Vector Antenna Analyzer FA-VA6

Kit for an easy-to-use vector antenna analyzer for the frequency range from 10 kHz to 1 GHz

Construction and operating instructions

Version English 1.0 23.06.2025

Foreword

Thank you for choosing the FA-VA6! The FA-VA6 is a high-quality measuring device that can be used for many amateur and professional measuring tasks. The application goes far beyond tuning antennas. For example, the length and various parameters of cables can also be determined, electronic components can be tested for their suitability at target frequencies and the proper functioning of antenna feed lines and other cables, including adapters, can be verified.
The FA-VA6 is aimed at both beginners and professional users. Beginners can carry out standard measurements immediately after installation, as the FA-VA6 is factory-calibrated. Professional users have a wide range of adjustment and calibration options.
Operation of the FA-VA6 is completely intuitive. A first-class user interface with a professional keyboard and a bright, high-quality display is complemented by software with uninterrupted, fluid interaction. The comprehensive VNWA software is available for the documentation of measurement results, but also for very advanced measurements and analyses, and should leave nothing to be desired.
The FA-VA6 uses a high-energy Lithium-Ion battery*, which results in a long runtime. Please read the safety instructions for handling Lithium-Ion batteries!
The device should be assembled quickly, as only a few components need to be soldered and mounted. You can then get started straight away, see the Quick start chapter. Many things can simply be tried out. The FA-VA6 is designed as a robust device. Incorrect operation cannot lead to damage. Only in the event of an external signal or external voltage at the measuring socket is a little more caution required.
If you have good ideas for further applications, preferably linked to the mathematical principles, then you are welcome to address them to *dg5mk@darc.de*. We will then try to implement them with a new firmware version if necessary.

We hope you enjoy using your FA-VA6!

* Due to transport restrictions imposed by our logistics service provider regarding hazardous goods, delivery with lithium-ion-battery is only possible within Germany. For users outside Germany, the FA-VA6 without battery is available under order number BX-246-A.

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Safety instructions

- The rechargeable battery used must not be short-circuited under any circumstances! Lithium-Ion batteries generate high short-circuit currents. There is an acute risk of fire.
- The FA-VA6 is a sensitive measuring device and is designed for measuring passive components. Electrostatic charges on non-earthed antennas must be discharged by short-circuiting to earth before measurement. If an antenna is connected, do not transmit in the immediate vicinity, as coupling via the connected antenna could damage the measurement input.
- The FA-VA6 generates a measurement signal with relevant strength, which may be emitted via connected measurement objects such as antennas. Measurements should therefore be limited to the required level.
- The charging and protection electronics of the FA-VA6 are designed for the battery type specified in the technical data. The use of other accumulators can lead to damage to the device or accumulator. Batteries with a lower capacity may overheat if the charging current is too high. There is a risk of fire. Batteries with a lower end-of-charge voltage may be overcharged, which in turn may cause overheating with the risk of fire.
- The rechargeable battery used must only be charged in the FA VA6, as external chargers may not be designed for the specific type of rechargeable battery.
- If the rechargeable battery used shows mechanical deformation or damage of any kind, it must be disposed of properly and replaced with a new rechargeable battery of the same type.
- The FA-VA6 should only be stored and operated within the temperature ranges specified in the technical data.
- The FA-VA6 is designed for storage and use in dry environments only.
- For proper disposal of the device or the battery used, use the disposal points available.

Technical data

Table 1: Technical data

Component	Remark
Frequency range	10 kHz to 1 GHz (resolution 1 Hz)
Measurement result *Single Frequency*	SWR, scattering parameter S11, magnitude and phase S11, return loss, mismatch loss, impedance Z by real and imaginary part, magnitude and phase of the impedance, resistance, capacitance, inductance and quality for series and parallel equivalent circuit model of the impedance
Measurement result *Multi-frequency*	SWR, impedance Z by real and imaginary part, scattering parameter S11 as Smith chart, scattering parameter S11 in dB, all values from single frequency at the position of the marker
Measurement result *5-band*	SWR
Length ranges *Time Domain (TDR)*	6.3 m, 12.6 m, 25.3 m, 50.6 m, 101.3 m, 202.7 m (with velocity factor 0.66)
Measurement result *Time Domain (TDR)*	Impulse response over length, impulse response in dB over length, step response over length, step response magnitude of impedance over length
Time Domain resolution (TDR)	Adjacent interference points: 0.5 ns, corresponds to 0.1 m at VF = 0.66 Individual interference points: < 0.05 ns, corresponds to 0.01 m at VF = 0.66
Current applications	Cable length according to known velocity factor Velocity factor according to known cable length Characteristic impedance of the cable (characteristic impedance) Cable attenuation at 10 MHz, 30 MHz, 50 MHz, 100 MHz, 200 MHz
Display	320 × 240 2.8" IPS TFT color display with 1000 cd/m^2 brightness, refresh rate (depending on application) 60 - 120 Hz
Dynamic range measuring chain	In each case up to 200 MHz, 200 MHz to 600 MHz, 600 MHz to 1 GHz Precise mode:> 80 dB / 69 dB / 57 dB Balanced mode: 80 dB / 64 dB / 54 dB Fast mode: 80 dB / 60 dB / 51 dB
Frequency stability	0.5 ppm
Signal processing	24-bit ADC, 32-bit DSP, 64-bit calculations
Measurement input	BNC socket 50 Ω

Component	Remark
Output signal	rectangular $f = 1$ MHz, R load = 50 Ω $P_1 = 3.2$ dBm (1st harmonic, fundamental) $P_2 = -6.4$ dBm (3rd harmonic) $P_3 = -10.9$ dBm (5th harmonic) $f = 200$ MHz, R load = 50 Ω $P_1 = 2.1$ dBm (1st harmonic, fundamental) $P_2 = -10.0$ dBm (3rd harmonic) $P_3 = -17.6$ dBm (5th harmonic)
Firmware	New versions free of charge, update via USB
Operating current and times	260 mA, approx. 12 h, 100 % brightness 165 mA, approx. 19 h, 50 % brightness 130 mA, approx. 24 h, 30 % brightness approx. 42 µA, switched off state incl. real-time clock
Currently supported languages	German, English
Power supply	Lithium-Ion industrial cell 18650
Accumulator type	Panasonic NCR18650BD 3.6 V 3180 mAh
Accumulator protection	Against reverse polarity, overcharging, deep discharge, short circuit, charging outside the operating temperature range
Accumulator charge	Via USB and built-in CI-CV charge controller with load balancing, simultaneous operation of the device possible
Operating and storage temperature	-20 °C to 60 °C
Dimensions	135 mm × 85 mm × 28 mm (L × W × H), without keypad and BNC socket
Weight	270 g incl. battery

We reserve the right to make technical changes to the device and the resulting changes to the technical data.

Building instructions

The FA-VA6 kit consists of just a few individual parts, meaning that it can be assembled by an experienced user in a short space of time. The circuit board, keypad and display are already pre-assembled and fully tested for functionality, including the enclosed measurement protocol.
The enclosed kit for SOL calibration elements only needs to be assembled if required. Alternatively, you can purchase ready-made SOL calibration elements. A high-quality set of SOL calibration elements is available from the supplier of the FA-VA6, which is individually measured and whose parameters can be entered in the FA-VA6. Finally, the FA-VA6 can also be operated without calibration elements, as it already contains a factory calibration. However, calibration elements are required to use some advanced functions.
It is recommended that you first check the completeness of the kit using the parts list in the appendix and familiarize yourself with the overall assembly sequence.

Figure 1 shows a fully assembled FA-VA6 when switched off.
Available supplements and help on structure and operation are published on the websites of the provider [1] or the developer [2] as required.

Tools required

In addition to the kit components, the following are required for assembly:
- a temperature-controlled soldering iron of medium power (60 W to 80 W)
- lead-free solder 0.5 mm to 1 mm with flux core

Building the enclosed SOL calibration elements, the following components are also required for assembly:
- electronics side cutter
- flat nose pliers
- small slotted screwdriver

Disassembling the circuit board

For transportation, the circuit board is inserted into the housing and secured with screws. Then remove the screws from the top shell of the housing using the bit insert

Figure 1: Assembled FA-VA6

provided. After removing the top shell of the housing, use the enclosed bit insert to remove the screws securing the circuit board. The circuit board is now folded upwards, starting with the side of the USB socket. To do this, disengage the USB socket from the lower part of the housing. This is done by pressing lightly with your thumb outwards against the bottom wall of the housing. As soon as the USB socket is free, the circuit board can be folded upwards and removed from the housing.

Preparation of the housing

The housing consists of a printed upper shell and a lower shell, which are joined together by four countersunk screws.
First, slowly remove the protective film from the bottom shell, if still present, starting at one corner. Due to the laser cut, protective film residue may remain on the edges. These can be easily removed with a cotton cloth or disposable wipes using a multi-purpose oil such as WD-40. Contact of the cleaning agent with the print on the upper shell should be avoided, as the agent could possibly attack the print. Furthermore, the cleaning agent could possibly remove the already glued-in insulation buffers on the underside of the upper shell. The insulation buffers are safety-relevant, see below, and must not be removed under any circumstances! The lower shell and, if necessary, the upper shell should then be thoroughly cleaned under running water using a commercially available detergent and then dried.

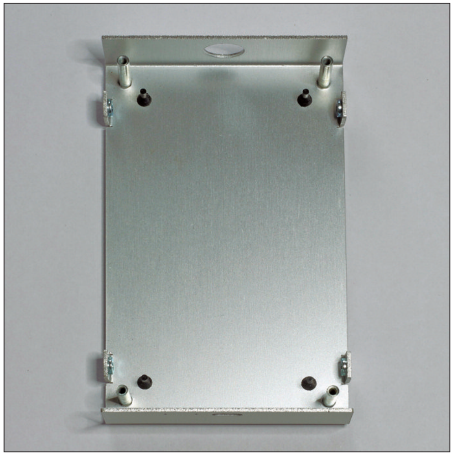

Figure 2: Lower shell with mounted rubber feet

The rubber feet must now be fitted to the housing. To do this, insert them into the holes in the lower shell from below with the pointed side first and then snap them into the holes by pulling firmly on the pointed side with your finger or pliers. Figure 2 shows the lower shell with the rubber feet fitted.

Soldering the battery holder

The circuit board must be completed by soldering in the battery holder. If not already done, this must be inserted on the front of the circuit board. The position is clear due to the locking knobs on the socket. Light pressure at both ends of the holder snaps it into the circuit board. Figure 3 shows the front of the circuit board after inserting the battery holder. The connections to be soldered are located to the left and right of the keypad.

Figure 3: Front of the circuit board with inserted battery holder

The solder connections of the battery holder are shortened so that they do not protrude beyond the circuit board. This is due to the need for insulation from the metal housing. As already mentioned,

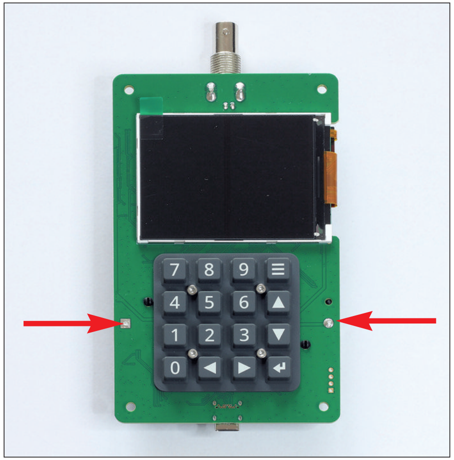

Figure 4: Front of the circuit board with soldered battery holder

plastic insulation buffers are glued into the top shell of the housing. Both measures ensure that there is no direct contact between the housing and the battery terminals.

Therefore, the solder joints of the battery holder must be relatively flat. The respective pad on the circuit board is heated with a soldering iron. By feeding solder into the hole of the pad, the tin flows into the pad and connects to the connections of the battery holder. Stop feeding the tin as soon as the pad is filled. Figure 4 shows the front of the circuit board after soldering the battery holder.

■ Inserting the accumulator

Caution! The terminals of the lithium-ion battery must not be short-circuited under any circumstances! A short circuit leads to an acute fire hazard!

The battery must be inserted into the battery holder with the correct polarity. The positive pole is clearly marked both on the battery holder and on the circuit board. On the battery itself, note the polarity at the lettering "+NCR18650-". The large black bars are NOT the negative terminal! The negative pole of the accumulator can also be identified by the large flat metal side. The positive terminal is smaller and has an insulating disk.

Light pressure snaps the battery into the holder. The FA-VA6 has protection against reverse polarity of the battery. If the battery has been inserted the wrong way round, it should be carefully removed from the holder by levering it out with your fingernail or a plastic tool and then inserted with the correct polarity.

After inserting the battery, the poles of the battery, the connections of the battery holder and the corresponding pads on the back of the circuit board must be regarded as critical points. These must not be connected to ground or other metal parts. The FA-VA6 has a battery protection circuit in the ground path. The negative pole of the battery is therefore NOT the same as ground of the circuit board and the housing. The circuit board itself and its ground are largely protected by the protective circuit.

Mounting the circuit board

The circuit board is installed in the reverse order to the disassembly described above. The circuit board is inserted from above into the lower housing shell with the BNC socket first and lowered. The USB-C socket touches the lower edge of the lower housing shell. To assemble, the lower plate of the lower housing shell is again bent away slightly by pressing outwards with the thumb so that the USB socket can snap into the recess.

The circuit board is then loosely fastened using the four cylinder head screws with the aid of the enclosed bit insert. After placing the washer and moderately tightening the nut of the BNC socket by hand, the four cylinder head screws can be tightened a little more. As a rule, a slight tightening by hand is completely sufficient.

After removing the display protection film, the top shell of the housing is placed in position and fastened using the four countersunk screws and the enclosed bit insert. Here, too, it is usually sufficient to tighten them lightly by hand.

Commissioning

As described above, the FA-VA6 has a protective circuit for the accumulator. After inserting a rechargeable battery for the first time, the protective circuit is locked for safety reasons. To unlock it, the FA-VA6 must be supplied with power once via USB cable.

As Lithium-Ion batteries are stored pre-charged, the FA-VA6 is immediately ready for mobile operation after unlocking the protective circuit. Note: When the battery is inserted for the first time and then charged, the built-in electronics require up to several hours to correctly display the charge status of the battery.

In any case, the FA-VA6 starts with the start screen and goes to the *Main menu*. Due to the factory calibration, a measurement can be started immediately, see next section *Quick start*.

Operating instructions

■ Quick start

The standing wave measurement (SWR) on an antenna for the 70 cm band is shown as an example. The antenna is connected to the BNC socket.

Navigation

Navigation follows the established standard with four arrow keys ◀ ▶ ▲ ▼, an enter key ↵ and a menu or back key ☰.

Switch on

The FA-VA6 is switched on by pressing the button ☰ After a short time, the *Main menu* appears as shown in Figure 5. Any necessary language change is described in the next section.

Language change

The FA-VA6 is supplied with the *English language* setting. Switching to the *German language* is done as follows: In the *Main menu*, select *Settings* with the ▲ ▼ buttons and confirm with the ↵ button. Then use the ▲ ▼ buttons to select *Language* and press the ↵ button to confirm. Use the ▲ ▼ buttons to select *German*. Press the ☰ button several times to return to *Main menu*.

Selection of multi-frequency operating mode

Use the buttons ▲ ▼ to select *Multi Frequency* and press the ↵ button. The display shows the SWR over a previously set frequency range according to Figure 6, in this case the total frequency range of the FA-VA6. The areas highlighted in blue show the amateur radio bands of the selected IARU region. Correspondingly small SWR values can be seen in the 2 m band and 70 cm band. The 70 cm band will now be examined in more detail.

Adjustment of the frequency range

An information bar is displayed in the lower area, which shows the most important available buttons and their actions. The 7 button shows and hides a help function for all possible buttons and their actions. Press the 3 button to open the mode configuration, see Figure 7. To set the frequen-

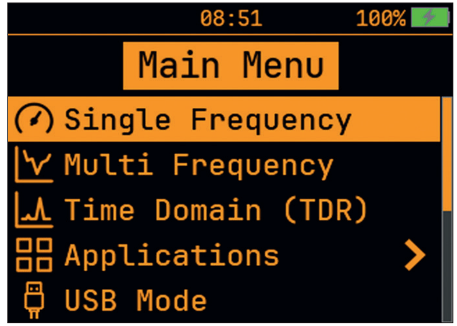

Figure 5: ***Main menu*** **after switching on**

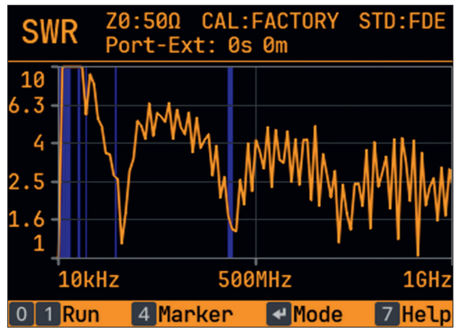

Figure 6: Multi Frequency display with total frequency span

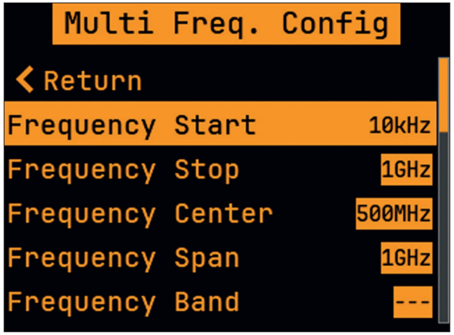

Figure 7: Multi-frequency configuration

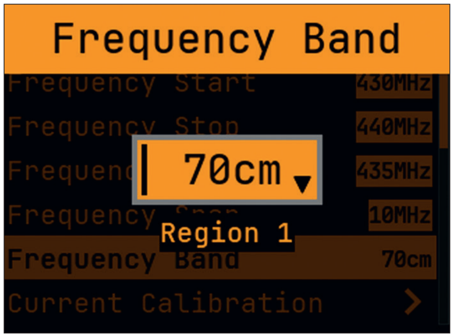

Figure 8: Selection of the 70 cm band

cies via a frequency band, use the ▲ ▼ buttons to select Frequency band and press the ↵ button. Figure 8 shows the selection of the band, which in turn was selected using the ▲ ▼ buttons. The configuration is exited by pressing the ≡ button twice, a new measurement run starts automatically and the SWR display appears again, but now for the desired frequency range (see Figure 9).

Reading the values

The x-axis of the diagram shows the frequency range, the y-axis the display range of the SWR values. For more precise values, a marker function can be used, which is activated and deactivated using the 4 button. Figure 10 shows the display with activated marker, shown as a white circle. The marker can be moved along the measurement curve using the ◀ ▶ buttons. The exact frequency at the position of the marker and the corresponding SWR value are now displayed in the upper area. Obviously, the antenna has the minimum SWR of 1.02 at approx. 434.4 MHz. The SWR can be further optimized or shifted by adjusting the antenna, see its instructions. To check this, a new measurement run can be started using the 0 button. Alternatively, a continuous measurement can be switched on and off using the 1 button.

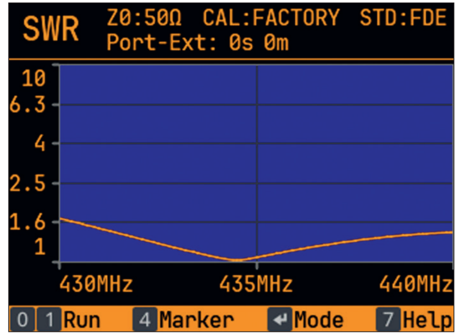

Figure 9: *Multi-frequency* display with the frequency limits of the 70 cm band

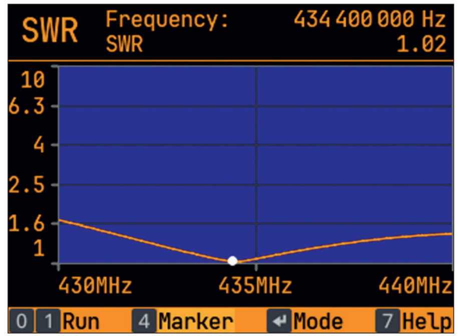

Figure 10: *Multi-frequency* display for the 70 cm band with activated marker

Switching off the FA-VA6

The FA-VA6 is switched off by pressing and holding the ☰ button. Set parameters are saved automatically.

Getting to know the FA-VA6

For optimum use of the FA-VA6, it makes sense to familiarize yourself with the basic operating principle of the device. This is followed by an examination of the device and its basic operation.

Functional principle

Figure 11 shows the basic functional principle of the FA-VA6.

A signal generator produces a signal (outgoing wave, e.g. sine wave or square wave) of a specific frequency, which is fed to the BNC socket via a measuring bridge. The measurement object, e.g. an antenna, is connected to the BNC socket. If an antenna is well matched to the source system (for the frequency in question), almost all of the signal's energy is radiated or partially converted into heat. If the antenna is not optimally matched, part of the fed-in signal is reflected and runs back to the BNC socket as a reflected wave, and thus to the FA-VA6.

A consideration of the ratio of the reflected to the incident signal, or the reflected to the incident wave, therefore says something directly about how well the antenna is matched. The ratio of the waves is also referred to as the gamma reflection factor or scattering parameter S11. If S11 is close to zero, the antenna is optimally matched. The return wave is minimally small. S11 close to zero would lead to an SWR of almost one via a calculation.

The FA-VA6 can measure and evaluate reflected and incident waves separately and calculate values such as the standing wave ratio SWR or the impedance Z from them. It does not matter whether the test object is an antenna, a component or a cable. The scattering parameter S11 (reflection factor) is always measured and this is mathematically evaluated.

If only the ratio of the amplitudes of the reflected wave to the incident wave is measured, this is the magnitude of S11. Such devices are also referred to as scalar analyzers. However, important information is lost in such an analysis. The reflect-

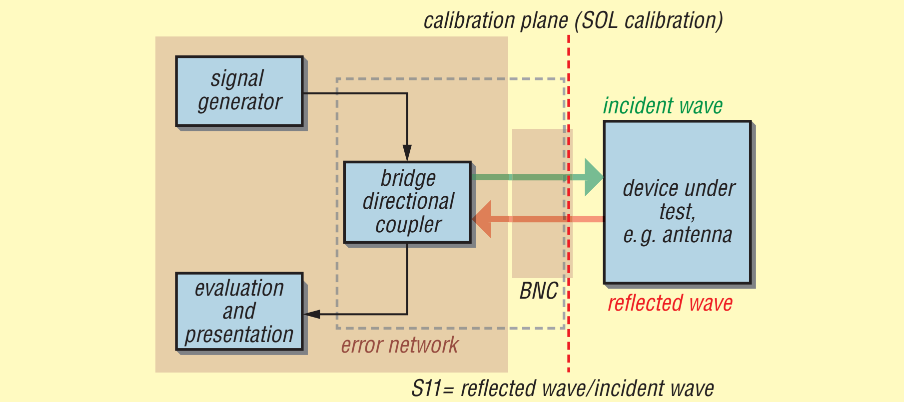

Figure 11: Functional principle of the FA-VA6

ed wave can differ from the incident wave not only in its amplitude, but also in its temporal position. The maxima and minima of a sine wave, for example, can be shifted in time. This shift is described by the phase of the scattering parameter S11. A complete evaluation of the measurement object is therefore only possible by considering the amplitude and phase of S11 together. S11 can also be described as an arrow with a length corresponding to the amplitude and a rotation corresponding to the phase of S11. Such an arrow is called a vector. Devices that can evaluate the amplitude and phase of S11 are therefore also referred to as vector analyzers. The FA-VA6 is a vector analyzer.

It should also be mentioned that existing mathematical models are often used to describe technical processes more simply. This is also the case with the scattering parameter S11. The vector S11 can also be described in the mathematical model of complex numbers. In an x-y coordinate system, the starting point of the vector is set to the coordinates zero, zero. The path to the end point of the vector is then considered. How far is to go along the x-axis (real part) and how far is to go along the y-axis (imaginary part). These two values are separated by an i or j to form a complex number. It does not matter whether the vector S11 is represented by magnitude and phase or as a complex number with real and imaginary parts. Both versions are equivalent and can be converted from one version to the other.

This consideration of S11 may sound a little complicated at first, but in the end it only describes the change in amplitude and the phase shift of the reflected signal to the incident signal. Once you have understood the relationships, the comprehensive displays of the FA-VA6 are also easier to understand.

There is also the question of where exactly the measurement is taken: With small wavelengths or high frequencies, an offset of just a few centimeters is enough to change the measurement situation significantly. The FA-VA6 can be calibrated for the exact positioning of this so-called reference plane. This plane is placed on the BNC socket at the factory (see red dotted vertical line in Figure 10). This corresponds to the factory calibration. Calibration means that unknown values within the measuring bridge up to the BNC socket (error network) are determined by means of three known calibration elements and mathematically calculated. The result is a well-defined reference plane.

The calibration elements are usually short (short circuit), open (open) and load (terminating resistor = 50 Ω) elements, abbreviated as SOL elements. Measurements are carried out one after the other by connecting the respective elements to the reference plane. The FA-VA6 then calculates correction values that are used for subsequent measurements in relation to the reference plane. Depending on the accuracy of the SOL calibration elements, highly accurate measurements are therefore possible.

However, the reference plane does not have to be at the BNC socket. The error network under consideration can also include a cable, e.g. the feed line of an antenna. If the calibration is performed with the SOL calibration elements at the end of the feed line, the reference plane is then located at the end of the feed line. The feed line is part of the error network and is 'calibrated out'. Highly accurate measurements are therefore possible, for example at the feedpoint of an antenna.

Get to know the FA-VA6

Figure 1 shows the fully assembled FA-VA6 from above. The FA-VA6 has a TFT display and is operated via a 4×4 keypad. The device is also switched on and off via the keypad.

In the unlikely event that the device can no longer be operated, there is a reset button on the side edge of the back of the circuit board. It is sufficient to remove the top cover to trigger the reset via this button.

Figure 12 shows the BNC socket of the FA-VA6, which is used to connect the device under test. If required, an adapter for other connector standards can also be connected.

Figure 13 shows the lower section of the FA-VA6. The USB-C socket is located in the middle. This is rotation-invariant and therefore much more user-friendly than previous USB standards. The FA-VA6 is supplied with power via the USB-C socket. At the same time, the built-in battery is charged via the USB-C socket. The USB-C socket is also used for data communication with a PC. There are two LEDs to the left of the USB-C socket to indicate the charging status.

Charging the accumulator

The battery is charged automatically when the USB cable is connected and the device is connected to a PC or charger. As shown, a blue LED lights up during the charging process. When the battery is fully charged, a green LED lights up instead. The built-in charging electronics balance the charging and operating current of the FA-VA6. When the battery is fully charged, the charging electronics supply a trickle current.

It should also be noted that more detailed information on the battery status is available in the Settings menu. Note: When the battery is inserted for the first time and then charged, the built-in electronics require up to several hours to correctly display the charge status of the battery.

Figure 12: FA-VA6 from above

Figure 13: FA-VA6 from below

Interaction model

The aim of the design of the operating concept is to make operation of the FA-VA6 as simple and intuitive as possible, so that operation is intuitive from within the application. The following elements were implemented for this purpose:

Simple navigation

A clear menu system (see appendix) is used to select the operating modes and configuration within an operating mode. Navigation follows the established standard with four arrow keys ◀ ▶ ▲ ▼, an enter key ↵ and a menu or back key ≡.
In addition, the configuration itself, as well as special functions, are called up via number keys. An information bar is displayed in the lower area, which shows the most important available buttons and their actions. The 7 button shows and hides a help function for all possible buttons and their actions.

Context-related functions

Only the parameters relevant to the operating mode are displayed. Furthermore, only the relevant settings are offered for the menu-guided applications.

Continuous settings concept

Operation is basically the same in all operating modes. Changes to general parameters, such as the setting of a port extension, apply to all operating modes. Changes to special parameters, such as performing a *current calibration*, apply to the respective operating mode.

Key assignment reference

The following table should be understood as a reference. The individual functions are explained in more detail in the respective operating modes.

Table: Key assignment

Key	Function
☰	**Menu button** Press and hold to switch the device off; Switches the device on; Menu and return function
▲ ▼	**Arrow keys up/down** Selection of menu elements; Setting frequency span, section (TDR) and scaling
↵	**Enter key** Selection of selected menu items; Confirmation of changes and actions; Selecting the measurement in an operating mode
◀ ▶	**Arrow keys left/right** Shift center frequency, section (TDR) and marker position
0	**Button 0** Start of a single measuring sequence
1	**Button 1** Start/stop continuous measurement Start/stop the output signal of the frequency generator
2	**Button 2** Setting the frequency in single frequency operating mode Setting the frequency in frequency generator mode
3	**Button 3** Calling up the configuration of an operating mode
4	**Button 4** Switching the marker on and off
5	**Button 5** Switching detailed information on and off in single frequency mode Switching detailed information on and off when marker mode is switched on
6	**Button 6** Start / stop the buzzer for SWR
7	**Button 7** Calling up the help function for key assignment
8	**Button 8** Calling up the saving functions for measurement data Large SWR display in single frequency operating mode
9	**Button 9** Calling up the loading functions for measurement data Deleting a measurement data record with save and load function
7 8 9 4 5 6 1 2 3 0	**Buttons 0 … 9** Enter a number

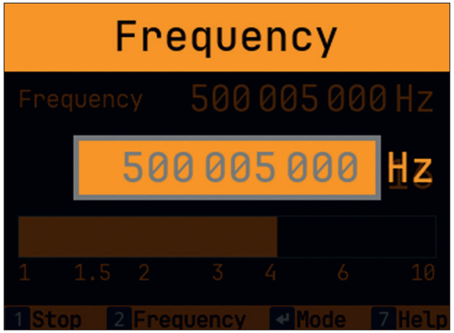

Figure 14: Number input field

Number input field

The FA-VA6 has numeric input fields at various points during operation, the operation of which is always the same. Figure 14 shows an example of the frequency setting in *single frequency* operating mode after selection.

A flashing cursor on the right indicates direct input mode. A number is entered using the 0 1 2 3 4 5 6 7 8 9 buttons and confirmed with the ↵ button. Alternatively, the digit mode can be activated using the ◀ ▶ keys: The cursor flashes under a digit to be set. Either the new number for this digit is entered directly or the ▲ ▼ buttons are used to change the number. If a negative number needs to be entered, this is done in digit mode. Use the ◀ ▶ buttons to select the digit to the right of the required minus sign. The ▼ button is then used to generate a minus sign to the left of the selected digit. An entry in direct input mode, as well as in digit mode, can also be confirmed using the ☰ button.

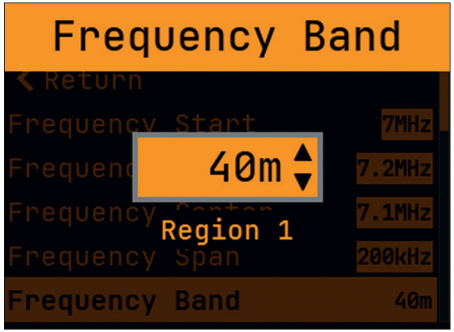

Figure 15: Selection field

Selection field

Another continuous input format of the FA-VA6 is a selection field as shown in Figure 15. This is explained using the example of selecting a frequency band after calling up the selection field.

Use the ▲ ▼ buttons to select the desired setting. Small arrows at the edge of the selection field indicate in which direction there are further options. In some selection fields, the selection jumps back to the beginning or end of the available options. Other selection fields do not allow this return and indicate the end of the list by temporarily flashing and changing the text color.

To confirm the desired option, press the ↵ button. Alternatively, you can accept the option and return by pressing the ☰ button.

Switching the device on and off

The device is switched on by pressing the ☰ button and switched off by holding down the ☰ button.

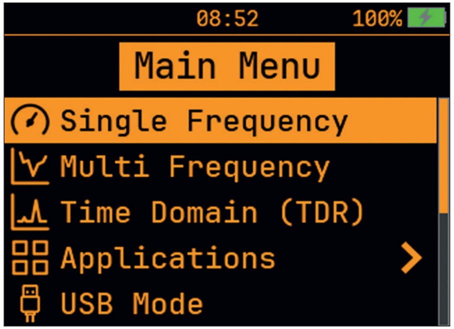

Figure 16: ***Main menu***

■ Menu system and Main menu

After switching on the device, the *Main menu* appears as shown in Figure 16. The current time and battery charge status are displayed at the top. A charging symbol also appears when the battery is charging. A reference to all menus can be found in the appendix.

A menu item is selected using the ▲▼ buttons and confirmed using the ↵ button. To return, press the ≡ button.

The following operating modes and settings are available:

Single frequency: Measurement of standing wave ratio SWR, impedance Z, scattering parameter S11 and LCR meter for a single frequency

Multi-frequency: Measurement of standing wave ratio SWR, impedance Z, scattering parameter S11 as Smith chart and scattering parameter S11 over a frequency span

Time domain (TDR): Measurement of the impulse response, the impulse response in dB, the step response and the step response as impedance Z over a measuring distance

Applications: Measurement of standing wave ratio SWR for five frequencies, measurement of length, velocity factor, impedance and loss of a cable

USB mode: Operating the FA-VA6 via the USB interface

Frequency generator: Operation of the FA-VA6 as a frequency generator up to 200 MHz

Clock: Display of date, time, day of the week and callsign, if applicable

Settings: Settings of the FA-VA6

Switch off: Switching off the FA-VA6

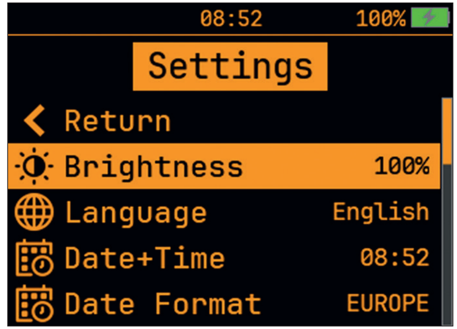

Figure 17: Settings menu

■ Settings menu

After selecting and choosing the *settings*, the settings menu appears as shown in Figure 17.

The following settings are available:

Brightness: Setting the display brightness from 10 % to 100 %

Language: Setting the language; the setting has a direct effect on all menus and operating modes

Date + Time: Setting the date and time for display in clock operating mode and for time stamps of saved data records

Date Format: Setting the date format (Europe, ISO, USA and UK)

IARU Region: Setting Region 1, 2 or 3 of the International Amateur Radio Union to select the respective band plan and display the respective frequency bands
Master Calibration: Master calibration using SOL calibration elements
Master Standards: Setting the parameters of the master calibration elements used; the parameters can be found in the respective information on the calibration elements
Callsign: Setting the call sign for display on the start screen and in clock mode
Appearance: Setting the display with the Normal or Bright profiles
Key Sounds: Activation or deactivation of a confirmation tone for a button press
USB Connect Popup: Activation or deactivation of a message that offers to switch to USB mode after connecting the FA-VA6 to a PC
Power Saver: Activation or deactivation of reduced display brightness after a selectable period of inactivity; a brighter display requires more power
Auto Power Off: Activation or deactivation of automatic switch-off after a selectable period of inactivity
Advanced Settings: Selecting the Advanced Settings menu

■ Advanced Settings menu

The *Advanced settings* menu shown in Figure 18 contains actions, settings and information that are not required for normal operation.
The elements of the *Advanced Settings* menu:
Device Info: Display of firmware version and serial number
Battery Info: Detailed displays of the current operating and charging current, as well as the charge and health status of the battery
Factory Calibration: Factory calibration using SOL calibration elements
Factory Standards: Setting the parameters of the factory calibration elements used; the parameters can be found in the respective information on the calibration elements
Game: A game to pass the time
Reset Device: Resetting the device to factory settings and deleting all data; the factory calibration is retained

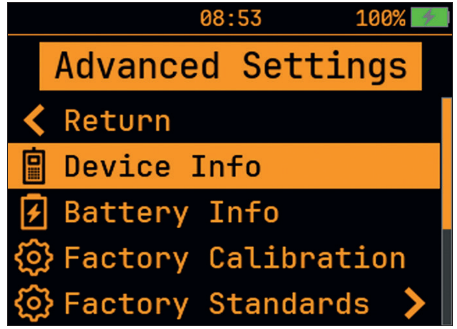

Figure 18: Advanced Settings menu

■ Single frequency operating mode

The *single frequency* operating mode allows the measurement of antennas, cables and components for a single frequency. This mode is suitable, for example, for adjusting antennas in narrowband or CW operation. The mode is particularly interesting for measuring components for a specific application frequency.

This mode enables the following measurements, which can be switched through cyclically by pressing the ↵ button:

SWR Measurement of the standing wave ratio

Z Measurement of the connected impedance

S11 Measurement of the scattering parameter S11 (reflection factor)

LCR Measurement of resistance, inductance, capacitance and quality of a connected impedance in the form of a serial or parallel equivalent circuit model

Switching through with the ↵ button does not start a new measurement, but only a calculation of the displayed values. Starting and stopping a new measurement are described in the next paragraph.

The mode always starts as a continuous measurement; the measurement sequence can be paused and restarted using the 1 button. When the measurement sequence is paused, an individual measurement sequence can be started using the 0 button.

The measurement parameters displayed are the same for all measurements. They mean

Z0 Currently set reference impedance

CAL Currently used SOL calibration

STD Model of the currently used calibration

Port-Extension Current reference plane of the calibration in time and length

The measuring frequency can be changed by pressing or holding the ◀ ▶ buttons. The frequency can be set using the 2 button. The *configuration* of the *single frequency* operating mode can be accessed via the 3 button, see below.

Single frequency operating mode: Standing wave ratio SWR

The measurement of the standing wave ratio SWR as shown in Figure 19 is limited to displaying the value of the SWR as a number and bar. In addition, a buzzer can be

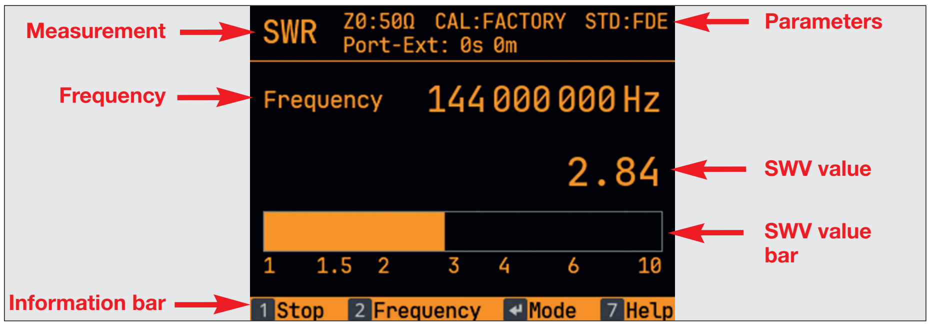

Figure 19: Single frequency operating mode: *Standing wave ratio SWR*

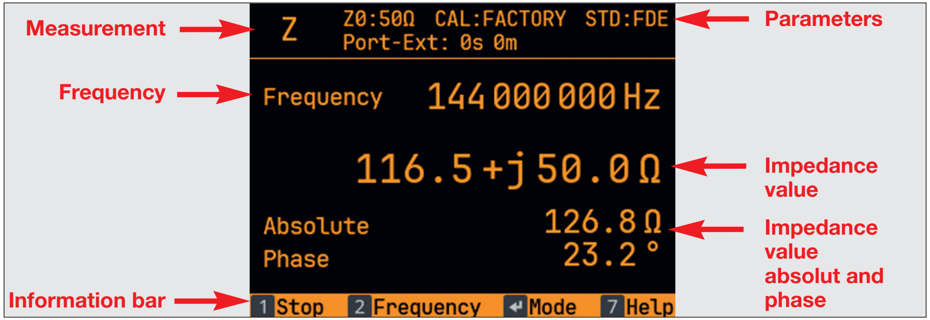

Figure 20: Single frequency operating mode: *Impedance Z*

switched on via the 6 button or via the *configuration*. Its signal interval decreases in the direction of one with an SWR, so that an antenna can also be tuned with acoustic support. In addition, a large SWR display can be shown via the 8 button, which allows the SWR to be tuned even at long distances.

Single frequency operating mode: Impedance Z

The impedance measurement in Figure 20 shows the value of the connected complex impedance according to the real and imaginary parts. The real part corresponds to the resistance, the imaginary part to the reactance. The reactance can be positive (inductance) or negative (capacitance). The absolute value of the impedance is also displayed. The indicated phase represents the phase shift between current and voltage, which is generated by this impedance.

Single frequency operating mode: Scattering parameter S11

The display of the scattering parameter S11 (reflection factor) as a complex value according to Figure 21 represents the ratio of the reflected to the incident wave and is therefore a measure for the matching of the connected test object. The introduction to the measuring principle above shows the relationships.

Single frequency operating mode: LCR meter

The *LCR meter* measurement shown in Figure 22 converts the values of the connected impedance Z into a series or parallel equivalent circuit model (EQC) con-

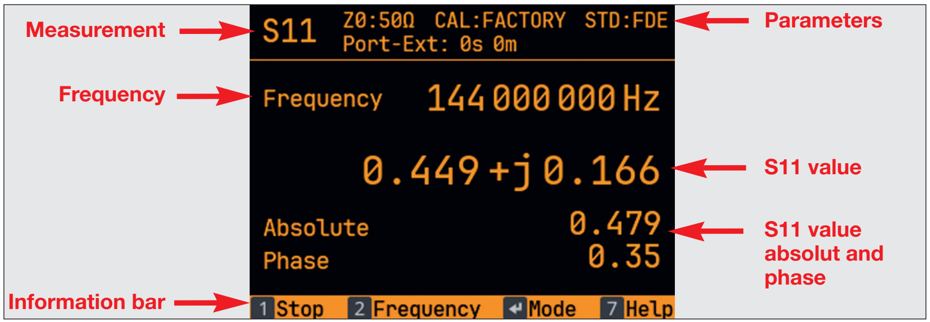

Figure 21: Single frequency operating mode: *Scattering parameter S11*

sisting of resistance, inductance and capacitor. Figure 23 shows the different models. The desired form of the EQC, serial or parallel, see later, can be selected via the *configuration* and is shown in the display.

The FA-VA6 recognizes whether it is an inductance or a capacitance and displays the values accordingly. In addition, the quality of the impedance is displayed, which results from the ratio of reactance to resistance. In a series equivalent circuit model, a small resistance R leads to a high quality. With a parallel equivalent circuit model, on the other hand, the resistance should be as high as possible for a high quality.

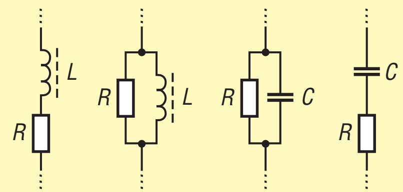

Figure 23: Equivalent circuit models of an impedance Z

This mode can be used in particular to measure components. For a connected coil, for example, its suitability for a certain frequency and its resulting quality can be determined directly. It should be noted that all components have capacitive and inductive components (parasitic values). The decisive factor is which part is dominant at a certain frequency. A later measurement example of the multi-frequency operating mode shows this behavior.

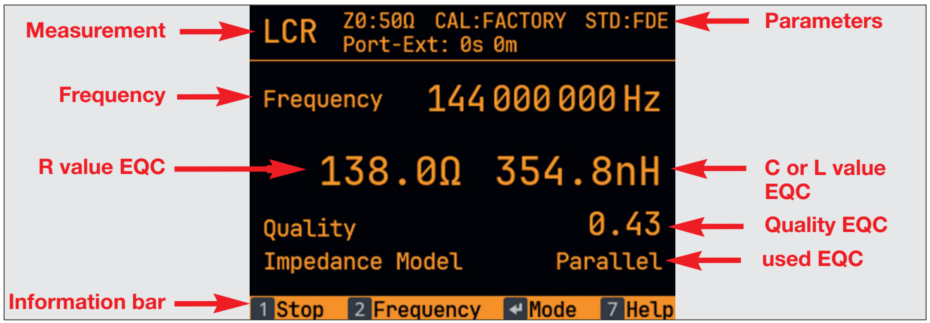

Figure 22: Single frequency operating mode: *LCR meter*

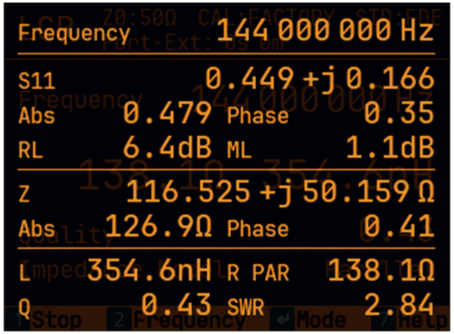

Figure 24: Single frequency operating mode: *Detailed information*

Single frequency operating mode: Detailed information

Detailed information on the measurement can be displayed and hidden from each measurement using the 5 button as shown in Figure 24. All previously explained values are summarized in the view. The calculated return loss (RL) and the calculated mismatch loss (ML) are also displayed.
The return loss is a specification in decibels that indicates the attenuation of the reflected signal. If the matching is good, only a small part of the signal is reflected and the attenuation of the reflected signal is correspondingly high. The higher the value, the better the matching.

The mismatch loss, on the other hand, is an indication of the power lost in the system due to a mismatch. If there is optimum matching, no power is lost and the mismatch loss is 0 dB. The worse the matching, the higher the value.
With both values, it should be noted that only the ratio of powers is considered here, not power. More precise definitions can be found in the standard literature. Furthermore, some of the values in the literature are also given with a negative sign. The procedure is not uniform. The FA-VA6 always shows positive values.

Single frequency operating mode: Help function

As already mentioned, the 7 button switches a help function on and off. Figure 25 shows the help function of the *single frequency* operating mode. The help function is self-explanatory.

Single frequency operating mode: Configuration

Use the 3 button to call up the configuration of the *single frequency* operating mode as shown in Figure 26.
The *configuration* called up corresponds to the operation of a menu. In addition, the

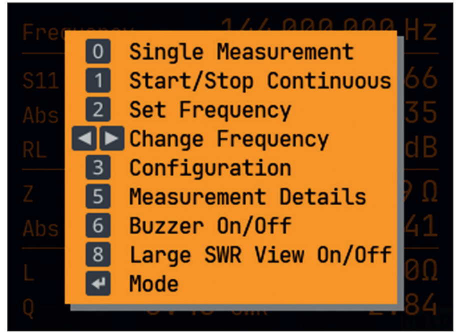

Figure 25: *Help function* of the single frequency operating mode

currently set value is displayed on the right-hand side of a menu element. Some menu elements branch to further actions, indicated by an arrow on the right.
The individual parameters mean:
Frequency: Setting the measuring frequency
Current Calibration: *Current calibration* using SOL calibration elements, valid for *single frequency* operating mode
Current Standards: Setting the parameters of the SOL calibration elements used; the parameters can be found in the respective information on the calibration elements
Calibration Select: Selection of a created calibration, if available, with the op-

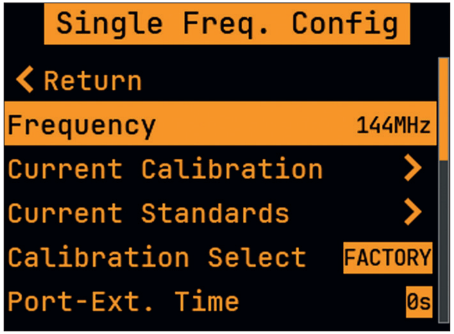

Figure 26: ***Configuration*** **of the single frequency operating mode**

tions *Current*, *Master*, *Factory* and *None*
Port-Extension Time: Setting a displacement of the reference plane with specification in nanoseconds
Port-Extension Length: Setting a displacement of the reference plane with specification in meters; this value depends on the velocity factor
VF Selection: Selection of the input of a velocity factor in the form of a selection of a cable type or the input of your own value
VF Cable Type: Specification of a velocity factor by selecting a cable type
VF Custom Value: Specification of a velocity factor by entering your own value
Reference Impedance: Currently set reference impedance; the FA-VA6 carries out a complete renormalization of the measured scattering parameters if the value is changed. The scattering parameter S11 and all values calculated from it are affected, but not the standing wave ratio SWR and the display of the connected impedance Z
Impedance Model: Selection of the equivalent circuit model used for the display in the LCR meter
Buzzer: Switching the buzzer on and off for the SWR measurement
Update Rate: Switching between fast and slow measuring rate

■ Multi-frequency operating mode

The multi-frequency operating mode is the mode of choice for measuring across entire frequency bands (amateur radio bands). As a rule, for example, the question of adapting an antenna for a specific radio band arises. However, this mode is also ideal for evaluating components with changing frequencies. This makes it possible to determine whether the component under investigation is suitable for different frequencies. A third application is the assessment of cables (transformation properties).

This mode enables the following measurements for a defined frequency range, which can be switched through cyclically by pressing the ↵ button:

SWR Measurement of the standing wave ratio
Z Measurement of the connected impedance
S11 Measurement of the scattering parameter S11 as a Smith chart
S11 Measurement of the scattering parameter S11 in dB

Switching through with the ↵ button does not start a new measurement sequence, but only a calculation of the displayed values. Starting and stopping a new measurement sequence is described in the next paragraph.

The multi-frequency operating mode starts after being called up with the measurement sequence paused. A continuous measurement can be started and stopped again using the 1 button. The 0 button starts a single measurement.

The measurement parameters displayed correspond to those of the *single frequency* operating mode:

Z0 Currently set reference impedance
CAL Currently used SOL calibration
STD Model of the currently used calibration
Port-Extension Current reference plane of the calibration in time and length

The frequency span can be reduced and increased using the ▲▼ buttons. The center frequency can be shifted using the ◄ ► buttons. The functions are locked according to the logic: For example, the center frequency cannot be shifted in such a way that the measuring range limits of the device would be exceeded by the defined frequency span.

The *configuration* of the multi-frequency operating mode can be called up again via the 3 button, see below.

A marker is displayed using the 4 button. The marker is symbolized by a white circle and can be moved along the measurement curve using the ◄ ► buttons. The exact frequency position of the marker and the corresponding measured value are displayed in the upper area.

When the marker is switched on, the scaling of the y-axis (measured values) can be changed using the ▲▼ buttons. The selected scaling is retained even after the marker is switched off. In addition, when the marker is switched on, the 5 button can be used to show and hide detailed information on measured values at the position of the marker.

The following diagrams show the individual measurements with the marker switched on.

Multi-frequency operating mode: Standing wave ratio SWR

The measurement of the standing wave ratio SWR in Figure 27 shows the standing wave ratio SWR for the defined frequency span. If the marker is activated and the corresponding function is switched on in the mode *configuration*, the marker jumps to the SWR minimum of the measurement curve after each measurement run.

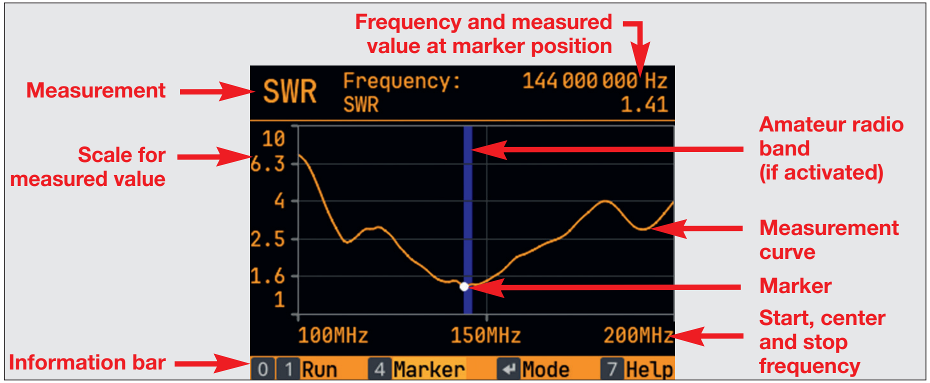

Figure 27: Multi-frequency operating mode: *Standing wave ratio SWR*

Multi-frequency operating mode: Impedance Z

The impedance measurement in Figure 28 shows the value of the connected complex impedance, separated into real and imaginary parts.

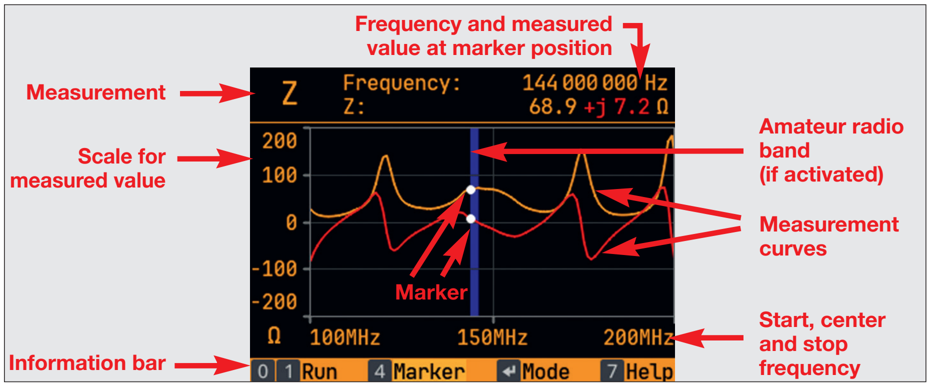

Figure 28: Multi-frequency operating mode: *Impedance Z*

Multi-frequency operating mode: Scattering parameter S11 as Smith chart

The display of the scattering parameter S11 (reflection factor) as a Smith chart according to Figure 29 differs significantly from the other measurements. The start, center and stop frequencies are on the left-hand side. Values for the position of the marker, as well as selected measurement parameters, are displayed at the bottom left edge. Scaling of the y-axis is not possible with the Smith chart.

The Smith chart represents a mapping of the complex impedance, normalized to the system impedance, to the plane of the scattering parameter S11. The point of optimum matching is therefore in the center of the circle. This corresponds to an S11 value of S11 = 0 + i0. A short circuit is shown on the far left of the circle and an open circuit on the far right. The x-axis represents the line of resistances. Capacitive reactances are shown in the lower area, inductive reactances in the upper area. With a little practice, the Smith chart can be used to quickly determine the deviation from an ideal match and the measures that need to be taken to match it.

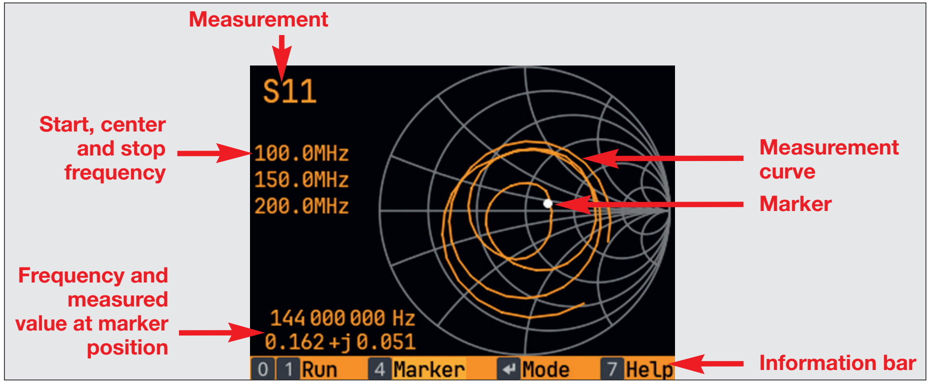

Figure 29: Multi-frequency operating mode: *Scattering parameter S11 as a Smith chart*

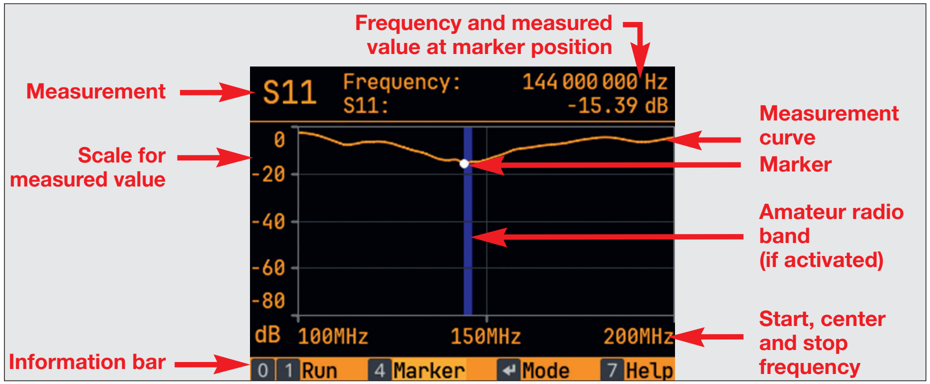

Figure 30: Multi-frequency operating mode: *Scattering parameter S11 in dB*

Figure 31: Multi-frequency operating mode: Detailed information

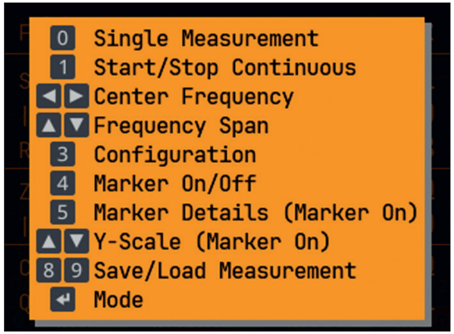

Figure 32: Help function of the multi-frequency operating mode

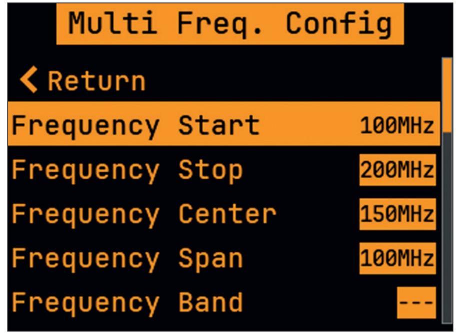

Figure 33: Configuration of the multi-frequency operating mode

Multi-frequency operating mode: Scattering parameter S11 in dB

Another measurement is the display of the scattering parameter S11 in dB according to Figure 30. The displayed value corresponds to the inverted value of the return loss.

Multi-frequency operating mode: Detailed information

After activating the marker using the 4 button, detailed information on the measurement can be displayed and hidden from each measurement using the 5 button as shown in Figure 31. The view corresponds to the view of the *single frequency* operating mode.

Multi-frequency operating mode: Help function

The 7 button also displays and hides a help function in multi-frequency operating mode. Figure 32 shows the help function, which is self-explanatory.

Multi-frequency operating mode: Configuration

Use the 3 button to call up the configuration of the multi-frequency operating mode as shown in Figure 33.

Most of the parameters correspond to those of the *single frequency* operating mode. They mean

Frequency Start: Setting the start measuring frequency; the center frequency and frequency span are automatically adjusted when changed

Frequency Stop: Setting the stop measurement frequency; the center frequency and frequency span are automatically adjusted when changed

Frequency Center: Setting the center measuring frequency; the start and stop frequency are automatically adjusted when changed

Frequency Span: Setting the frequency span; the start and stop frequency are automatically adjusted when changed

Frequency Band: Setting all frequency parameters by selecting a dedicated frequency band; the displayed bands and frequencies differ depending on the selection of the *IARU Region* in *Settings*.

Current Calibration: *Current calibration* using SOL calibration elements, valid for multi-frequency operating mode

Current Standards: Setting the parameters of the SOL calibration elements used; the parameters can be found in the respective information on the calibration elements

Calibration Select: Selection of a created calibration, if available, with the options *Current*, *Master*, *Factory* and *None*

Port-Extension Time: Setting a displacement of the reference plane with specification in nanoseconds

Port-Extension Length: Setting a displacement of the reference plane with specification in meters; this value depends on the velocity factor

VF Selection: Selection of the input of a velocity factor in the form of a selection of a cable type or the input of your own value

VF Cable Type: Specification of a velocity factor by selecting a cable type

VF Custom Value: Specification of a velocity factor by entering your own value

Reference Impedance: Currently set reference impedance; the FA-VA6 carries out a complete renormalization of the measured leakage parameters if the value is changed. The scattering parameter S11 and all values calculated from it are affected, but not the standing wave ratio SWR and the display of the connected impedance Z

Impedance Model: Selection of the equivalent circuit model used for the detailed display when the marker is activated

Sweep Mode: Setting the *Fast*, *Balanced*, *Precise* mode, which defines the complexity of digital signal processing and balances measurement duration to accuracy

Show Frequency Band: Switching the graphic display of the amateur radio bands on and off according to the selected *IARU Region*

SWR Marker Autoset: Sets an activated marker to the SWR minimum after a new measurement run

■ Time domain operating mode

Cable fault measurements can be carried out using the time domain operating mode. This allows faulty adapters, short circuits or crushes in a cable and similar to be quickly identified and precisely localized. In addition, the impedance of cables and their local course can be determined so that cables with different impedances can be quickly identified. This mode can also be used to easily determine the length of cables.

In practice, the FA-VA6 first measures the reflections from a connected device under test over a wide frequency range (transfer function). These measured values are then mathematically transformed into the time domain (impulse response). The impulse response corresponds to the measurement method in the time domain, in which a very short voltage pulse at a device under test causes a reaction. The resulting reaction is the impulse response. The impulse response makes it possible to display reflections along time. Reflections can be assigned to a distance with a known velocity factor. The maximum measuring time / measuring distance is defined by the number of frequency measuring points. In addition, the impedance of the measurement object can also be displayed via a further mathematical calculation (step response). Further details can be found in [6].

This mode enables the following measurements, which can be switched through cyclically by pressing the ↵ button:

IR Measurement of the impulse response (reflections) along a distance (section)

IR Measurement of the impulse response (reflections) in dB along a distance (section)

SR Measurement of the step response along a distance (section)

SRZ Measurement of step response (impedance) in ohms along a distance (section)

Switching through with the ↵ button does not start a new measurement sequence, but only a calculation of the displayed values. Starting and stopping a new measurement sequence is described in the next paragraph.

The time domain operating mode starts with a single measurement after being called up. A continuous measurement can be started and stopped using the 1 button. The 0 button starts a single measurement. Due to the multi-stage, sometimes longer measurement sequence, it is advisable to use a single measurement sequence.

The measurement parameters displayed correspond to those of the *single frequency* operating mode:

Z0 Currently set reference impedance

CAL Currently used SOL calibration

STD Model of the currently used calibration

Port-Extension Current reference plane of the calibration in time and length

The section can be reduced and enlarged using the ▲ ▼ buttons. The section can be moved using the ◀ ▶ buttons. These functions are also locked according to the logic. For example, a section cannot be moved beyond the maximum possible measuring distance.

The *configuration* of the time domain operating mode can be called up again via the **3** button, see below.
A marker is displayed using the **4** button. The marker is symbolized by a white circle and can be moved along the measurement curve using the ◀ ▶ buttons. The exact position at the location of the marker and the corresponding measured value are displayed in the upper area.
When the marker is switched on, the scaling of the y-axis (measured values) can be changed using the ▲ ▼ buttons. The selected scaling is retained even after the marker is switched off. In addition, when the marker is switched on, the **5** button can be used to show and hide detailed information on measured values at the position of the marker.
The following diagrams show the individual measurements with the marker switched on:

Time domain operating mode: Impulse response

The measurement of the impulse response according to Figure 34 shows reflections along a defined distance. Open curcuits are shown with a positive value, short cir-

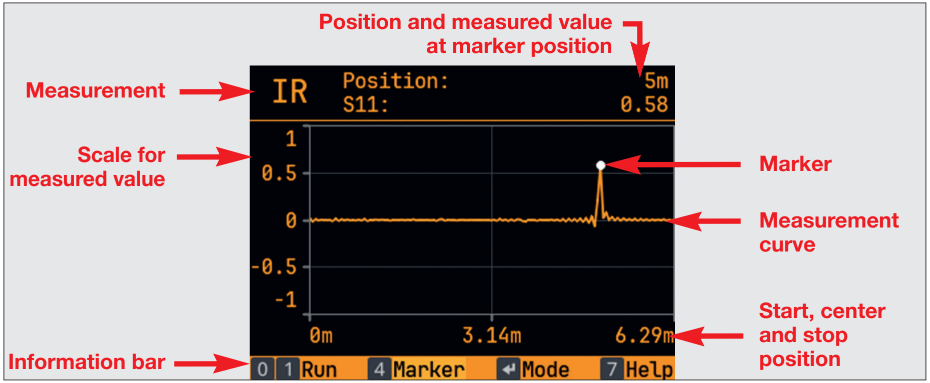

Figure 34: Time domain operating mode: *Impulse response*

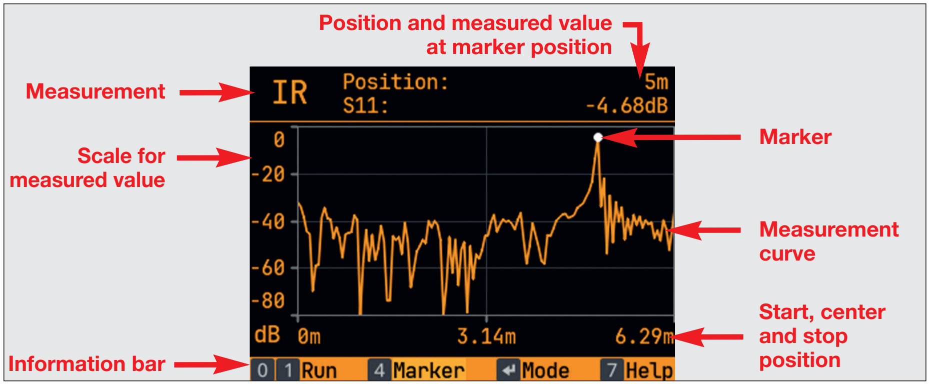

Figure 35: Time domain operating mode: *Impulse response in dB*

cuits with a negative value. A total reflection results in an impulse response value of +1 or –1. In practice, this value is smaller due to losses, e.g. along a cable.

Time domain operating mode: Impulse response in dB

The measurement of the impulse response in dB according to Figure 35 corresponds to the previous measurement, whereby the magnitude of the impulse response is now displayed in dB. The logarithmic display simplifies the assessment of the relevance of the reflections.

Time domain operating mode: Step response

The display of the step response in Figure 36 results from a mathematical operation, the integration of the impulse response. In a figurative sense, a voltage step rather than a voltage pulse was used for the measurement in the time domain. This means that a DC component is superimposed on the measurement, which enables the impedance to be evaluated, among other things. The measurement is suitable for displaying changes over distances (see application examples). Knowledge of the

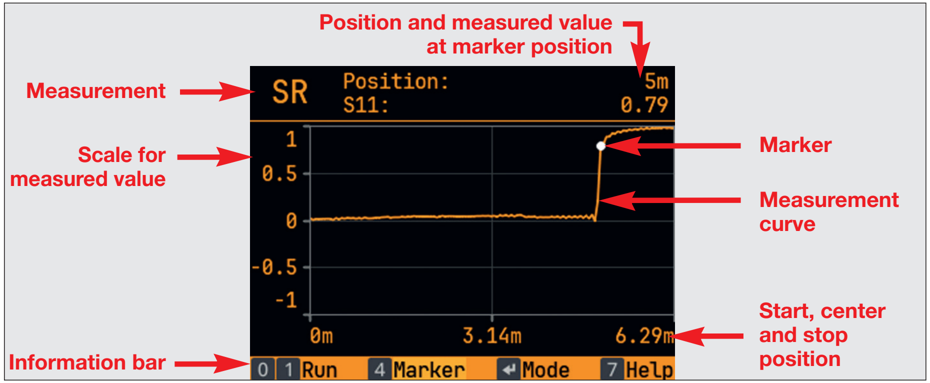

Figure 36: Time domain operating mode: *Step response*

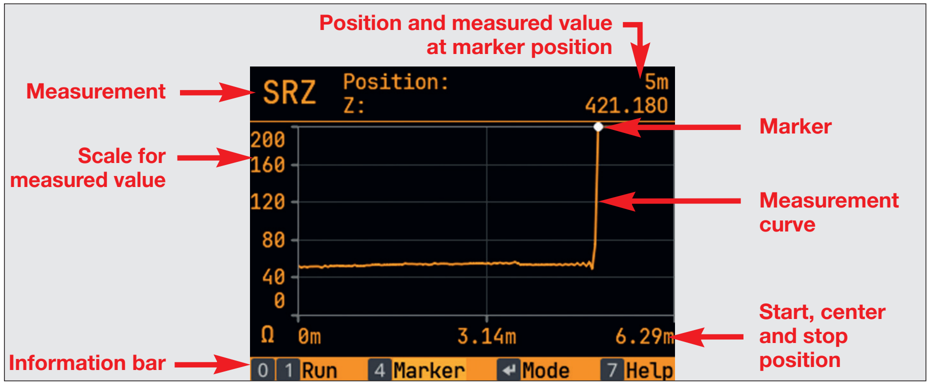

Figure 37: Time domain operating mode: *Step response impedance Z*

DC impedance (Z_0) is important for correct functioning. This can therefoe be entered manually under *Configuration* if required.

Time domain operating mode: Step response Impedance Z

The display of the step response as impedance *Z* along a distance is shown in Figure 37. The displayed impedance depends on the set velocity factor.

Time domain operating mode: Detailed information

After activating the marker using the **4**, button, detailed information on measured values at the position of the marker can be displayed and hidden from each measurement using the **5** button (Figure 38).

Time domain operating mode: Help function

As before, the **7** button displays and hides a help function. Figure 39 shows the help function, which is self-explanatory.

Figure 38: Time domain operating mode: *Detailed information*

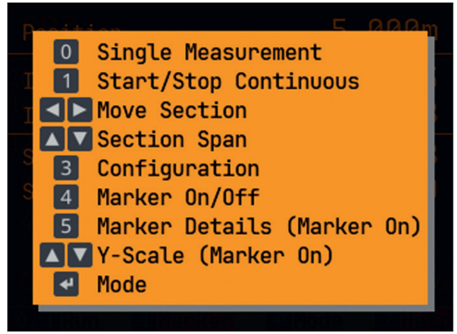

Figure 39: Help function of the time domain operating mode

Time domain operating mode: Configuration

Use the **3** button to call up the *configuration* of the time domain operating mode as shown in Figure 40.

Some of the parameters differ from the multi-frequency operating mode. The parameters mean:

Number Of Samples: Setting the number of measurement samples

Windowing: Activation of a Hann window in the calculation

Z0 Selection: Selection of the *Auto-calcul.* method or *Own value* for setting the DC impedance Z0; affects the step response

Z0 Custom Value: Specification of a DC impedance (Z0) by entering your own value

Calibration Select: Selection of a created calibration, if available, with the options *Master*, *Factory* and *None*. Note: The time domian operating mode does not use *Current calibration*

Port-Extension Time: Setting a displacement of the reference plane with specification in nanoseconds

Port-Extension Length: Setting a displacement of the reference plane with specification in meters; this value depends on the velocity factor

VF Selection: Selection of the input of a velocity factor in the form of a selection of a cable type or the input of your own value
VF Cable Type: Specification of a velocity factor by selecting a cable type
VF Custom value: Specification of a velocity factor by entering your own value
Sweep Mode: Setting the *Fast*, *Balanced*, *Precise mode*, which defines the complexity of digital signal processing and balances measurement duration to accuracy
The *Number Of Samples* setting results in a defined maximum measuring distance. The more values are measured, the longer the measurement and calculation will take. The number of values must therefore be selected so that the distance to be examined is fully covered. The length of this distance can be taken from the x-axis of the diagram.
The optional activation of *windowing* suppresses the display of pre- and post-oscillations for a shown reflection, but the displayed pulse becomes wider. Furthermore, the amplitude of the displayed pulse may deviate.

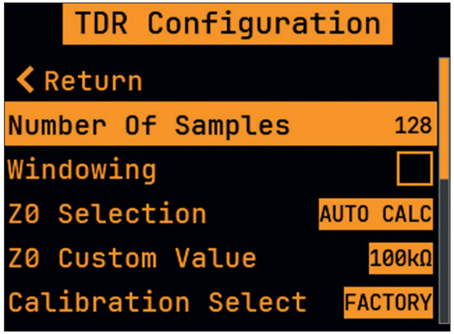

Figure 40: Parameters of the time domain operating mode

Applications

The FA-VA6 offers a range of applications that facilitate the measurement of typical applications.

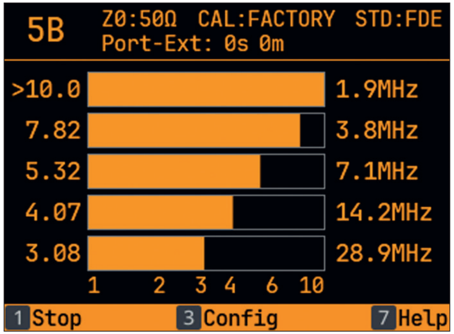

Figure 41: ***5-band SWR*** **application**

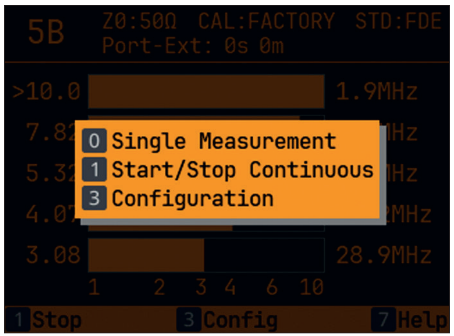

Figure 42: 5-band help

5-band SWR

The 5-band SWR application enables the quasi-simultaneous measurement of a standing wave ratio for five different frequencies. This makes it particularly easy to calibrate a multiband antenna where an adjustment affects the SWR at several frequencies simultaneously.

Figure 41 shows the corresponding display. The SWR is displayed numerically and as a bar. The measurement parameters displayed correspond to those of the *single frequency* operating mode:

Z0	Currently set reference impedance
CAL	Currently used SOL calibration
STD	Model of the currently used calibration
Port-Extension	Current reference plane of the calibration in time and length

The help function as shown in Figure 42 can be activated via the 7 button.

The *configuration*, accessible via the 3 button, differs from the configuration of the *single frequency* operating mode essentially only in the setting of the five frequencies, see Figure 43.

The adjustable parameters are:

Frequency 1: Setting the first measuring frequency

Frequency 2: Setting the second measuring frequency

Frequency 3: Setting the third measuring frequency

Frequency 4: Setting the fourth measuring frequency

Frequency 5: Setting the fifth measuring frequency

Current Calibration: Current calibration using SOL calibration elements, valid for the 5-band operating mode

Current Standards: Setting the parameters of the SOL calibration elements used; the parameters can be found in the respective information on the calibration elements

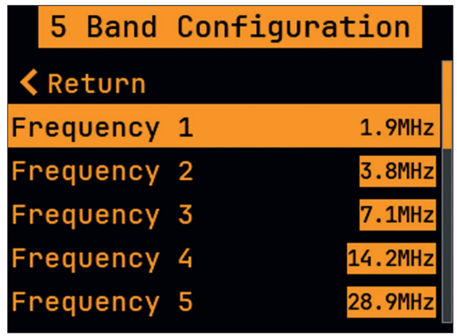

Figure 43: Configuration ***5-band SWR***

Calibration Select: Selection of a created calibration, if available, with the options *Current*, *Master*, *Factory* and *None*
Port-Extension Time: Setting a displacement of the reference plane with specification in nanoseconds
Port-Extension Length: Setting a displacement of the reference plane with specification in meters; this value depends on the velocity factor
VF Selection: Selection of the input of a velocity factor in the form of a selection of a cable type or the input of your own value
VF Cable Type: Specification of a velocity factor by selecting a cable type
VF Custom Value: Specification of a velocity factor by entering your own value
Reference Impedance: Currently set reference impedance; the FA-VA6 performs a complete renormalization of the measured scattering parameters if the value is changed. The scattering parameter S11 and all values calculated from it are affected, but not the standing wave ratio SWR and the display of the connected impedance Z
Update Rate: Switching between fast and slow measuring rate

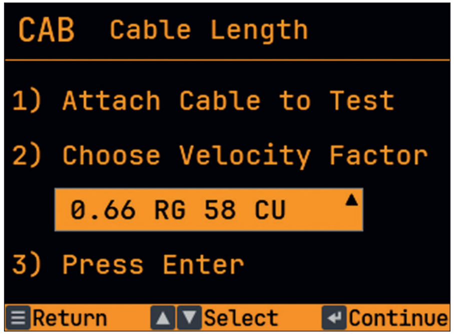

Figure 44: *Cable length* application

Cable length

The *Cable length* application allows you to determine the length of a cable with a known velocity factor according to Figure 44.
The procedure is largely self-explanatory. A cable with an open or short end can be measured. After entering the velocity factor, the type of termination and the determined mechanical length are displayed. Depending on the velocity factor, cables with a length of approx. 0.5 m to 100 m can be measured.

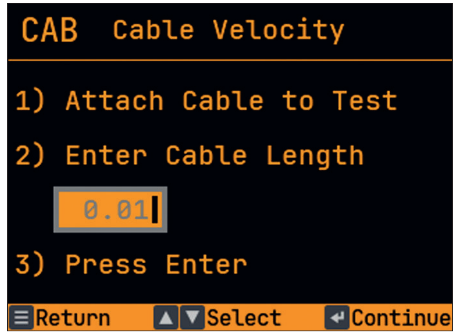

Figure 45: *Cable velocity* application

Cable velocity

The *Cable velocity* application allows you to determine the velocity factor of a cable with a known mechanical length as shown in Figure 45.
The procedure is explained in the respective steps. A cable with an open or short end can be measured. After entering the length, the type of termination and the determined velocity factor are displayed. Cables with a length of approx. 0.5 m to 100 m can be measured.

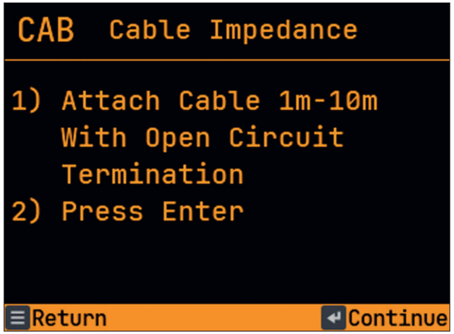

Figure 46: *Cable impedance* application

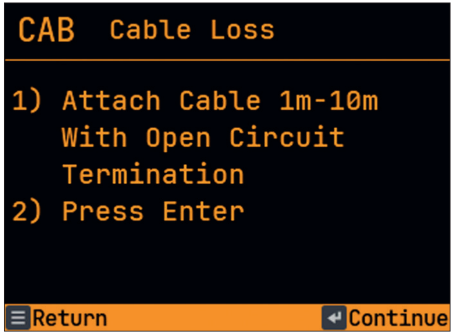

Figure 47: *Cable loss* application

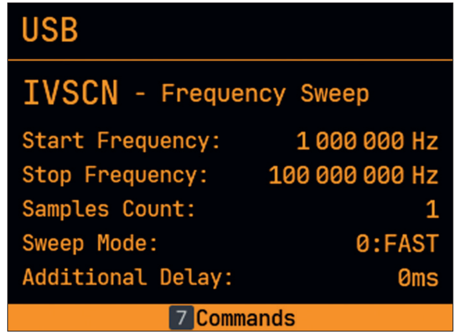

Figure 48: USB mode

Cable impedance

The *cable impedance* application allows the characteristic impedance of a cable to be determined as shown in Figure 46.
Cables from approx. 1 m to 10 m can be measured. First connect the cable to be tested with one end open. A further measurement step, not shown here, prompts you to measure the same cable with a short-circuited end. After performing the second measurement, the characteristic impedance of the cable is displayed. The frequency at which the electrical cable length corresponds to one eighth of the wavelength is also displayed. From this, conclusions can be drawn about the relationship between mechanical length and velocity factor.

Cable loss

First connect the cable to be tested with one end open. A further measurement step, not shown here, prompts you to measure the same cable with a short-circuited end. After the second measurement has been carried out, the loss of the cable determined for the five frequencies 10 MHz, 30 MHz, 50 MHz, 100 MHz and 200 MHz is displayed. These frequencies correspond to the common specifications in cable data sheets. The actual mechanical length must be taken into account when making a comparison.

■ USB mode

USB mode allows the FA-VA6 to be controlled via a connected USB cable as shown in Figure 48. No parameter settings are available.
When the FA-VA6 is connected to a PC via a USB cable, a message appears asking whether to switch to USB mode. The appearance of this message can be deactivated via *USB connection popup* in the *Settings* menu.
The last control command received via USB is shown in the display in Figure 48.
A help function, accessible via the 7, button, displays a brief explanation of the possible commands.

Control via the commands described can be carried out using a terminal program or other software. The comprehensive VNWA software is adapted to control the FA-VA6. Details can be found in the later chapter VNWA software for the FA-VA6.

■ Frequency generator

The frequency generator operating mode allows the FA-VA6 to be used as a simple signal generator in the frequency range up to 200 MHz as shown in Figure 49. The generator frequency can be changed by pressing or holding the ◀ ▶ buttons. The frequency can be set using the 2 button. The 1 button activates or deactivates the signal output. The output signal at the BNC socket is a square wave signal. As before, the 7 button shows and hides a help function. Figure 50 shows the help function, which is self-explanatory.

■ Clock

Figure 51 shows the clock operating mode. In addition to the date, day of the week and time, the callsign entered in the *settings* is also displayed, if set.

■ SOL calibration

One of the strengths of the FA-VA6 is its extensive calibration options. For beginners, the relationships may sometimes seem complicated. This is why the FA-VA6 comes with a factory calibration that allows measurements to be taken directly in relation to the BNC socket.
However, the full accuracy and other applications can only be achieved by using the full calibration options of the FA-VA6. As explained in the *Functional principle chapter*, calibration is used to determine values for error correction in relation to a specific reference plane. This requires three different calibration elements, in this case Short, Open and Load (SOL). The reference plane is exactly where the three calibration elements were measured. A determined error network now applies to this local point and all further measurements are based on this reference plane. By using a reference plane, cables, e.g. antenna

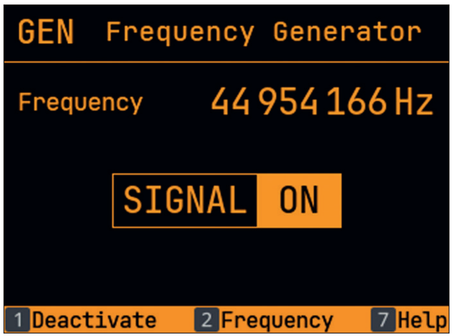

Figure 49: Frequency generator

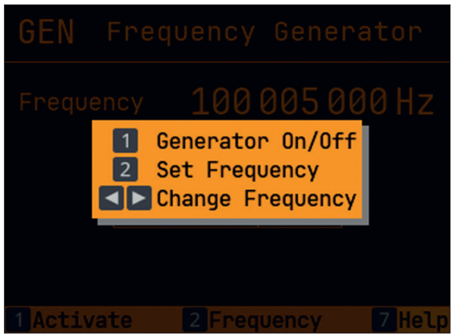

Figure 50: Frequency generator help

Figure 51: Clock

feed lines, can be included and the measured values then reflect the conditions at the end of the cable.
For calibration, a short, open and load calibration element must always be connected to the reference plane in succession and measured. This process is shown in the FA-VA6 menu and is self-explanatory. The parameters to be used for the calibration elements must be specified during the process. There are two models:

IDEAL Ideal model. Here, 0 Ω (S11 = –1+i0) is assumed for Short, an infinitely high value in ohms (S11 = 1+i0) for Open and 50 ohms (S11 = 0+i0) for Load.

FDE Frequency-dependent model. Here, the values of the calibration elements change with the frequency. The model can be found in the help document of the VNWA software [4], where it is referred to as *Simple Model*.

For the second model, *FDE*, the values, at least for the load of the calibration elements, differ for each specific calibration kit. These must therefore be measured individually and communicated to the FA-VA6. These values are supplied by the manufacturer of the calibration elements, or they must be measured with a calibrated high-precision device.
For increased flexibility, the FA-VA6 offers three different calibrations that can be selected by the user via the *configuration* of an operating mode. These three calibrations are

Factory This calibration refers to the reference plane of the BNC socket and has already been carried out at the factory. However, it can be carried out again in the *Advanced Settings* menu if the socket is changed. It is based on reference points. The correction values are interpolated for measurements at frequency values outside the reference points.

Master This calibration corresponds to the *factory* calibration, but can be used by the user as a supplement, e.g. to include an adapter.

Current This calibration exists individually for the *single frequency*, *multi-frequency* and *5-band* operating modes. Correction values are determined exactly for the respective measuring frequencies. This calibration potentially provides the highest accuracy.

It should also be mentioned that the FA-VA6 always automatically selects the best available calibration first. In this case, *current* comes before *master* before *factory*. However, the user can override the automatic selection by making an explicit selection as described above.
Changing parameters, e.g. the measuring frequency, invalidates a *current calibration* that has been performed. For the time domain operating mode and for most applications, the *master* or *factory* calibration is always used.
The *current calibrations* can always be accessed via the *configuration* of the corresponding operating mode, the *master calibration* can be accessed via the *settings*

Figure 52: *Current calibration*: First step

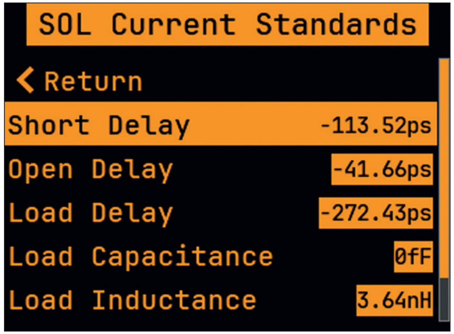

Figure 53: *Current calibration*: Setting the parameters of the calibration elements

menu and the *factory calibration* via the *advanced settings* menu.
The calibration process itself is the same everywhere. Figure 52 shows an example of the first step of menu-guided calibration in multi-frequency operating mode.
First enter the model of the parameters used for the calibration elements, see next section, and confirm with the ↵ button. Then connect the Short element and confirm the process with the ↵ button. Then connect the open element and the load element and confirm the respective process with the ↵ button.
Before the calibration itself, the parameters of the model can be entered if the frequency-dependent model *FDE* is used. Such an entry is usually only made once, as the same calibration elements are usually used. Figure 53 shows this for standards for a *current calibration*.
The entries correspond to the structure of the FDE *model* described above and must be entered exactly as listed. For the precision BNC calibration elements available as accessories, the values are specified on an instruction leaflet.

■ Saving and loading data records

The FA-VA6 can save the measured and calibrated data records for measurements in multi-frequency operating mode. The stored data records can be retrieved by other programs, e.g. by the VNWA software (see later chapter), via the USB interface. Stored data records can also be displayed on the device.

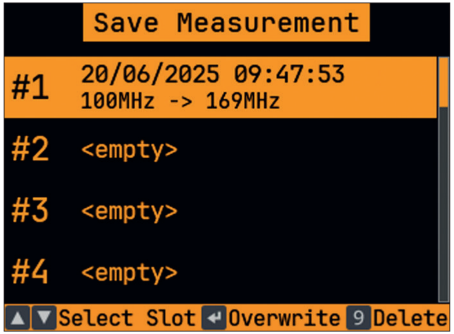

Figure 54: Saving measurement data

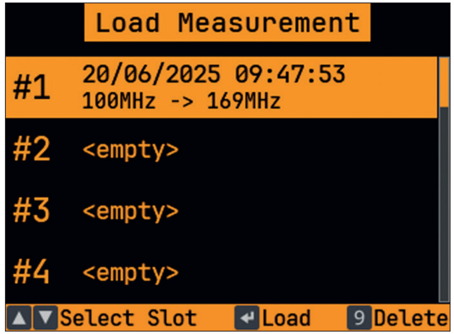

Figure 55: Loading measurement data

There are memory locations for 16 data records. The memory function can be accessed via the 8 button. Figure 54 shows the corresponding display. A memory location can be selected using the ▲ ▼ buttons.

For an occupied memory location, the time stamp at the time of saving and the frequency span used are displayed. The current data record can be saved using the ↵ button. If a memory location is occupied, a confirmation prompt is displayed before overwriting. The data of a memory location can also be deleted at any time using the 9 button. Here too, a confirmation prompt is displayed before the data is overwritten.

Note: The FA-VA6 works internally with 101 sampled values so that the start, end and center frequencies as well as all intermediate values are optimally mapped. However, for compatibility reasons with the predecessor FA-VA5, only the first 100 values are loaded by the VNWA software. The last value is discarded.

The display for loading memory records as shown in Figure 55 corresponds to the operating concept described above. The loaded measurement data is displayed in *multi-frequency* operating mode. The actions are, as usual, derived from the information bar and the help function.

Measurement examples

The following measurement examples are intended to enable even less experienced users to use the FA-VA6 quickly and should in no way be regarded as exhaustive. There are many other applications for measurements with vector 1-port analyzers on the Internet and in the literature. For a simple SWR measurement on an antenna, please also refer to the *Quick Start* chapter.

Fault measurement on an antenna feed line

An approx. 60 m long antenna feed line with cable type H155 is measured. The antenna feed line has two built-in adapters, one after a few meters and one approximately in the middle of the feed line. An automatic tuner is connected to the end of the antenna feed line, which connects the feed line to ground in the idle state.

After selecting the *time domain* (TDR), the number of measured values must first be increased via the configuration. 2048 values are selected, as this results in a maximum measurement distance of 101.33 m. Furthermore, the selection of the velocity factor is changed to *cable type* in the *configuration* and the corresponding cable *H155* is selected. The greater velocity factor also changes the maximum measuring distance to a length of 122.82 m.

The next step is optional and improves the accuracy of the subsequent measurement of the *step response Z*. It is known that the end of the antenna feed line is connected to ground. For this reason, the setting *Own value* is selected in the *configuration* under *Z0 selection* and this value is set to 0 Ω under *Z0 own value*. If the end were open, a high value of e.g. 1000 Ω would have to be entered here. With the default setting *Auto Calc* under *Z0 selection*, the FA-VA6 determines this value automatically from its own measurement.

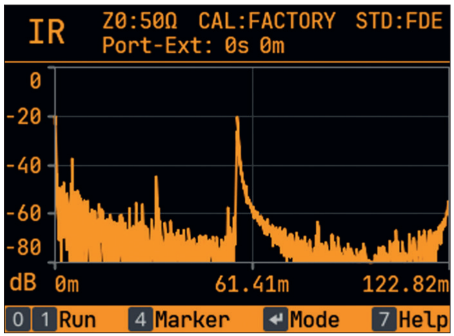

Figure 56: Measurement of the antenna feed line: overall view of the *impulse response dB*

The *impulse response* measurement only shows a small negative deflection. Therefore, the measurement is switched to *impulse response dB*. This results in the display shown in Figure 56.

The closer the impulse response values are to 0 dB, the stronger the reflection. Obviously, there is a relatively strong reflection just before 60 m. Two further, smaller reflections appear in front of this strong reflection.

The marker can now be switched on for localization and the interference points can be 'approached'. The three reflections are assigned to the distances 5.3 m, 31.4 m and 56.6 m. The two adapters and the end point of the feed line on the automatic tuner are located at these distances. Alternatively, with the marker switched off, you can use the arrow keys to select a sub section of the measuring section to be viewed in terms of length and position. This is always useful if local areas are to be examined more closely. For the second reflection, for example, this results in the section shown in Figure 57.

The superposition of two pulses can be seen here, as there is a multi-transition due to the inserted adapter. In fact, a female-female adapter is used. However, the val-

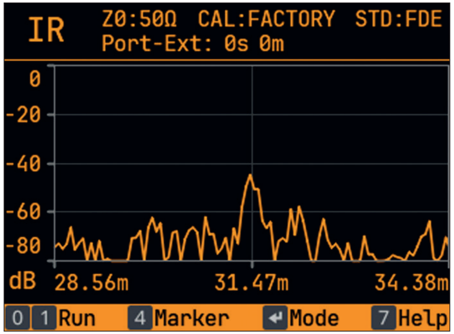

Figure 57: Measurement of the antenna feed line: section of the *impulse response dB*

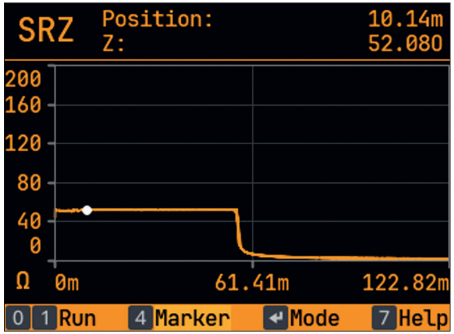

Figure 58: Measurement of the antenna feed line: *step response Z*

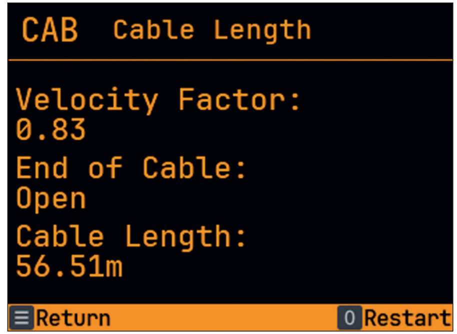

Figure 59: Display of the result of the *cable length* application

ues for the first and second reflections indicate that the interference points are of low relevance.

The display of the step response measurement as impedance Z over the entire distance is also interesting, see Figure 58. The impedance jump from the characteristic impedance of the cable, from approx. 52 Ω to 0 Ω, can be clearly seen at the end of the supply line.

Parameter measurement of a cable

The length and other parameters of a type H2007 cable are to be determined. First determine the length of a 'roll' of cable. This can be done using the *time domain mode* (TDR) as described above. A simpler alternative are the cable applications. To do this, the *Cable length* application is started when the cable is connected. After selecting cable type *H2007*, the display shown in Figure 59 appears at the end of the measurement.

The end of the cable is identified as open. The cable length is specified as 56.5 meters. A comparison with the manufacturer's printed linear meters gives a length of 53 meters. Such deviations may result, for example, from a different velocity factor. Therefore, a shorter section of the same cable type is now measured. A mechanical length of 8.3 m is determined in advance. After entering the length of 8.3 m, the application *cable velocity* is shown in Figure 60 after the measurement.

The velocity factor shown is 0.78, instead of the factor of 0.83 listed in the data sheet for cable type H2007. With this slightly different velocity factor, the correct value of 53 m length would also result for the first measurement.

The characteristic impedance and loss should now be determined for the shorter cable of 8.3 m in length. For both applications, the end of the cable must be terminated once with *Open* and once with *Short*. If an appropriate adapter is selected, the existing calibration elements can be used for this.

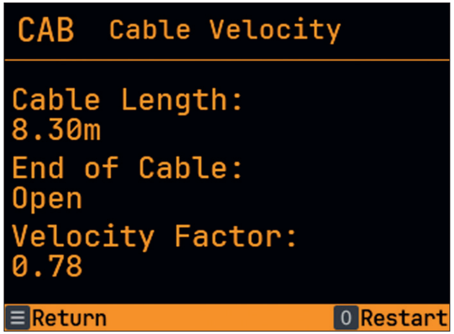

Figure 60: Display of the result of the *cable velocity* application

Figure 61 shows the result for the *cable impedance* application. A characteristic impedance of 51 Ω is determined. The data sheet shows a range of 48 Ω to 52 Ω for the characteristic impedance.
For the *cable loss* application, the results in Figure 62 must be converted to the usual values per 100 meters using the actual cable length. The data sheet shows an attenuation of 2.2 dB / 100 m at 10 MHz. Here, the 0.19 dB / 8.3 m shown must be converted to 100 meters. The logarithmic values can simply be added together. This results in a total of 2.29 dB / 100 m.

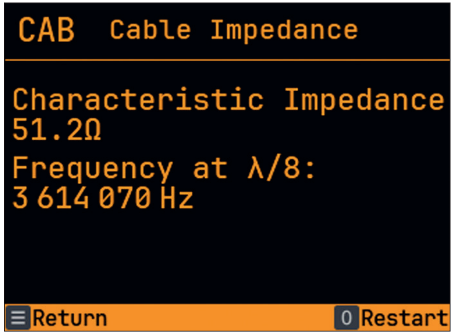

Figure 61: Display of the result of the *cable impedance* application

Measurement on a coil

Adapters can be made or purchased for measuring components. For low frequencies, a commercially available BNC to banana jack adapter can be used. A wired 49.9 Ω resistor is then used as a *load* and a piece of silver wire as a short. *Open* is simply leaving the sockets open. An *actual calibration* is therefore carried out in such a way that the calibration elements are always connected to the screw terminals of the banana jacks. This means that the reference plane is then located to the screw terminals of the banana jacks.

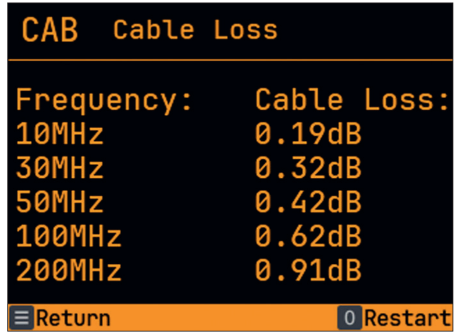

Bild 62: Anzeige des Ergebnisses der Applikation *Kabel-Verlust*

The test object is now connected and measured here. Adapters consisting of 2.54 mm sockets and headers are suitable for medium frequencies. The calibration elements then consist of SMD resistors.

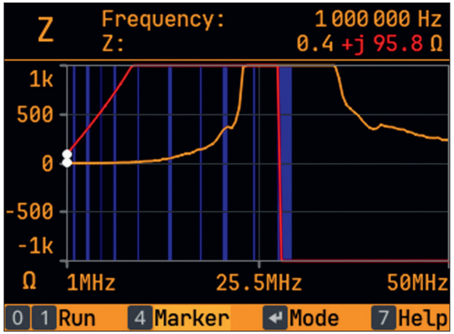

Figure 63: Measurement of a coil: Display *impedance Z*

The values of a self-wound toroidal coil for the short-wave range are now to be determined here using the first type of adapter mentioned. It is a T106-2 toroid (red) with 33 turns of enameled copper wire. Calculation programs on the Internet show an inductance of 14.7 µH for these specifications. For an overview, Figure 63 shows the result of an *impedance Z* measurement in multi-frequency mode for the range 1 MHz to 50 MHz. First, a *current calibration* was performed as described above. The marker was then activated and the Y scaling was changed to the maximum value, in this case 1000 Ω.

The measurement result is characteristic of a coil. The real part of the impedance Z, the resistance, increases only slightly with the frequency, approaches a maximum at approx. 30 MHz and then falls again. The imaginary part of the impedance Z, the reactance, increases linearly with the frequency, but then falls steeply into the negative at approx. 30 MHz. This point, at approx. 30 MHz, is the resonance frequency of the coil. At even higher frequencies, stray capacitances predominate and the component acts as a capacitor. A parallel resonant circuit is present at the resonant frequency. As a rule, the component can only be used as a coil to the left of the resonant frequency. This behavior can also be seen very well in the measurement S11 *Smith chart*, according to Figure 64.

The almost ideal inductance is shown on the circle of the Smith chart almost exclusively in the upper, inductive area of the chart and then runs into the lower, capacitive area at higher frequencies.

As the coil is to be used in the 30 m band at 10.1 MHz, the *single frequency* operating mode with the *LCR meter* measurement is selected to optimize the coil. After a *current calibration*, as shown above, the display is as shown in Figure 65. The

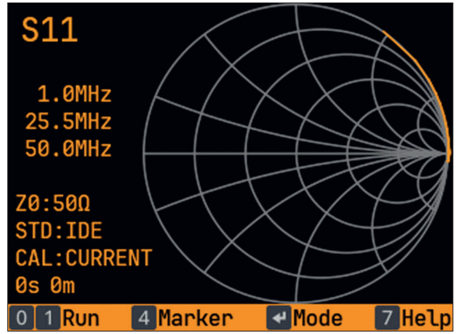

Figure 64: Measurement of a coil: Display *S11 Smith*

impedance model *Serial* is selected in the configuration. As a result, the coil is assumed to be a series connection of an ideal inductance and an ideal resistance and the values of the corresponding equivalent circuit model are displayed.

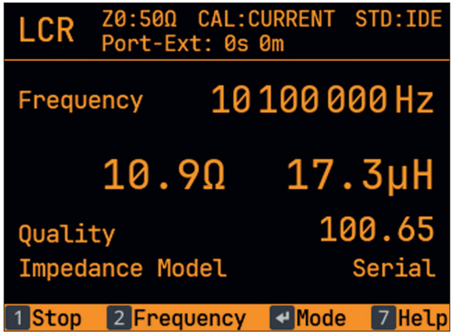

Figure 65: Measurement of a coil: Display LCR in *single frequency* operating mode

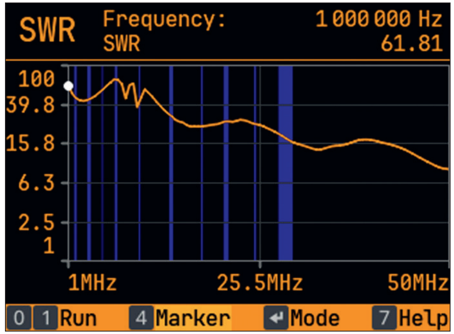

Figure 66: Measurement of a magnetic antenna: SWR range 1 MHz to 50 MHz

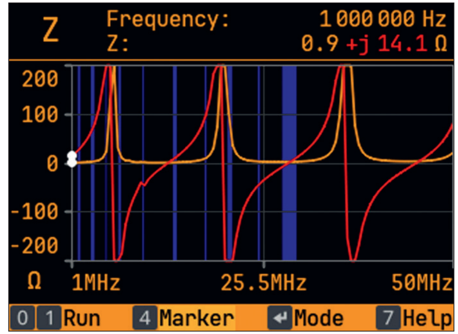

Figure 67: Measurement of a magnetic antenna: *Impedance Z* range 1 MHz to 50 MHz

At the target frequency, this results in a loss resistance of just over 10 Ω and an inductance of 17.3 µH instead of the calculated 14.7 µH Deviations of this magnitude are quite common. Average values are also often specified. At a target frequency of 5 MHz, not shown here, the coil in question has an inductance of 15.8 µH. Due to such deviations, it is always better to measure a self-made component for the target frequency in question.

SWR measurement on a magnetic antenna

Magnetic antennas sometimes have very narrow resonance points, which may be overlooked during the measurement. A magnetic antenna is measured via a 5 m feed line. First of all, a measurement of the SWR in *multi-frequency* operating mode for the frequency range 1 MHz to 50 MHz produces Figure 66. The marker was activated and the maximum value of the SWR was set to 100 using Y-scaling. This is the only way to read a continuous SWR.

Based on the curve, you can still guess that the current resonance is around 10 MHz. However, it is also possible that a resonance does not appear at all because it falls between two measured values. The *impedance Z* measurement in Figure 67 does not help either. The impedance of the antenna feed line dominates here.

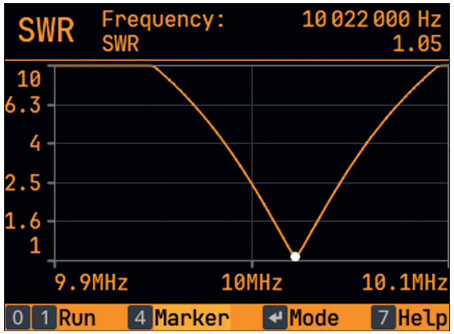

Figure 68: Measurement of a magnetic antenna: SWR range 1 MHz to 50 MHz

Only setting the center frequency to 10 MHz and setting a frequency span of 200 kHz provides the desired result as shown in Figure 68.

At 10.02 MHz, the SWR is determined to be 1.05. The bandwidth of this magnetic antenna is only a few kHz. Measurements on very narrow-band antennas may therefore require some patience and experience.

Updating the firmware

If newer firmware is available, it can be loaded very easily. The FA-VA6 must be connected to a PC via USB. The firmware is provided as an executable program which automatically detects the connected FA-VA6 and installs the new firmware after confirmation.

Care instructions

The FA-VA6 does not require any special maintenance or care. Dirt should be removed with a damp cloth. Cleaning with microfiber cloths is not recommended, as these can damage the display plastics in particular.

When cleaning the housing, bear in mind that it is not waterproof. Strong solvents should always be avoided when cleaning.

When not in use, the FA-VA6 should be stored in the case supplied. Excessive lateral pressure should be avoided as this could accidentally switch on the FA-VA6.

If the battery is not used for several months, a charge of 30 % to 50 % has proven to be optimal. Lithium-Ion batteries that are charged too high or too low can lose capacity. In general, the self-discharge rate of Lithium-Ion batteries is very low.

VNWA software for the FA-VA6

The VNWA software developed by Thomas Baier, DG8SAQ, is available for connecting the FA-VA6 to the PC. VNWA was originally created for the 2-port network analyzer VNWA3. Thomas Baier has adapted VNWA accordingly to the FA-VA5 and FA-VA6 so that all relevant 1-port measurements and evaluations can be carried out. In addition, FA-VA6 data records can be imported into VNWA for documentation purposes and other tasks.
VNWA is a very comprehensive piece of software that should leave nothing to be desired, even for experienced users. The program itself is only available in English, but the detailed VNWA help file is also available in German at [4]. All 1-port measurements (two-pole measurements) described there can also be carried out with the FA-VA6. The VNWA and FA-VA6 duet therefore provides a fully-fledged 1-port measuring station up to 1 GHz.
Not all available VNWA functions can be described in these installation and operating instructions. The introduction is therefore limited to the connection of the FA-VA6 to the PC and VNWA, the import of data records and a simple measurement example. A more comprehensive introduction for the predecessor FA-VA5 is available at [3] and [4]. All aspects described there can be transferred to the FA-VA6 accordingly.
The basic interaction between VNWA and FA-VA6 is as follows: Windows provides a virtual COM port for the FA-VA6 connected via USB. VNWA sends control commands to the FA-VA6 via this virtual COM port. After the desired measurement, the FA-VA6 responds by transmitting measurement data in a structured format. The measurement data consists of the measured scattering parameter S11 for each frequency point and is made available in touchstone format. The protocol of the control commands and the format of the resulting measurement data are described in the appendix. In addition, data records stored on the FA-VA6 are read out with corresponding control commands. In both cases, VNWA thus receives sets of scattering parameters S11 for each frequency point, which are stored in the VNWA internal measured value memory. These measured scattering parameters S11 are evaluated by VNWA. All evaluations that can be displayed there are mathematically derived from the measured scattering parameters S11.

■ PC connection of the FA-VA6

As soon as the FA-VA6 is connected to a USB port on a PC, it is registered as a virtual COM port in the Windows operating system. A separate driver installation is not required for current Windows versions. However, the number of the COM port is required for further configuration.
The successful registration and the number of the COM port can be verified via the Windows Device Manager. The entry *Serial USB device* should appear under *COM & LPT ports*. In the example in Figure 69, the FA-VA6 occupies the virtual COM port COM3.

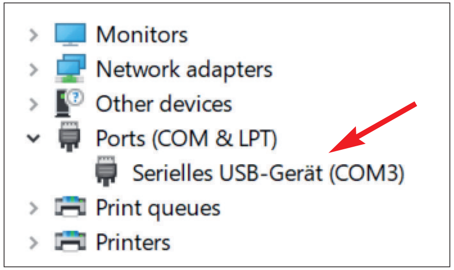

Figure 69: Registration as a virtual COM port under Windows

Note: Double-clicking on the entry opens a window with the details of the installed driver. Under the Details tab, the entry *Device instance path* can be called up under *Property*. The *value* shows a character string starting with FA_VA6_. The following number represents the serial number of the device.

■ Installation of VNWA

VNWA can be downloaded from [4]. The corresponding file is called *VNWA-installer.exe*. This is an executable file that already contains all the software libraries required for connecting the FA-VA6.
After downloading the EXE file, it must be executed. As is usual with Windows software, the following installation is menu-driven and largely self-explanatory. All suggested entries can be confirmed with *Next*. License keys or certificates are not required for operation with the FA-VA6. Confirm the request with *Next/Next* or *Exit*.
After installing the VNWA software, it must be started. A warning message appears which does not affect the FA-VA6 and can therefore be confirmed with ok. The same applies to the following message. VNWA initially displays its initial screen (Figure 70). The software correctly reports at the bottom left of the window that no VNWA hardware has been detected.

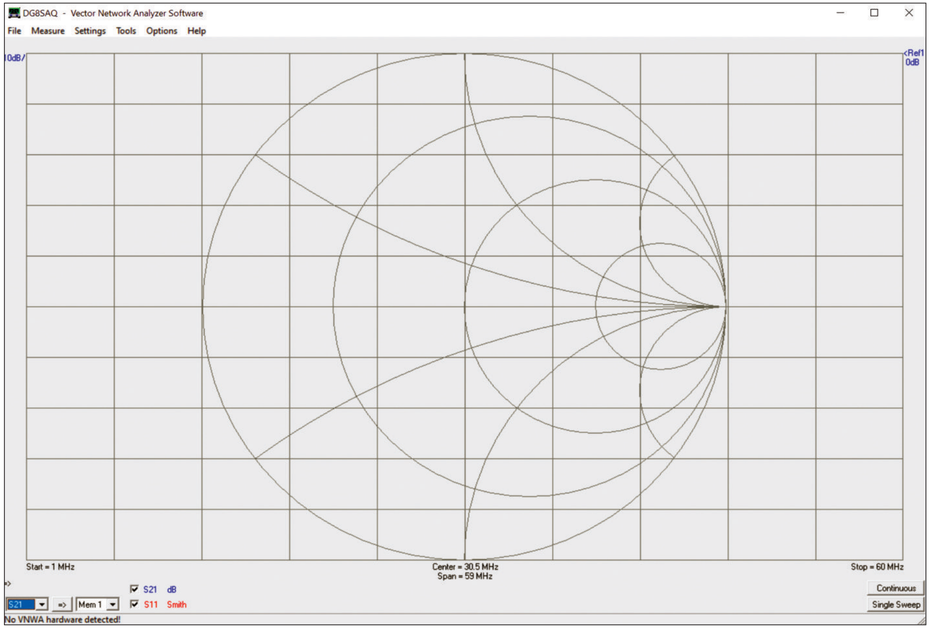

Figure 70: VNWA start screen after installation

If the existing grid is not clearly visible (depending on the default window color of the Windows version), the background color can be changed via the menu item *Settings* **Æ** *Diagrams* **Æ** *Display* **Æ** *Grid Options* and thus adapted to your own taste.

■ Connection of the FA-VA6 to VNWA

Before you can work with VNWA, the FA-VA6 must be able to communicate with the PC software. To do this, it must be set to USB mode by selecting it in the *Main menu*.

Once this has been done, select *Select Instruments* **Æ** *Add to/remove from Select List* **Æ** *DG5MK Antenna Analyzer* in VNWA. The FA-VA6 has now been added to the list of selectable devices. The actual selection is then made using *Options* **Æ** *Select Instrument* **Æ** *DG5MK Antenna Analyzer*.

The COM port determined via the Windows device manager must now be "communicated" to VNWA. This is done under *Options* **Æ** *Setup*. A new window opens and the COM port must be selected from the list under *Port*. The successful connection to the FA-VA6 is acknowledged with

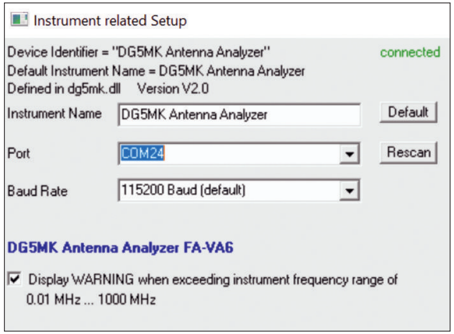

Figure 71: Example FA-VA6 setup in VNWA

a green connected at the top right, a blue lettering indicates the version of the analyzer (Figure 71).

This completes the connection of the FA-VA6 to the VNWA software. Incidentally, this "remembers" all settings after the program is closed. For this reason, the FA-VA6 should be put into operation the next time before starting the program again on the same USB port.

A second important setting and selection area in the interaction between FA-VA6 and VNWA can be found under *Settings* **Æ** *Sweep* (Figure 72).

In addition to some basic settings for multi-frequency measurements with VNWA as the controlling software, the second tab

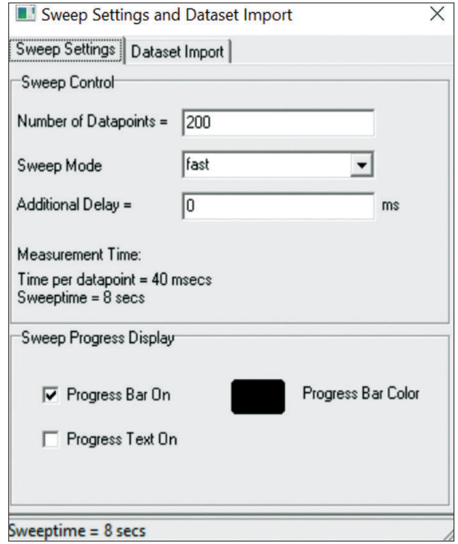

Figure 72: Basic settings for multi-frequency measurement and data import

of this window allows the import of locally saved data sets from the FA-VA6, as described below:

Import of data records

After clicking on the second tab in Figure 72, a window like the one in Figure 73 appears, where the 16 available data records are listed with their time stamp, similar to the local menu of the FA-VA6.

Selecting a data record by left-clicking and then right-clicking opens a context menu. By left-clicking on the corresponding line in the context menu, the corresponding data is now saved to a file or the Windows clipboard. The latter can also be done directly by double-clicking with the left mouse button. The file path and name of the file can be freely selected. Its format corresponds to the common *Touchstone* format, which can also be read as a text file, e. g. with an editor.

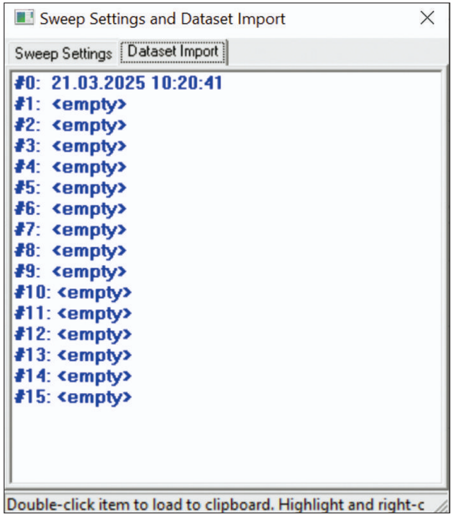

Figure 73: Selection window for data import

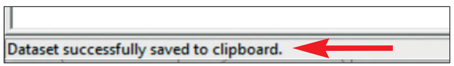

Figure 74: Acknowledgement of the data import

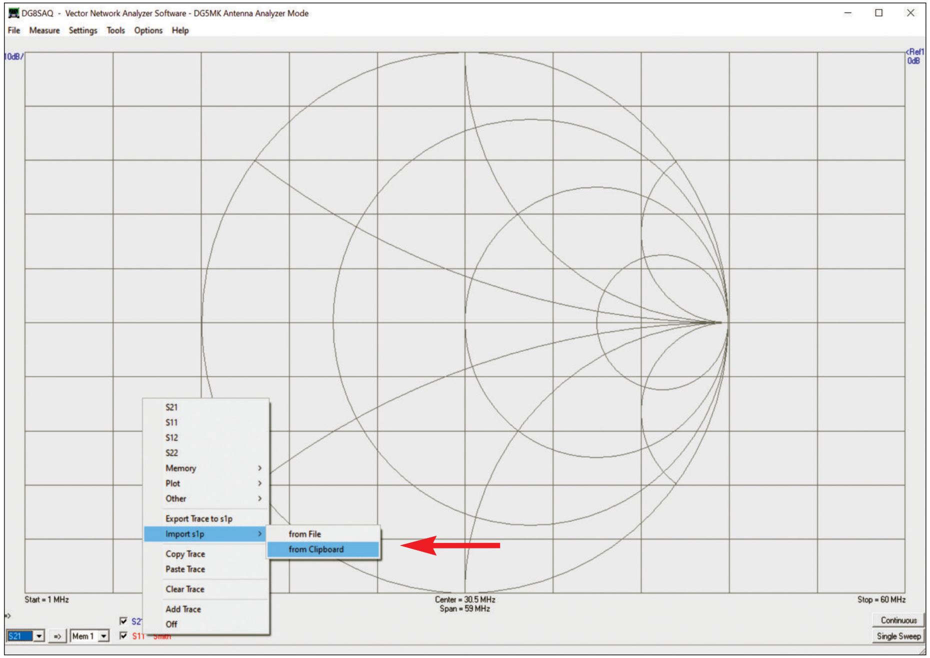

Figure 75: Importing measured values from the clipboard into the measured value memory

In the following example, the data is copied to the clipboard. After double-clicking, VNWA reads the data into the Windows clipboard and acknowledges the process (Figure 74). The relevant window can then be closed.

The last step is to transfer the data from the clipboard to the measured value memory of VNWA. The measured value memory relevant for the FA-VA6 should always be S11, as this corresponds to the scattering parameter of a 1-port device.

The transfer is carried out by right-clicking on a displayed S11 output channel (Figure 75). In the main window, for example, a channel S11 Smith is visible in red at the bottom left. Right-click directly on *S11* and *Import s1p* ***Æ*** *from Clipboard* to load the data into the S11 measured value memory.

They are displayed graphically in the main window of the program immediately after they have been read in; an info window appears to confirm that the read-in process has taken place (Figure 76).

The following quick solution is available for the familiar SWR display, which has already been anticipated in Figure 76: Double-click on the *S21* in blue, which is also visible, select the abbreviation VSWR instead of dB in the bottom left of the following window and also select the parameter S11 instead of S21. The locally measured standing wave ratio in the frequency range of the measurement is now shown as a blue curve. In the interest of better readability, one or more so-called frequency markers can be added. This allows any points on the curve to be "approached" in order to be able to read the measurement

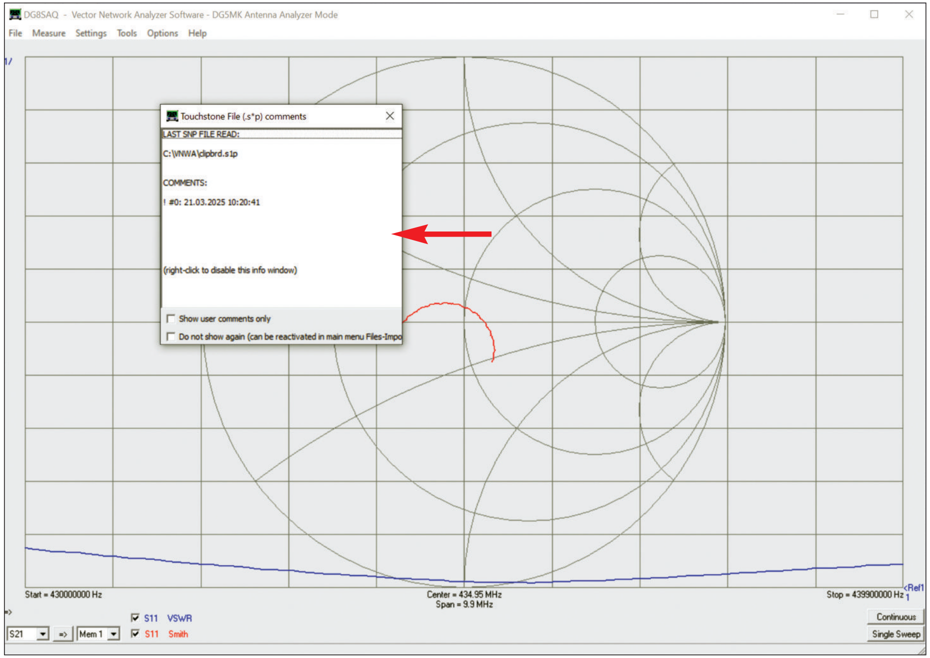

Figure 76: Acknowledgement of the data import into the measured value memory with display of the comments

frequency and measurement result precisely.

To do this, simply right-click within the grid frame and an empty area. A context menu opens as shown in Figure 77, click on *Add Frequency Marker Æ Normal*. The frequency marker 1 that is then generated is a small triangle at the top with an associated number. It can be moved along the measurement curve by left-clicking and holding the mouse button. At the top left of the main window, the corresponding frequency and the corresponding value of the associated SWR are then displayed in the same color as the curve, i.e. in blue. In the example in Figure 77, the frequency marker is at 435 MHz. An SWR value of 1.12 was measured there.

The procedure described above sounds a little complicated at first due to its detailed description. However, once you have practiced the actually simple data transfer process a few times, it should no longer cause any difficulties.

The measurement diagrams displayed in VNWA can be saved and printed. To do this, select the menu item *File Æ Print* in the main window of VNWA. The graph can then be saved as an image or printed out on a printer.

FA-VA6 as USB measuring front-end

USB measurement front-end here means that the VNWA PC software takes over the control and evaluation of a measurement. As described, the FA-VA6 supplies the measured scattering parameters S11 for the requested frequencies after a control command. For example, parameters of a multi-frequency measurement, such as the number of measuring points (instead of the locally fixed 101 points), can be defi-

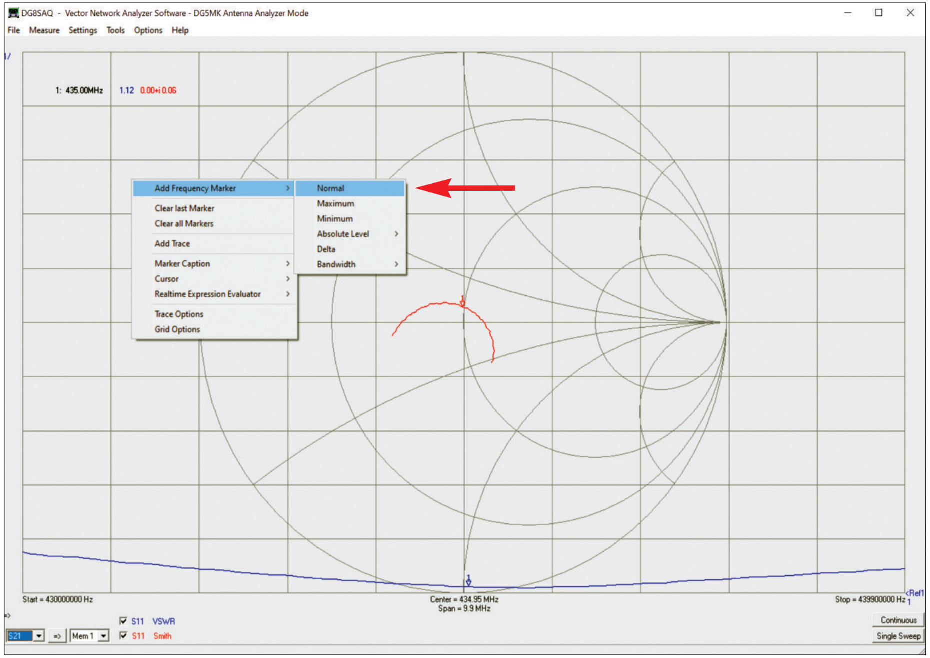

Figure 77: Adding a frequency marker

ned as required within predefined limits. In the following sections, the procedure is explained using a simple measurement with values to be determined for SWR and impedance as an example.
Basically, the process is divided into the individual steps *Determining the measurement parameters*, *Calibration*, *Measurement* and *Display and calculation*. Calibration is always required when measurement parameters change. Once the measurement has been carried out and the scattering parameters S11 have been stored in the internal measured value memory S11, a large number of possible different displays and calculations can be selected. These always refer to the current data in the measured value memory S11. A new measurement is not required if the display and calculation are changed. The measurement on an antenna for the 70 cm band is shown here as an example.

Step 1: Determining the measurement parameters

The first step is to define the frequency to be viewed. In the main window of VNWA (Figure 77), this can be easily done by double-clicking on a frequency specification at the bottom left, center or right. The input window that opens (Input) allows you to enter the start and stop frequency of a multi-frequency measurement. Note the decimal point separating the digits before and after the decimal point. For the example, 430 MHz to 440 MHz was selected (Figure 78).
Other parameters are device-specific and can be set for the FA-VA6 via the familiar window shown in Figure 72 (*Settings* Æ *Sweep*). In addition to the number of measuring points (*Number of datapoints*), one of the three FA-VA6 accuracy levels (*Sweep mode*) can be selected: fast, standard or precise. In addition, a further delay can be set for each measured value (*Additional delay*). This can be useful when measuring low-frequency filters, which have a long settling time. VNWA calculates the resulting time for the multi-frequency measurement. The window can be closed here with the default values and all measurement parameters are now defined.

Step 2: Calibration

Calibration is mandatory after changing measurement parameters and before a measurement. The values of a local FA-VA6 calibration, e.g. the *factory calibration*, as

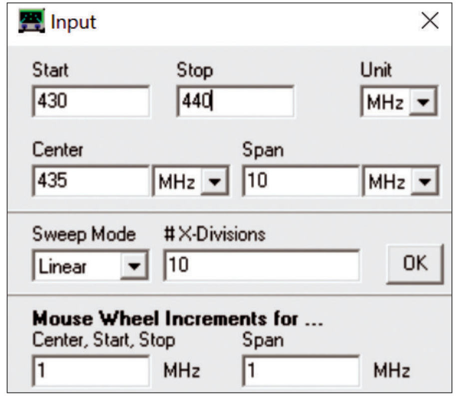

Figure 78: Input window for start and stop frequency

well as the parameters of the SOL calibration elements defined in FA-VA6 are not known to VNWA. VNWA must therefore carry out this calibration itself for the measurement parameters selected in VNWA. In addition, the parameters of the calibration elements used must be entered once in VNWA. The measured values obtained after a measurement can only be meaningfully evaluated after calibration.

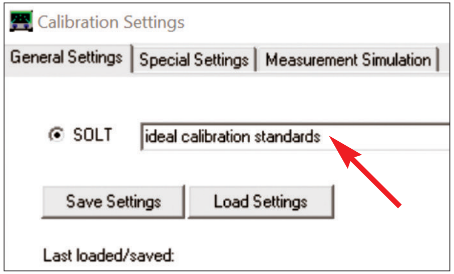

Figure 79: Parameters of the calibration elements used: here *ideal standards*

As in the local mode of the FA-VA6, calibration elements with ideal or measured parameters (frequency-dependent) can be used. The included kit of calibration elements is classified as ideal because the parameters would have to be measured individually after assembly. The precision elements [5] available as accessories are individually measured, which tends to lead to more accurate measurement results.
The parameters of the calibration elements used are entered under *Setting Æ Calibration Kit*. The window shown in Figure 79 opens after the *General Settings* tab has been selected. *Ideal calibration standards* must be selected for the calibration element kit. No further parameters need to be entered.

For the precision elements, select simple model *custom calibration standards* instead of *ideal calibration standards*. After selecting the *Simple SOLT Model Settings* tab, the window shown in Figure 80 appears. The values from the instruction leaflet for the precision elements can be entered manually here. Other values should not be changed.
The instruction leaflet also contains a link to the corresponding parameter file, which can alternatively be loaded via VNWA. After saving the file, the parameters of the calibration elements are imported via *Load Settings* after selecting the file and Open, see Figure 79. The parameters only need to be entered once; VNWA saves the values until they are overwritten by new values. Normally, this is not necessary for all subsequent measurements and evaluations, as only one set of calibration elements is normally used.

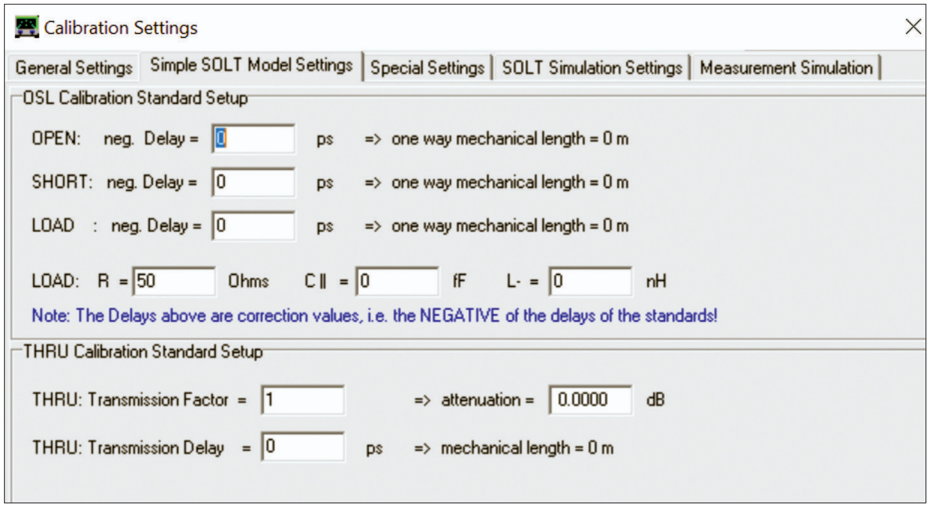

Figure 80: Parameters of the calibration elements used: here *precision standards*

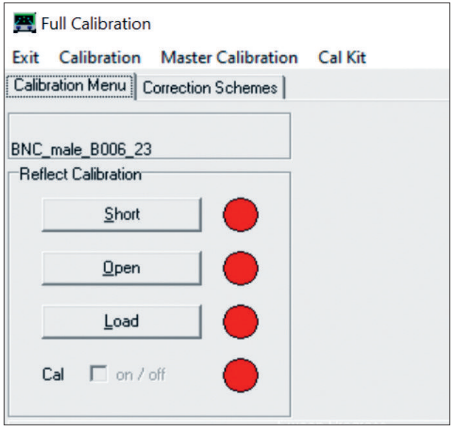

Figure 81: Calibration window of the VNWA software

The actual calibration for the defined measurement parameters, suitable for the subsequent measurement, is carried out via the menu item *Measure* Æ *Calibrate*. The window that opens according to Figure 81 shows the status of the current calibration in the form of red circles, in this case it is uncalibrated. Left-click on the *Short* button to open another window, which now prompts you to connect the Short calibration element to the FA-VA6. Once it has been connected and confirmed, a measurement cycle starts and the circle turns green with a red *M* in the middle. Calibration for *Open* and *Load* must be carried out in the same way and the window can then be closed. A *Cal* for calibrated should now appear at the bottom left of the main VNWA window.

The advantage of this calibration procedure is that the hardware and measurement parameters have now been calibrated exactly to the current measurement configuration. An extension cable used, for example, is simply "calibrated in" when the calibration is performed at the end of the cable.

Step 3: Carrying out the measurement

The measurement itself is very simple once the measurement object has been connected. In the main window, click on *Single Sweep* (bottom right) to start a single multi-frequency measurement. As a result, the measured values are stored in memory S11. With the display settings from the example of the data read in by the FA-VA6, a view as shown in Figure 82 results.

If, for example, you want to permanently monitor the result of an adjustment process on the measurement object, press the *Continuous* button to start constantly repeating measurement runs, which can only be ended by pressing the *Stop* button.

Step 4: Selecting the display and calculation

One of the strengths of VNWA is the extensive options for displaying and evaluating measurement results. A total of up to six different output channels and their calculation rules can be selected.

After double-clicking on the colored S11 of an existing channel in the main window of VNWA at the bottom left, a new window opens as shown in Figure 83. Among other things, you can define in detail here which channel (*trace*) is to be displayed with which meaning. In the example, the simple settings shown in Figure 83 apply. Only the values calculated from S11 for the standing wave ratio (VSWR) should be displayed here in blue. The reflection coefficient is shown as a red curve in the Smith chart.

Again, please refer to the help document [4] for the extensive additional options.

The last step is to format the selected output channels appropriately. In the main window (Figure 83), you will find a color-coded indication of the scaling at the top left, which shows the change in the displayed values per grid unit. On the right-hand side, again color-coded, is the indication of the reference level or value. Both

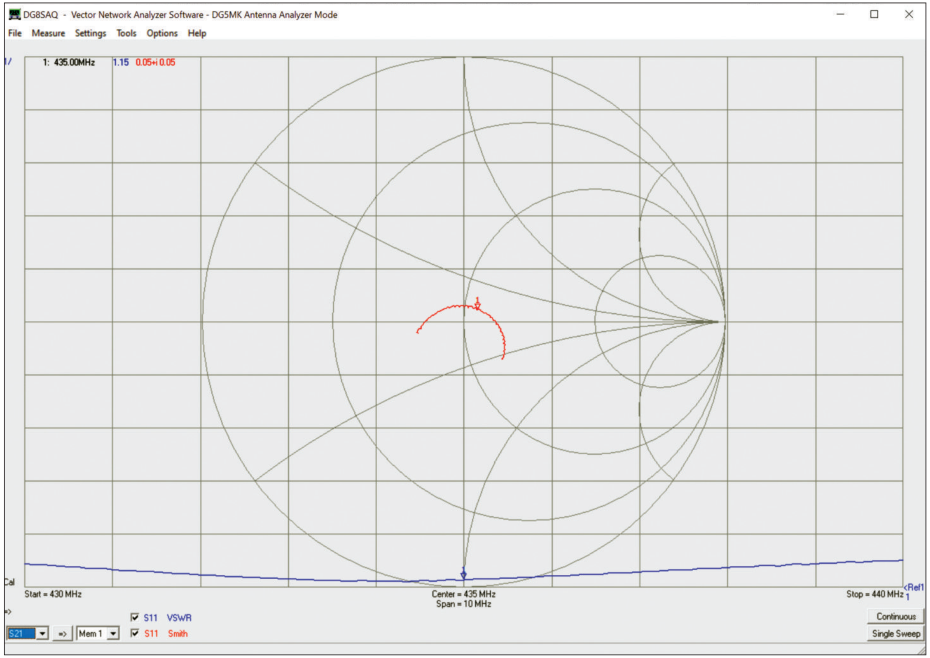

Figure 82: Result of a measurement run after calibration

can be set by double-clicking on one of the values in a window that then opens. The reference level can also be moved by clicking and holding. In the example shown in Figure 83, the bottom line in the diagram corresponds to the value SWR = 1, the line above it means SWR = 2, the other lines follow this pattern.

The high flexibility of scaling and positioning serves to improve readability. As long as the scaling and reference level are known, it does not matter where the curves

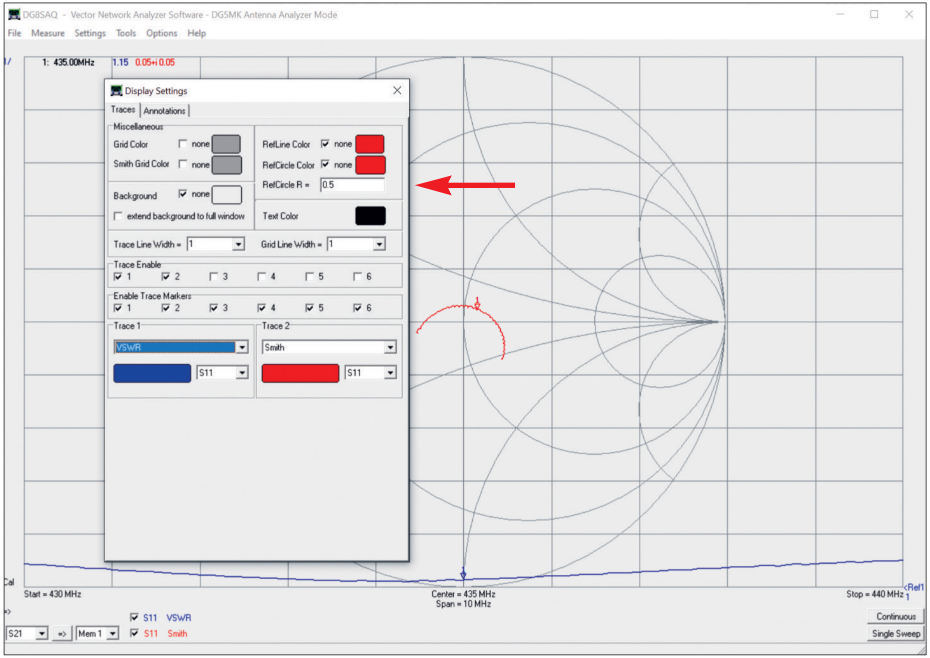

Figure 83: Selection of output channels and calculation rule

are positioned in the grid, they can be moved.
A practical function and a good starting point is auto-scaling (*Autoscale*), which can be accessed by left-clicking on the scaling values. The subsequent setting to smooth values makes it easier to read. Last but not least, frequency markers help to better examine individual values along the curves. Various marker functions can be called up by right-clicking in an empty area within the grid frame. In the example, a marker was created by right-clicking on *Add Æ Frequency Marker Æ Normal*. Double-click on the triangle of the marker to open a window as shown in Figure 84.

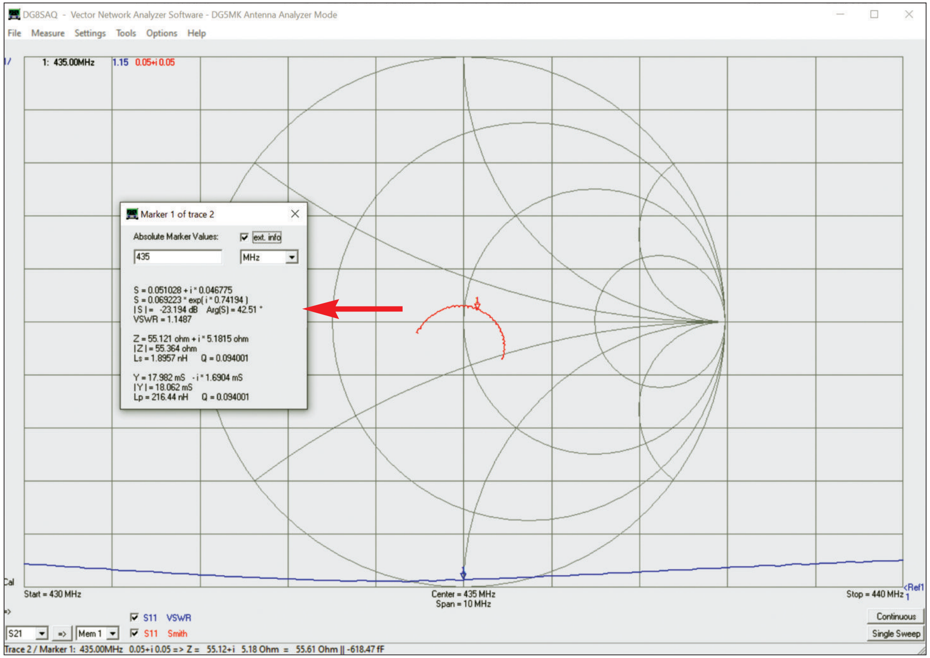

Figure 84: Detailed information on the measured value at the marker position

First, by entering the frequency value in the window, the marker can be set exactly at a desired frequency point, in the example at 425 MHz. In addition, calculated detailed values for the measured value are displayed at the position of the marker. For example, an impedance Z with a real part of 55.121 Ω and an imaginary part of 5.1815 Ω is displayed. The impedance value of 55.364 Ω is close to the desired system impedance of 50 Ω, which results in a good SWR of 1.15. The positive imaginary part indicates an antenna with a slightly inductive character, it is too long. By fine-tuning the mechanical elements, you could now try to bring the imaginary part as close as possible to zero.

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[2] Knitter, M., DG5MK: *www.dg5mk.de*

[3] Knitter, M., DG5MK: Vektorieller Antennenanalysator FA-VA5 für 10 kHz bis 600 MHz. FUNKAMATEUR 67 (2018) H. 4, S. 322–326, H. 5, S. 436–441

[4] Baier, T., DG8SAQ: VNWA-Software. *www.sdr-kits.net* Æ *DG8SAQ VNWA 3* Æ *Software & Documentation*

[5] FUNKAMATEUR-Leserservice, Majakowskiring 38, 13156 Berlin, Tel. (030) 44 66 94-72, Fax -69; *www.box73.de* Æ *BX-245-SOL*

[6] Knitter, M., DG5MK: Vektorieller Antennenanalysator FA-VA6 für Messungen bis 1 GHz. FUNKAMATEUR 74 (2025) H. 5, S. 360–362; H. 6, S. 465–467

Appendix

Table 3: Parts list

Component	Quantity	Remark
Holder for 18650 battery	1	
Keyboard 4×4	1	pre-assembled
Screws T6 M2×6	4	pre-assembled on keyboard
Nuts M2	4	pre-assembled on keyboard
TFT display	1	pre-assembled
Adhesive strip 45 mm × 60 mm	1	pre-assembled on display
Housing, printed	1	consists of upper and lower shell
Rubber feet	4	
Insulation pads	2	pre-assembled in upper housing shell
Cylinder screws T10 M3x6	4	for mounting circuit board in housing
Nut and washer for BNC socket	1	
Countersunk head screws T10 M3×6	4	for screwing on the housing shells
T10 bit insert	1	
USB cable (USB-C to USB-2.0)	1	
Case with foam inserts	1	
Construction and operating instructions	1	
Type plate	1	to be glued to the underside
BNC connector	3	for SOL self-assembly kit
49.9 Ω Resistor	1	for SOL self-assembly kit
Silver wire, approx. 5 cm	1	for SOL self-assembly kit
Accumulator*	1	Panasonic NCR18650BD
Measurement report	1	single page

* Due to transport restrictions imposed by our logistics service provider regarding hazardous goods, delivery with lithium-ion-battery is only possible within Germany. For users outside Germany, the FA-VA6 without battery is available under order number BX-246-A.

Table 4: Parameter explanations

Abbreviation	Parameters	Explanation
SWR	Standing wave ratio	Ratio of maximum to minimum of an envelope curve, which results from the superposition of incident and reflected wave. SWR = 1 means no reflected wave (maximum = minimum) and therefore optimum matching of a load to a source (usually 50 Ω).
Z0	Reference impedance	Actual impedance of the source (usually 50 Ω) or value for the conversion of displayed values to a new, fictitious reference impedance (what-if consideration)
Z	Measured impedance	Impedance of the test object as a complex value after the real and imaginary parts. The real part is the resistance, the imaginary part is the reactance.
Abs(Z), |Z|	Absolute value (amount) of Z	Amount of the measured impedance Z. Also referred to as impedance.
Phase(Z), Arg(Z)	Phase from Z	Indicates the phase shift of voltage and current caused by connecting the impedance Z. Is specified in degrees or in radians.
S11	Scattering parameter (reflection factor)	Ratio of a reflected to an incident wave as a complex value according to real part and imaginary part. S11 is a measure for the adaptation of a load to the source. With optimum matching, S11 is zero.
Abs(S11), |S11|	Absolute value (amount) of S11	Amount of the measured scattering parameter S11. Only considers the magnitude ratio of a reflected to an incident wave, without evaluating the phase.
Phase(S11), Arg(S11)	Phase of S11	Specifies the phase shift of the reflected wave to the incident wave. Is usually specified in radians.
R, Rs, Rp	Resistance R	Designates the value of the resistance R for a series or parallel equivalent circuit model for a measured impedance Z.
C, Cp, Cs L, Lp, Ls	Capacitance C, Inductance L	Designates the value of the capacitance or inductance for a series or parallel equivalent circuit model for a measured impedance Z.
Q	Quality	Describes the quality of a measured impedance Z as the ratio of the imaginary part to the real part of the impedance Z.
RL	Return loss	The return loss is a specification in decibels that indicates the attenuation of the reflected wave. If the load is well matched to the source, only a small part of the wave is reflected and the attenuation of the reflected signal is correspondingly high. The higher the value, the better the matching.
ML	Mismatch loss	The mismatch loss is an indication of the power lost in the system due to a mismatch. With optimum matching, no power is lost and the mismatch loss is 0 dB. The worse the matching, the higher the value.
IR	Impulse response	The impulse response is the reaction of a system to a very short but strong voltage impulse. The impulse response of a cable can be used to draw conclusions about the significance and location of interference points based on the strength and time of reflections.

Table 4: Parameter explanations continued

Abbreviation	Parameters	Explanation
SR	Step response	The step response is the reaction of a system to a very steep voltage step. By superposing a DC component in a cable, conclusions can be drawn about the impedance according to time and location.
PE	Port extension	Virtual displacement of the reference plane in seconds (usually nanoseconds) or via the velocity factor of a cable in meters.
VF	Velocity factor	Describes the propagation speed of a wave in a cable in relation to the speed of light in a vacuum.

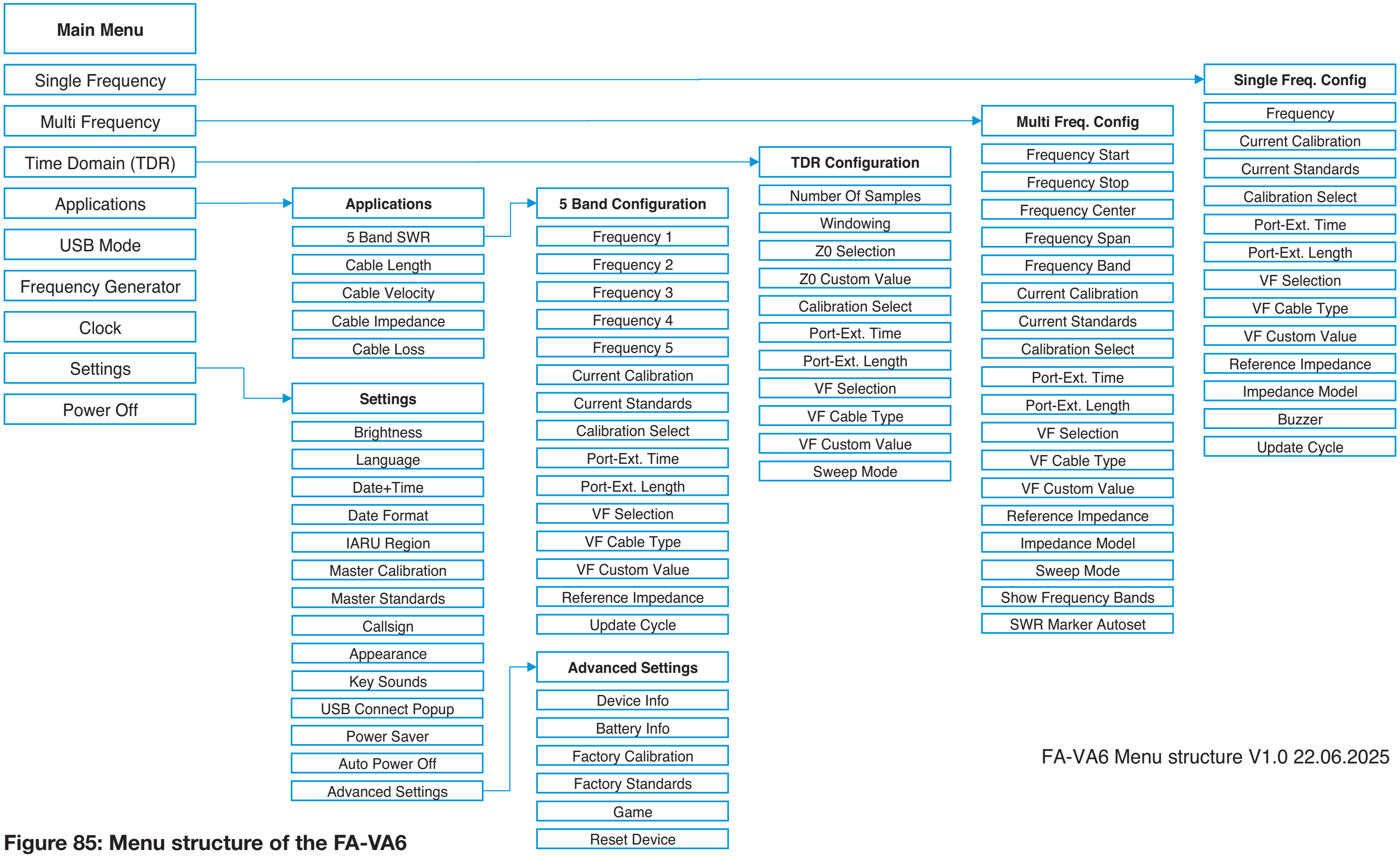

Figure 85: Menu structure of the FA-VA6

■ USB protocol

The FA-VA6 can be controlled via a simple serial protocol, which also enables integration into your own projects. The USB connection is registered on a PC with Windows as a virtual serial interface (virtual COM port). Equivalent to a real, hardware-based serial interface, both commands and measurement data can be exchanged by transmitting ASCII characters. This means that the FA-VA6 can also be operated with simple terminal software or other third-party programs. The interface is designed for communication with the settings 8 data bits, no parity bit, one stop bit (8, N, 1). The baud rate is 115200 baud. Lines must be terminated with line feed (LF).

Table 5: USB protocol

IVIDF	Identification of the FA-VA6	Parameters: none; the return consists of a line of characters that identifies the device
IVRAG	Available frequency range of the FA-VA6	Parameters: none The return consists of two integers that indicate the frequency limits of the supported measuring range
IVSCN	Starts a single or multi-frequency measurement	Parameter: *start_frequency*, *stop_frequency*, *number_of_samples precision[0,1,2]*, *wait_time*, *start_frequency and stop_frequency* must be specified as integers. *number_of_samples* must be specified as an integer. *Precision* describes the available accuracy of the internal processing with 0 = *Fast*, 1 = *Balance*d, 2 = *Precise*. *wait_time* describes an additional delay before each measured value in milliseconds and must be specified as an integer. The FA-VA6 returns data in the form of a *touchstone* format. The first line describes the data format: "# Hz S RI R 50". The line indicates that the following values of the frequency in Hz and the complex scattering parameter *S* are output as real part and imaginary part, related to a system impedance of 50 Ω. This is followed by a number of lines as requested with *number_of_samples*. The first value per line is the frequency, followed by the real part and imaginary part of the uncalibrated S11 value of the measurement. Processing of the uncalibrated values and calculation of the standing wave ratio and other values, including any necessary calibration, must be carried out by the calling software
IVSTP	Stops a measurement sequence	Parameters: none; the return consists of the characters "OK"
IVLDS	Lists the saved measured value records	Parameters: none; the return consists of one line per measured value set, which contains the time stamp of the respective measured value set or "<empty>" if nothing is saved
IVRD6	Reads the saved data record *dataset_index*	Parameters: *dataset_index[0…15]*; the return is analog "IVSCN" in a touchstone format and consists of the 101 stored and calibrated S11 values of the system impedance 50 Ω.
IVRDS	Reads the first 100 measured values from the saved data set *dataset_index*	Parameters: *dataset_index[0…15]* The return is analogous to "IVSCN" in a touchstone format and consists of the first 100 stored and calibrated S11 values of the system impedance 50 Ω. As the FA-VA6 works internally with 101 values, but the predecessor model with 100 values, the 101st measured value is discarded and not transmitted for reasons of compatibility.

The control commands to the FA-VA6 consist of a five-character command with options, separated by spaces and terminated with LF.

■ Measurement protocol

The kit comes with an individual measurement protocol for the circuit board of the respective kit in the form of a single sheet. This shows the scattering parameter S11 in dB and consecutive phase.

As a rule, these values can only be reproduced after careful *actual calibration* with the *Ideal* model. Ideally, there should be an *additional delay* of around 100 ms between the multi-frequency values. The load calibration element should not be removed from the socket after calibration. Even removing and reconnecting it can lead to changing transition resistances, which have a relevant influence on the measured values.

■ SOL calibration element kit

The kit contains all the parts required to build a simple set of BNC-SOL calibration elements. The elements created can easily be used for calibration purposes up to a frequency of 100 MHz, but also beyond that. Patience and a little dexterity are required in some places for the assembly.

The calibration elements consist of a short (short circuit), open (open) and load element (defined terminating resistor). These elements are each produced using a BNC crimp connector. A 49.9 Ω resistor is used for the defined terminating resistor instead of a 50 Ω resistor. The resulting deviations are insignificant for practical purposes.

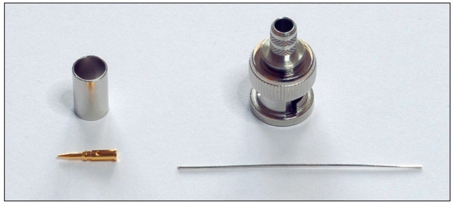

Figure 86: Short and open element components

The BNC connectors each consist of the actual BNC housing, a gold-plated center contact and a crimp sleeve. The use of the crimp sleeve is optional.

Open element

Figure 86 shows the components used for the short and open element, whereby only the center contact is used for the open element.

Using the enclosed piece of silver wire, insert the center contact into the BNC housing from behind and push it forward with flat-nose pliers until you feel it click into place. The piece of silver wire is pulled off again and used later for the short element.

Figure 87 shows the prepared process. Alternatively, the center contact can be inserted with the piece of silver wire and then snapped into place with light pressure using a small screwdriver.

Short element

The components shown in Figure 86 are used for the short element, while the crimp sleeve is again optional. First solder the silver wire to the center contact. No solder must get onto the outer area of the contact.

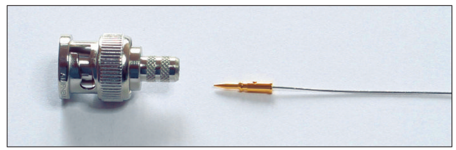

Figure 87: Preparing the open element

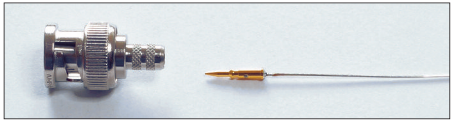

Figure 88: Preparation of short element

This can be done very easily using pliers that hold the center contact and silver wire in a vertical position. The solder then flows into the center contact during the soldering process. Figure 88 shows the desired result in preparation for the next step.

The center contact, with the soldered silver wire, must in turn be inserted into the BNC housing. The notes on the open element apply for snapping in. The silver wire must now be folded over on the outside of the BNC housing and shortened to a few millimeters using the side cutter. Figure 89 shows the desired result.

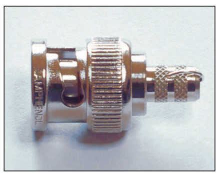

Figure 89: BNC connector with folded and shortened wire

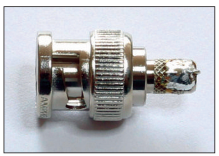

Figure 90: BNC connector with soldered wire

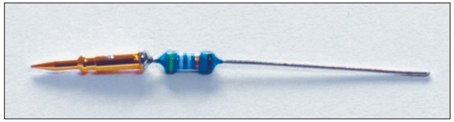

Figure 91: Preparation of load element

The last step is to solder the folded and shortened wire to the outside of the BNC housing. A good contact requires plenty of heat and solder. The BNC housing can be locked in a pair of pliers for the soldering process. Figure 90 shows the corresponding point after the soldering process.

Load element

The load element is created in the same way as the short element. Only the 49.9 Ω resistor is used instead of the silver wire. The connecting wires must be shortened accordingly. However, the resistor should not rest directly on the center contact. Figure 91 shows the preparation of the load element.

Special care is required when engaging the center contact. The connecting wires of the resistor are very thin and can bend quickly. If necessary, only very careful support can be provided with a screwdriver.

Figure 92 shows the completed set of calibration elements. If you have the appropriate crimping pliers, you can attach the three crimp sleeves to provide better protection for the calibration elements. Figure 93 shows the set with crimp sleeves attached.

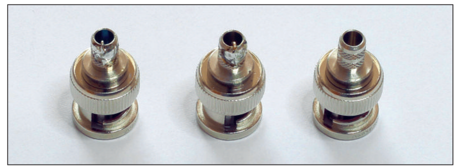

Figure 92: Completed calibration elements

Figure 93: Completed calibration elements with crimp sleeves

Function test

The FA-VA6 itself can be used for the function test of the calibration elements. For this purpose, the three elements are connected one after the other at a low measurement frequency of e.g. 1 MHz in *single frequency* operating mode. In the *impedance Z* measurement, the FA-VA6 should display a value close to zero for Short, a very high value for Open and a value of approx. 50 Ω for Load.
For the load, the return loss can also be used to assess the usability at higher frequencies. To do this, the FA-VA6 is set to the maximum frequency range of 10 kHz to 1 GHz in *multi-frequency* operating mode with measurement *S11 in dB*. A cycle is started when the load is connected. The return loss corresponds to the amount after S11 in dB. At low frequencies, the attenuation should be better than 50 dB and decreases rapidly to 20 dB to 10 dB at higher frequencies. The values displayed are heavily dependent on the calibration performed before. If the existing factory calibration is used, solid reference values are obtained. However, if an *actual calibration* is carried out directly beforehand using a high-quality set with known and entered parameters, very accurate values can be determined for the self-made load.

■ Version history

23.6.2025, Version 1.0

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Order no. BX-246 / BX-246-A

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As of November 2025

Please report problems to *support@funkamateur.de*

When disposing of this product, please observe the regulations for the handling of electronic waste. Electronic devices, batteries and components do not belong in household waste. For further information please check *www.box73.de*