

## **SoftRock RXTX TX op-amp low pass filter modification**

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Leif, SM5BSZ, has provided a wealth of measurements showing that all sound cards have wide band noise output that, when allowed to enter the TX line input of an unmodified Softrock RXTX, will modulate in the mixer and produce noise sidebands on either side of LO. This noise, if strong enough, can produce interference to receivers tuned to any frequency within several hundred kHz of the SoftRock output signal. While the level of such noise will be low for 1 Watt output, and would be below band noise for distant LF/HF receivers. it could become a problem to others, such as nearby ham neighbours, and high levels of soundcard noise could easily become a problem even at a distance if the RXTX output were amplified 20 or more dB.

Below I show how the RXTX TX input op amp filter can be modified to reduce the level of this noise and provide results showing the effect.

Leif's video showing the noise output of a Delta44 soundcard, which is the best of all the cards he tested:

<https://www.youtube.com/watch?v=UBT-DT-oZuI>

His video showing the noise seen with other sound cards:

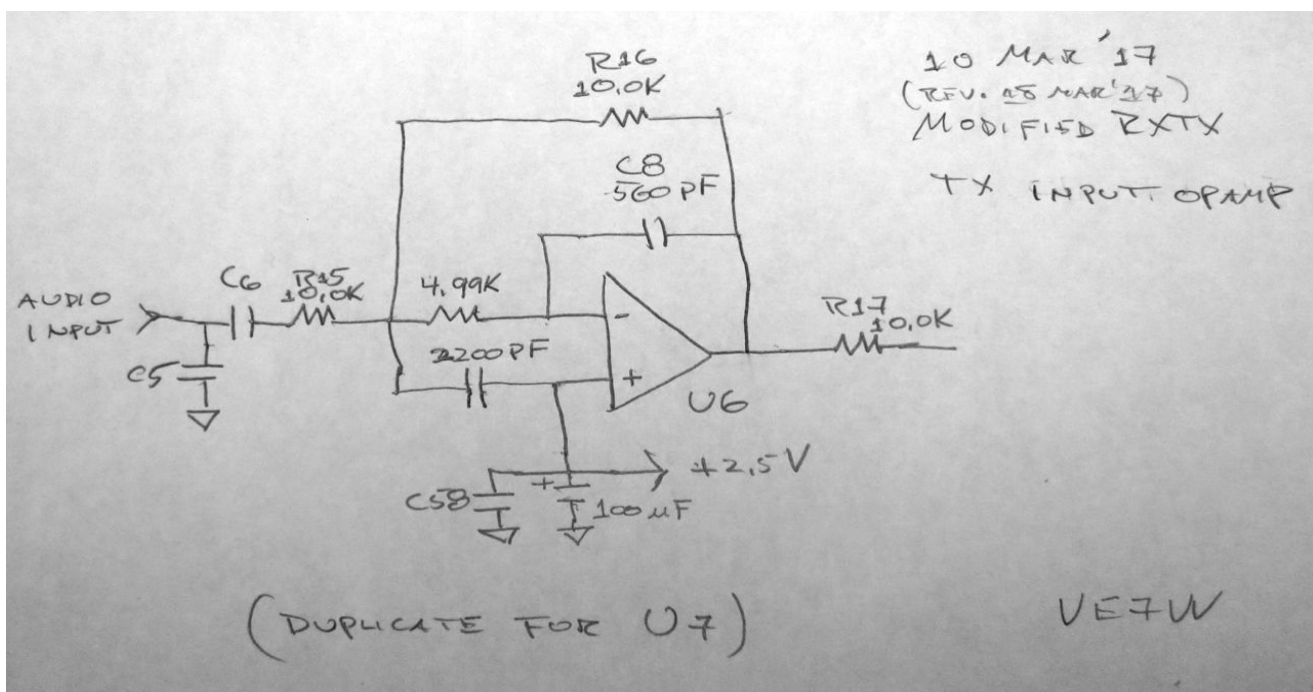
[https://www.youtube.com/watch?v=KIHow\\_NbiYQ](https://www.youtube.com/watch?v=KIHow_NbiYQ)

According to his measurements, the level and frequency range of the noise varies with the sound card. In some cases the noise becomes much worse as the sound card sampling rate is reduced. The noise is generally independent of the tone level so that when the audio drive is reduced below maximum output to keep the RF output down to 1W, the relative strength of the noise becomes worse. These considerations argue for using high sampling rates, high bit depth, and keeping the sound card output high by using an attenuator if necessary.

I discovered that my sound card, a Focusrite Scarlet 2i2 (a "pro audio" unit intended for live microphone/instrument recording), which works very well with low noise on RX, has a very high level of wide band noise on the analog output that peaks at 100 kHz. The modulated sideband noise was only about 50 dB down from the 1 Watt signal. In my case, changing the sampling frequency or bit depth had no effect on the noise.

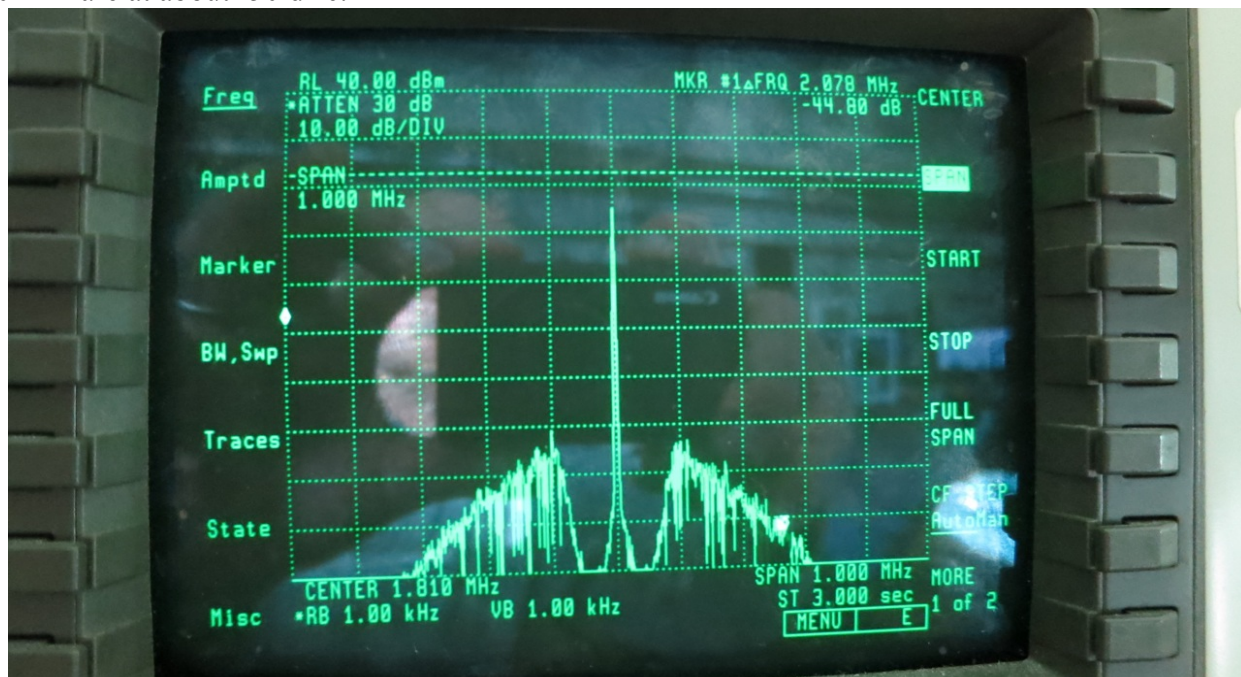
The stock RXTX TX input op amp has a 1 pole RC low pass filter (10 kOhm, 100 pF) that rolls off 2 dB at 100 kHz so it does not do much to help with my soundcard noise peak. Since I planned to use PowerSDR, which shifts the LO to the "carrier" frequency, and since I would never be using modulation above 3 kHz, a TX low pass filter of 20 kHz would be fine (to avoid too much phase shift at 3 kHz).

Simply changing the 100 pF caps on the TX op amps to 560 pF would provide significant improvement in the filtering of sound card noise, down 12 dB at 100 kHz and 2 dB down at 20 kHz. However, to provide even better filtering, I changed the op amp filter circuit to a 2 pole design that should provide 30 dB attenuation at 100 kHz, 4 dB at 20 kHz and 15 degree phase shift at 3 kHz. The circuit is shown below. I also added a 100 uF cap to the +2.5V line, soldered to the leads of R22 (+ lead to the hairpin).



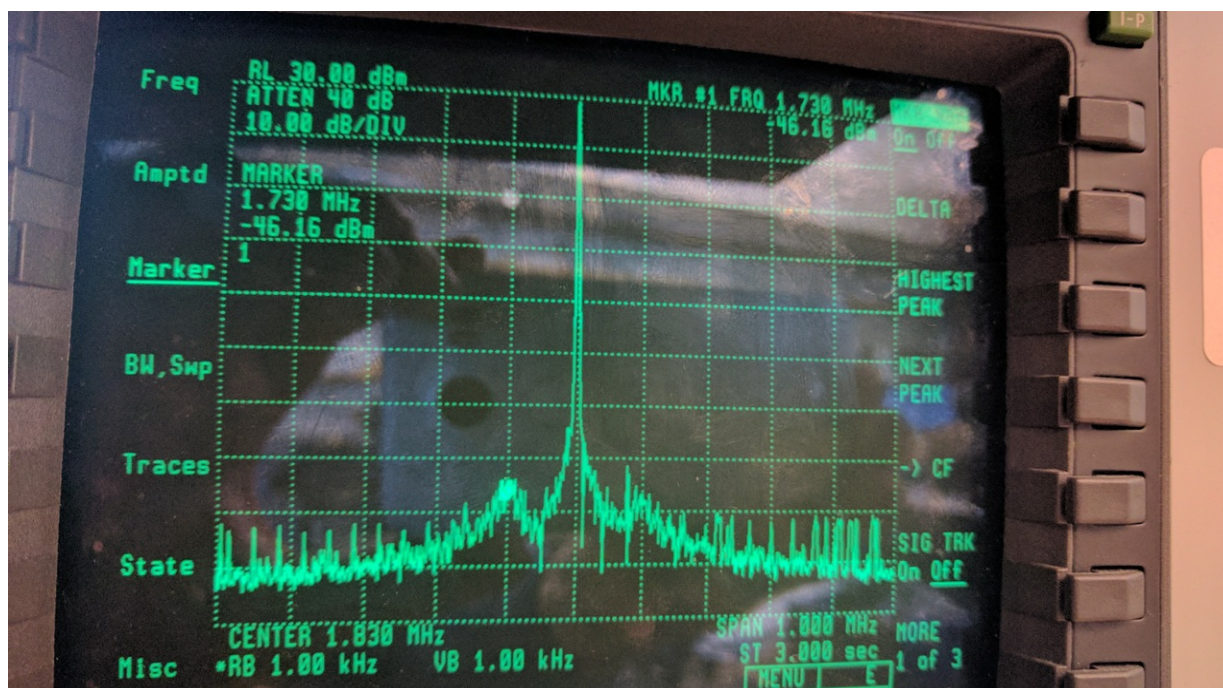
The effect of this filter is shown in the spectrum analyzer photos below. The RXTX is my modified version that covers the 2200, 630 and 160 mtr bands. As far as the sound card noise issue is concerned, the results should be the same for any band and for the standard RXTX. Power output is 1W, +30 dBm at 1.83 MHz, using PowerSDR in "tune" mode to generate a tone at 700 Hz above the LO.

The next photo shows the noise sidebands with the stock RXTX op amp circuit. The noise peaks at +/- 100 kHz are at about -50 dBc.

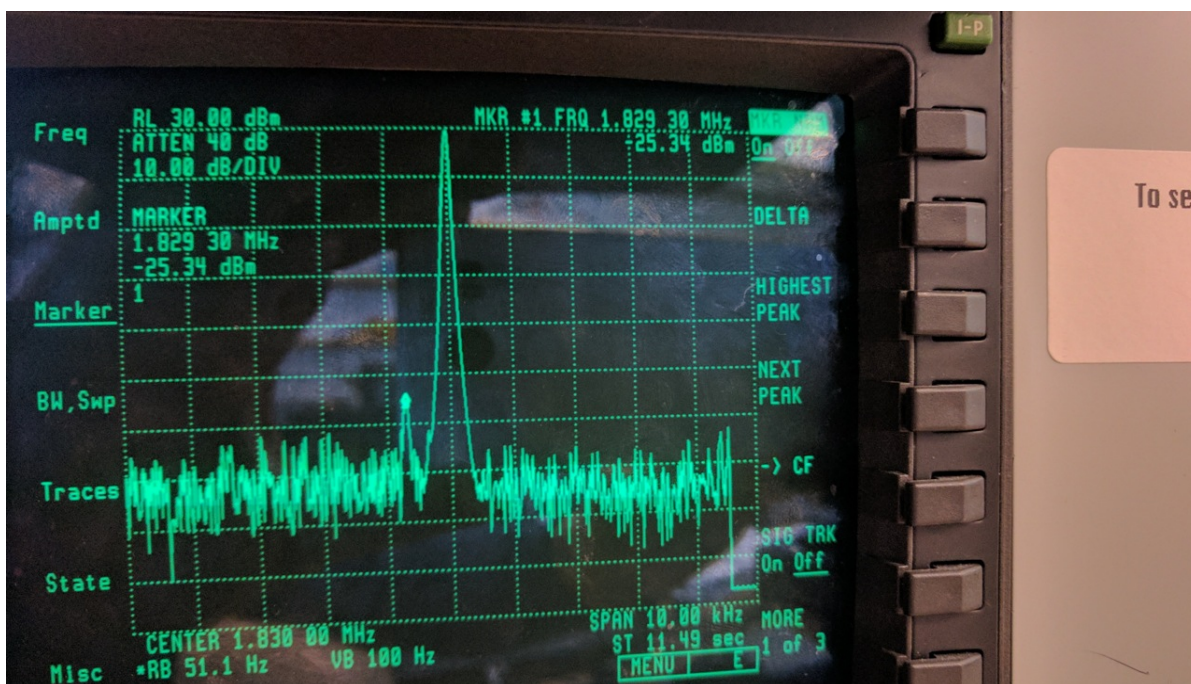


The next photo shows the noise after the op amp modification. The noise is now down to about -75 dBc at 100 kHz, an improvement of about 25 dB, not quite what the Spice analysis predicted but much better.





There is still significant noise close-in to the main signal, as shown in the next photo. This noise is about -70 dBc.



The spectrum analyzer noise floor, when the RXTX PTT is not keyed, is about -96 dB below the +30 dBm top scale, so all the noise shown in these photos is spurious sideband noise produced by the sound card.

Since all sound cards produce some unwanted wideband noise, adding low pass filtering to the audio I/Q input is highly desirable. The simplest mod is just to change C8 and C9 to 560 pF to provide some

rolloff beginning at 20 kHz. It is not too difficult to sharpen this rolloff by using the 2 pole mod. The filtering could also be done with external filters, which could be made to have much sharper roll off yet. This can only be done if the LO to modulation offset (plus modulation bandwidth for USB) is less than 20 kHz, which is always the case with PowerSDR and Linrad, but would not always be the case with HSDR. Alan, G4ZFQ, explains how to set the LO offset with HSDR in his webpage: [https://sites.google.com/site/g4zfqradio/hdsdr-iq-balance#LO Offset](https://sites.google.com/site/g4zfqradio/hdsdr-iq-balance#LO%20Offset)

Ideally, one would use a sound card that has much less noise than mine to start with. This is the best solution of all. I am looking into options to replace mine.

My build of the mod is shown below.

