Workshop Notes

Measuring with the VNWA
&
Aids for beginners and advanced

Volume 2

work in progress

To this document is still being worked

version 06

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contents

1 Introduction ----- ----- work in progress

2 Calibrate Part 2 - What's new

2.1 Magi-Cal – Automatic Calibration Function for the VNWA

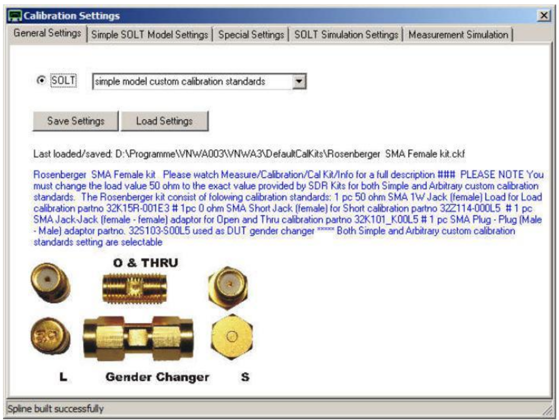
The newly introduced "Magi-Cal" Automatic Calibrator for the VNWA3 or VNWA3E is a very convenient Tool offering significant time savings and improved efficiency when performing calibration. In addition, it saves wear of the Rosenberger Short, Load, Open and Thru calibration components. Normally automatic 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.

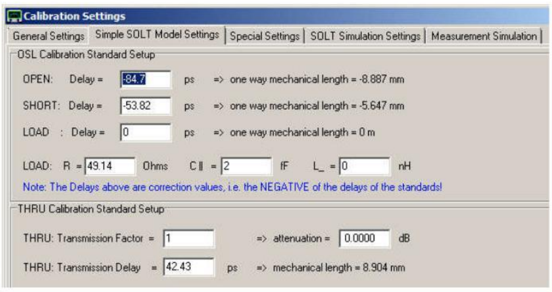
Measurement results with vector network analyzers are only as good as the quality of the calibration performed. In event of a bad calibration with incomplete electrical characteristics and mathematical models, the measurements will not be accurate and in worst case may be completely wrong. At frequencies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

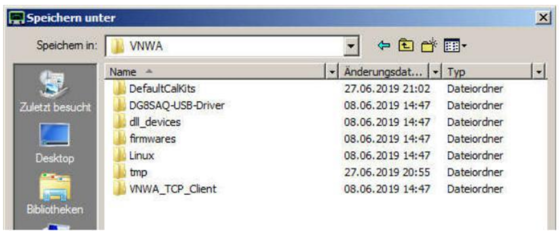
The Magi-Cal is designed to provide calibration of the full frequency range of the VNWA3 to 1.3 GHz. The quality of the calibration is better, compared to a good calibration set with the Rosenberger elements (the kit serial number 579 - 18.4.2016 was used for comparison). Each Magi-Cal Automatic Calibrator 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.

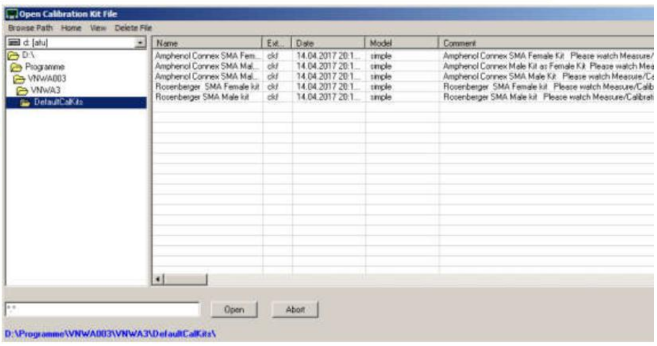
2.1.1 Securing the old settings

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”









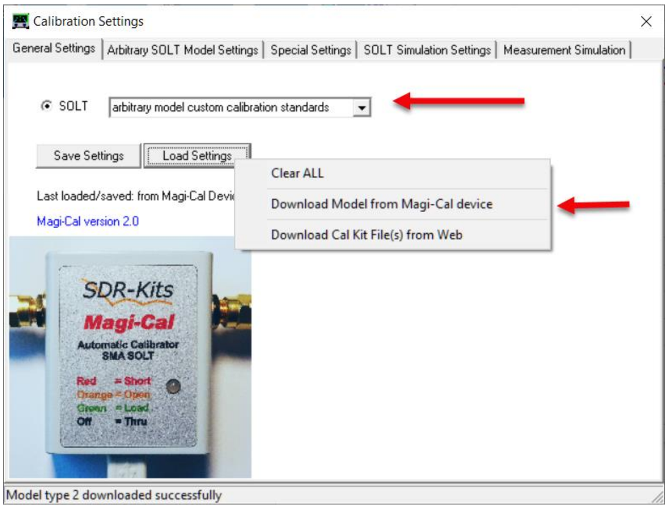
2.1.2 Calibration with the Magi-Cal

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.

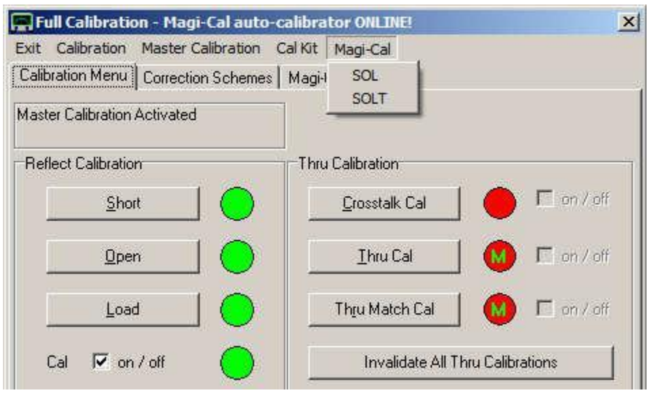
When the Magi-Cal has been detected, an entry will be found by clicking on Menu “Settings” and on dropdown item “Calibration Kit” (K). The first tab "Calibration Settings" is now shown. Load the Magi-Cal settings by using a Right Hand Mouse click on the button "Load Settings”. A drop-down menu now appears 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 loading of the Magi-Cal calibration file, the window will change, as shown in the accompanying picture.



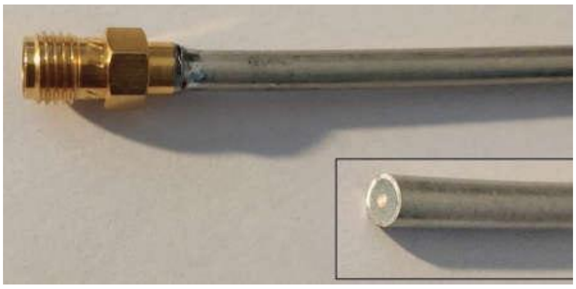
Calibration with the Magi-Cal unit is done by clicking on the tab “Magi-Cal” and next a drop-down menu now appears. Here you can choose between a SOL or SOLT Calibration. Click your choice and Calibration now will be done automatically and you can monitor progress by observing the status of the Calibration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

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



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

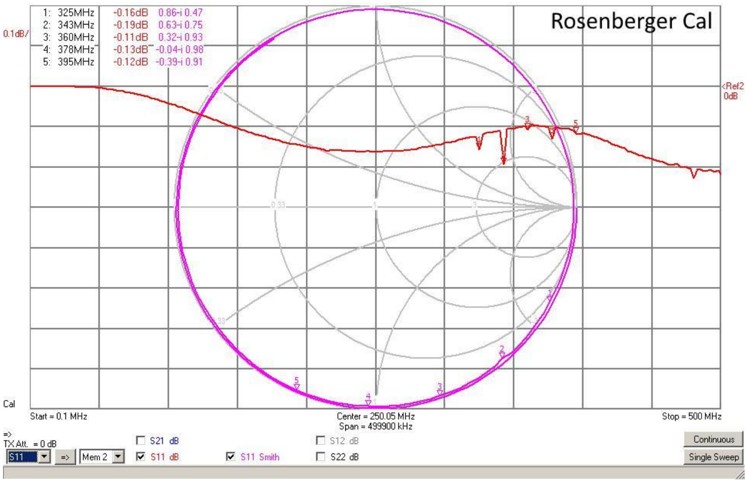
The quality of a calibration can be easily checked with the following method. After a Short Open Load (SOL) calibration has been performed, makea an S11 measurement using a specially prepared approximately 35cm length of UT-141 rigid line. This test method is even more precise than the T-Check Method 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.

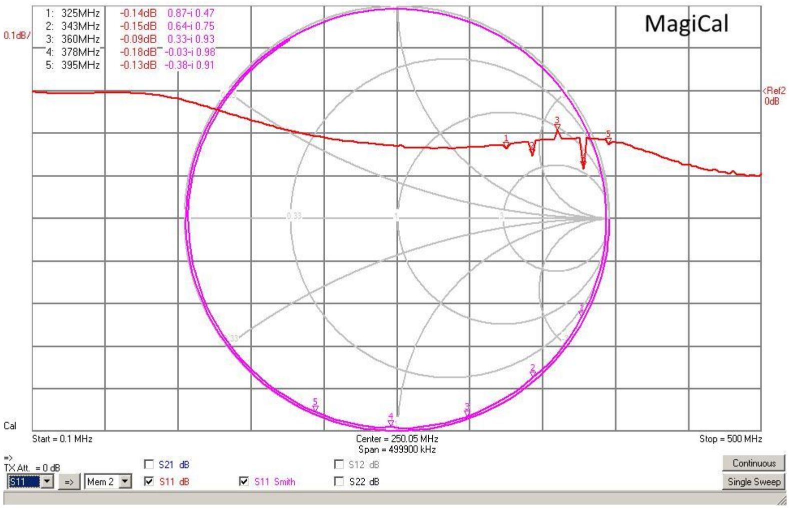
<u>Calibration with the calibration kit with the Rosenberger elements:</u>
The figure below shows an S11 measurement of 0.1 MHz to 500 MHz with 201 measurement points and maximum sweep time measurement (Tab “Settings” and “Sweep” sample time = 100mS).

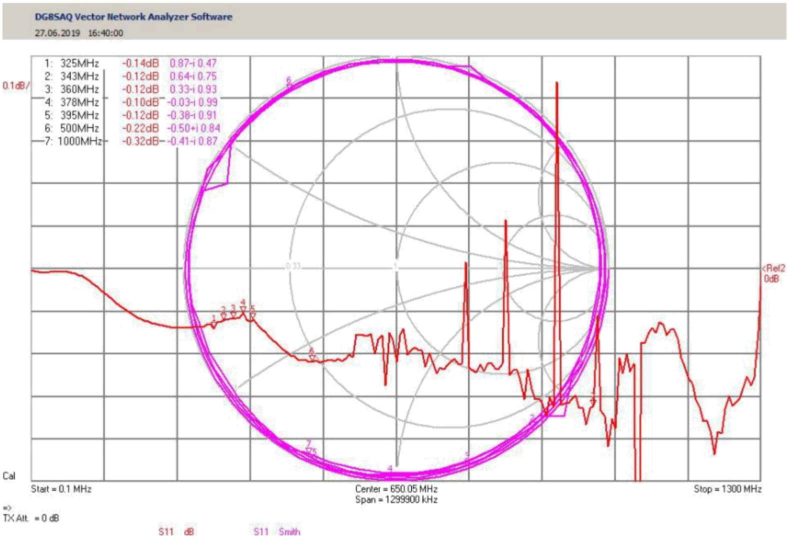
The S11 trace shows the Smith chart circles that are slightly spiral. The spiral shape is caused by low attenuation of the measuring line. The red curve shows the measured S11 measurement with 0.1 dB per box. Clearly, the attenuation can be seen. The slight wavy line is caused by very small errors in 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.



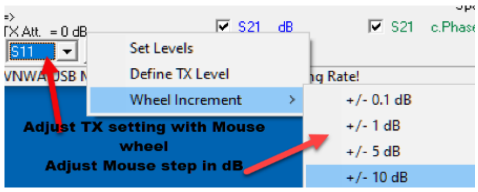


The figure on the left shows an S11 measurement from 0.1 MHz to 1300 MHz with 201 measurement points and maximum measurement duration (VNWA Settings Sweep) after calibration with the Magi-Cal. More spurious responses are visible at frequencies above 500 MHz and at the highest frquencies the VNWA becomes 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.

2.1.4 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.

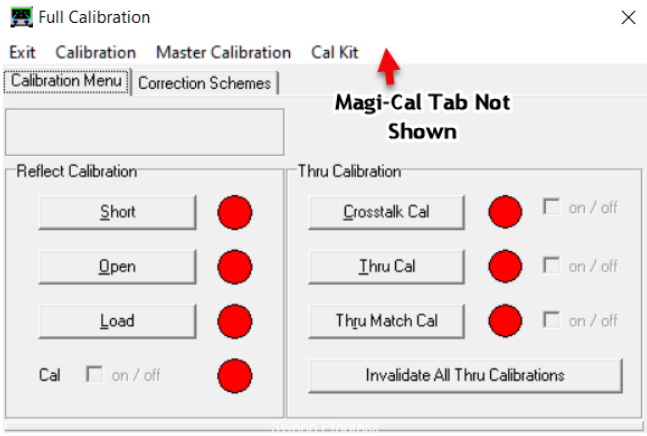


If you wish to measure an amplifier whose output power could destroy the VNWA, it can be useful on the RX side of VNWA to insert an attenuator component between Port and the cable to the RX port. Then for S11 or S21 measurement it effectively belongs to the RX port of the VNWA. The calibration is then 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.

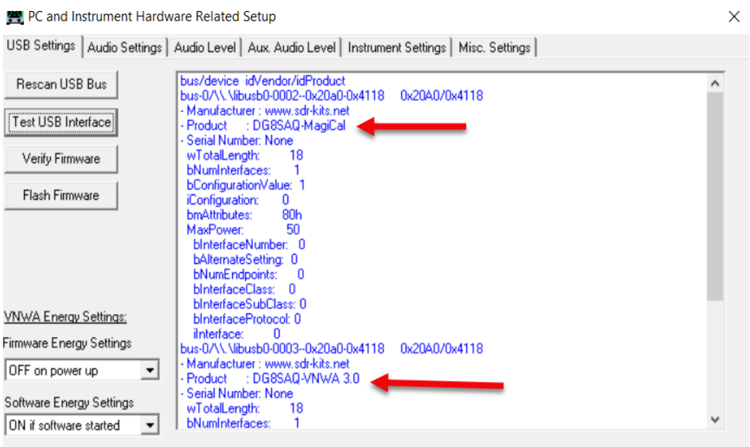
What can go wrong?

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

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

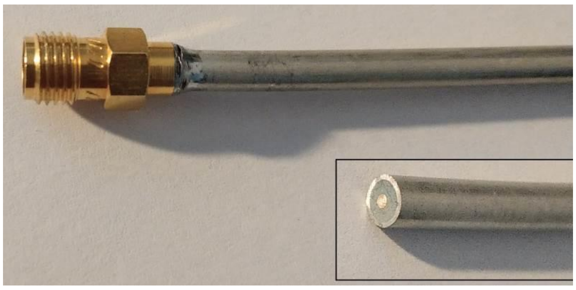


If "Magi-Cal" is not shown in the Calibration Kit menu then the USB link with the PC has not been established. In this case it is also not shown in the tab "Setup" and "USB Settings". The USB link can be restored by pressing the the button "Rescan USB BUS". The line: "**DG8SAQ-MagiCal**" is displayed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

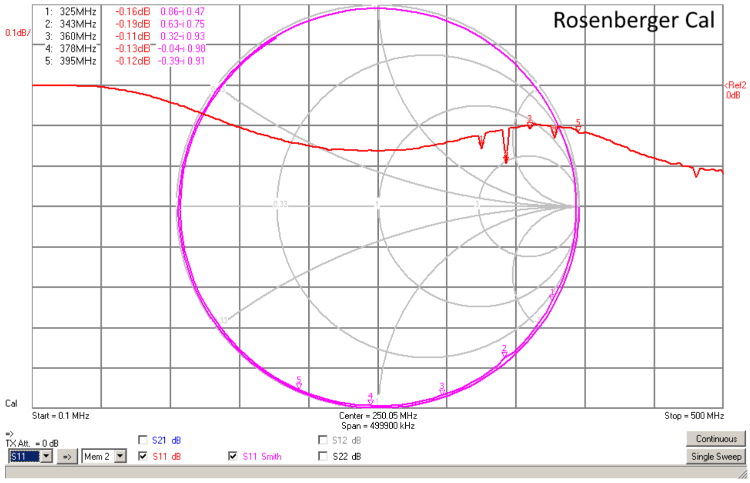


2.2 Checking the quality of a SOL calibration (Short, Open, Load)

The quality of a calibration can easily be checked with a trick. After a short-open-load calibration (SOL) has been carried out, an S11 measurement is used to measure a specially prepared approx. 35 cm long UT-141 Rigid cable. This test procedure is even harder than the T-check recommended by R & S. The measuring line: The measuring line is built from a straight UT-141 Rigid line that has never been bent. On one side is a female SMA connector. On the other side, the rigid cable was cut with a jigsaw and the cut surface was smoothed vertically with a fine file. The entire pipe is about 35 cm long.



Calibration with the calibration kit with the Rosenberger elements: The following figure shows an S11 measurement from 0.1 MHz to 500 MHz with 201 measurement points and maximum measurement duration (VNWA Sweep Settings). The S11 trace shows circles in the Smith chart that are slightly helical. The spiral shape is caused by the slight attenuation of the measuring line. The red trace shows the S11 measurement at 0.1 dB per div. Very clearly the damping can be seen. The slight wavy line is caused by the smallest errors in the calibration. This very sharp test procedure shows that the wave motion up to 500 MHz is very small and the calibration elements are very good. In the last three years, the calibration elements have been used very frequently. I assume that the results were even better on delivery. Nevertheless, they are still very good now. The small spikes are secondary reception points that can not be avoided. Note the extremely fine subdivision of 0.1dB / div! Overall, a very pleasing result.



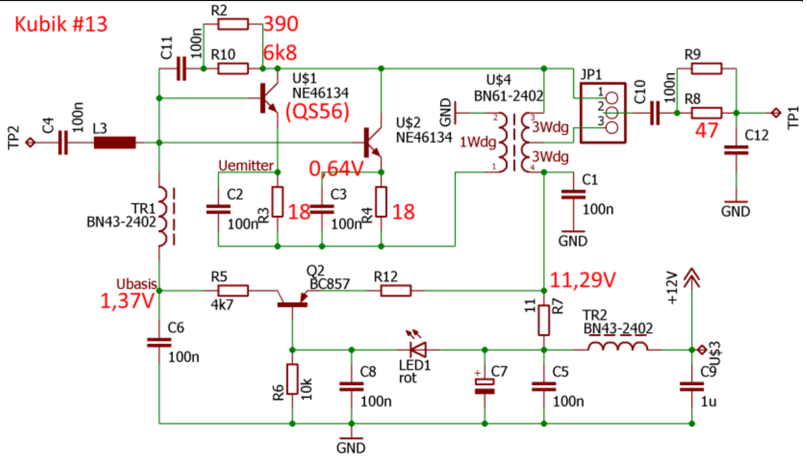
3 amplifiers measure

When measuring the active components may endanger to destroy the VNWA. All levels greater than 0 dBm can cause irreparable damage to the VNWA! The measurement of an amplifier should always start with the measurement of the level maximum occurring with a power meter. A fault or a swing may occur quickly.

The VNWA works with levels to -17 dBm. All major levels lead to an overload. There are ways to avoid such a distortion. Either an external attenuator during the calibration is reduced with looped or is at VNWA the transmission level. Refer to VNWA-helpfile,

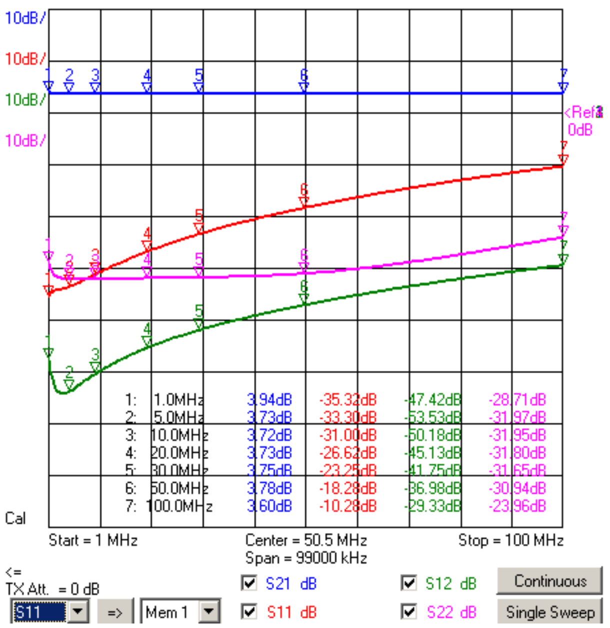
At this point I would like to present a good amplifier for the range of shortwave example, the gain is switchable. The amplifier is measured and interpreted the results. The amplifier is more accurately described here: https://www.bartelsos.de/dk7jb.php/der-kubik-verstaerker

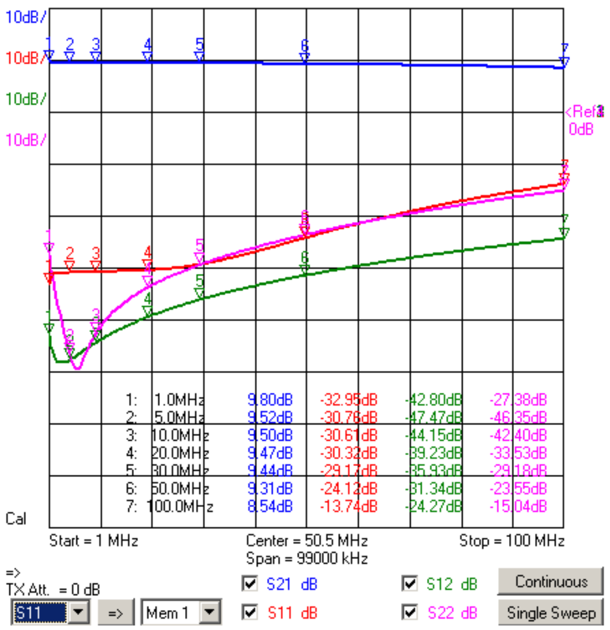
Cubic amplifier # 13 switchable gain		
	Position 1	Switch position 2
reinforcement	S21 = 3.8 dB	S21 = 9.6 dB
noise	NF = 3.0 dB	NF = 2.2 dB
IP3 based on the starting	OIP3 = 40.5 dB	OIP3 = 41.9 dB
IP3 referred to input	IIP3 = 37.2 dB	IIP3 = 32.7 dB
operating voltage	12V at 72 mA	12V at 72 mA



This amplifier offers in the shortwave band a very good adaptation and isolation at almost constant gain. He works very stable in responding almost without reaction to mismatches at the other port. At the same time the noise is low and the IP3 value very high.

The behavior of an amplifier to mismatch can easily be tested by not completed after a S11 or S22 measurement with the second port 50 ohms. then changes when re-measurement, the adjustment of the amplifier is not rückwirkungsfrei.Man, the reverse gain S21, and the port adjustments S11 (Port 1) and S22 (Port 2) look at each other.



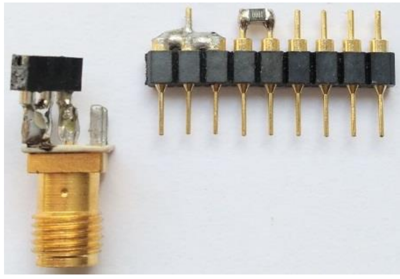


4 inductors

This chapter inductors be examined more closely. It is wound as a toroidal T50-6 that an inductance of 1uH results. Toroidal cores can be easily calculated with the program "Mini Ring Core Calculator":http://www.dl0hst.de/mini-ringkern-rechner.htm

Experience has shown that the program for the number of turns indicates always one or two turns too many. A toroid T50-6 is so then wound with 14 turns of 0.4mm-CU.

4.1 The S11-measurement



Inductors I always Vermesse with a self-made measuring adapter.

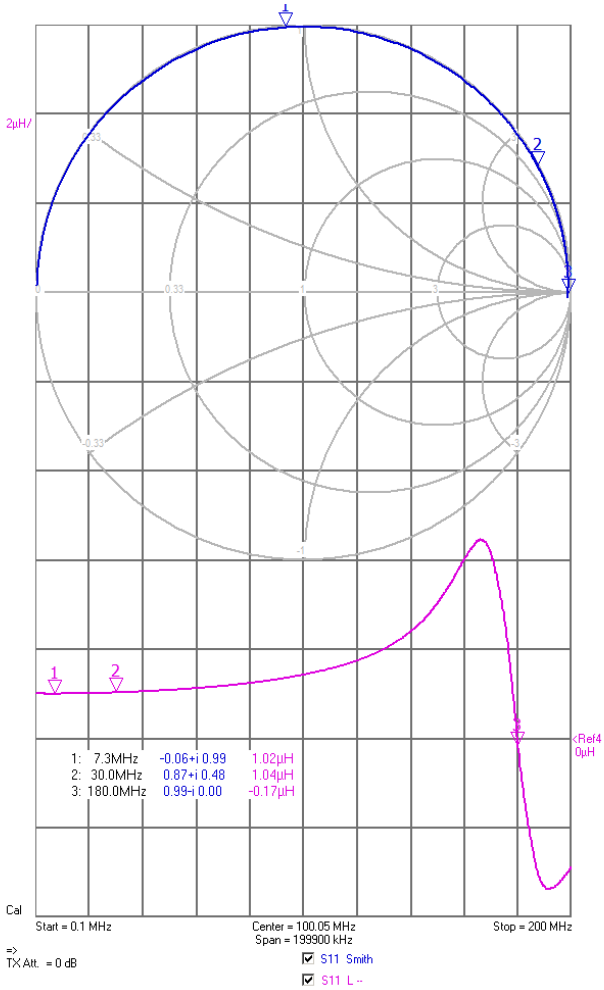
The picture shows my measuring adapter for measuring S11 and my Kalibrierstücke. For such an ideal calibration Calibration is turned on. Load as two parallel-connected 100 ohm resistors are used. Either very precisely measured resistances or two 0805 SMT resistors with an accuracy of 0.1% .Not forgotten to change after this measurement back to the normal calibration back!

With a freshly calibrated VNWA an S11 measurement is then performed (SOL calibration). is measured in the frequency range 1-200MHz, with 801 points and a longer sweep time.

4.2 Frequency dependence of the inductance

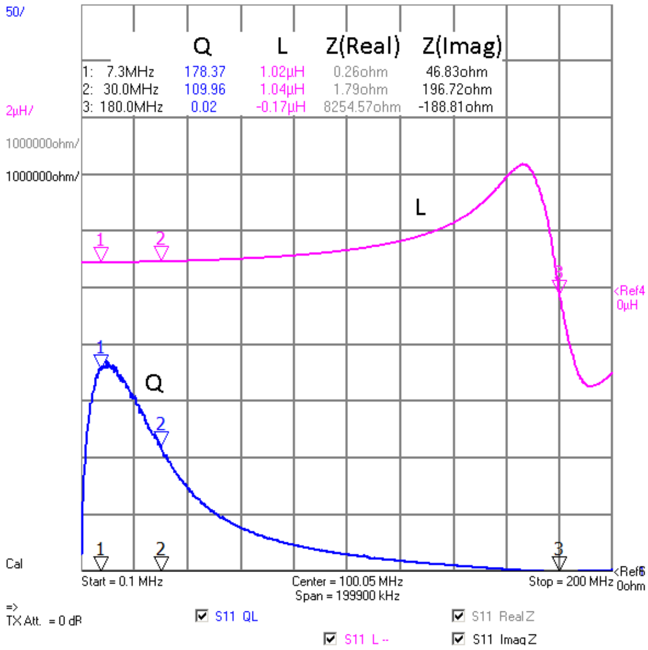
In the diagram we let the inductance (L) and view the Smith chart.

The diagram shows a dependence of the inductance of the frequency. With increasing frequency, the value of the inductor increases until it decreases again. At 180 MHz, the coil self-resonance is. Together with the parasitic capacitances of the windings, a resonant circuit which occurs at this frequency in resonance forms. At still higher frequencies, the coil can act only capacitive.



4.3 Q of the coils used

In the diagram we let the inductance L and the quality QL, and show the real part of the impedance Zreal and the imaginary part of the impedance Zimag.



The quality of a coil QL calculated from the quotient QL = Zreal / Zimag

The quality of this coil exhibits a pronounced maximum at around 8 MHz. In the design of bandpass filters must be taken to ensure that the inductors used have their goodness maximum at the calculated angular frequencies. Only the attenuation of the bandpass filters as small as possible and the selectivity is as high as possible.

The determination of the quality is always difficult, there is formed in the calculation of the quotient of two measured values which have a big difference. This quickly leads to larger measurement errors. The value for Zreal is very small and the value for Zimag relatively very large. Only with a fresh calibration and long measurement period is obtained reasonable results. Even if you work very carefully, I expect an error of about 10% -15%!

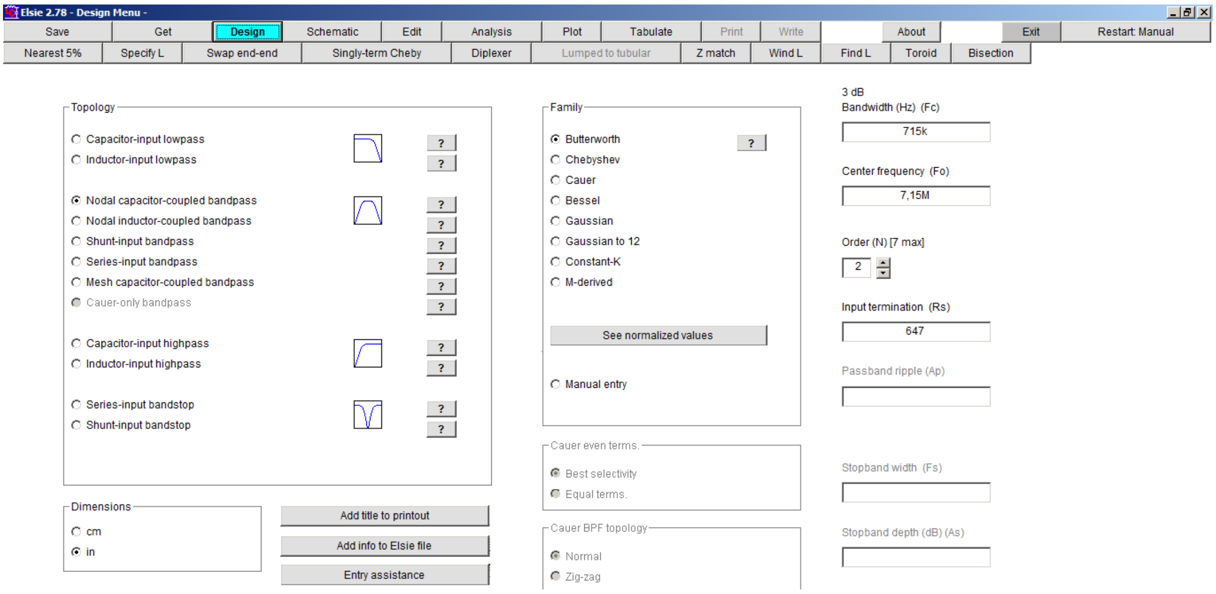
5 Filter design with Elsie and vote by Time Domain

Here I describe two options for the design of bandpass filters. The dimensions of the filter presented here draws on an example from the help file of VNWAs and should present the steps that are necessary to the draft.

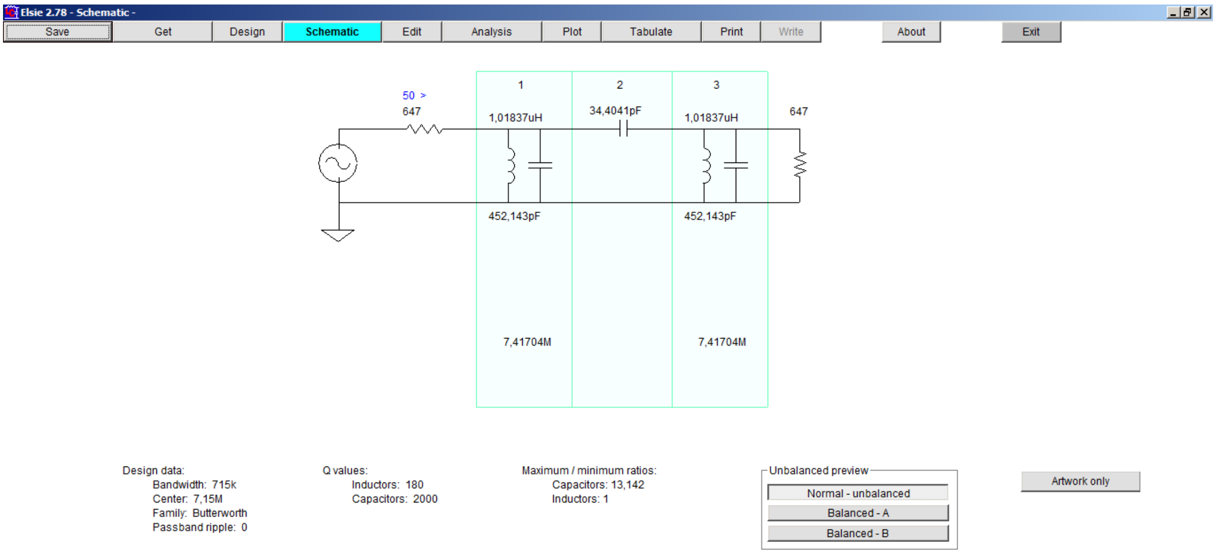
5.1 Filter design with the program ELSIE

Used Filterberechungs- and Simmulationsprogramm ELSIE: http://www.tonnesoftware.com
On this website you will find other interesting programs.

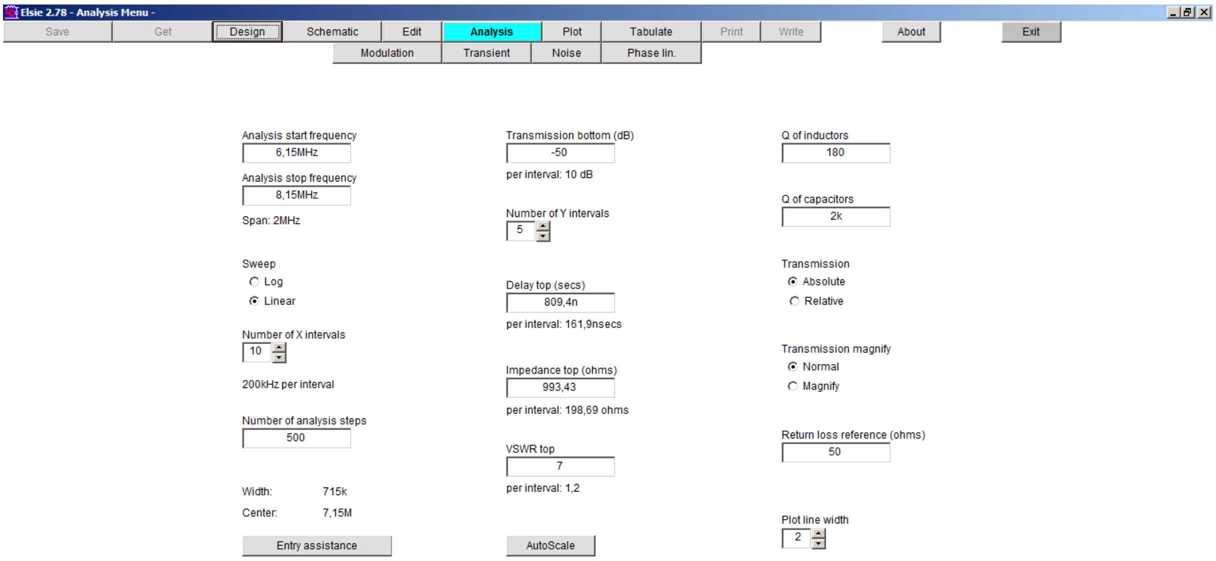
There is a "Nodal capacitator coupled bandpass" elected by a "Butterworth" filter shape and with a filter center of 7.15 MHz, a 715 kHz bandwidth and an order of the second Then played with the filter impedance "Input termination" until the values of all capacitors and inductors are in a reasonable range. In this example, I've chosen a filter impedance of 647 ohms, since an inductance of approximately 1 uH can wrap well. In a later design stage, the subsequent adjustment to the 50 ohm environment is. The wiring diagram can be found under "Schematic".



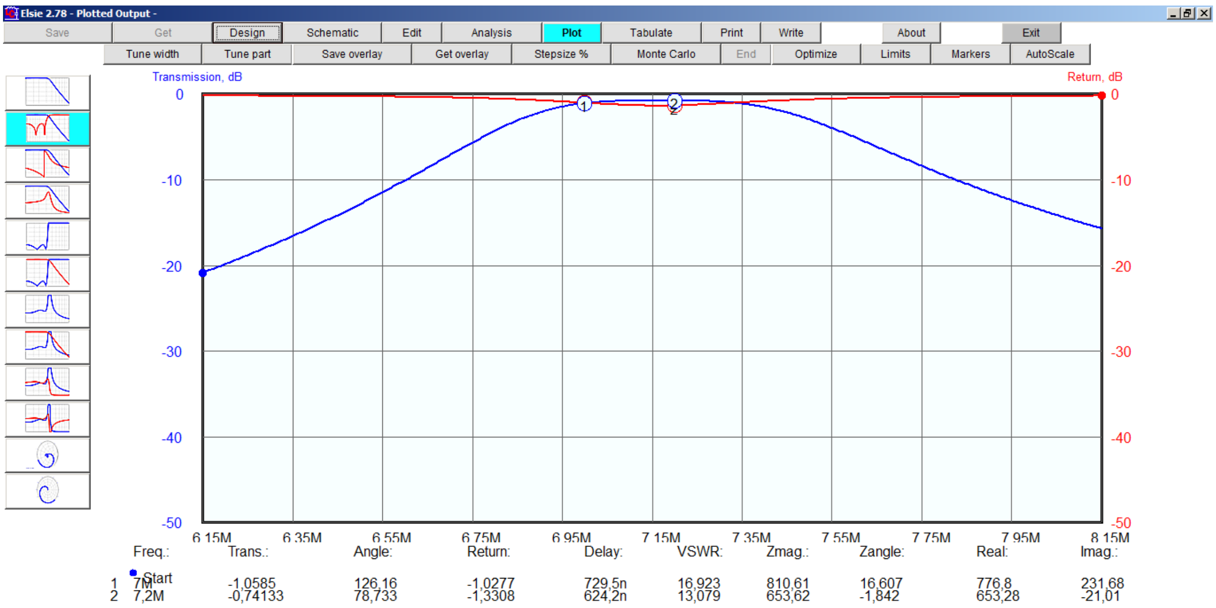
The following figure shows the result of the design.



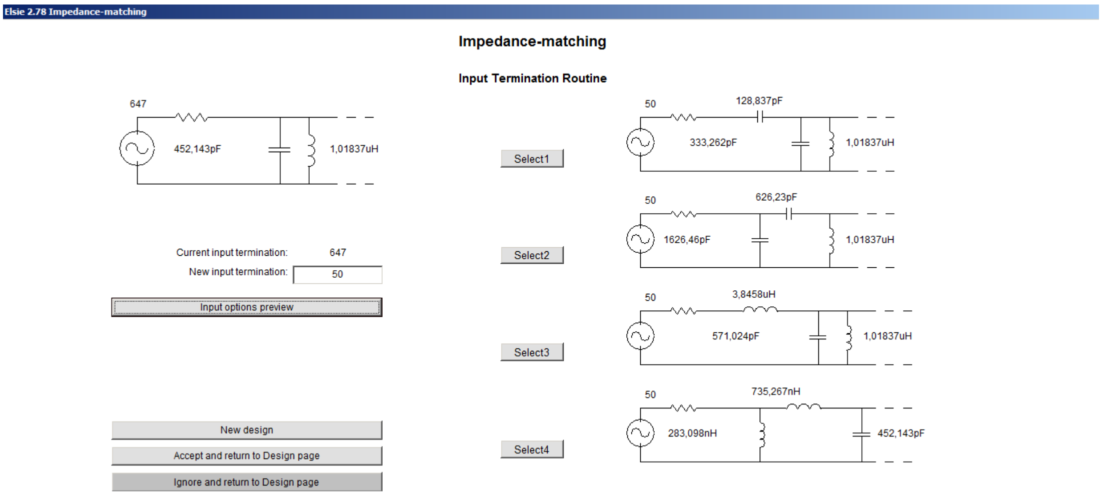
This image shows the settings required for the proper setting of the graph and the subsequent creation of the S2P parameters:



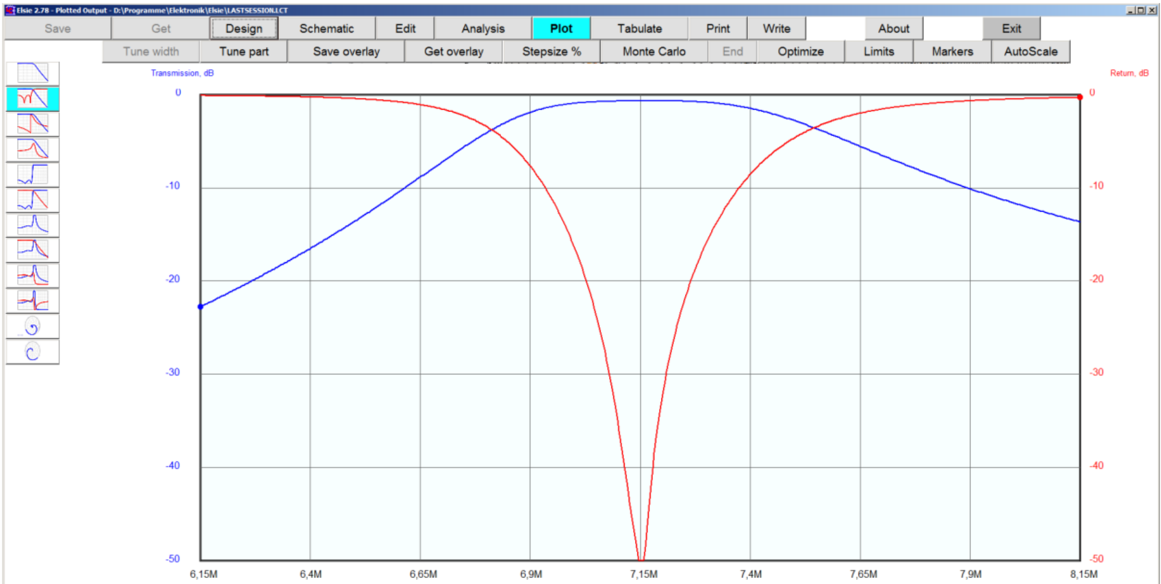
Here is the result of our design. It must be noted that at this time an impedance mismatch exists.

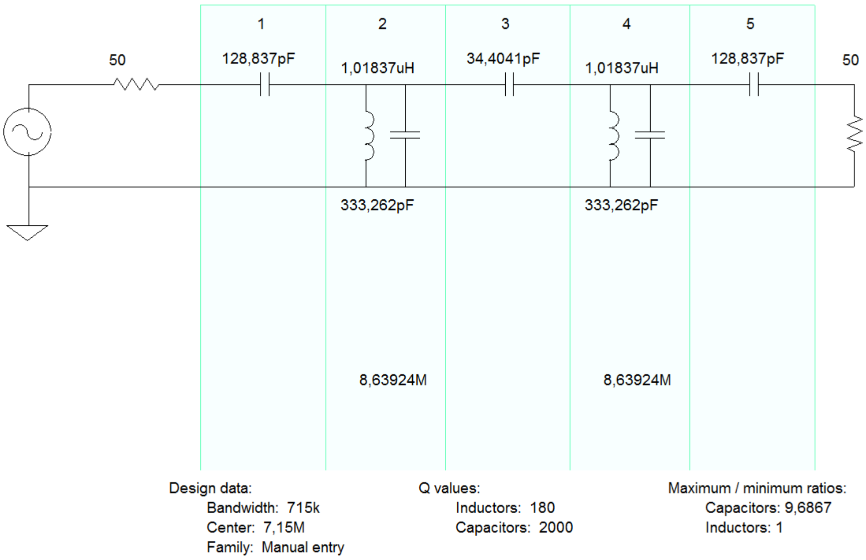


Now, the impedance matching of the output of 647 ohms and Filtereingangs- takes place after 50 ohms. Simply go back to the "Design" window and click "Z's" and follow the input. The following figure shows only the first window of the impedance matching routine. Everything is intuitive.

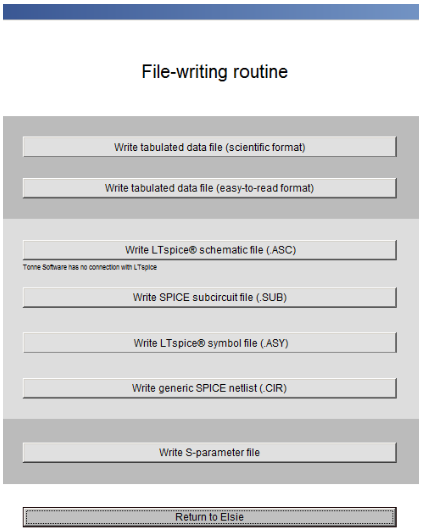


Here is the custom for a 50 ohm environment filter curve:

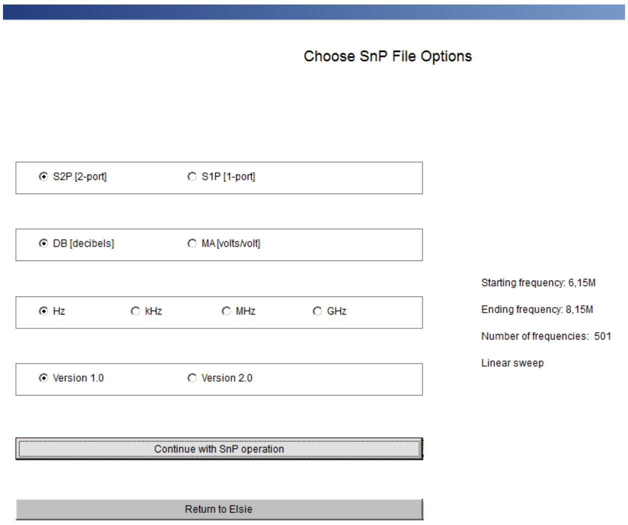




From the plot window out a S2P file can be written out. The S2P file can then be passed to the VNWA software and contains all the necessary RF information about our sample bandpass. Click the button "Write S_parameter file" and follow the Elsie program.



and then

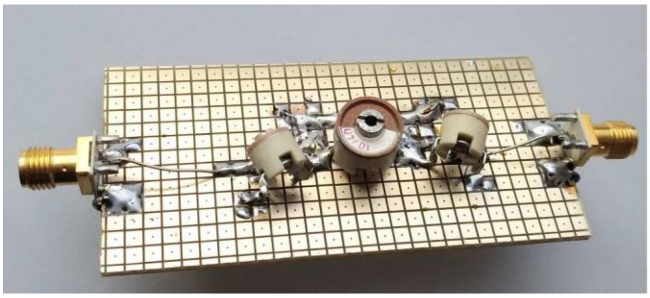


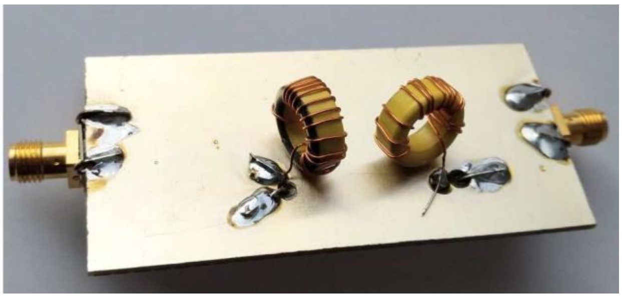
The S2P file can now be read with the VNWA software. (File - Import Data - S2P)

5.2 build filters and vote

The filter assembly of 2 or 3-pole bandpass filters is simple if one assesses the Kondenstoren accuracy of 1% and misses the inductors with the VNWA at the mesh frequency. By slight displacement of the windings on the toroidal core, the measured filter curve of the simulation can be adjusted (from Elsie program). If necessary, the coupling capacitors must be then adjusted slightly. This process starts with a little practice easily and quickly. The measured values for S11 and S21 can be found on the next page.

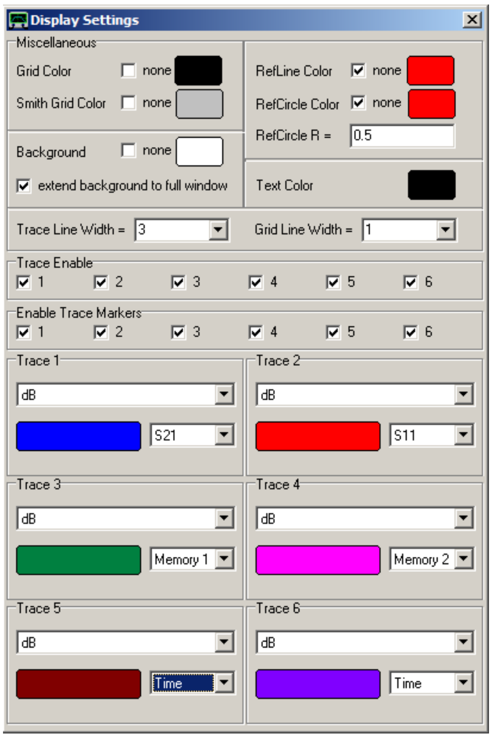
My example filter I've designed so that all series capacitors are provided with a trimmer, so that the adjustment can be practiced.

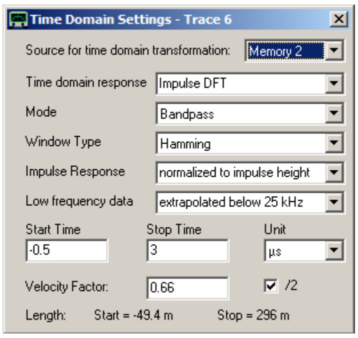


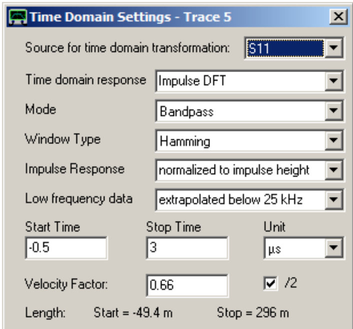


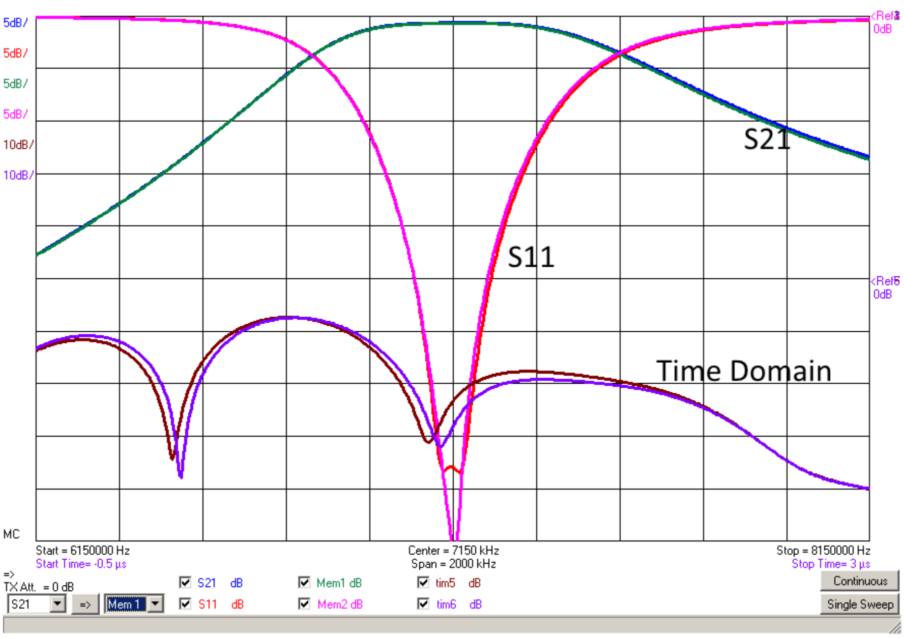
As a little exercise and as an addition I want to introduce another option at this point that can complement the intelligent and iterative try and speed. With the time-domain method can be measured over into an S11 measurement in the filter. It is so the influence of each individual filter element visible. Both methods of filter tuning complementary.

The following figures show the settings in the VNWA software. After setting the display settings you have to run to arrive at the time domain settings for the displayed curves 5 and 6 in VNWA main window using the mouse double-click "TIM5" and "tim6" (bottom).









The picture now shows the simulated and measured waveforms of the examined here bandpass. There are the S21, the S11 appears and the time domain curves. For this I have exactly matched my bandpass. the VNWA please help file can extract more information about the Time Domain measurements and adjustments of bandpass filters in the chapter "TUNING FILTERS IN TIME DOMAIN".

In the diagram, the predicted filter data are superimposed with the measurement curves.

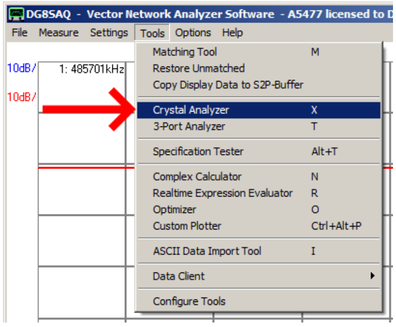
> VNWA-Help File:
> Tuning filter in Time Domain
>
> "Set the center frequency to the frequency resontant because the resonators must be coordinated. If you do not do that, then the BPF are tuned to the wrong frequency. Place the chip on the two to five times the bandwidth of the BPF. Put the mouse wheel Increments to 5 KHz. "

6 Quartz filters for VNWA workshop - work in progress -----

In this chapter I will describe as a 4-pole crystal filter is designed. starting the measurement of the crystals. Subsequently, the quartz filter is calculated and set up. everything is then measured with the VNWA and a virtual impedance matching performed by software.

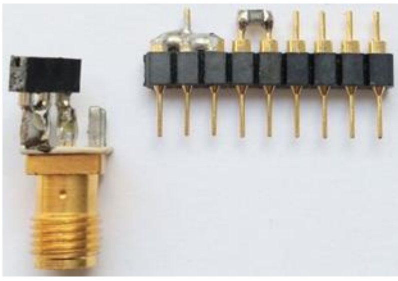
In a subsequent chapter, the RF simulation program QucsStudio is presented and the quartz filter simulated and the results compared with the real measurement result.

6.1 Crystals measured



I measure the 13 MHz crystals that have been delivered on VNWA Test Board Kit (see Workshop Notes Volume 1). The VNWA did your quartz tool with which the surrogate parameter of a crystal can be determined. You can find it under "Tools-Crystal Analyzer".

Just as in Chapter 4.1I described revert to self-created adapter with homemade Kalibrierelementen. Please make sure to read through the instructions in that Chapter.

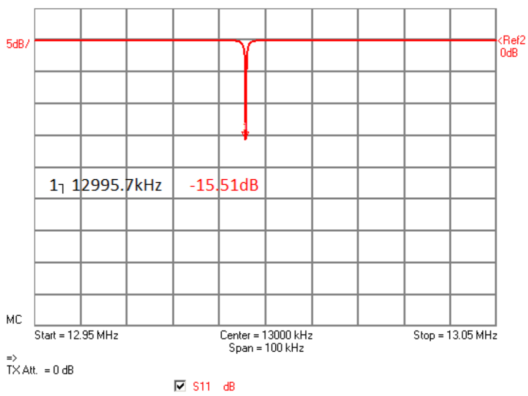


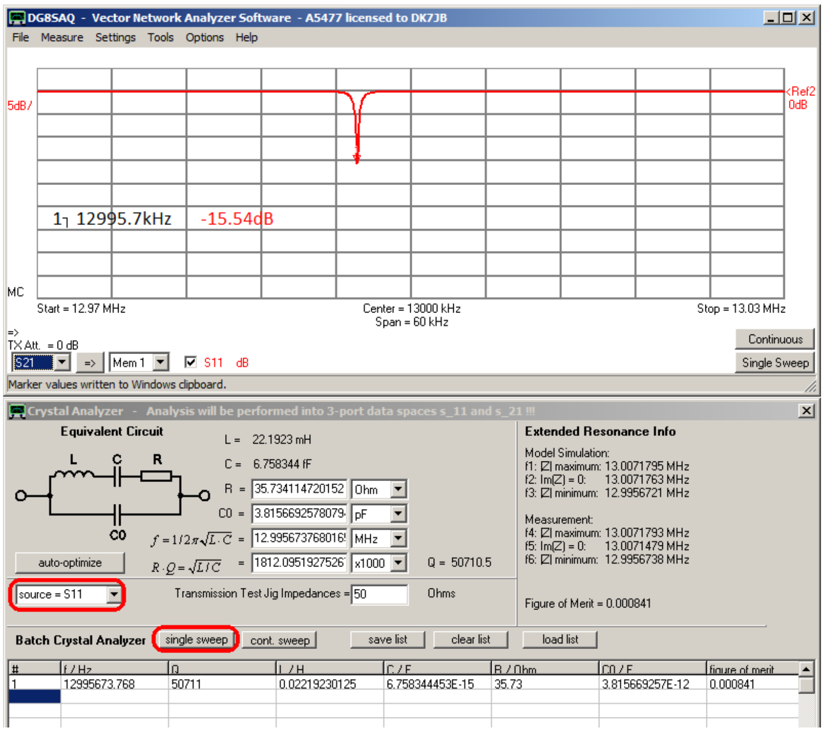
Crystals have legs that are slightly thinner than the twisted bushes of self-developed measuring adapter is often provided. The twisted sleeves and wear out quickly. If you want to measure crystals, you should create you such an adapter fresh.

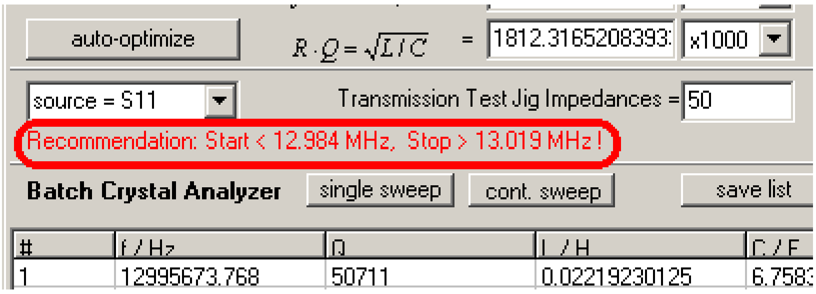
With a fresh calibration, I mean that you do not work with a master calibration and the calibration has been performed directly before the measurement.

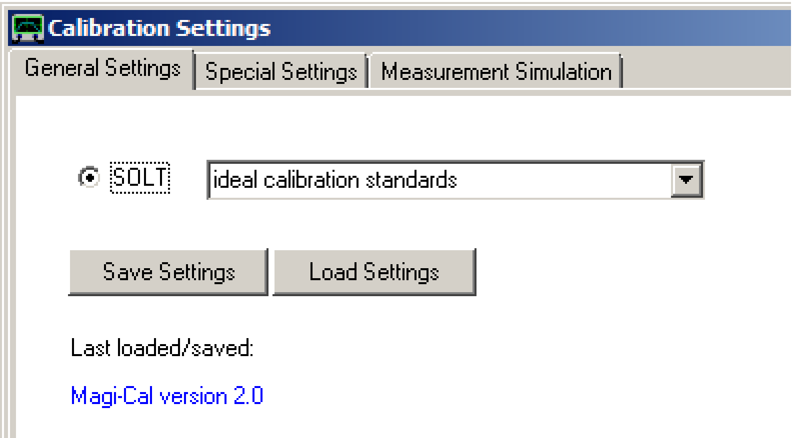
But now for the exact measurement procedure:

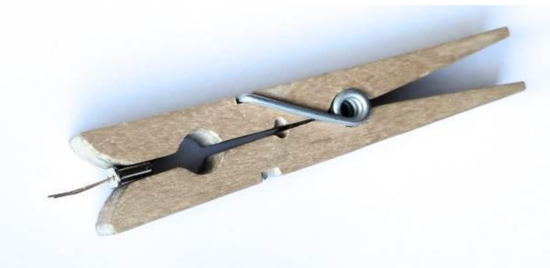
In the first step, the frequency range must be set. At this time, still working with the previous master calibration. As the center frequency, the frequency is entered, which is printed on the quartz. As tension we provide a 100 kHz.



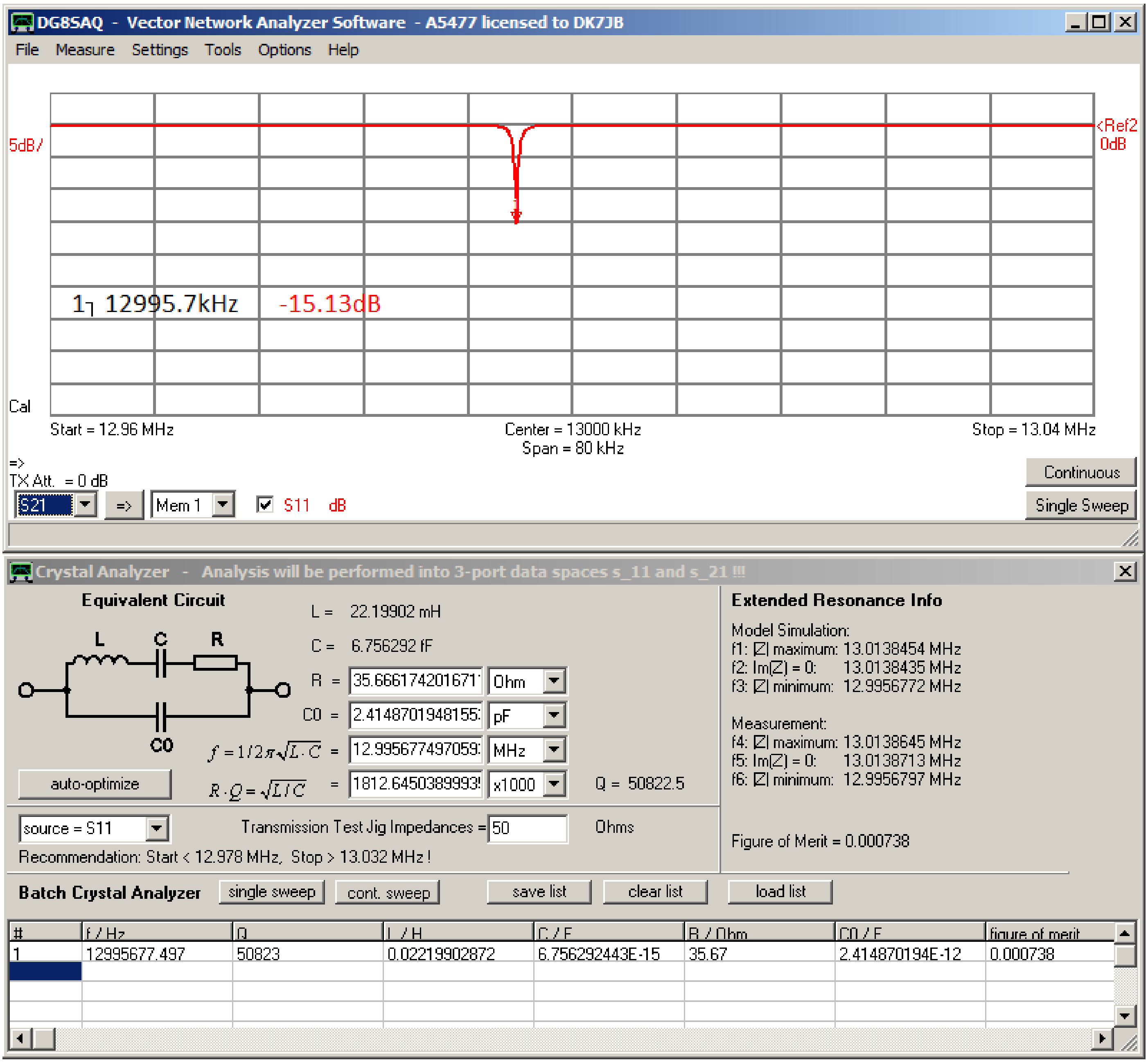

DG8SAQ - Vector Network Analyzer Software - A5477 licensed to DK7JB
File Measure Settings Tools Options Help
5dB /
<Ref2
0dB
1 12995.7kHz -15.54dB
MC
Start = 12.97 MHz
Center = 13000 kHz
Span = 60 kHz
Stop = 13.03 MHz
TX Att. = 0 dB
S21
Mem 1
S11 dB
Continuous
Single Sweep
Marker values written to Windows clipboard.
Crystal Analyzer - Analysis will be performed into 3-port data spaces s_11 and s_21 !!!
Equivalent Circuit
L C R
C0
L = 22.1923 mH
C = 6.758344 fF
R = 35.734114720152 Ohm
C0 = 3.8156692578079 pF
12.995673768016 MHz
1812.0951927526 x1000
Q = 50710.5
auto-optimize
source = S11
Transmission Test Jig Impedances = 50 Ohms
Extended Resonance Info
Model Simulation:
f1: maximum: 13.0071795 MHz
f2: Im[Z] = 0: 13.0071763 MHz
f3: minimum: 12.9956721 MHz
Measurement:
f4: maximum: 13.0071793 MHz
f5: Im[Z] = 0: 13.0071479 MHz
f6: minimum: 12.9956738 MHz
Figure of Merit = 0.000841
Batch Crystal Analyzer
single sweep
cont. sweep
save list
clear list
load list
f / Hz Q L / H C / F R / Ohm C0 / F figure of merit
1 12995673.768 50711 0.02219230125 6.758344453E-15 35.73 3.815669257E-12 0.000841


auto-optimize
= 1812.3165208393 x1000
source = S11
Transmission Test Jig Impedances = 50
Recommendation: Start < 12.984 MHz, Stop > 13.019 MHz !
Batch Crystal Analyzer
single sweep
cont. sweep
save list
f / Hz Q L / H C / F
1 12995673.768 50711 0.02219230125 6.7583


Calibration Settings
General Settings
Special Settings
Measurement Simulation
SOLT
ideal calibration standards
Save Settings
Load Settings
Last loaded/saved:
Magi-Cal version 2.0



Finished measurement quartz number 1



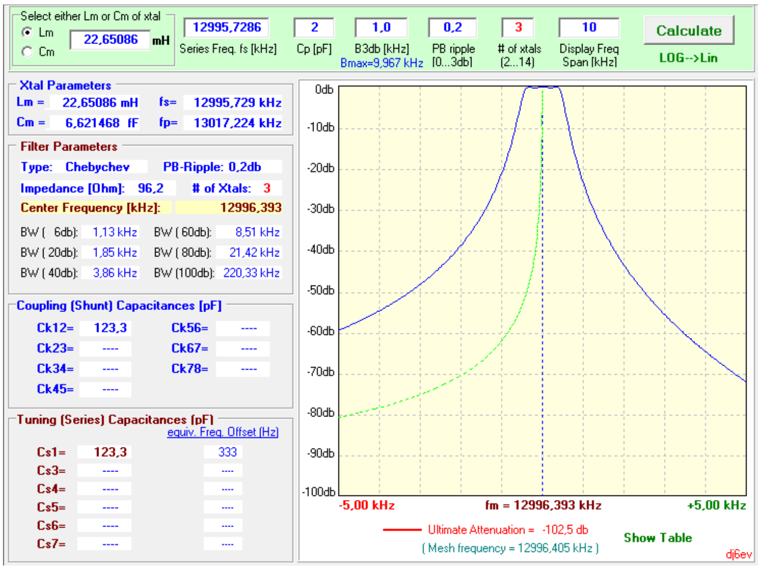
is first

2,48pF Tonghui Electronics TH2821A LCR Meter

#	f / Hz	Q	L / H	C / F	R / Ohm	C0 / F	figure of meri
1	12995664,3	52332	0,02225448	6,74E-15	34,72	2,08E-12	0,000491
2	12995827,7	75316	0,02302515	6,51E-15	24,96	1,96E-12	0,00177
3	12995753,8	74671	0,02283838	6,57E-15	24,97	1,86E-12	0,00445
4	12995771,6	66362	0,02287513	6,56E-15	28,15	1,96E-12	0,00325
5	12995728,6	69814	0,02265086	6,62E-15	26,49	2,10E-12	0,00131

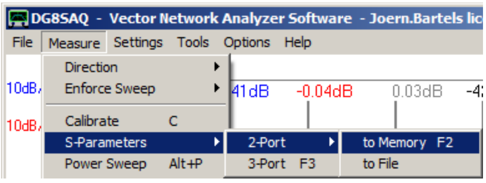
outlook

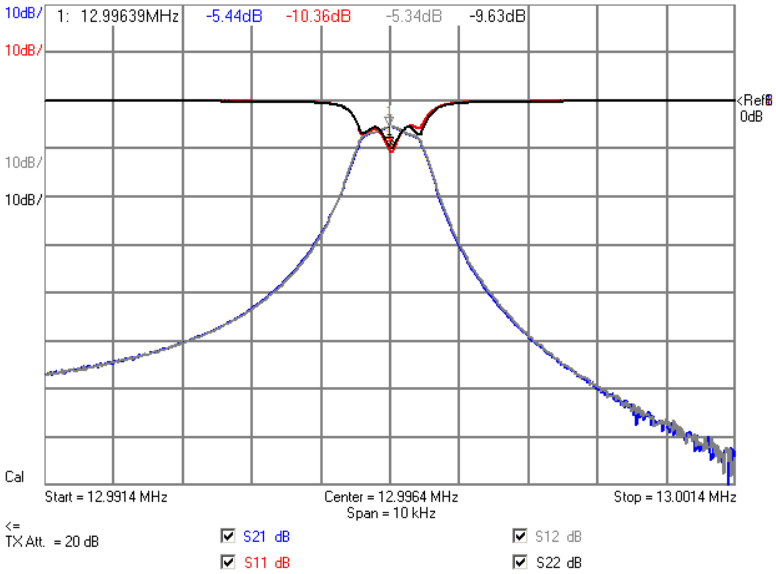
6.2 calculate quartz filter



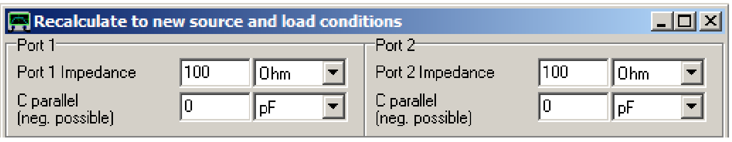
6.3 build crystal filter

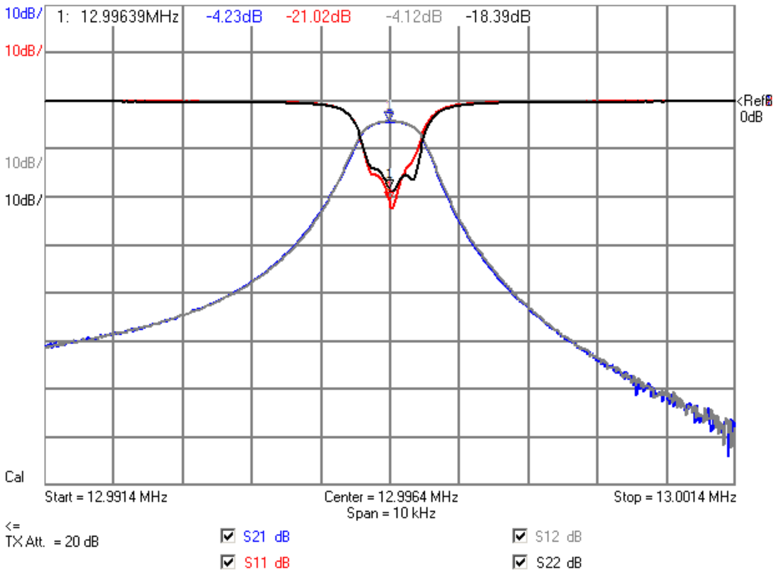
6.4 Measurement results (in 50 ohm environment)



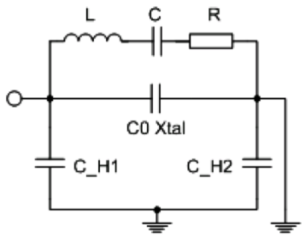


6.5 Measurement results with virtual impedance matching

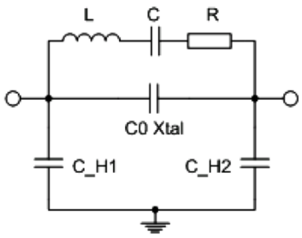




More information



Reflection (S11)



Transmission (S21)

7 Introduction to the RF circuit simulation with the example of a quartz filter QucsStudio

The RF simulation program used in the industry, are very expensive. Therefore, it is very gratifying that many years ago a software group has begun around Michael DD6UM to write such a program itself. Started the project under the name Software Qucs has. After a few years, the group Qucs and QucsStudio has disconnected and there are two projects emerged. In this chapter I describe the free program QucsStudio. Further background can be found in the tutorial by Gunthard Kraus, who also wrote a great tutorial for getting started with QucsStudio:
http://www.gunthard-kraus.de/qucsstudio/index_qucsstudio.html

In this chapter I describe how a quartz filter is simulated. The quartz filters from Chapter6 serves as example.The circuit consists of two parts, the actual circuit and a sub-circuit having the equivalent circuit of the quartz as Sub-Circuit.Am end of the chapter will be discussed possibilities of optimization of RF circuits, as well as the export of s2p files.

7.1 install and set QucsStudio

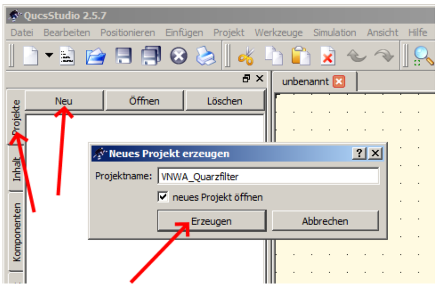
The software can be found on the homepage of Michael DD6UM: http://dd6um.darc.de/QucsStudio/index.html
Just download and install it.

Special setting: Open QucsStudio with parameters

I install my Ham program always in a separate folder outside the C partition and my project files in the cloud, so I can access two remotely. Should this be of interest to you, you must locate the installation folder and locate the file manager the file "qucs.exe". From this file you created then a link that can be copied to the desktop. Right-click the "Properties" must then be selected. more parameters under "Target" then the program path also be added:
[Program Path] - [path for the project folder]
D: \ Program Files \ QucsStudio-2.5.7 \ QucsStudio \ bin \ qucs.exe C: \ Users \ Joern \ Dropbox \ QucsStudio \ Projects
First, the program path and then behind a minus of the path comes to project files.

7.2 Open project

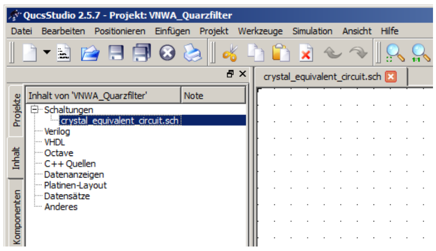
After the QucsStudio program has started a new project called "VNWA crystal filter" will be opened.

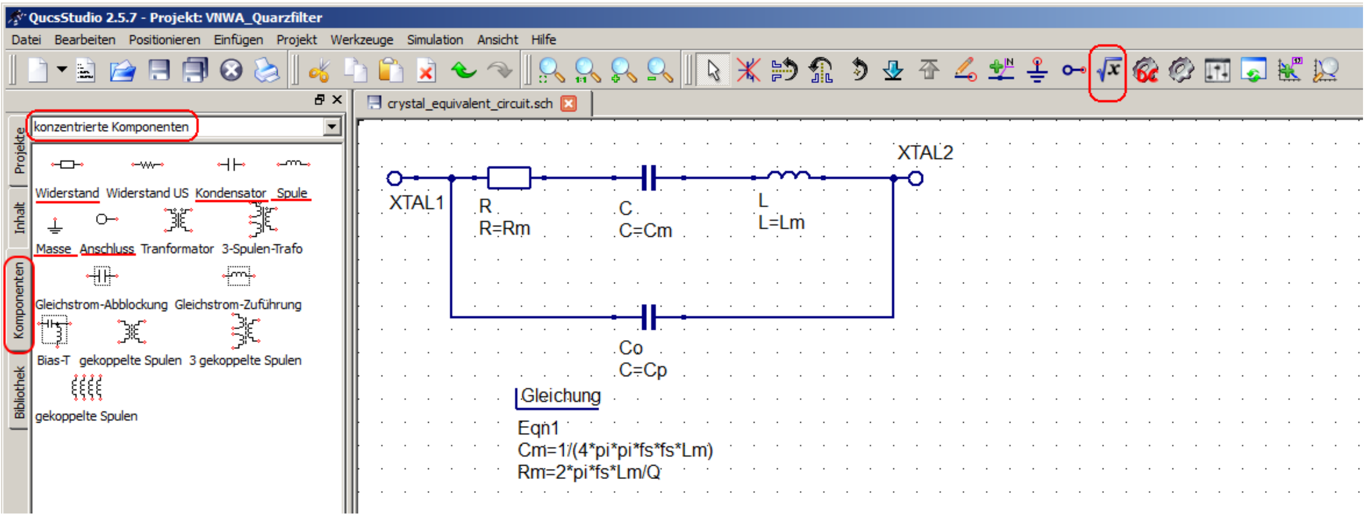


7.3 Create sub-circuit with quartz diagram

First we need to create a component for a real crystal by creating a sub-diagram, in which we, the parameters of our quartz measurements from Chapter 6 can enter.

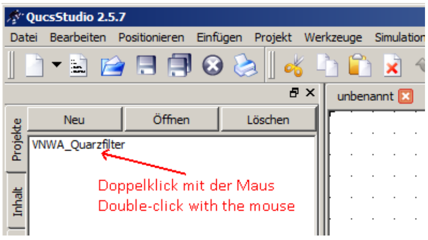
With File New A new circuit diagram is opened and saved under "crystal_equivalent_circuit". Then the equivalent circuit diagram of the quartz is drawn, please just like in the picture. To help some controls of the program are highlighted.



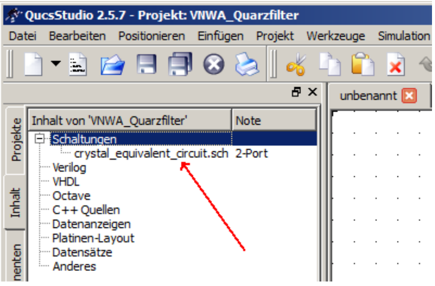


With the right mouse button, the properties can be adjusted. Then everything is stored.

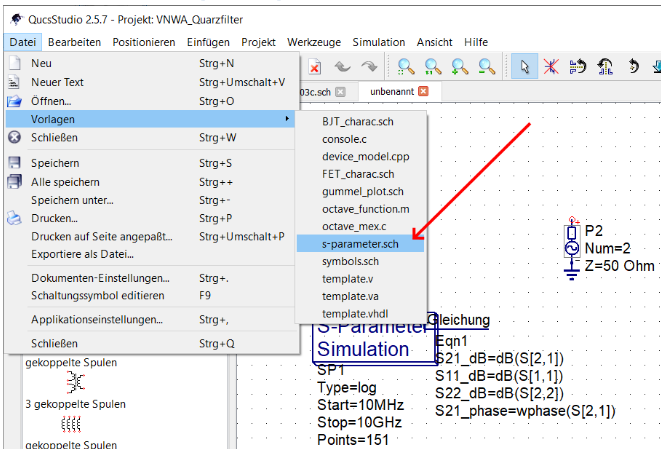
You can check if everything was done correctly, by restarting the program and the project on the right tab opens with projects and double-clicking the mouse on the project name.



Now the rider would have to "content" as open in the image.

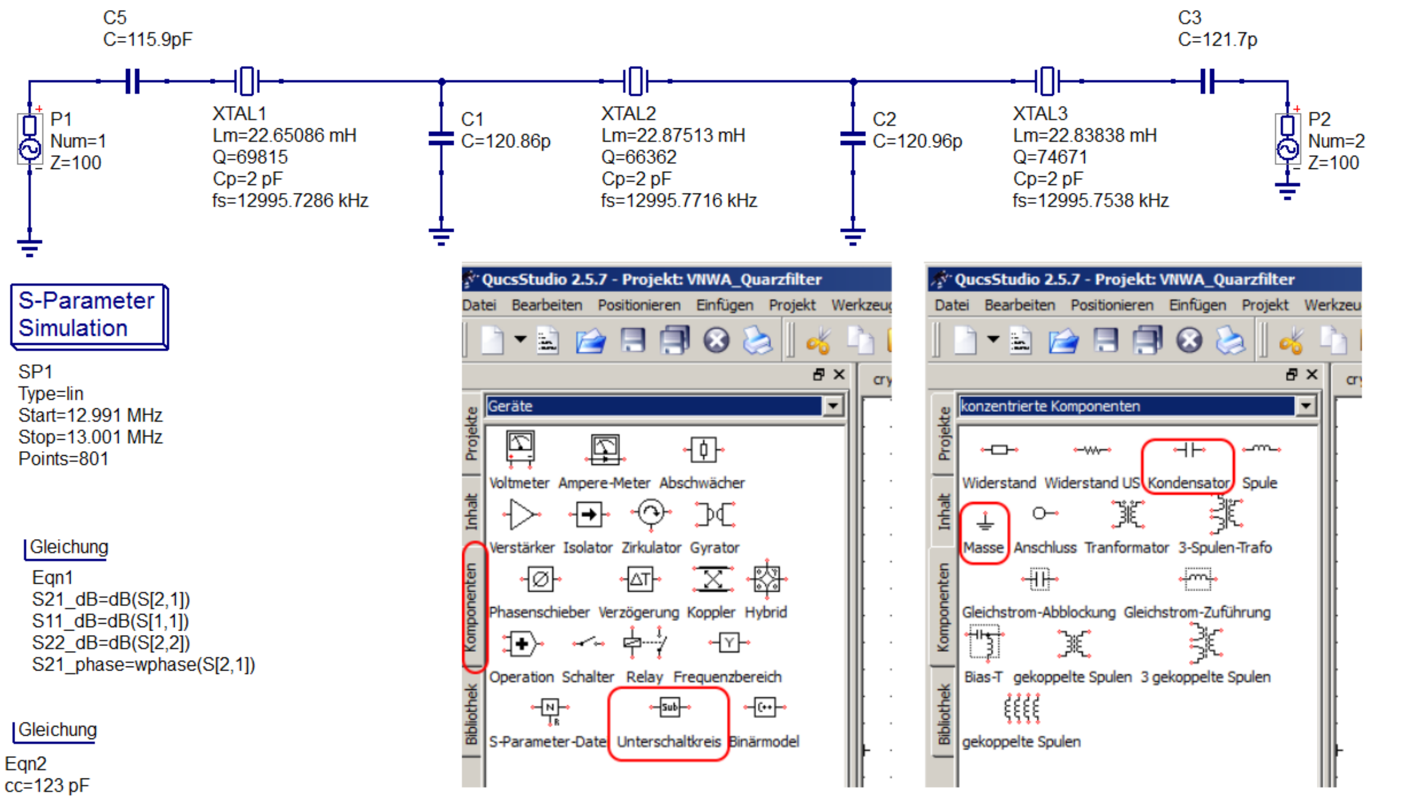


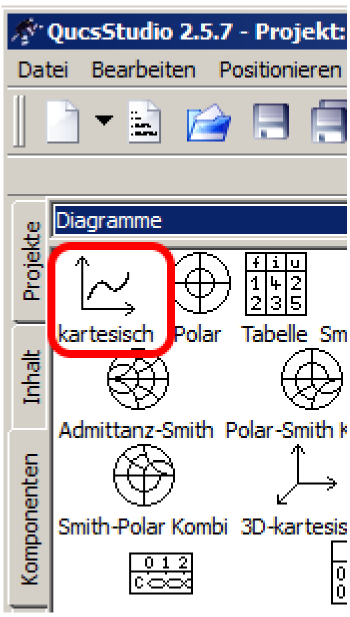
7.4 drawing diagram



we start the circuit diagram with the template "template's parameter.sch" and save the document newly opened in "quarzfilter_3polig.sch" from.

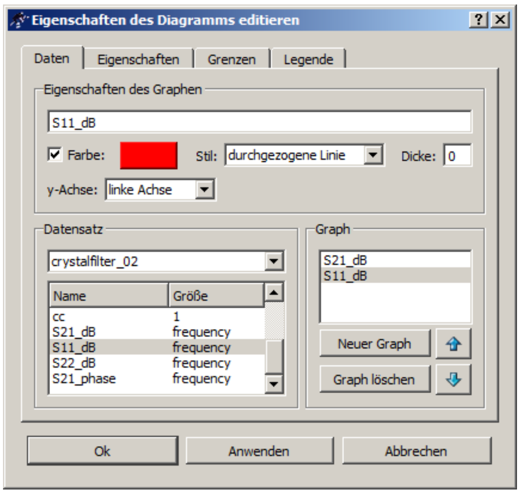
The circuit diagram can now be drawn. The following figure shows the Crystals and capacitors used by me. In the picture I showed excerpts from the program so that the search for the components and subcircuits easier.



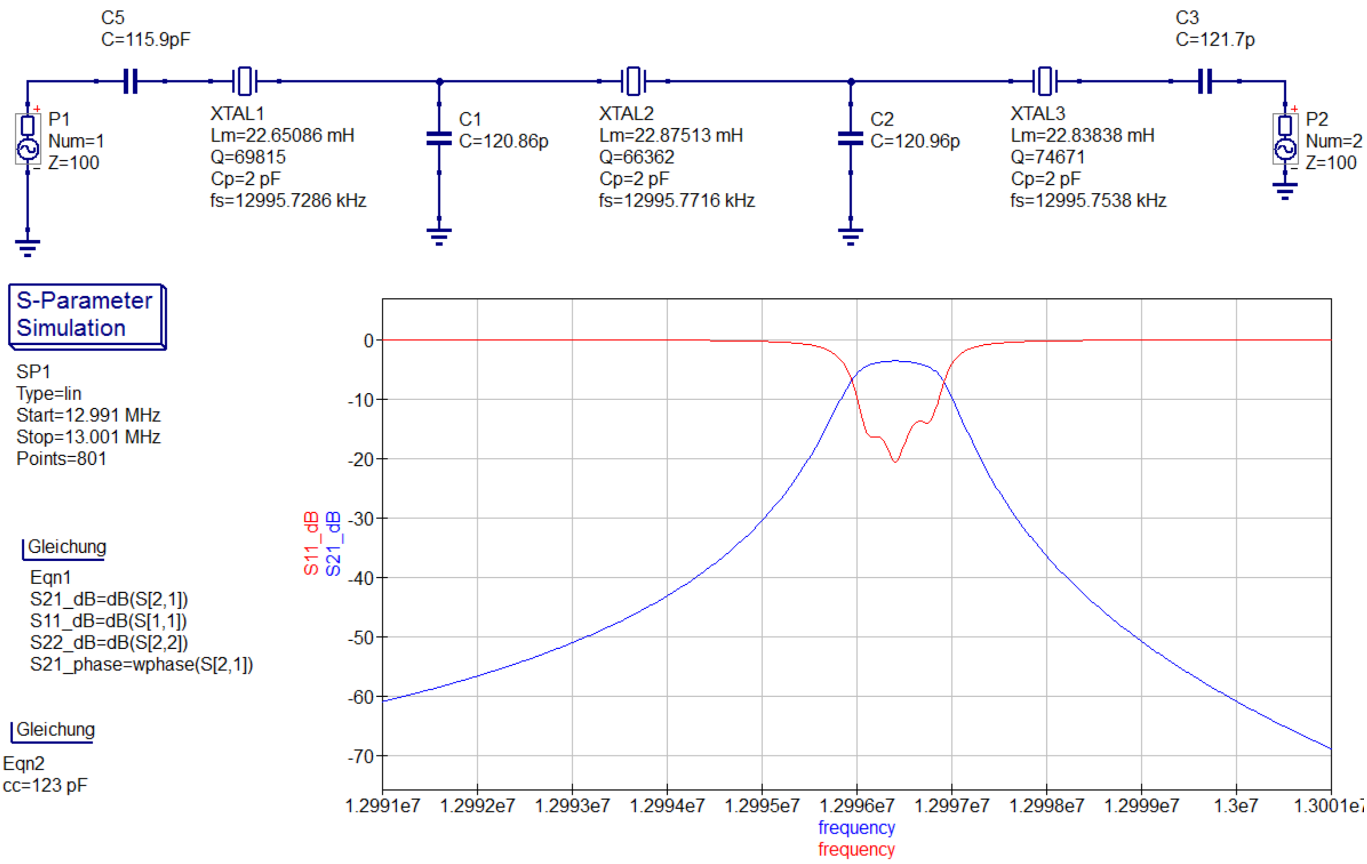


Now please save everything. Now, only the output is missing as S-parameter diagram. Graphics output as shown in the picture to find "components Diagrams" tab. Please pull into the diagram window.

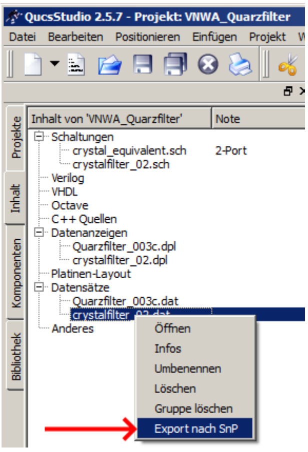
It automatically opens another sub-window setting options. the graphs S21_dB and S11_db must be inserted. Also possible is the input dB (S [1,1]) and dB (S [2,1])



Now the simulation has to look exactly like the following picture.

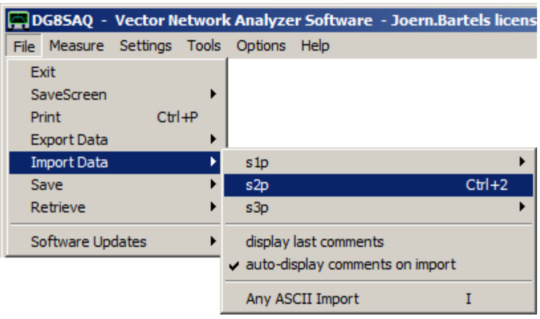


7.5 export graphs from QucsStudio and import them into the software VNWA



After a successful simulation, the S2P parameter file can be exported very easily. Unfortunately, this is not intuitive. The picture shows the hidden export function that can only be seen by right-clicking the mouse on the corresponding record. This will open a new dialog, which must be followed easily.

On VNWA the S2P file can now be read.



Shall simulation data are imported into the VNWA software, I recommend the following procedure. First, the simulation S2P data is imported into the VNWA software and copied to Plot1 to Plot4. the measurement of the real quartz filter is then performed with subsequent port matching subsequently.

8 Filter design with Excel sheet by Horst dj6ev ---- work in progress -----

Horst dj6ev wrote an Excel sheet, which allows you to create very simple three- or four-pole bandpass filters. Explanations can be found here:
http://www.bartelsos.de/dk7jb.php/bandpaesse-horst-dj6ev

Although this method has proven successful for me, it will not be described here. Follows please just the link.

In the craft diary to my DIY project TRX2012 you will find many additional information and examples in the field of band-pass filters:

http://www.bartelsos.de/dk7jb.php/selbstbau-trx-2012

9 Links ----- ----- work in progress

On my homepage (DK7JB) you can find many more examples and links: www.bartelsos.de

For example: http://www.bartelsos.de/dk7jb.php/links-zum-vnwa

Orhttp://www.bartelsos.de/dk7jb.php/projekte/quarzfilter-und-bandfilter/

10 What is still missing? ----- work in progress -----

LCR meter

Banpassfilter: Pre3 and Mesh3

~~Baluns: alternative methods of measurement / comparison + more baluns measured not want☹~~

Check calibration with T-check

If there are problems: see book by Gerfried

S-Parameter Test Set

& Condenser coil with the equivalent circuit diagram, L-curve, power curve, Optimize, LCR meter self-resonant

Insertion of a matching messenmit the matching tool

Matching Tool see 383