How to check the calibration for perfection of the VNWA or any other VNA

Preface:

After a calibration of the VNWA (or the VNA), an open or short airline is connected to the calibration plane. If an airline is not available then a good quality semirigid cable may be used, or a highgrade test cable. Then a sweep is performed and monitored as follows:

Watch the Smith Chart Trace and a S11 dB trace with resolution of e.g. 0.1 or 0.2dB, dependent how fine a dB resolution is wanted for the observation.

In below example for the VNWA calibration is used a professional SMA calibration kit HP85033C and the airline used is a series connection of two APC7 airlines of 10cm (HP11566A) and one 20cm airline (HP11567A). The transition from APC7 to SMA consisted of an APC7 to SMA adaptor from the HP85033C calibration kit. Thus, a total length of some 43 cm airline suitable for the frequency span selected from 20KHz to 600MHz, allowing several 360 degree turns within the Smith Chart. This allows explaining what is going on in the transmission line during the frequency sweep.

Further traces enabled are a phase trace with 36 degree per division and 0 degree reference at division 5, a ImagZ trace with 50 ohm per division and 0 ohm reference at division 5 and finally a RealZ trace with 1000 ohm per division and 0 ohm reference at division 1.

I have no SMA airline but above combination is fully adequate for checking the calibration and I will show how the 50 ohm semirigid cable performs in comparison. However, if you have a SMA airline that is the airline to use.

Finally, the calibration is also done with the SDR-Kits Rosenberger female kit for comparison.

Please study the thin trace, within the Smith Chart, and the markers placed on important points, where the trace for the open airline, is moving from extreme right (we may call it East position), being the open position in the Smith Chart, and from 20KHz at marker 1 the trace is moving clockwise along the circumference of the Smith Chart, and then at 84MHz and marker 2(where the airline is 1/8 of a wavelength) it is -50 ohm Imaginary part and 0 ohm real part. This position we may call the South position.

At marker 3, which we may call the West position, we are at the Smith Chart's short position, and the transmission line is here a ¼ wavelength long, and both imaginary and real parts is 0 ohm. We also see a sudden change of phase from -180degree to + 180 degree, at the West position, as we move into the upper part of the Smith Chart, where all imaginary parts are positive and thus inductive.

Likewise from marker 1 to marker 3 the imaginary part is negative and thus capacitive, and in all position below the Smith Charts horizontal line (from East to West) the imaginary parts is capacitive, and above inductive.

We continue moving to marker 4 at 252 MHz (the North position) where the airline is 3/8 wavelength long and the imaginary part is +50 ohm and the real part 0 ohm. Finally we move to marker 5 at 337 MHz, at the East position, which is the open position of the Smith Chart, and we have moved 360 degree along the circumference of the Smith Chart. At marker 5 the exact frequency is 337.1221649 MHz and the length of the airline then exactly 44.49cm as 0.5 wavelenght long at marker 5. From there on marker 6 is at South position (5/8 wavelenght), Marker 7 at West position (3/4 wavelenght) and marker 8 at North position (7/8 wavelenght).

As seen the trace must always be within the Smith Chart else the calibration is wrong and as seen, it spins slightly inwards due to the negligible losses in the airline and SMA to APC7 adaptor, in addition to the losses in the junctions between the three APC7 airlines.

What is important to notice is for the S11 dB trace, it must move as a continuous smooth line representing these losses, and above marker 4 in the screen captures below, as a straight line. From the lowest to the highest frequency it shall be without oscillations with peak and valleys close to the South, West, North and East positions, caused by imperfection in the calibration standards and their calibration settings.

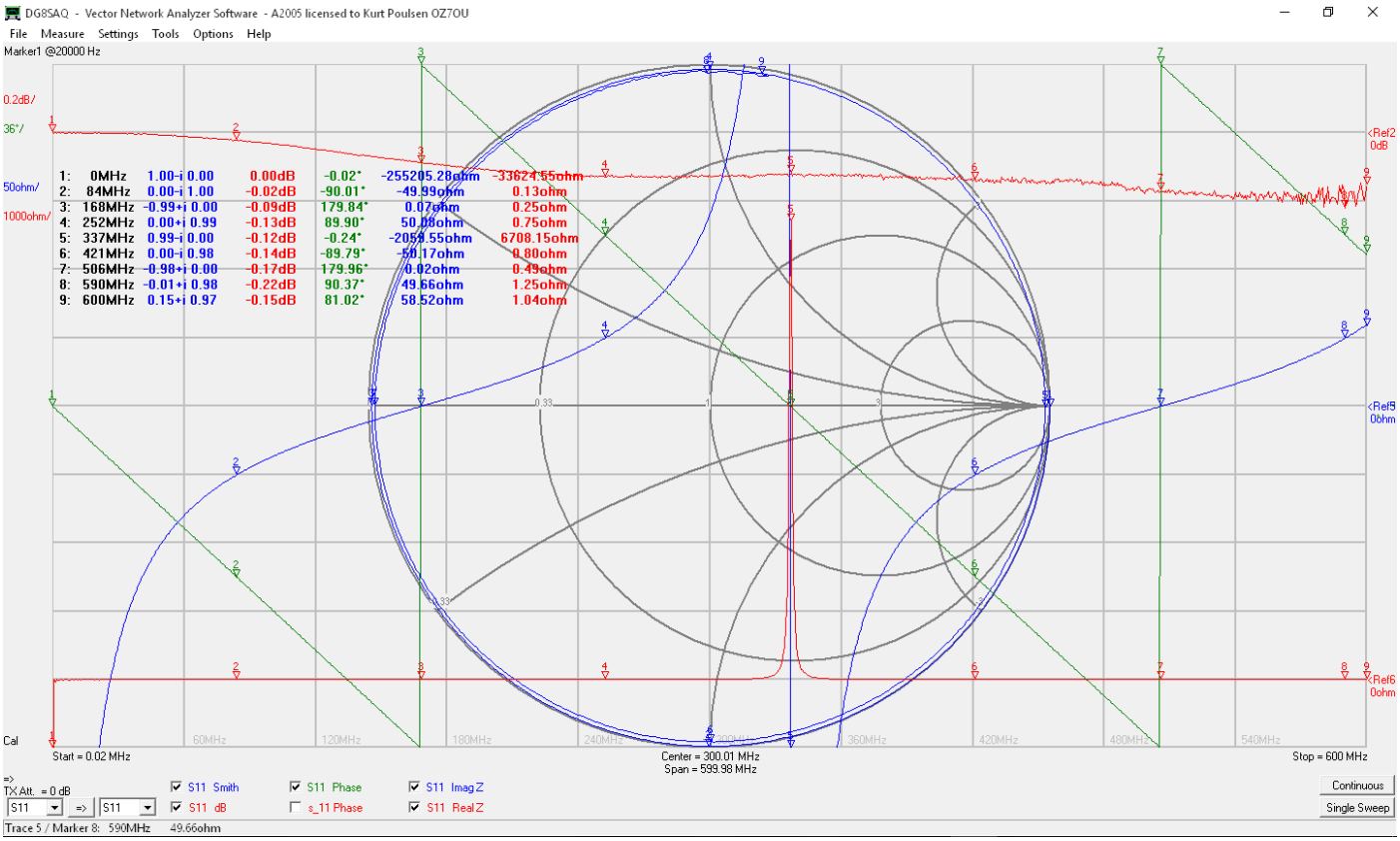
The first screen capture is for the APC7 airlines in open condition, terminated with an APC open calibration Standard, and the second screen capture is for termination with an APC7 short calibration standard.

The third Screen capture is with an SMA fitted 50 ohm semirigid cable of about 50cm length. In the screen capture a slight tendency to oscillation is seen for the S11 dB trace, but still the trace is perfectly within the Smith Chart and I will still consider the performance as an very good calibration even when using a non-professional transmission line and thus this method an acceptable way of checking the calibration. Remember the semirigid cable should be of good quality.

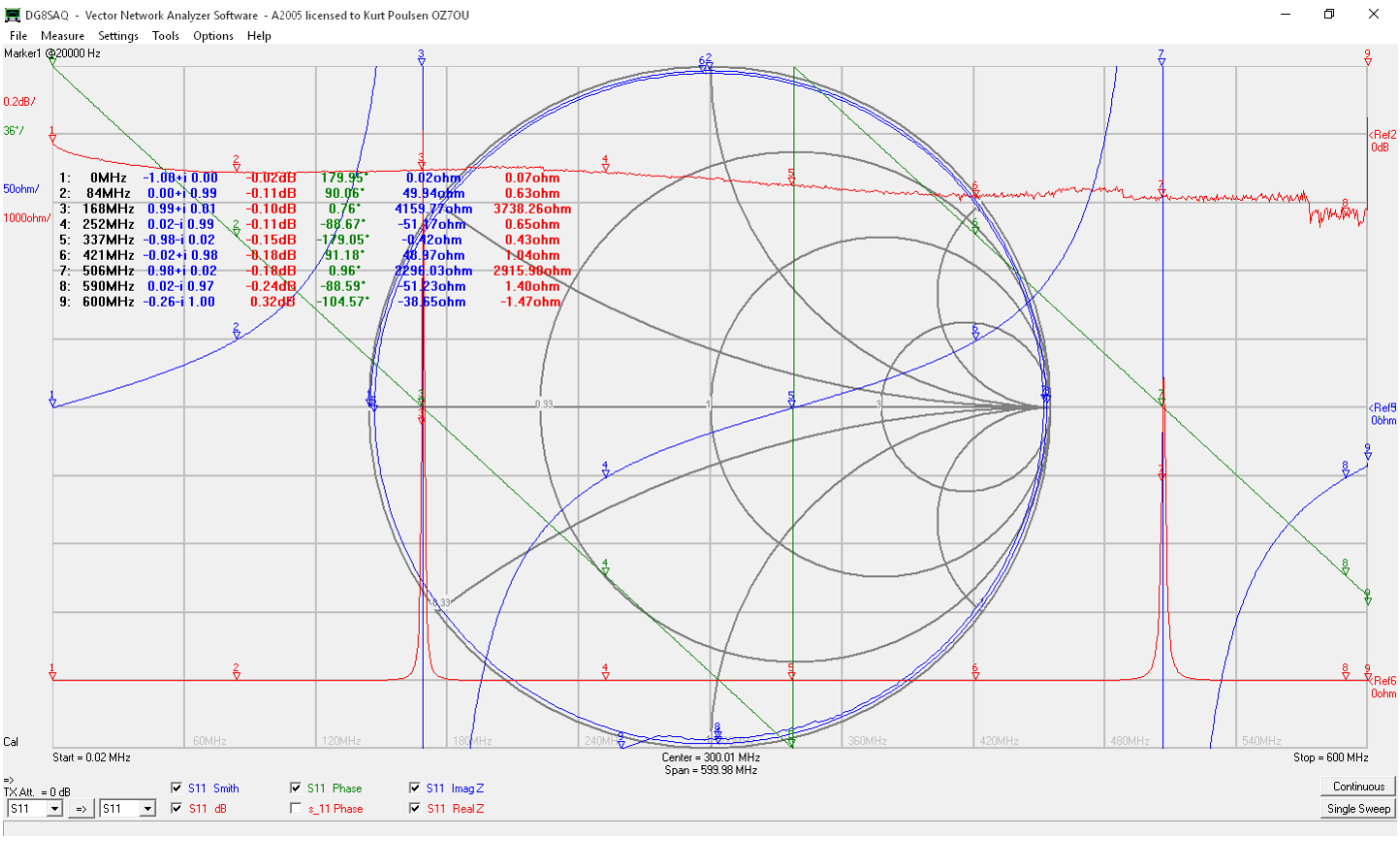
Screen capture 4 is for a 60cm long Rosenberger semirigid cable which was bended in three soft right angles and

straightened by be to a straight cable and still works acceptable.

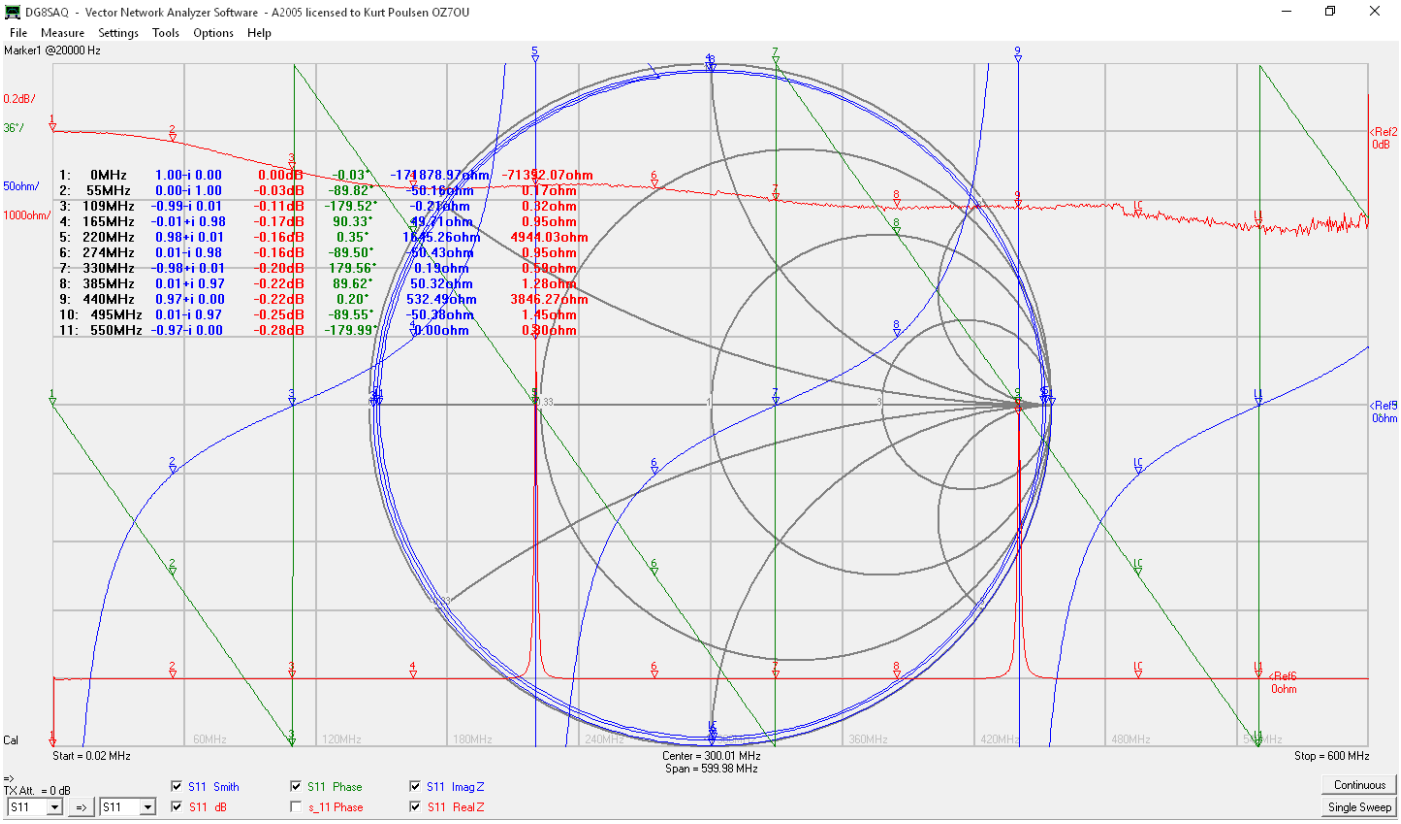
Below the 3 APC7 Airline in series and in open condition



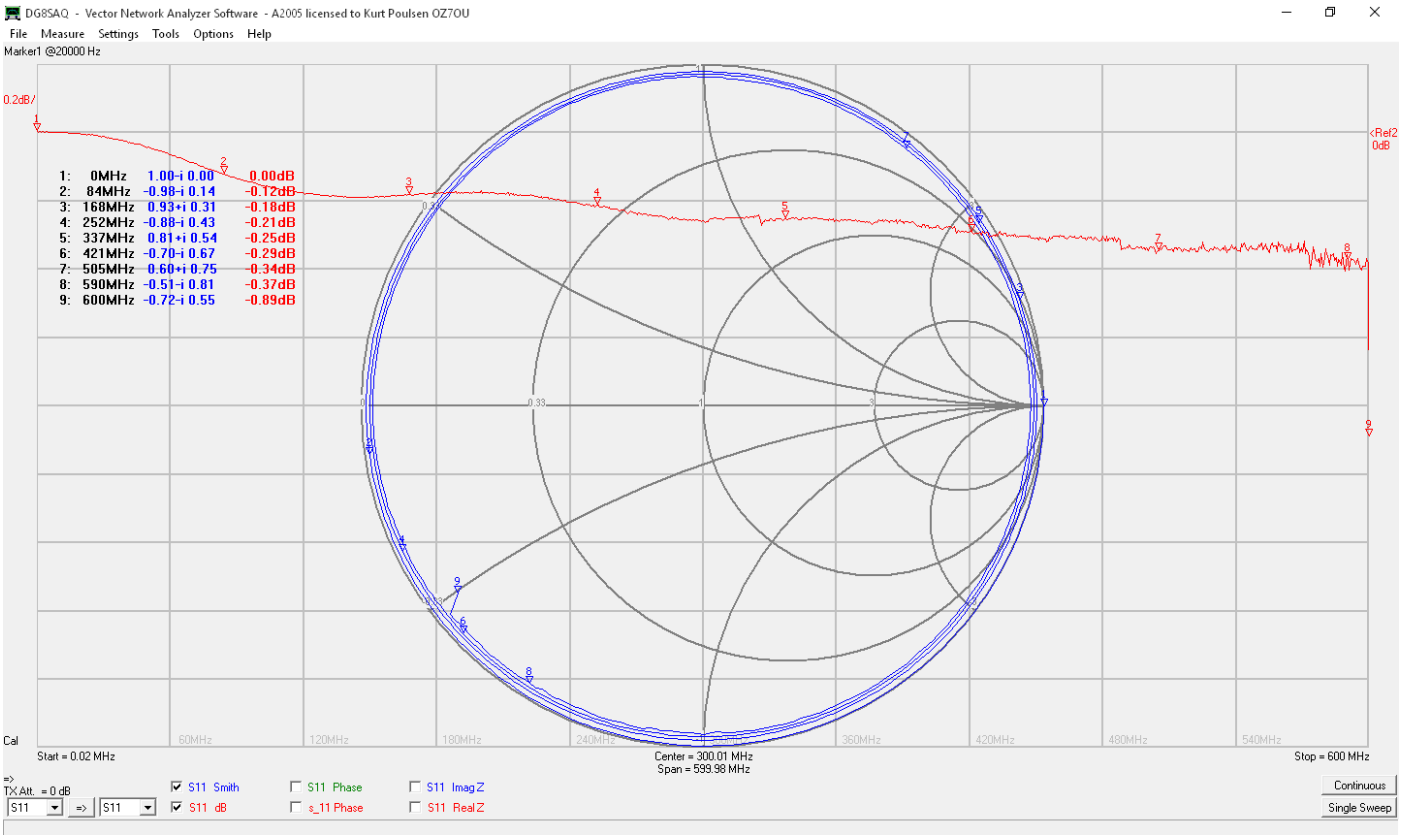
Below the 3 APC7 Airline in series and in shorted condition



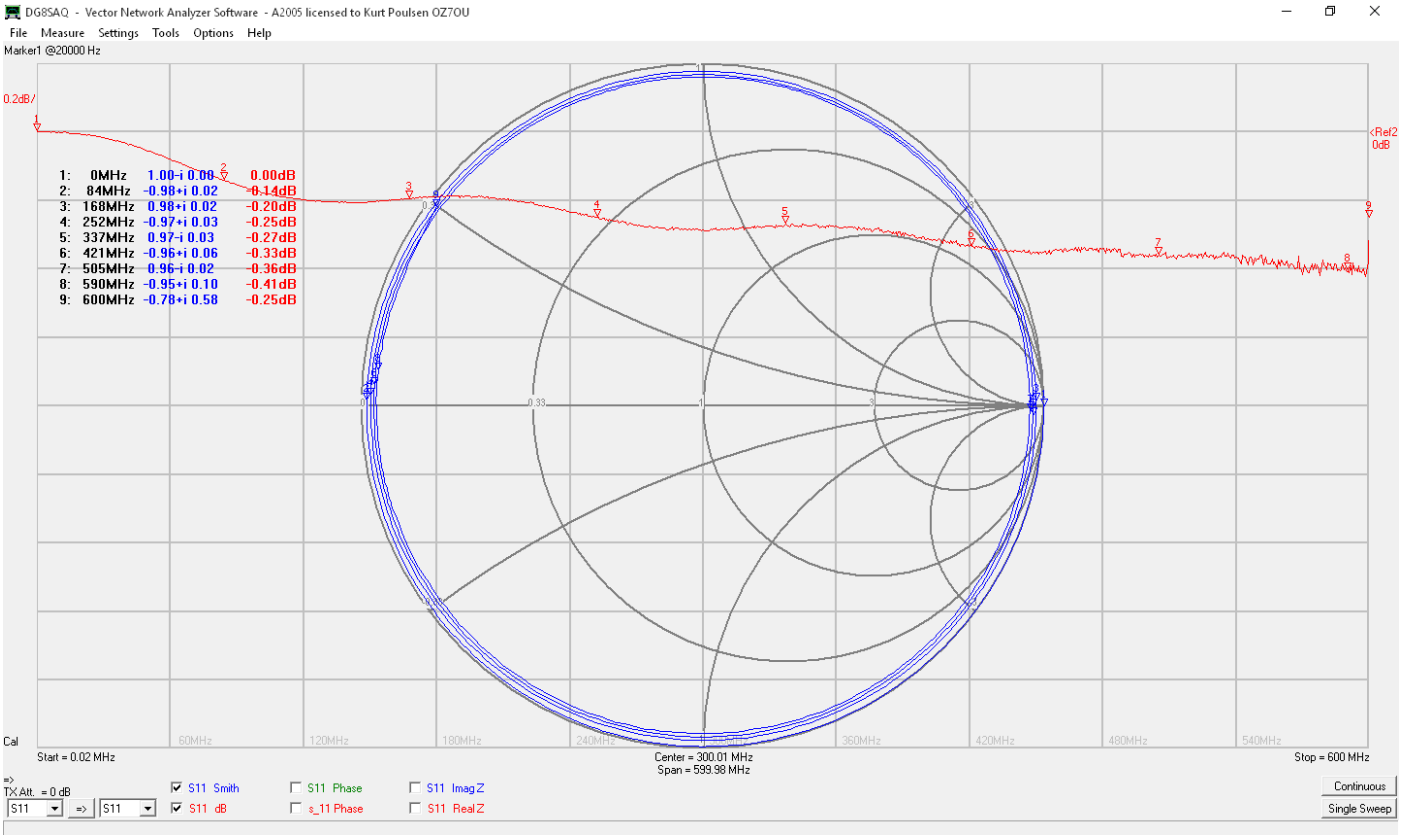
Below a SMA fitted 3.5mm Semirigid cable of length 50cm used in open condition



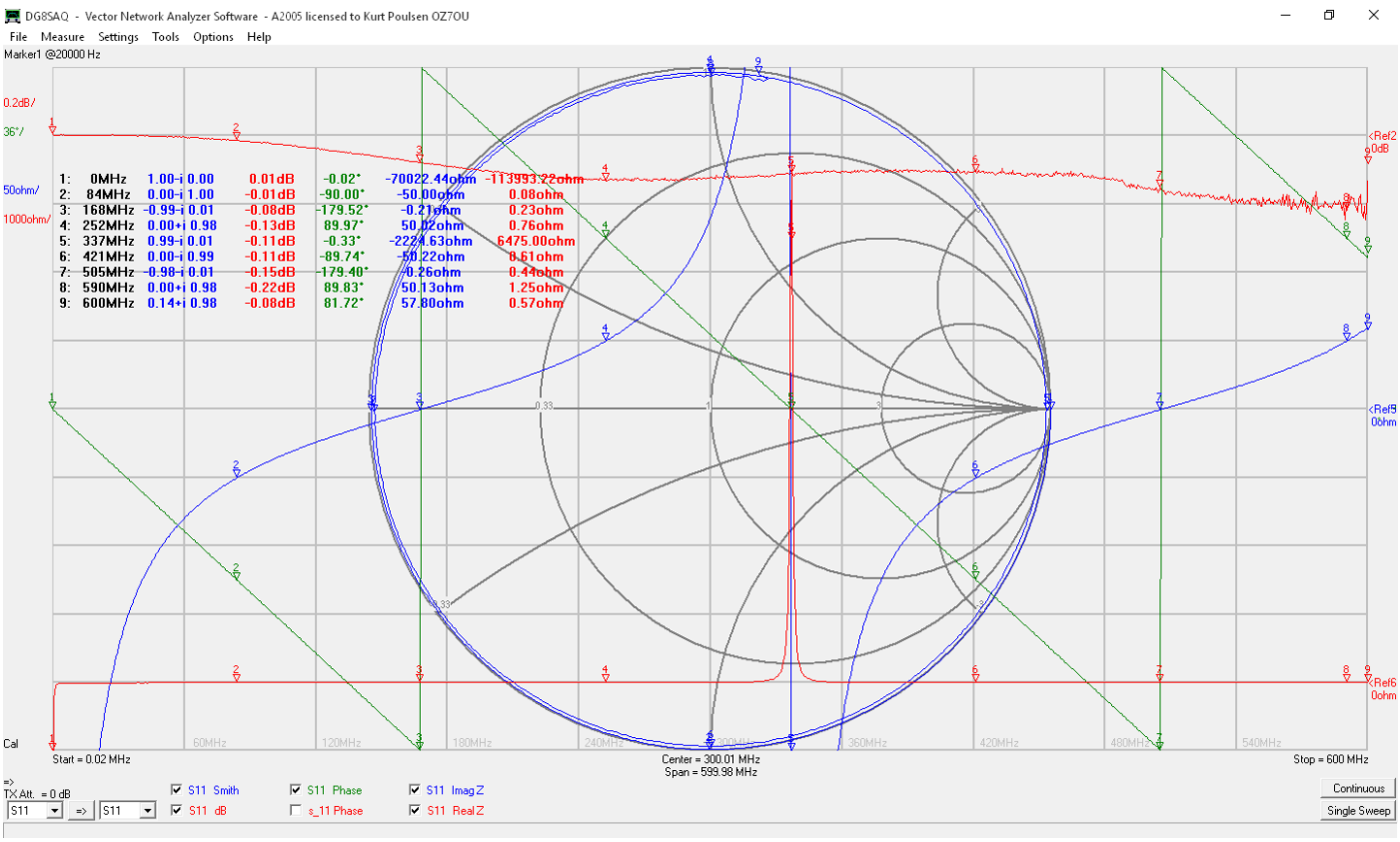
Below a SMA fitted 3.5mm Rosenberger Semirigid cable of length 60cm used in open condition



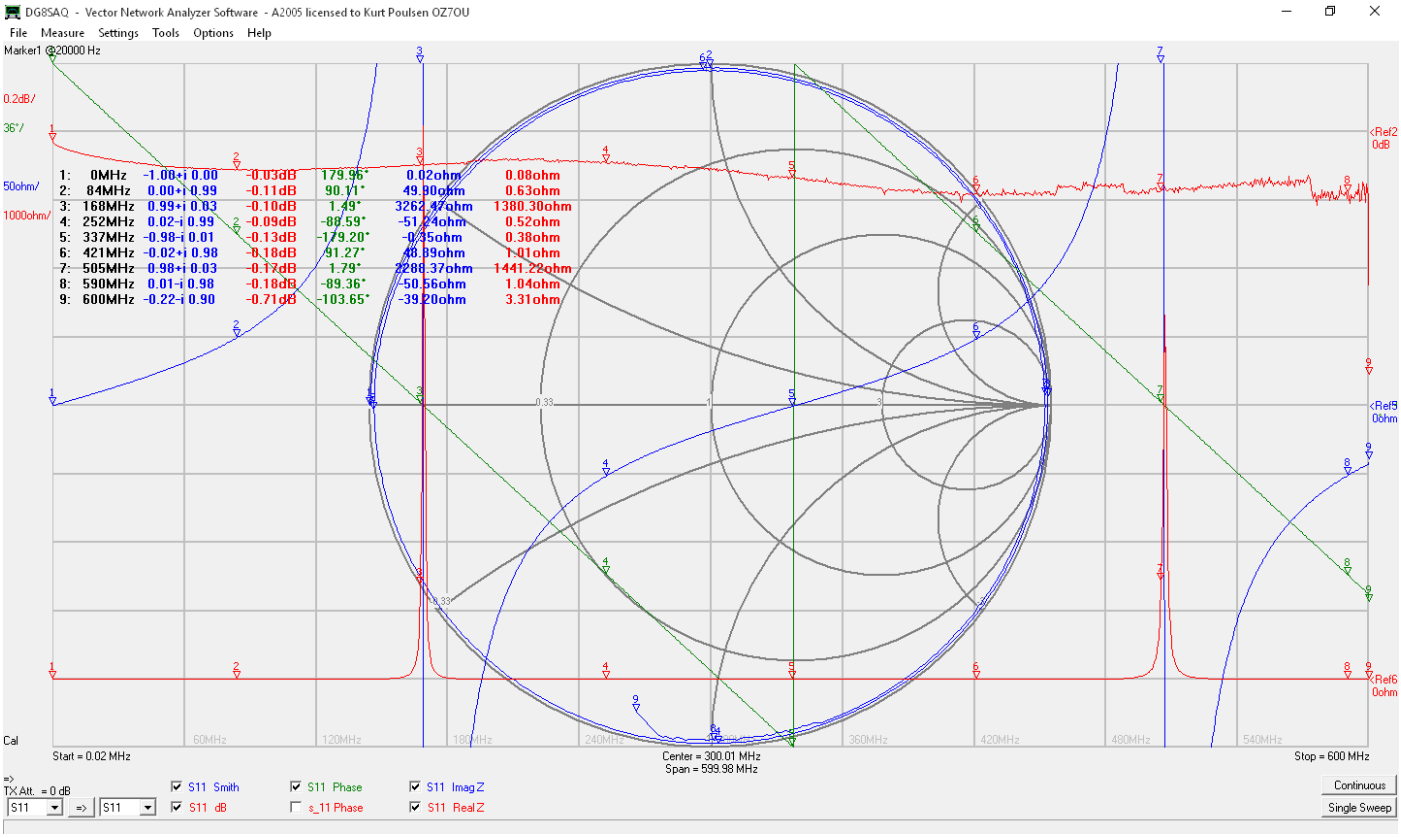
Below an APC7 to APC7 HP 8120-4971-1 test cable used in open condition.



For the next few screen captures the calibration performed with Rosenberger female SDR-Kits calibration kit. Below the three APC7 airlines used in open condition.



Calibration performed with Rosenberger female SDR-Kits calibration kit and the three APC7 airlines in shorted condition.



These results are quite Ok, and the increased S11 dB oscillations are due to imperfection in the fringe capacitance (being slightly frequency dependant) and in particular in the inaccuracy of the delay of the Thu adaptor used for the open calibration, as being frequency dependant to a small degree, as the characteristic impedance is not exactly 50 ohm, and not reflected in the calibration settings.
This is unavoidable and some fine tuning is possible by using the function “real time recalibration” in the calibration settings, but trimming the open delay has the same effect as trimming the Load Shunt C, so which is the right one to trim ?.
This is a topic beyond this report and if you see an S11 dB trace similar to this report just be happy ☺
Kind regards
Kurt de OZ7OU

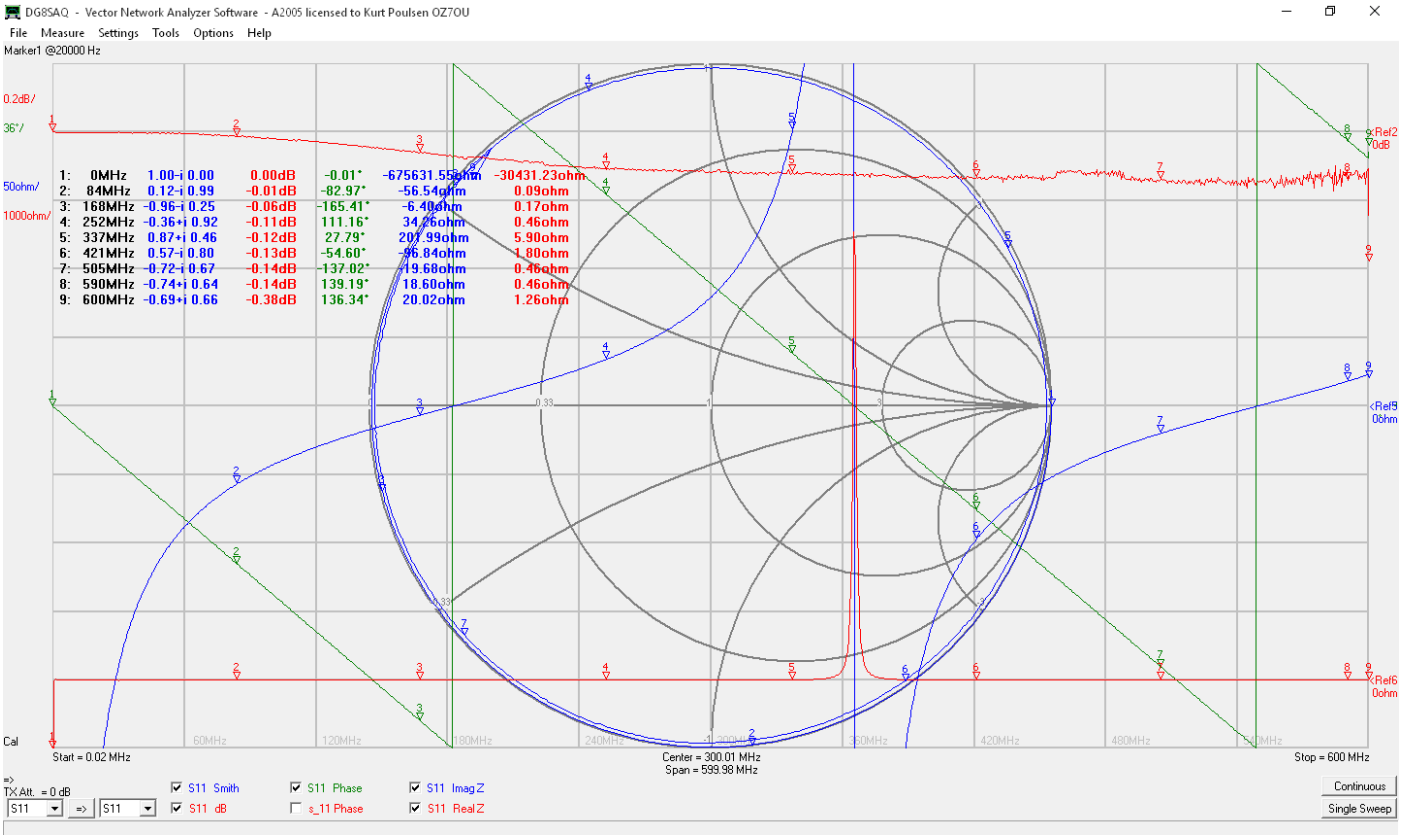
September 20 2015

Addendum:

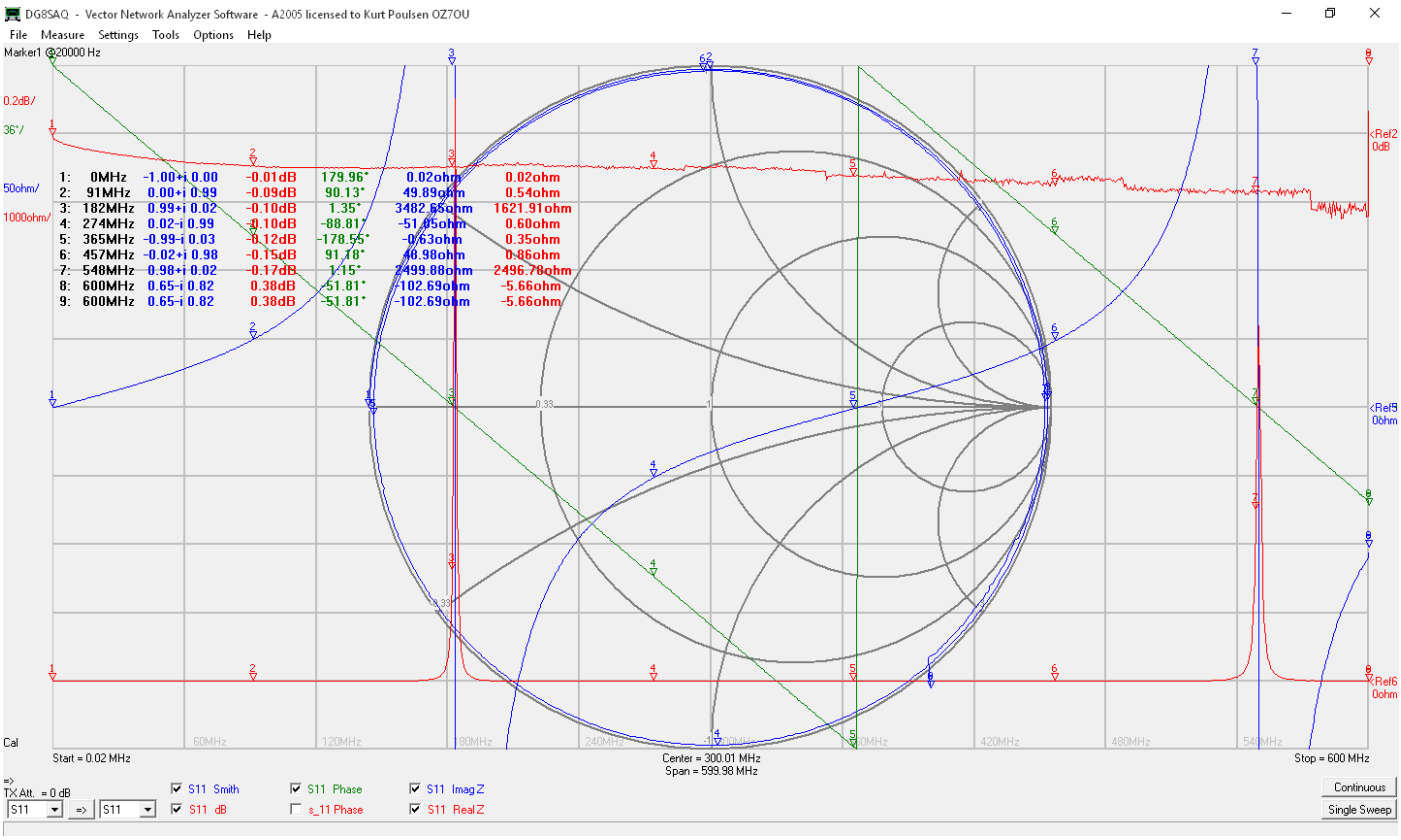
To see how accurate such a test can be, see below for a clean APC7 system test

Finally the VNWA calibrated using a APC7 calibration kit using my APC Front end to the VNWA. Then the APC7 to SMA adaptor not in use.

Below seen the three APC 7 airlines in open condition



Below seen the three APC 7 airlines in shorted condition



Images of the setup used.


HP AGILENT
CALIBRATION KIT
16195A ~~85031B~~
APC-7
04191-60200
10 CM AIR LINE
MODEL 11566A
HEWLETT PACKARD
50Ω TERMINAT
SER NO 504
04191-85302
D 7mm
H 20mm
04191-85300
10 CM AIR LINE
HEWLETT PACKARD