Time to Assemble. *TeeHee.*

Contents

Preface

Components
Please visit the TeeHee HaLow product listing for a comprehensive and hyperlinked BOM.

Tools
For a list of tools used in this guide, please refer to the Workshop Setup page on makeyourown.lol. The peripheral workstation used for testing throughout this guide is presumed to run macOS, but you can use whatever operating system you would like as long as the device supports IP connections over Ethernet.

Dry Time Intervals
Hot glue will take 90 seconds to fully dry after any step that requires it. Be especially mindful of this dry time for bonds that affect placement of electronics and electronic contacts to prevent inadvertent disconnections.

Loctite will set in 10-20 minutes and takes 24 hours to fully cure.

Self-Assembly Disclaimer

These instructions were written for individuals proficient with soldering. DOT LOL, INC. provides this set of assembly instructions as a standalone courtesy and is not responsible for any incorrect execution, nor does DOT LOL, INC. warrant any craftsmanship or other labor provided by third-parties.

These instructions were written to be used in tandem with a machined enclosure, which is part of the OEM BOM for TeeHee HaLow. You may utilize other hardware workarounds (like USB-C to voltage input adapters) to reduce the complexity of certain techniques delineated herein. If you substitute alternative components not listed in the official TeeHee HaLow BOM, however, you are doing so at your own risk and the final assembled product may not function as expected.

Workspace Prep

Prepare the environment for ESD-safe component handling. Ensure that contingency plans with relevant safety equipment, PPE and other hardware are in place before you begin, including ventilation for extraction of any soldering fumes. Please follow all relevant safety guidelines for dealing with mobile device battery installation, if applicable.

Wire Prep List

Here's a complete list of what you'll want to have set aside if you want to prepare all the wires beforehand. Lengths are also mentioned in each step throughout the guide; the following list just enumerates them all in a single place for reference. "Pair" simply refers to a positive/negative color-coded wire set.

Solid Core Wires
2x 40mm pairs (NanoPi R2S Plus power input)

Stranded Wires
1x 60mm pair (Pololu/UPS > NanoPi R2S Plus solid core wires)
1x 40mm pair (Lemo > Pololu)
1x 30mm pair (Pololu > UPS) [UPS variant only]

Other Wire Prep
LED: 70mm leads (from tip of diode dome)
Battery: 10mm leads [UPS variant only]

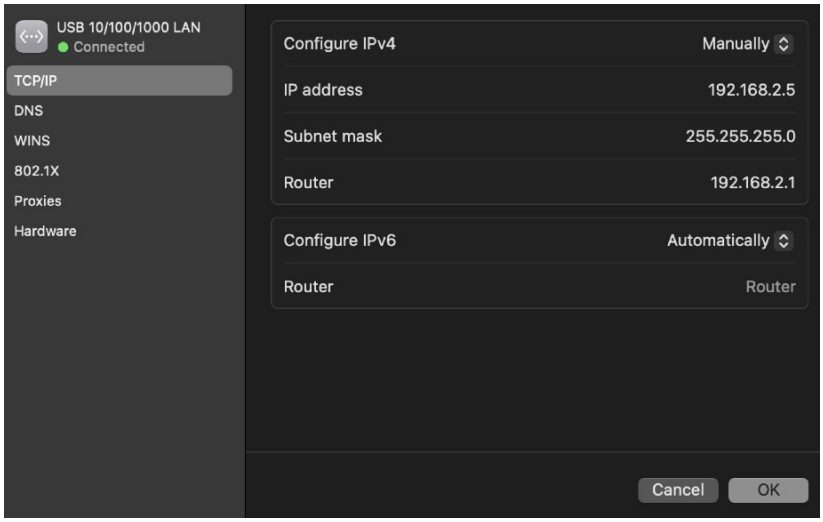
Software Prep

The NanoPi R2S Plus model has a quirk that prevents the M.2 HaLow module from operating properly when the NanoPi R2S Plus board boots from the internal eMMC. Therefore, we need to first tell the NanoPi R2S Plus to not boot from the internal eMMC and instead boot from an external module; second, we need to image the external eMMC module with the appropriate OS (.img) file. The eMMC module listed in the TeeHee HaLow BOM was chosen as the most durable hardware solution for running the TeeHee HaLow OS.

Prepare NanoPi R2S Plus

1. Provide power to the NanoPi R2S Plus via the *5V IN & DATA* USB-C port. This can be from a computer or an external USB-C power supply, including those that support USB-C PD (NanoPi R2S Plus will automatically negotiate 5V).
2. Using an RJ45 dongle if necessary, connect NanoPi R2S Plus to your computer via the RJ45 port labeled *LAN*.

3. Under the appropriate network interface within System Settings.app, set the TCP/IP fields as follows:



4. Click *OK*.
5. Open Terminal.app and type:

   ssh root@192.168.2.1

   Hit return.
6. Address the host discrepancy error message, if necessary. If this doesn't appear, skip to Step 7.

```
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@    WARNING: REMOTE HOST IDENTIFICATION HAS CHANGED!     @
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
IT IS POSSIBLE THAT SOMEONE IS DOING SOMETHING NASTY!
```

   a. Open Finder and navigate to Macintosh HD > Users > [YOUR_NAME]
   b. Reveal hidden files with the keyboard shortcut Shift+CMD+Period (.).

   c. In the *.ssh* folder, select the *known_hosts* file and delete it.
   d. Re-attempt Step 5.
7. Type *yes*. Hit return.

```
The authenticity of host '192.168.2.1 (192.168.2.1)' can't be established.
ED25519 key fingerprint is SHA256:kY4QqpWmUIQKpwdXAdQJarft0bgcJah7u3XERsFdyz4.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])?
```

8. Type *password*. Hit return.

```
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '192.168.2.1' (ED25519) to the list of known hosts.
root@192.168.2.1's password:
```

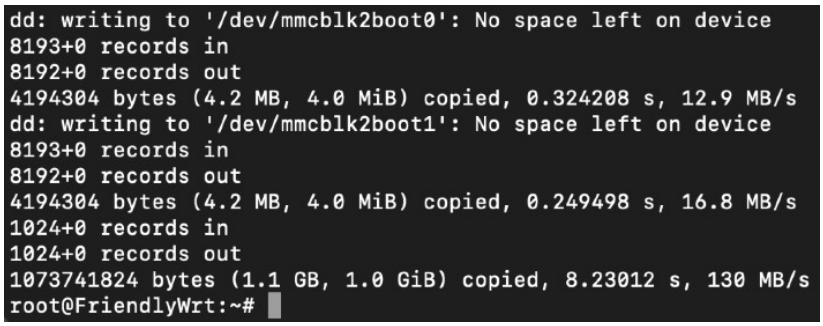
9. You'll be welcomed with the FriendlyWrt splash screen.

Type the following as a single command:[1]

echo 0 > /sys/block/mmcblk2/mmcblk2boot0/force_ro
echo 0 > /sys/block/mmcblk2/mmcblk2boot1/force_ro
dd if=/dev/zero of=/dev/mmcblk2boot0
dd if=/dev/zero of=/dev/mmcblk2boot1
dd if=/dev/zero of=/dev/mmcblk2 bs=1M count=1024

Hit return.

10. Wait for the commands to run. You will see a total of **three** "copied" outputs in Terminal when this step is complete. **The third "copied" output takes about 10 seconds to appear.** Do not proceed to Step 11 until the third "copied" output is returned.



11. The PCB is now programmed to run its OS from the external eMMC module. Remove external power and RJ45 connection from the NanoPi R2S Plus.

Image eMMC Module with OS

1. Attach the eMMC module to your computer using a standard Micro SD card reader.
2. Download the current TeeHee HaLow software image from the TeeHee HaLow product listing.
3. Open Terminal.app. Type the following command, followed by the filepath of the downloaded .gz file:

   gzip -d

   For example, the full command will look something like:

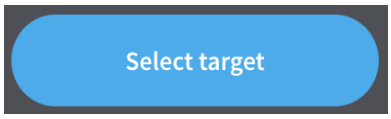
   gzip -d /Users/sampetrov.lol/Downloads/test.img.gz

   Hit return. The original file will now be uncompressed and end in .img.

[1] If you ever need to reverse this process, use *dd* in Terminal to write the Micro SD card contents back to the internal eMMC. In order to avoid copying empty space, only copy the partition table and partition contents.

4. Open Balena Etcher.
5. Click *Flash from file*.

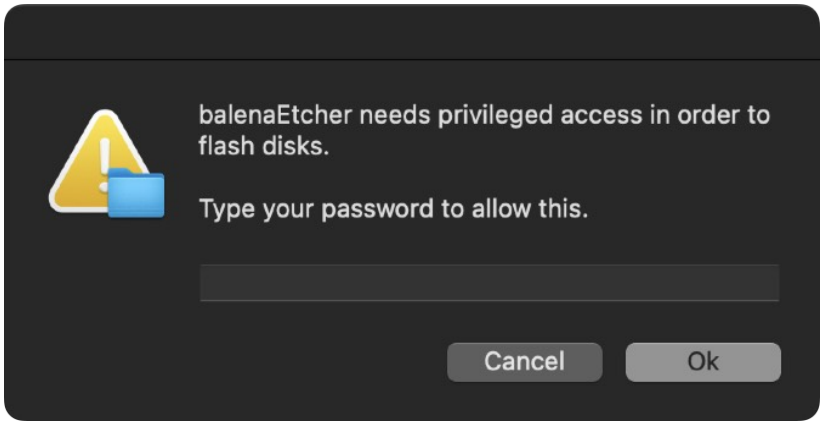
6. Select the .img file from Step 3.
7. Click *Select target*.



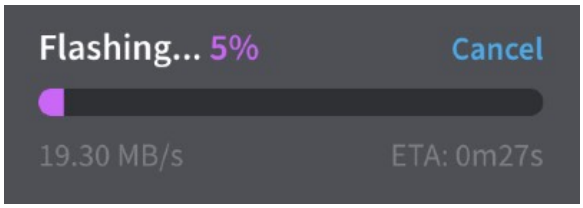
8. Select your attached eMMC module as your destination.

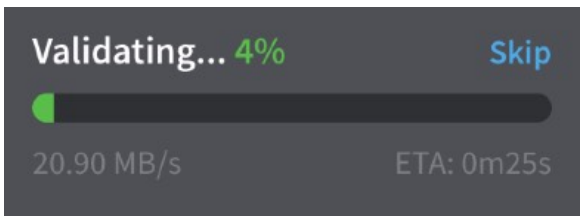
9. Click *Flash!*.

10. Enter your local computer password if prompted. This step may not be necessary if you're flashing more than one eMMC module in a single sitting.



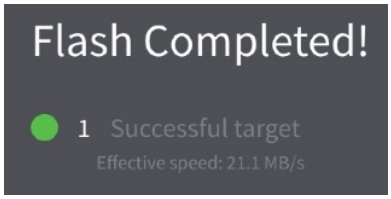
11. The flashing process should take about a minute; half of that time is spent writing while the other half is used for reading and verifying.





☞ Heads up! If this process takes two minutes per step (i.e. four minutes total), you likely have a bad eMMC module and it will not function properly to run the OS for TeeHee HaLow. Please replace it before proceeding.

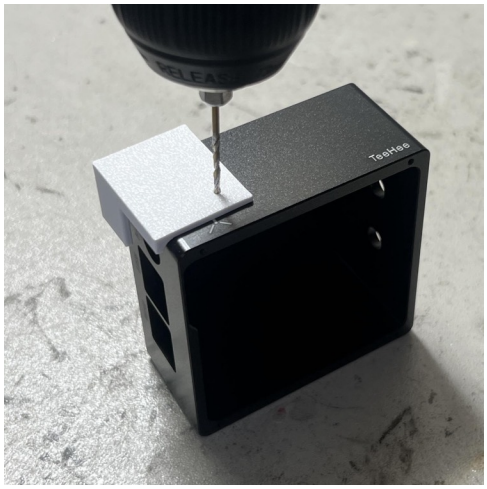
12. Once you reach the completion screen, you may physically remove the eMMC module from your computer. There's no need to eject it on the software side.



Hardware Prep

Chassis

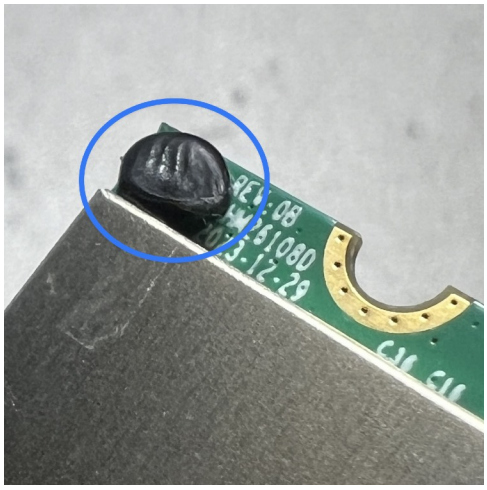
1. Use the Button Hole Stencil to drill a 1/16" hole next to the LOL logo.



2. Adhere the Lid Vinyl to mitigate the risk of inadvertent PCB solder contact.

M.2 HaLow Module

1. Cover the status light with opaque hot glue. Do not let glue exceed the vertical clearance of the silver metallic module cover.

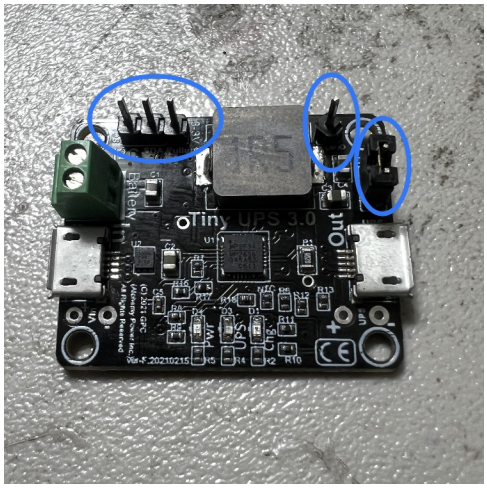


Lemo 0B

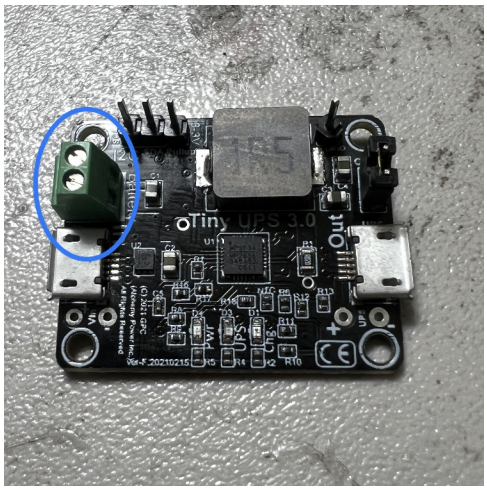
1. Tin the chassis power connector's solder cups.

Tiny UPS 3.0 [UPS Variant Only]

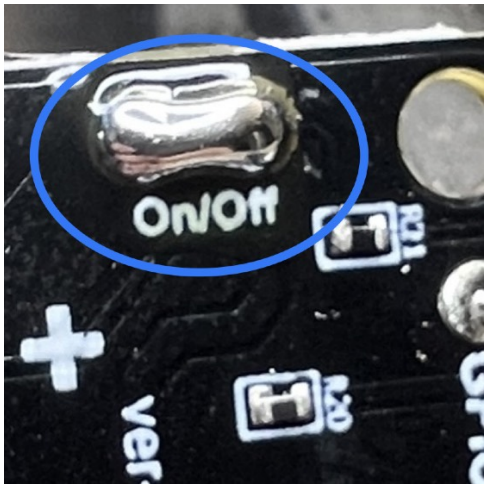
1. Desolder all components that utilize DuPont connectors, which include the *I2C* annular ring (one), *GPIO* annular rings (three) and *On/Off* annular rings.



2. Desolder the battery input screw-down terminals and wick away any excess solder from the *Battery* annular rings.



3. Connect the two *On-Off* annular rings with a solder bridge.

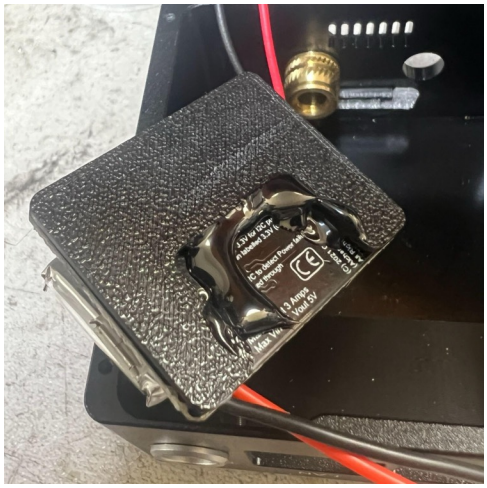


4. Attach the external battery.
    a. Trim battery leads to 10mm.
    b. Strip and tin the battery leads.

c. Solder the two battery leads to their respective *Battery* annular rings.
d. Test board functionality using the micro USB power input: Status lights will change based on the presence of an external power source.
e. Hot glue the *Battery* annular ring solder joints for extra durability.

5. Use opaque hot glue to cover SMD status lights.

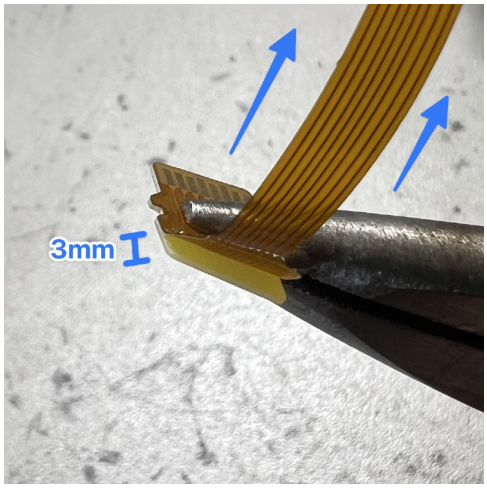
6. Hot glue the UPS Insulator to the bottom to electrically isolate the exposed solder joints.



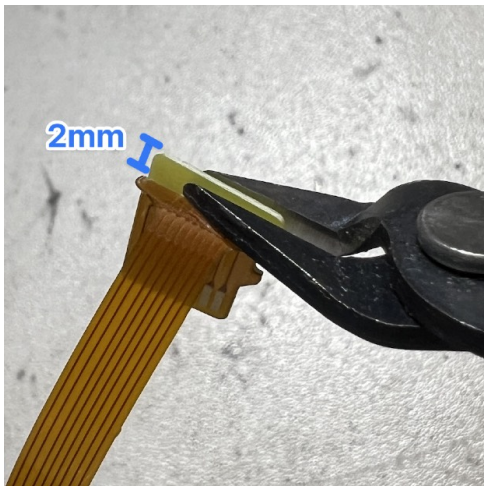
Micro SD Ribbon Extension Cable

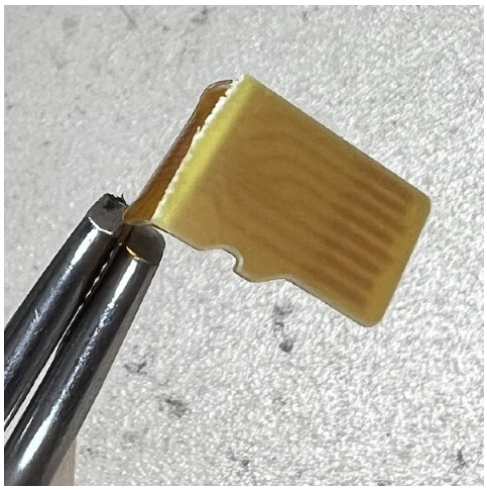
1. Deftly hold ribbon cable with crucible tongs. On the male dummy end and contact-pins side of the ribbon cable, apply high heat from a heat gun for 10 seconds.

2. On the male dummy end of the ribbon cable, use a needle nose pliers to hold the rigid plastic while applying even lateral pressure across the ribbon to gently peel back 3mm from the plastic stencil.



3. Use a flush cutter to remove 2mm of plastic from the rear edge of the male end plastic dummy unit that you just delaminated.



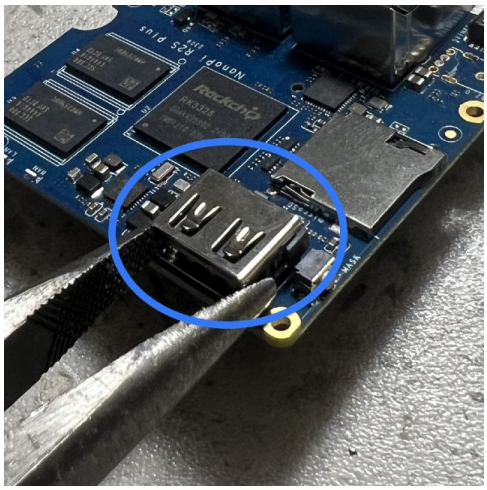
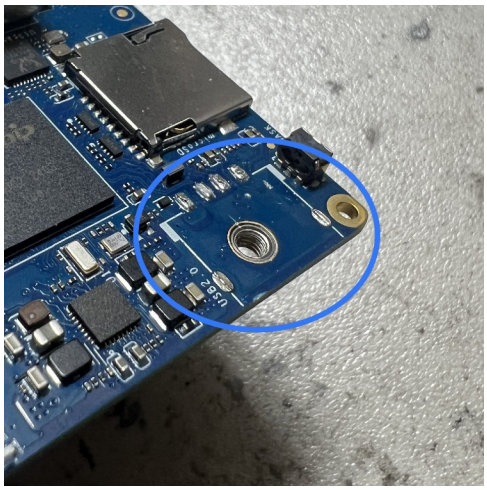


NanoPi R2S Plus: Component Excision

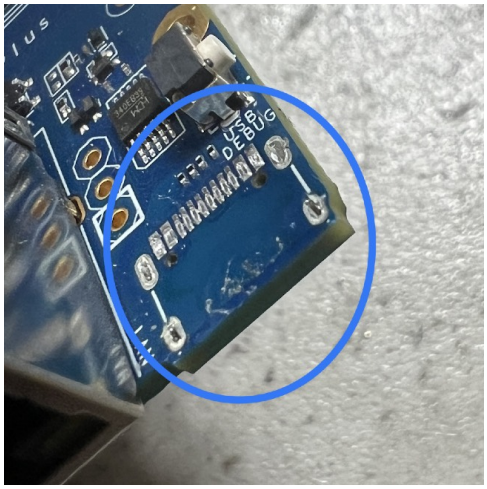
Careful! Be mindful of adjacent PCB components during physical excision (Steps 1-3). You don't want to accidentally "bump" that component that you can barely see without a microscope only to later discover that the entire board no longer functions.

1. With a needle nose pliers and flush cutter, physically remove the vertical USB-A port labeled *USB 2.0*.


2. With a needle nose pliers and flush cutter, physically remove the horizontal USB-A port labeled *USB 2.0*.

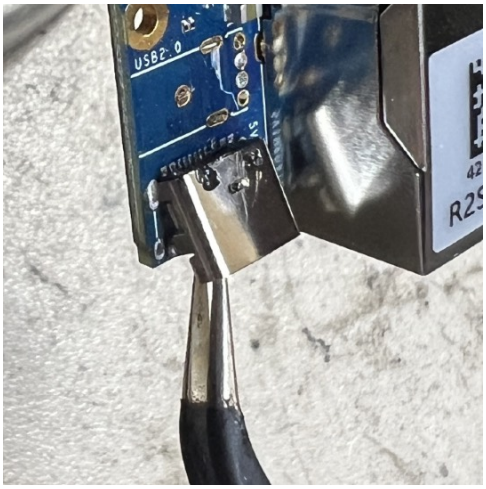



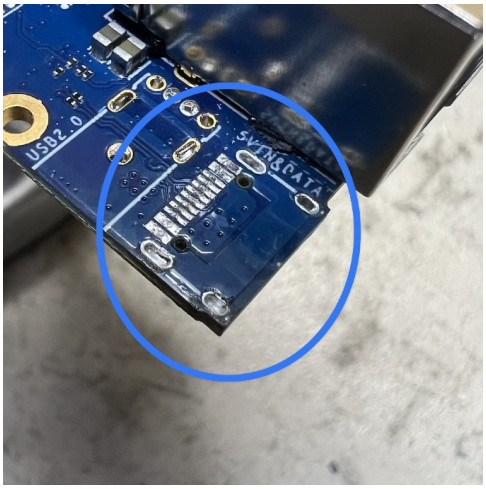
3. With a needle nose pliers and flush cutter, physically remove the horizontal USB-C port labeled *USB DEBUG*.

4. Chemically remove the horizontal USB-C port labeled *5V IN & DATA*.

a. Use a hot-air rework station with a 5mm air nozzle. Suggested settings (based on SparkFun 8508D) are: AIR=4, HEATER=480° C.
   Careful! Be mindful of the adjacent RJ45 WAN port which contains plastic and may deform if you aren't meticulous with your airflow. (The plastic on the excised USB-C port will inevitably melt during this step, but it will be discarded.)
b. After your hot-air rework station reaches temperature, slowly rotate the hot air nozzle in a circular motion around the USB-C port, dwelling on the through-hole solder points because they will take the longest to loosen. (Some rework stations without a pneumatic pump may take up to several minutes to sufficiently heat the component for easy removal, so be patient.)
c. Gently pull upwards on the USB-C port with ESD-safe tweezers, starting from the edge of the PCB and working inwards and using the SMD pads as your fulcrum. Prioritize preserving the solder pads of the USB-C port.
   Careful! These USB-C solder pads are the sole power input on the NanoPi R2S Plus.

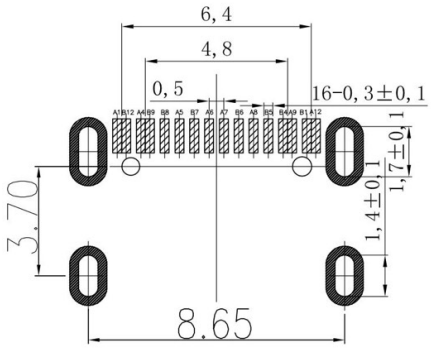




d. Using an ESD cleaning brush, gently scrub 90%+ isopropyl alcohol over the SMD pads once the port has been fully removed. Allow time to air dry or dab dry with an ESD polyester wipe.

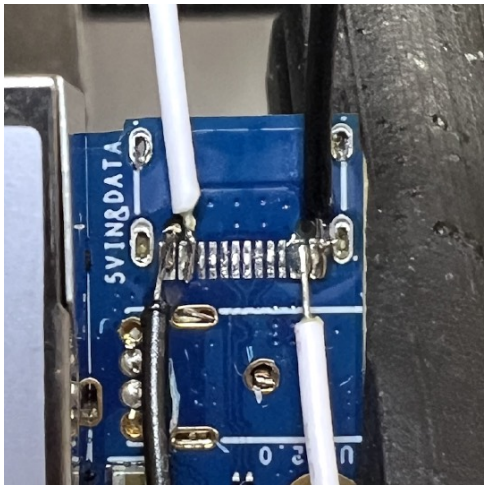
NanoPi R2S Plus: Power Input

1. Cut solid core wires to 40mm each. You will need two positive and two ground wires.
2. Strip and tin the four aforementioned wires.
3. Add flux to the SMD pads. Syringe-style gel flux is recommended.
4. With a solder iron wearing a super thin, elongated cone tip, use the normal temperature settings for your chosen solder stock. Have your solder tip "tinned" with a dab of solder before making contact with the PCB. Solder the wires to the SMD pads (A1, A12, B1 and B12) according to the following schematic:

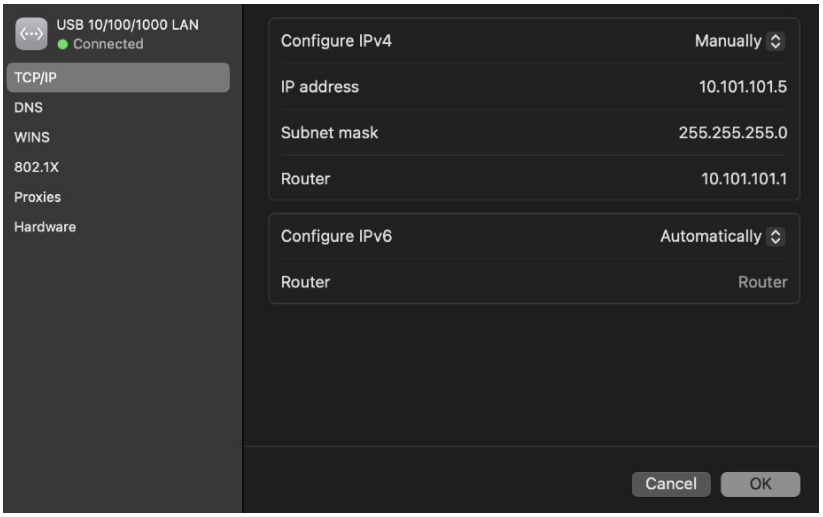


A1	GND	B12	GND
A4	VBUS	B9	VBUS
A5	CC1	B8	SBU2
A6	DP1	B7	DN2
A7	DN1	B6	DP2
A8	SBU1	B5	CC2
A9	VBUS	B4	VBUS
A12	GND	B1	GND
PIN	SIGNAL NAME	PIN	SIGNAL NAME

5. Going left to right, alternate up and down exits with each wire as pictured below:

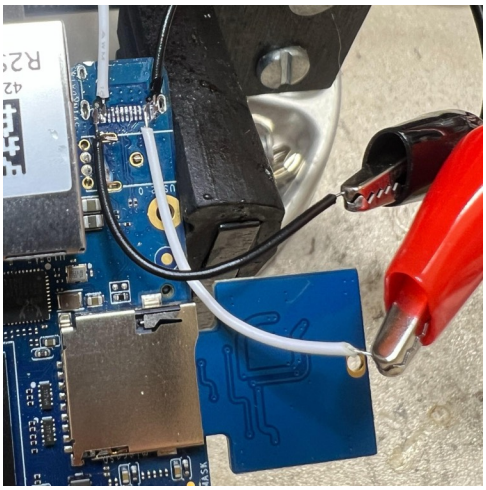


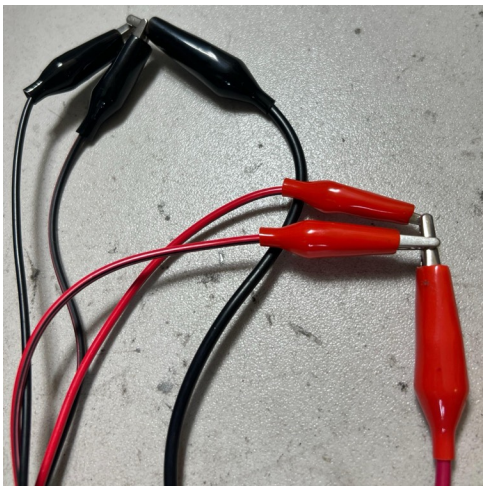
6. Verify your solder job.
    a. Temporarily insert the imaged eMMC module directly into the NanoPi R2S Plus Micro SD slot.
    b. Connect a computer or other device to the NanoPi R2S Plus *LAN* port.
    c. Set your computer's network settings as follows:



    d. Using a bench power supply set to 5.2V, connect leads to each of the four wires separately. (The board will not boot properly if you connect your PSU

to the wires in pairs; the split must happen at the PSU/probes so that the wires you just soldered never actually touch each other.)



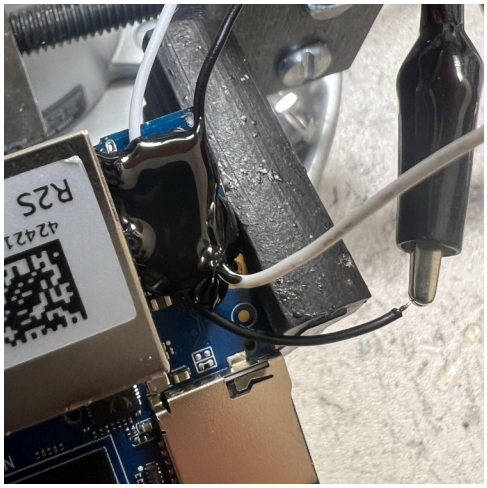


e. Verify full boot after waiting 30 seconds. With an external device attached, you can verify your computer's connection by referencing the SMD status light labeled *LAN*, which should illuminate solid green.

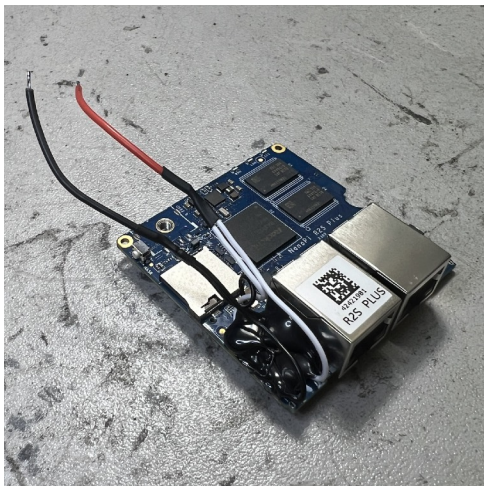
If you encounter issues with this verification, it may help to use an ESD cleaning brush and gently scrub 90%+ isopropyl alcohol over your solder work. Allow time to air dry or dab dry with an ESD polyester wipe.

f. Disconnect external power along with the RJ45 test cable.
g. Remove the eMMC module from the Micro SD slot after a successful test.

7. Hot glue over solder pads to reinforce the physical connection.



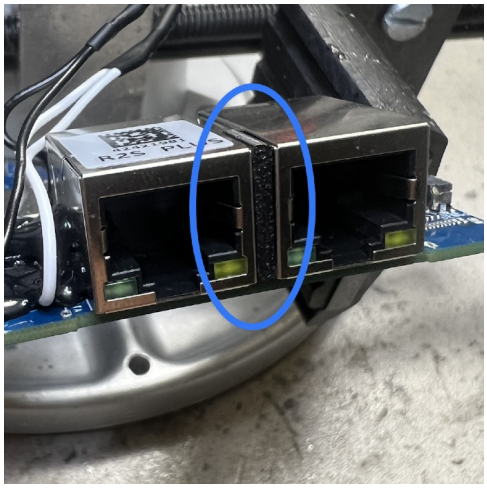
8. Solder both ground wires together; solder both positive wires together.
9. Add 2mm heat shrink to each wire pair.
10. Solder an additional 60mm of stranded wire to the solid core wires.
11. Guide and melt the heat shrink to protect the exposed solder joints.



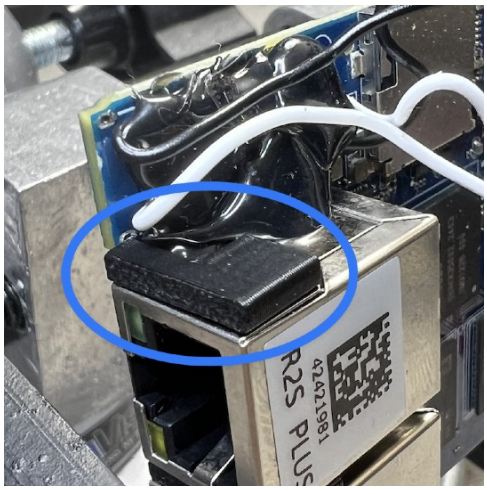
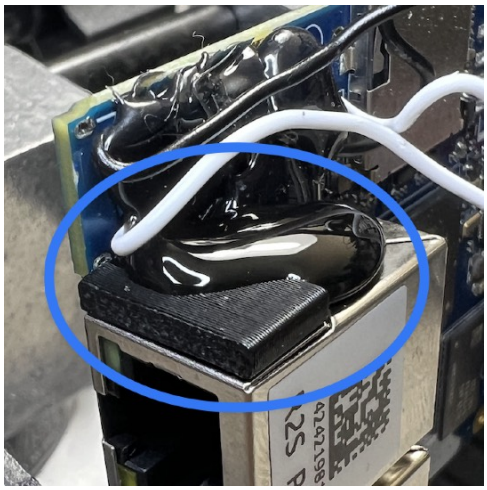
Pre-Assembly

RJ45 Spacers

1. Pressure fit RJ45 Gap Spacer One into place with the textured side exposed.

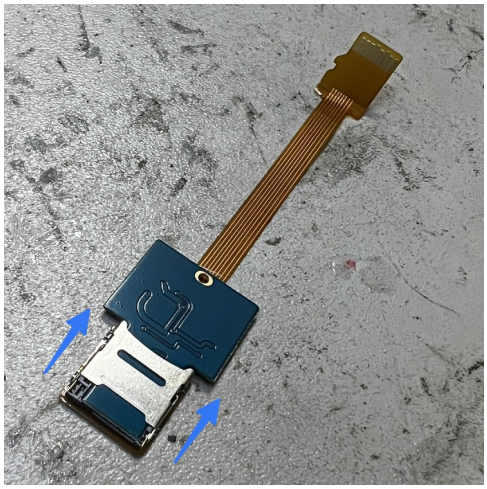


2. Align RJ45 Gap Spacer Two adjacent to the *LAN* port with the textured side exposed; hot glue into place.

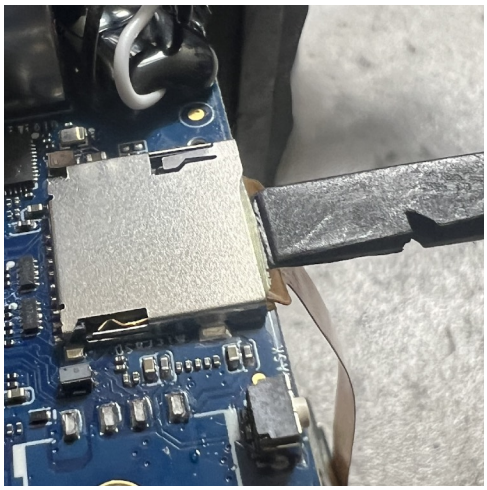



eMMC Module Attachment

1. Insert the imaged eMMC module into the Micro SD ribbon extension cable. Lock into place using the integrated silver slot cover.

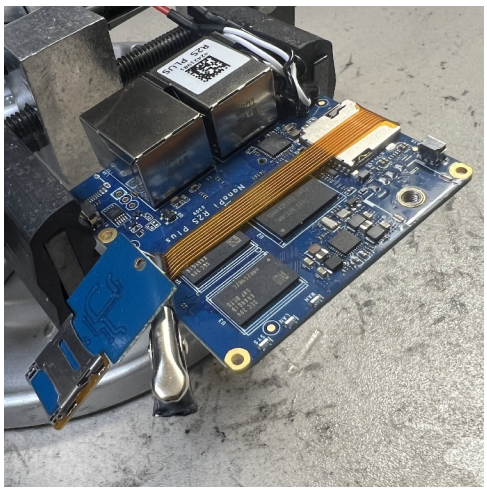


2. Using the flat end of a nylon probe, insert the prepared dummy Micro SD male end into the NanoPi R2S Plus Micro SD card slot, ensuring it “clicks” into place.

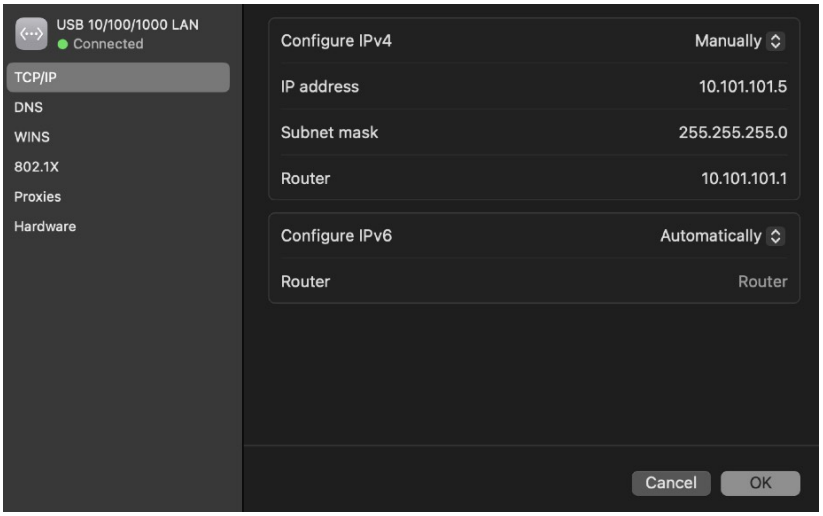


Careful! Despite hearing the click sound, the dummy card will still come out if not handled carefully.

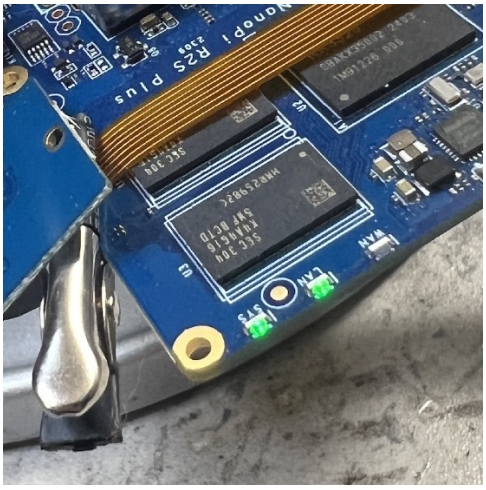
3. Gently bend the exposed ribbon 180° over the top of the NanoPi’s Micro SD card slot. Pull taut while being mindful not to dislodge the dummy Micro SD card insert from the slot.
4. Temporarily secure the ribbon in its current position using a rubber-coated alligator clip.



5. Verify OS boot sequence over the ribbon-cabled eMMC module.
    a. Connect a computer or other device to the NanoPi R2S Plus *LAN* port.
    b. Using a bench power supply set to 5.2V, connect leads to each of the two braided power input wires you recently soldered.
    c. Set your computer’s network settings as follows:



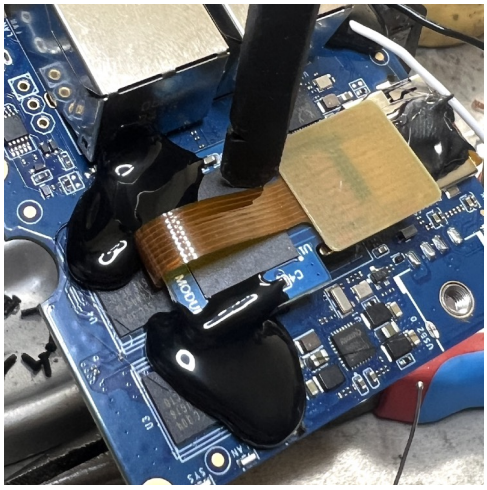
d. Verify full boot after waiting 30 seconds. With an external device attached, you can verify your computer's connection by referencing the SMD status light labeled *LAN*, which should illuminate solid green.



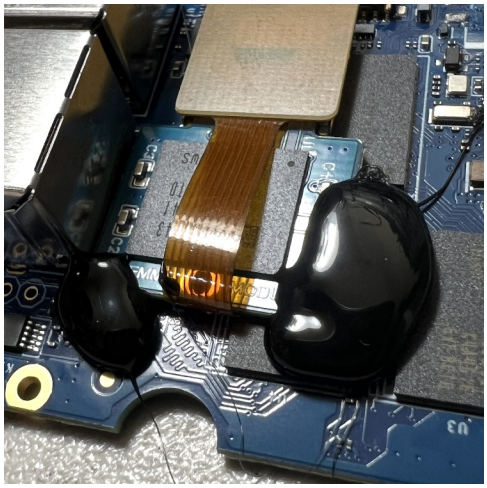
e. If this test fails, disconnect external power, reseat the ribbon cable and reconnect power until you reach a stable and repeatable boot sequence.

6. Use hot glue to secure the ribbon cable over the Micro SD slot, ensuring both edges of the ribbon cable are secured in place. Try to prevent hot glue from oozing into mechanical cavities of the Micro SD card slot, if possible.

7. Disconnect external power along with the RJ45 test cable, which were used during Step 5.
8. Now that the hot glue has dried, disconnect the rubber-coated alligator clip that secured the ribbon cable.
9. Orient the eMMC module so the ribbon cable wraps around it 180°, back towards the Micro SD card slot.
10. Position the eMMC module atop the RK3328 chip on the NanoPi R2S Plus using a rubber-coated alligator clip. To ensure a reliable connection, avoid creasing the ribbon.
11. Repeat Step 5 again before committing to the final eMMC placement with hot glue.
12. Secure the eMMC module into place by lining the perimeter of the eMMC module with hot glue near the two black rectangular RAM modules. Try to keep the ribbon itself devoid of any hot glue.



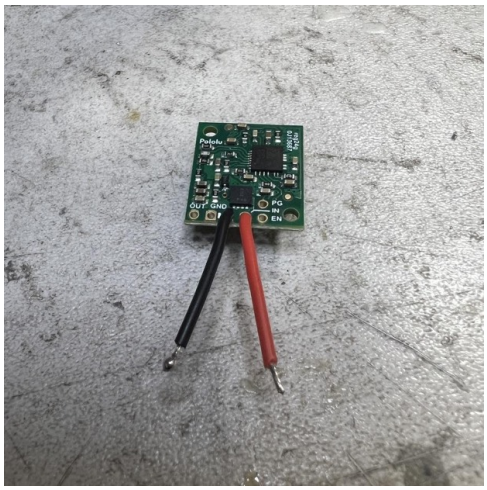
13. Once the hot glue has dried, disconnect the rubber-coated alligator clip that secured the eMMC module.



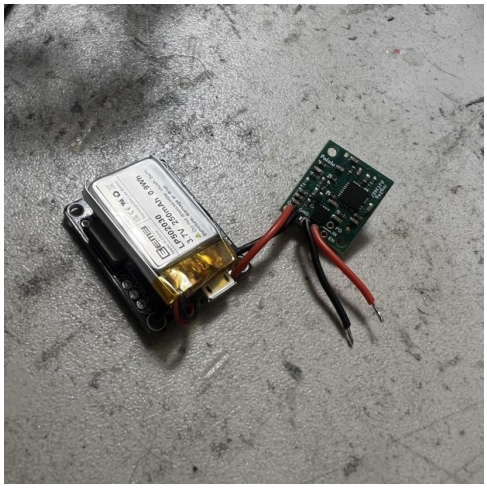
14. Repeat Step 5 one final time to verify a reliable connection.

Circuit

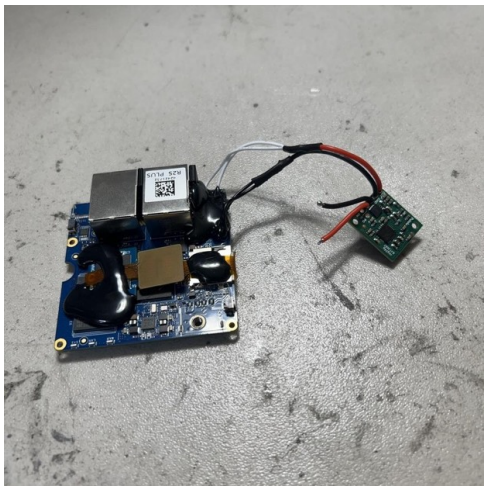
1. Cut, strip and tin wires as necessary (see lengths).
2. Solder 40mm ground and positive wires to the Pololu buck converter input backside (the side without cylindrical capacitors).



If you're assembling the UPS variant: Also solder 30mm ground and positive wires from the Pololu buck converter output backside (the side without cylindrical capacitors) to the UPS's *Vin* annular rings on the frontside (the side with the 1R5 inductor).

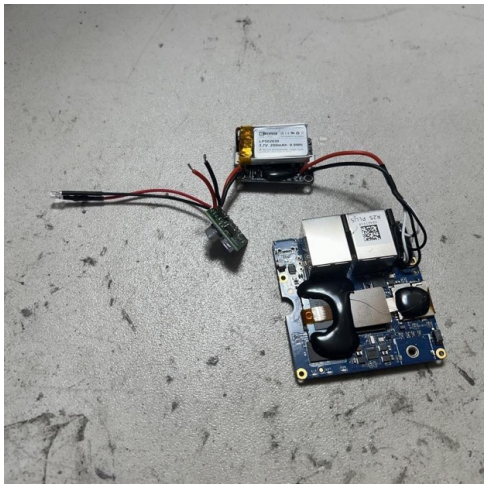


3. Solder the two flying lead input wires you prepared earlier on the NanoPi R2S Plus to the Pololu output annular rings (on the backside).



If you are assembling the UPS variant, solder the two flying lead input wires you prepared earlier on the NanoPi R2S Plus to the UPS's *UPS* annular rings (on the frontside) instead.

4. Cut, strip and tin the LED power status light to 70mm length as measured from the tip of the diode dome.
5. Connect the respective wires from the LED to the Pololu buck converter output frontside (the side with the cylindrical capacitors).

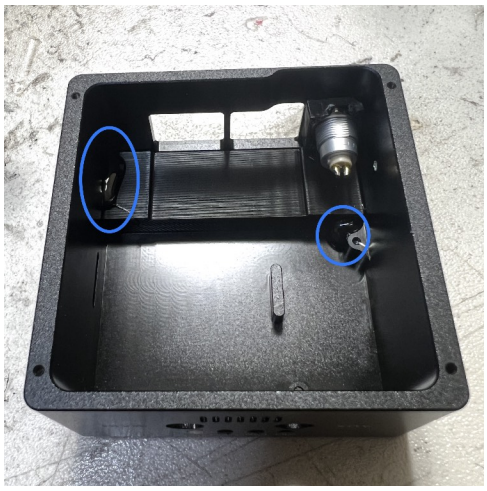


Final Assembly

1. Place the Void Spacer below the RJ45 port cutouts with the middle deboss visible.
2. Insert the Status Light Insert.

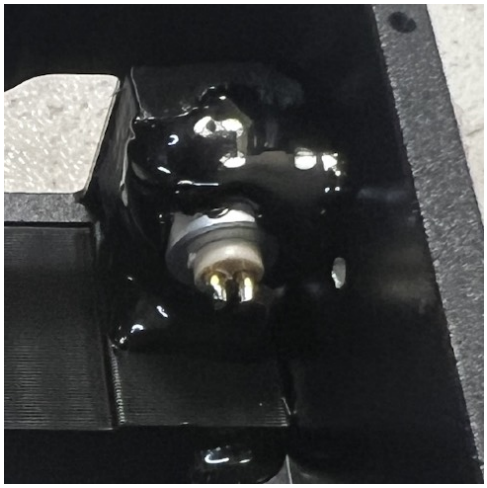
3. Apply high strength Loctite to 1mm of the thread on the Lemo 0B 2-Pin chassis connector, closest to the flange. Dab any excess Loctite with a paper towel, if necessary.

4. Insert and tighten the Lemo 0B 2-Pin chassis connector, using the Corner Lemo Adapter and the OEM metal nut. The red dot denoting “ground” should be oriented adjacent to the *LAN* port cutout.[2]
5. Apply hot glue dollops as pictured:



6. Encapsulate the Lemo 0B 2-Pin chassis connector in hot glue to prevent loosening over time. Ensure the solder cups of the connector and the multipurpose button hole remain exposed and accessible.

[2] You may need to rotate the nut to achieve the proper final orientation.

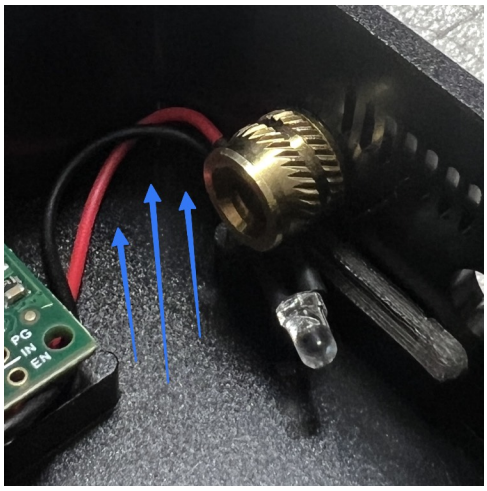


7. Apply high strength Loctite to the ¼-20 AUX hole cap screw. Dab any excess Loctite with a paper towel, if necessary.

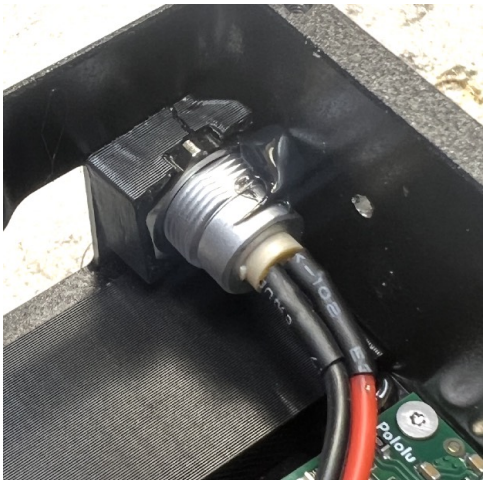
8. Insert and secure the AUX hole cap screw with a 3mm hex driver, using the ¼-20 insert as the female mating thread. The wider end of the insert should sit adjacent to the chassis.

9. Secure the Pololu buck converter to the aluminum chassis: Using the tapped hole near the Lemo power input, place the Pololu buck converter face-down (leaving the side without cylindrical capacitors exposed) and thread the 0-80 T3 star screw through the PCB hole that's adjacent to the word *Pololu*. Screw until snug, being mindful not to strip the screw head's star pattern.

10. Guide the LED wires into the corner near the ¼-20 thread.

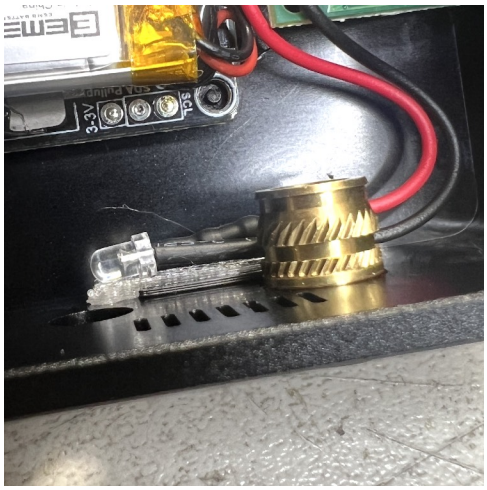


11. UPS variant only: Hot glue the UPS to the chassis in the remaining cavity, leaving 2mm of clearance from the perimeter near the Micro SD card slot cutout. The status light side of the UPS should buttress the edge of the Void Spacer. Hot glue should be applied to the blank PCB surface area on the UPS that displays the CE marking and copyright info.
12. Insert the Micro SD Slot Cover. Hot glue into place.
13. Connect 0B Lemo.
    a. Add 2mm heat shrink to the power input wires.
    b. Solder the Pololu buck converter input wires to the Lemo 0B 2-Pin chassis connector.
    c. Move heat shrink into place using ESD-safe tweezers. Melt heat shrink to protect the exposed solder joints.



d. Connect external power to the 0B Lemo port and observe the power input light. Disconnect power after a successful test.

14. Position and hot glue the LED perpendicular to the translucent *PWR* light plastic. Hot glue into place.

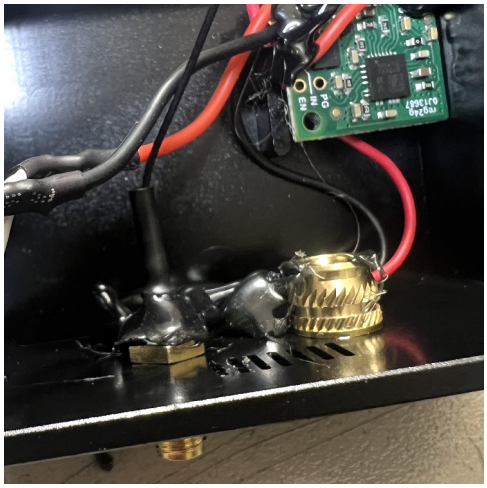


15. UPS variant only: Hot glue the UPS battery into the corner adjacent to the Pololu buck converter.

16. Attach the RP-SMA antenna mount.
    a. From inside the chassis, insert the RP-SMA antenna mount through the hole labeled *MAIN*.
    b. Add the thin, toothed washer to the RP-SMA antenna mount from the outside of the chassis.

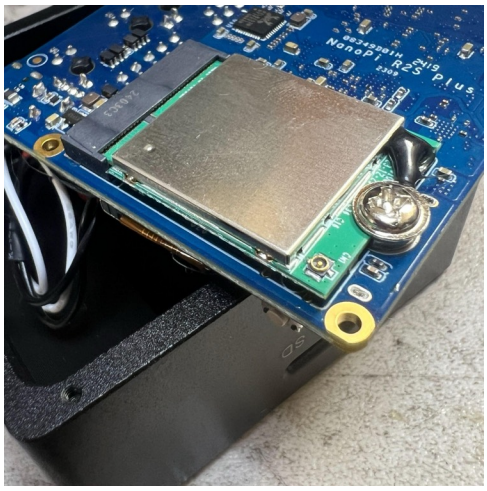
    c. Apply high strength Loctite to 1mm of the exposed RP-SMA threads closest to the chassis. Dab any excess Loctite with a paper towel, if necessary.

    d. Using an 8mm wrench to hold the connector in place inside the chassis along with an 8mm nut driver, tighten the RP-SMA antenna mount nut until snug.
17. Hot glue components for extra durability.

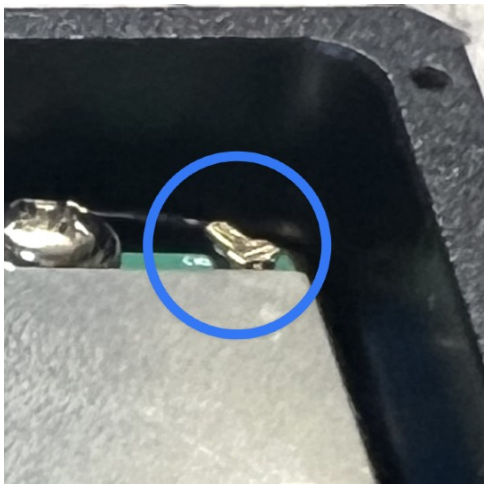


a. Hot glue the 0-80 T3 star screw head along with the four Pololu buck converter inputs and outputs to isolate electrical current and increase longevity.
b. Hot glue the ¼-20 AUX screw female thread in its current position.
c. Hot glue the RP-SMA antenna mount into place from the inside of the chassis.

18. Install the HaLow M.2 module to the NanoPi R2S Plus with the M.2 mounting screw.

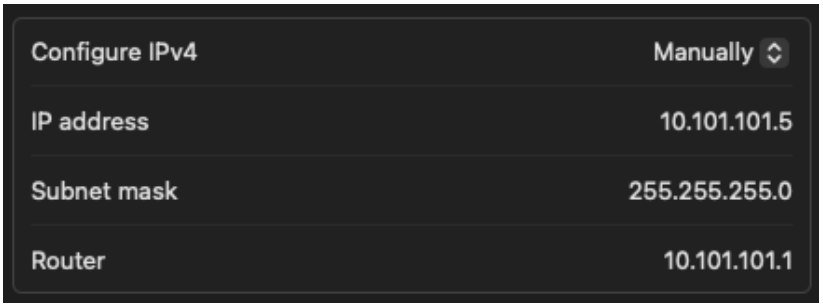


19. Connect the I-PEX MHF4 connector to the M.2 HaLow module.



20. Insert the NanoPi R2S Plus into the chassis, RJ45 ports first. Guide the RP-SMA extension cable through the crescent gap on the side of the NanoPi R2S Plus while ensuring no wires get pinched.

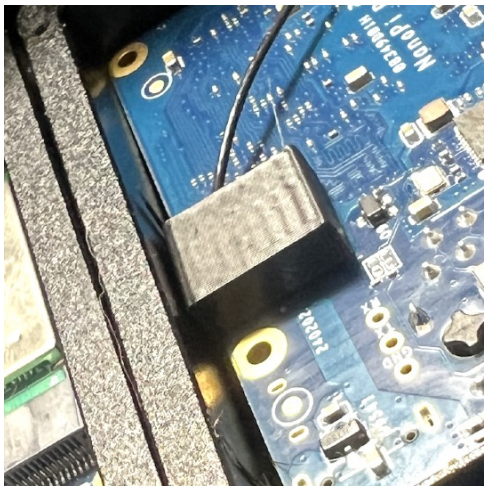
21. Verify OS boot sequence.
    a. Connect a computer or other device to the NanoPi R2S Plus *LAN* port.
    b. Set your computer's network settings as follows:



    c. Connect external power via 0B 2-Pin Lemo (5-50V).
    d. Verify full boot after waiting 30 seconds: With an external device attached, you can confirm active network connection by referencing the integrated green and yellow status lights on the LAN RJ45 port. The yellow light will flash intermittently to denote data packet transfer.

e. Disconnect external Lemo power along with the RJ45 test cable.

22. Attach the Lid Spacer.



23. Attach the lid using the four black 0-80 screws. Secure the two screws on the RJ45 side first.

Well done. TeeHee HaLow is now fully assembled! 😃