# Phase Noise Measurements of Some Synthesizers

Paul Wade W1GHZ ©2018, updated ©2019
w1ghz@arrl.net

At the 44th Eastern VHF/UHF/Microwave Conference in April 2018, I got a chance to measure phase noise of some of the newer microwave synthesizers. Few hams have test equipment capable of making phase noise measurements of good oscillators, so we must rely on test equipment at various VHF and Microwave conferences. The excellent equipment at this conference was provided by Greg Bonaguide, WA1VUG, of Rohde & Schwarz.

More recently, at the VHF Super Conference in April 2019, I tested a new synthesizer, as well as one of the best previous ones for comparison. Since Greg provided different Rohde & Schwarz test equipment, the results are presented separately.

A frequency synthesizer is an attractive way of generating a signal at a desired frequency, particularly since it has become very difficult to find quality crystals. A modern synthesizer may operate at a high enough frequency to provide the Local Oscillator for a microwave system, and the frequency may be locked to an accurate reference to provide frequency accuracy and stability.

## Phase Noise

However, the phase noise generated by almost all synthesizers is significantly worse than a good crystal oscillator. For very weak signals, my experiments[1] in 2009 suggest that the difference in Minimum Detectable Signal is about 2 dB, between a multiplied crystal oscillator LO and a synthesizer LO. On the other hand, 10 GHz MDS tests at the NEWS (North East Weak Signal group – www.newsvhf.com) picnic over several years suggest that knowing the frequency of a very weak signal can improve the MDS by up to 5 dB, when listening by ear. The addition of an SDR waterfall display eliminates the unknown frequency problem – all signals appear on the screen – so minimizing phase noise can help to hear very weak signals.

In 2012, I developed a locked VCXO[2] which can provide the source for a microwave LO with phase noise very nearly as good as a crystal oscillator and also be locked to a reference source to provide frequency accuracy and stability. This might be an ideal solution, but there are few choices for available VCXO frequency. As part of the development, phase noise comparisons were made with the synthesizers available at that time, shown in Figure 1. The bottom three curves clearly show how phase noise increase with frequency multiplication, whether done my a classic frequency multiplier or in a phase-locked loop. Since all the synthesizers are operating at 1152 MHz and are referenced from the same 10 MHz TCXO, any phase noise greater than the multiplied VCXO is additional noise generated by the synthesizer.

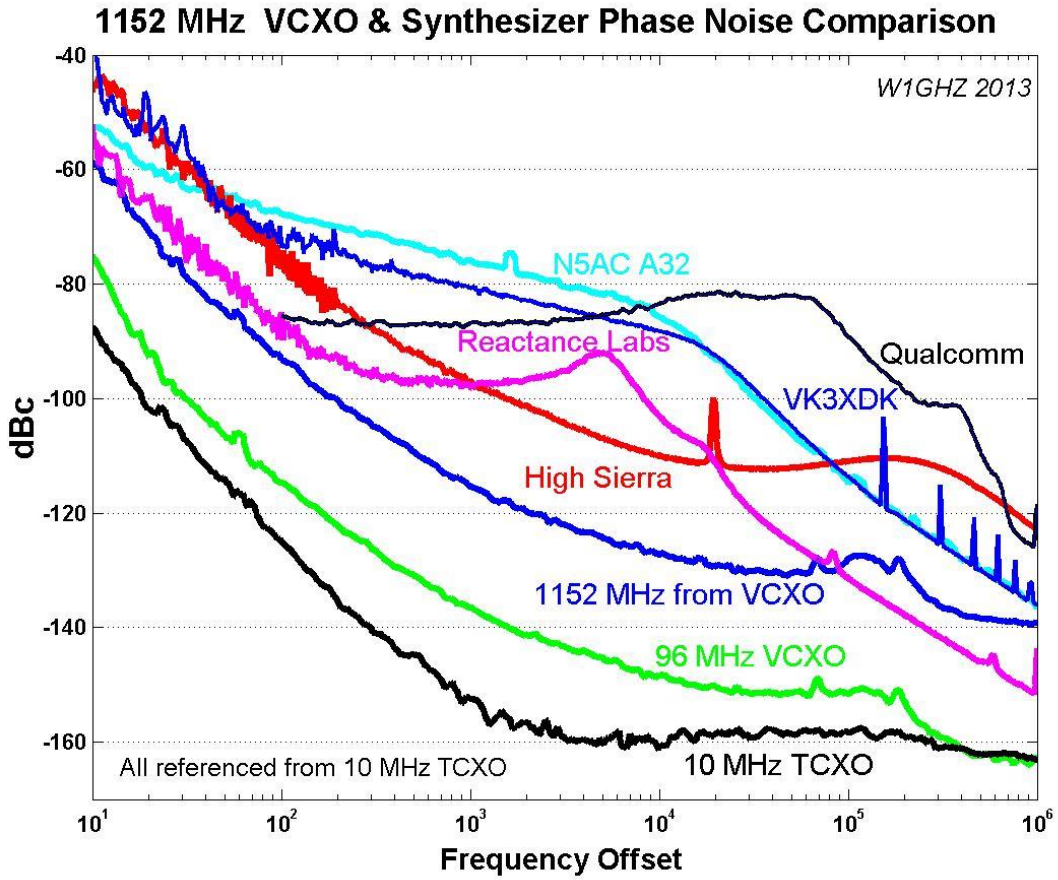



**Figure 1 - Synthesizer Phase Noise measurements from 2012 and 2013**

More recent synthesizers may have better phase noise characteristics than the N5AC A32 used for my 2009 experiments. Many of the synthesizers in Figure 1 are better, at least over part of the range of frequency offsets.

The measurements at the 44th Eastern VHF/UHF/Microwave Conference in April 2018 are shown in Figure 2. These were made with a Rohde & Schwarz FSW-43 analyzer. Where possible, synthesizers were referenced to a 10 MHz TCXO, the same unit as Figure 1. The VCXO system and several other synthesizers from Figure 1 are also included for comparison, including the N5AC A32. Some of the units were provided by conference attendees for a wider range of comparisons. Figure 3 includes a picture of each unit, and the Appendix provides more details.

Note that these are not definitive measurements, just what we able to accomplish during the lunch break at the conference. The measurements were made with 10X averaging, so they should be reasonably accurate. Better results might possibly be found with different programming of the synthesizer chips – for instance, for some New England beacons, W1EX found that an ADF4153 programmed for multiplication by four to 10368.320 or 10368.400 had fewer spurious outputs than at other nearby frequencies.

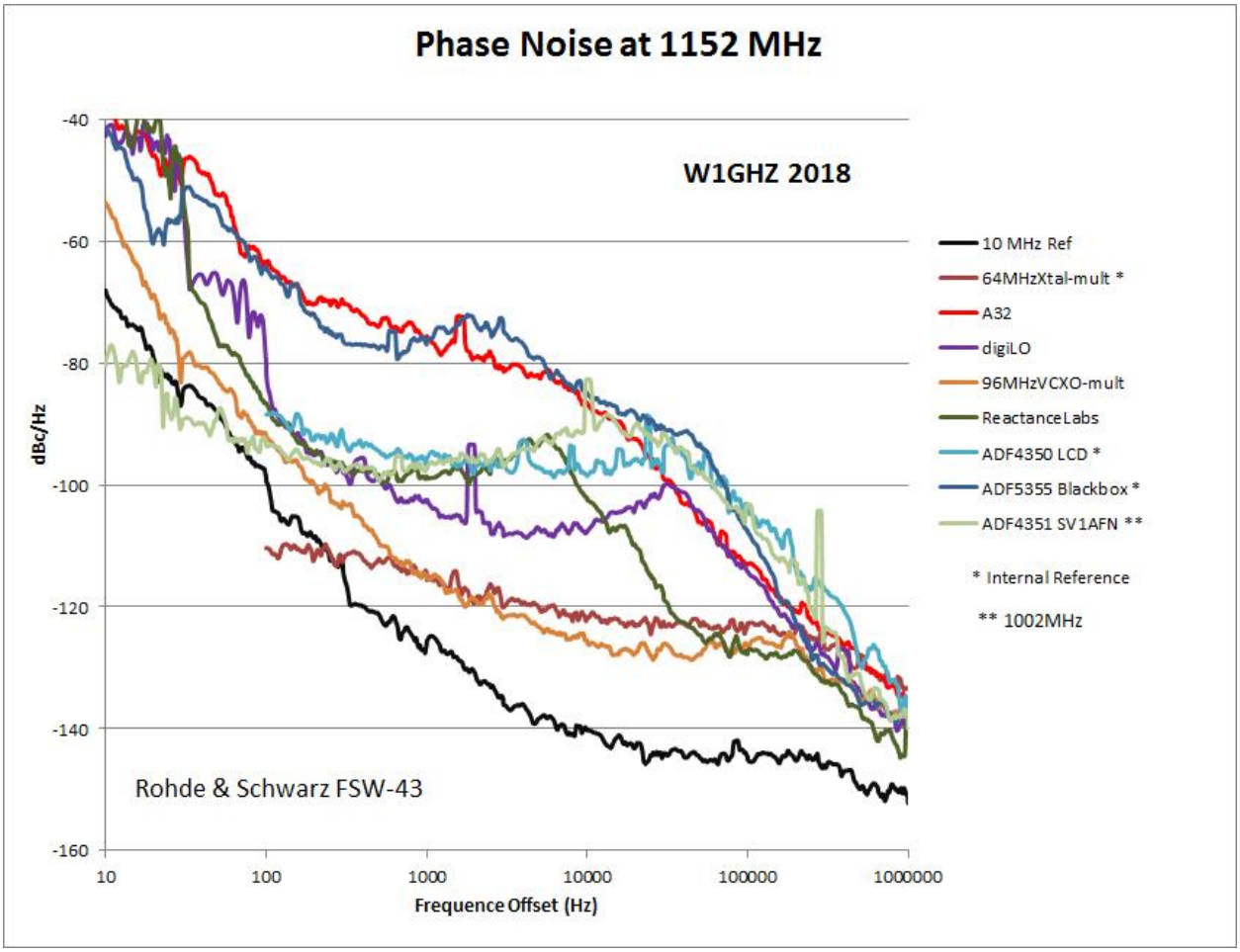


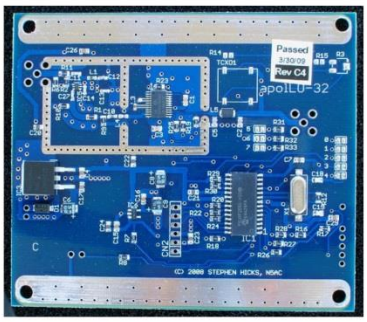

**Figure 2 – 1152 MHz Phase Noise measurements at 2018 Eastern VHF Conference**

Several of the newer synthesizers have pretty good performance. The digiLO from Q5 Signal (q5signal.com) has the best phase noise at 1152 MHz except for a spike at 2 KHz; it can be easily programmed with jumpers to popular ham frequencies from 23.5 MHz to 6 GHz.

A surprisingly good one is the ADF4350 with the LCD display and programming buttons[3], available from China on ebay, which goes up to 4 GHz. The buttons make it able to run standalone – with a USB battery, it makes a handy signal source.

And a good cost-effective one is the SV1AFN ADF4351 (www.sv1afn.com/adf4351m.html), which requires something like an Arduino for programming, to frequencies anywhere between 35 and 4400 MHz.

The ADF5355, available complete as shown or as a programmable board, operates up to 13.6 GHz. This one arrived just before the conference, so I didn't get a chance to check it out thoroughly.



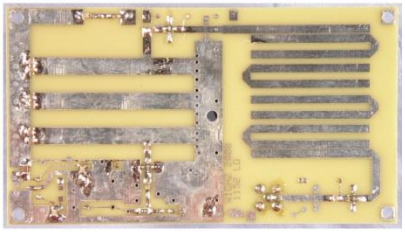

A32 - N5AC

digiLO
q5signal.com

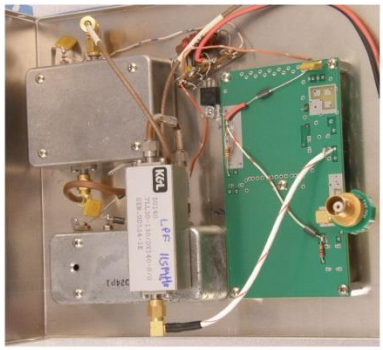

ADF4350


OLED digital ADF5355 54M-13.6...
ADF5355

1152 MHz
Sources



64 MHZ Oscillator & Multiplier



96 MHz VCXO & Multiplier


Reactance Labs


**Figure 3 – 1152 MHz sources measured in Figure 2**

## X-Band Synthesizers

Conference attendees also brought several synthesizers that work directly at X-band, good for 10 GHz or higher bands. The phase noise of these units is comparable to what we would expect from the other synthesizers after frequency multiplication. The 120 Hz spike on the ZL-PLL curves are hum from a crappy power supply – a clean power supply makes a difference.

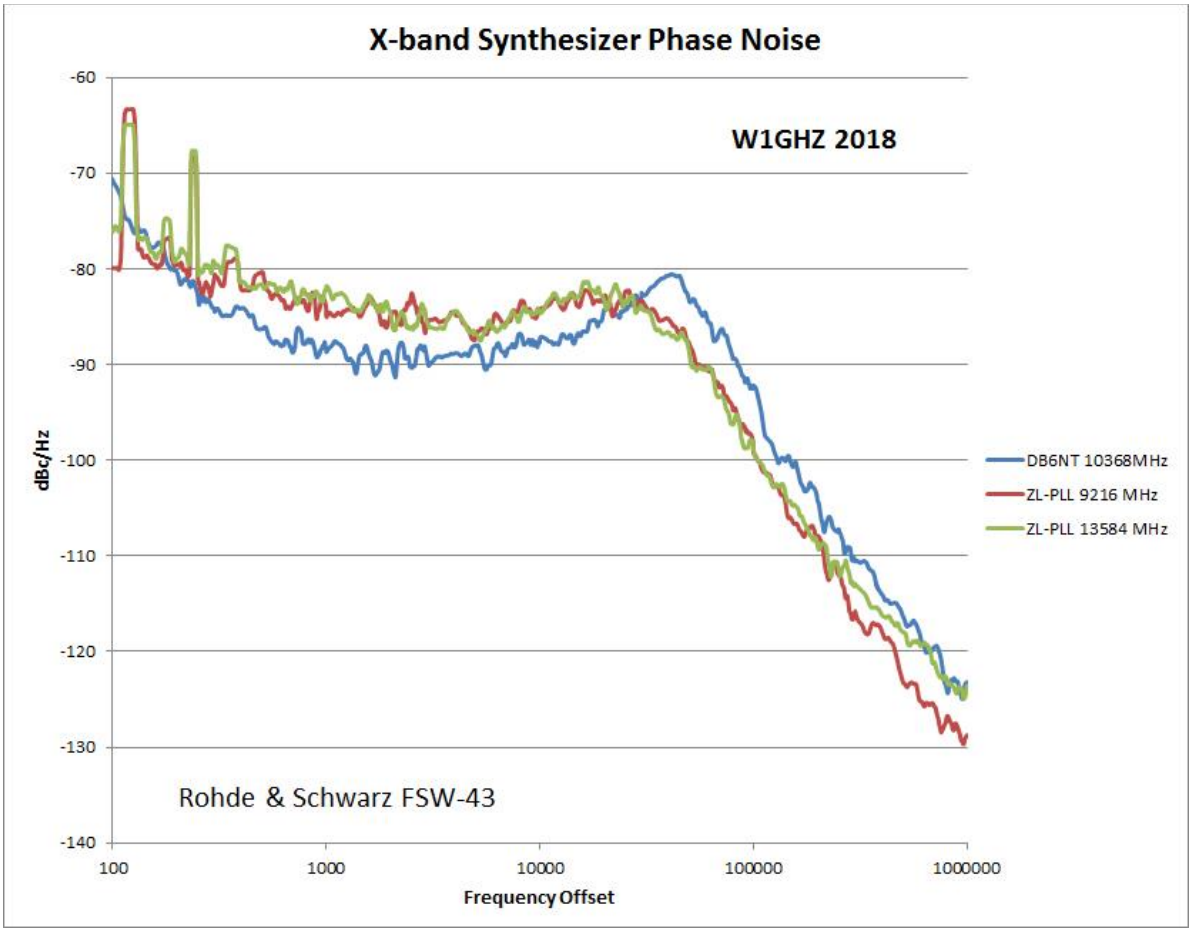



**Figure 4 – X-band Phase Noise measurements at 2018 Eastern VHF Conference**

DB6NT = MKU LO 8-13 (kuhne-electronic.de)
ZL-PLL = ZL-PLL 14G (zl2bkc.com)

## 2019 Measurements

Since the previous measurements, a new synthesizer has become available from VHFDesign.com, the **LO-PLL-USB-MAX2871-SHF-PCB**. This unit has attractive features: it is programmable from 1 to 6000 MHz, and includes a programmable beacon mode. The phase noise results at 1152 MHz are shown in Figure 5. Compared to the **DigiLO**, the best synthesizer measured so far, this unit is almost 20 dB worse, or comparable to some of the inexpensive synthesizers in Figures 2 and 3.

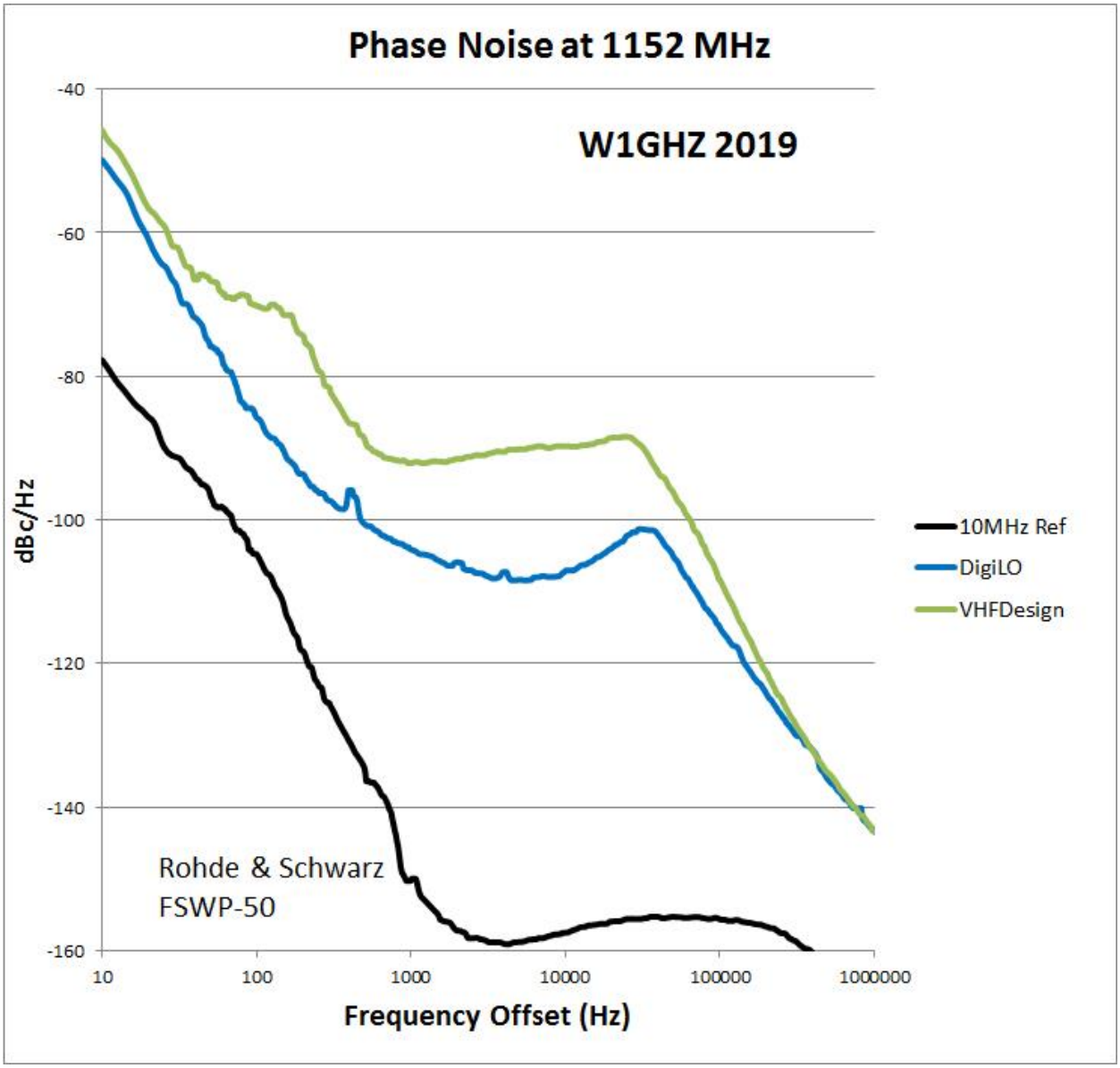



**Figure 5 - 1152 MHz Phase Noise measurements at 2019 VHF Super Conference**

**Notes:**

1. Paul Wade, W1GHZ, "Phase Noise and MDS," *Proceedings of Microwave Update 2009,* ARRL, 2009, pp. 193-196.
2. Paul Wade, W1GHZ, "A Flexible VCXO Locking Board," *Proceedings of Microwave Update 2012*, ARRL, 2012, pp. 101-113.
3. Paul Wade, W1GHZ, "Synthesized Signal Source From China," *44th Eastern VHF/UHF/Microwave Conference*, 2018.