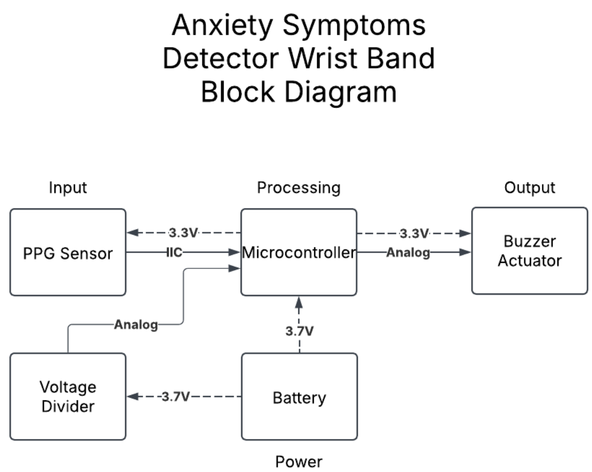
Kaylyn King
CSCE 5612

Milestone 4

System Hardware Block Diagram



I removed the following parts due to complexity and time constraints:

- sEMG
- IMU
- Pressure
- Voltage regulator and battery charger (I didn't realize that the microcontroller had one)

I added the voltage divider to read the voltage on the battery to indicate when the battery needs charging.

I redrew the power lines to show that the power is going through the microcontroller rather than the actual battery.

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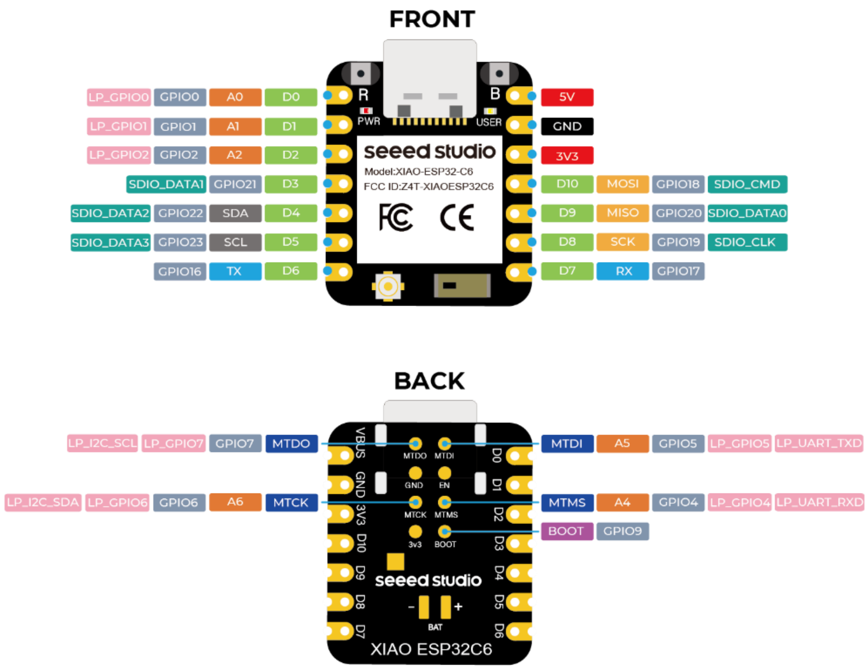
Pin Mapping and Electrical Connections



So 

Pin	Function	Component	Justification	Passive Component
D0	Analog Input (ADC)	Voltage divider from LiPo battery	The D0 pin can read scaled battery voltage safely	Two 100 kΩ resistors for safe reading
D4	Serial Data Line (SDA)	PPG Sensor	The D4 pin is the default I2C SDA pin.	
D5	Serial Clock Line (SCL)	PPG Sensor	The D5 is the default I2C SCL pin.	
D6	Pulse Width Modulation (PWM)	Buzzer	The D6 pin supports PWM and is easily accessible.	100 Ω resistor to protect pin from current
3V3	Power Output	PPG Sensor and Buzzer	Provides power to sensors	
GND	Ground	PPG Sensor and Buzzer	Grounds sensors	

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Power Management and Battery Plan

Power Source

My device is using the PRT-13854 3.7V 1000mAh LiPo battery due to its compact size and rechargeable capabilities. This will allow the device to be wearable on the wrist and allow for hours of continuous operations.

Regulation and Distribution

Regulation: The XIAO ESP32C6 has a built-in LDO regulator to reduce the battery voltage from 3.7V to 3.3V.

Distribution: The 3.3V output pin on the XIAO ESP32C6 board distributes power to the PPG sensor and the buzzer which both operate within the 3.3V logic and power range.

Charging and Monitoring

Charging: The microcontroller includes a charging component for the battery with a USB Type-C port for a universal connection.

Monitoring: The system includes a voltage divider using two 100 kΩ resistors. The voltage divider is going to be placed between the battery positive terminal and ground with the midpoint of the divider connected to the D0 pin. Using two 100 kΩ resistors gives an output voltage that is half of the battery voltage, making it easy to calculate.

$$V_{adc} = V_{bat} \times (R2 / (R1 + R2))$$

$$R2 / (R2 + R1) = (100\ k\Omega) / (100\ k\Omega + 100\ k\Omega) = \frac{1}{2}$$

$$V_{adc} = \frac{1}{2} \times V_{bat}$$

Therefore, the max input voltage into the D0 pin is 3.7V / 2 = 1.85V which is below the max safe voltage of 3.3V for the pin.

The total current consumption will be around 200 mA based on the current consumption microprocessor listed in the datasheet. The estimated battery life on a single charge will be around:

$$1000\ \text{mA hours} / 200\ \text{mA} = 5\ \text{hours}$$

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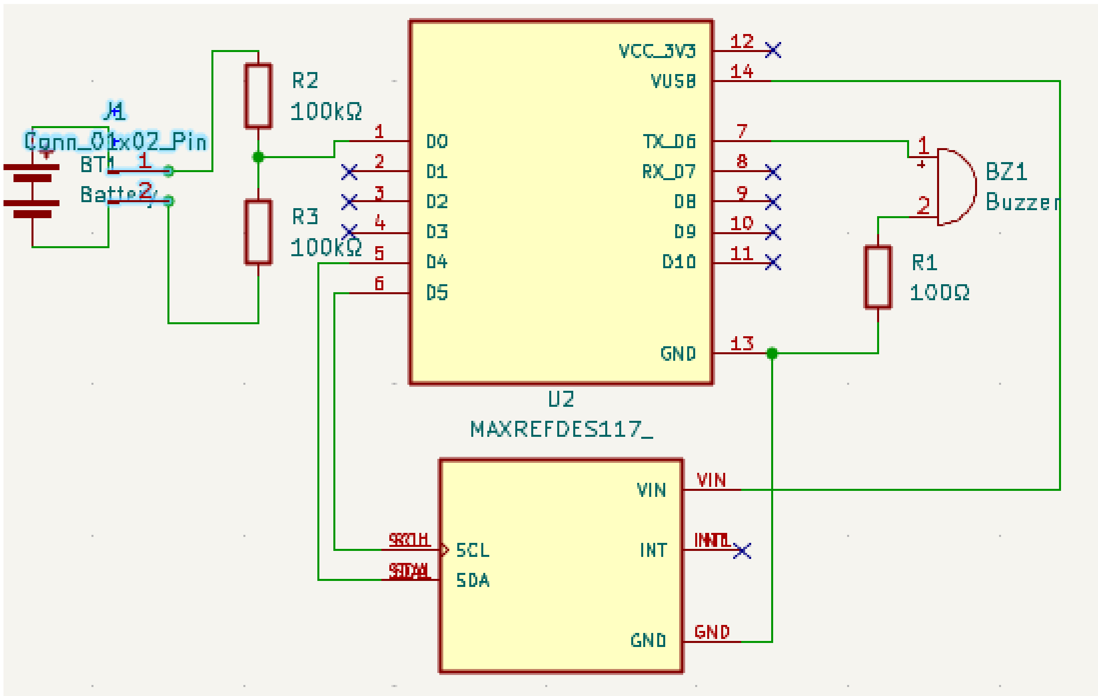
PCB Shield Design with KiCad

Schematic



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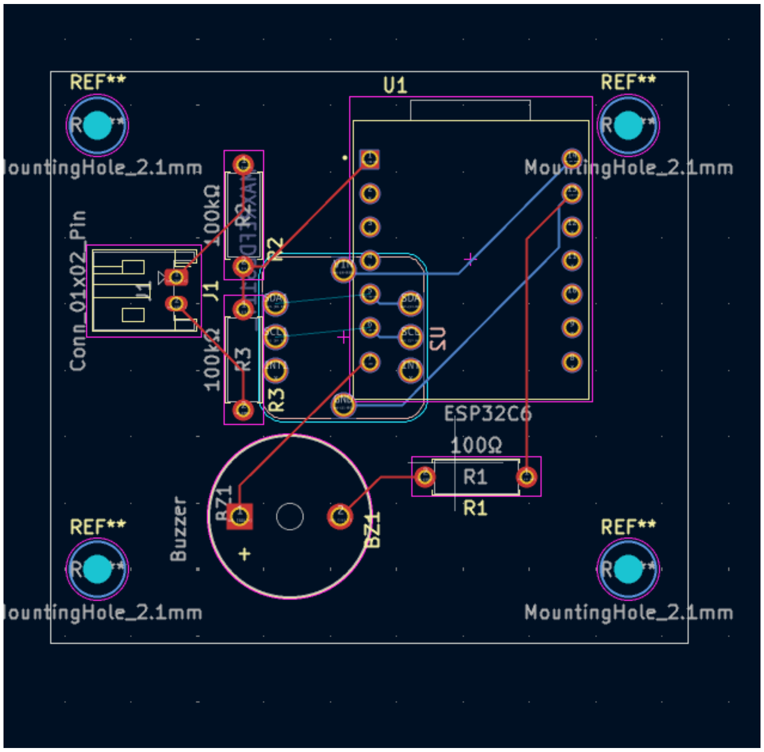
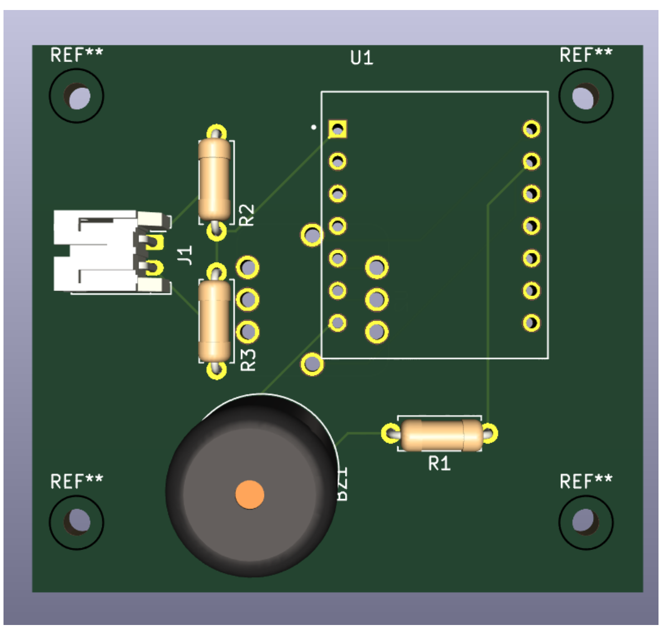
Front Side





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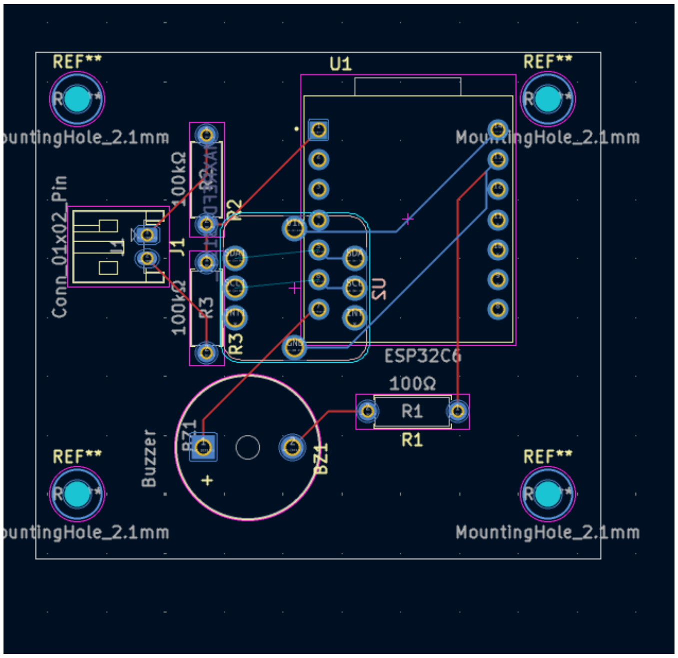
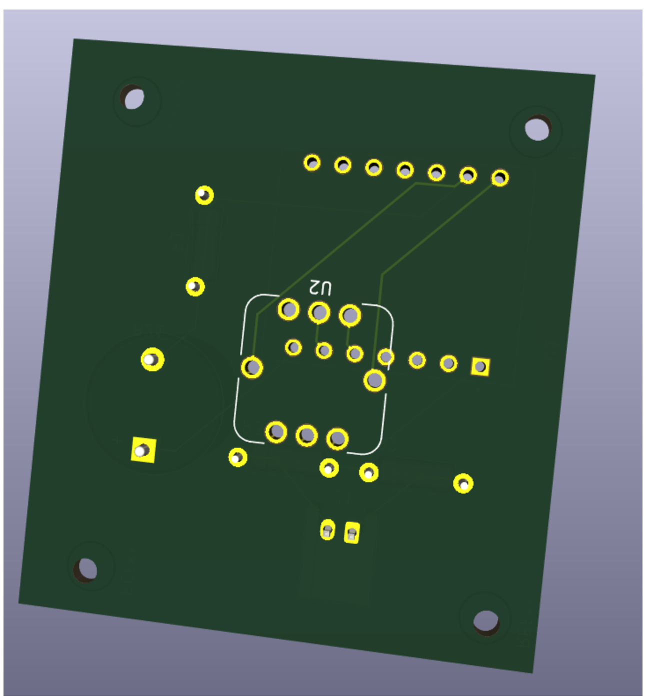
Back Side





Hardware Assembly Plan

Bill of Materials

BoM level	Part #	Description	Qty	Cost

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1	MAXREFDES117	PPG Sensor	1	18.84
1	XIAO ESP32C6	Microcontroller	1	4.99
1	PRT-13854	3.7V LiPo Battery	1	13.61
1	CFS1/4C101J	100 Ω Resistor	1	.12
1	CF1/4C104J	100 kΩ Resistor	2	.26
2	PPPC071LFBN-RC	7-position 2.54mm pitch sockets	2	1.06
1	PCB Board	PCB Board	3	15.95
2	S2B-PH-K-S	2.0mm pitch JST Connector	1	.10
1	DC 3V Active Buzzer	Buzzer	1	.80
			Total:	55.73

Details

Header Types: 2 1x7, 2.54mm pitch female headers for the XIAO ESP32C6.

Connectors:

- 2-Pin JST-PH Connector for the LiPo battery connection
- Pin headers for soldering the PPG sensor

Sensors: MAXREFDES117 PPG Sensor for measuring heart rate and blood oxygen saturation

Mounting: 4 2.1mm diameter mounting holes located at each corner for a clear 3D-printed enclosure to protect the device.

Board Assembly Steps

1. Solder through-hole components:
    a. Female headers
    b. Buzzer
    c. PPG Sensor
    d. Resistors
    e. JST connector
2. Insert XIAO ESP32C6 into the female headers
3. Secure PCB in the 3D-printed enclosure
4. Plug in the battery and test basic power

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Validation Plan

Continuity

Goal: Ensure all electrical connections are correctly routed and soldered

- Use a digital multimeter in continuity mode
    - Place a prob between power rails, microcontroller pin headers and connected components, and JST battery connector and XIAO VBAT/GND
- Verify no unintended shorts between adjacent pads
- Check that mounting holes are not electrically connected

Sensor Functionality

Sensor: MAXREFDES117

- Upload test code to XIAO ESP32C6 through Arduino
    - Ex: SparkFun MAX3010x Library
- Make sure the sensor is outputting raw PPG values
    - Constant flat value when not on wrist
    - All 0s or 65535 means sensor is not initialized properly
    - Fluctating numbers indicates sensor is working correctly
- Confirm that sensor responds within 200ms and no communication errors are printed

Power Stability

Goal: Ensure the device operates correctly on both USB and battery

- Power device through LiPo battery
    - Voltage should be 3.7V at VBAT pin
- Plug in USB-C
    - Charging LED on XIAO lights up
    - No reboot or reset of MCU during charging
- Run the system under full load and monitor for voltage drops or resets
- Test voltage divider output
    - Should be 1.65V at ADC pin

Communication Protocols

I2C: Confirm device address appears via I2C scan and read/write operations return data

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Bluetooth: Pair device with the smart phone and verify notifications work