

Milestone 4: Hardware Integration and Custom Shield Design

Project: AI-Powered Wearable Health Monitor

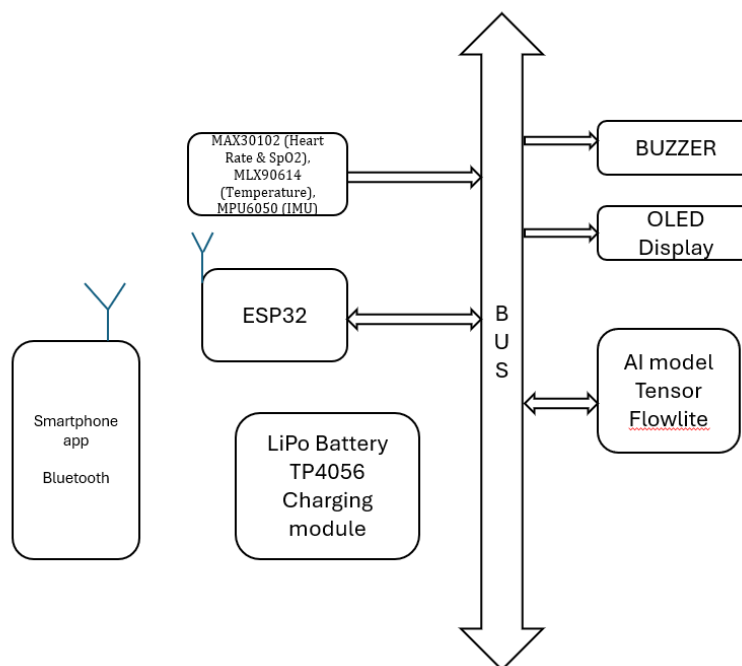
1. System Hardware Block Diagram

The system includes the following components:

- Xiao ESP32-C3 (Microcontroller)
- MAX30102 (Heart Rate and SpO₂ sensor)
- MLX90614 (Body Temperature sensor)
- MPU6050 (IMU - Accelerometer and Gyroscope)
- OLED Display (128x64 I²C)
- TP4056 Module (LiPo battery charging and protection)
- LiPo Battery (3.7V)

Communication protocol used: I²C (shared bus for sensors and display).

Power source: 3.7V LiPo regulated to 3.3V via onboard LDO.



2. Pin Mapping and Electrical Connections

Pin assignment table for the Xiao ESP32-C3:

Pin #	Function	Connected Component	Justification
D4 (PA08)	I ² C SDA	MAX30102, MLX90614, MPU6050, OLED	Shared I ² C data line
D5 (PA09)	I ² C SCL	MAX30102, MLX90614, MPU6050, OLED	Shared I ² C clock line
D2	GPIO	Buzzer (optional)	Alert output
D3	GPIO / PWM	Vibration Motor (optional)	Motion alert output
3.3V	Power Output	All Sensors and OLED	Power supply (regulated from battery)
GND	Ground	All Modules	Common ground reference

Passive components used:

- 2 x 4.7k Ω pull-up resistors for SDA and SCL
- 0.1 μ F decoupling capacitors for each sensor.

3. Power Management and Battery Plan

The system is powered by a 3.7V LiPo battery. Power is regulated to 3.3V using an onboard LDO regulator on the Xiao ESP32-C3.

- Charging is handled via a TP4056 module.
- BAT+ of TP4056 connects to the battery and to the Xiao BAT input.
- Battery voltage may optionally be monitored via a voltage divider connected to an ADC pin.

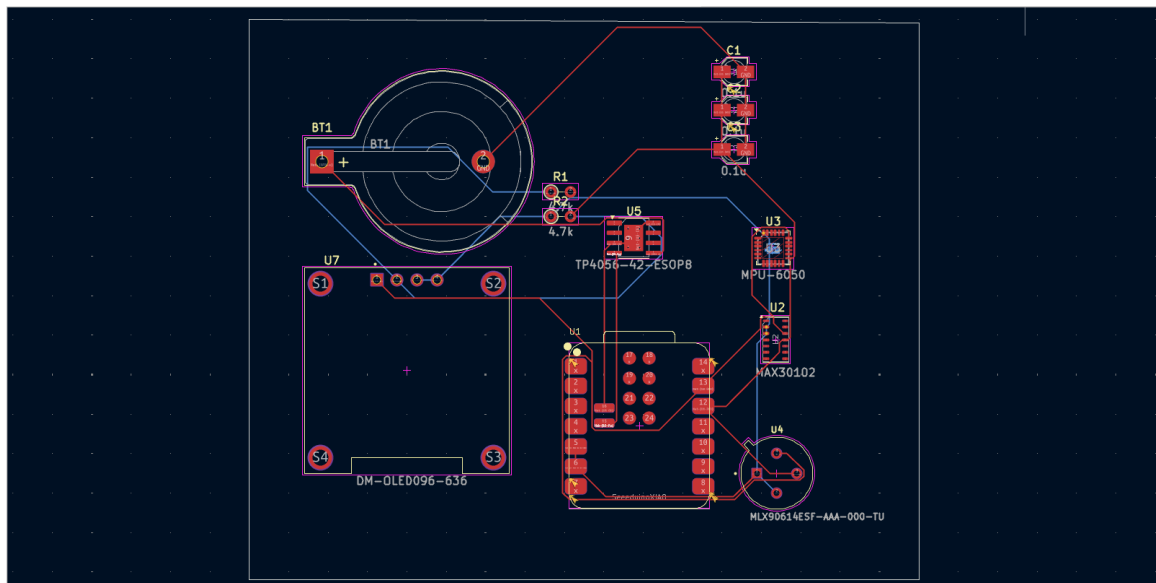
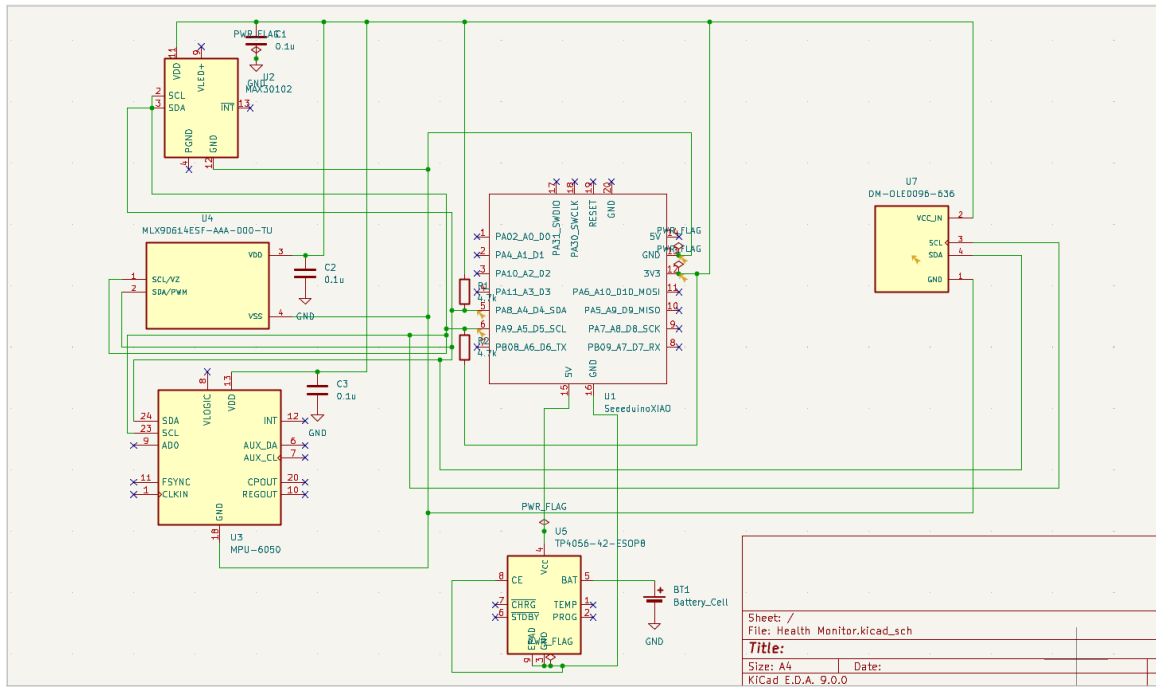
4. PCB Shield Design with KiCad

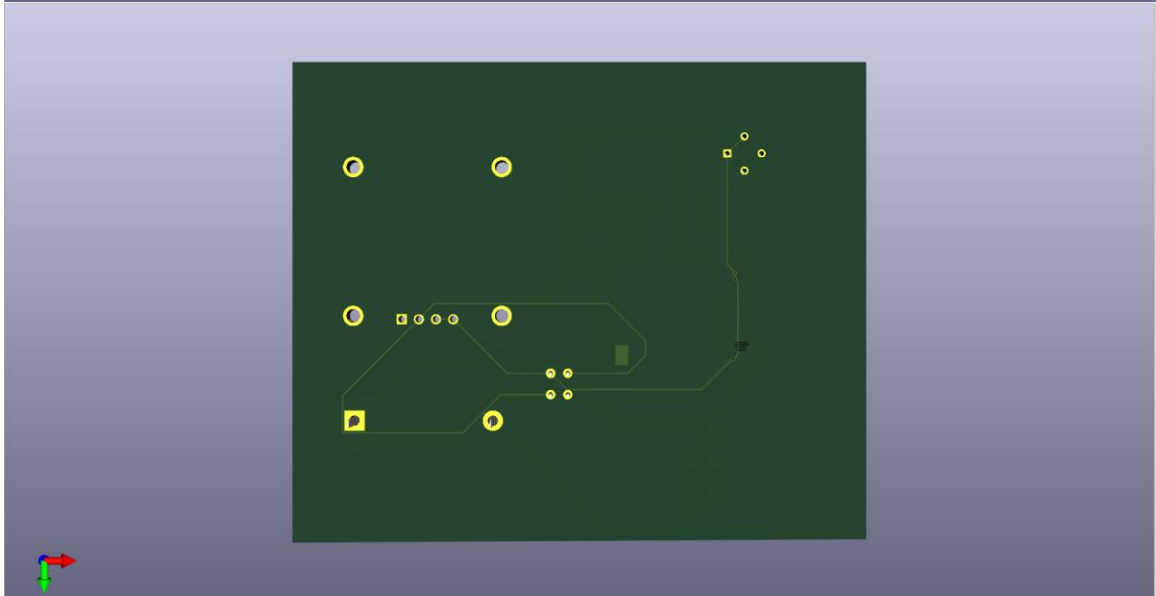
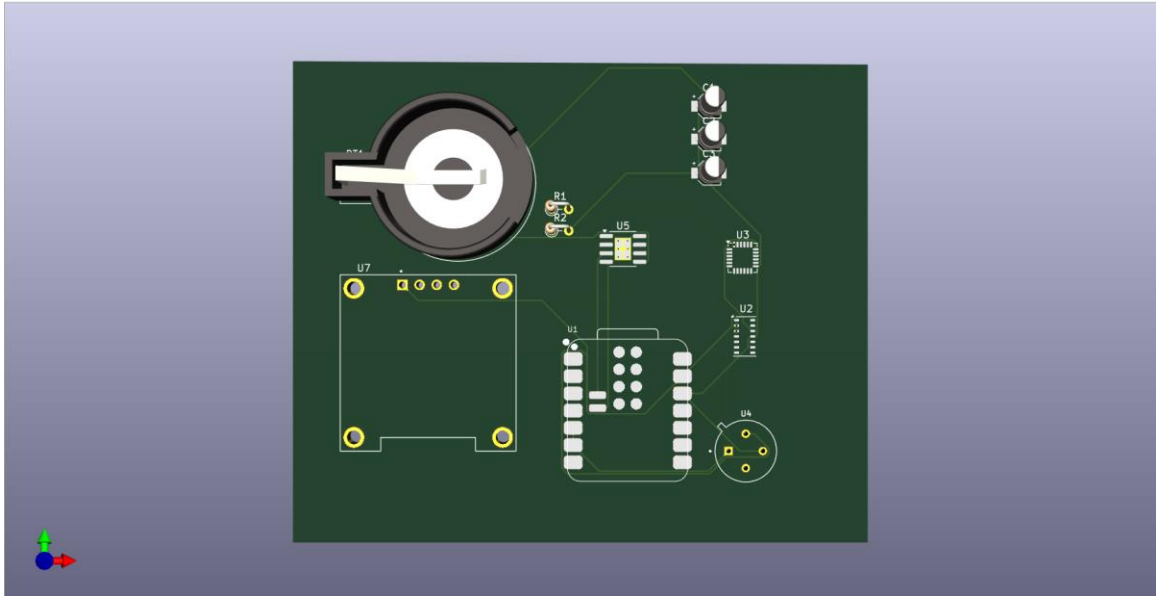
A custom PCB shield was created using KiCad that includes:

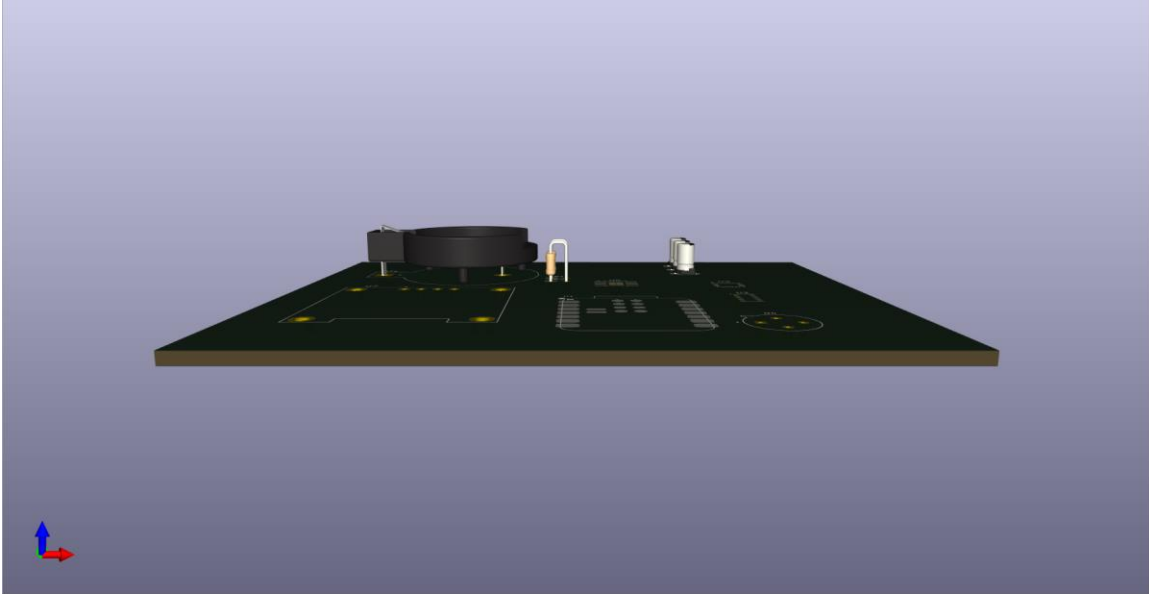
- Xiao ESP32-C3 footprint
- Breakouts for I²C, GND, and 3.3V
- 4-pin headers for sensor modules
- Space for optional components (LED, vibration motor)

Files Delivered:

- KiCad schematic (.sch)
- KiCad layout (.kicad_pcb)
- PCB screenshots (top and bottom)
- Gerber zip file







5. Hardware Assembly Plan

BoM includes:

- 1x Xiao ESP32-C3
- 1x MAX30102
- 1x MLX90614
- 1x MPU6050
- 1x 0.96" I²C OLED
- 1x TP4056 module
- 1x LiPo Battery (3.7V, 500–1000mAh)
- 2x 4.7k Ω resistors
- 5x 0.1 μ F capacitors
- 1x JST 2-pin connector
- Optional: LEDs, Vibration motor, SPST switch

Assembly involves placing the Xiao and modules via headers, soldering SMD passives, connecting battery to JST, and verifying module fit. Designed to fit inside a compact 3D-printed wrist-wearable case.

6. Validation Plan

Validation steps:

- Continuity test: Multimeter across all power and I²C lines
- Sensor test: Read live data from each sensor via serial monitor
- Power test: Verify 3.3V regulation under load
- Protocol test: Run I²C scanner, ensure all devices respond
- Functional test: Simulate real-time input and verify display + communication.