0m
5. Hit the start button to begin obtaining values on the accelerometer
6. Begin walking in a straight line, while timing on a phone
7. Stop walking and stop the timer
8. Measure the distance between start and finish
9. Record distance and speed (m/s)
10. Repeat steps 4 through 9, 3 times for 3 different walking speeds
11. Fill in table 1 with all recorded data with comparison of output readings from the accelerometer
12. Once complete ensure that all power supplies are turned off before deconstructing the circuit
13. Make a graph of the line of best fit of Accelerometer vs Measured values for each trial.

Table 1: Blank table of the accelerometer readings and hand measured values

Time Elapsed(s)	Measured Distance Accelerometer (m)	Measured Speed Distance (m)	Measured Speed (m/s)	Accelerometer Speed (m/s)
-----------------	--	--------------------------------	-------------------------	------------------------------

Conclusions/action items:

This can now be used for the completion of accelerometer testing.



2024/11/08 - MTS Load Cell Testing

Jacob Parsons - Nov 15, 2024, 12:41 PM CST

Title: MTS load Cell Testing

Date: 11/8/24

Content by: Jacob & James

Present: Jacob

Goals: To make a resistance vs load curve

Content:

- See XCEL below
- The MTS testing was not successful, there was no change in resistance when all 4 of the load cells received the load from the machine.
- This lead the team to believe that there was an improper method in how the load was being applied; as in the load cells needed to be alternated in orientation (which way is up), or the deflection must be obtained in an alternative way

Jacob Parsons - Nov 08, 2024, 12:27 PM CST

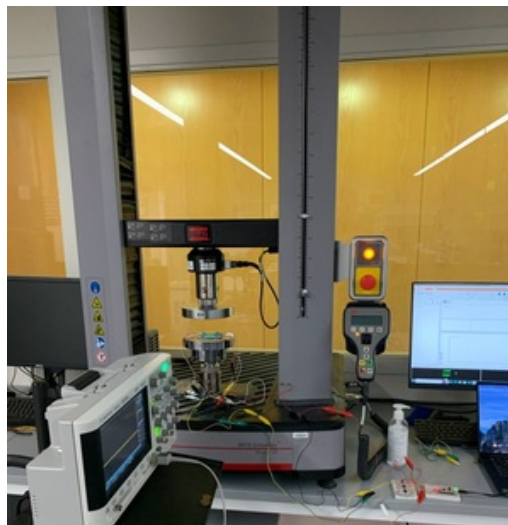
Force Applied (N)	Resistance (Ohm)	Resistance (Ohm)	Force Applied (N)	Resistance (Ohm)
0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000

Force Applied (N)	Resistance (Ohm)	Resistance (Ohm)	Force Applied (N)	Resistance (Ohm)
0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000

[Download](#)

Load_Sensor_Testing.xlsx (5.89 kB)

James Waldenberger - Dec 11, 2024, 9:28 PM CST





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MTS_Test.jpg (144 kB)



2024/11/21 - Load Cell Calibration

James Waldenberger - Dec 11, 2024, 9:27 PM CST

Title: Load Cell Calibration

Date: 11/21/24

Content by: Jacob

Present: James (only)

Goals: To calibrate the load cells

Content:

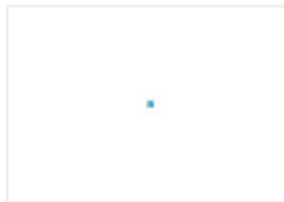
- Following the load cell calibration steps from the protocol, James calibrated the load cells
- The xcel files below have the output voltages at different applied loads

Conclusions/action items:

Use these results to create the code for the load cell measurements. Now the team can integrate the load cells into the legs of the walker as well and conduct testing then.

Jacob Parsons - Nov 21, 2024, 4:34 PM CST

Weight (lbs)	Power (V)	avgTemp (°C)	MaxTemp (°C)	MaxTemp (°C)
0	0	19.99	1.60	1.87
10	498.754	5.75	4.70	4.74
20	123.144	3.77	1.74	1.78
30	200.234	1.92	1.11	1.84
40	269.790	1.99	1.55	1.87
50	333.772	1.91	1.11	1.87
60	400.124	1.99	1.60	1.87
70	464.977	1.98	1.59	2
80	526.221	2.07	2.50	2.18
90	587.444	2.14	2.11	2.18
100	678.1	2.34	2.22	2.24
200	897.954	2.33	2.3	2.34



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load_cell_calibration.xlsx (23.1 kB) xcel file of the calibration results.

James Waldenberger - Dec 11, 2024, 9:22 PM CST

Overview

Worksheet: Sheet1

Weight (lbs)	Power (V)	avgTemp (°C)	MaxTemp (°C)	MaxTemp (°C)
0	0	19.99	1.60	1.87
10	498.754	5.75	4.70	4.74
20	123.144	3.77	1.74	1.78
30	200.234	1.92	1.11	1.84
40	269.790	1.99	1.55	1.87
50	333.772	1.91	1.11	1.87
60	400.124	1.99	1.60	1.87
70	464.977	1.98	1.59	2
80	526.221	2.07	2.50	2.18
90	587.444	2.14	2.11	2.18
100	678.1	2.34	2.22	2.24
200	897.954	2.33	2.3	2.34

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Load_Sensor_Testing.xlsx (20.2 kB)

James Waldenberger - Dec 11, 2024, 9:24 PM CST



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Load_Sensor_Calibration_1.jpg (115 kB)

James Waldenberger - Dec 11, 2024, 9:25 PM CST



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Load_Sensor_Calibration_2.jpg (120 kB)



2024/11/21 - Accelerometer Drift Debugging

Jacob Parsons - Nov 22, 2024, 12:07 PM CST

Title: Accelerometer Drift Debugging

Date: 11/21/24

Content by: Jacob

Present: Jacob, Nolan, James

Goals: To observe drift issues with the accelerometer

Content:

See PDF below

Conclusions/action items:

Find out why this is happening and try to see if there is a way to work around it/fix it. Worst case we run with a different measuring device.

Jacob Parsons - Nov 22, 2024, 12:07 PM CST

- Tipped to the side
- Plugged in before starting
- Start with plugged in
- Time out 10 seconds
- Remove switch
- Measure accelerations over time, final velocity, total distance traveled, and time elapsed

Trial	Bandwidth	Time (s)	Distance (m)	Velocity (m/s)
1	+/-2 g	10.00	2.24	0.22
2	+/-2 g	9.99	-0.03	0.01
3	+/-2 g	10.00	-0.02	0.00
4	+/-4 g	9.48	0.43	0.04
5	+/-4 g	10.00	0.34	0.03
6	+/-4 g	10.10	0.43	0.04
7	+/-8 g	10.01	-0.02	0.00
8	+/-8 g	10.50	0.80	0.08
9	+/-8 g	10.47	0.81	0.08
10	+/-16 g	10.20	-0.00	0.00
11	+/-16 g	10.20	0.00	0.00
12	+/-16 g	10.20	0.00	0.00

Trial 1:
 Acceleration (X): 0.08 G, Velocity: 0.00 m/s, Distance: 0.00 m
 Acceleration (X): 0.04 G, Velocity: 0.00 m/s, Distance: 0.00 m
 Acceleration (X): 0.04 G, Velocity: 0.01 m/s, Distance: 0.00 m
 Acceleration (X): 0.00 G, Velocity: 0.01 m/s, Distance: 0.00 m
 Acceleration (X): 0.08 G, Velocity: 0.02 m/s, Distance: 0.00 m
 Acceleration (X): 0.04 G, Velocity: 0.02 m/s, Distance: 0.01 m
 Acceleration (X): 0.00 G, Velocity: 0.02 m/s, Distance: 0.01 m
 Acceleration (X): 0.04 G, Velocity: 0.02 m/s, Distance: 0.01 m
 Acceleration (X): 0.04 G, Velocity: 0.03 m/s, Distance: 0.01 m
 Acceleration (X): 0.00 G, Velocity: 0.03 m/s, Distance: 0.02 m
 Acceleration (X): 0.08 G, Velocity: 0.04 m/s, Distance: 0.02 m
 Acceleration (X): 0.08 G, Velocity: 0.04 m/s, Distance: 0.03 m
 Acceleration (X): 0.08 G, Velocity: 0.05 m/s, Distance: 0.03 m

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Accelerometer_Debugging.pdf (94.9 kB)

Jacob Parsons - Dec 11, 2024, 5:20 PM CST



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IMG_4897.MOV (42.2 MB)



2024/11/19 -Solidworks Simulation Load Cell Holder

EVA SCHILTZ - Dec 07, 2024, 1:56 PM CST

Title: Solidworks Simulation Load Cell Holder

Date: 11/19/24

Content by: Eva

Present: Eva

Goals: Perform simulation testing to gauge whether the dimensions and material of the load cell holder are sufficient to withstand expected forces during use.

Content:

Attached below is the full report from the simulation. The material chosen for the prototype testing was ABS. I assumed the most likely mode of failure would be through a horizontal force applied at the bottom of the walker. I therefore put 50 lb of force on the bottom of the load cell holder while holding the top fixed.

The max stress experienced by the load cell holder was 6.94 MPa. As the minimum flexural yield strength of ABS is 60.6 MPA this yields a factor of safety of 8 [1].

[1] ABS material data sheet, http://teststandard.com/data_sheets/ABS_Data_sheet.pdf (accessed Dec. 5, 2024).

Conclusions/action items:

Though 3D printing will reduce the mechanical strength of the load cell holder, the high factor of safety combined with an increased infill should be sufficient to withstand expected forces. Further testing will need to be performed once the final prototypes have been printed.

EVA SCHILTZ - Dec 07, 2024, 1:38 PM CST

Simulation of Load_Cell_Holder_Bottom

Date: Tuesday, November 19, 2024
 Designer: Solidworks
 Study name: Static 1
 Analysis type: Static

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Description
 No Data

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Load_Cell_Holder_Bottom-Static_1-1.pdf (607 kB)



2024/12/11 - Load Cell Testing in Comparison to Scale

Jacob Parsons - Dec 11, 2024, 5:19 PM CST

Title: Load Cell Testing Compared to a Bathroom Scale

Date: 12/5/24

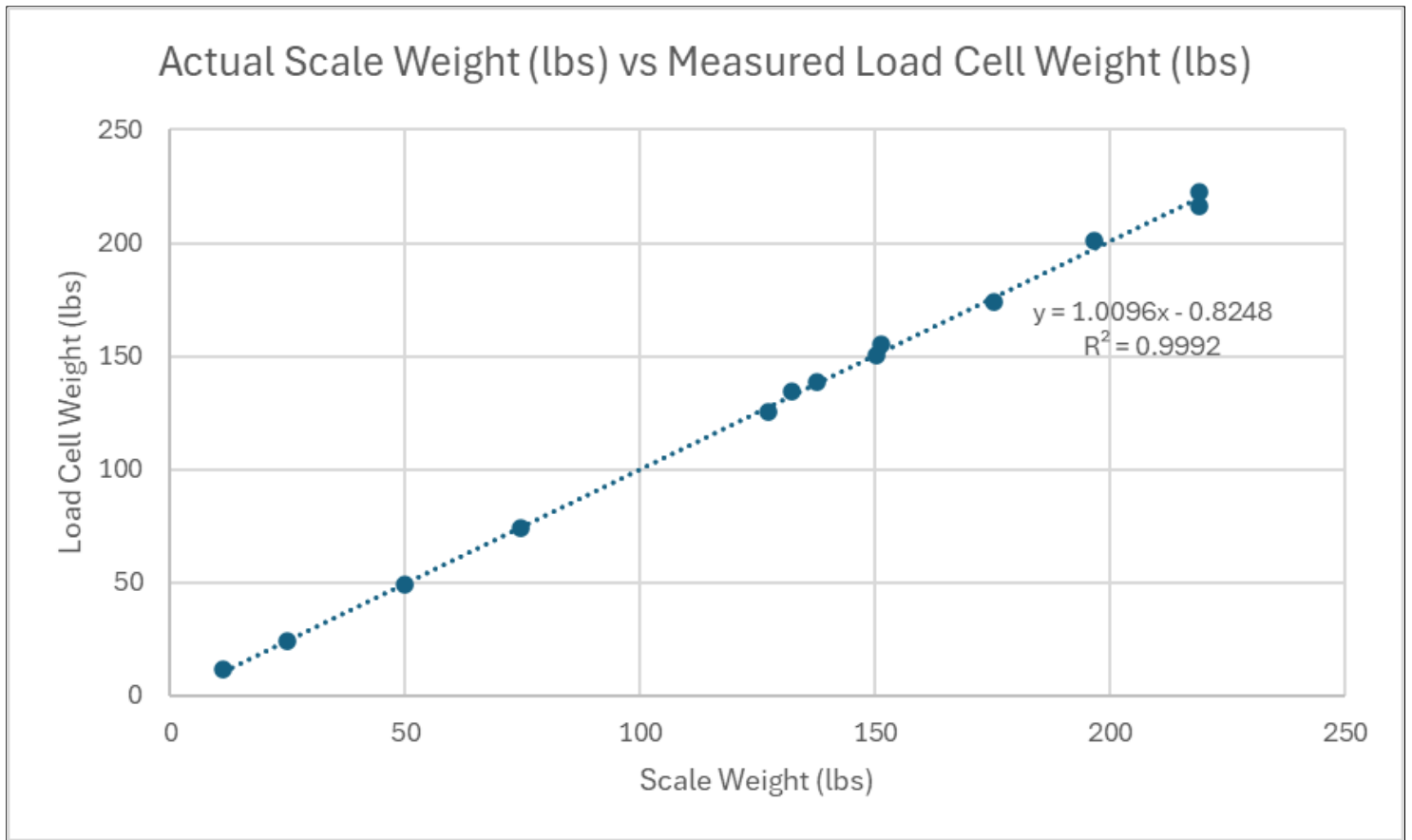
Content by: Jacob Parsons

Present: Jacob Parsons

Goals: Complete Testing

Content:

- See images below of testing setup and attachments of the results
- The complete circuit was completed and an individual would stand on the scale, then stand on the load cell and have the comparison of their values be measured.
- The test yielded a 1.39% accuracy, which is well within the bounds the team was aiming for (5%).



Scale Weight (lb	Code Weight (lbs)
150.4	150.24
175.4	174.16
24.8	24.07
49.8	48.99
74.6	74.19
219	216.47
127.4	125.3
137.8	138.8
151.4	154.92
196.8	200.72
11.4	11.23
219.2	222.5
132.4	134.14

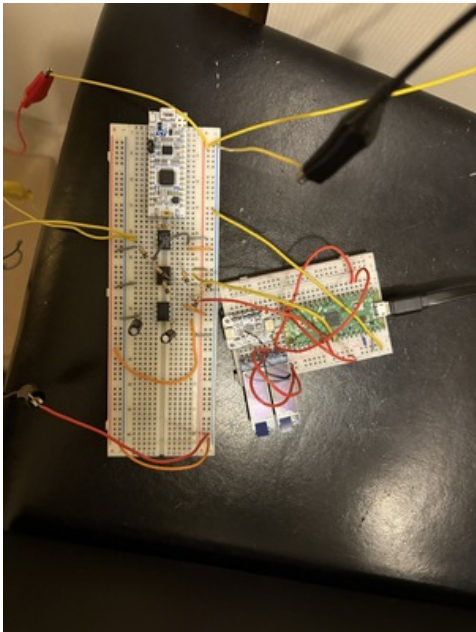
Jacob Parsons - Dec 11, 2024, 5:20 PM CST



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IMG_5121.JPG (5.35 MB)

Jacob Parsons - Dec 11, 2024, 5:20 PM CST



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IMG_5122.JPG (5.63 MB)



2024/10/10 - Product Design Specifications (PDS)

Jacob Parsons - Oct 10, 2024, 8:07 PM CDT

Title: Product Design Specifications (PDS)

Date: 10/10/24

Content by: Jacob Parsons

Present: Whole Team

Goals: Express needs of client and design requirements

Content:

- See PDF below

Jacob Parsons - Oct 10, 2024, 8:07 PM CDT

BME Design: Product Design Specification

Date: 9/10/2024

Team project: Smart Walker

Lab section: 400

Group members:

Luskin@cornell.edu; Nolan@cornell.edu; Horowitz@cornell.edu

DSAC: Dan Sack for @nolan@cornell.edu

DSAC: James Winkler for @james@cornell.edu

DSAC: Jacob Parsons for @jacob@cornell.edu

Client: Dan Kucharski

Advisor: Arnd Neukirch

Function

In the rehabilitation process of acute strokes or similar conditions, it is necessary for the patient to be able to walk well enough before returning home to ensure their safety. The client, Mr. Dan Kucharski, is a physical therapist that evaluates patients that come from an acute care clinic. His requests a device that will improve the evaluation process of the patients and is able to work in conjunction with a standard clinical walker. In order for the physical therapist to evaluate the patient's ability to walk, they must obtain various forms of data such as the speed the patient goes, the distance they are able to travel, and the power is applied to the walker from the patient. All of these sensors will be focused and powered on the walker, and after the metrics are taken, they will be displayed to a screen on the walker. The Smart Walker would enhance the ability of an client to evaluate the rehabilitation process of his patients.

Client requirements

- The device will be designed to enhance a standard physical therapy walker so that be used in a clinical setting for the client.
- The Smart Walker must be durable enough to withstand daily usage, year round with minimal maintenance.
- The device must be manufactured within the budget of \$300, which will be purchased with the target is a walker, electrical components, and other housing components.
- A display module attached to the walker will display measured data from the enhancements to the walker. Such data will be the pressure applied to the walker, the speed of the walker, and the distance traveled.
- An initiate and terminate button for the walker will be implemented so the device is only measured during the trial period.
- All measurements will be in customary units so the patients have a better understanding of their performance.

[Download](#)

Smart_Walker_PDS.pdf (122 kB)



2024/10/10 - Preliminary Presentation

Jacob Parsons - Oct 10, 2024, 8:08 PM CDT

Title: Preliminary Presentation

Date: 10/10/24

Content by: Jacob Parsons

Present: Whole Team

Goals: Express Team's Initial Plan for the Project

Content:

- See power point below

Jacob Parsons - Oct 10, 2024, 8:08 PM CDT



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Preliminary_Presentation_Smart_Walker.pptx (8.91 MB)



2024/10/10 - Preliminary Report

Jacob Parsons - Oct 10, 2024, 8:09 PM CDT

Title: Preliminary Report

Date: 10/10/24

Content by: Jacob Parsons

Present: Whole Team

Goals: Express preliminary plans of the project

Content:

- See PDF below

Jacob Parsons - Oct 10, 2024, 8:09 PM CDT



SMART WALKER

Biomedical Engineering Design
Department of Biomedical Engineering
University of Wisconsin-Madison
October 04, 2024
Class
Das Anweibers
Abstar
Dr. Anis Nussler
Team
Nolan Blomfield (Leader & Commentator)
Eva Skille (BAC)
Jacob Parsons (BPAG)
James Wollenberger (BHTG)

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Preliminary_Report-Smart_Walker.pdf (1.27 MB)



2024/12/11 - Outreach Draft

Jacob Parsons - Dec 11, 2024, 6:55 PM CST

Title: Outreach Draft

Date: 12/11/24

Content by: Jacob

Present: N/A

Goals: To lay out the activity and plans for the outreach the team will conduct the second semester

Content:

- See PDF below

Jacob Parsons - Dec 11, 2024, 6:54 PM CST

D E P A R T M E N T O F
Biomedical Engineering
College of Engineering University of Wisconsin-Madison

Engineering Surgical Devices

Organization: University of Wisconsin-Madison Department of Biomedical Engineering

Contact person/s: Nolan Blom Willis, Eva Schiltz, James Waldenberger, Jacob Parsons
 Contact information: blomwillis@wisc.edu, schiltz@wisc.edu, jacobparsons@wisc.edu, evashiltz@wisc.edu

General Description

Table top activity:
 Visitors will participate in an activity that will introduce them to cyst removal on an elementary level. The flow of the activity will have visitors start by fabricating a pair of tweezers out of various materials, such as paperclippers, paper clips, cardboard, straws, tape, and buttons. They will then each be given pre-made gelatin solutions with beads embedded within them, simulation cysts within the human body. With their fabricated tweezers, the visitors will attempt to remove as many of the embedded beads as possible within a minute. Students with the most beads removed during the allotted time will win a reward.

Program Objectives

Big idea: The overall theme is to teach the elementary students to see through the eyes of a biomedical engineer. This would be done by designing a surgical device such as tweezers.

Learning goals:
 As a result of participating in this program, visitors will be able to:

1. Gain insight into the design of medical equipment as an engineer would.
2. Learn about what a Cyst is.
3. Learn about a surgical device and how it can be applied in surgery.
4. Understand the precise and technical skill required to complete complex procedures.

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BlomWillis_Schiltz_Waldenberger_Parsons_Outreach_Draft_Activity_Guide.docx_1_.pdf (220 kB)



2024/12/11 - Final Report 1

James Waldenberger - Dec 11, 2024, 9:42 PM CST

Title: Final Report 1

Date: 12/11/2024

Content by: James Waldenberger

Present: N/A

Goals: Provide a place to find the final report for semester 1.

Content:

See attached files

Conclusions/action items:

Continue the project next semester.

James Waldenberger - Dec 11, 2024, 10:05 PM CST



[Download](#)

Semester_1_Final_Report__Smart_Walker.pdf (4.29 MB)



2024/9/13-Walker Research

NOLAN BLOMWillIS - Sep 13, 2024, 1:46 PM CDT

Title: Research on Smart Walker study

Date: 9/13/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Gain an understanding

Content:

[1] S. B. Thies *et al.*, "Are older people putting themselves at risk when using their walking frames?," *BMC Geriatrics*, vol. 20, no. 1, 2020, doi: <https://doi.org/10.1186/s12877-020-1450-2>.

- Load Cells on the bottom legs to track pressure induced
- Must take into account the time an individual may lift a walker up
- Gait measurements studies have been done a lot but not much on Gait stability which is what this works on
- The big takeaway is that when individuals use a walker in a clinical setting it is done much better than when at home.

Conclusions/action items:

Understand the use of walkers and got a good basis and ideas for these walkers. Going to research sensors next and what could be used for pressure measurements in the walker.



2024/9/19-Gait Analysis Patent

NOLAN BLOMWillIS - Sep 19, 2024, 10:11 PM CDT

Title: Gait Analysis Patent

Date: 9/19/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Look into what is out there for Gait Analysis

Content:

[1] "JP2012000343A - Gait analysis system and gait analysis method - Google Patents," *Google.com*, Jun. 18, 2010. [https://patents.google.com/patent/JP2012000343A/en?q=\(walker+measurement\)&oq=walker+measurement](https://patents.google.com/patent/JP2012000343A/en?q=(walker+measurement)&oq=walker+measurement) (accessed Sep. 20, 2024).

- This is attaching the gait sensor to the patient not a walker or device
- This gait sensor should be able to have 3D tracking

Conclusions/action items:

A gait sensor would not be able to apply to the walker we are working with and our requirements



2024/9/13-Differential Pressure Sensor

NOLAN BLOMWillIS - Sep 13, 2024, 2:03 PM CDT

Title: Absolute Pressure Sensors

Date: 9/13/24

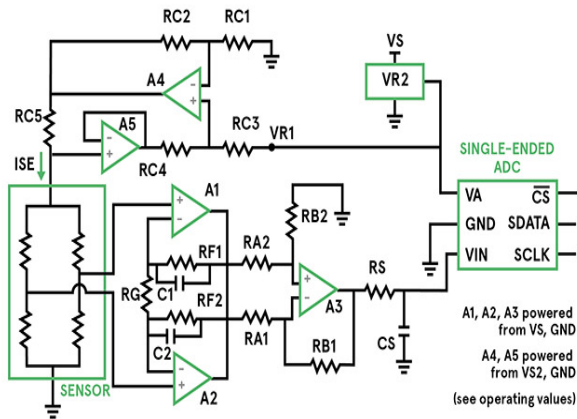
Content by: Nolan BlomWillis

Present: Myself

Goals: Gain an understanding of Absolute pressure sensors.

Content:

[1] "The Different Types of Pressure Sensors | The Design Engineer's Guide | Avnet Abacus," *Avnet.com*, 2015. <https://my.avnet.com/abacus/solutions/technologies/sensors/pressure-sensors/types/> (accessed Sep. 13, 2024). **Differential Sensor** - Measures the difference in pressure at two points -Sometimes it is two separate absolute sensors attached at the ends -Used in pipes and tank usually.



This is a circuit showing how to amplify the signal of the sensor.

Conclusions/action items:

Probably won't be the route the team takes.



2024/9/13-Absolute Pressure Sensor

NOLAN BLOMWillIS - Sep 13, 2024, 2:05 PM CDT

Title: Absolute Pressure Sensors

Date: 9/13/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Gain an understanding of Absolute pressure sensors.

Content:

[1] "The Different Types of Pressure Sensors | The Design Engineer's Guide | Avnet Abacus," Avnet.com, 2015.

<https://my.avnet.com/abacus/solutions/technologies/sensors/pressure-sensors/types/> (accessed Sep. 13, 2024). **Absolute Sensor**

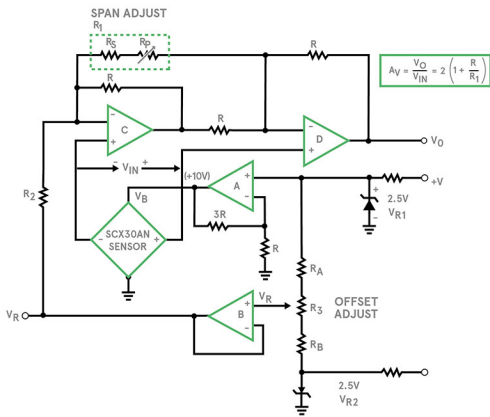


Diagram of how to output this sensor.

Conclusions/action items:



2024/9/19-Piezoresistive Sensors

NOLAN BLOMWillIS - Sep 20, 2024, 12:41 PM CDT

Title: Piezoresistive sensor refresher

Date: 9/19/24

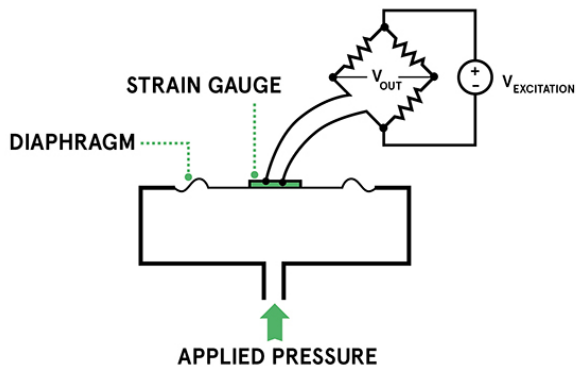
Content by: Nolan BlomWillis

Present: Myself

Goals: Refresh my knowledge on piezoresistive sensors

Content:

<https://my.avnet.com/abacus/solutions/technologies/sensors/pressure-sensors/core-technologies/piezoresistive-strain-gauge/>



- Uses a strain gauge to change its electric resistance when stretched
- The resistance of a conductor is proportional to its length so stretching increases the resistance
- As the conductor is stretched, its cross-sectional area is reduced, which also increases the resistance
- Wheatstone bridge circuit are usually used for measurements of the pressure
- Might need an adjustable resistor to tweak so there is 0 resistance when there is no pressure
- Sometimes can use a lot of power, need to make sure it can be battery operated.

Conclusions/action items:

Look into pressure sensor pads that don't use a lot of power



2024/9/19-Flexiforce pressure pads

NOLAN BLOMWillIS - Sep 20, 2024, 12:33 PM CDT

Title: Flexiforce Pressure Sensors

Date: 9/19/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Look into different options for pressure pads that are compatible with a raspberry pi

Content:

<https://www.tekscan.com/flexiforce-loadforce-sensors-and-systems>

-Thin and FLEXIBLE

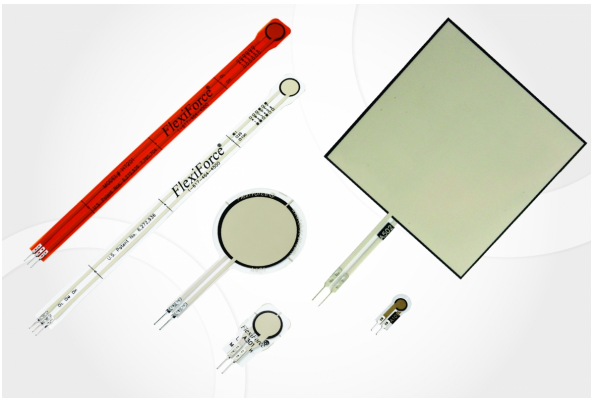
-Low-Power

-Sensor output is not area dependent

-Could fit around a handle

-+/- 3% accuracy according to website

-Piezoresistive strain gauge pressure sensor



Conclusions/action items:



2024/9/19-Pressure Sensor tutorial for raspberry pi

NOLAN BLOMWillIS - Sep 19, 2024, 8:48 PM CDT

Title: Tutorial for pressure sensor

Date: 9/19/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Note a tutorial to apply a pressure sensor pad

Content:

<https://pimylifeup.com/raspberry-pi-pressure-pad/>

Conclusions/action items:

Use this to apply a pressure sensor for raspberry pi



2024/9/26-Load Cell Research

NOLAN BLOMWillIS - Sep 26, 2024, 10:55 PM CDT

Title: Load Cell Research

Date: 9/26/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Gain an understanding of what load cells are available to us for the project

Content:

Pack of 4, 50kg Load cell

https://www.amazon.com/gp/aw/d/B07B4DNJ2L?psc=1&ref=ppx_pop_mob_b_asin_title



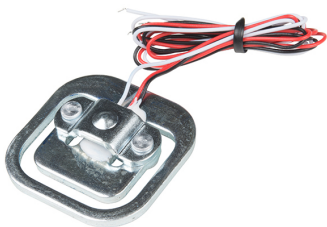
- Arduino Option

- 110 pounds max force for each. All four used =440 lbs

-9 bucks for 4 load cells, \$2.25 per load cell

Single 50kg Load cell

<https://www.sparkfun.com/products/10245>



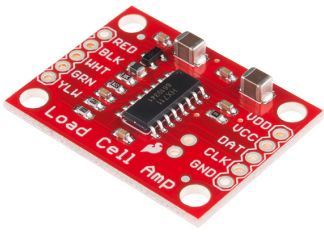
- Single load cell for \$4.50

-110 pounds max force

-Problem is reviews say you need combinator and to have 4 units combined to get it to work.

Load Cell Amplifier-Basic

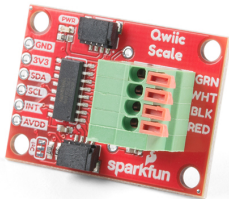
<https://learn.sparkfun.com/tutorials/load-cell-amplifier-hx711-breakout-hookup-guide/all>



- Need this to get readings from the load cell
- \$10.95 per amplifier
- Connect this amplifier to the microcontroller in the block diagram

Load Cell Amplifier-Qwiic Scale

<https://www.sparkfun.com/products/15242>



- No soldering required
- \$16.50
- operates at 3.3 V

Conclusions/action items:

Build block diagram for potential setup of sensors



2024/10/17-Load Cell Base Resistance Readings

NOLAN BLOMWillIS - Nov 18, 2024, 11:05 PM CST

Title: Load Cell Resistance Readings

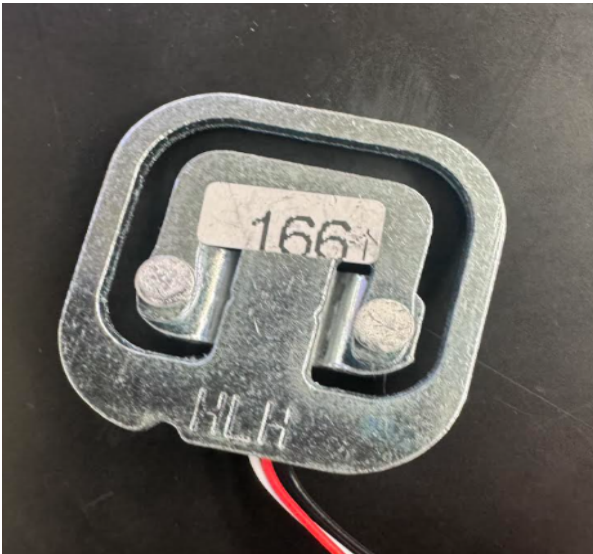
Date: 10/17/2024

Content by: Nolan BlomWillis

Present: Myself

Goals: Get Resistance values for white a black wire of each load cell to see what the exact values of them are

Content:



Black Wire - 993 Ohms

White Wire - 995 Ohms



Black Wire - 1001 Ohms

White Wire - 1000 Ohms



Black Wire - 998 Ohms

White Wire - 996 Ohms



Black Wire - 998 Ohms

White Wire - 1001 Ohms

Conclusions/action items:

Use these values to solder the load cells together into a wheat stone bridge configuration



2024/10/24-Load Cell Work

NOLAN BLOMWillIS - Oct 24, 2024, 5:48 PM CDT

Title: Load Cell Work

Date: 10/24/25

Content by: Nolan BlomWillis

Present: Myself

Goals: Create a wheatstone bridge of the load cells using soldering technique

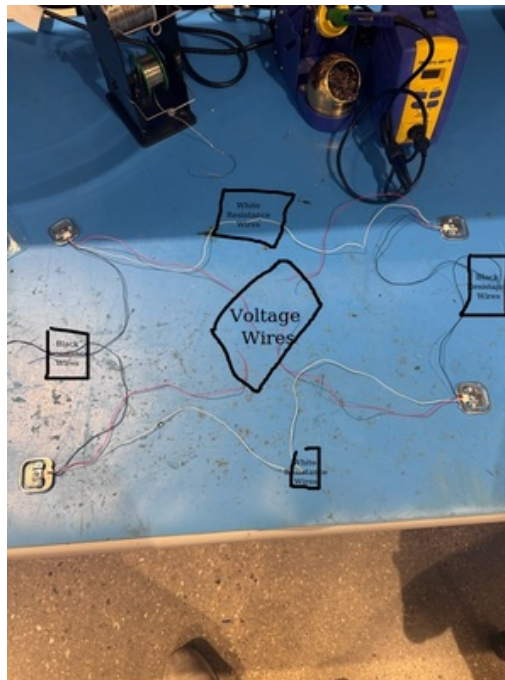
Content:

Below is an image of the white and black wires respectively soldered together and then the red voltage wires sitting in the middle that will go into the amplifier circuit.

Conclusions/action items:

James will now connect this to his circuit and we can begin working on the code for this

NOLAN BLOMWillIS - Oct 24, 2024, 5:53 PM CDT



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5F0C115E-79D7-4709-AEEE-313A80286BBB.jpg (189 kB)



2024/11/15 Load Cell Testing

NOLAN BLOMWillIS - Nov 15, 2024, 12:10 PM CST

Title: Load Cell Testing

Date: 11/15/24

Content by: Nolan BlomWillis

Present: Nolan, James, Jacob

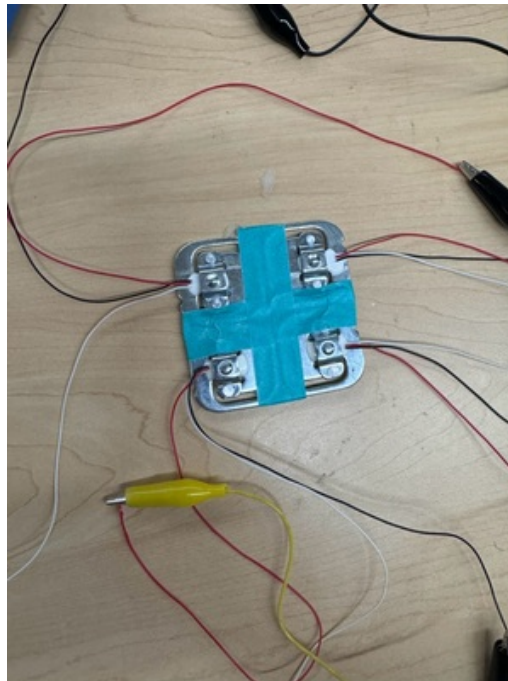
Goals: Get load cell testing done

Content:

Setup of testing might be the issue

Conclusions/action items:

NOLAN BLOMWillIS - Nov 15, 2024, 1:10 PM CST



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079A0BCD-88BB-44A7-BFFF-813DE1128384.jpg (173 kB)



2024/12/11-Walker Modification

NOLAN BLOMWillIS - Dec 11, 2024, 7:47 PM CST

Title: Walker Modification

Date: 12/11/24

Content by: Nolan BlomWillis

Present: Nolan BlomWillis and Eva Schiltz

Goals: Make cuts on the walker to get the walker ready for the load cell holder testing

Content:

See attached image below for the cuts. Cuts were done using a hack saw. All cuts to legs were done on the same plane.

Conclusions/action items:

Now testing can be done on the walker with the load cell holders

NOLAN BLOMWillIS - Dec 11, 2024, 7:47 PM CST



[Download](#)

thumbnail_IMG_7825.jpg (344 kB)



2024/11/15-Tong Lecture

NOLAN BLOMWillIS - Nov 15, 2024, 12:45 PM CST

Title: Tong Lecture

Date: 11/15/24

Content by: Nolan BlomWillis

Present: Myself

Goals: Listen to how Tasso was built

Content:

Dr. Benjamin, Started with a cold email to beebie for microfluidics

Dr. Erwin, also sent a cold email to beebie and got in as well

How can we fix the blood draw world

Future of healthcare is in the home

Worked with the law and entrepreneurship clinic helped a lot.

Writing grants was a huge breakthrough

Got a grant from DARPA, \$150,000

Presented technology in Washington DC to DARPA

Quality is Key

Got a break with the MLB who brought tasso to the majors

Covid opened up a huge door with a higher need for antibody testing

FDA strategy

Conclusions/action items:



2024/09/11- Neurorehabilitation Research

EVA SCHILTZ - Nov 15, 2024, 4:25 PM CST

Title: Neurorehabilitation Research

Date: 9/11/24

Content by: Eva

Present: Eva

Goals: To learn background information about the motivation for creating a smart walker.

Content:

Search term: 'Neurorehabilitation Gait Analysis'

Title: Gait Analysis in Neurorehabilitation: From Research to Clinical Practice

Citation: [1] M. Bonanno *et al.*, "Gait analysis in neurorehabilitation: From Research to Clinical Practice," *Bioengineering*, vol. 10, no. 7, p. 785, Jun. 2023. doi:10.3390/bioengineering10070785

- Gait/postural impairments are most frequent symptoms of neurological diseases - cause great reduction in quality of life, increased risk of falls and subsequent hospitalization
- Ex. of neurological diseases - acquired brain injury (stroke and traumatic brain injury), neurodegenerative disorders (Parkinson disease, cerebellar ataxia and multiple sclerosis)
- Reduction in speed walking, difficulties walking in tandem and in maintaining balance
- Observational gait assessment methods widely used by physiotherapists
- clinical tests for acquired brain injury patients include 10-min walking test, functional ambulation scale or motor assessment scale
- Article includes more information on gait alterations of specific neurological diseases
- Increased variability and asymmetry during walking - most important predictive characteristics for risk of falling

Search term: 'Neurological Rehabilitation Motivation'

Title: Leveraging Factors of Self-Efficacy and Motivation to Optimize Stroke Recovery

Citation: [1] R. Gangwani, A. Cain, A. Collins, and J. M. Cassidy, "Leveraging factors of self-efficacy and motivation to optimize stroke recovery," *Frontiers in Neurology*, vol. 13, Feb. 2022. doi:10.3389/fneur.2022.823202

- 'Stroke rehabilitation practice and research now acknowledge self-efficacy and motivation as critical elements in post-stroke recovery, and increasing evidence highlights their contributions to motor (re)learning
- Influence constructive behaviors, attitudes, and beliefs in post-stroke recovery. Influence an individuals engagement in and adherence to the rehabilitation process

Conclusions/action items:

These sources clearly show the importance of gait analysis measurements in neurological rehabilitation. They also show how a device which helps to improve self-efficacy and provides motivation could help with the neurological rehabilitation process. This information will be helpful in writing about the motivations of this project.



2024/09/12- Distance Measuring Walker Patent

EVA SCHILTZ - Sep 12, 2024, 11:01 PM CDT

Title: Distance Measuring Walker Patent

Date: 9/12/24

Content by: Eva

Present: Eva

Goals: To understand the existing intellectual property in the smart walker space.

Content:

Search Term: 'Walker measurement'

Title of Patent: Walker distance measuring device

Citation: [1] "US7044361B2 - Walker Distance Measuring Device," Google Patents, <https://patents.google.com/patent/US7044361B2/en> (accessed Sep. 12, 2024).

- Features distance and speed measuring sensors built into the wheels of the walker
- Also includes a display which would display information from the sensors?
- Not a lot of information included
- No pressure measurements recorded

Patent Application Publication Apr. 14, 2005 Sheet 1 of 3 US 2005/0077345 A1

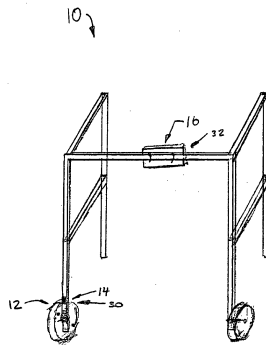


FIGURE 1

Conclusions/action items:

The sensor built into the wheels and the display seem like elements we would want to include in our design. However, this patent does not include weight/ pressure measurements or include many details on the sensor mechanism.



2024/09/19- Walking Aid Standard

EVA SCHILTZ - Sep 19, 2024, 5:36 PM CDT

Title: Walking Aid Standard

Date: 9/19/24

Content by: Eva

Present: Eva

Goals: To understand the requirements for walkers in order to write my sections of the PDS.

Content:

Search term: 'Walking Aid Standards'

Title: 'Walking aids manipulated by both arms — Requirements and test methods — Part 3: Walking tables'

Citation: [1] "ISO 11199-3:2005," ISO, <https://www.iso.org/standard/41191.html> (accessed Sep. 19, 2024).

- When folded into its position for transport or storage, the walking table should stay folded when lifted
- For cleaning purposes, the materials and surface treatments used should withstand ordinary alkaline domestic cleaning detergents or spirits, and be easy to dry. After such cleaning agents have been used, corrosion or ageing of the walking table materials should not accelerate.
- **Braking test:** Activate the brakes by applying to one or each of the running brake operating devices, depending on whether there are central brakes or not, a pulling force of $40\text{ N} \pm 2\%$ or a pushing force of $60\text{ N} \pm 2\%$ along the grip distance, whichever is the motion to activate the brakes.
- **Static strength test:** Apply a loading force of $1\,500\text{ N} \pm 2\%$ for a user mass of 100 kg

Conclusions/action items:

This standard lists values for braking forces and static strength forces that the walker should be able to withstand. It also offers insight into the other standards which walkers must meet during storage or operation. This information will be very useful in completing my portions of the PDS.



2024/09/19- Initial Sensor Research

EVA SCHILTZ - Sep 20, 2024, 12:26 PM CDT

Title: Initial Sensor Research

Date: 9/19/2024

Content by: Eva

Present: Eva

Goals: To research the different types of sensors we could use for the pressure and speed measurements on the Smart Walker. This information will be useful when creating designs for the design matrix.

Content:

Search Term:

Title:

Citation:

Search Term: 'Low Speed Revolution Wheel Tracking'

Title: Improving wheel Speed Sensing and Estimation

Citation: C. Trobro and M. Magnusson, Improving wheel speed sensing and estimation, <https://lup.lub.lu.se/student-papers/record/8848126/file/8859460.pdf> (accessed Sep. 20, 2024).

- Gear- tooth wheel made of ferromagnetic material. When wheel is moving the sensor can "feel" the changes of the magnetic field between the target wheel and a permanent magnet in the sensor. The sensor transforms the variation in flux to an output voltage. The frequency of the voltage is proportional to the wheel frequency

- Inductive Sensors : weaker signal for lower velocities -> filtering and amplification required

- Solid-State sensor (Hall effect or Magneto-resistive sensors): semiconductor applied to stationary magnet producing an electrical signal - electrical signal is dependent on size of semiconductor but independent of velocity of the wheel. Magnet generates a stationary flux which the sensors can register unlike with inductive sensors

- Hall coefficient: different for different materials - slightly differs from sensor to sensor. Two Hall Effect sensors could lead to differences in amplitude signals causing problems with wheel speed estimation

- Magneto resistive sensor: measures resistance variation in proportion to wheel speed. Larger output signals are achieved compared to Hall Effect or Inductive sensor

This article describes methods used by the previous group working on this project. It raises interesting questions about what caused the issues with the Hall Effect sensors: too many sensors causing amplitude differences? Would the amplification and filtering need to be improved?

- Mentions Tracking Demodulation which uses two inductive sensors with a phase of 90 degrees between them. PI controller, integrator and closed feedback loop
- A Hall Effect sensor can be used to get around this problem. This sensor gives a good, stable signal that changes between low and high state, as the teeth of the target wheel pass by. But also, this sensor has problems below 20 km/h. In this case, the problem is that the time between states changes at these speeds start to rise to such values that it will be impossible to calculate velocity estimation within demanded deadlines
- Below 20 km/h it is suggested that Tracking Demodulation shall be used. By making an estimation error between the correct- and estimated position, it is possible to estimate the wheel speed.

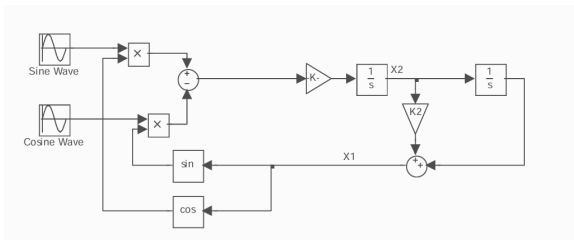


Figure 5.6. Block model for the Tracking Demodulation.

- Masters thesis, not sure how easy this would be to set up with our time frame

Search Term: 'Measuring Wheel Speed'

Title: 'Measuring Wheel Systems MWE21'

Citation: F. Z. Robert Petrovic, "MWE21," MWE21 Measuring Wheel Systems Product details - Kübler Group - USA, <https://www.kuebler.com/us/products/measurement/linear-measuring-systems/product-finder/product-details/MWE21> (accessed Sep. 19, 2024).

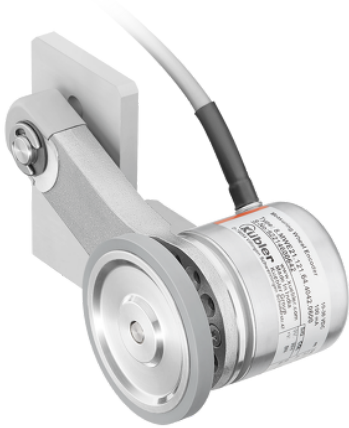
Trying to look for a sensor similar to those used in



Keson Measuring Wheel MP Replacement Counter Assembly



Kubler Sensor



Measuring wheel systems from Kübler are the ideal solution for reliable speed, position and distance measurement in applications with linear movements. These are recorded rotationally directly on the surface of the material to be measured via the measuring wheel with attached encoder and converted into linear data

Can withstand up to 20 N contact force - could be used alongside regular wheel?

Could a surveying wheel be used to capture speed?

Search Term: 'Wheel Speed Sensor'

Title: Understanding wheel speed sensors: How they work

Citation: R. Muscoplat, "Understanding wheel speed sensors: How they work," Ricks Free Auto Repair Advice, <https://ricksfreeautorepairadvice.com/understanding-wheel-speed-sensors-how-they-work/> (accessed Sep. 20, 2024).

Active vs passive sensors: passive only operate when wheel reaches a certain speed - low accuracy at low speeds.
Active sensors are Hall Effect and Magneto -resistive



Multi-pole rubber encoder ring and Hall effect wheel speed sensor



Conventional steel tone ring and either active or passive wheel speed sensor

ABS Wheel Speed Sensor(Rear)



Can Wheel Speed Sensor be adapted to use with the Smart Walker?

Conclusions/action items:

Use this research to brainstorm design ideas for the Smart Walker speed sensor to be used in the design matrix.



204/09/26- Force Sensor Research

EVA SCHILTZ - Sep 26, 2024, 3:11 PM CDT

Title: Force Sensor Research

Date: 9/26/24

Content by: Eva

Present: Eva

Goals: To research the various force sensors available to gather weight distribution data.

Content:

Search Term:

Title:

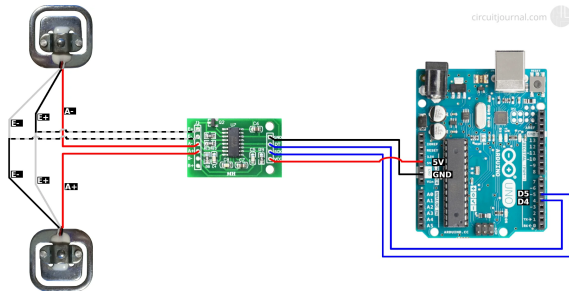
Citation:

Search Term: 'Load cell for use with Arduino

Title: 50kg load cells with HX711 and Arduino. 4X, 2x, 1x diagrams.

Citation: "50kg load cells with HX711 and Arduino. 4X, 2x, 1x diagrams.," 50kg Load Cells with HX711 and Arduino. 4x, 2x, 1x Diagrams. - Circuit Journal, <https://circuitjournal.com/50kg-load-cells-with-HX711> (accessed Sep. 26, 2024).

- Circuit used by the previous group



- Could measure up to 220 lbs with 2 sensors

- After a heavier weight has been applied takes time to settle back to zero.

- Has a full tutorial on creating the circuit



[YZC 50/100kg Scale Weighing Sensor Load Cell Weight Pressure Sensor For Arduino | eBay](#)

- Bulkier than strain gauge sensors -> Harder to incorporate without affecting user experience with walker.

Conclusions/action items:

It seems that either of these load cells could be viable options though they would need to be incorporated into the walker in different ways. The team will likely use this research as well as previous sensor research to inform our decision making for the design matrices.



2024/11/15- Tong Lecture

EVA SCHILTZ - Nov 15, 2024, 1:12 PM CST

Title: Tong Lecture

Date: 11/15/24

Content by: Eva

Present: Whole team

Goals: To learn from the experiences of past UW Madison BME graduates.

Content:

Blood testing for sports- mlb, ufc, cyclism

3d printing one new concept a day- continual iteration

7000 different types of tests

USAda looking to switch anti-doping to blood but everyone hates needles and lancets

Tasso developed a tamper proof security case to solve the chain of custody problem

Drowning in sea of possibility - focus in on a problem and a customer

Scaling up -

Covid - everything shut down

All of a sudden they need more at home testing, huge increase in orders

From 100 a week to 300,000 a month

Quality is key- one customer with bad experience kills the product, better to push timeline than skimp on quality

Culture - values that you can share to help people make the same decision you would, communication between teams

Regulatory strategy

FDA- diagnostic product, million dollar clinical trial, 18 months

Lancet collects blood - doesn't have tube attached

Just sell the two separately - just create lancet class I, easy clearance

First lancet that became cleared this way- beat competitors to the punch

Figure it out along the way

Conclusions/action items:

Use the information and lessons imparted from the Tong lecture to inform future career moves and planning. A lot of the advice that was given would be very useful to consider while creating a new medical device.



2024/10/18- Pico Raspberry Pi Case

EVA SCHILTZ - Oct 18, 2024, 8:22 AM CDT

Title: Pico Raspberry Pi Case

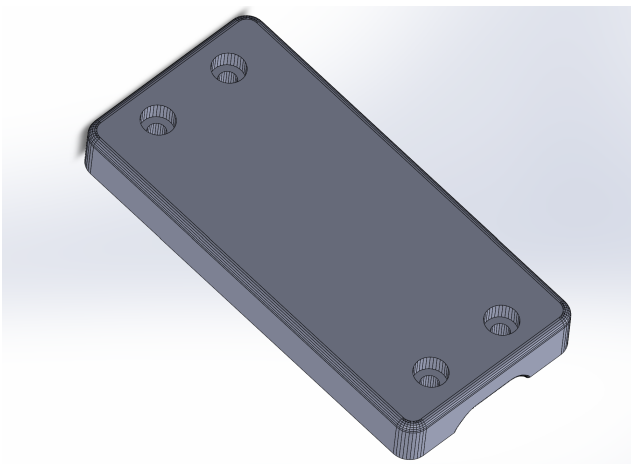
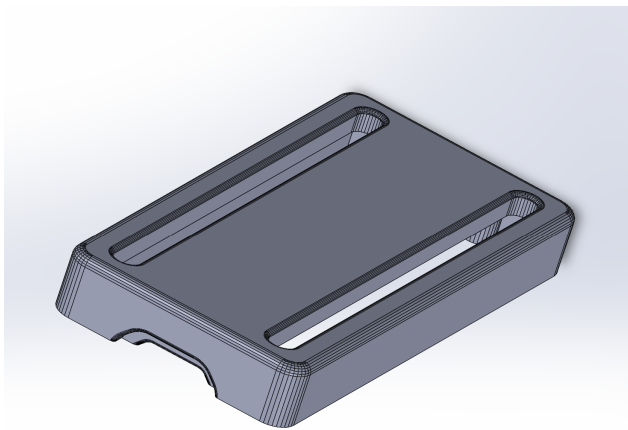
Date: 10/18/24

Content by: Eva

Present: Eva

Goals: To begin working on the display box which will contain the hardware for our circuits.

Content:



Conclusions/action items:

The case for the pico can be placed within the larger overall display box. However before designing that box we will need to determine which kind of display we are using as well as how the user will be interacting with the display (buttons).



2024/10/24- Ideas for Integration of Load Cell with Walker

EVA SCHILTZ - Nov 14, 2024, 10:34 PM CST

Title: Ideas for Integration of Load Cell with Walker

Date: 10/24/24

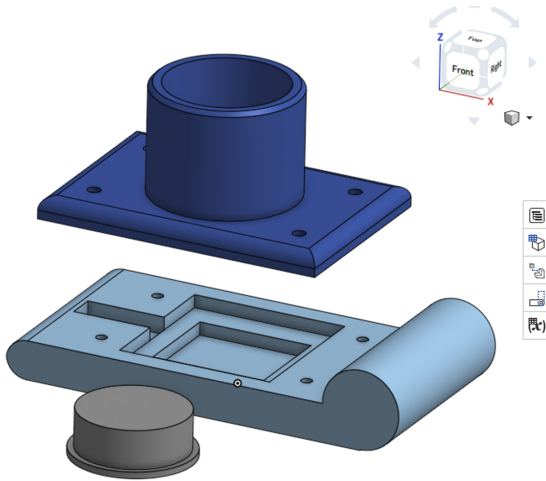
Content by: Eva

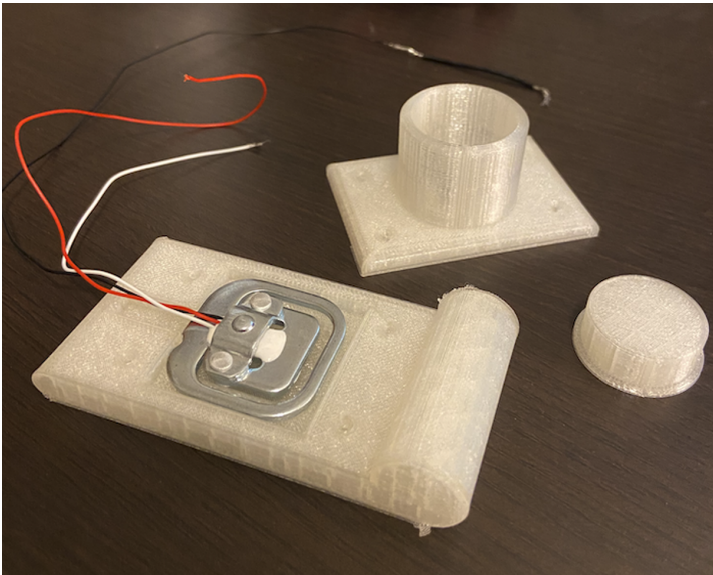
Present: Eva

Goals: To brainstorm an idea for how to integrate the load cell into the legs of the walker.

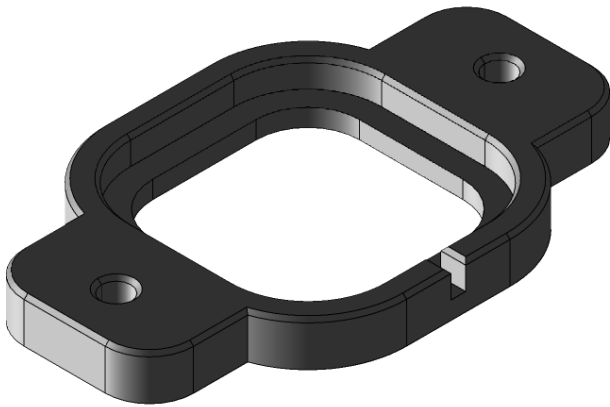
Content:

Below are images of the previous groups design which seemed to work relatively well. They used an end cap over the hollow end of the walker leg to evenly distribute the force of the leg across the strain gauge. They also included a recess to allow the strain gauge to flex - allowing for more accurate measurements. The main drawbacks to this design is in the wiring. They created a tunnel to allow the wires to exit the foot of the walker but left them exposed to the user. Also the design is form fit but has no other method of ensuring the load cell stays connected to the walker. It seems to work relatively well but does leave some room for user error.

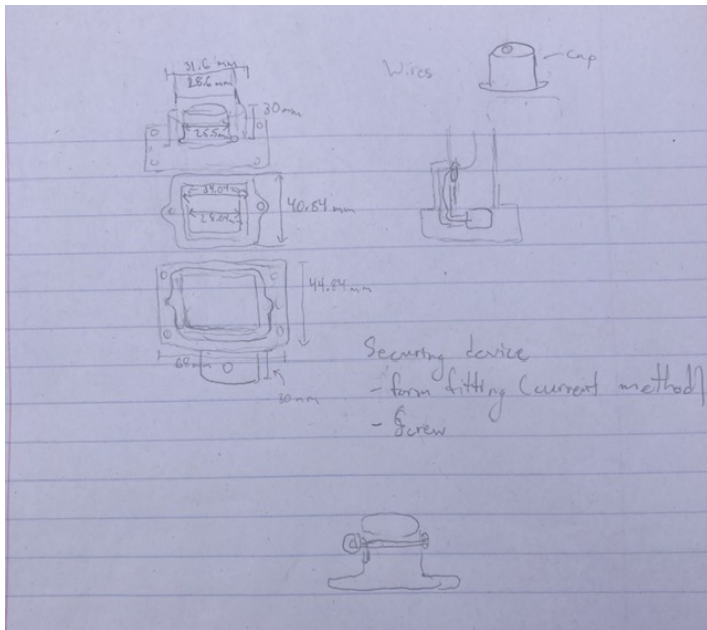




Below is an image of a bracket created for the strain gauge we are currently using. This design is useful but will need to be incorporated into a larger model which would fit to the legs of the walker.



Below is an image of the design I created. It would still use some of the ideas from the previous groups design while incorporating the load cell bracket for securing the load cell. The wires could either be run through a hole in the end cap or through a separate contained route along outer edge of the walker leg. This design could also be attached with screws, potentially through a slot on the upper leg to ensure that the leg can properly apply pressure to the strain gauge.



Conclusions/action items:

Share my design ideas with the group and get their feedback. Incorporate any new ideas and begin building the solidworks model for the design so that it can eventually be 3D printed.



2024/11/05- Modified Load Cell Model from Previous Group

EVA SCHILTZ - Nov 08, 2024, 9:34 AM CST

Title: Modified Load Cell Model from Previous Group

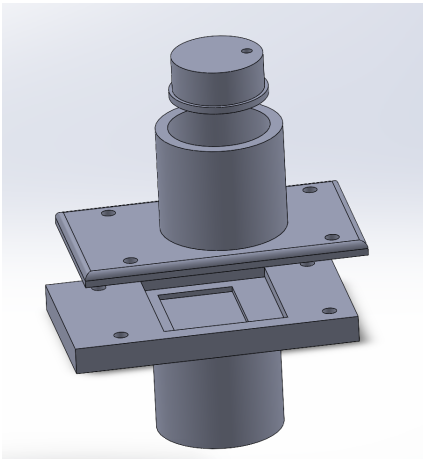
Date: 11/5/24

Content by: Eva

Present: Eva

Goals: Modify the previous groups load cell container model to be implemented into the middle of the walker leg instead of the end.

Content:



This design is similar to the last groups design but modified to suit the middle of the walker legs instead of their feet.

Conclusions/action items:

Show this design to the rest of the group and bring these ideas to Jesse Darley for the design consultation.

EVA SCHILTZ - Nov 05, 2024, 7:30 PM CST



[Download](#)

OriginalTop.SLDPRT (129 kB)

EVA SCHILTZ - Nov 05, 2024, 7:51 PM CST



[Download](#)

OriginalEndCap.SLDPRT (98.4 kB)

EVA SCHILTZ - Nov 05, 2024, 7:51 PM CST



[Download](#)

OriginalAssembly.SLDASM (108 kB)

EVA SCHILTZ - Nov 08, 2024, 9:32 AM CST



[Download](#)

OriginalBase.SLDPRT (140 kB)



2024/11/08- Design Consultation Notes

EVA SCHILTZ - Nov 08, 2024, 10:33 AM CST

Title: Design Consultation Notes

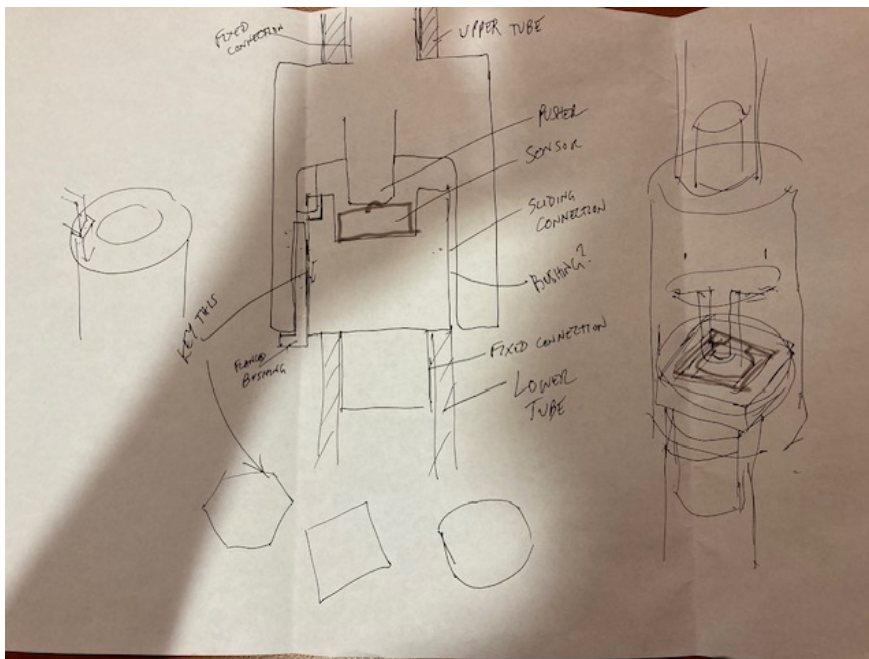
Date: 11/8/24

Content by: Eva

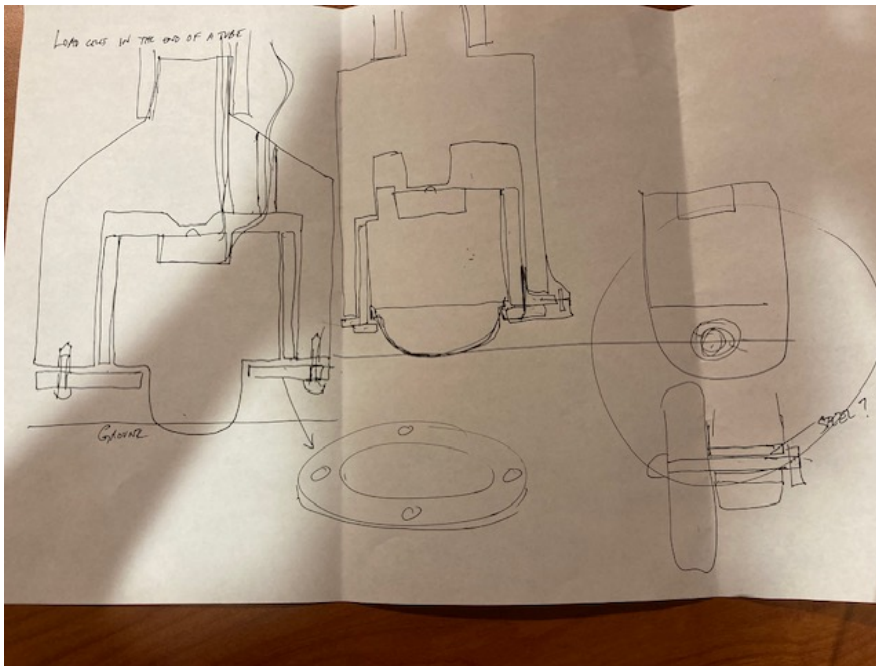
Present: Eva

Goals: Meet with Jesse Darley to discuss our design ideas and determine the best path forward for integrating the load cell.

Content:



The first design Jesse came up with was similar to our current idea but featured some added details that would help make our design more accurate. These include a smaller area of contact on the load cell to place pressure more directly on the strain gauge, a bushing around the edge of the base to reduce friction between the two parts and a key mechanism to prevent the walker leg from rotating and moving the wheel. The upper and lower pieces would be fixed to the walker leg either with an adhesive or a pin.



This design would again be incorporated into the bottom of the walker leg. It has similar features but for two of the legs a hole would be bored through the middle to allow the axle of the wheel to pass through. This base piece would either need to be machined out of aluminum or the 3d printed piece would need to be reinforced with metal to support the shear forces of the wheel. This design would also need to have a washer like design at the bottom which would screw into the top to prevent the base piece from falling when lifted.

Conclusions/action items:

I will share these designs with the team so we can decide which we want to proceed with. Once we have decided I will create the Solidworks model this weekend so we can begin fabrication next week.



2024/11/08- New Load Cell Holder Model

EVA SCHILTZ - Nov 08, 2024, 12:13 PM CST

Title: New Load Cell Holder

Date: 11/8/24

Content by: Eva

Present: Eva

Goals: To begin working on the solidworks model for the new load holder design

Content:

Attached below are the initial solidworks models for the new load holder.

Conclusions/action items:

I will finish modeling these pieces over the weekend and begin 3d printing next week.

EVA SCHILTZ - Nov 08, 2024, 12:00 PM CST



[Download](#)

Load_Cell_Holder_Top.SLDPRT (79.5 kB)

EVA SCHILTZ - Nov 08, 2024, 12:00 PM CST



[Download](#)

Load_Cell_Holder_Bushing.SLDPRT (79 kB)

EVA SCHILTZ - Nov 08, 2024, 12:01 PM CST



[Download](#)

Load_Cell_Holder_Base.SLDPRT (67.4 kB)



2024/11/14- New Load Cell Holder Completed Model

EVA SCHILTZ - Nov 15, 2024, 4:25 PM CST

Title: New Load Cell Holder Completed Model

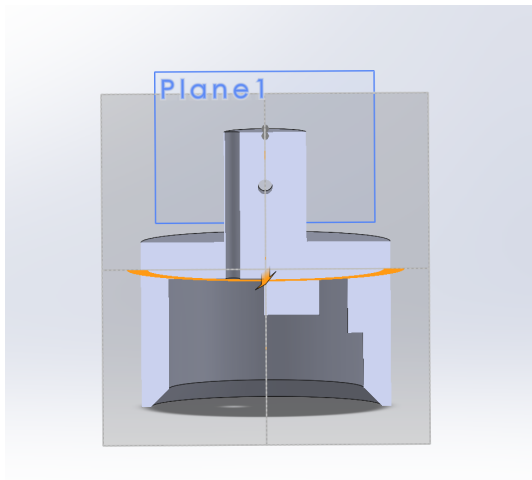
Date: 11/14/24

Content by: Eva

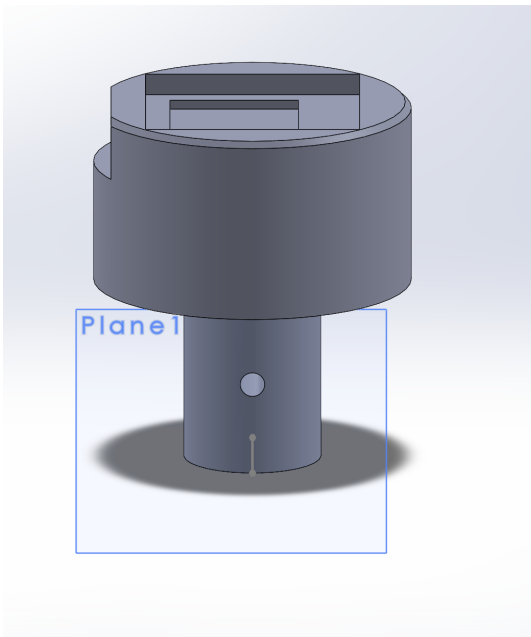
Present: Eva

Goals: To finish the initial Solidworks model of the load cell holder so that we can move on to 3d printing the first prototype.

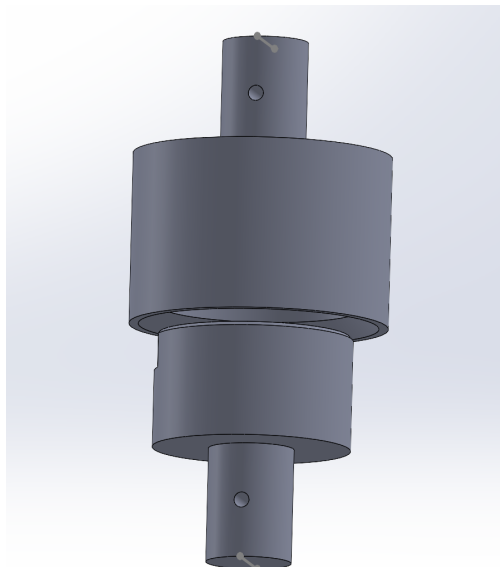
Content:



This is the top of the load cell holder. The smaller cylinder at the top will insert into the leg of the walker and has a hole to be fixed with a screw/pin. Running through this cylinder is a hole that the wires from the load cell can be fed through into the tubing of the leg. This design also features a key mechanism which will prevent the load cell holder from rotating.



This is the bottom of the load cell holder.



This is what the full load cell holder will look like.

While designing this Solidworks model I discussed the bushing feature which we were previously planning on incorporating with Jesse Darley as the desired size for the bushing would make the feature relatively expensive. He advised to test with the current load cell holder model without the bushing and determine how much friction is affecting the reported weight from the load cell. From there we can either apply some type of waxing or move forward with the bushing if deemed necessary.

Conclusions/action items:

I will share the new plan for the bushing feature with the rest of the team. I will then 3D print an initial prototype and make adjustments to the model dimensions if necessary. Finally I will begin to work on the design for the display box on the walker.



2024/11/15- Initial 3D printed Load Cell Holder

EVA SCHILTZ - Nov 22, 2024, 12:31 PM CST

Title: Initial 3D Printed Load Cell Holder

Date: 11/15/24

Content by: Eva

Present: Eva

Goals: To analyze the initial 3D printed load cell holder and determine whether its dimensions need to be adjusted.

Content:



This is a picture of the assembled load cell holder. Though the pieces do fit together, they fit too tightly and are difficult to take apart once put together. I will increase the width of the top load cell holder piece. The key feature seemed to work but I also might increase the depth of the groove the key fits into.



Here are the load cell holder pieces when disassembled. The pieces which insert into the walker fit but allow a little more room than I would have liked so I might increase their width.



I also 3D printed this load cell bracket to use for testing the load cell while the load cell holder is being adjusted.

[50kg Loadcell Bracket versionF by_patrick3345 - Thingiverse](#)

Conclusions/action items:

I will make the listed adjustments to the load cell holder dimensions. I will then 3D print the new model and retest it. Finally I will begin working on designing the display box.



2024/11/21- Testing and Fabrication Preparation

EVA SCHILTZ - Nov 21, 2024, 10:35 PM CST

Title: Testing and fabrication preparation

Date: 11/21/24

Content by: Eva

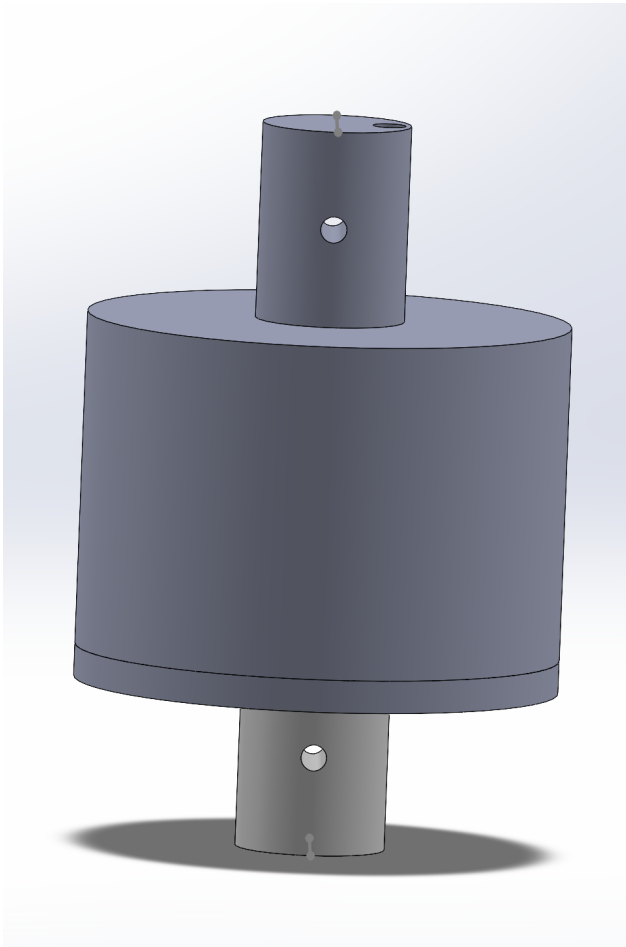
Present: Eva

Goals: To create a load cell testing setup and adjust the dimensions of the load cell holder.

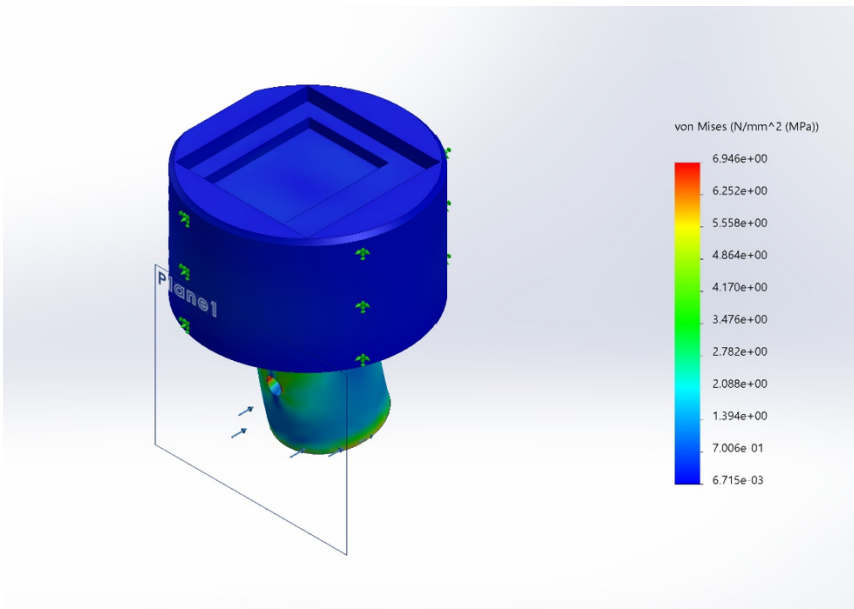
Content:



I printed four of the brackets listed in the previous notebook entry, cut a 8" x 1' 2" rectangle out of scrap wood in the makerspace and screwed the brackets into corners of the wood board. This will allow us to place an even weight distribution on all of the load cells as they are being tested.



I made the adjustments detailed in the last entry to the dimensions of the load cell holder. I will begin printing the new model tomorrow.



I also ran a static study on the load cell holder of the presumed most likely method of failure which would be a horizontal force applied to the legs of the walker. This test was run with an ABS material and 200 N applied to the parts of the load cell holder contained within the lower leg of the walker. The results were promising as the material has a much higher ultimate yield strength of approximately 19-51 MPa than any of the forces it would experience during regular loading. However, this test is not a very reliable indicator of the safety of the device as our model will be 3D printed and likely exposed to some unpredictable loading situations.

Jesse Darley mentioned creating a FMEA document for the client as well as testing the device ourselves to ensure its safety. However, he also mentioned many of the potential risks of the device are mitigated due to its controlled use in a clinical environment in the presence of a professional.

Conclusions/action items:

The team can now test the load cells in a controlled manner and execute our testing protocols. I will print the new model of the load cell holder to ensure its dimensions are correct before attempting to integrate them with the walker. Finally I will work on creating the model for the display box



2024/09/18 - Distance and Speed Measuring Research

Jacob Parsons - Sep 25, 2024, 11:46 PM CDT

Title: Distance and Speed Measuring Research

Date: 9/18/24

Content by: Jacob Parsons

Present: N/A

Goals: To learn some basic ways to set up various devices to measure distance and speed

Content:

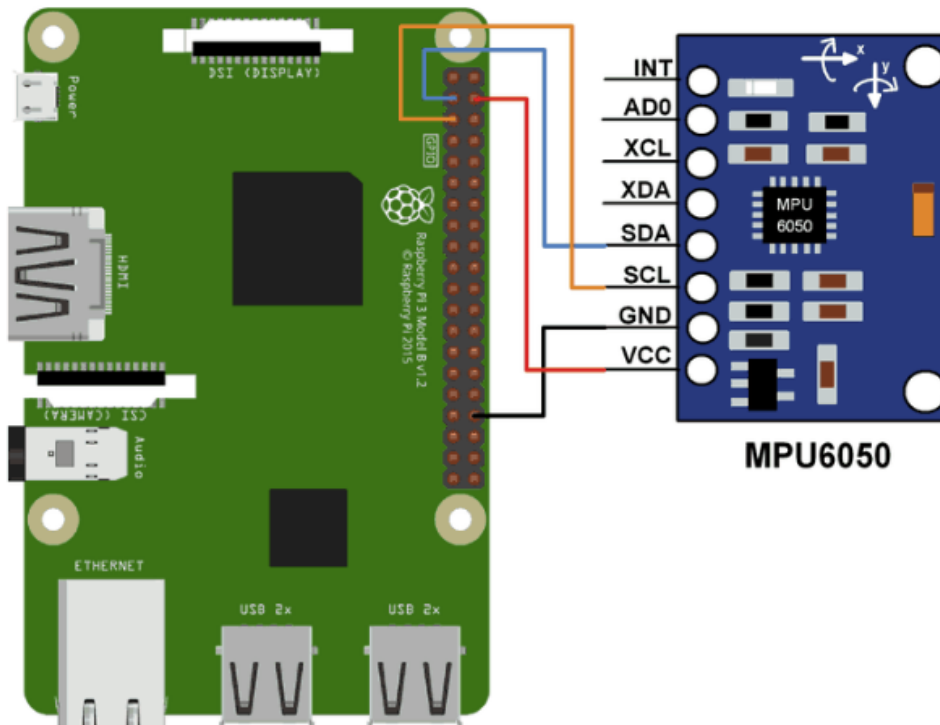
Accelerometer/Gyroscope

<https://www.electronicwings.com/raspberry-pi/mpu6050-accelerometergyroscope-interfacing-with-raspberry-pi>

<https://www.youtube.com/watch?v=nGYZChwjiMo>

[1] "MPU6050 (accelerometer+gyroscope) interfacing with Raspberry Pi," ..., <https://www.electronicwings.com/raspberry-pi/mpu6050-accelerometergyroscope-interfacing-with-raspberry-pi> (accessed Sep. 18, 2024).

- Use of the MPU6050 sensor module (6 axis motion tracking device)
- 3-axis gyroscope, 3-axis accelerometer, digital motion processor, and a temperature sensor
- Can accept inputs from other sensors, if a 3-axis magnetometer or pressure sensor is added in conjunction it can provide a complete 9-axis motion fusion output
- It can communicate with a microcontroller using I2C communication protocol
- XYZ axis readings for both the gyroscope and accelerometer: gyroscope readings are in degrees per second and accelerometer are in g unit
- Power supply range from 2.375 V to 3.46 V

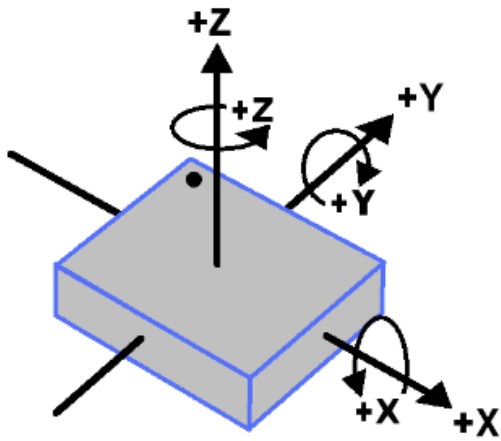


MPU6050 Interfacing with Raspberry Pi

Figure 1: Sensor interface with a raspberry pi

- Website includes code in Python and C to display output values

- Includes a forum for questions as well



MPU-6050 Orientation & Polarity of Rotation

Figure 2: Gyroscope orientation and polarity

- During rotation, Coriolis effect causes vibration that is detected inside. The output is then computed into angular velocity

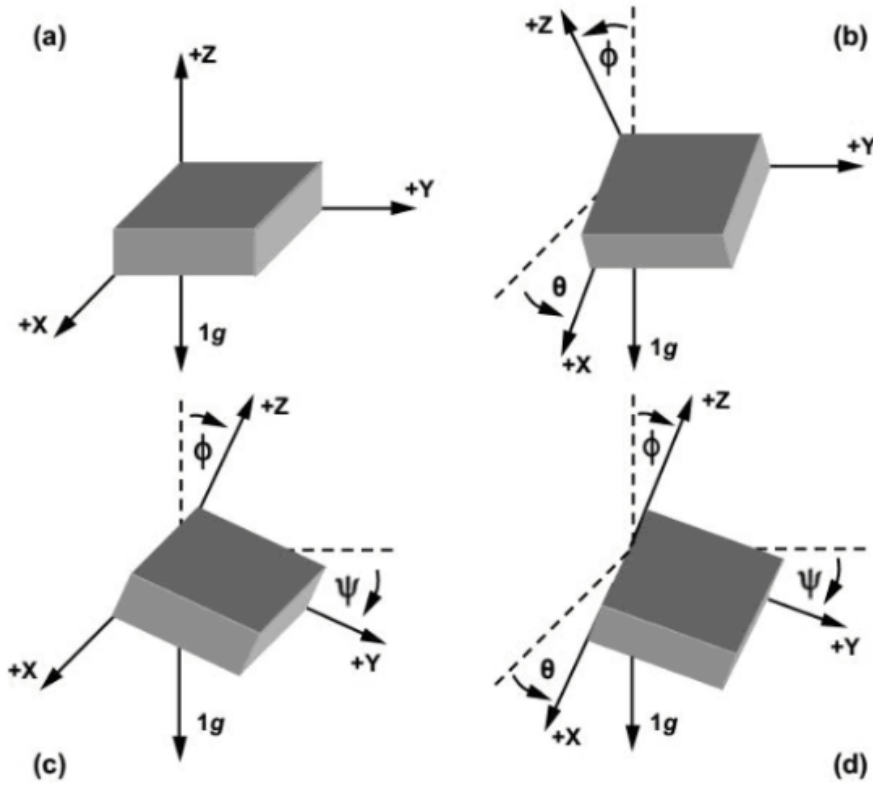
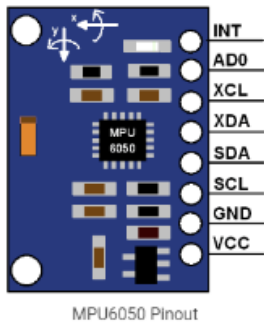


Figure 3: 3-axis accelerometer basic movement and orientation

- The displacement of the moving plate unbalanced the differential capacitor and results in an output
- The output amplitude is proportional to acceleration
- 16-bit ADC is used to get digitized output, it is measured in g's
- When placed flat it will measure 0g on X & Y axis, +1 g on Z axis



MPU6050 Pinout

MPU6050 Pin Description

The MPU-6050 module has 8 pins,

- **INT:** Interrupt digital output pin.
- **AD0:** I2C Slave Address LSB pin. This is 0th bit in 7-bit slave address of device. If connected to VCC then it is read as logic one and slave address changes.
- **XCL:** Auxiliary Serial Clock pin. This pin is used to connect other I2C interface enabled sensors SCL pin to MPU-6050.
- **XDA:** Auxiliary Serial Data pin. This pin is used to connect other I2C interface enabled sensors SDA pin to MPU-6050.
- **SCL:** Serial Clock pin. Connect this pin to microcontrollers SCL pin.
- **SDA:** Serial Data pin. Connect this pin to microcontrollers SDA pin.
- **GND:** Ground pin. Connect this pin to ground connection.
- **VCC:** Power supply pin. Connect this pin to +5V DC supply.
- MPU-6050 module has Slave address (When AD0 = 0, i.e. it is not connected to Vcc) as,
 - Slave Write address(SLA+W): 0xD0
 - Slave Read address(SLA+R): 0xD1

Figure 4: Pinout of sensor and pin descriptions

Hall Effect Sensor

<https://www.raspberrypi-spy.co.uk/2015/09/how-to-use-a-hall-effect-sensor-with-the-raspberry-pi/>

[2] Matt, "How to use a hall effect sensor with the Raspberry Pi," Raspberry Pi Spy, <https://www.raspberrypi-spy.co.uk/2015/09/how-to-use-a-hall-effect-sensor-with-the-raspberry-pi/> (accessed Sep. 18, 2024).

- Hall effect sensor detects magnetic fields
- Used Allegro hall effect sensor A1120EUA-T (~\$1)
- 3 pin hall effect sensor, Vcc, Gnd, Vout
- Decide on a magnet that fits the necessary dimensions

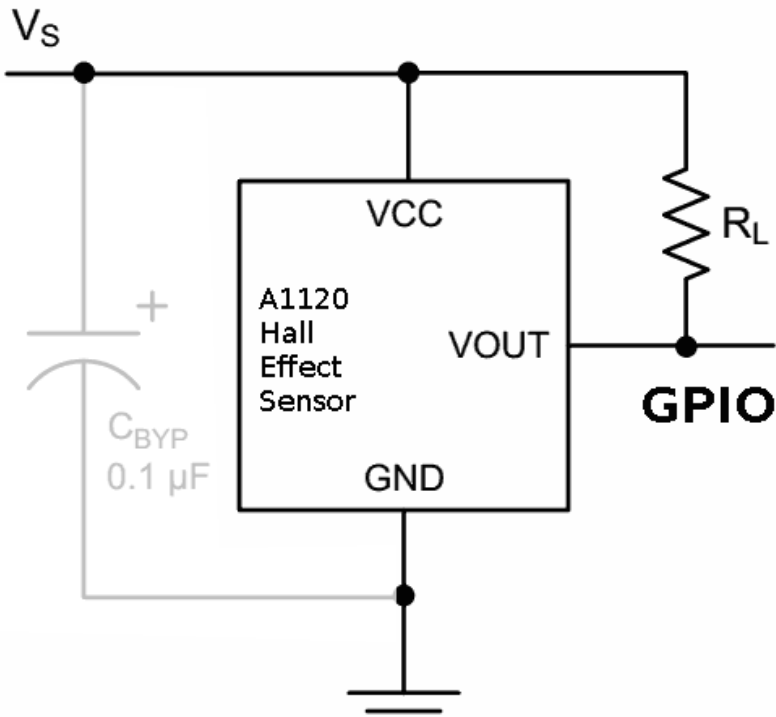


Figure 5: Circuit diagram of simple, effective hall effect sensor

- Recommendation to use a 0.1 uF capacitor b/w Vcc and GND to reduce noise (may not be necessary)

Table 1: Pinout of the hall effect sensor with raspberry pi

Pi Header	A1120
3.3V (Pin 1)	Pin 1
Gnd (Pin 6)	Pin 2
GPIO17 (Pin 11)	Pin 3

- The page also includes some example code

<https://forums.raspberrypi.com/viewtopic.php?t=279519>

[3] Motorcycle speedometer - raspberry pi forums, <https://forums.raspberrypi.com/viewtopic.php?t=279519> (accessed Sep. 19, 2024).

- Using a raspberry pi 3b and hall effect sensor (55505 Hall Effect Sensor from Hamlin)
- 3 V output, 20 mA current output (GPIO spec is 16 mA, so some sort of resistor)
- Calculate the rotations
- More information here if necessary

Ultrasonic Sensor/Lidar

<https://projects.raspberrypi.org/en/projects/physical-computing/12>

[4] "Using an Ultrasonic Sensor," Projects.raspberrypi.org, <https://projects.raspberrypi.org/en/projects/physical-computing/12> (accessed Sep. 18, 2024).

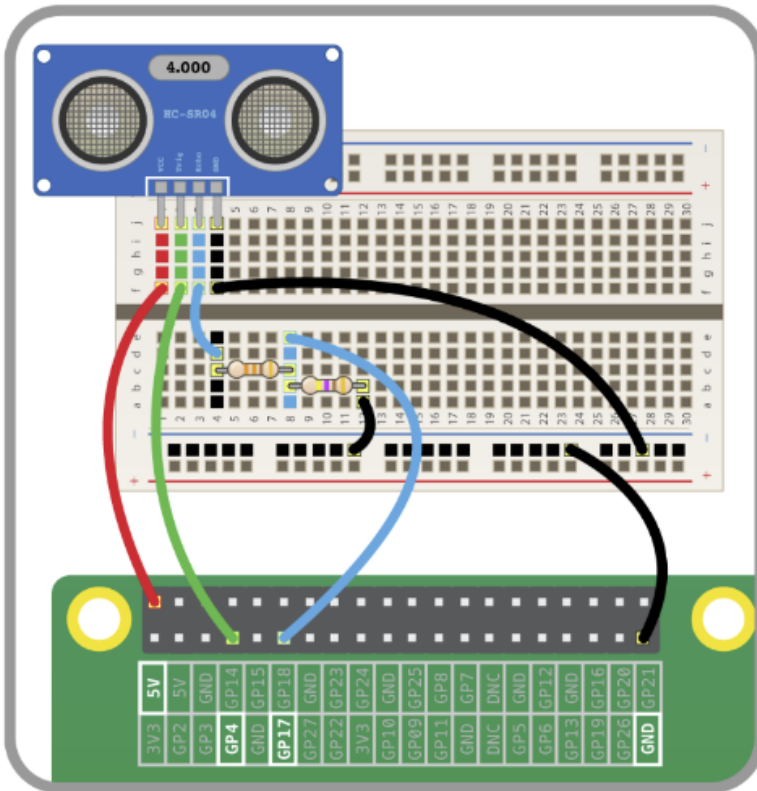


Figure 6: Pinout of ultrasonic sensor with raspberry pi_

- Code is included
- Maximum reading of 13 feet (may be too small)
- 5 V power supply and 15 mA working current
- Measuring angle of 30 degrees
- Does the measuring cone go in all dimensions? Like an ice cream cone leaving the ultrasonic sensor (will it pick up other things?)

<https://www.raspberrypi.com/news/how-to-build-a-laser-range-finder/>

[5] How to build a laser range finder - raspberry pi, <https://www.raspberrypi.com/news/how-to-build-a-laser-range-finder/> (accessed Sep. 19, 2024).

- Used waveshare RP2040-zero board (works with raspberry pi)
- Time-of-flight distance sensor
- 2.4" TFT display
- Uses I2C communication protocol
- Input supply voltage of 5 V
- Adjustable to 2000 mm (6.5 ft)
- Designed own PCB, used C/C++ to code it

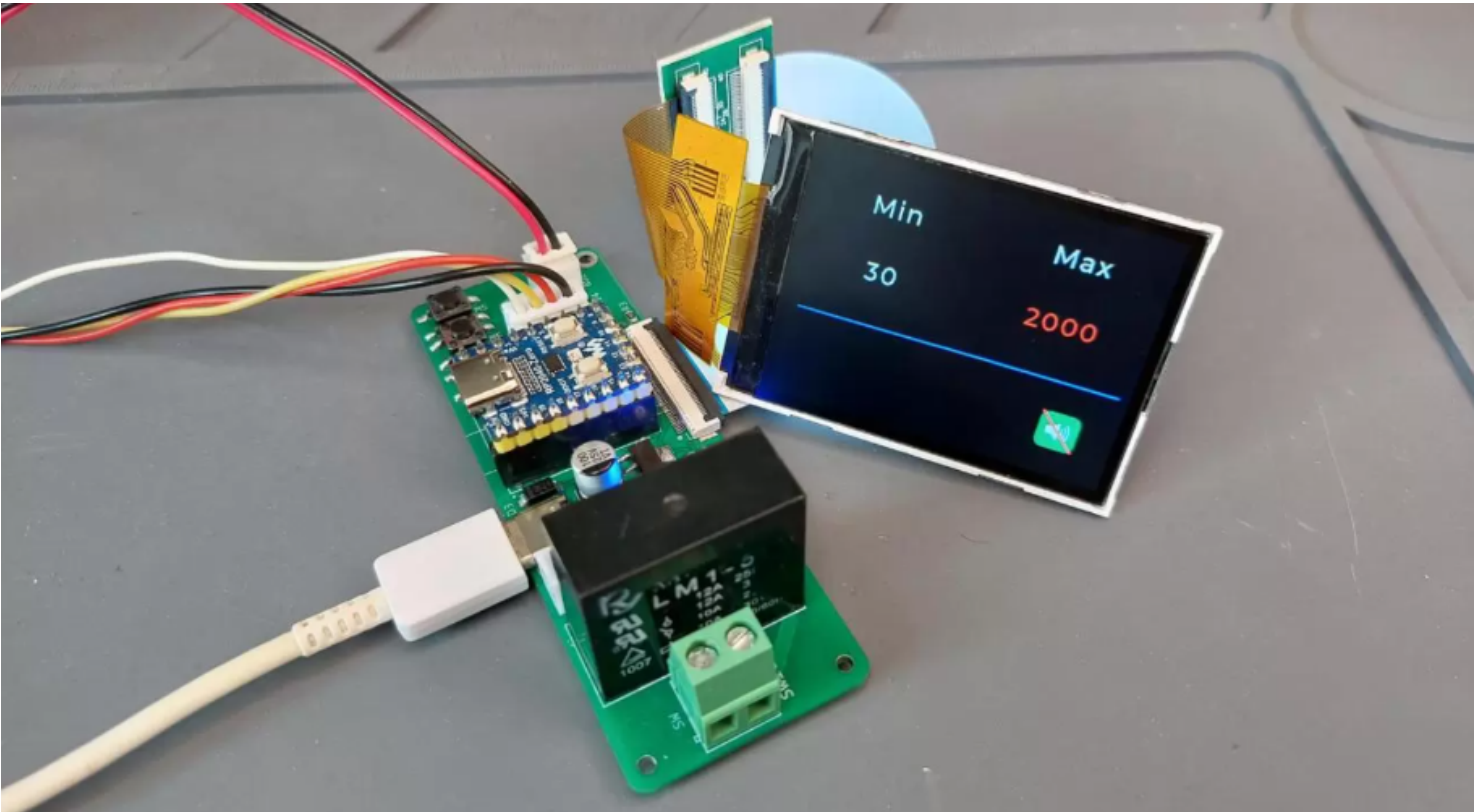


Figure 7: Working lidar sensor with display screen.

- Measuring range is TOO small, would need a different sensor

<https://www.digikey.com/en/htmldatasheets/production/8249724/0/0/1/sen-18009>

[6] "DigiKey Home," DigiKey, <https://www.digikey.com/> (accessed Sep. 19, 2024).

- Operating voltage is 4.75 to 5.25 V
- 3.3 I/O voltage
- Can measure distances between 5 cm to 10 m (32.8 ft)
- Has a beam divergence of 4.77 degrees
- I2C communication protocol
- 2.8x1x0.9 inches

Camera Sensor

<https://forums.raspberrypi.com/viewtopic.php?t=363255>

[7] Raspberry pi forums - index page, <https://forums.raspberrypi.com/viewtopic.php?t=373193> (accessed Sep. 19, 2024).

- Object recognition camera
- Works with raspberry pi
- Lots of processing
- Needed components
- Raspberry pi (4)
- Micro SD
- Power supply
- Raspberry pi visual camera model b2
- NEEDS extra computing power
- 2 videos that explain how it works + forum for questions present

Mechanical Sensor

[https://www.sola.at/en/products/measuring-wheels-](https://www.sola.at/en/products/measuring-wheels-c249309#:~:text=The%20measuring%20wheel%20%E2%80%93%20also%20known,to%20calculate%20the%20distance%20covered.)

[c249309#:~:text=The%20measuring%20wheel%20%E2%80%93%20also%20known,to%20calculate%20the%20distance%20covered.](https://www.sola.at/en/products/measuring-wheels-c249309#:~:text=The%20measuring%20wheel%20%E2%80%93%20also%20known,to%20calculate%20the%20distance%20covered.)

[8] "Measuring wheels – quick distance measuring," SOLA, [https://www.sola.at/en/products/measuring-wheels-](https://www.sola.at/en/products/measuring-wheels-c249309#:~:text=The%20measuring%20wheel%20%E2%80%93%20also%20known,to%20calculate%20the%20distance%20covered.)

[c249309#:~:text=The%20measuring%20wheel%20%E2%80%93%20also%20known,to%20calculate%20the%20distance%20covered.](https://www.sola.at/en/products/measuring-wheels-c249309#:~:text=The%20measuring%20wheel%20%E2%80%93%20also%20known,to%20calculate%20the%20distance%20covered.) (accessed Sep. 18,

- 2024).
- Look into how measuring wheels work
 - Consists of a wheel, counting mechanism, and guide rod
 - As the wheel moves, a mechanical counting mechanism calculates the number of rotations and then calculates distance from known wheel circumference
 - Counting mechanism is attached to measuring wheel and has a reset button

<https://patents.google.com/patent/US3151397A/en>

[9] P. W. King and R. H. Spurrell, "Measuring Wheels," Oct. 6, 1964

<https://patents.google.com/patent/US2557481A/en>

[10] J. D. Staples and J. J. Mccrory, "Measuring Wheels," Jun. 19, 1951

- Linked above are 2 different patents for the measuring wheel
- Can be used to evaluate most effective mechanical design

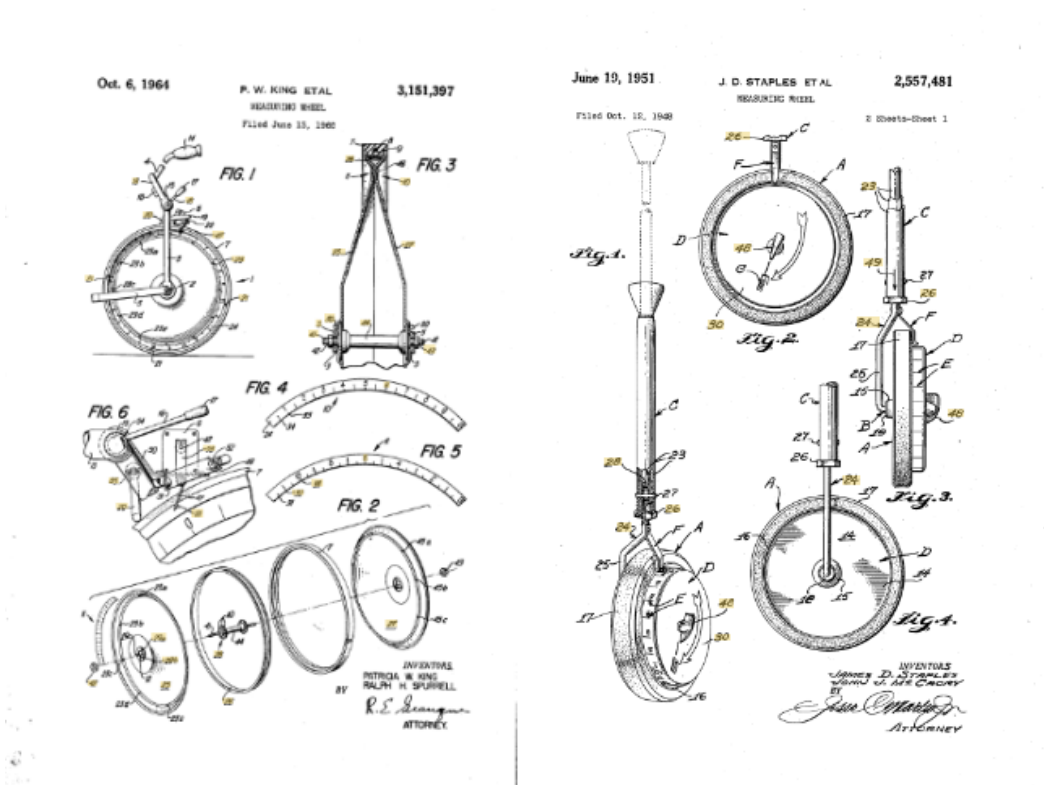


Figure 8: Sketches of patents for the measuring wheel

Conclusions/action items:

After reviewing various options to measure distance and speed I have come to a conclusion on which devices may work better than others. The gyroscope/accelerometer and hall effect sensor are both viable options since they are small and simple enough that the computing power required will be minimal. They are both generally accurate and precise as well, however last years project makes me want to really ensure that the hall effect would work. The lidar/ultrasonic sensor route is viable, however we have yet to see how large of a clinic he will be testing the patients in and the material of the walls. On top of this there is a range issue and a measuring angle dilemma that may pick up on objects that are not intended to be measured. The camera sensor, while interesting, will likely be expensive and require a lot of processing and work to be effective. To sum up, it is an over engineered idea for this project. The mechanical sensor is a viable and affordable option that would require little to no electrical components, and it is proven to work in a manner that we are looking to use it for. The top 3 design ideas out of this are to use the gyroscope/accelerometer, hall effect sensor, or a mechanical sensor. With the camera and ultrasonic/lidar being back-up options in case someone really believes one could work better.

In the process of looking I found a forum where people ask questions about raspberry pi:

<https://forum.core-electronics.com.au/>



2024/09/24 - Sensor Research

Title: Sensor Research for Preliminary Design Matrix

Date: 9/24/24

Content by: Jacob Parsons

Present: N/A

Goals: Find viable sensors on DigiKey or other websites

Content:

MPU-6050 Gyroscope/Accelerometer

https://www.digikey.com/en/products/detail/adafruit-industries-llc/3886/10709725?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20243063506_adg-_ad-__dev-c_ext-_prd-10709725_sig-Cj0KcQjwXsm3BhDrARIsAMtVz6MX1qVri0w7XrvD7ukBoOIEZHcVpYtDsbzYDscitySXL6yMYInMaAieqEALw_wcB&gad_source=1&gclid=Cj0KcQjwXsm3BhDrARIsAMtVz6MX1qVri0w7XrvD

[1] Adafruit distributor | DigiKey, <https://www.digikey.com/en/supplier-centers/adafruit> (accessed Sep. 26, 2024).

- Both 5 V and 3.3 V voltage supply options
 - Has manual for how to use included
 - Example code online (Raspberry Pi compatible)
 - 6 DOF accelerometer & gyroscope
 - 16 bit measurements
 - 3.3 Voltage output with up to 100 mA output current
 - I2C logic
 - \$12.95
 - See more in last week's research
-

DRV5013ADQLPGM Hall Effect

https://www.digikey.com/en/products/detail/texas-instruments/DRV5013ADQLPGM/5181338?utm_adgroup=Texas%20Instruments&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Supplier_Texas%20Instruments&utm_term=&utm_content=Texas%20Instru5181338_sig-Cj0KcQjwXsm3BhDrARIsAMtVz6PD_HDO_P0oGmSl03DPesBpY68lwtmjRtrTzAPZ9u8hhuheGPCUUaAhr5EALw_wcB&gad_source=1&gclid=Cj0KcQjwXsm3BhDrARIsAMtVz6PD_HDO_P0

[2] "DigiKey Home," DigiKey, <https://www.digikey.com/> (accessed Sep. 25, 2024).

- GND, Vout, and Vcc pin
- 2.8-38 V power input voltage (states to bypass this pin to GND pin with a 0.01 uF (min) ceramic capacitor rated for Vcc
- Output pin Voltage is -0.5-40 V, 100 mA current supply
- See previous notes under competing designs research for distance and speed sensors for code how it works
- Bop and Brp sensitivity options

\$0.62

U084 Hall Effect

https://www.digikey.com/en/products/detail/m5stack-technology-co.-,ltd./U084/13148784?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=cmp-20243063506_Cj0KcQjwXsm3BhDrARIsAMtVz6NwcNhF0rLsFLrPXgWM-E9nRcdJ0VdNGaV0YVYVwWTrLAowuF_jiH0aAoC4EALw_wcB&gad_source=1&gclid=Cj0KcQjwXsm3BhDrARIsAMtVz6NwcNhF0rLsFLrPXgWM-E9nRcdJ0VdNGaV0YVYVwWTrLAowuF_jiH0aAoC4EALw_wcB

[3] "M5Stack distributor | DigiKey Electronics, <https://www.digikey.com/en/supplier-centers/m5stack> (accessed Sep. 26, 2024).

- Has an Arduino example code
 - Comes with a magnet
 - GROVE cable
 - Not much information provided
 - 24x32x8 mm
 - \$5.95
-

DRV5023BIQLPGM Hall Effect

[https://www.digikey.com/en/products/detail/rochester-electronics,-llc/DRV5023BIQLPGM/13506615?](https://www.digikey.com/en/products/detail/rochester-electronics,-llc/DRV5023BIQLPGM/13506615?utm_adgroup=Sensors%2C%20Transducers&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_DK%2BSupplier_Rochester&utm_term=&utm_content=Sensors%2C%20Tran:539598865099_pla-354083421525_dev-c_ext-_prd-13506615_sig-Cj0KcQjwXsm3BhDrARisAMtVz6N-yy4UZp4uwDTAUtrqTXglxUPhOf2ASsthXy9JFdcGYB1i7nG43XsaAmJwEALw_wcB&gacyy4UZp4uwDTAUtrqTXglxUPhOf2ASsthXy9JFdcGYB1i7nG43XsaAmJwEALw_wcB)

[utm_adgroup=Sensors%2C%20Transducers&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_DK%2BSupplier_Rochester&utm_term=&utm_content=Sensors%2C%20Tran:539598865099_pla-354083421525_dev-c_ext-_prd-13506615_sig-Cj0KcQjwXsm3BhDrARisAMtVz6N-yy4UZp4uwDTAUtrqTXglxUPhOf2ASsthXy9JFdcGYB1i7nG43XsaAmJwEALw_wcB&gacyy4UZp4uwDTAUtrqTXglxUPhOf2ASsthXy9JFdcGYB1i7nG43XsaAmJwEALw_wcB](https://www.digikey.com/en/products/detail/rochester-electronics,-llc/DRV5023BIQLPGM/13506615?utm_adgroup=Sensors%2C%20Transducers&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_DK%2BSupplier_Rochester&utm_term=&utm_content=Sensors%2C%20Tran:539598865099_pla-354083421525_dev-c_ext-_prd-13506615_sig-Cj0KcQjwXsm3BhDrARisAMtVz6N-yy4UZp4uwDTAUtrqTXglxUPhOf2ASsthXy9JFdcGYB1i7nG43XsaAmJwEALw_wcB&gacyy4UZp4uwDTAUtrqTXglxUPhOf2ASsthXy9JFdcGYB1i7nG43XsaAmJwEALw_wcB)

[4] "DigiKey Home," DigiKey, <https://www.digikey.com/> (accessed Sep. 25, 2024).

- \$0.44
 - Bop and Brp sensitivity options
 - 2.5-38 V input range
 - Similar setup to 1st hall effect sensor
-

AMT132S-V Rotary Encoder

<https://www.digikey.com/en/products/detail/same-sky/AMT132S-V/10269185>

[5] Amt132s-v cui devices | sensors, transducers, <https://www.digikey.com/en/products/detail/cui-devices/AMT132S-V/10269185> (accessed Sep. 26, 2024).

- \$39.31
 - Modular, as in rotary shaft size can change
 - 4.5-5.5 V supply
 - 200 ms start up time
 - 0.2 degree accuracy
 - Serial UART protocol
 - Diameter sizing includes: 9mm, 3/8 in, 10mm, 11mm, 12mm, 1/2in, 13mm, 14mm
 - Includes step by step assembly
-



2024/09/26 - Finalized Sensors

Jacob Parsons - Nov 07, 2024, 1:49 PM CST

Title: Design Winning Sensor Research

Date: 9/26/24

Content by: Jacob Parsons

Present: N/A

Goals: Find some accelerometers and load cells

Content:

MPU-6050 Accelerometer

<https://www.electronicwings.com/raspberry-pi/mpu6050-accelerometergyroscope-interfacing-with-raspberry-pi>

<https://www.youtube.com/watch?v=nGYZChwjiMo>

[1] "MPU6050 (accelerometer+gyroscope) interfacing with Raspberry Pi," ..., <https://www.electronicwings.com/raspberry-pi/mpu6050-accelerometergyroscope-interfacing-with-raspberry-pi> (accessed Sep. 18, 2024).

- Use of the MPU6050 sensor module (6 axis motion tracking device)
- 3-axis gyroscope, 3-axis accelerometer, digital motion processor, and a temperature sensor
- Can accept inputs from other sensors, if a 3-axis magnetometer or pressure sensor is added in conjunction it can provide a complete 9-axis motion fusion output
- It can communicate with a microcontroller using I2C communication protocol
- XYZ axis readings for both the gyroscope and accelerometer: gyroscope readings are in degrees per second and accelerometer are in g unit
- Power supply range from 2.375 V to 3.46 V
- \$13 on Digikey
- 1 x 0.9 in (25.4 x 22.86 mm)

ADXL345 Accelerometer

[https://www.digikey.com/en/products/detail/adafruit-industries-llc/1231/4990764?](https://www.digikey.com/en/products/detail/adafruit-industries-llc/1231/4990764?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-20243063506_adg-_ad-__dev-c_ext-_prd-4990764_sig-Cj0KCQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB&gad_source=1&gclid=Cj0KCQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB)

[utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-20243063506_adg-_ad-__dev-c_ext-_prd-4990764_sig-Cj0KCQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB&gad_source=1&gclid=Cj0KCQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB](https://www.digikey.com/en/products/detail/adafruit-industries-llc/1231/4990764?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-20243063506_adg-_ad-__dev-c_ext-_prd-4990764_sig-Cj0KCQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB&gad_source=1&gclid=Cj0KCQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB)

- 1 x .75 inches (25.4 x 19.05 mm)
- Can sense up to 16 g's (within range)
- 3.3 or 5V voltage supply
- I2C, serial, SPI communication protocols
- \$17.50 on Digikey
- Full Python code provided online
- 3.3 V output
- Requires calibration
- Lower range gives more resolution for slower movements (likely us)
- Very similar to MPU-6050 from what I could find (slightly pricier)

SparkFun Load Cell (last semester's selection)

<https://www.sparkfun.com/products/10245>

- \$4.50
- Measure up to 110 lbs (50kg)
- 1.34x1.34 inches (34x34mm)
- Explanation of setup and use provided
- Simple load cell that is known to work since previous semester used it

SEN-13329 Load Cell

[https://www.digikey.com/en/products/detail/sparkfun-electronics/SEN-13329/7393715?](https://www.digikey.com/en/products/detail/sparkfun-electronics/SEN-13329/7393715?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-20243063506_adg-_ad-__dev-c_ext-_prd-7393715_sig-Cj0KCQjwr9m3BhDHARIsANut04ZOFnuMiWtL8VkPT8vLInFaQtYpvhXVvpA2AA-zqXubzbLyOCrxQN8aAgy3EALw_wcB&gad_source=1&gclid=Cj0KCQjwr9m3BhDHARIsANut04ZOFnuMiWtL8VkPT8vLInFaQtYpvhXVvpA2AA-zqXubzbLyOCrxQN8aAgy3EALw_wcB)

[utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-20243063506_adg-_ad-__dev-c_ext-_prd-7393715_sig-Cj0KCQjwr9m3BhDHARIsANut04ZOFnuMiWtL8VkPT8vLInFaQtYpvhXVvpA2AA-zqXubzbLyOCrxQN8aAgy3EALw_wcB&gad_source=1&gclid=Cj0KCQjwr9m3BhDHARIsANut04ZOFnuMiWtL8VkPT8vLInFaQtYpvhXVvpA2AA-zqXubzbLyOCrxQN8aAgy3EALw_wcB](https://www.digikey.com/en/products/detail/sparkfun-electronics/SEN-13329/7393715?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-20243063506_adg-_ad-__dev-c_ext-_prd-7393715_sig-Cj0KCQjwr9m3BhDHARIsANut04ZOFnuMiWtL8VkPT8vLInFaQtYpvhXVvpA2AA-zqXubzbLyOCrxQN8aAgy3EALw_wcB&gad_source=1&gclid=Cj0KCQjwr9m3BhDHARIsANut04ZOFnuMiWtL8VkPT8vLInFaQtYpvhXVvpA2AA-zqXubzbLyOCrxQN8aAgy3EALw_wcB)

- \$9.69
- 200 kg max (440 lbs)
- 80x12.7x12.7 mm (3.15x0.5x0.5)
- Bar shaped (not a circular disc)
- 5-10V power supply
- Potential option, however unlikely to be applicable for our design



2024/10/24 - OLED Display Research

Jacob Parsons - Nov 08, 2024, 12:18 PM CST

Title: OLED Display Research

Date: 10/24/24

Content by: Jacob Parsons

Present: N/A

Goals: Find an affordable OLED display that works with the pico

Content:

[SSD1306 OLED Display](#)

<https://www.instructables.com/How-to-Use-an-OLED-Display-With-Raspberry-Pi-Pico/>

https://www.amazon.com/dp/B06XRBYJR8/ref=twister_B076DYCWC8?_encoding=UTF8&th=1

- I2C and SPI communication protocols

- 4 pins

- \$6.99

- 0.96", 128x64 bit display

- Tutorials provided for code

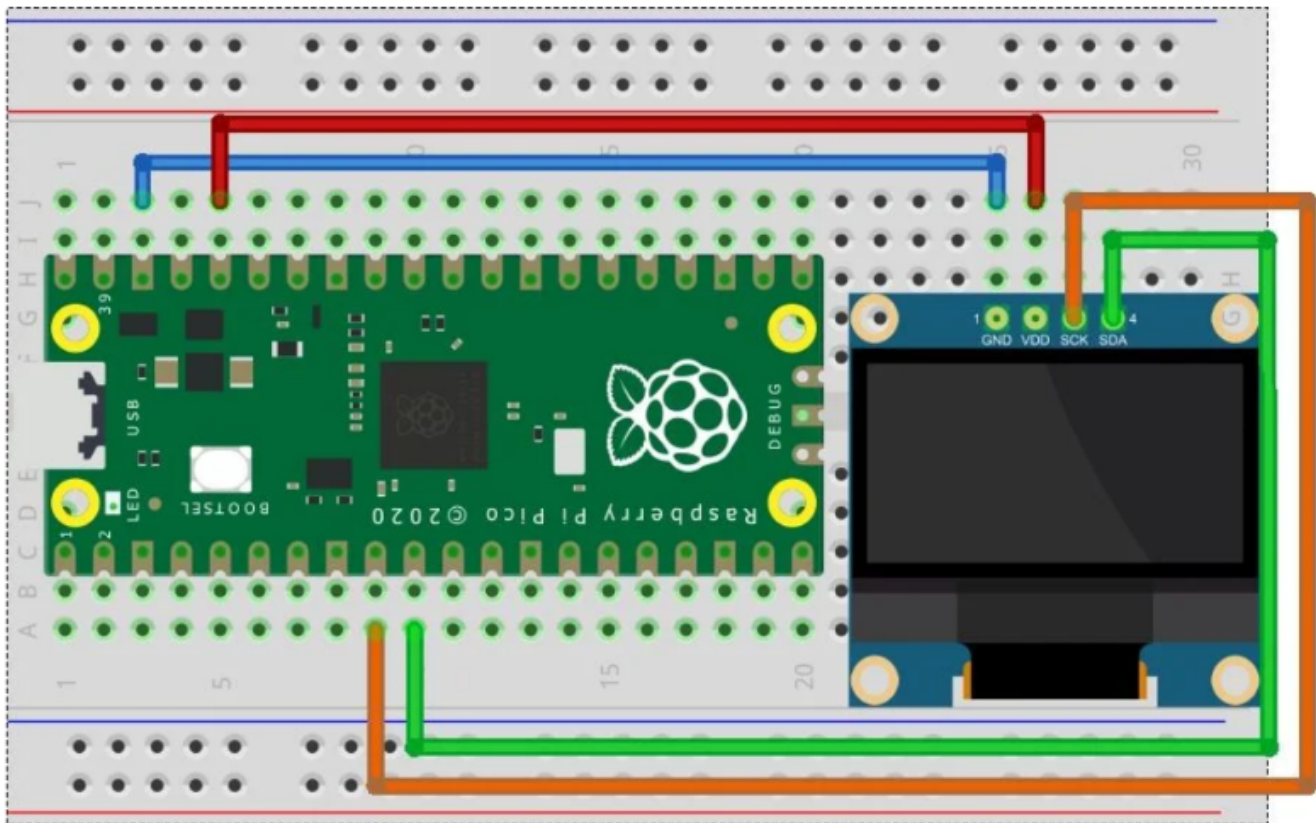


Figure 1: Simple pinout of OLED display with raspberry pi pico.

[Forum asking about larger sizes](#)

<https://forums.raspberrypi.com/viewtopic.php?t=334502>

- Use this when looking for potential larger sizes

SSD1322 OLED Display.

<https://www.amazon.com/display-screen-interface-SSD1322-monochrome/dp/B0C73WCJQ9?th=1>

<https://www.hpinfotech.ro/SSD1322.pdf>

- \$36.77

- Requires both a 3.3V power supply and a 10-20 V power supply

- SPI only, no I2C (4 wire SPI)

Long SSD1306 OLED Display.

https://www.amazon.com/dp/B0925SSKHB?ref=ppx_yo2ov_dt_b_fed_asin_title&th=1

- Purchased pack of 2 for this.

Conclusions/action items:

The team intends to purchase the smaller one. This will then be used in conjunction with the rpi pico and a 3D housing chamber will be prototyped.



2024/10/24 - Power Supply Set Up

Jacob Parsons - Oct 24, 2024, 6:08 PM CDT

Title: Power Supply Set Up

Date: 10/24/24

Content by: Jacob Parsons

Present: Jacob Parsons

Goals: Understand how a battery pack breakout board, voltage regulator, and the rest of our circuit work together.

Content:

[Chat GPT Help](#)

Yes, you can definitely use a rechargeable battery solution! One popular option is using a **LiPo (Lithium Polymer)** or **Li-ion (Lithium-Ion)** battery pack. These batteries are lightweight, compact, and rechargeable, making them great for powering projects like your Raspberry Pi Pico. Here's how you can set it up:

Components for a Rechargeable Setup:

1. LiPo/Li-ion Battery:

- These batteries come in various capacities and voltages (e.g., 3.7V, 7.4V). Choose one that matches the voltage requirements of your components or one that can be regulated down to the required voltage.

2. Battery Pack Breakout Board with Charging Circuit:

- Look for a breakout board designed for LiPo/Li-ion batteries, often called a **LiPo charger module** (e.g., TP4056 module). These boards allow you to charge the battery through a USB connection and provide outputs for powering your devices.

3. Voltage Regulator:

- If the battery voltage doesn't match what your components need, use a voltage regulator (like a buck converter) to step it down or up to the required voltage (e.g., 3.3V or 5V).

How to Set It Up:

1. Connect the LiPo Battery to the Charger Module:

- Plug the battery into the connector on the charger module. This module will manage charging when you connect it to a power source (like a USB cable).

2. Connect the Output of the Charger Module to the Voltage Regulator:

- The charger module provides power from the battery, but if the voltage is too high or low for your Raspberry Pi Pico, connect the output to a voltage regulator.
- Adjust the voltage regulator to provide the correct output voltage (e.g., 3.3V or 5V).

3. Connect the Regulated Output to Your Device:

- Connect the output of the voltage regulator to your device's power input (e.g., 3.3V input on the Raspberry Pi Pico) and connect the ground properly.

Advantages:

- **Rechargeable:** You can recharge the battery by plugging in the charger module to a USB power source.
- **Portable and Lightweight:** LiPo/Li-ion batteries are compact, making them suitable for mobile or compact setups.
- **Consistent Power Supply:** With the right voltage regulator, you ensure a steady, safe power supply to your components.

This setup offers a rechargeable and reliable solution without relying on standard AA or AAA batteries.

- From block diagram:

1. LiPo Battery (Lithium polymer/ lithium ion) will be plugged into charger module

2. The charger module output will be delivered to the voltage regulator.

Q1: Do we need multiple voltage regulators? Or do we need a voltage regulator with multiple outputs? Or both?

a. Here we will regulate the voltage and drop it if need be to the intended device(s)

3. Connect the voltage regulator to devices

- Raspberry pi pico

- OLED display?

- Load cells

- ADXL345?

[TP4056 LiPo charger module](#)

https://www.amazon.com/Charging-Lithium-Battery-Charger-Protection/dp/B08X6G26Q8/ref=asc_df_B08X6G26Q8/?tag=hyprod-20&linkCode=df0&hvadid=692875362841&hvpos=&hvnetw=g&hvrand=6563758511579974993&hvptwo=&hvqmt=&hvdev=c&hvdvcmld=&hvllocint=&hvllocphy=9018943&hvtargid=pla-2281435178098&mcid=c7a299d8eac031228cc4047ed785e8b3&hvocijid=6563758511579974993-B08X6G26Q8-&hvexpln=73&th=1

- \$9.99 for 15, 5 V charging boards

- USB-C plug in

- Has "protection"

https://www.amazon.com/HiLetgo-Lithium-Charging-Protection-Functions/dp/B07PKND8KG/ref=asc_df_B07PKND8KG/?tag=hyprod-20&linkCode=df0&hvadid=692875362841&hvpos=&hvnetw=g&hvrnd=6563758511579974993&hvpon=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvllocint=&hvllocphy=9018943&hvtargid=pla-2281435178298&psc=1&mcid=582532d88b30334da0eb72382cf0d57a&hvocij=6563758511579974993-B07PKND8KG-&hvexpln=73

- Another one, 3 pieces for \$5.99

- What makes one better than the other?

5 V Voltage Regulator

<https://www.adafruit.com/product/2164>

- This converts 7-35 V inputs to 5 V outputs with 2% variation

- Can provide up to 1.5 A

- Purchase a heat sink?

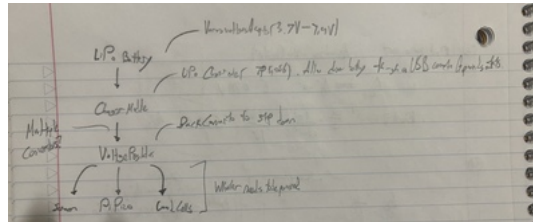
-\$0.75, really cheap

- Ground, input, and output pins - only 1 output (can power a line)

Conclusions/action items:

- Ask if the flowchart makes sense. Verify the products are good. After this purchase the products.

Jacob Parsons - Oct 24, 2024, 5:47 PM CDT



[Download](#)

IMG_4901.jpg (1.85 MB) Block diagram of physical components involved in power supply



2024/10/30 - Voltage Regulator

Title: Voltage Regulator

Date: 10/30/24

Content by: Jacob Parsons

Present: N/A

Goals: To find some voltage regulator options

Content:

[LM7812CT/NOPB](#)

[https://www.digikey.com/en/products/detail/texas-instruments/LM7812CT%2FNOPB/3901975?](https://www.digikey.com/en/products/detail/texas-instruments/LM7812CT%2FNOPB/3901975?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Medium%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-2022337Cj0KcQjwsoe5BhDiARIsAOXVoUuHlW5StamWoBGqHw4dT_m45MuMxBDMI5Wfdxz3A3_cq3dvTgUA_UaAn16EALw_wcB&gad_source=1&gclid=Cj0KcQjwsoe5BhDiARIsAOXVoUuHlW5Stai)

[utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Medium%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-2022337Cj0KcQjwsoe5BhDiARIsAOXVoUuHlW5StamWoBGqHw4dT_m45MuMxBDMI5Wfdxz3A3_cq3dvTgUA_UaAn16EALw_wcB&gad_source=1&gclid=Cj0KcQjwsoe5BhDiARIsAOXVoUuHlW5Stai](https://www.digikey.com/en/products/detail/texas-instruments/LM7812CT%2FNOPB/3901975?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Medium%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-2022337Cj0KcQjwsoe5BhDiARIsAOXVoUuHlW5StamWoBGqHw4dT_m45MuMxBDMI5Wfdxz3A3_cq3dvTgUA_UaAn16EALw_wcB&gad_source=1&gclid=Cj0KcQjwsoe5BhDiARIsAOXVoUuHlW5Stai)

- Output current up to 1.5 A

- 5, 12, 15 V options

- 3 pin; input, output, ground



2024/09/11 - Previous Semester Project

Jacob Parsons - Sep 13, 2024, 2:02 PM CDT

Title: Previous Semester Notes

Date: 9/11/24

Content by: Jacob Parsons

Present: N/A

Goals: To learn what the prior group did

Content:

- Requirements: Track distance traveled, gait speed, and applied pressure distribution on the walker
- Not really been done before on the market
- *How much weight?*
- *Height adjusting?*
- *Weight limit?*
- *Size Limit?*
- *Live feedback?*
- *Budget?*
- Hall effect sensor was used to detect magnets on the wheels: as wheel rotates Voltage will spike and speed and distance will be tracked.
 - NOT very accurate
- Force plates located at the foot/slider: more accurate (7% error ish)
- Use of Arduino

Ideas:

Force plate in wheel?

Force plate on hand grips?

Conclusions/action items:

- Questions and ideas are my action items for the talk with our client.



2024/10/02 - Speed Sensor Design Matrix Fixes

Jacob Parsons - Oct

Title: Speed Sensor Design Matrix Fixes

Date: 10/2/24

Content by: Jacob Parsons

Present: N/A

Goals: Re-evaluate the design matrix with specific and directly cite the references. This way the team will also know which one(s) to purchase to begin testing

Content:

Accelerometer

ADXL345

<https://www.analog.com/en/products/adxl345.html#part-details>

[https://www.digikey.com/en/products/detail/adafruit-industries-llc/1231/4990764?](https://www.digikey.com/en/products/detail/adafruit-industries-llc/1231/4990764?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-2024306350_prd-4990764_sig-Cj0KcQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB&gad_source=1&gclid=Cj0KcQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB)

[utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-2024306350_prd-4990764_sig-Cj0KcQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB&gad_source=1&gclid=Cj0KcQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB](https://www.digikey.com/en/products/detail/adafruit-industries-llc/1231/4990764?utm_adgroup=&utm_source=google&utm_medium=cpc&utm_campaign=PMax%20Shopping_Product_Low%20ROAS%20Categories&utm_term=&utm_content=&utm_id=go_cmp-2024306350_prd-4990764_sig-Cj0KcQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB&gad_source=1&gclid=Cj0KcQjwr9m3BhDHARIsANut04bPGPY5jbZcj8F7XtWGCQXBoB-frsDbSqwsqubekB6EU4K-cDJH8w8aAmDOEALw_wcB)

- Accuracy
 - 13 bit resolution
 - 3.9 mg/LSB (milli g per least significant bit), can measure less than 1 degree change
 - +/- 0.1 degrees alignment error
 - "1% error"
- Ease of Use
 - Calibrated in the factory, can be re-calibrated if need be
 - Instructions for calibration
- Price
 - \$17.50 on Digikey, cheaper options out there (\$3 for component only)
- Fabrication
 - Coding options available online (C/C++, python)
 - Options for individual component (PCB), or mini-board option
 - I2C, simple pinout
- Reusability
 - 3.3 V power supply will be sufficient
 - 23 microamp current
- Safety
 - Low power

MPU-6050

<https://www.electronicwings.com/raspberry-pi/mpu6050-accelerometergyroscope-interfacing-with-raspberry-pi>

<https://www.adafruit.com/product/3886>

- Accuracy
 - Both an accelerometer & gyroscope (IMU)
 - 6 axis motion tracking
 - 16 bit resolution accelerometer & gyroscope
 - 0.061 mg/LSB
- Ease of Use
 - Calibration required for higher precision
- Price
 - \$12.95 on Digikey, \$6.12 for component only
- Fabrication
 - Coding options available online (Python and C)
 - I2C communication, simple pinout
 - Options for PCB board from single component
- Reusability
 - 3.3 V power supply
 - 3.6 mA operating current for gyroscope, 500 uA operating current for accelerometer
- Safety
 - Low power

Rotary Encoder

AMT132S-V

<https://www.digikey.com/en/products/detail/same-sky/AMT132S-V/10269185>

- Accuracy
 - 0.2 degree accuracy

- 1 pulse per 360 degree rotation (adjustable)
- Ease of Use
 - 200 ms start up time
 -
- Price
 - \$53.17 on Digikey
- Fabrication
 - UART protocol
 - 8 data bits, 1 stop bit, least significant bit 1st
 - 115200 baud
 - Modular shaft diameters
 - Assembly procedure laid out
- Reusability
 - 5V power supply
 - 16 mA current consumption
- Safety
 - Irrelevant

Hall Effect Sensor

[https://www.digikey.com/en/products/detail/rochester-electronics,-llc/DRV5023BIQLPGM/13506615?](https://www.digikey.com/en/products/detail/rochester-electronics,-llc/DRV5023BIQLPGM/13506615?utm_adgroup=Sensors%2C%20Transducers&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_DK%2BSupplier_Rochester&utm_term=&utm_content=Sensors%2C%20Transducers&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_DK%2BSupplier_Rochester&utm_term=&utm_content=Sensors%2C%20Transducers)

[utm_adgroup=Sensors%2C%20Transducers&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_DK%2BSupplier_Rochester&utm_term=&utm_content=Sensors%2C%20Transducers](https://www.digikey.com/en/products/detail/rochester-electronics,-llc/DRV5023BIQLPGM/13506615?utm_adgroup=Sensors%2C%20Transducers&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_DK%2BSupplier_Rochester&utm_term=&utm_content=Sensors%2C%20Transducers)
[14247218536_adg-126150562316_ad-539598865099_pla-354083421525_dev-c_ext_prd-13506615_sig-Cj0KCQjwXsm3BhDrARisAMtVz6N-yy4UZp4uWDTAUrqTXglxUPhOf2ASstHxy9JFdcGYB1i7nG43XsaAmJwEALw_wcB&gad_source=1&gclid=Cj0KCQjwXsm3BhDrARisAMtVz6N-yy4UZp4uWDTAUrqTXglxUPhOf2ASstHxy9JFdcGYB1i7nG43XsaAmJwEALw_wcB](https://www.digikey.com/en/products/detail/rochester-electronics,-llc/DRV5023BIQLPGM/13506615?utm_adgroup=Sensors%2C%20Transducers&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_DK%2BSupplier_Rochester&utm_term=&utm_content=Sensors%2C%20Transducers)

- Accuracy
 - Multiple sensitivity options
 - 2 mT is lowest (milli-Tesla, measure of magnetic field) - fridge magnet is 5 mT at/near surface
- Ease of Use
 - No large magnetic things in operating area (shouldn't be an issue)
 -
- Price
 - \$0.44 per unit, will require purchase of components and magnets
- Fabrication
 - SOT-23 or TO-92 options (if we'd like to breadboard or PCB)
 - Only detects 1 pole
- Reusability
 - 2.8 to 38 V power supply (what?)
 - 3 mA supply current
- Safety
 - Irrelevant

Conclusions/faction items:

- Just an accelerometer or just a gyroscope will have issues. Gyroscopes measured angular movements and the accelerometer will pick up on little bumps and movements in all directions. A cool IMU.



2024/10/16 - Set Up for Accelerometer

James Waldenberger - Nov 07, 2024, 11:49 PM CST

Title: Set up for Accelerometer

Date: 10/16/24

Content by: Jacob Parsons

Present: N/A

Goals: Set up the accelerometer

Content:

<https://www.youtube.com/watch?v=ELYBqCB-S9E>

- Tutorial for set up of ADXL345

- Look at attached links for the callibration

<https://cdn-learn.adafruit.com/downloads/pdf/adxl345-digital-accelerometer.pdf>

- Datasheet

- Unable to recognize I2C device, idk why it wasn't reading

- Switched to SPI communication protocol

- Got output, but all 0, so something isn't being read.



2024/11/07 - Combined Display and Sensor Code

Jacob Parsons - Nov 07, 2024, 7:27 PM CST

Title: Combined Display and Sensor Code

Date: 11/7/24

Content by: Jacob Parsons

Present: N/A

Goals: Establish working code

Content:

```

from machine import Pin, I2C
import ustruct
import time
import ssd1306

# Constants for ADXL345
ADXL345_ADDRESS = 0x53
ADXL345_POWER_CTL = 0x2D
ADXL345_DATA_FORMAT = 0x31
ADXL345_DATAX0 = 0x32
G_CONVERSION = 0.168 # Adjust based on the sensitivity setting (0.0039)

# Initialize I2C for ADXL345 on pins 0 (SDA) and 1 (SCL)
i2c_adxl = I2C(0, scl=Pin(1), sda=Pin(0), freq=100000)

# Initialize I2C for OLED on pins 4 (SDA) and 5 (SCL)
i2c_oled = I2C(0, scl=Pin(5), sda=Pin(4), freq=100000)

# Initialize the OLED display
oled_width = 128
oled_height = 32
oled = ssd1306.SSD1306_I2C(oled_width, oled_height, i2c_oled)

# Initialize the ADXL345 accelerometer
def init_adxl345():
    i2c_adxl.writeto_mem(ADXL345_ADDRESS, ADXL345_POWER_CTL, bytearray([0x08])) # Enable measurement mode
    i2c_adxl.writeto_mem(ADXL345_ADDRESS, ADXL345_DATA_FORMAT, bytearray([0x02])) # Set data format

# Read acceleration data
def read_accel_data():
    data = i2c_adxl.readfrom_mem(ADXL345_ADDRESS, ADXL345_DATAX0, 6)
    x, y, z = ustruct.unpack('<3h', data)
    x = round(x * G_CONVERSION, 2)
    y = round(y * G_CONVERSION, 2)
    z = round(z * G_CONVERSION, 2)
    return x, y, z

# Calculate velocity and distance
def calculate_velocity_distance():
    velocity = 0
    distance = 0
    total_velocity = 0
    sample_count = 0
    start_time = time.ticks_ms()
    previous_time = start_time

    while switch.value(): # Active when the switch is on
        current_time = time.ticks_ms()
        delta_time = (current_time - previous_time) / 1000 # Convert to seconds

```

```

# Read acceleration
ax, ay, az = read_accel_data()

# Update velocity and distance
velocity += ax * delta_time
distance += velocity * delta_time + 0.5 * ax * (delta_time ** 2)

# Accumulate velocity for average calculation
total_velocity += abs(velocity)
sample_count += 1

previous_time = current_time
time.sleep(0.1) # Sampling rate

end_time = time.time()
elapsed_time = (end_time - start_time) / 1000 # Total time in seconds

# Calculate average velocity
average_velocity = total_velocity / sample_count if sample_count > 0 else 0
return average_velocity, distance, elapsed_time

# Display text on OLED
def display_message(message):
    oled.fill(0)
    oled.text(message, 0, 0)
    oled.show()

# Initialize components
init_adxl345()
switch = Pin(15, Pin.IN, Pin.PULL_DOWN)

# Main Program Loop
while True:
    if switch.value(): # If switch is active
        display_message("Running")
        avg_velocity, total_distance, total_time = calculate_velocity_distance()

        # Display results on OLED
        oled.fill(0)
        oled.text("Avg Vel: {:.2f} m/s".format(avg_velocity), 0, 0)
        oled.text("Distance: {:.2f} m".format(total_distance), 0, 10)
        oled.text("Time: {:.2f} s".format(total_time), 0, 20)
        oled.show()

        # Wait for the switch to be deactivated before resetting
        while switch.value():
            time.sleep(0.1)
    else:
        display_message("Waiting")
        time.sleep(0.5) # Debounce delay

```

Conclusions/action items:

Fix wiring problems: new raspberry pi?



2024/11/19 - Troubleshooting Code

Jacob Parsons - Nov 19, 2024, 7:29 PM CST

Title: Troubleshooting Code

Date: 11/19/24

Content by: Jacob Parsons

Present: Jacob

Goals: To work through the code and try to use both display modules at the same time

Content:

- I have learned that there are only 2 buses on the raspberry pi pico: hence there are only 2 unique devices that can be used at the same time
- So I can read information from the accelerometer and display it on one display, but in order to display something unique on the second display I will either need to purchase some sort of hardware, or "de-initialize" the accelerometer and set the second display to that bus.
- Another idea is that I change the code for the accelerometer and have it be SPI, that way I can use both I2C buses for the displays
- Or I can just not use the second display in general



2024/11/19 - ADXL345 Specs

Jacob Parsons - Nov 19, 2024, 8:01 PM CST

Title: ADXL345 Specs

Date: 11/19/24

Content by: Jacob

Present: Jacob

Goals: Figure out ADXL345 stuff

Content:

<https://www.analog.com/media/en/technical-documentation/data-sheets/adxl345.pdf>

1. ±2 g Range:

$$\text{Sensitivity} = 3.9 \text{ mg/LSB} = 0.0039 \text{ g/LSB}$$

$$\text{Conversion Factor} = 0.0039 \times 9.80665 = 0.038245935 \text{ m/s}^2/\text{LSB}$$

2. ±4 g Range:

$$\text{Sensitivity} = 7.8 \text{ mg/LSB} = 0.0078 \text{ g/LSB}$$

$$\text{Conversion Factor} = 0.0078 \times 9.80665 = 0.07649187 \text{ m/s}^2/\text{LSB}$$

3. ±8 g Range:

$$\text{Sensitivity} = 15.6 \text{ mg/LSB} = 0.0156 \text{ g/LSB}$$

$$\text{Conversion Factor} = 0.0156 \times 9.80665 = 0.15298374 \text{ m/s}^2/\text{LSB}$$

4. ±16 g Range:

$$\text{Sensitivity} = 31.2 \text{ mg/LSB} = 0.0312 \text{ g/LSB}$$

$$\text{Conversion Factor} = 0.0312 \times 9.80665 = 0.30596748 \text{ m/s}^2/\text{LSB}$$

Conclusions/action items:

Use this when coding.



2024/11/21 - Load Cell Basic Code

Jacob Parsons - Nov 21, 2024, 4:30 PM CST

Title: Load Cell Basic Code**Date:** 11/21/24**Content by:** Jacob Parsons**Present:** N/A**Goals:** To get the load cell code working**Content:***The code for just the load cell*

```
from machine import ADC, Pin
import time

# Initialize ADC on pin GP26 (ADC0)
adc = ADC(Pin(26)) # GP26 corresponds to ADC0

# Function to read and convert ADC value to voltage
def read_voltage(adc, vref=3.3):
    raw_value = adc.read_u16() # Read the raw 16-bit ADC value
    voltage = (raw_value / 65535) * vref # Convert to voltage
    return voltage

# Function to calculate weight from voltage using the linear relationship
def calculate_weight(voltage):
    # Apply the inverse of the equation: y = 0.0032 * x + 1.6709
    weight = (voltage - 1.6709) / 0.0032
    return weight

# Continuous loop to read voltage and calculate weight
try:
    while True:
        voltage = read_voltage(adc) # Measure voltage
        weight = calculate_weight(voltage) # Calculate weight
        print(f"Voltage: {voltage:.3f} V, Weight: {weight:.2f} lbs")
        time.sleep(0.5) # Delay for readability
except KeyboardInterrupt:
    print("Stopped reading.")
```

Conclusions/action items:

Implement this into the complete code.



2024/12/1 - Display for Poster Presentation

Jacob Parsons - Dec 01, 2024, 11:12 PM CST

Title: Load Cell for Poster

Date: 12/1/24

Content by: Jacob

Present: N/A

Goals: To have working code to display the average weight of the scale over a period of time

Content:

```

from machine import ADC, Pin, I2C
import ssd1306
import time

# Set up the ADC
adc = ADC(Pin(26)) # GP26 corresponds to ADC0

# Set up the switch
switch = Pin(15, Pin.IN, Pin.PULL_DOWN) # Ensure this matches your GPIO setup

# Function to read and convert ADC value to voltage
def read_voltage(adc, vref=3.3):
    raw_value = adc.read_u16() # Read the raw 16-bit ADC value
    voltage = (raw_value / 65535) * vref # Convert to voltage
    return voltage

# Function to calculate weight from voltage using the linear relationship
def calculate_weight(voltage):
    # Apply the inverse of the equation: y = 0.0032 * x + 1.6709
    weight = (voltage - 1.6709) / 0.0032
    return weight

# Set up the I2C connection for the OLED display
i2c = I2C(1, scl=Pin(3), sda=Pin(2), freq=100000)

# Initialize the OLED display
oled_width = 128
oled_height = 32
oled = ssd1306.SSD1306_I2C(oled_width, oled_height, i2c)

# Clear the OLED display
oled.fill(0)
oled.show()

# Main loop
try:
    while True:
        if switch.value(): # Start measuring when switch is "on"
            print("Switch is ON. Measuring weight...")
            measurements = [] # List to store weight measurements

            while switch.value(): # Continue measuring until switch turns off
                voltage = read_voltage(adc) # Measure voltage
                weight = calculate_weight(voltage) # Calculate weight
                measurements.append(weight) # Store weight measurement
                print(f"Voltage: {voltage:.3f} V, Weight: {weight:.2f} lbs")
                time.sleep(0.5) # Sampling delay

            # Once switch is turned off

```

```
print("Switch turned OFF. Calculating average weight...")
if measurements: # Ensure there are measurements to average
    average_weight = sum(measurements) / len(measurements)
else:
    average_weight = 0

# Display the average weight on the OLED for 10 seconds
oled.fill(0)
oled.text("Avg Weight:", 0, 0)
oled.text(f"{average_weight:.2f} lbs", 0, 10)
oled.show()
print(f"Average Weight: {average_weight:.2f} lbs displayed for 10 seconds.")

time.sleep(10) # Keep the average weight displayed for 10 seconds

# Clear the OLED display
oled.fill(0)
oled.show()
print("Display cleared.")
else:
    print("Waiting for the switch to turn ON...")
    time.sleep(0.5) # Polling delay
except KeyboardInterrupt:
    print("Program stopped.")
```

Conclusions/action items:

Integrate function accelerometer and 2nd display module code. Remember that there were issues with spi/i2c.



9/19/2024 Force Sensors

James Waldenberger - Dec 11, 2024, 9:46 PM CST

Title: Force Sensors

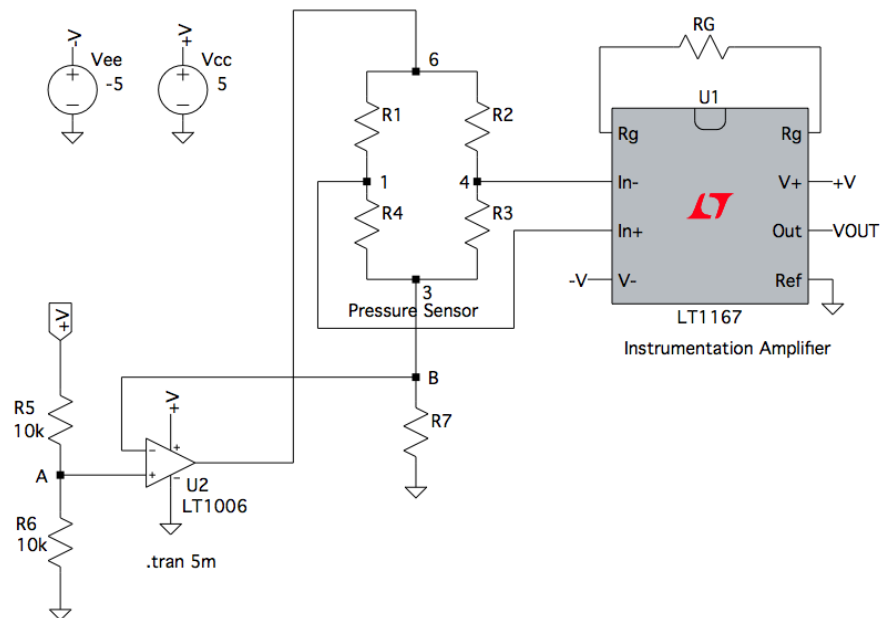
Date: 9/19/2024

Content by: James Waldenberger

Present: N/A

Goals: Get a grasp on the different types of sensors that can measure force for that aspect of the Smart Walker, and then figure out how to implement them into a circuit to accurately determine the force through the legs of the walker.

Content:



As Nimunkar mentioned last week, we have previously used a pressure sensor circuit in BME 310, so something similar to the above circuit might work for our design in 401. We would copy this setup and create the Wheatstone bridge with the load sensors.

<https://www.iqsdirectory.com/articles/load-cell/force-sensors.html>

This source goes into some detail about different types of force sensors, their applications, and some pros/cons about them. Listed here are the different types:

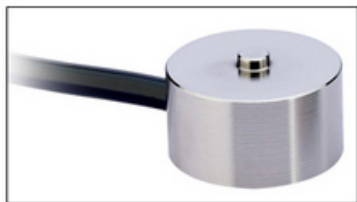
- Inductive sensor
- Capacitive sensor
- Magnetic sensor
- Piezoresistive sensor
- Strain gauge sensor

Out of all of these the most realistic and cost-effective option seems to be the strain gauge sensor. Be sure to ask Nimunkar his opinion on sensor option.

<https://www.800loadcel.com/white-papers/how-a-load-cell-works.html>

According to this source, load cells are strain gauges arranged on a body called a spring element and arranged into a Wheatstone bridge conformation, wherein an applied deformation results in a change in voltage that can be measured and be used in calculating force based on the calibration curve of the sensor. However,

price of these load cells according to Google seems to be pretty expensive? The picture below is similar to what the past team used for their force sensor, although they were slightly less accurate than expected.



Conclusions/action items:

Make a decision on the type of sensor we want to use moving forward.



9/19/2024 Movement Sensor

James Waldenberger - Sep 20, 2024, 12:07 PM CDT

Title: Movement Sensor

Date: 9/19/2024

Content by: James Waldenberger

Present: N/A

Goals: Start to understand the different methods of sensing distance traveled by the Smart Walker, and the working principle of the sensors used.

Content:

Accelerometer

<https://www.geeksforgeeks.org/accelerometer/>

There are multiple different working principles for accelerometers, but they all do the same thing on the big picture scale. Converts acceleration of the sensor into an electrical signal, that can be integrated once or twice to determine velocity and distance respectively.

With this integration however, it would mean that any error in the accelerometer's measurement would be intensified each time.

Optical sensor

Another method of measuring the distance and speed of the walker would be to have a camera or other optical sensor pointed towards the ground to detect high-contrast markings with known distance between them.

What kind of camera/sensor would be best?

Optical encoder

<https://www.encoder.com/article-what-is-an-optical-encoder>

Detects beams of light that slip through slits in a disk as it spins around, thus creating a sinusoidal-like waveform that can determine how many rotations have occurred. This could be used in our situation to measure total number of rotations of the wheels of the walker, which would in turn give us a decent measurement of distance traveled and speed.

This is similar to the method that the previous team used, so there could be some concern with the accuracy, but having a prebuilt sensor to do all the work seems like a better option than their magnets. However, if the wheels slip or are otherwise don't have perfect traction on the ground, then there would be some error in the measurement.

Conclusions/action items:

Figure out what type of sensing we want the walker to use to measure distance and speed.



9/26/2024 Specific Sensors

James Waldenberger - Sep 26, 2024, 11:29 PM CDT

Title: Specific Sensors

Date: 9/26/2024

Content by: James Waldenberger

Present: N/A

Goals: Research specific load cells and accelerometers to find one of each that fits our requirements for the project, and then get it ordered shortly

Content:

Specific Sensors

Accelerometers

ADXL345

- Datasheet: <https://www.analog.com/en/products/adxl345.html#part-details>
- Tutorial: <https://www.youtube.com/watch?v=NPTK0inTldw>
- Go to accelerometer for a lot of different Raspberry Pi projects
- About \$3, very small
- 2.0-3.6 volt supply
- 10-13 bit resolution
- There are a lot of “frills”, maybe **ADXL335** would be better suited:
<https://www.analog.com/en/products/adxl335.html#part-details>

LIS2DW12TR

- Website: https://estore.st.com/en/lis2dw12tr-cpn.html?srsltid=AfmBOoqJg4qEEzXO_JylqaPc3vK-esHqCixDkWbNHn2s2SI-SaCWi0PM
- Similar to the ADXL345: 1.6-3.6 volt supply and low power consumption, about \$3
- 16 bit resolution

MPU-6050

- Website: <https://www.adafruit.com/product/3886>
- 6 DoF sensor (gyroscopes included, is that needed?)
- Largest out of the three, but not too big
- Simple connections
- Most expensive at \$13

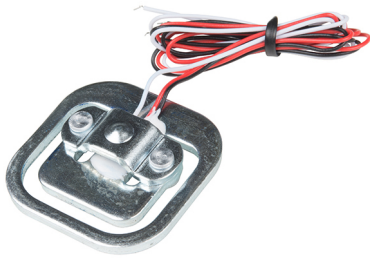
Load cells

Building a weight sensor example: <https://tutorials-raspberrypi.com/digital-raspberry-pi-scale-weight-sensor-hx711/>

Not a lot of very good ones? The decent ones are very expensive !!!

Generic Sparkfun Load Sensor (1 strain gauge)

- Website: <https://www.sparkfun.com/products/10245>
- 50kg weight (is that enough?)
- Requires 4 in a wheatstone bridge conformation with amplification
- Use-case: <https://learn.sparkfun.com/tutorials/getting-started-with-load-cells>
- Load cell amplifier: <https://www.sparkfun.com/products/13879>
- ~\$31 for all of the components

**Conclusions/action items:**

Combine research with team and decide on the sensors we want to use for the project, and order them shortly thereafter.



11/7/2024 Voltage Regulators

James Waldenberger - Dec 11, 2024, 5:25 PM CST

Title: Voltage Regulators

Date: 11/7/24

Content by: James Waldenberger

Present: N/A

Goals: Get an idea of how voltage regulators work and find some that will work for our specific case with the Smart Walker.

Content:

DC to DC buck converters:

<https://www.adafruit.com/product/2745#technical-details>

https://www.sparkfun.com/products/21337?gad_source=1&gclid=Cj0KCQiA57G5BhDUARIsACgCYnynKAaxXzPy-eel45isqqXlvXzx9E_8kEVkA5qnxSTJ5muNPAkSHnwaAtzKEALw_wcB

These are both 6 volt inputs and 3.3 volt outputs, there doesn't seem to be a 12-3.3 volt converter, what do we do?

Conclusions/action items:

Continue research into finding the proper voltage regulators for the project.



9/12/24 Previous Work

James Waldenberger - Sep 13, 2024, 1:40 PM CDT

Title: Previous Work

Date: 9/12/2024

Content by: James Waldenberger

Present: N/A

Goals: Analyze the previous team's work on the Smart Walker and determine what went well and what didn't.

Content:

SMART WALKER

NIHIL CHANDRA, AMARA MONSON, JOSEPH KOCH, BALJINDER SINGH, LANCE JOHNSON, JAKE MAISEL
CLIENT: MR. DAN KUTSCHERA
FACULTY ADVISOR: DR. CHRISTA WILLE
BME 200/300, DEC 8TH 2023

College of Engineering
UNIVERSITY OF WISCONSIN-MADISON

PROBLEM STATEMENT

- Within the neurorehabilitation process, clinicians or physical therapists often aim to reduce a patient's dependency upon walkers as they regain motor control.
- The client, Mr. Dan Kutschera, a physical therapist at the UW Rehabilitation Hospital, requests a sensorized smart walker that can track in real time a patient's distance traveled, gait speed, and applied pressure distribution on the walker.
- The data can be utilized for motivational purposes and to evaluate improvement and the efficacy of intervention strategies for insurance/medicare reasons.

FINAL DESIGN AND PROTOTYPE

Figure 3. iOS App User Interface, SwiftUI

Figure 4. Complete Foot Assembly with integrated load cells

Figure 5. Wheel with equally spaced magnets and hall effect sensor

Figure 6. Full view of walker with integrated sensors and microcontroller

Figure 7. Load Cell and Hall Effect Sensor Circuit, TinkerCad

Figure 8. Walker Foot Model, Side View
Figure created in Onshape

TESTING & RESULTS

- Near real-time values can be sent from walker and saved to Google Firebase & App when connected to WIFI
- 3 trials of varying known weights were applied to walker handles
- Performed a paired t-test
- $p(0.05) = 0.4182$, scale weights and walker weights not statistically different
- Average error: 7.97%
- $CI_{95}(0.95) = 8.39\%$

Figure 9: Scale Weight vs Walker Weight

Figure 10: Manual Speed vs Walker Speed

Figure 11 (left): Manual Speed vs Walker Speed

MOTIVATION AND BACKGROUND

- A number of neurological disorders and injuries (stroke, traumatic brain or spinal cord injury, ALS) can lead to physical impairment[1]
- Patients in physical therapy often use transitional devices(walkers) to practice various daily activities
- No clinically targeted "smart" walker on the market to measure various metrics such as gait speed, pressure, distance.[2]
- A sensorized smart walker would enhance the neurorehabilitation process by providing vital data for progress monitoring of a patient's motor independence.

Figure 1. Camino Smart Walker[2]
Motorized smart walker at \$2000 with many unneeded features for clinical use

DESIGN SPECIFICATIONS

- The Smart Walker should support 136 kg, be adjustable for varying patient heights, and have sensors accurate within 5% and read up to a speed of 3.0 mph(0.1 mph precision)
- Pressure sensors should measure up to 70kg (1 kg precision), and the design must be insensitive to sanitizing materials for safe use by multiple patients in a clinic setting.
- The walker used by our client for his patients has 2 wheels and 2 gliders.
- The design must avoid obstructing the patient's path and should not add more than 1.81 kg to the 3.63kg purchased walker.

Figure 2: Walker [3]
Similar model to that found in clients facility

CONCLUSION/FUTURE WORK

PDS Criteria: Speed Accuracy, Precision, Range

- Successfully measures speed to 0.1 m/s precision and within a range of 0 to 3 m/s
- Min error of 31%(5% target), significant refinement needed

Pressure Accuracy, Precision, Range

- Successfully measures up to 70kg weight to 0.1 kg precision.
- Average error of 7.97% is greater than 5% and not within accuracy tolerance
- More tuning/calibration of load cells needed

Walker weight and assembly

- Added weight is 0.23 kg(<1.81 kg target)
- Prototype cost \$283(<\$400 budget)
- Can reduce interference by raising wiring through walker legs
- Implement arduino for sending data and arduino for sensors for temporal accuracy

Manual Speed vs Walker Speed

- Strolled walker along 10ft path
- Min error = 31%
- Paired t-test
- $p(0.05) = 0.035$, statistically different

REFERENCES

[1] J. L. G. et al., "Smart Walker: A Smart Walker for Patients with Physical Disabilities," *IEEE Access*, vol. 10, no. 1, pp. 10212-10220, 2022.

[2] "Camino Smart Walker," *Camino Smart Walker*, accessed 10/12/2023.

[3] "Walker," *Walker*, accessed 10/12/2023.

The previous smart walker project was on the right track with what the client is looking for, but failed to deliver in terms of accuracy and lacked a proper housing for the electronic components. The previous team used a load cell to measure the force through the legs of the walker and a hall effect sensor to sense the rotation of the wheel and estimate the distance traveled, the latter of which was wildly inaccurate.

Pros

- Tailored to the user's needs very well and even incorporates an app that shows the user their biometrics during their walk in real-time
- Very simple circuits and mechanical components mean that this prototype is cheap compared to other options
- Their application of load cells, while slightly outside of their PDS range for error, showed promise for this specific application
- Could feasibly be modified to be an attachment to an existing walker rather than an entirely new walker, meaning an expanded market

Cons

- No housing for the electrical components

- Hall effect sensor and magnetic wheels did not really work for their intended purpose, likely meaning that a new approach is needed for this semester's project to work

Conclusions/action items:

Incorporate the pros into our design and try and find design solutions to the cons.



9/12/24 Competing Designs

James Waldenberger - Sep 13, 2024, 1:45 PM CDT

Title: Competing Designs

Date: 9/12/2024

Content by: James Waldenberger

Present: N/A

Goals: Look at designs for various smart walker type devices that are already on the market/patented and see what they have in common and what design decisions that we'll have to make in regards to sensors type and sensor location.

Content:

Camino Smart Walker

Search term: "smart walker"

Google

<https://caminomobility.com/>

More orientated to be a product than a device for medicine, however it does have some interesting features. Most of the "smart" parts of the walker are used for navigation, with built in boost and breaks, and sensors to help move the walker on an incline. The part most similar to our project is the integration of AI to track 22 different gait metrics (however it doesn't say what ones). That being said, there probably isn't much similarity between this product and our project because of the different use-cases. Also to note, something of this complexity is already costing around \$2,500.

Volaris Smart Rollator Walker

Search term: "smart walker"

Google

<https://xlentcare.com/product/volaris-smart-rollator-walker/>

Concerns itself heavily with the ease-of-use and convenience of the walker. Has some very good features that could be implemented if we were to make a walker from scratch for this project, although that doesn't seem to be the case.

Walker with anti-fall technology for elderly safety

Search term: "walker with sensors"

Google

<https://www.frontiersin.org/journals/neurorobotics/articles/10.3389/fnbot.2020.575889/full>

Slightly unwieldy walker packed chock-full of technology to help the elderly navigate while also protecting from a fall. It senses pressure from the grip of the user and determines whether or not a fall is predicted with that information via microcontroller. The pressure is measured by air pressure sensors that are within the sponge grip of the walker, so they can detect how much it is being squeezed. They also bring up the concern that a touch UI could be difficult for people who are severely limited with their movement to use, so we need to keep that in mind when designing buttons or controls for our walker.

Mobility assistance apparatus

Search term: "smart walker"

Google patents

[https://patents.google.com/patent/US20220211568A1/en?q=\(smart+walker\)&oq=smart+walker](https://patents.google.com/patent/US20220211568A1/en?q=(smart+walker)&oq=smart+walker)

Uses loading cells and strain gauges to determine the force through the walker's limbs, and this data, among other biometrics being derived from a number of different types of sensors, is output to the user to determine their health. The kinematics part of the biometrics is mainly being done by accelerometers and IMUs.

Instrumented mobility assistance device

Search term: "walker with sensor"

Google patents

[https://patents.google.com/patent/US7826983B2/en?q=\(walker+sensor\)&oq=walker+with+sensor](https://patents.google.com/patent/US7826983B2/en?q=(walker+sensor)&oq=walker+with+sensor)

Similar to some of the other walkers, this one uses sensors in the handle to measure the force transmitted through the user to the walker. The peaks and valleys of the output force vs. time graph are correlated to parts of the users gait, and can be used to make calculations to infer about the users gait speed, travel distance, and stability/balance when using the walker. The load cells used on the handle are commercially-available 6-DoF sensors.

Conclusions/action items:

This research has led me to have a couple of questions about the project. Namely, we need to decide on an interface that is accessible to people who have trouble moving, as a touch screen (and possibly buttons) could be too difficult to use. With force sensing, there seems to be two popular locations for the load cells/force sensors: The handle, or the legs of the walker.



11/15/24 Tong Lecture

James Waldenberger - Dec 11, 2024, 5:28 PM CST

Title: Tong Lecture

Date: 11/15/24

Content by: James Waldenberger

Present: N/A

Goals: Listen to the people at Tasso and glean any advice about a future in BME design.

Content:

- Billions of blood draws per year in the US, kind of a hassle to get blood drawn, and there are plenty of at-home companies getting started circa 2010 -> Found a company that can relieve some of the pain of making a blood test appointment by doing it at home.
- Funding opportunities can be obtained through SBIR grants.
- When trying to improve a product, it's important to know when to switch gears if something new/better comes along.
- When trying to sell a product, find the people that need your product and find someone who will champion your design process.
- Scaling up is important to consider, find a route for growth that's specific because you can't solve every problem with one device.
 - Quality is key for scaling up to keep customers happy.
- When you want to get approved by the FDA, keep in mind what the goal is and determine if class I, II, or III medical device testing is necessary because the testing can be very expensive.
 - Find someone who will be an aggressive regulatory person, instead of a conservative one.
 - Box checking
- Tasso created the Manufacturing area by using standalone cleanroom facilities to get some sanitation concerns out of the way.
- You can also outsource some manufacturing to get it done more quickly.

Conclusions/action items:

None.



9/12/24 Preliminary Design Ideas

James Waldenberger - Sep 13, 2024, 1:45 PM CDT

Title: Preliminary Design Ideas

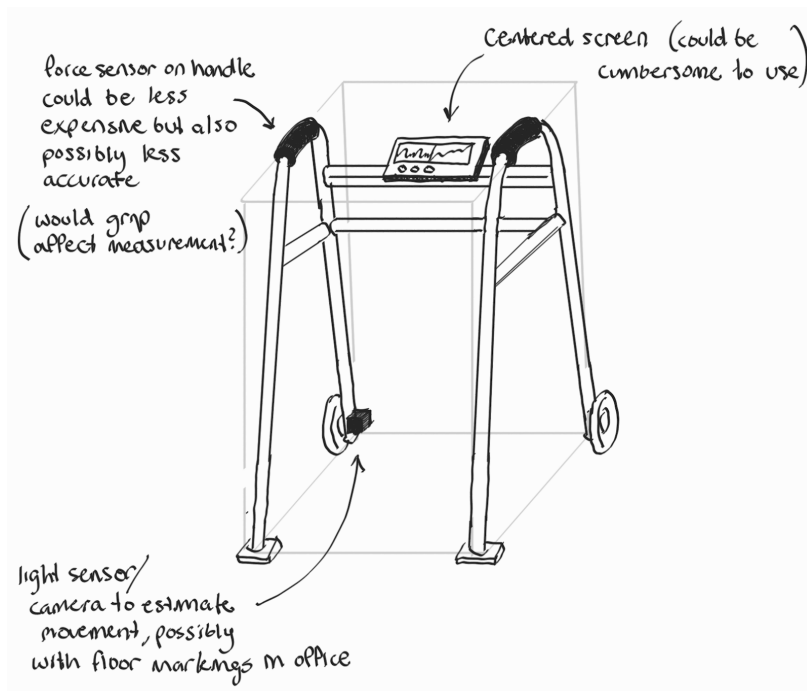
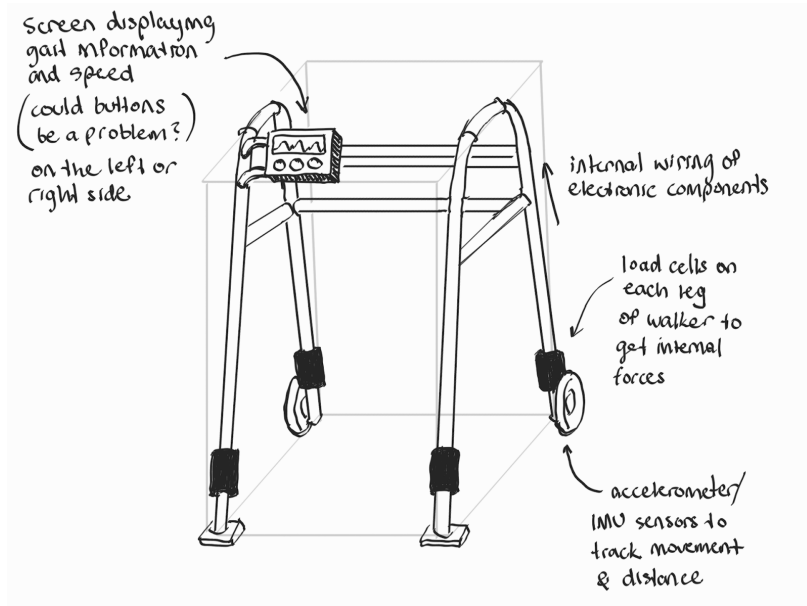
Date: 9/12/2024

Content by: James Waldenberger

Present: N/A

Goals: Present preliminary ideas through a couple of drawings to visualize different components the design.

Content:



Conclusions/action items:

Finalize design ideas and make an improved drawing of the design for the preliminary presentation.



10/16/24 Load Sensor Circuit

James Waldenberger - Oct 24, 2024, 11:17 PM CDT

Title: Load Sensor Circuit

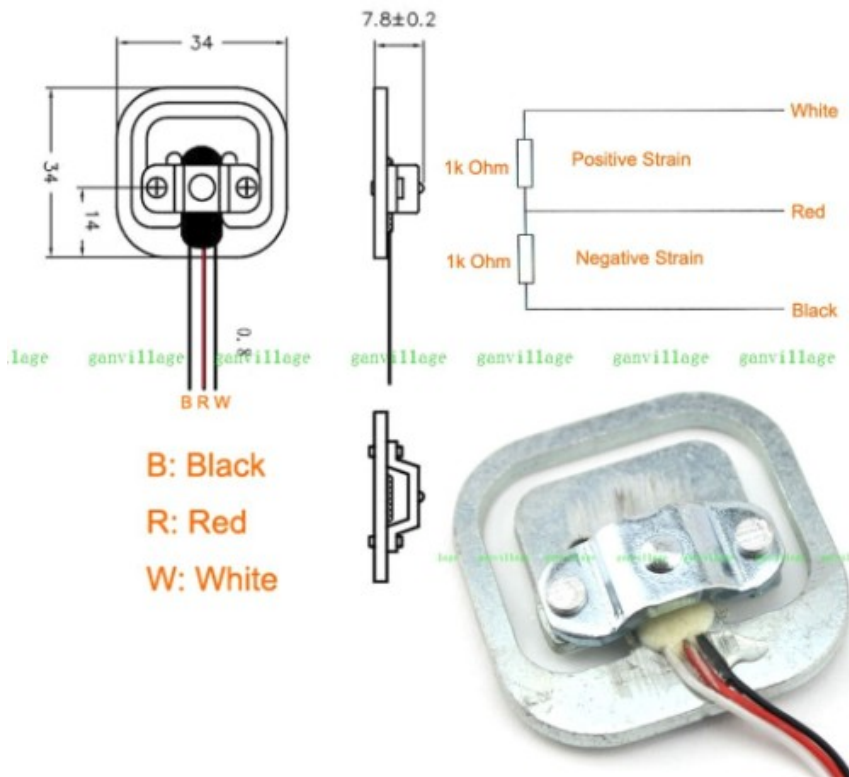
Date: 10/16/24

Content by: James Waldenberger

Present: N/A

Goals: Design a circuit for the load sensor to get force input and output readings from the Pi Pico.

Content:



Possibly a good resource: https://electronics.stackexchange.com/questions/102164/3-wire-load-cells-and-wheatstone-bridges-from-a-bathroom-scale#comment201017_102167

Gain Calculation:

According to datasheet, resistance can be 1000 ± 20 ohms on the input and output resistance of the load sensor

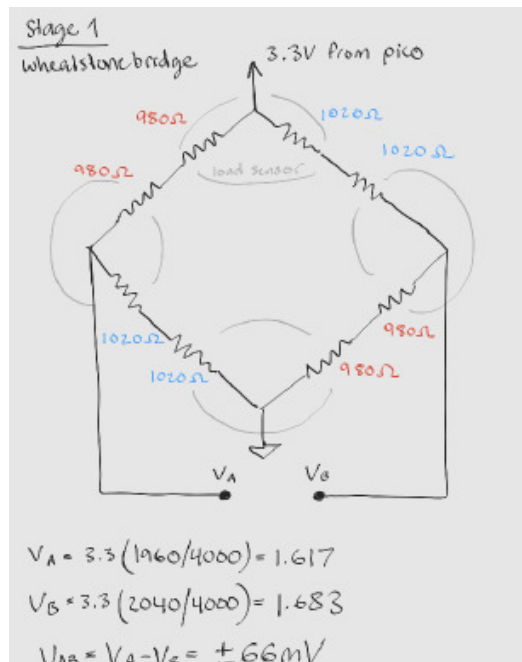
In a voltage divide with a 1kohm fixed resistor, this value will fluctuate by no more than 17mv in either direction $1.65 - 3.3(980/1980) = 0.0167V$ and $3.3(1020/2020) - 1.65 = 0.0163V$, meaning gain $g = 3.3/0.017 = 194.12 V/V$

However, voltage divider is not the only possible circuit setup. Here I will explore some options for the force measurement circuitry:

Conclusions/action items:

Finish building circuit and start calibrating load cells based on voltage increase/decrease from microcontroller input.

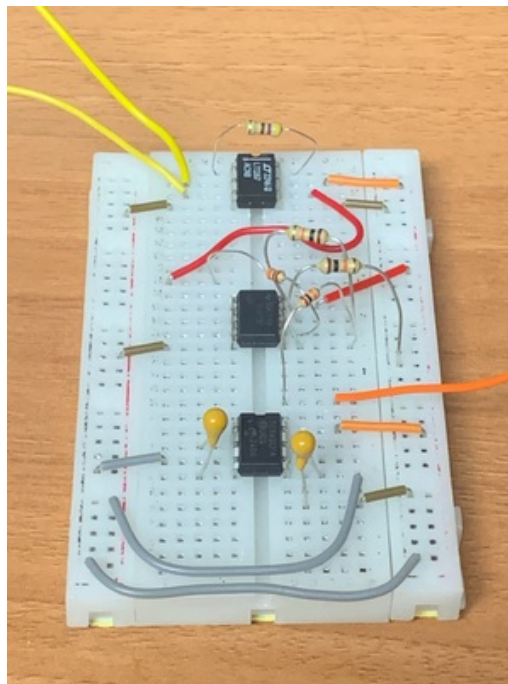
James Waldenberger - Oct 18, 2024, 10:55 AM CDT



[Download](#)

Load_Sensor_Circuit_diagram_241018_105414.pdf (2.52 MB)

James Waldenberger - Dec 11, 2024, 9:26 PM CST



[Download](#)

Breadboarded_Circuit_.jpg (157 kB)



10/24/24 Load Testing

James Waldenberger - Nov 11, 2024, 1:50 PM CST

Title: Load Testing

Date: 10/24/24

Content by: James Waldenberger

Present: N/A

Goals: Try out the load sensor circuit and see if it is functional. If so, then calibrate the circuit based on weight input to get a calibration curve that can be used to plot the voltage to force relationship.

Content:

Within Expectations

- Resistance between Wheatstone bridge terminals with no load = ~ 2 kOhm <- good because each load cell is approximately 2 kOhm, so $4k \parallel 4k = 2k\text{Ohm}$
- Voltage of each terminal of Wheatstone bridge with no load = 1.660-1.662 V (each one measured separately, yields similar voltage values)
- From 5 V Nucleo power, and 3.3 V Nucleo input into level shifter, there seems to be minimal noise, and the level shifter output is centered around 1.644 V (with 1.65 V expected)

Existing issues (to be fixed for show and tell)

- 25 mv difference from LT1920 output that decreases to zero if pressure is applied -- I had thought that the voltage difference should increase.
- Approximate 20 mv change in voltage from pressure to an individual load sensor, doesn't seem to change at all when multiple sensors have pressure applied.
- Fixed all wiring errors on breadboard. [10/24]
- Insecure connections.

Further Testing

LT1920 input with one load sensor (V+ to white, GND to black, red wire to non-inverting terminal) and 1k/1k voltage divider (middle to inverting terminal) gave an output voltage that INCREASED with an increase in pressure to the load sensor, meaning the white-to-red resistance decreases and the black-to-red resistance increases with pressure applied. This was consistent between all four load sensors. This means that the Wheatstone bridge should be between similar wires connecting each load sensor, as was drawn in the *Load Sensor Circuit* entry. That also means that the lack of voltage output change with pressure to the Wheatstone bridge was caused by something else, although Jacob and I hooked up the Wheatstone bridge to the circuit and it gave a +1V change when pressure was applied to all four load sensors (what is the reason behind this inconsistency? It's possible that I hooked something up wrong with my first test).

Conclusions/action items:

Fix existing issues in the circuit for show and tell.



11/7/24 Power Supply

James Waldenberger - Nov 14, 2024, 9:38 PM CST

Title: Power Supply

Date: 11/7/24

Content by: James Waldenberger

Present: N/A

Goals: Run some calculations to see what power supply will be needed for the circuitry.

Content:

Load Sensor Circuit

LT1920 = ± 18 V

TL072 = ± 20 V

TC962 = 3-18 V

Current draw of load sensor circuit including wheatstone bridge = ~ 16 mA

Microcontroller (<https://datasheets.raspberrypi.com/pico/pico-datasheet.pdf>)

Raspberry Pi Pico = 1.8-5.5 V

Average current draw at room temp = ~ 86.5 mA

SSD1306 OLED Display (<https://cdn-shop.adafruit.com/datasheets/SSD1306.pdf>)

Vdd [IC logic] = 1.65-3.30 V

Vcc [Panel Driving] = 7-15 V

Idd = 430 μ A

Icc = 50 μ A

Iseg [Segment Display] = 100 μ A (depends on contrast)

Iref = 12.5 μ A

ADXL345 (<https://www.analog.com/media/en/technical-documentation/data-sheets/adxl345.pdf>)

Supply voltage = 2.0-3.6 V

I/O voltage = 1.7-Vs V

12.5-3200 Hz in regular mode = 50-140 μ A

12.5-400 Hz in power saving mode = 34-90 μ A

- 12 V battery
- 3.3 V voltage regulator for microcontroller and accelerometer? OR will 5 V be necessary for the Raspberry Pi?

Update 11/14/2024

12V power bank

12V regulator - L7812CV

<https://www.digikey.com/en/products/detail/stmicroelectronics/L7812CV/585973>

Possibly would need a higher voltage power bank to use this. Need a 0.33uF and 0.1uF capacitor to hook up along with the chip to get a better output (see load regulation circuit on datasheet). Output would go to positive rail of breadboard, input from power bank.

12V to 5V DC to DC converter - 78SRH-5/2-C

<https://www.mouser.com/ProductDetail/Murata-Power-Solutions/78SRH-5-2-C/?qs=35WhQNrE6p2lJ6BniHrImQ%3D%3D>

2A output with 2% output voltage accuracy, 8-32Vdc input from the 12V regulator, would be used to drive Pico. How would you go from output wire to micro-USB? Or is there a place to power the Pico elsewhere?

Could also use another L7805 possibly (same as above).

3.3V regulator

Use regulated 3.3V output from the accelerometer, rated for ___ amps, goes to level shifter non-inverting terminal.

Conclusions/action items:

Get the circuit running with regulation and portable, rechargeable power supply.



11/7/24 Altium Schematic [Full Circuit]

James Waldenberger - Dec 11, 2024, 9:48 PM CST

Title: Altium Schematic [Full Circuit]

Date: 11/7/24

Content by: James Waldenberger

Present: N/A

Goals: Create a schematic for the full circuit including Raspberry Pi microcontroller and all other accessories.

Content:

List of components

- LT1167 instrumentation amp
- 480 ohm resistor
- 2x 10 kohm resistors
- 2x 20 kohm resistors
- TL072 op amp
- 2x 10 uF capacitors
- TC962CPA
- 4x Load sensors
- Raspberry Pi Pico microcontroller
- ADXL345 accelerometer
- 2x SSD1306 OLED display

Conclusions/action items:

Update when new components are added/existing components are tweaked.



11/19/24 Load Sensor Calibration For Poster Presentation

James Waldenberger - Nov 19, 2024, 5:45 PM CST

Title: Load Sensor Calibration For Poster Presentation

Date: 11/19/24

Content by: James Waldenberger

Present: N/A

Goals: Calibrate the load sensor circuit with a calibration curve to be used by the microcontroller during the poster presentation to display the weight placed on the platform based on the voltage input to the microcontroller.

Content (Also see Team activities -> Testing and Results -> Protocols -> Load Cell Calibration Curve Testing):

Weight (lbs)	Force (N)	Avg Vout (V)	Min Vout (V)	Max Vout (V)
0	0	1.665	1.64	1.69
15	66.75	1.730	1.71	1.75
30	133.49	1.775	1.76	1.79
45	200.24	1.820	1.80	1.84
60	266.98	1.860	1.85	1.87
75	333.73	1.915	1.90	1.93
90	400.48	1.955	1.94	1.97
100	444.97	1.980	1.96	2.00
125	556.22	2.075	2.05	2.10
150	667.46	2.165	2.14	2.19
175	778.70	2.240	2.22	2.26
200	889.95	2.320	2.30	2.34

With reversed leads gives:

Weight (lbs)	Force (N)	Avg Vout (V)	Min Vout (V)	Max Vout (V)
0	0	1.665	1.64	1.69
15	66.75	1.590	1.57	1.61
30	133.49	1.525	1.51	1.54
45	200.24	1.470	1.45	1.49

60	266.98	1.450	1.43	1.47
75	333.73	1.410	1.39	1.43
90	400.48	1.360	1.34	1.38
100	444.97	1.325	1.31	1.34
125	556.22	1.235	1.22	1.25
150	667.46	1.155	1.14	1.17
175	778.70	1.070	1.05	1.09
200	889.95	0.990	0.970	1.01

Testing done without non-inverting amplifier stage (just instrumentation amp and level shifter which has about 50 V/V of gain total)

Other notes from testing:

- Slightly noisy signal, as apparent in the difference between max and min values in the graph above. However, this was done without voltage regulation from the 12V power and 3.3V power, so improvements could be seen by implementing some changes outline in my power supply notes
- Level shifter output was spot on at 1.64-1.69V (1.65V expected), non-inverting amp stage messed with this value and brought it down to about 1.0 V (is a voltage buffer necessary if that were to be implemented?)
- Could increase gain leaving the circuit as-is, OR could increase gain and remove level shifter (so long as the leads give a positive voltage based on instrumentation amp output), which would effectively double the gain. HOWEVER, R_g for the LT1920 is already practically as low as possible, this would require another amplification stage.

Conclusions/action items:

Try to improve the noisiness of the signal and the total gain of the signal for the finished product next semester.



2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity. subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.



Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: