

Screening Habit Correction Headband

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Abstract

The Screentime Habit Correction Headband is a wearable device designed to mitigate digital eye strain and forward head posture. The system utilizes a Time-of-Flight (ToF) sensor and an Inertial Measurement Unit (IMU) to continuously monitor user screen distance and head tilt angle. When poor posture is sustained beyond a three-second threshold, the microcontroller triggers a progressive feedback system that utilizes an ERM vibration motor, a piezoelectric buzzer, and panel-mounted LEDs. A local Wi-Fi access point hosted by the microcontroller enables session data logging via a React Native mobile application, ensuring user privacy without transmitting raw biometrics to external servers. The custom-routed PCB and 3.7V LiPo power management system are housed within a custom 3D-printed enclosure optimized for horizontal forehead mounting.

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1. Introduction

1.1 Problem

In the modern digital era, the widespread use of desktop computers and personal devices has led to an increase in daily screen exposure. As people spend long periods seated in front of a monitor, they often fall into poor posture habits. According to Brown University Health, modern posture is often characterized by sitting at a computer with a tilted pelvis, slumped shoulders, and a forward head position [1]. This lack of proper posture is a major cause of the back and neck pain experienced by millions of people.

Poor posture causes imbalances in the body where some muscles get stretched and weakened while others become shortened and tight. Over time, this leads to stiffness and pain. Additionally, increased shoulder tension from bad posture can lead to headaches [1]. Regarding eye health, looking at digital screens for long periods can cause digital eye strain. When using these devices, people tend to blink only 5 to 7 times a minute, compared to the normal rate of 15 times a minute. This lack of moisture can cause vision to blur and eyes to become dry, achy, or stinging [2]. Addressing these habits is critical for maintaining physical well-being and preventing daily discomfort.

1.2 Solution

Our solution, the Screentime Habit Correction Headband, is a wearable lightweight headband designed to correct posture habits through real-time feedback. The headband uses sensors to continuously monitor the user's position relative to their workstation. Specifically, an Inertial Measurement Unit (IMU) tracks the angle of the head to detect slouching or looking down, while a Time-of-Flight (ToF) sensor measures the exact distance between the eyes and the screen.

To correct the user, the device compares sensor data against a baseline, set when the device is powered on. If the user leans closer than the recommended distance or has bad posture, the system triggers immediate feedback via a vibration motor, a buzzer, and LEDs. The hardware platform, including the 3.7V LiPo battery, power management circuitry, sensors, and the microcontroller (MCU), is consolidated into a lightweight 3D-printed enclosure worn directly on the forehead. Additionally, the MCU hosts a local Wi-Fi Access Point, sending the real-time sensor readings via HTTP requests to a companion mobile app. This allows users to view their habits, track improvements over time, and log data regarding their posture and screen time.

1.3 Visual Aid

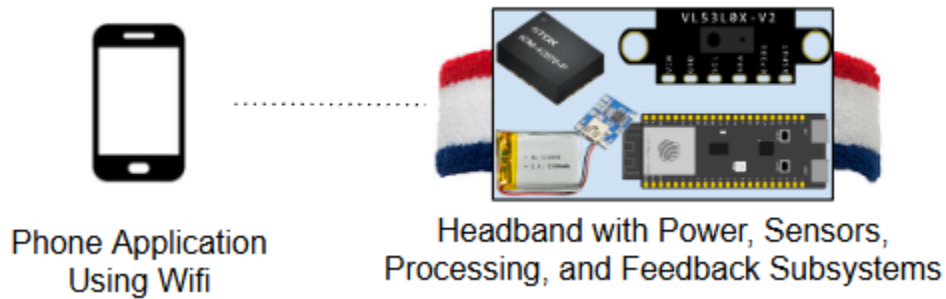


Figure 1: General placement of main components.

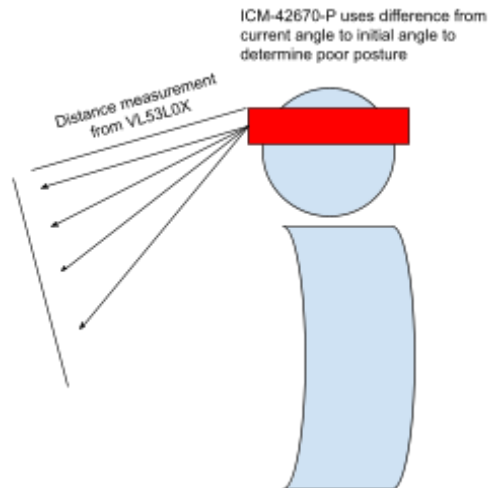


Figure 2: Visual aid of sensor functions and headband use.

1.4 High-level Requirements

- The device must measure the distance from the user to the screen with an accuracy of ± 5 mm and the offset angle from the zeroed baseline with an accuracy of ± 2 degrees.
- The system must trigger the motor, buzzer, and LEDs within 3 seconds when the user is less than 30 cm from the screen or when the offset angle from the zeroed baseline is greater than 15 degrees.
- The device must operate continuously for at least 2 hours on a single battery charge while maintaining a local Wi-Fi connection and collecting sensor data.

2. Design

2.1 Block Diagram

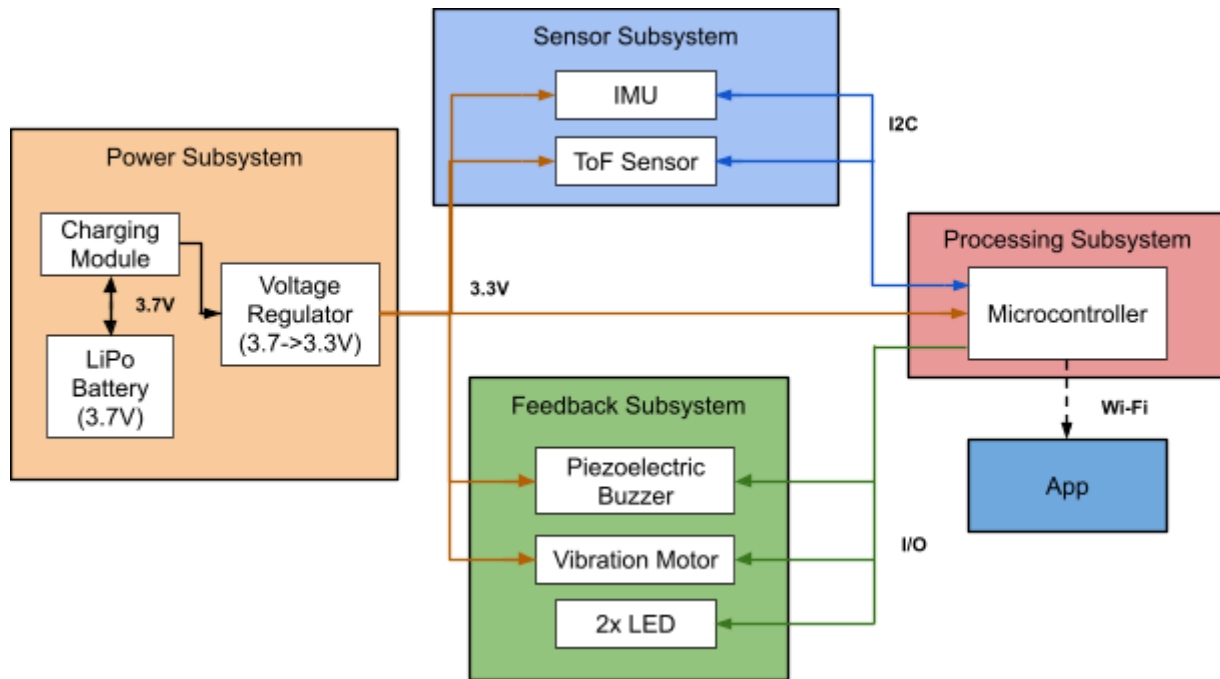


Figure 3: Block diagram of system

The design is divided into five main subsystems: power, sensor, feedback, processing, and app. The power subsystem utilizes a 3.7 V LiPo battery, a charging module, and a linear voltage regulator connected in series to supply a stable 3.3 V to the rest of the device while providing recharging capabilities. The sensor subsystem collects real-time user data using an IMU to record head pitch angle and a Time-of-Flight (ToF) sensor to record screen distance. This data is transmitted via I2C to the processing subsystem, where a MCU evaluates the inputs against calibrated thresholds. If poor posture or inadequate distance is detected for a sustained period, the MCU triggers the feedback subsystem, activating LEDs, the piezoelectric buzzer, and the vibration motor to alert the user. Concurrently, the processing subsystem hosts a local Wi-Fi Access Point to transmit the posture data via HTTP requests to the app for long-term user tracking and visualization.

2.2 Physical Design

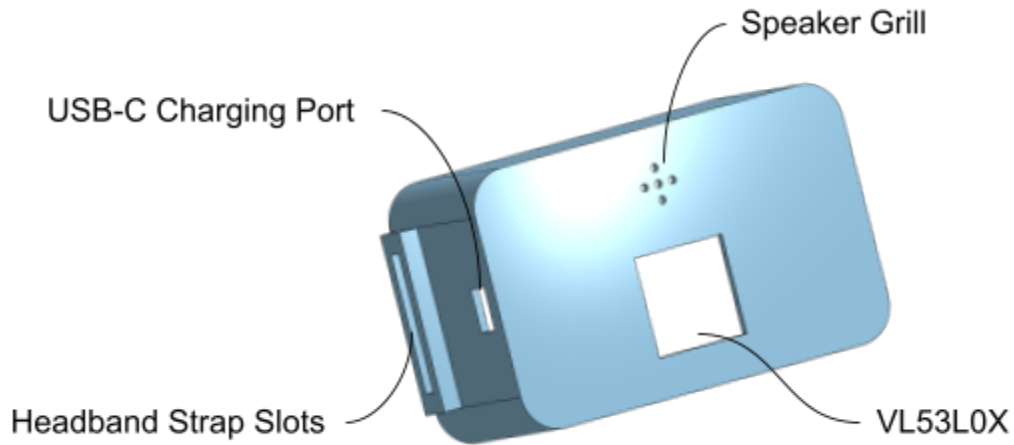


Figure 4: Outside view of the headband.

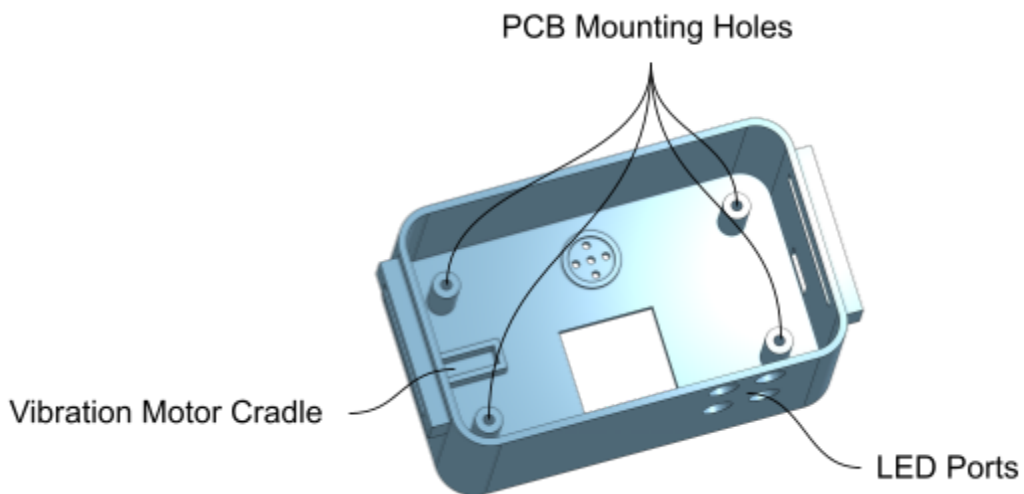


Figure 5: Inside view of the headband.

The Screentime Habit Correction system is consolidated into a single, unibody physical enclosure worn on the head. A custom 3D-printed tub (105 mm x 65 mm x 45 mm) is attached to an adjustable elastic suspension strap, mounting the device horizontally across the user's forehead. A custom PCB is mounted on 10 mm internal standoffs. The ToF sensor and IMU are mounted on the outward-facing bottom side of the PCB, utilizing a hardware-mapped 25 mm by 25 mm window in the plastic for unobstructed measurement of screen distance and head tilt. The enclosure contains all power electronics, including the 3.7V LiPo battery and charging module, alongside the ESP32-S3 MCU. The front face of the enclosure features an acoustic grill for the 12 mm buzzer and 6.5 mm press-fit holes for the two status LEDs, while the side wall provides access to a USB-C charging port.

2.3 Subsystem Overview

2.3.1 Power

Our power subsystem is in charge of regulating and directing power to the rest of the components in the device. Completely residing in the 3D-printed enclosure, it will contain a 3.7 V lithium-polymer battery as well as a charging module, allowing the battery to be rechargeable. The power subsystem will step down the battery voltage using an LD1117-3.3 linear voltage regulator to supply a stable 3.3 V to the microcontroller, sensors, and feedback components. The device is meant to be worn for a period of time, so the power subsystem should also be able to power the device for at least 120 minutes continuously.

The battery is connected directly to the charging module, which is built in with protection against overcharge, overdischarge, and overcurrent and has a USB-C port for charging. Using a connector, the charging module is connected to the voltage regulator circuit on the PCB, shown in Figure 6. The circuit was built according to the “Typical Application Circuit” section of the LD1117 datasheet [7]. At the output of the circuit, a solder jumper and two test points are used to test the voltage before connecting to the rest of the device.

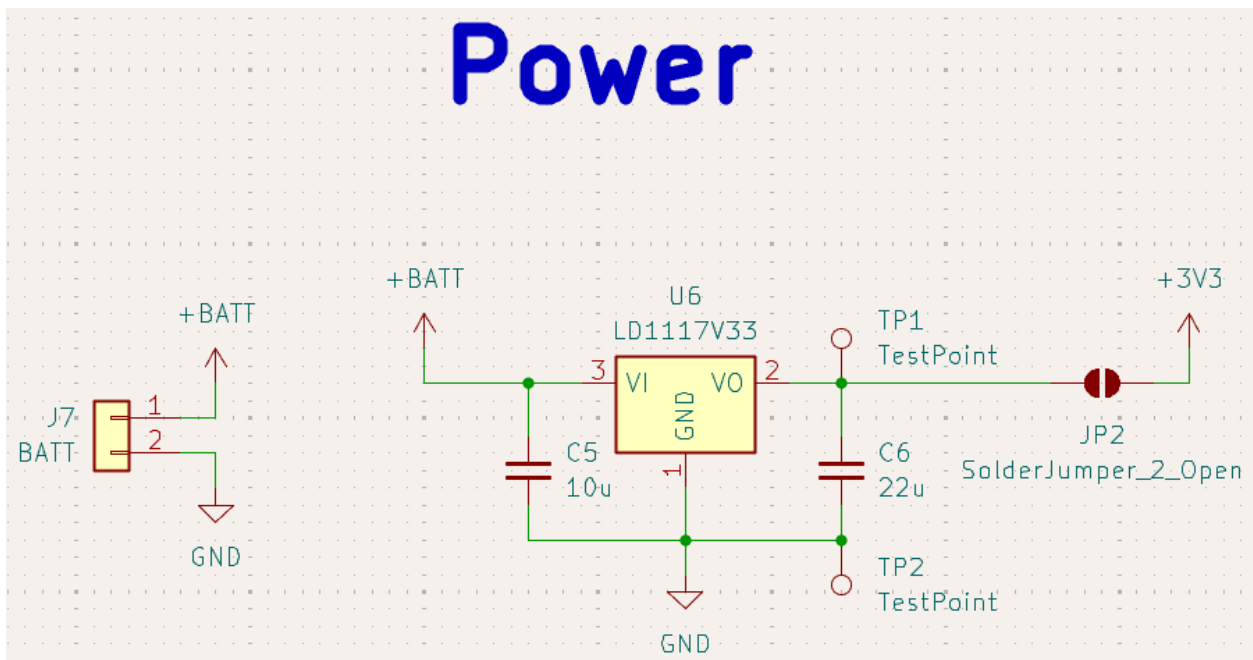


Figure 6: Power subsystem schematic

2.3.2 Sensors

There are two sensors inside the device. One sensor is the BMI160, an IMU that is able to sense position and orientation to tell the MCU to send feedback when the user's posture is bad. Figure 7 shows the application schematic for a circuit with the sensor using I2C to communicate to the host, which has less noise compared to using SPI. The other sensor is the VL53L0X ToF sensor, which is able to detect the distance to a screen to tell the MCU to send feedback when the user is too close to their screen. Figure 8 shows the application schematic for the VL53L0X. Both sensors are powered by 3.3 V coming from the linear voltage regulator.

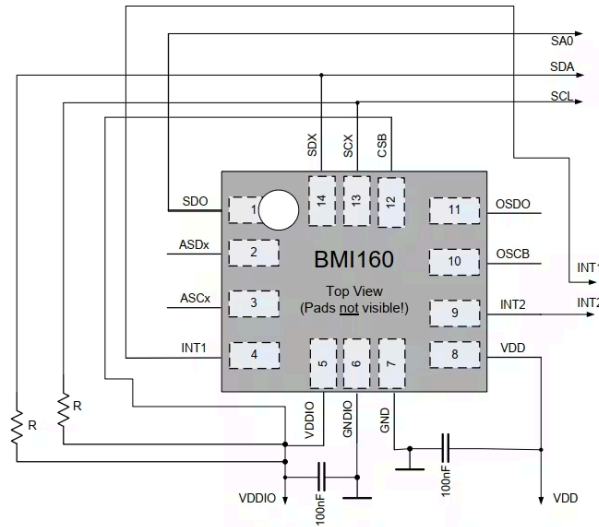


Figure 7: BMI160 Application Schematic (I2C Interface to Host) [5]

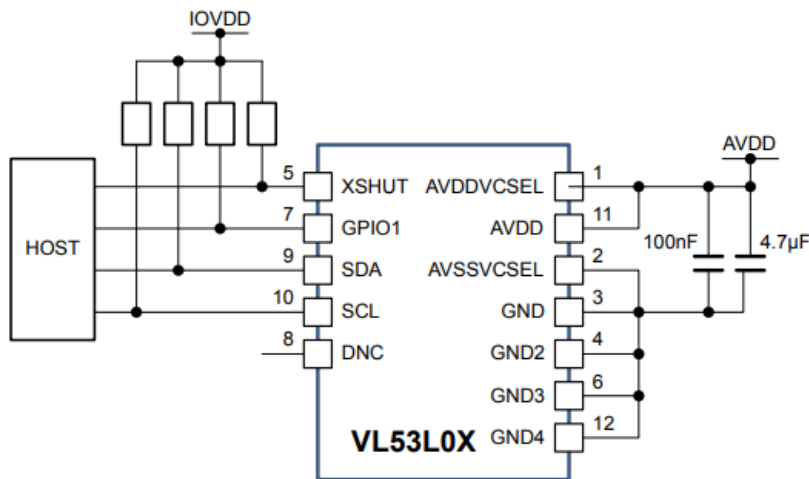


Figure 8: VL53L0X Application Schematic [6]

2.3.3 Feedback

The feedback subsystem consists of a vibration motor, speaker, and two LEDs. The feedback components are all driven by 3.3 V. The feedback subsystem will activate for two cases: if the user is slouching, or too close to the screen. Each case will turn on a separate LED, while both cases will activate the vibration motor and speaker. All feedback components reside directly within the headband's 3D-printed enclosure to provide immediate, localized alerts to the user.

The MCU directly powers the LEDs from its GPIO pins, with a resistor in between to prevent burning out the LED. We chose a 330 Ω resistor to send about 5 mA to the LED, based on the MCU's output voltage of 3.3 V. The motor and the buzzer are connected to power and a BJT, whose base is connected to GPIO pins in order to control the current going through the feedback components. Because both components' operating currents are more than the 30 mA max of the MCU's GPIO pins, the BJT allows control of the current going through the motor and buzzer. The components are connected as shown in Figure 9.



Figure 9: Feedback Subsystem Schematic

2.3.4 Processing

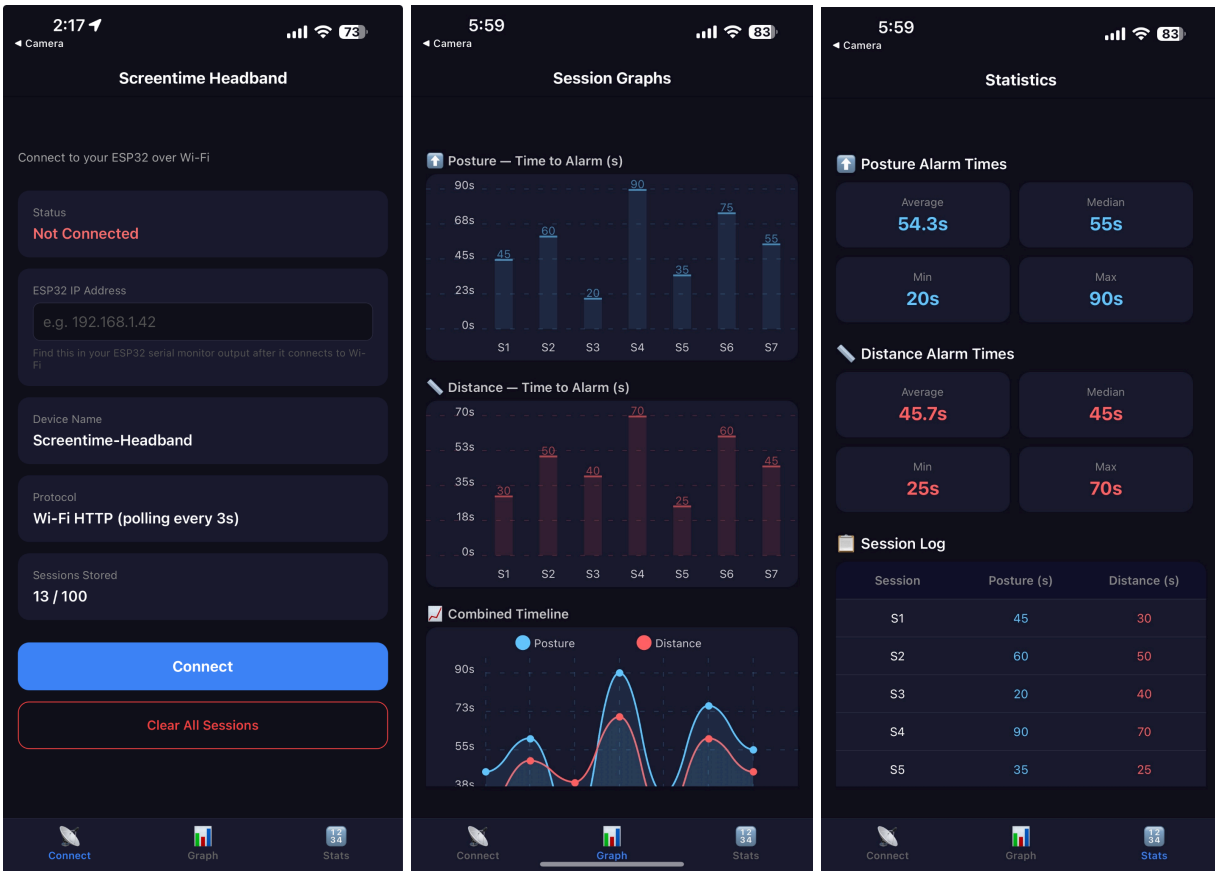
The processing subsystem consists of the microcontroller, which is powered by 3.3V coming from the linear voltage regulator in the power subsystem. The MCU that we will be using is the ESP32-S3. It will use sensor data as well as its own timer to determine when to send feedback to the user based on time of exposure to a screen, distance to a screen, and posture. The MCU will also manipulate the sensor data so the two cases' feedback won't interfere with each other. In addition, the MCU will host a local Wi-Fi access point that will be able to communicate with the app and allow it to track data.



Figure 10: Finite-State Machine logic for processing

2.3.5 App

The mobile application logs event data sent from the microcontroller over a local Wi-Fi connection. Instead of continuously streaming raw sensor data, the system utilizes an event-driven architecture where the headband pushes a timestamp to the app only when the poor posture threshold is breached. The primary metric the app tracks is the time elapsed between these consecutive poor posture detections. By tracking how long it takes for the user's posture to deteriorate, the app can visualize the user's ergonomic improvement over time. Ideally, as muscle memory improves, the time between triggers will increase. The app graphs these statistics so the user can easily monitor their progress over the course of days or weeks.



Figures 11, 12, 13: Screenshots of app pages

2.4 Tolerance Analysis

A potential risk of using the BMI160 IMU is the possibility of drift over a long period of time. Because the head angle is calculated by integrating the gyroscope's angular velocity, small baseline errors compound rapidly over time. The head pitch angle, $\theta(t)$, is calculated by integrating the gyroscope's angular velocity, $\omega(\tau)$, over time:

$$\theta(t) = \theta_0 + \int_0^t \omega(\tau) d\tau$$

Due to the gyroscope's inherent bias, denoted as ω_{bias} , the integration error grows linearly:

$$\theta_{error}(t) = \omega_{bias} \times t$$

According to the BMI160 datasheet, the typical Initial Zero-Rate Output (ZRO) tolerance is $\pm 1^\circ/s$. Without correction, the drift over a 5-minute (300 seconds) period is calculated as:

$$\theta_{error} = 1^\circ/s \times 300 s = 300^\circ$$

This 300° error completely invalidates the 15° posture threshold. To resolve this issue, our software will rely on the sensor's tilt angles (pitch and roll), calculated using the accelerometer's gravity measurements as an absolute reference to determine which direction is down. At power on, the initial angle is recorded as a reference point and the alarm is only activated when the current angle differs from this reference by over 15 degrees. Furthermore, to reduce the electrical noise that contributes to the drift of our measured position, we will power the IMU using a dedicated LP2950CZ-5.0 voltage regulator as opposed to a buck converter. Finally, if minor drift still accumulates over extended use, the system will allow the user to manually trigger a recalibration to reset the baseline angle.

3. Verification

3.1 Power

The power subsystem was able to provide power for more than two hours with a 2000 mAh battery and a voltage regulator rated at 1 A. However, for the steady voltage at 3.3 V requirement, the voltage that we measured was around 3 V instead. Our device still functions properly because our components are rated to still operate above 3 V. We were getting this reading because we stepped down the battery's 3.7 V down to 3.3 V, and the voltage difference did not exceed the voltage regulator's dropout voltage of about 1 V [7]. This caused the regulator's output voltage to be dragged down.

3.2 Sensors

The ToF sensor made measurements every 10 cm from 0 cm to 50 cm. The measurements were more accurate but less precise as the distance increased, unable to completely meet our requirements. At the distance of 0 cm to 40 cm, the measurements had a 4 cm offset which may be due to testing error. The IMU also made measurements every 5 degrees from 0 degrees to 20 degrees. The IMU is accurate and precise, being able to meet our requirements.

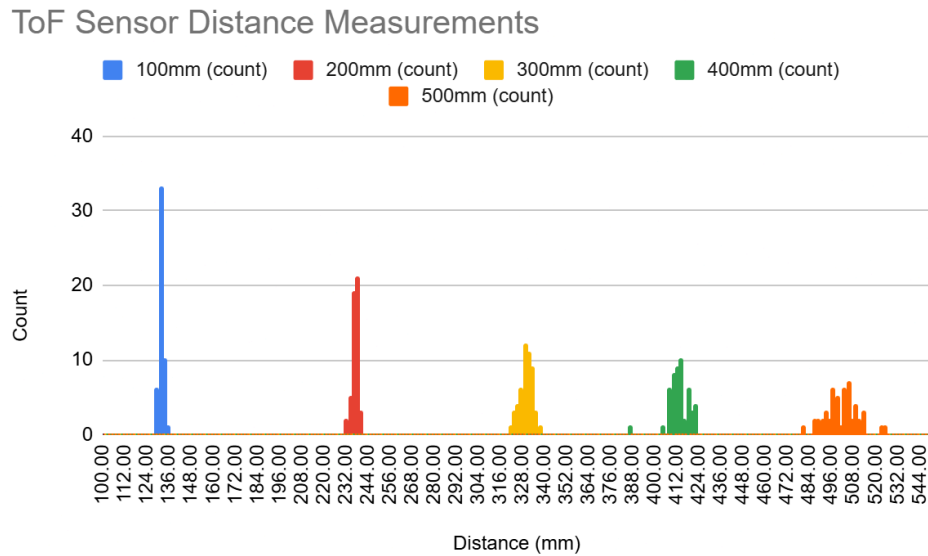


Figure 14: Distance accuracy and precision measurements of ToF sensor

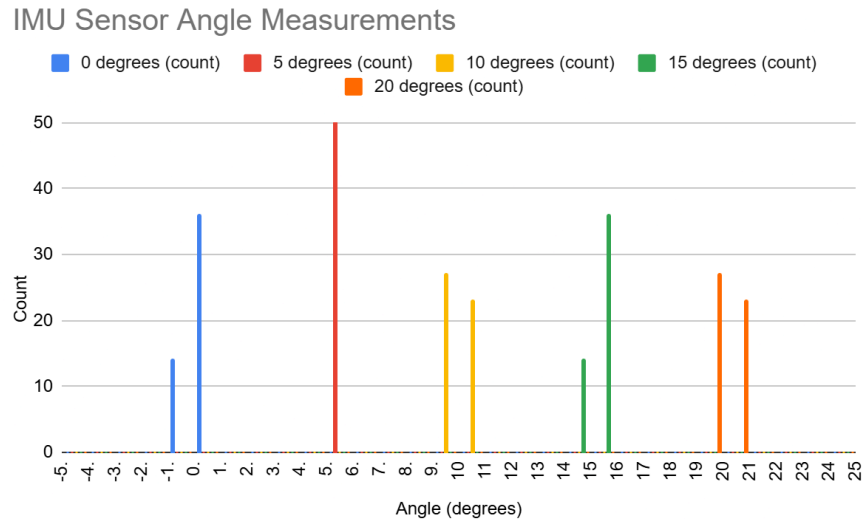


Figure 15: Angle accuracy and precision measurements of IMU

3.3 Feedback

The feedback subsystem was powered by 3 V due to the power subsystem failing to consistently provide 3.3 V. With this lower voltage, both LEDs would turn on within 3 seconds of poor posture angle or distance detected. The motor and buzzer would also activate when alarms are triggered. The motor's feature of linearly increasing over 3 seconds functioned as expected and the buzzer would turn on whenever an alarm state was activated. The feedback system also turned off within a second of good posture/distance being detected. If necessary, the intensity of all the feedback components can be adjusted with pulse width modulation.

3.4 Processing

The ESP32 enforced the 3 second time in the warning state before the alarm state. In testing, it was confirmed that the alarm would activate after 3 seconds within a 0.2 second error consistently over 10 .

3.5 App

The mobile app was able to connect to the ESP32 via Wi-Fi and was able to store more than 50 datapoints and display them in the app.

4. Cost and Schedule

4.1 Cost Analysis

Labor costs are calculated using the course guideline: Hourly Salary x 2.5 x Hours to Complete. Assuming a \$50/hour rate and an estimated 50 hours of remaining work per team member, the labor breakdown is as follows:

- Colin Moy: \$50/hr x 2.5 x 50 hours = \$6,250
- Jake Chen: \$50/hr x 2.5 x 50 hours = \$6,250
- Zhiyuan Chen: \$50/hr x 2.5 x 50 hours = \$6,250
- Total Labor Cost: \$18,750

The cost of parts so far adds up to \$34.51, and the total cost adds up to \$18,784.51 for both labor and parts.

Table 6: Itemized list of Components and Costs

Description	Manufacturer	Quantity	Extended Price	Link
ESP32-S3-WROOM-1-N16	Espressif	1	\$6.10	link
BATTERY LITH-ION 3.7V 2AH	Adafruit Industries LLC	1	\$12.50	link
Lithium Battery Charger and Protection Module	NanJing Top Power ASIC Corp.	1	\$2.00	link
IC REG LINEAR 3.3V 1A SOT-223-3L	UMW	1	\$0.31	link
BMI160 6DOF 6-axis Acceleration Gyro Gravity Sensor	Bosch Sensortec	1	\$2.90	link
SENSOR OPTICAL 24CM I2C	STMicroelectronics	1	\$5.18	link
VIBRATION MOTOR 11.64.64.8MM	Pololu	1	\$6.95	link
BUZZER MAGNETIC 3.5V 12.00MM TH	Same Sky (Formerly CUI Devices)	1	\$0.94	link
LED RED DIFFUSED 5MM ROUND T/H	Würth Elektronik	2	\$0.30	link
TRANS NPN 25V 1.5A SOT-23-3	Comchip Technology	4	\$0.96	link
CAP CER 10000PF 100V X7R 0805	Samsung Electro-Mechanics	1	\$0.10	link
CAP CER 0.1UF 50V X7R 0805	YAGEO	3	\$0.33	link
CAP CER 1UF 50V X7R 0805	Samsung Electro-Mechanics	2	\$0.24	link
CAP CER 4.7UF 25V X5R 0805	Samsung Electro-Mechanics	2	\$0.22	link
CAP CER 10UF 50V X5R 0805	Murata Electronics	2	\$0.62	link
CAP CER 22UF 6.3V X5R 0805	KEMET	1	\$0.71	link

RES 330 OHM 1% 1/4W 0805	KOA Speer Electronics, Inc.	3	\$0.30	link
RES SMD 10K OHM 1% 1/8W 0805	YAGEO	8	\$0.88	link
RES 1K OHM 5% 1/8W 0805	Stackpole Electronics Inc	1	\$0.10	link
RES 100K OHM 5% 1/8W 0805	Stackpole Electronics Inc	2	\$0.20	link
RES 3.16K OHM 1% 1/4W 0805	KOA Speer Electronics, Inc.	1	\$0.10	link
SWITCH TACTILE SPST-NO 0.05A 12V	C&K	2	\$0.72	link
DIODE ZENER 5.6V 3W SMB	onsemi	2	\$1.00	link
CONN RCPT 2POS IDC 22AWG TIN	TE Connectivity AMP Connectors	5	\$0.75	link
CONN HEADER VERT 2POS 2.54MM	Molex	5	\$0.75	link
CONN RCPT 3POS IDC 22AWG TIN	TE Connectivity AMP Connectors	1	\$0.38	link
CONN HEADER VERT 5POS 2.54MM	Molex	1	\$0.30	link

4.2 Schedule

Table 7: Schedule for Project Progression

Week	Task	Person
2/22 - 2/28	Organize and order parts for prototyping	Everyone
	Work on PCB design	Jake
	Research bluetooth communication	Colin/Zhiyuan
3/1 - 3/7	Finish and audit PCB design	Jake
	Order missing parts	Everyone
	Prepare for breadboard demo	
	Design review	
	Second round PCB orders	
3/8 - 3/14	Start processing	Colin
	Start app	Zhiyuan
	Modify PCB design if needed	Jake
	Breadboard Demo	Everyone
	Third round PCB orders	
3/15 - 3/21 (Spring Break)	Continue working on programming and PCB design	Everyone
3/22 - 3/28	Continue working on app and bluetooth comm.	Zhiyuan
	Complete processing	Colin
	Build physical design	Everyone
	Fourth round PCB orders (last free PCB changes)	
3/29 - 4/4	Debug subsystems	Everyone
	Individual progress reports	
4/5 - 4/11	Debug processing	Colin
	Complete app	Zhiyuan

	Start assembly	Jake
	Debug subsystems	Everyone
	Team contract assessment	
	Progress demo	
4/12 - 4/18	Complete assembly Testing Debugging	Everyone
4/19 - 4/25	Last minute debugging	Everyone
	Mock demo and presentation	
	Last-minute touches to demo and presentation	
4/26 - 5/2	Work on final paper	Everyone
	Final demo and presentation	
5/3 - 5/9	Submit final paper by Wednesday	Everyone
	Turn in lab notebooks by Thursday	
	Lab checkout	

5. Conclusion

5.1 Accomplishments

The project successfully resulted in a functional, wearable prototype capable of detecting and correcting forward head posture. The transition from an ESP32-C6 breadboard prototype to a custom-routed ESP32-S3 PCB was completed successfully, integrating a voltage regulator to safely step the battery power down to a constant 3.3V for the microcontroller. The firmware's non-blocking logic acts as a continuous stopwatch, allowing the system to poll the I2C sensors and manage the local Wi-Fi server simultaneously without freezing. When poor posture is detected, the system immediately engages the vibration motor, linearly ramping its strength from 0% to 50% over the course of three seconds. If the posture is not corrected within this 3.0-second window, the system triggers the binary full-alarm state, activating the 12mm buzzer and panel-mounted LEDs. Mechanically, the custom 3D-printed enclosure seamlessly houses the electronics, utilizing a hardware-aligned ToF window and a dedicated motor cradle to deliver crisp haptic feedback.

5.2 Uncertainties

While the prototype successfully demonstrates core functionality, a few uncertainties remain regarding real-world, long-term use. First, while the BMI160 IMU performed exceptionally well without noticeable drift during our testing sessions, the physical stability of the wearable introduces uncertainty. If the elastic suspension strap stretches or shifts during extended use, the physical angle of the enclosure will change. This would invalidate the initial calibrated posture baseline and require the user to manually trigger a recalibration. Second, the exact battery life of the device under daily working conditions remains uncertain. Because the system utilizes an event-driven architecture, transmitting Wi-Fi data to the app only when poor posture is detected, the battery drain fluctuates heavily based on the user's physical habits. If a user has particularly poor posture and triggers the system frequently, the repeated Wi-Fi transmissions will deplete the battery significantly faster than if the user maintains good posture.

5.3 Ethical Considerations

In developing the Screentime Habit Correction Headband, we are committed to upholding the IEEE Code of Ethics, Section I, Item 1, which mandates that we hold paramount the safety, health, and welfare of the public [3]. Since our device is a wearable health monitor that provides physical feedback, our primary ethical responsibility is ensuring the user's safety. To prevent harm, the feedback mechanisms (vibration and audio) will be calibrated to non-intrusive levels to avoid startling the user or causing hearing damage. Furthermore, we must address the safety risks associated with our power subsystem, specifically the Lithium-Polymer (Li-Po) battery. Li-Po batteries can pose fire hazards if compromised. To mitigate this, we are utilizing a TP4056 charging module with built-in protection against overcharging and short-circuiting. Furthermore, the battery is shielded from external impacts by the rigid 3D-printed PLA enclosure worn on the user's head.

We also adhere to the ACM Code of Ethics, Section 1.6, which requires us to respect privacy [4]. As our device collects data regarding user posture and screen time habits, we are responsible for handling this information securely. The companion app will only collect data necessary for functionality, specifically distance metrics and posture states, without storing unnecessary personal identifiers or sharing data with third parties without consent.

Finally, we recognize the societal and environmental impact of our project. Societally, our device aims to alleviate the widespread public health issue of musculoskeletal disorders and digital eye strain. This has the potential to improve workforce productivity and long-term quality of life. Environmentally, we are conscious of e-waste. By designing a durable, rechargeable system rather than one dependent on disposable batteries, we aim to minimize our environmental footprint. We will also encourage responsible recycling of the electronic components at the end of the device's lifecycle.

5.4 Future work

Future iterations of the device would focus heavily on miniaturization and power optimization. Transitioning the wireless communication protocol from a Wi-Fi Access Point to Bluetooth Low Energy (BLE) would significantly reduce the active current draw, extending the operational battery life. Mechanically, the unibody 3D-printed enclosure could be redesigned into a split-pack architecture, moving the LiPo battery and charging circuitry to the rear of the headband to provide a more balanced weight distribution for the user.

6. References

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Appendix A Requirements and Verification

Table 1: Power Subsystem – Requirements & Verification

Requirement	Verification	Verification Status
The voltage regulator must step down the battery voltage to supply a stable $3.3V \pm 0.1V$ to the sensors.	<ol style="list-style-type: none"> 1. Connect the fully charged 3.7V LiPo battery to the input of the power subsystem. 2. Probe the 3.3V output pins of the voltage regulator using a Digital Multimeter (DMM). 3. Record the measured voltage in a data table to verify it remains between 3.2V and 3.4V. 	N
The 3.7V LiPo battery must power the device continuously for at least 120 minutes while maintaining a minimum output voltage of 3.3V under a standard operating load.	<ol style="list-style-type: none"> 1. Fully charge the battery to 4.2V. 2. Connect the battery to the assembled system and power it on. 3. Connect a DMM across the battery output terminals. 4. Use a stopwatch to measure the time elapsed until the battery voltage drops to 3.3V. 5. Record the total elapsed time to verify it meets or exceeds 120 minutes. 	Y

Table 2: Sensor Subsystem – Requirements & Verification

Requirement	Verification	Verification Status
The VL53L0X Time-of-Flight sensor must measure the user's screen distance with an accuracy of ± 5 mm for distances ranging from 0 to 500 millimeters.	<ol style="list-style-type: none"> 1. Mount the ToF sensor on a fixed stand facing a flat monitor. 2. Use a yardstick to place the monitor exactly 100, 200, 300, 400 and 500 millimeters away from the sensor. 3. Read the distance output via the serial monitor on a connected laptop. 4. Record the physical distance and the sensor output in a comparison table to verify the error margin. 	Y

<p>The BMI160 IMU must detect head pitch angles with an accuracy of ± 2 degrees for angles up to 20 degrees from the calibrated baseline.</p>	<ol style="list-style-type: none"> 1. Secure the IMU to be laid flat. 2. Establish a 0-degree baseline and zero the system. 3. Physically tilt the assembly to 0, 5, 10, 15, 20 degrees. 4. Read the computed angle from the ESP32 serial output. 5. Plot the measured angles versus the true angle on a graph to verify accuracy falls within the ± 2 degree tolerance. 6. 	<p>Y</p>
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Table 3: Feedback Subsystem – Requirements & Verification

Requirement	Verification	Verification Status
<p>The feedback components are powered by 3.3V.</p>	<ol style="list-style-type: none"> 1. Connect LEDs, speaker, and vibration motor to the microcontroller. 2. Power on system, drawing power from the battery. 3. Use a multimeter in parallel to measure the voltage going into the system. 4. Ensure stable 3.3 V with ± 0.1 V fluctuations. 	<p>N</p>
<p>One LED turns on after 3 seconds of head posture angle over 15 degrees.</p>	<ol style="list-style-type: none"> 1. Connect LED to microcontroller. 2. Initialize the IMU sensor. 3. Position IMU sensor with an angle of more than 15 degrees from initial position. 4. Time 3 seconds with a timer. 5. Ensure LED continuously lights up without fluctuations until sensor is brought back to horizontal. 	<p>Y</p>
<p>Other LED turns on after 3 seconds of screen distance less than 30 centimeters.</p>	<ol style="list-style-type: none"> 1. Connect LED to microcontroller. 2. Initialize the ToF sensor. 3. Position ToF sensor at 30 inches from the screen. 4. Time 3 seconds with a timer. 5. Ensure LED continuously emit light without fluctuations until sensor is brought back to horizontal. 	<p>Y</p>

Motor and buzzer activate when head posture angle or screen distance alarms are both detected.	<ol style="list-style-type: none"> 1. Connect motor and buzzer to microcontroller 2. Initialize both sensors. 3. Position IMU at an angle of more than 15 degrees from horizontal. 4. Time for 5 seconds to ensure that the sensor activates the alarm 5. Move back the IMU and position the ToF sensor at 10 inches from the screen and repeat step 4. 6. Do steps 3 and 5 together, time for 5 seconds, and make sure both LEDs turn on. 	Y
Feedback system turns off within a second of good position detected.	<ol style="list-style-type: none"> 1. Test for all three cases: only IMU alarm activated, only ToF alarm activated, Both activated 2. With all three, when conditions are no longer present, LEDs turn off and motor and buzzer turn off 	Y

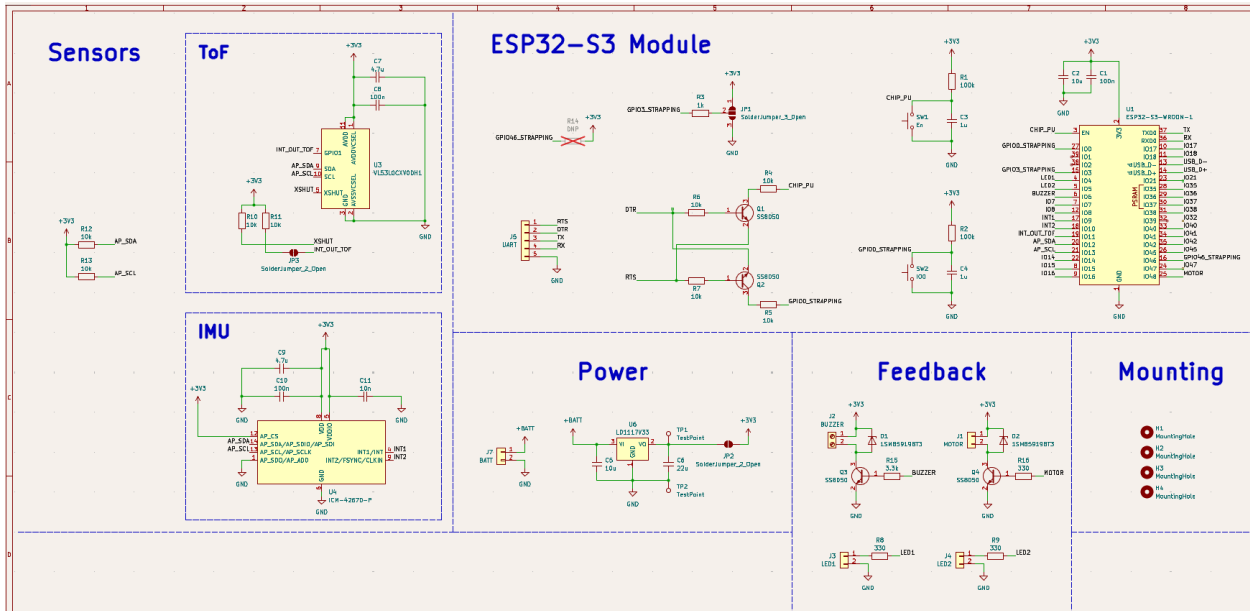
Table 4: Processing Subsystem – Requirements & Verification

Requirement	Verification	Verification Status
The ESP32 must enforce a 3.0-second continuous threshold (± 0.2 seconds) of tilted posture or low distance before triggering the HIGH alarm signal on its output pins.	<ol style="list-style-type: none"> 1. Connect an oscilloscope to the alarm output pin of the ESP32. 2. Programmatically feed a simulated IMU angle of 20 degrees into the ESP32 logic. 3. Start a stopwatch exactly when the simulated data transmission begins and stop it when the oscilloscope detects a rising edge on the output pin. 4. Record the elapsed time as a single numerical value to verify it is between 2.8 and 3.2 seconds. 	Y

Table 5: App Subsystem – Requirements & Verification

Requirement	Verification	Verification Status
The mobile application must successfully receive and store 50 data points from the microcontroller through WiFi.	<ol style="list-style-type: none"> 1. Program the ESP32 to set up Wi-Fi and run the mobile application. 2. Simulate IMU or ToF data to trigger an alarm. 3. Verify that data points are sent to the app when the alarm is triggered. 4. Repeat steps 2 and 3 until the mobile application stores 50 data points. 	Y

Appendix B Schematic



Appendix C PCB Board Layout

