

QMX+ ATU, Battery, Charger and speaker solution (ABS)

Build instructions

Ver 2.0

By AC8L

WARNING!!! The battery portion of a solution is for the QMX+ 12V build only!!! It will damage the 9V QMX+ !!!

Please read instructions to the end before starting the assembly. Then start the assembly by following instructions step by step from the beginning.

ATU PCB will arrive with most of the component's factory-assembled, you will need to wind and install just inductors and few connectors. The battery board will need just handful large side through hole components to be soldered. Bot require beginner skills.

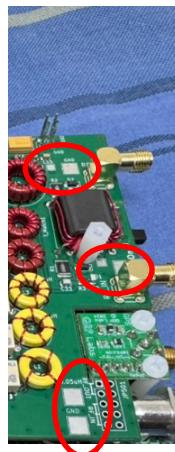
1. Decide how you want to build the ATU board.

ATU can be integrated with QMX+ in two different ways.

- a. Using SMA connectors and a jumper coax from the rear of the enclosure



- b. Using internal coax jumper wires soldered to the pads on the ATU and to the JP501 connector.

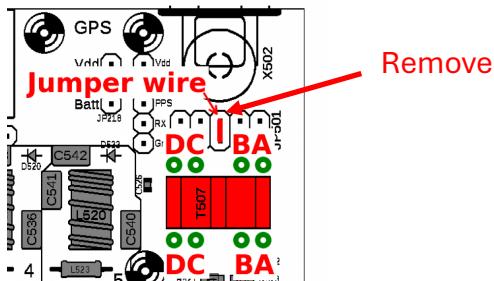


Option (a) is more favorable in situations when you interchangeably use the resonant and non-resonant antenna's and do not always use the ATU. Or you experience tuning problems on higher frequencies like 6m. Or want to use an external tuner. It gives flexibility to quickly connect and disconnect the ATU e.g. for troubleshooting.

Option (b) is preferred if you want the ATU to be integrated with QMX+ on a permanent basis internally and want fewer external cables and connectors hanging out of the rig enclosure.

If you decide on option (a) – ignore the rest of this section and go section (2). Otherwise for option (b):

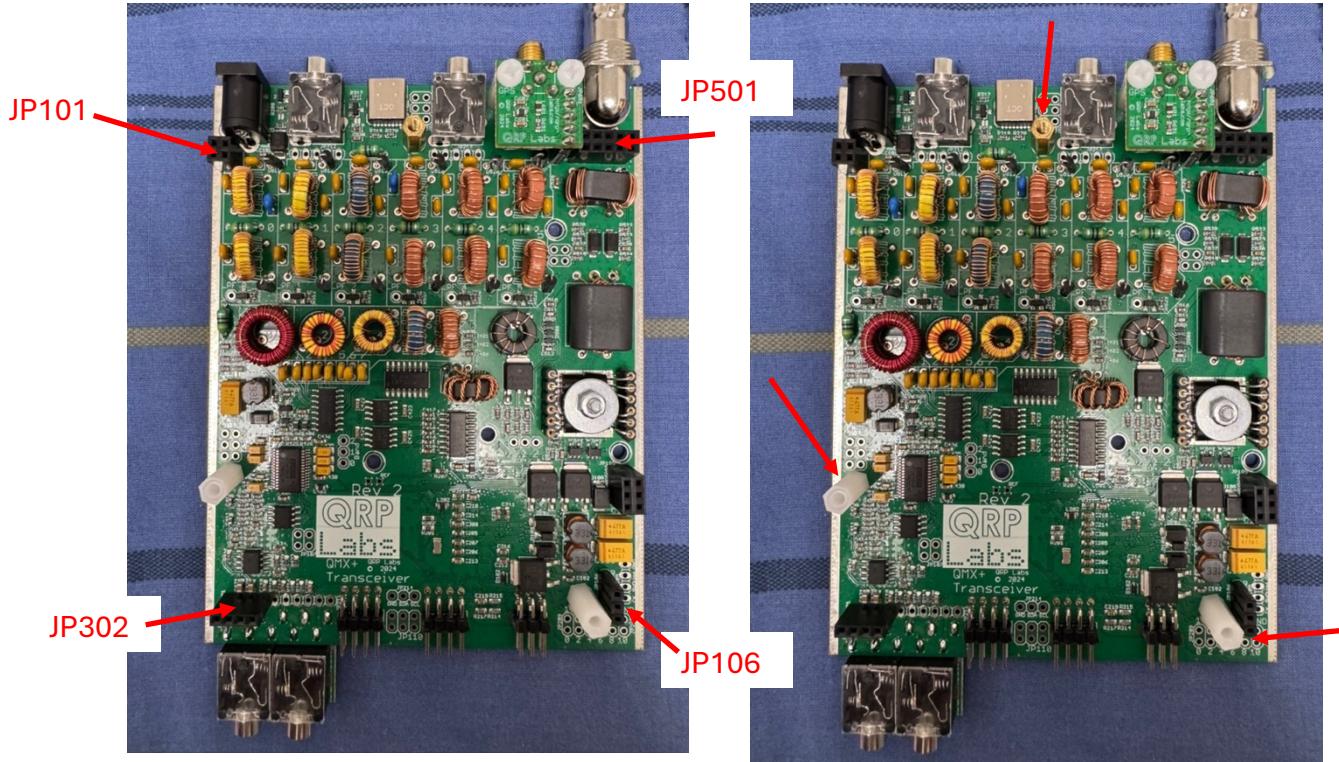
If you have QMX+ pre-built and functioning – prior to soldering JP501 you MUST remove the jumper wire soldered on it (QMX+ assembly instruction REV2.0 page 37).



Do this carefully not to damage the nearby elements and soldering pads! E.g. completely remove GPS module if installed and unscrew its nylon spacers. After jumper wire removed – use desoldering suction tool to remove excess solder and cleanup holes preparing them for soldering the JP501 female socket.

2. Install connectors to the QMX+ main board

3. Install three 11mm nylon standoff spacers



Use 6mm nylon screws to secure spacers from the bottom of the QMX+ main board.

4. Wind and solder L1-L7 inductors to the ATU

Below are types of the ferrite cores and number of turns per inductor:

- L1: T37-6, 4 turns
- L2: T37-6, 6 turns
- L3: T37-6, 9 turns
- L4: T37-2, 11 turns
- L5: T37-2, 16 turns
- L6: T37-1, 17 turns
- L7: T37-1, 24 turns

Use AWG24 (0.5mm enameled wire). L7 requires quite tight winding (24 turns) but is perfectly doable:



Tips on TOROID winding:

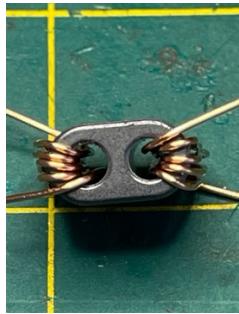
- One turn means one pass of wire through center of toroid core.
- Always clean enamel coating from end of winding thoroughly. There are two proven methods to achieve this:
 1. Heat end of wire enough so that all enamel coating burns up. Then soak with solder to cover that section.
 2. Scrape the enamel coating using cutting knife and then heat up for remaining residue then solder soak to have a shiny solder covered solder point.
 3. Always test with a continuity tester all is good and exposed before soldering and after soldering.

5. Wind and solder tandem match binocular transformer

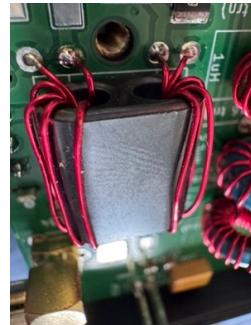
Tandem match binocular core is the most important part of this ATU build and needs special attention and care for good operating results.

Each side of BN43-202 Binocular core has 5 turns. One turn means passing wire once inside the core. For 5 turns we need to pass 5 times. Use 0.5mm/AWG24 wire for both winding and for straight through feedback wires.

5 turns wound tandem match:



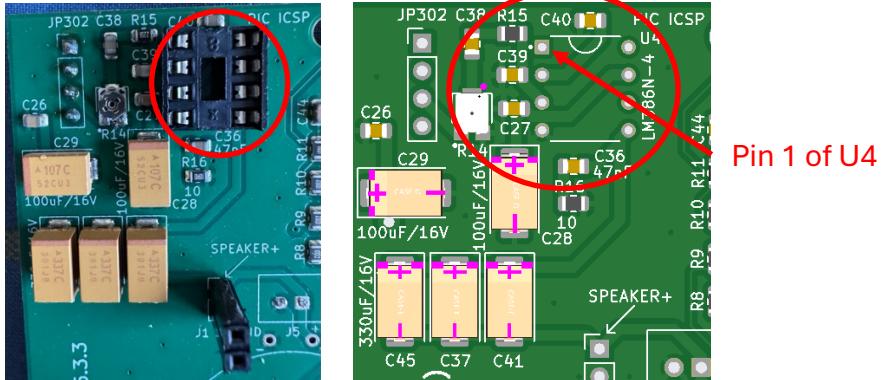
Installed tandem match transformer:



When winding tandem match just be careful to start winding one side from bottom to top and adjacent core hole on same side start from top to bottom as in the left photo above.

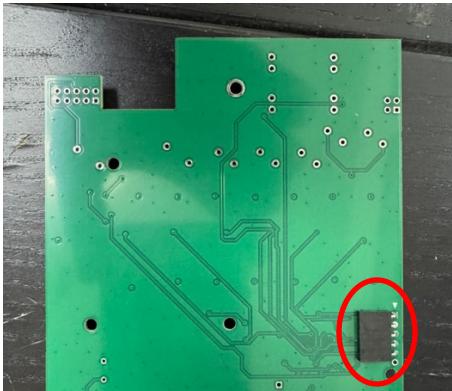


6. Solder the 1x8 Pos DIP Socket



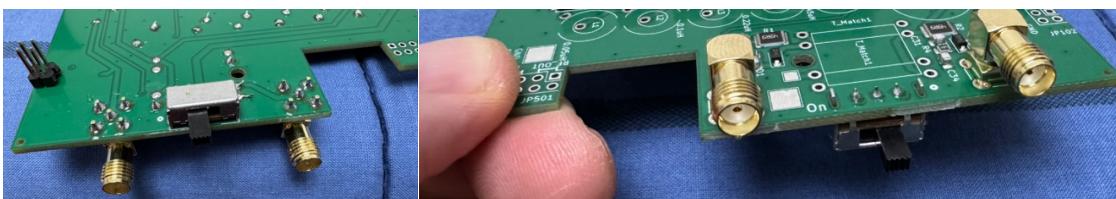
Pay attention to the pin marking. There is a dot on PCB marking pin 1 (right photo).

7. Solder the PIC ICSP programming header



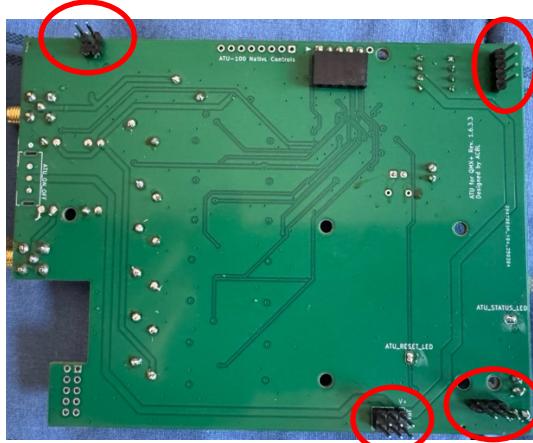
Solder the 5 POS right angled connector UNDER the ATU PCB as shown on the photo above. Make sure the first pin is inserter to the hole marked with white triangle. The last 6th hole should stay empty.

8. Solder SMA connectors and ATU power switch

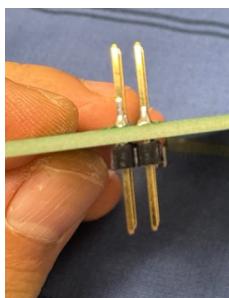


IMPORTANT: Power switch is soldered under the PCB (left photo above), SMA connectors – to the top (right photo).

9. Install bottom pin headers to ATU PCB



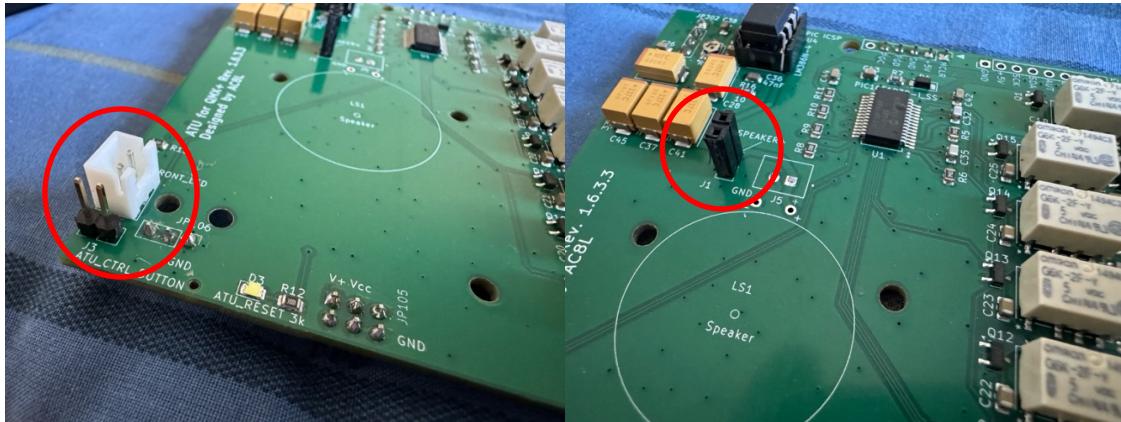
Remember, JP102 connector is a long tail! Make sure the plastic part is flush at the bottom of the PCB.



The best tactic is to make sure pin headers are properly aligned with the female connectors on QMX+:

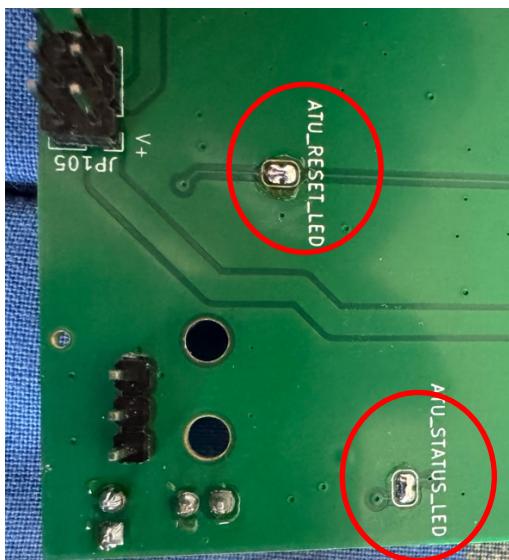
- Insert them into the female connectors on QMX+ main board
- Place ATU PCB on top, make sure pin headers are all inserted into their places on the ATU.
- Temporarily secure the ATU to the QMX+ using three 6mm nylon screws. Screw them into the nylon spacers that are already attached to the QMX+ main board.
- Carefully solder pin headers of all connectors from the top of the ATU.
- Unscrew 6mm nylon screws and detach the ATU from QMX+

10. Install top pin headers to ATU PCB



At this point you also can go ahead and insert the U4 (LM386N-4) opamp into its 1x8POS socket.

11. Solder (connect) jumpers



Go ahead and short the ATU_RESET_LED and ATU_STATUS_LED jumpers on bottom side of the ATU using moderate amount of a solder.

The reason that jumpers are there – is because PIC MCU pins used to drive those LED's are also can be used for OLED display. Using OLED display with ABS is an experimental feature and is not covered in this document.

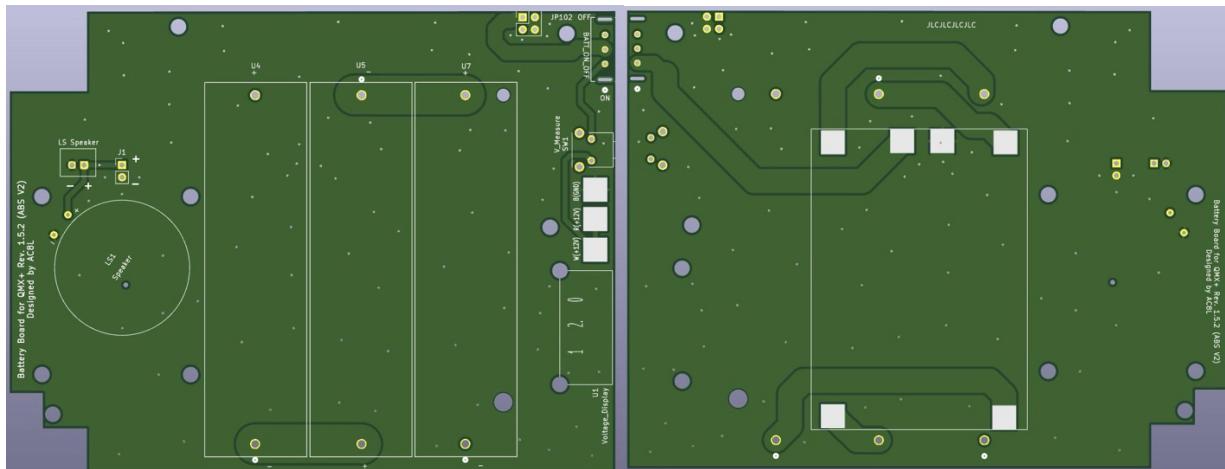
This concludes the ABS ATU PCB assembly process.

12. Assemble the Battery / Speaker PCB

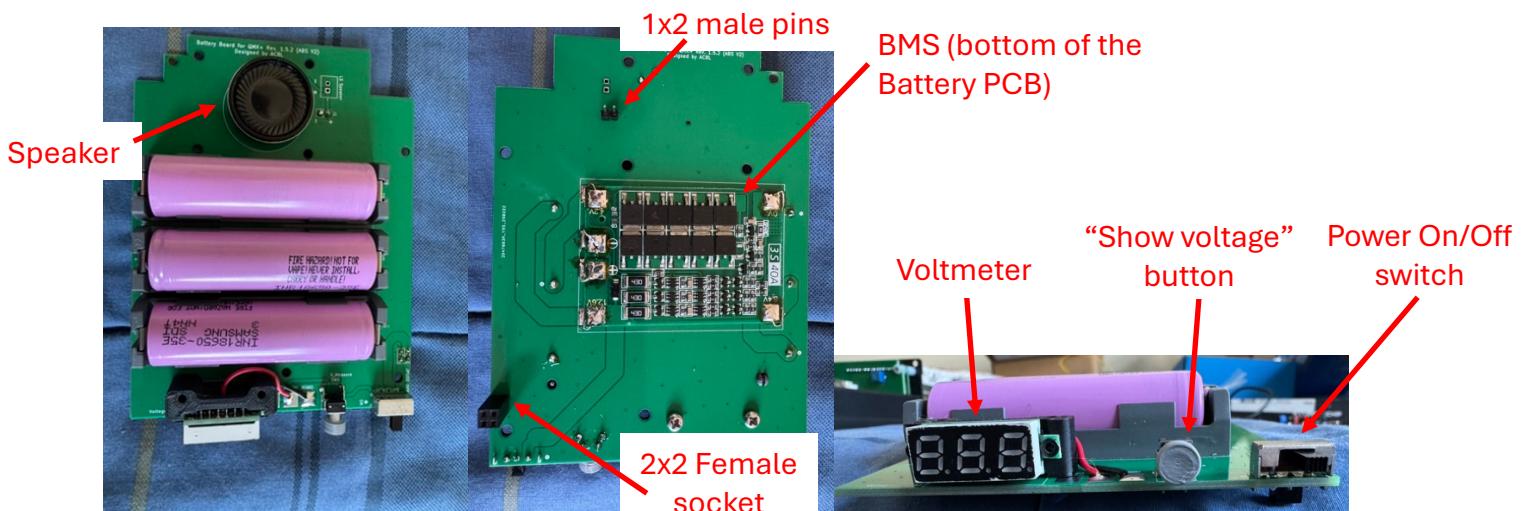
The solution essentially consists of THREE distinct mods (ATU, battery and speaker), independent from each other, loosely coupled only through the QMX+ itself. You can pick and choose which one(s) you are going to build and add others later. Please consider following possible build configurations for the solution:

- All inclusive - ATU, battery, speaker.
- ATU and speaker only

If you do not want the internal battery – you can omit this section of the manual.



The front (left photo), back (middle photo) and rear side (right photo) of fully populated Battery/Speaker PCB is shown below.



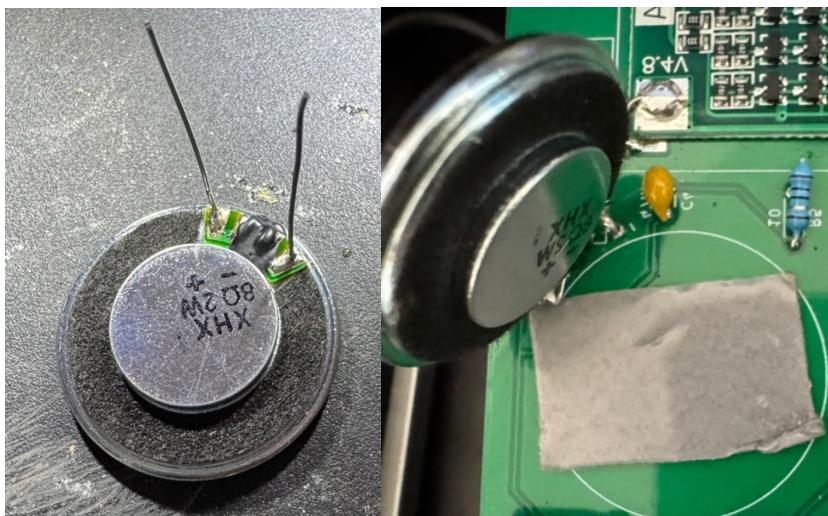
- Small plastic mounting pins for the battery holders must be cut off using a wire cutter:



- When installed on the PCB – battery holders bottom must be flush against the PCB surface!
- **It is mandatory to make sure that battery holder's polarity is matched with +/- signs printed on the silkscreen. Otherwise, you are risking losing your QMX+!**
- The U4, U5 and U7 footprints are highlighted with a white border line on the silkscreen.
- Make sure, batteries are not inserted into battery holders during the entire assembly process! They will be inserted during final checkups and assembly step.

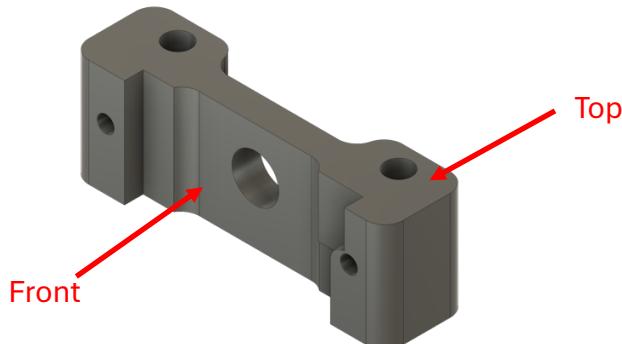
12a. Speaker

- Audio amplifier output matching circuit is calculated to match an 8 Ohm speaker. However, testing showed excellent results with 4 Ohm and 16 Ohm speakers too. So, feel free experimenting.
- Use THT component cutoff pins for speaker installation. Left photo below shows speaker with pins soldered on it.
- Solder pins to the speaker connector pads, insert it to the PCB and solder pins from the PCB bottom.
- Use 3M double-sided tape to secure the speaker to the PCB. This will also suppress the rattling sound.



12b. Mounting the voltmeter

To mount the voltmeter to the PCB – print the bracket on a 3D printer using PLA filament. No support is necessary. STL file can be downloaded from project's github repository.



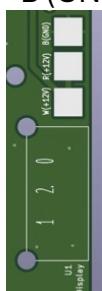
Use two 2mm metal screws to attach the voltmeter to the bracket:



Then screw-in voltmeter-bracket assembly to the PCB using 3mm metal screws from under the Batter/Speaker PCB:



Solder voltmeter wires to the soldering pads. Black (ground) wire goes to the pad marked “B (GND)”. Red wire goes to the pad marked “R”. Ignore third pad marked “W”.



This concludes the ABS Battery/Speaker PCB assembly process.

13. Modifications of the front panel of the QMX+ enclosure

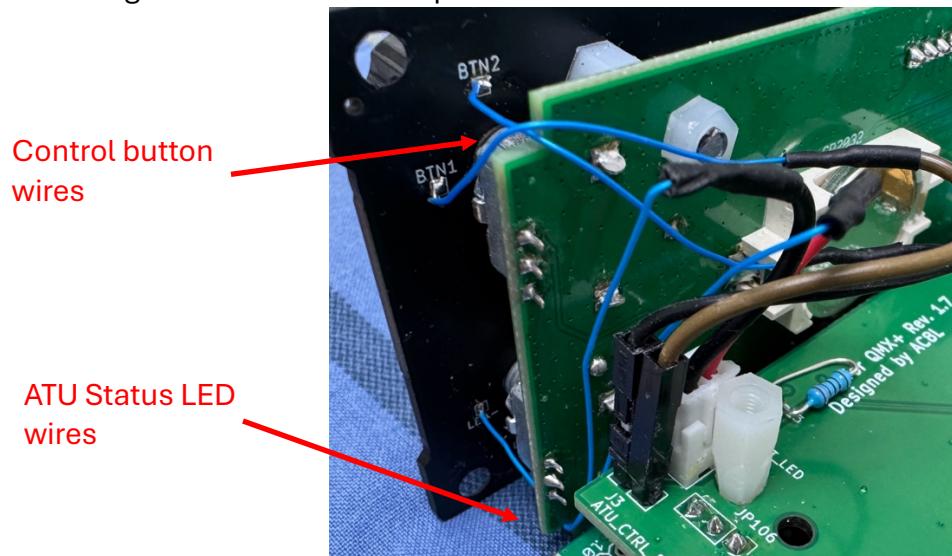
We have two options for the front panel modification:

1. Printing the replacement front panel on a 3D printer (budget option). STL file can be downloaded from [here](#). PETG filament is recommended due to the outdoor exposure.
2. Ordering the front panel from JLCPCB (most aesthetically appealing option).

This step requires working with the 30 AWG Kynar wire. The only challenge with it - is that many cheap wire stripping tools are not stripping its insulation properly. The one of few that 100% is guaranteed to do the job – is Hakko CHP CSP-30-1 wire stripper: <https://a.co/d/90oB19d>.

The wire passing instructions are common for both front panel modification options.

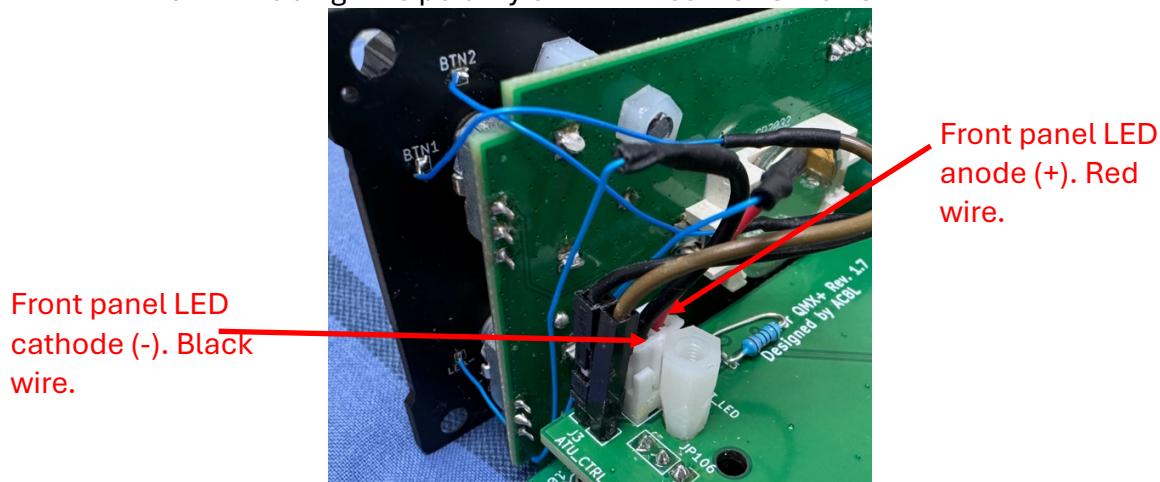
The only “safe” place to pass wires from the LED and button to the PCB compartment – is through corners of the front panel:



Now it probably makes sense why Kynar wire is used – it is to achieve this pass-through without risk of metal enclosure tearing down the thicker wire insulation.

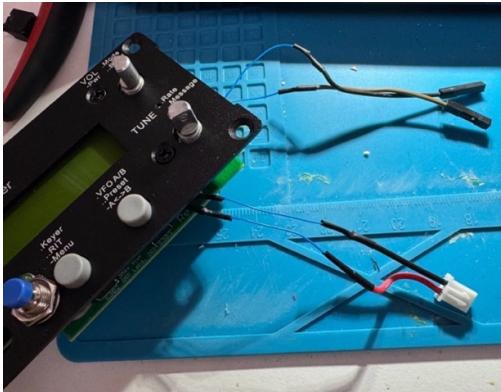
1. Attach front panel to the QMX+ main PCB.
2. Attach the ATU mount PCB to the QMX+ main PCB.

3. Pass the control button Kynar wires from the top corner of the front panel as shown in the photo above.
4. Cut out the excess Kynar wires at approx. 3-4 cm from the corner. Cut and solder jumper wires to both ends of the Kynar wire. Use shrink tubing. The length of jumper wires should be around 7-8cm and jumpers should be able freely seated into their respective pin headers. The polarity of control button wires are not important.
5. Repeat the same procedure for LED wires. Except that LED already has a JST connection at the end of its pigtails. So, gently bend pigtails around bottom corner of the front panel. Find out the 7-8 cm long segment that bends through the front panel PCB edge. Cut out both wires and replace them using Kynar wire. Again, use shrink tubing. The polarity of LED wires DOES matter:



If wire positions do not match the photo (which is a usual case with Chinese pigtails from Amazon) – use tweezers to remove them from the JST connector and swap. Or you can just swap them while cutting and adding Kynar between them. Make sure that polarity is observed using multimeter's diode mode.

6. Disconnect the front panel ATU Status LED and control button from ATU Mount PCB. Detach the front panel from QMX+ main PCB. The front panel with modifications should look like this:



OPTION 1 – 3D printed front panel



- Since mounting holes are already in place – just insert and screw in the control button.
- For LED – no need to glue it in. LED hole tolerance is enough for just squeezing the LED in. It will securely sit in its place.

OPTION 2 – PCB Front panel

Go ahead and order one of two versions of the PCB front panel:



- with LED manually soldered from the back.
Fabrication files are [here](#).

- with SMD LED factory-soldered on the front.
Fabrication files are [here](#).

Assembly process for both versions are identical except that for the second version we do not solder the LED – it is already there for us.

1. Bend and cut LED pins as shown in the picture below:



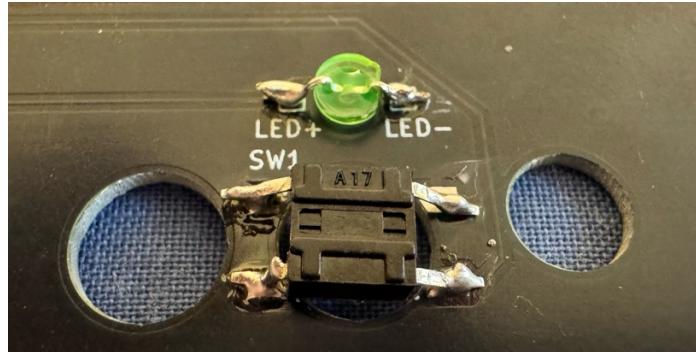
2. Insert the LED to the panel hole and solder it paying attention to the polarity:



3. Bend contacts of a 6x6 tactile button (6.5mm height):



4. Solder the button from the back of the front panel:



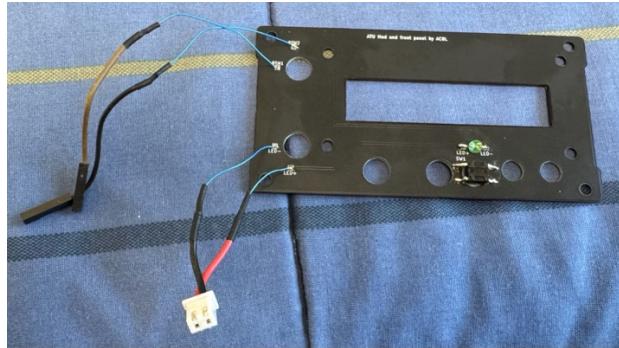
5. Make sure that button is flush against the surface and centered:



6. Print the button cap in 3D printer with gray filament and attach to the button's knob. [STL file can be downloaded from here](#).



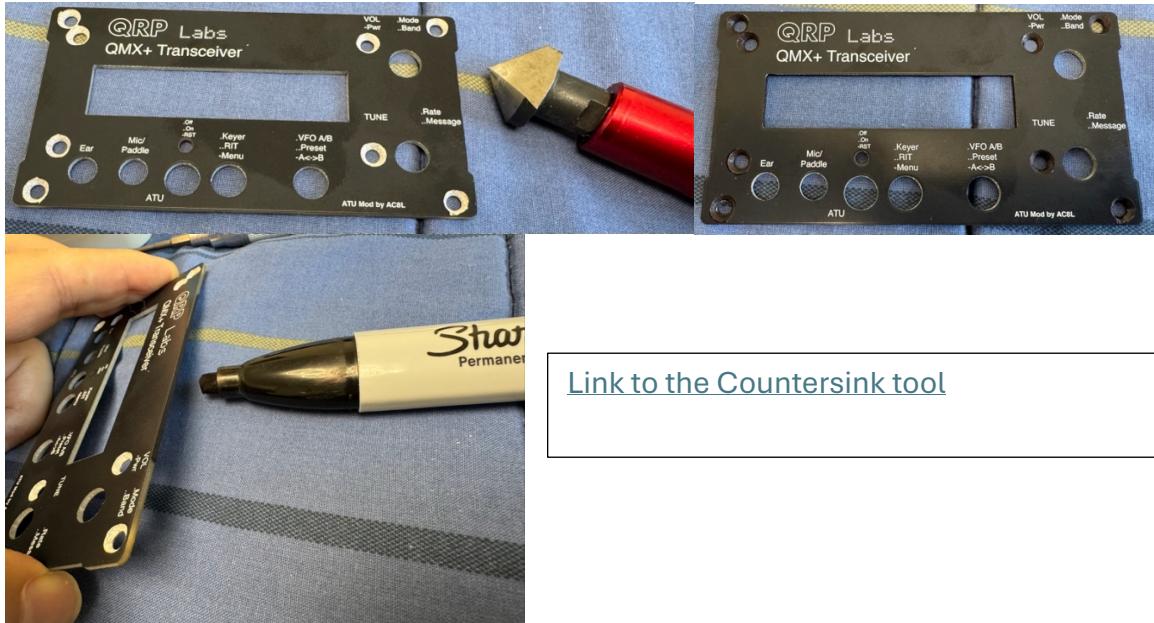
7. Solder LED JST connector and button wires with Kynar ends to the appropriate pads on the panel. Pay attention to the JST connector polarity:



8. Assemble the front panel module of QMX+.

Optional steps for PCB front and rear panels

The mounting holes of the PCB front and rear panels have a diameter that allows flat head screws used in QMX+ front panel and enclosure to fit such a way that only about .5 mm of their head is over the surface of the panel. However, if you want a perfect fit – you can use a Countersink tool on screw holes. To blacken the white PCB opening – use a Sharpie. The same sharpie can be used on PCB white edges and edges of panel's opening for the LCD:



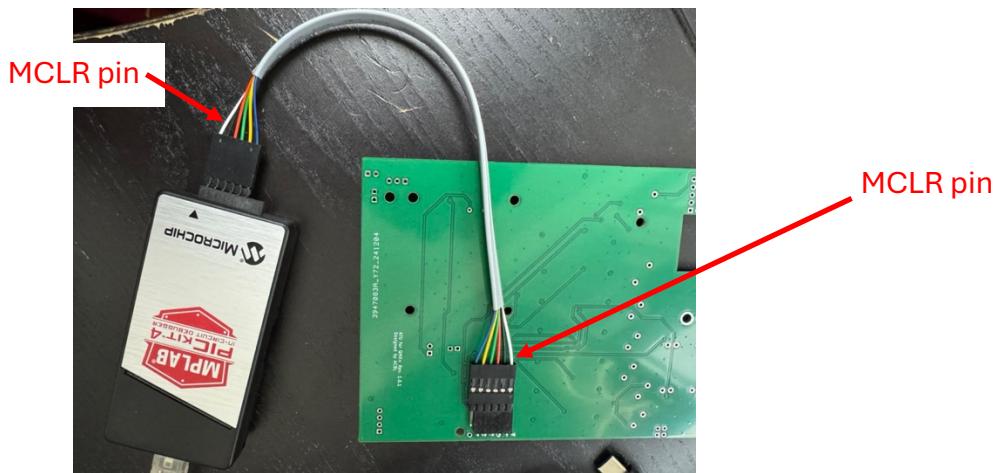
***** Congratulations! If you have completed building the hardware portion of ABS! *****

14. Firmware upload to PIC16F1938

If you got the ABS kit through a group buy, most likely the ATU came with firmware already uploaded. In this case you can conveniently omit this section of instructions.

The ATU for QMX+ integration needs a custom firmware that can be downloaded from [here](#).

For programming you will need one of PIC programmers (PICKIT 2,3 or 4). Attach the PICKIT to the ATU board as shown below. Make sure MCLR pin on programmer and PCB match! Both are marked with a triangle sign. On the photo white wire is used on MCLR.



An example of how to use the PICKIT programmer to program the PIC microcontroller can be found [here](#) thanks to Barb (WB2CBA).

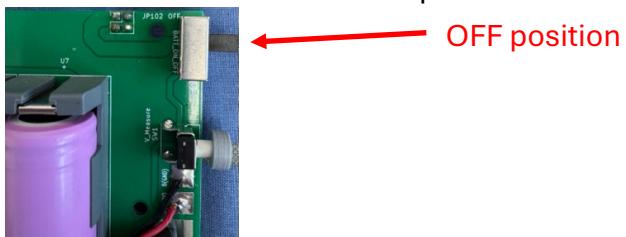
Do not forget to disconnect the PICKIT programmer from ATU.

***** Congratulations! If you have reached the last milestone before the final assembly and just a step away from enjoying the All-In-One QMX+ solution! *****

15.Final tests and assembly into the enclosure

1. Make sure ABS ATU is detached from QMX+ main board and ABS Battery/Speaker board is detached from ATU. The QMX+ assembly should be removed from the enclosure.

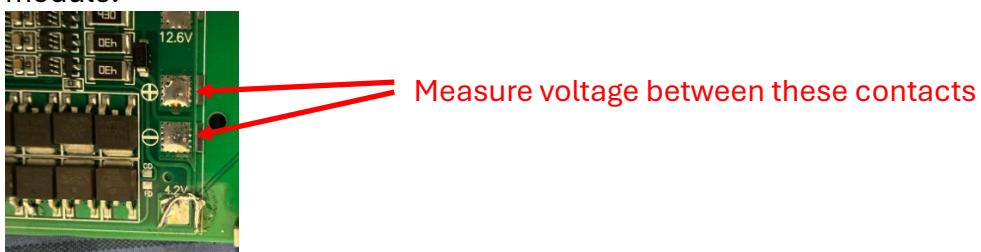
2. Make sure switch on ATU Companion board is on OFF position:



3. Using multimeter, measure the voltage between contacts of each of the 18650 batteries individually. Batteries ship partially charged, so the voltage could be somewhere around 2.5-3V.
4. Insert batteries into battery holders, paying attention to the proper polarity:

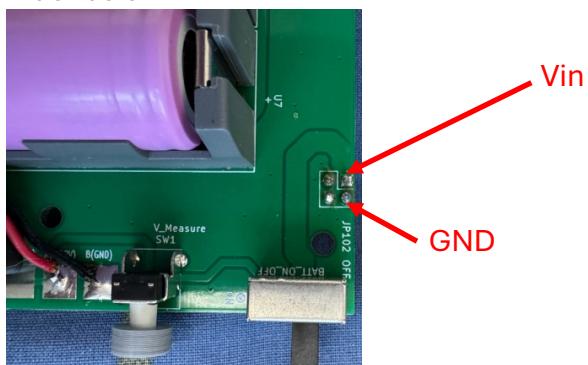


5. Using multimeter, measure the voltage between (+) and (-) contacts of the BMS module:

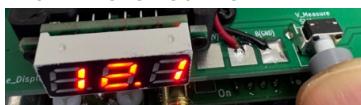


Voltage must be a sum of the three individual 18650 batteries. For example, if each battery had voltage 3v, the sum should be 9V. If voltage significantly differs (more than 0.3V) from the sum, this might mean either improper polarity, or bad soldering of battery holders, or bad soldering of the BMS module. If this is the case, stop, remove batteries from battery holders, check contacts and fix the problem before proceeding further. **Improper battery placement or bad contacts between BMS module and PCB soldering pads might cause serious damage to the QMX+, thermal issues or even a fire if external charger is connected to the battery pack.**

6. Measure the voltage between Vin and GND contacts of the JP102 connector. Voltage must be 0V.



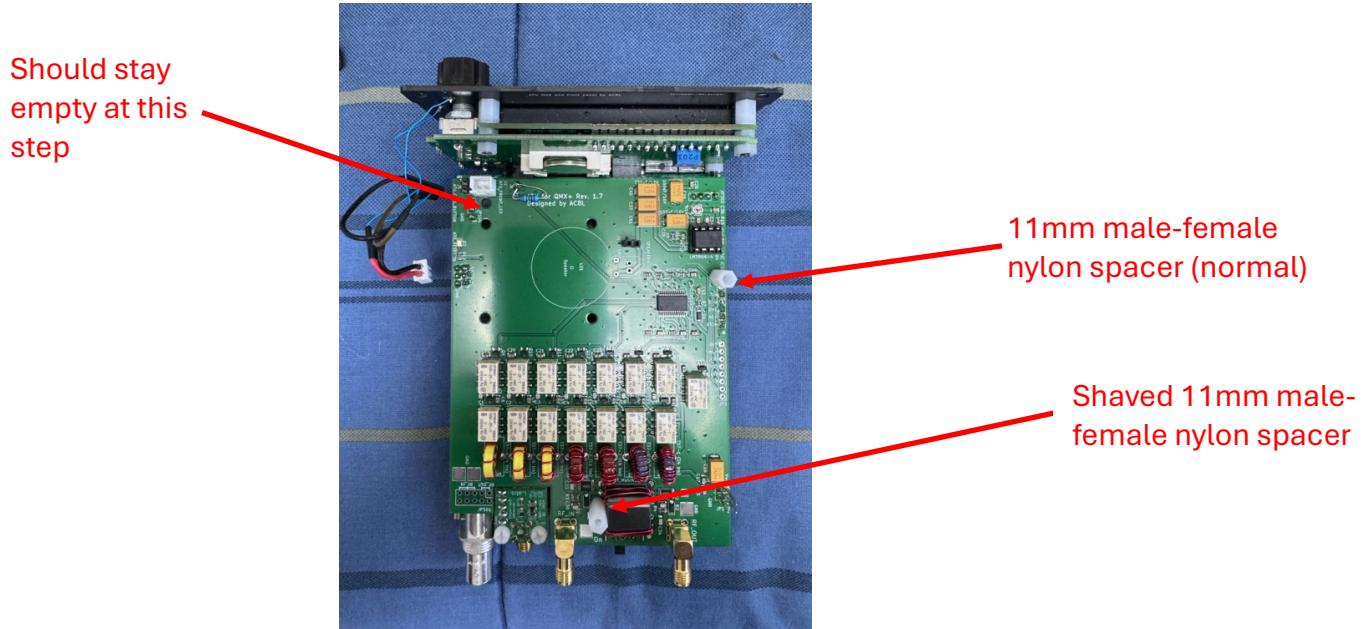
7. Turn switch to the ON position.
8. Measure the voltage between Vin and GND contacts of the JP102 again. Voltage must be equal to the voltage measured between (+) and (-) contacts of the BMS module.
9. **Turn switch to the OFF position!!!**
10. Test voltmeter by pressing the “Show Voltage” button. While button is pressed the voltmeter should show the same voltage or very close to what was measured by a multimeter earlier:



11. Attach ABS Front Panel PCB into QMX+ main board.
12. This installation requires three 11mm male-female nylon spacers. Two of these spacers need to be shaved using a cutoff knife. Be careful not to damage the thread:



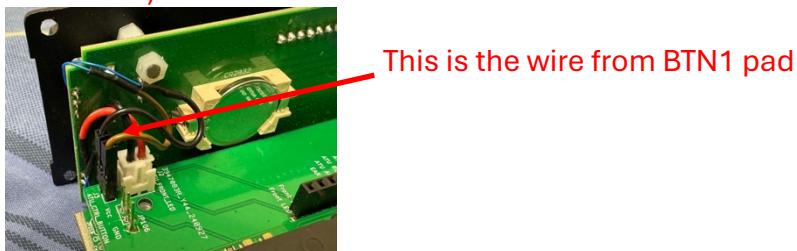
13. Attach the ABS ATU PCB to the top of the QMX+ main PCB and secure using two 11mm male-female spacers. For the hole next to the match transformer use shaved spacer:



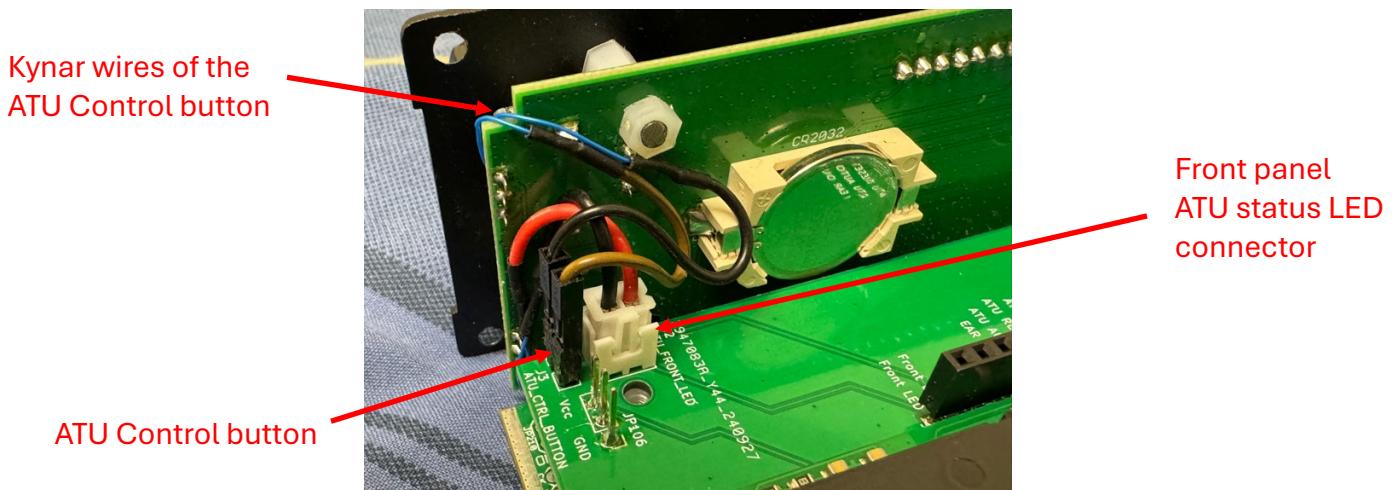
Make sure that male connectors JP106, JP302 and JP102 are properly inserted and secure within their female counterparts on the QMX+ main PCB.

14. Attach the JST connector of the front panel LED into its socket (J2) to the ATU PCB.

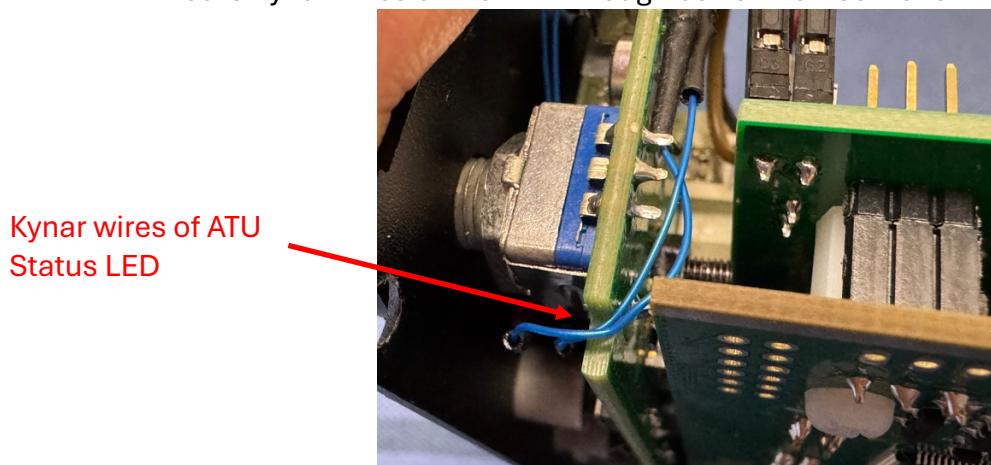
15. Insert the female pin connectors of the ATU control button into its connector (J3) on the ATU PCB. **Make sure that wire coming from BTN1 soldering pad of the front panel is inserted to the male pin furthest from the Mount PCB front (closest to the JP106 connector):**



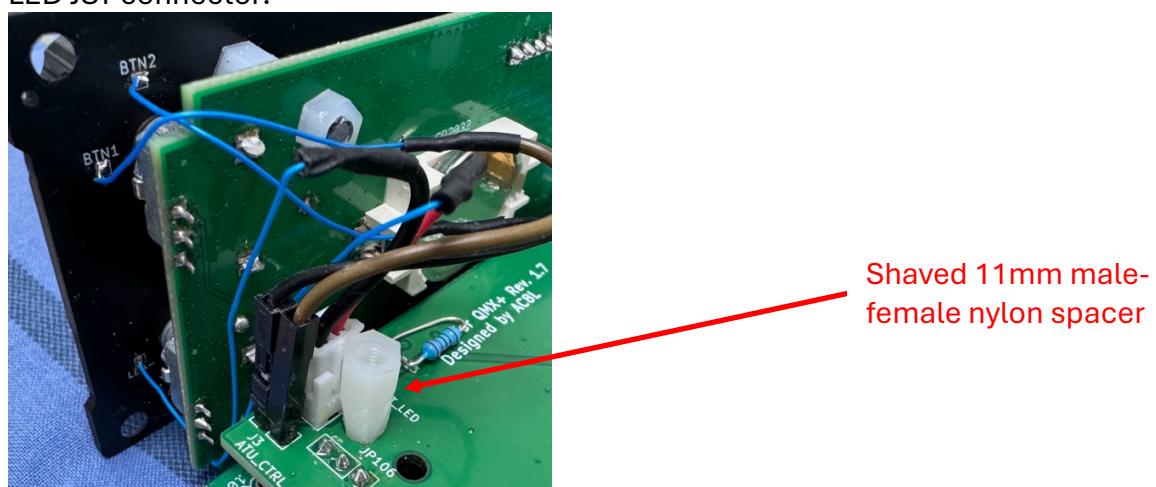
16. Route Kynar wires of the ATU control button through top left corner of the QMX+ front panel:



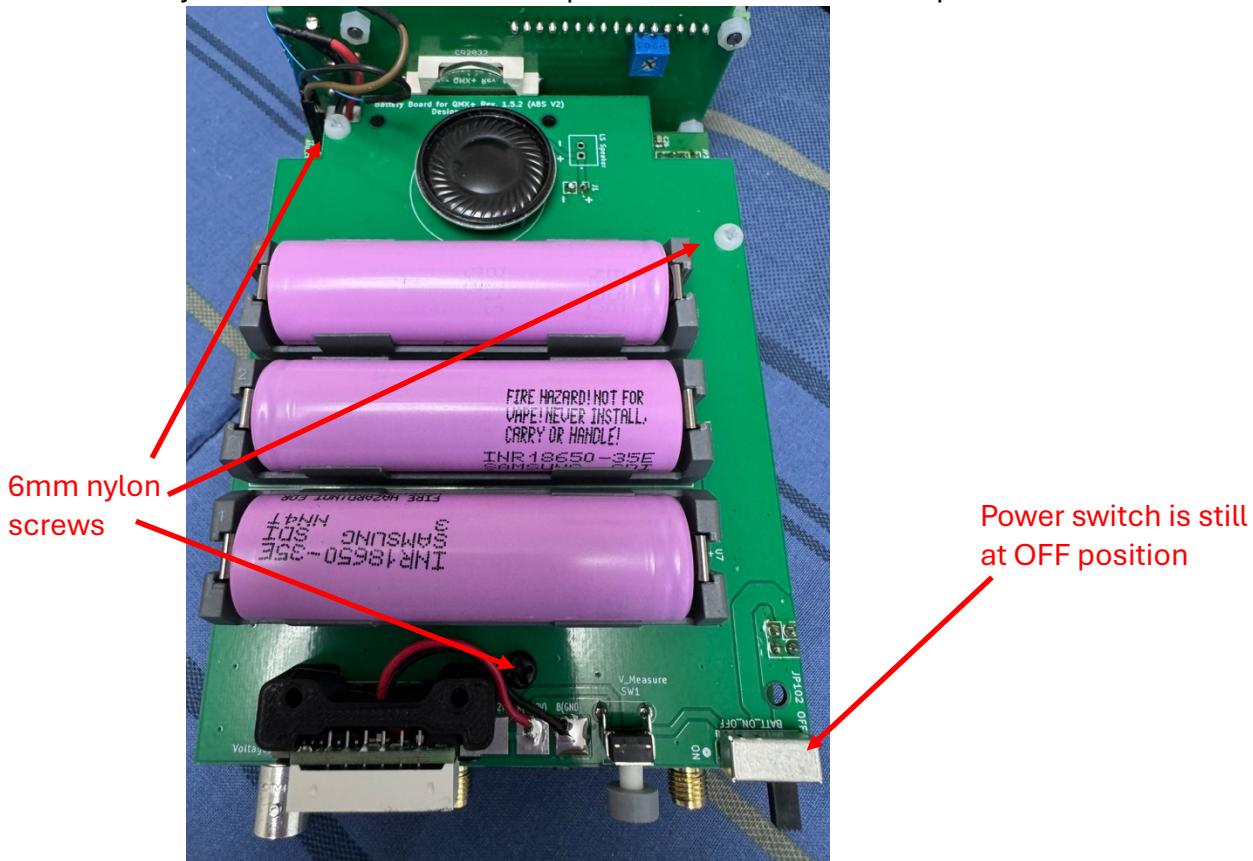
17. Route Kynar wires of the LED through bottom left corner of the QMX+ front panel:



18. Screw in 11mm shaved male-female nylon spacer to the mounting hole next to the LED JST connector:

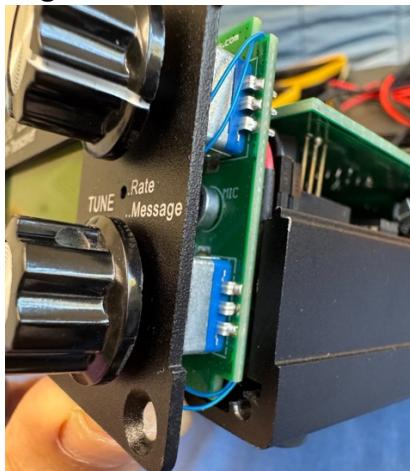


19. Attach ATU Companion PCB on top of the ATU Mounting PCB and secure using two 6mm nylon screws. Make sure that power switch is still in OFF position!



Make sure that connectors JP102, JP106 and J1 between ATU Companion PCB and ATU Mounting PCBs are properly inserted into each other.

20. Insert QMX+ assembly into the enclosure's lower half and secure by screwing in two lower front panel screws. While doing it – make sure that Kynar wires from the bottom corner of the front panel securely pass between front panel PCB and the edge of the enclosure. There should be a plenty of the clearance space:



21. Attach the ABS Rear Panel PCB and secure it to the bottom half of the enclosure using two lower screws.
22. Gently close the enclosure by its top and secure it using two front and two back screws. While doing this try not to touch front panel's control elements.
23. Move the slider of Battery Control switch to ON position.



***** Congratulations! We are done! *****

16. Operations

Power On Behavior

1. When battery charge level is above the minimum threshold specified in power protection settings of the QMX+ (default is 7V), radio should turn on by pressing radio's power button.
2. If radio does not turn on, attach an external 12V power supply and try to charge the battery pack above minimum protection threshold.
3. It is important to enable the numerical voltage display in QMX+ settings to monitor both – internal battery pack voltage and the voltage of an external power supply.
4. Usually with healthy batteries they should charge above the 7V level within less than an hour. After one hour you can test the battery behavior by:
 - Turning radio off
 - Disconnect external power supply
 - Turn radio on
5. After a successful test - continue charging battery pack to its full capacity of 12V for another hour or two. With 13.8V external power supply the battery pack will charge to the 12.4V capacity.
6. Because it is not recommended to power the QMX+ with higher than 12V, radio should be turned off while charging the battery pack with 13.8V.
7. With 12V power supply you can continue charging the battery pack while radio is ON. However, if battery is heavily discharged, the recommendation is not to do a TX while battery is charging, and radio is ON.
8. When ATU is present, and radio is being turned on - you should hear a click of ATU's relay within 1 sec after LCD screen is ON. This should be accompanied with a short 1 sec blink of ATU's status LED.
9. When speaker is present, depending on a volume level and band with antenna disconnected - you can hear a gentle hiss. You can adjust the volume level to observe the hiss behavior.

ATU

- To enable the autotune – the SWR protection must be turned OFF with QMX+ firmware version 27. With version 23 it could work with SWR protection level 4.
- Single click – enable autotune
- Single click – disable ATU
- Basically, single ATU button click toggles the autotune on and off.
- Long press – ATU reset
- The RF power higher than 2.9 Watt is enough to trigger the ATU tuning.
- The ATU remembers the autotune settings in EEPROM between power cycles.

Battery

- Enable voltage display from QMX+ settings. The LCD will display current battery voltage.
- When external power supply is plugged – it will charge the battery and QMX+ display will show the voltage of an external power supply.
- When rear power on/off slider is in ON position - the QMX+ barrel connector is ALWAYS HOT. This could be used either for powering a small flashlight from QMX+ itself, or even for emergency charging of a cell phone using an adapter like this: <https://a.co/d/1OmcKwj>



You will need to attach a barrel connector to it.

But nothing that draws more current, like a bigger tablet, computer, PA, etc.

- While travelling and for safety reasons please keep the rear power slider in the OFF position.

Internal speaker

- Just use volume level, internal speaker has enough volume for the sound to come out of the enclosure. No drilling of an enclosure is necessary.
- Use on PCB potentiometer to adjust the speaker baseline volume. The good baseline is when speaker volume matches the volume of your preferred headphone connected to the QMX+ front connector.