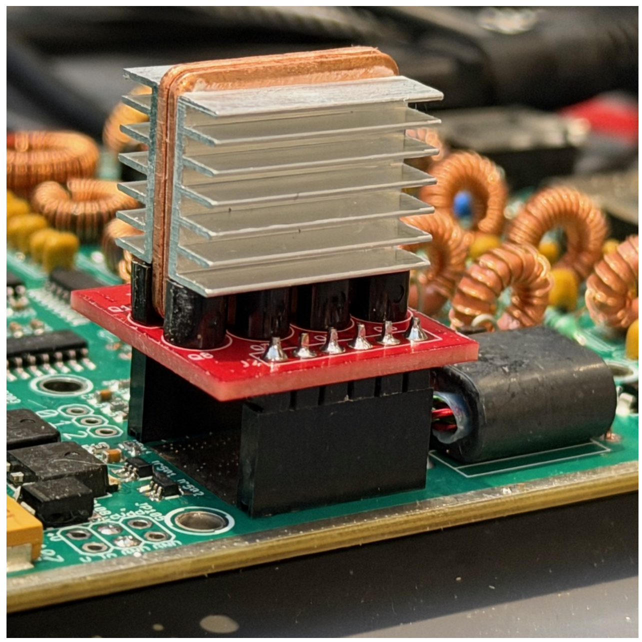
8X Finals for QMX+ Rev 3.0

Kit Contents

1 – Printed Circuit Board
8 – OnSemi BS170 MOSFETs
2 – Copper shims
3 – Aluminum heat sinks
2 – Male pin headers
2 – Female pin headers
Thermally conductive tape
24AWG Wire for rewinding T501 – 2 colors

Instructions are available online at www.w1nc.org

This is what the finished product should look like.



Assembly steps:

1. Remove the 4 finals and T501 from the QMX+. Be careful to not lift any PCB pads and clean out the solder from the holes. I use solder wick and lots of flux.

2. Insert and solder 8 finals into the supplied PCB board following the silkscreen outline on the PCB. Flat part faces inward. Mount them flush to the PCB (No Space)

2. Insert the 2 female headers into the QMX+ PCB and solder one pin on each header only. Get them straight and flush with the PCB.

3. Insert the 2 male headers on the underside of the red supplied PCB and solder one pin only on each one on the top side of the board.

4. Insert the supplied red PCB with the male pins into the headers on the QMX+. This ensures that everything is straight and square before soldering the rest of the pins.

5. Touch your soldering iron briefly to each of the single soldered pins on the red PCB and the QMX+. This relieves any stress due to misalignment. Only now solder the rest of the header pins on each board.

6. Remove the 8x Finals board from the socket.

7. Install the two copper shims and the aluminum heat sinks. Small strips of thermal tape (included) should be used to hold and pad the shims to each other and to the heat sinks. Thin strips should be used

to adhere the copper strips to the 8 BS170s as well. Put a small strip of tape to the bottom of the copper shims to make it adhere to the red PCB.

8. Remove the old wire from T501 and rewind T501 it for the WTST (9V) method in the QRPLABs documents. I use red for the primary and green for the secondary. But it doesn't matter of course.

9. Make sure there are no solder bridges anywhere. Look closely.

Operation:

1. Start at 6.5 to 7 volts and turn on the rig. Make sure there is no excessive current draw after it comes up. It should be just as it was before this mod.

2. Shutdown and increase the voltage to 8 volts. Then key down and give a brief dot or dash TX attempt. You should see close to 4-5 watts at 160M. +/- a little is ok. If all this looks ok, shut down again and increase voltage to 12V. Repeat the same test. You should now see between 9-11 watts at 160M. Lower power on higher bands.

Expectations and Tests:

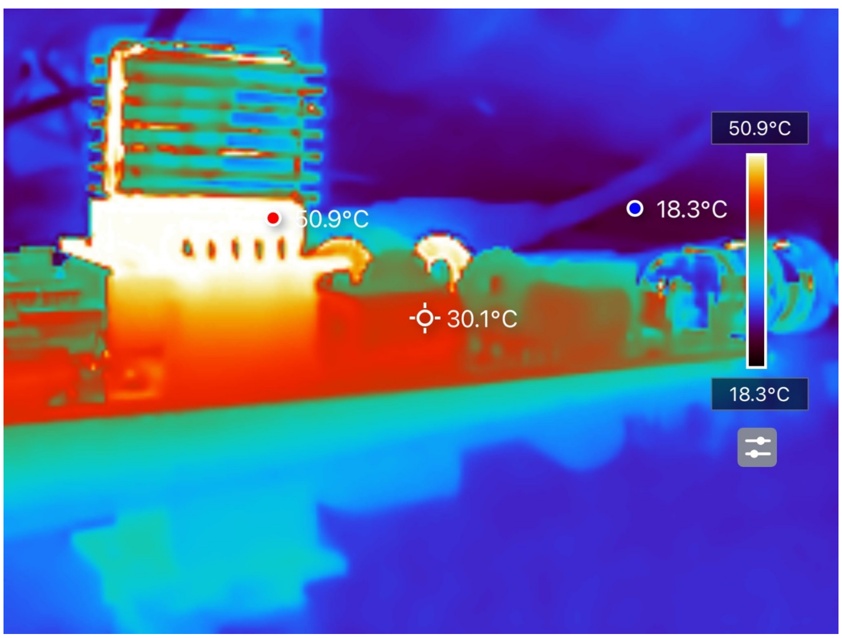
These are the things that I was concerned about for this modification. Power Out, Efficiency, Heat, Over voltage on the drains of the finals, Current consumption and Spectral purity. I performed many tests to ensure that this was going to be a net benefit. I became convinced enough on all issues that I am now using this in my main rig all the time. I run my rig at anywhere between 9V and 12V depending on how good I feel about holding the SWR of my antenna at a reasonable level (2:1 or less) and what band I am operating on.

Power out – At 12V, it is typical to see 10+ watts at 160M. At 6 meters, you will se 4-5 watts out. The efficiency of the original QMX+ design and this 8X design are both less efficient at frequency goes up.

Efficiency & Heat – Regardless of supply voltage, I have measured system efficiencies between 60% at 160M and 30% at 6M. This is SYSTEM efficiency. Power is lost in the 74ACT08 driver, the finals, T501, the current mirror feeding voltage to the PAs and through the low pass filter banks. Some of these are frequency dependent and others are not.

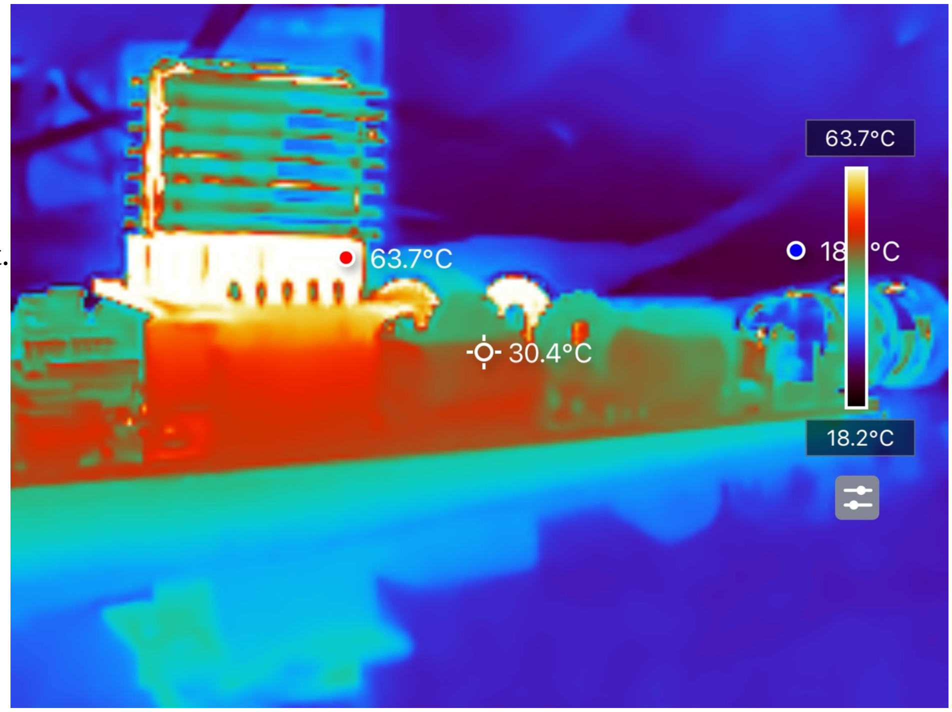
Here are some thermal images that show heat generated in the QMX+ with this modification. This was all measured at 10 meters.

This was after running FT8 for a while and reaching a steady state. At the beginning of a 15 second TX period, this is the image. Finals are at 50.9C. You can see the LPF toroid peeking up to the right. It gets quite warm.



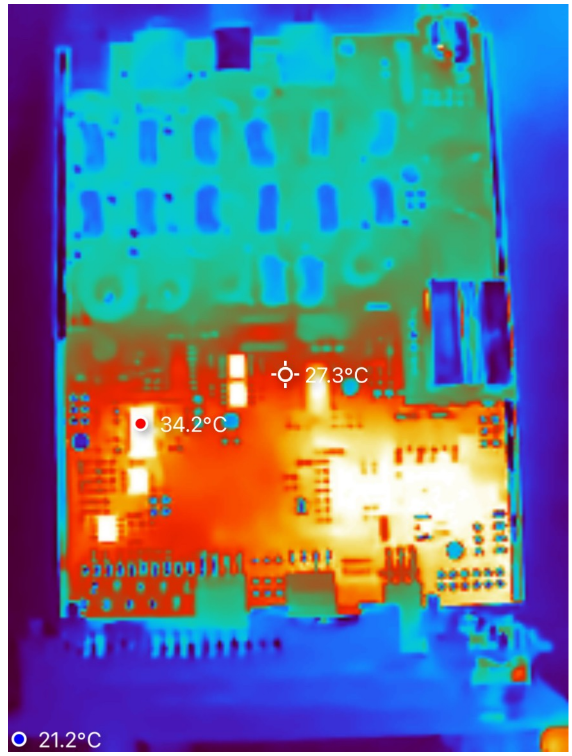
This was at the end of a 15 second TX period in FT8. I typically saw the finals run between 65C and 70C at the end. They would then cool down to around 50C (shown above). The cycle would repeat.

This particular shot shows the finals at 63.7C

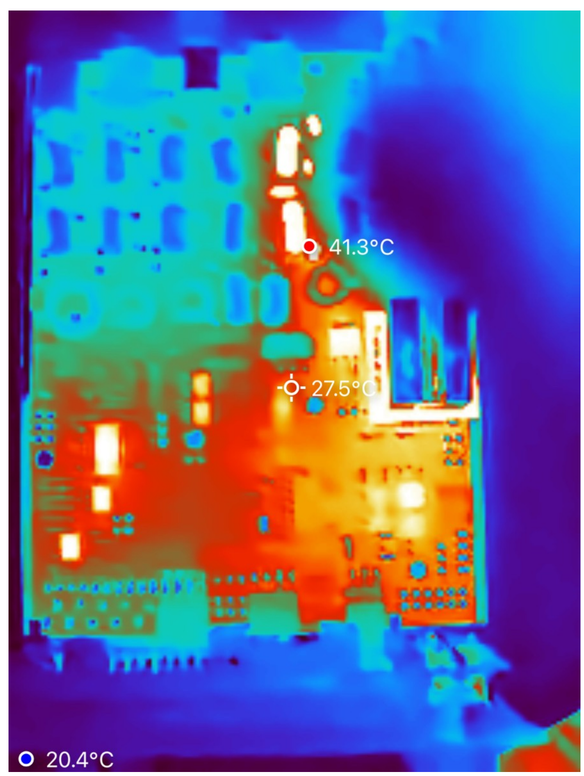


Just out of interest, I shot a heat map of the QMX+ from above. This is after sitting a few minutes in RX state. 12V applied. You can clearly see a few chips getting a little warm (34C max). Nothing unusual.

From L to R, you see IC404, IC401, IC407 (The A to D converter and warmest), IC406, IC405, IC403, Heat radiating through the board from the CPU underneath, and finally the SMPS supplies. You can also see some residual heat in the 8X finals board.



This is the same shot after about 5 seconds of transmission. You can clearly see the 10 meter LPF components - L517, L518, :522, D5129, D520 & C536 getting warm. The LPF toroid reached 41.3C after 5 seconds. Also of note is the 8x finals board getting hot. The copper portion of the heat sink is thermally connected to the board.



Over Voltage – Maximum specified Vdss (Drain to Source) for the BS170 is 60V. When I use 12V and have a dummy load of 50 ohms, I never see above 50V on the drains – even with a 12V supply. And, that is measured at 160 meters. However, if the SWR starts to vary, that voltage can go up. That is why I run at 12V if I am confident in my antenna SWR and the operating frequency is high. If not, I drop down to 8 – 10 volts. The higher in frequency you go, because of the inefficiencies in the mosfets, you will see less Vdss than at the lower bands. The worst case is 160M with a poor VSWR. At 20M and above I almost always run at 12V since the Vdss level is so low (typically 30V) to begin with.

Current Consumption – It's always best to limit current, especially with a battery. If something goes bad, these 8 mosfets can sink a lot of current. A 1.5 to 2 amp limit is reasonable. However, the rig will pull almost 1.5 amps during normal TX operation. My LDO regulator limits current to 1.5 amps and has a settable output voltage. It's a good companion to this modification.

Spectral Purity – I have measured the spectrum of the original QMX, QMX+ and the QMX+ with this modification. 3rd harmonic levels are at least 45 db down from the fundamental. Fifth harmonic levels are at least 55db down. Often the harmonic levels are so low that they are hard to measure. So, this is not a worry at 9 to 12V DC input.

Final Thoughts

This is an experimental design and implementation. So, proceed with a spirit of caution, curiosity and a sense of learning. For me all of Ham radio since I was in my youth (many decades ago) has been exactly this. It is the best part of the hobby for me. I use this little addition for the finals in my everyday use (in home or the field). But if it's really hot on a summer day and the sun is beating down, I run at a reduced voltage to give myself an extra margin of safety. Or if I'm operating above 15 meters and my antenna is less than ideal, I'll run at a reduced voltage and hence lower power output.