Build Instructions for UKRAA Muon Detector Kit (UKR085)

Acknowledgements

Design

The UKRAA muon detector kit is developed from the work of
CosmicWatch v2 detector

Testing Team

The UKRAA muon detector kit was tested by
Paul Hearn

Production Team

The initial batch of the UKRAA muon detector kit was produced by
Paul Hearn and John Thain

Contributors

The following authors have contributed to the muon detector kit manual
Richard Knott, Paul Hearn, Andrew Thomas and John Thain

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Introduction to build instructions.

UKRAA

The UK Radio Astronomy Association (UKRAA) is a non-profit-making charitable company limited by guarantee. It was established by the Radio Astronomy Group of the British Astronomical Association (BAA) to facilitate the production and sale of radio astronomy products.

This Manual describes how to connect and use the UKRAA VLF Aerial Tuning Unit. Any suggestions or recommendations for improvement of this Manual would be appreciated. See the Contacts page for further details.

The UKRAA muon detector kit

The UKRAA Muon Detector kit

The muon detector kit is designed to provide a means of detecting muons generated from cosmic rays interacting with Earth's atmosphere. The muon detector used a silicon photomultiplier to detect light photons generated within a plastic scintillator from ionisation events. The signal is amplified and extended and recorded by on-board microcontroller. The microcontroller prints interaction data to its serial port for external recording and data analysis. There is also on-board microSD card storage available for portability.

When used in conjunction with a second muon detector, coincidence events can be recorded – these are muons created 15km above the Earth's surface and illustrate Einstein's Special Relativity Theory through demonstration of time dilation for the muon.

Support

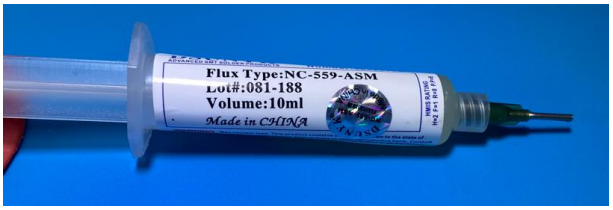
All users of the UKRAA muon detector kit are encouraged to make use of the support available from UKRAA for setting up and operation. Please see the Contacts section for details.

What tools do we need?

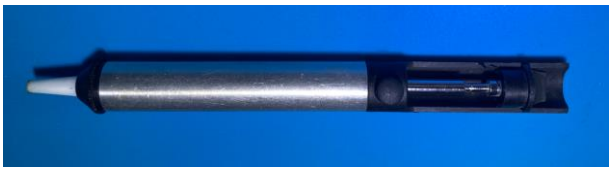
You will need the following tools to construct the UKRAA muon detector kit:

Soldering iron

Flux (optional)



De-solder tool (optional)



Lead free solder

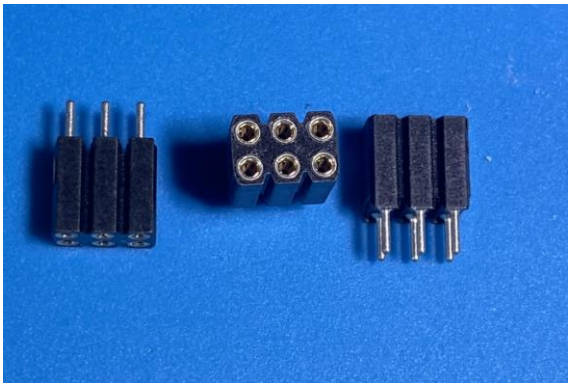
End cut pliers

Isopropyl Alcohol (to clean flux residue from PCB – optional)

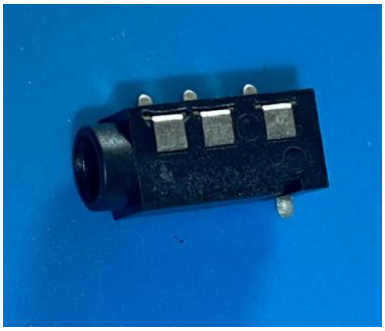
Multimeter

Parts supplied with Muon Detector Kit

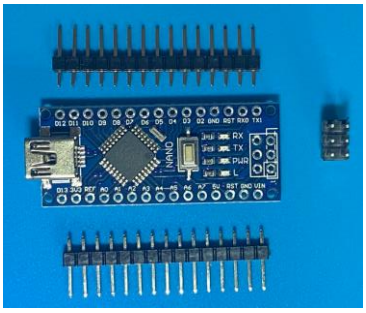
SiPM 2x3 sockets:



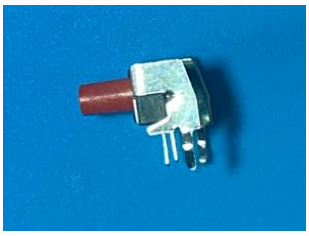
3.5mm audio socket:



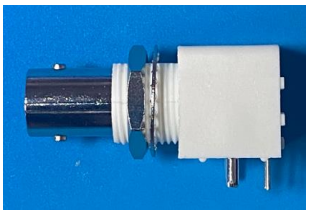
Arduino Nano clone:



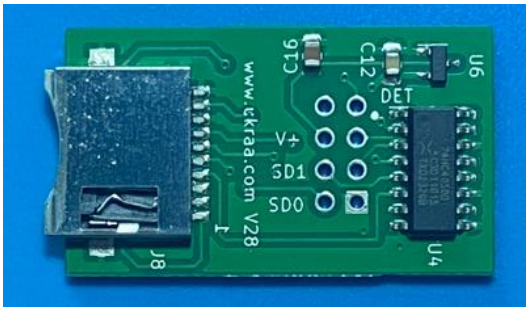
Reset switch:



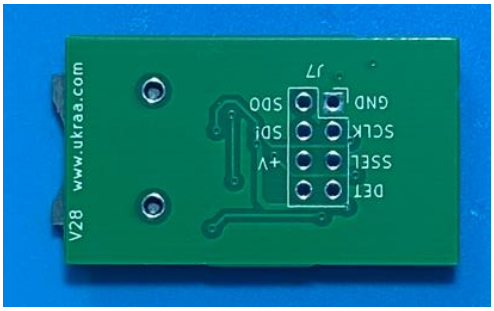
Female BNC socket:



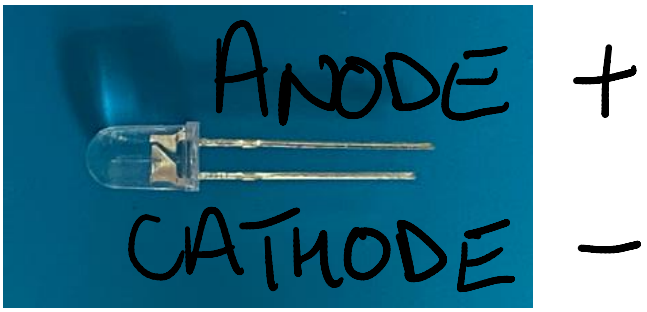
SDcard module PCB: **Front**



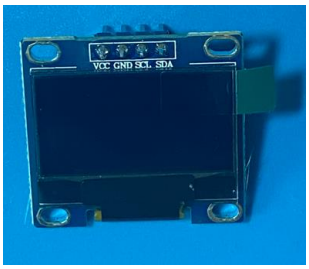
Rear



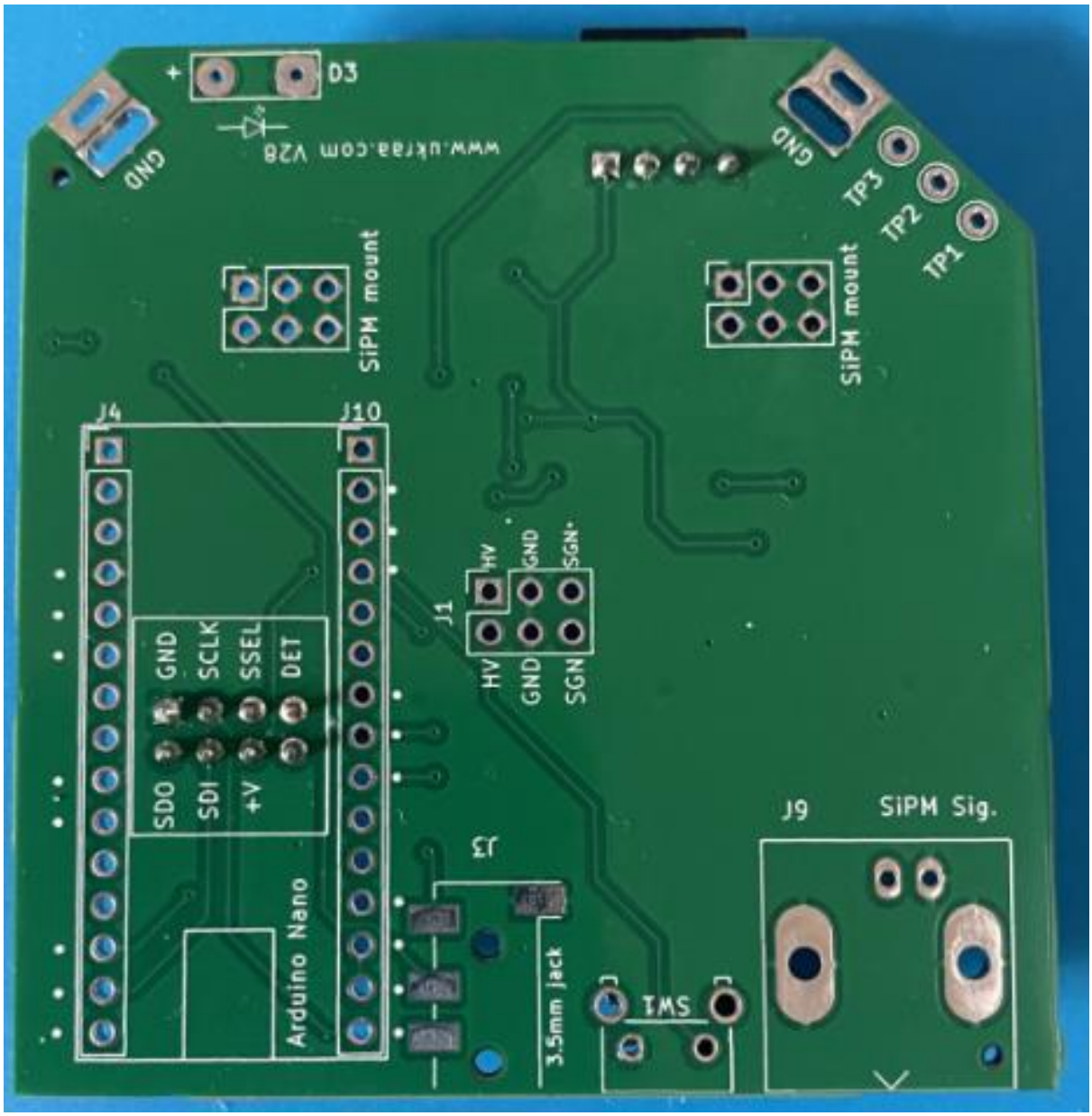
LED:



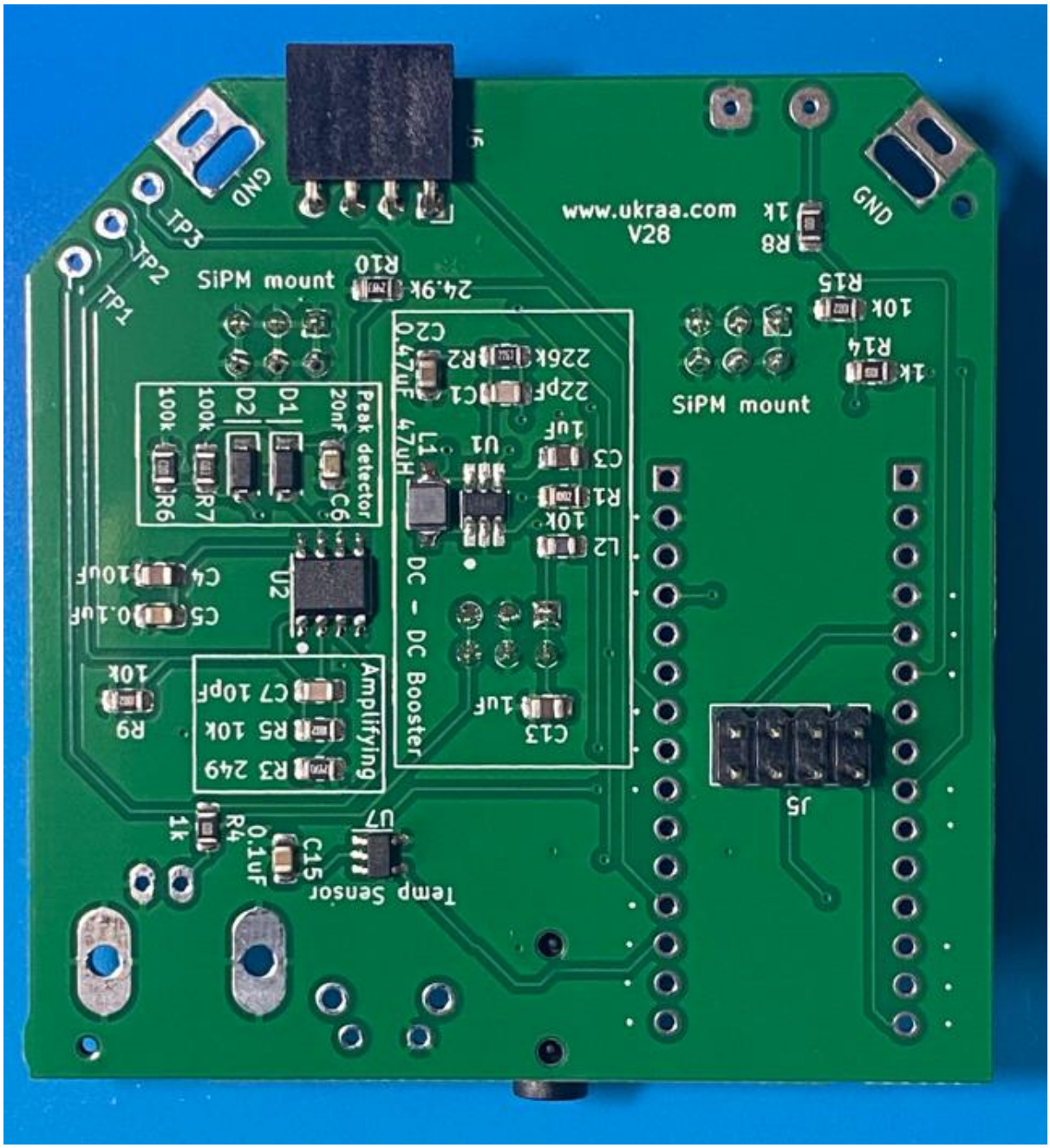
0.96” OLED display:



Main PCB – Front:

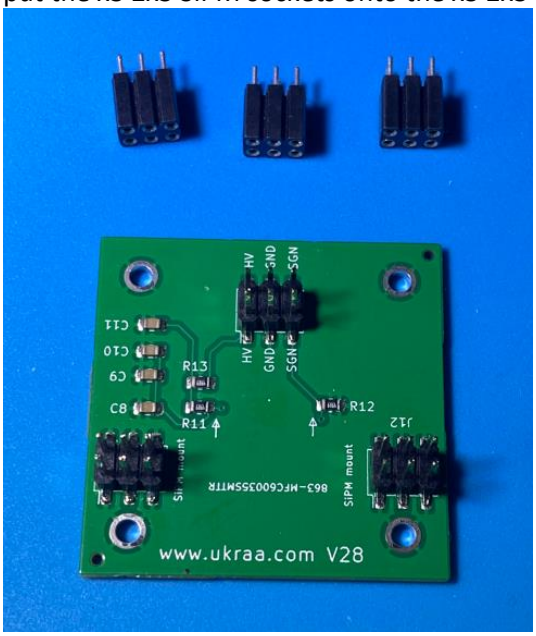


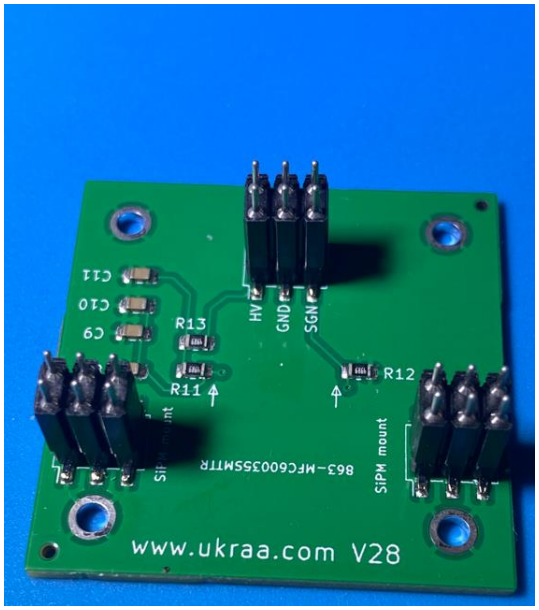
Main PCB – Rear:



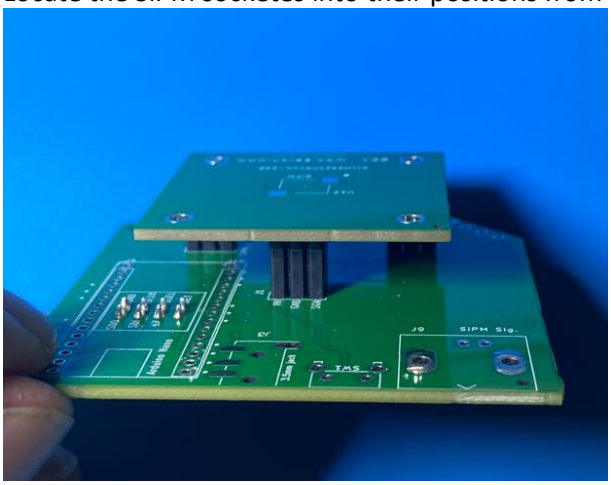
Install SiPM 2x3 sockets

1. To assist in aligning the SiPM mount sockets – take your SiPM PCB (or complete unit) and put the x3 2x3 SiPM sockets onto the x3 2x3 SiPM headers.

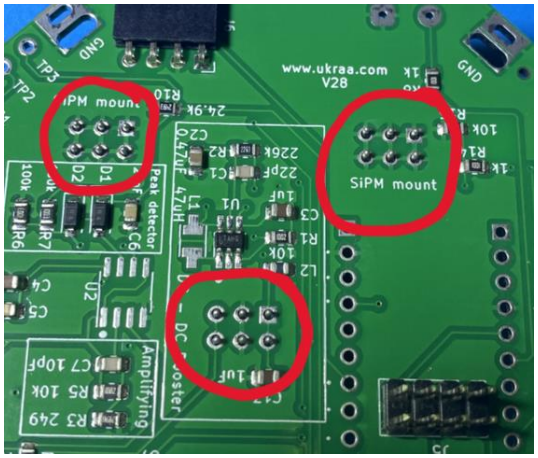




2. Locate the SiPM socketes into their positions from the top side of the main PCB

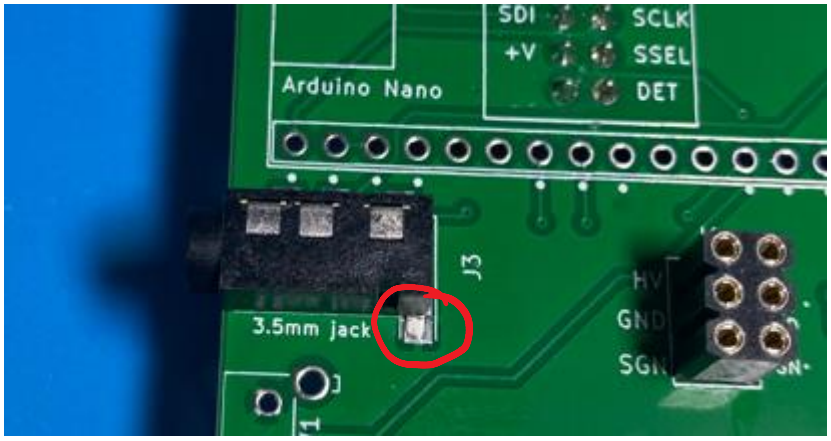


3. Rotate the main board over, ensure the pins are fully through the board and solder all three sets of 2x3 pins in place.

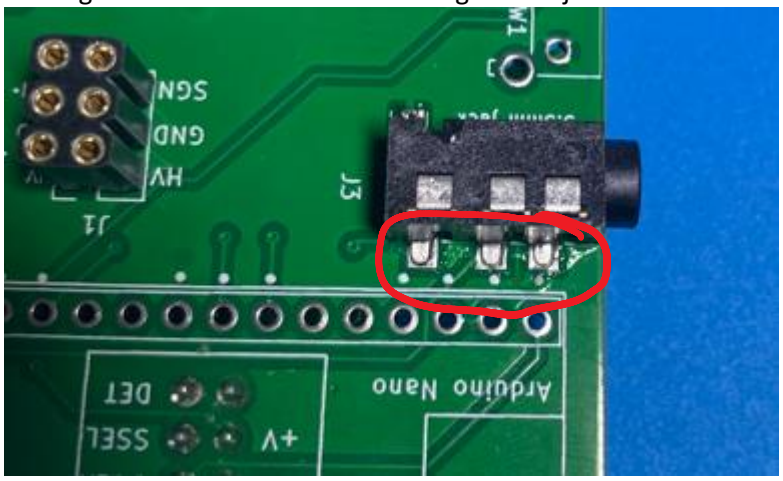


Install 3.5mm socket

1. Position the 3.5mm socket onto the main PCB at J3 – there are two location pins on the bottom of the 3.5mm socket that locate the socket to the board.

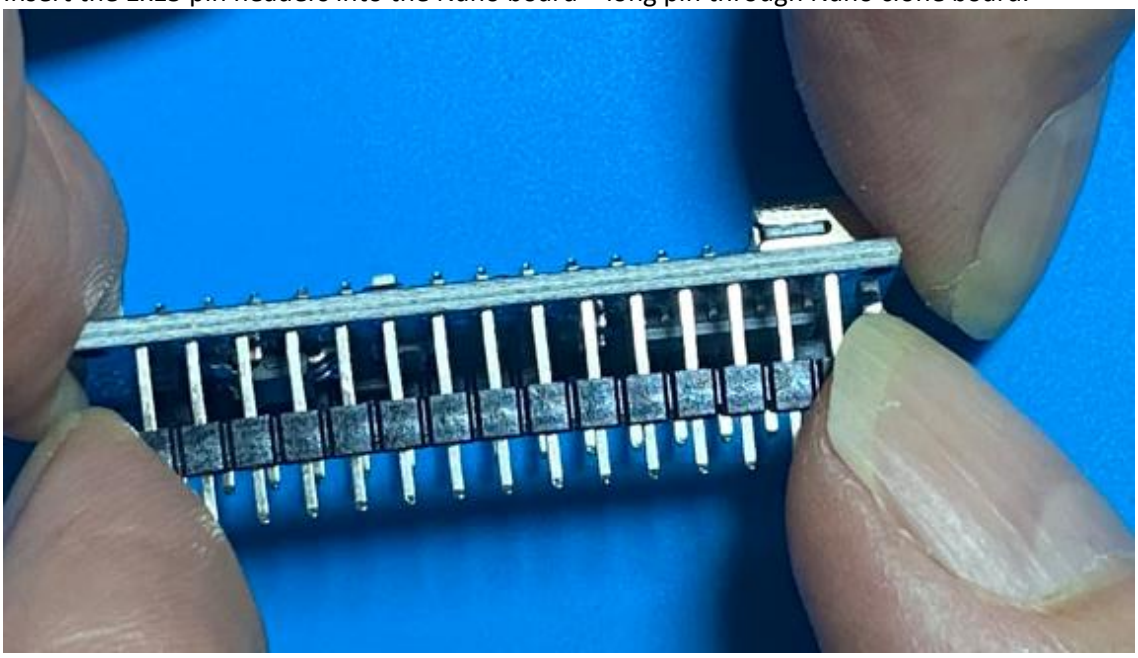


2. Solder the single tab adjacent to the 3.5mm jack silkscreen and then rotate the board by 180deg and solder the three remaining tabs adjacent to the Arduino Nano silkscreen.

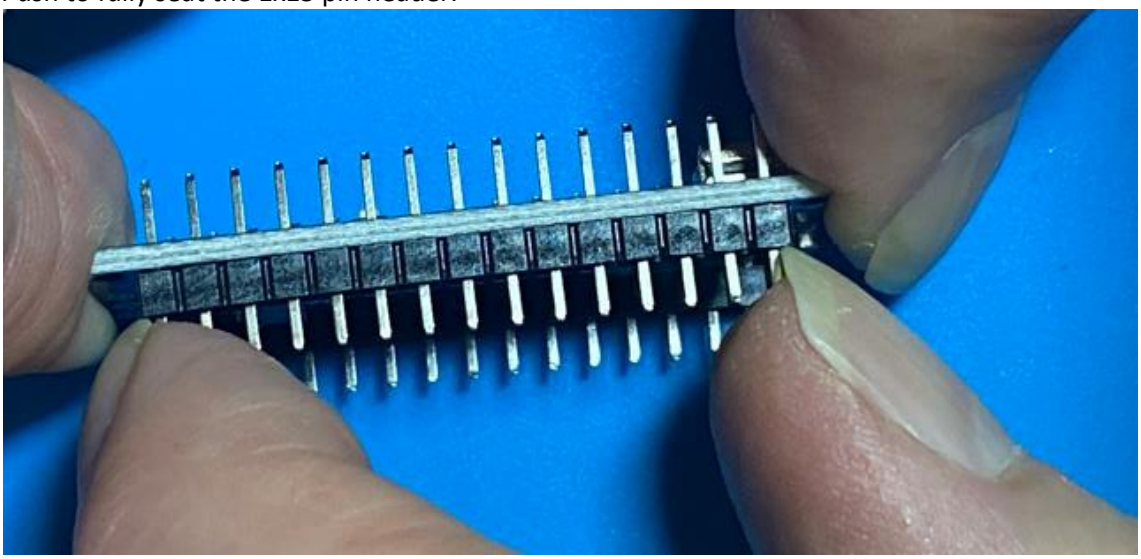


Install Arduino Nano clone

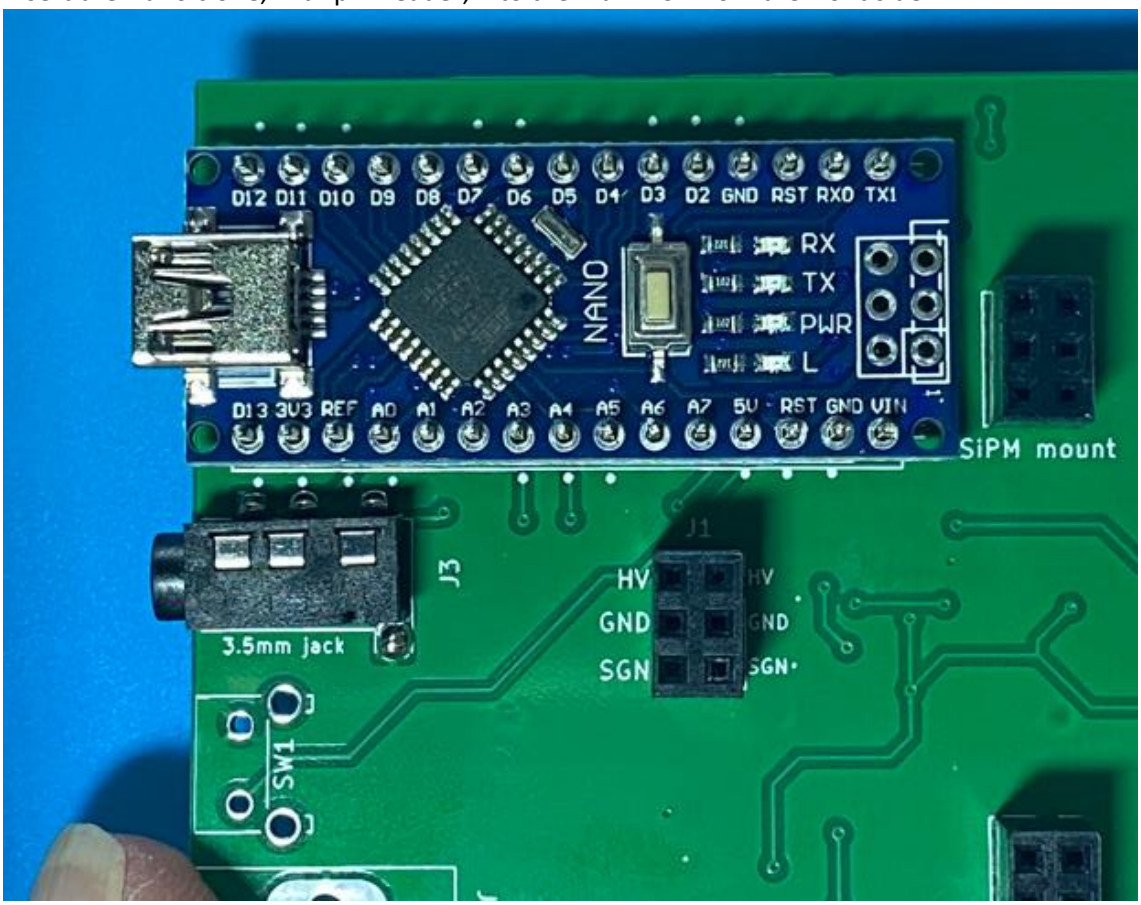
1. Insert the 1x15 pin headers into the Nano board – long pin through Nano clone board.



Push to fully seat the 1x15 pin header.

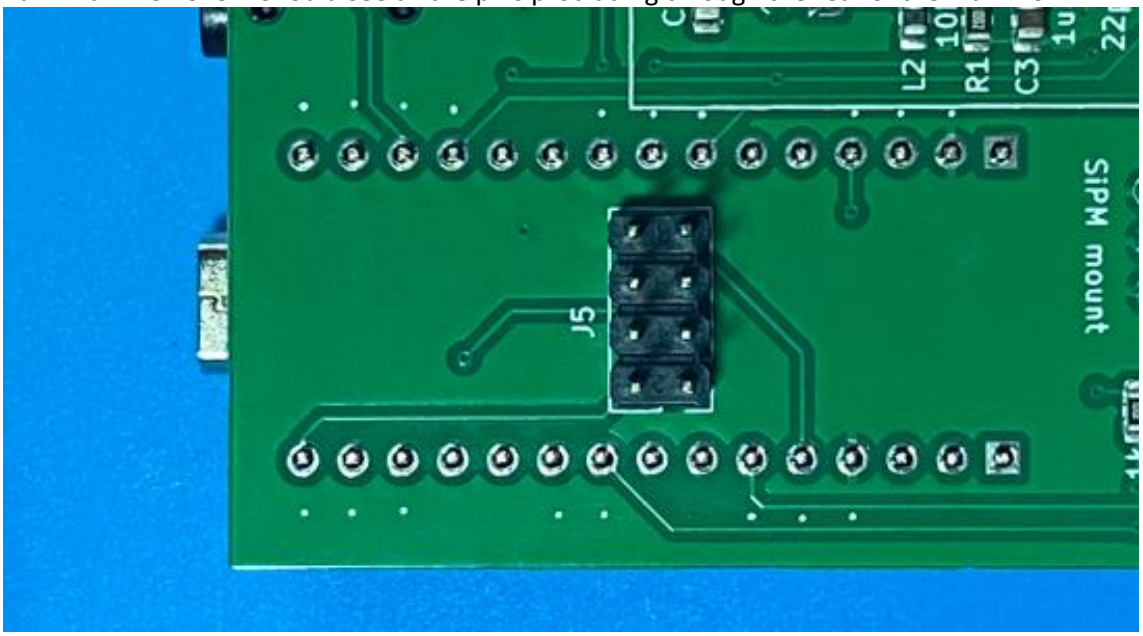


3. Insert the Nano clone, with pin header, into the main PCB from the front side.

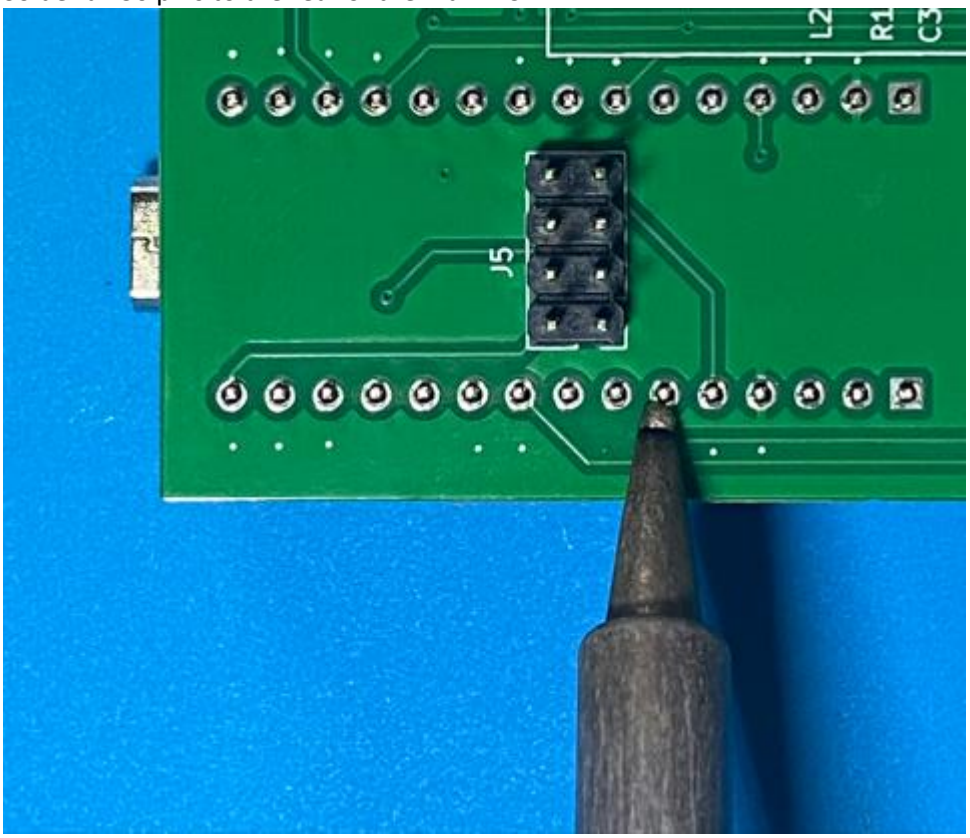


Ensure it is fully seated to the main PCB

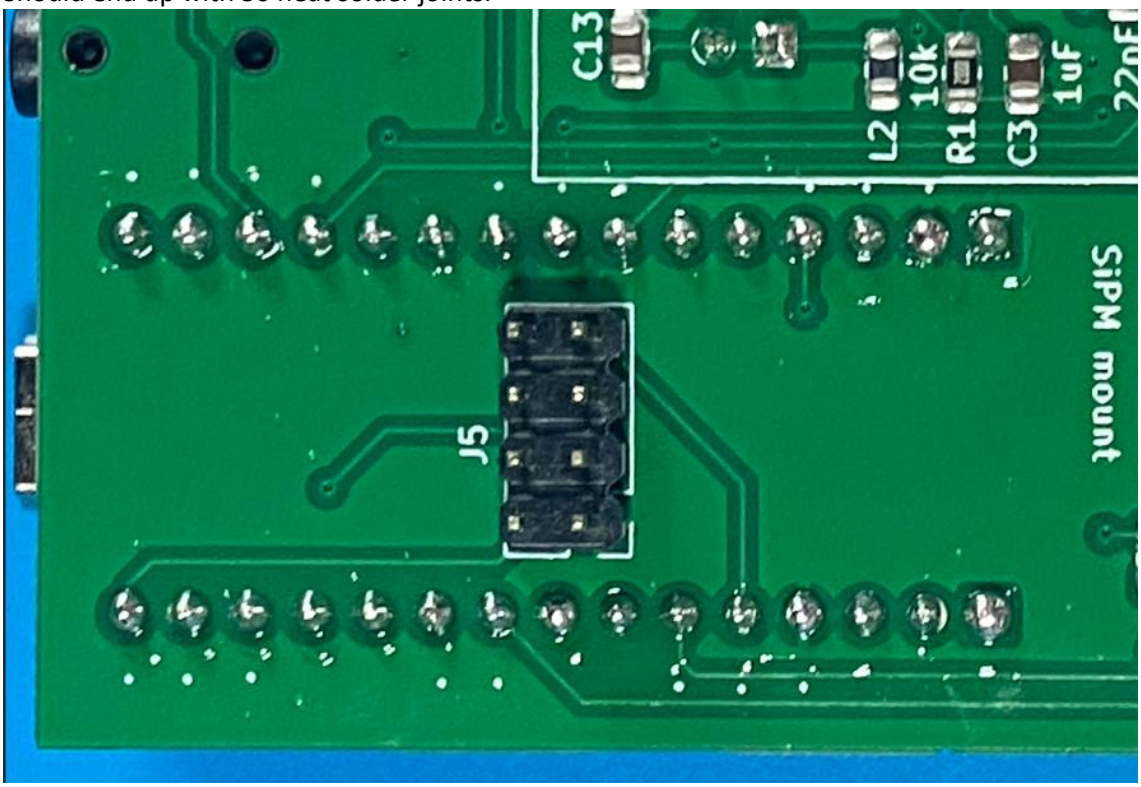
4. Turn main PCB over. Should see all the pins protruding through the rear of the main PCB.



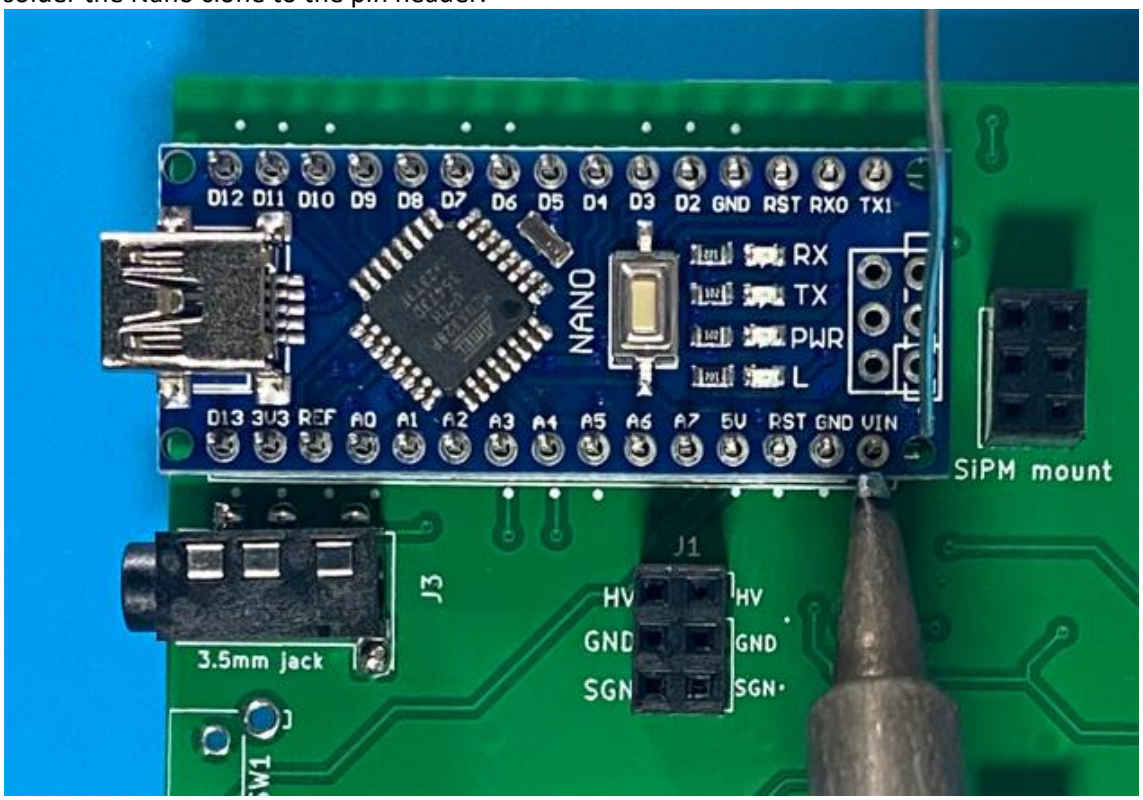
5. Solder all 30 pins to the rear of the main PCB



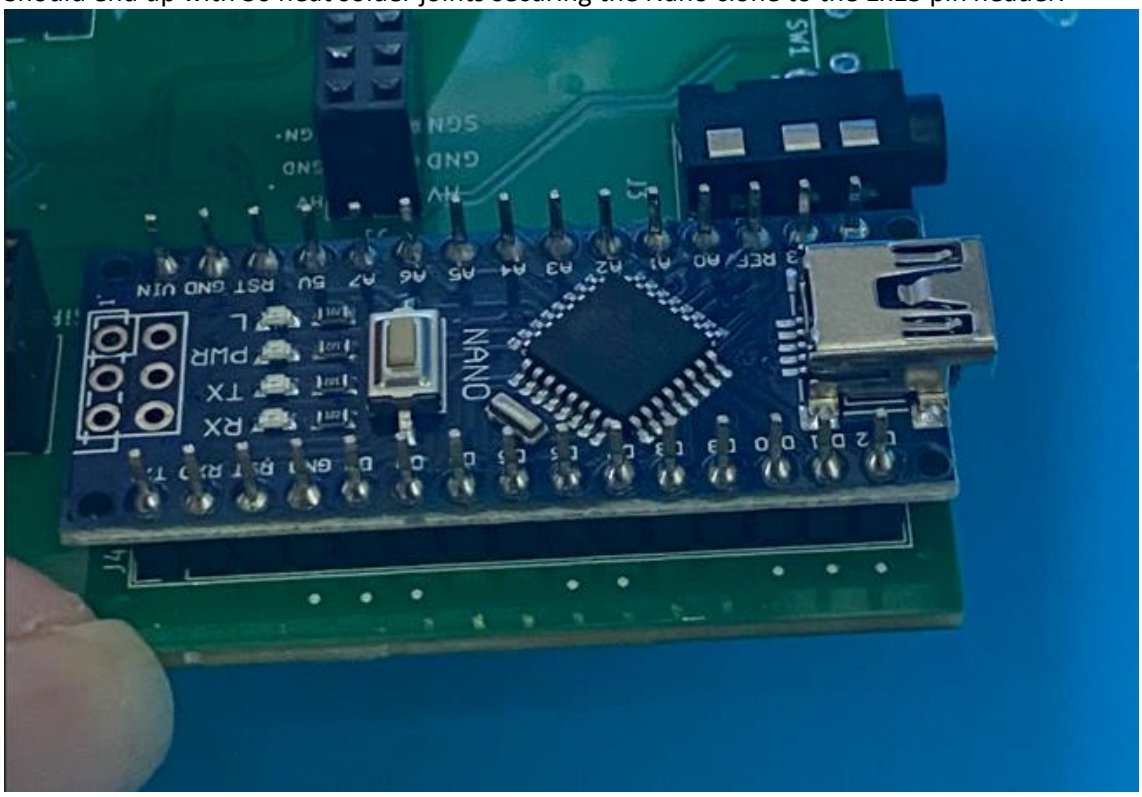
Should end up with 30 neat solder joints.



6. Turn main PCB over. Check that the Nano clone is still seated to the 1x15 pin headers and solder the Nano clone to the pin header.

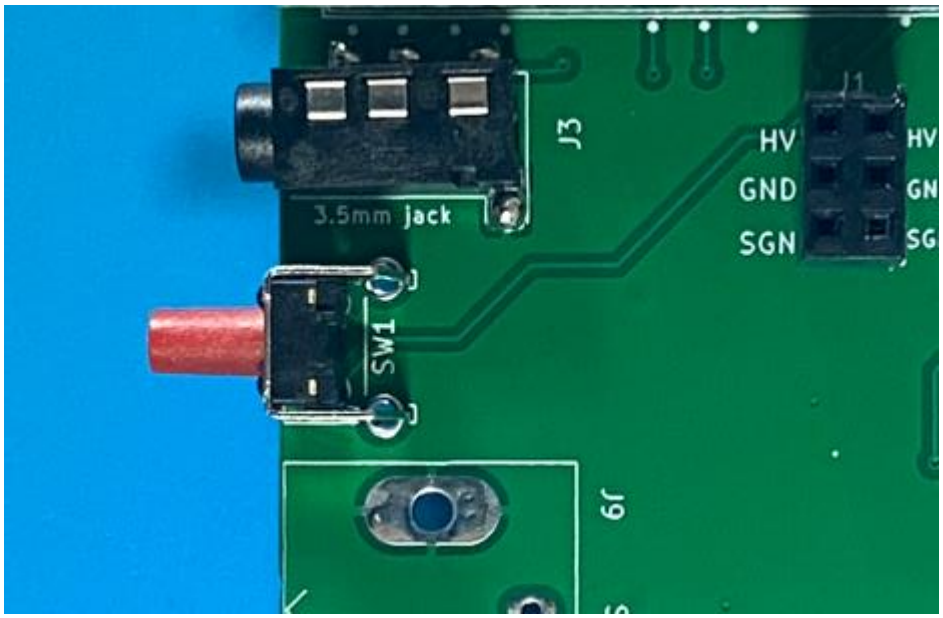


7. Should end up with 30 neat solder joints securing the Nano clone to the 1x15 pin header.

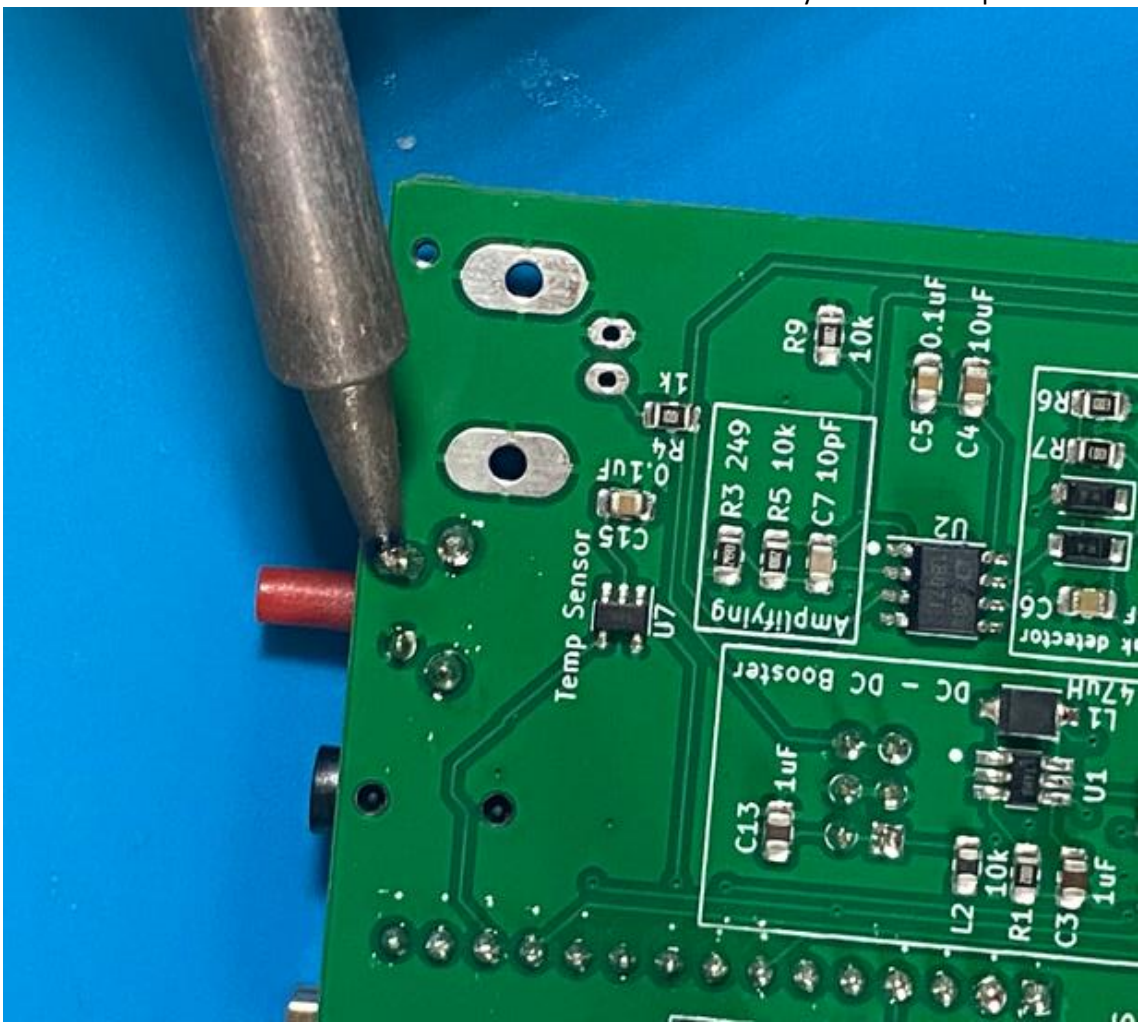


Install Reset Switch

1. Insert the reset switch into the main PCB from the front side

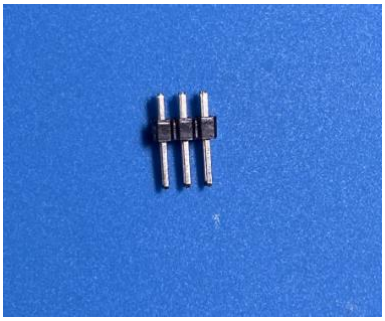
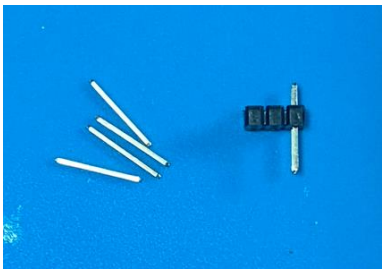


2. Turn main PCB over. Check that the Reset Switch is seated correctly and solder in position.



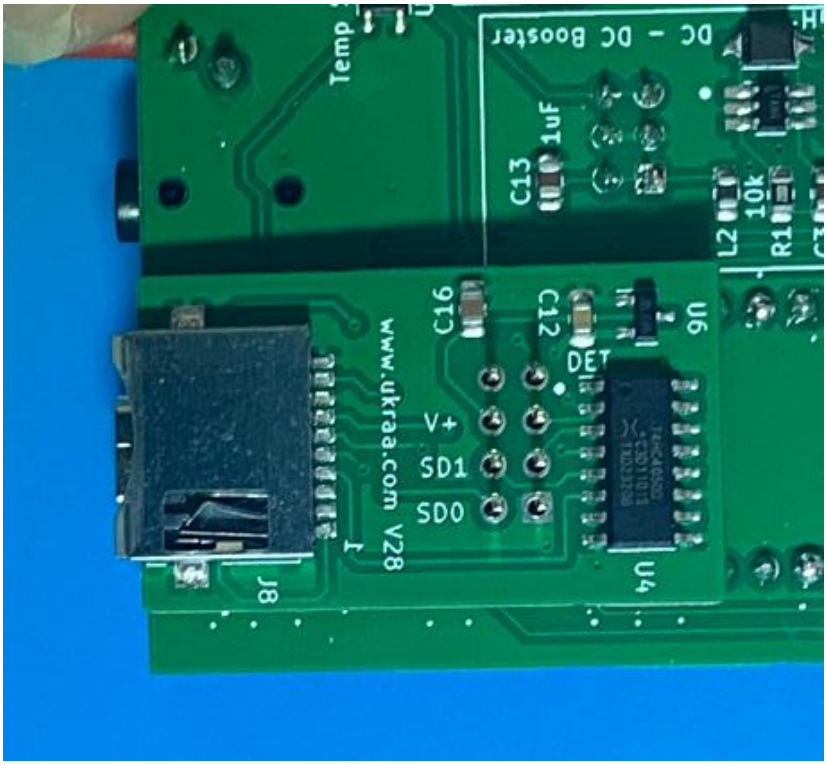
Install SDcard module PCB

1. The Nano clone is supplied with a 2x3 pin header. Locate this pin header and remove the 4 pins from the first 2 rows.

From:  To: 

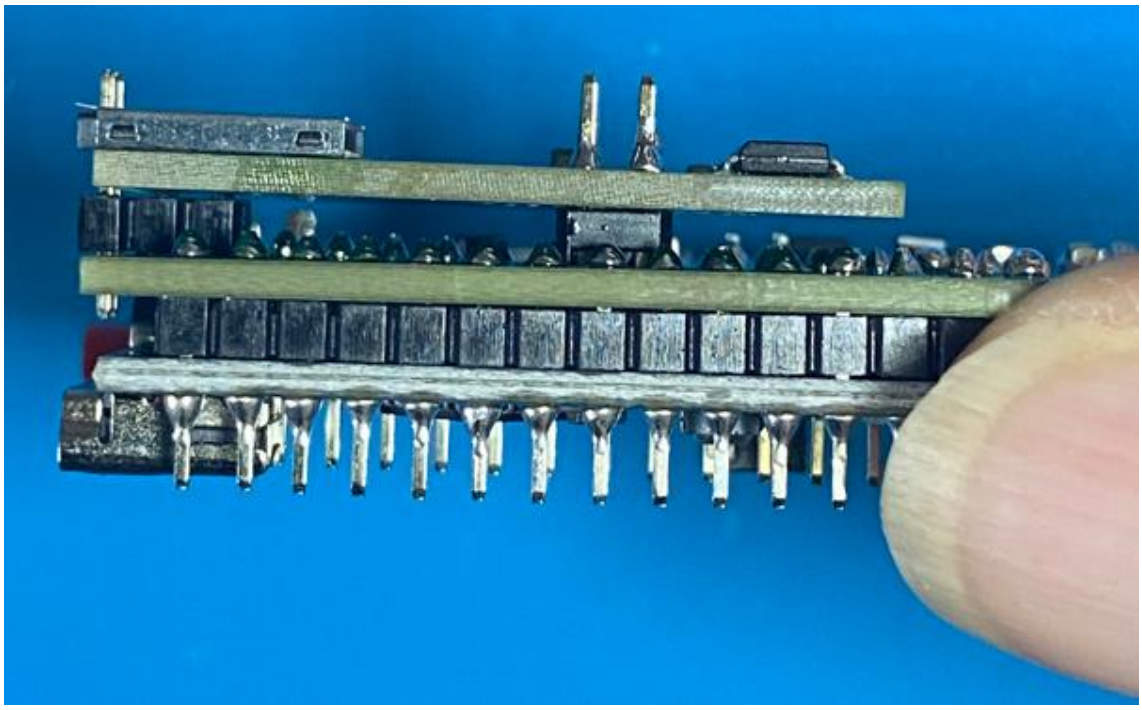
We will use this as a spacer to align the SDcard module PCB to the main PCB.

2. Position the SDcard module PCB onto the 2x3 pin header located on the rear of the mainPCB.

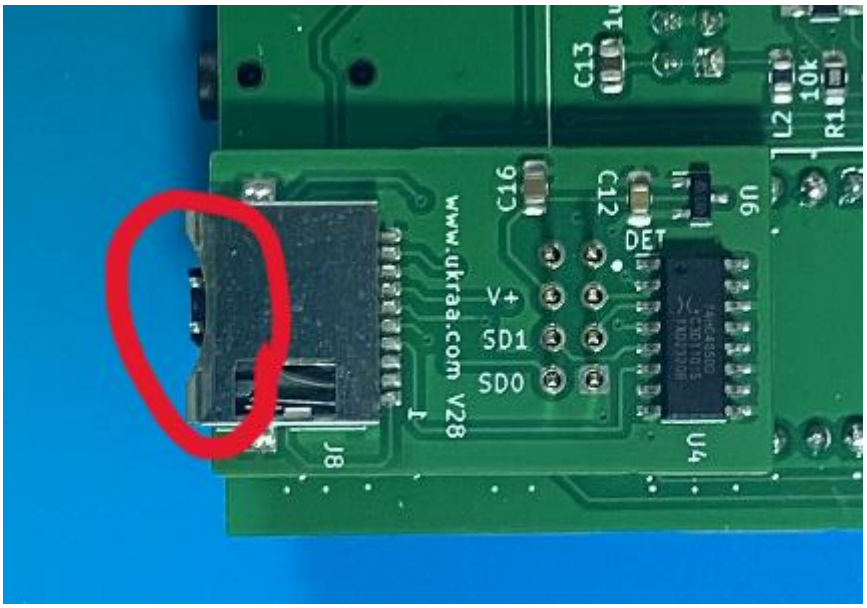


3. Take the modified 2x3 pin header made above and slide between the main PCB and the SDcard module PCB to get the correct spacing between the two PCBs.

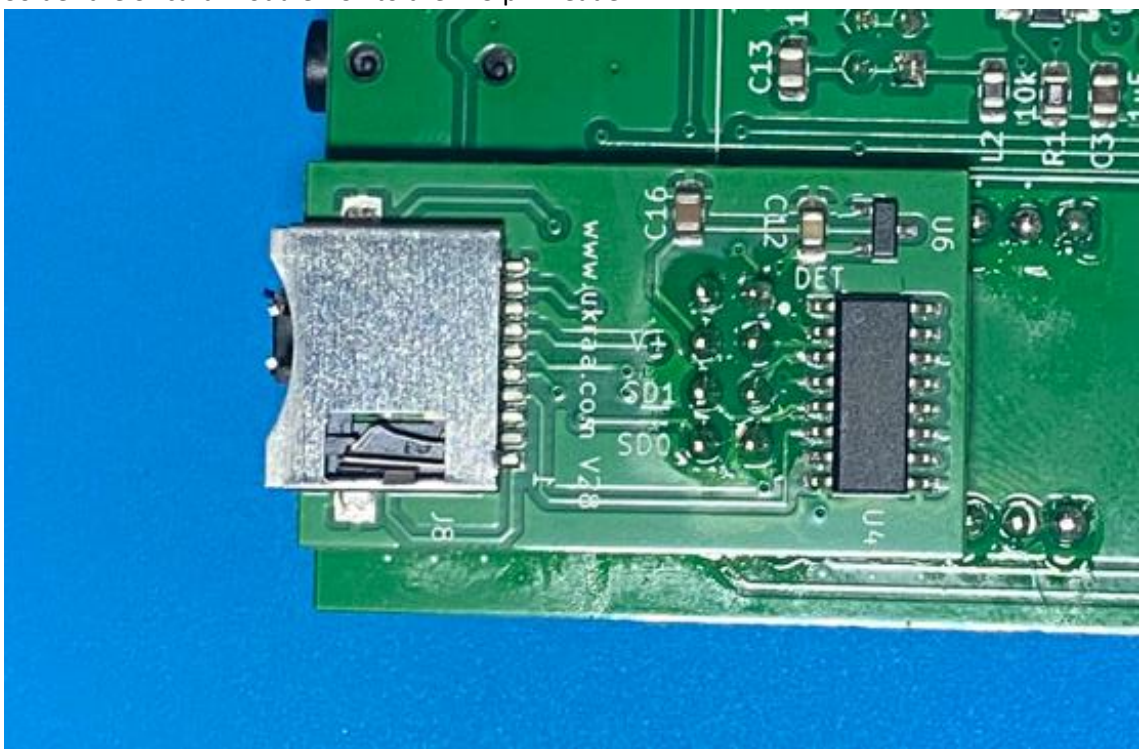
Side view:



Top view:

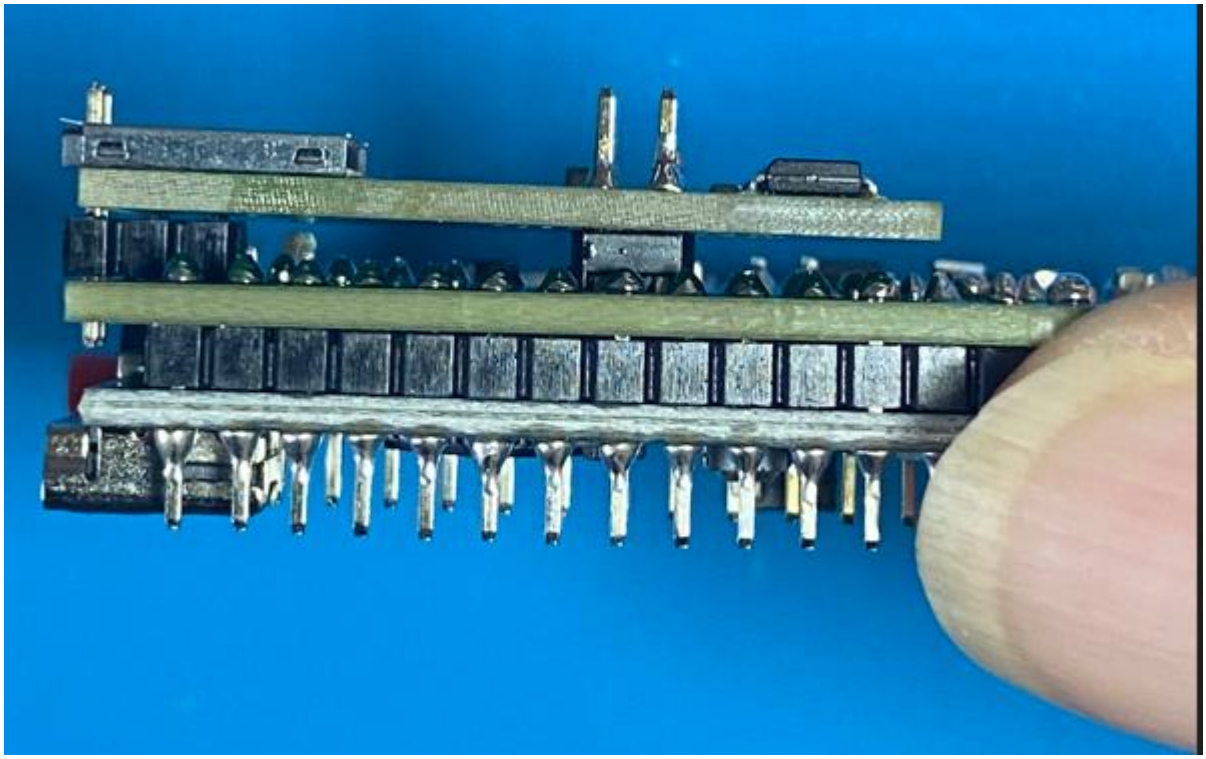


4. Solder the SDcard module PCB to the 2x3 pin header.

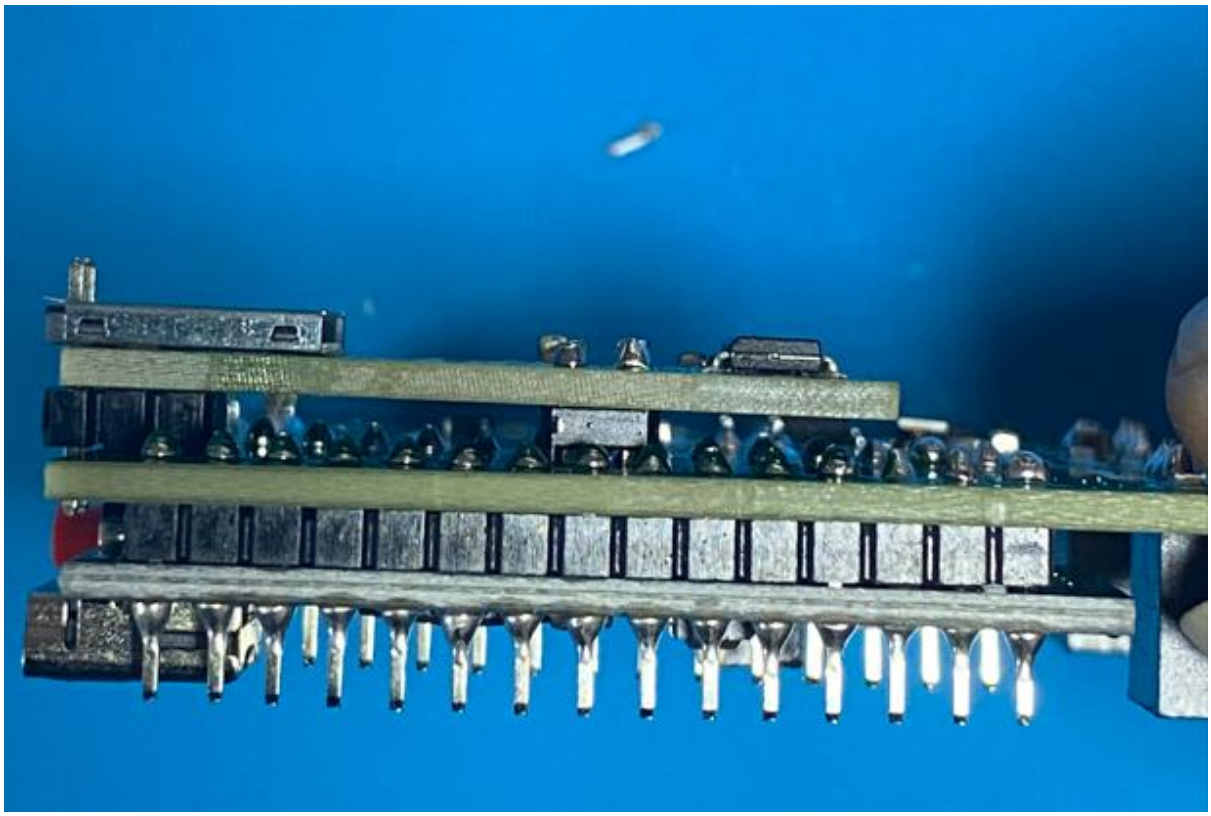


5. Using a pair of side cutters, cut the protruding pins – careful not to cut through your solder joint.

From:

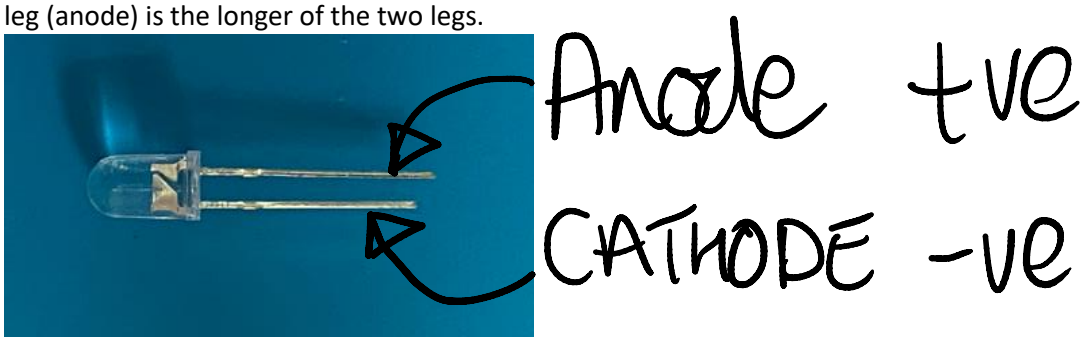


To:



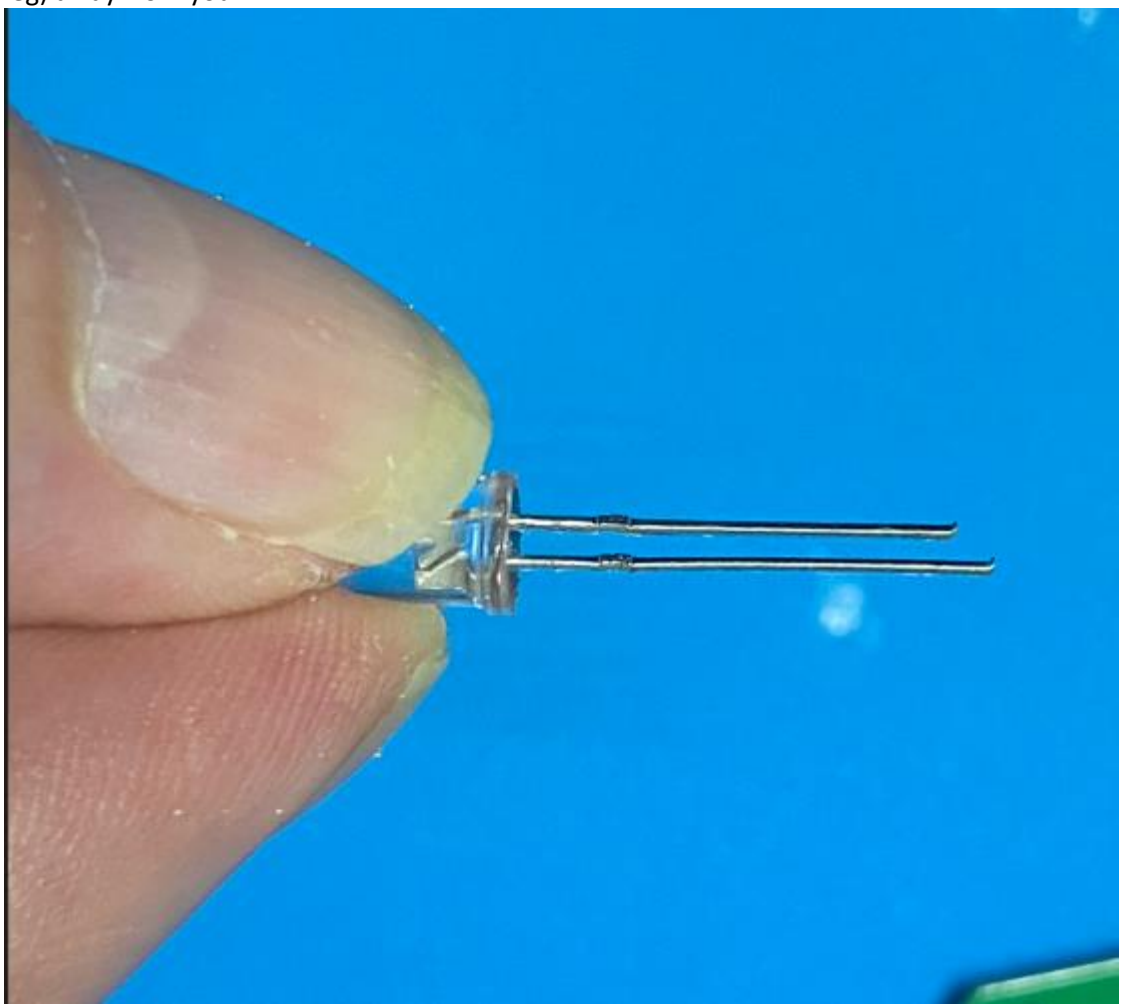
Install LED

1. The LED is a light emitting diode, so has a +ve leg (anode) and a –ve leg (cathode). The +ve leg (anode) is the longer of the two legs.

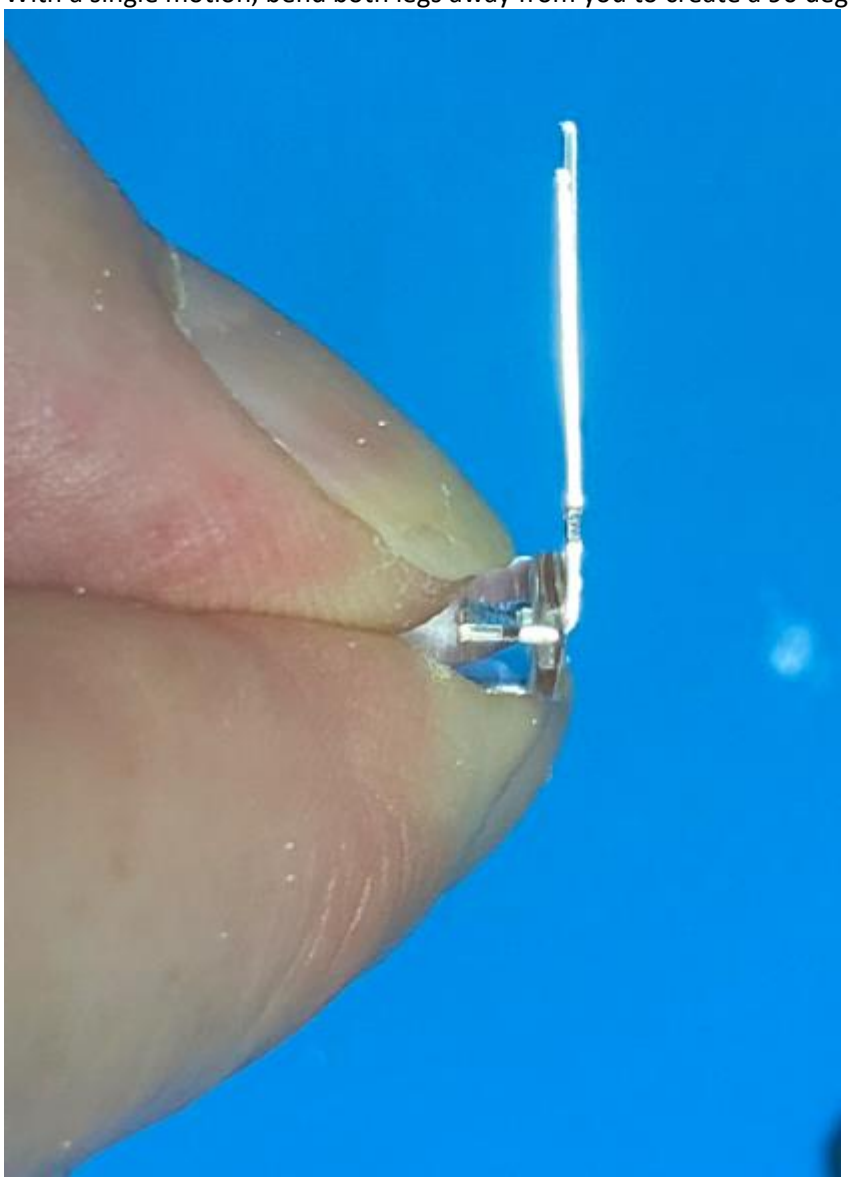


2. The LED is thus directional and must be installed in the correct orientation into the main PCB to be able to work correctly. The longer leg must be inserted into the + hole on the main PCB.

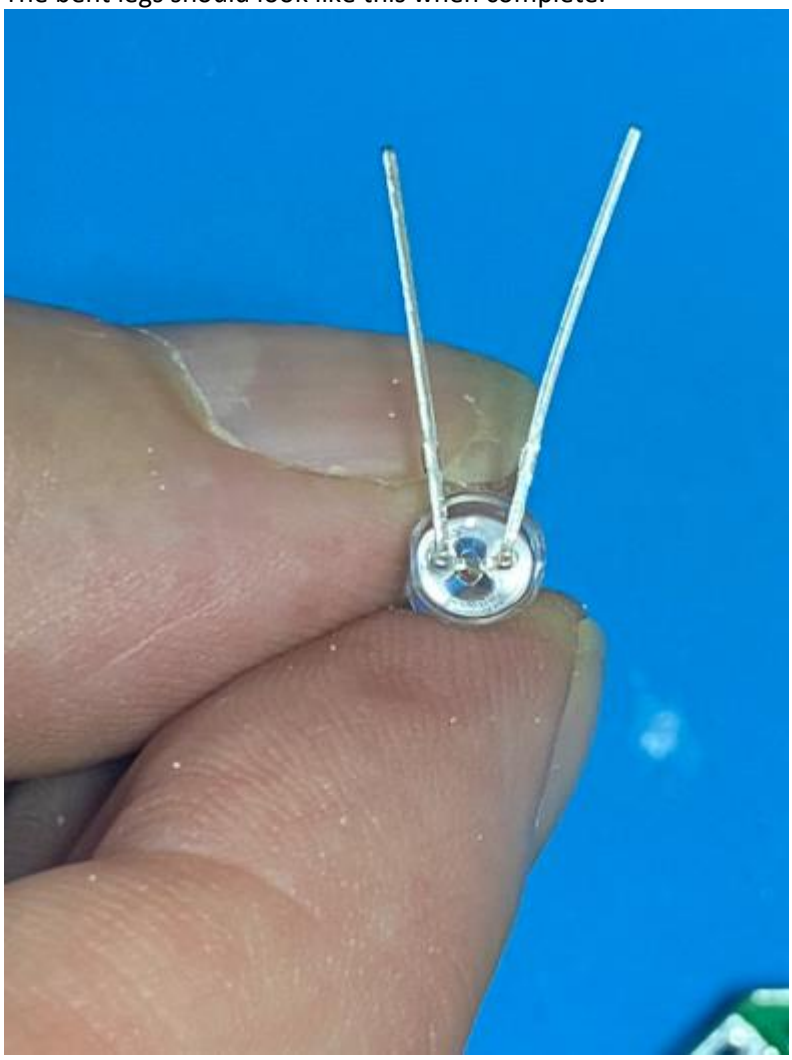
3. We need to bend the LED legs to enable it to be inserted and viewable from the front of the unit in operation. Hold the LED between your thumb and first finger, with the anode (longer leg) away from you.



4. With a single motion, bend both legs away from you to create a 90 degree bend.

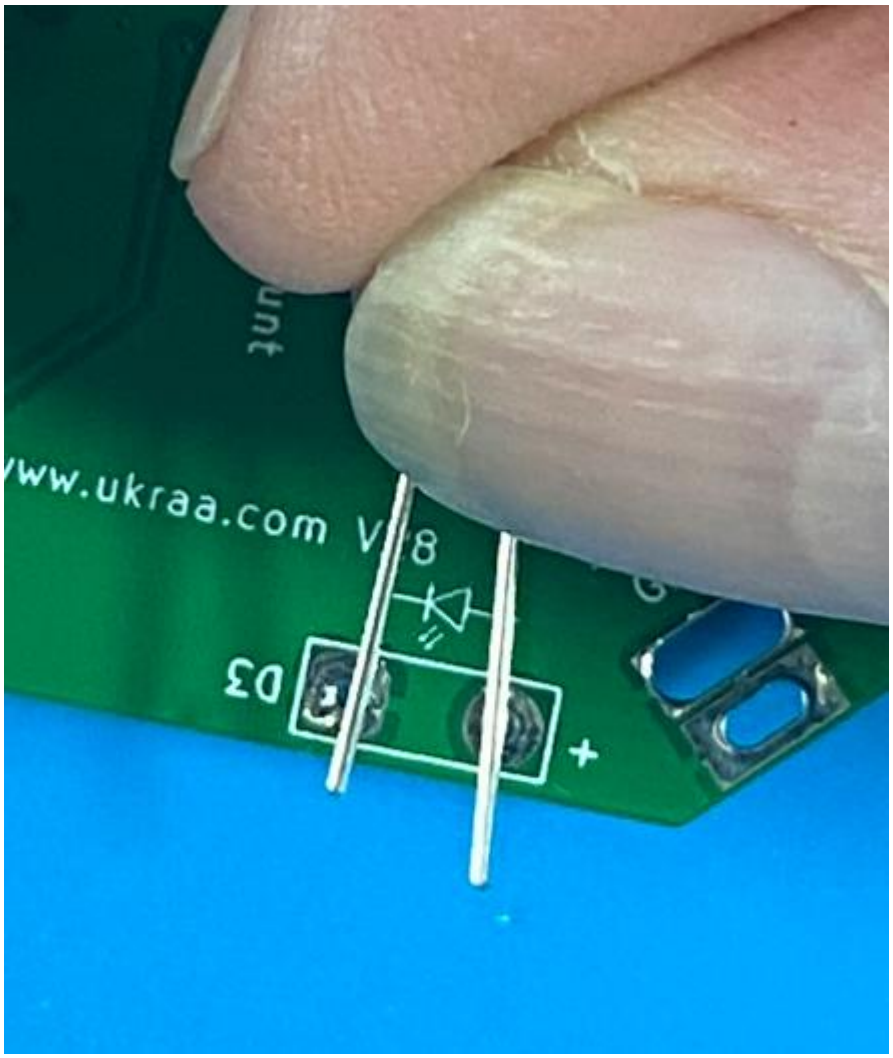


The bent legs should look like this when complete.

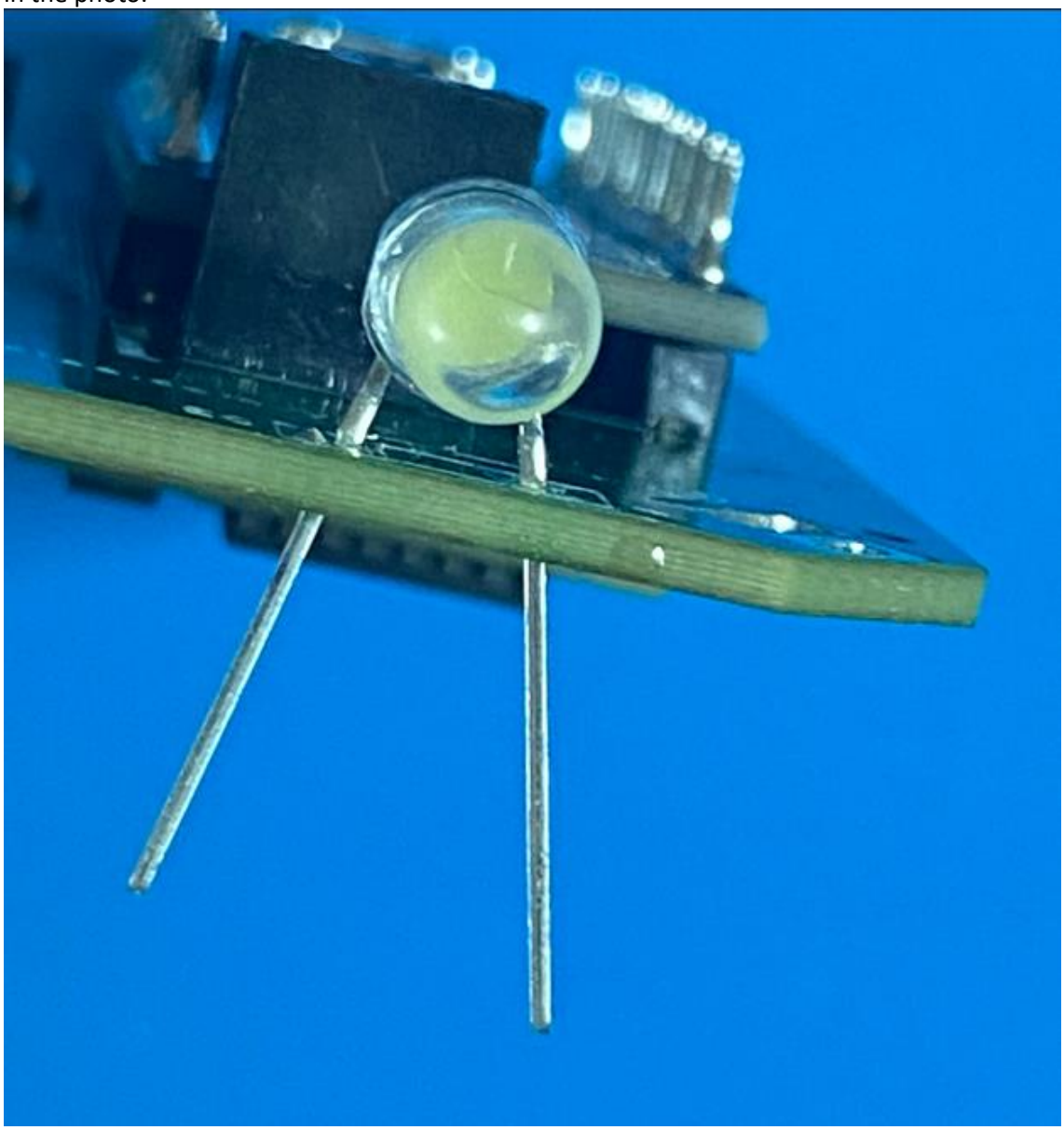


You can see that the legs have also been slightly bent apart to make installation into the main PCB easier

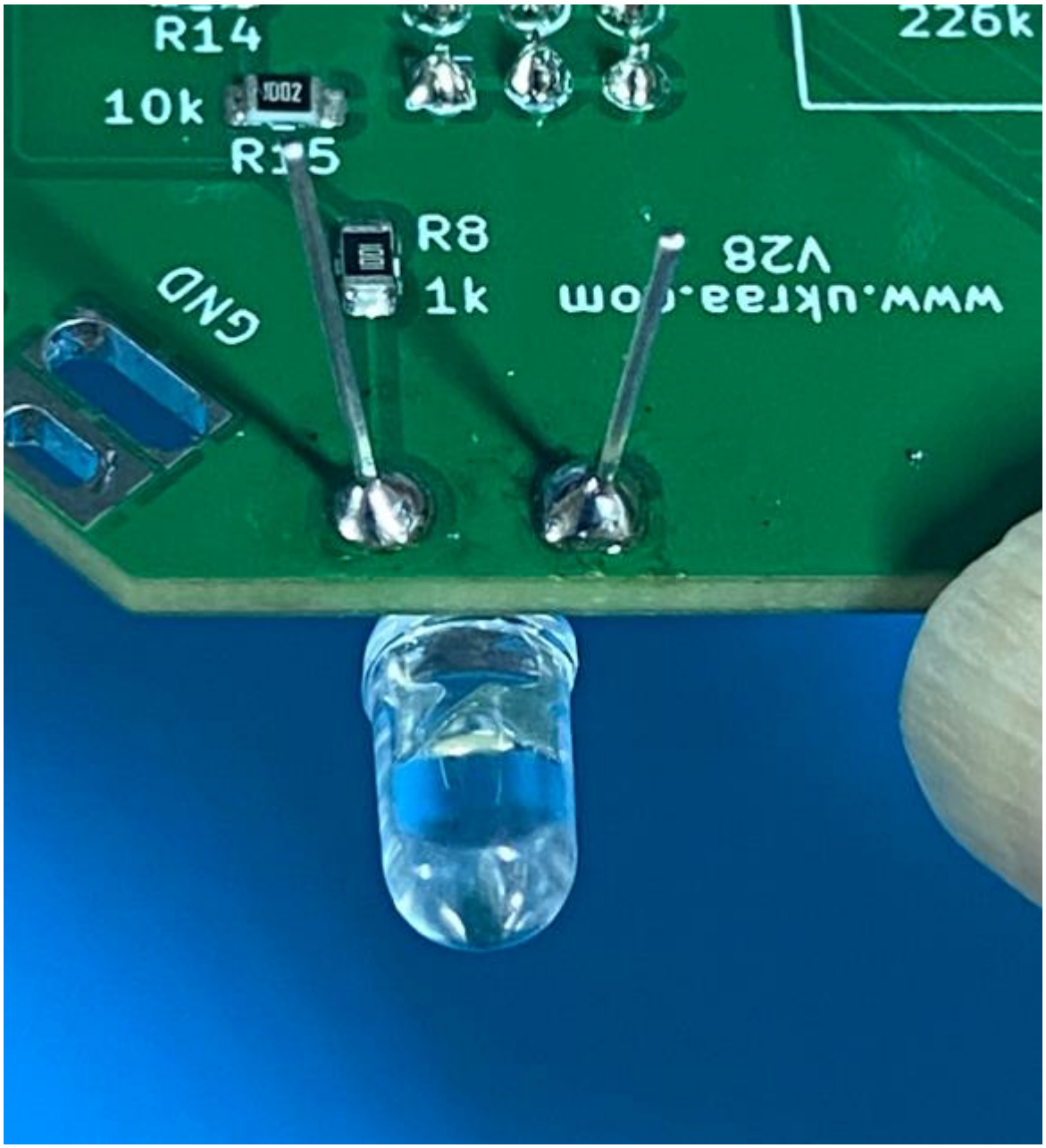
5. Insert the LED into the main PCB from the front – again ensuring that the longer leg (anode) goes through the + hole.



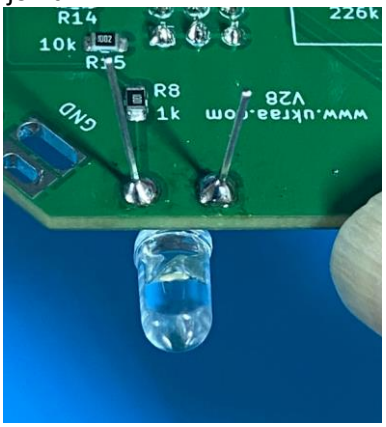
6. Seat the LED to the main PCB so that the position of the LED is similar to the position shown in the photo.

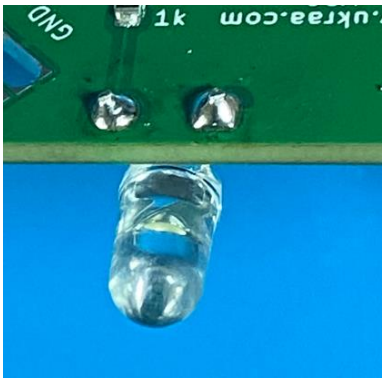


7. Turn the main PCB over and solder the LED to the main PCB.



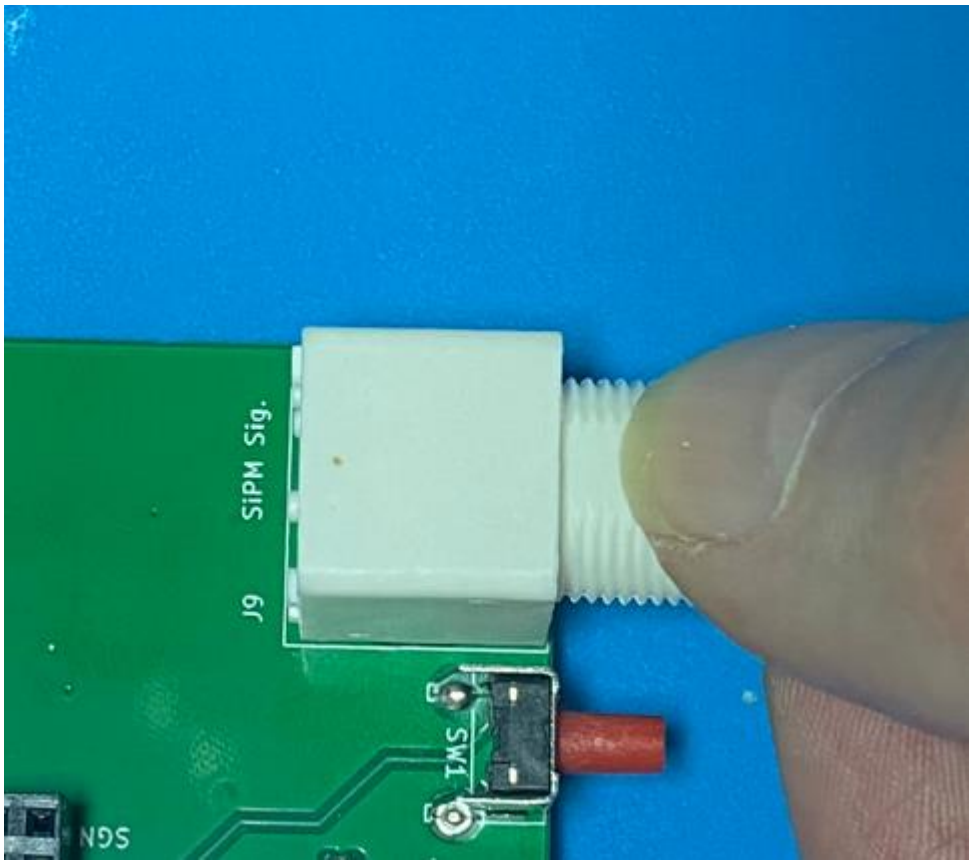
8. Using a pair of side cutters, cut the protruding LED legs – careful not to cut through your solder joint.

From: 

To: 

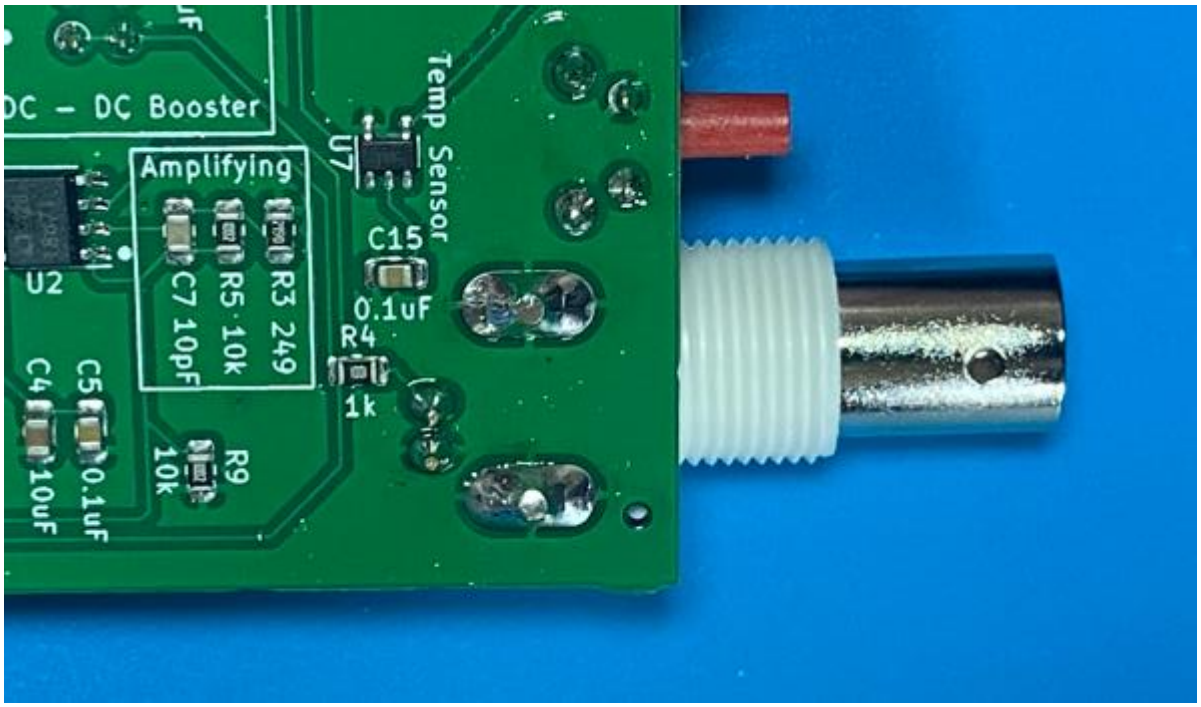
Installing female BNC socket

1. Insert the female BNC socket into the main PCB from the front side



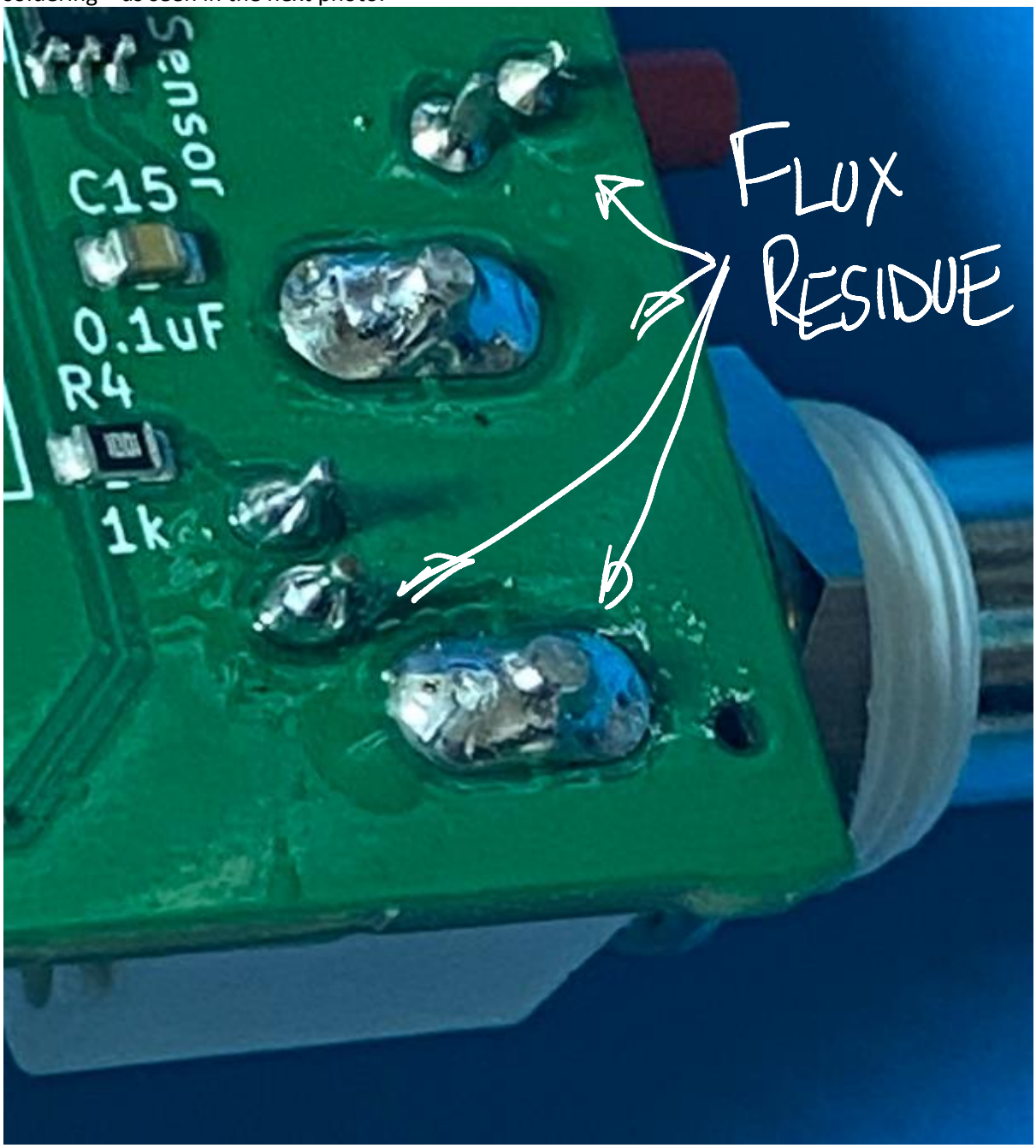
Pay careful attention to the BNC socket aligning to the silkscreen on the PCB.

2. Turn the main PCB over and solder the female BNC socket to the main PCB.



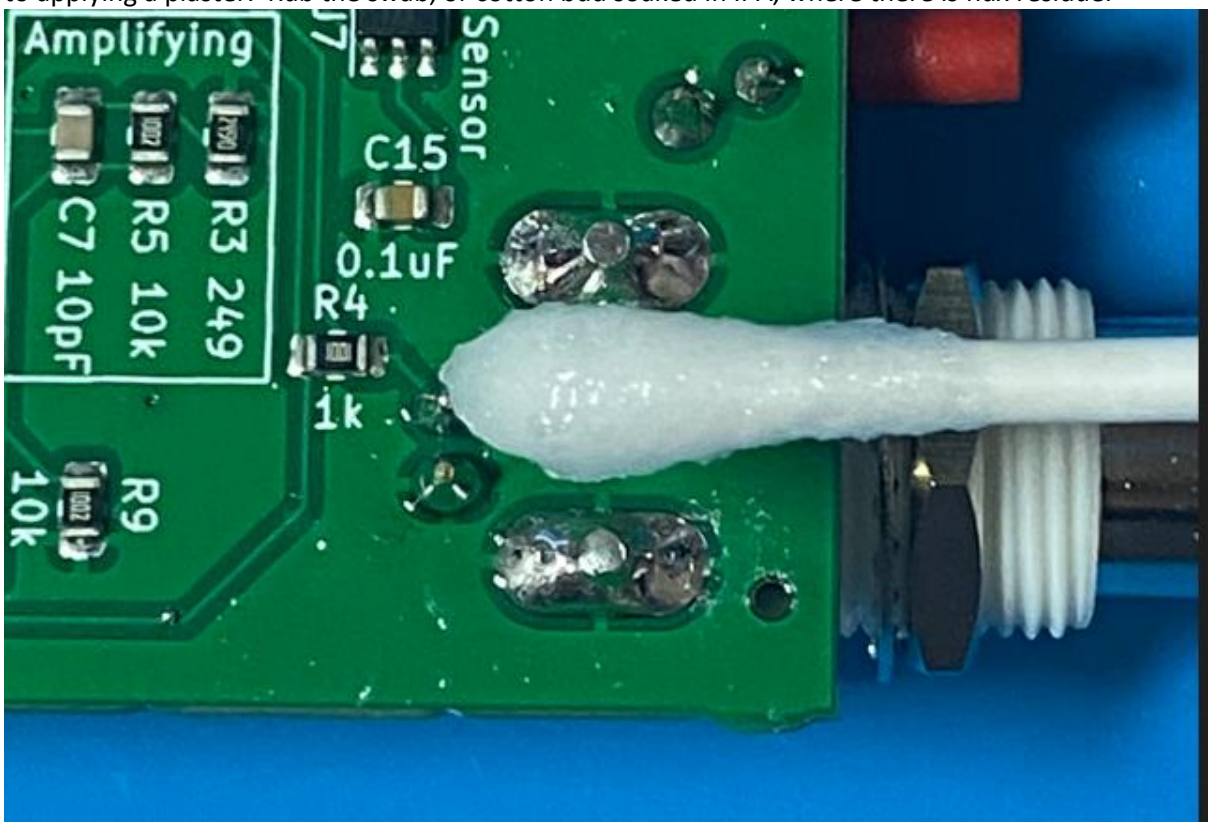
Cleaning the main PCB

1. Depending on the solder used, you may have some flux residue on the main PCB from your soldering – as seen in the next photo.

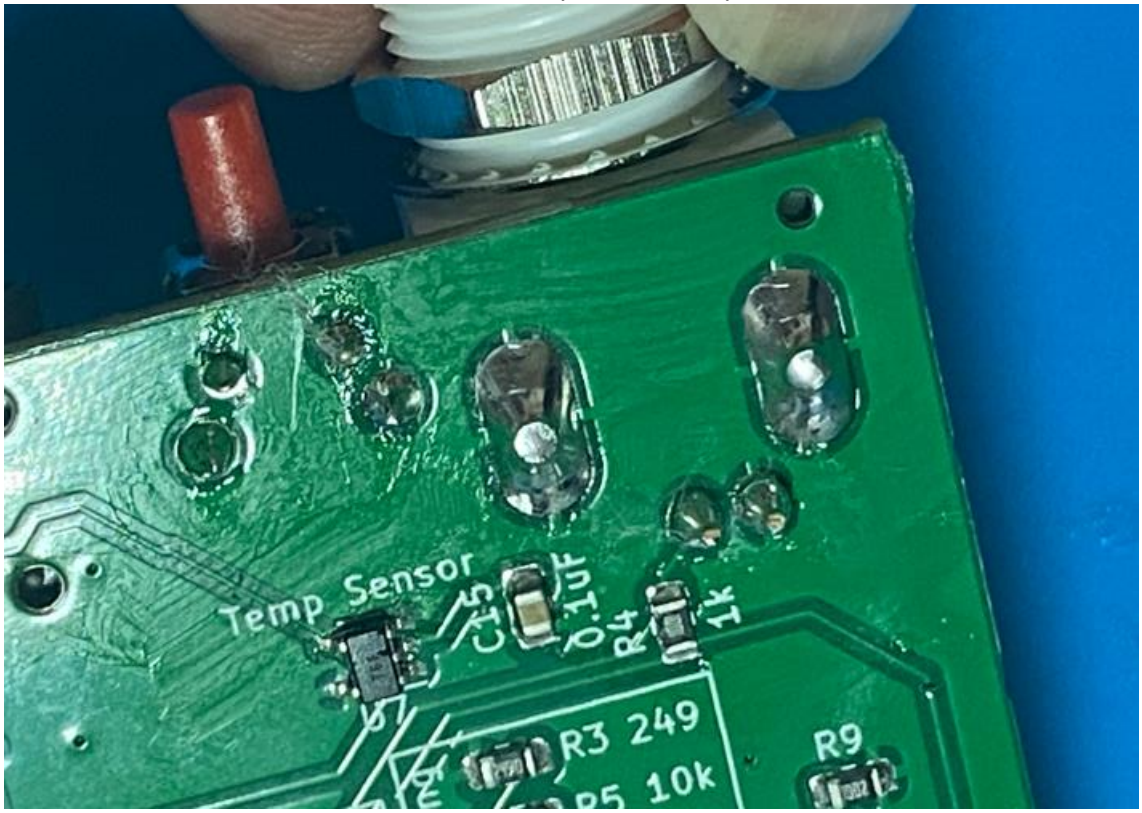


This should be removed if possible.

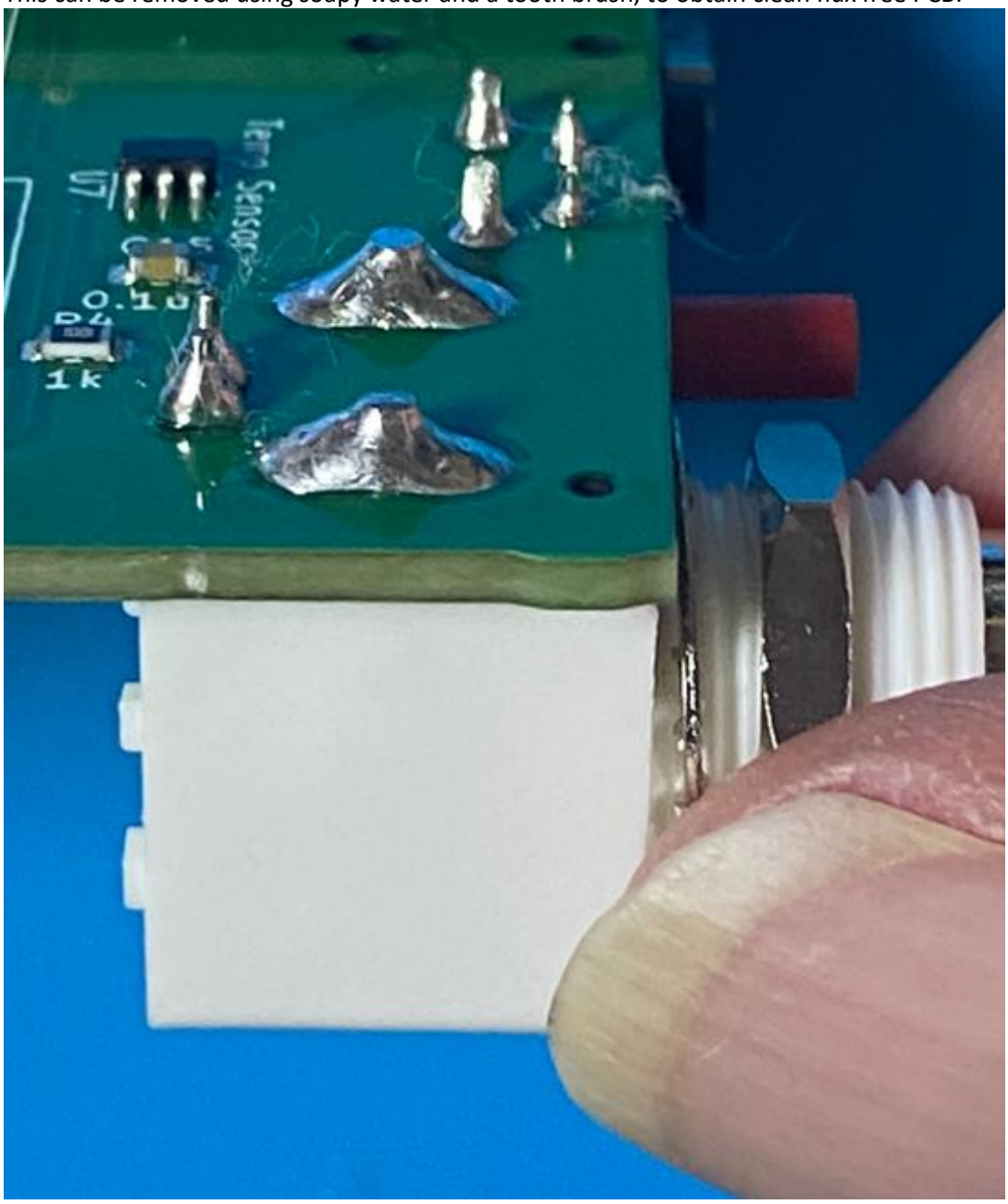
2. There are numerous methods to remove flux residue. One of the best methods is to use IPA (isopropyl alcohol) – this is commonly used in skin cleansing swabs used to clean cuts prior to applying a plaster. Rub the swab, or cotton bud soaked in IPA, where there is flux residue.



3. The IPA will break down the flux residue. It may leave a sticky smeared surface finish.



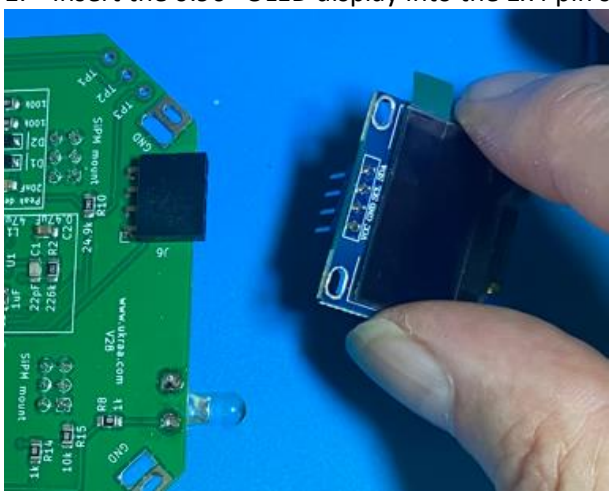
4. This can be removed using soapy water and a tooth brush, to obtain clean flux free PCB.

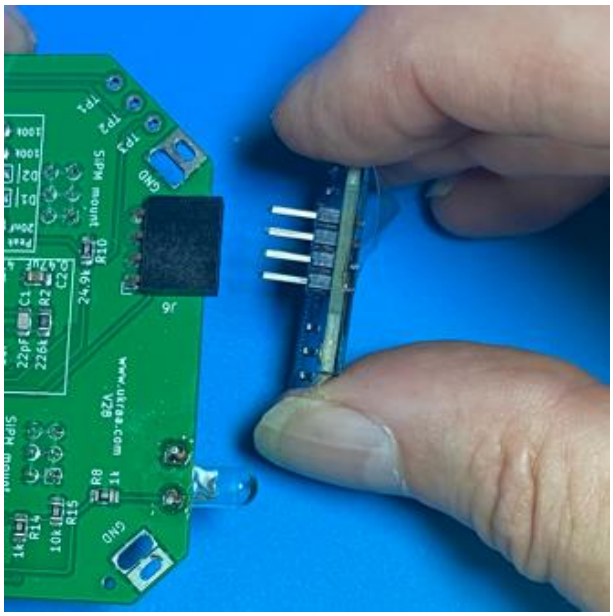


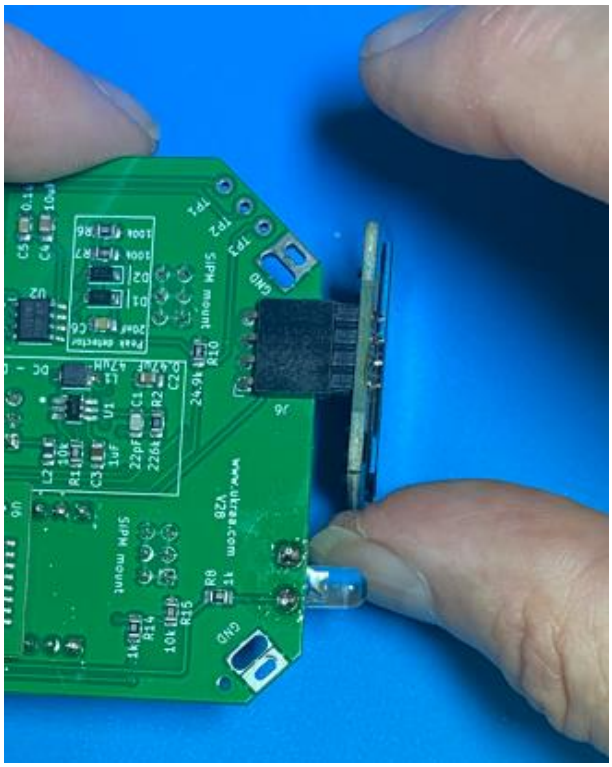
5. Always allow the main PCB to fully air dry if you use soapy water on the main PCB to clean the flux residue.

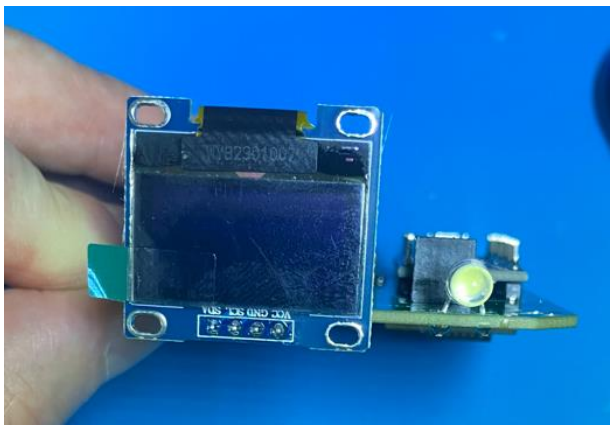
Install 0.96” OLED display

1. Insert the 0.96” OLED display into the 1x4 pin socket located on the rear of the main PCB.







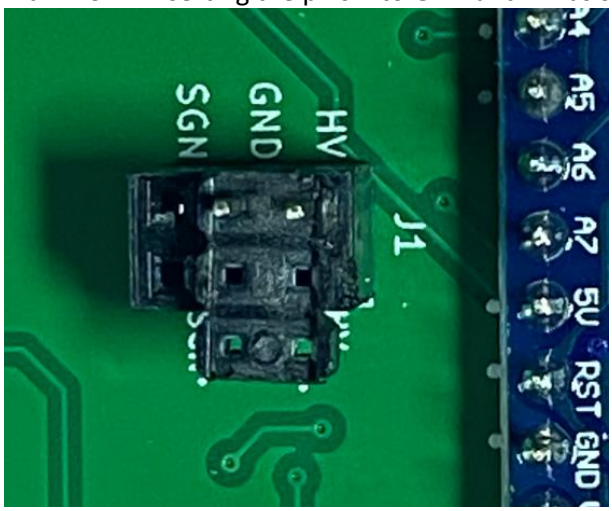


Initial testing of main PCB

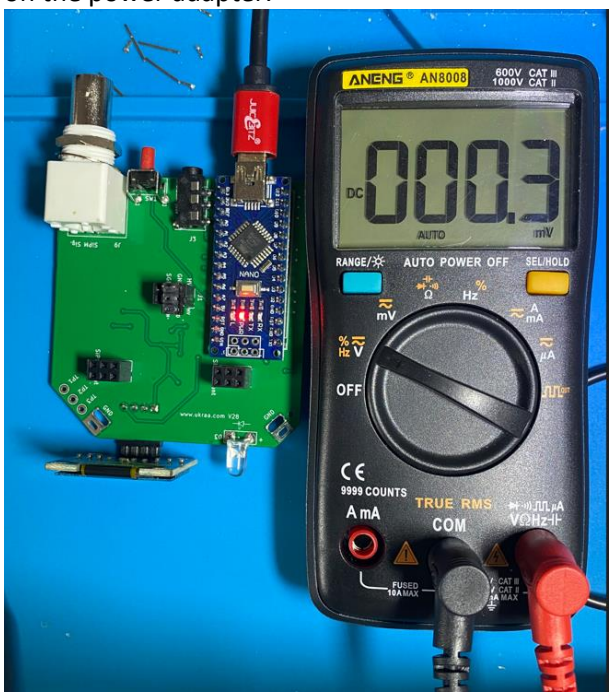
1. We are now ready to undertake an initial test of the main PCB.

2. For this initial test we will need
    a. the modified 2x3 pin header,
    b. a multimeter that measures DC voltage,
    c. a USB A to USB mini cable, and
    d. A suitable USB power adapter.

3. Take the modified 2x3 pin header and insert it into J1 (the 2x3 pin socket) on the front of the main PCB – inserting the pins into GND and HV as shown in photo.

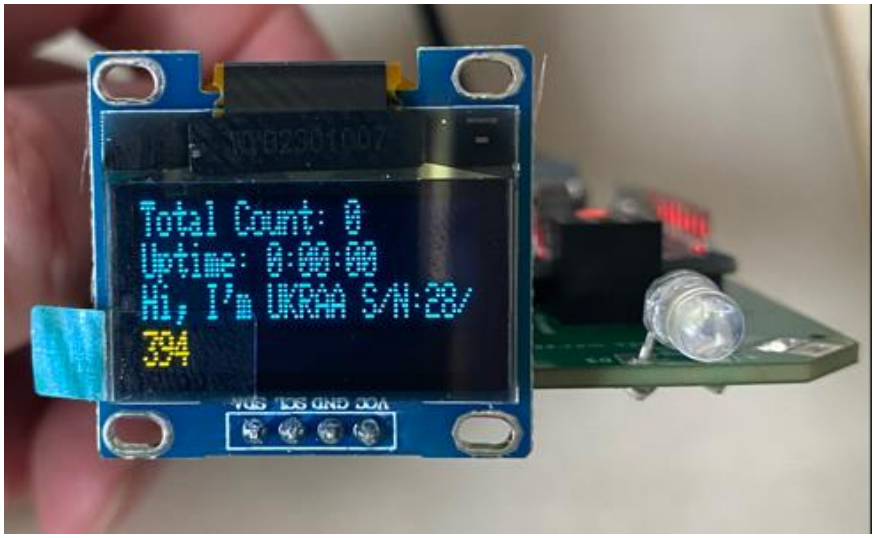


4. Set your multimeter to measure DC voltage. Plug the USB mini into the Nano clone and turn on the power adapter.

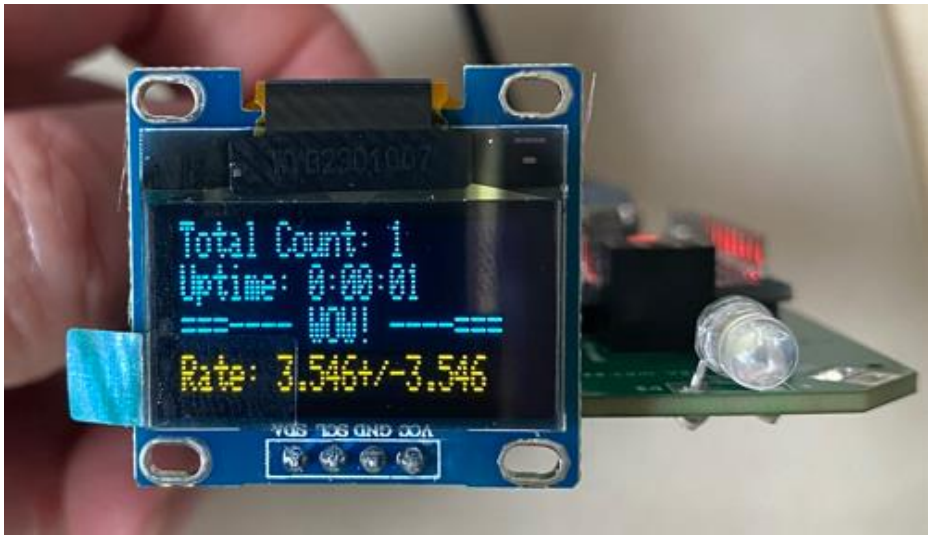


5. You should see the following splash screen displayed on the 0.96” OLED.

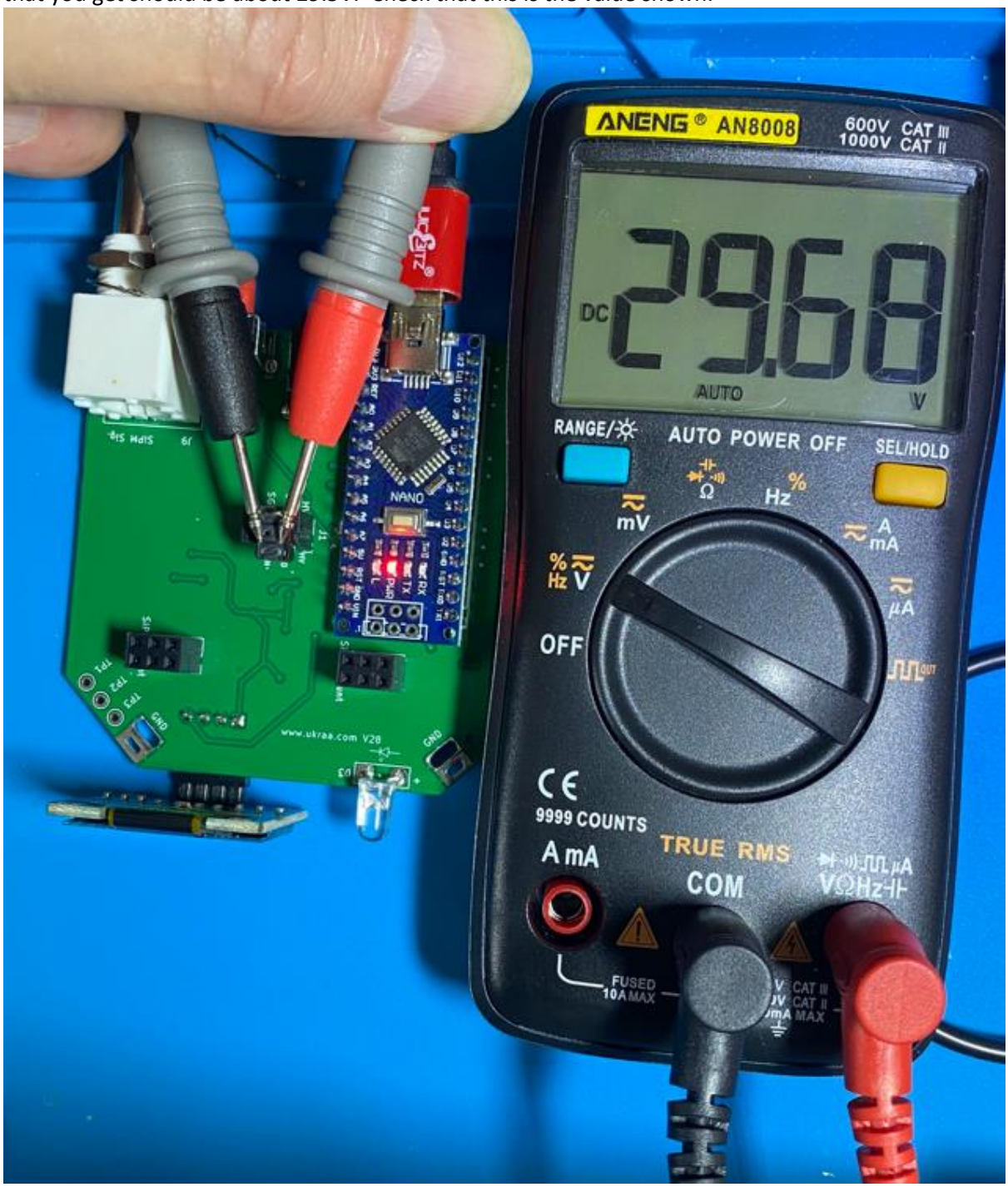
6. The OLED display should change to the following – note, the name of the detector will be different.



7. The LED should flash once and the OLED display should change to the following.



8. We now need to check that the HV to the SiPM module is correct. Using your multimeter, put your black (COM) lead on the GND pin and your red (V) lead on the HV pin. The reading that you get should be about 29.5V. Check that this is the value shown.



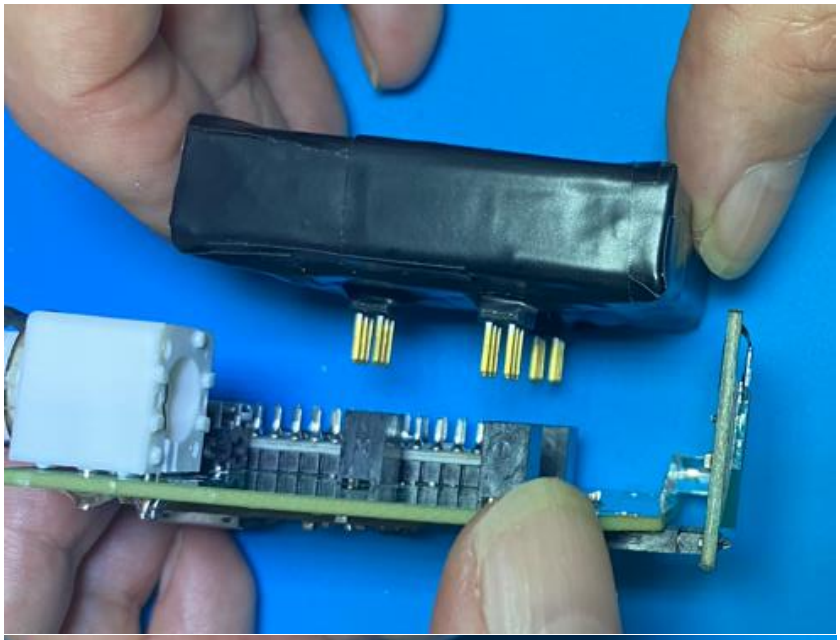
9. If you do not get a voltage of about 29.5V – disconnect the mini USB plug from the Nano clone and contact info@ukraa.com for support.

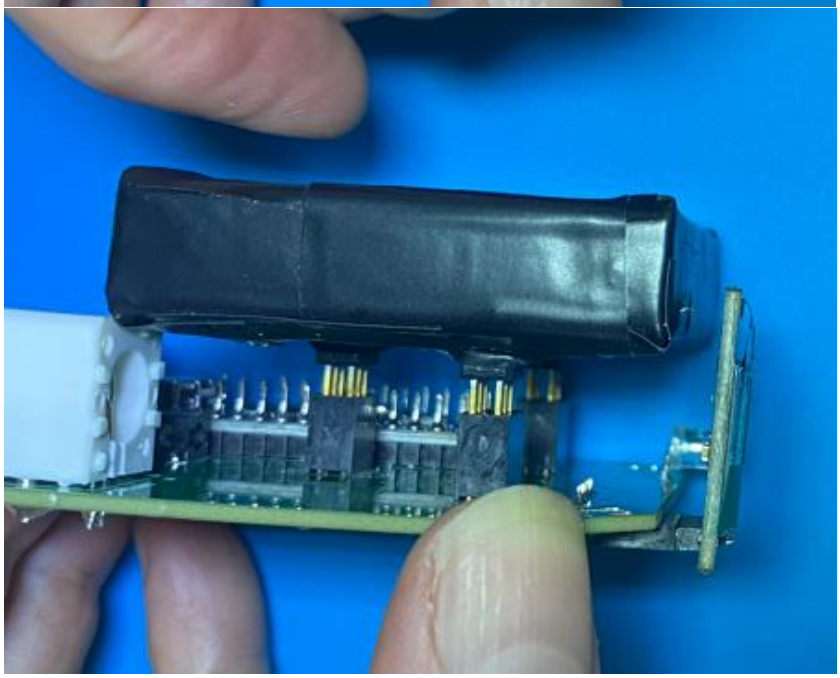
Install the SiPM/scintillator module

1. Time to install the SiPM/scintillator module to the main PCB.

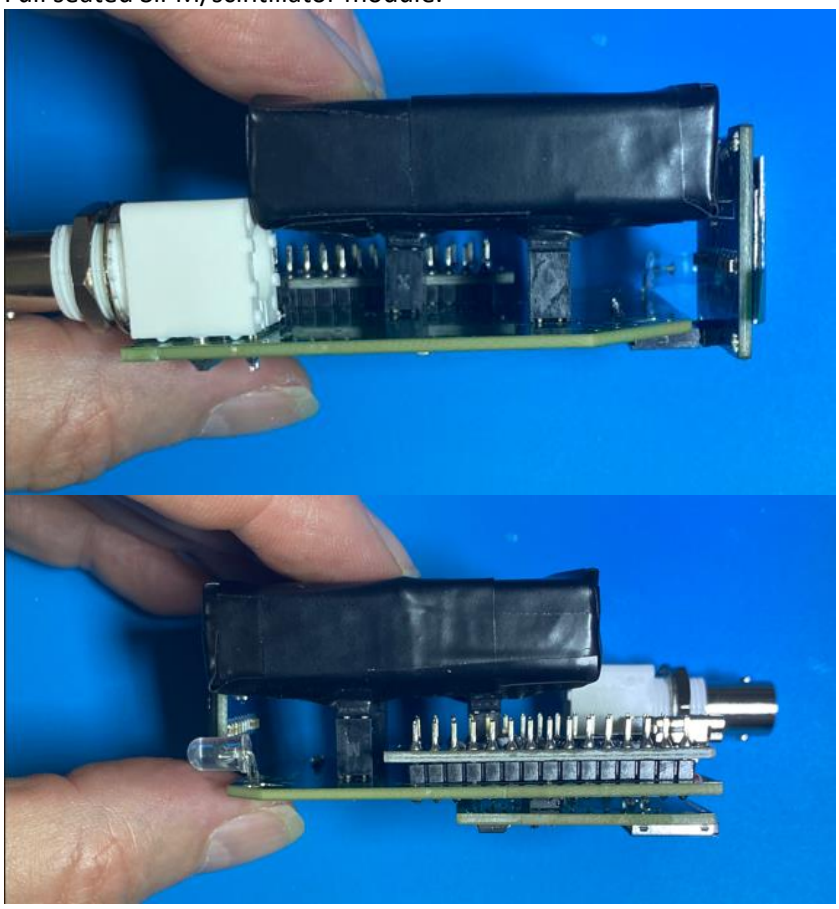
2. It is easy to misalign the pins for the 3 mounting positions – care should be taken to ensure that the SiPM/scintillator module is located/sited correctly to the main PCB.

3. It is sometimes easier to have the main PCB on its side to locate/position the SiPM/scintillator module pins into the sockets on the main PCB. Note, you may have to flex the main PCB a little to get the SiPM/Scintillator module to fully seat into the sockets on the main PCB.





4. Full seated SiPM/scintillator module.



5. Detector assembly is now complete.

Glossary

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Website: www.britastro.org/radio

Appendix 1 – Regulatory Compiance

RoHS

The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC, (commonly referred to as the Restriction of Hazardous Substances Directive or RoHS) was adopted in February 2003 by the European Union. The RoHS directive took effect on 2006 July 1, and is required to be enforced and become law in each member state. This directive restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment. In speech, RoHS is often spelled out, or pronounced "rosh".

The above paragraph was taken from the Wikipedia essay on RoHS.

The RoHS Directive restricts the use of the following six hazardous substances in electronic and electrical equipment products falling within the Directive:

- Lead
- Mercury
- Cadmium
- Hexavalent chromium
- Polybrominated biphenyls
- Polybrominated diphenyl ethers

UKRAA confirms that the suppliers of the components and materials used in the UKRAA VLF Aerial Tuning Unit have stated that such components and materials are RoHS compliant and that reasonable steps have been taken to confirm these statements.

WEEE

RoHS is closely linked with the Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC that sets collection, recycling and recovery targets for electrical goods and is part of a legislative initiative to solve the problem of huge amounts of toxic e-waste.

The Waste Electrical and Electronic Equipment (WEEE) Directive is designed to ensure the efficient collection and recycling of electrical and electronic equipment at end-of-life. If a customer purchases a new product from UKRAA which falls within the WEEE Directive to replace an existing one (of similar function to the one that has been sold) and intends to dispose of the existing one, then the customer can request that we take back the existing product and deal with the costs and logistics of recycling it. Any customer wishing to take advantage of this facility should contact us. Provided that the existing product comes within the scope of the WEEE Directive, we will make arrangements for its return or collection and will deal with its disposal.

Revision History

Revision	Date	Author	Status
Draft A	2024-08-11	R Knott	Internal draft for peer review
Draft B	2024-09-03	R Knott	Amended internal draft for peer review
Issue 1			

Outstanding Work

Await peer review of draft b.