How to measure filters at 2.3 to 2.5 GHz with about 40dB dynamic range using VNWA2 and VNWA3

Preface:

I recently aquired some filters for the WiFi Band (2.401 to 2.467 GHz) and was interested in seeing how the VNWA would perform using a 2448MHz Bandpass filter with 100MHz bandwidth (covering channel 1 to 11) in series with the RX port, during S21 calibration. Then I afterwards would measure the 3 filters designed for channel 1, 6 and 11, still having the 100MHz bandpassflter in series with the RX port.

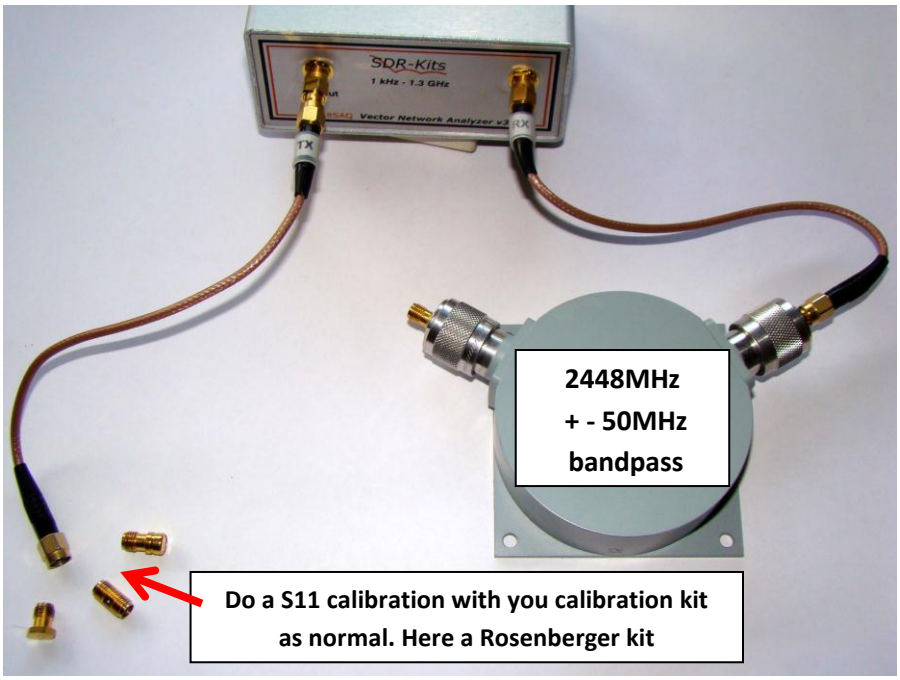
As the VNWA has a spectrum with zero power at the RF and LO DDS clock frequencies (Fc in the following) and their multiplum, then the maximum power will be inbetween e.g. 3 x Fc and 4 x Fc for the 2.4GHz range running the two DDS at maximum possible clock frequencies. For the WiFi bandpass filter with center freq of 2438MHz will a division of 3.5 give 697MHz and by selecting RF and LO DDS clock frequencies on either side of 697MHz we will have good output power for the entire WiFi band.

For the premultiplier of x 3 the RF DDS multiplier x 20 gives a RF DDS clock of 720MHz and likewise with a LO DDS multiplier of x 19 gives a LO DDS clock of 684MHz.

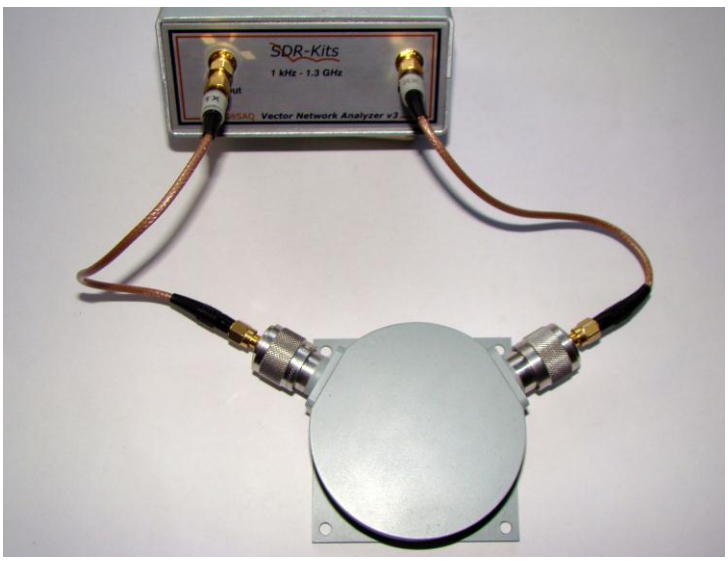
If by using x 19 for the LO DDS and x 20 for the RF DDS might be better but not investigated yet. These setting for VNWA3 but the VNWA2 has identical setting posibilities.

Hints about calibration:

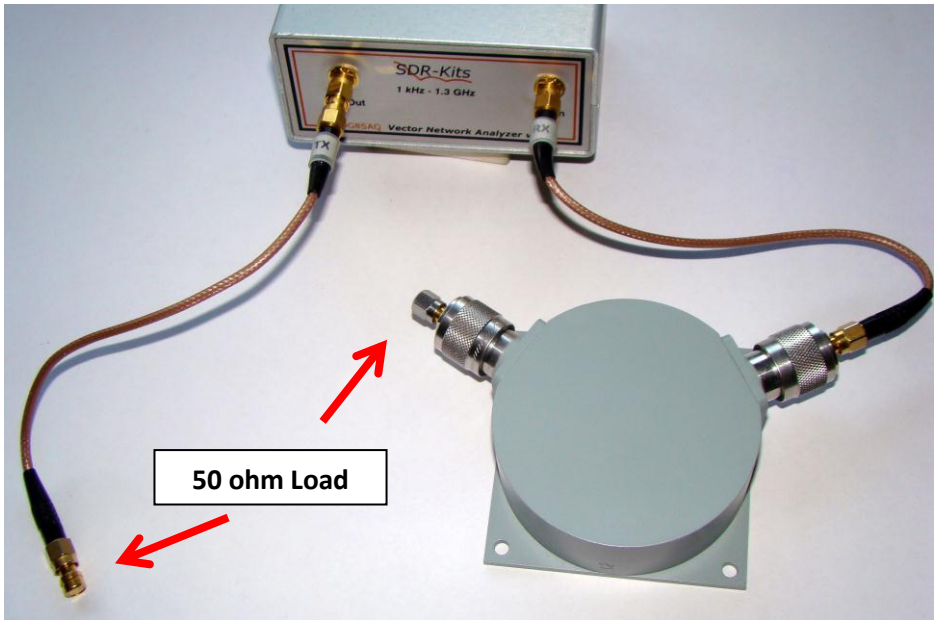
- Do a normal S11 calibration at the end of the TX port testcable before the S21 calibration.

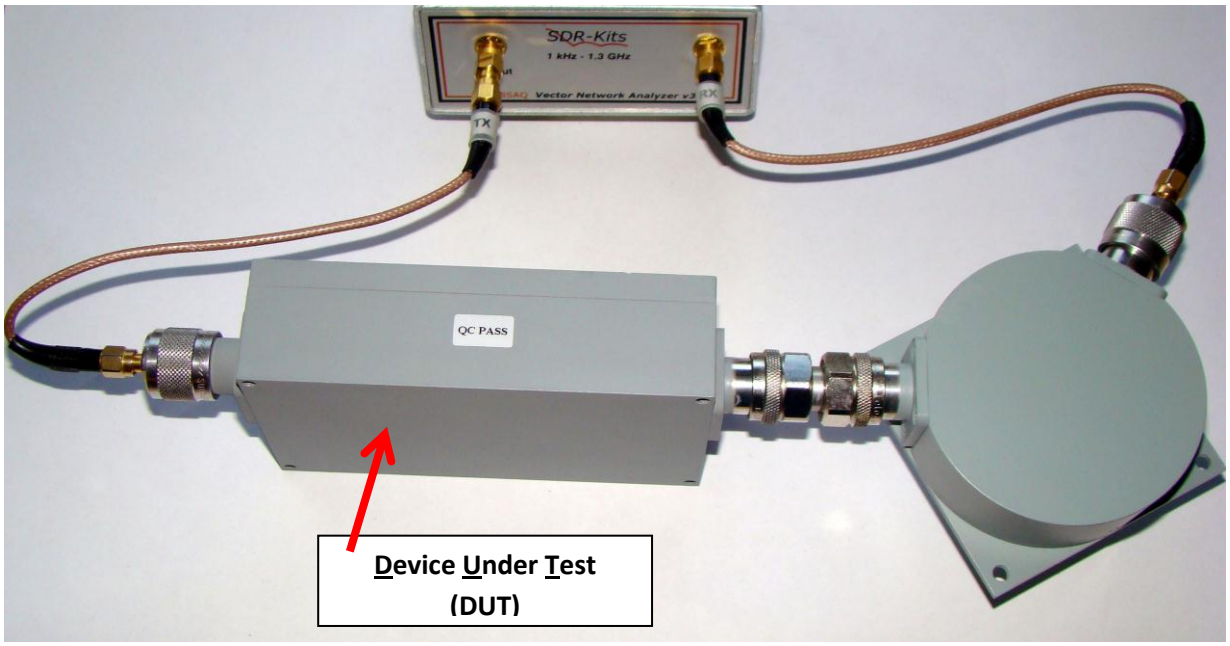


Do a S21 Through calibration



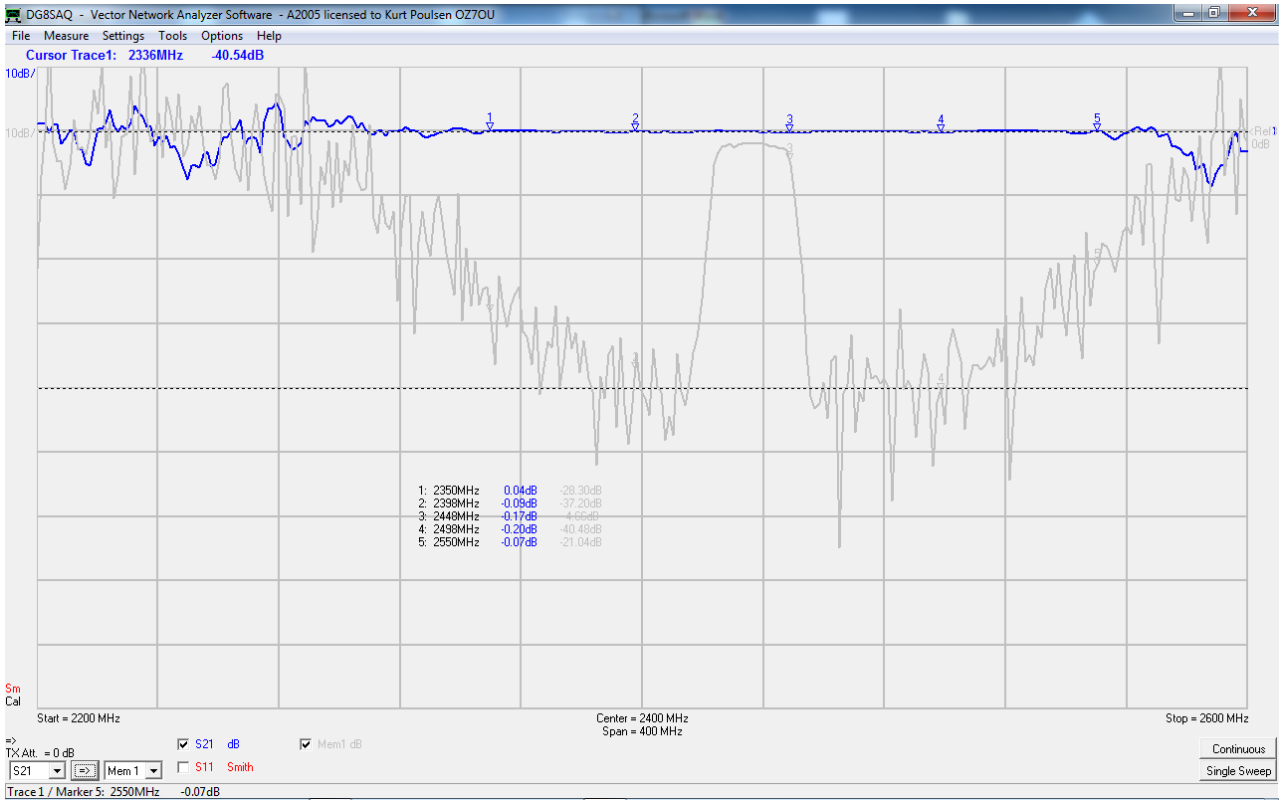
- Doing a Thru Match calibration is not recommended.
- However a crosstalk calibration seems to be beneficial provided the TX port testcable terminated with 50 ohm and the input to the bandpass filter in series with the RX port also is terminated with 50 ohm as seen below.



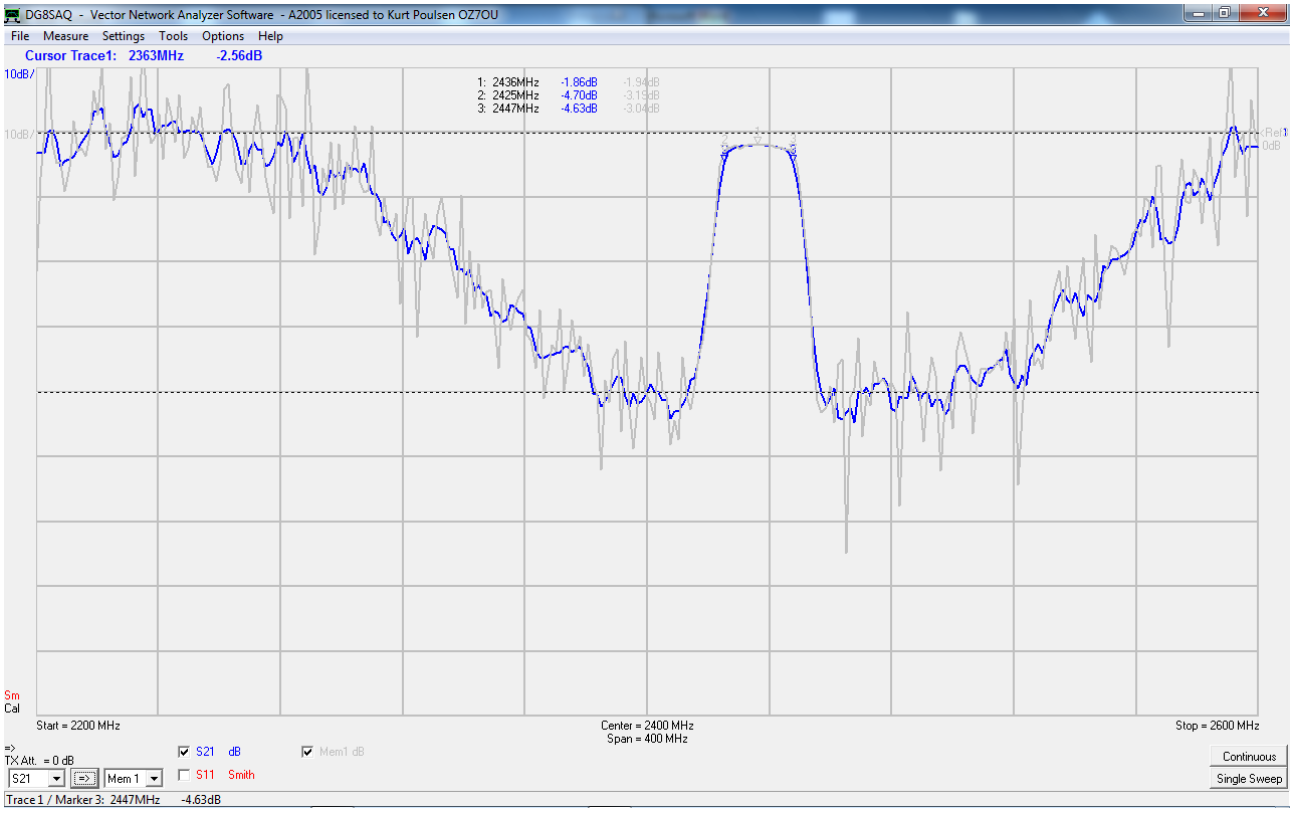


Above the setup for S21 filter measurements

Some initial measurements:
Doing a S21 calibration according to above explanation and using 300 points with 100mS per point from 2.2 to 2.6GHz gives a “noiseless” 0 dB response from marker 1 at 2350MHz to 2550MHz and by watching the gray plot in MEM1 from a sweep of a CH6 filter (center freq 2437MHz) we see that dynamic range aproaching 40dB between marker 2 and 4 which nicely correspond to the filterspec of 2448Mhz + - 50MHz. For the S21 plot is used averaging over 8 measurements.

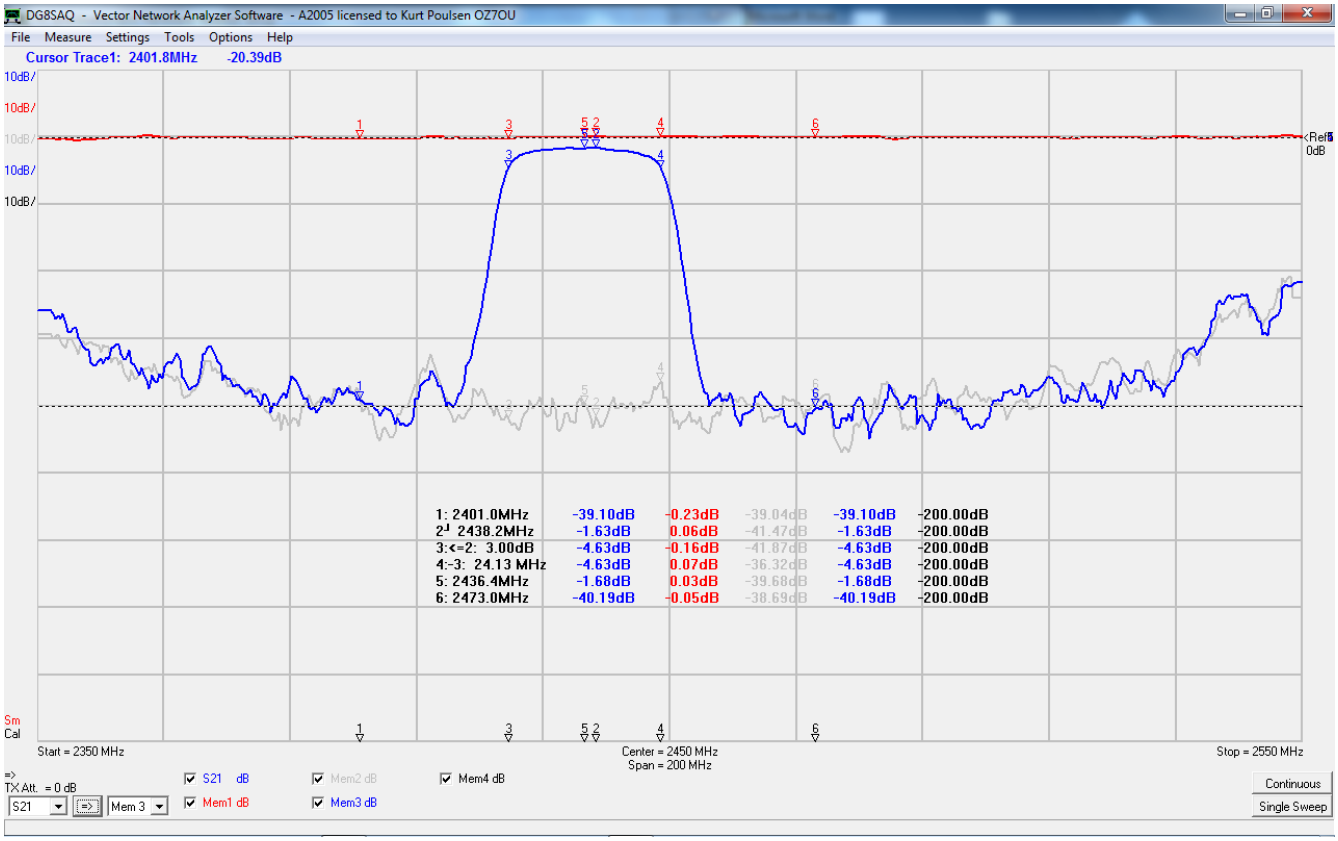


Below is seen the effect of the averaging over 8 measurements, as the grey plot in MEM1 is without averaging.

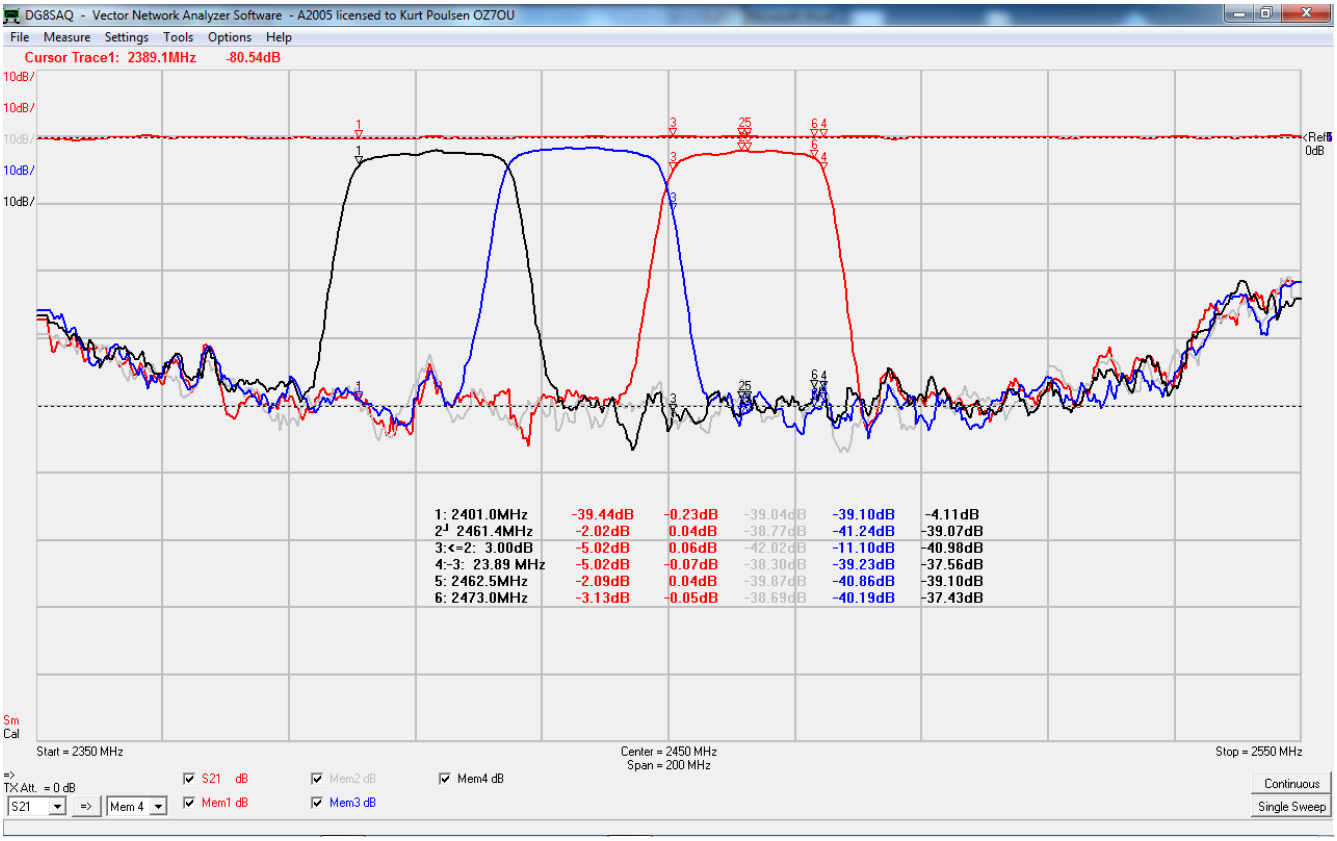


The -3dB bandwidth for the CH6 filter is 22MHz and that is seems to be measured correctly. However the center frequency measured to 2436MHz but I have not checked the VNWA frequency lately.

Next step is to use a frequency span of 2350MHz to 2550MHz and increase the number of point to 500



MEM1 (red trace) is the S21 calibration (0dB reference level) MEM2 (grey trace) is the S21 noise floor: MEM3 (and S21) is the CH6 filter measured and the Center frequency measured to 2436.4MHz (spec 2437MHz), insertion loss -1.68dB (spec 2dB) and -3dB bandwidth to 24.13MHz (spec 22MHz)



Here is added CH1 filter (MEM4) as black Trace and CH11 filter as S21 red trace. Again excellent result as Center frequency measured to 2462.5Hz (spec 2462MHz) insertion loss -2.09dB (spec 2dB) and -3dB bandwidth to 23.89MHz (spec 22MHz)

Final comment:
The linearity is checked and I have a Narda 60dB DC to 12.4GHz Microline mini – turret 10dB step attenuator, and 0 dB, -10dB, -20dB and -30 dB checked with OK result. A further -3dB additional attenuation also checked with OK result.
Filter techniques for picking up the required operating frequencies for S21 measurements is an efficient method as above test demonstrates.
Using filter technique for S11 measurements, in the traditional way, is not giving any useable result as the VNWA bridge at 50 ohm load is providing 0 output so everything drowns in noise for this frequency range. A separate document is prepared how to measure S11 with quite useable result:
Better S21 results may be possible by fine tuning the clock multiplier selections, but the guideline given in this document is a good start.
The technique can off course be used on other frequency ranges.
Use of highpass filter might also give some acceptable result.
Links to the specs for the filter used is as follows.

2448MHz 100MHx BW http://www.l-com.com/item.aspx?id=22047

Channel 1, 6 and 11 http://www.l-com.com/productfamily.aspx?id=6352

20/8 2012 Kurt de OZ7OU

Revised 20/8 2012 with pictures added.