SoftRock RXTX - Modification for 2200, 630 and 160 Metre Operation

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The frequencies that can be selected with a SoftRock RXTX[1] are limited by the division ratio of the SI570 clock. All current unmodified RXTX circuit boards provide a divide-by-4 ratio that allows selection of frequencies between approximately 800 kHz to 40 MHz. Thus, all of these RXTX boards basically support operation over the entire 160-10 mtr band range - what further limits operation to specific bands in the various versions is primarily the band-specific transformers and filters. The divide-by-4 clock ratio does allow coverage of the entire 160-10 mtr range if wide-band transformers and switched filters are provided. Such a 160-10 mtr "all band" modification has been described. For operation below 800 kHz, however, the clock must be divided by a larger ratio.

With an added divide-by-4, selection of frequencies from 200 kHz to 10 MHz becomes possible, potentially allowing operation on 630 mtrs to 40 mtrs.

With an added divide-by-16, selection of frequencies from 50 kHz to 2.5 MHz becomes possible, potentially allowing operation on 2200 to 160 mtrs.

Tony Parks can supply an add-on divide-by-16 daughter board especially designed to fit onto the RXTX board. (This board could easily be wired by the user to provide a divide-by-4 ratio if this were desired.) Please see Note 1 below for more details on this divide-by-16 board.

I installed one of Tony's add-on divide-by-16 daughter boards and modified an RXTX board as described below. The modified board functions for RX from 50 kHz to 2.5 MHz and for TX on 2200, 630 and 160 mtrs with 1 Watt of output. (I began with a 160 mtr RXTX, but any of the band versions could be used as long as the components listed below are installed or replaced.)

Component values on the RXTX board for LF/MF operation

All components other than those listed below have values that are common to all versions and these values, which are shown on the RXTX schematic, need not be changed for LF/MF operation.

Note: smaller size type 73 binocular cores may work, I used the larger 302, 202 sizes that I had on hand.

C64, C66, C67, C68, C70, C71	0.1 uF	(5 V bus bypass caps)
R55, R58	49.9 Ohm	(RX op amp input gain control resistors)
R42, C22	omit	(Driver emitter bypass)
C20, L1	replace with band specific low pass filter (TX mixer LPF)	
C21	0.022 uF	(Driver input coupling cap)
C24, C25, C26, L2, L3	replace with band specific low pass filter (PA LPF)	
C27	0.022 uF	(RX input coupling cap)
C39	omit	
L4	replace with jumper (also see Note 5)	
RFC1	600 uH	24T on BN-43-1502
		(9T on BN73-302 should also work)

T2	(TX mixer)	8T secondary wound on top of 4T bifilar primaries, BN73-302
T3	(TX driver)	8T primary wound on top of 4T bifilar secondaries, BN73-202
		(10T primary wound on top of 5T bifilar secondaries, BN73-302, should also work)
T4	(PA output)	7T secondary wound on top of 5T bifilar primaries, BN73-302
T5	(RX mixer)	6T trifilar on BN73-302
T6	(RF input)	7T bifilar on BN73-302

To prevent VHF parasitic oscillation in the PA, I first installed a 51 Ohm resistor in each PA mosfet gate circuit by soldering a 1/4 W resistor in the top circuit board holes for the T3 secondary leads and then soldering the T3 secondary leads to the top of the resistors. After Alan, G4ZFQ, suggested a more elegant method - cutting the circuit board traces that run on the top of the board between the Q7 and Q8 gate holes and the holes for R47 and R46, and then soldering a 1/4 W resistor on the bottom of the board between the Q7 gate hole and the R46 hole and another one between the Q6 gate hole and the R47 hole, I moved the 51 Ohm resistors to that location. (I believe that a small ferrite bead would also likely work instead of these resistors.)

To lower the gain by approximately 6 dB (28 June 2018 mod), I added negative feedback to the driver stage by soldering a 1K Ohm resistor in series with a small .022 uF foil capacitor across R44. Audio drive at about -6 dB below 1 Vrms input is then sufficient to yield 1W output.

Si570 Firmware

For proper frequency selection with the added divide-by-16 board, open CFGSR, select the "LO" tab, change the "Multiply" field from 4 to 64, click "Save" and then close CFGSR.

Low Pass Filters

Appropriate low pass filters (one after the TX mixer and one after the PA) must be provided for each TX band to reduce IMD and harmonics on the TX signal to acceptable levels.

My solution for the TX mixer LPF was to provide band-specific plug-in filters. I installed a male circuit board header (3 active pins) with the outside two pins soldered into the L1 holes and the center pin bent sideways and soldered to a jumper wire soldered into the ground hole of the nearby (uninstalled) R42. The filter components were soldered to a female header that plugs onto the male header.

TX mixer LPF, 3rd order Chebyshev pi configuration, note that the impedance level here is 200 ohms.

2200 mtrs	.022 uF caps and 111 uH inductor (80T on T50-3 toroid)
630 mtrs	6800 pF caps and 30.2 uH inductor (42T on T50-3 toroid)
160 mtrs	.0017 uF caps (.001 uF parallel with 680 pf) and 8.4 uH inductor (22T on T50-3)

Input/Output LPF, 5th order Chebyshev. At least 5th order is needed at my location to reduce the level of strong AM broadcast signals enough to prevent RX overloading on LF/MF. I chose to install mine as external filters in separate enclosures. Alternatively the LPF(s) could be installed in the standard location on the RXTX board - either as single band or plug-in or switched for multi-band operation. Use high Q capacitors, either good quality metalized polypropylene film or C0G/NPO ceramic, at least 250Vdc rated.

For 2200 mtrs — Pi configuration - Constant k design: 50 Ohm reactances at 137 kHz

.022 uF	60 uH	.047 uF	60 uH	.022 uF	

inductors wound as 58T on T50-3 toroids.

T configuration - Constant k design: 50 Ohm reactances at 137 kHz

58 uH	.022 uF	117 uH	.022 uF	58 uH

inductors wound as 57T and 84T on T50-3 toroids.

For 630 mtrs	T configuration - Constant k design with 50 Ohm reactances at 500 kHz				
17 uH	6800 pF	34 uH	6800 pF	17 uH	
	inductors wound as 31T and 44T on T50-3 toroids.				
	(59T and 83T on T50-2 toroids would be a better choice for this band.)				
	Pi configuration - Constant k design				
6800 pF	16.5 uH	.0136 uF	16.5 uH	6800 pF	
For 160 mtrs	Pi configuration - The 160 mtr LPF shown on the standard RXTX schematic				
2200 pF	3.4 uH	4700 pF	3.4 uH	2200 pF	
	inductors wound as 29T on T37-2 toroids.				
	Pi configuration - Constant k design				
1500 pF	4.9 uH	3000 pF	4.9 uH	1500 pF	

Note: the Constant k design with 50 Ohm reactances at the cut-off frequency optimizes the input impedance at the operating frequency - the curve is flat at 50 Ohms - and with loss of less than 0.5 dB.

Note: with a tapped base loading coil resonator on 2200 and 630 mtrs I found that, on receive, the T configuration gave better suppression of AM broadcast band interference than did the Pi configuration. I assume that, on transmit, harmonics would also be better suppressed. (With a constant 50 Ohm load the Pi and T configurations give identical performance, but this is not what a real antenna presents.)

With the above LPF's, harmonic levels measured with a spectrum analyzer (thus with constant 50 Ohm load on the LPFs) were lower than -43 dB relative to 1 Watt CW output on all three bands (<-56 dBc on 630 mtrs). Levels of close-in spurs were lower than -60 dBc (see Note 2.)

Optional Modifications

TX op-amp low pass filters. See Note 3.

Clock and divider bypass filtering. See Note 4.

Reducing RX sensitivity. See Note 5.

Add-on RX functions panel. See Note 6.

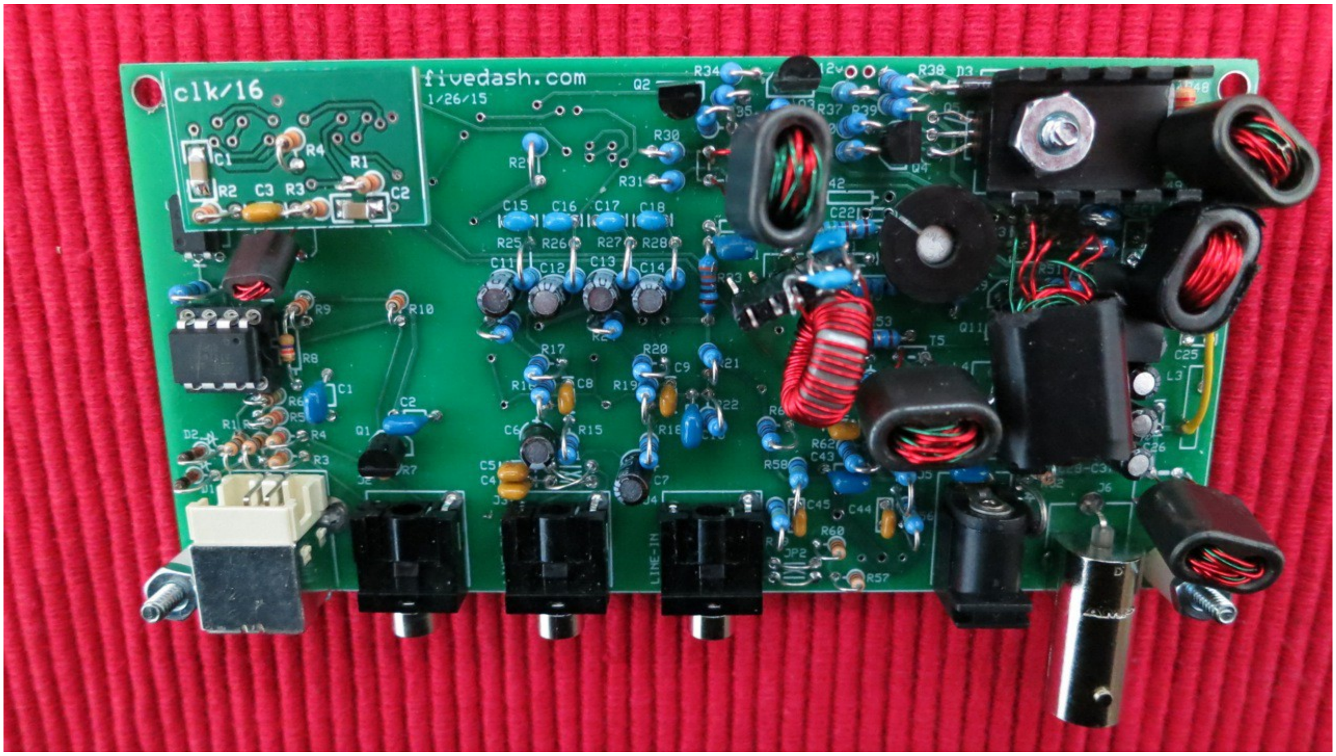
Software

I have operated the modified RXTX on 630 mtrs using PowerSDR with WSJT-X in WSPR-2 and JT-9 modes and with FLDigi, MultiPSK and N1MM software in (keyboard and/or macro) CW. FLDigi also provides PSK31, Domino-EX and other digital modes. Note: PowerSDR will not transmit on 630 or 2200 mtrs until these bands are defined in the “XVTR” (transverter) tab and then selected from the XVTR band panel.

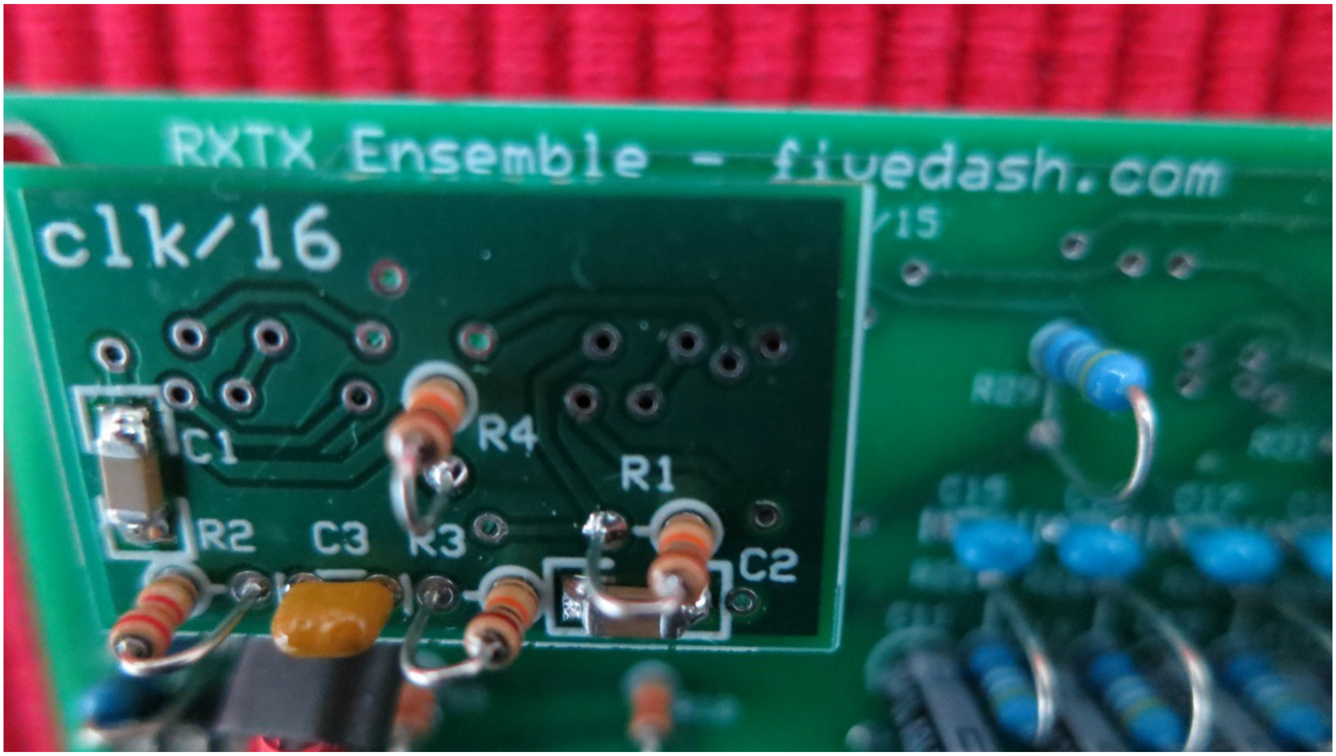
I have also operated using HDSDR with WSJT-X and FlDigi but I prefer PowerSDR since the latter transmits with the LO shifted to the “carrier” frequency which keeps the TX image close to the main signal and minimizes the chance of the image falling outside of the narrow 630 and 2200 mtr amateur bands. HDSDR can, however, be set to operate with a small or zero LO offset. Alan, G4ZFQ, explains how to set the LO offset with HDSDR in his webpage: [https://sites.google.com/site/g4zfqradio/hdsdr-iq-balance#LO Offset](https://sites.google.com/site/g4zfqradio/hdsdr-iq-balance#LO_Offset)

CW Keying

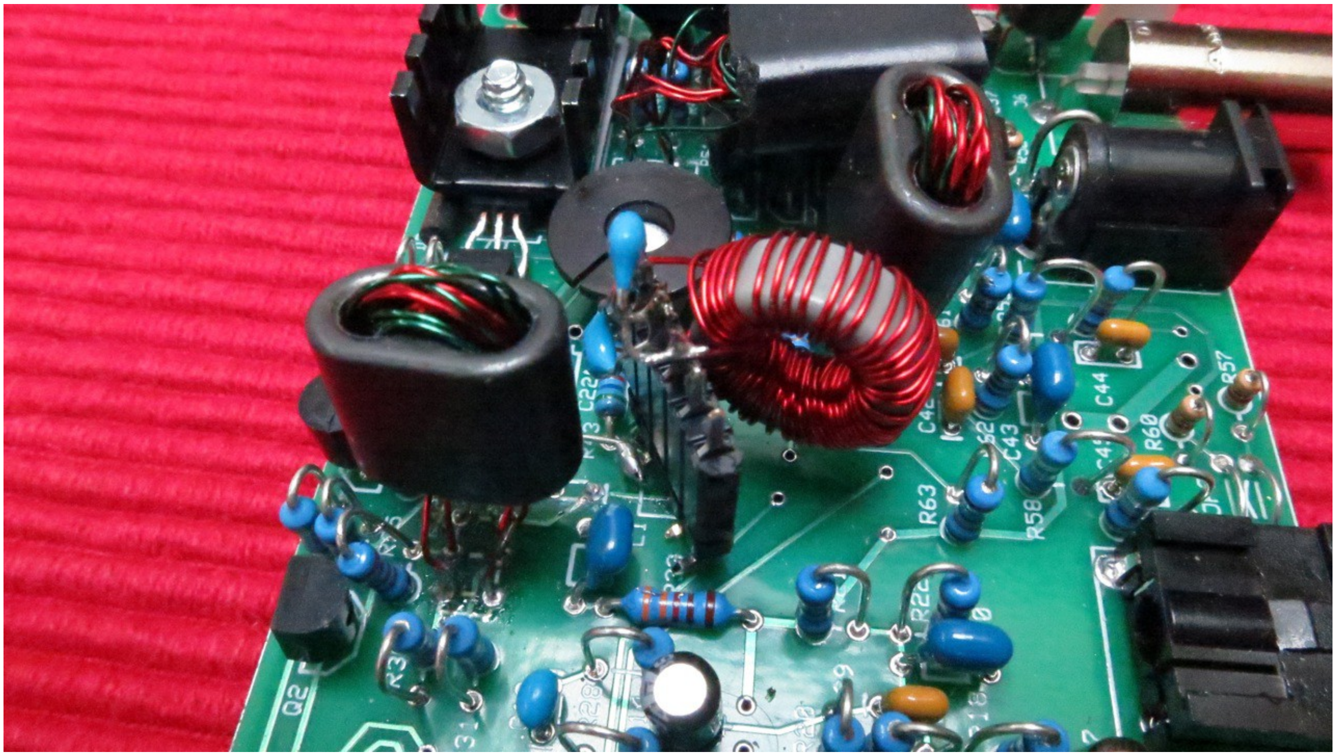
The software mentioned above can provide computer (keyboard and macro) generated CW. For manual keying, PSDR can, in principle, provide this if a paddle is connected to a serial port. However since the latency is so long as to make this method unusable, I use an external keyer connected to a serial port. See http://qsl.net/ve7vv/Files/PowerSDR - instruction for paddle.pdf for info on connecting keys/keyers to a serial port.



Completed 2200 to 160 mtr RXTX board



Close-up showing the add-on divide-by-16 board



Close-up showing the plug-in TX mixer low pass filter

Note 1.

The clock mod could be done several ways. The schematic for the LF option of the Ensemble II receiver shows how a string of dividers would be connected. R12, R13, R14 and C3 (as labelled on the RXTX schematic) need to exist between the clock transformer and the first divider. Where they are installed physically could vary. The way that Tony arranged this for his add-on RXTX clock divider board has R12, R14 and C3 effectively removed from the RXTX board and moved to the new add-on board, leads from the new board's input circuit go to the transformer and a lead from the new board's output goes to R13. Thus the new board is interposed between the clock transformer and the input to the existing RXTX clock divider. All this is shown and explained on Tony's schematic of his new divide-by-16 board. With Tony Park's permission, I have uploaded a copy of his schematic to

http://qsl.net/ve7vv/Files/clk_by_16.pdf

Please note that Tony's schematic provides "Band-specific" values for transformers and filters that are intended for operation only on 2200 or only on 630 mtrs, preserving the same configuration as used in all the other RXTX's. My modification changed the configuration to allow for multi-band operation. I have not built and tested a board using the transformer and filter designs shown on the "clk_by_16" schematic. While they look fine to me, without testing I can not myself report how well an RXTX would work with them. If someone were to build a board following those designs, I would suggest that the value of RFC1 be increased to 600 uH to provide at least 500 ohm impedance at 136 kHz.

Note 2.

Spectrum analyzer measurements shown below were made using PowerSDR in “tune” mode, which produces a single audio tone 700 Hz above the local oscillator frequency, with audio drive level set to provide a power output of 1 Watt (+30 dBm) at the main frequency. Note that typically the strongest spur most commonly observed is at 4X the modulating frequency below the main USB signal, which in this case would be 2.8 KHz below the main signal and within the displayed range of these photos. Neither this spur nor any others are visible within the displayed range on any of the three bands. (They would be if the sound card noise were lower, so these measurement give an upper limit of how strong the spurs might be.) N.b., these measurements were made after the optional mods shown in Notes 3 and 4 were completed, but as far as I know those mods would not affect spur levels.

Photo 1. Output 137 kHz. All spurious signals, including the LO and image, within +/- 5 kHz of the main signal, were at least -60 dBc.

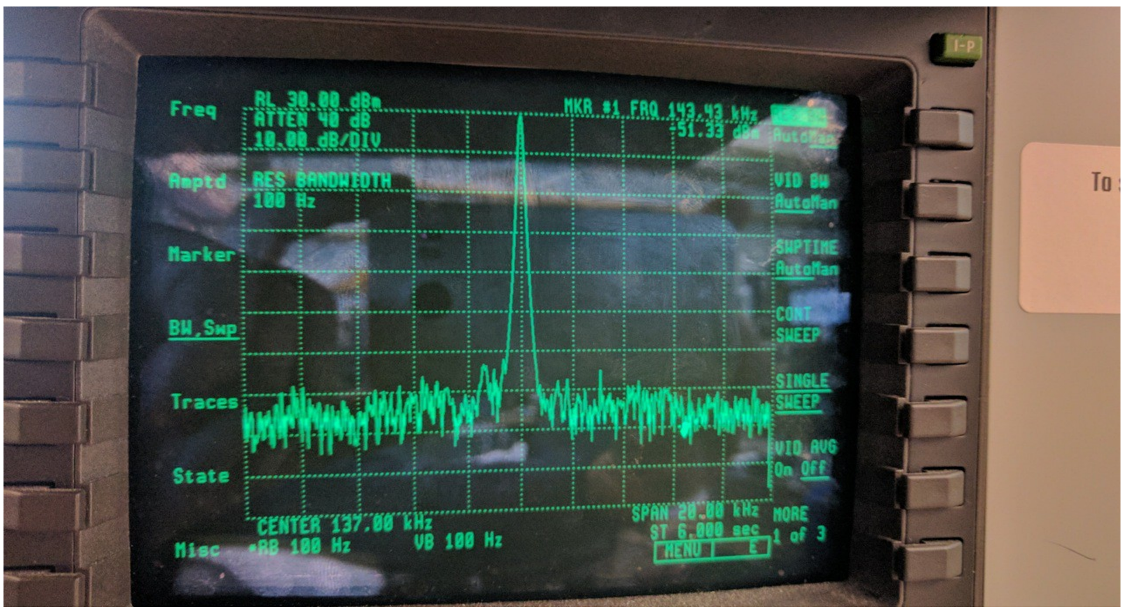


Photo 2. Output 475 kHz. All spurious signals, including the LO and image, within +/- 5 kHz of the main signal, were at least -60 dBc.

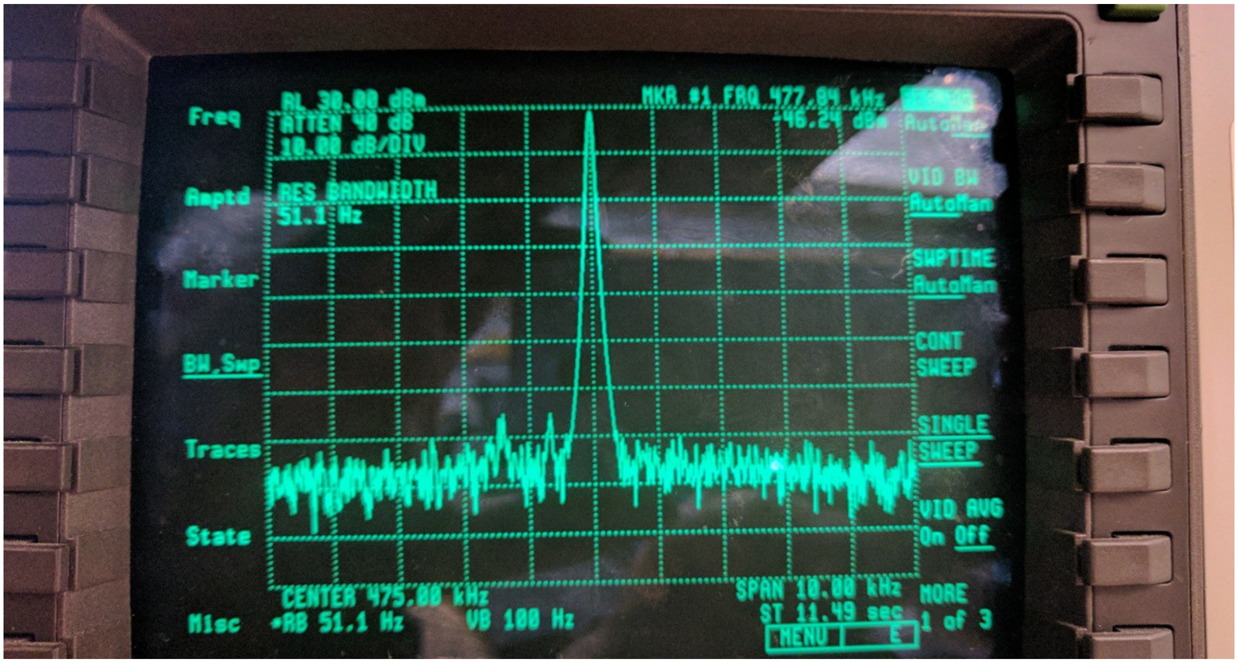
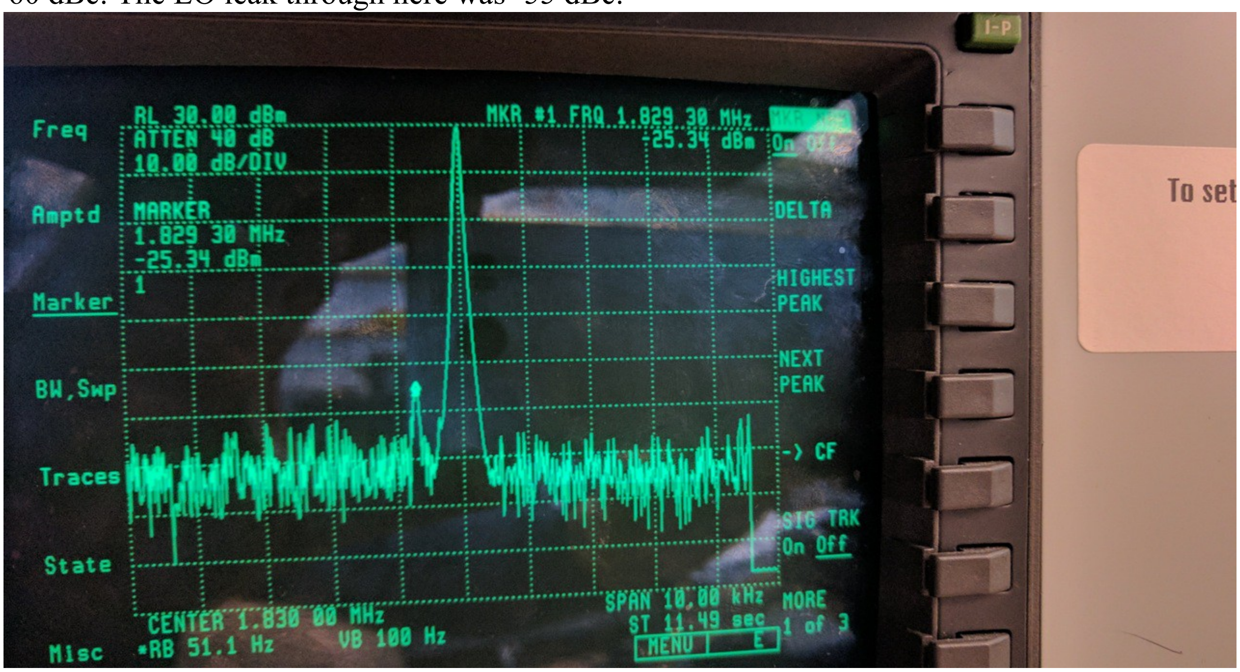
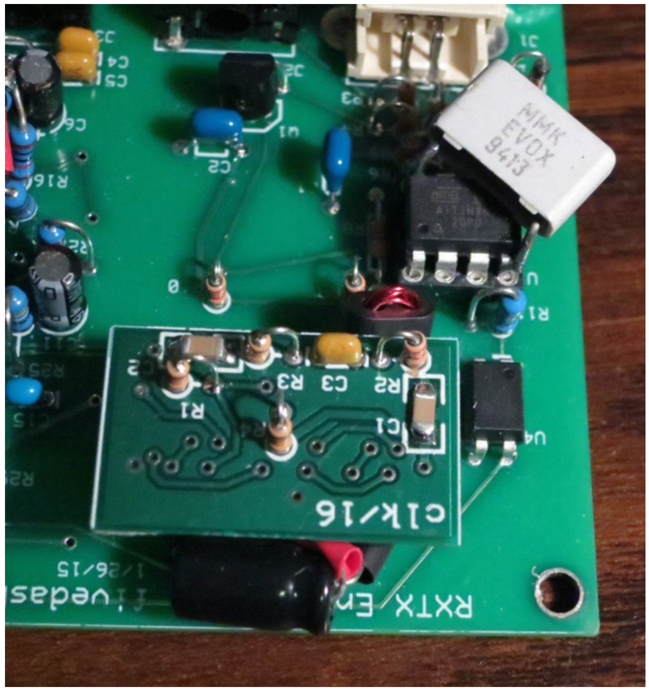


Photo 3. 1830 KHz. All spurious signals, including the image, within +/- 5 kHz of the main signal, were at least -60 dBc. The LO leak through here was -55 dBc.

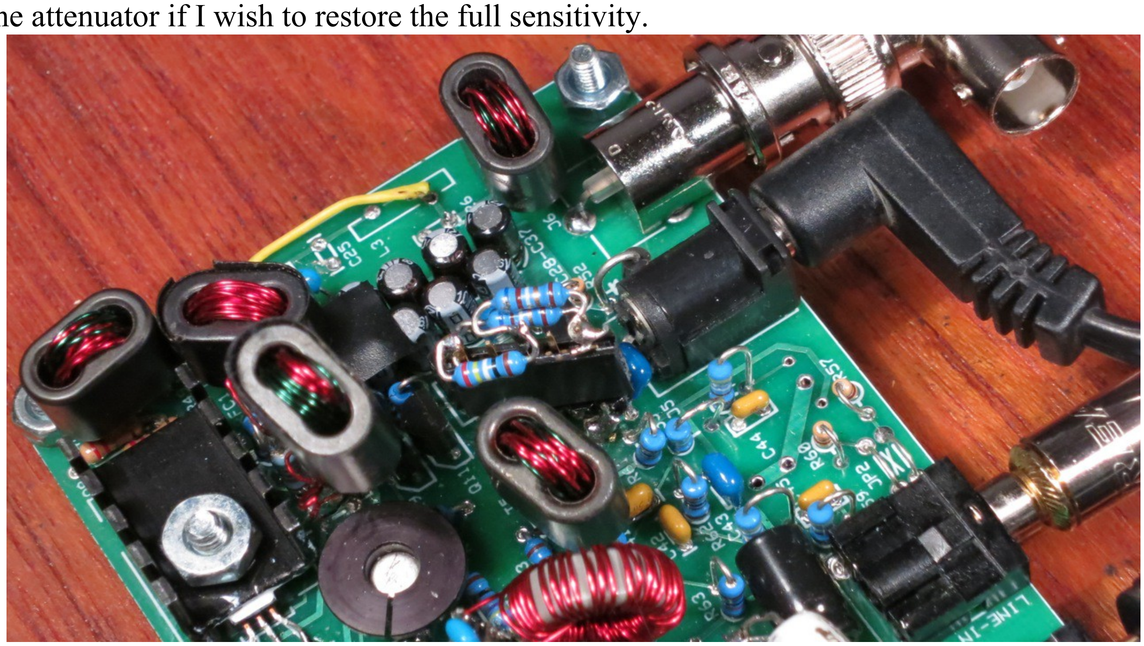


Note 3. TX op amp low pass filter modification.
See http://qsl.net/ve7vv/Files/RXTX TX op amp filter mod.pdf

Note 4. Clock and divider bypass filtering modification.
Leif, SM5BSZ, recommends adding additional filtering bypass capacitors to the ATtiny (150 nF across pins 4 and 8) and divider +V to reduce USB and other noise.
See https://www.youtube.com/watch?v=iW8X4J5VGxY (Look at about 13 and 23 minutes into the video.)
Leif installed a 470 uF capacitor, while I used a 100 uF low ESR type, between GND and the +5V line near the 74AC74 chip. My mod to my RXTX is shown below.



Note 5. Reducing RX sensitivity.
The RXTX receiver is more sensitive than needed when connected to a LF TX antenna or an active RX antenna, which reduces the dynamic range and makes overload from strong BC stations more likely. Reducing the gain when such antennas are used is desirable. I found that decreasing the gain by 20 dB on 630 mtrs retained sufficient sensitivity in my (high noise) location. One method would be to decrease the RX op-amp gain by decreasing the value of R56 and R59 by a factor of 10 to 499 Ohm. C44 and C45 would have to be increased in value by X10 to 2200 pF as well. Since I wanted to preserve the option of having the full sensitivity, I chose to install a plug-in attenuator in front of T5, the RX mixer transformer. I installed a circuit board header with two pins into the L4 holes (having removed the jumper) and with a third pin bent to connect with the pad where the ground lead of C39 had been. A 20 dB attenuator was soldered to the pins of a mating header. A separate mating header with a straight jumper is available to replace the attenuator if I wish to restore the full sensitivity.



Note 6. Add-on receive functions panel.

I replaced the RX attenuator plug-in (Note 5) with a plug that has two mini-coax cables. The cables go to a panel that has: first, a switch to select either the line from the T/R circuit (for the TX antenna) or an RX antenna coax jack; next, a pair of coax jacks for either a jumper cable or for a BPF or HPF; next, a switch for a 20 dB attenuator; finally, the coax cable to go back to the plug to connect to the RX mixer input transformer.

1 http://fivedash.com/index.php?main_page=product_info&cPath=1&products_id=7
http://www.wb5rvz.org/ensemble_rxtx/