BUDGET CLIP-ON POSTURE CHECKER

ECE 445 Final Report - FALL 2025

Team #33

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1 Introduction

1.1 Problem

More than 80 percent of jobs in the United States involve mostly sedentary activities, resulting in long sitting hours [1]. When one sits for extended periods of time, it is quite common for their posture to change, with that change often being slouching, which can result in chronic back and shoulder pain, fatigue, and respiratory issues such as trouble breathing. For example, sitting for extended periods of time while playing video games on a computer can lead to a slouched posture. Current solutions for this issue involve a tight brace, which can be restrictive and uncomfortable for users [2]. Some solutions are also very impractical, such as one that uses a camera that the user needs to sit in front of in order to track their posture [3].

1.2 Solution

The Clip-On Posture Checker is a small wearable clip-on device that monitors your posture and provides real-time feedback via a vibration motor, LED, or buzzer to indicate when your posture has deviated too far from the desired position. The device not only clips onto the user's shirt but also has shoulder straps for additional security. There will be a calibration feature in the form of a button that, when held down, sets the current position of the sensors as the "desired position."

1.3 Visual Aid

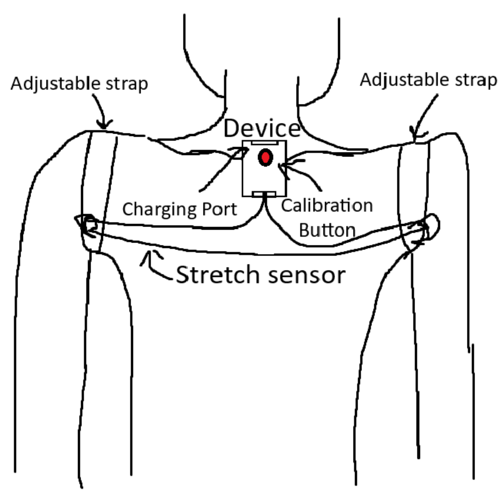


Figure 1: Visual of what the Budget Clip-On Posture Checker will look like.

The device includes a calibration button (red circle in Figure 1) that lets the user set their preferred posture. After a brief ~2-second calibration, the internal sensors continuously check for deviations. Adjustable straps were removed to prioritize technical requirements, and the enclosure design has changed due to PCB updates. The stretch sensor provides an additional measure of posture by detecting shoulder slouching.

1.4 High-Level Requirements

1. The device shall detect the user's torso tilt angle relative to the calibrated upright posture with an accuracy of at least ±5°.
2. The device shall provide real-time feedback (vibration or LED) within 3 seconds of when posture deviation exceeds a threshold angle (e.g., 15° forward lean).
3. The stretch sensor attached to the clip-on device will act as a secondary point of measurement to ensure accurate measurement of posture deviation from calibration. It will detect elongation of the shoulders corresponding to poor posture with ± 1 cm change in length, to help distinguish between breathing and posture deviations.

2 Design

2.1 Block Diagram

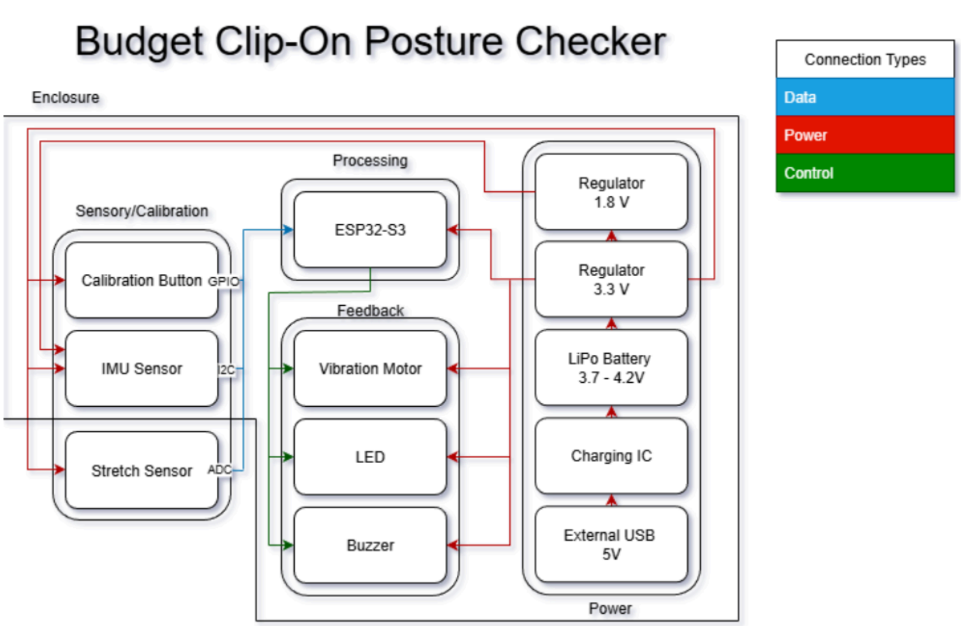


Figure 2: Block Diagram

2.2 Functional Overview & Requirements

2.2.1 Sensory Subsystem

The Sensory Subsystem measures the user's body orientation and back curvature relative to a calibrated posture. It includes an IMU (ICM-20948), a resistive stretch sensor, and a calibration button, and sends all data to the Processing Subsystem. The ICM-20948 provides accelerometer and gyroscope data for detecting orientation changes. The 12/14" stretch sensor, read through a simple voltage-divider circuit, captures back curvature and slouching by measuring resistance changes. The user wears adjustable shoulder straps with anchor points for the sensor(in our initial design). The calibration button records the user's preferred posture and serves as the reference for evaluating deviation.

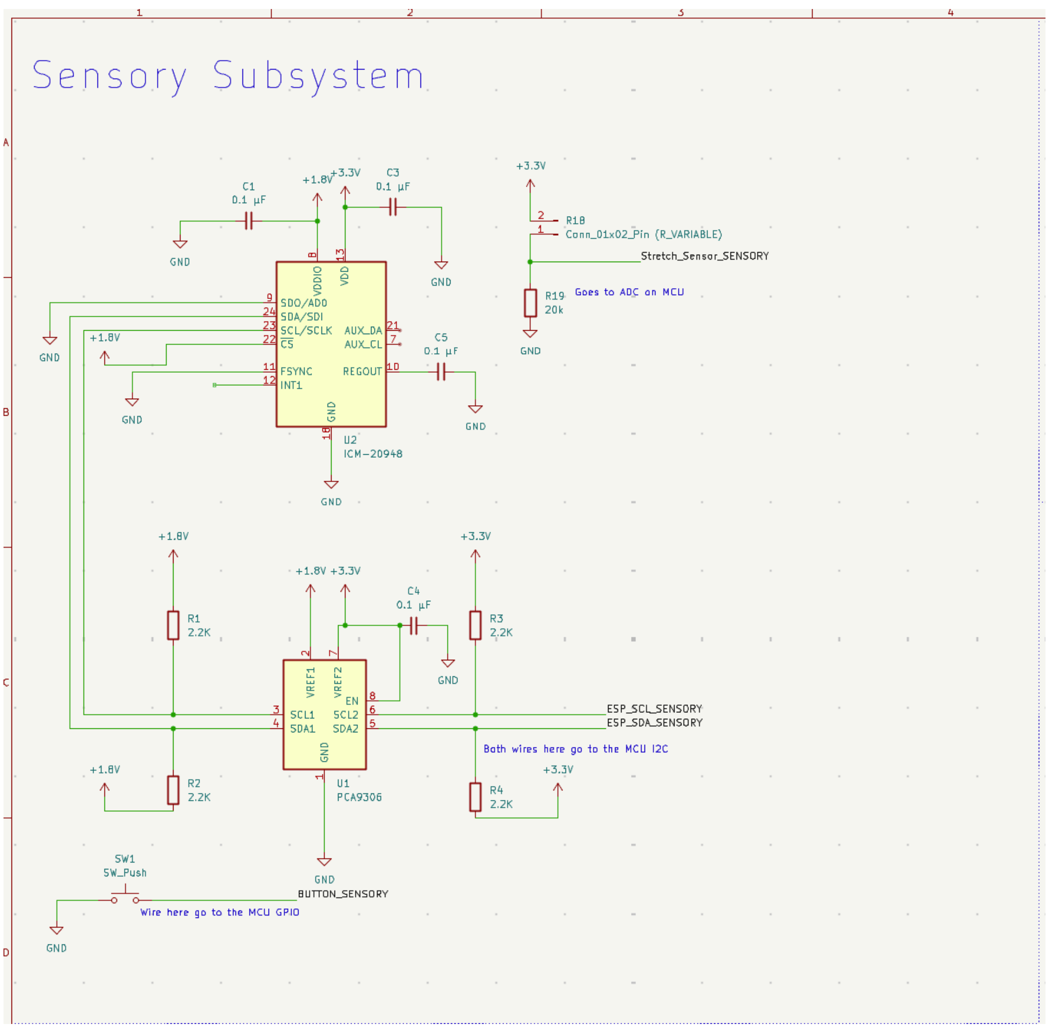


Figure 3: KiCAD Schematic of the Sensory Subsystem

<table>
<tr><th>Requirements</th><th>Verification</th><th colspan="2">Testing</th></tr>
<tr><td>The IMU shall provide accelerometer and gyroscope readings at ≥ 50 Hz which resulting in 50 readings taken per second</td><td>• Run a 10-second loop that prints the sample readings
• Count total samples after 10s and ensure that the samples counted ≥ 500
• Store these samples in an Excel sheet to save the data</td><td colspan="2">Across three trials, the IMU consistently met the required 50 Hz sampling rate. The first test produced 503 samples in 10 seconds (dataset included in the appendix). Trials 2 and 3 got 583 samples and 548 samples. All exceeded the minimum requirement of 500 samples.</td></tr>
<tr><td>The system shall detect a change in stretch of ≥ 1cm across the shoulders, averaged over 10 seconds</td><td>• Mount the strap on a stable setup
• From neutral, extend to 1 cm and hold for 10s
• Log ADC values during the hold
• Ensure that the feedback system is alerted, and an alert is provided after 10 seconds
• Store these samples in an Excel sheet to save the data</td><td colspan="2">Natural Position = 1.65 V
$(1.65 / 3.3) \times 4095 \approx 2047$ counts
Stretched position = 1.55 V
$(1.55 / 3.3) \times 4095 \approx 1921$ counts
Change in Sensor readings:
$2047 - 1921 = 126$ counts
126 counts ≈ 1.2 cm stretch</td></tr>
<tr><td>The signal will be set at 1.65 V ± 0.05 to be able to detect a slouch</td><td>• With the stretch sensor set at neutral, measure the ADC input using a DMM, ensuring it is within 1.60 -</td><td>DMM Reading</td><td>MCU Reading</td></tr>
</table>

	1.70 V ● Briefly apply a small stretch and show that the reading decreases from the set position and can capture a slouch ● Take a photo of the DMM at the neutral position and when the sensor is deviated	1.638V	1.64V
		1.644V	1.65V
		1.641V	1.64V
The calibration button should only detect a single press per time, which will be done through a debouncer with 20ms	● Probe the button GPIO with an oscilloscope ● Press the button 10 times at normal speed ● Read the MCU's press counter using a serial output ● And ensure that the MCU only detected 10 presses, not more or not less ● Store these samples in an Excel sheet to save the data	* Couldn't probe the button due to stabilization issues, and couldn't get a clear waveform However, the MCU testing confirmed correct operation of the calibration button, with the MCU detecting exactly 10 presses. No additional or missed presses	

Table 1: Requirements and verifications for the Sensory Subsystem

2.2.2 Feedback Subsystem

The goal of the Feedback Subsystem is to provide real-time feedback to the user in order for them to 1) recognize that their posture has deviated from the ideal posture and 2) be able to rectify that issue by adjusting their posture to their original calibrated position. This Subsystem will contain, at a minimum, a DC vibration motor that has an operating range between 2V and 3.6V [4]. This Subsystem will be connected to the Processing Subsystem, which is where we will determine if the motor, buzzer, or LED needs to be triggered. We also decided to include a passive buzzer [5] and an LED for additional means of notification. There was also a need to pull the 4.7kΩ resistors up to 3.3V, as they were not pulled up correctly in the original schematic.

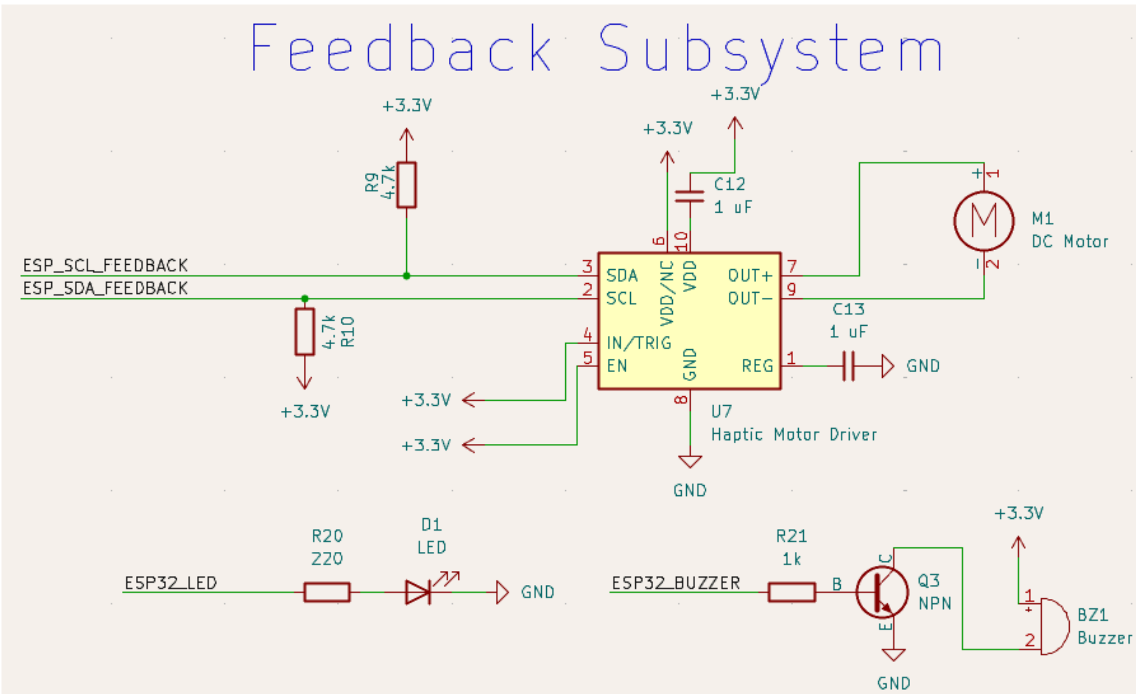


Figure 4: KiCAD Schematic of Feedback Subsystem

Requirements	**Verifications**
The LED, buzzer, and/or vibration motor are activated after a deviation of the user's posture has been detected, with the deviation occurring over an average of 10 seconds.	• Mount the strap on a stable setup • From neutral, extend to 3 mm and hold for 10s • Ensure that the Feedback system is alerted, and an alert is provided after 10 seconds • Once the Feedback Subsystem is alerted, the vibration motor should vibrate, the

	buzzer should beep, and the LED should light up.
The LED, buzzer, and/or vibration motor should all turn off after a previous posture deviation has been corrected and the correct posture is maintained for at least 2 seconds.	• Follow the previous requirement steps to ensure that the LED, buzzer, and motor are currently active • Have the user adjust posture to neutral and hold for 2-4 seconds • After 2-4 seconds of corrected posture, the LED, buzzer, and motor should all turn off.

Table 2: Requirements and Verifications for Feedback Subsystem

2.2.3 Power Subsystem

The Power Subsystem provides the power to the device and is essential for the device to function. As shown below, the first stage is the USB4085-GF-A, which allows for external input to charge the battery and power the system through a USB-C connection. This connection feeds power to the MCP73812T-420I/OT. This charging IC allows for safe and reliable charging to the LIPO801735 400mAh 3.7V Li-ion polymer battery, which will serve as the source of power when the device is not being charged. This feeds into the voltage regulator system consists of the TLV75533PDBVR and TLV75518BPDBV. Calculations can be referred to in the Tolerance Analysis section.

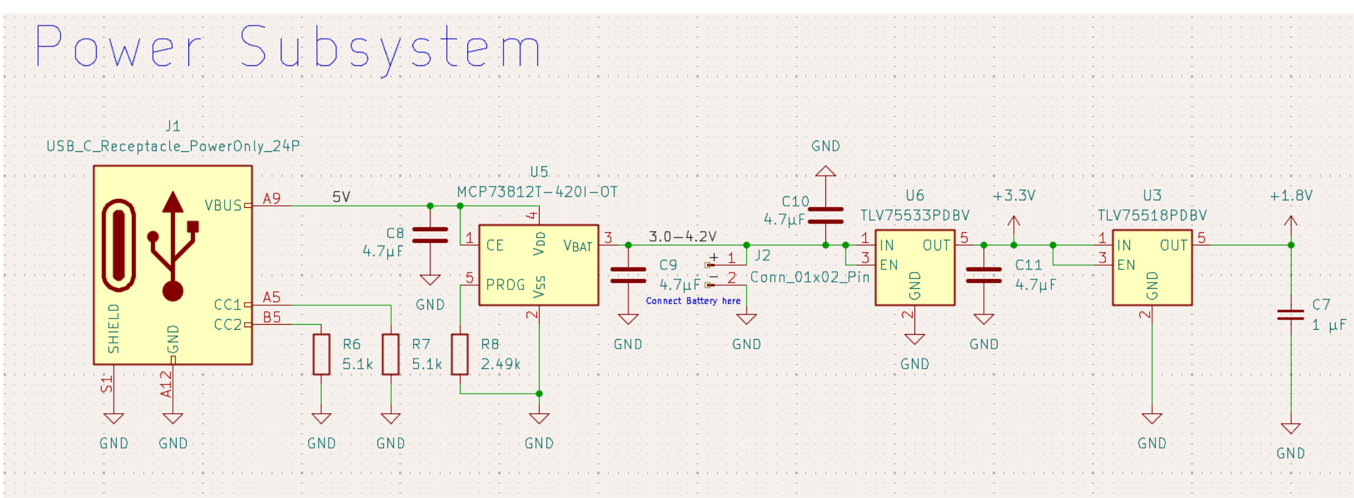


Figure 4: KiCad Schematic of the Power Subsystem

<table>
<tr><th>Requirements</th><th>Verification</th><th colspan="2">Results</th></tr>
<tr><td rowspan="9">The device must remain operational for at least 8 hours continuously on a fully charged 400 mAh 3.7 V Li-Po battery.</td><td rowspan="9">Fully charge the battery using the MCP73812T-420I/OT IC, then disconnect from external power. Power the device on and record the start/end time of when the system shuts off automatically.
Measure the average current draw during operation by probing battery pins with a multimeter or current meter, and confirm that 400 mAh / I_avg ≥ 8 hours.
Repeat this test on three separate occasions to ensure consistency of results in a ± 5% consistency.</td><td colspan="2">Last ≥ 50 minutes</td></tr>
<tr><td colspan="2">Yes</td></tr>
<tr><td colspan="2">Yes</td></tr>
<tr><td colspan="2">Yes</td></tr>
<tr><td>Measured Current</td><td>Calculated operational time</td></tr>
<tr><td>140 mA</td><td>2.86 Hours</td></tr>
<tr><td>132 mA</td><td>3.03 Hours</td></tr>
<tr><td>135 mA</td><td>2.96 Hours</td></tr>
<tr><td colspan="2"></td></tr>
</table>

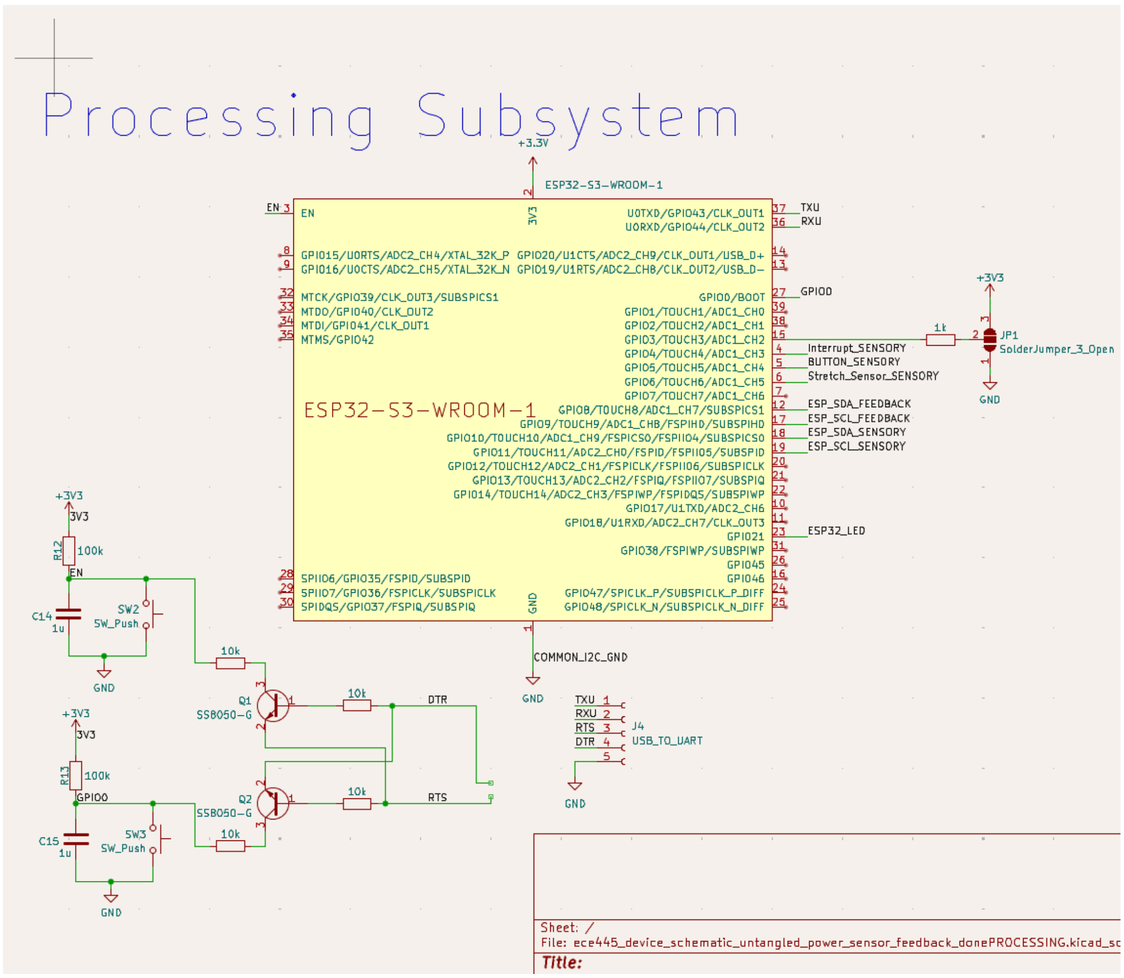
<table>
<tr><td rowspan="4">The MCP73812T-420I/OT charging IC should charge the battery from 3.0 V to 4.2 V within 2.5 hours, when powered through the USB4085-GF-A</td><td rowspan="4">Connect external power via the USB-C connector, measure the battery voltage vs. time during a charging cycle, ensuring that 4.20 ± 0.05 V is reached within 2.5 hours.
Probe the PROG pin using a multimeter or current meter, measure the charging current at the start, and confirm the charging current tapers < 10 mA at full charge
After the current drops below 10 mA, the charger must remain in standby mode, so no further charging pulses should be observed.</td><td colspan="2">4.20 ± 0.05 V is reached within 2.5 hours.</td></tr>
<tr><td colspan="2">Yes</td></tr>
<tr><td colspan="2">Current @ Full Charge
~ 8 mA</td></tr>
<tr><td colspan="2">Observed charging pulses
None</td></tr>
<tr><td rowspan="3">The TLV75533/18PDBVR voltage regulator output should maintain a steady 3.3 V ± 5% under all charging and operating conditions.</td><td rowspan="3">Probe the TLV75533/18PDBVR output port, measure the output voltage using an oscilloscope, and verify</td><td>TLV75533</td><td>TLV75518</td></tr>
<tr><td>3.293 V</td><td>1.874 V</td></tr>
<tr><td>3.293 V</td><td>1.875 V</td></tr>
</table>

	that the readings stay within 3.135 - 3.465 V. ● Ensure maximum load is applied by turning on the device, stretching the sensor, and actively trying to trigger the feedback system, using the same procedure, measure the output voltage, and confirm it does not fall below 3.135 V. ● Now plug in the external USB-C connection to begin charging, monitor the regulator output with the oscilloscope to detect that the readings stay within 3.135 - 3.465 V.	3.293 V	1.875 V
		TLV75533	TLV75518
		3.291 V	1.867 V
		3.291 V	1.867 V
		3.291 V	1.868 V
		TLV75533	TLV75518
		3.292 V	1.869 V
		3.292 V	1.867 V
		3.292 V	1.867 V

Table 3: Requirements and verifications for the Power Subsystem

2.2.4 Processing Subsystem

The Processing Subsystem is centered on the ESP32-S3-WROOM-1 microcontroller module because it has basic GPIOs and common interfaces like I2C, and is readily available in the ESP32 Dev Kit. It serves as the central controller for the posture checker, interfacing with the IMU sensor (via I2C), stretch sensor(via ADC pins), haptic motor driver (via I2C), and external programming source(via a USB-to-UART bridge). It receives a 3.3V input from the power system. It collects sensor data, sensor interrupts, and sensor calibration events via I2C and ADC, performs posture analysis using embedded algorithms, determines whether the user is in poor posture, and issues vibration feedback based on computed results.



Requirements	Verifications
The processing system auto-enters programming mode when buttons aren't pushed, and the USB-to-UART bridge is connected to an active computer USB output and auto-enters normal boot mode otherwise.	1. Connect the MCU to the PC through the USB-to-UART bridge. 2. Test all four cases (USB active/inactive × buttons pressed/released). 3. For each case, record EN/GPIO0 timing and UART messages.

	Pass if and only if the computer reports stub running on Arduino IDE for the "USB active + buttons released" case and normal firmware banner for all others.
The MCU should read the IMU and stretch sensor at ≥ 50 samples/second and should calculate the posture readings at ≥ 20 times/second	1. Load firmware that timestamps each IMU sensor data, stretch sensor data, and compute events. 2. Run for 120 s while recording counters and I2C traffic. Verification passes if every second window shows ≥ 50 samples for each sensor and ≥ 20 computation results.
The MCU should record the calibrated posture after the calibration button is pressed for 2 seconds	1. Press the button for 0.5 s, 1.5 s, 1.9 s, 2.0 s, 2.1 s, 3.0 s (3 times for each). 2. Observe the firmware "calibrated posture saved" message, timestamp, and the relevant metrics. Pass if no calibration occurs for < 1.9 s, presses and events always occur at 2.0 ± 0.1 s.
The MCU should activate the feedback Subsystem via I2C when it detects a torso tilt of ≥ 15° for 10 seconds from the calibrated position or when the stretch change is > than the threshold(counting from the moment that the MCU receives the first poor posture data) and deactivate when the user is back to good posture for more than 4 seconds.	1. Calibrate at 0°, then tilt to 15° and hold 12 s while recording angle and I²C command time. 2. Return upright and measure deactivation delay with printed decision logs. 3. Repeat using stretch input above threshold for 3s, then below threshold. Verification passes if activation occurs 10.0 ± 0.2 s after the first poor sample and deactivation occurs 4.0 ± 0.2 s after good posture

	in all trials.
I2C bus voltage levels must remain within 0–3.3 V with logic HIGH ≥ 2.3 V and LOW ≤ 1.0 V.	1. Capture I2C waveforms during active communication and record VHIGH and VLOW. 2. Verification passes if for both SDA and SCL lines VHIGH ≥ 2.3 V, VLOW ≤ 1.0 V
GPIO output logic HIGH shall be ≥ 2.4 V and LOW ≤ 0.4 V.	1. Configure all used GIPOs to toggle HIGH/LOW under firmware control. 2. Verification passes if for all used GPIOs VOH ≥ 2.4 V and VOL ≤ 0.4 V

Table 4: Requirements and verifications for the Processing Subsystem

2.3 Tolerance Analysis

To properly ensure that the device can function without any issues, the Power Subsystem requires meeting certain tolerances specified by the needs of all the other Subsystems. Specifically, the Processing and Sensory Subsystems are of most concern since they are the most active during operation.

Component	Max Voltage	Max Current
Microcontroller (ESP32-S3-WROOM-1)	3.3 V	~300 mA
Stretch Sensor	3.3 V	< 1 mA
IMU Sensor	3.6 V	4.5 mA

Calibration Button	24 V	50 mA
Voltage Translator	7 V	128 mA
Translation Transreceiver	4.6 V	100 mA

Table 4: Peak Requirements for the device

Component	Max Voltage	Max Current
External Power Connector USB4085-GF-A	48 V	5 A
3.3 V Regulator (TLV75533PDBVR)	5.5 V	500 mA
1.8 V Regulator (TLV7551BPDBV)	5.5 V	500 mA
Charging IC (MCP73812T-420I/OT)	4.2 V	500 mA
Battery (LIPO801735 400mAh 3.7V)	4.2 V	600 mA (discharge) 400 mA (charging)

Table 5: Maximum ratings for Power Subsystem

Component	Max Voltage	Max Current
Haptic Motor Driver (DRV2605L)	5.5 V	3.5 mA

Piezoelectronic Buzzer (PS1240P02BT)	30 V	-
Green 570nm LED Indication - Discrete 2.2V 0805 (2012 Metric) (151051RS11000)	(Forward Voltage) 2.2 V (Reverse Voltage) 5 V	100 mA
DC Vibration Motor (B1034.FL45-00-015)	3.6 V	60 mA

Table 6: Maximum ratings for the Feedback Subsystem

The key analysis focuses on the battery's discharge capability versus the device's peak current needs. The charging IC operates safely within the battery's voltage and current limits, and its charge current is programmable. Summing all subsystem maximum currents gives 582.5 mA, just under the battery's 600 mA discharge rating. Since the microcontroller's listed peak assumes wireless use (not used in our design), its actual draw is closer to 60–100 mA, reducing total peak consumption to about 382.5 mA—well within regulator and battery limits. In testing, the device lasted roughly 3 hours without using ESP32 sleep mode, so it comfortably exceeds the 50-minute demo requirement and could last even longer with power-saving features enabled.

3 Costs and Schedule

3.1 Costs

The total cost of the parts shown in the appendix is $81.52, including the optional ICM 20948 Development Board for testing.

According to ZipRecruiter, the average annual salary for someone with a Bachelor's in Computer Engineering is $117, 751 [11] while the average salary for someone with a Bachelor's in Electrical

Engineering is $107, 650 [12]. These become $57 and $52 per hour. Seeing as our project has a team of four people, 3 of whom are in Computer Engineering and 1 of whom is in Electrical Engineering, the breakdown is as follows:

Assuming our team works full-time on this project for the duration of the semester (16 weeks):

$$\$52/hour \ * \ 40\ hours/week \ * \ 16\ weeks \ = \ \$33,280$$

$$3\ people \ * \ (\$57/hour \ * \ 40\ hours/week \ * \ 16\ weeks) \ = \ \$109,440$$

$$\$33,280 \ + \ \$109,440 \ = \ \$142,720$$

Our group spent a total of roughly 75 hours in the lab, which changes the math a bit:

$$3\ people \ * \ (\$57/hour \ * \ 75\ hours \ * \ 2.5) \ = \$32,062.50$$

$$1\ person \ * \ (\$52/hour \ * \ 75\ hours \ * \ 2.5) \ = \ \$9,750$$

$$\$32,062.50 \ + \ \$9,750 \ + \ 81.52 \ = \ \$41,894.02$$

2.3 Schedule

Week	Task	Group Members
9/22	Divide Tasks	All
	Sensor Subsystem Research	Ashit Anandkumar
	Processing Subsystem Research	Yue Cao
	Feedback Subsystem Research	Destiny Jefferson
	Power Subsystem Research	Edward Ruan
9/29	Component Data Sheet collection	All
	Sensor Subsystem Schematic	Ashit Anandkumar
	Processing Subsystem Schematic	Yue Cao
	Feedback Subsystem Schematic	Destiny Jefferson
	Power Subsystem Schematic	Edward Ruan
10/6	Feedback and Stretch Sensor Breadboard	All
	Sensor Subsystem Schematic	Ashit Anandkumar
	Processing Subsystem Schematic	Yue Cao
	Feedback Subsystem Schematic	Destiny Jefferson

	Power Subsystem Schematic	Edward Ruan
	Work on Design Document	All
10/13	Order Components Required	All
	Assemble PCB	All
	Start PCB testing	All
10/20	Start Programming Microcontroller	Yue Cao
	Continue PCB testing	All
	Revise PCB layout and make necessary edits	All
10/27	Sensor Breadboard	Ashit Anandkumar
	Power Breadboard	Edward Ruan
	Assemble PCB and Test PCB	All
11/3	Continue Testing PCB	All
	Start designing the enclosure	All
	Make necessary edits to PCB layout	All
11/10	Final PCB Layout submission if Necessary	All
	Final assembly of all components	All
	Mock Demo Preparation	All
11/17	Mock Demo	All
	Start working on final report	All
	Finalize Presentation	All
12/1	Final Demo	All
	Complete final report	All
	Mock presentation	All
12/8	Final presentation	All
	Submit Final papers	All

Table 9: Budget clip on posture check timeline

4 Conclusions

4.1 Accomplishments

Since this was the first experience most of our group had with soldering, this project allowed us to develop skills in soldering, sensor programming, and using KiCAD. We also worked well together and were able to coordinate our conflicting schedules to put together a functional device.

4.2 Challenges

Time management was a struggle due to a late PCB order that caused us to rush through the soldering and testing process for the final PCB submission. We also had an important component burnout in the Feedback Subsystem, and we did not have enough time to recover from the setback.

4.3 Future Works

Overall, the prototype shows that a budget posture detector could compete with existing posture correctors, though it still needs improvement. We hope to streamline the Feedback Subsystem to a single notifier to save space and cost, reduce the device size with smaller components and more precise soldering, and potentially develop a mobile app for real-time posture tracking and user history.

4.4 Ethics and Safety

Ethical Concerns

- E-waste from batteries and other electrical components is a concern.
- The product should be designed to work with diverse body types and clothing styles.

Safety Concerns

- If the device breaks, sharp edges or exposed wires could cause injury.
- The device should be durable enough to withstand drops and moderate stress.
- A battery malfunction could lead to a fire hazard. Fail-safes such as short-circuit protection are needed to mitigate the risk of fires.

5 Citations

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[12] "Salary: Bachelor Electrical Engineering in Illinois (Mar 25)," ZipRecruiter, https://www.ziprecruiter.com/Salaries/Bachelor-Electrical-Engineering-Salary--in-Illinois (accessed Oct. 14, 2025).

6 Appendix:

	A	B	C	D	E	F	G	H
1	Sample #	Time (s)	ax (g)	ay (g)	az (g)	gx (dps)	gy (dps)	gz (dps)
2	1	0	0	0.029	0.972	-1.41	1.46	0.54
3	2	0.02	-0.006	-0.019	0.975	1.3	-1	-0.78
4	3	0.04	0.016	-0.006	1.009	-0.19	-0.71	-0.27
5	4	0.06	-0.014	-0.003	1.014	0.96	0.04	-0.3
6	5	0.08	-0.013	-0.015	1.006	1.48	0.82	0.4
7	6	0.1	-0.015	-0.009	1.021	-0.37	-0.04	1.36
8	7	0.12	-0.016	0.028	1.004	-1.35	-1.05	-0.18
9	8	0.14	0.03	0.011	0.985	0.84	0.83	1.4
10	9	0.16	0.007	-0.014	1.015	0.84	-0.89	-0.11
11	10	0.18	0.001	-0.021	0.982	-0.37	-1.23	1.25
12	11	0.2	0.015	0.005	0.984	-1.4	1.26	-1.37
13	12	0.22	0.013	-0.023	0.985	0.77	0.99	-1.45
14	13	0.24	-0.029	0.019	0.974	-0.96	-0.71	-0.04
15	14	0.26	0.023	-0.012	0.992	1.45	0.38	1.23
16	15	0.28	-0.02	-0.006	1.015	-1.38	-0.59	0.99
17	16	0.3	0.024	-0.019	1.014	0.98	-0.69	1.02
18	17	0.32	-0.017	-0.028	1.027	0.15	-0.87	-1.48
19	18	0.34	0.018	-0.03	0.986	1.43	-0.65	0.5
20	19	0.36	0.022	0.006	0.984	0.09	0.13	0.03
21	20	0.38	-0.019	0.008	0.974	0.94	-0.34	0.48
22	21	0.4	-0.018	0.013	1.001	0.31	0.73	-0.54
23	22	0.42	0	0.007	0.972	-1.3	0.63	1.4
24	23	0.44	0.021	-0.024	0.989	1.23	-1.3	1.1
25	24	0.46	-0.022	-0.008	1.002	0.53	0.97	0.71
26	25	0.48	-0.022	0.004	0.996	-1.09	-0.74	-1.23
27	26	0.5	-0.025	-0.022	1.017	-0.1	1.45	0.25
28	27	0.52	-0.01	-0.023	1.029	-0.56	1.12	-0.8
29	28	0.54	-0.008	0.002	0.99	0.92	0.58	0.4
30	29	0.56	-0.018	-0.004	1.011	0.95	-0.12	0.01
31	30	0.58	-0.012	-0.025	1.028	0.9	-0.03	1.21
32	31	0.6	0.011	-0.016	1.013	-0.06	-1.1	-1.21
33	32	0.62	0.011	-0.021	0.974	1.32	-0.92	-0.38
34	33	0.64	-0.014	-0.007	1.014	-1.21	-0.67	-1.35
35	34	0.66	0.014	0.004	1.002	0.16	-1.3	-1.46
36	35	0.68	-0.013	0.018	0.977	0.81	-1.36	1.01
37	36	0.7	-0.024	0.029	0.994	-0.57	-0.91	1.03
38	37	0.72	0.02	-0.014	1.01	-0.55	0.28	1.21
39	38	0.74	0.008	-0.023	1.002	0.24	1.16	1.47
40	39	0.76	-0.004	-0.022	0.985	0.36	-0.18	1.43
41	40	0.78	-0.026	-0.015	0.991	-0.98	0.18	-0.33
42	41	0.8	-0.004	-0.026	0.973	1.2	-0.16	0.69
43	42	0.82	-0.005	-0.021	1.003	1.36	-0.48	0.92
44	43	0.84	0.021	0.022	0.971	-0.34	0.89	0.43
45	44	0.86	-0.003	-0.011	0.999	0.15	1.05	-0.69
46	45	0.88	0.023	-0.029	0.981	0.46	0.09	-1.01
47	46	0.9	-0.021	-0.011	1.023	0.28	0.05	-1.36
48	47	0.92	-0.029	0	1.002	0.15	1.28	-0.5
49	48	0.94	0.013	-0.023	0.983	1.27	0.46	0.46
50	49	0.96	-0.027	0.01	1.014	-0.01	0.18	0.05

Appendix 1: First 50 sample data of IMU reading for testing

Item	Link	Price	Quantity
PCA9306 (VSSOP)	Link to PCA9306	0.68	2
74AVC4T245D	Link to 74AVC4T245D	0.73	2
ICM 20948 Dev board (Optional used for testing)	Link to ICM 20948	21	1
ICM 20948 Chip	Link to ICM 20948 Chip	6	2
USB4085-GF-A	Link to USB4085-GF-A	0.88	1
TLV75533PDBVR	Link to TLV75533PDBVR	0.36	1
MCP73812T-420I/OT	Link to MCP73812T-420I/OT	0.73	1
LIPO801735 400mAh3.7V	Link to LIPO801735	$6.95	1
Stretch Sensor 14”	Link to Stretch Sensor 14"	$20.95	1
DRV2605L - Haptic Motor Driver	Link to Haptic Motor Driver	$11.95	1
DC Vibration Motor	Link to DC Vibration Motor	$2.95	1
Piezoelectronic Buzzer	Link to Piezoelectronic Buzzer	$0.78	1
Green 570nm LED Indication - Discrete 2.2V 0805 (2012 Metric)	Link to Green LED Indication	$0.15	1

Appendix 2: Purchase List of All Parts Needed for Clip-On Posture Checker