KiwiSDR IMD & Noise Measurement

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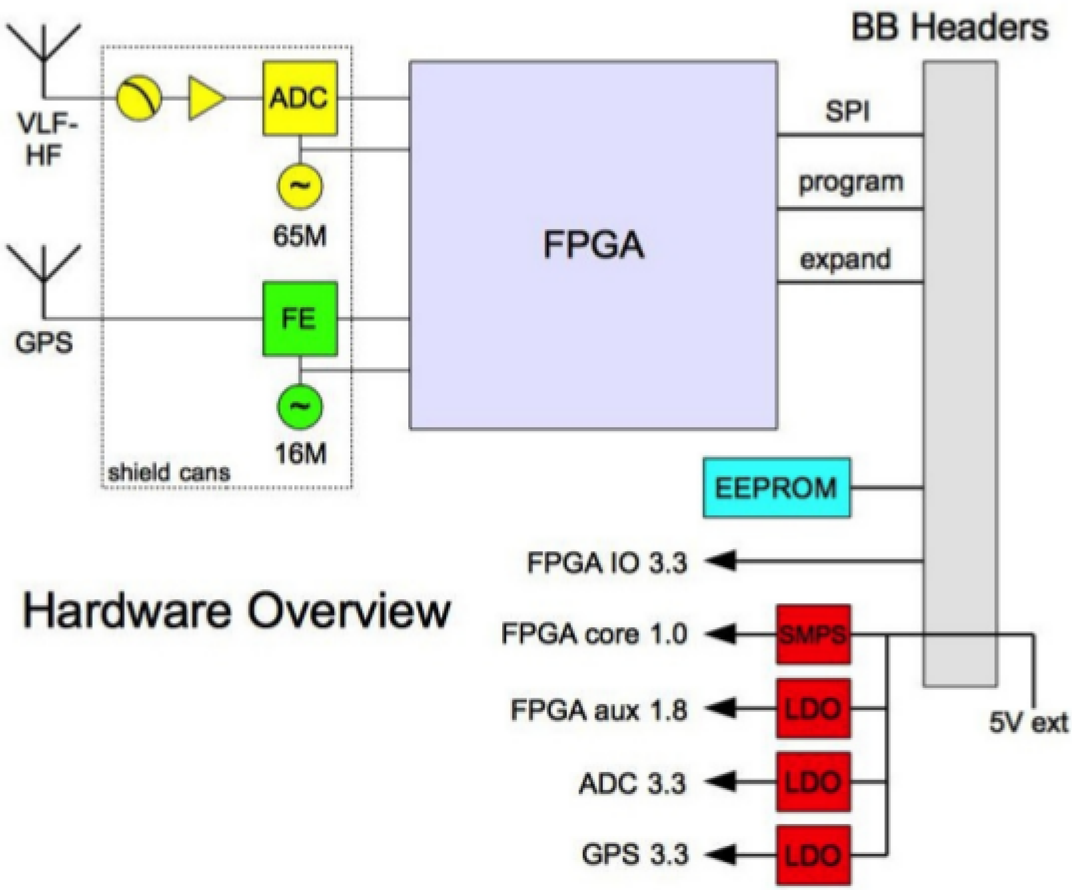
I powered up and configured a new KiwiSDR I just received June 2018 via Mass Drop. If I'm reading the handwritten value, it's serial #3444.. The process got me thinking about using it to measure IMD of some active antenna preamps I've been working on. These are dual amplifiers, JFET input and bipolar output much like the Trask design designed to work with a dipole rather than a monopole. This is so I can hopefully achieve very good symmetry and common mode noise rejection. I've been working to improve even order distortion performance as I found the Trask circuit shown in Fig. 12 of his document not to work and with very stron broadcast band stations, or with WWVB at 60 kHz very close as is my case, a preamp has to tolerate very large signal levels without introducing distortion products or noise.

The KiwiSDR Design Review document doesn't claim it to be intended as a measurement grade tool but since a bare ADC should be almost completely without IMD and the Kiwi has only a single 20 dB gain stage, an LTC6401 with high spec'd output TOI, if I'm correctly understanding the Linear Technology charts about +52 dBm at 10 MHz, the KiwiSDR might make a pretty good measurement tool.

The KiwiSDR has a smaller signal level tolerance than do my preamps. This makes it a different measurement problem from that which I encountered with the preamplifier.s which I tested at +3 dBm or higher signal levels. It appears that this KiwiSDR goes into overload around -28 dBm or so.

As a reminder, the KiwiSDR block diagram looks like this:



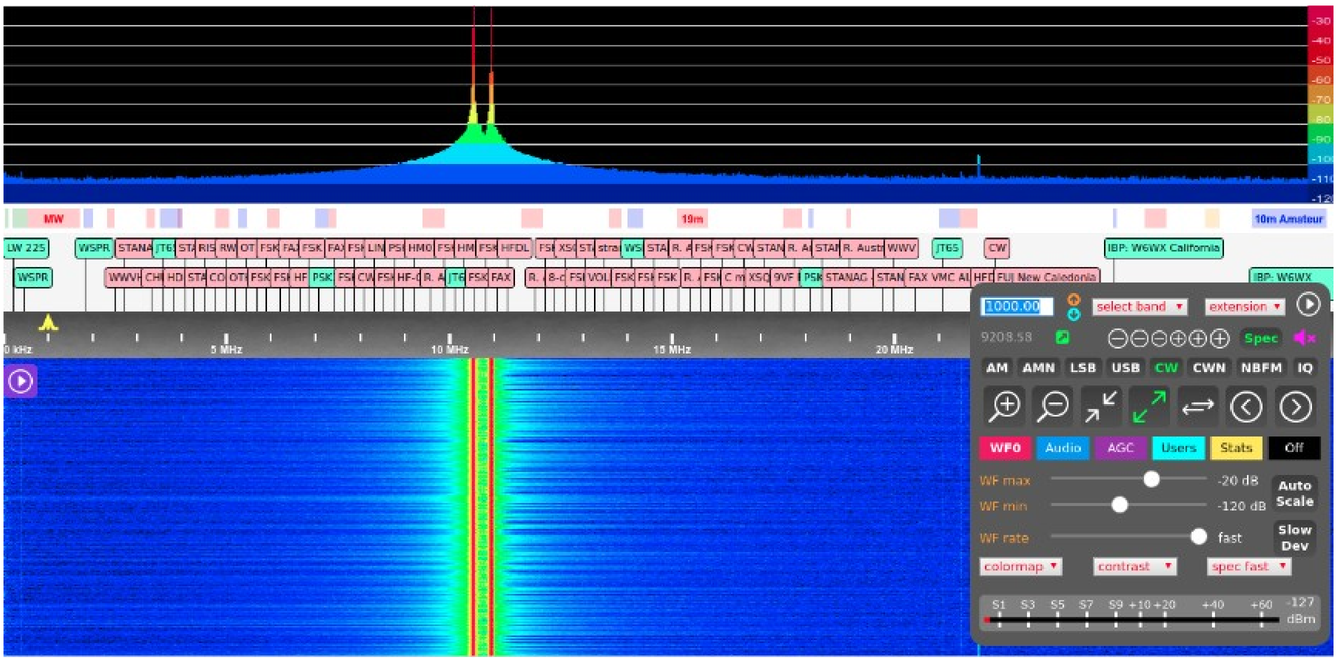
The test signals I use are from an HP8640B, F1=10550 kHz and an HP86732A, F2=10950 kHz, signal generators. I run each at slightly lower than maximum available output, in the vicinity of +13 dBm. These are followed by about 20 dB of attenuation and then combined in a lumped hybrid I previously built which shows about 35 db of port-port isolation near 10.7 MHz and 3 dB insertion loss for each of the two ports being combined. With the additional attenuation, the result is two -10 dBm signals at the hybrid output with at least 55 dB of generator-generator isolation. I don't know what the IMD of the generator output stages are but they should be pretty high since each signal generator can make +20 dBm. Accurately measuring the IMD from this test source probably requires building additional filtering and measurement equipment, I haven't done this yet but with a well-configured HP ESA4403 spectrum analyzer, I believe a measurement is still analyzer limited.

After the hybrid/combiner I added ano extra 10 dB attenuation which reduces the level to two -20 dBm signals, -17 dBm total power, at the Kiwi input. The 10 dB helps fix any KiwiSDR input match issues for the hybrid too, though I measure in excess of 16 dB from .3 to 30 MHz on the KiwiSDR input so I guess its 30 MHz LPF isn't performing too badly.

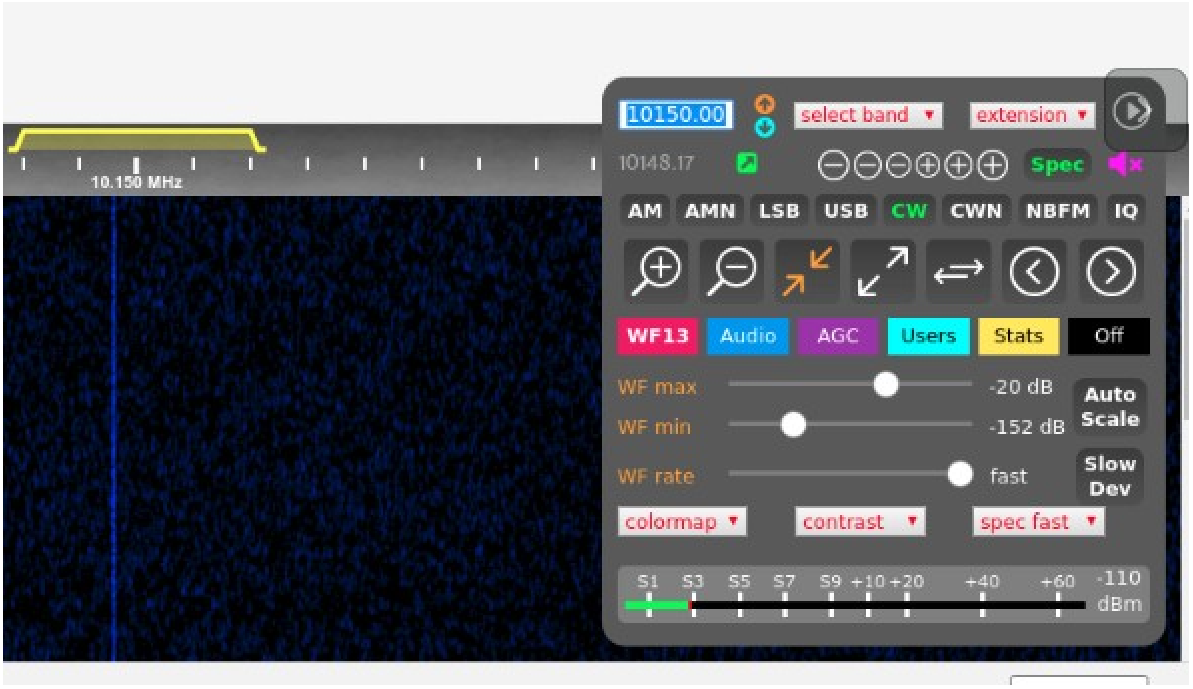
If the test set up is good enough, based on the LTC amplifier data sheet I might expect the distortion term internal to the KiwiSDR, out of the KiwiSDR's 20 dB gain amplifier, to be +3dBm - 2*(50-3) = -91 dBm internal to the Kiwi. . This level will be displayed 20 dB lower since the KiWiSDR S meter is input referenced so the display should read -111 dBm if everything is calibrated. At the outset I did calibrate the KiwiSDR, resulting in the test signals each measuring -20 dBm, in agreement with the ESA.

Prior to measuring distortion I decided to measure the KiwiSDR’s noise figure and noise floor.

The first screen grab below is a wide sweep with the two test signals F1 & F2 present, a 1 kHz resolution bandwidth and the tuning set down to 1 MHz where any phase noise from the generators should be gone, leaving only Kiwi noise contributions. You can see that the indicated noise floor is -127 - 30 db (1 kHz RBW) = -157 dBm/Hz. Comparing results from a calibrated CW source and a calibrated noise source I've previously tested Kiwi software to verify that the KiwiSDR’s noise measurement is average noise power rather than peak. This result indicates approximately a 17 dB noise figure for the complete KiwiSDR.

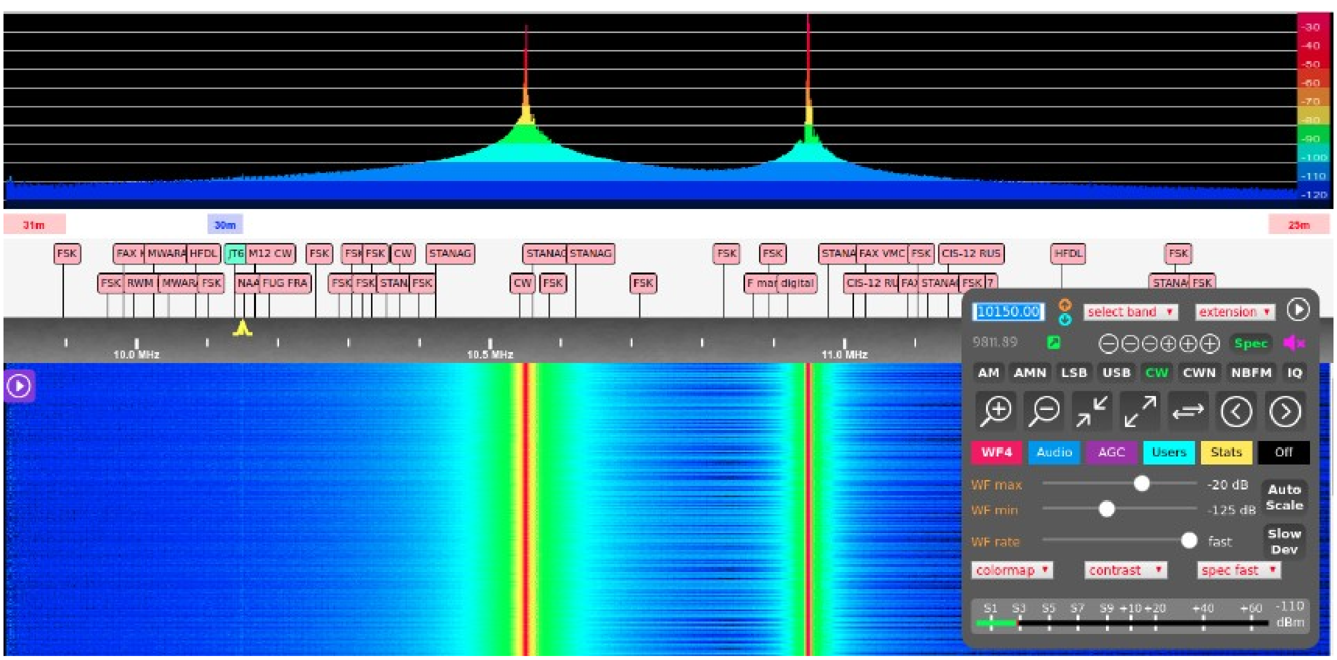


The second shot is the 10.150 MHz 2F1-F2 TOI term.



At -110 dBm this distortion term is within measurment error of LTC's "typical" LTC6401 TOI numbers.

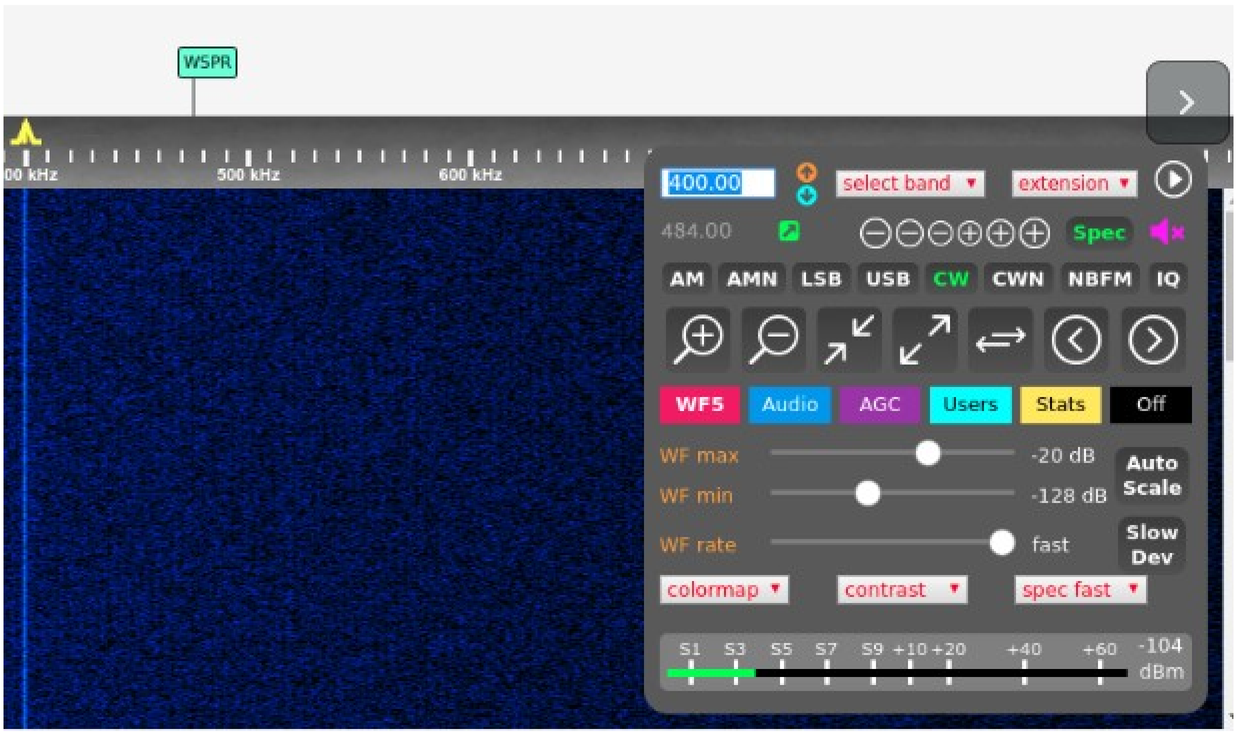
The third shot is a mid-width one to show the two test signals, phase noise and both TOI terms. I've tuned to measure the larger one at 10150 kHz again. It still measures -110 dBm.



Checking with the ESA, by measuring it without the extra 10 dB attenuation and turning the input attenuator up so I can see anything at all, the signal there is no bigger than -103 dBm, so somebody, ESA or test set up, is producing the equivalent -7+96/2 = +36 dBm TOI with this ESA input attenuator setting. This is far enough from +29.5 for the Kiwi that I tend to think the Kiwi measurement may be OK.

The slight apparent difference in noise around each carrier may be real and due to the generator differences. The 8640B is a divided UHF cavity oscillator while the newer HP86732A is synthesized. I don't know what to expect. The 10 MHz TTL output from my hamshack reference, a Wenzel GPSDO looks about like F2 for noise skirts. Too close to call whether the KiwiSDR clock or generators are responsible but pretty decent in either case.

The last shot is at F2-F1=400 kHz to try to examine SHI and even order distortion further. You may have noticed the (single) ~20MHz second harmonic term in the first screen grab. Perhaps that is real and from one of the generators.



At -104 dBm F2-F1 is 87 dB below total input power for an indicated SHI of -17 + 87 = +70 dBm, input referenced. The amplifier output is 20 dB higher so would be +90 dBm and can be compared to LTC specifications for the part. I have difficulty understanding since there are so many conditions. Schematic for the Kiwi which shows amplifier termination impedances, which appear to be important, is at KiwiSDR schematic.

The ESA with -7 dBm aggregate input says the distortion term is below -88 dBm, 81 dB below total power for at least a +74 dBm SHI. Again, this leads me toward thinking the Kiwi measurement may be OK.

In summary I guess I'm leaning toward calling this newest Kiwi:

> **TOI=+30 dBm**
>
> **SHI = +70 dBm**
>
> **Noise figure 17 dB**
>
> **Phase noise as good or better than the worst of my two generators.**
>
> **Amplitude accuracy for both signal and noise average power pretty good at least down to the 1 dB resolution of the current software.**
>
> **Pretty high SFDR, not studied but nothing big is obvious, e.g. the GPS clock at 16.358 MHz is just barely visible in the waterfall.**

Perhaps this KiwiSDR isn’t quite as good as my spectrum analyzer for measuring distortion but it is faster and very helpful in optimizing the preamplifiers. Since I intend to use the resulting active antenna with a KiwiSDR, it helps me set levels, dipole size, any filtering and other parameters optimumly.

I briefly measured my other KiwiSDR and found similar though not precisely equal values.

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