How to add a power trace to the VNWA in spectrum analyzer mode

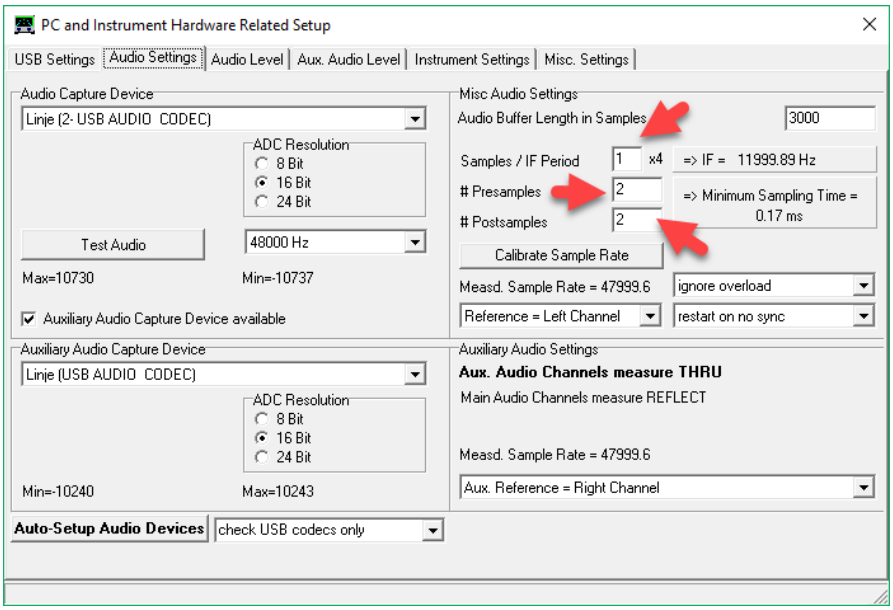
Preface:

By use of a custom trace it is possible to add a power trace, when running the VNWA in spectrum analyzer mode. By small trick and using external attenuators, you may display the power in both dBm as well as kW, W, mW or nW down to less than 10nW. Up to 50MHz my VNWA3E TX output is flat at -17dBm within + - 0.1dB, and more accurate than most available signal generators as digitally originated. A second VNWA3E I have is with -17.35dBm. The VNWA2 has also -17dBm output and I am convinced all VNWA's have very little deviation from e.g. -17.1dBm
Thus it can be used for sensitivity calibration of the VNWA in spectrum analyzer mode. The drop is 0.3 dB at 100MHz (-17.3dBm), 0.8dB at 145MHz (-17,8dBm) and 6.3dB at 435MHz(-23.3dBm) so for these HAM bands it is still possible, in a narrow frequency range around these frequencies, to use the VNWA TX out for calibration, as will be commented in the Appendix

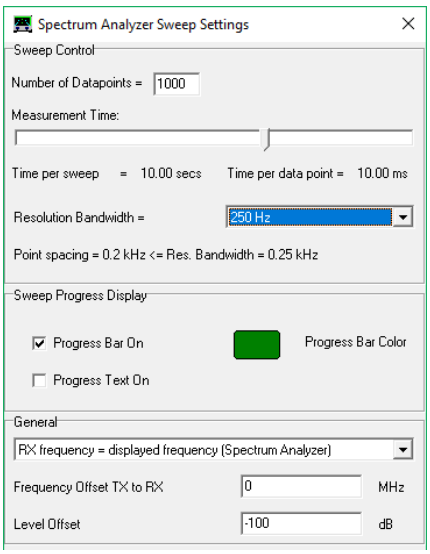
PLEASE NOTE the DDS multipliers are to be set to Auto x3 Auto for these levels and thus also compatible with the VNWA2. You may use 3xauto but then you have to measure yourself.

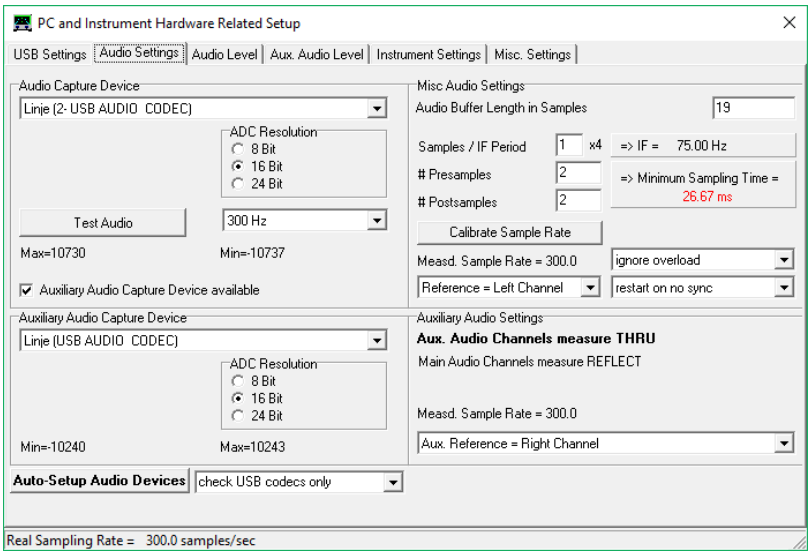
More on this subject in the Appendix.

These below shown methods are done with the new Audio Setup settings, as per spring 2017 where IF is changed from 1.2KHz to 12KHz. You may still use standard 1.2KHz, as it has no big impact on the Spectrum Analyzer Settings, as in the Sweep Settings these parameters is changed, as per what settings are chosen with respect to Resolution Bandwidth. These new settings are giving less noise and facilitate fast sweep at all times down to 0.17ms per point.

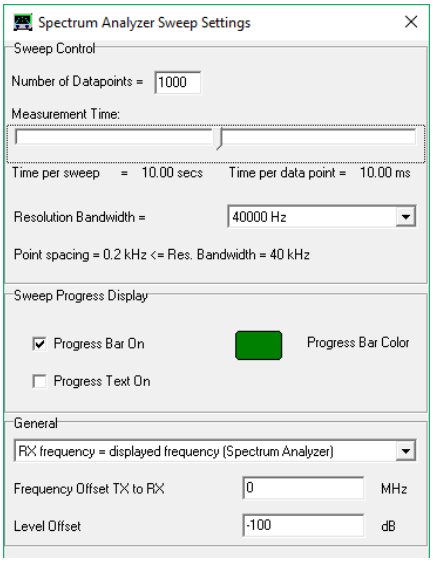


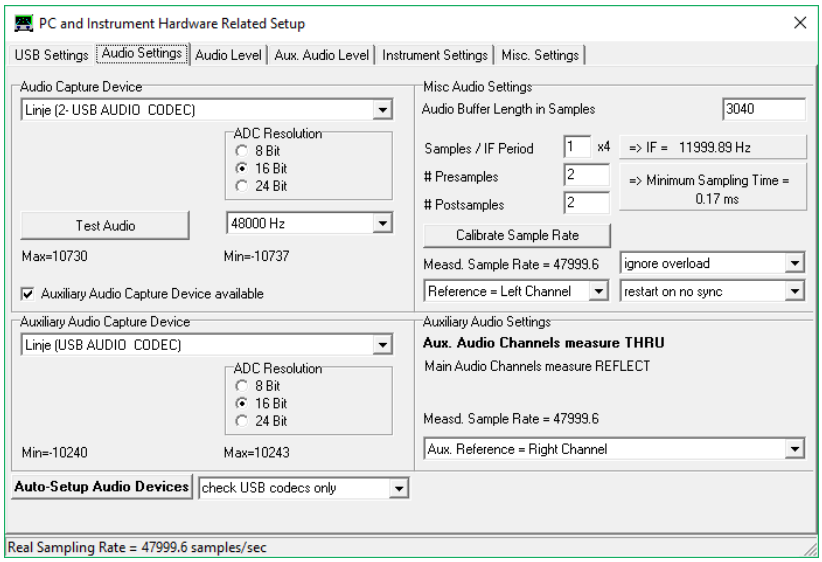
Below a Resolution Bandwidth of 250Hz (the smallest) chosen and the Audio Buffer length now only 19 samples, the IF = 75Hz and running with 300 samples per second





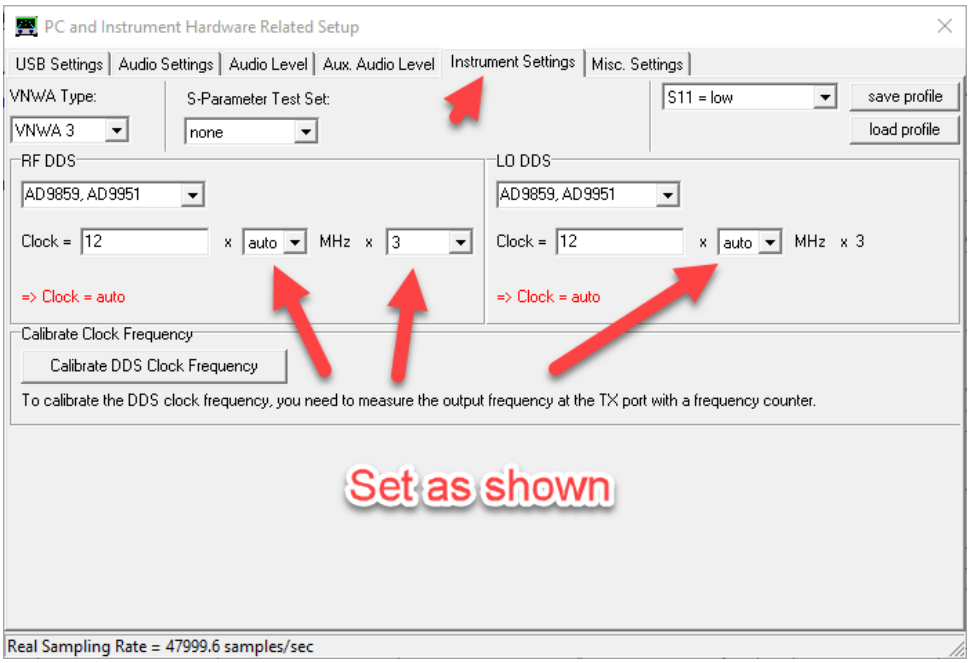
For a Resolution Bandwidth of 40KHz (the largest) then settings revert to default except the buffer changed to 3040 instead of 3000. Going back to VNWA mode this setting of buffer size maintained.



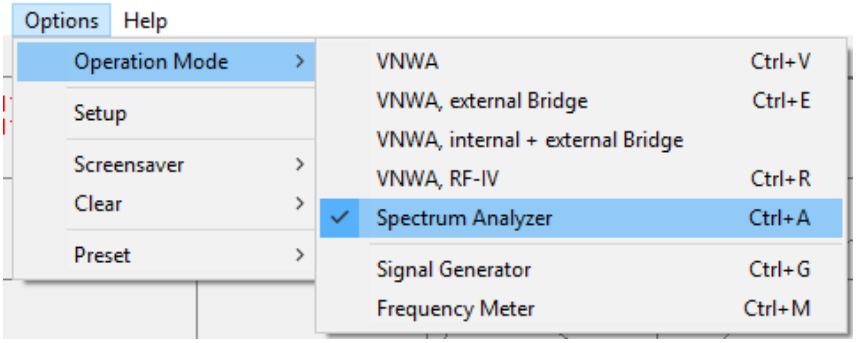


The calibration of the VNWA sensitivity

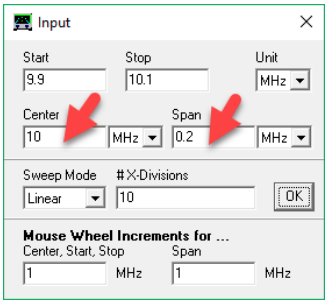
First of all select the “Options/Setup/Instrument Setting and set as shown below, maintaining compatibility with VNWA2 by choosing auto x3 auto multiplier settings.

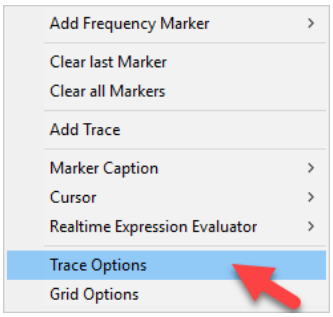


Next select Options/Operation Mode and select Spectrum Analyzer as shown below

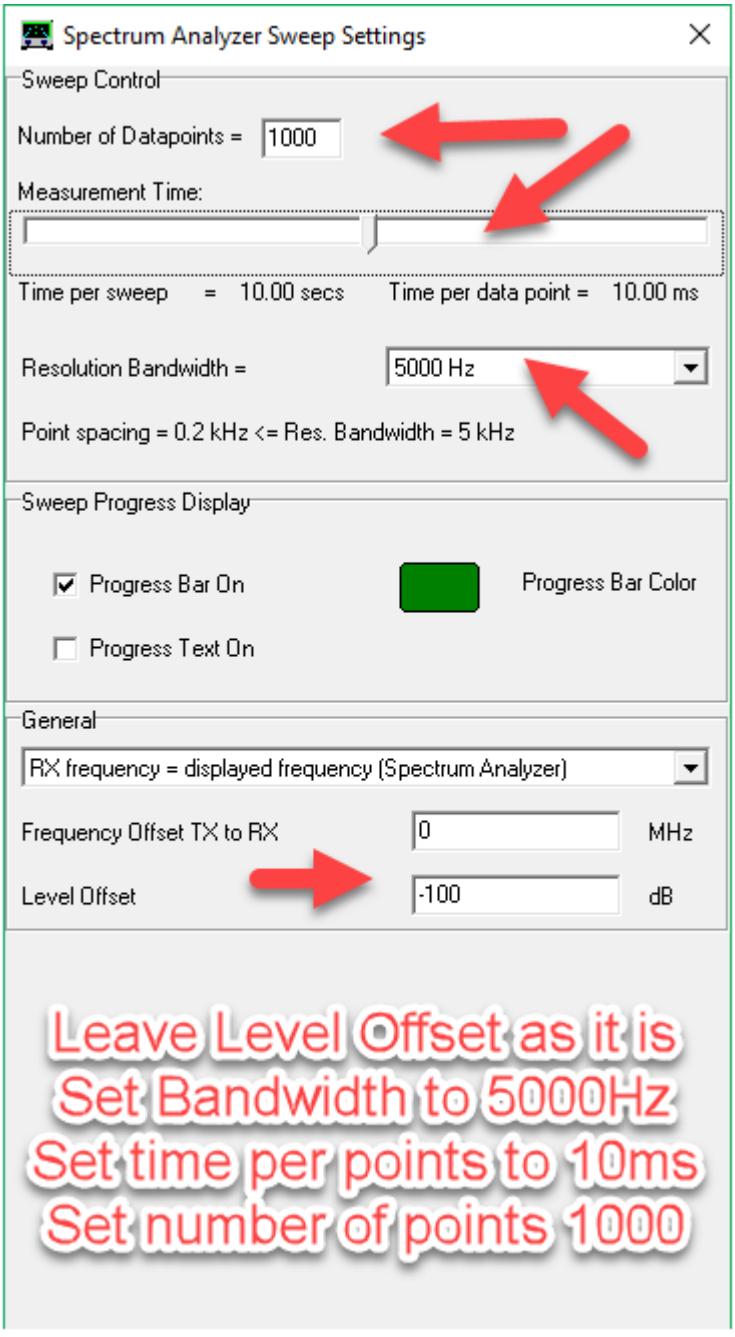


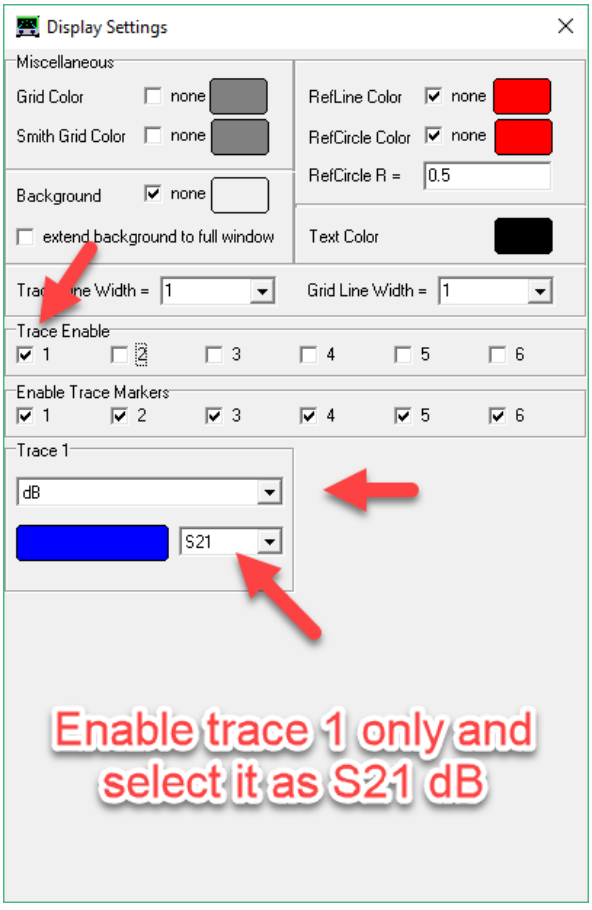
Next choose the frequency and span you want to investigate, here used 10MHz Span 0.2 MHz.
Next right click in window and choose Trace Options and see below on the left side what to do.





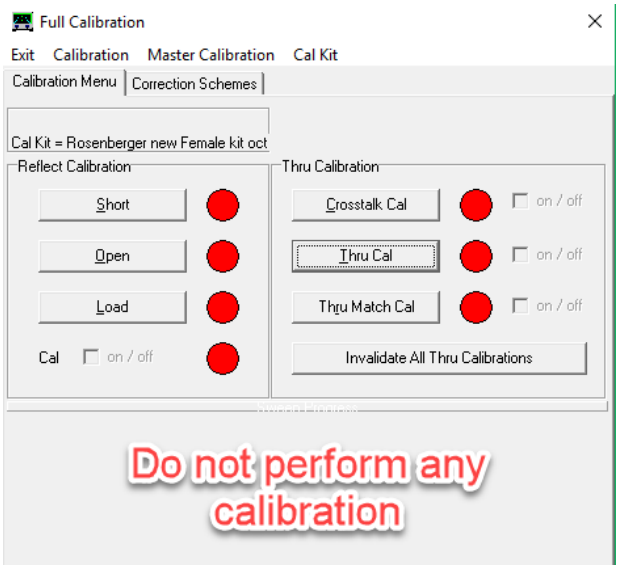
Beyond the Display Settings chose Settings/Sweep from the menu and select as shown to the right. This is just an example for the settings. Number of point, Measurement time and Resolution Bandwidth may vary considerable pending the purpose of the measurement to perform.



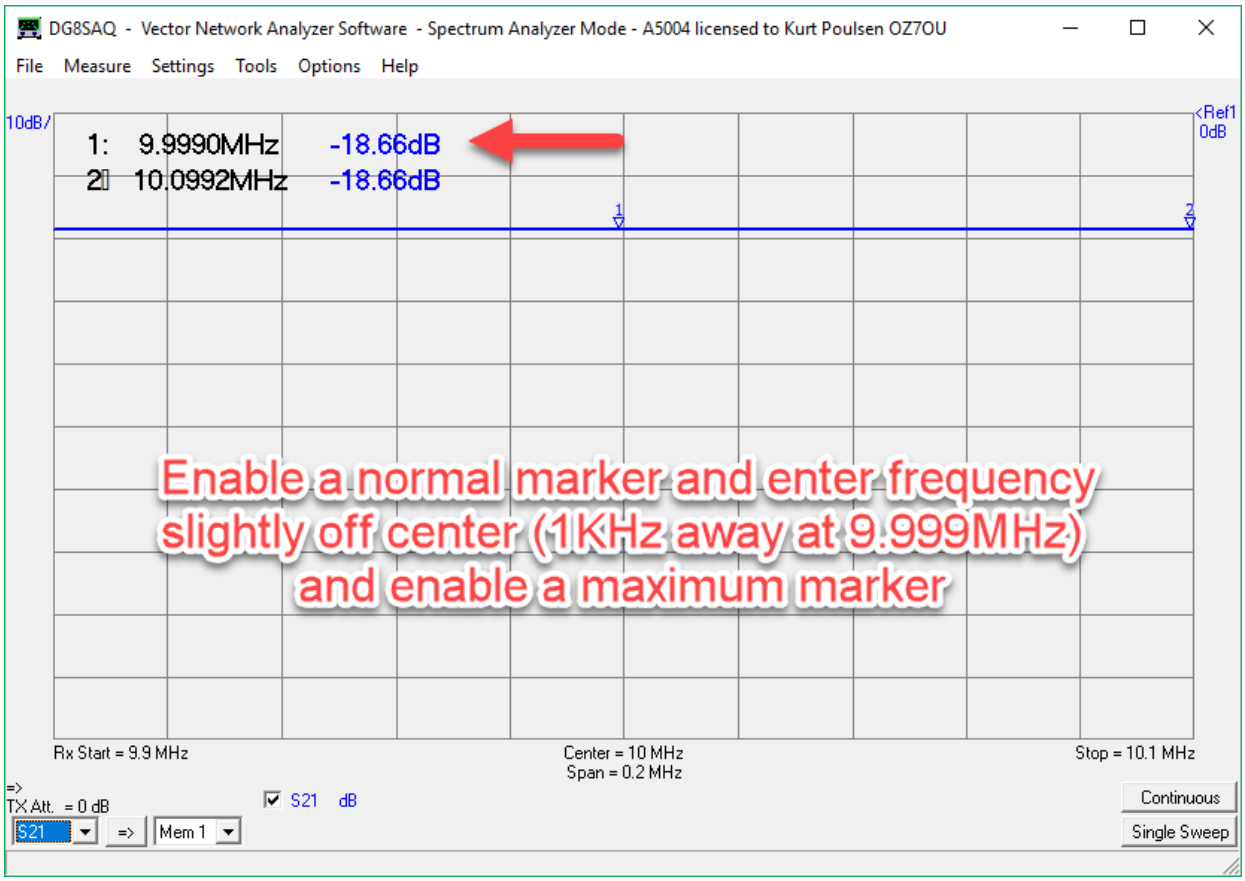


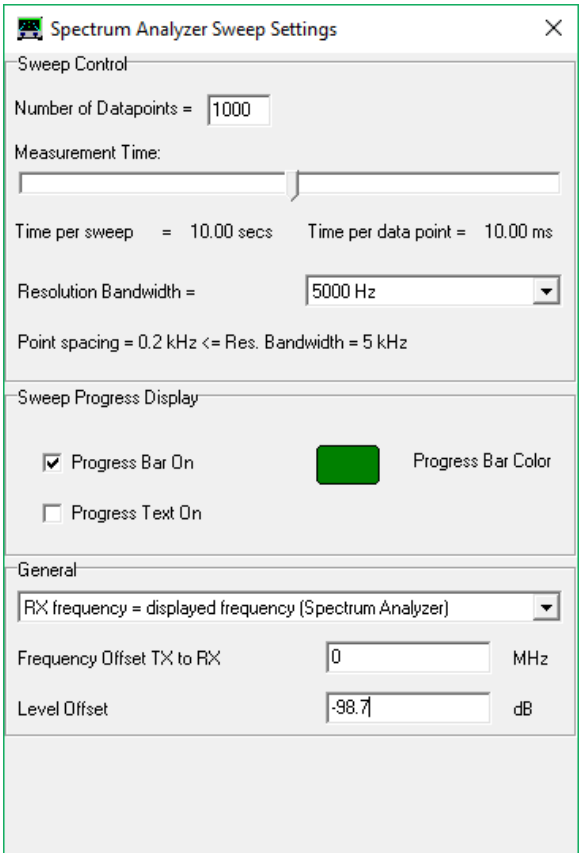
Next we must connect the TX port with the RX port with a short test cable.

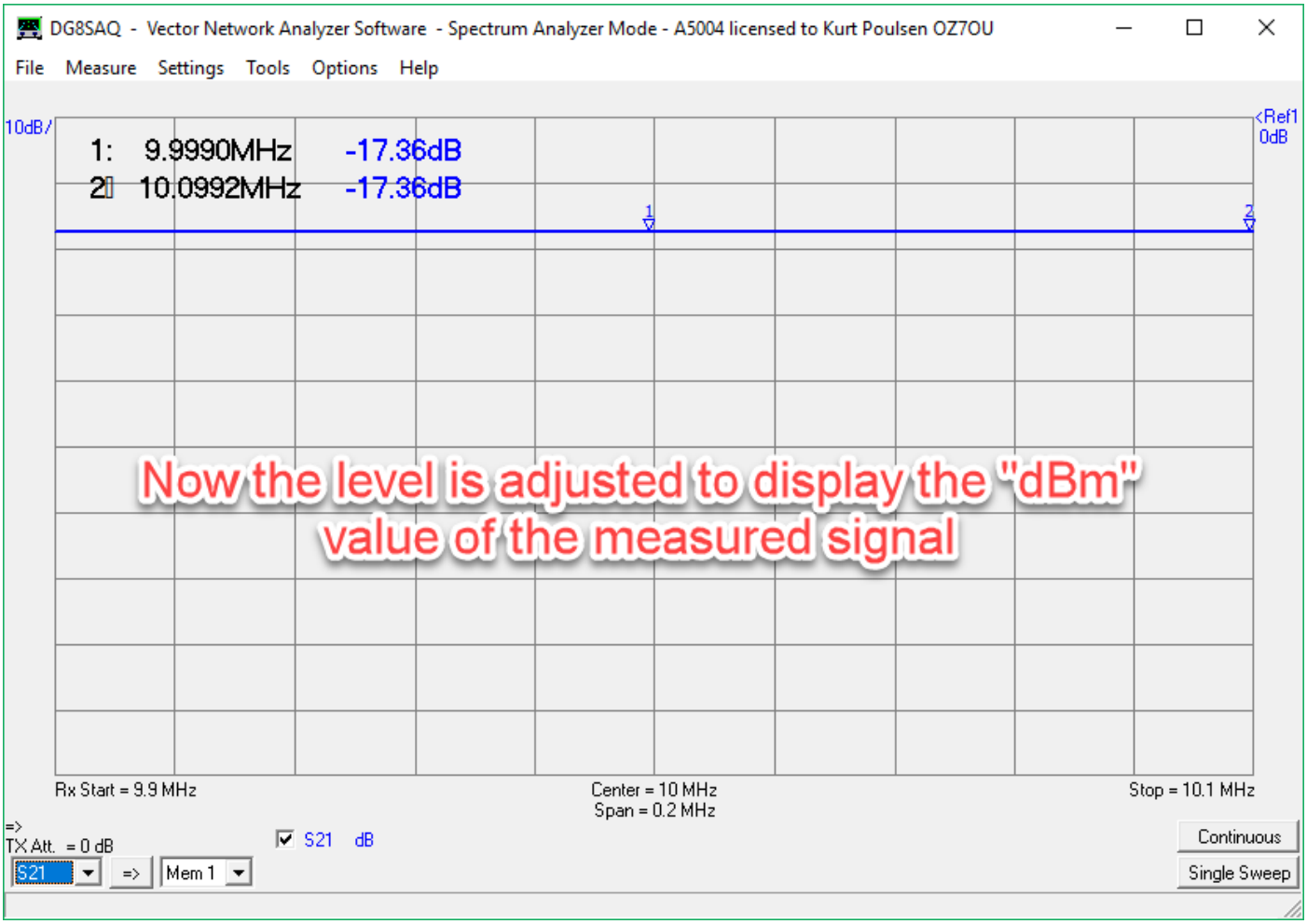
DO NOT PERFORM any kind of calibration and check it is disabled even master calibration

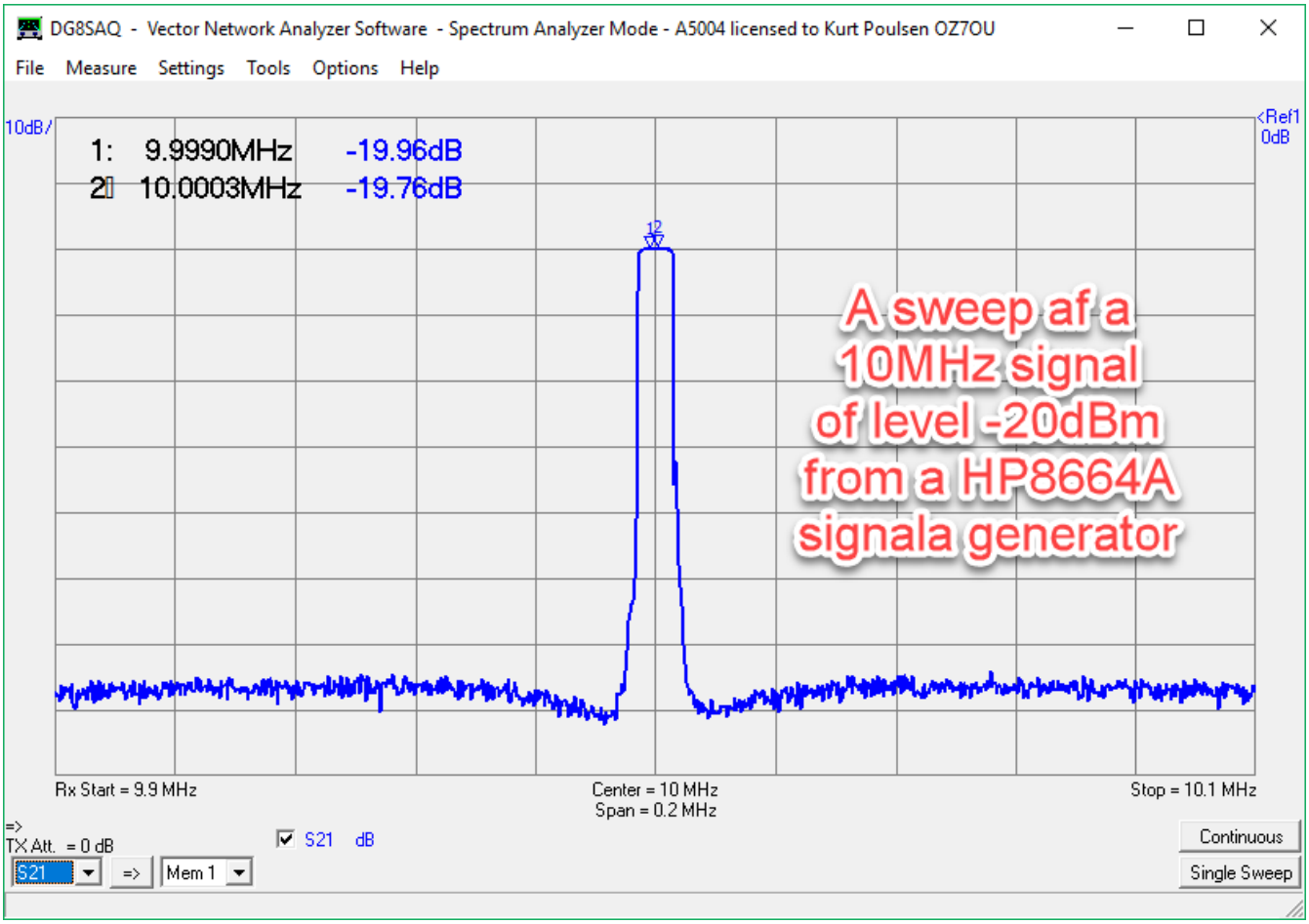


Now run a single sweep and observe the dB reading being close to the VNWA TX output of -17.35dBm for this particular VNWA3E measured by a HP4327B power meter. The difference is 1.31dB to be added to the Offset level of -100dB for the new value to be entered as - 98.7dB



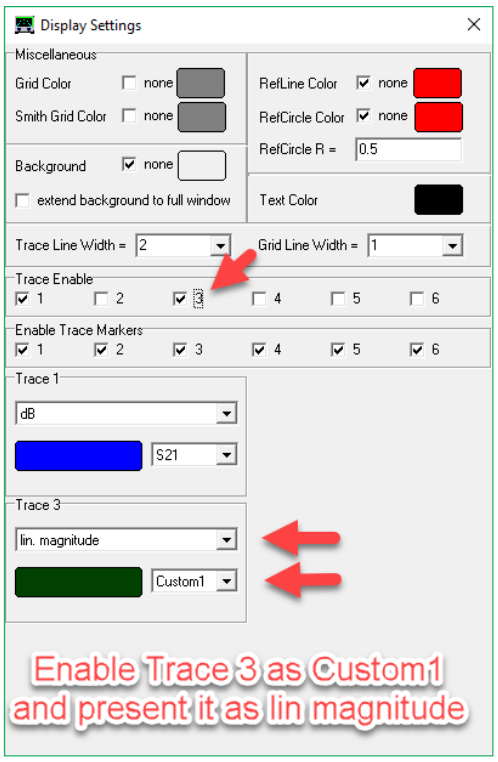

Spectrum Analyzer Sweep Settings
Sweep Control
Number of Datapoints = 1000
Measurement Time:
Time per sweep = 10.00 secs
Time per data point = 10.00 ms
Resolution Bandwidth = 5000 Hz
Point spacing = 0.2 kHz <= Res. Bandwidth = 5 kHz
Sweep Progress Display
Progress Bar On
Progress Bar Color
Progress Text On
General
RX frequency = displayed frequency (Spectrum Analyzer)
Frequency Offset TX to RX 0 MHz
Level Offset -98.7 dB


DG8SAQ - Vector Network Analyzer Software - Spectrum Analyzer Mode - A5004 licensed to Kurt Poulsen OZ7OU
File Measure Settings Tools Options Help
10dB/
<Ref1
0dB
1: 9.9990MHz -17.36dB
2 10.0992MHz -17.36dB
Now the level is adjusted to display the "dBm" value of the measured signal
Rx Start = 9.9 MHz
Center = 10 MHz
Span = 0.2 MHz
Stop = 10.1 MHz
=>
TX Att. = 0 dB
S21 dB
S21
=>
Mem 1
Continuous
Single Sweep

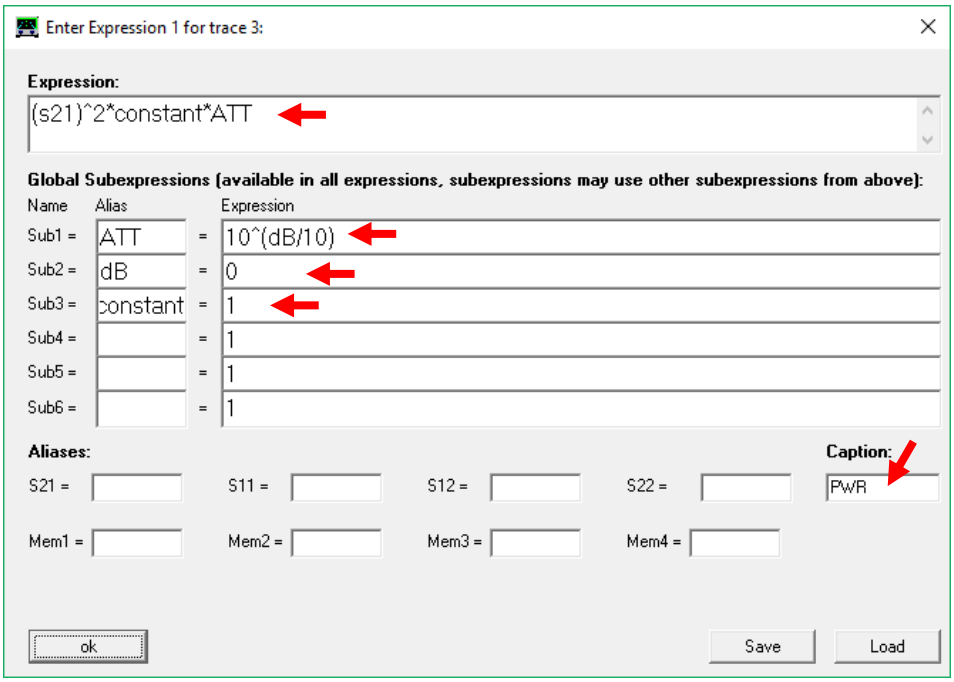


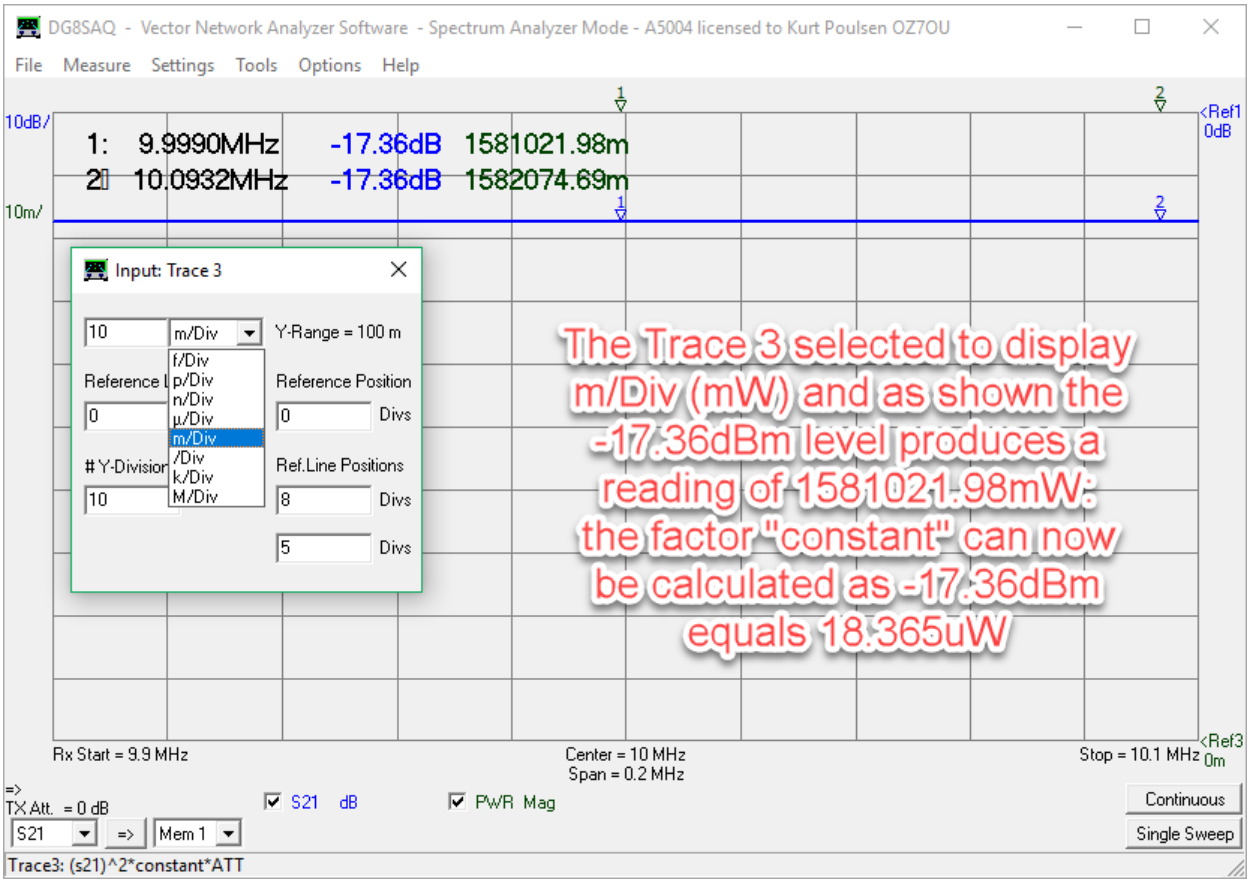
Next topic is to create a custom trace which displays the Power Level of the measured signal.

You may use the TX output or a signal generator but in any case the Resolution Bandwidth must not be chosen too high, as the top must be flat and e.g. 40KHz does have “slanted” top, and thus measuring a lower value when TX out signal used for calibration, and when an accurate signal generator is not available. 5KHz ideal for the span used in this example. See later on this matter where all available resolution bandwidth shown with history trace (Storage Screen) enabled. Actually this is not a problem when using an external signal generator when setting of Level Offset.

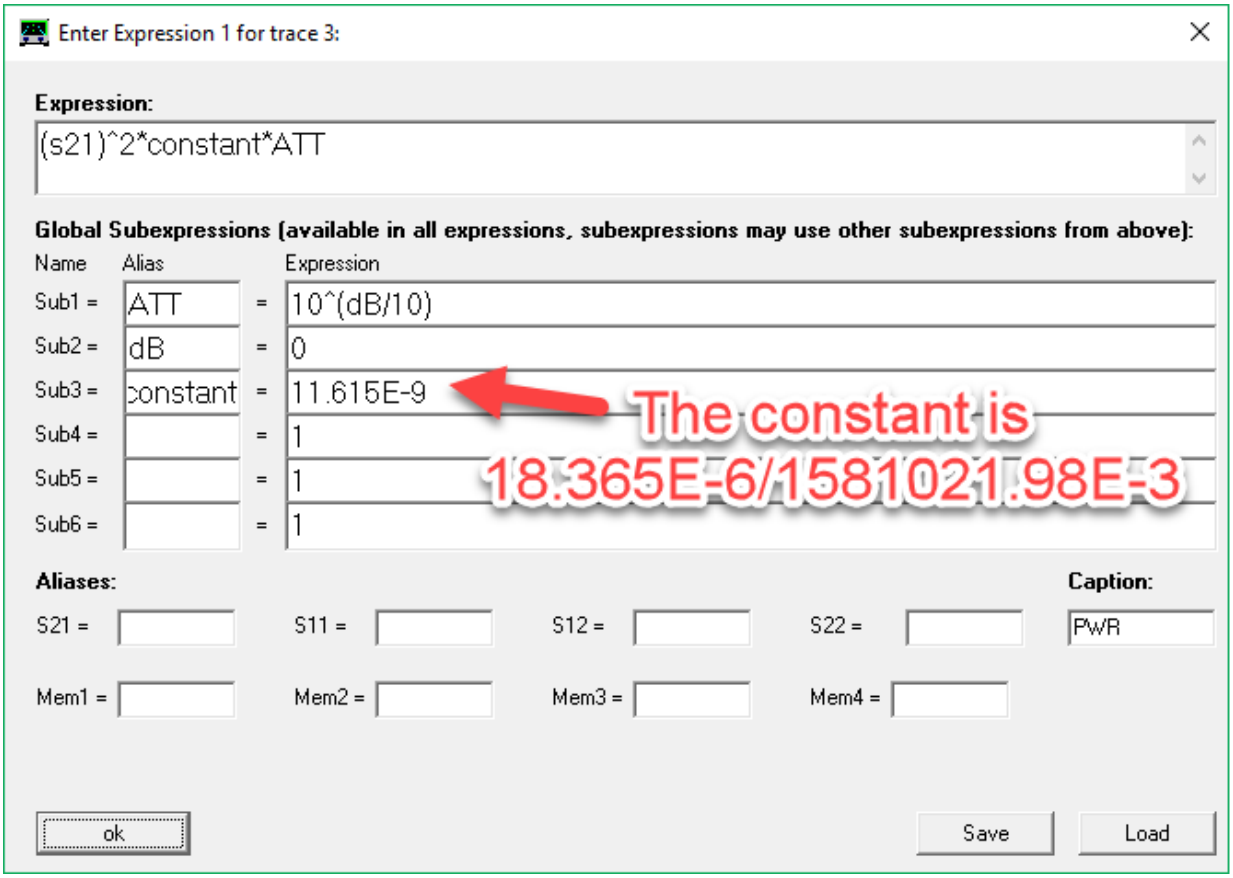


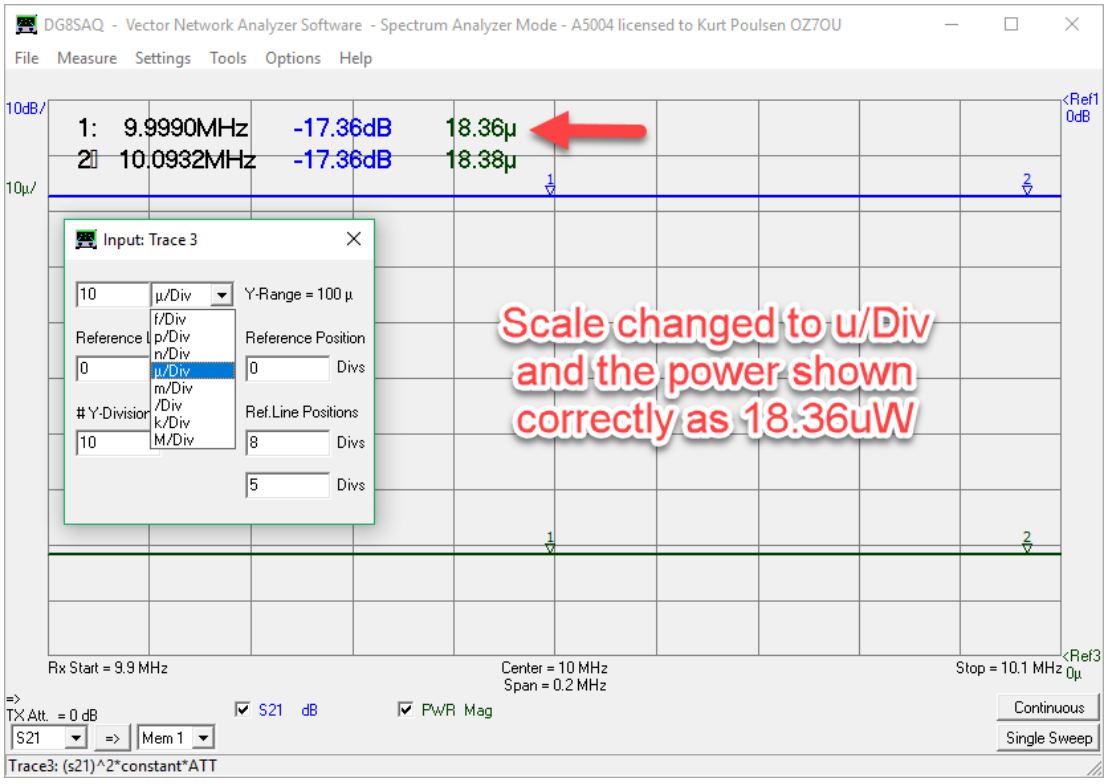
Double click on the new Custom Trace and change the caption to **PWR** so the Custom Trace is named, and enter the formulas as shown. As we are dealing with power S21 must be squared (s21)^2 and multiplied by a "**constant**" so the power of the signal can be presented as KW, W, mW, nW or pW. The constant set to **1** as a start. Any attenuator place in front of the RX port can be entered in Sub2 with the dB value, initially entered as **0 dB** and the factor **ATT** calculated in Sub1 as 10dB is attenuating power with a factor of 10.





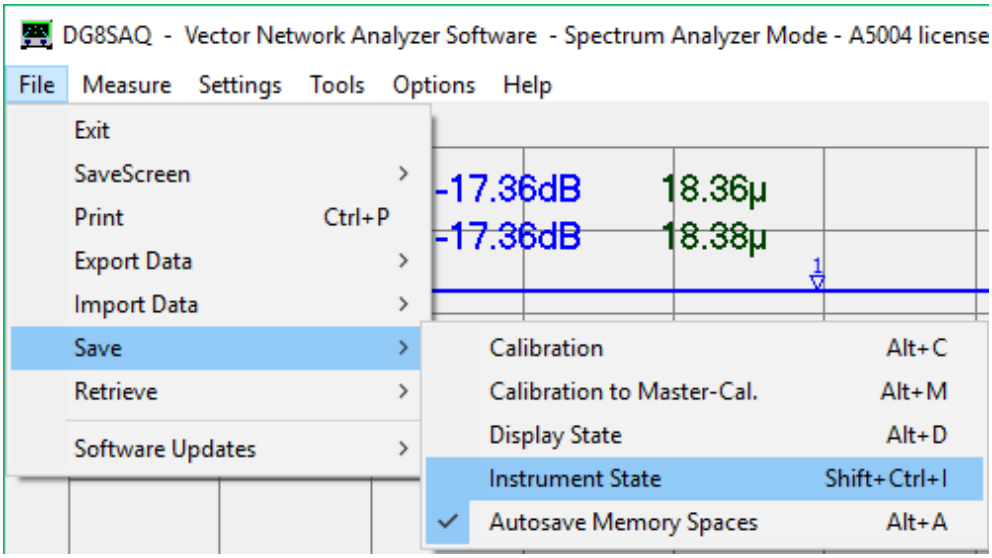
Use this link for calculation of power from dBm values
http://rapidtables.com/convert/power/dBm_to_mW.htm

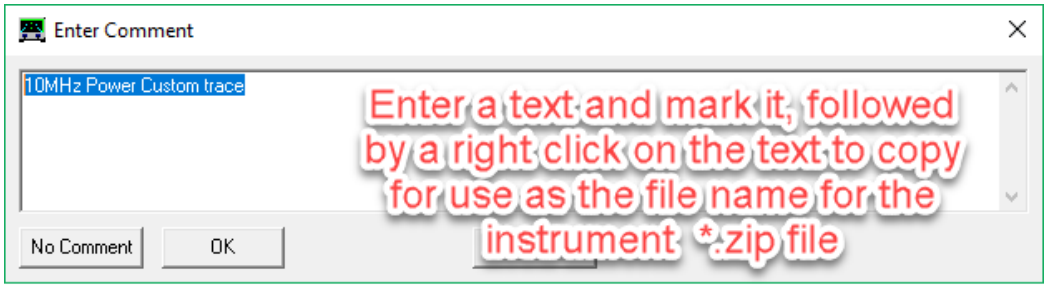


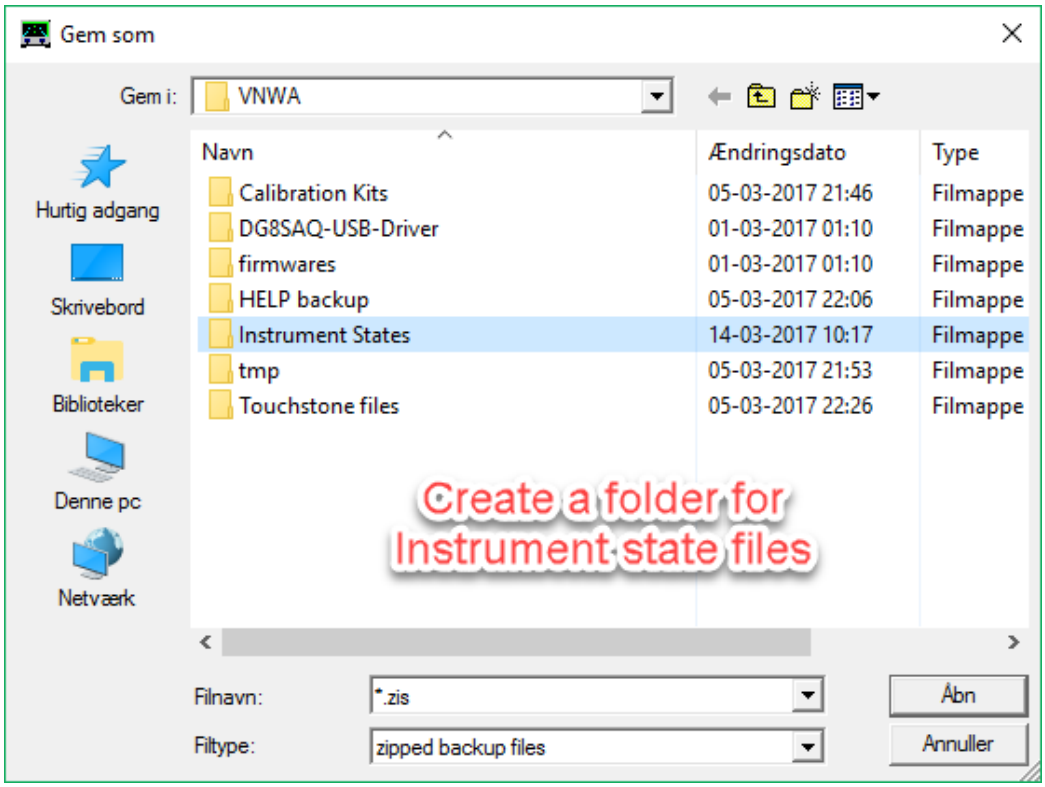


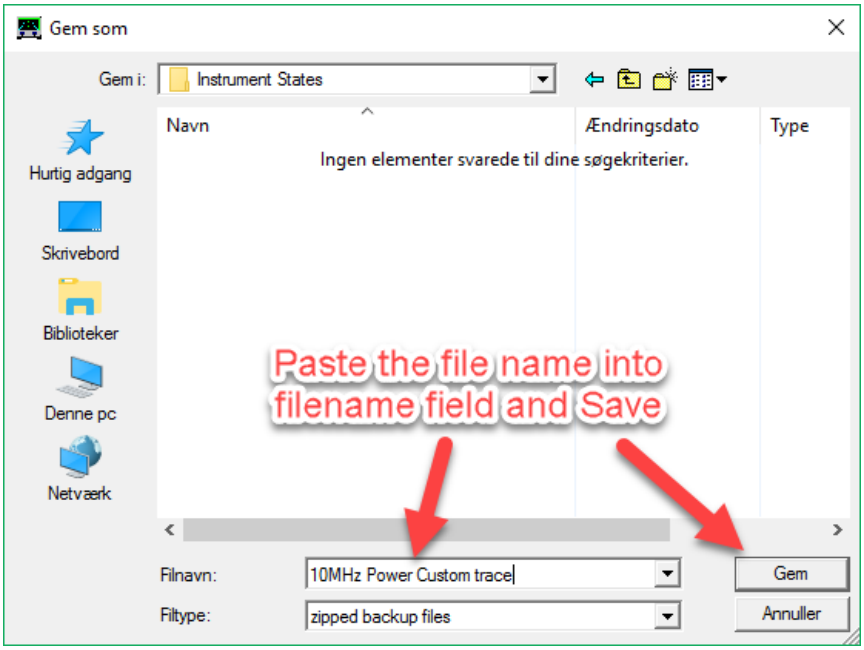
That concludes the calibration of the VNWA sensitivity settings and custom trace creation and calibration

To measure higher power level than the VNWA TX out it is required to use attenuator in front of the RX port. The attenuation can be inserted in the PWR custom trace. VNWA is a precision instrument, which very accurate can measure the exact attenuation, so next we will do so, but before we do it, a really good idea is to save the setup saved in an instrument state file before we revert to standard VNWA mode. Then after we have measured the exact attenuation we quickly can revert back to the SA mode, by retrieving the instrument state file saved.

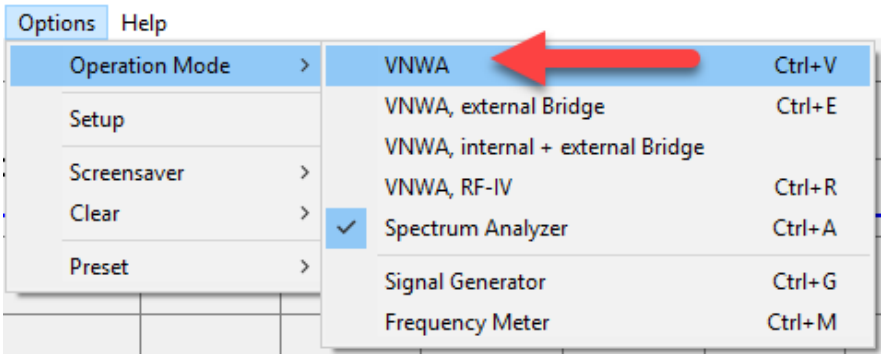




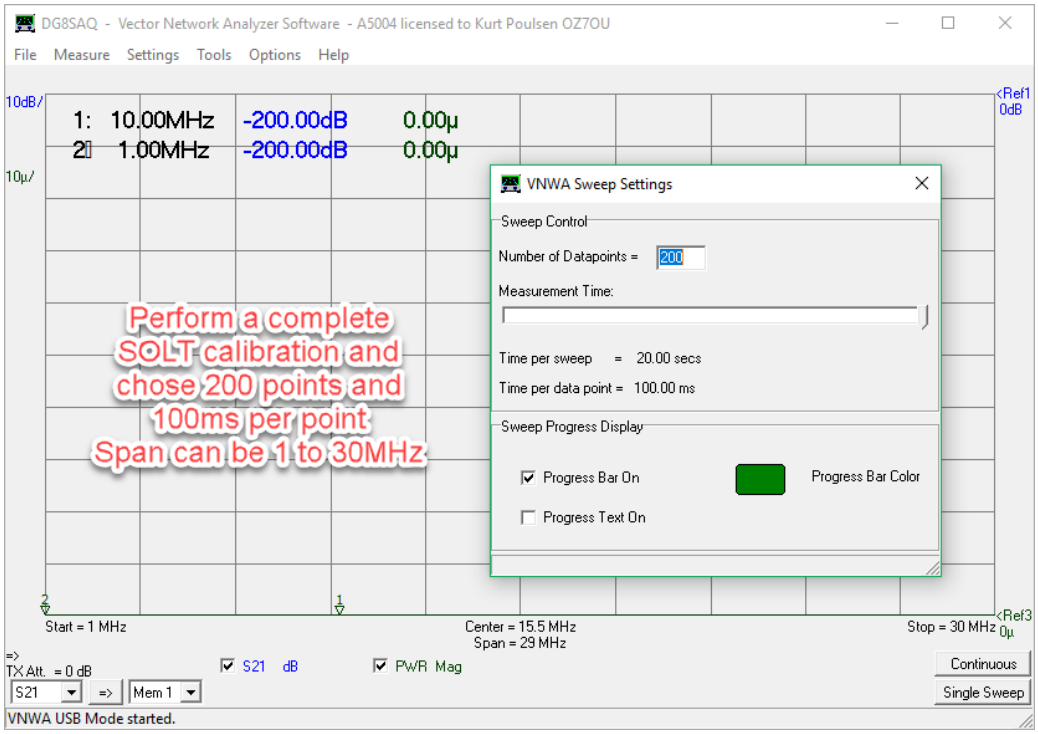


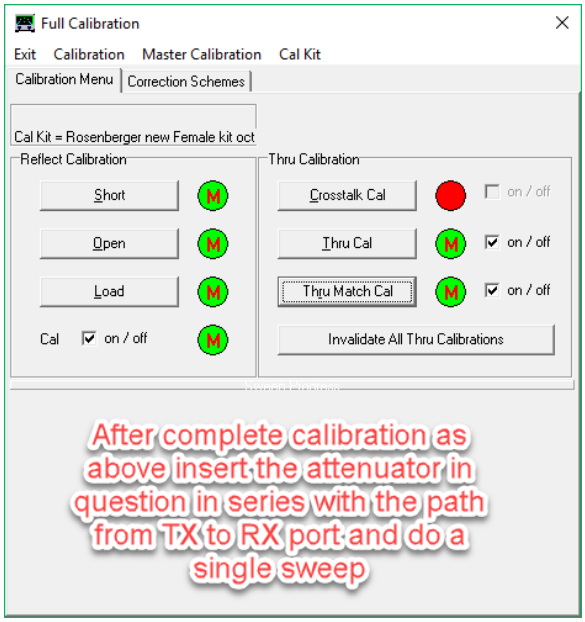


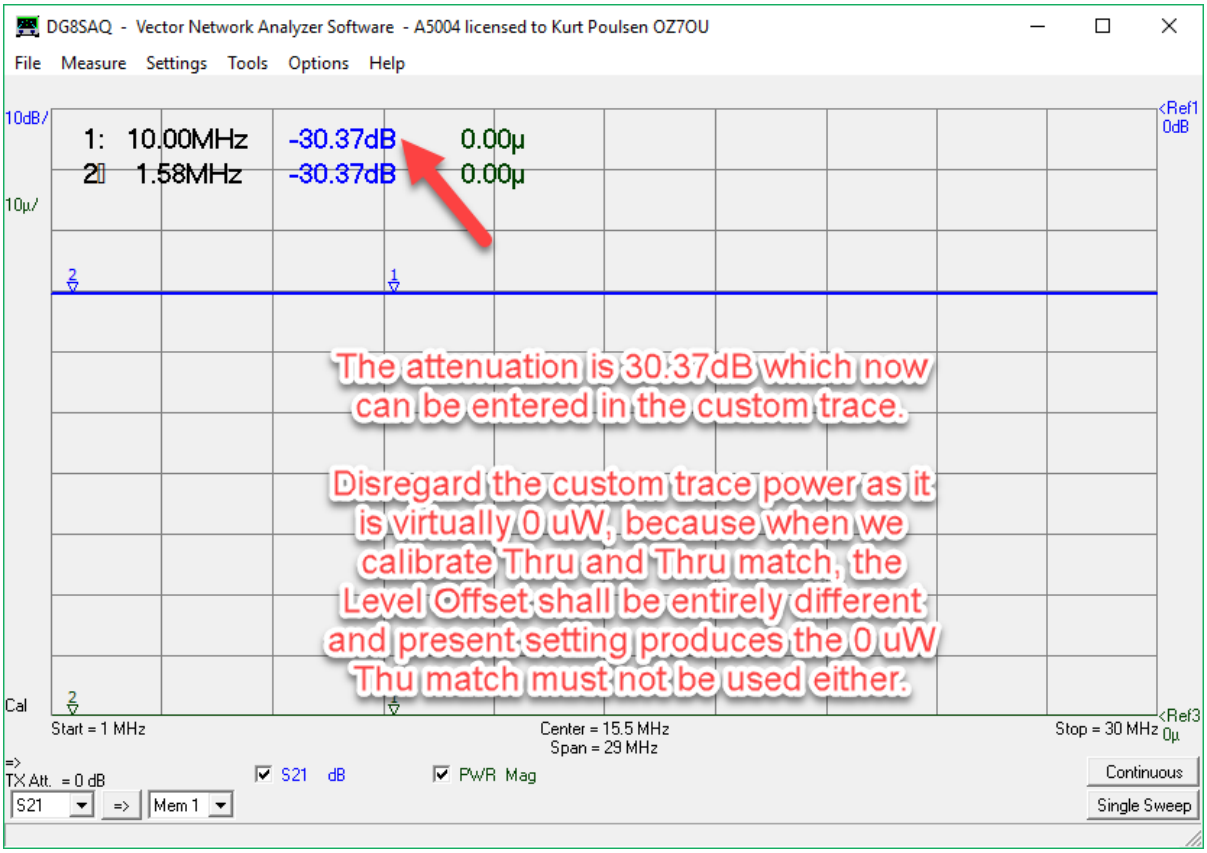
Now revert to standard VNWA Instrument mode



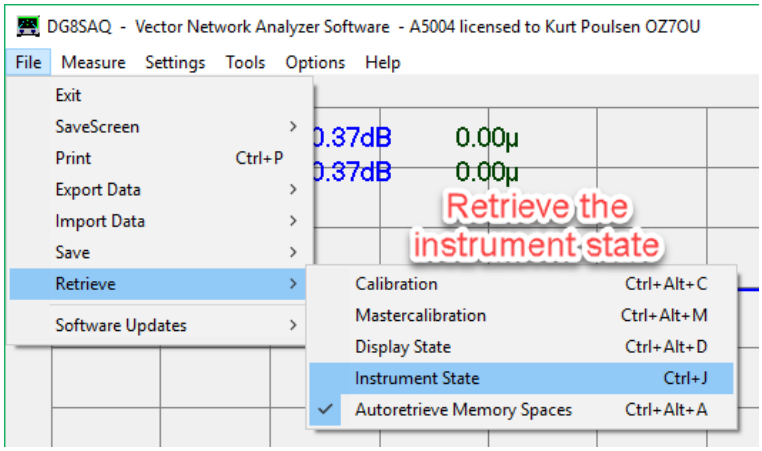
Next perform a complete SOLT calibration after a Sweep Setting done

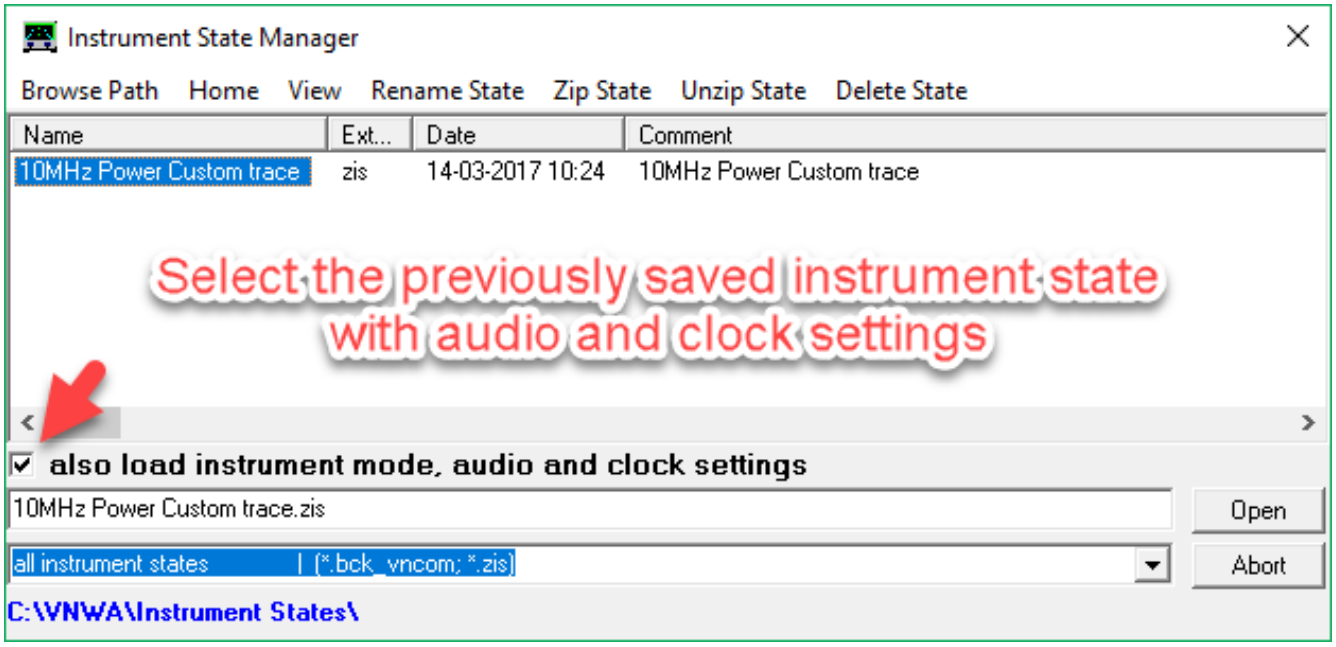


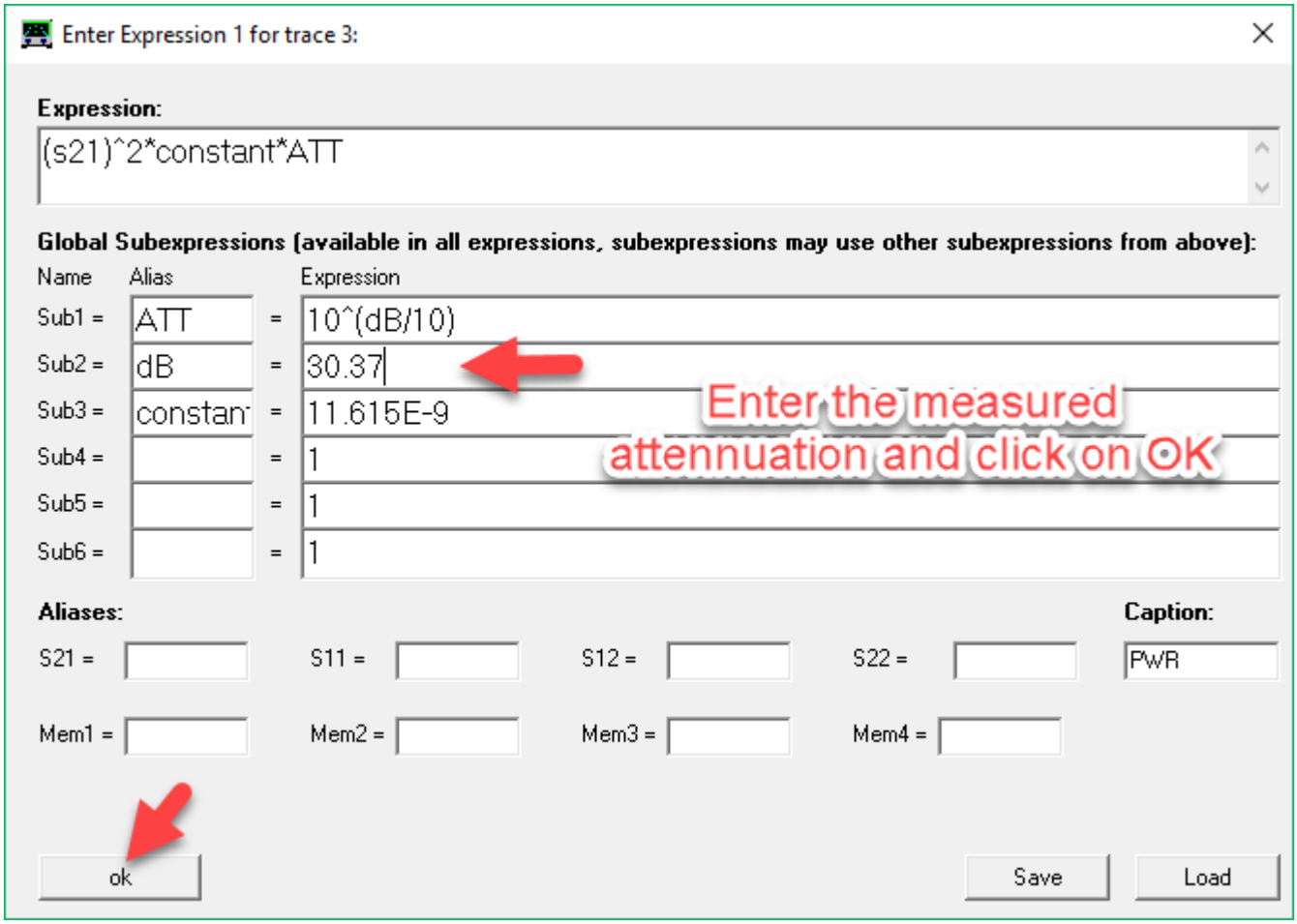




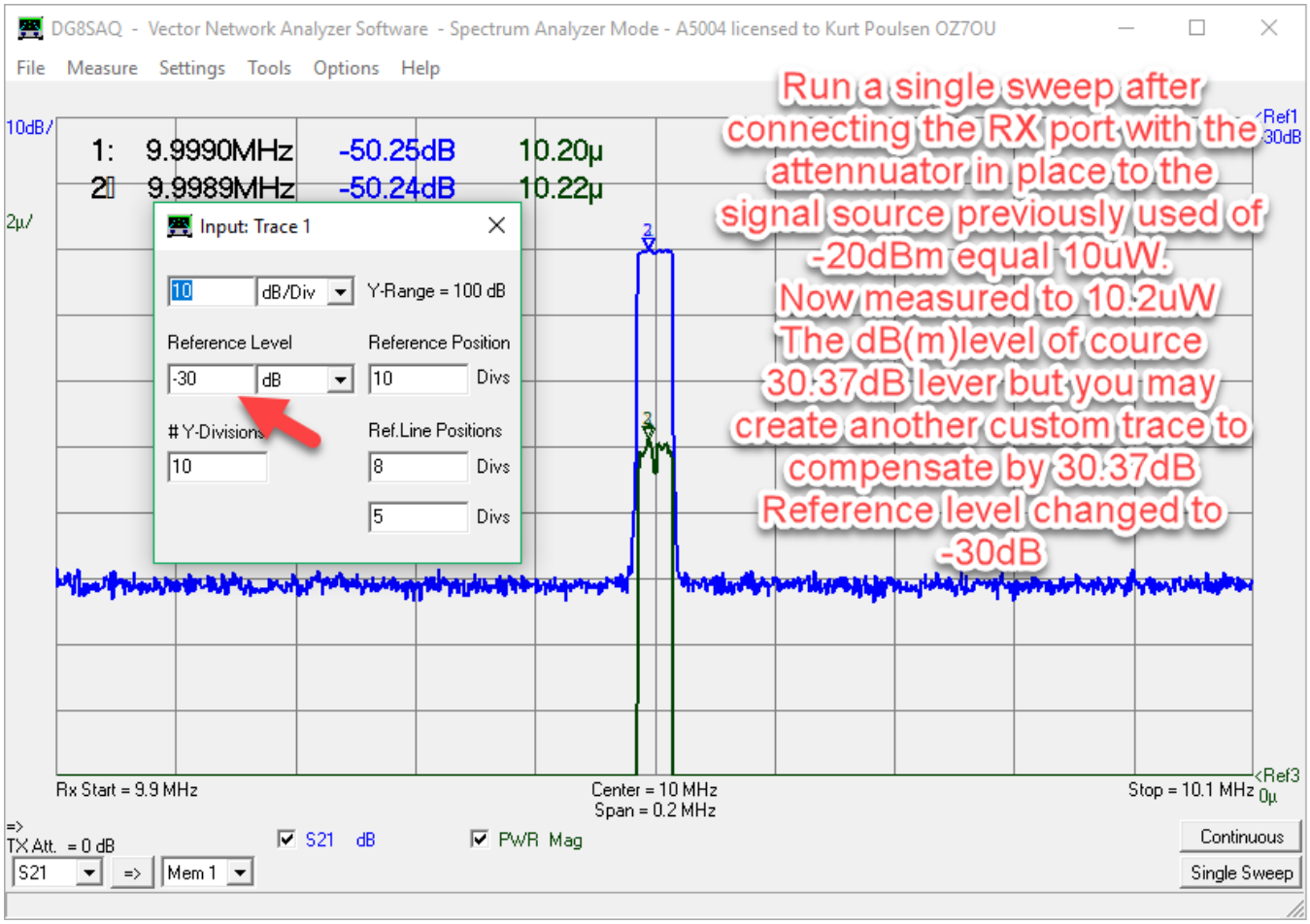
After the measurement of the attenuation we revert to the Spectrum Analyzer mode by loading the retrieving the Instrument state file







We are now ready to see how accurate the power measurement are by applying the previous used test signal of -20dBm from the HP8464A signal generator.
In fact the VNWA and the HP8464A had been switched off overnight, so there might be small temperature drifts in the VNWA, but that was not the case. Let the VNWA be on for 30 minutes to stabilize.

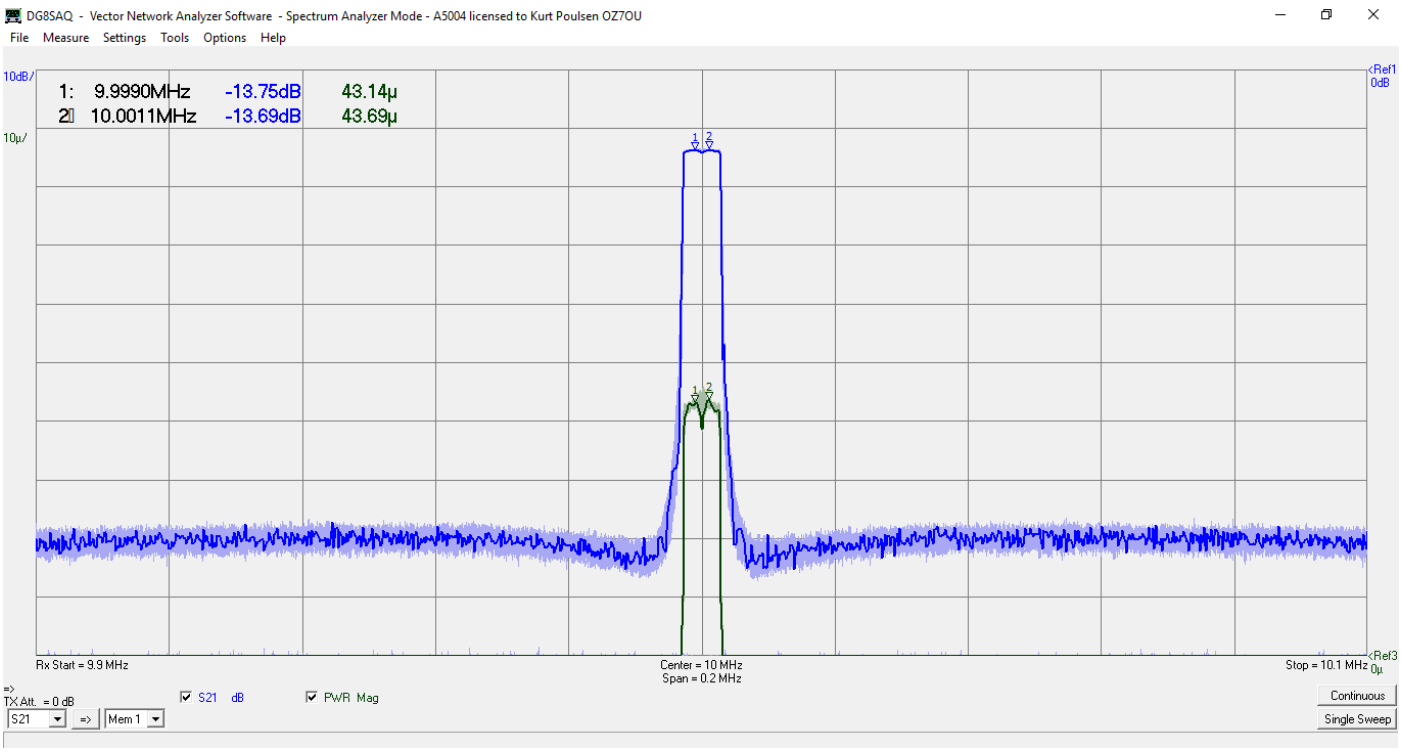


That's it Gents. Concept proven. A number of subsequent sweep showed from 10.0 to 10.3uW, indeed perfect

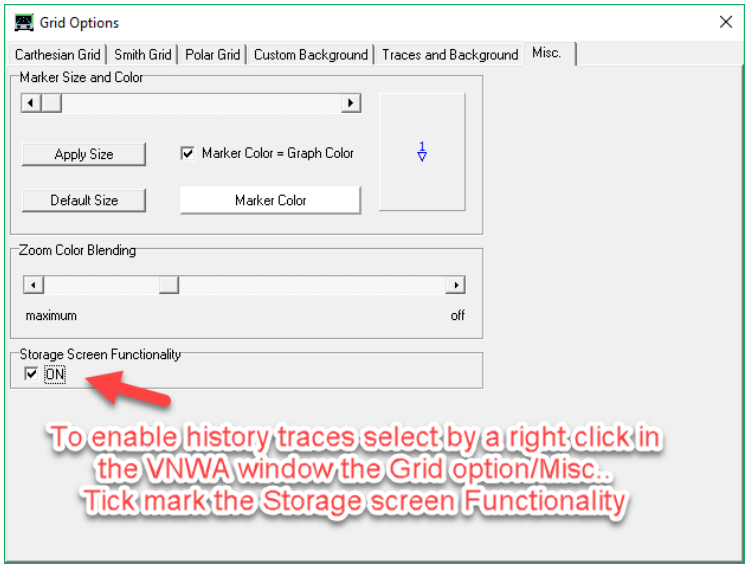
The Appendix:

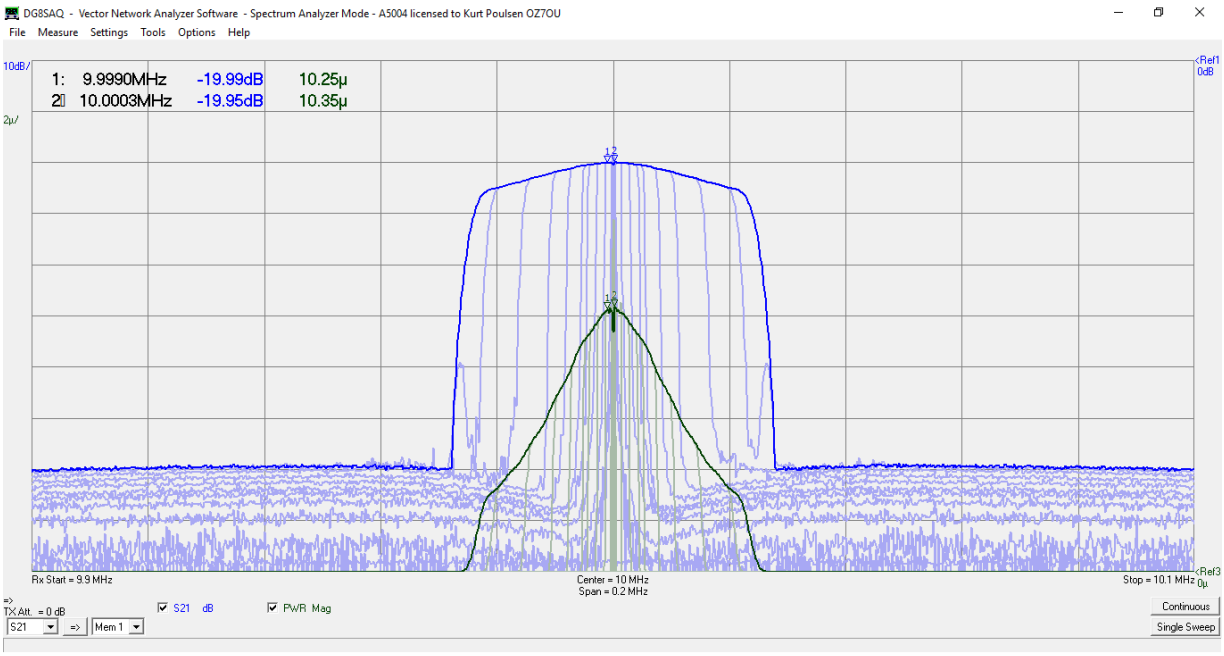
A number of trails performed

Monitoring over several hours of a 10MHz signal from the Leobodnar GPSDO via a SMA 30dB inline attenuator

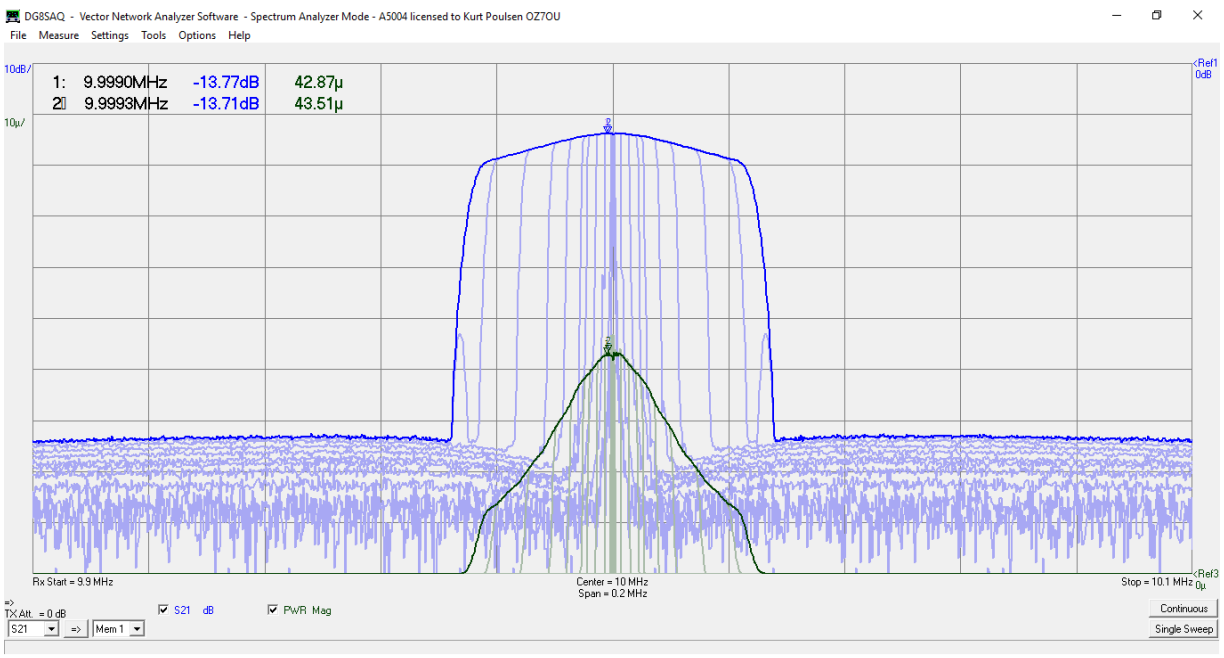


All available Resolution Bandwidth selected and shown as history traces for the HP8664A signal of -20dBm





Same as above for a signal from the Lebodnar GPSDO signal generator



What about higher frequencies ?
As an example the 2 meter band from 144 to 146MHz and the 70cm band from 432 to 438Mhz is of interest.
In previous published documents the TX Level as function of frequency documented, so even for these frequencies you will obtain decent results. Alternative if you have access to a reliable signal generator it might be used as well. However, note that the fundamental signal is still present at the TX out, so the Level Offset might be handled with care, not to let the fundamental signal create overload. Alternative use a high pass or even better a band pass filter for those frequencies where harmonics of the fundamental being used.
The level drops across the span can actually be compensated as an extra frequency dependent factor as a formula in the custom trace, so have fun.
I have written 4 documents before, where such details are described in depth.
http://www.hamcom.dk/VNWA/How to calibrate the VNWA Spectrum Analyzer using the TX output as signal source.pdf
http://www.hamcom.dk/VNWA/How to calibrate the VNWA sensitivity in Spectrum Analyzer mode.pdf
http://www.hamcom.dk/VNWA/RF Generator-Output-VNWA3-and VNWA2rev1.pdf
http://www.hamcom.dk/VNWA/RF Generator-Output-VNWA3-version-35.2.u.pdf

The first article contains an error, as it describes the use of Thru and Thru Match calibration. Thru Match must not be used, as can create unexpected result in the VNWA software. In addition, as described in the beginning of this report, it is much better to use totally uncalibrated method, as then Resolution Bandwidth, Number of Points, Frequency and Span can be modified without any recalibration, just fine tuning when final setup found, as when using Thru calibration any single change will cancel calibration. So this document will be totally rewritten soonest possible
Kurt de OZ7OU
Marts 14 2017