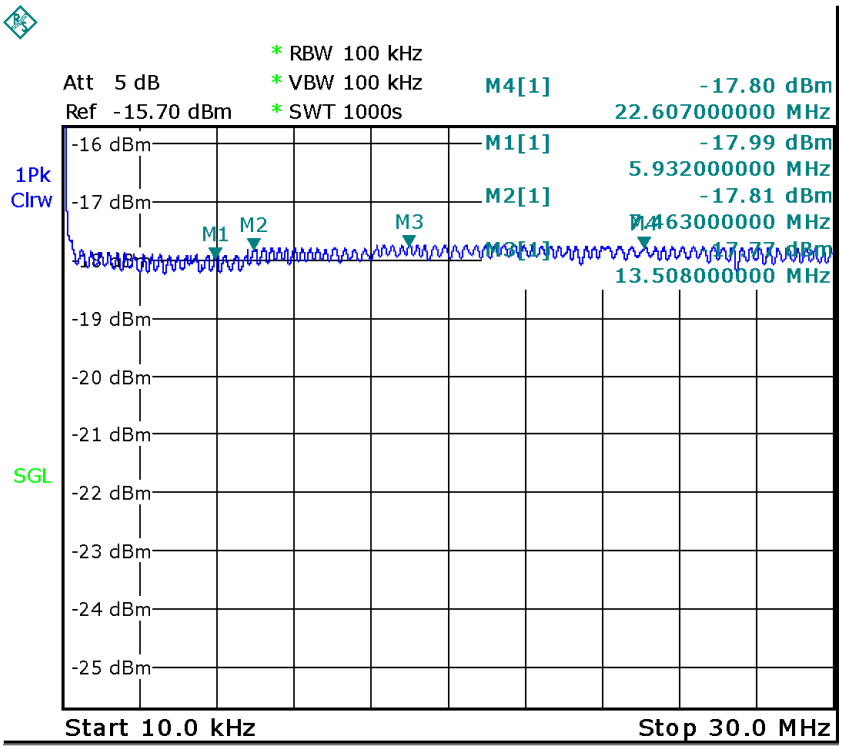
How to calibrate the VNWA sensitivity in Spectrum Analyzer mode

Preface:
When using the VNWA as spectrum Analyzer (SA) the sensitivity is varying as function of frequency. This because the LO DDS feed to the RX mixer has an output dropping with frequency being zero at the clock frequency and it's multiplum as 2xFclock 3x Fclock and so on. When the WNWA2 and VNWA3 is running in the RFauto Clock x 3 LOauto mode and in RFauto Auto LOauto mode for VNWA3, the switching scheme for the internal multiplier of the RF and LO DDS and the VNWA3 clock pre-multiplier does a fair job to change setting for optimum output of the LO DDS (the RF DDS not used in this SA application) as frequency changes during the sweep. When approaching the MAX DDS frequency and certainly when working above the LO clock frequency we will observe a drop in signal amplitude from the LO DDS and thereby also the sensitivity of the mixer/the RX port.
Study the helpfile under General / functional principle to understand how the VNWA works as SA as the analyzed spectrum is feed to the RX port.
For the very low frequencies like the radio amateur frequency band HF up to 30MHz the output from the LO DDS is fairly constant and if we connect the TX port and the RX port we measure the RF DDS as function of frequency and we know the TX port output in 50 ohm delivers -17dB we can quickly observe the flatness.

You have two option either run in (S21) non calibrated mode (as below measurements is using) or do a calibration of the S21 and we will later on see how that works out as well.

Let us get started
For a measurement of the VNWA TX out from 10kHz to 30MHz with an R&S spectrum analyzer model FSL3 we see the level is in between



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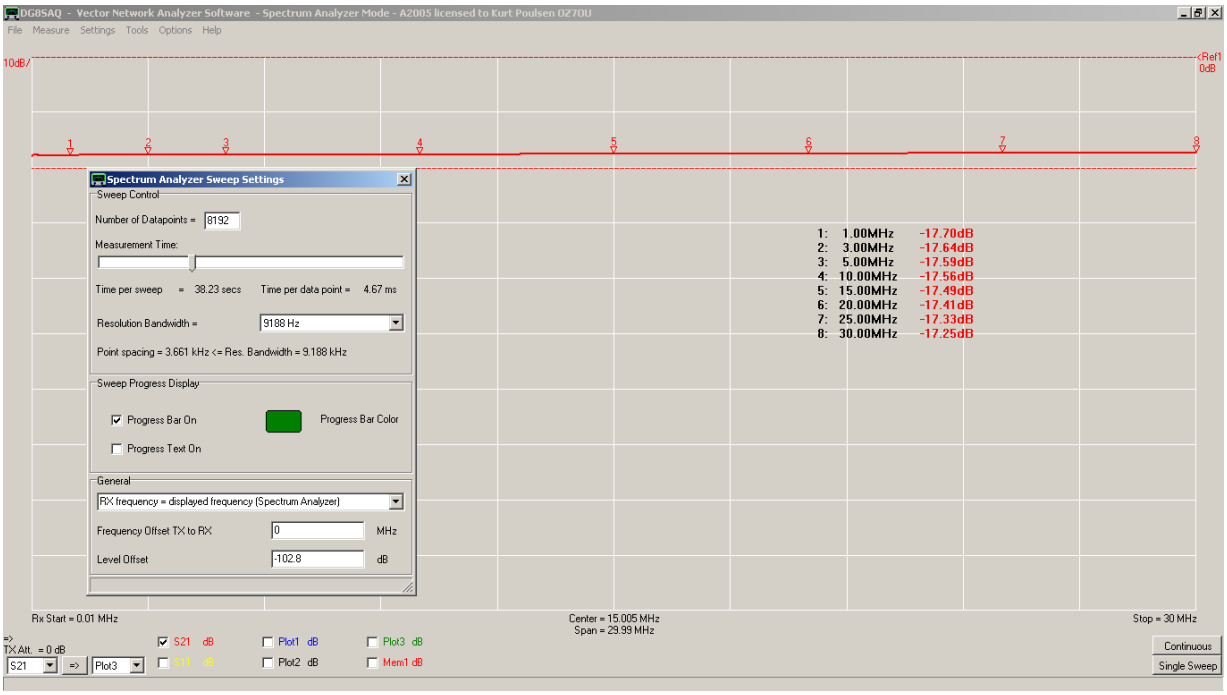
As a supplement I measured the TX output through a 30MHz high power Lowpass filter compensation for the filter loss ranging from 0,01dB at 1 MHz to 0.23dB at 30MHz. This filter used to remove the harmonics an aliases utmost. Output measured selectively with the R&S SA model FSL3 as well with HP Power meter 437B, using a compensation table for degradation below 10MHz. These measurements are shown in the Table below.

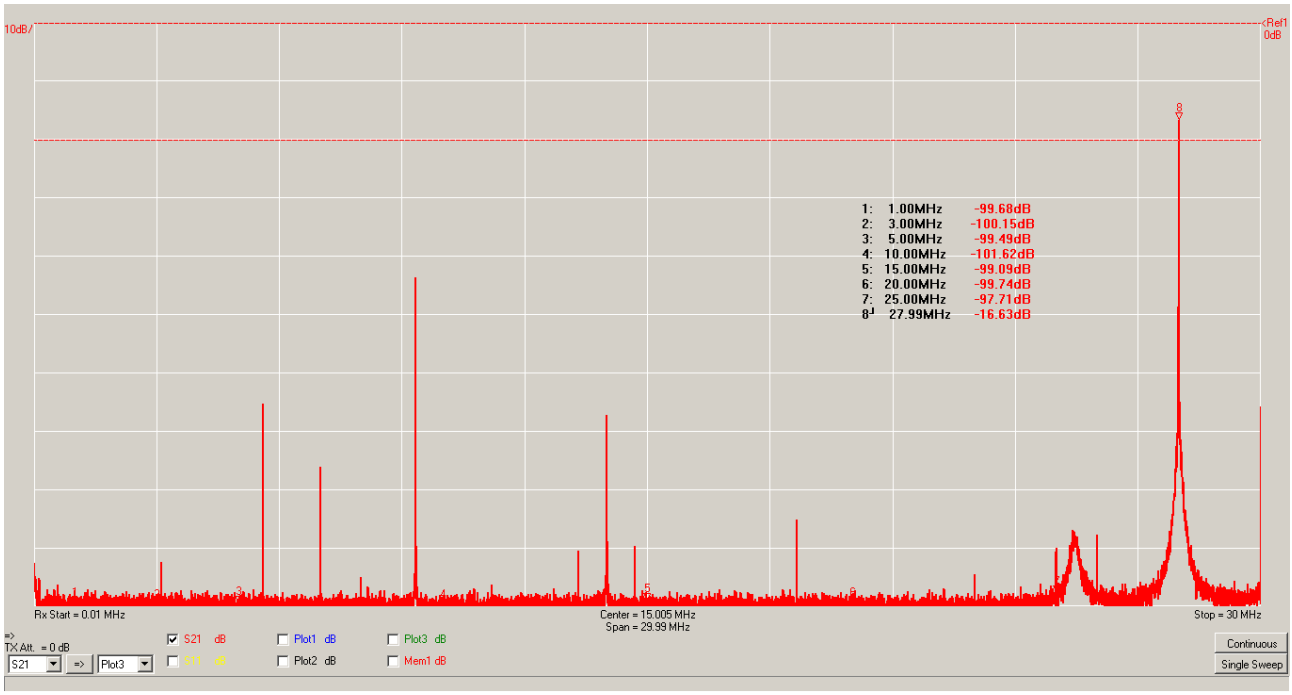
F / MHz	1	2	3	4	5	10	15	20	25	30
HP dBm	-17.47	-17.56	-17.51	-17.46	-17.43	-17.53	-17.55	-17.56	-17.63	-17.60
R&S	-17.70	-17.80	-17.80	-17.80	-17.90	-17.80	-17.90	-17.9	-17.90	-17.90
HP dBm without 30 MHZ LP filter	-17.35	-17.31	-17.61	-17.26	-17.23	-17.32	-17.35	-17.30	-17.36	-17.42

The HP RMS power level is about 0.2dB higher without the 30MHz filter and that is what the harmonic counts for.

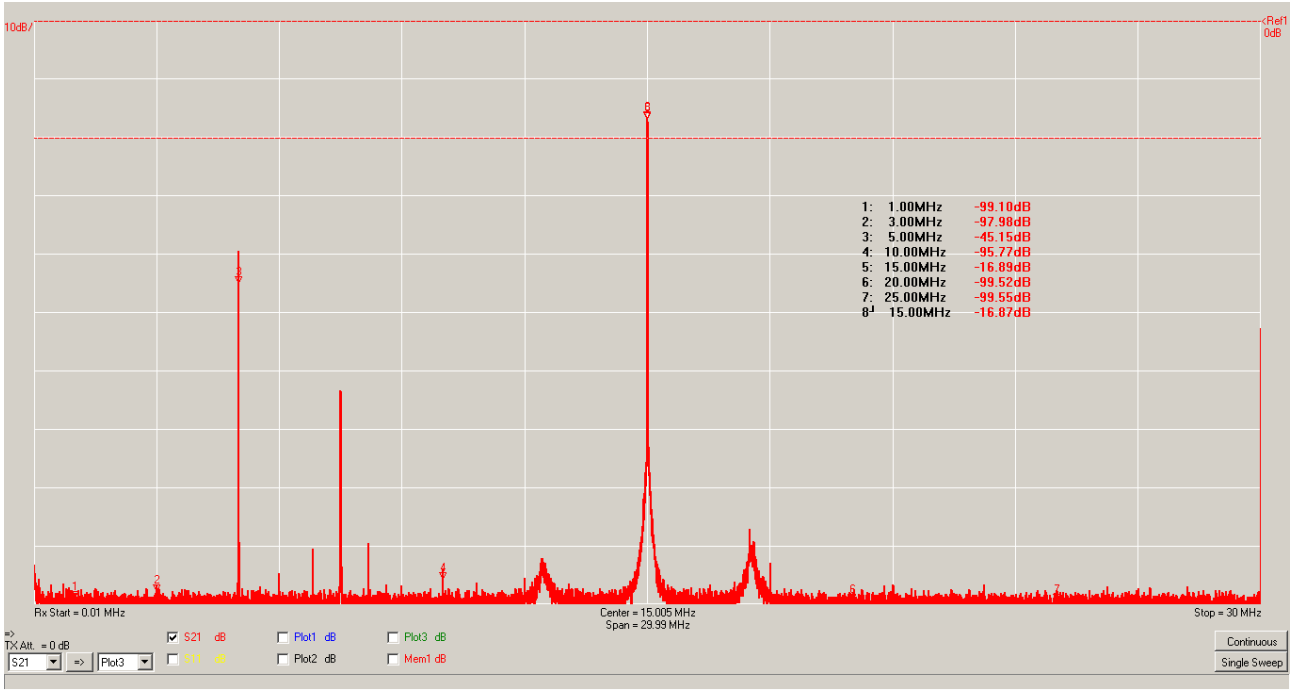
Based on these levels we can now calibrate the VNWA SA such that the entered Level Offset gives the same result when measuring the TX out by connecting a short cable between TX and RX. The Level decided to be 17.55dBm at 10MHz nd the VNWA SA Level offset entered as -102.8dB gives a TX out measurement which gives that value. See below for the markerdata.



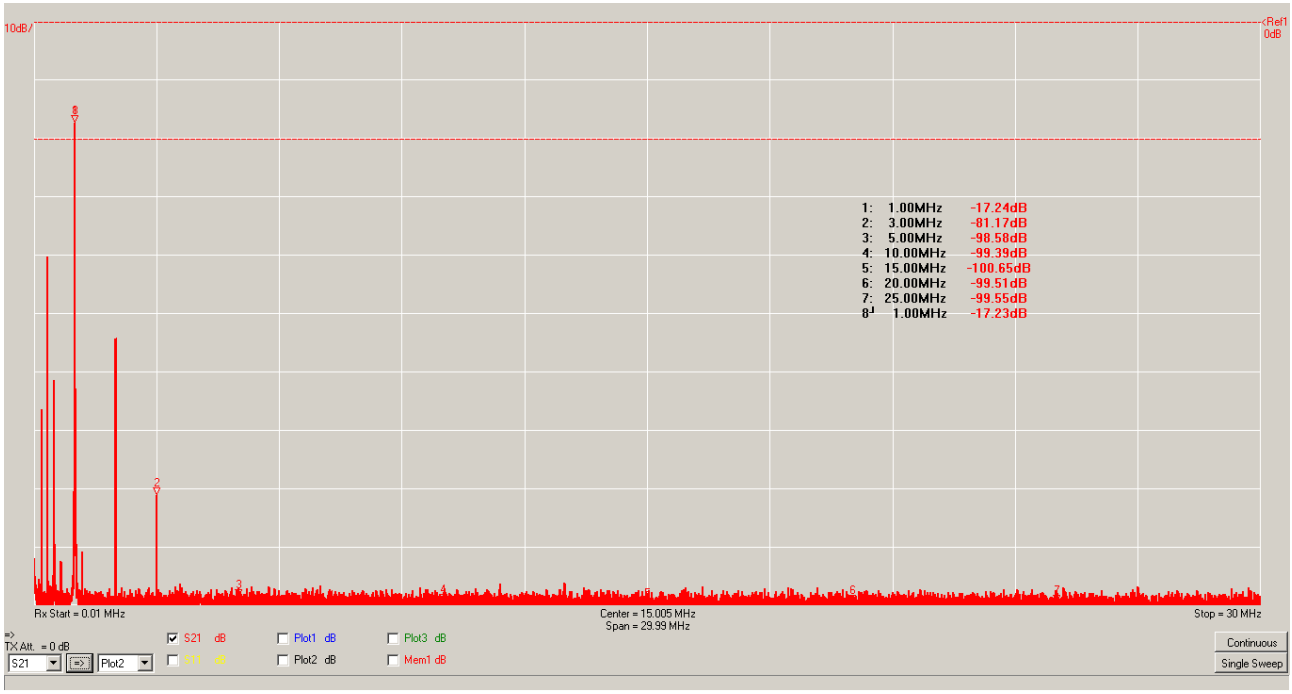
TX connected to RX with a short cable and a sweep from 10KHz to 30MHz performed



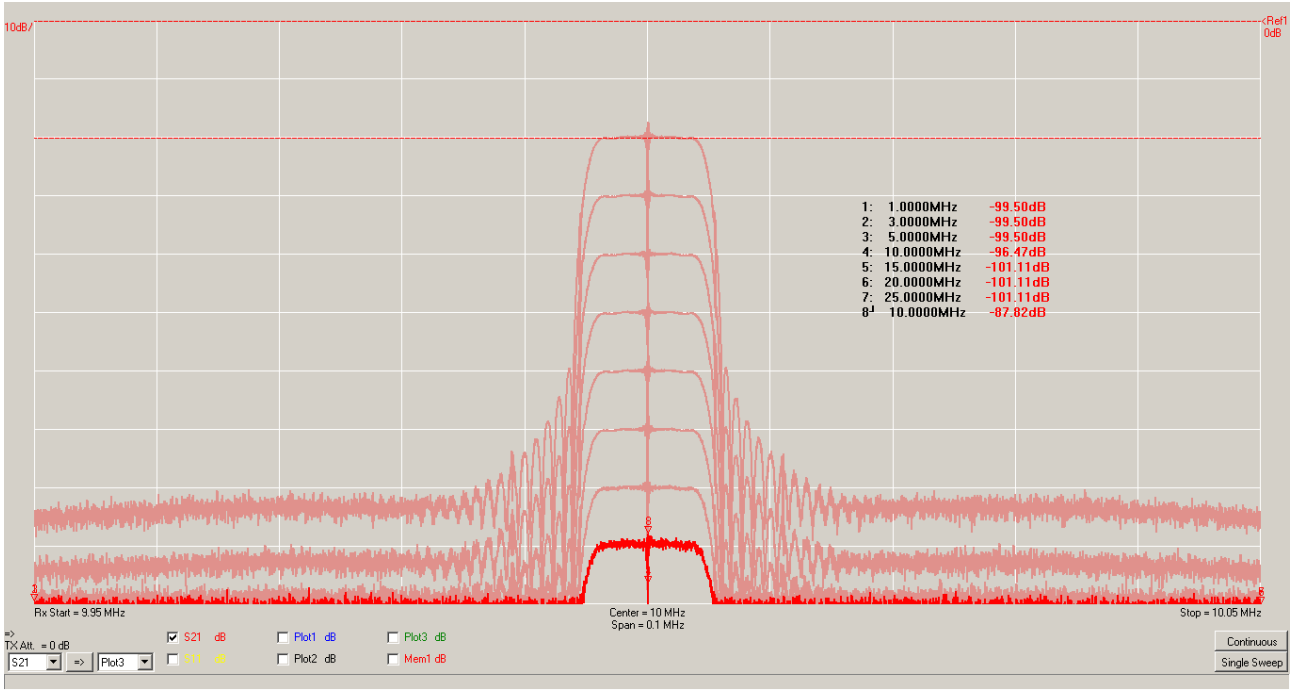
Marconi Generator 2022A set to 28MHz and -17dBm. Se marker 8 for reading of max value



Marconi generator 2022A set to 15MHz and -17dBm. Se marker 8 for reading of max value

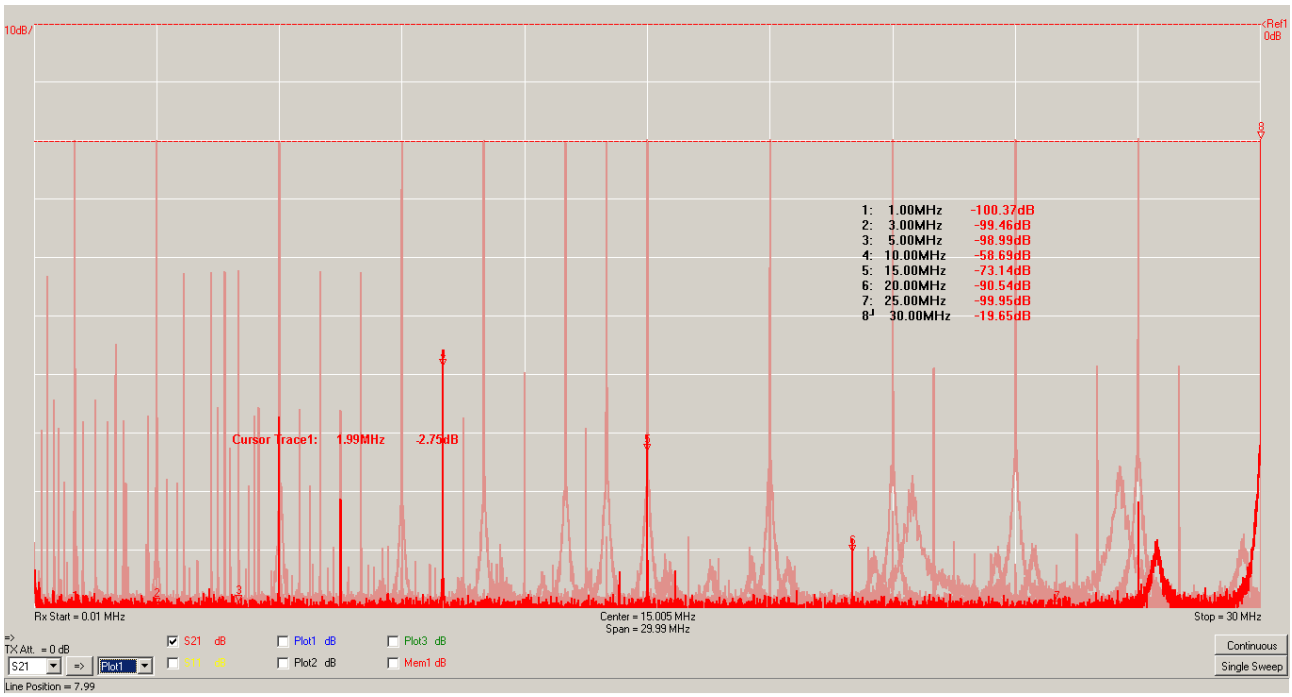


Marconi generator 2022A set to 1MHz and -17dBm. Se marker 8 for reading of max value

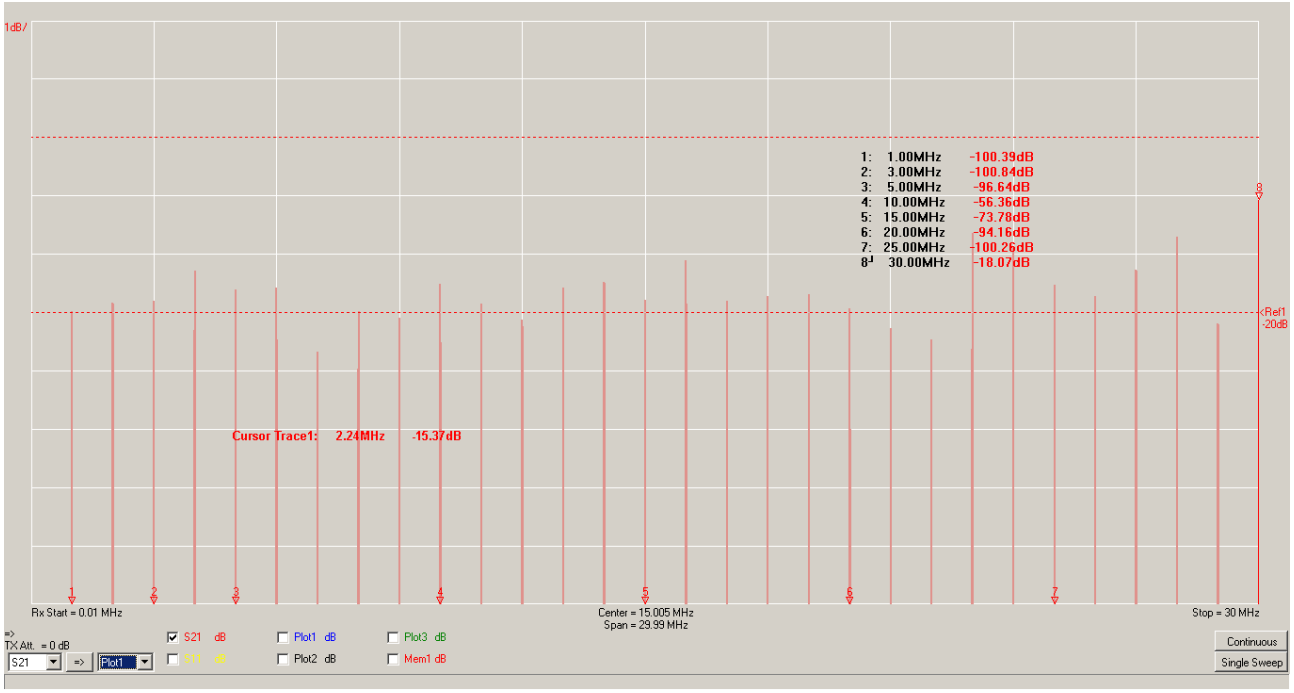


Frequency of the Marconi generator set to 10MHz and levels to -20, -30, -40, -50, -60, -70, -80 and -90dBm
As soon input rises above -17dBm a flashing overload warning appears, as the max input is set to -17dBm

The noise floor is down at -100dBm and thus the dynamic range is 80dB which indeed is excellent and comparable to profession equipment, taking the bandwidth of 9.188KHz into account.
The used signal generator is really noisy with white noise 60dB down as being close to carrier by 10 to 50KHz



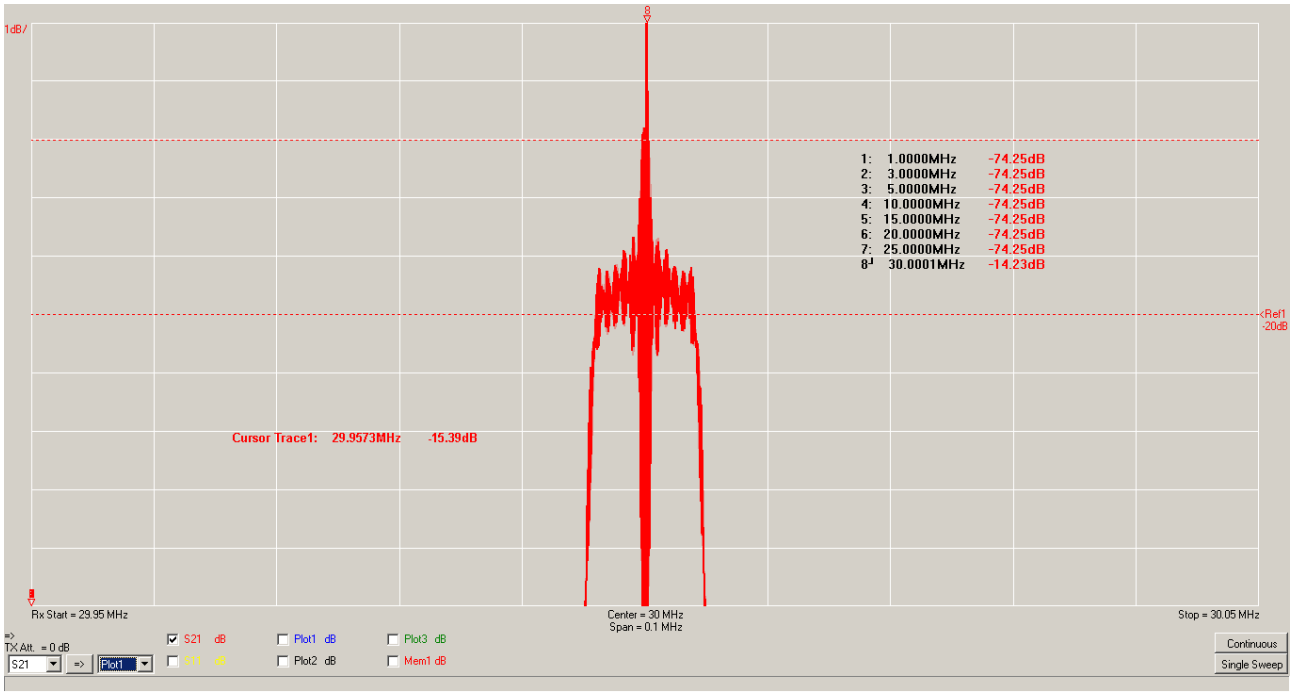
Sweeping across the entire range and stepping the frequency in steps of 1, 2 or 3MHz. We see that all peaks hit the 20dB line ohhhhh… so nicely.



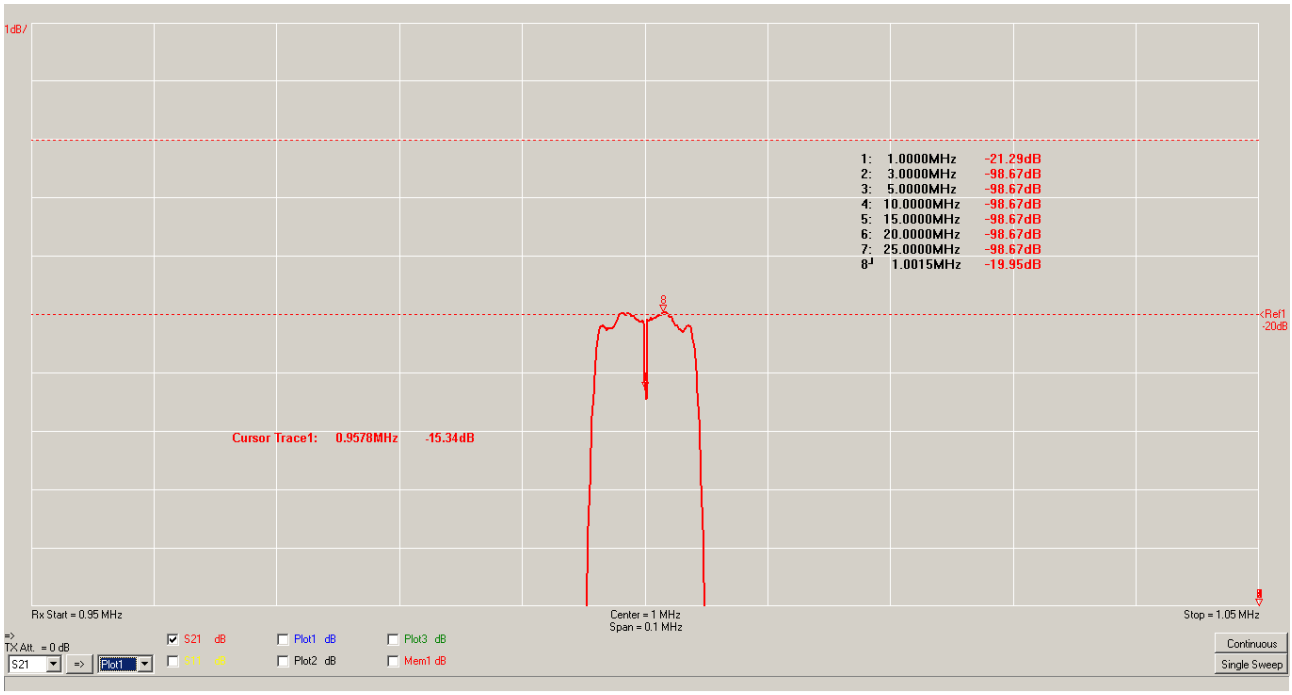
Now increasing the resolution to 1 dB per division with -20dB reference at division 5 alos where the marker line is placed. Above and below the marker line we should see the small deviations from -20dB, but ….

This is a 30 sweeps where the signal generator set to -20dBm and frequency stepped in 1MHz increment from 1 to 30 MHz. Why are the value jumping up and down across the frequency span more than antisipated?

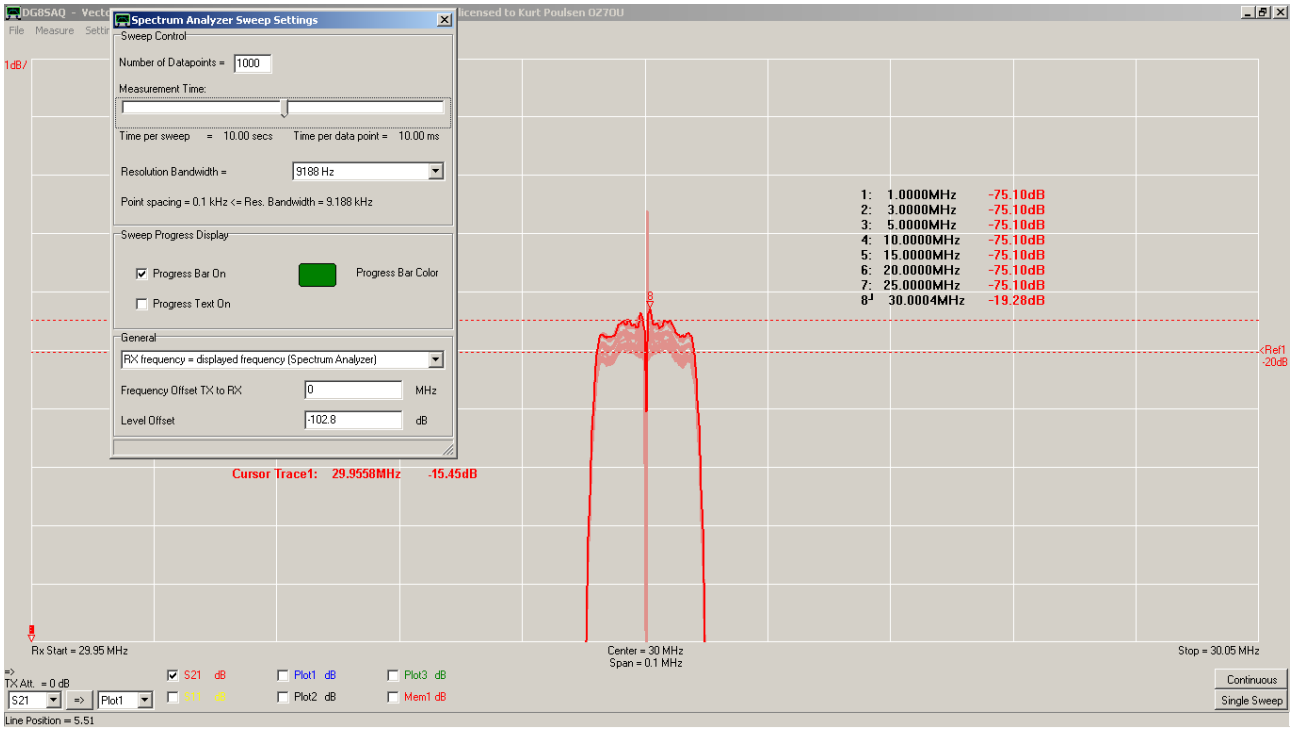
Let us have a look why.



When we look at e.g. 30MHz with a span of 0.1MHz we see why. The very solid spike in the center is the zero beat in the sound channel, and totally unavoidable based in the principle of the VNWA SA function. That peak is what is monitored in above picture and not at all representing the true level.



However by tuning the SA setup a bit, we can improve the measurement by changing number of points and time per point. See below for details.



The number of point changed from 8192 to 1000 and time per point increased thru increasing measuring time.

Center frequency then changed from 1 to 30MHz in step of 1MHz. The sensitivity spread from 1 to 30MHz is only 19.48-20 dB=0.5dB (-19.46dB where the upper marker line positioned and -20dB for the lower). The amplitude is rising with frequency.

It might be the Marconi 2022A generator used, or the VNWA sensitivity or both in combination which causes this rather small spread.

Changing the measurement unit from dBm to dBuV:

For special cases it might be desirable to measure the level in e.g. dBuV.

0dBm equals 106.99dBuV so it is just a matter of rescaling using a custom trace.