Phase Noise measurements

Some concepts around phase noise measurements are difficult to understand.
I will do my best to explain them.

I will use the example of the Siglent SSA3021X Spectrum Analyser.
Its specification states its phase noise is -98dBc/Hz at 10 kHz spacing at 1 GHz carrier frequency

The SSA3021X Analyser uses a heterodyne type conversion system. It converts 0 -2.1 GHz up to a higher frequency. So that one VCO can cover the range. Its normally above the max frequency. Since the SSA3021X is also 3.2 GHz capable, the VCO is probably in the 3.5 to 6.7 GHz region.

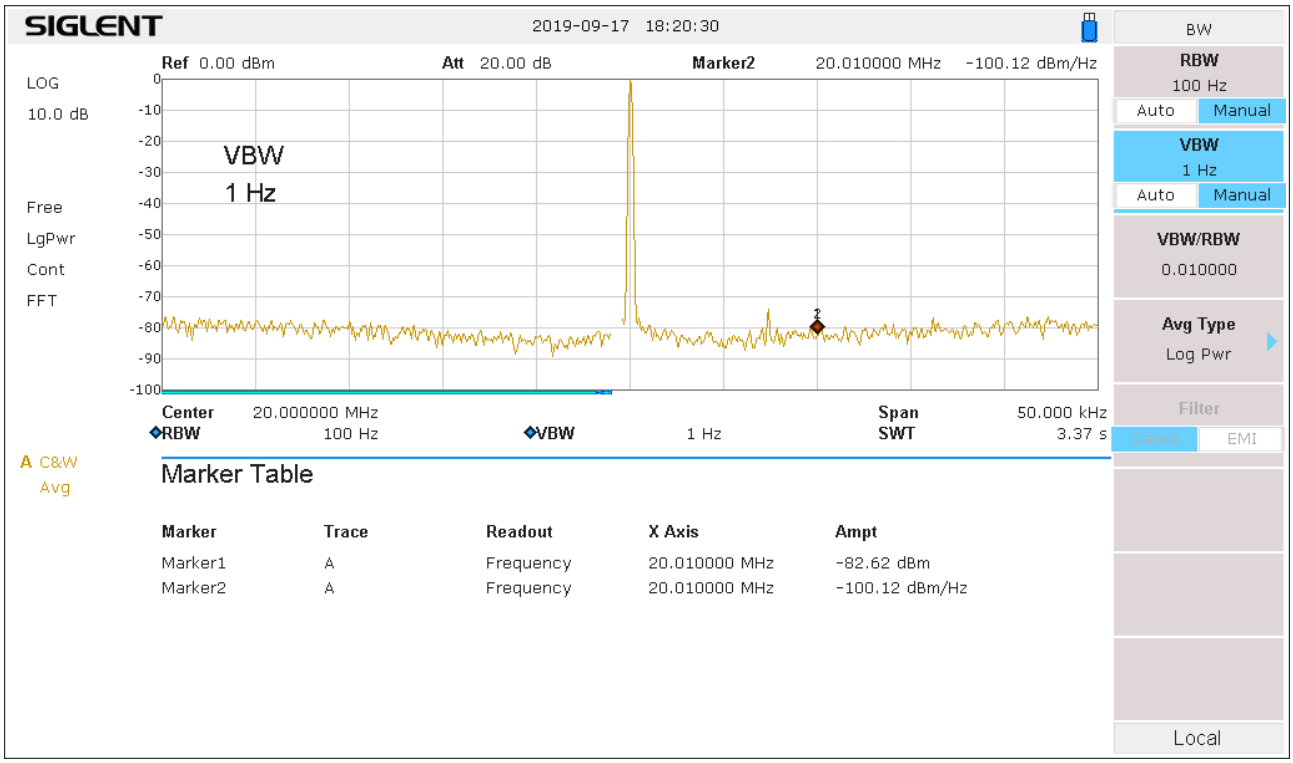
I would expect the VCO phase noise to be moderate at those frequencies, and this is reflected in the phase noise spec. I would also expect the noise to be fairly flat across the VCO Range (+/- 5dB). Although slighty noiser at top end, due to higher tuning volts on varicap

So a clean signal coming in whether its at 5 MHz or 2.1 GHz, will be mixed with the (moderately noisy) internal VCO, to produce a product which is processed by the SSA3021X architecture.

If I put a clean source into the SSA3021X, then what we see in a direct measurement of noise on the screen is essentially internal VCO noise...

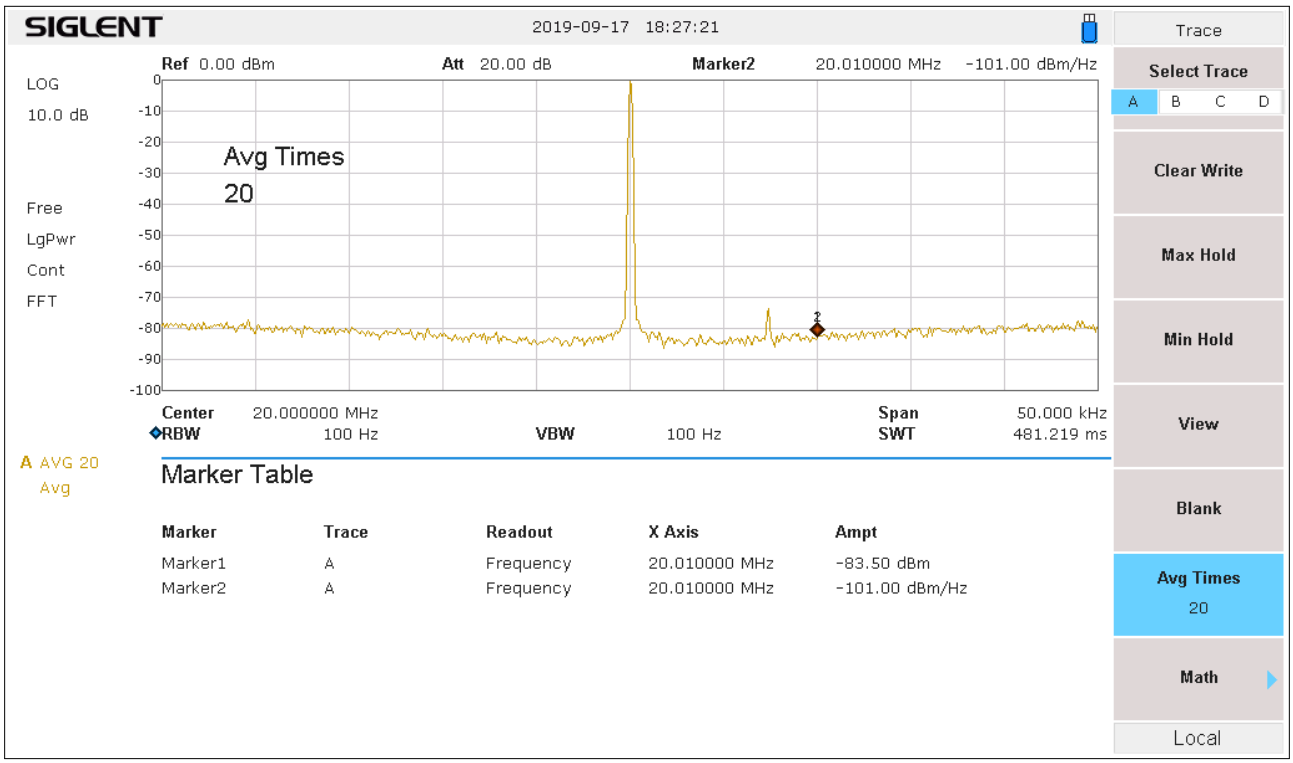
I will use QRPLABS VFO to produce a signal at 20 MHz, since its noise is much better than the SSA3021X phase noise.

I set the level of a external attenuator so that, the carrier was very close to 0 dBm. So that the dBm/Hz needed no correction since level was referenced to 0 dBm.



The plot is taken with 100 Hz Resolution bandwidth and 1Hz video bandwidth,
The 2 markers are set at the same point +10kHz from F centre.

Marker 1 is power taken at 100Hz resolution B/W. A reading of -82.6 dBm.
Marker 2 is referenced to dBm/Hz (-20 dB going from 100 to 1 Hz b/w)
and corrected for noise. (+2.5 dB) so reads as -100.12 dBm/Hz



The plot is taken with 100 Hz Resolution bandwidth and 100Hz video bandwidth, but with 20 trace averages. One can see the noise is fractionally quieter (0.9 dB), probably closer due to multiple averages, whereas the 1Hz video B/w sweep is the result of one sweep

The 2 markers are set at the same point +10kHz from F centre.

Marker 1 is power taken at 100Hz resolution B/W. A reading of -83.5 dBm.
Marker 2 is referenced to dBm/Hz (-20 dB going from 100 to 1 Hz b/w)
and corrected for noise. (+2.5 dB) so reads as -101 dBm/Hz

Again 17.5 dB difference between Mkr 1 and 2

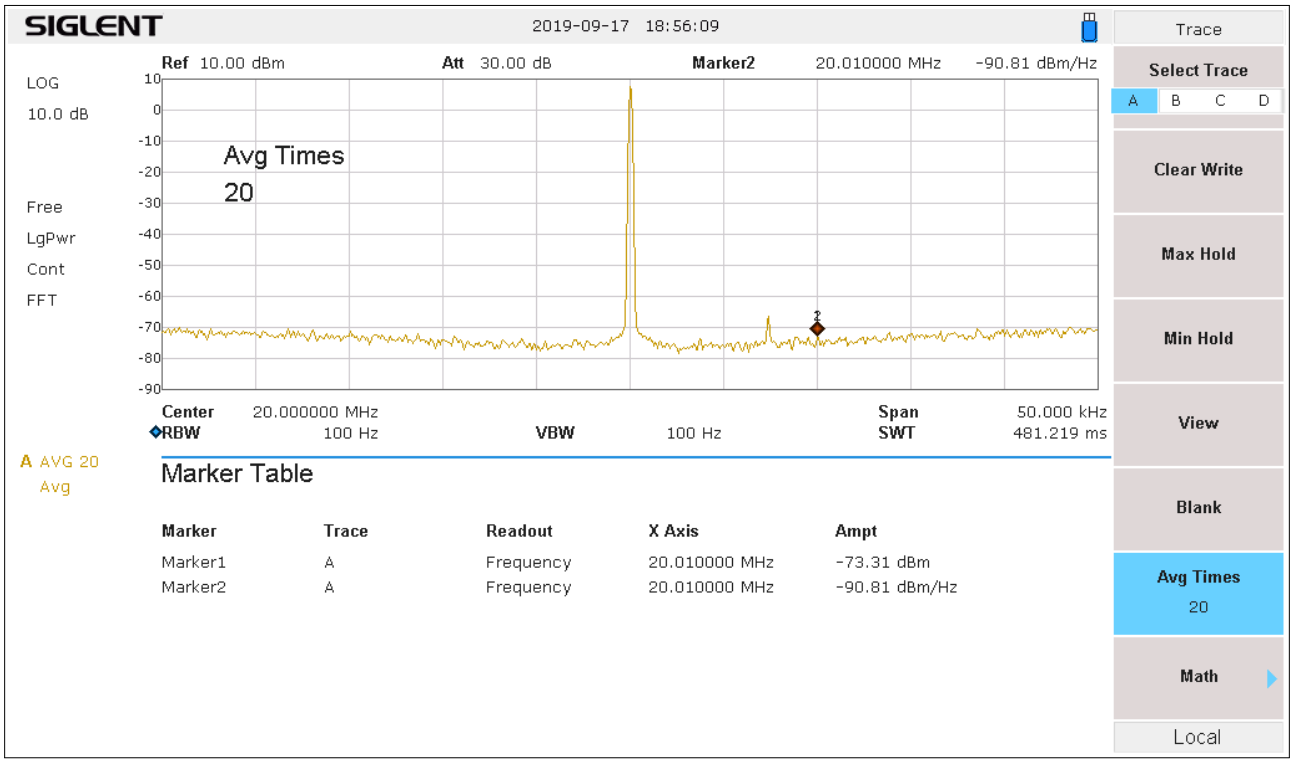
The result of these measurements is that the SSA3021x, meets its phase noise spec of -98dBc/Hz.
The marker is referenced to 0 dBm, so any difference in level must be corrected.

In the example below, I have increased the carrier level to about +10 dBm, so the difference relates to that. Subtracting the noise level from +10 dBm, gives a similar reading to the previous example

10 dB- (-73.3) gives 83.3dB difference, or close to 101 dbc/Hz

Unless one has a working Noise marker, I would subtract the 10 log BW (wrt 1 Hz) then add 2.5 dB
The 2.5 dB relates to difference between real world filters and noise filters, and also a correction due to log amps and how they react to carrier and noise

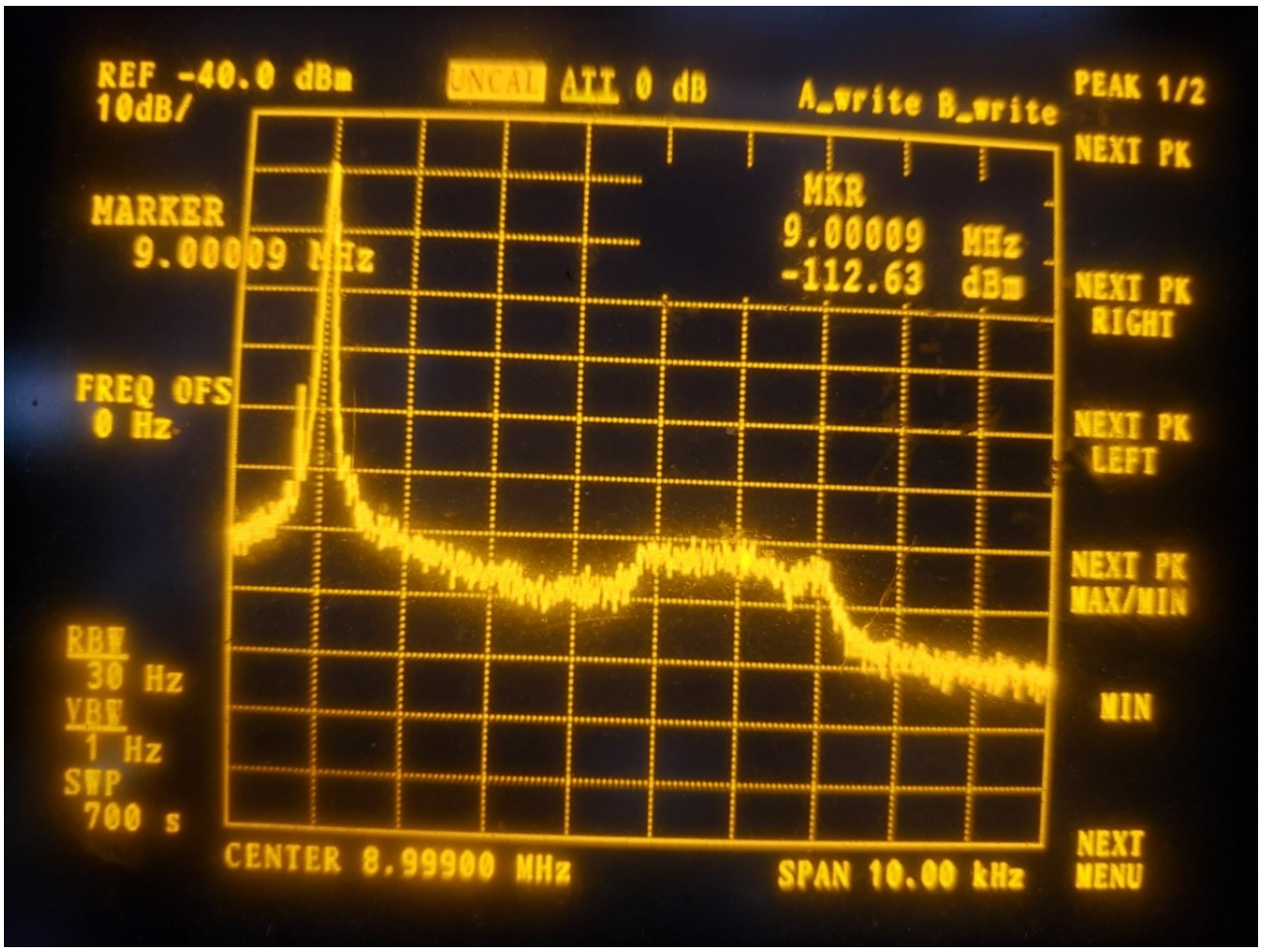
So for 100 Hz. The correction factor is 10 log (100) + 2.5 or 20-2.5 or 17.5 dB
For 30 Hz it is 12.3 dB (14.8- 2.5)



In the example below. You were running I think -7.5 dBm out of your filter into your operational RF amp which has +19 dB gain. So your carrier reference seen on your screen would be around +11.5 dBm (-7.5 +19)
At 5 kHz spacing from carrier it is -112.5 dBm (in a 30 Hz BW) See pic below.
You do not have the noise marker operational
Difference is -124 dB (in a 30 Hz B/w)
For 1 Hz BW it is -124 – 12.3 or -136.3 dBc/Hz (See 12.3dB correction)

My readings show -138 to -140 below carrier reference for similar spacing

It is a different item (QCX vs VFO) and different frequency 9 MHz vs 5.6 MHz (which is 20 log 9/5.6) or 4 dB greater.
Subtracting 4 dB from your reading of -136.3 gives -140.3 dBc/Hz...


REF -40.0 dBm
10dB/
UNCAL
ATT 0 dB
A_write B_write
PEAK 1/2
NEXT PK
MARKER
9.00009 MHz
MKR
9.00009 MHz
-112.63 dBm
NEXT PK RIGHT
FREQ OFS
0 Hz
NEXT PK LEFT
NEXT PK MAX/MIN
RBW
30 Hz
VBW
1 Hz
SWP
700 s
MIN
CENTER 8.99900 MHz
SPAN 10.00 kHz
NEXT MENU