How to calibrate the Tindie SAA2 and Hugen SAA-2 with the provided calibration kit

As these units are based on the same design develop by OwOcomm they are supposed to be identical and thus I focus on SAA-2 for no other reason that SAA-2 are a complete product in a metal case with test cables, USB cable and calibration kit in addition a nice case for storing.

The Hugen SAA-2 with all the delivered items shown

The Tindie is a DIY kit came with no battery and no case and neither test cable or calibration kit delivered. It is no longer in production but being substituted by a newer version which I do not have available. The data provided will be direct useable

This is the SAA2 from Tindie with case bought separately from Germany

SAA-2 is delivered with a well known NanoVNA calibration kit and 2 male-male good quality test cables

As standalone unit the Tindie SAA2 and Hugen SAA-2 assumes that 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-2, being 0.05MHz to 3000MHz.
However the delay difference between short and open are very small and for frequencies up to 500MHz the load is OK so calibrations are quite useable in that frequency range.
But when connected to a PC it is possible to calibrate with very good accuracy for the entire specification frequency range to 3GHz and beyond to 3.8GHz.
Using the touchstone calibration kit files, designed for the VNA-QT software, to be download from the provided link, up to 3.8GHz is possible with good result as shall be demonstrated.

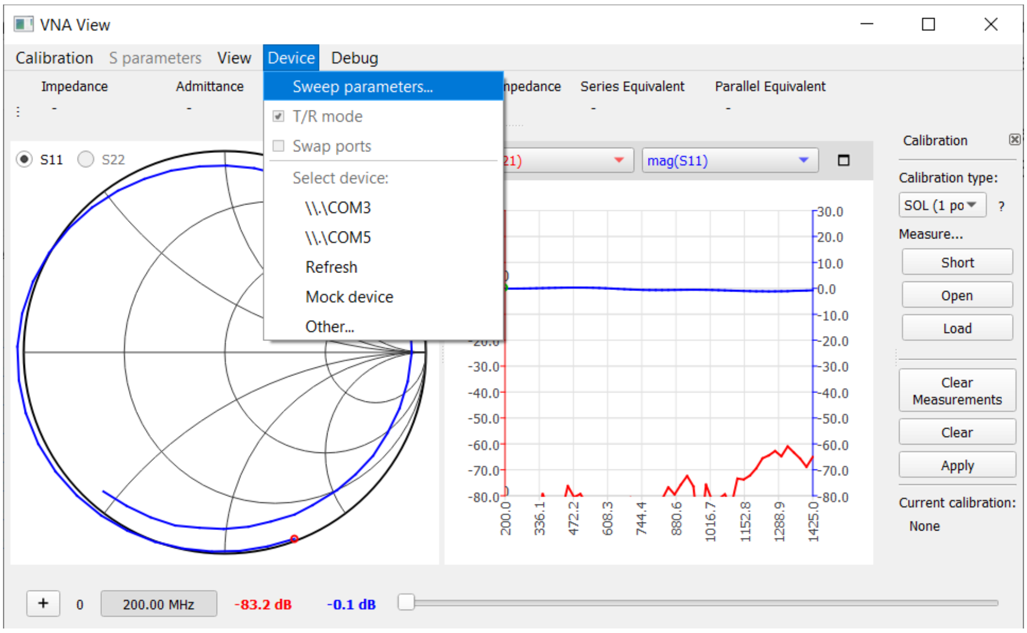
For use with the VNA-QT software calibration is requiring use of three SOL s1p touchstone files for reflection and one s2p touchstone file for thru calibration. These calibration kit files for 0.1MHz to 3800MHz with 500 point can be downloaded from http://www.hamcom.dk/SAA-2/SAA-2 VNA-QT calibration kits files.zip and incudes 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.
a set of s1p/s2p calibration kit files is also provided in the download for the frequency range 0.1 to 100MHz, also with 500 points, for high precision calibration in said frequency range.
These calibration kit files when loaded into VNA_QT software can be used for any frequency span and number of points within the frequency range 0.1MHz to 3800MHz and for the precision files within 0.1MHz to 100MHz
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-2/SAA-2-NanoVNA-Saver ini file addition.zip and also listed later in this report

Detailed instruction follows below how to do the calibration…..

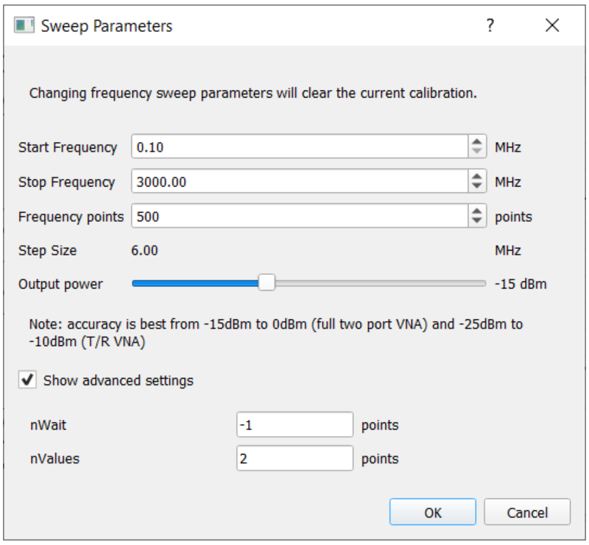
A few words about calibration and the calibration planes by using either VNA-QT or NanoVNA-saver
With the male calibration kit you can either calibrate directly at the female port1 or at the end of a test cable connected to port1 with the provided female female adaptor fitted. The second test cable connected 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 at 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 correct calibration plane, which was at the end of the female female adaptor now removed.
However means are provided for moving the calibration plane from the end of the female female adaptor to the male adaptors reference plane of the test cable.
Enable DISPLAY/SCALE/ELECTRICAL DELAY function and enter the delay equal to the delay for the female female adaptor being 46.16ps for 3.8GHz settings and 47.43ps for the 100MHz settings
Using the female kit and inserting the female female adaptor during thru calibration everything is perfectly calibrated but only when used with a PC. As stand alone the S11 and s21 phase relationships is lost when the female female adaptor is removed for measuring a DUT.
For using the SAA-2 without computer the calibration is based on ideal calibration kit and the provided calibration kit are so to speak ideal.

How to calibrate using the VNA-QT software.

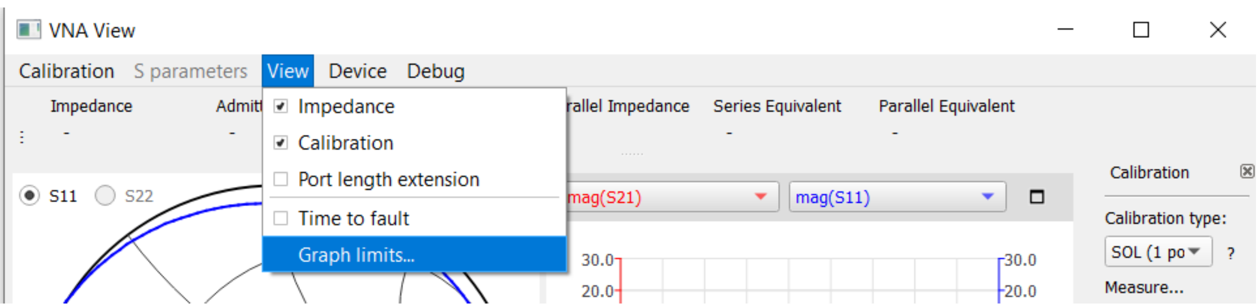
At first go to Device and Sweep parameters and set start (min. 0.1MHz) and stop frequency and number of points

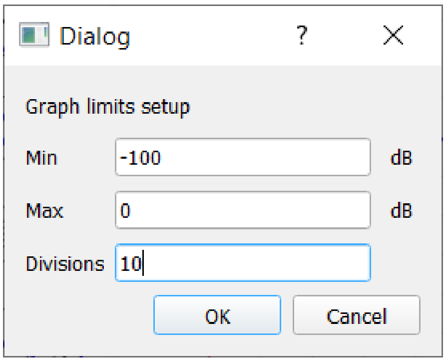


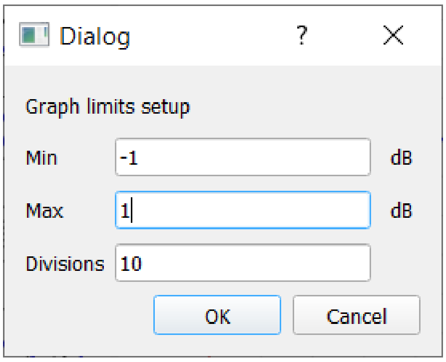
If you enable “Show advanced settings” and by increasing nValues you get more measurements per point



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.

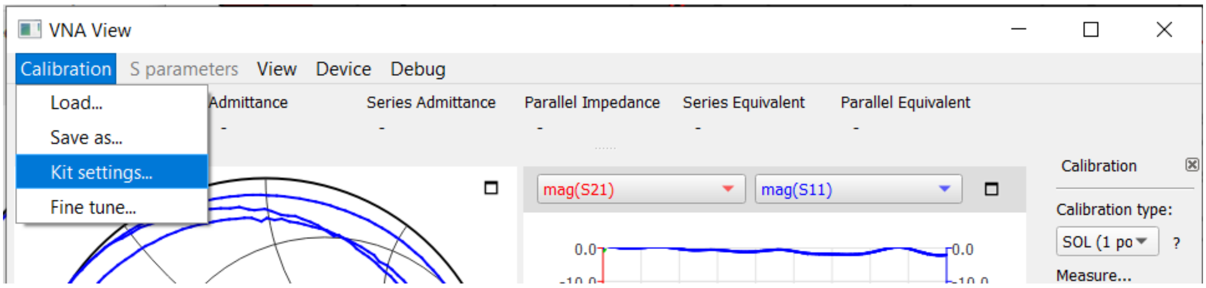




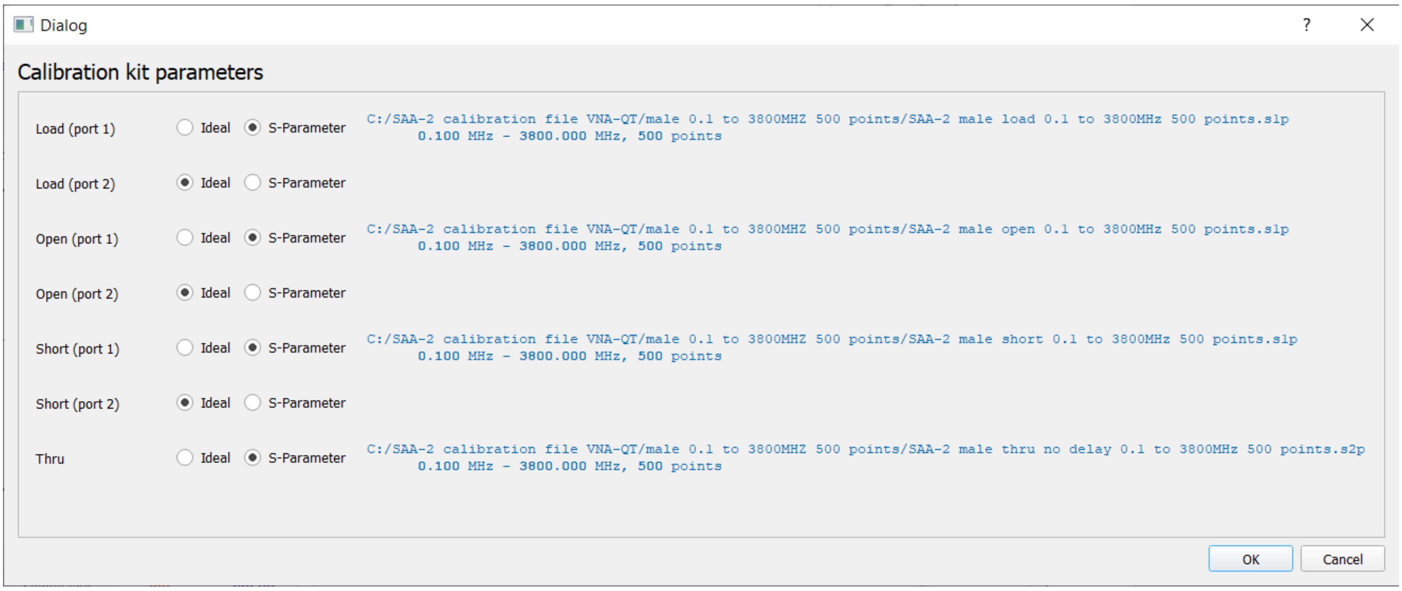


Next load the s1p load, open and short calibration kit files and the s2p thru calibration kit file for transmission

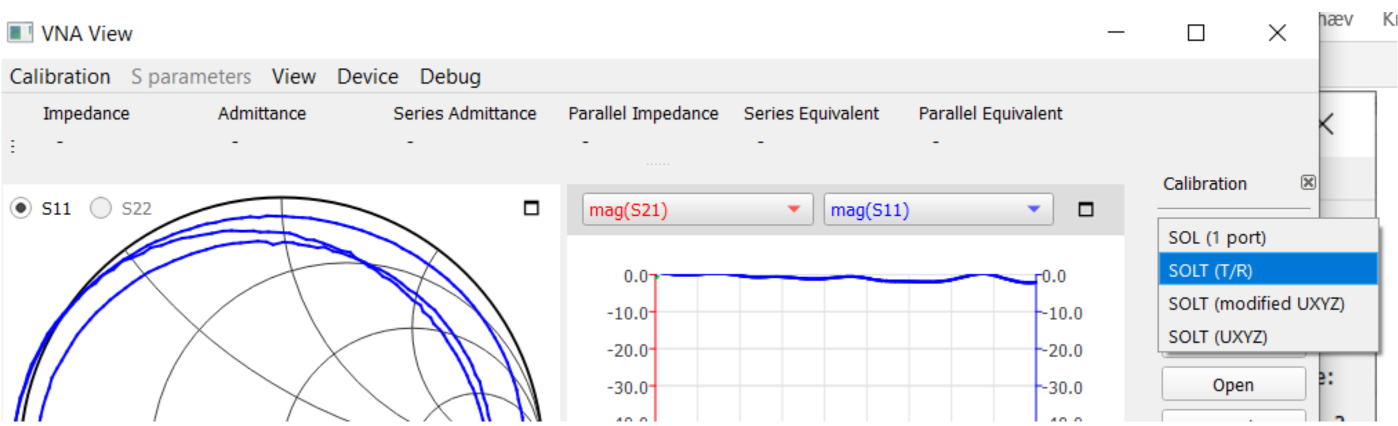
Open the Calibration and Kit settings and load the relevant files



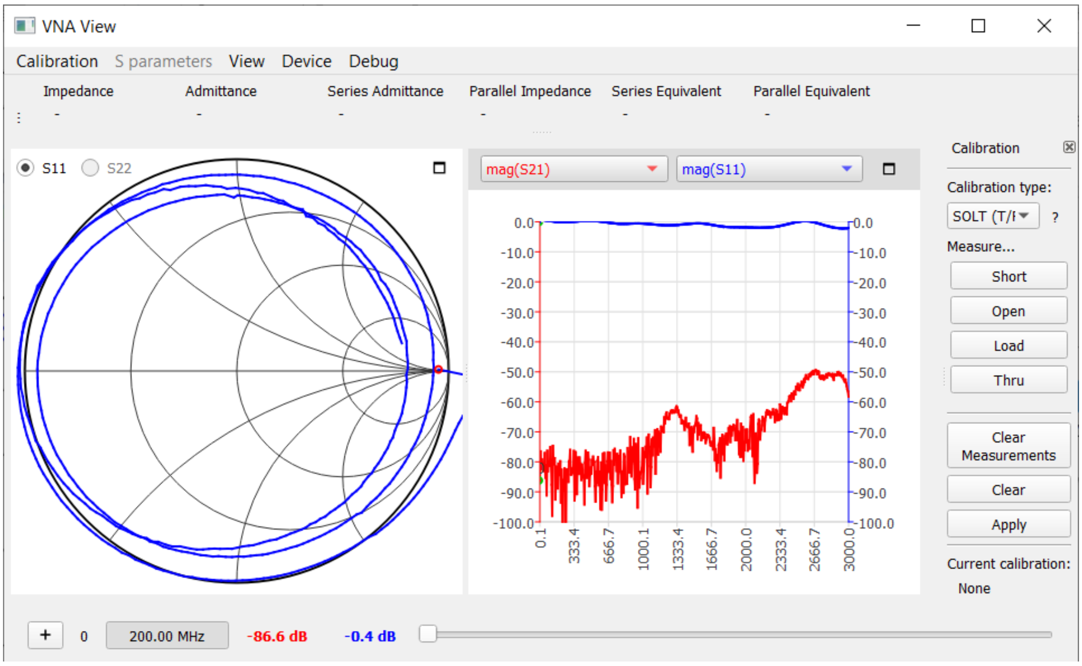
By clicking on the S-Parameter text you find the files where you have saved the s1p and s2p files and only port1



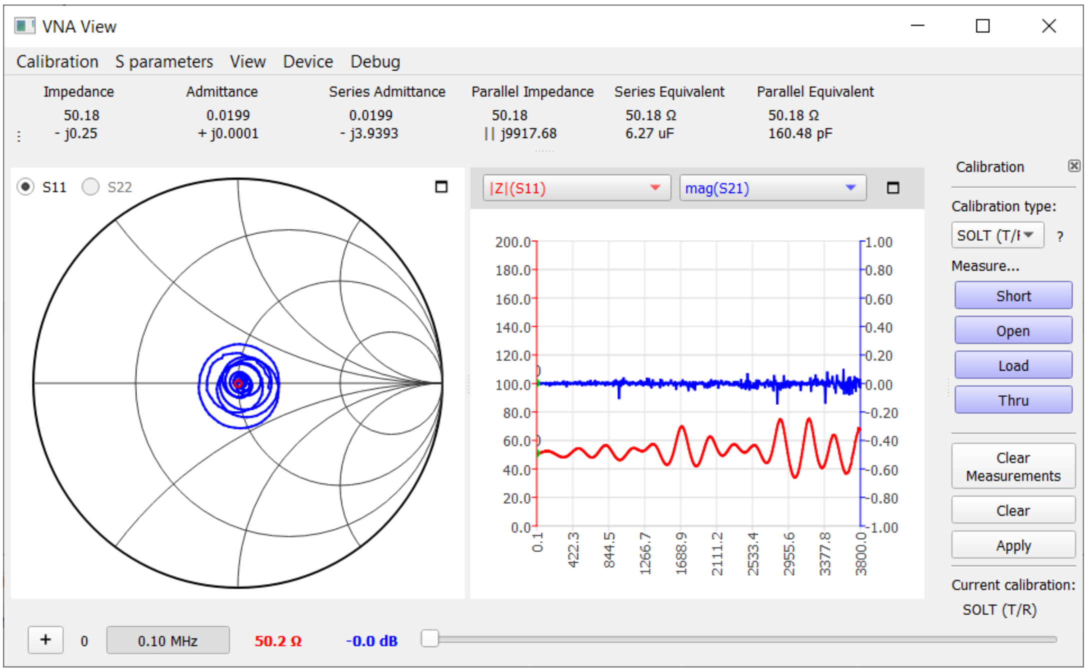
Next decide if you want to SOL or SOLT calibrate



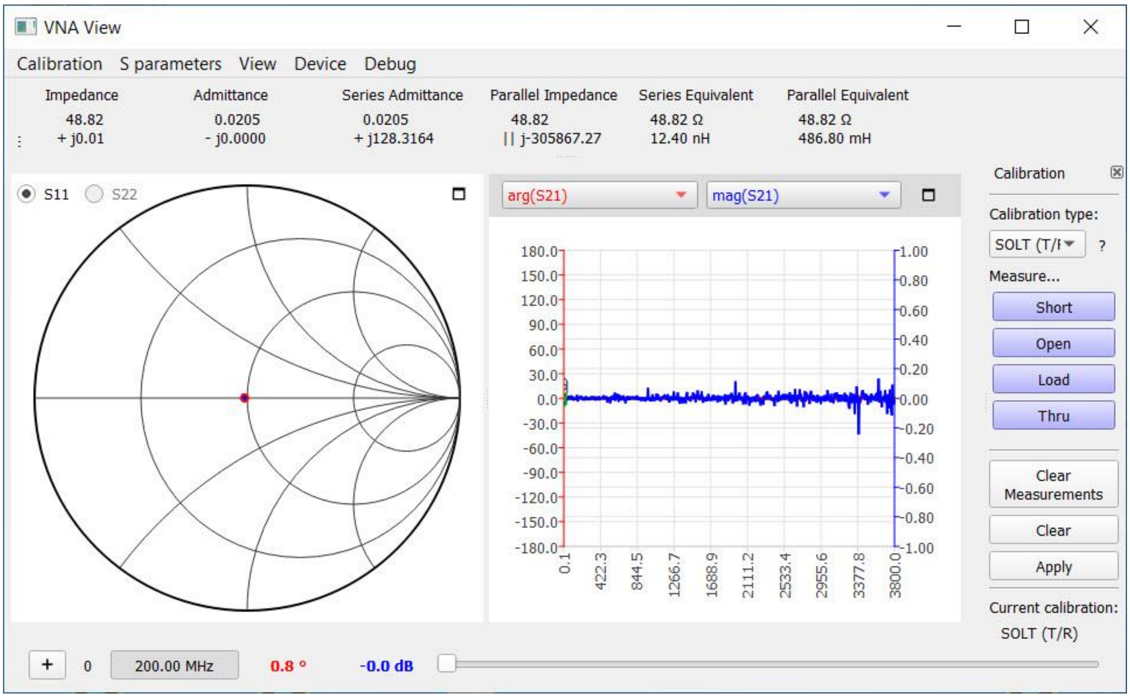
Mount the SOLT calibration standards one by one and click on the Short, Open, Load and Thru buttons and wait until they are no longer dimmed in contrast and finally click on Apply. Now your system I calibrated and ready for measurements. **Below image is prior to do calibration an always show weird traces and readings**



Thru calibration with male male test cable fitted. The smith chart show the Port 2 (RX) input impedance measured thru the test cable

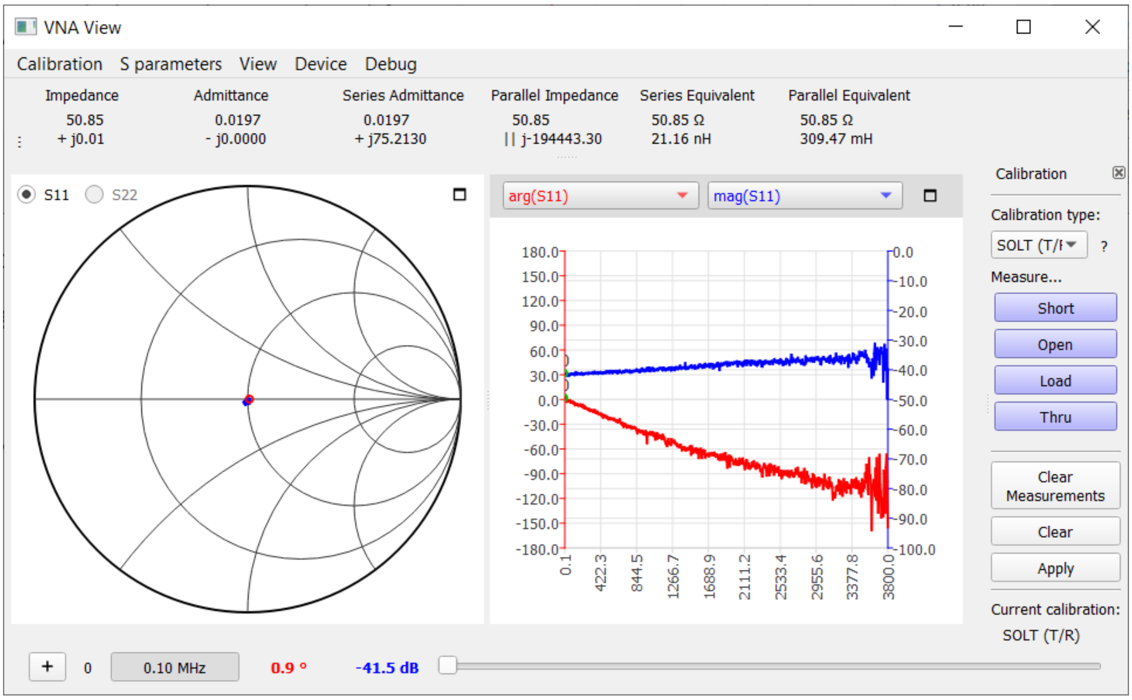


Mounting a 20dB attenuator at the input of the test cable, thus between the Port 1 and the test cable stabilized the port 2 input impedance (mismatch) considerable. The attenuator must be mounted also during Thru calibration Same applies if you calibrate at the end of a test cable connected to port1

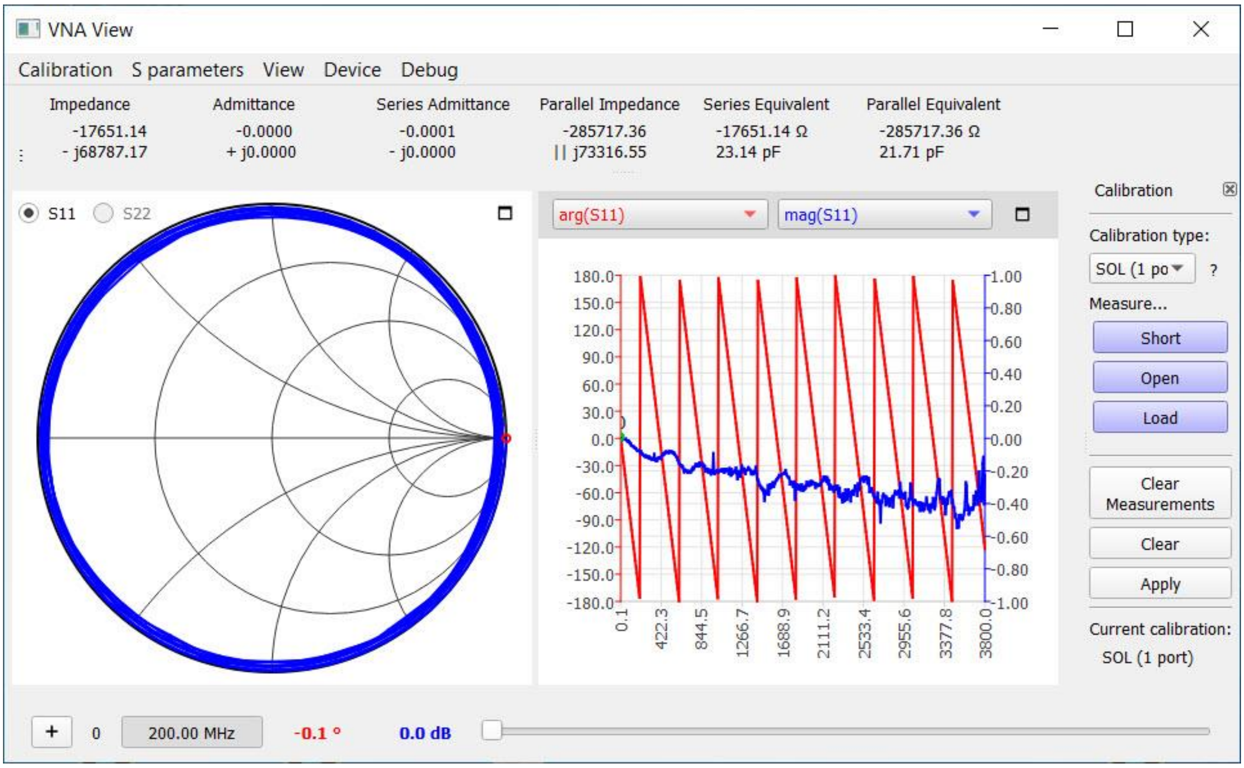


Measurement of the load after calibration. nValues increased from 2 to 4

My load measured 50.845ohm at DC. Measurement of several male load varies from 49,5 to 52 ohm which will reflect some measurements error around 50 ohm in the range of + - 2% for YOUR load

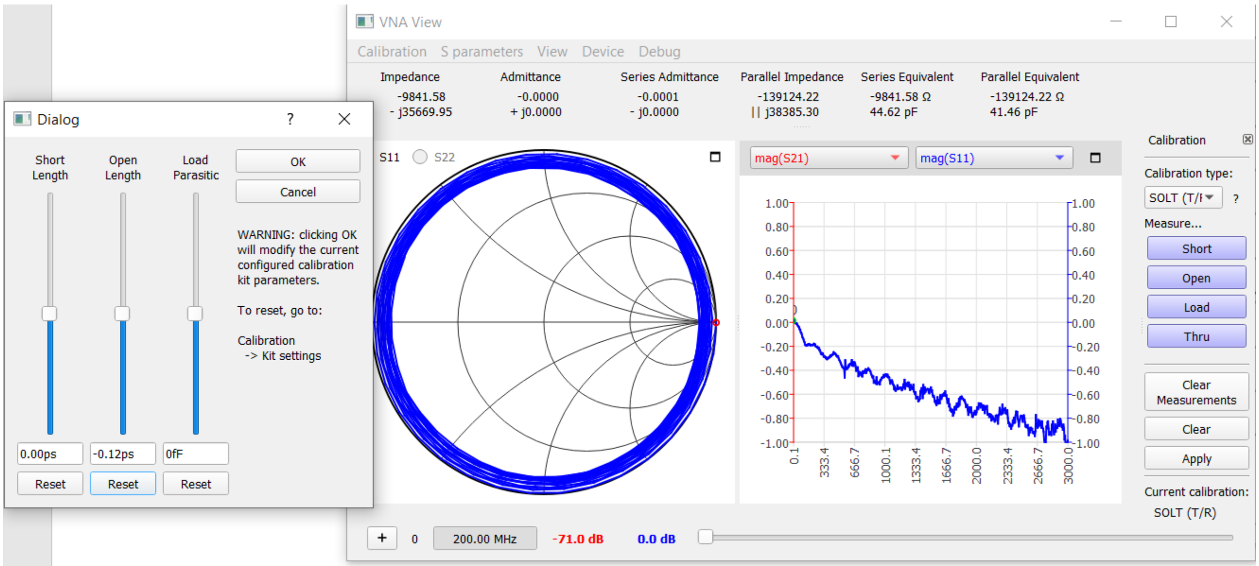


Test of calibration by sweep of the open ended test line. In my case a UT141A rigid line of 26.1cm length. Your testcable amy also be used. The oscillation is supposed to fade out with increasing frequency. Trust the male short an open calibration files and maybe fine tuning of the load might provide improvement.
for the female calibration kit files small deviations for the SAA-2 female female adaptor delay may be corrected for, by using the fine tuning found under Calibration/Fine tune, but be careful not to destroy a good calibration. Tune and see if ripple at the end of frequencies can be reduced else cancel finetuning .

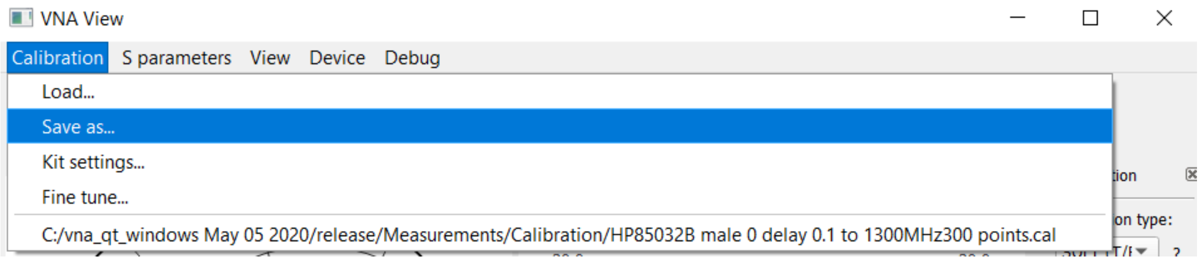


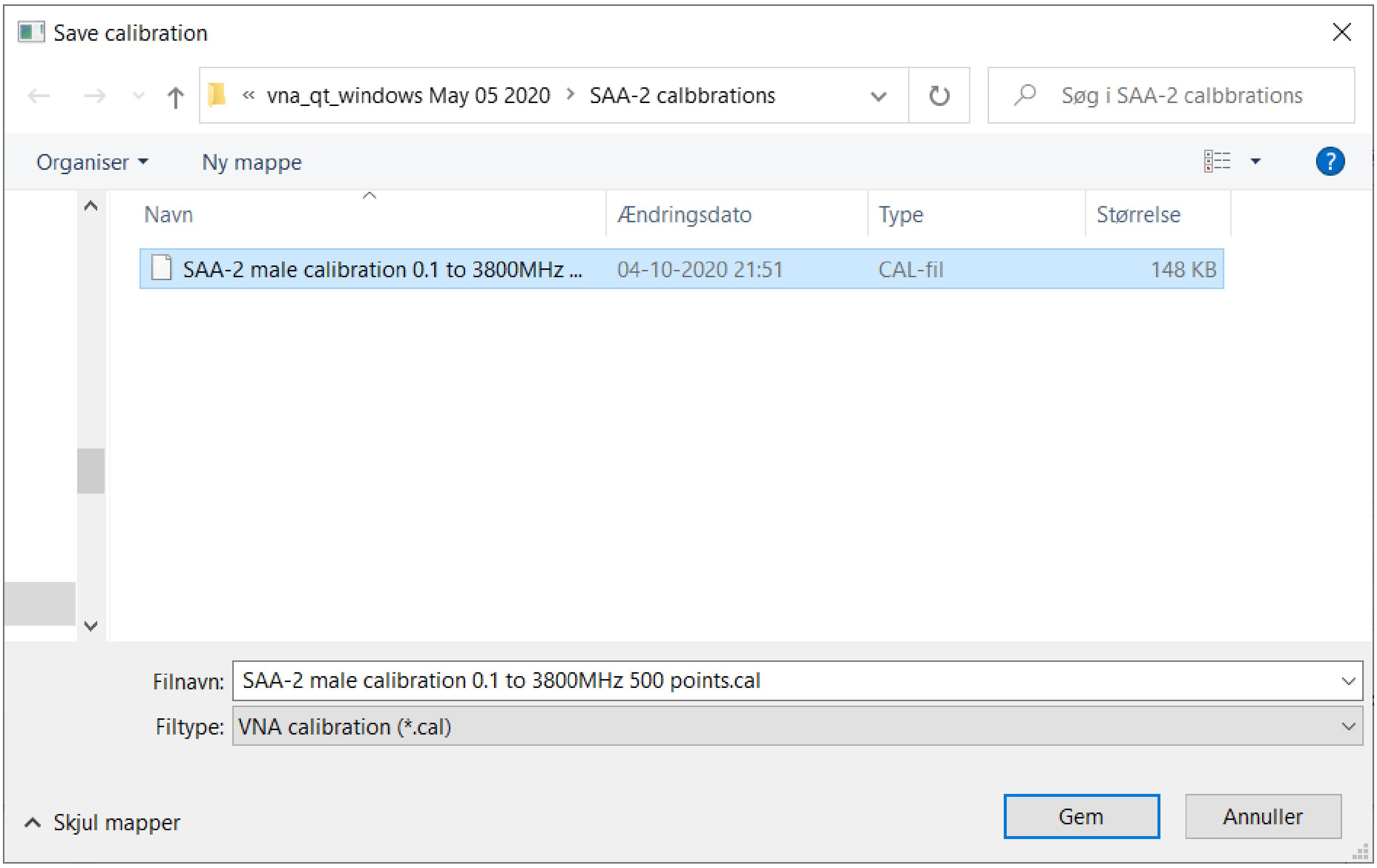
Below is just an example form another calibration with a N kit to demonstrate the technique

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 else 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...

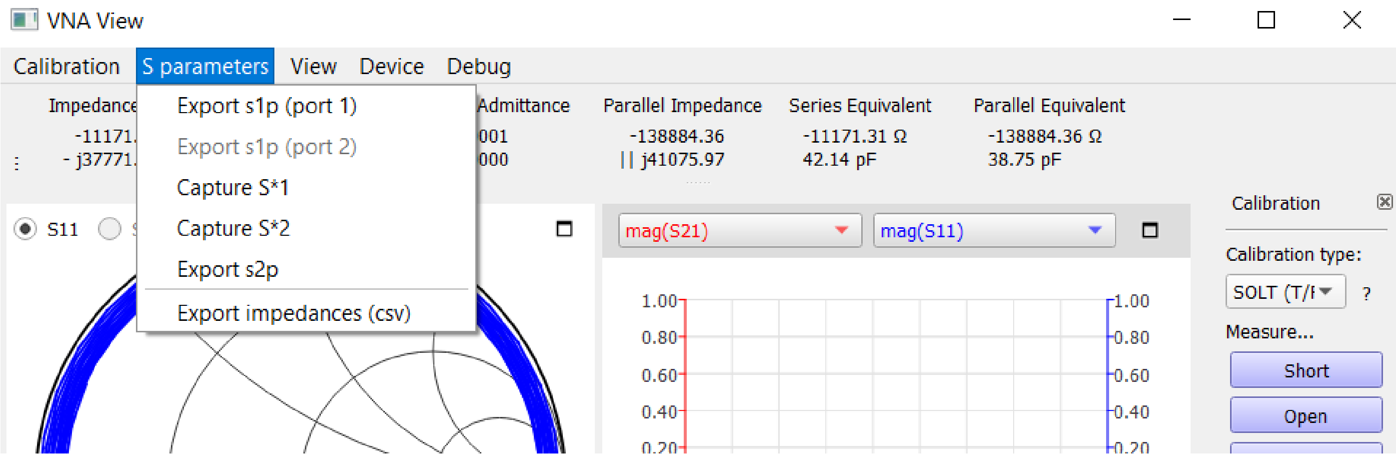




Saving of measurements:

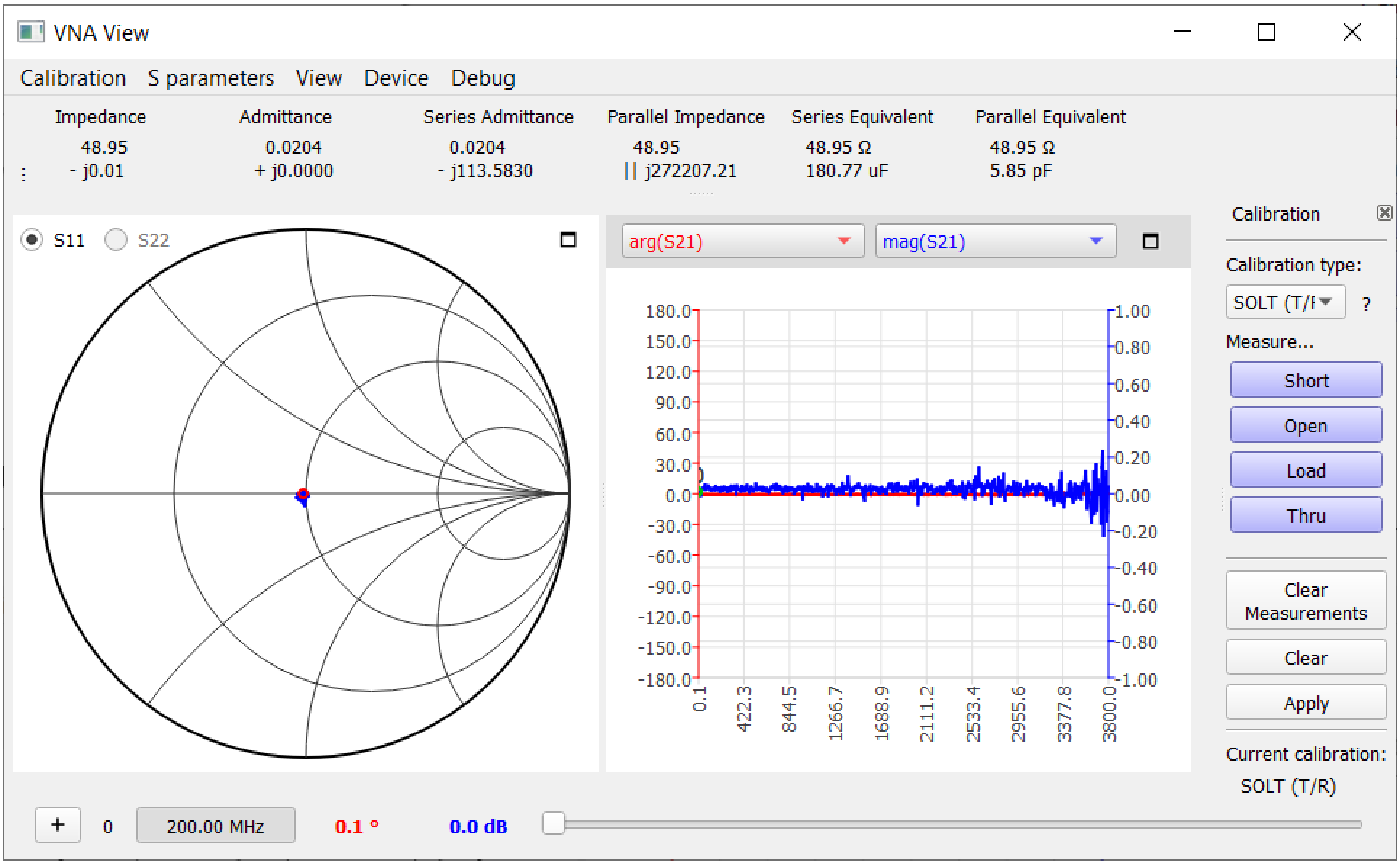
By choosing S parameter any measurement can be saved for reflection s1p (port1) and a click ask you to provide a file name for saving, **but watch out the measurement to save is first performed after the saving of the file name**. The various button are dimmed until measurements are done:

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 Captures you must wait until done. Then Export s2p and as soon the file name saved you are done.



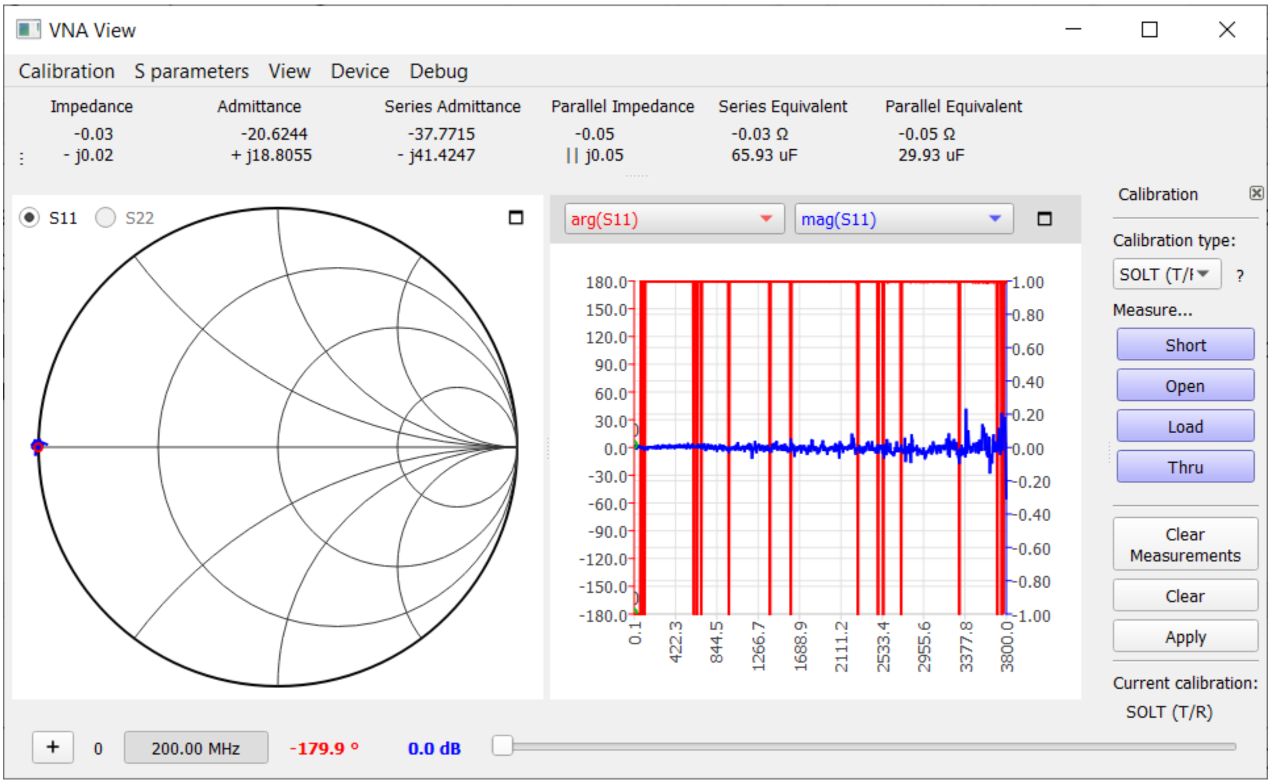
male calibration of end of test cable with female female adaptor fitted

As seen insertion 20dB attenuation is 0dB Mag(s21) and phase angle is 0 arg(S21) as expected



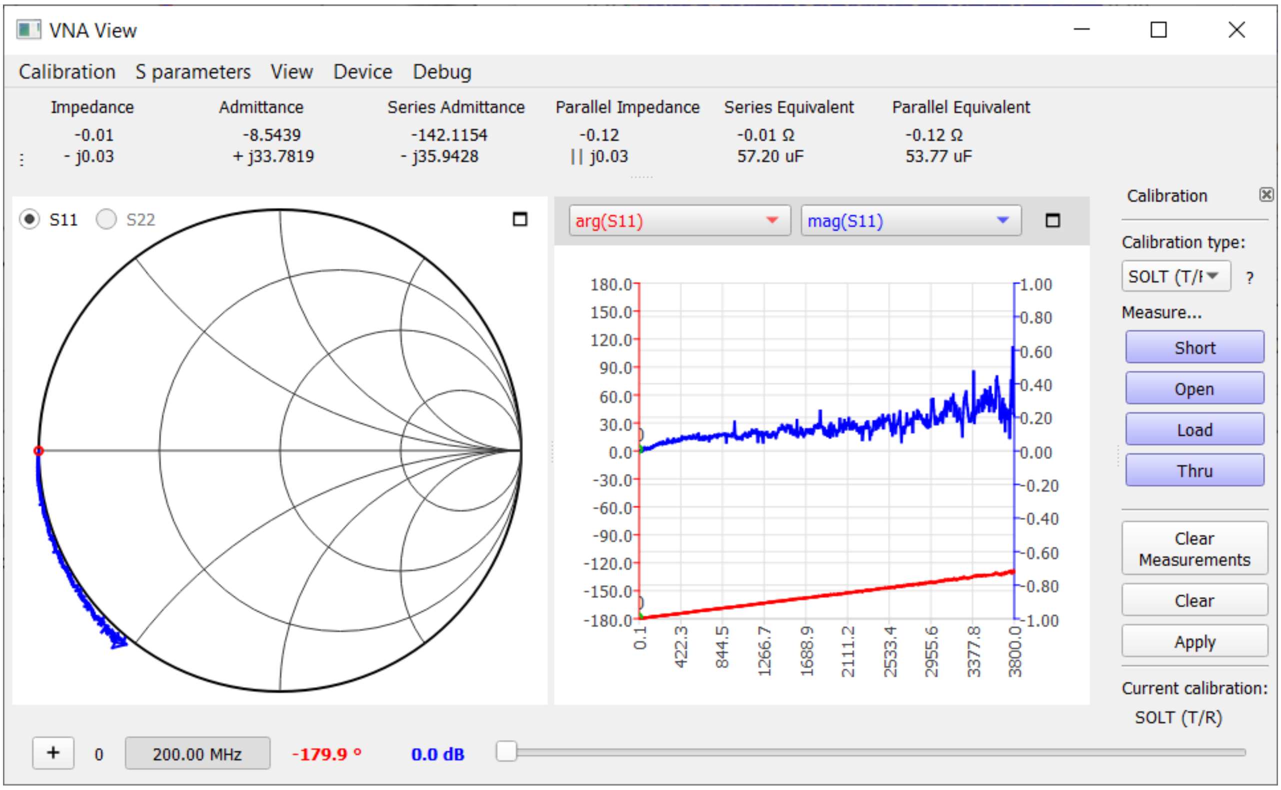
What happens if we remove the female female adaptor after a male calibration ?

That is best illustrated by firt fitting the 0 ps male short to the female female adaptor and we see the male short calibration at end of the female adaptor provides a perfect dot extreme left in the Smith chart



Next the female female adaptor is removed which has a delay of 46.1ps Next we fit a 26.9ps female short fitted at the end of the Port1 male SMA test cable

As seen the short turns the wrong way round due to the missing female female adaptor and the delay for the fitted female short has less delay than the female female adaptor. We will now compensate for the missing delay being 46.1-26.9= 19.2ps to get the dot back to the end of female calibration by ADDING a delay of 19.2ps.



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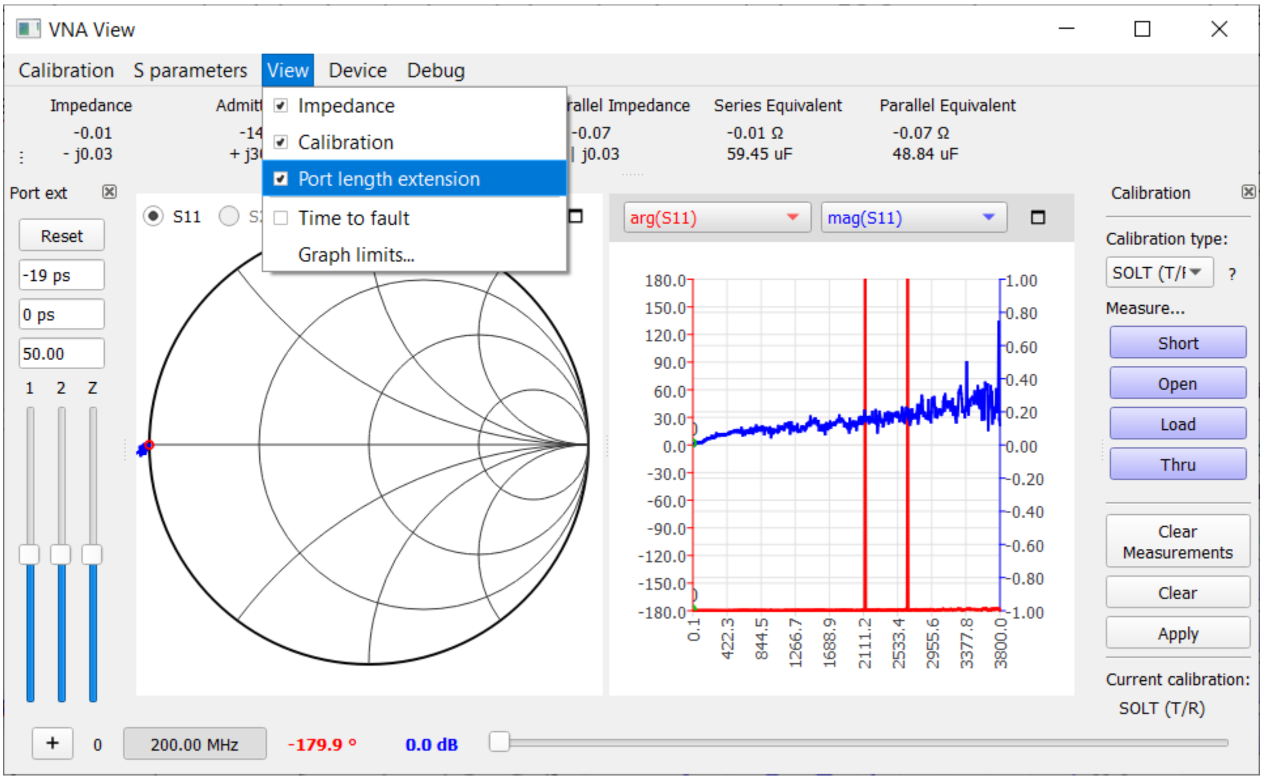
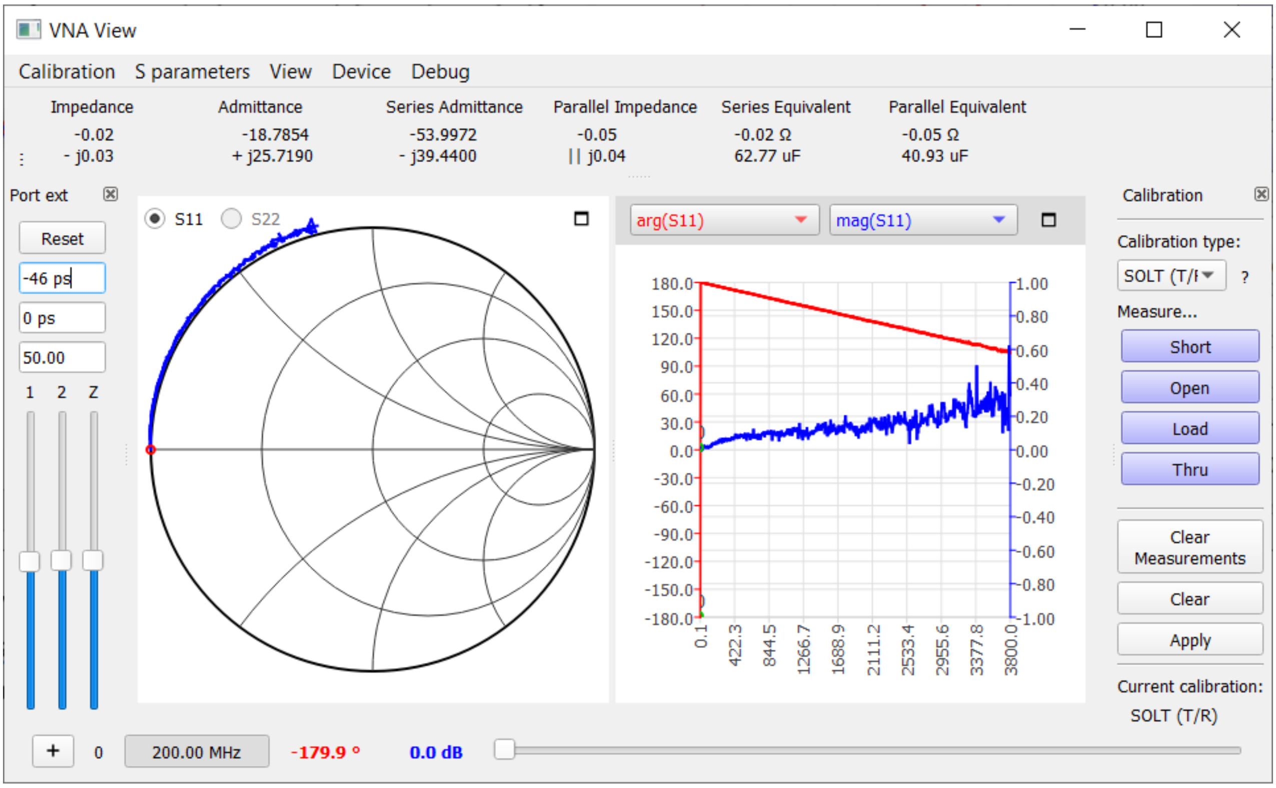
By choosing View and enable Port length extension we now tune Port 1 until the position in the Smithchart is at extreme left and the arg(s11) is flipping between + - 180 degree. So basically we have done nothing except letting the female short substitute the female female adaptor terminated with the male short 😊

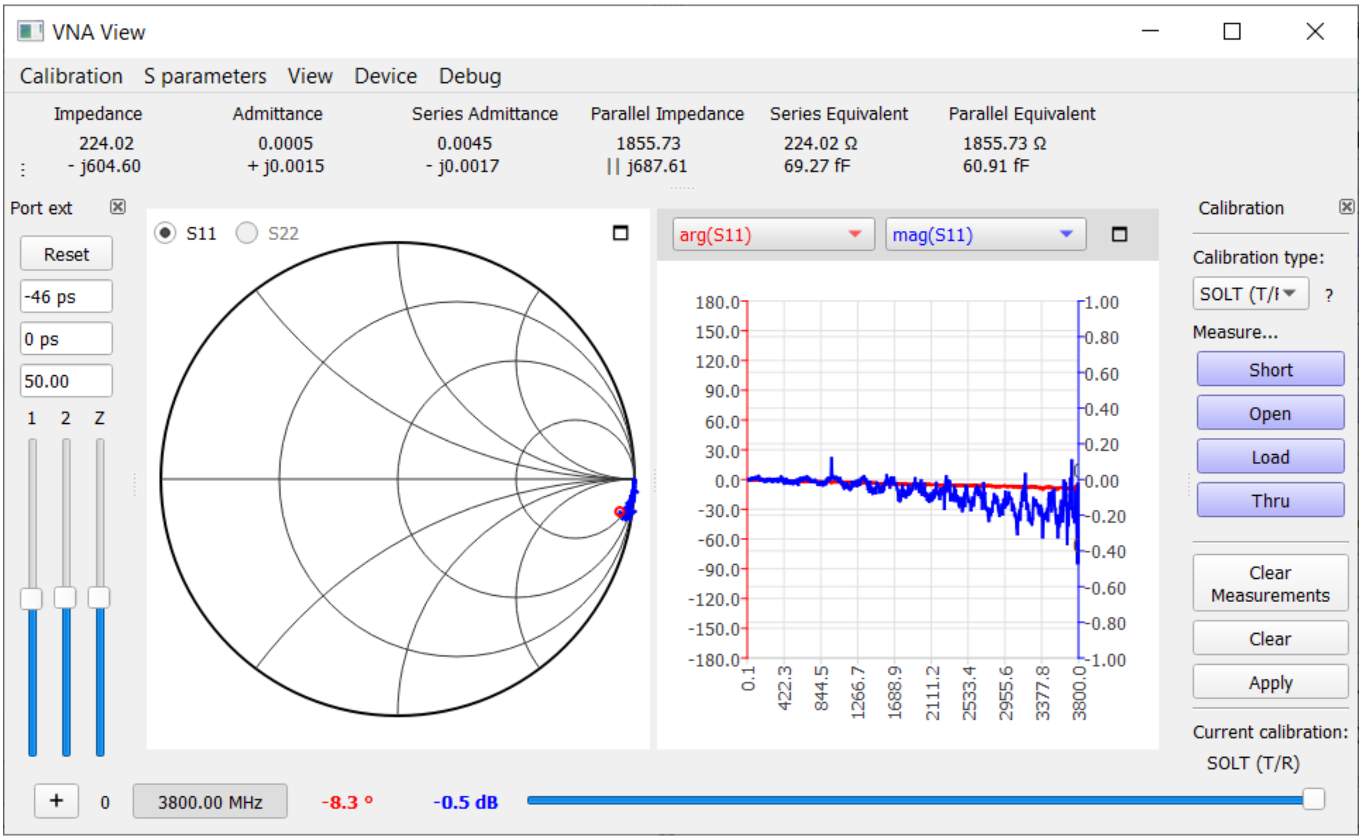


We could have entered the delay of the female adaptor delay 46.16ps and the calibration plane then moved to the SMA male adaptor calibration plane of the SMA male adaptor at the testcable connected to port1

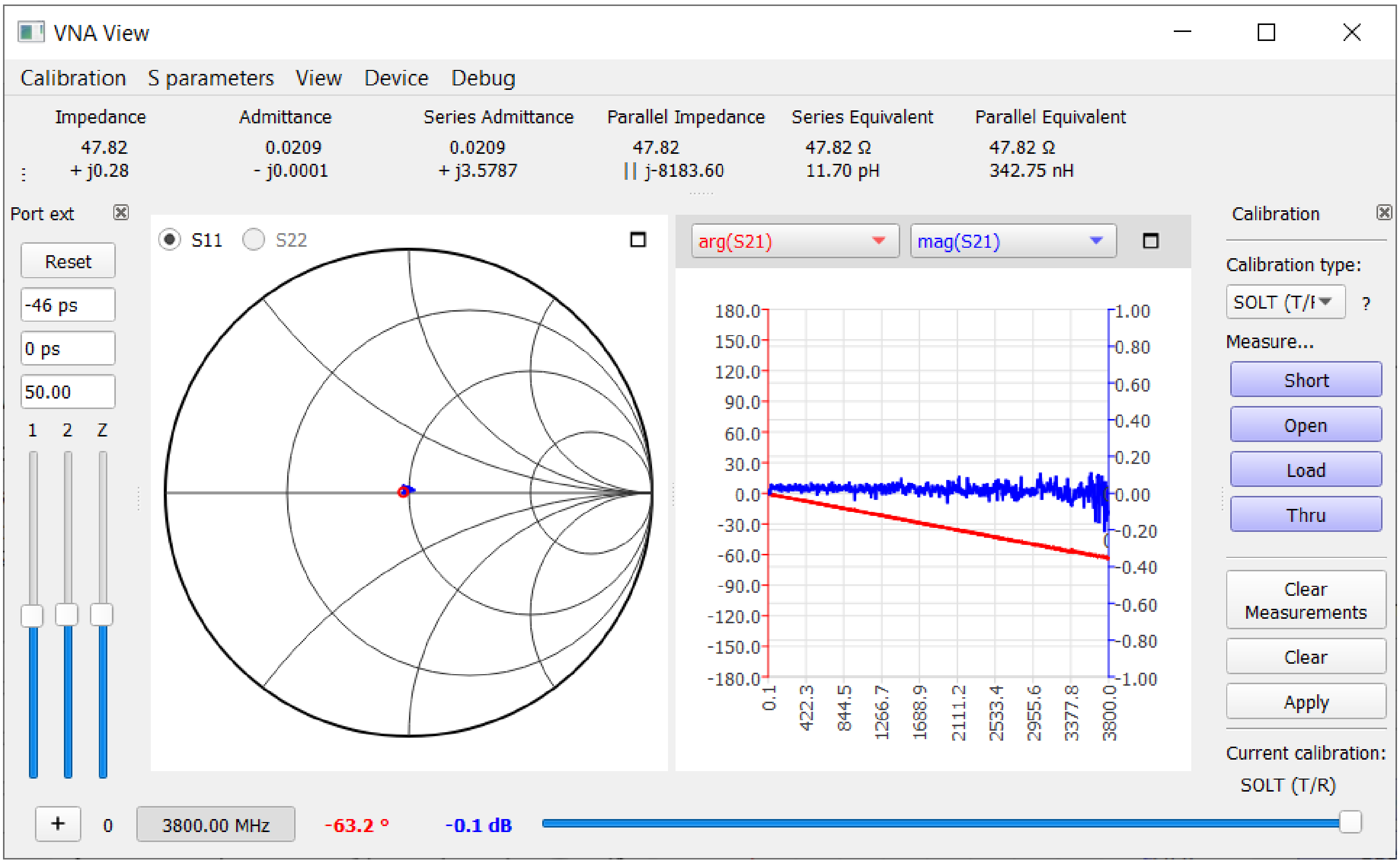
Now the calibration plane is the port 1 test cable male adaptor at the end of the male test cable and the female short of 26.9ps is now measured .Do you believe ?? Let us remove the female short.



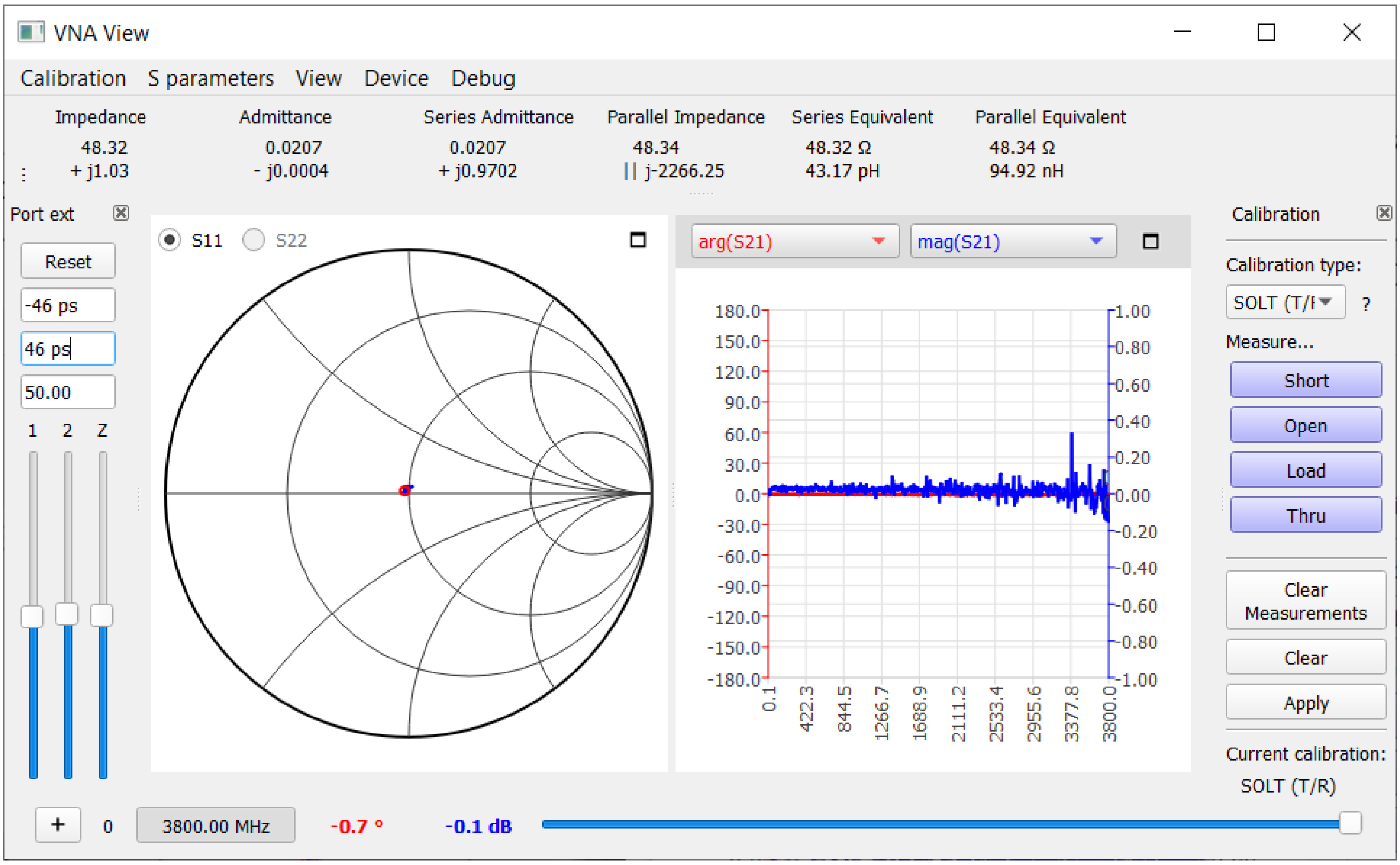
Now the male male test cable is left open and we see a small delay which is caused by the male center pin having a small fringe capacitance causing 8.3degree at 3800MHz according to the marker



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

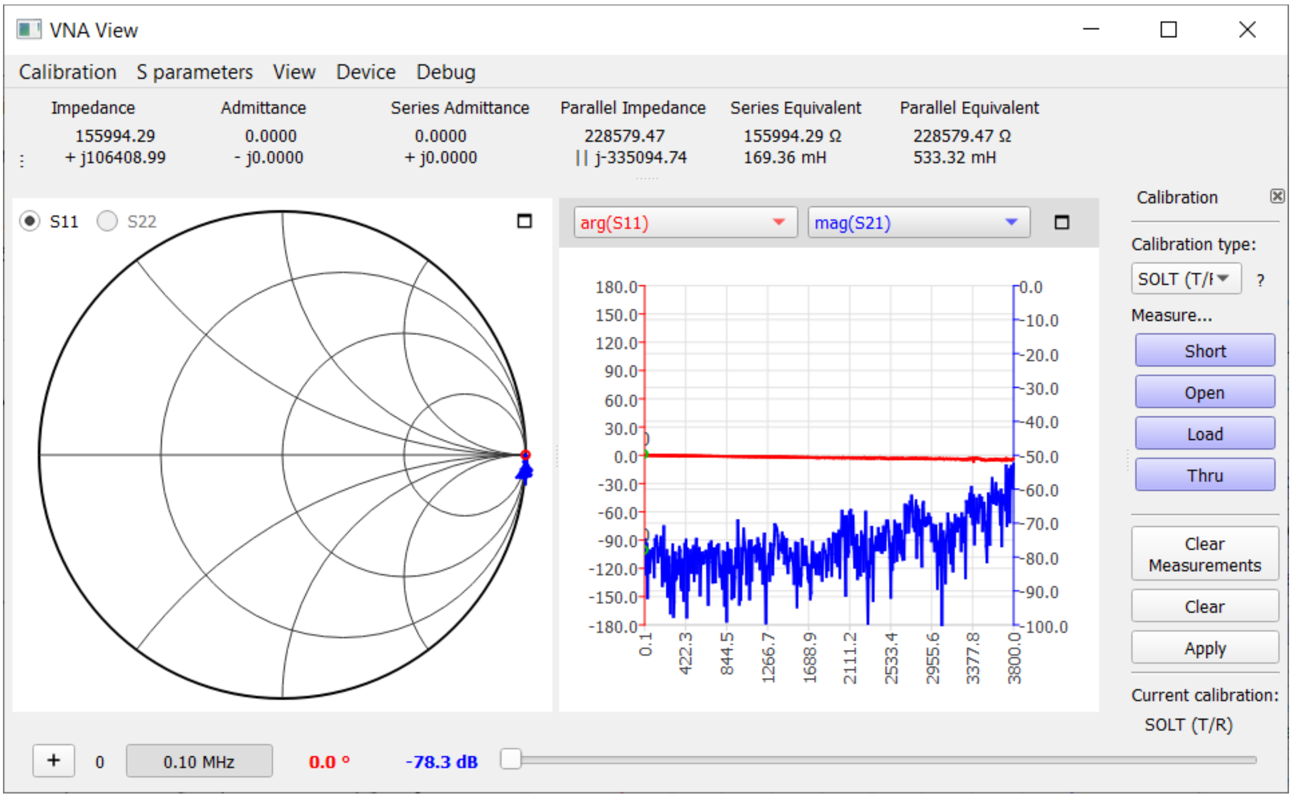


As a control, just for fun we can offset this delay adjustment by adding +46.16ps to port2 as seen below
The VNA-QT round off the decimal point to 46ps



What kind of S21 dynamic range ?

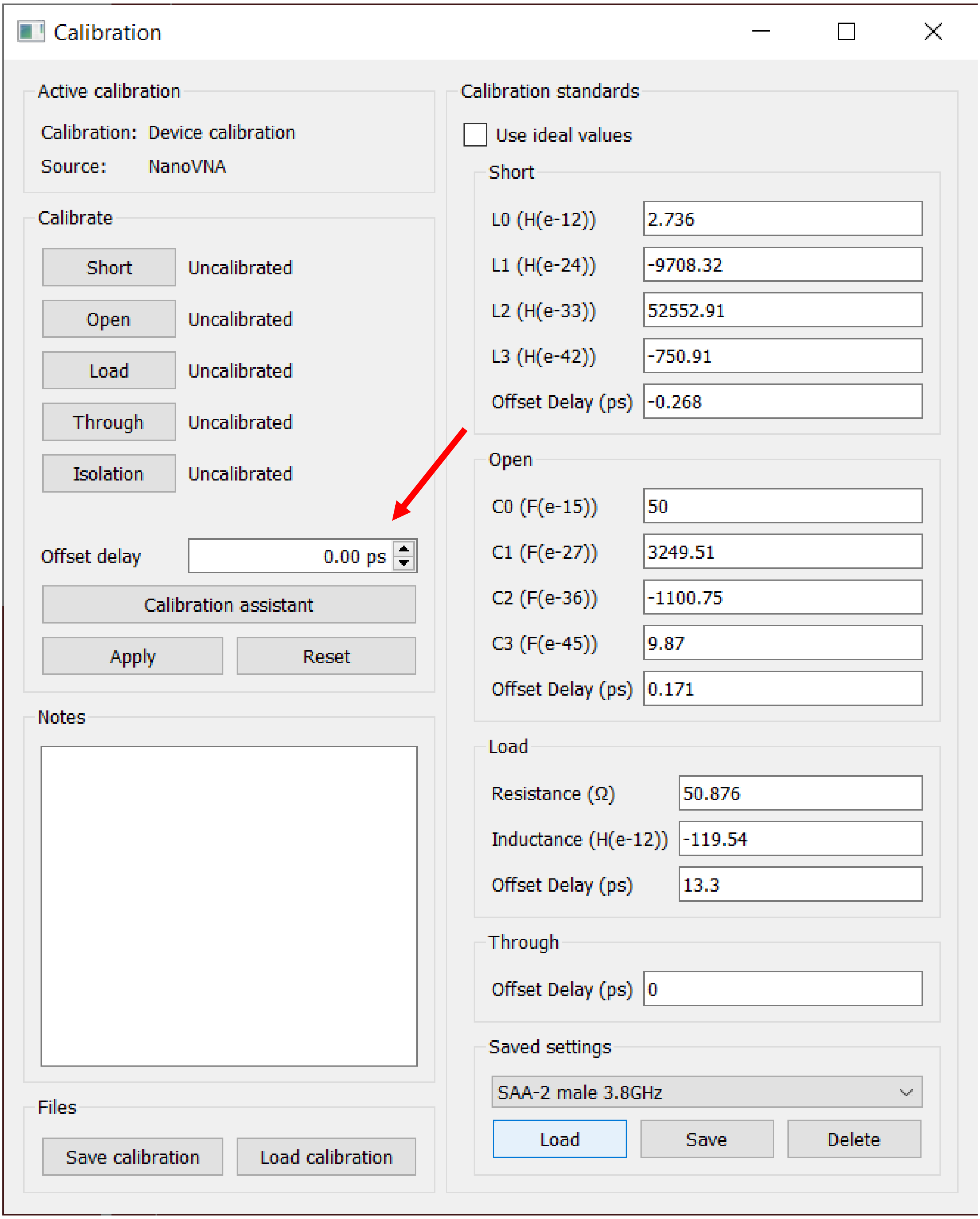
S21 noise floor 0.1 to 3800MHz



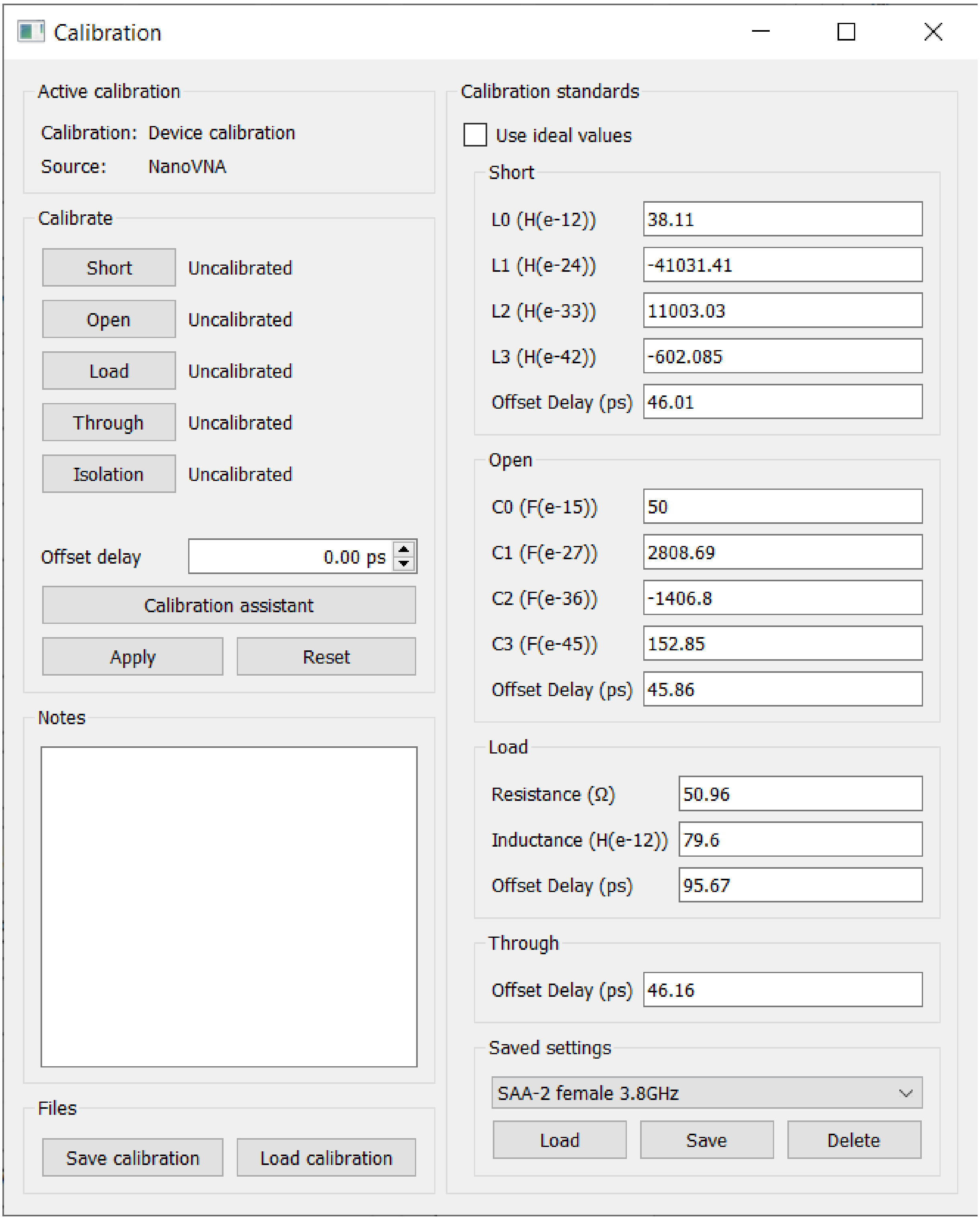
How to calibrate using the NanoVNA-saver software

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

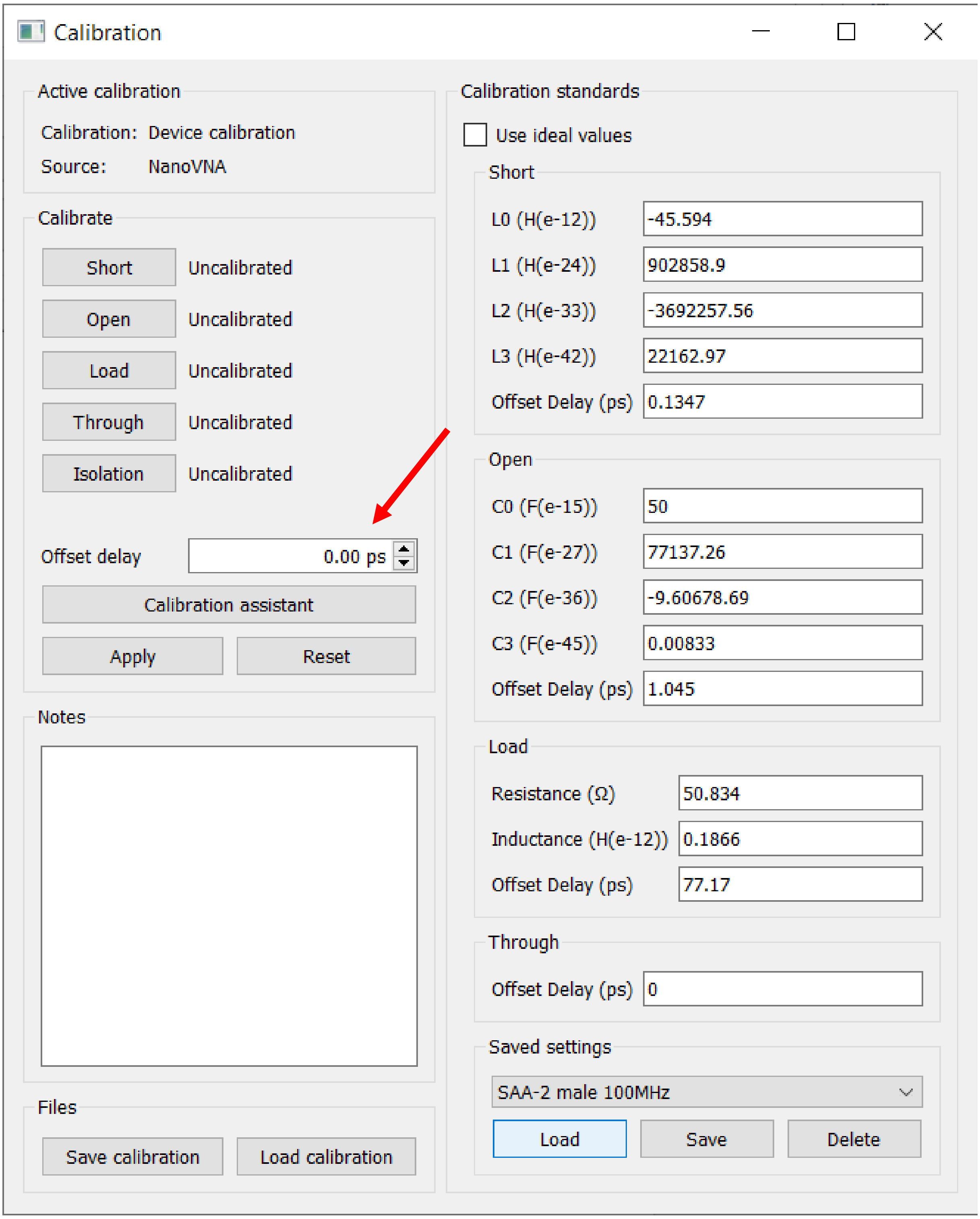
The male kit settings to 3.8GHz



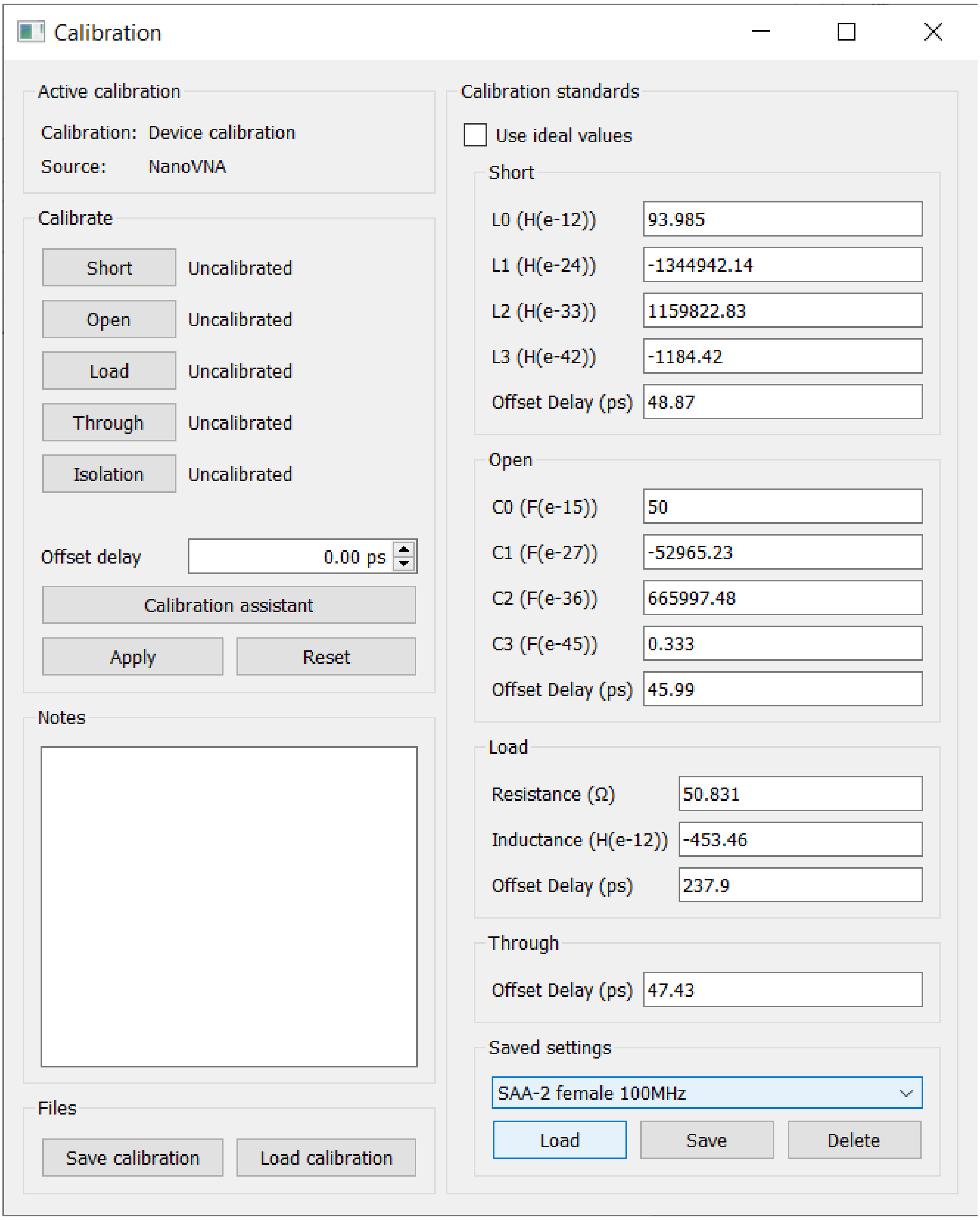
The female kit settings for 3.8GHz



The male kit settings to 100MHz

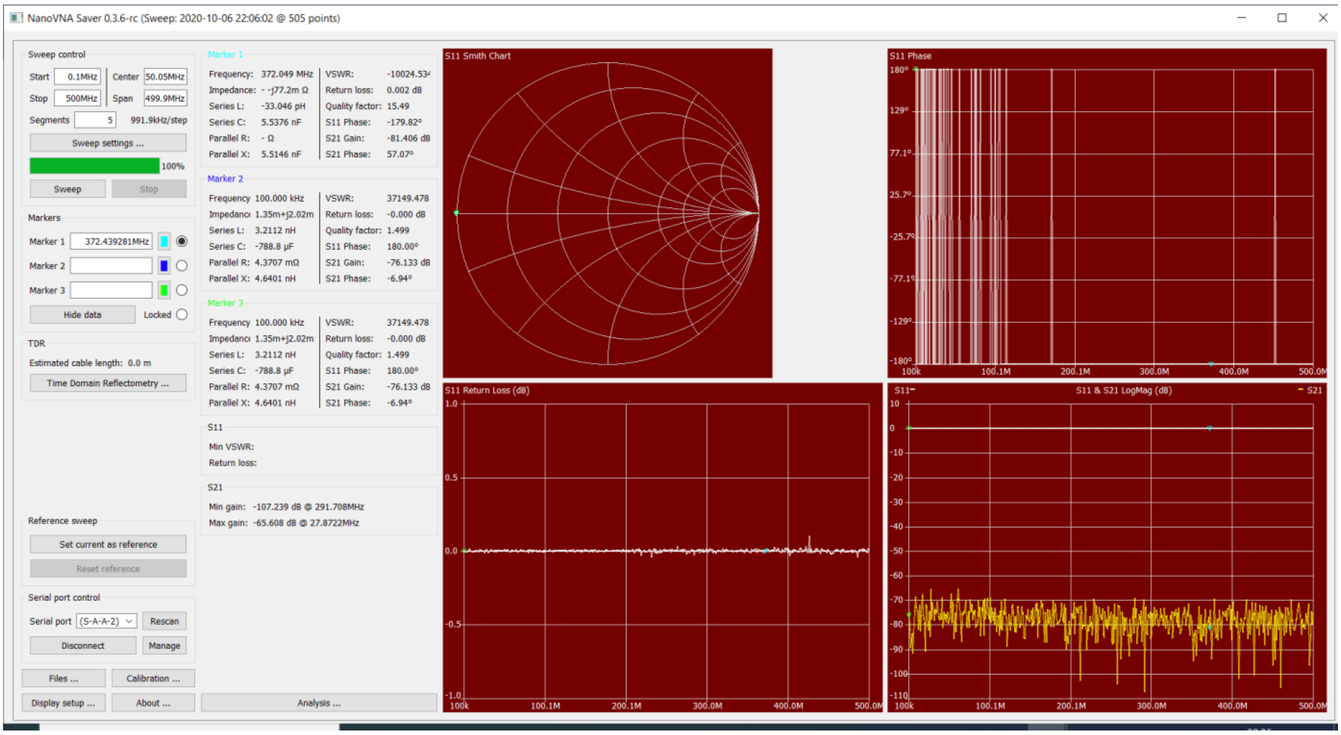


The female kit settings to 100MHz

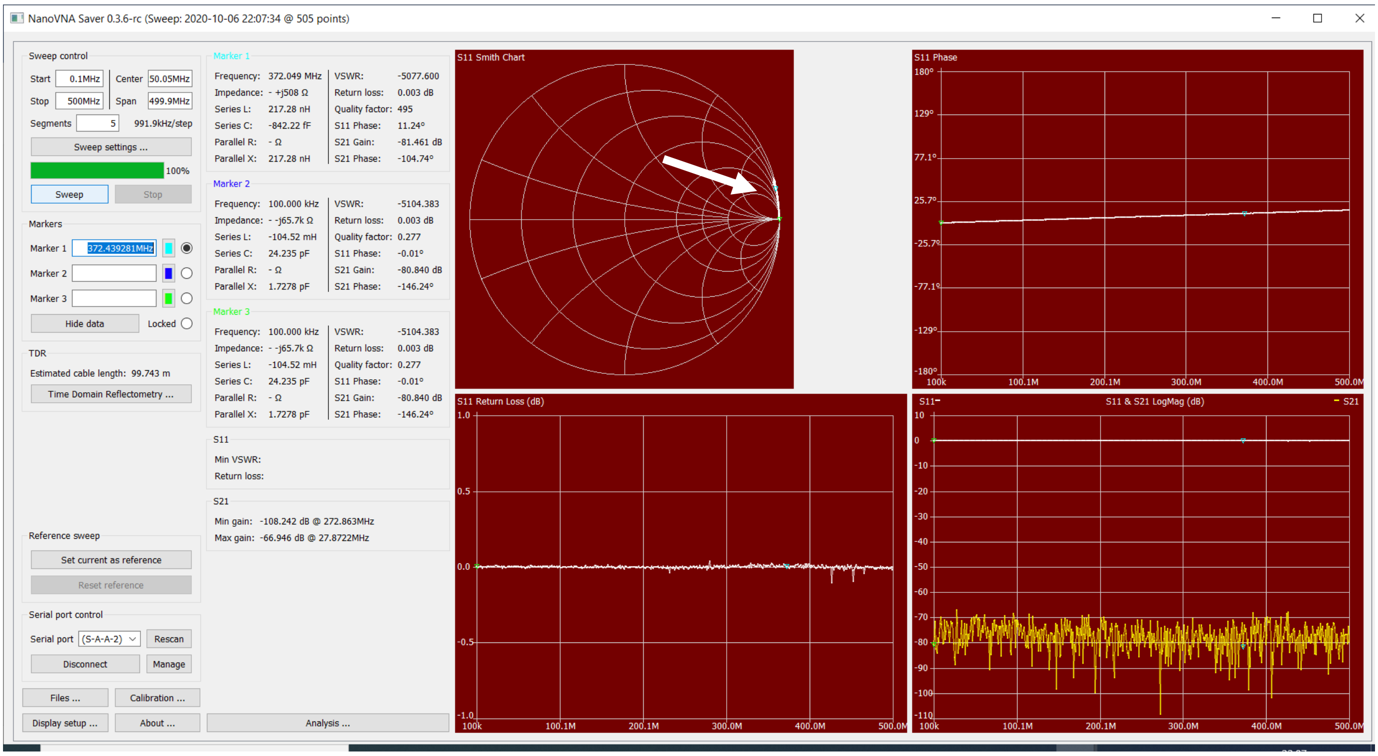


Some additional notes to the NanoVNA-saver

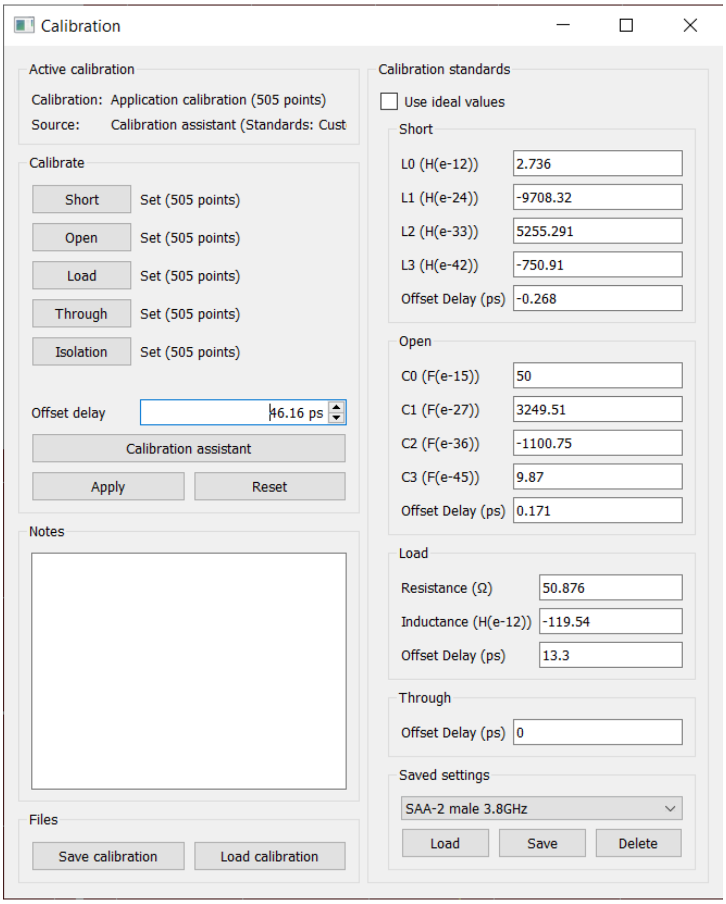
The same possibility exists for the NanoVNA saver to male calibrate at the end of the port1 test cable when fitted with the female female adaptor, and then do an Offset delay by -46.16ps for 3.8GHz settings and -47.43ps for the 100MHz settings at the red arrow. Below is showing how to do for a male calibration performed at the end of the female female adaptor and using 5 segment providing 500 points from 0.1 to 500MHz.
This result of Offset delay entry is shown dynamically
Here is shown the sweep after the calibration where female female adaptor is terminated with the male short having 0 ps offset delay. The measurement shows the correct position extreme left in the Smith chart and the S11 phase toggling wildly between + - 180 degree. The S11 return loss 0dB also as it should be.



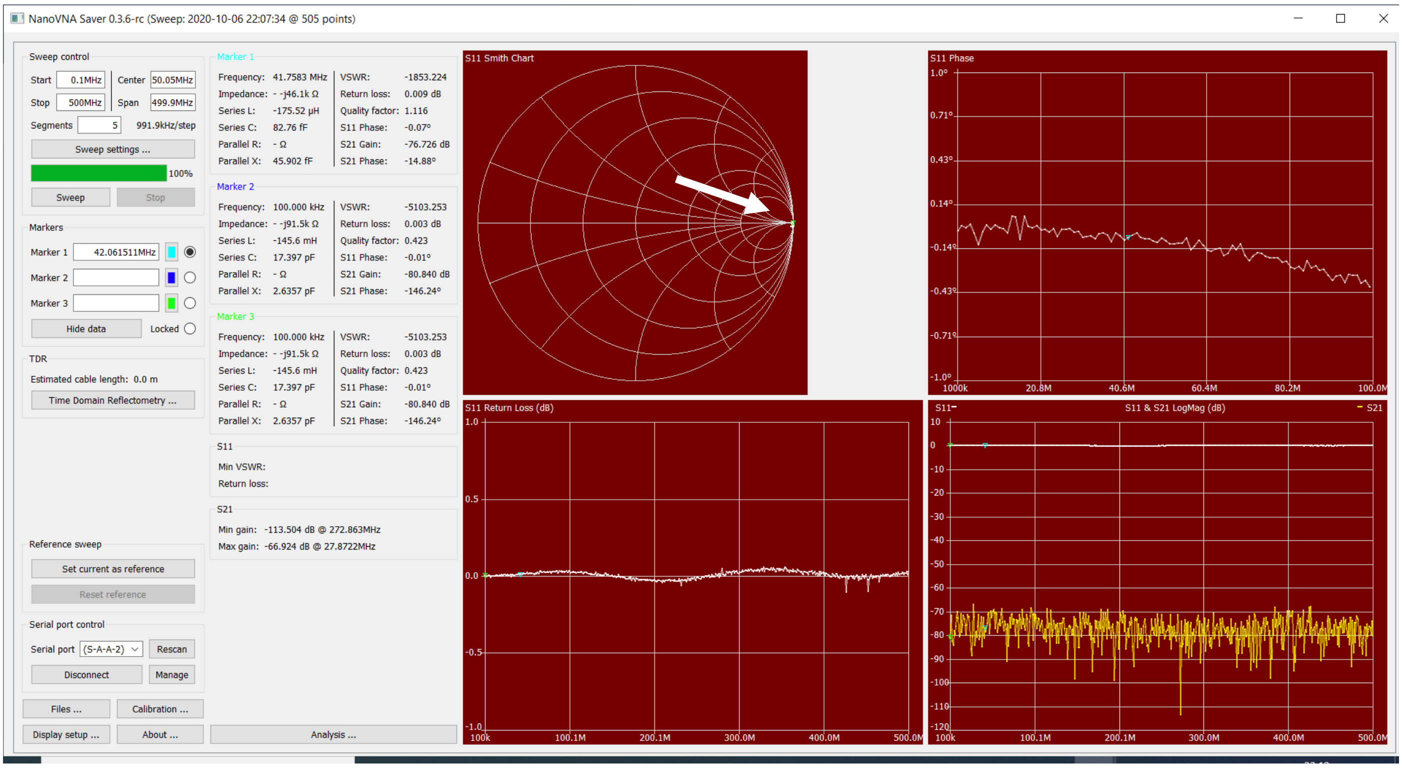
Removing the female female adaptor and doing a new sweep show now an open test cable but the trace turns the wrong way round (anti clockwise) in the Smith chart.



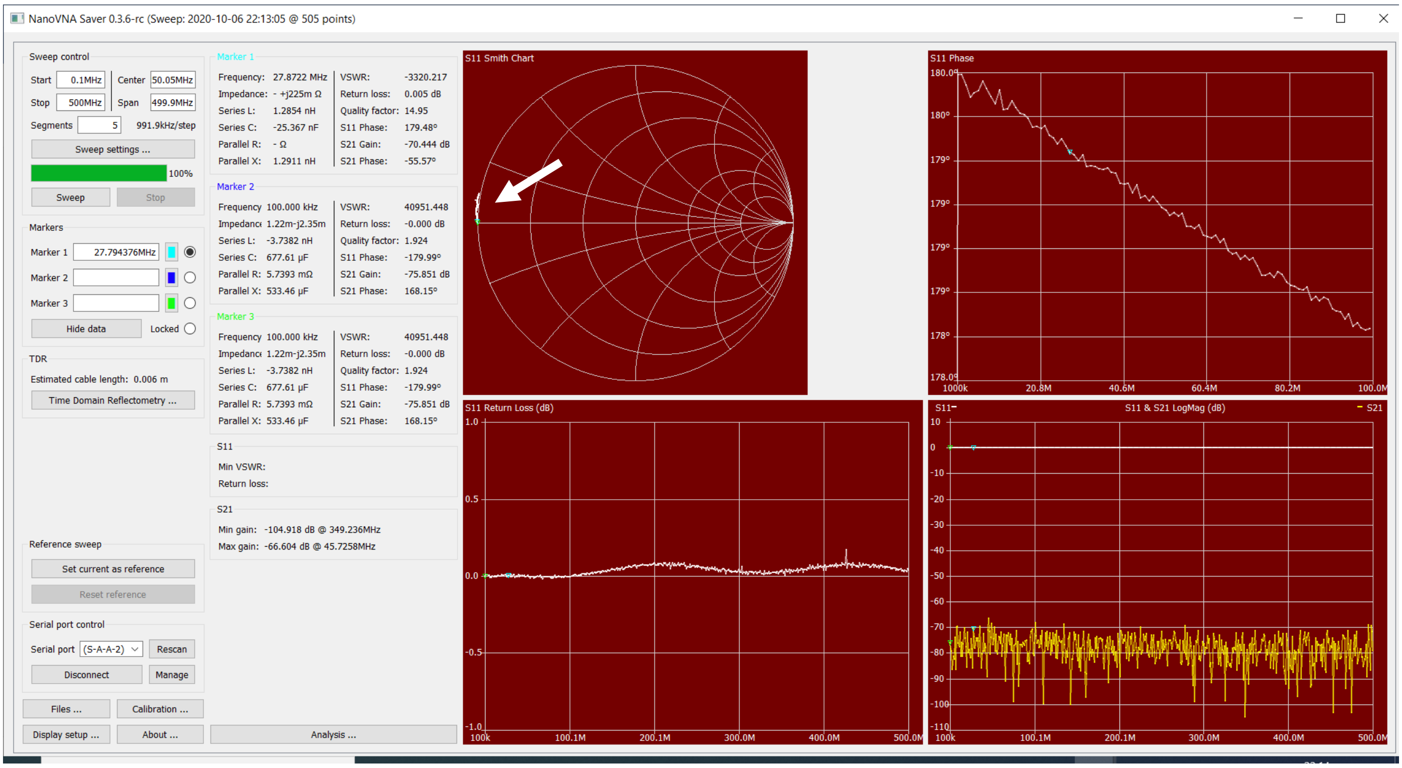
However a the SMA male adaptor at the end of the test cable has a centerpin capacitance and thus a unknow delay so we can not just tune the offset delay to a dot extreme right in the Smith chart but as we know the delay of the female adaptors thru delay to be 46.16ps we enter that value in the Offset delay field



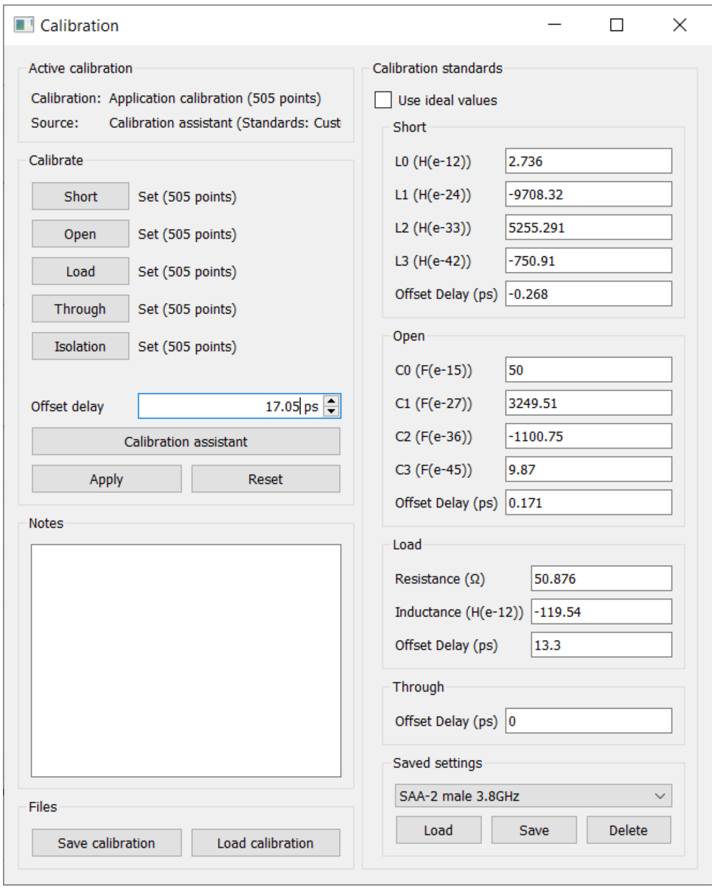
The trace are now running slightly clockwise from the open position. However the calibration plane is now moved from end of the female female adaptor the SMA male adaptor sitting at the end of the test cable as wanted.



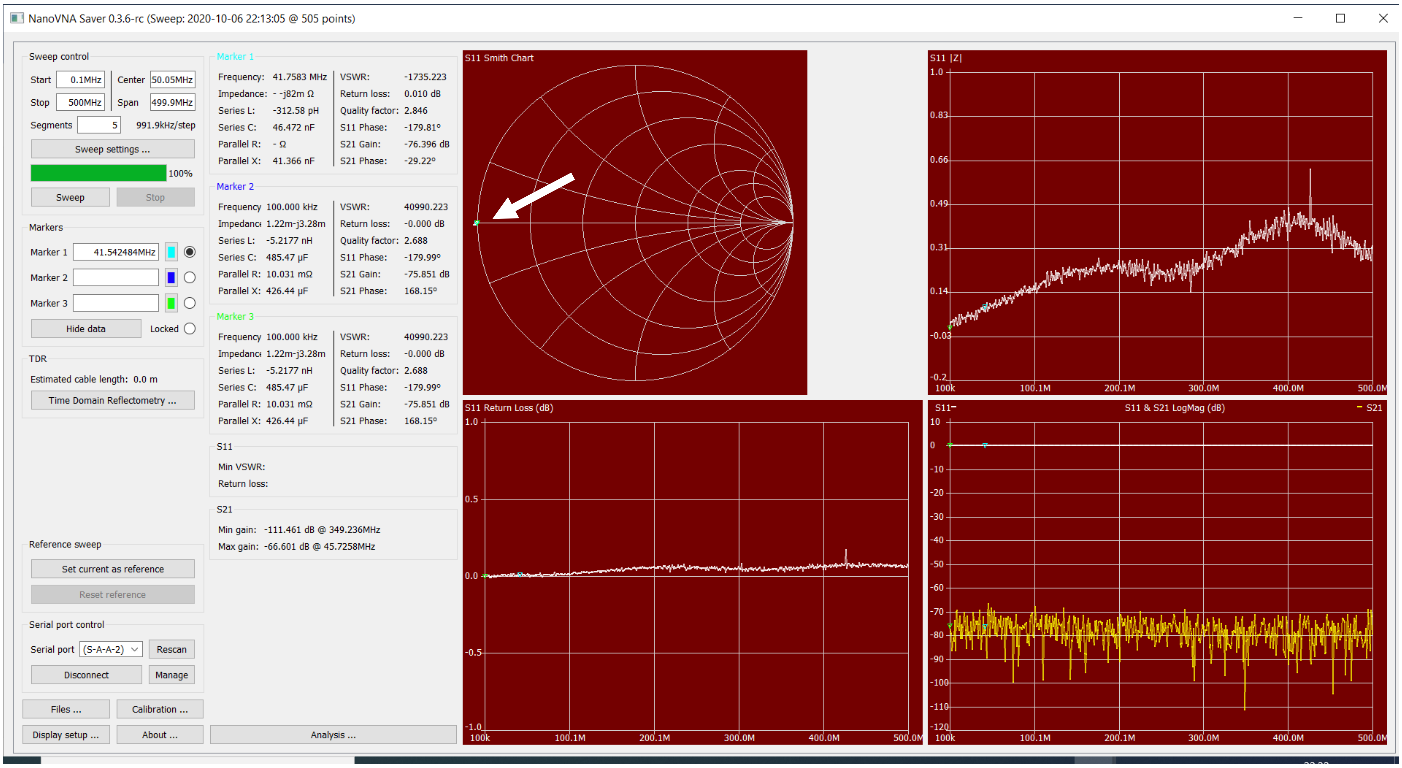
Just for the fun of it and to check we obtained to move the calibration plane, we now terminated the test cable with a quality female short with a delay of 26.91ps and thus we should now measure the delay of this female short which seam to be the case as trace is running clockwise from the short position extreme left.



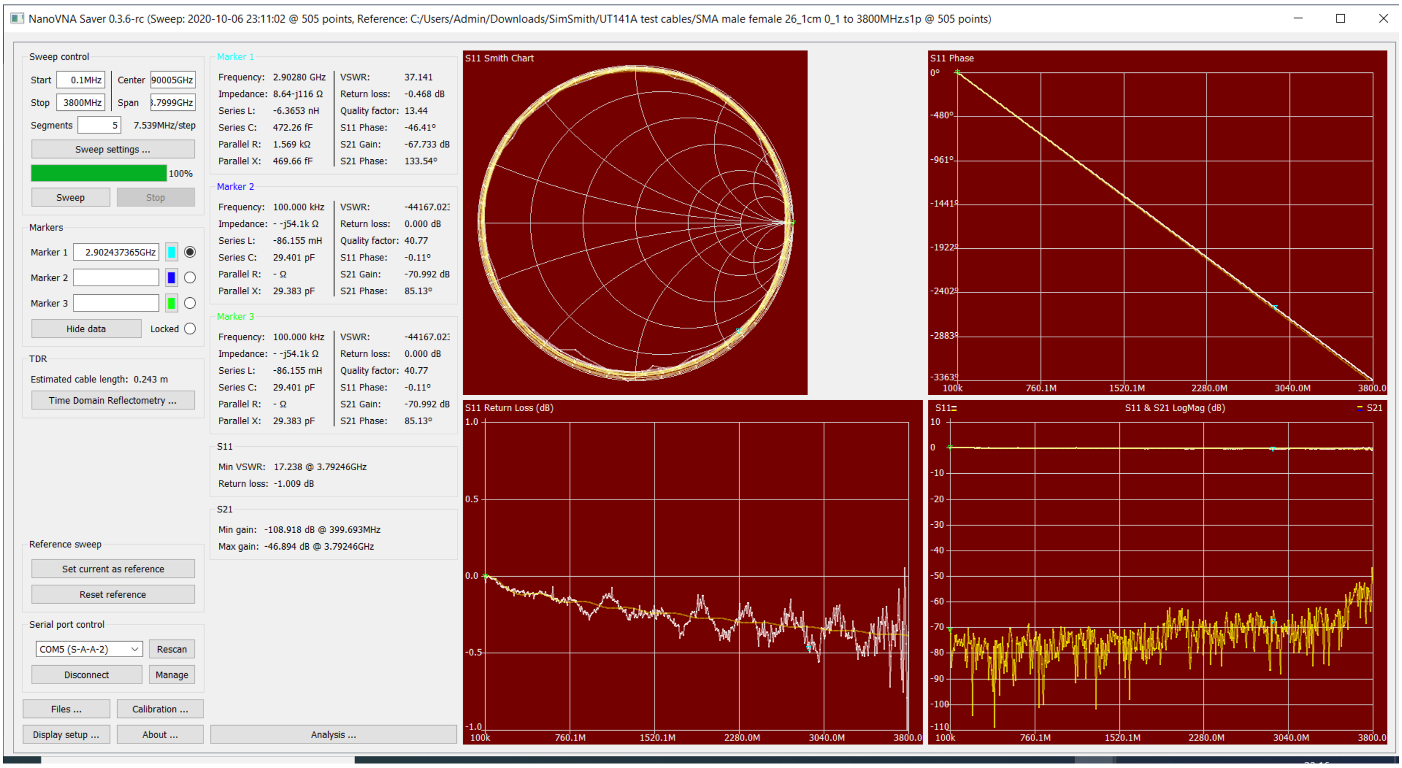
As the female female adaptor has a delay of 46.96ps and the female short 26.91ps then the difference is 17.05ps and by entering this value in the Offset field we see a new result where the dot is at the extreme left



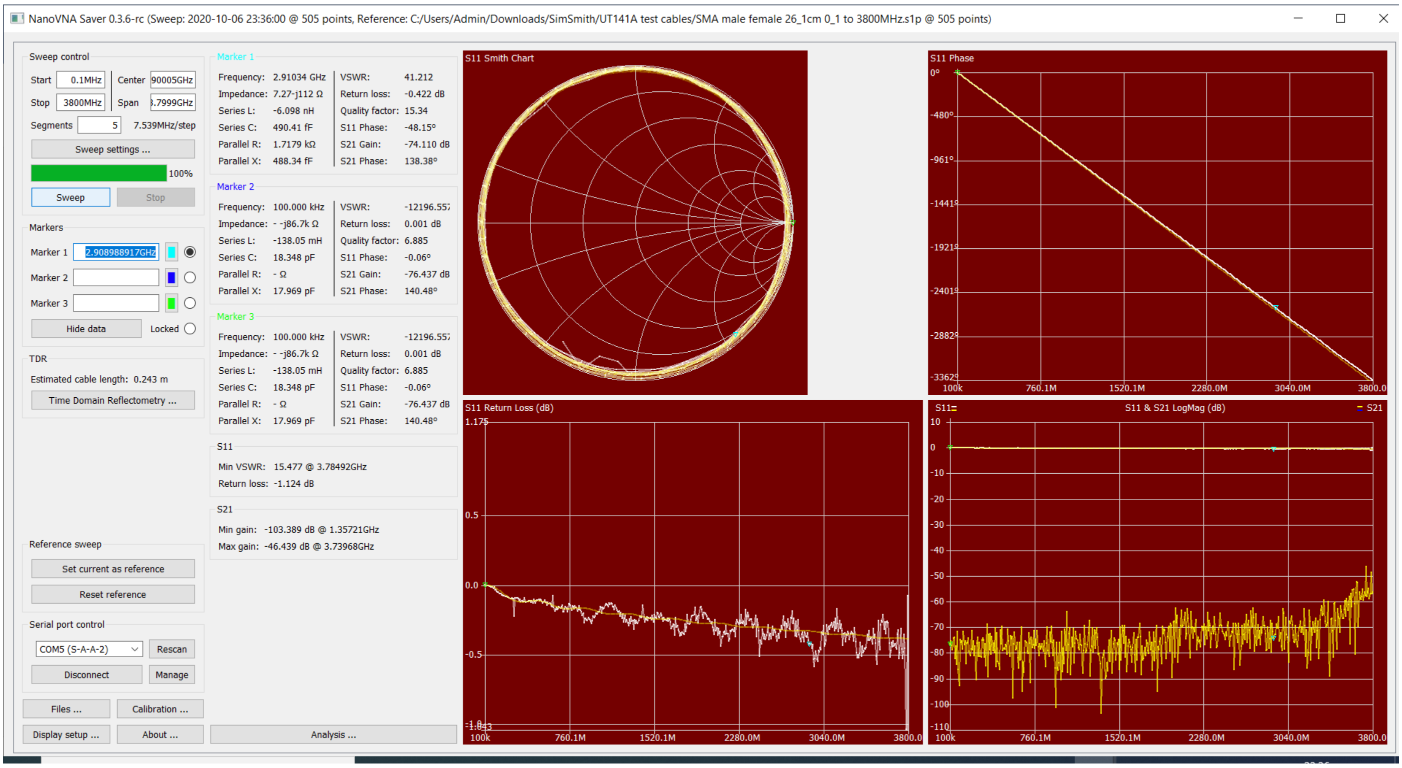
The S11 |Z| is now showing a trace with less than 0.3ohm so both the calibration as the movement of calibration plane verified by entering of the thru adaptor delay. If fine tuning the Offset delay the |Z| can get closer to a horizontal line but due to the fact the female female adaptor has a frequency dependent delay and the NanoVNA-saver assumes the Offset shift is based on a clean 50 ohm transmission line female female adaptor, which is not the case, then such discrepancies are to expect



The same principle as for the VNA-QT software can be used to sweep the calibration plane with an open Ut141A Rigid line and as the NanoVNA-saver have a facility to import a reference file via the file menu then we this way can judge the quality of the calibration. The reference file is the orange trace and the live sweep is the white trace and a perfect match exist for the low frequencies and also when "averaging" the ripple for the measurements at higher frequencies so everything is fine. Oscillations are due to calibration limitations as e.g. load characterization does not include enough complexity, and looses for the open and short calibration standards are not encountered for.



The consequences for a calibration with ideal male calibration standards, just like when the SAA-2 is used not connected to a PC is still performing an acceptable calibration.



06-10-2020 Kurt Poulsen