UNSW

School of Mechanical and Manufacturing Engineering

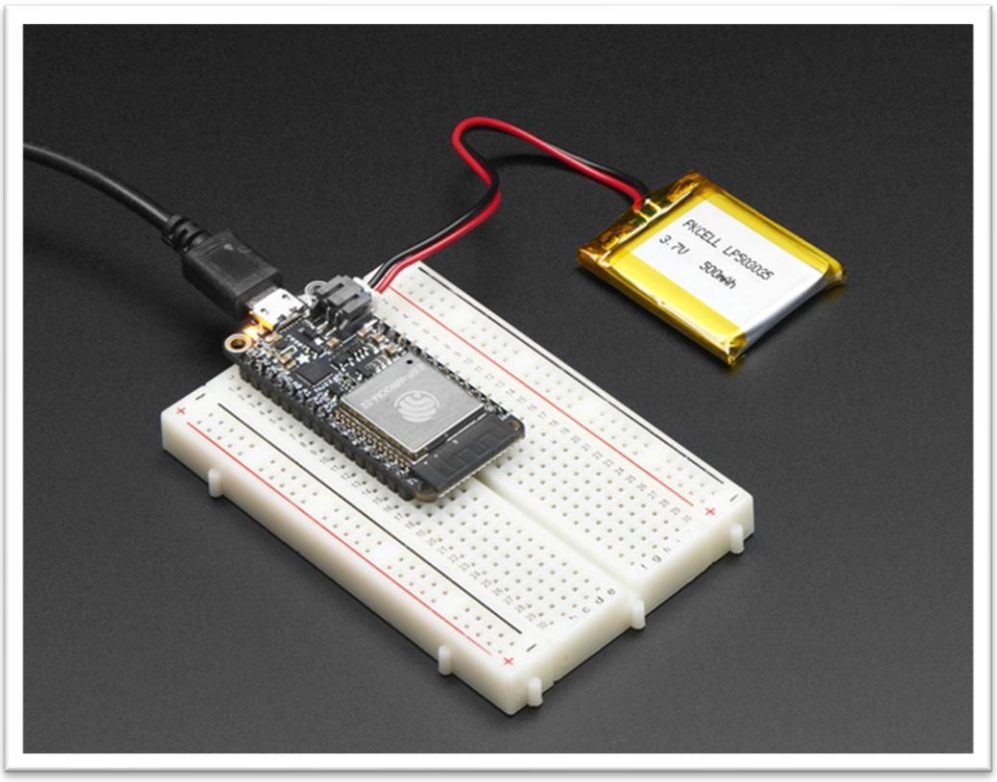
MMAN4020 – Thesis B

Project 06 – Purple House

Version: 13/11/2022

LiPO Battery, Installation & Maintenance User Manual

For use in conjunction with remote telemetry temperature monitoring systems for dialysis sites.



A. Disclaimer

A.1) **Warning:** It is STRONGLY recommended to read and understand this document in its entirety at the following points in the device lifecycle:

i. Before device implementation.

ii. Before device maintenance.

iii. Before battery removal/replacement.

A.2) While the document provides useful and relevant information specific to the remote telemetry temperature monitoring device, it should NOT be utilised as a substitute for comprehensive safety information regarding LiPO batteries. See *Section B* for a summarised recount of the best practices when carrying out instructions outlined in the manual.

A.3) Refer to an alternative bundled document titled ‘README for information regarding setup and initiating typical use of the device. This is not covered in the current document.

B. Battery Safety Guide

B.1) Battery Hazards

When not handled correctly, LiPO batteries present multiple potential injury risks. These risks and their required first aid measures include but are not limited to:

- Battery ignition/explosion:

  Utilize water spray, dry chemical, carbon dioxide or chemical foam to extinguish small fires. Seek emergency services if fire spreads or explosion has caused injury.

- Contact with battery chemicals:

  Depending on the affected area perform the following. Flush eyes with water for ≈15 minutes, lifting upper and lower eyelids. Shower for ≈15 minutes and remove contaminated clothing. Seek emergency services if condition worsens.

- Inhalation of toxic fumes

  Relocate to a well-ventilated area immediately. Seek emergency services if condition worsens.

Sections B.2 – B.5 describe typical use cases where the risk of injury may multiply in magnitude and ways in which to execute preventive measures to greatly mitigate this risk.

B.2) Battery Management & Storage

B.2.1) When not in use, store LiPO battery in a cool dry location away from any flammable material. Ensure battery is clear of direct sunlight and environmental temperatures are constrained to between 0-50° C.

B.2.2) Store battery at ≈50% of a full charge when storing over long periods of time for capacity longevity.

B.3) Battery Handling

B.3.1) When handling the LiPO battery, avoid the following:

- Punctures or any other mechanical stress to the battery body

- Contact with liquid of any kind

B.3.2) Unknowingly shorting the power pins of the battery can cause the battery to swell and overheat, causing irreversible damage. Adhering to the following steps can work in combination to mitigate this risk.

- Utilizing insulated tooling.

- Removing unnecessary metal objects from working area that may cause a short.

- Following ideal maintenance practices (organized workspace, background knowledge, limited distractions).

- Handling the battery without excessive force.

B.3.3) If the battery is especially swollen, extremely warm or emitting a strong odour, DO NOT attempt to handle the battery. Instead, do the following:

- Utilize eye and face protection.

- Move the entire device into an insulated apparatus if possible, away from any flammable material.

- Utilize the assistance of a professional service for removal and disposal of the battery.

B.4) Battery Charging

B.4.1) Charge the battery ONLY with a charger specifically rated for the specifications of a polymer lithium ion battery (not included with the device),

OR

through the Adafruit ESP32 Feather Board connected to mains power.

B.4.2) Ensure rate of charge matches the rated capacity of the battery (400mAh in this case). Charging at > 1C can shorten battery lifespan or even cause ignition. Do not overcharge or excessively discharge the battery.

B.4.3) When not charging in device enclosure, adhere to all relevant safety steps in *Section B.2.*

B.5) Battery Disposal

B.5.1) Dispose of battery suitably at an e-waste collection point or battery recycling drop off location, ensuring battery terminals are insulated in order to prevent a short circuit.

Contents

1.0 Battery Specifications

Table 1: Battery Specifications

Cell Voltage	3.7 V
Capacity	400mAh
Connector	Standard 2-pin JST-PH
Continuous Discharge Rate	2C
Self-Discharge Rate	< 8%
Temperature Reliability Range	-10 to 50°C
Dimensions	38 x 25 x 6mm
Weight	11g
Protection Circuitry	• Over-Voltage • Over-Current • Min-Voltage

2.0 Quick Check Guide

2.1 On Arrival/Before Device Implementation

The temperature monitoring device has been tested thoroughly throughout development, ensuring it is able to perform its function in simulated environments modelling the worst-case conditions experienced over Purple House sites. Despite this, the device may have experienced damage during its lengthy transit period and should be tested before being set into production.

i) Inspect all component seals of casing for potential damage or exposed orifices with particular emphasis around the cable glands.

> ⓘ *It is crucial that the battery, microcontroller, and display do not absorb any excessive moisture, or their function may be adversely affected.*

ii) Observing through the top of the case:

- Ensure all internal connectors are seated correctly.
- Ensure the battery, microcontroller, display and other primary components aren't dangerously loose in the casing.

> ⓘ *Please note that these modules aren't mounted to the casing walls but shouldn't be excessively loose where they can be damaged during typical use.*

iii) As the LiPO battery levels will be drained completely upon delivery, functionality while connected to mains power should be tested first. Connect the microcontroller to mains power using the **black -> white** USB connector protruding from the **white** gland in Figure 1.

- Once power is being supplied to the device, the device will turn on and the Adafruit logo will appear on the display. The device will then go through the setup steps to ensure that device is fully functional.

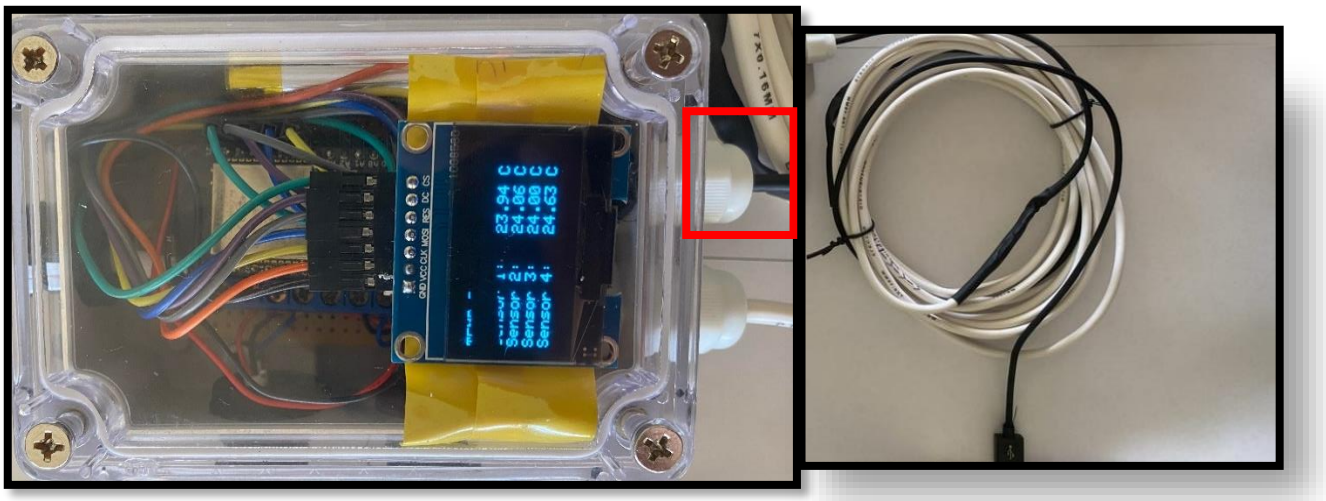


Figure 1: Mains Power Connection Location

iii) Perform basic functional checks of the device as follows:

- Observe if yellow indicator LED on the microcontroller *(directly in line with the power cord in Figure 1)* is illuminated as shown in Figure 2.

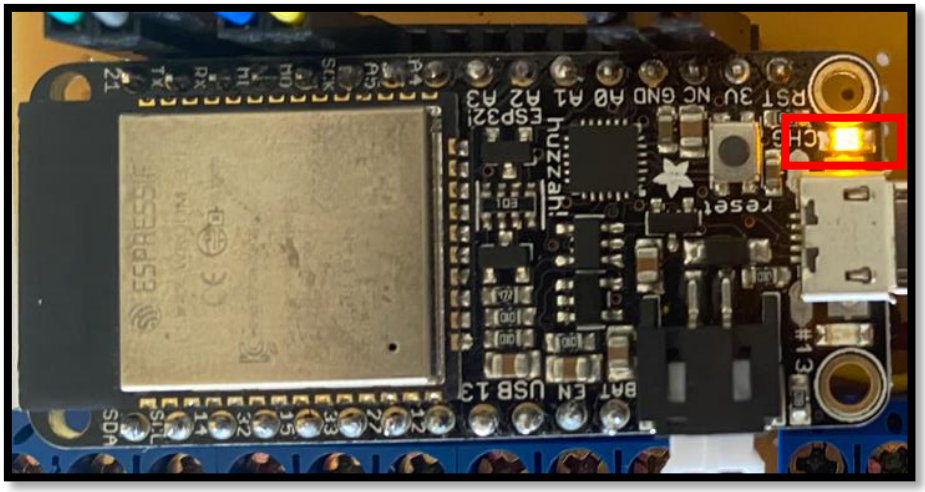


Figure 2: Microcontroller Yellow Indicator Location

- Observe if the display is providing sustained image/text with all key elements as shown in Figure 3.

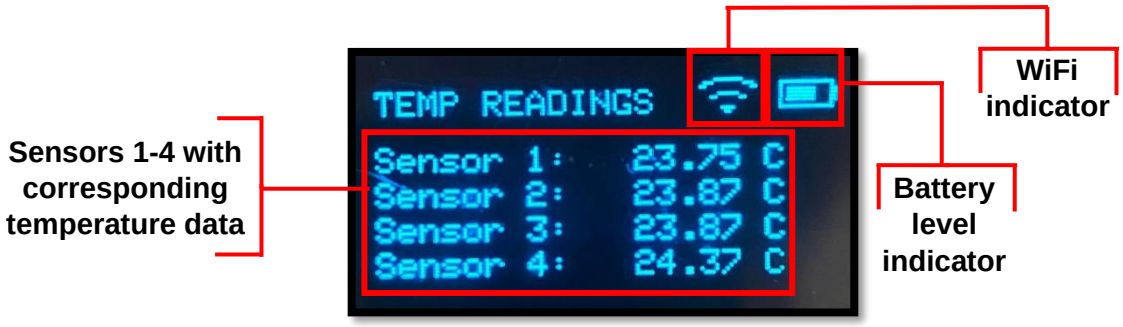


Figure 3: Display Elements

If functional checks are inconclusive, repeat steps **2.1i** – **2.1ii**.

iv) Allow ≈30mins for battery to charge (this occurs automatically while board is connected to mains power).

v) Disconnect the mains power cord from its power source to test battery power. Perform steps **2.1iv** once again.

Continue to **3.1** for more extensive debugging of the device if functional checks are unable to be verified. If device functionality appears to be nominal, skip to **2.2** for advice regarding device implementation.

2.2 On Device Implementation

When selecting a location to act as a ‘hub’ for the device module/housing, consider the following:

- Temperature sensor wires are 3m in length.
- Typical WiFi connection range is 50m line of sight.
- The top of the housing is transparent to allow for reading of the display, and as such should not be exposed to direct sunlight to protect against battery and microcontroller overtemperature.

3.0 Device Maintenance & Battery Replacement

3.1 Fault Isolation Table

Table 2 should be logically followed from top to bottom, as it is ordered by priority.

Table 2: Fault Isolation Tasks

Defect	Configuration Description	Most Likely Root Cause	Relevant Maintenance Task
Yellow Indicator Extinguished	Only Connected to Mains Power	1. Mains power connector unseated or faulty.	**3.3.1** **3.3.2**
	Only Connected to LiPO Battery	1. Battery unseated, faulty or fully drained.	**3.3.1** **3.3.2**
	Connected to Both	1. Microcontroller issue/faulty 2. OR root causes	N/A
Display Completely Inactive	Only Connected to Mains Power	1. Mains power connector unseated or faulty.	**3.3.1** **3.3.2**
	Only Connected to LiPO Battery	1. Battery unseated, faulty or fully drained.	**3.3.1** **3.3.2**
	Connected to Both	1. Female jumper wire (connected to display) unseated. 2. Male jumper wire (connected to microcontroller) unseated. 3. Solder to proto board dislodged.	**3.3.4**
Null Temperature Sensor Readings	All Temp Sensor Readings Null	1. One or more jumper wires dislodged. 2. One or more solders dislodged from proto board. 3. ALL sensor wires dislodged from screw terminal.	**3.3.3**
	(1-3) Temp Sensor Readings Null	1. Respective sensor wire dislodged from screw terminal 2. Respective jumper wire dislodged 3. Respective screw terminal solder dislodged from proto board.	**3.3.3**
Battery indicators empty after charging.	All	1. Battery unseated, faulty or fully drained. 2. Mains power connector unseated or faulty.	**3.3.1** **3.3.2**
Wi-Fi Failing to Connect When Prompted	All	1. Check that the code has the correct Wi-Fi SSID and password, and this has been uploaded to the board. 2. Also ensure that the device is functioning within the range of the Wi-Fi access point.	N/A

3.2 When is a Battery Replacement Required?

There may be rare cases throughout the life of the device where the battery may fail or not function adequately for the needs of the system. An indication that this is occurring could be:

- Swollen battery
- Emission of fumes
- Loss of temperature data when not connected to mains
- Intermittent flashing/flickering of display when not connected to mains

In this case, a battery replacement may be required by following **3.3.1** – **3.3.2** below.

3.3 Maintenance

3.3.1 Maintenance Preparation

i) Remove enclosure screws and lift transparent lid as shown in Figure 4 to access internals.

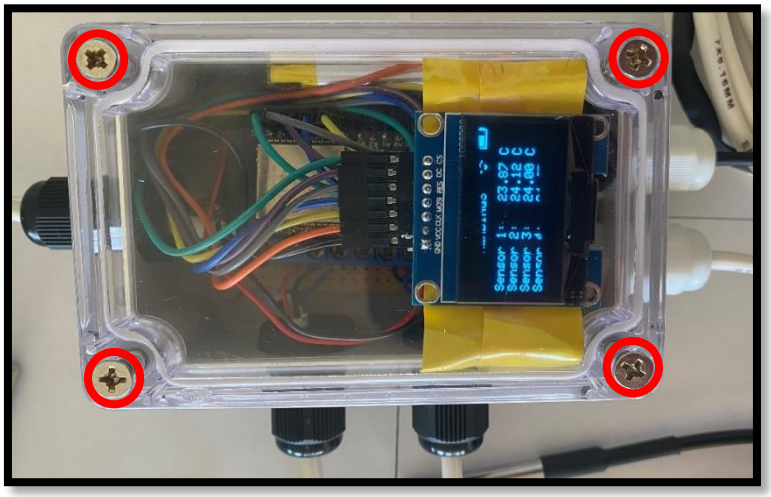


Figure 4: Housing Screws Location

ii) Lay out internals in a similar configuration to the one shown in Figure 5. Take care not to short the battery, unseat any connectors or dislodge any solder when unpacking wires.

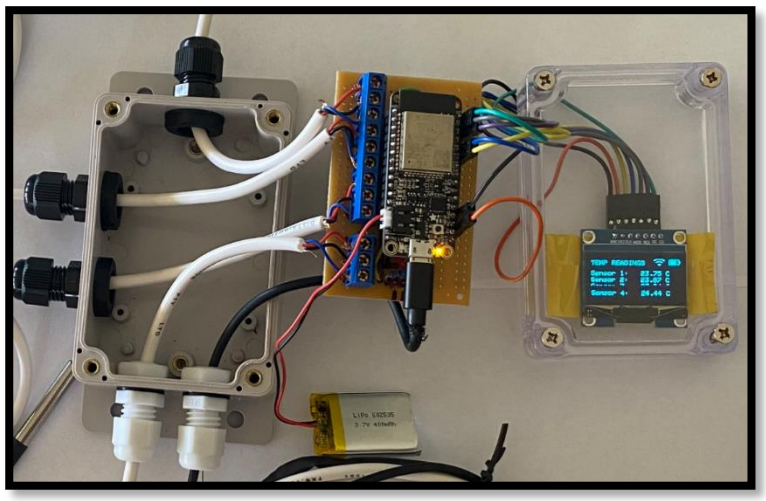


Figure 5: Maintenance Configuration

ⓘ *Note that the tip of the temperature sensors are too thick to pass through the casing glands. As a result, the configuration shown above is most optimal.*

3.3.2 Battery Replacement

i) Ensure adherence to all relevant safety procedures for REMOVAL of old battery. Refer to **Section B B.1/B.2/B.3/B.5**. Do NOT remove battery without professional assistance if it is considerably swollen/emitting strong fumes.

ii) Disconnect mains power from its source (from USB). Subsequently disconnect the mains power connector from the microcontroller using the **RED** location shown below in Figure 6 as reference.

iii) Disconnect the LiPO Battery from the LiPoly JST jack using the **GREEN** location shown below in Figure 6 as reference.

ⓘ *When disconnecting from the jack, ensure that a moderate lateral force is applied on the plug only (force applied directly to the wires may cause damage). If the connector won't come loose, try loosely wiggling the plug rather than applying a purely unidirectional force.*

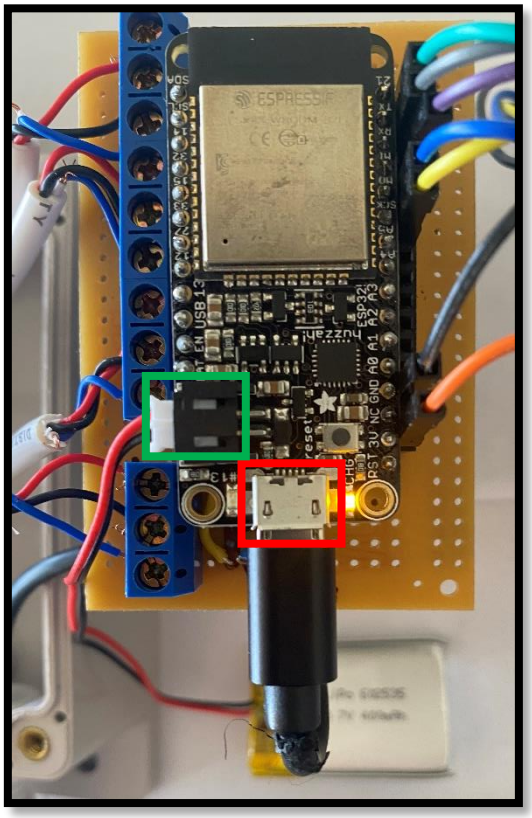


Figure 6: Battery & Mains Jack Locations

iv) Ensure adherence to all relevant safety procedures for INSTALLATION of new battery. Refer to **Section B B.1/B.2/B.3.**

v) Connect the new 4.2/3.7V Lithium Polymer battery to the green connection in Figure 6. The microcontroller will power upon connection if the battery isn't drained.

vi) Reconnect the mains power connector to the red connection in Figure 6.

3.3.3 Temperature Sensor Connection

> ⓘ *If ALL temperature sensor readings aren't being displayed, skip to **3.3.3iv** of this task.*

i) Perform steps **3.3.2 i-iii** to remove power from the microcontroller.

ii) Examine temperature sensor connections as shown in Figure 7. Each individual temperature sensor is connected to a three-way screw terminal, requiring all three wiring elements to be connected.

- If any temperature sensor wiring is dislodged, unscrew the respective terminal header, and place the wiring inside.

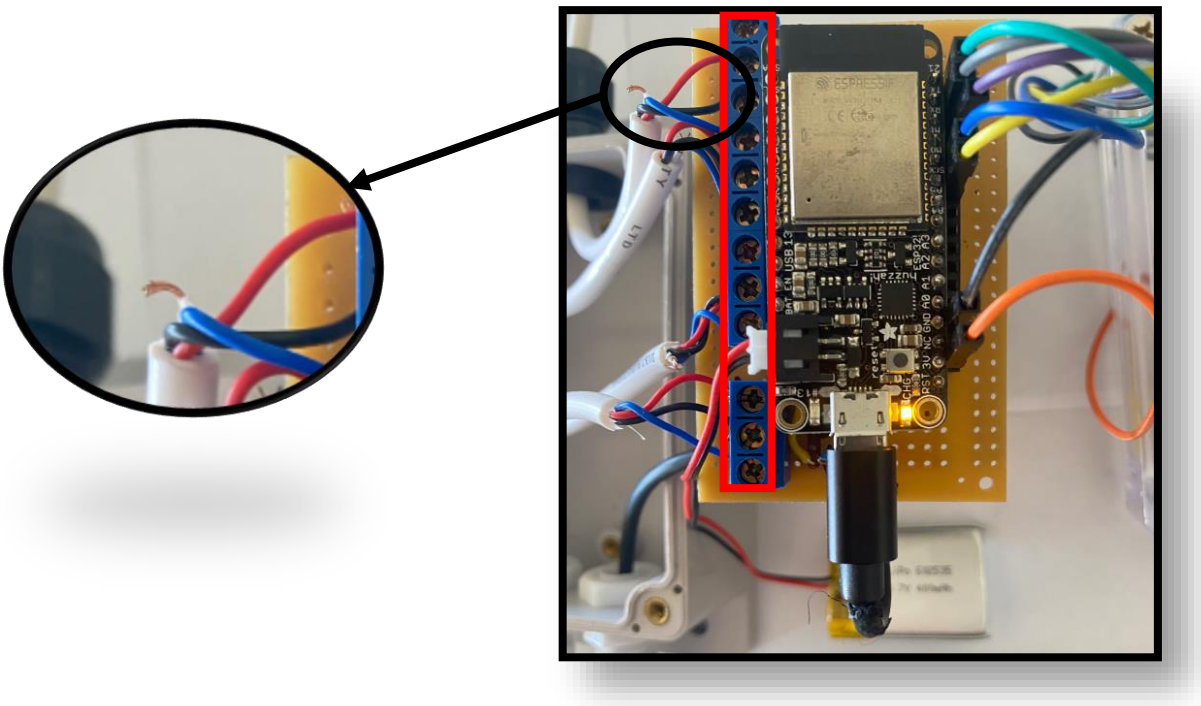


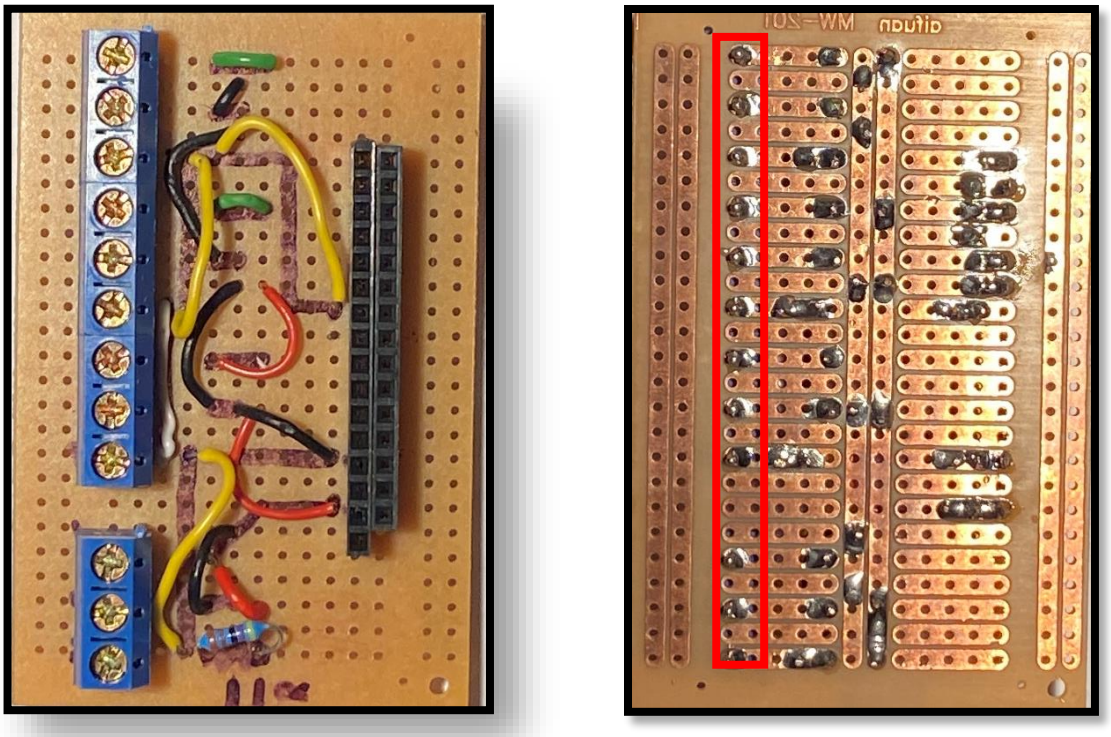
Figure 7: Temperature Sensor Connections

iii) Perform steps **3.3.2 v-vi** to supply power to the microcontroller. If the issue isn't resolved and temperature sensor readings aren't restored, continue to **3.3.3iv**.

iv) Remove the microcontroller from its black male/female headers attached to the proto board by lifting with a gentle, consistent force across its surface area.

v) Perform checks of the solder and extension jumper wires for any damage or loose connections. Prioritise the **yellow wire path** as outlined in Figure 8 for this task.

- If issue persists, consult Figure 8 in combination with the circuit diagram in Appendix A to determine the faulty connection.



Note that the soldering board image has been flipped to better pair with the jumper wire configuration image.

Figure 8: Temperature Sensor Solder & Wire Connections

3.3.4 Display Connection

i) Perform steps **3.3.2 i-iii** to remove power from the microcontroller.

ii) Check or unseat and re-seat the following male/female jumper wires as shown in Figure 9.

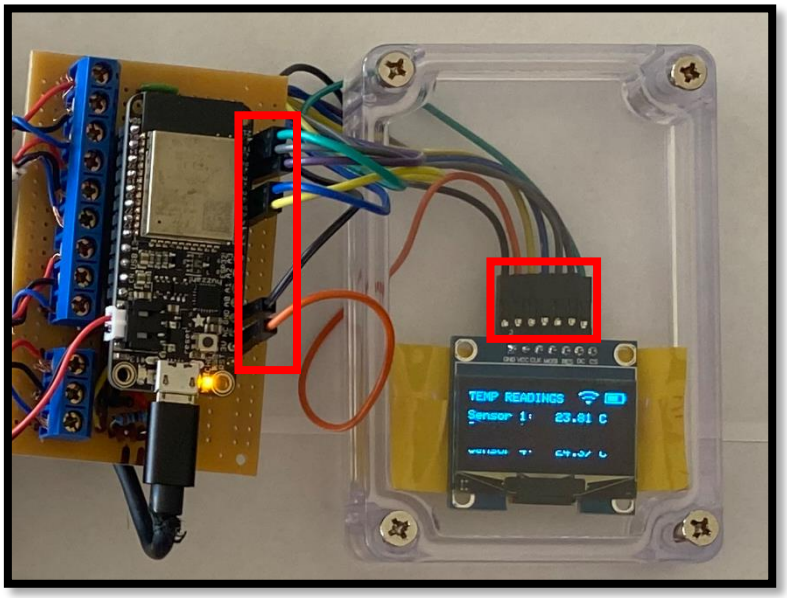


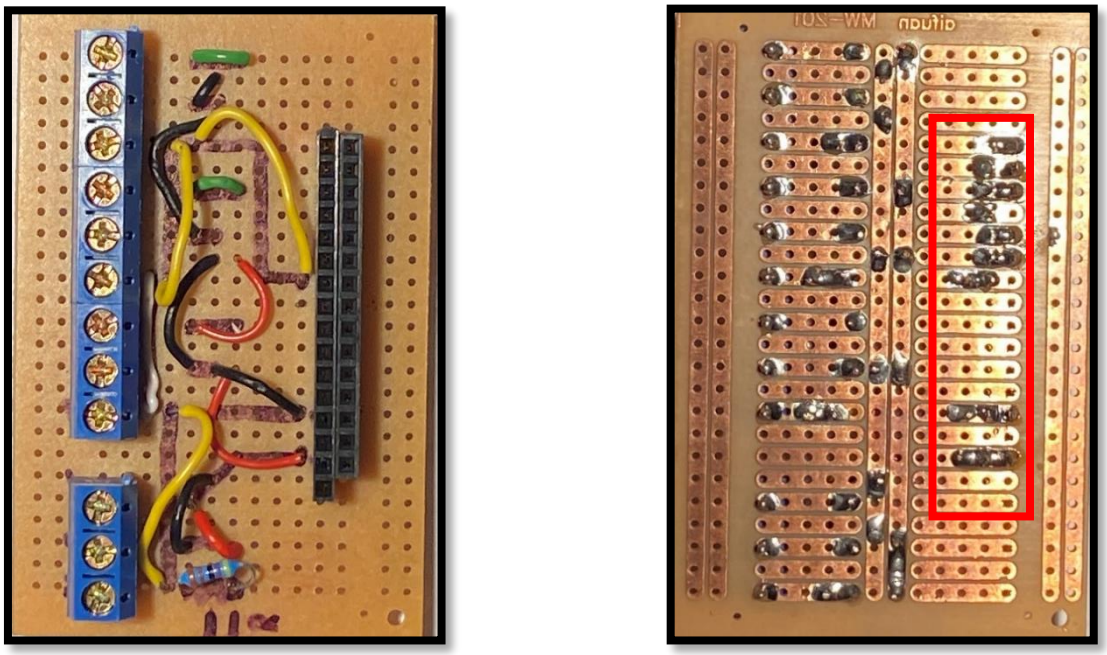
Figure 9: Display Connections

iii) Perform steps **3.3.2 v-vi** to supply power to the microcontroller. If the issue isn't resolved and display elements aren't restored, continue to **3.3.4iv**.

iv) Remove the microcontroller from its black male/female headers attached to the proto board by lifting with a gentle, consistent force across its surface area.

v) Perform checks of the solder and extension jumper wires for any damage or loose connections. Prioritise **ALL** wire paths as outlined in Figure 10 for this task.

- If issue persists, consult Figure 10 in combination with the circuit diagram in Appendix A to determine the faulty connection.



Note that the soldering board image has been flipped to better pair with the jumper wire configuration image.

Figure 10: Display Solder & Wire Connections

4.0 Battery Functionalities

4.1 Monitoring Battery Levels

> ⓘ *LiPoly batteries are 'maxed out' at 4.2V and stick around 3.7V for much of the battery life, then slowly sink down to 3.2V or so before the protection circuitry cuts it off. By measuring the voltage you can quickly tell when you're heading below 3.7V.*
>
> [https://learn.adafruit.com/adafruit-huzzah32-esp32-feather/power-management]

Monitoring battery levels is primarily performed through the onboard display or monitoring through the AskSensor service (or any IOT service the user intends to utilize). Due to the 'hot-swap' nature of the device, information regarding battery levels will only be notably relevant when the device is not in service.

During standard operations and discounting irregular mains power downtime, a healthy LiPO battery shouldn't come close to critical levels throughout its implementation.

> ⓘ *'Since the ESP32 has tons of ADC pins, we 'sacrifice' one for Lipoly battery monitoring. You can read half of the battery voltage off of A13. Don't forget to double the voltage you read, since there is a divider.'*
>
> *See Figure 11.*
>
> [https://learn.adafruit.com/adafruit-huzzah32-esp32-feather/power-management]

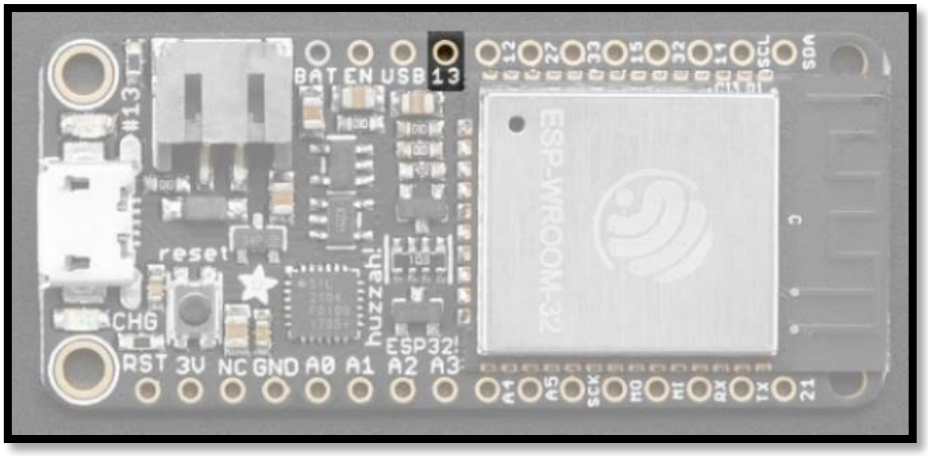


Figure 11: Battery Monitoring ADC Pin

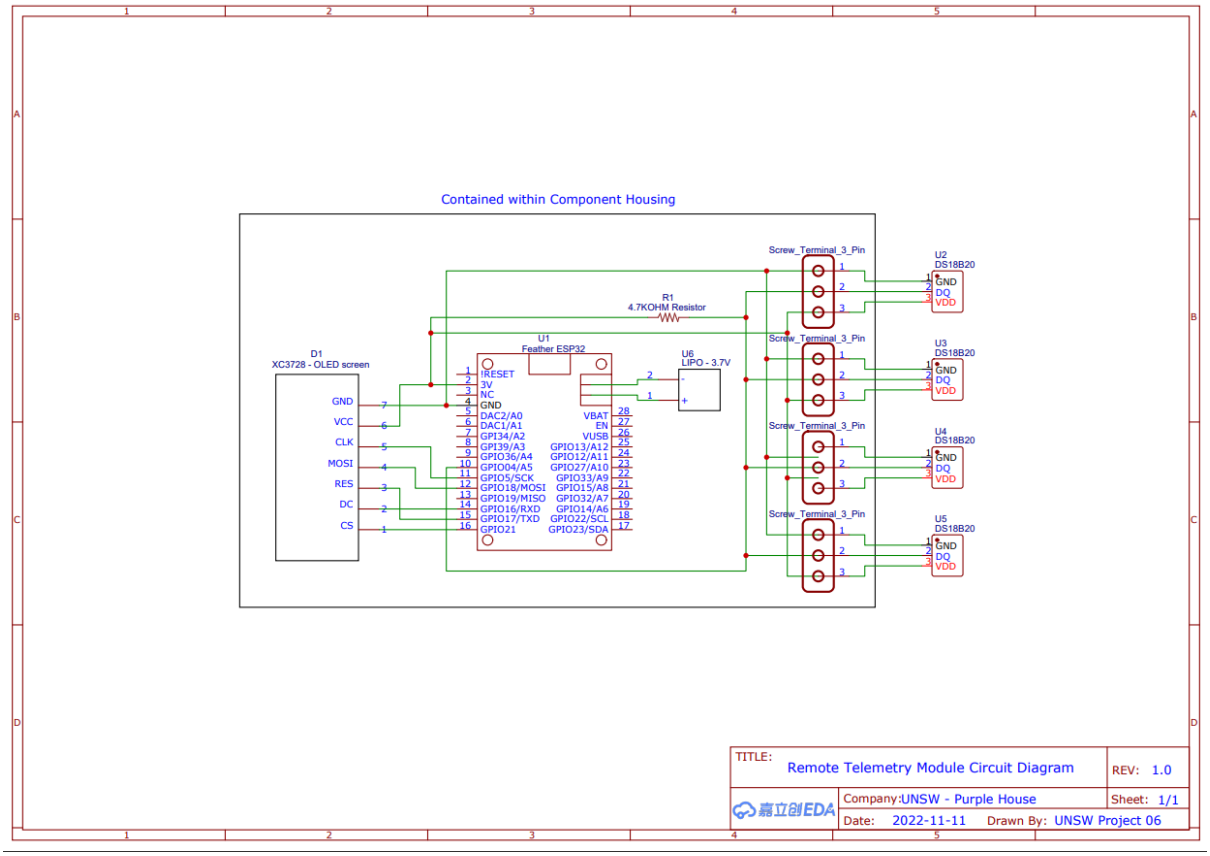
4.2 Recharging Battery

In its current configuration, the device is designed to run off mains power until an outage occurs, in which the installed LiPO battery will automatically act as a redundancy to avoid loss of function.

When mains power is restored, the battery is then recharged accordingly. Such a configuration means that the device will always be powered on even when mains power is disconnected, assuming the battery capacity isn't drained, and the connector isn't unseated.

> ⓘ *'When the USB power is powered, it will automatically switch over to USB for power, as well as start charging the battery (if attached). This happens 'hot-swap' style so you can always keep the LiPoly connected as a 'backup' power that will only get used when USB power is lost.'*
>
> [https://learn.adafruit.com/adafruit-huzzah32-esp32-feather/power-management]

Appendix A


Contained within Component Housing
D1
XC3728 - OLED screen
GND
VCC
CLK
MOSI
RES
DC
CS
U1
Feather ESP32
RESET
3V
NC
GND
DAC2/A0
DAC1/A1
GPI34/A2
GPI39/A3
GPIO36/A4
GPIO04/A5
GPIO5/SCK
GPIO18/MOSI
GPIO19/MISO
GPIO16/RXD
GPIO17/TXD
GPIO21
VBAT
EN
VUSB
GPIO13/A12
GPIO12/A11
GPIO27/A10
GPIO33/A9
GPIO15/A8
GPIO32/A7
GPIO14/A6
GPIO22/SCL
GPIO23/SDA
R1
4.7KOHM Resistor
U6
LIPO - 3.7V
Screw_Terminal_3_Pin
U2
DS18B20
U3
DS18B20
U4
DS18B20
U5
DS18B20
GND
DQ
VDD
TITLE:
Remote Telemetry Module Circuit Diagram
REV: 1.0
Company:UNSW - Purple House
Sheet: 1/1
Date: 2022-11-11
Drawn By: UNSW Project 06