NanoVNA V2+/+4
PC Interface
INSTALLATION and USERS MANUAL
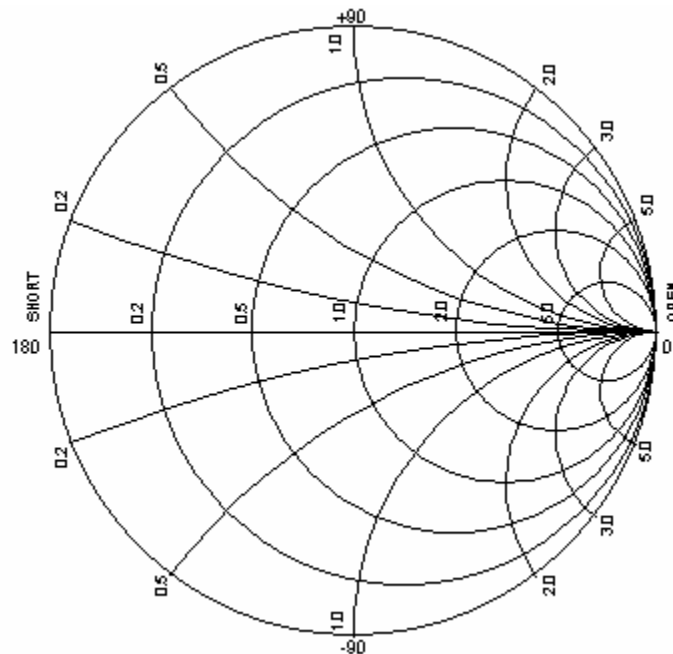
Revision Level: 0.05
December 4, 2020

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1. Documentation Update Log

Page Nos.	Amendment	Rev	Date
All	Draft	0.04	December 5, 2020
All	Add crystal measurements and segmented sweeps	0.05	December 6, 2020

2. Trademarks

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3. Scope

This software is loosely based on a program I had written for my HP8754A, which still requires a copy of Windows XP to run. After receiving the original NanoVNA, I rewrote the software to support it along with Windows 10. It was then used as a basis for my other vintage VNAs. The real benefit is that the software has the same look and feel for all of my analyzers and it allows me to automate various experiments.

Upon receiving the V2+ and being unsuccessful with the standard software supplied with it, it made sense to support it as well. I have no need to support multiple analyzers with one software package. However, there are features that the software supports that the V2+ is lacking. Namely, any narrow band work.

This software supports measuring and sorting your collection of crystals to design your next filter, the V2+ just isn't up to the task. I had hoped that the new V2+ would out perform my original NanoVNA in every way but it's not the case.

There are a few undocumented differences between the V2+ and V2+4 that were discovered during the development of this software. The primary difference has been that the V2+ appears to lockup during long data collections and requires being power cycled to recover. This hasn't been seen with the V2+4.   In this document, I will refer to both the NanoVNA Version 2 Plus and Version 2 Plus 4 as the V2+.   As far as the software is concerned, the products are the same.

The author is not an amateur radio or citizens band operator. Because the software was written for my own personal use, there are many features that may be lacking or have not been completed. This is most likely due to my lack of having a use for them. Some parts of the software may be doing something totally different than what a typical user may expect. I change the software often depending on the tests I am trying to run.

This software can be viewed as an engineering tool at best. Its primary use was to extend the author's understanding of V2+. It was never intended to be used as a general tool for radio hobbyist to tune their antennas. The software is fairly buggy and not very robust. Even under normal conditions, expect to run into several problems if attempting to use this software. It's a very poor choice for the beginner.

This manual assumes the reader is PC literate and has some basic understanding of how a VNA works. It is not a learner's guide on using a VNA and offers no assistance into solving basic computer related problems.

The software is continually being developed. You may find some screen shots and features change throughout this document as a result.

4. Applicable Documents

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed.

NUMBER	TITLE/AUTHOR
1EZ43_0E	T-Check Accuracy Test for Vector Network Analyzers using a Tee-junction / Rohde&Schwarz
	Measurement of Electronic Component Impedance Using A Vector Network Analyzer / Copper Mountain Technologies

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5. Definition of Terms and Acronyms

Acronym	Definition
HPAK	Hewlett Packard Agilent Keysight
PCB	Printed Circuit Board
SOLT	Short Open Load

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6. Feature Summery

The following features are supported

- Generic control of add on transfer relays
- Support for external up/down conversion
- Support linear stage
- Uses common standard coefficients

7. Installation

Depending on what features you want to use and what other peripherals are attached to your NanoVNA V2+, you may need to install additional drivers.   The software will include an installer which contains the runtime engine.

7.1 Before you begin

The software supports the V2+ and +4 NanoVNAs only
Written in LabView 2011
Requires LabView 2011 runtime engine
Tested with Windows 10

You will want to have all the drivers installed and make sure your PC is seeing the device before getting started. The software was tested using both the recommended Cypress as well as MicroSoft's included drivers. No differences in their performance was noted.

USB Serial Port (COM5)

Driver Provider:	Cypress
Driver Date:	10/13/2015
Driver Version:	3.13.0.59
Digital Signer:	Microsoft Windows Hardware Compatibility Publisher

8. Button Quick Reference

The software contains quick tips. Hover the mouse over the button to see a description.

9. Getting Started

For some of this section, we will be using a low cost set of attenuators available from various sources.
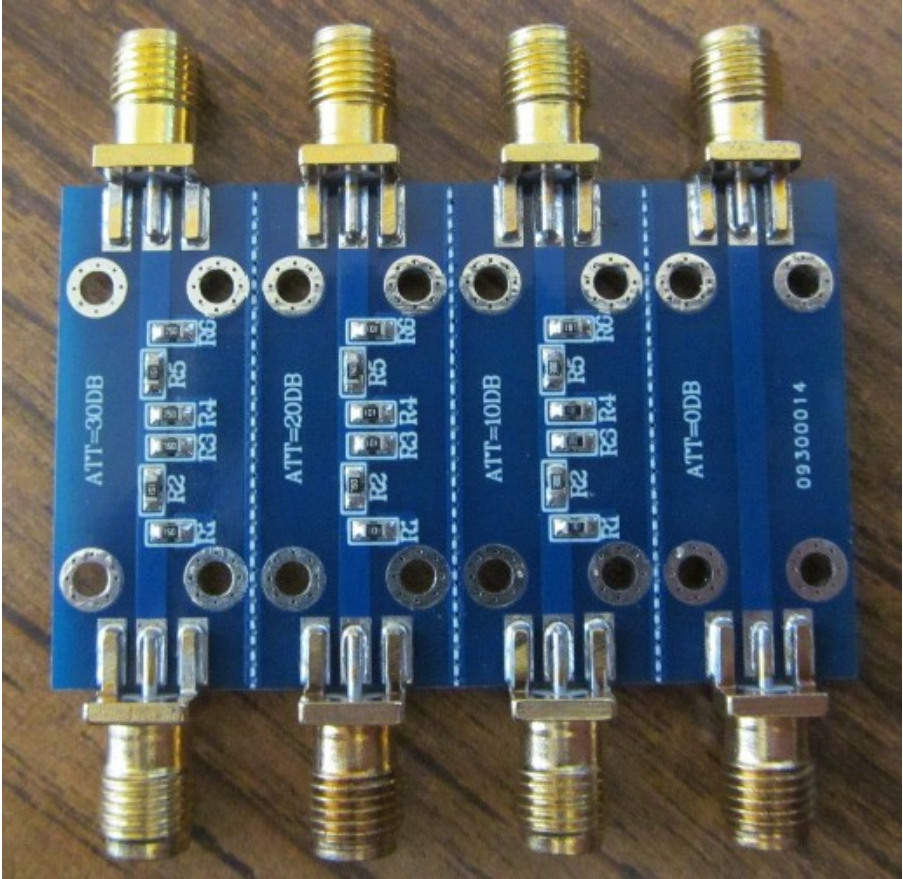
Features:
1.Special usage: This is a DC 4.0GHz RF Radio Frequency Fixed Attenuator.
2.The board layout is reasonable: beautiful, little current sound.
3.Uses the high quality material: stable and reliable performance.
4.Portable design: easy to install.
5.Good quality:durable to use.

Descriptions:
1.The is a DC 4.0GHz RF Radio Frequency Fixed Attenuator Maximum power 23dBm SMA Double Female Head 0dB 10dB 20dB 30dB.
2.Compact design, easy to install.

Specifications:
Color:Green
Frequency range: DC-4.0GHz
Maximum power: 23dBm (200mW)
Standing wave ratio: 1.20
System impedance: 50
RF : SMA double female head (Outer screw inner hole)
Attenuation:

Direct: 0dB (reference)
Level 1: 10 0.8 dB
Level 2: 20 1.1 dB
Level 3: 30 1.5dB

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9.1 Software Defaults

When starting the software, it will prompt you for a file that contains the default settings.
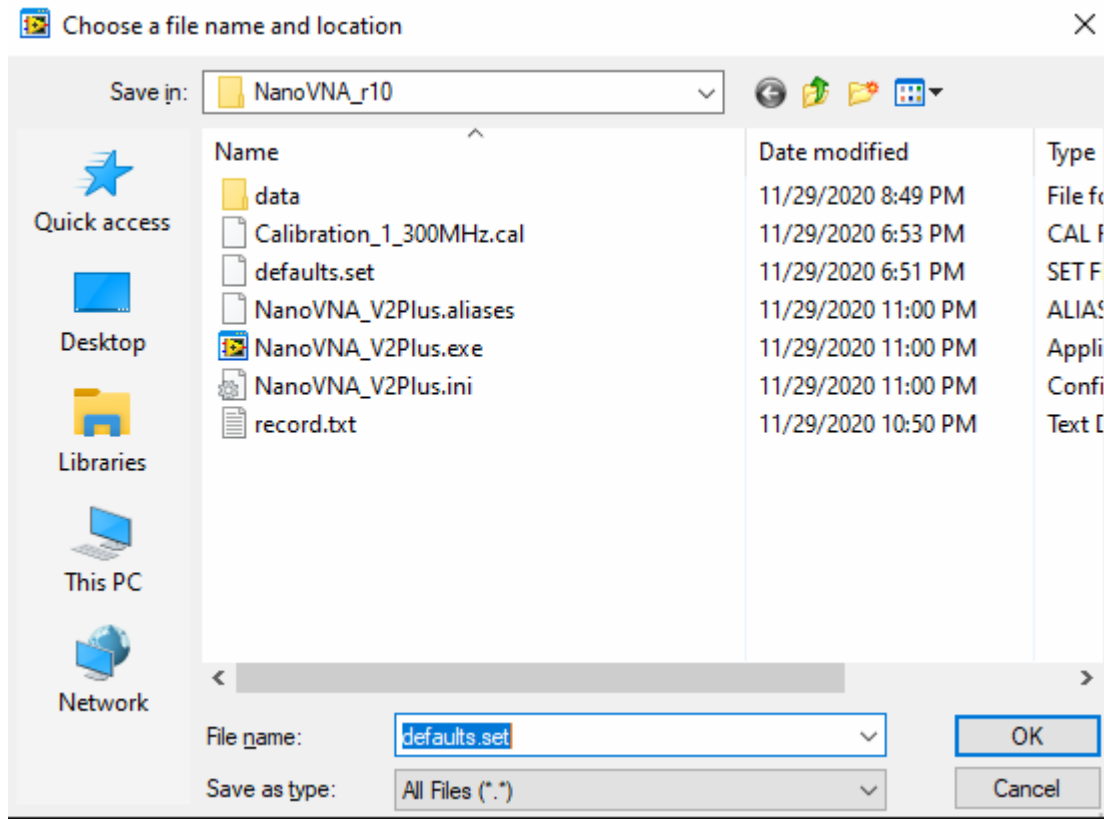
This file is not ASCII readable. It contains information about serial port settings, units, calibration standards and what peripherals are available. If you don't have a default setup, just select cancel and the software will load with its default values.

Once the software has loaded you will be presented with the main menu. At this time, the software has not made any attempt to connect to the V2+ or any of the peripherals. If you do not yet have a properly configured, default file, you will need to create one before attempting to do anything else with the software.

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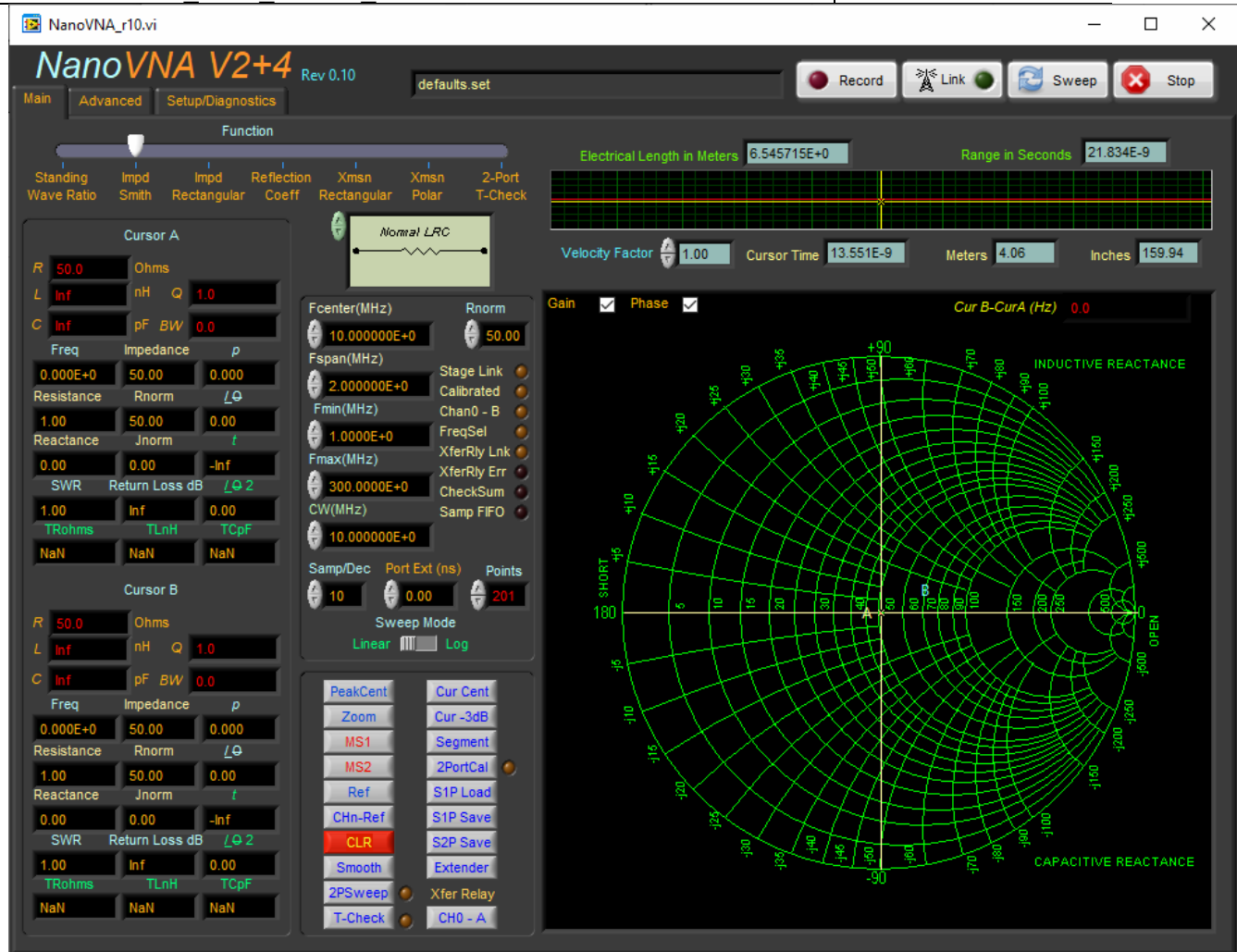
9.2 Selecting the Communication Port

You will now need to setup the software. Start by selecting the Setup/Diagnostics tab.

In the upper right, select the communications port for the V2+. The BAUD rate for this device will have no effect on the transaction rates and can be ignored.

9.3 Selecting Calibration Standards

A quick word on the calibration standards. If you are familiar with HP, Agilent and Keysight (HPAK) analyzers, you may find the format familiar. This is by design. At this time the Loss coefficients for all of the standards is being ignored. The Load and Thru's delay are also ignored. There is also a port extension setting on the main page.

For the calibration standards, I suggest leaving the custom ideal standard selected. If you have characterized your standards against a known set, you may enter the data into the calibration standards tables.

You may create a new standard of modify an existing set. You may add as many standards as you like. Scroll through the available standards with the up/down arrows. The set currently displayed is the one being used. You can also copy/paste/insert and delete standards. This entire database of standards is stored into the default file.

The V2+ was designed to work above 3GHz but it seems to have a fair amount of leakage (or cross coupling) between ports 1&2. Using the leakage terms can introduce noise into the reading and is normally ignored. However, it seems that without accounting for these terms with the V2+, the errors above 3GHz make the unit useless. You may manually enable these by selecting Leakage Terms. This setting is stored into the default file.

Once you have everything the way you like it, just select the SaveSetup and the software will prompt you for a file name. Use the default and select OK.

Keep in mind that you can change all of the settings at any time. You do not have to save them in order for them to take effect.

9.4 Linking to the Device

With the proper serial ports selected and known working, return to the main page and select Link. If the software locates the V2+, the link LED will turn green and information about the VNA will be displayed in the status bar (top center of screen).

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The Nano will display USB MODE. There is absolutely no use for the display when using the V2+ with the PC. As a matter of fact, I have performed tests with the LCD completely removed, using only the main PCB.
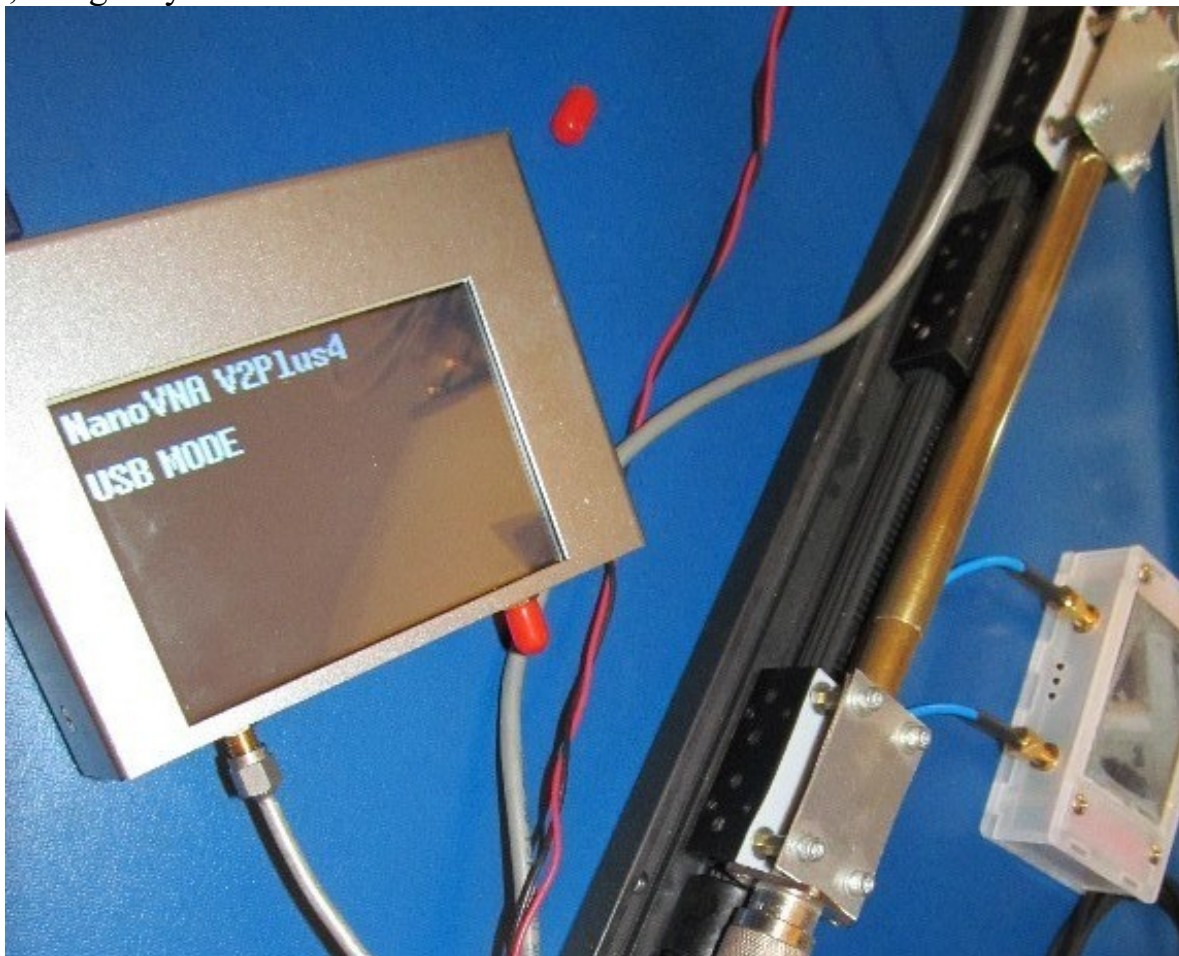
9.5 Displaying Data

The software will default to a center frequency of 10MHz with a 2MHz span and 201 data points. The V2+ was programmed with these defaults when the connection was made. The V2+ is actually sweeping at this time. Select the Sweep button and the software will begin collecting data from the V2+.

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9.6 Normalization Example

In the following graph, a 10dB attenuator had been attached between Port 1&2. We can see that S11 is showing very close to 50ohm without performing any calibration.
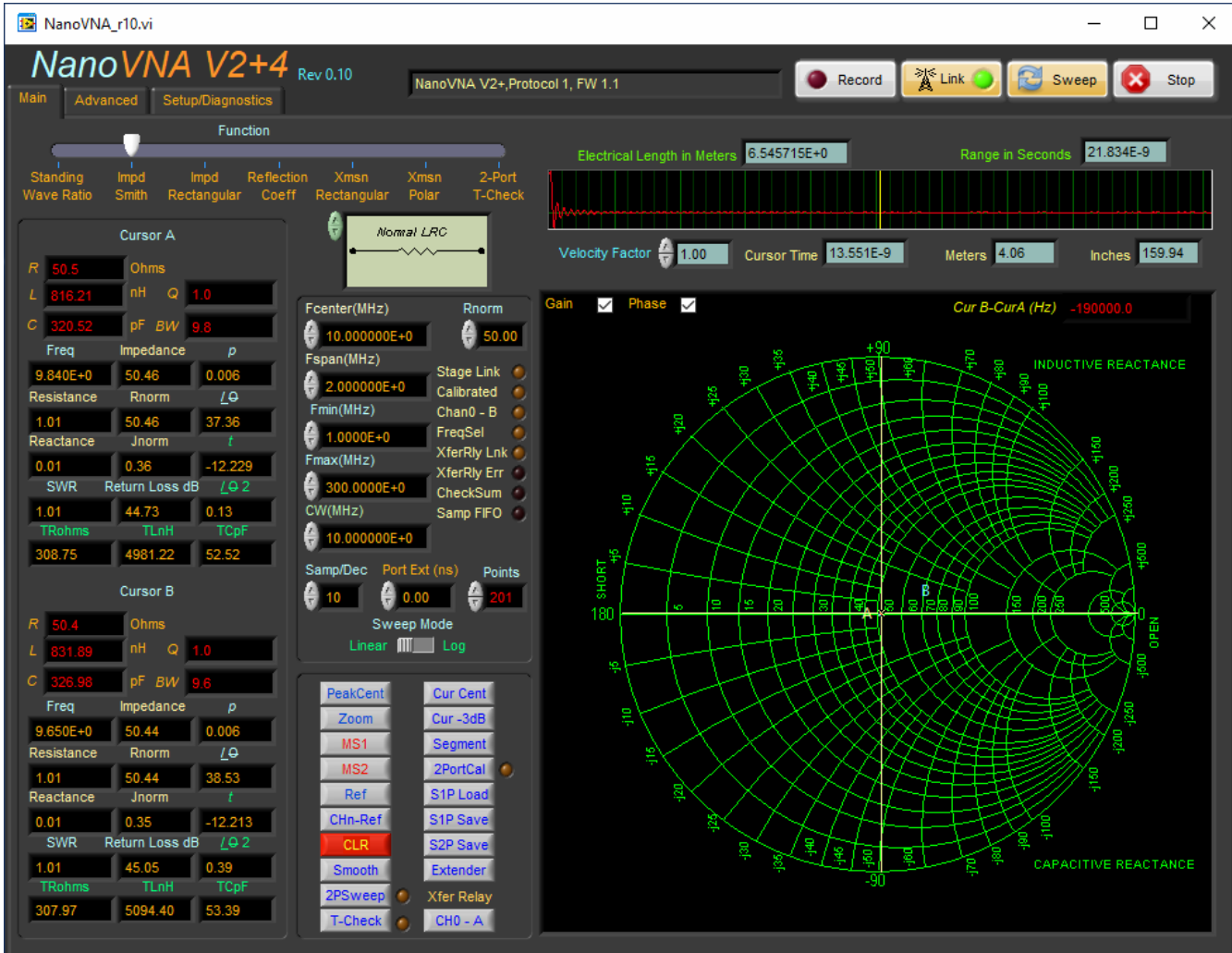
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Select the transmission function Xmsn Rectangular.   Notice that the 10dB attenuator is reading a couple of dB lower than expected.   We can get a better idea of what this attenuator looks like without performing a full calibration or selecting any standards by normalizing the data.

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The first thing to do is replace the attenuator with a thru.   This would normally be 0dB but as shown, the measurement is roughly 2dB lower than expected.

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Select the Ref button which will temporarily store the swept data as a reference. Next select the CHn-Ref. This will cause the software to use this reference to normalize all further readings to zero. With the thru still inserted, the software now displays very close to 0dB +/-0.02dB.

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Reinserting the 10dB attenuator, we can now see the software displays very close to 10dB across the entire swept range.

As was mentioned earlier, the V2+ exhibits a fair amount of cross talk and normalization may not always yield good results.   To demonstrate this, start by changing the stop frequency Fmax(MHz) to 4000. This will set the upper sweep range to 4GHz. Next change the start frequency Fmin(MHz) to 2500 or 2.5GHz. Next, deselect the Phase checkbox in the upper left corner of the graph.   Now deselect the CHn-Ref to turn off the normalization and reinstall the thru.

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As we can see rather than 0dB, the V2+ is displaying from -3 to -9dB.   The waveform should be very stable.

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As before, go ahead and select the Ref followed by CHn-Ref to once again normalize the data. As shown, the data is now within +/-0.1dB over the entire 1.5GHz range.

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Go ahead and install the 30dB attenuator section. You may notice that the V2+ displays something other than 30dB. My setup is anywhere from -28 to -24dB.

Just how much of that error is from the low cost attenuator? Let's consider the cost of this set was in the order of $5. The author has some better components so, let's go ahead and install an 18GHz, 30dB attenuator from Midwest Microwave.

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The data for this part looks much better. We can see once we get above 3GHz, the error is greatly increased.

If we were to continue to sweep even higher to say 4.4GHz, this error would continue to increase. Likewise if we were to use a 40dB attenuator the errors would increase.

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Shown below, the thru was reinstalled and the VNA was programmed to sweep from 2.5 to 4.4GHz. A new reference was then stored. The thru was then replaced with an 18GHz, 40dB attenuator from Midwest Microwave.

Is the attenuator really this poor, or is it the V2+? Midwest isn't known for making poor products and we would expect better performance from the V2+. So what's going on? As mentioned, normalization may not always work very well.

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9.7 The V2+ SOLT Standards

It's time to try and calibrate the V2+. I purchased both the V2 Plus and the V2 Plus 4 with cables and standards. There are a few problems with these. The short's center conductor is locked and will turn as the nut is tightened. The thru standard doesn't have a flat. There is no way to hold it securely with your ignition wrench while you torque it.

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The bigger problem is the return loss of the load is not very good. The following compares the load supplied with my original Nano against the two included with my V2+ VNAs, along with two Mini-Circuits ANNE-50+ terminators. Also shown as a reference, the Keysight 85033 standard load. (No standards were harmed during these measurements!!)

We can see the loads supplied with both my V2+ VNAs have very similar performance and offer a much improved return loss over the standard supplied with my original Nano. However when we compare these with the Mini-Circuits ANNE's, they are not as good.
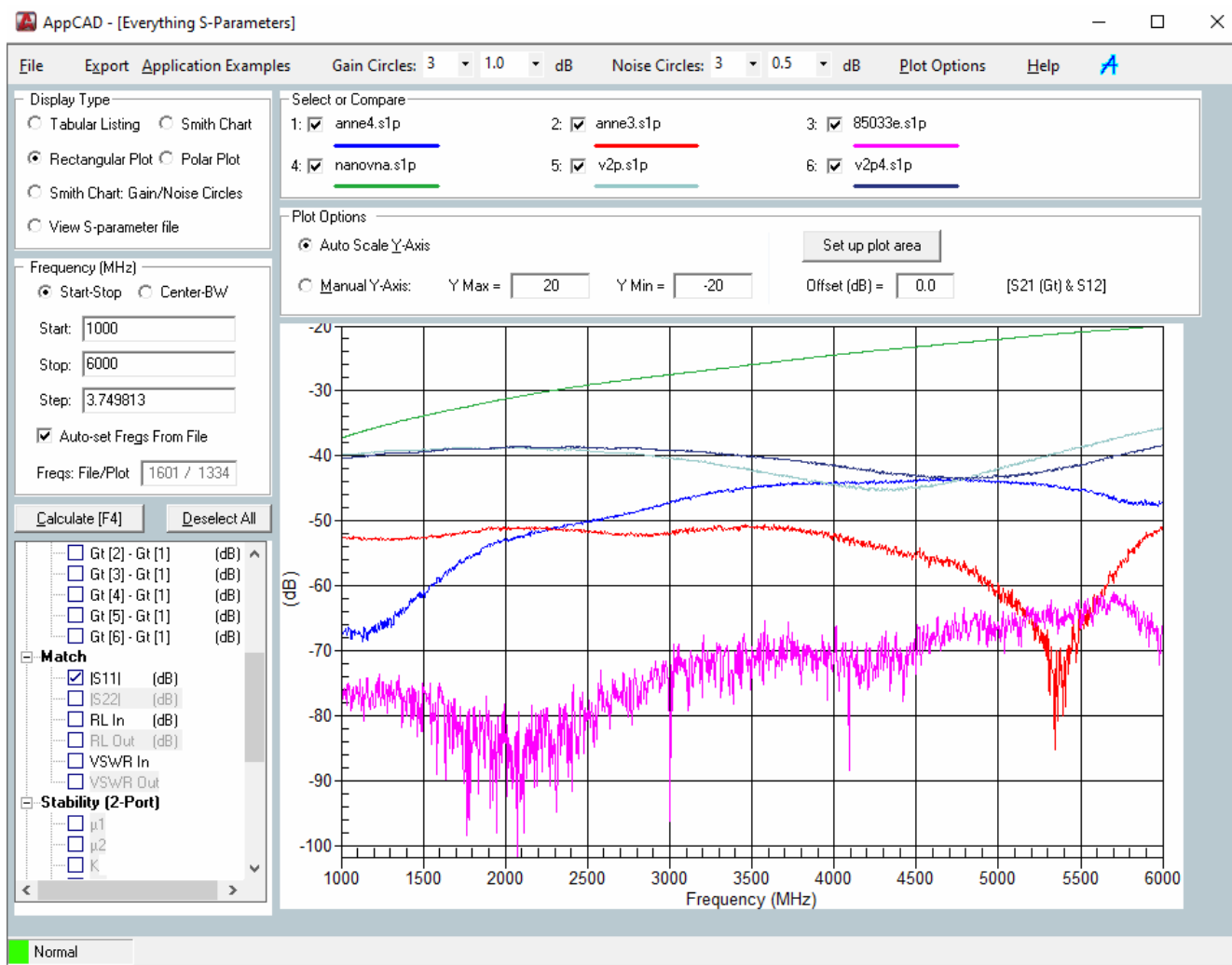
These two ANNE's are from a batch of seven that I purchased. I then sorted them. The two shown are the best out of the group. ANNE #3 is what I use as my standard for my lab experiments. For the V2+, the original load was swapped out for ANNE #4.

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I've shown some of my home made standards using various SMT resistors for GHz and lower.
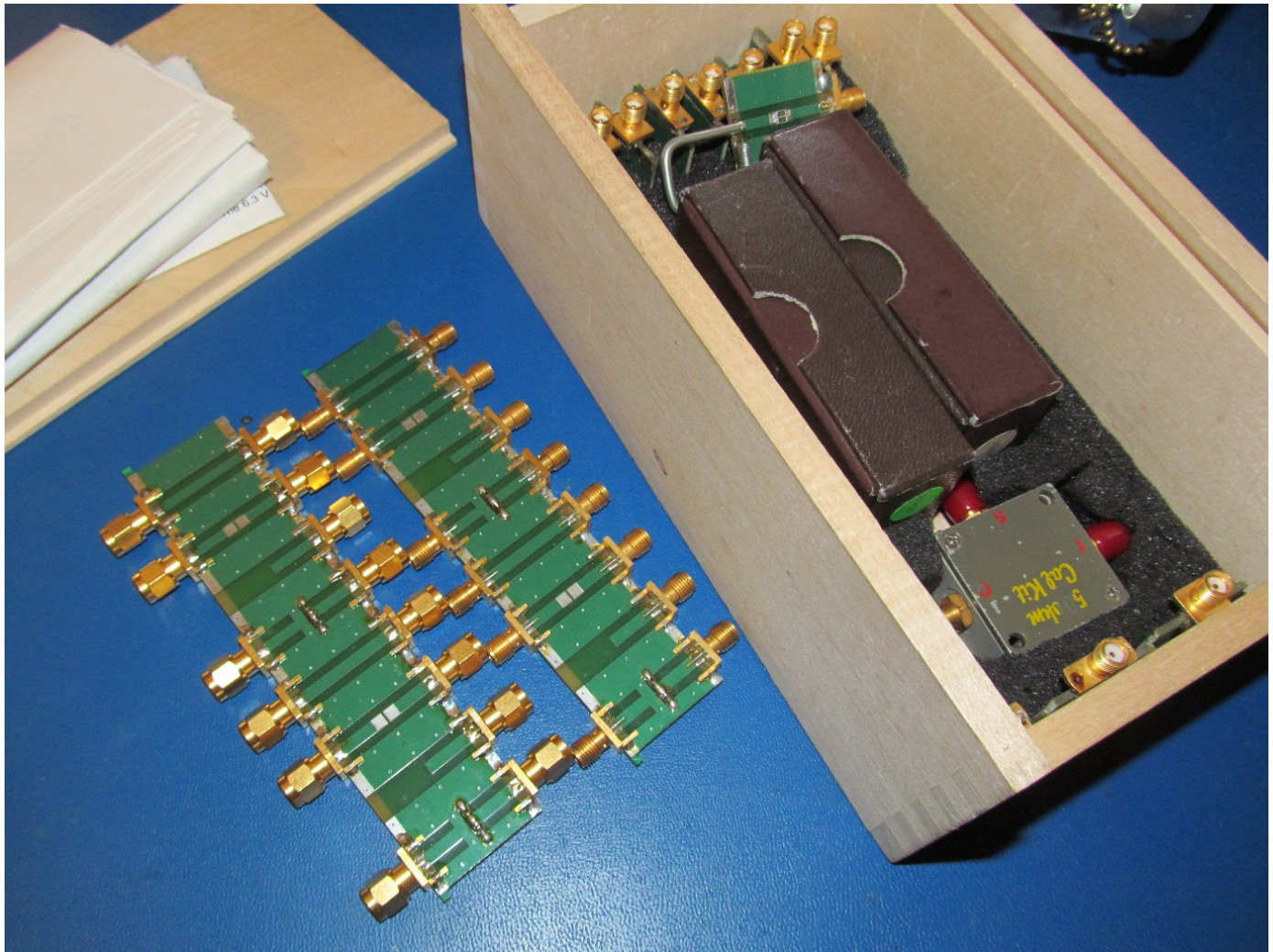
Attempting to make a decent load for 3GHz, good luck with that!

Shown is an attempt at making a set of TRL standards using some
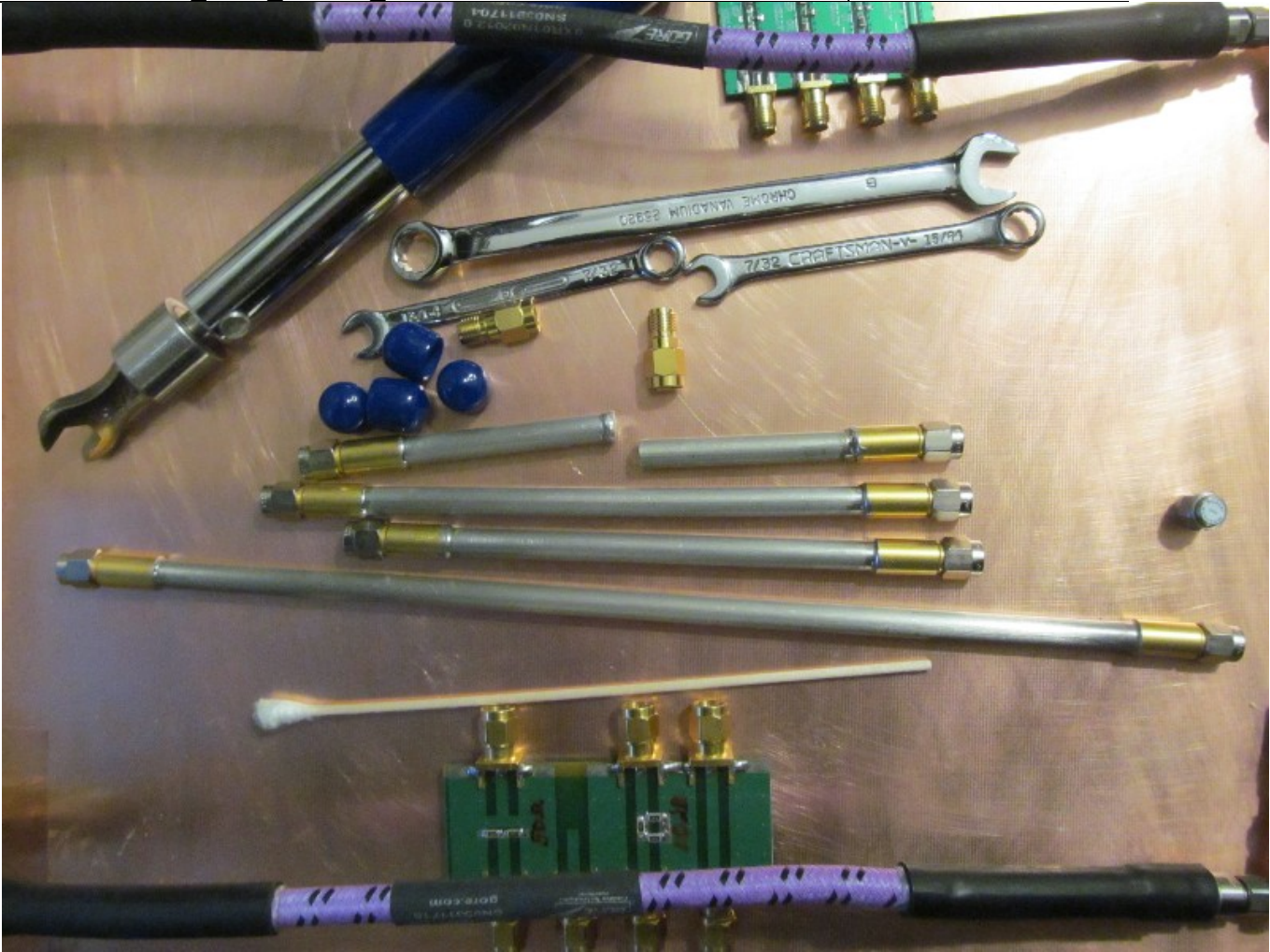
Shown below are some of my homemade standards for experimenting in the GHz range. Toward the left are the N and SMA standards. These were characterized using a set of HPAK standards.
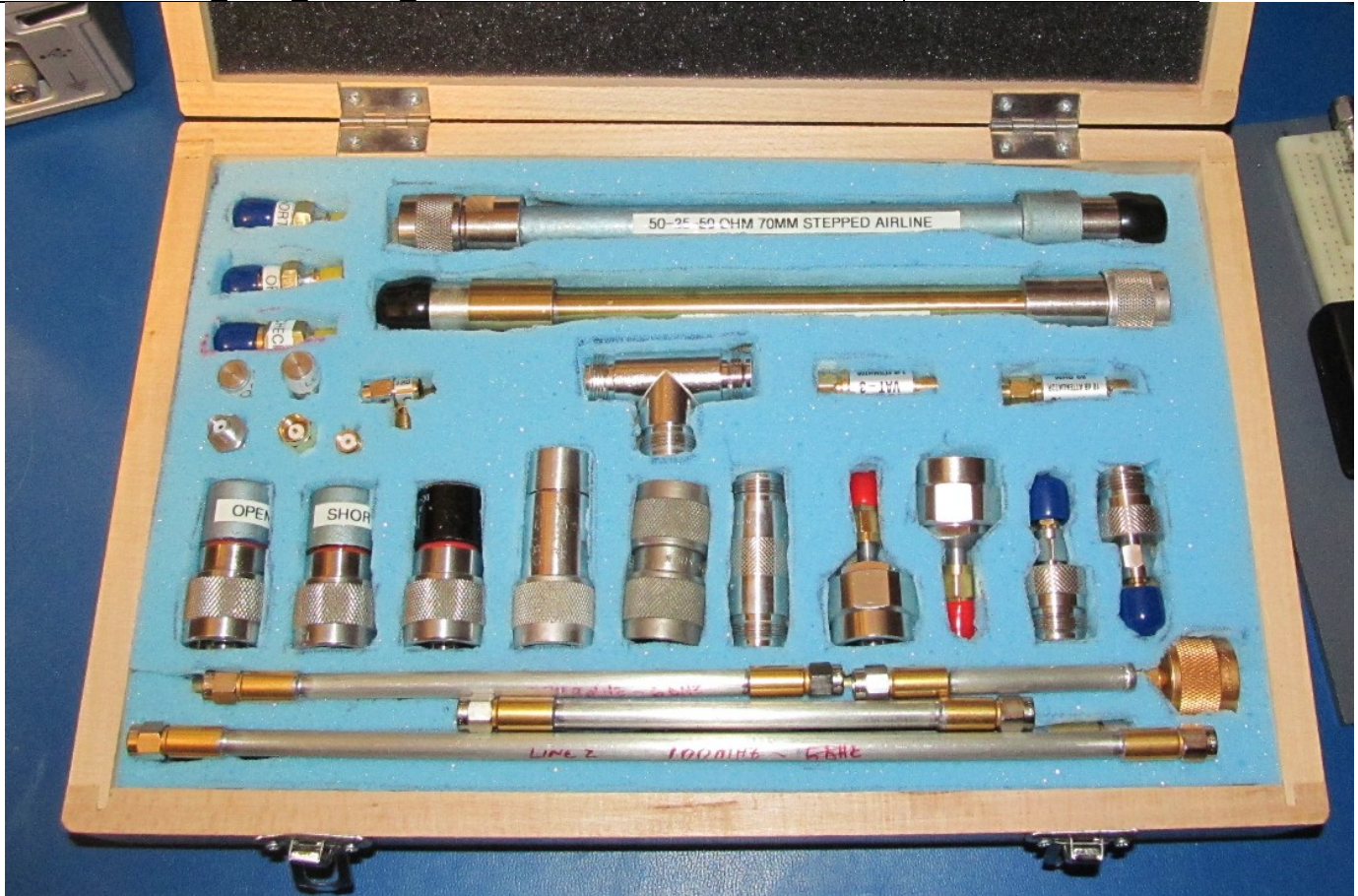
Don't expect to just go out and buy a new part from Mini-Circuits and replace yours. They need to be characterized as their tolerances can vary a fair amount.

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- defense & radar

Electrical Specifications T$_{AMB}$=25°C

FREQUENCY (MHz)	IMPEDANCE (OHMS)	RETURN LOSS (dB) MIN.				POWER RATING* (W)
		DC-4 GHz	4-8 GHz	8-12 GHz	12-18 GHz	
DC-18000	50	30	27	23	21	1.0

*At 50°C, derate linearly to 350mW at 100°C.

ANNE-50+

Typical Performance Data

Frequency (MHz)	Return Loss (dB)
100	51.21
1072	43.38
2024	38.95
2800	36.93
3400	35.82
4000	35.20

CASE STYLE: LL561

Connectors	Model
SMA-Male	ANNE-50+

Features
- wideband coverage, DC to 18000 MHz
- return loss, 35 dB typ. up to 4000 MHz and 27 dB typ. 10000 to 18000 MHz
- rugged construction

Shown is the new thru with a flat and ANNE included in my V2+ cal kit.

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9.8 SOLT Calibration

For this experiment, we will use the included cables and modified calibration kit. Select CHn-Ref to disable the normalization. Next select the 2PortCal. You will be prompted to create a new calibration or load a previously saved one. You can have as many calibration files as you want. If you had a previously loaded calibration and you select Cancel, it will purge the current calibration.

SOLT   ×

Perform a New 2-port calibration or load an Old calibration file. Note: Select transfer relay and crosstalk prior to running calibration.

                              New   Old   Cancel
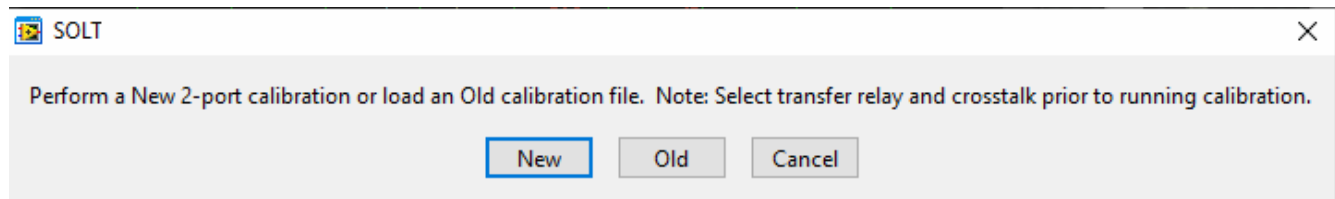
Select New. You will be prompted to insert the short on Port A (Port 1).

Install Short on Port A

OK
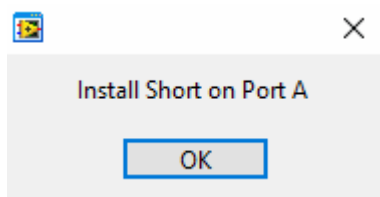
After you have it properly installed (cleaned, torqued…) go ahead and select OK. The software will not prompt you to install the Open standard.

Install Open on Port A

OK
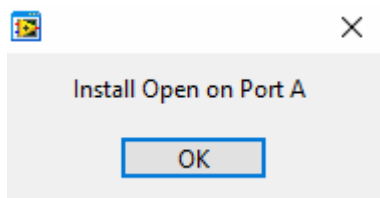
Replace the short with the open and select OK. The software will measure the crosstalk during this time and will then prompt for you to install the load.

Install Load on Port A

OK
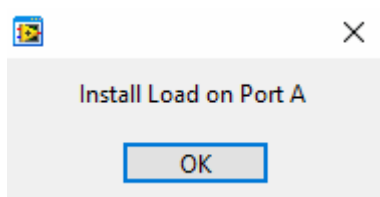
Again, select OK after installing. Now install the thru.

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Install Thru Between A and B

OK

This software has the ability to control a transfer relay. If this option was enabled prior to selecting the calibration, you would be prompted to repeat this process for port B (2). After collecting the data, the software will request you to enter where you would like to save this new calibration. It defaults to Calibration.cal. I like to use descriptive names. As shown, you can see I will include the start and stop frequencies in the file name.

Choose a file name and location

Save in: NanoVNA_r10

Name	Date modified	Type	Size
data	11/30/2020 6:55 PM	File folder	
Calibration.cal	11/30/2020 9:06 PM	CAL File	21 KB
Calibration_1_300MHz.cal	11/29/2020 6:53 PM	CAL File	21 KB
defaults.set	11/29/2020 6:51 PM	SET File	2 KB
NanoVNA_V2Plus.aliases	11/30/2020 6:55 PM	ALIASES File	1 KB
NanoVNA_V2Plus.exe	11/30/2020 6:55 PM	Application	14,620 KB
NanoVNA_V2Plus.ini	11/30/2020 6:55 PM	Configuration sett...	1 KB
record.txt	11/30/2020 3:42 AM	Text Document	154,726 KB

File name: Calibration.cal

Save as type: All Files (*.*)

OK

Cancel

Select OK. With the thru still installed, select the rectangular transmission function.

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The software now shows the V2+ is calibrated.   As we can see, with no normalization the V2+ is showing < 0.2 dB of error.

Now lets install the Midwest Microwave 40dB attenuator.   It's not very good but remember, I mentioned the problem with cross talk at these higher frequencies.

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Select the Setup/Diagnostics menu and then select the Calibration Terms submenu. Now select the Leakage Terms checkbox.

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After you have selected Leakage Terms, return to the main menu. Notice now that our attenuator is now within 2dB all the way up to 4.4GHz. Keep in mind that the V2+4 is only rated to 4GHz where our part is within +/- 1dB.

Of course, you may be curious if this is correct or not, so here is the same attenuator shown on one of my old VNAs using my own home made calibration kit.
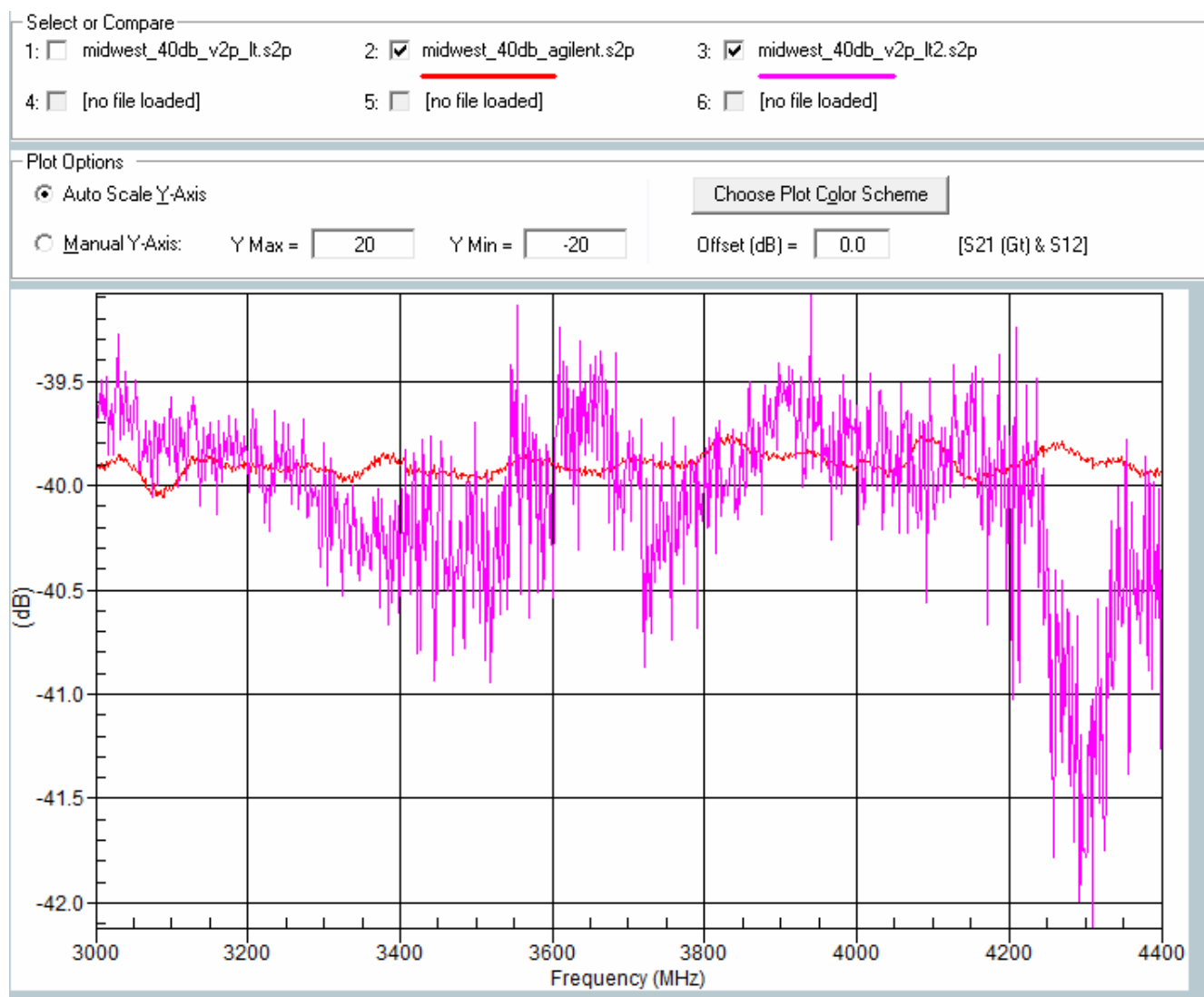
Now let's install our very low cost 30dB attenuator. From before, we had swept it from 2.5 – 4GHz and saw from 28.2 to 24 dB. It's not much better but again, it's a $5 part and rated for

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4GHz with a 1.5dB flatness. The author has purchased two different versions of these low cost attenuators. One of them performed much closer to the claimed specification.

10. Using Memories

The software has three memories that may be used to temporarily store and overlay waveforms. The Ref and CHn-Ref is a special memory that is used to normalize the data. MS1&2 have no math functional associated with them.

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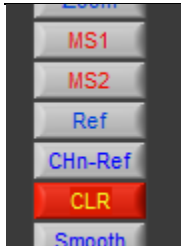
Store the current waveform by selecting one of the two buttons, MS1 or 2. The waveform will be immediately displayed. In the following two different waveforms have been saved.
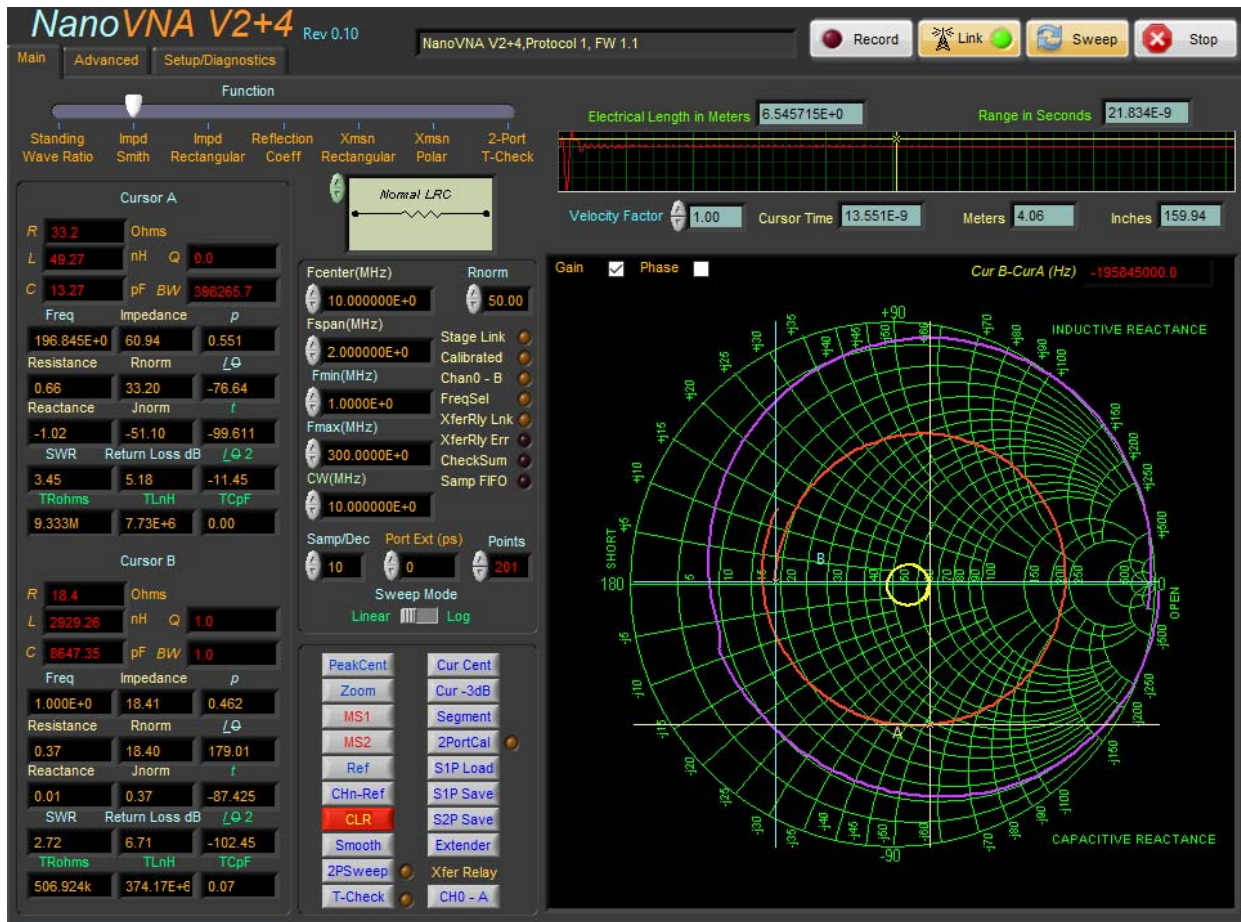
Selecting the clear button will erase all three memories and turn them off. You do not have to erase a memory before storing a waveform to it. Pressing one of the memory keys will always overwrite the previously stored waveform.

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11. Recording Multiple Sweeps to Disk

The software has the ability to record the swept data to disk. Once you have the VNA setup, select the Record button. You will be prompted to enter a filename.
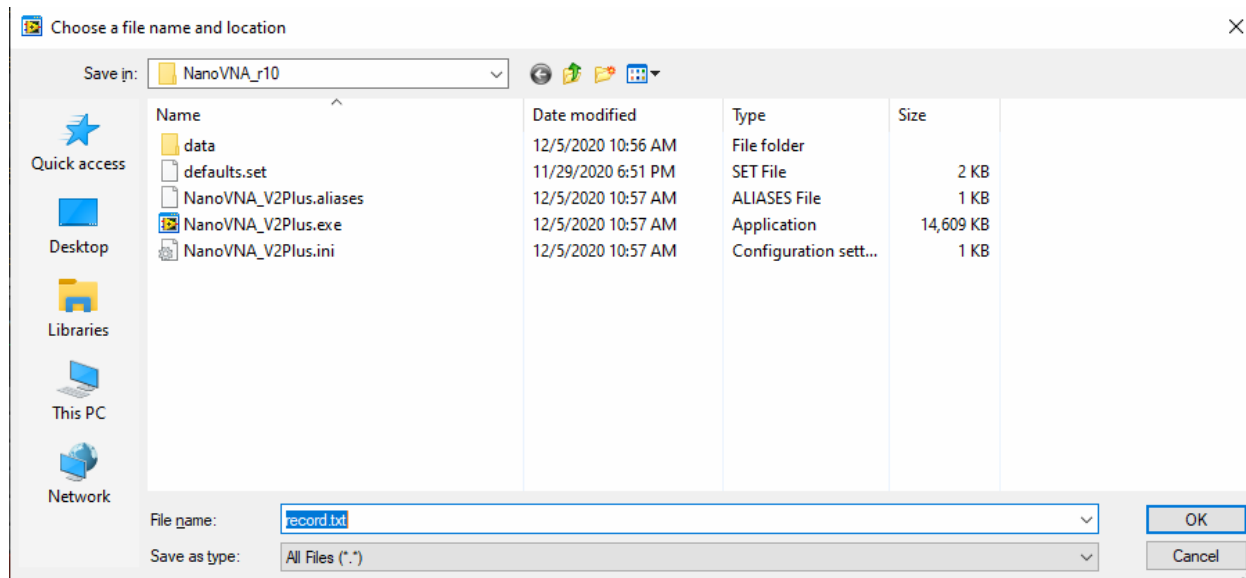
The software will immediately begin recording all of the corrected S-parameters.   Selecting standards, performing a calibration, changing the port extension and enabling filters will all have an effect on the recorded data.

The author has found the V2+ (not the +4 model) to be very unreliable when running for extended times. The NanoVNA itself appears to lockup and will require a power cycle to clear it.   The +4 model does not appear to have this problem.   You need to be aware of this if you are attempting to run a long term study.

Once you have finished recording your data, just select Record again to stop the collection.

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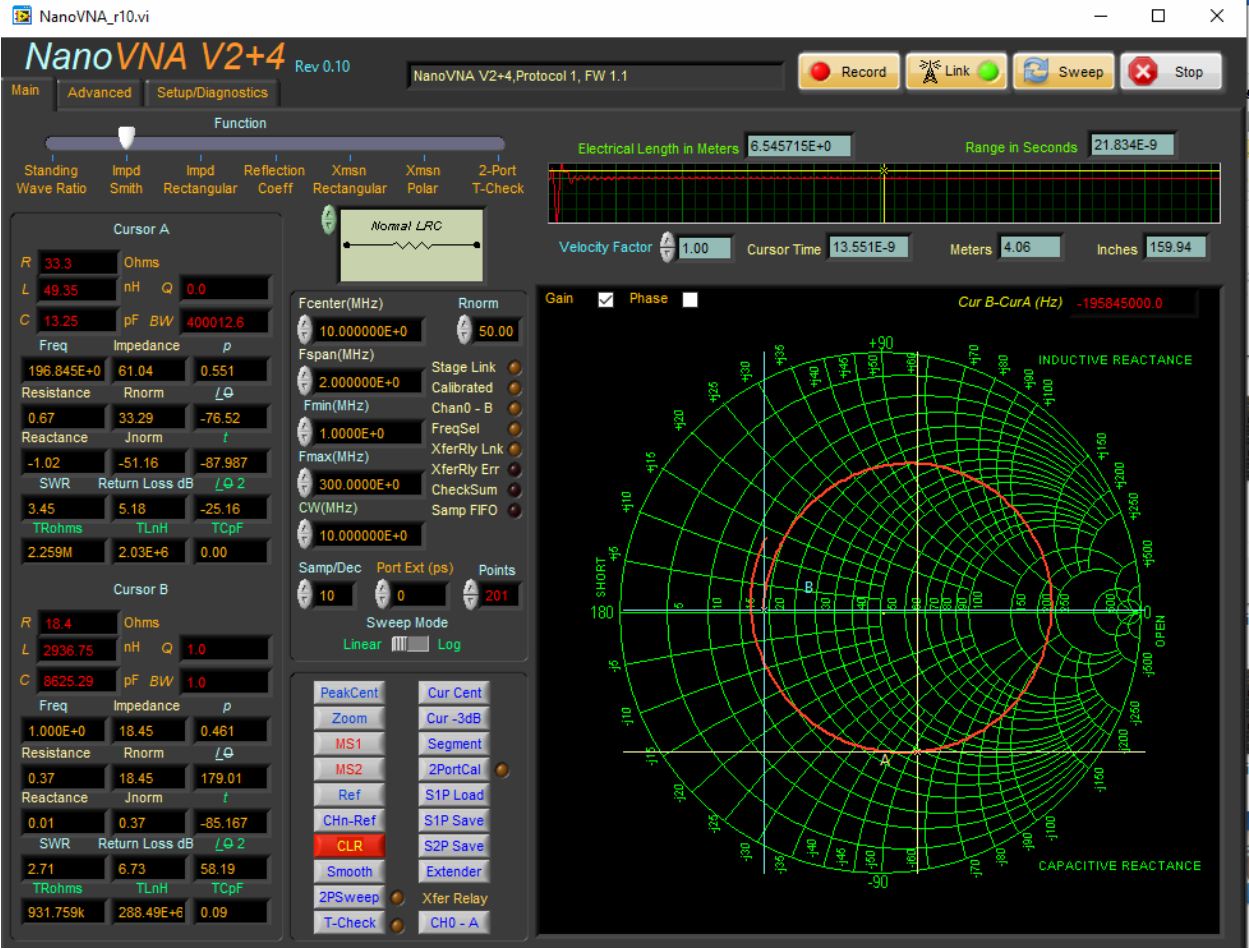
11.1 Post Processing

Selecting the Advanced tab followed by the Surface tab will bring up the following menu.

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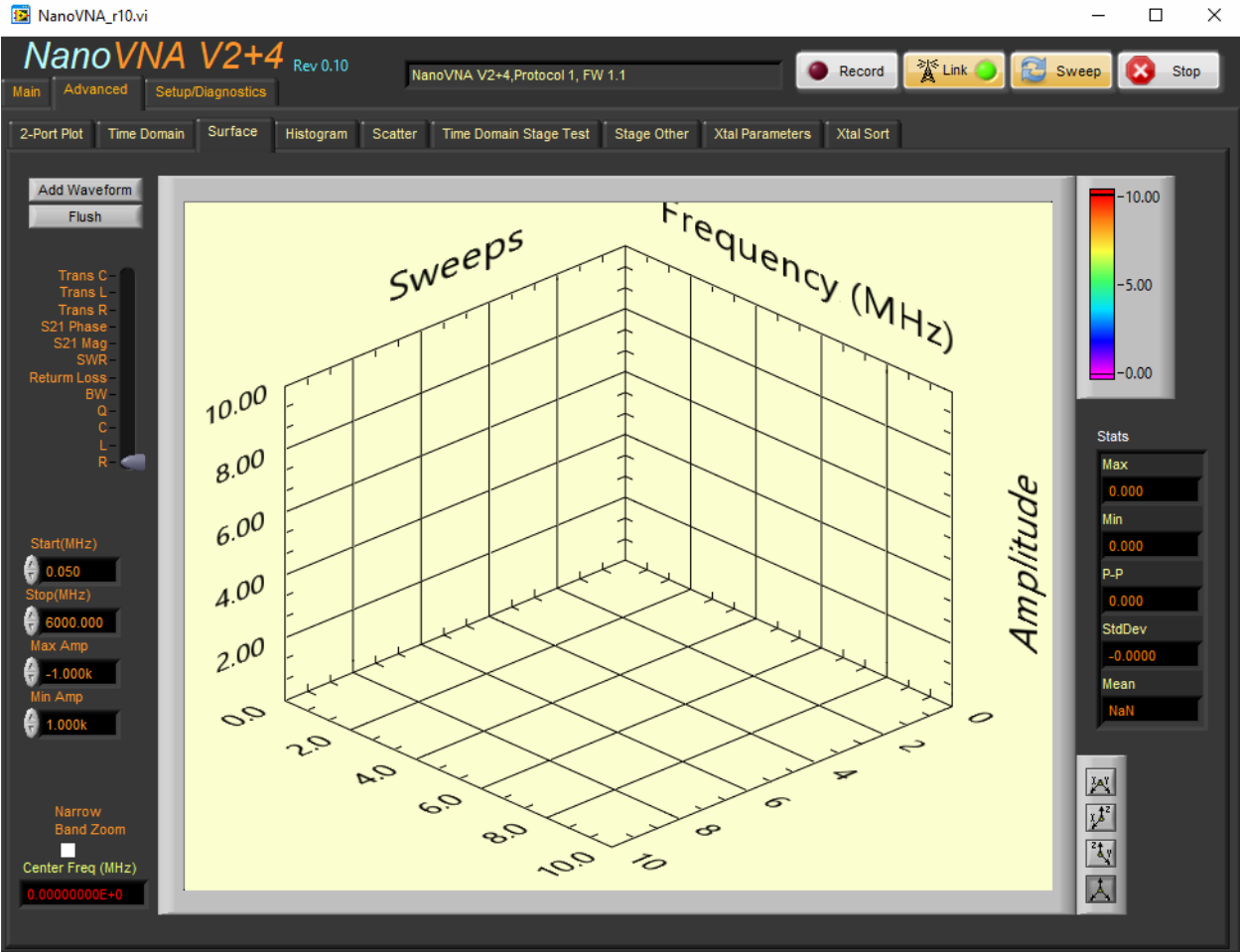
You may now select your file by selecting Add Waveform. You will be prompted for a file name. Note there is now a file named record.txt which is the file we have just created.
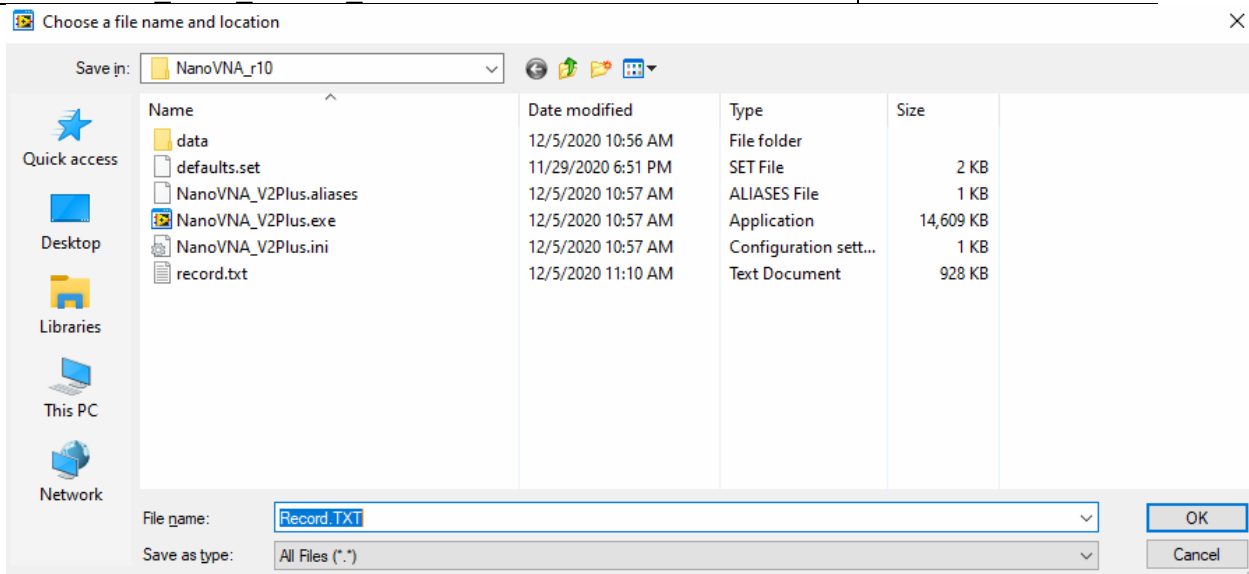
Once the file has been loaded, you may use the slider on the left to select the parameter you would like to view.

Selecting Flush will purge the memory.

In some cases we want to view very narrow band data. The Narrow Band Zoom feature allows rescaling the graph about the center frequency.   You may also use the Start, Stop, Max and Min amplitudes to change the displayed range of the graph.

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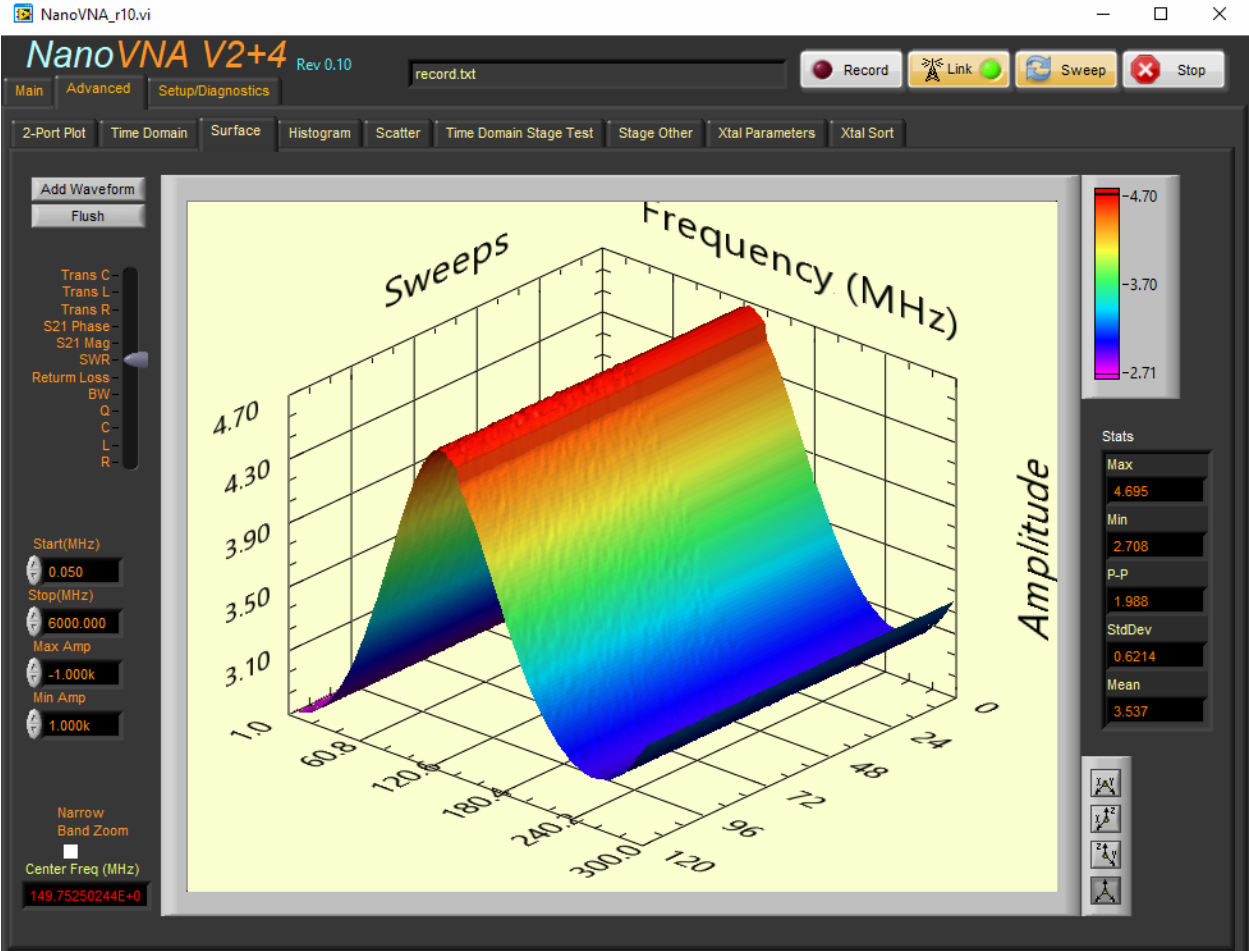
11.2 Histograms and Scattering Diagrams

You may also display the histogram for the selected data.

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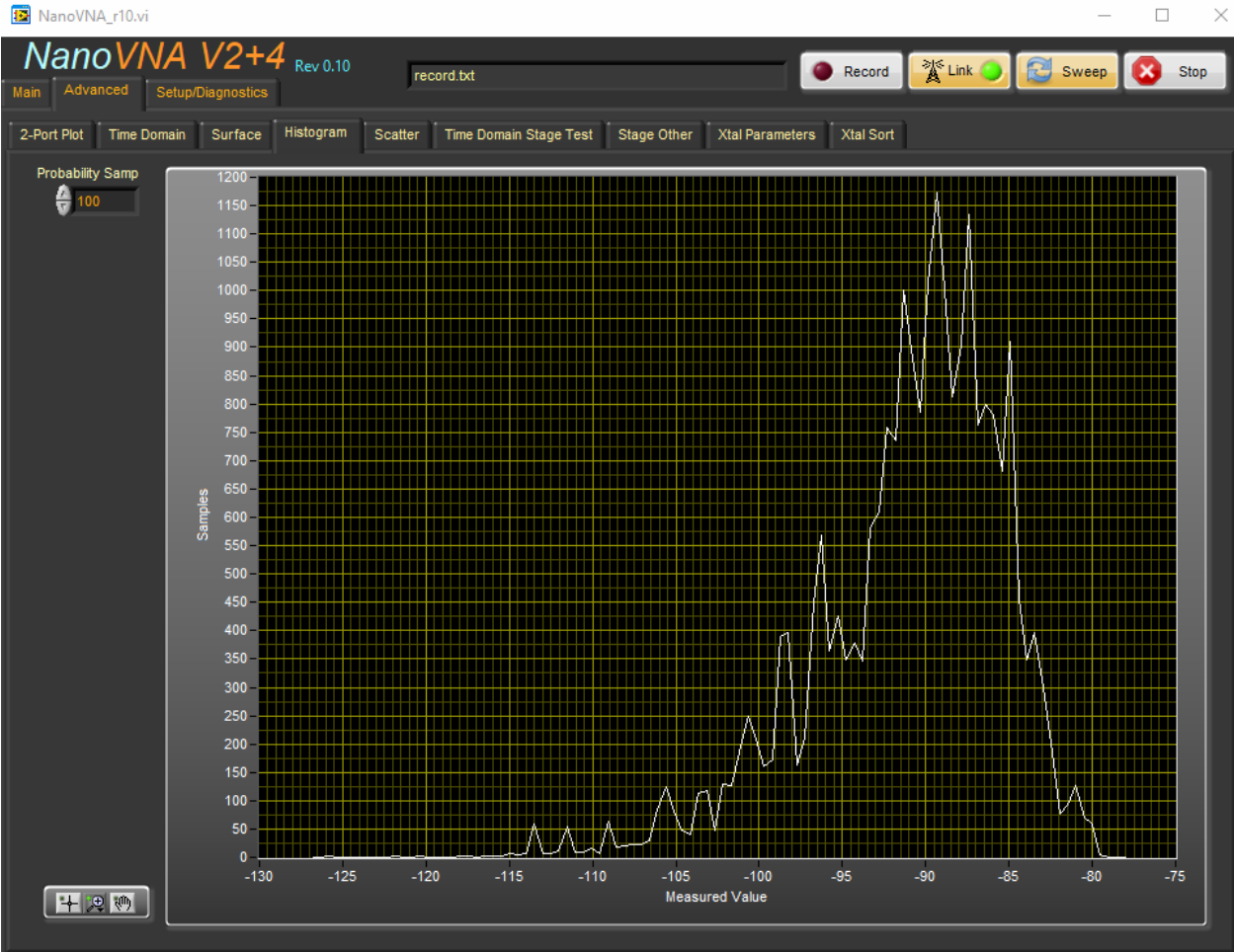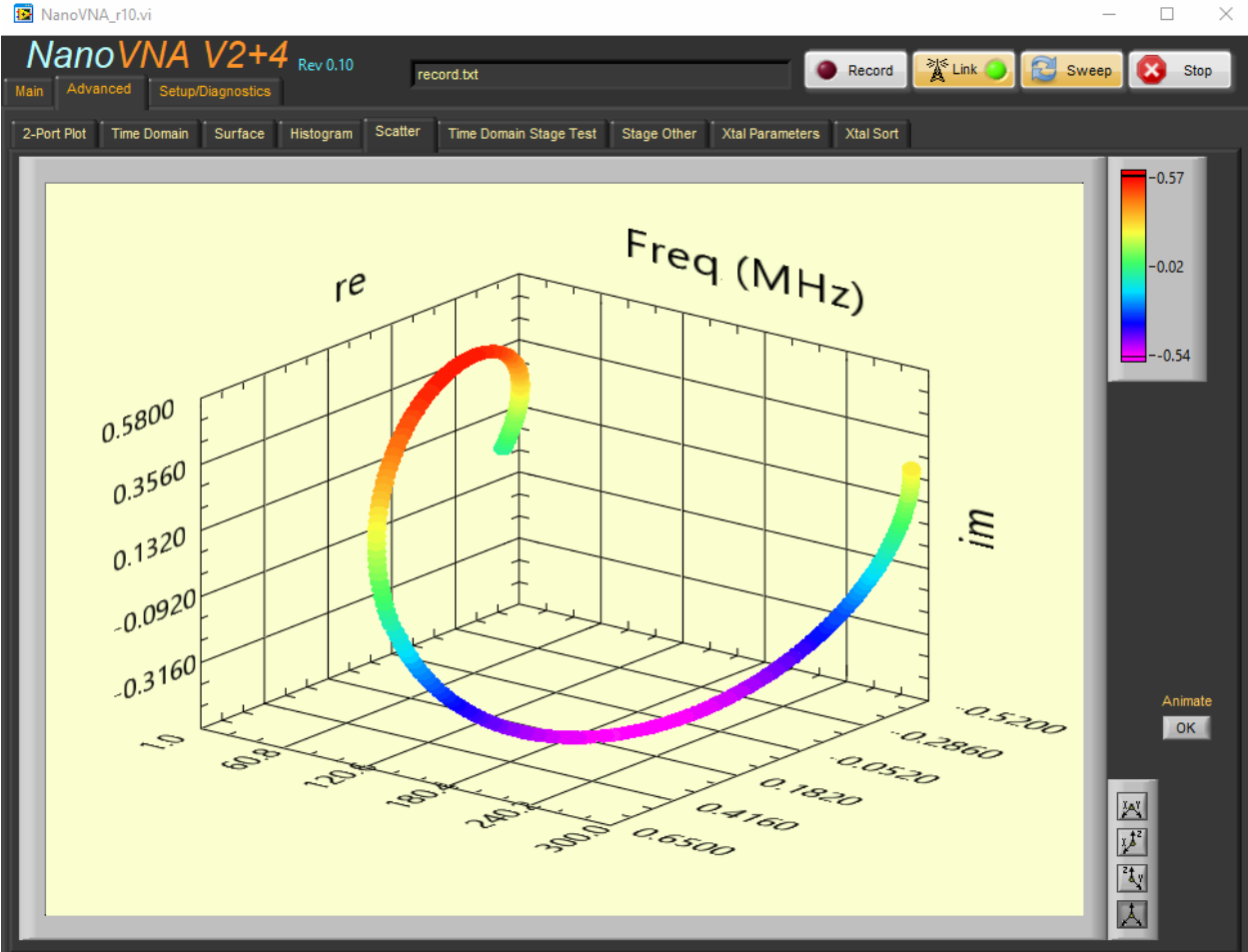
12. Narrow Band Measurements

&$#&%$#%^!!!!!!!!!!!!!!!!!

While the original NanoVNA did a very nice job making narrow band measurements, sadly the V2+ is not able to make these same measurements. The various features have been included but do not expect them to provide any useful data.

12.1 Segmented Sweeps

Segmented sweep were originally added to the NanoVNA software to provide a means of creating high resolution Touchstone files that could be used to generate SPICE models. The original NanoVNA supported a fixed 101 data points for a given sweep range. Segmented sweeps provided a way to work around this limitation. The resolution was really only limited by how long the user wanted to wait for their data and the hardware's minimum step size.

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The V2+'s native firmware supports more than enough data to make these measurements without the need for segmentation.

12.1.1 Linear / Log Sweep

When using segments, you may select linear or logarithmic sweeps.   Linear is fairly straight forward.   For log sweeps, the software computes the step size for each segment based on the samples per decade.   While not a true log sweep in the sense, it does allow collecting a higher number of data points for lower frequencies.

12.1.2 Setting up the Segmented Mode

Assuming you are running a linear sweep, set Fspan to the frequency range of each segment. The step size is the span divided by the number of data points selected.

Next, set the start (Fmin) and stop (Fmax) to the range of frequencies you would like to sweep.

IMPORTANT!!!!

There is an order to how you select the data. The software will always program the V2+ to the last setting you made. If you change Fcenter, the software will use the center and span to calculate the new range. If you change Fmin, the software will use the min (start) and max (stop) to calculate the range.   If you were to program the min and max first, then change the span, the V2+'s start and stop would change.

Also, changing the number of points will cause the software to recalculate the sweep range based on the min (start) and max (stop).

Using the defaults, the software will start by sweeping from 1MHz to 3MHz, with 201 data points.   It will then continue to the next segment.

By attaching a 12MHz 5 pole LP filter, we can see that the resolution in the lower frequencies is poor. You can see I have changed the span from 2MHz to 50MHz.

Selecting Segment, we have gone from 201 points to 1005 points. We can now see a lot more detail.

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The software currently supports up to 1600 data points.   By changing the number of points to 1005 the V2+ will send the same amount of data with a normal sweep.

As shown below, there is no difference between the segmented sweep and the normal sweep. Except that the sweep time in the normal mode is roughly 4 seconds.

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12.2 Measuring Crystals

While the original NanoVNA made this measurements fairly accurately compared with the author's other VNAs and various equipment, the V2+ lacks the ability to perform any narrowband measurements.   This section of the document has been included only to provide details how the software works. Do not expect to make use of these specific modes unless an improved V2+ that is software compatible with the current versions is released.

The following table from CopperMountain shows the equations for the three types of impedance measurements.   For these measurements, we will be looking at the crystals series impedance.

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| 1	$Z_0 \cdot \dfrac{1+S_{11}}{1-S_{11}}$	$\Delta Z^{max} = \dfrac{2Z_0 \cdot \left\|\Delta S_{11}^{max}\right\|}{\left\|1-S_{11}\right\|^2}$, $\left\|\Delta S_{11}^{max}\right\| = \left\|D\right\| + \left\|R-1\right\| \cdot \left\|S_{11}\right\| + \left\|M\right\| \cdot \left\|S_{11}\right\|^2$	2.5 Ohm to 1 kOhm
2	$\dfrac{Z_0}{2} \cdot \dfrac{S_{21}}{1-S_{21}}$	$\Delta Z^{max} = \dfrac{Z_0 \cdot \left\|\Delta S_{21}^{max}\right\|}{2 \cdot \left\|1-S_{21}\right\|^2}$, $\left\|\Delta S_{21}^{max}\right\| = \left(\left\|T-1\right\| + \left\|M\right\| + \left\|L\right\|\right) \cdot \left\|S_{21}\right\| + \left\|X\right\|$	1 mOhm to 100 Ohm
3	$2Z_0 \cdot \dfrac{1-S_{21}}{S_{21}}$	$\Delta Z_3^{max} = \dfrac{2Z_0 \cdot \left\|\Delta S_{21}^{max}\right\|}{\left\|S_{21}\right\|^2}$, $\left\|\Delta S_{21}^{max}\right\| = \left\|T-1\right\| \cdot \left\|S_{21}\right\| + \left\|X\right\|$	8 Ohm to 100 kOhm

12.3 Test Fixture

To make these measurements, a custom test fixture was created.   This is nothing more than two 3dB attenuators and two ten-turn bifilar transformers wound with Teflon wire.   This fixture works fairly well for measuring crystals in the range of 2-30MHz.

The standards along with the fixture are shown below.   The copper block and connector is just a heatsink for soldering these.

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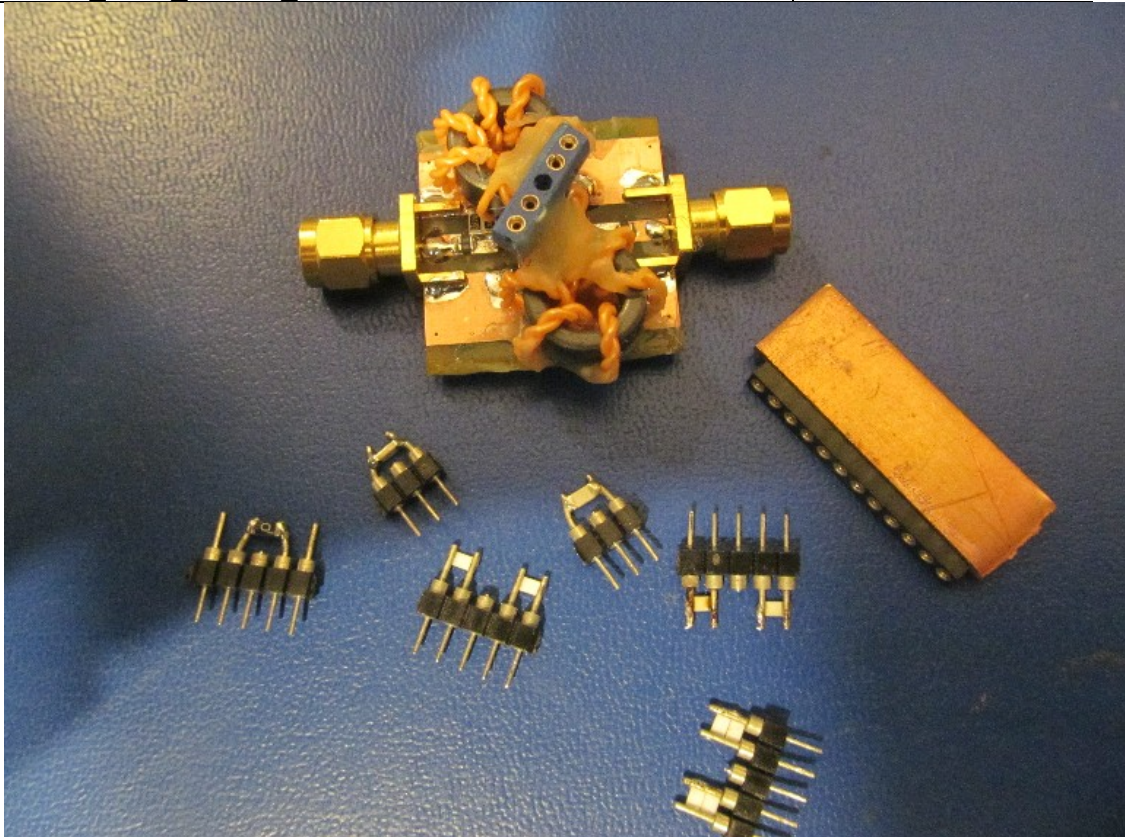
12.4 Crystal Example

For this example we are using a 3.6864MHz crystal from Fox, series 0368S. Start by setting the minimum and maximum frequencies to 3.5 and 4.0MHz. In this example, no calibration was performed.   Performing a sweep, we can clearly see the resonance.

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As we adjust the start and stop frequencies to zoom into this area, we can begin to see a problem. Normally, we would expect this to be a very smooth curve but the limitation of the V2+ is already causing problems.

Selecting the Zoom button will cause the software to zoom into the peak. Once finished, we can set the cursors to the 3dB points by selecting Cur-3dB. Note the steps in the data.

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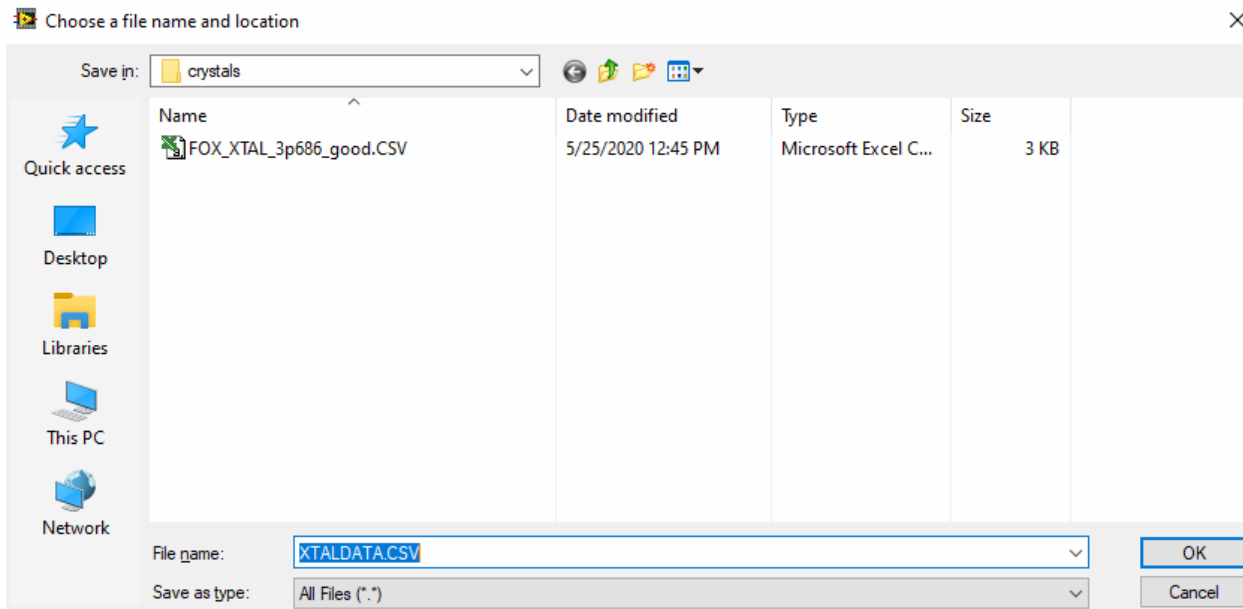
Let's go ahead and calibrate our setup. Then select the Advanced tab followed by Xtal Parameters. Allow the temperature to stabilize. We can see this by monitoring the Series Frequency.

Once the crystal is stable, selecting the C0 button will cause the software to automatically make this measurement. You may now clear the series frequency graph. Allowing the system to run, you can get a feel for the noise.

The software has made all the measurements and you can enter a serial number, brand and model that will be stored with the data.
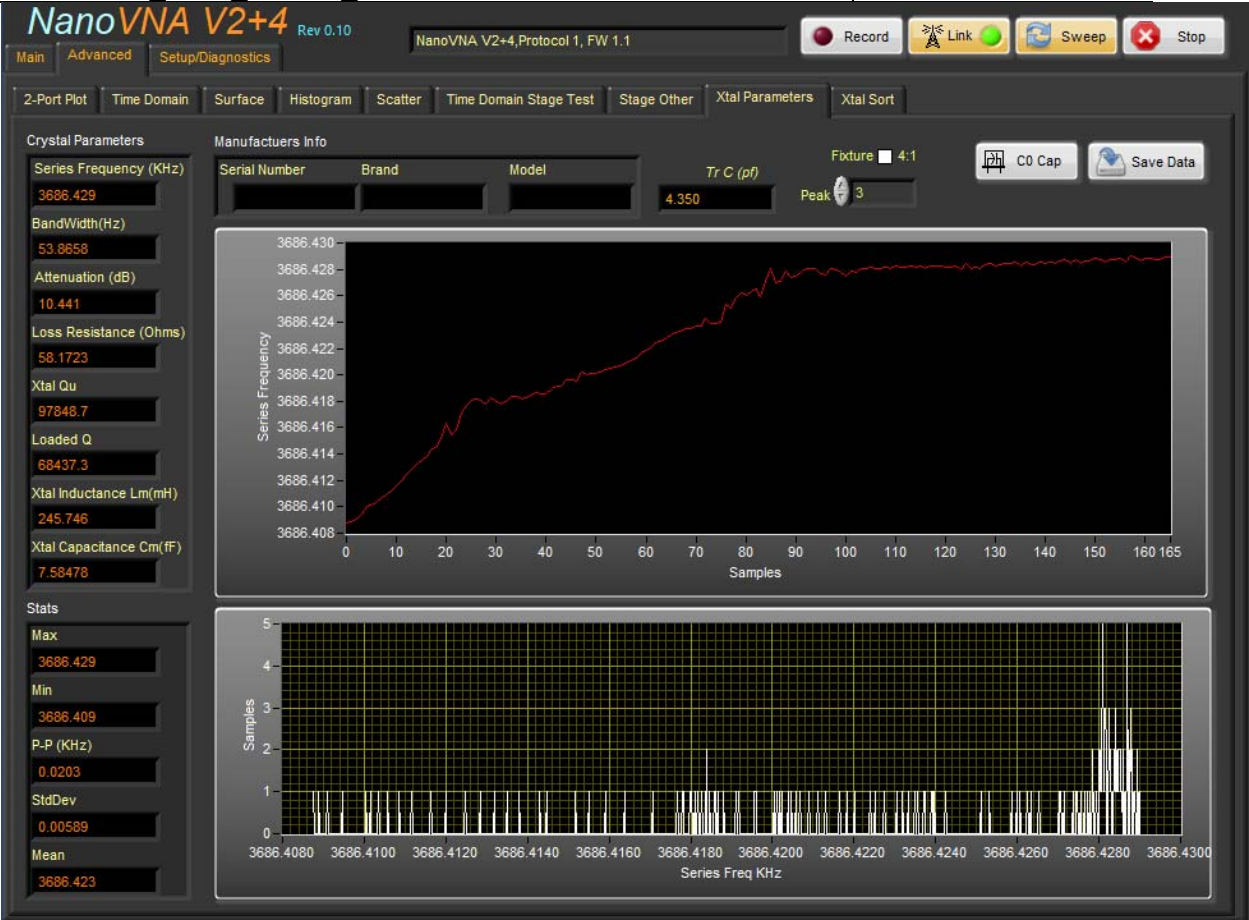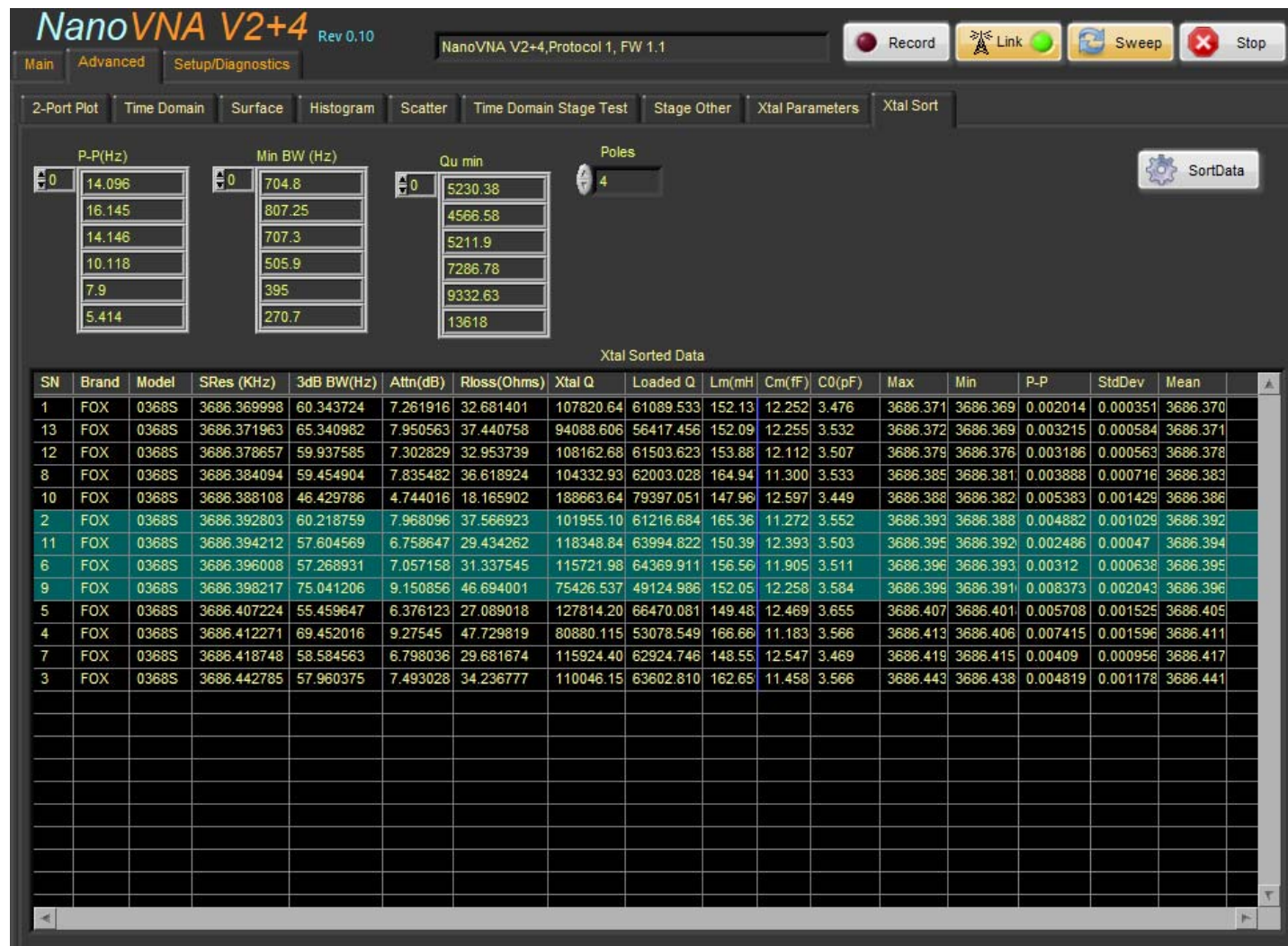
Select Save Data and you will be prompted for a file name.   It's best to name the file with a meaningful description.

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Selecting Xtal Sort tab will allow you to sort the data you have collected.   Select the SortData button and you will be asked to select the file name to sort.   For this example, we will use some data previously collected using the original NanoVNA.
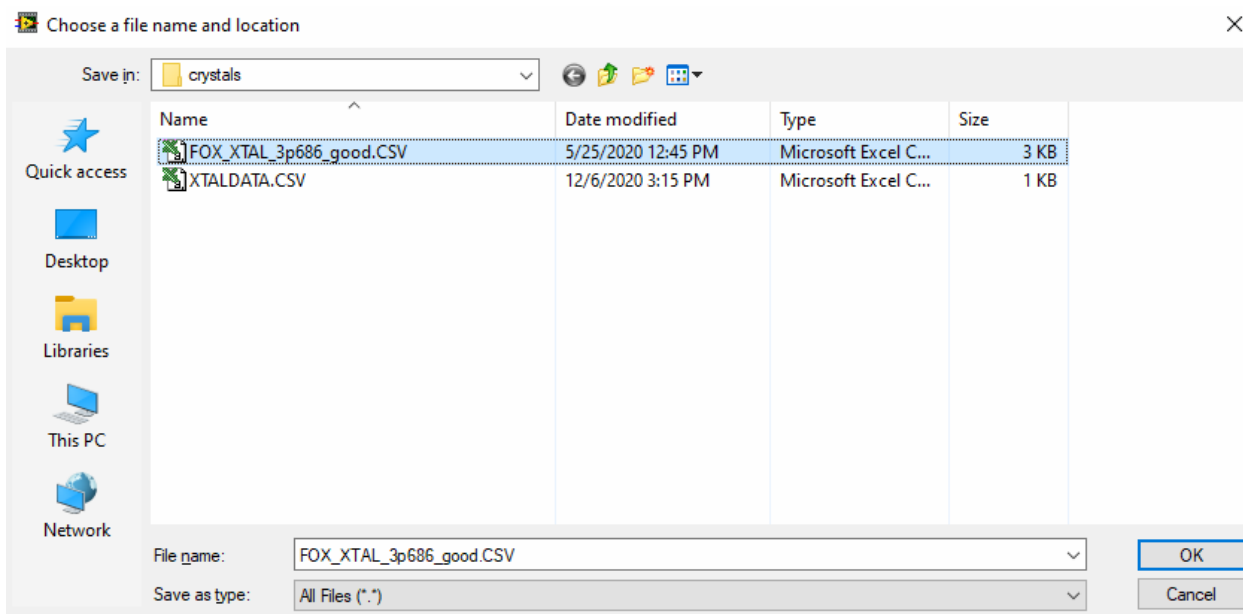
The crystal data will be presented in table format. You may then select the number of poles for the filter you are designing and the software will highlight the closest match.

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However, let's compare this data with the part we just measured. Notice that while the series frequency and bandwidth are good, the attenuation is about 3dB off. The measured loss resistance is more than 20 ohms high. Lm, Cm and C0 are not even close. The author owns a few old VNAs that are more than capable of making this measurement and the data collected with the original Nano is very close to what I get with the other systems, using the same test jig.

Crystal Parameters

Series Frequency (KHz)
3686.430

BandWidth(Hz)
59.6149

Attenuation (dB)
10.478

Loss Resistance (Ohms)
58.525

Xtal Qu
88252.3

Loaded Q
61837.4

Xtal Inductance Lm(mH)
222.988

Xtal Capacitance Cm(fF)
8.35884

Tr C (pf)
4.365

SN	Brand	Model	SRes (KHz)	3dB BW(Hz)	Attn(dB)	Rloss(Ohms)	Xtal Q	Loaded Q	Lm(mH)	Cm(fF)	C0(pF)
1	FOX	0368S	3686.369998	60.343724	7.261916	32.681401	107820.64	61089.533	152.13	12.252	3.476
13	FOX	0368S	3686.371963	65.340982	7.950563	37.440758	94088.606	56417.456	152.09	12.255	3.532
12	FOX	0368S	3686.378657	59.937585	7.302829	32.953739	108162.68	61503.623	153.88	12.112	3.507
8	FOX	0368S	3686.384094	59.454904	7.835482	36.618924	104332.93	62003.028	164.94	11.300	3.533
10	FOX	0368S	3686.388108	46.429786	4.744016	18.165902	188663.64	79397.051	147.96	12.597	3.449
2	FOX	0368S	3686.392803	60.218759	7.968096	37.566923	101955.10	61216.684	165.36	11.272	3.552
11	FOX	0368S	3686.394212	57.604569	6.758647	29.434262	118348.84	63994.822	150.39	12.393	3.503
6	FOX	0368S	3686.396008	57.268931	7.057158	31.337545	115721.98	64369.911	156.56	11.905	3.511
9	FOX	0368S	3686.398217	75.041206	9.150856	46.694001	75426.537	49124.986	152.05	12.258	3.584
5	FOX	0368S	3686.407224	55.459647	6.376123	27.089018	127814.20	66470.081	149.48	12.469	3.655
4	FOX	0368S	3686.412271	69.452016	9.27545	47.729819	80880.115	53078.549	166.66	11.183	3.566
7	FOX	0368S	3686.418748	58.584563	6.798036	29.681674	115924.40	62924.746	148.55	12.547	3.469
3	FOX	0368S	3686.442785	57.960375	7.493028	34.236777	110046.15	63602.810	162.65	11.458	3.566

So while it may be interesting for some to play with this feature, it really offers no value at this time.

13. Filtering

14. Touchstone

15. Integrating a Transfer Relay

The software supports adding an external transfer relay.   The author has attempted to construct some low cost units based on GaAs and relay technologies for experimenting with the NanoVNA. Their performance was very poor.

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Note that there are 6 ports total on the two home made transfer relays. These provided bias-Ts for each of the two ports.

The left most relay is an old Transco device. It was designed for operation to 18GHz and is well suited for this task.

The software really doesn't care what type of transfer relay is attached. It uses a common USB – TTL adapter from FTDI.   The RTS signal is used to select the state of the relay and the CTS is used to monitor it's status. The communications port is selected in the Setup/Diagnostics page using the XferPort. Again, the BAUD rate has no effect. The selected port is saved as part of the defaults.   Shown in the FTDI cable attached to the Transco controller.

15.1 Manually Controlling the Transfer Relay

With the correct communications port selected, the next time Link is selected, the software will check for the presence of the port. There is no other check beyond it finding a valid port number.   If found the XferRly Lnk indicator found on the main page, will become active.

You can manually change the state of the relay by selecting the CH0-A switch on the front panel. Once selected, the Chan0-B indicator will become active. If the relay does not change states, the XferRly Err indicator will become active.
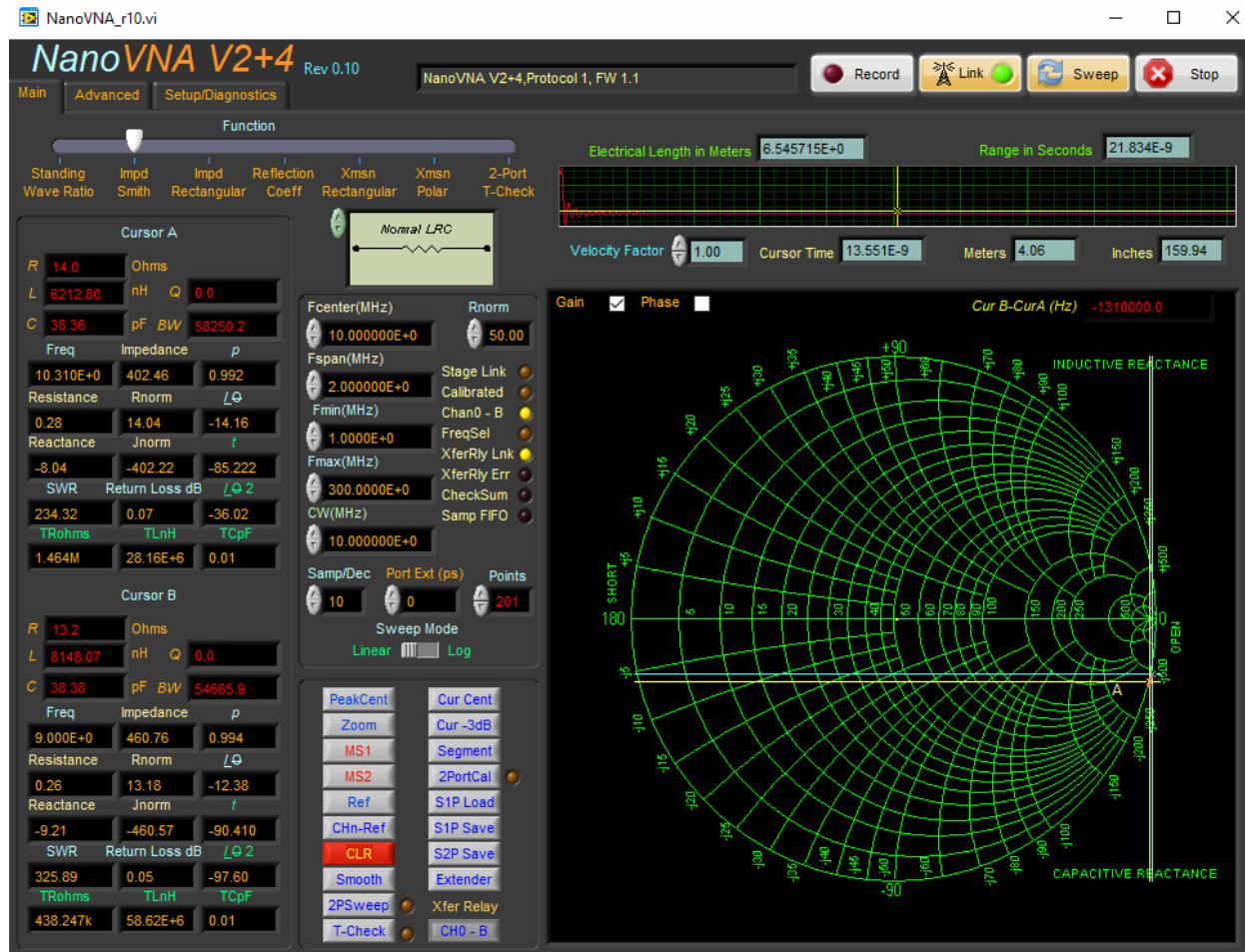
15.2 Full 2-Port Calibration

Once the transfer relay is inserted, selecting a 2PortCal will now walk you through a full 2-Port calibration. You will be prompted to insert the SOL standards on each port rather than just Port1.

Once calibrated, you should see very little difference measuring between the two ports. In the following a parallel LC circuit was installed first on Port1. The data was stored into MS1 and then the circuit was moved to Port2. Notice the two are basically identical.

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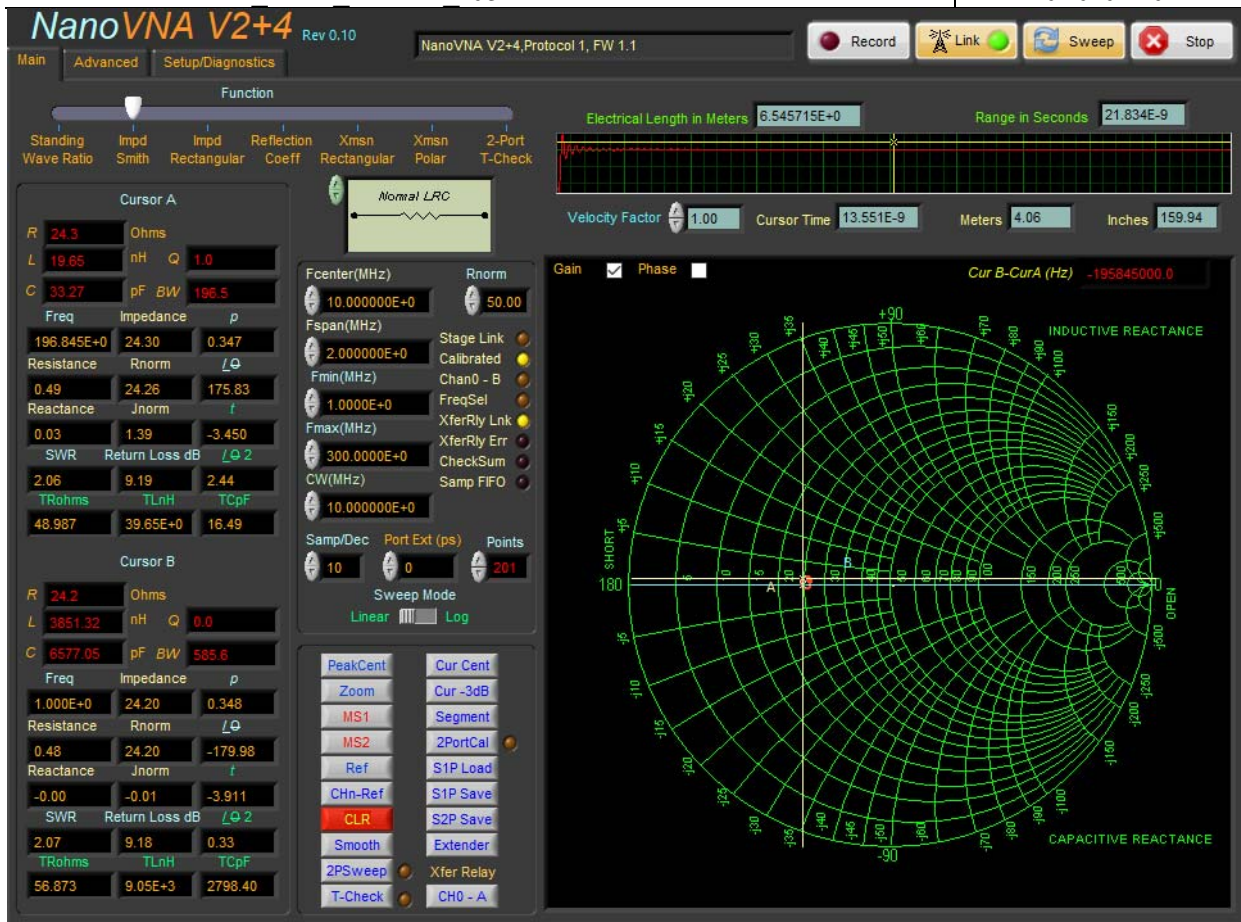
15.3 T-Check Testing 2 port calibration

The software supports using a T-Check as a means to ensure the calibration is valid. The T-Check is nothing more than a T with the stub terminated. For this example I am using some home made standards and T-Check

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to help remove any errors due to the fixtures. This is very doable at these low frequencies.

Once installed, you should see something close to 25 ohms as shown. Again saving a channel and then changing the state of the transfer relay should show very little difference.

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Next select the T-Check button. You will be prompted to install the T-Check adapter.

Install 50 ohm T-Check Adapter

OK
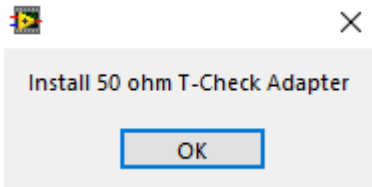
Select OK after you have everything ready. The software will then select the 2-Port T-Check function. You can also manually select it at anytime.   It will then run through a series of sweeps while automatically programming the transfer relay.

Once complete, you should see a graph similar to the following. Deviations of +/-10 are minor. You should not see more than +/-15%.

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15.4 2-Port Sweep

To run a 2-Port sweep, select the 2PSweep button. The software will sweep then automatically change the state of the transfer relay before collecting a second sweep.   Once complete, it will turn off the 2PSweep indicator. Select the Advanced tab and then the 2-Port Plot to view the data.

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15.5 Transco PN# 82152-70070200 Driver

The Transco relay requires 24V and is a latching type relay. A simple DC-DC converter was designed using a 7400 gate that boosts the USB voltage to 24V and charges a large capacitor. This capacitor holds the charge needed to drive the relay.

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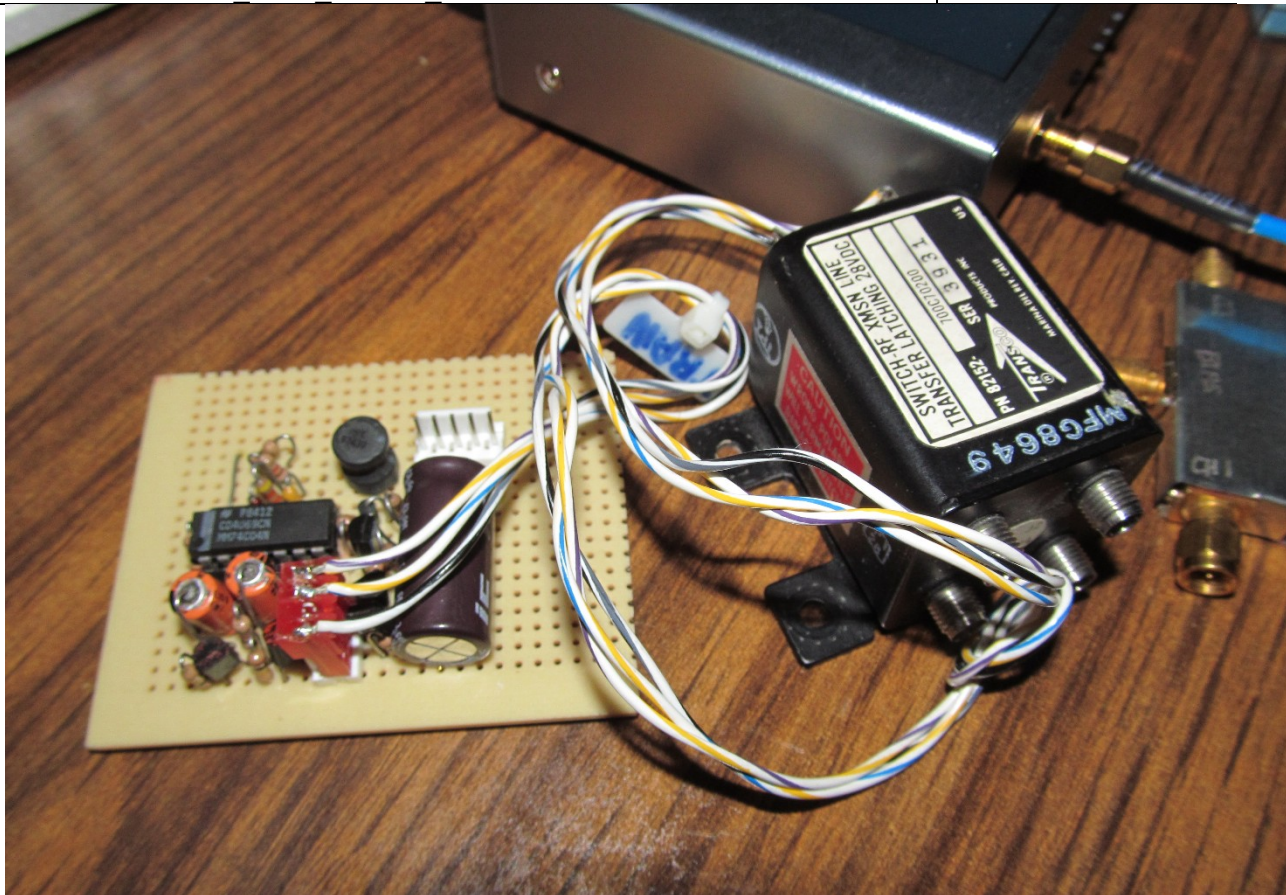
Shown below is the DC-DC converter made from a 7404 hex inverter. The two remaining gates are used to buffer the signals to drive the relay coils.   This is not meant as a reference to base your own design from. Rather this is what I put together with what I had on-hand.
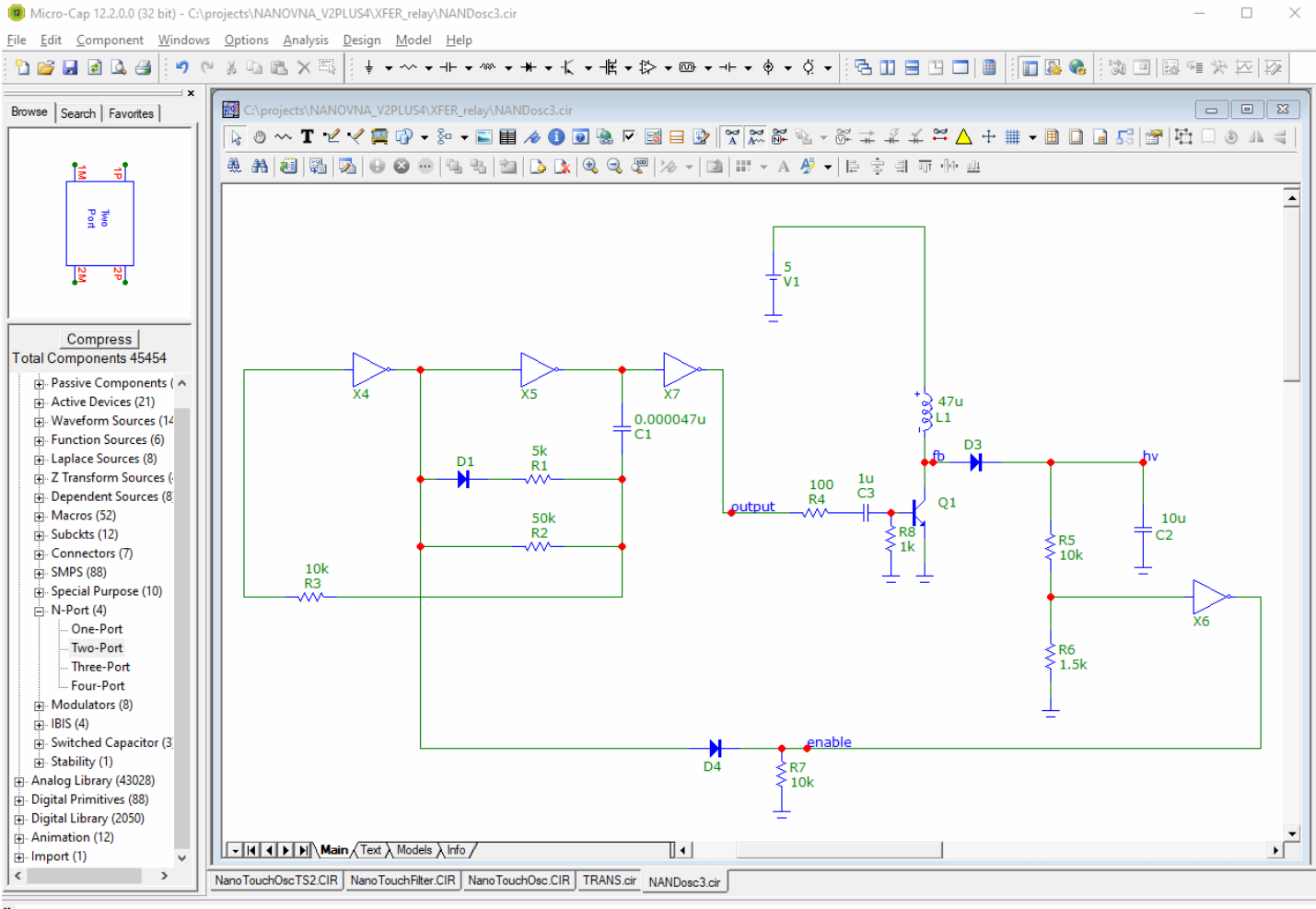
16. Up/Down conversion

Appendix A – Factory Settings and Parameters

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		FACTORY SETTINGS	
SETTING	RANGE		

Appendix B – Warranty

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