How to calibrate the SAA-2N with the provided calibration kit

SAA-2N is delivered with a very good calibration kit and 2 male-male high quality test cables

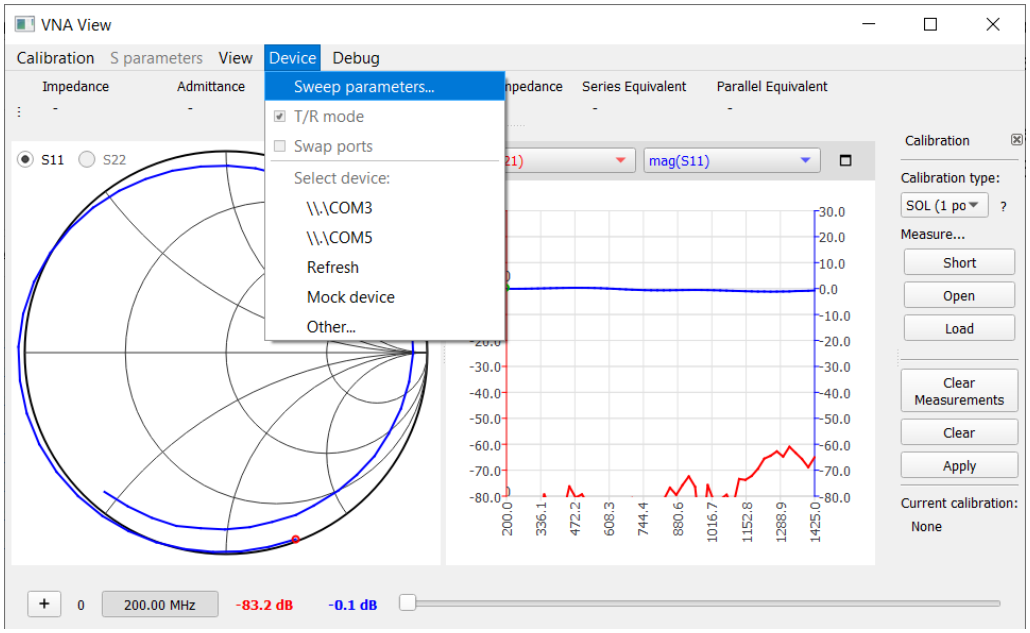
As standalone unit the SAA-2N requires thar the calibration kit is ideal meaning short and open are with no delay and the load is pure 50 ohm for the entire frequency range specified for the Saa-2N being 0.05MHz to 3000MHz. However the delay difference between short and open are pretty small and for frequencies up to 500MHz the load is OK so calibrations are quite useable in that frequency range, and by using by introducing an average delay for the short and open under Display/Scale/Electrical Delay the measurement plane is moved to the calibration plane.
But when connected to a PC it is possible to calibrate with good accuracy.

For use with the VNA-QT software calibration is requiring use of three s1p touchstone files for reflection and one s2p touchstone file for thru calibration. These calibration kit files for 0.1MHz to 3000MHz with 500 point can be downloaded from http://www.hamcom.dk/SAA-2N/SAA-2N VNA-QT calibration kits files.zip and contain both a male kit and a female kit because the supplied female-female adaptor terminated with short, open and load then constitutes a female kit
These calibration kit files when loaded into VNA_QT software can be used for any frequency span and number of points with the frequency range 0.1MHz to 3000MHz
For use with the NanoVNA-saver is required to use some L C and R values and these are to download from http://www.hamcom.dk/SAA-2N/NanoVNA-Saver ini file addition.zip and listed later in this report

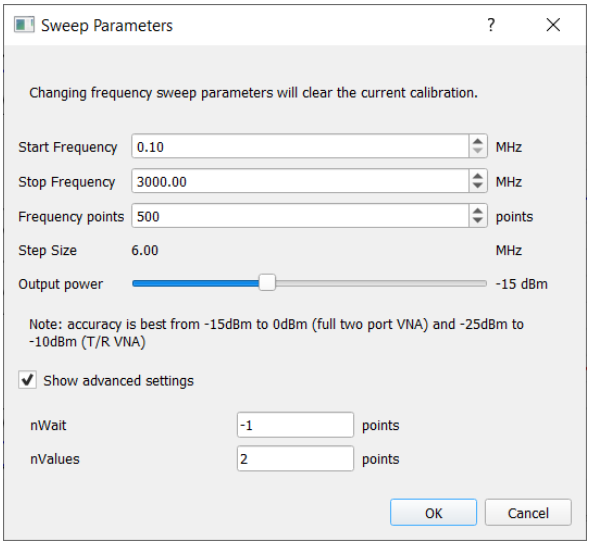
Detailed instruction follows below how to do the calibration

A few words about calibration and the calibration planes by using either VNA-QT or NanoVNA-saver
With the male calibration kit you can either calibrate directly at the female port1 and at the end of a test cable connected to port with the provided female female adaptor fitted. The second test cable connected to port 2 is the fitted to the female female adaptor if thru calibration is performed as well. In this case you may consider it as a virtual 0 length male female adaptor used. This means that the DUT to test must be fitted with a male adaptor in the input and a female adaptor on the output. If you remove the female female adaptor for measuring a DUT with female adaptors on both input and output, then the phase sync between Reflection and Transmission is lost and the measurement is not done at the calibration plane, which was at the end of the female female adaptor now removed. However means are moving the calibration plane from the end of the female female adaptor to the male adaptors reference plane, to be demonstrated later.
Using the female kit and inserting the female female adaptor during thru calibration everything is perfectly calibrated.
For using the SAA-2N without computer the calibration is based on ideal calibration kit and it also possible to shift calbrations plane to the reference plane by DISPLAY/SCALE/ELECTRICAL DELAY function by entering the average delay for short and open being 20.4ps for male and 78.3ps for female, as well for the female female adaptor which is 58.3ps. More on that later as load is a bit problematic and the load and short delay are frequency dependent

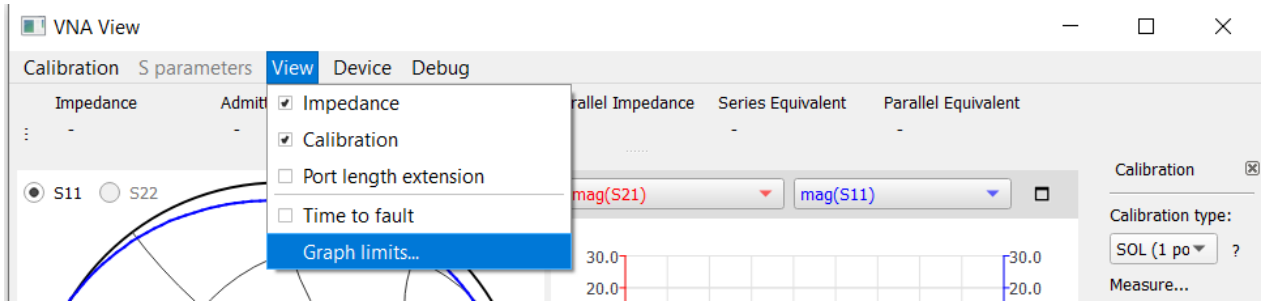
How to calibrate using the VNA-QT software.
At first go to Device and Sweep parameters and set start (min. 0.1MHz) and stop frequency and number of points

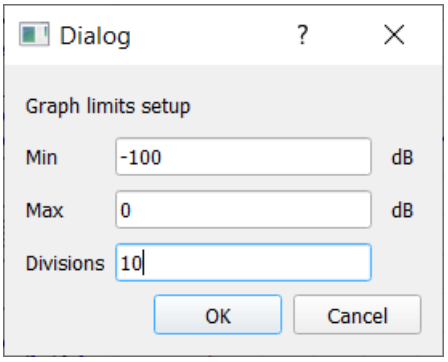


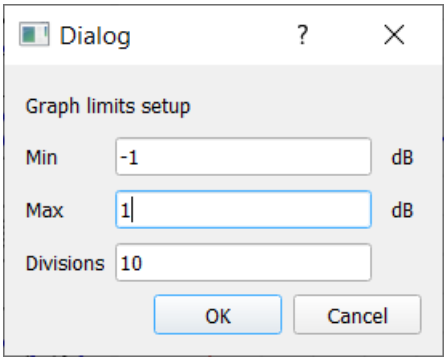
If you enable “Show advanced settings” and by increasing nValues you get more measurements per point



By enabling View Graph limits you can set the scaling. Two common setting are shown below for measuring with large dynamic range and with high resolution when measuring high impedances and very low reflection coefficients and transmission with low loss.

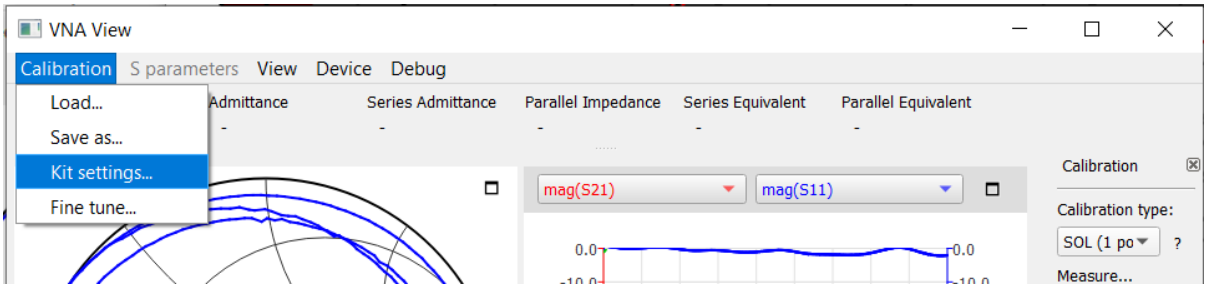




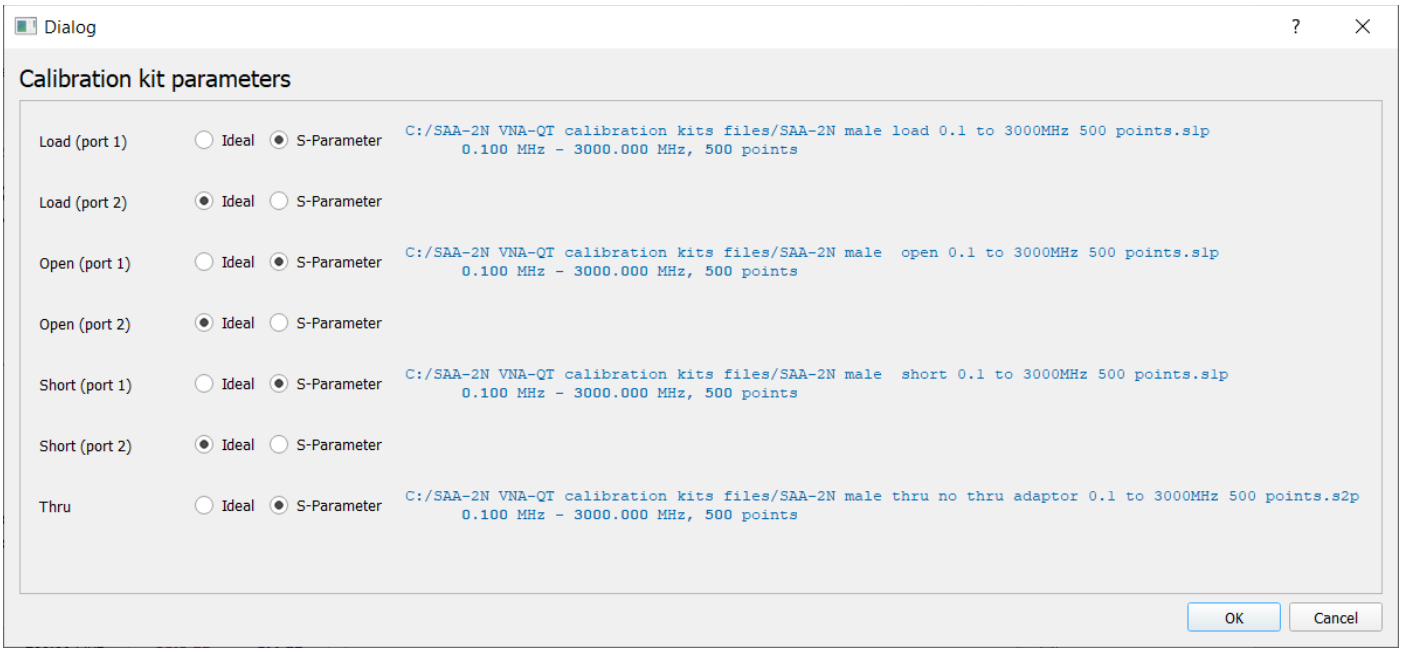


Next load the s1p Load, open and short calibration kit files and the s2p thru calibration kit file for transmission

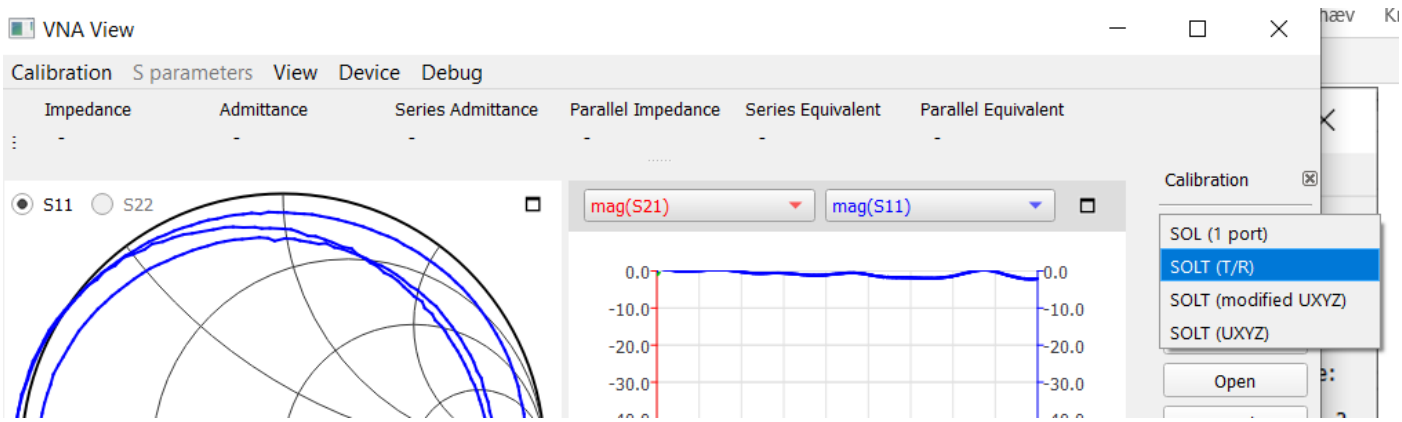
Open the Calibration and Kit settings and load the relevant files



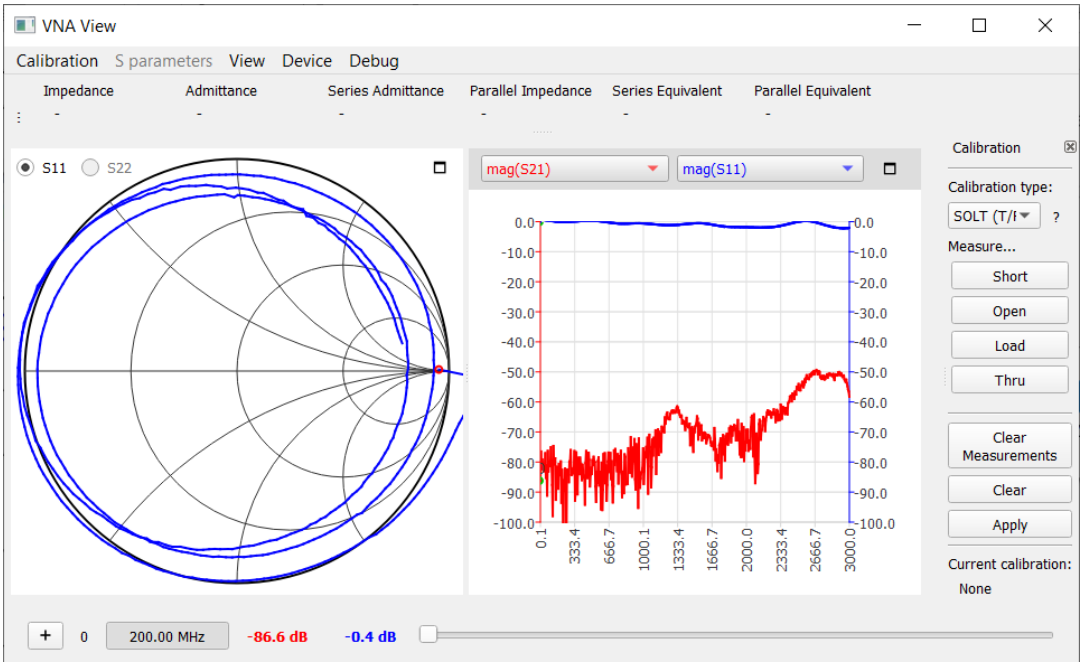
By clicking on the S-Parameter text you find the files where you have saved the s1p and s2p files and only port1



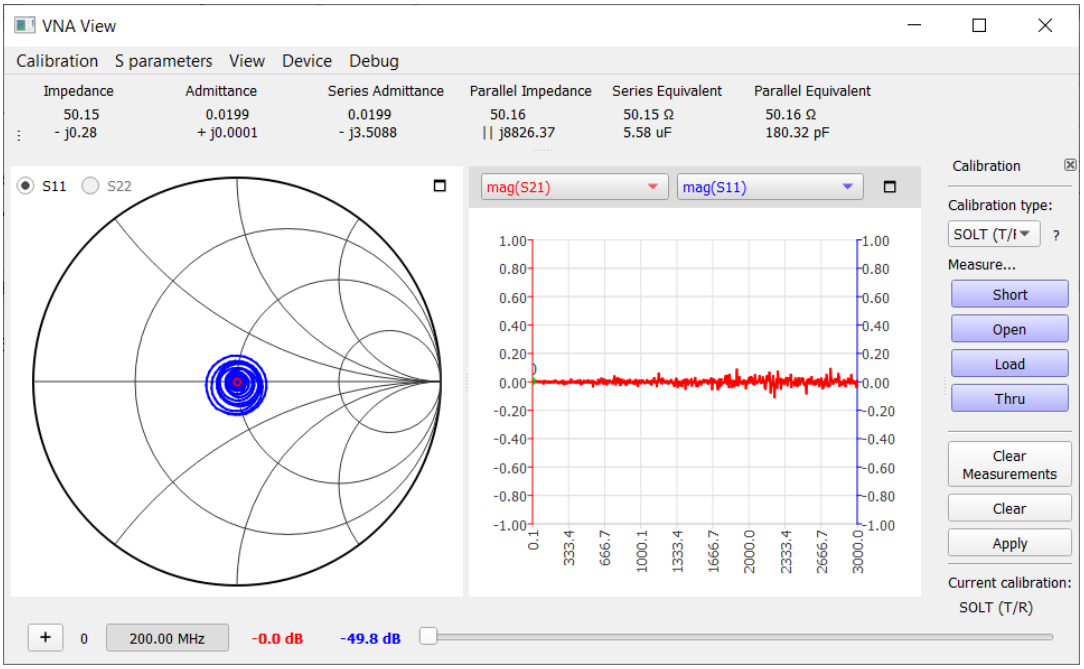
Next decide if you want to SOL or SOLT calibrate



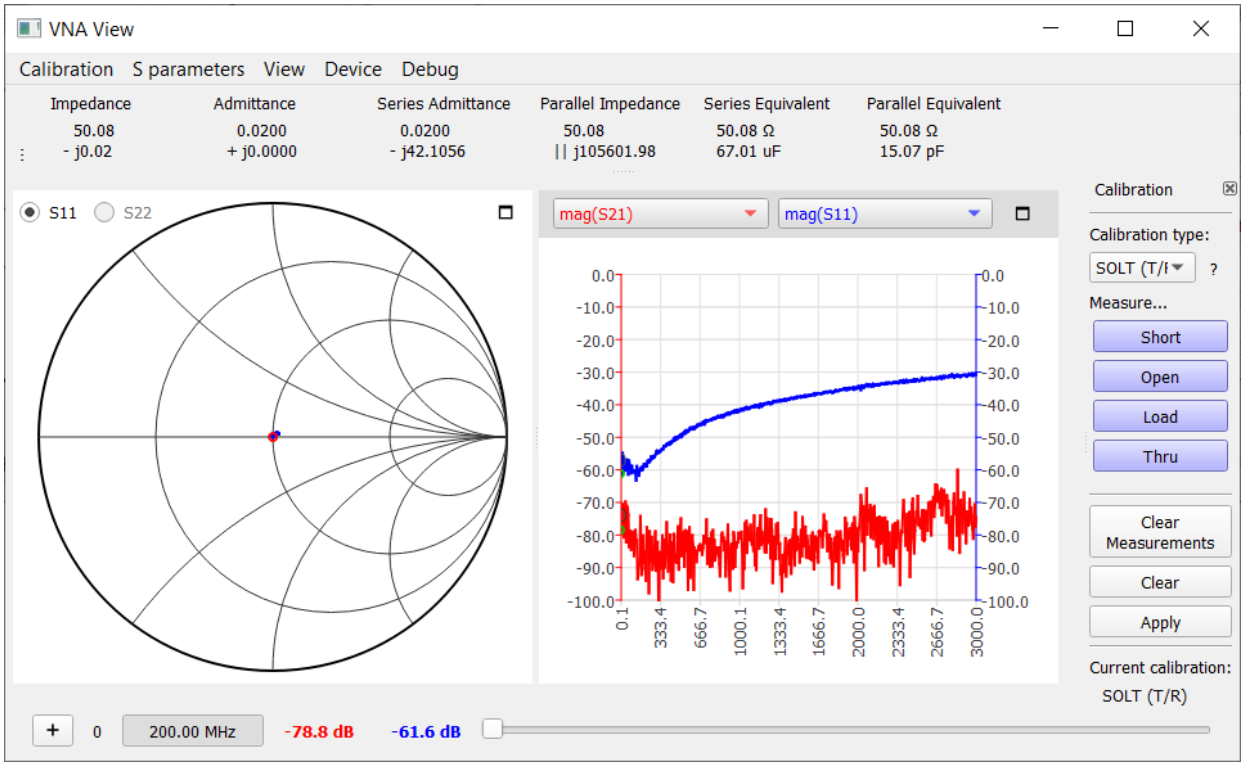
Now click on the Short, Open, Load and Thru buttons and wait until they are no longer dimmed in contrast and finally click on Apply. Now you system I calibrated and ready for measurements



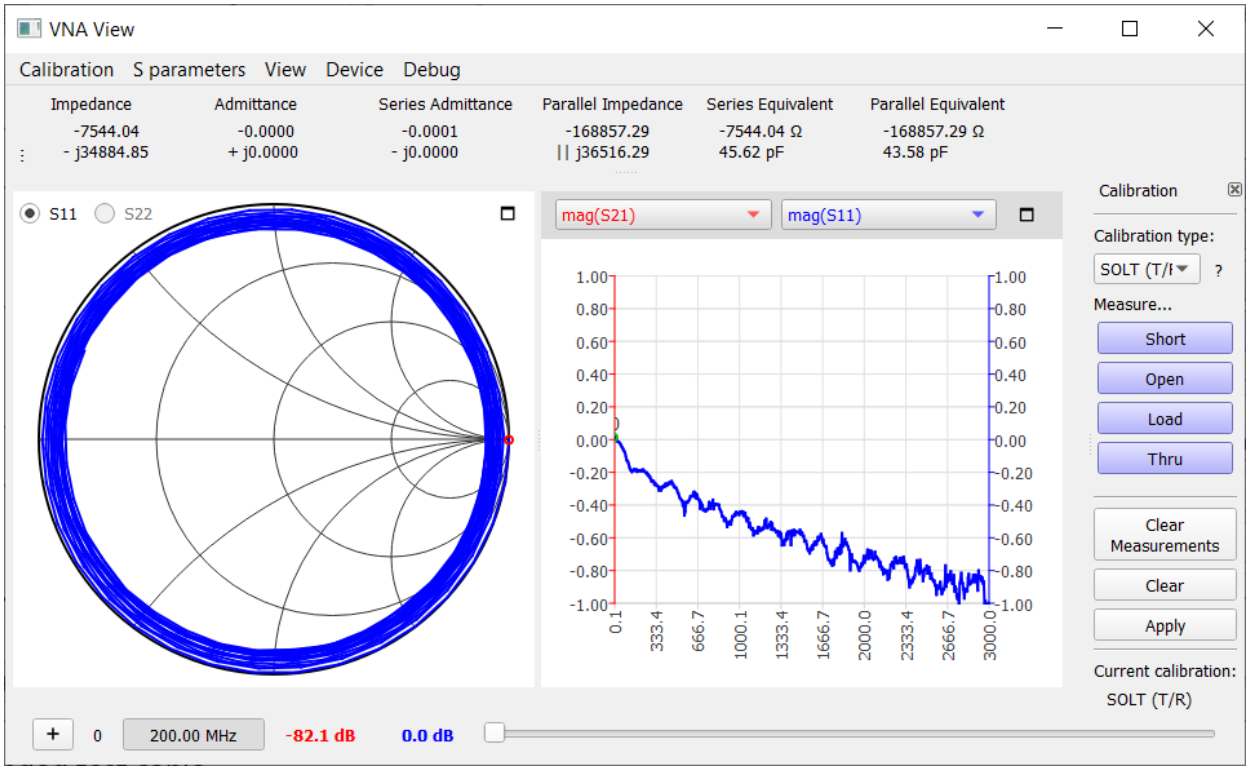
Thru calibration with male male test cable fitted



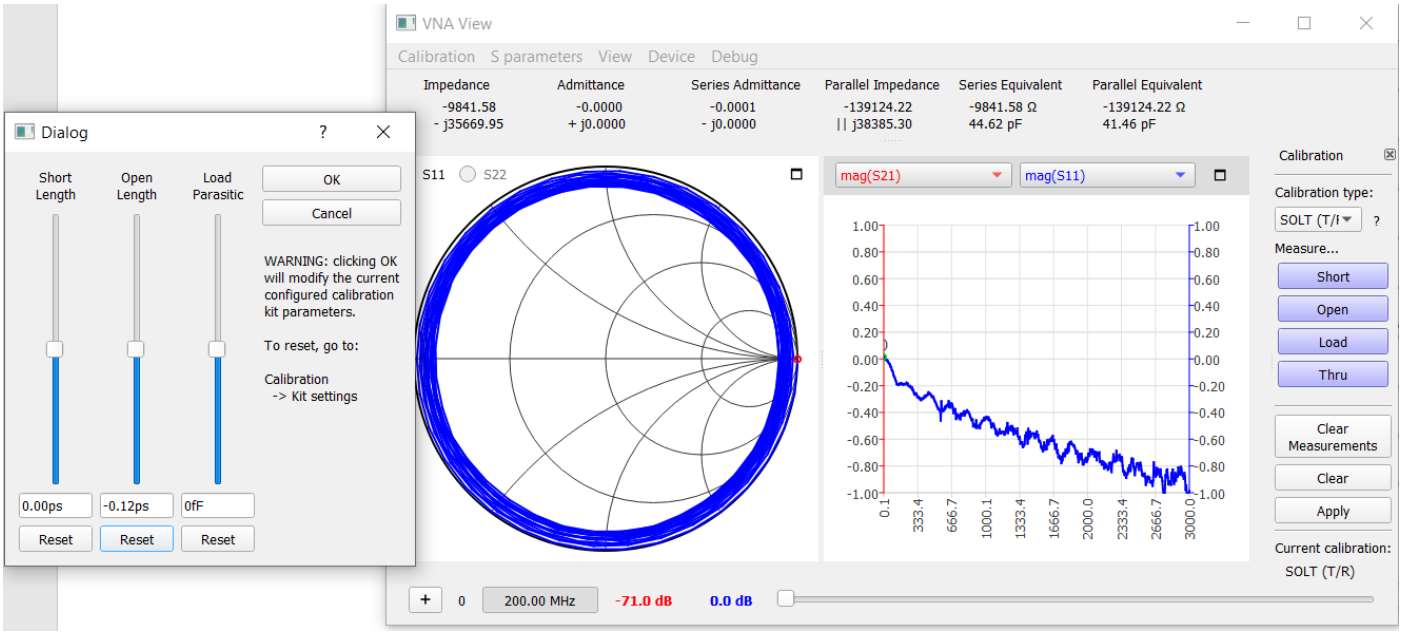
Measurement of the load after calibration. nValues increased from 2 to 4



Test of calibration by sweep of the open ended test cable. The oscillation is supposed to fade out with increasing frequency but small deviations from SAA-2N female female adaptors can be corrected for by using a fine tuning found under Calibration/Fine tune

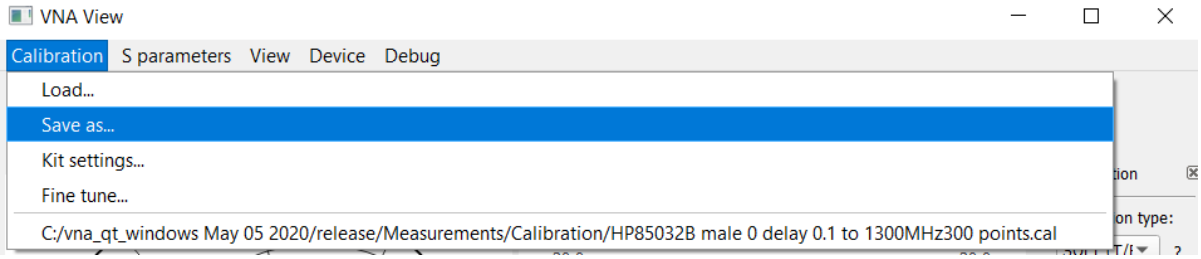


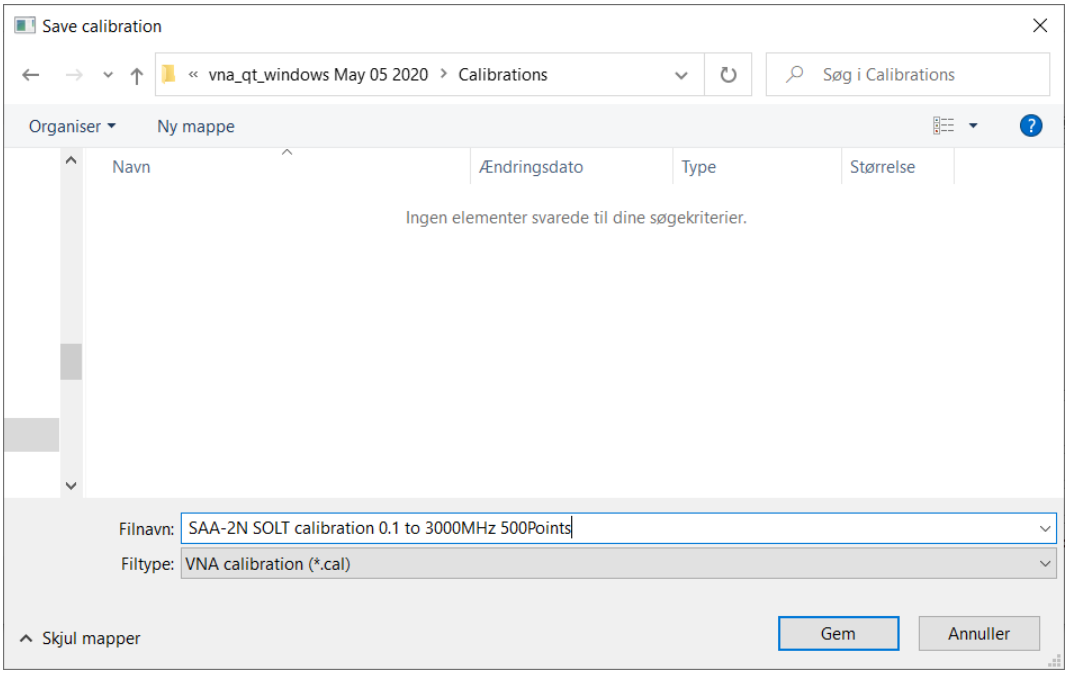
By using the mouse scroll wheel, it is possible to finetune a bit and -0.12ps was the very small improvement possible and not worth correction, which is performed permanently by a click on OK



Saving and Loading of calibrations

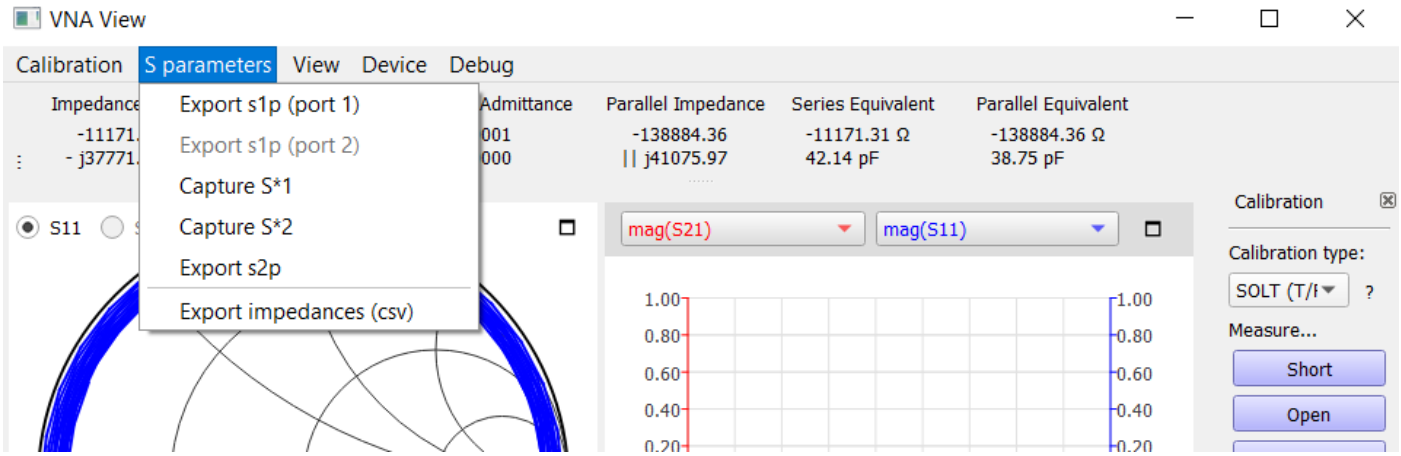
By clicking on Save… you are invited to create a descriptive name for the actual calibration to be retrieved later by a click on Load…



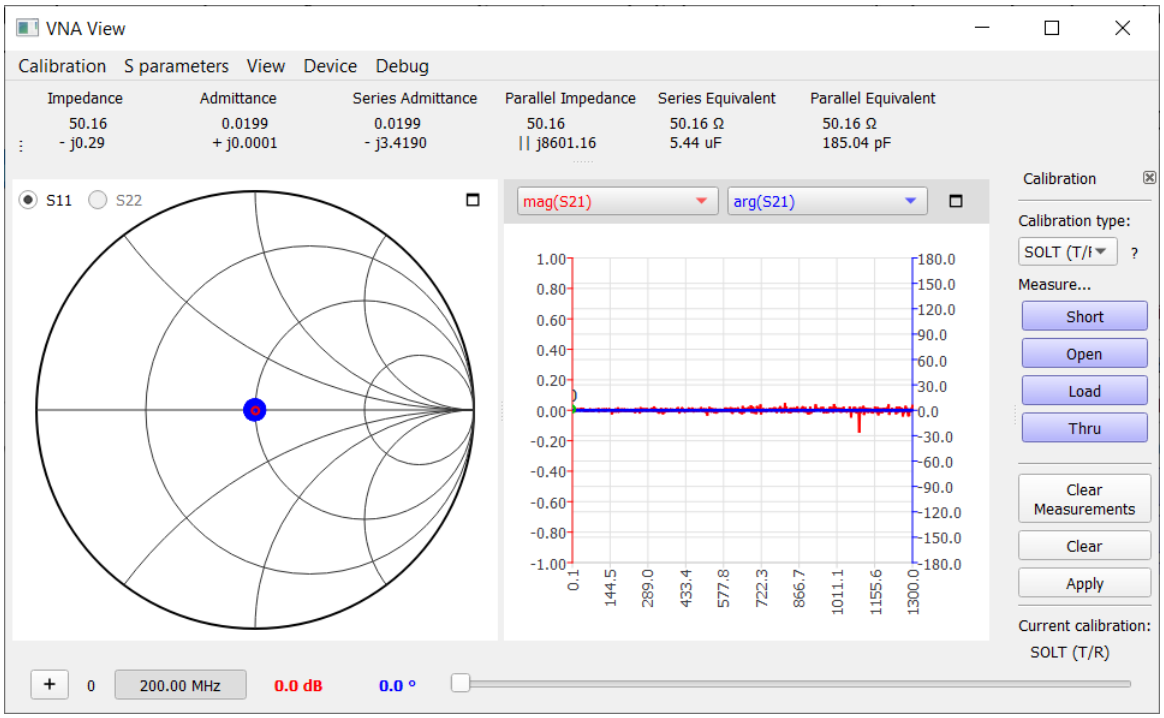


Saving of measurements:
By choosing S parameter any measurement can be saved for reflection s1p (port1) a click ask you to provided a file name for saving but watch out the measurement to save is first performed after the saving of the file name. The various button are dimmed until measurements are done:

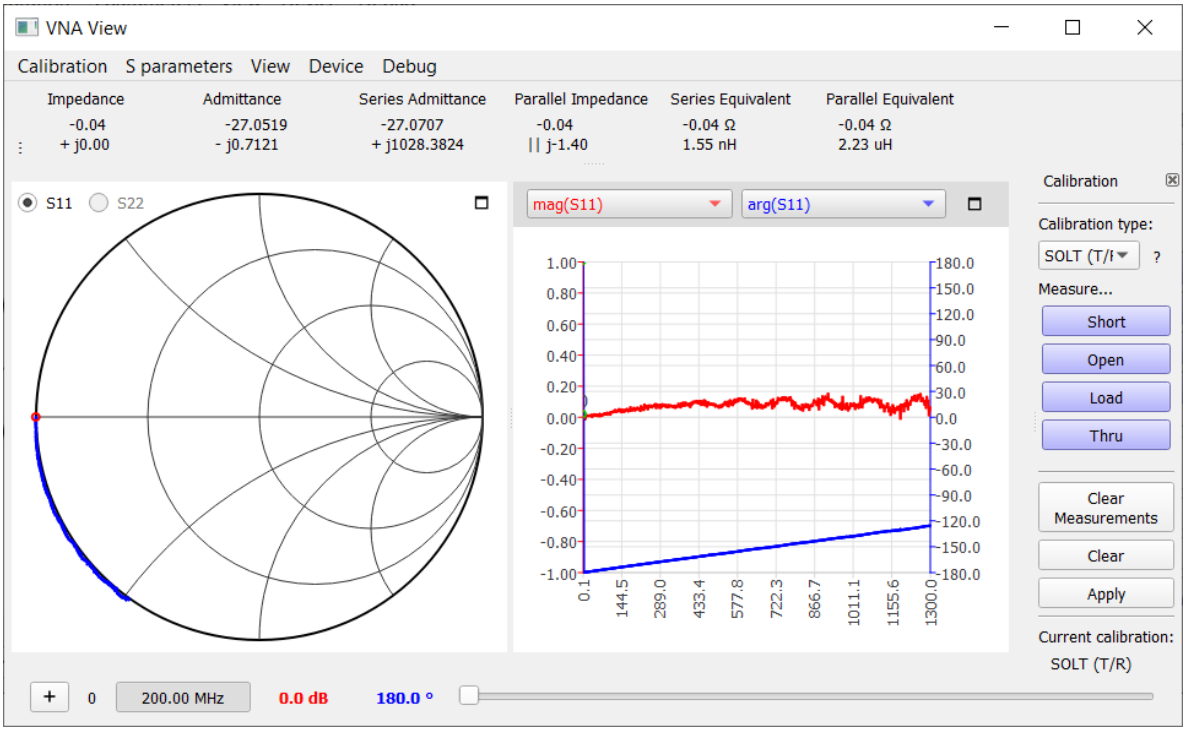
For transmission measurement you must first click on Capture S*1 (s11 and s21) with the DUT connected for forward measurements. Then revert the DUT for a reverse direction and click on Capture S*2 (S22 and S12). For both Capture you must wait until done. Then Export s2p and as soon the file name saved you are done.



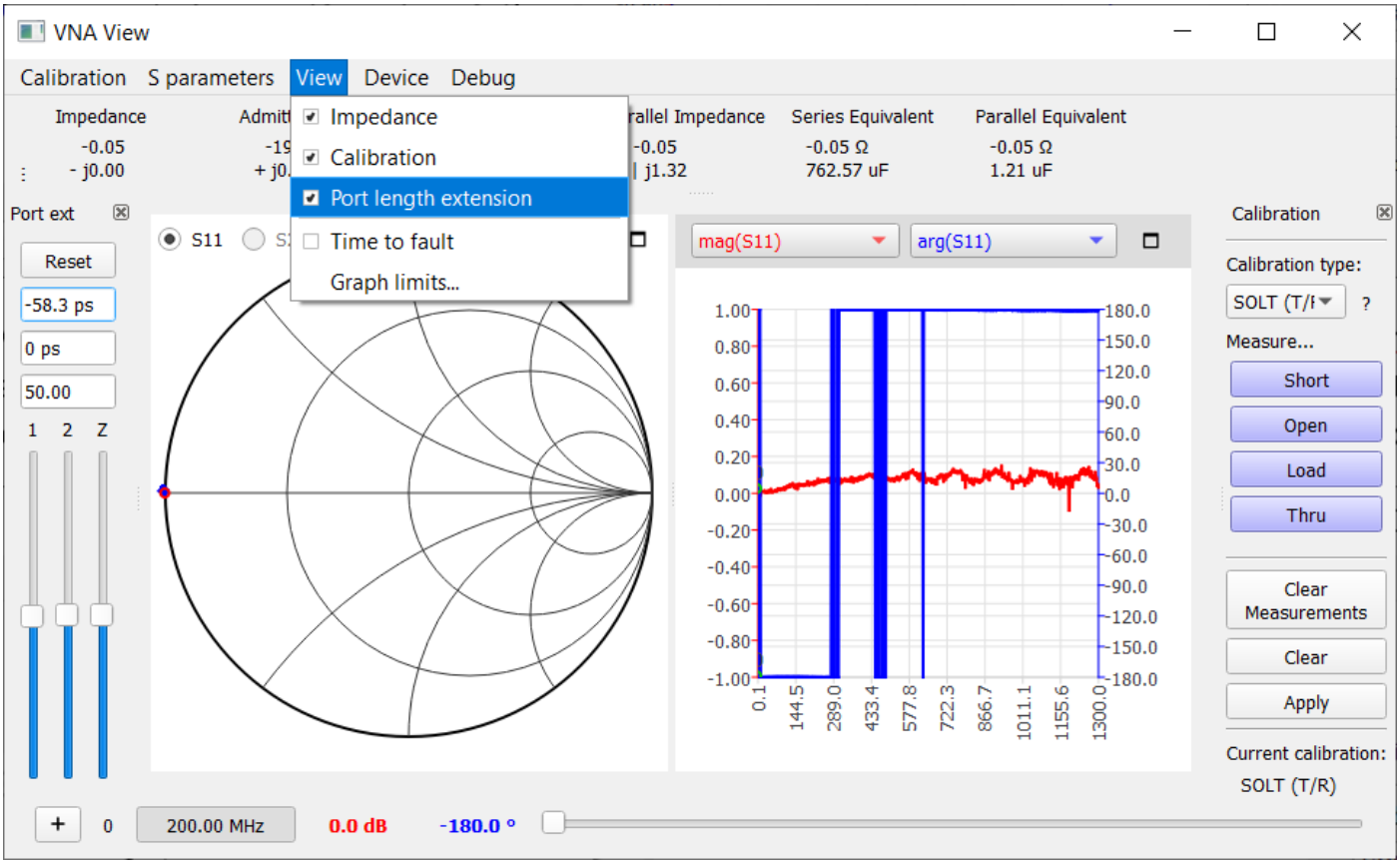
male calibration of end of test cable with female female adaptor fitted
As seen insertion attenuation is 0dB Mag(s21) and phase angle is 0 arg(S21) as expected



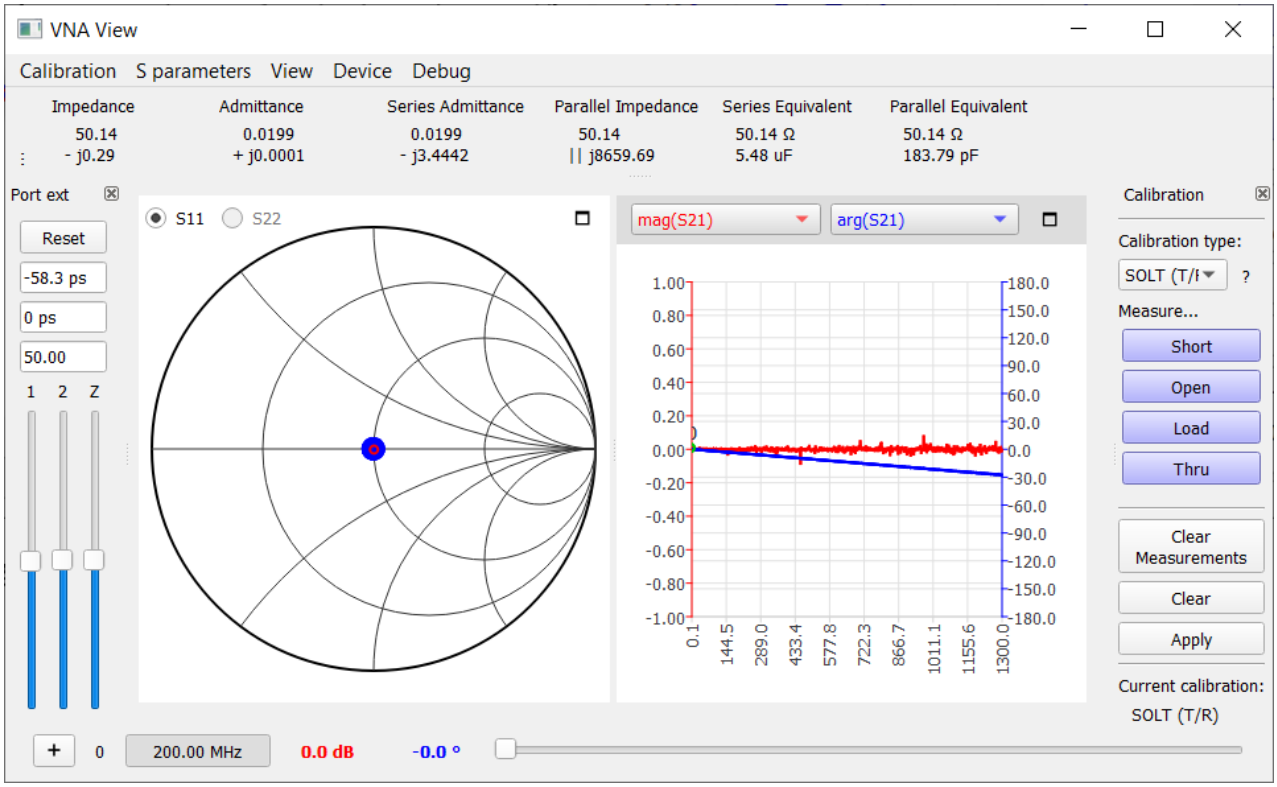
Next the female female adaptor removed and an 0 ps short fitted at the end of the Port1 test cable
As seen the short turns the wrong way round due to the missing female female adaptor and we now will compensate for the missing delay.



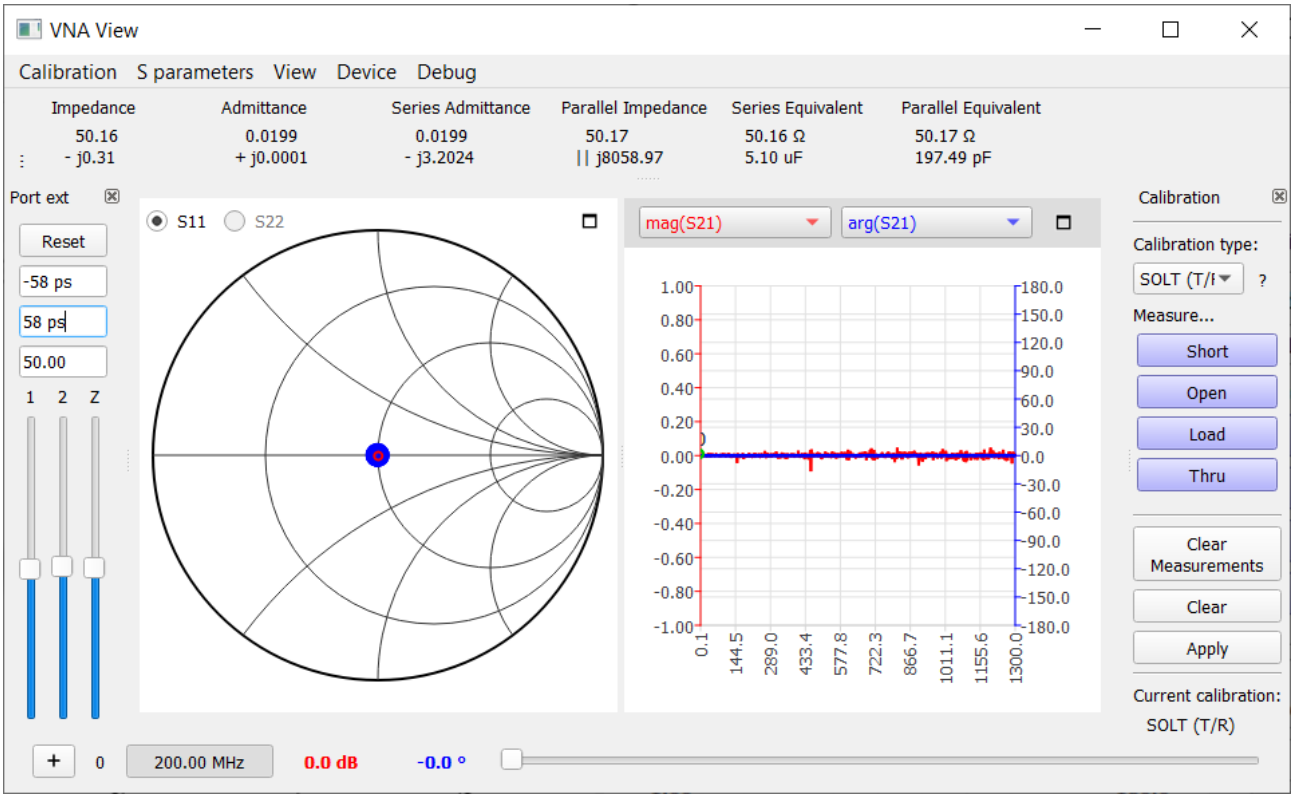
By choosing View and enable Port length extension we now tune Port 1 until the position in the Smithchart is at extreme left and the arg(s11) is flipping between + - 180 degree.
Actually you can just enter the delay for the female female adaptor being -58.3ps as I on purpose used the 0 ps female short adaptor for the demonstration. Now the calibration plane is the port 1 test cable male adaptor at the end of the testcable



By re-inserting the female female adaptor we should now measure the female female adaptor. There shall not be changed anything for port2, as the delay thru the port 2 test cable is unchanged.



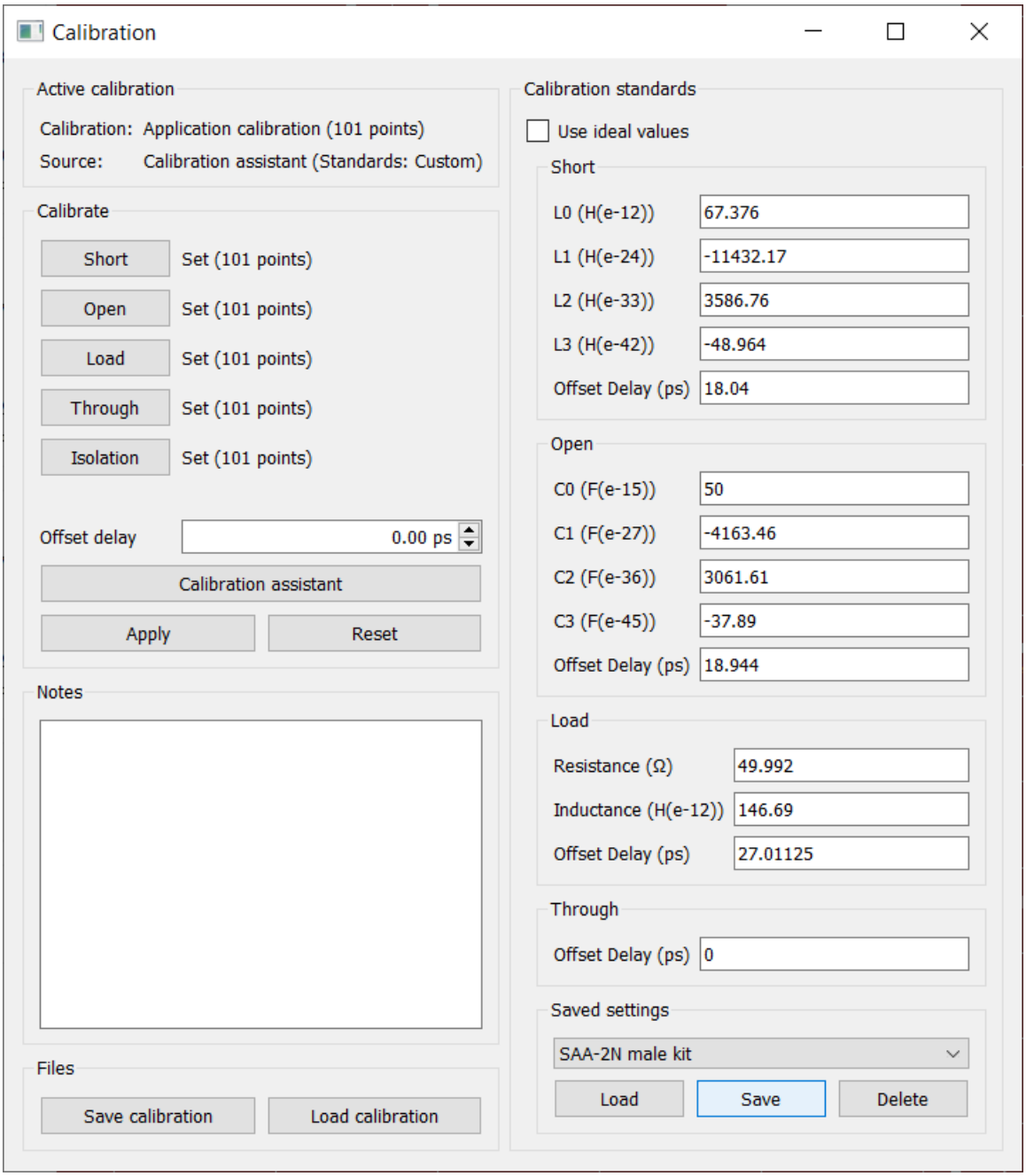
As a control, just for fun we can offset this delay adjustment by adding +58.3ps to port2 as seen below
The VNA-QT round off the decimal point 58.3 to 58ps



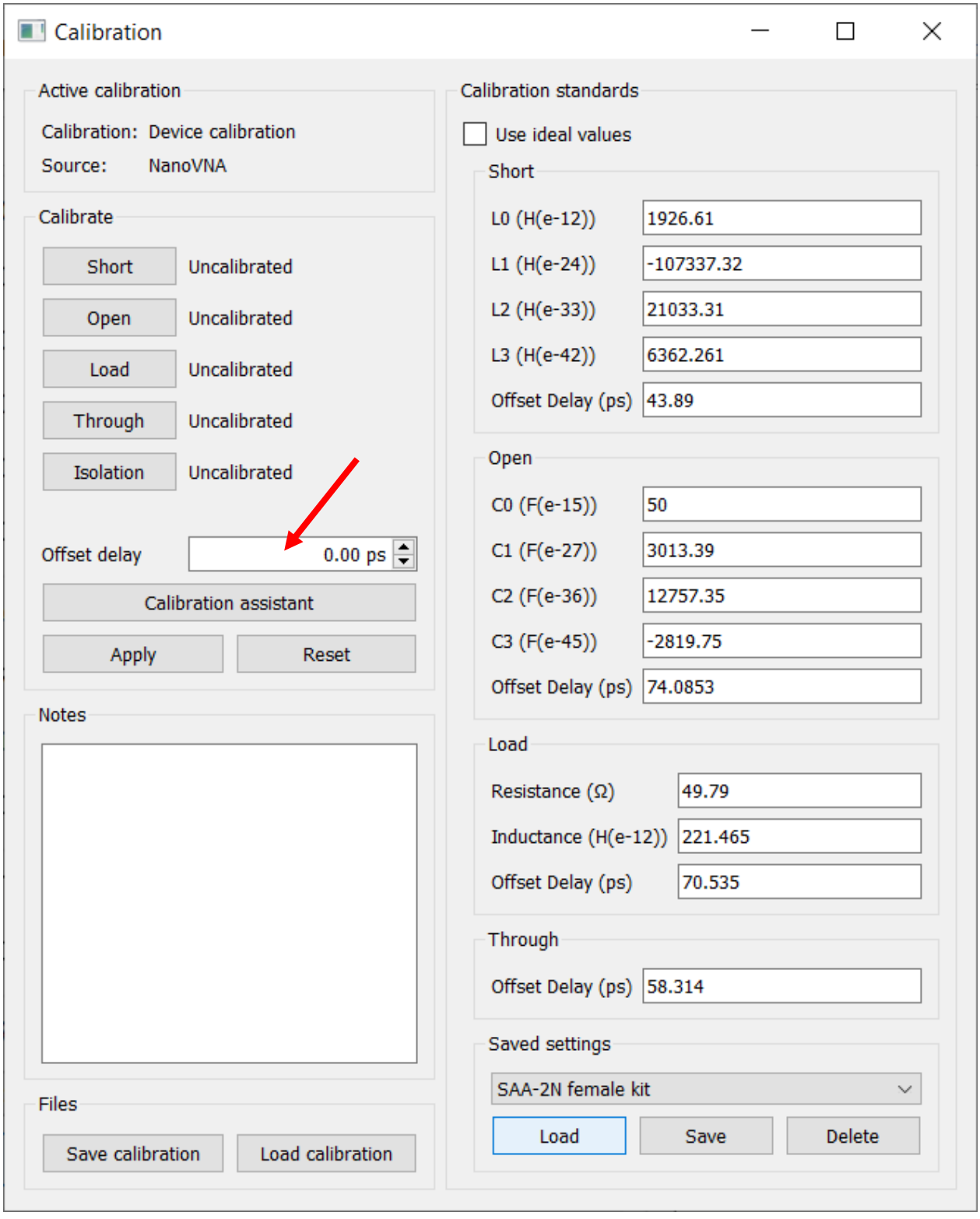
How to calibrate using the NanoVNA-saver software

It is quite simple to calibrate for any frequency span and any number of segments by creation following calibration kit files and save under a descriptive name. Then use the “Calibration assistant” and follow the prompting

The male kit settings



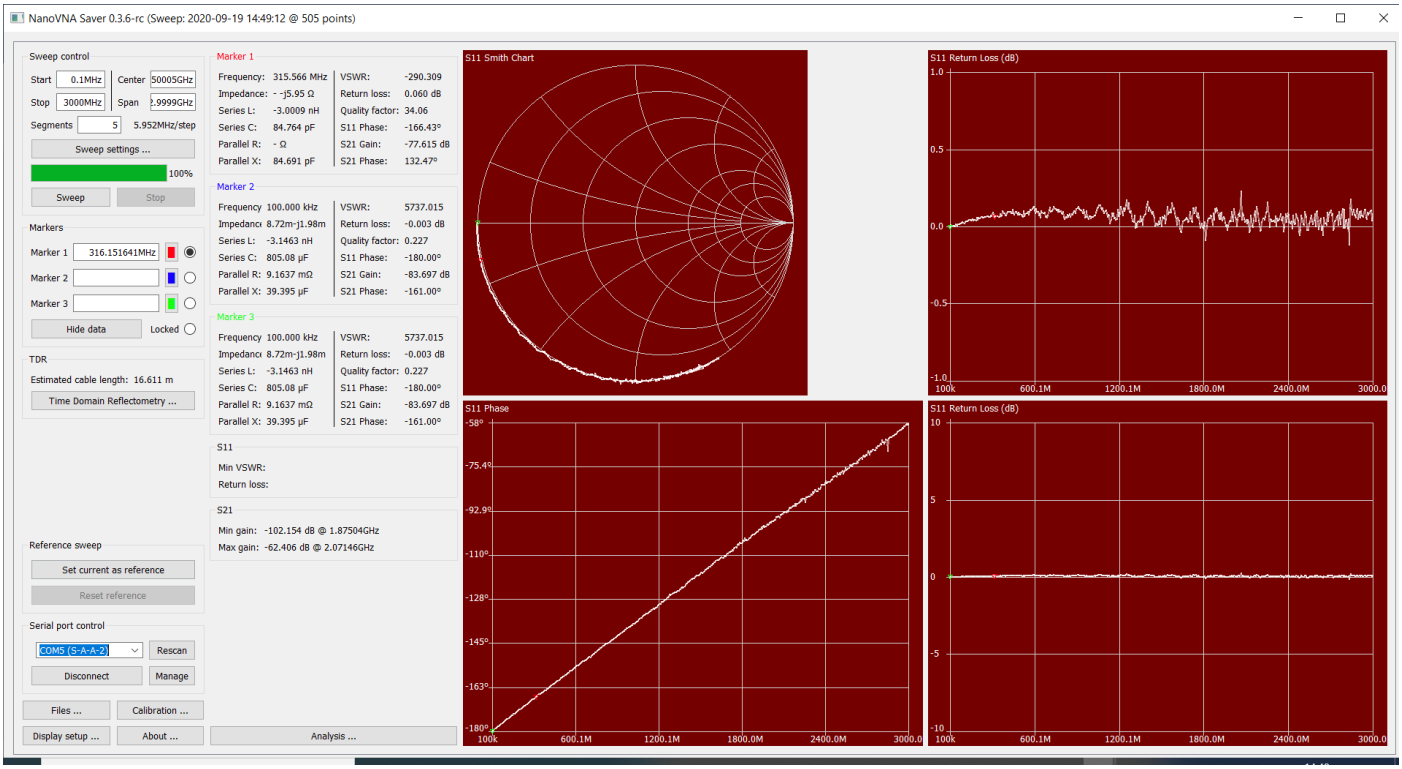
The female kit settings



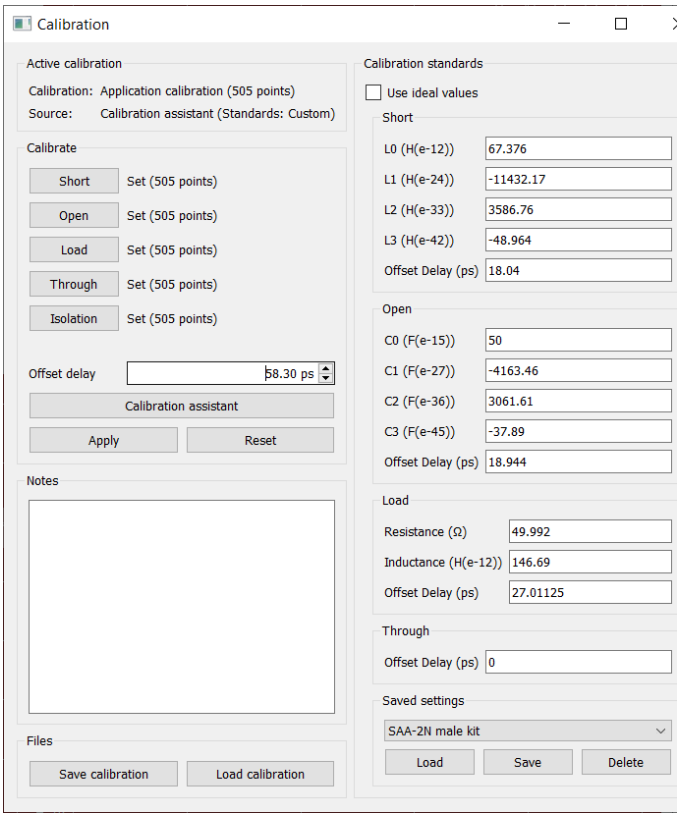
Some additional notes to the NanoVNA-saver

The same possibility exist for the NanoVNA saver to male calibrate at the end of the port1 test cable when fitted with the female female adaptor and the do an Offset delay by -58.3ps at the red arrow.
This result of Offset delay entry are shown dynamically

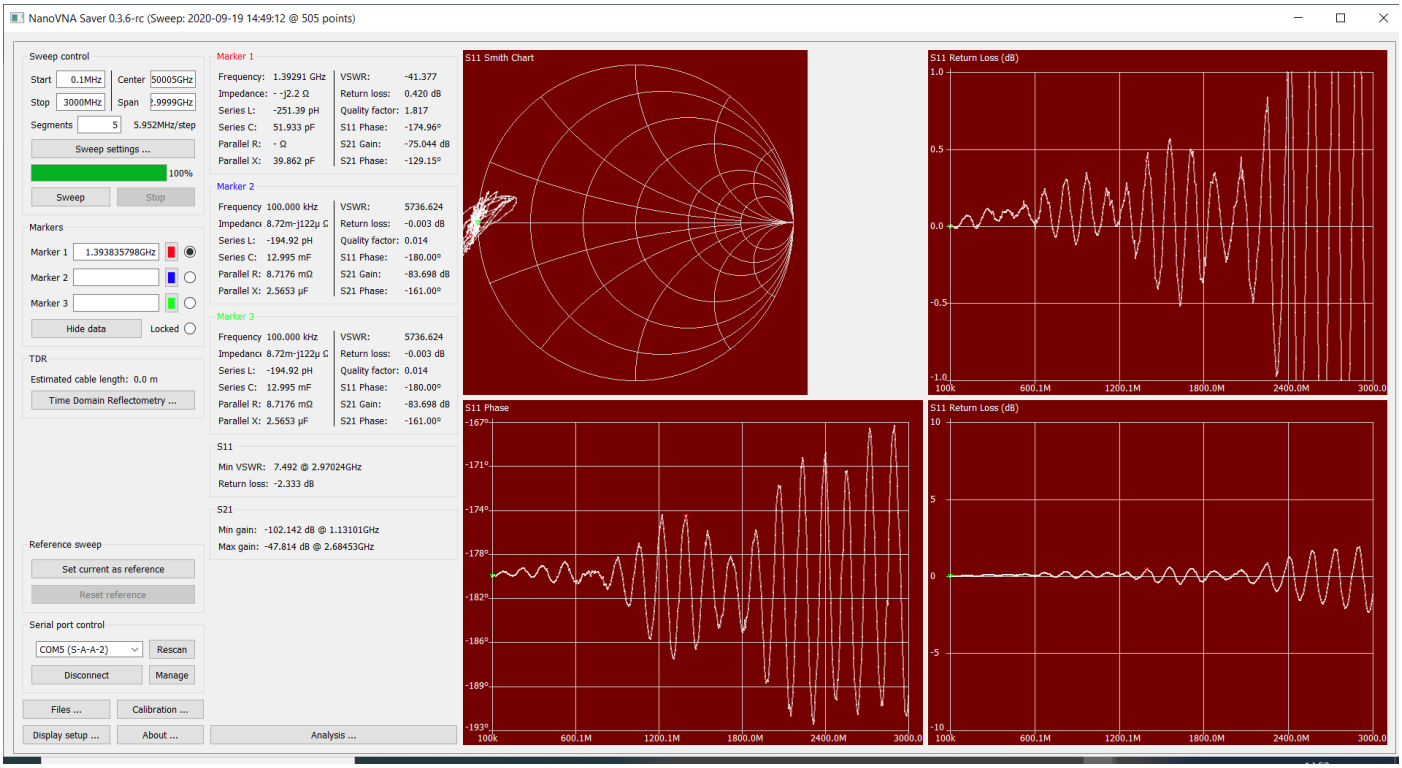
Here is shown the sweep after the female female adaptor is removed with a 0 ps short terminating the male adaptor of the SAA-2N port 1 test cable. As before it the trace turn anticlockwise



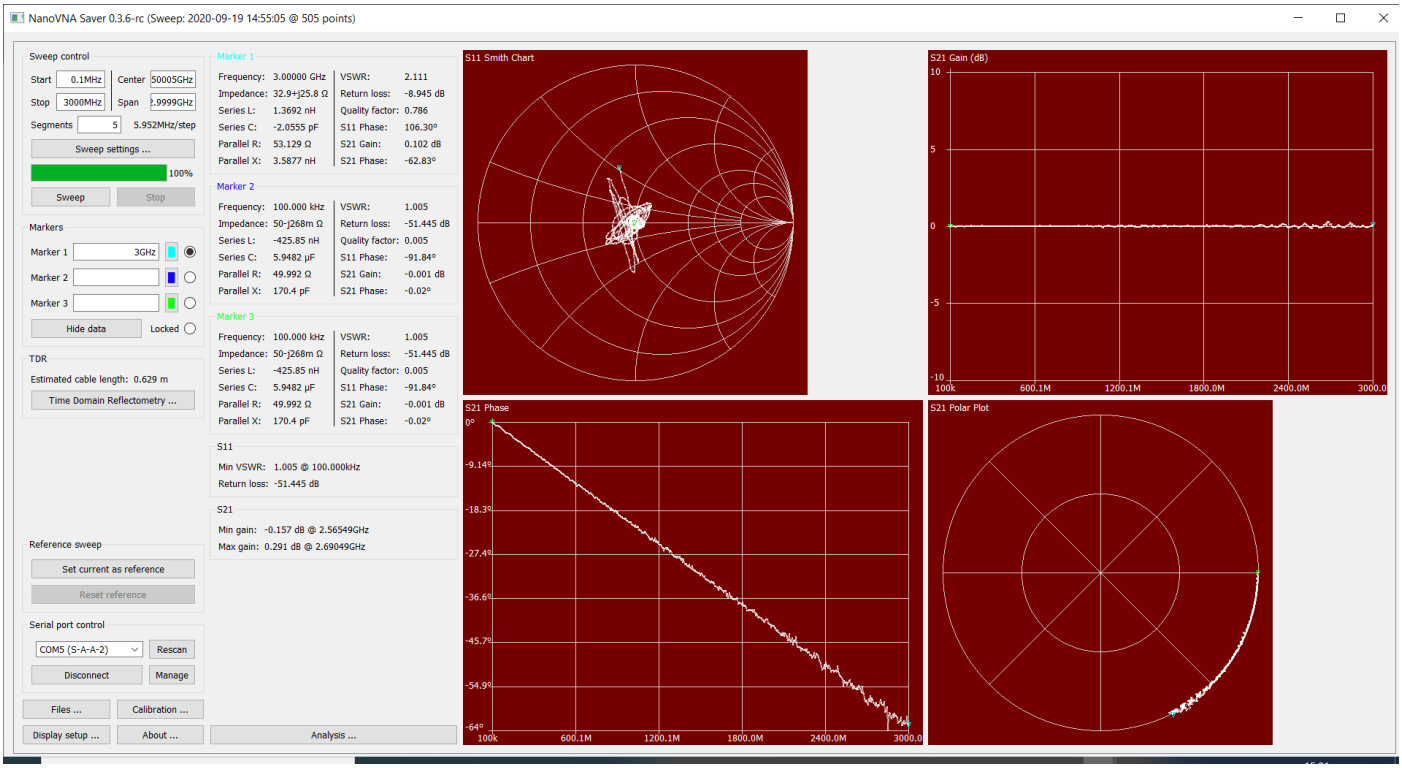
Entry of the female female adaptors delay 58.3ps



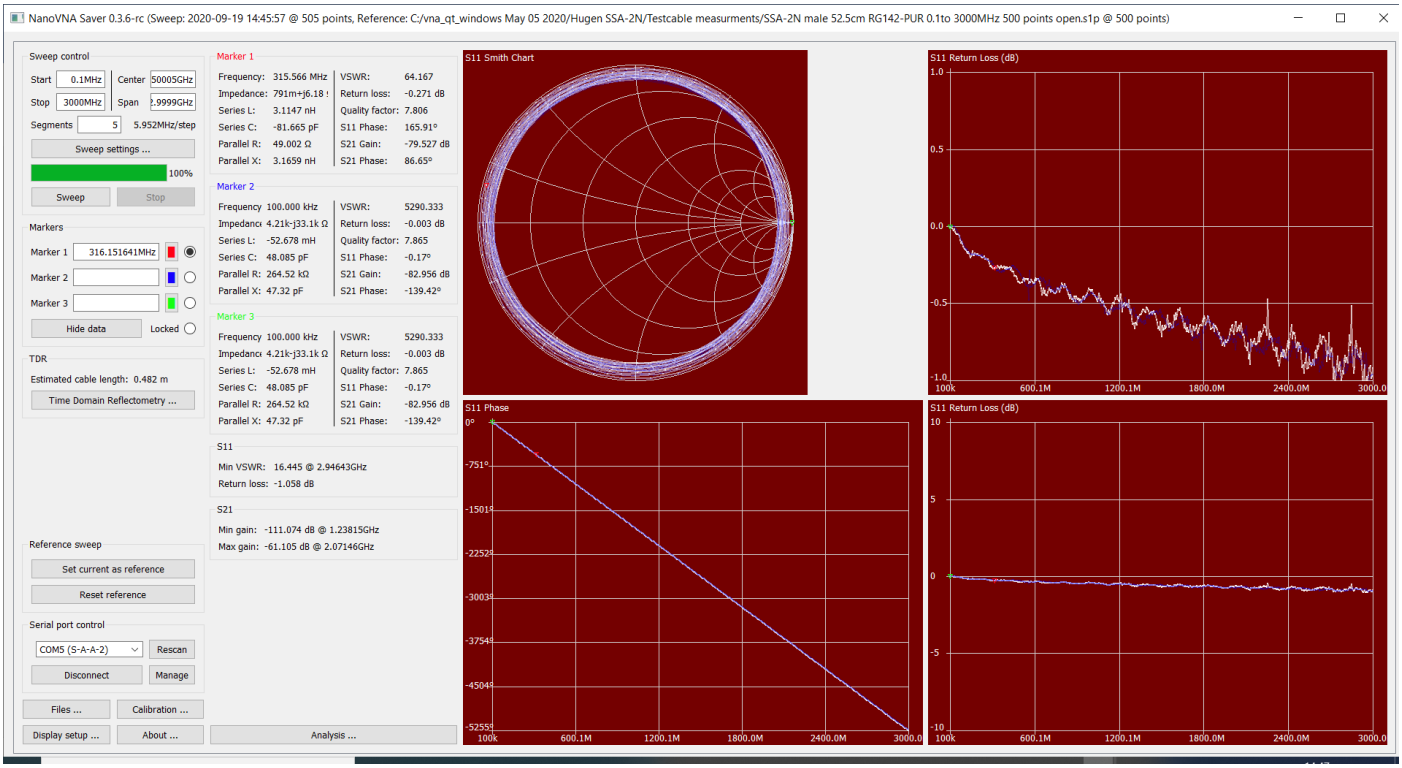
And we see the the shorted test cable now show no delay as expected. The noise is due to the female female adaptor is frequency dependent in the high end of the spectrum and not encountered for by the NanoVNA-saver as only a delay is being set in the calibration setting.



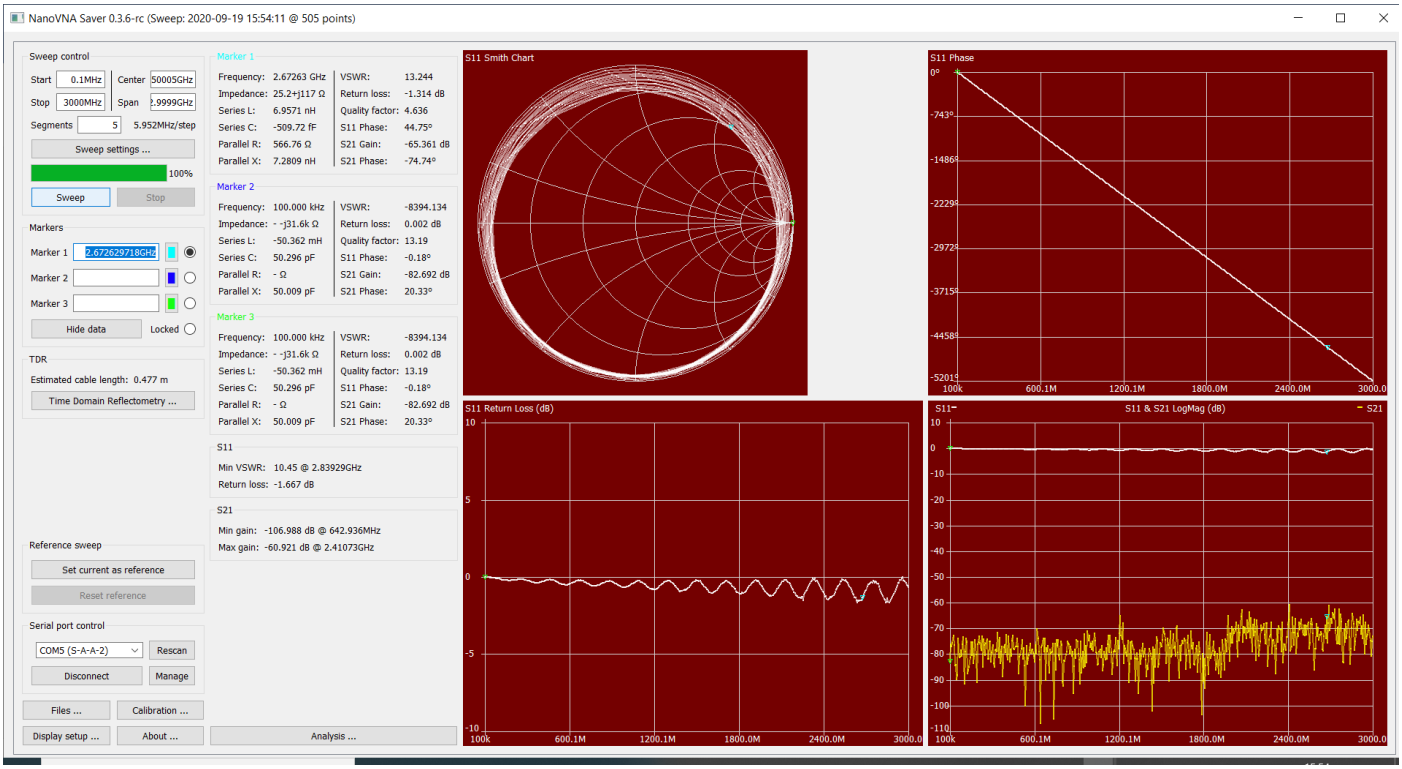
The female female adaptor inserted again and a new sweep done. The phase delay measured for marker 1 to be 62.83degree at 3GHz which is equal to a delay of 58.18ps



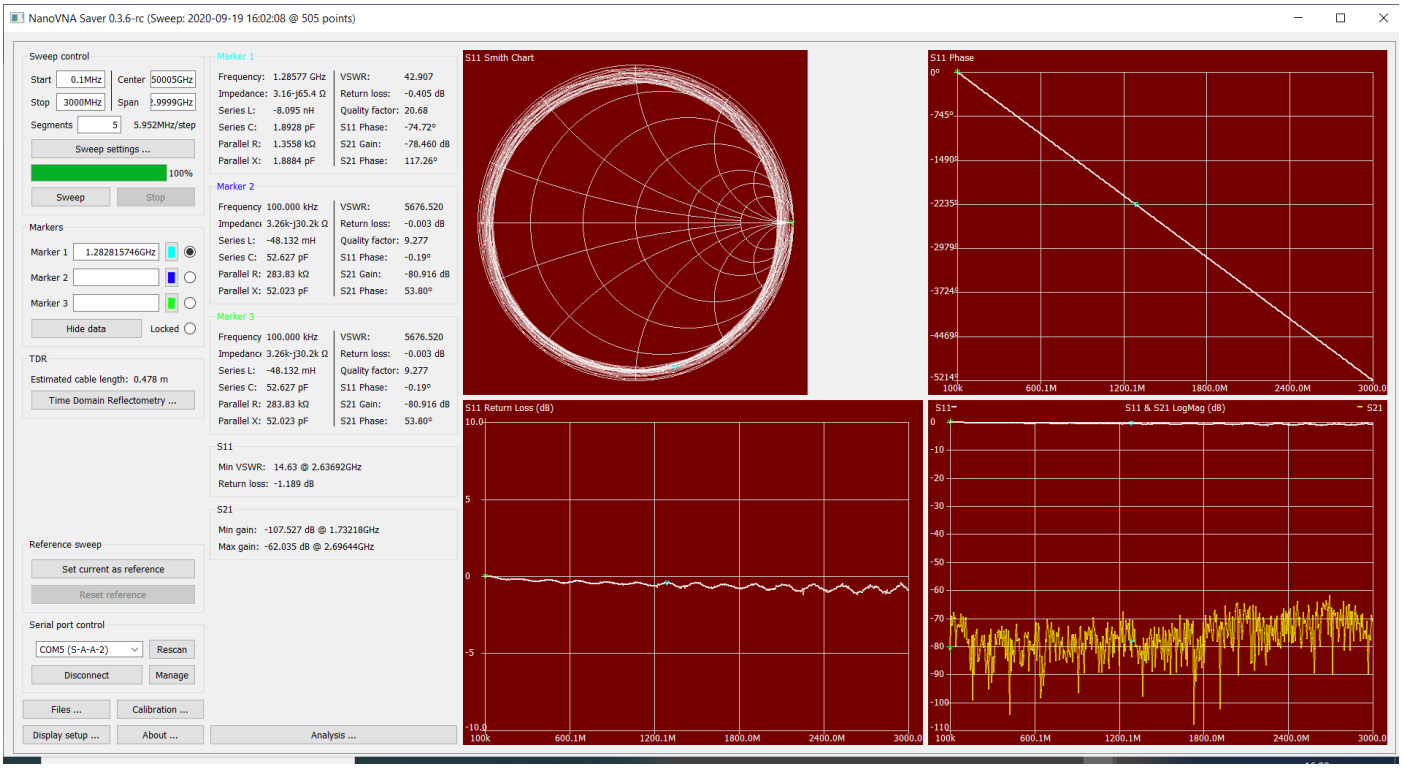
The same principle can be used by sweep the open SAA-2N test cable and the NanoVNA-saver facilitates to import a reference file via the file menu. The reference file is the blur trace and the live sweep is the white trace and a perfect match exist. Such a s1p reference file for the test cable is also part of the files provided.



The consequences for a calibration with ideal standards just like when the SAA-2N is used not connected to a PC



If a perfect load was used during calibration a far better result obtained



19-09-2020 Kurt Poulsen