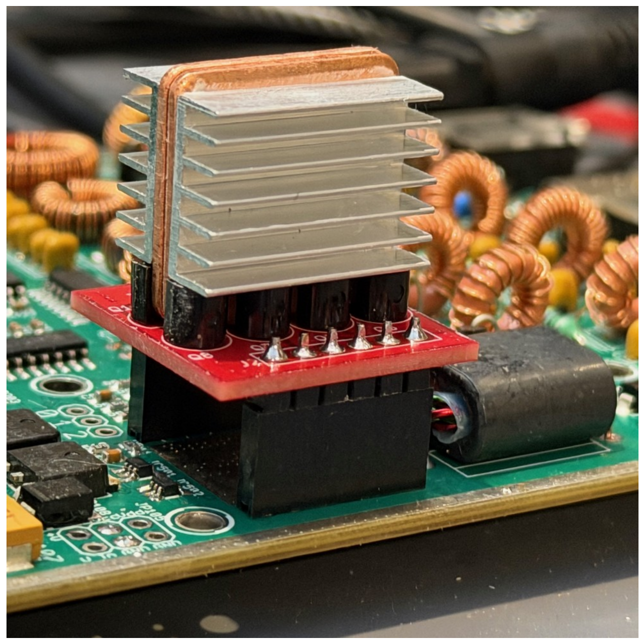
8X Finals for QMX+ Rev 3.0

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:

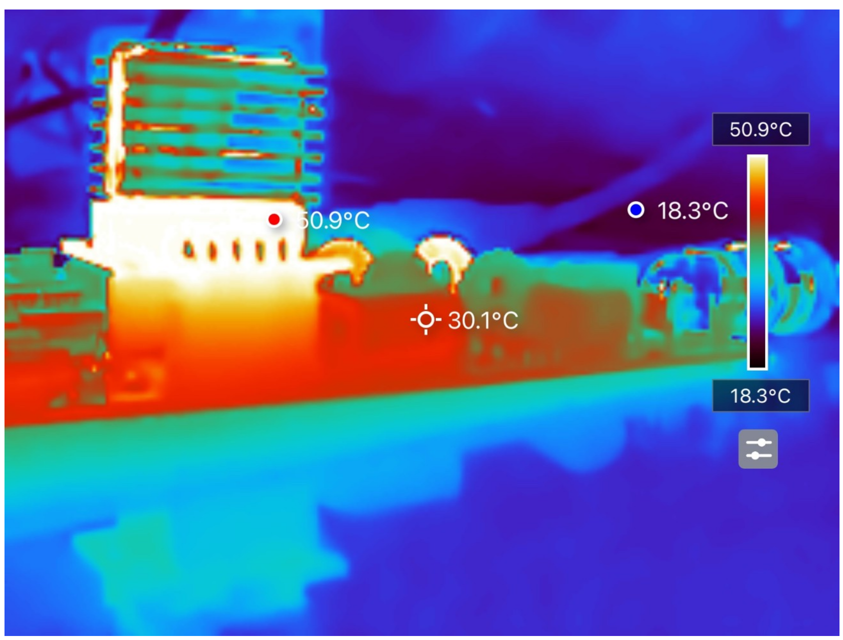
These are the things that I was concerned about for this modification. Power Out, Efficiency, Heat, Over voltage on the drains of the finals, Current consumption and Spectral purity. I performed many tests to ensure that this was going to be a net benefit. I became convinced enough on all issues that 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.

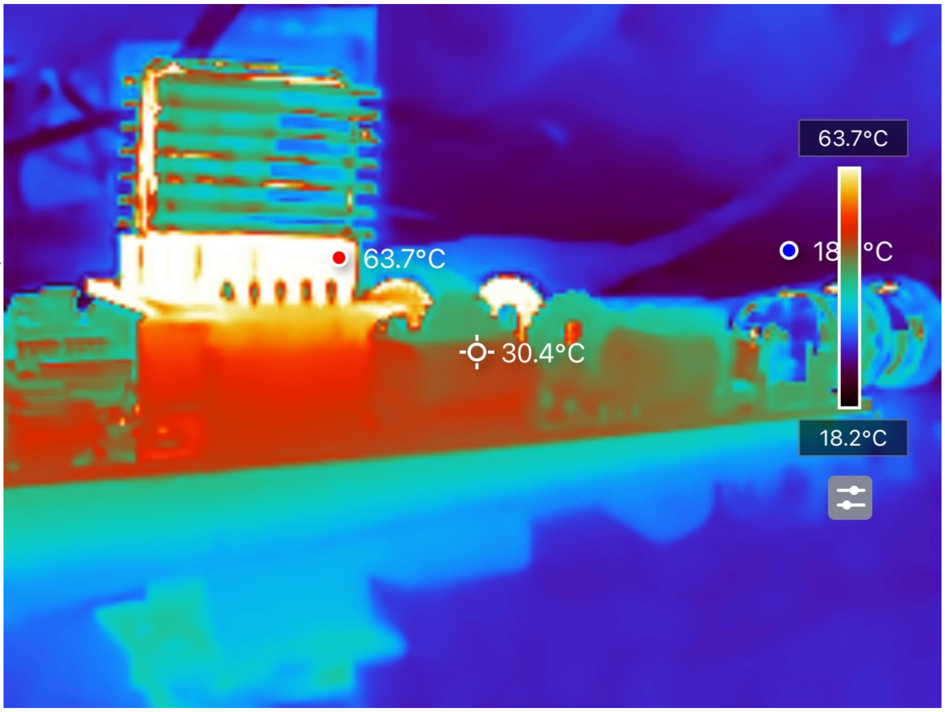
Here are some thermal images that show heat generated in the QMX+ with this modification. This was all measured at 10 meters.

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.



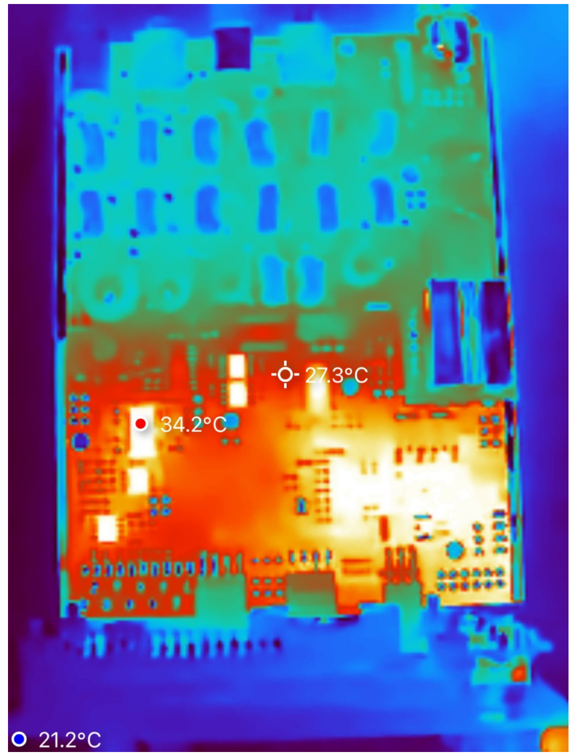
This was at the end of a 15 second TX period in FT8. I typically saw the finals run between 65C and 70C at the end. They would then cool down to around 50C (shown above). The cycle would repeat.

This particular shot shows the finals at 63.7C

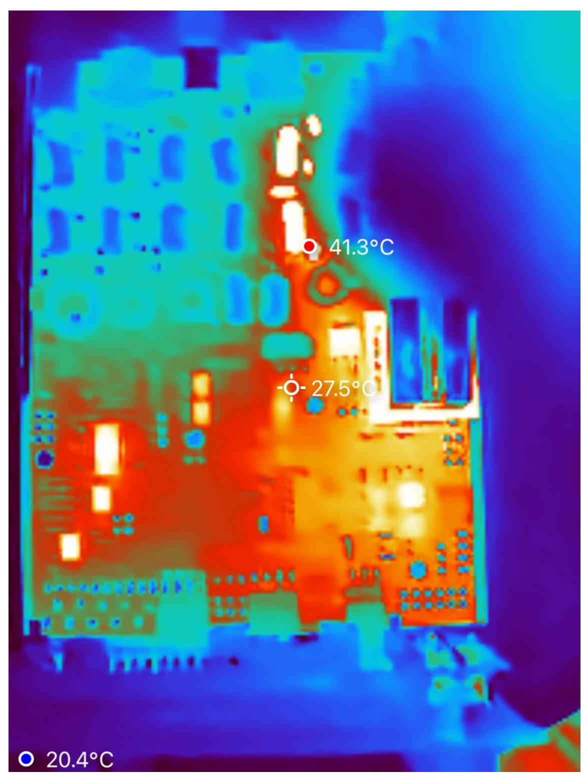


Just out of interest, I shot a heat map of the QMX+ from above. This is after sitting a few minutes in RX state. 12V applied. You can clearly see a few chips getting a little warm (34C max). Nothing unusual.

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.

From a post that I made on 2/14/2026…

I wanted to share my concerns and some of what I learned from creating the 8x finals board for the QMX+. I've also been trying to reconcile some of the very good theoretical work that's been discussed on the forum and compare it to my real world findings. Having repaired over 700 QMX rigs over the last 2 years, my perspective is somewhat unique. I do the theory part too. But my experience in the real world with scopes, spectrum analyzers, thermal cameras, solder, and repairing pcbs give me a solid (and to me away) complete and very enjoyable view.

Over the last 2 years when all rigs had 4 BS170 finals, I saw a lot of standard QMXs and QMX+ rigs (with 4 finals) that have fused and/or cracked open BS170s and blown up 74ACT08. That is not uncommon. But I don't ever know which failure came first. There are plenty of potential culprits. And once a failure happens it can easily cascade across the entire Tx chain from the si5351 timer through the gates, the 74ACT08 driver and the BS170 finals.

When I was trying out design approaches for using an 8x bs170 board to improve matters, I was concerned about several things. Heat, too much current in the drivers, high voltage spikes on the drains of the finals, high capacitance on driving that many finals, spectral purity, and rfi noise generation.

The 8x board I'm currently shipping is the third generation. My first prototype had the Tx chain of drivers, finals and output transformer on an add on board. I even had 2 of the 74act08 drivers on the board. I did it so I could separate some of the signals and components to see where the issues were. I learned a lot from that exercise. In the end I came up with the current approach. 8 finals on a single board (except for rewinding T501). Plugged into a socket on the main pcb. Everything else is left in place on the main board. As an aside, one thing I learned is that T501 is very efficient. I've measured very little heat coming directly from that component. That surprised me. Separating out components of the TX chain gave me the chance to see that clearly and directly. I also learned that the lpf chain can get very warm while transmitting. Not too surprising.

Heat & Current - these are closely linked. But high current spikes alone can kill a chip regardless of measured heat. In the BS170, the amount of current supplied to the gates by the 74ACT08 driver is difficult to measure directly because it is dynamic. It comes from having to overcome the gate capacitance as you switch the mosfet on or off. This becomes more of a factor the faster you try and switch it. That's why on higher bands the 74ACT08 tries to deliver more current on average and thus gets hotter.

Using the 8x finals board, I've measured the temp of the 74ACT08 as a part of my overall testing. It is a very indirect and relative way of measuring current being delivered to the gates of the finals. At higher frequencies, that chip gets hot. The 74ACT08 is trying to drive 8 gates. But, because it is so well thermally bonded to the Main PCB, it never gets too hot as long IF you give it a chance to cool down between Tx cycles. At 10 meters, for example, the temp of that chip goes from 27C ambient to about 51C over a 15 second TX cycle. Then during the 15 second RX period, (Mimicking FT8) it cools down to under 40C. Over time everything gets warmer and even the outer enclosure gets warm. But I've never seen that particular chip get so warm that it worried me. I've never seen the 74ACT08 reach above 60C. I remeasured at 6 meters and the temps are 2-3C higher. Yes, it tries to deliver too much current to the finals. But the heat from that chip might not be the cause of a potential thermal run away. If you try to transmit with very high duty cycles however, that could be a problem regardless of how many finals that you have.

When I use my 8X board, the dynamics are different. The Main PCB heats up far less. That's good for the 74ACT08 drivers. But the 8x finals PCB gets hot. The heat sinks (via the copper shims) are there to help cool it down. A future revision might find better placement of the heat sinks. But given the fact that it isn't connected to the enclosure, there is little place for that heat to dissipate except the air inside the enclosure. The air inside the QMX+ gets warmer than a factory standard unit. It's hard to quantify. That can be more of a problem on a hot sunny day when the ambient temperature is higher. I tend to not engage in POTA activities when there is a foot of snow on the ground and windchills near or below 0.

Heat & current in the bs170 finals. The drain current is the largest contributor to heat in the bs170s. 4 finals divided this by 2 on each half cycle of an Rf waveform. 8 finals divided this by 4 for each half cycle. So as far as current alone, 8 is better than 4. Given all else being equal. Alas, not all else is equal. With a WTST T501, and powering the QMX+ with 12v, we now have more current. That's one reason to current limit the power supply. Also it's one reason why running this at lower voltage is more conservative and reasonable at times. I personally always use a current limited supply - on the bench or in the field. And, I run sometimes at 8v, sometimes at 10V and if I'm on a lower band, I'll run it at 12V. If I'm using FT8 or any higher duty cycle digital mode, I rarely use 12V.

I've learned that the bs170 dissipates most of its heat through its leads. Very little comes through the plastic case. In my 8X design, the copper shims touch the board through some thermal tape. You can actually see (on a thermal imaging camera) the heat being wicked up the copper shims and very little heat being generated from the plastic body of the mosfet. I've cracked open a bs170 and it's easy to see how that makes perfect sense. That's why I put the mosfets mounted flush to the pcb.

I think the finals getting too hot is the biggest vulnerability in this design. I am not 100% confident that enough heat is getting dissipated over time to make it bullet proof at the higher frequencies and at 12v power. That's why running more conservatively makes sense to me. More is not always better.

High voltage spikes on the drains - On the Vdss (Vdss max on the bs170 is 60V) issue. On the original QMX/QMX+ design with 4 finals, I would see pretty big voltage spikes on the drains of the BS170s. 70- 90V was typical. But I do not see it on the 8x finals. At 160M (worst case), I never see over 50V. I don't know why it's better in the 8x design though. That was a surprise. It could be the higher gate capacitance damps the switching enough that these resulting drain spikes are dampened. But that's a guess.

Spectral purity- I have measured the spectrums of all bands with 4x and 8x finals. In every case all even harmonics are so far down that they are unmeasurable. The 3rd and 5th harmonics are where I concentrated my measurements. With 4x 3rd harmonic levels are down at least 45db. That's very good. 5th harmonic levels are down at least 50db. With 8x finals these are even lower. I'm not sure why. It may be the result of not seeing those high energy VDss spikes that you see on the stock unit. Again, a guess.

I think the best thing we can all do is to run the rig at less than 12V at all times regardless of whether you have the original 4X finals or the 8X finals board installed. I run normally at 8-10 volts. With 8X finals & WTST, you are not compromising the power output significantly. It gives you a 4-5 watt rig.

RFI- Having the 8x be a plug in board can be a potential problem because you are exposing the high voltage Rf signal to the world through the plugin leads away from the protection of the pcb ground plane. So far I have not seen any problems in this area. I'd like to find a much lower profile machined socket for this. But they are expensive and I'm still evaluating the options. A future revision may have this. They also tend to hold better.

This 8x finals board is a way of having some options. I personally wanted these options. If I blow up my finals (blown down antenna, dumb mistake, whatever) I can plug in a new one easily. There are only so many bs170 desoldering and soldering that QMX can take. Plus, who wants to do that - or send the rig to me to do that? If I want 4x finals instead of 8x, just populate the add on board with 4. Same as stock with less heat being dumped into the main pcb and an easier fix if you do blow it up. If I want higher power, I can increase the supply voltage. Especially reasonable on the lower bands with CW, or ssb. I live to experiment and this gives me more options.

For those waiting for their 8x kits, the first shipments just went out on 2/13/26. I ran out of parts and will be shipping the rest this coming week. Please give me feedback. I'll be making improvements over time and your data will help to make this better.

73
Jeff Moore
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