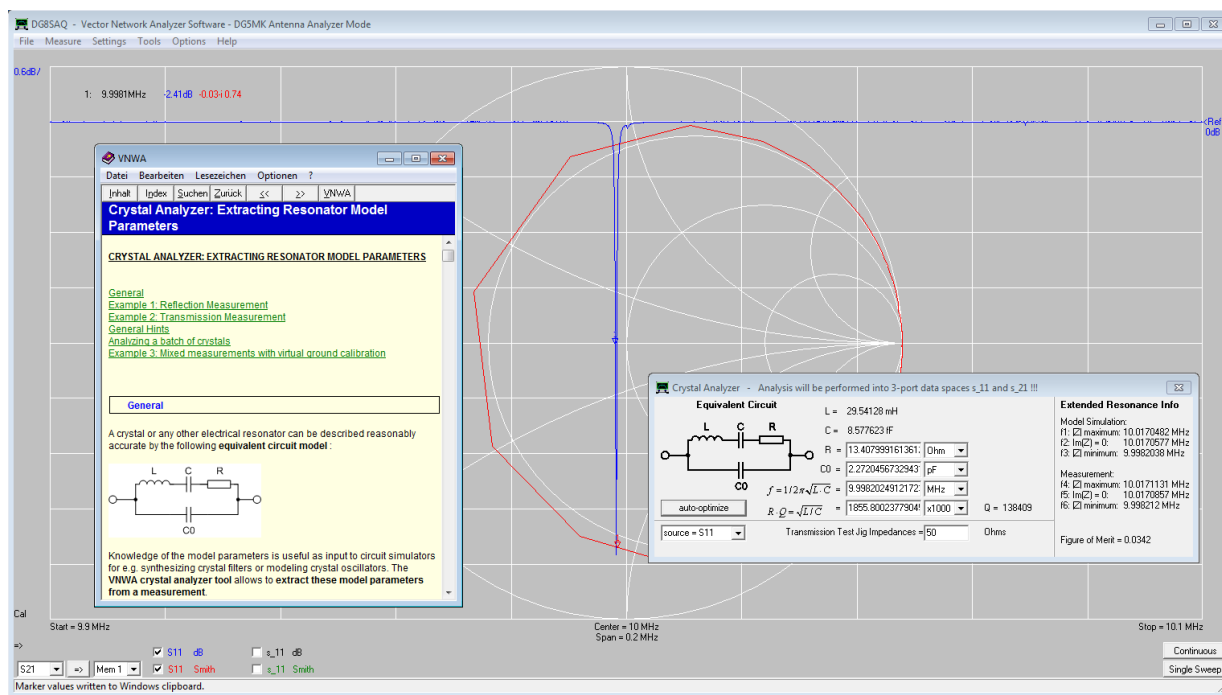


# Vector Antenna Analyzer FA-VA 5 – VNWA Connection and Usage

Michael Knitter – DG5MK

The last article described the new features of the FA-VA 5 compared to its predecessor. The use of the optional PC-USB connection together with the powerful VNWA-Software leads to a lot of new applications. The following paragraphs will describe how to install VNWA, connect the FA-VA 5 to the software, the principles of VNWA usage and some practical examples with a focus on HAM radio.



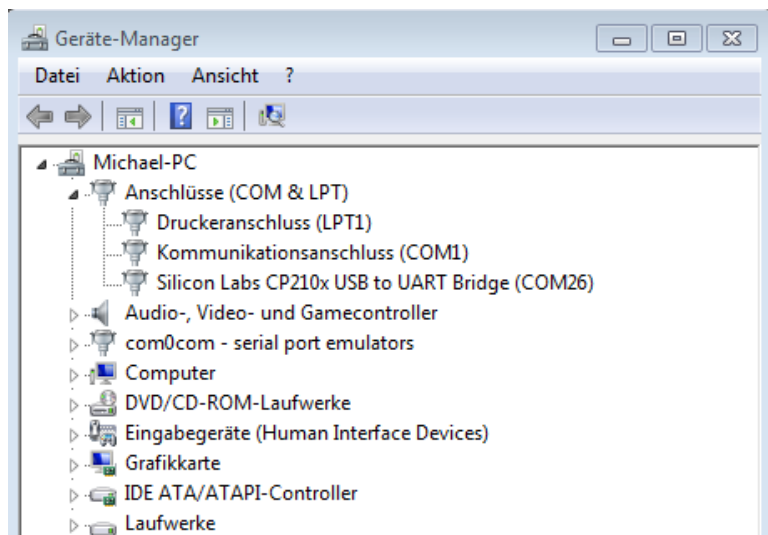
Picture 1: Analyzing a 10 MHz crystal with the integrated Crystal-Analyzer of VNWA

Defining the functionality and features of the FA-VA 5 it became very clear that a PC-USB connection does only deliver a lot of value if powerful and mature PC software will be available. Prof. Thomas Baier, DG8SAQ offered to use his VNWA-Software which has been build over many years to support the VNWA 3 hardware. This software is rich of features and mature in such a manner, that it satisfies also professional needs. In addition to the software there is a 600 pages help document available [1] which does not only describe all the features of VNWA, it is also a good introduction to the brought topic of vector network analysis. The following paragraphs will give an overview about usage and applications of VNWA. The manual of the FA-VA 5 will provide additional details and links to further readings.

## Software Installation

The installation of the USB driver starts with the first connection of the FA-VA 5 to the PC. The analyzer does not need to be switched on as the USB bus will

provide the analyzer with the needed power. Windows versions 7, 8, 10 were tested to automatically identify and load the correct driver from Silicon Labs. In case of any trouble the driver can be downloaded and installed from [2] manually. It is possible to confirm the successful installation of the driver with the Windows device manager. *Connections* (COM & LPT) should show the corresponding driver from Silicon Labs. Please also note the assigned virtual COM-port (COM26 in picture 2) as this information is needed later during VNWA setup. By the way, Windows assigns a virtual COM-port according to the USB-port used. If a different USB-port is used next time, the assigned COM-port will change.



Picture 2: Installed driver and assigned COM-port

The VNWA-software can be downloaded from [1]. VNWA-installer.exe is an executable file which does include all needed libraries for the FA-VA 5 connection. After downloading execute the file. The following installation procedure is menu driven and pretty much self explaining. All proposed information has just to be confirmed. A license-key is not needed to use the FA-VA 5 with VNWA. The corresponding question should be answered with *Next*.

After installation please start the program. There will be a warning which does not apply to the FA-VA 5, please respond with *ok*. The same respond please for the following hint.

VNWA does show up with a relatively clean main window. It states correctly that there is no VNWA hardware connected.

In case the grid is not clearly visible (this depends on the default background color of Windows), *Settings -> Diagrams -> Display -> Grid Options* does allow changing the background color. For the following pictures a dark grey is used.

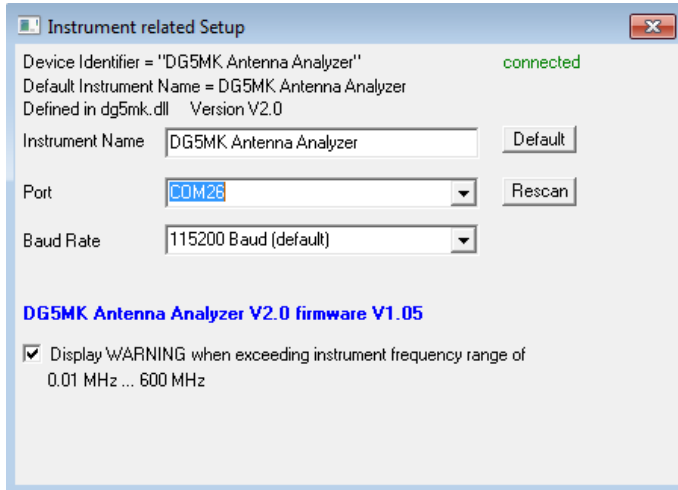
### FA-VA 5 Connection

To be able communicating with VNWA the FA-VA 5 has to be switched to USB-mode. This will happen automatically during USB-cable connection if the local setting under *Setup -> USB-auto-mode* was not changed. Anyway this can always be achieved via the main menu.

Now back to VNWA select *Options -> Select Instruments -> Add to/remove from Select List -> DG5MK Antenna Analyzer*. Now the FA-VA 5 is on the list of available instruments. The actual selection takes place via *Options -> Select*

*Instrument -> DG5MK Antenna Analyzer.*

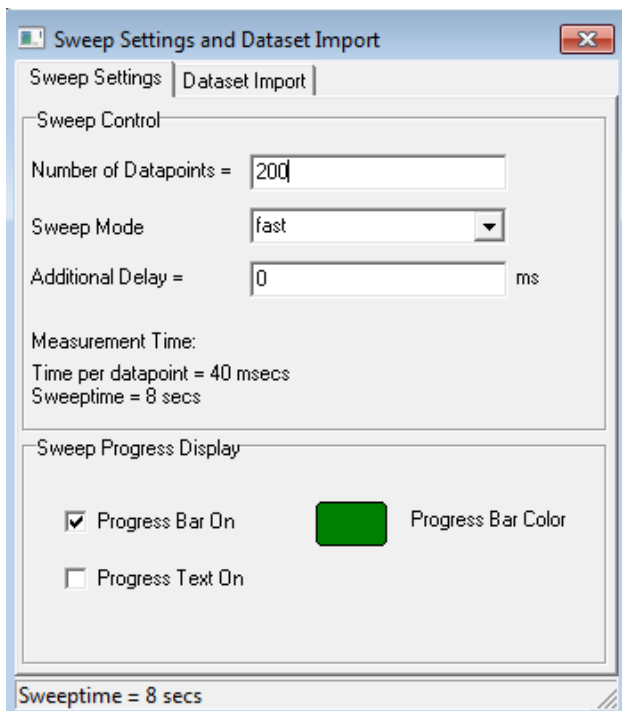
The last thing is to tell VNWA the assigned virtual COM-port for the analyzer. This has to be done via *Options -> Setup*. A new window will pop up and the assigned port has to be selected from the *Port* drop down list. If the connection to the FA-VA 5 is successful there will show up 'connected' top right and also the firmware version of the FA-VA 5 will become visible (picture 3).



Picture 3: Setup window confirming a successful connection to the FA-VA 5

This finalizes the connection of the FA-VA 5 to VNWA. The window may be closed. The software does store all settings after closing. For a new start of VNWA it does make sense to use the same USB-port as before to avoid any new setup. Besides the described connection setup there is only a second part which differs from the general VNWA. This part can be found under *Settings -> Sweep* (picture 4).

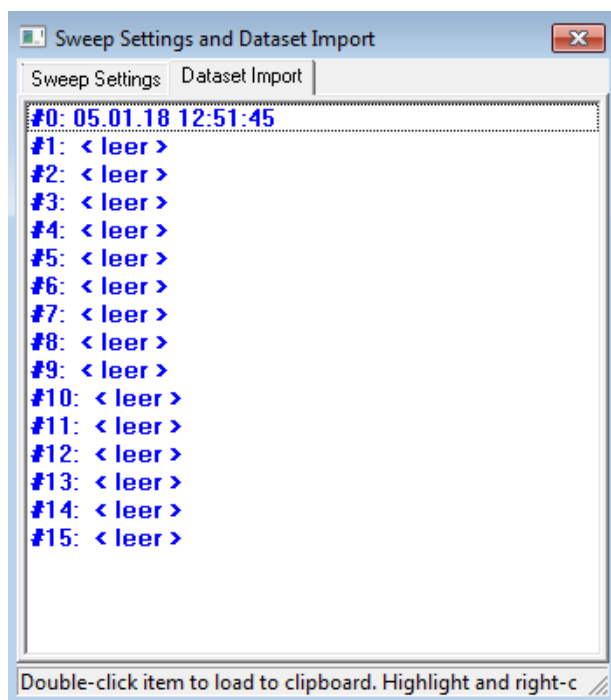
The second tab of this window does allow importing datasets from the local FA-VA 5 storage as described in the following paragraph.



Picture 4: Setup of some parameters for FA-VA 5 sweeps

### Import of FA-VA 5 datasets

After selecting the second tab *Dataset Import* there will be a window like picture 5.



Picture 5: Window to import datasets from the FA-VA 5 local storage

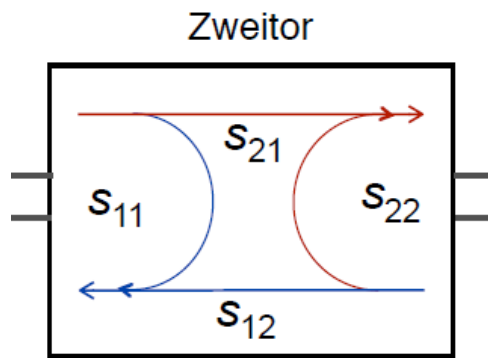
The listed records do correspond to the 16 available local records of datasets and timestamps in the FA-VA 5. Picture 5 shows just one dataset used, the rest is empty. A dataset can be selected with a left mouse click and following right click enables the user to store the dataset into the clipboard or into a file. Clipboard transfer may also be achieved via a double left mouse click.

Path and name of the file may be defined as needed. The format used is the popular Touchstone file format which is readable with any standard editor.

The following example uses the clipboard. After the described double left mouse click data will get transferred and the window may be closed.

The last step is to import the data from the clipboard into a VNWA memory space. Using the FA-VA 5 the relevant memory space is always S11 (see separate section about scattering parameters). The import itself can be achieved via a right mouse click on one of the S11-traces. In the main window of the freshly installed VNWA you will find such a trace bottom left in red (*S11 Smith*, picture 6). A right mouse click directly on S11 allows selection of *Import s1p -> from Clipboard*. The data will get transferred into the S11 memory space.

## *Scattering Parameters Start*



*Picture: 2-port linear network*

The used memory space  $S_{11}$  for the FA-VA 5 is part of a group of memory spaces of VNWA. According memory spaces are  $S_{12}$ ,  $S_{21}$  and  $S_{22}$  (not used here). The letter S stands for scattering parameter. These parameters describe the behavior of networks along values of waves. A 2-port network has 4 poles, an entry and an exit (like an amplifier). It can be measured what part of an incoming wave will get transferred to the output ( $S_{21}$ ), or what part of an incoming wave on the exit will be transferred to the entry ( $S_{12}$ ). In addition a part of the wave may be reflected on the entry ( $S_{11}$ ) or on the exit ( $S_{22}$ ).

The 4 parameters  $S_{11}$ ,  $S_{21}$ ,  $S_{12}$ ,  $S_{22}$  do describe a linear network completely, without knowing anything about what is inside the black box.

The VNWA-software was made for the VNWA-3-hardware which does have both a transmitting exit to measure reflections but also a receiver input to measure transfer of waves. Therefore that hardware can measure  $S_{11}$  and  $S_{21}$  (transmission). By switching entry and exit of the device under test,  $S_{12}$  and  $S_{22}$  can be measured as well.

Antennas and other elements with 2 poles do have just one electrical port.

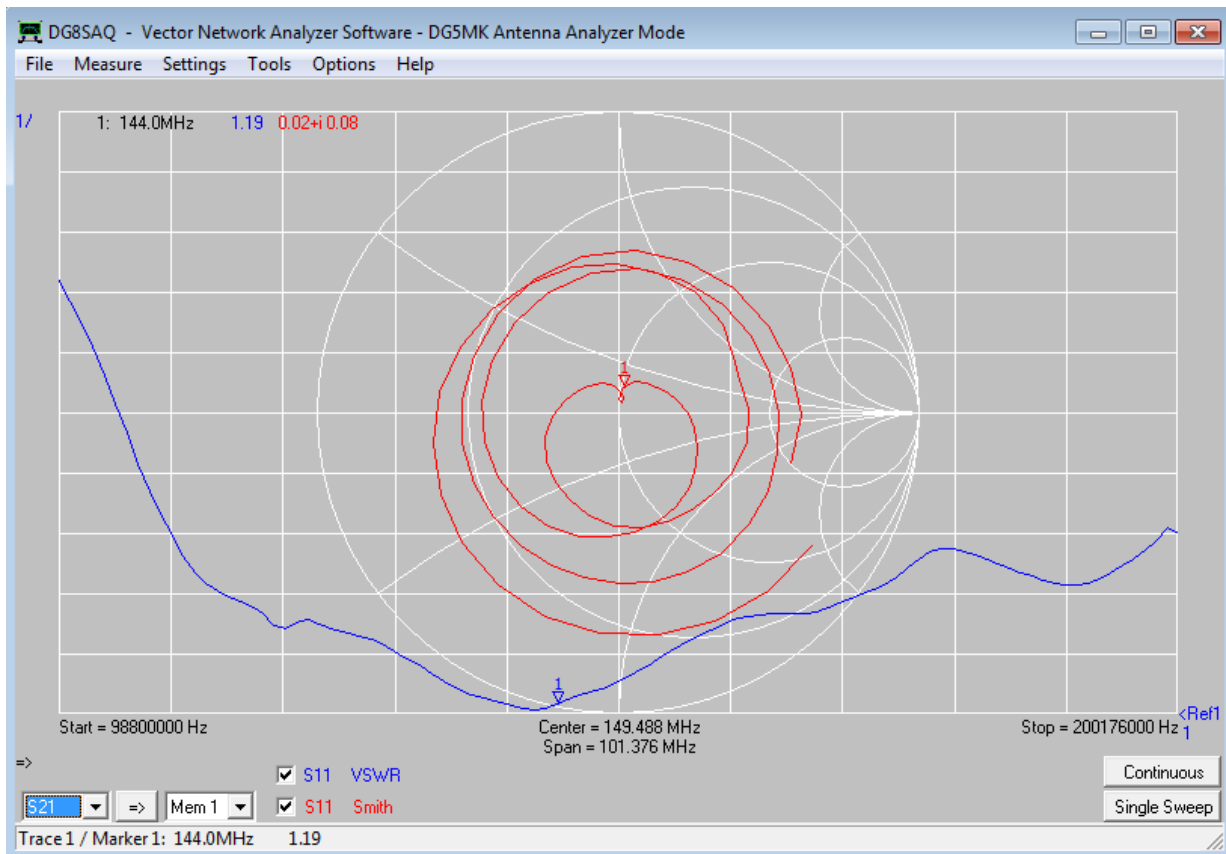
Therefore the FA-VA 5 does just have one measurement connector. Only  $S_{11}$  can be measured. This is the reason why  $S_{11}$  is relevant for FA-VA 5 measurements with VNWA.

$S_{11}$  is a complex reflection coefficient, made up of a real and imaginary component. A lot of other values can be derived from  $S_{11}$  like Standing Wave Ratio (SWR) and impedance Z. Very often those values will be displayed using a special chart type, the Smith-Chart. The Smith-Chart does allow solving a lot of matching problems graphically.

## *Scattering Parameters End*

As the name tells, the data gets formatted in a Smith-Chart. To add a SWR-view the following quick solution will work: Double mouse click on the adjacent  $S_{21}$  in blue. In the popup window change the memory space to  $S_{11}$  and the view to *VSWR* (voltage standing wave ratio). The locally measured SWR can be seen as a blue trace (picture 6).

For better readability a marker may be added. A right mouse click somewhere on an empty space in the grid allows selecting *Add Frequency Marker* -> *Normal*. The created marker 1 may be pulled left or right along the trace via left mouse click and hold. Top left values like corresponding frequency and SWR value are shown (same color as the trace).



Picture 6: Exemplary impedance and SWR traces based on a dataset import from FA-VA 5 after selecting SWR-view and addition of a marker at 144 MHz  
 At first glance this procedure seems to be complicated. In order to better understand the underlying structure the general principles of measuring with VNWA will be explained in the next paragraph.

### General Principles of Measuring with VNWA

Successful measurement with VNWA requires the knowledge of the general procedure of a measurement which consists of the following 4 steps:

1. Defining the measurement parameters like frequency span, duration of measurement, number of measurement samples, and accuracy of measurement.
2. Calibration of measurement instrument and setup towards the defined parameters.
3. Execution of measurement (with the FA-VA 5 the result are S11 scattering parameters in the S11 memory space of VNWA).
4. Defining view and calculation. This does include derived values from S11 like SWR and impedance but also very complex mathematical calculations.

Importing locally measured data from the FA-VA 5 does not need steps 1 to 3 as those steps are already done and 'included' in the data. The previous paragraph therefore was just about importing S11 data and selecting an according view. In opposite to an import of local data, VNWA is able to use the FA-VA 5 as a true USB-measurement-frontend. This leads to extended capabilities. In that case, all 4

described steps of the measurement principles have to be considered.

## FA-VA 5 as an USB-Measurement-Frontend

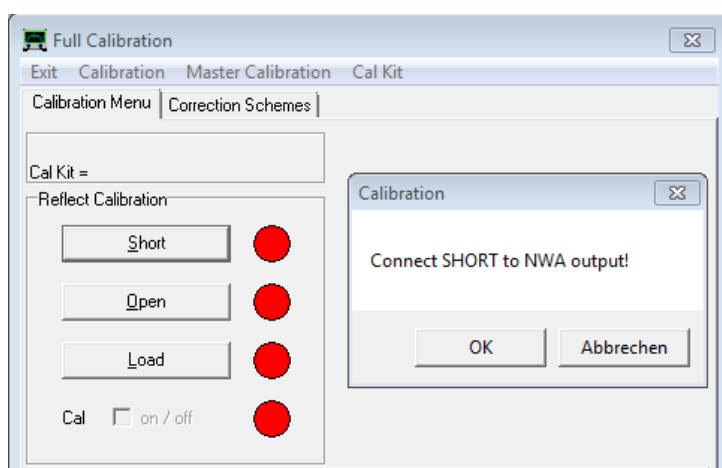
USB-measurement-frontend means that VNWA will handle the whole control and evaluation of a measurement. In simple terms, in that case the FA-VA 5 does only deliver measured voltages for a requested frequency. This allows, for example, freely defining the number of samples in opposite to the fixed 100 samples in local mode. Using the example of a simple antenna SWR measurement the procedure will be explained.

### *Step 1: Parameters of measurement*

First of all the measurement frequency and span has to be defined. This can easily be done in the VNWA main window (picture 6) with a double mouse click on the shown frequency values bottom left, mid or right. A pop up window (*Input*) will show up, to enter start and stop frequency. For the following example 10 MHz and 500 MHz are used (picture 9). Additional parameters are FA-VA 5 specific and may be entered in the already described window *Settings* -> *Sweep* (picture 4). Besides the number of data points (number of measurement samples) one out of 3 level of accuracy (fast, standard, precise) may be selected. On top of that an additional delay for each measurement may be defined. This can be important for measurement on low frequency filters as they need a relatively long time to arrive at a steady state. VNWA does calculate the resulting time for a sweep. For this example the window may be closed with all standard parameters unchanged.

### *Step 2: Calibration*

Calibration before measurement is mandatory. In contrast to the FA-VA 5 local modes there will be no calculation based on known values of used components in the signal chain. The topic of master calibration and others is covered in the help document [1].



Picture 7: Calibration window with request to connect Short to the measurement connector

To start the calibration *Measure* -> *Calibrate* opens a new window (picture 7). The current state of calibration is shown along 3 red circles. Red means no calibration.

A mouse click on the Short button will show up a new window which requests to connect the Short element to the measurement connector of the FA-VA 5. Once confirmed a measurement cycle will start. The red circle will turn green with a red M inside it. Open and Load has to be handled the same way. The window may be closed. In the bottom left part of the main Window of VNWA a Cal for calibrated should appear.

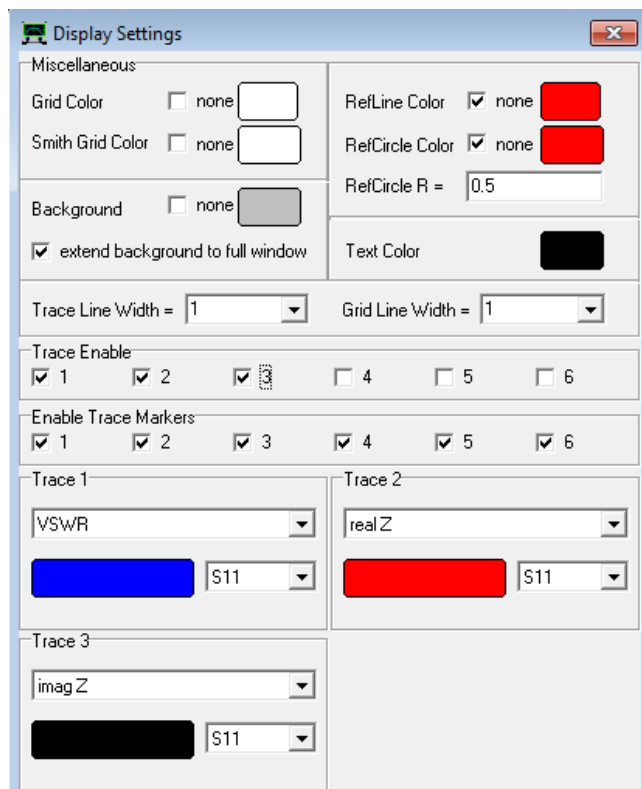
The advantage of this procedure is the exact calibration against the defined measurement configuration in both parameters but also hardware. A used extension cable will simply be calibrated into the measurement.

### Step 3: Execution of measurement

The measurement itself is as simple as possible. After connecting the device under test (here antenna Diamond MR77 with 3.5 m cable) the sweep can be started by clicking on the *Single Sweep* button bottom right in the main window of VNWA. The results are measurement data in the memory space S11. With the view settings from the previous example the picture should look like picture 9, a little bit like abstract art in the area of the Smith-Chart. By the way these forms are based on a low number of data points.

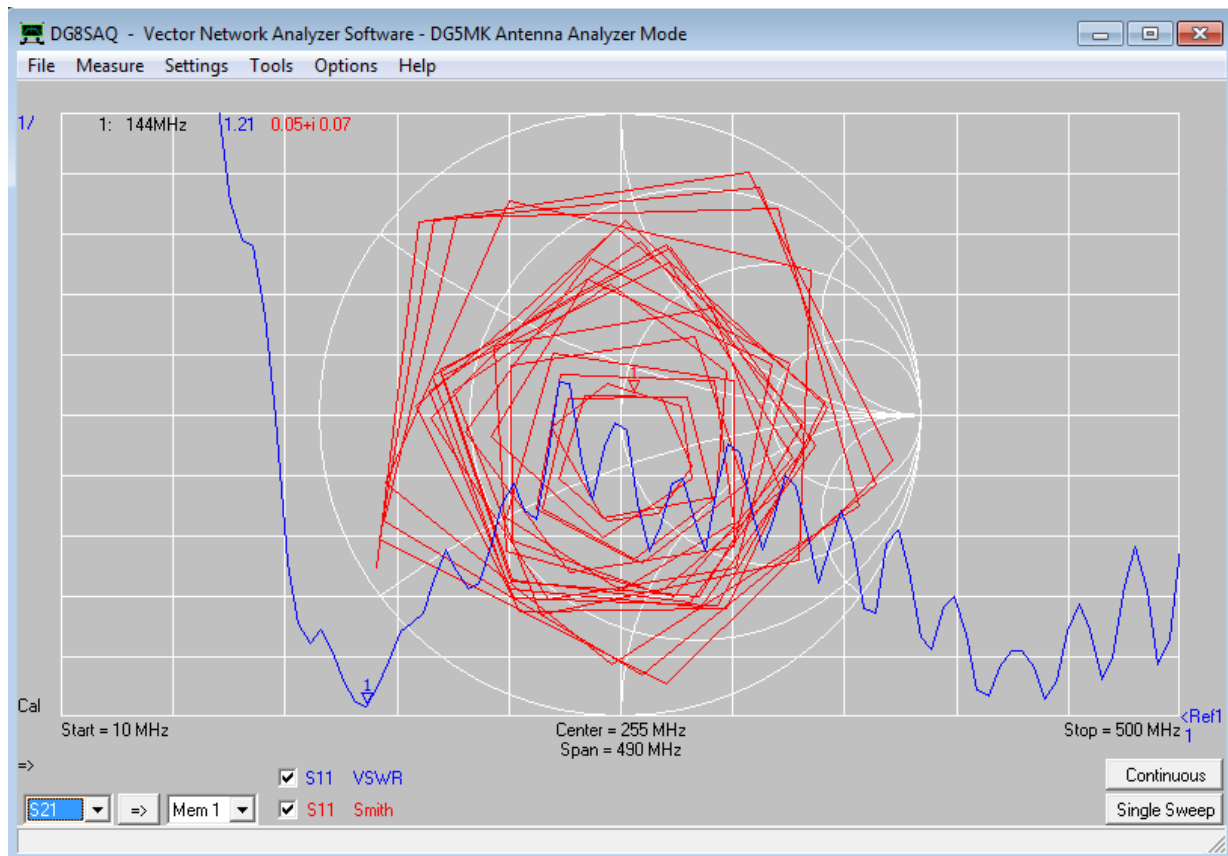
### Step 4: View and Calculation

One off the strong features of VNWA is an extended portfolio of views and measurement data evaluation. Up to 6 traces and corresponding calculation methodologies may be defined. A double mouse click on the colored S11 of an actual trace will open up a new window (picture 8).



Picture 8: Window *Display Setting* to set SWR (trace 1) and impedance (traces 2 and 3) to be calculated from memory space S11

This window allows to define in detail with traces should be viewable, their source (memory space) and the corresponding mathematical procedure (like VSWR). For the current example the settings from picture 8 should be used. 3 traces are enabled, all take the S11 memory space as the source and the calculation procedure is VSWR, real part of impedance and imaginary part of impedance.



Picture 9: Visualization of measuring a Diamond MR-77 mobile antenna before formatting; the somewhat angular forms are based on a low number of data points

The very last step is formatting the traces in the main window. Top left the scaling of each trace shows up. It defines to what extent the values of the trace do change by the grid spacing. On the right side the reference level of the trace shows up. Both values may be changed by a double mouse click on one of the values. A new pop up window does allow changing the values. The reference level may also be changed by click on the value, hold and shift.

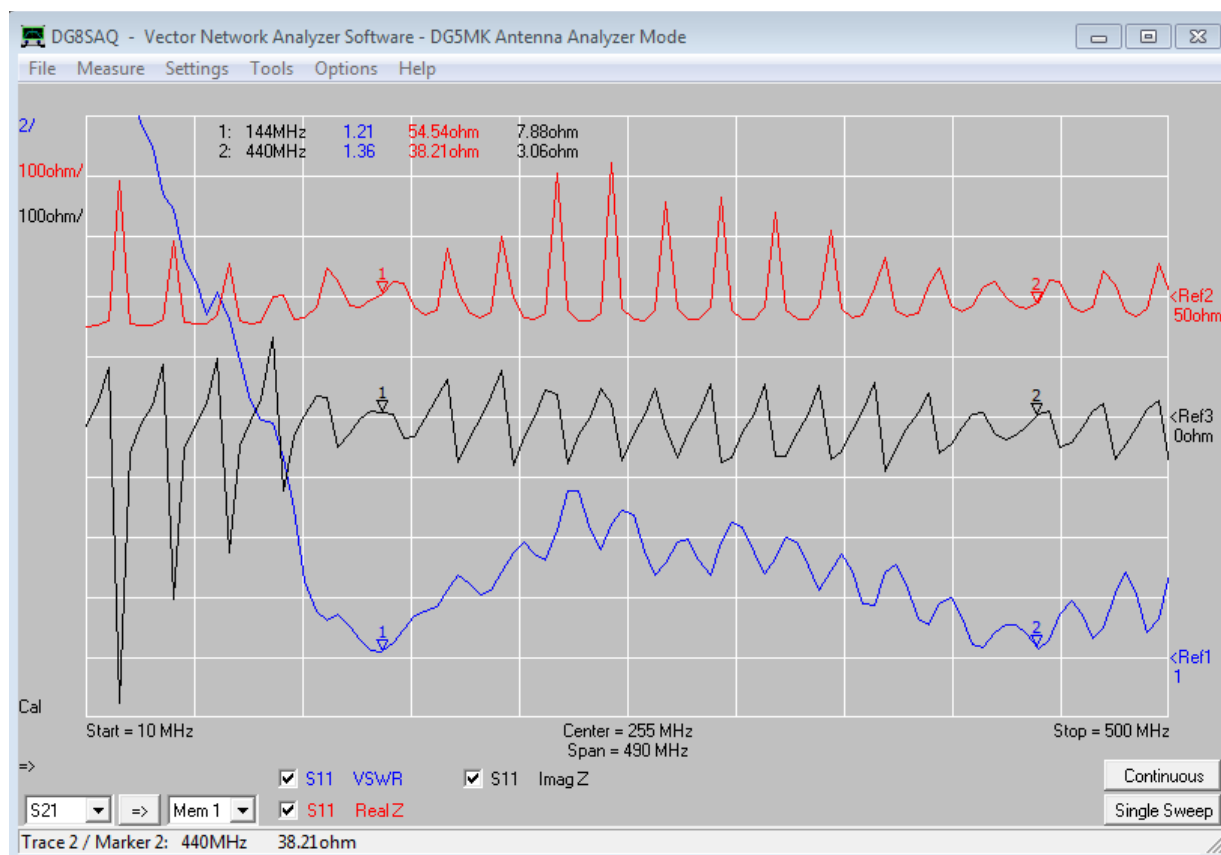
The high flexibility of scaling and positioning leads to a better readability. As long as both scaling and reference level are known the traces may be placed freely on the grid.

A very practical feature and a good first step in formatting is *Auto Scaling*. This can be reached via a left mouse click on the scaling values. A follow on setting to even scaling values fosters a better readability.

Last but not least markers help to increase readability of values along frequencies. A right mouse click in a free space inside the grid allows defining different markers. For the current example a second marker may be added via *Add Frequency Marker -> Normal*. Via click and hold the marker may be dragged along the trace towards the frequency of 440 MHz. A second way to achieve this is via mouse double click on the marker. The frequency value may be entered into

the pop up window.

The result is the formatting as shown in picture 10. Don't get confused by the ripple of the impedance. This is based on the transformational characteristic of the transmission line – antenna unit.

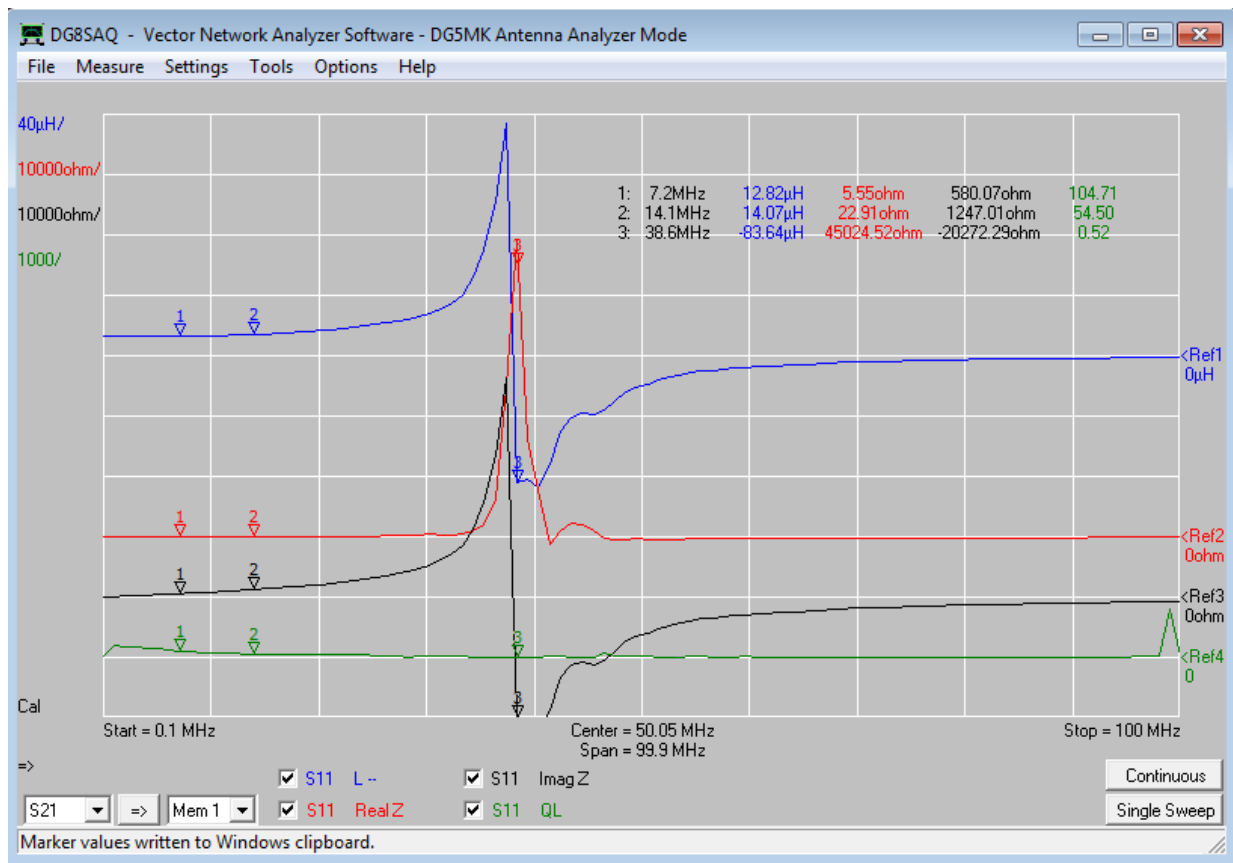


Picture 10: Impedance measurement on a Diamond MR-77 antenna for the 2m and 70cm band along 10 MHz to 500 MHz; markers at 144 MHz and 440 MHz do show SWR values of 1.2 and 1.4

### Measurement on Components

The procedure for measuring components is pretty much the same as measuring antennas. The only differences are changed calculation methodology and formatting.

Picture 11 does show such a measurement on a 12.6  $\mu$ H toroid inductor in the frequency range of 0.1 MHz to 100 MHz using accuracy mode *Precise*. After defining traces and formatting as shown it is an easy task to find out inductance and quality of the inductor in the 40m and 20m bands. Around 39 MHz there is a resonance. The inductor becomes a capacitor because of parasitic capacitance.



Picture 11: Measurement on a 12.6  $\mu$ H toroid inductor in the frequency range of 0.1 MHz to 100 MHz; clearly visible is the self-resonance around 39 MHz

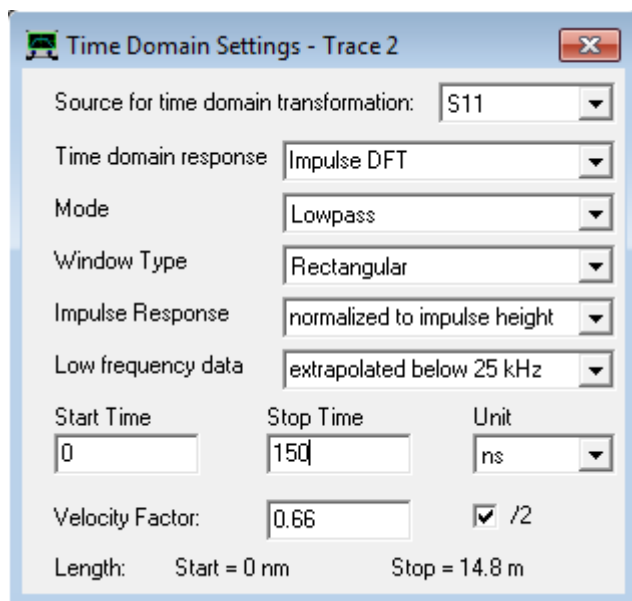
### Time Domain Reflectometry (TDR)

As a last example measurement of discontinuities in antenna cables will be discussed. VNWA does have extended capabilities for the so called Time Domain Reflectometry (TDR). The methodology is to measure values along frequency and transform them towards equivalent values along time. The mathematics for the methodology is quiet complex and is described in detail in the help document [1] starting page 446.

The following example requires preparing the measurement for the full frequency range of 10 kHz to 600 MHz with 1000 measurement samples and mode *Precise* as described in steps 1 to 3 discussed before. After calibration, the device under test has to be connected. Used here are 2 pieces of 5 m RG58 coax cable, connected with a BNC-BNC adapter and one end left open. The following sweep does result in measurement data in the memory space S11. 2 traces should be defined for viewing. One is the return loss of S11 in decibel. The second trace is a *Time* trace, again in decibel. Parameter settings for this time trace may be done via double mouse click on the colored *tim1* or *tim2* in the main window bottom left. A new pop up window will show up as shown in picture 12. All settings should be done as shown.

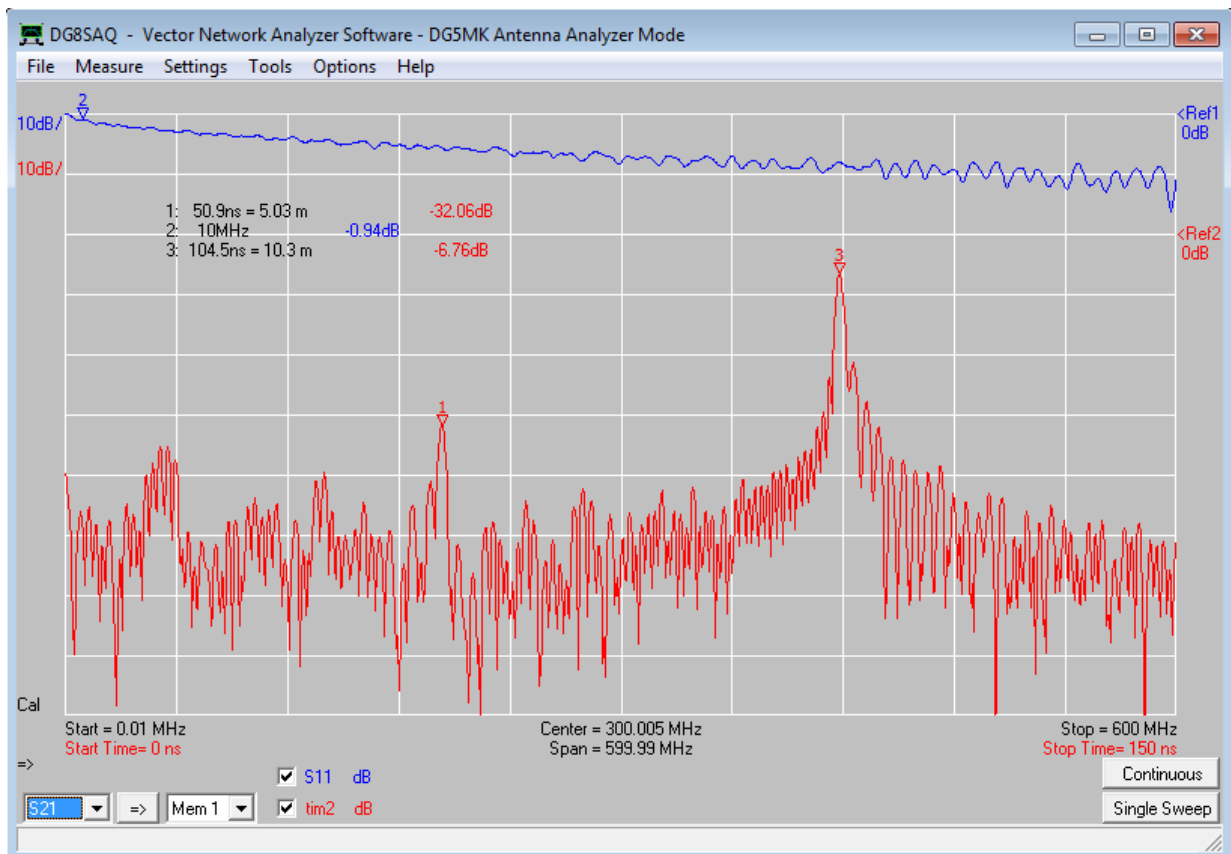
Using RG58 cable the velocity factor of 0.66 is fine. The defined time range of 0 to 150 ns allows evaluation of mechanical length up to 15 m as shown bottom right. After closing the window and corresponding formatting the plot should look like picture 13. 2 additional time markers were added via mouse right click in a free space of the grid and *Add Time Marker*.

An open end cable should reflect any incoming wave completely back to the entry. Therefore the return loss (blue trace) is directly the attenuation of the cable. 0.94 dB at 2 x 10 m are equivalent to 4.7 dB attenuation at 10 m length at 10 MHz. This matches quite good to attenuation values from RG58 data sheets. The red trace also expresses reflection of the incoming wave, but as the values were transformed to the time domain it shows reflection along mechanical length, based on the travel time of the wave. Marker 3 shows a maximum at 104.5 ns / 10.3 m. The attenuation is relatively high at 6.8 dB which corresponds to a strong discontinuity (open end of cable). Weaker discontinuities will result in lower maxima of attenuation. Marker 1 does show such a weaker discontinuity at 50.9 ns / 5.03 m. Obviously, this is the place where the 2 cables are connected with a BNC to BNC connector.



Picture 12: Window to configure a time trace

For practical evaluation of discontinuities on cables it may be better to terminate the cable with a value of the cable impedance. The more or less homogenous trace will show maxima in case of discontinuities. Using markers the place of the discontinuity can be evaluated easily and according actions can be done to solve the issue.



Picture 13: Time domain measurement of 2 connected RG58 coax cables with one end left open

## Summary

VNWA does include additional features. Crystals may be evaluated and their corresponding equivalent circuit can be characterized using the included *Crystal Analyzer* (picture 1). Calibration standards can be characterized arbitrary to exactly match the current measurement situation and measurement plane. Using the Smith-Chart and import and export of data is also a wide area to deal with. The help document [1] does help here with a lot of good information. All areas which correspond to any measurement on 2 poles / 1 port networks can be done with the FA-VA 5.

With the FA-VA 5 and VNWA the user does get a powerful combination of hardware and software for portable and stationary measurements on antennas and other 1 port networks which should cover even extended requirements. Once getting used to VNWA the user may get appetite for 2 port measurements and beyond. The corresponding VNWA 3 hardware should be evaluated as the price / performance ratio is outstanding. This hardware allows 2 port measurements up to 1.3 GHz.

## Literature

[1] Baier, T, DG8SAQ: VNWA Software. <http://www.sdr-kits.net> > *DG8SAQ VNWA 3 > Software & Documentation > VNWA Installer.exe*

[2] Download VCP-Driver: <https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcv-drivers> > VCP Driver

### ADDENDUM Written by OZ7OU

Since this article was written and forwarded to the German HAM magazine FUNKSAMATEUR for publishing in the May 2018 issue, some further news and developments has been finalized.

For the FA-VA5 the design for a high quality BNC 3 parts calibration kit has been finalized.

Thus some further vital information can to be informed about, regarding the design of the FA-VA 5 and its uniqueness on the market place.

1. The FA-VA 5 can, with excellent accuracy, be calibrated in local mode by using this BNC 3 part calibration kit, by once and for all, entering the calibration kit parameter for the short, open and load calibration kit parts, provided to the user when purchasing the 3 part BNC calibration kit. This is unique to the FA-VA 5 and a great feature.
2. When connecting the FA-VA 5 to the VNWA software, via the USB to PC connection, then the FA-VA 5, as described in the article, is handled as a measurement front-end hardware, and the calibration is no longer dependent of the local mode calibration but solely managed by the VNWA calibration procedures. This implies that in step 2 for the section **General Principles of Measuring with VNWA** above, the user must load a calibration kit file, which contain very complex parameters for the BNC calibration kit, with even greater accuracy than in local mode. This calibration kit file for the 3 part BNC calibration kit is directly downloadable by the user, after a purchase, as a code and link for download is also provided.
3. In near future a N calibration kit will be available from SDR Kits and by using a BNC to N adaptor to the FA-VA5 then suddenly is a N type antenna analyzer fully calibrated from the VNWA software, by loading the provided N calibration kit file. The N calibration kit will be available as a 4 part calibration kit, by addition of a female to female adaptor, to which the male short, open and load calibration parts is fitted, and thus be both a male and a female calibration kit, fully characterized by two calibration kit files provided when purchased.
4. Likewise the BNC calibration kit will be available as a 4 part kit, so being both a male and a female calibration kit, which implies when calibrated from the VNWA a male-male test cable can be fitted to the FA-VA 5 and calibration taken place at the end of the test cable, using the female kit.
5. All these topics will be further described in the provided user manual for the FA-VA 5.

Where to find information about this product ?

The FUNKAMATEUR On-Line Shop has already information with pricing and shortly SDR Kits will also shortly announce, as indicated on the web shop when studying the Webshop closely under BNC parts. The 3 parts BNC kit already on stock.

Find more information about the FA-VA 5 on the link <http://www.box73.de/> and [http://www.box73.de/product\\_info.php?products\\_id=4019&XTCsid=45510c2736b20d2ae170e185d95c8523](http://www.box73.de/product_info.php?products_id=4019&XTCsid=45510c2736b20d2ae170e185d95c8523)

Three 3 part BNC calibration kit is part number BX-254-SOL at the link [http://www.box73.de/product\\_info.php?products\\_id=4020](http://www.box73.de/product_info.php?products_id=4020)

Or on SDR Kits webshop where the 4 part BNC kit shortly will be announced [https://www.sdr-kits.net/index.php?route=product/category&path=66\\_68\\_90](https://www.sdr-kits.net/index.php?route=product/category&path=66_68_90)

End of addendum

22.05.2018 Kurt Poulsen

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