2 Magi-Cal – Automatic Calibration Function for the VNWA

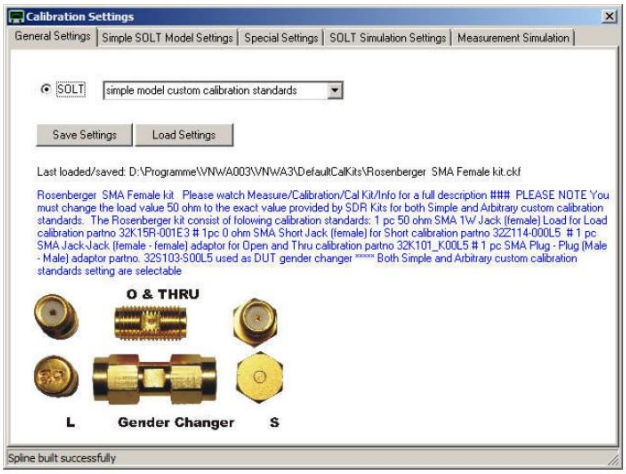
The newly introduced "Magi-Cal" Automatic Calibrator for the VNWA3 or VNWA3E is a very convenient Tool offering significant time savings and improved efficiency when performing calibration. In addition, it saves wear of the Rosenberger Short, Load, Open and Thru calibration components. Normally automatic calibration is only available on the most expensive Vector Network Analyzers used in the industry, costing often as much as a full-size car. Credit is due to Thomas Baier DG8SAQ and his team of supporting developers who have made such a function available to a much wider public through the budget priced VNWA.

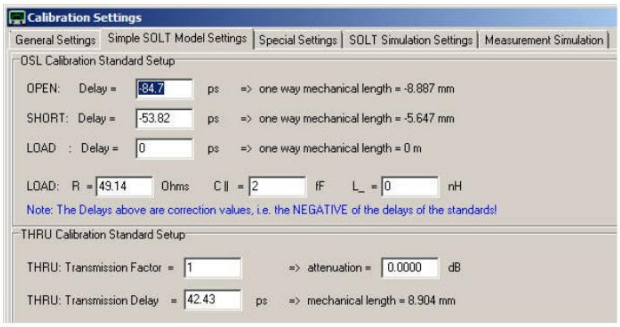
Measurement results with vector network analyzers are only as good as the quality of the calibration performed. In event of a bad calibration with incomplete electrical characteristics and mathematical models, the measurements will not be accurate and in worst case may be completely wrong. At frequencies from VHF band and higher the quality of the calibration becomes increasingly important.

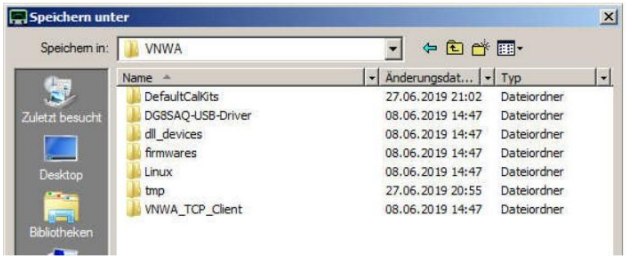
The Magi-Cal is designed to provide calibration of the full frequency range of the VNWA3 to 1.3 GHz. The quality of the calibration is better, compared to a good calibration set with the Rosenberger elements (the kit serial number 579 - 18.4.2016 was used for comparison). Each Magi-Cal Automatic Calibrator is individually commissioned and calibrated prior to shipment to the customer after manufacturing. The calibration data is stored in each Magi-Cal and must be transferred to the VNWA via USB.

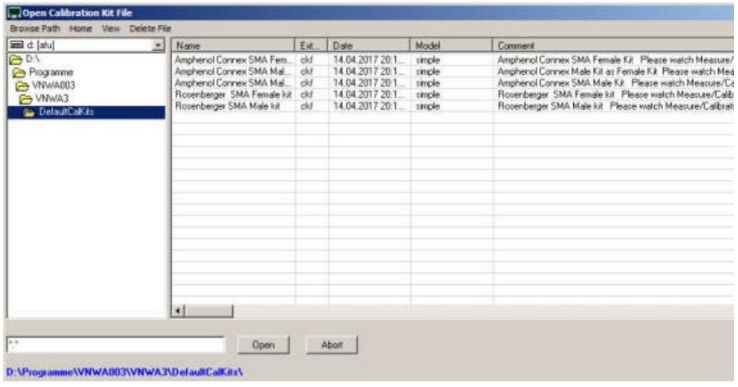
2.1 Securing the old settings

First, old calibration kit settings from my calibration kit with Rosenberger elements s/n # 579 are saved.
Saving is done in the VNWA folder “DefaultCalKits” by selecting the tab “Single SOLT Model Setting” and “Save Settings” button. Enter a suitable file name and the previous calibration kit setting will be saved together with other Default Calibration Kit files in the VNWA Folder “DefaultCalKits”









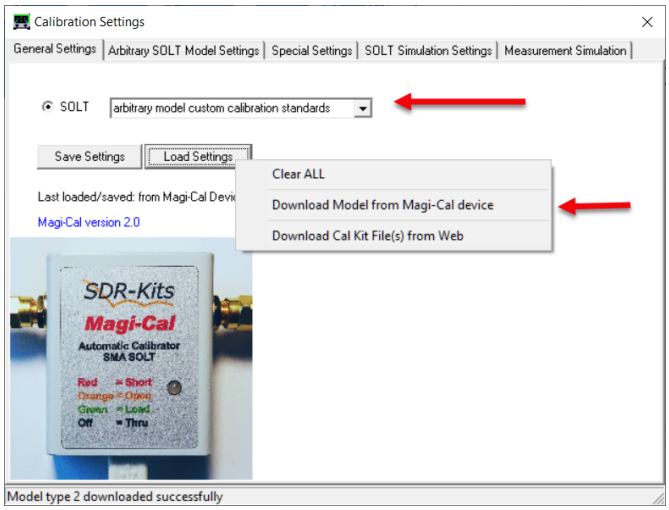
2.2 Calibration with the Magi-Cal

I currently use a pre-production model of the Magi-Cal with the serial number # 3 and the VNWA software 36.7.7. I assume that in subsequent versions of the software, the menu may change slightly. This chapter will then be edited.

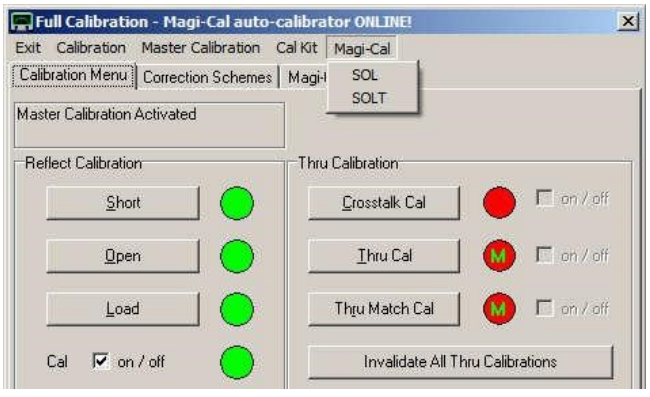
The Magi-Cal is connected via a USB cable to the PC. Only when the Magi-Cal Automatic Calibrator has been detected, the corresponding menu for this hardware will be shown. I personally recommend the Magi-Cal is directly connected to the PC or laptop without a USB hub.

When the Magi-Cal has been detected, an entry will be found by clicking on Menu “Settings” and on dropdown item “Calibration Kit” (K). The first tab "Calibration Settings" is now shown. Load the Magi-Cal settings by using a Right Hand Mouse click on the button "Load Settings”. A drop-down menu now appears and select “Download Model from Magi-Cal device”
All calibration data and models for the calibration of Magi-Cal will now be transferred from the Magi-Cal to the VNWA. These settings apply only to the Magi-Cal that is connected to the Computer. Each Magi-Cal has their own settings.

After successful loadng of the Magi-Cal calibration file, the window will change, as shown in the accompanying picture.



Calibration with the Magi-Cal unit is done by clicking on the tab “Magi-Cal” and next a drop-down menu now appears. Here you can choose between a SOL or SOLT Calibration.
Click your choice and Calibration now will be done automatically and you can monitor progress by observing the status of the Calibration LED.



SOL: Short, Open, Load
SOLT: Short, Open, Load, Thru

2.3 Checking the quality of a SOL calibration with the Magi-Cal

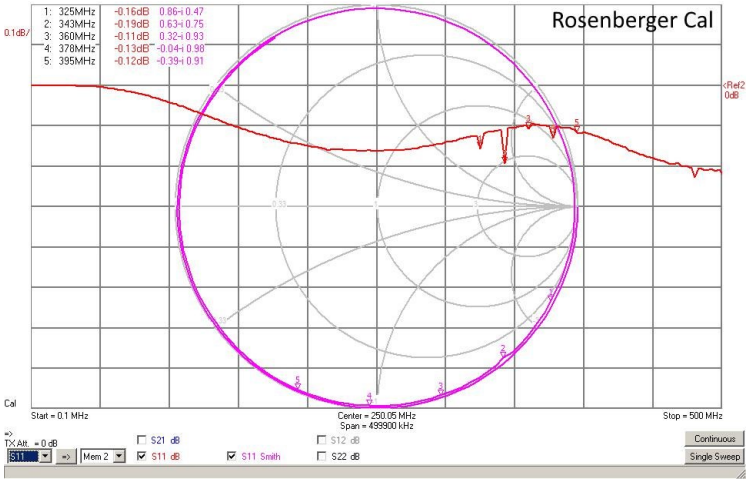
The quality of a calibration can be easily checked with the following method. After a Short Open Load (SOL) calibration has been performed, makea an S11 measurement using a specially prepared approximately 35cm length of UT-141 rigid line. This test method is even more precise than the T-Check Method which is recommended by Rohde & Schwartz (R&S). The Measuring Cable should be built from a straight length of UT-141 rigid cable which has never been bent before.

On one side a female SMA connector is soldered.

On the other end, the rigid pipe has been cut with a coping saw and the cut surface smoothed at a perpendicular angle with a fine file. The entire line is about 35 cm long.

Calibration with the calibration kit with the Rosenberger elements:

The figure below shows an S11 measurement of 0.1 MHz to 500 MHz with 201 measurement points and maximum sweep time measurement (Tab “Settings” and “Sweep” sample time = 100mS).

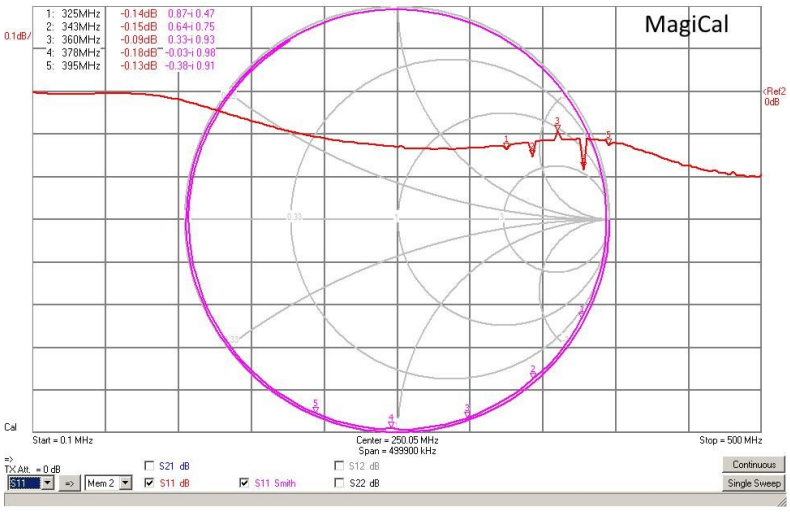


The S11 trace shows the Smith chart circles that are slightly spiral. The spiral shape is caused by low attenuation of the measuring line. The red curve shows the measured S11 measurement with 0.1 dB per box. Clearly, the attenuation can be seen. The slight wavy line is caused by very small errors in the calibration. This test method shows that the changes in attenuation up to 500 MHz are very small and the calibration elements are very good. In the last three years, these calibration elements have been frequently used. Of course, the calibration elements were in better shape on delivery and the results were better.

Nevertheless, the results are now still very good.

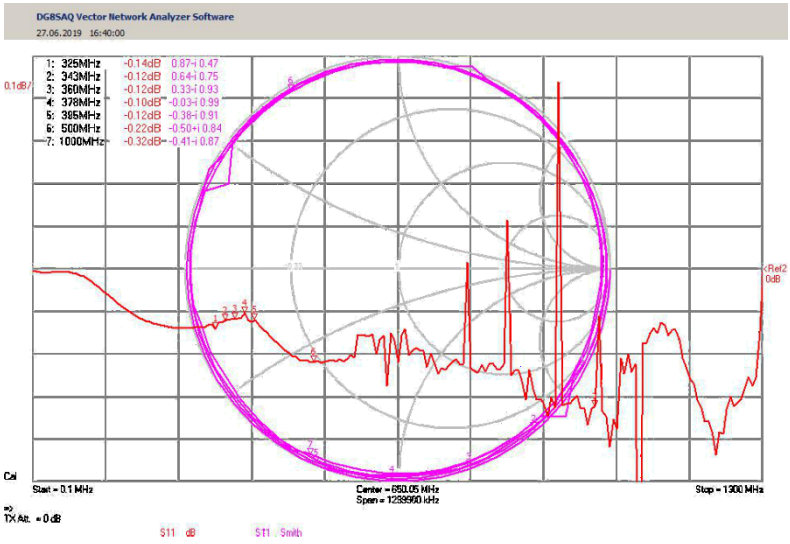
The small spikes are spurious responses, which cannot be avoided.

Note: the fine subdivision of 0.1 dB / Div! Overall a very pleasing result.



The side figure shows a calibration with the new Magi-Cal. Again this is a measurement from 0.1 MHz to 500 MHz, done with 201 measurement points and maximum sweep duration selected (VNWA “Settings” “Sweep” Sample time = 100mS)

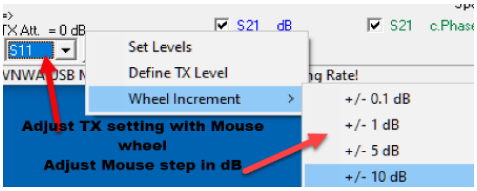
The ripple is even smaller, indicating that the calibration is excellent.



The figure on the left shows an S11 measurement from 0.1 MHz to 1300 MHz with 201 measurement points and maximum measurement duration (VNWA Settings Sweep) after calibration with the Magi-Cal. More spurious responses are visible at frequencies above 500 MHz and at the highest frquencies the VNWA becomes slightly less accurate, but it still shows a very acceptable calibration of the VNWA.

Conclusion: Personally, I am delighted with the usefulness and accuracy of the calibration with the new Magi-Cal Auto Calibrator. The method is accurate as well as quick and convenient. I wish I had this powerful tool years many years ago.

2.4 Calibration with the Magi-Cal and external Attenuator



If you want to do measurements on an Amplifier there are two possibilities.
The first is for the level of the RF Output on the TX SMA port to be reduced in order to avoid over-driving the VNWA RX port (or the input or output limits of the Amplifier!).
When the VNWA is calibrated using the Magi-Cal, no precautions need to be taken in this case, see picture on the right.

If you wish to measure an amplifier whose output power could destroy the VNWA, it can be useful on the RX side of VNWA to insert an attenuator component between Port and the cable to the RX port. Then for S11 or S21 measurement it effectively belongs to the RX port of the VNWA. The calibration is then easily performed with the attenuator inserted between the output of the amplifier and the cable to the RX port. The option of using an external attenuator is only necessary when protection of the RX port of the VNWA is needed.
Normally, a reduction in the TX Output level will be sufficient.

What can go wrong?

The following procedure leads to incorrect results. If the attenuator is inserted after successful Magi-Cal calibration (Thru calibration without an attenuator) this of course leads to incorrect results.
Remedy: Always calibrate the Attenuator (if fitted) together with the Magi-Cal.
When removing the Attenuator, the Magi-Cal Thru calibration is no longer valid and a new Magi-Cal calibration needs to be applied

2.5. How can you tell whether the Magi-Cal has been correctly identified?

If "Magi-Cal" is not shown in the Calibration Kit menu then the USB link with the PC has not been established. In this case it is also not shown in the tab "Setup" and "USB Settings". The USB link can be restored by pressing the the button "Rescan USB BUS". The line: "**DG8SAQ-MagiCal**" is displayed when both VNWA and Magi-Cal USB links are available as shown in the picture below.