A 222 MHz Transverter for the Yaesu FT-817 — Revisited

An update on a project that adds 222 MHz to a popular transceiver.

Paul Wade, W1GHZ

My 222 MHz transverter project was intended to provide the missing band to the Yaesu FT-817 transceiver, a great rover rig.[1] It proved to be quite popular, and I hope it got some new stations on this neglected band.

The FT-817, and the newer FT-817ND, are still the only low-power all-mode transceivers. They are the preferred radios for battery-powered rover operation and for microwave transverter intermediate frequency (IF) use. Newer radios seem to be 100 W rigs, even if the package is almost as small as the FT-817 — the higher power requires much more current and is more difficult to interface to a transverter.

There is still interest in the 222 MHz transverter, but the problem is component obsolescensce. Several of the key transverter components, the Toko filters and the power amplifier module, have become unavailable. Other common parts are no longer offered by the manufacturers that I chose, so the published parts list is no longer valid. However, equivalent parts are readily available. One bright spot is that Mini-Circuits, supplier of the monolithic microwave integrated circuits (MMICs), is very good about making parts available for a long time and making parts available to hams in small quantities.

In 2012, a fellow North East Weak Signal Group member located and acquired a stash of some of the obsolete parts.[2] This inspired me to update the PC board design to accommodate both these parts and alternatives, so that additional transverters could be built.

Modifications to PCB

Because I was ordering new boards, I decided to make a few modifications to extend the life, usefulness, and flexibility of these boards. Making them usable with other transceivers, particularly the FLEX-1500 and other low-power SDR rigs, was also a consideration.

The Mini-Circuits TUF-1H (+12 dBm) mixer is replaced with less expensive ADE series surface-mount mixers from Mini-Circuits. The new boards have a footprint for these devices. The mixers cover a range of local oscillator (LO) powers, including a standard level ADE-1 or ADE-2 (+7 dBm), the ADE-1LH (+10 dBm), the ADE-1MH (+13 dBm), and the high-level ADE-1H (+17 dBm) mixer for maximum IMD performance. The mixer mounts on the bottom of the board (see Figure 1), but the silkscreen pattern showing placement is on the top. Pin 1 is also indicated in copper on the bottom.

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A surface-mount oscillator footprint has been added, because oscillators with pins are getting hard to find. If you do find one, it will still fit. The LO filter is no longer available, so the footprint is modified to fit a Mini-Circuits BPF-B199+ surface-mount filter. An alternative is to connect an external LO to the external LO connection points shown in Figure 1.

Another alternative is to change the IF frequency. Once the FT-817 transmit range is unlocked, any IF below 30 MHz is possible.[3] One choice might be 22 MHz, using a 200 MHz LO, which can be generated by a common 66.67 MHz oscillator, a 200 MHz oscillator, or a 200 MHz VCXO locked to GPS.[4]

Power Amplifier

The power amplifier section now has the option to use a Mitsubishi RA07M2127M MOSFET module in place of the original Mitsubishi M67723 bipolar module. The newer module is significantly less expensive than the older ones. Because they have different footprints, the board has pads for both varieties, but the pads have tighter spacing, so soldering of the bypass capacitors will require more care.

If the original Mitsubishi M67723 is to be used, the original schematic and parts still apply. The placement and soldering of the bypass capacitors will require minor adjustment because of the tighter spacing. The only change is the new bias resistors, R101 and R102. R101 is 0 Ω, a piece of wire, and R102 is omitted.

The Mitsubishi RA07M2127M MOSFET module requires different bypassing and a significant change in voltages. The part is placed with the output lead on the same pad as the original module, but the other leads land on new pads. The new input pad is not connected to the original, so the jumper wire is required.

The MOSFET module is specified to operate at 7.2 V, and capable of 8 to 10 W output at a current drain in excess of 2 A. This means that the voltage must be reduced with a voltage regulator that will dissipate perhaps 15 W from a 13.6 V supply — I suggest lots of heatsinking if you plan on FM ragchewing.

There are a few ways to reduce the voltage:

1) Use a separate three-terminal regulator providing 7.2 V to the PA "+VPA" terminal on the board. Adjustable LM350 or LT1085 regulators will provide the needed current with the adjustment resistors set for 7.2 V.

2) Use a large 8 V regulator for the whole transverter in place of U2. A series diode rated for at least 3 A will reduce the PA voltage to roughly 7.2 V.

Finally, you could risk running the PA at 8 V and get a bit more output power — the data sheet goes up to 9 V.

The MOSFET module also requires setting the gate bias for the desired idle current. Typical gate bias voltage is 3.0 to 3.5 V and is set by R101 and R102. The output power doesn't change a lot with idling current, but the gain increases with higher idling current. A good starting point would be 200 Ω for R101 and 330 Ω for R102, which should yield about 3.1 V of gate bias.

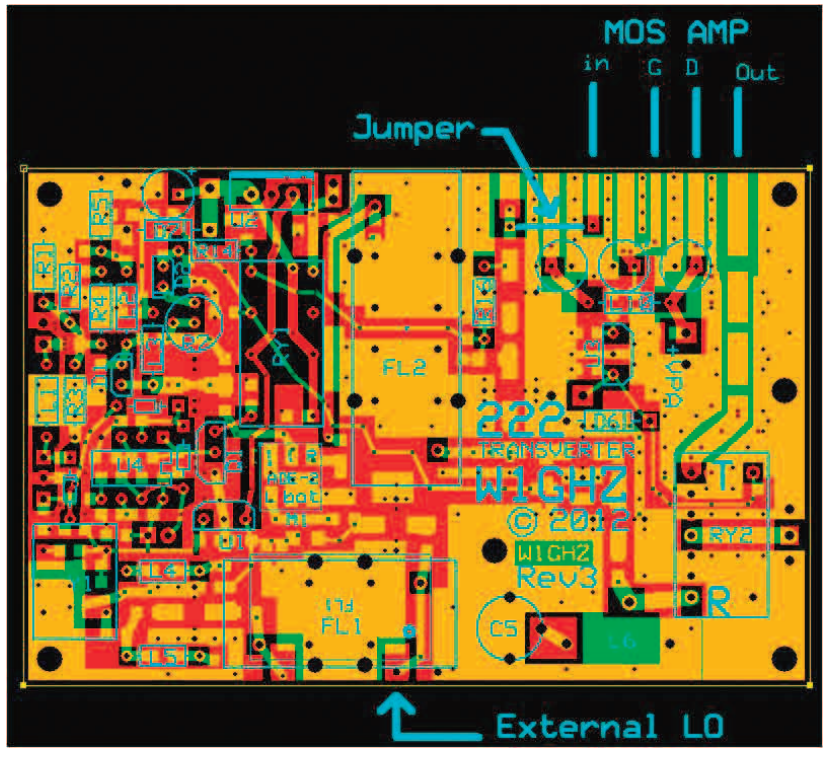

Figure 1 — The new PCB accommodates a range of LO choices and can be adapted to other bands. Copper traces on the top surface are shown in red; copper traces on the bottom surface are shown in green (but appear orange when seen through the top surface) and copper silkscreen legends and outlines are shown in blue. The schematic is on the **www.arrl.org/qst-in-depth** web page.

Use with Other Transceivers

Many SDR transceivers, like the FLEX-1500, have a transverter port with an output of roughly 0 dBm, adjustable in software. At this level, no TR switch is necessary, so we can simplify things — remove the PIN diode switch and reduce the input attenuator to perhaps 3 dB, just enough to provide a good match to the mixer. R1 and R5 are each 300 Ω, R4 is 18 Ω; C42 and D1 are replaced by wires to provide a straight-through connection. Components to be omitted are R2, R3, R6 – R10, R14, D2, L3, C21, C43 – C46, and C75.

The "Band Data" input should be greater than 4 V to activate the transverter. This can be provided through the IF connector J1 if desired. Then the "PTT LO" pin is pulled to ground to transmit. My FT-817 radios have been modified to put roughly +8 V on the coax when transmitting, and my transverters use this voltage for PTT, so no separate PTT cable is needed. Simpler is better for rover operation.

If, for some reason, you wish to use a high-power transceiver, you'll have to figure out what to do with the excess transmitter power. Turning the power

output down may not work, because many rigs output a spike at full power before the ALC reduces the power. That spike will damage something sooner or later.

Other Bands

Most of the SDR transceivers go up to only 6 meters — but we would like to use them on higher bands. The only components in this transverter that are frequency-sensitive are the LO, the filters, and the PA module. We have already considered the possibility of an external LO. MOSFET PA modules with the same pinouts are available for 144 MHz (RA08H1317M) and 432 MHz (RA07H4047M). These versions also operate from 12 V, simplifying the regulator problem.

The remaining problem is the obsolete Toko filter, FL2. Digi-Key apparently has several hundred Toko filters for 222 MHz remaining at a good price (part number TK3501-ND), but otherwise they are unavailable. Temwell makes equivalent filters, but the minimum order is a bit steep. They also make similar filters in a smaller package, which Down East Microwave, Inc. (DEMI), uses in their current products. DEMI might also have an adaptor PCB to fit the Temwell filters in a Toko footprint.

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The receiver input coil L6 and the transmit low-pass filter L7, C6, L8, C7, and L9 must be adjusted for other bands. These are hand-wound coils, so changing values is not a major problem.

FT-817 Panadapter

An SDR receiver is really good for finding elusive signals on less populated bands like 222 MHz and microwaves, but most of them are less convenient than the FT-817 for portable operation. We can have the best of both worlds by tapping into the 68 MHz IF of the FT-817, before the filter, and using a small inexpensive dongle as an SDR panadapter.[5, 6] I have used both a FUNcube Dongle and a DTV Dongle (less than $20) with a small netbook computer running *HDSDR* software to find signals.[7] The advantage of this approach is that the FT-817 works just as well as ever without the dongle attached.

Performance Enhancements

The small QRP transverter provides the missing VHF band for the FT-817 for rover operation. But sooner or later, more performance is desirable. Recently, LDMOS solid-state amplifiers have become available, which provide serious high power with only 5 to 10 W of drive — a perfect match for this transverter. However, the transverter output emissions are marginally clean enough at the 5 W level. The transverter output should be well band-pass filtered before amplification.

A preamplifier can also improve the receiver performance. Many preamps are rather broadband, so they can also amplify strong out-of-band signals, which the transverter may not have enough selectivity to reject. A good band-pass filter can make a real difference here. For example, there are many broadcast FM and TV stations in my area. I found that putting a sharp comb-line filter before the preamp lowered the noise floor significantly and improved my ability to hear weak signals, even though the noise figure is increased by the 1 dB filter loss.

PC Boards

Figure 1 shows the PC boards for the 222 MHz transverter (see details at **www.w1ghz.org/222xvtr/222XVTR_Rev3.zip**). For the FT-817 panadapter board and details, see **www.w1ghz.org/small_proj/FT817_Panadapter-N1JEZ.zip**.[8]

Notes

[1]Paul Wade, W1GHZ, "A 222 MHz Transverter for the Yaesu FT-817," *QST*, Jan. 2003, pp. 31 – 38. Online at **www.arrl.org/qst-in-depth**; see also **www.w1ghz.org/222xvtr/222.htm**.
[2]**www.newsvhf.com**
[3]**www.mods.dk/view.php?ArticleKey=40f4da34bbe180214c23b9e55da4f772&i=1-yaesu-FT-817-FT817-Transverter-PTT-interface**
[4]Paul Wade, W1GHZ, "Locked VCXOs for Stable Microwave Local Oscillators with Low Phase Noise," *QEX*, May/June 2014.
[5]Mike Seguin, N1JEZ, "A Panadapter for the FT-817," Proceedings of Microwave Update 2011, ARRL, 2011.
[6]**huprf.com/huprf/pat-board/**
[7]**www.hdsdr.de**
[8]**www.w1ghz.org/filter/Combline_Filters_for_VHF_and_UHF.pdf.**

Paul Wade, W1GHZ, previously N1BWT and WA2ZZF, has been licensed since 1962 and has never made a contact below 50 MHz. He has been a microwave experimenter for years and has written numerous articles, as well as the "Microwavelengths" column in *QST*. He is active in the Vermont 10 GHz Group and is past President of the North East Weak Signal Group. An ongoing project is the "W1GHZ Microwave Antenna Book" — online at **www.w1ghz.org**. In 1997, he was honored by the Central States VHF Society as the recipient of the Chambers Award. He has been honored by ARRL with the 2000 Microwave Development Award, in 2001 with the Thomas Kirby Eastern VHF/UHF Society Award, and in 2009 by Microwave Update and the North Texas Microwave Society with the Don Hilliard Award for Technical Contributions to the Microwave Community. After a long career in electrical engineering, including microwaves, computer hardware, and signal integrity, he and Beth, N1SAI, are now happily retired in Vermont with a new puppy named Hannah. Paul was also a ski instructor for a time, and now enjoys skiing on sunny weekdays, and skijoring with Hannah. You can reach Paul at **w1ghz@arrl.net**.

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