Bode 100, Bode 500

Vector Network Analyzer

User Manual

Smart Measurement Solutions®

Version: ENU1284 05 01 — Year: 2024

Contents

1 Introduction

1.1 About this document

This User Manual was written for professional specialists in electronics and electrical engineering. Its purpose is to familiarize you with the *Bode 100 or Bode 500* vector network analyzer and its various application fields. It contains helpful instructions on how to use *Bode 100 or Bode 500* safely, properly, and efficiently.
This User Manual provides you with information on how to download and install the *Bode Analyzer Suite* and how to connect the *Bode 100 or Bode 500* to your computer. It is intended as an aid for you to take the *Bode 100 or Bode 500* into operation quickly and easily.

The latest version of the Bode 100, Bode 500 User Manual and Quick Start Guides can be downloaded from www.omicron-lab.com.

1.2 Safety symbols used

DANGER

Death or severe injury will occur if the appropriate safety instructions are not observed.

WARNING

Death or severe injury can occur if the appropriate safety instructions are not observed.

CAUTION

Minor or moderate injury may occur if the appropriate safety instructions are not observed.

NOTICE

Equipment damage or loss of data possible

1.3 Bode 100 compliance statements

In the following statement, the *Bode 100* device is designated as "product", "equipment", or "apparatus". The OMICRON contact address can be found on the last page of this document.

Declaration of conformity (EU)

The equipment adheres to the guidelines of the council of the European Community for meeting the requirements of the member states regarding the following directives:

- Electromagnetic compatibility (EMC) directive
- RoHS directive

Declaration of conformity (UK)

The equipment adheres to the regulations of the UK government for meeting the requirements regarding the following regulations:

- Electromagnetic Compatibility (EMC) Regulation
- Regulation for Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

FCC compliance (USA)

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. If this equipment does cause harmful interference to radio or television reception, contact OMICRON Support.

Declaration of compliance (Canada)

This Class A digital apparatus complies with Canadian ICES-003. Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.

The use of the delivered mains adapter is required to comply with FCC and ICES rules as well as the EMC directive.

1.4 Bode 500 compliance statements

In the following statement, the *Bode 500* device is designated as "product", "equipment", or "apparatus". The OMICRON contact address can be found on the last page (back page) of this document.

Declaration of conformity (EU)

The equipment adheres to the guidelines of the council of the European Community for meeting the requirements of the member states regarding the following directives:

- Electromagnetic compatibility (EMC) directive
- RoHS directive

Declaration of conformity (UK)

The equipment adheres to the regulations of the UK government for meeting the requirements regarding the following regulations:

- Electromagnetic Compatibility (EMC) Regulation
- Regulation for Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

FCC compliance (USA)

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

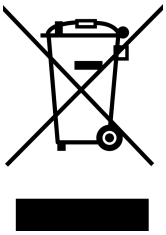
Declaration of compliance (Canada)

This Class B digital apparatus complies with Canadian ICES-003. Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

The use of the delivered mains adapter is required to comply with FCC and ICES rules as well as the EMC directive.

If an antenna is connected to the Bode 500, the emission limits for class B will be violated. If this application is required, ensure that the other environment is electromagnetically protected.

1.5 Information for disposal and recycling



Bode 100, Bode 500, and its accessories, are not intended for household use. At the end of its service life, do not dispose of the device with household waste!

For customers in EU countries (incl. European Economic Area)

OMICRON devices are subject to the EU Waste Electrical and Electronic Equipment Directive (WEEE directive). As part of our legal obligations under this legislation, OMICRON offers to take back the device and to ensure that it is disposed of by authorized recycling agents.

For customers outside the European Economic Area

Contact the authorities in charge of the relevant environmental regulations in your country and dispose of the OMICRON device only in accordance with your local legal requirements.

1.6 Cleaning

Use a cloth dampened with isopropanol alcohol to clean *Bode 100*, *Bode 500* and its accessories.

2 Safety instructions

Before operating *Bode 100, Bode 500*, and their accessories, read the safety instructions in this document carefully. A summary and translation of the safety instructions can be found at the end of this document. If you do not fully understand any safety instruction or any part thereof, contact OMICRON Lab before proceeding. When working with *Bode 100 or Bode 500*, observe all safety instructions in this document. You are responsible for every application that makes use of an OMICRON or OMICRON Lab product. Any miss-operation can result in damage to property or persons. Maintenance and repair of *Bode 100, Bode 500* and its accessories is only permitted by qualified experts either at OMICRON Lab or at certified repair centers.

Following these instructions will help you to prevent danger, repair costs and possible down time due to incorrect operation. Furthermore, it ensures the reliability and life-cycle of *Bode 100 or Bode 500*.

Use *Bode 100 or Bode 500* in observance of all existing safety requirements from national standards for accident prevention and environmental protection.

Reading the *Bode 100, Bode 500* manual alone does not release you from the duty of complying with all national and international safety regulations relevant for working with *Bode 100 or Bode 500*.

2.1 Operator qualifications

- Testing with *Bode 100 or Bode 500* must only be carried out by qualified, skilled and authorized personnel.
- Personnel receiving training, instructions, directions, or education on *Bode 100 or Bode 500* must be under constant supervision of an experienced operator while working with the equipment.
- Testing with *Bode 100 or Bode 500* must comply with the on-site safety instructions as well as additional relevant documents.

2.2 Rules for use

- *Bode 100 or Bode 500* is exclusively intended for the application area specified in this document. The manufacturer/distributors are not liable for damage resulting from a use other than the specified operation. The user alone assumes all responsibility and risk.
- Use *Bode 100 or Bode 500* only when it is in a technically sound condition.
- Do not operate *Bode 100 or Bode 500* in the presence of explosive gas or vapours.
- Do not operate *Bode 100 or Bode 500* under ambient conditions that exceed the temperature and humidity limits listed in the user documentation.
- Do not open *Bode 100, Bode 500* or remove any of its housing components.
- The *Bode 100 or Bode 500* does not contain any serviceable parts. Do not open the *Bode 100, Bode 500* or carry out any modifications, extensions, or adaptations.
- Use *Bode 100 or Bode 500* in observance of all existing safety requirements from national and international standards for accident prevention and environmental protection.

- Always keep the manual as PDF file or printed at the site where *Bode 100 or Bode 500* is used. The manual must be read by all people working with *Bode 100 or Bode 500*. In addition to the manual and the applicable regulations for accident prevention in the country and at the site of operation, heed the accepted technical procedures for safe and competent work.

2.3 Designated use

Bode 100, Bode 500 and their accessories are especially designed for Gain/Phase, S-Parameter and Impedance measurements of electronic circuits in laboratory and manufacturing environments.
Typical applications are:

- Measurement of the complex transfer function of amplifiers, filters and attenuators
- S-Parameter measurement in the 50 Ω domain
- Stability assessment of control loops
- Determination of resonance frequencies of piezo elements and quartz crystals
- Impedance measurement of inductors, capacitors and resistors

Disclaimer

The advisory procedures and information contained within this document have been compiled as a guide for a safe and effective operation of *Bode 100 or Bode 500*. It has been prepared in conjunction with application engineers and the collective experience of the manufacturer. The in-service conditions for the use of *Bode 100 or Bode 500* may vary between customers and end-users.
Consequently, this document is offered as a guide only. It shall be used in conjunction with the customers own safety procedures, maintenance program, engineering judgment, and training qualifications.
Using *Bode 100, Bode 500* or its accessories in a manner not specified by the manufacturer may result in damage to property or persons.

3 Description

3.1 Functional description

The flexible hardware concept of *Bode 100* and *Bode 500* allows to use it for several applications such as:

- Transmission / Reflection measurements
- Gain / Phase (transfer function) measurements
- Impedance measurements

The devices operate in a wide frequency range from 1 Hz up to 50 MHz for **Bode 100** and from 1 Hz up to 450 MHz for *Bode 500*. Both devices generate a sine-wave at a frequency and measure two complex voltage signals. The generation of the sine wave and both voltage measurements are synchronized such that the magnitude and phase relation of the two measured voltages can be derived. This method is called stepped-sine-wave frequency response analysis. The measurement is frequency-sensitive, meaning that the receiver rejects side-band frequencies and noise. This results in a high dynamic range and a high noise rejection.

From the magnitude and phase ratio of the two voltages, the *Bode Analyzer Suite* calculates complex values such as Impedance, Reflection, Admittance, Transmission or Gain of the DUT (Device Under Test).

For a complete list of all possible measurements that you can perform with **Bode 100** and **Bode 500** see 7 Measurement types and applications on page 52.

3.2 Connectors

Bode 100 connectors

Bode 100 is a USB controlled vector network analyzer. The system consists of the *Bode 100* hardware and the *Bode Analyzer Suite* software. In the following the *Bode 100* hardware is described in detail. To learn more about the *Bode Analyzer Suite*, please check out 6 Bode Analyzer Suite introduction on page 33 ff.

Bode 100 provides the following three connectors at the front panel:

- OUTPUT: signal output (BNC socket)
- CH 1: channel 1 signal input (BNC socket)
- CH 2: channel 2 signal input (BNC socket)

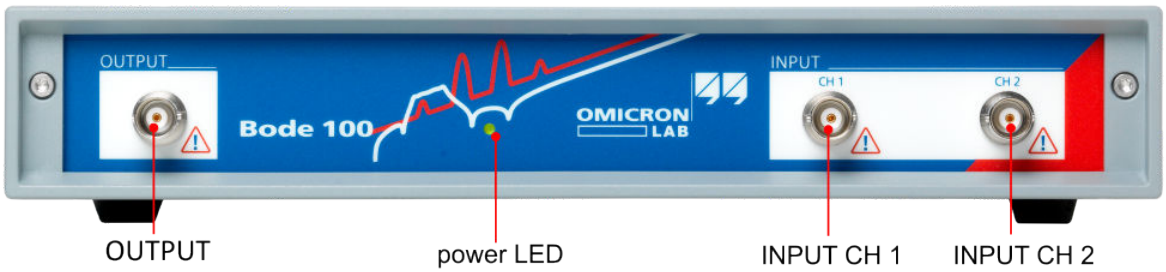


Figure 3-1: *Bode 100* front view

WARNING

Death or severe injury can occur if hazardous voltages are connected to the *Bode 100*.

Bode 100 is a SELV device (SELV = Safety Extra Low Voltage according to IEC 60950-1), also known as protection class III or ES1 equipment according to IEC 62368-1).

- ► Do not apply voltage levels > 50 V DC or > 25 V AC to the inputs of *Bode 100*.
- ► When working with external voltage or current sources in the test setup, ensure that they can not exceed the SELV levels and provide appropriate isolation to other hazardous circuits, such as the AC line voltage supply.
- ► Be aware that the *Bode 100* has no indicator to show if the output is active. This could be especially critical if amplifiers are connected to the *Bode 100*

Bode 100 provides the following three connectors at the rear panel:

- Supply power input for DC voltages from 9 V to 24 V (5.5 mm coaxial plug with 2.5 mm pin)
- USB: data interface (USB type B port)
- ⏚: Ground connector for external ground connection (4 mm banana-socket)

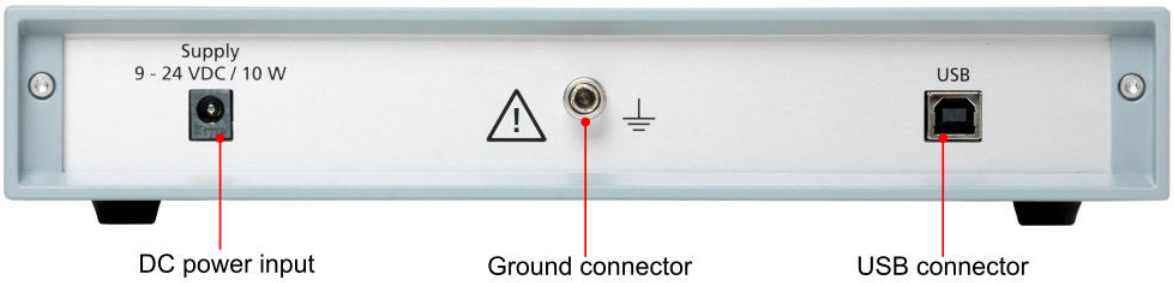


Figure 3-2: *Bode 100* rear view

NOTICE

Risk of permanent damage of the device.

Exceeding the absolute maximum ratings will result in equipment damage.

- ► The AC-coupled inputs represent a high impedance for DC signal. Before using passive probes, check out 8.5 Using external probes & injection transformers on page 100.

NOTICE

Risk of permanent damage of the device.

Connecting a charged DUT to the *Bode 100* can damage the input and output ports.

- ► Always discharge the DUT (e.g. piezo or capacitor) before connecting it to the *Bode 100*.

Bode 500 connectors

Bode 500 is a portable vector network analyzer. The system consists of the *Bode 500* hardware and the *Bode Analyzer Suite* software. In the following, the *Bode 500* hardware is described in detail. To learn more about the *Bode Analyzer Suite*, please check out 6 Bode Analyzer Suite introduction on page 33 ff.

Bode 500 provides the following connectors and indicators at the front panel:

- OUTPUT: signal source output (Type-N socket)
- Source ON LED (yellow): indicates when a signal generated at the output port
- Power/Status LED (RGB): yellow during power-up phase; adjustable color after device has booted
- CH 1: channel 1 signal input (Type-N socket)
- CH1 Termination LED (yellow): indicates channel input impedance (50Ω or high-impedance)
- CH 2: channel 2 signal input (Type-N socket)
- CH2 Termination LED (yellow): indicates channel input impedance (50Ω or high-impedance)

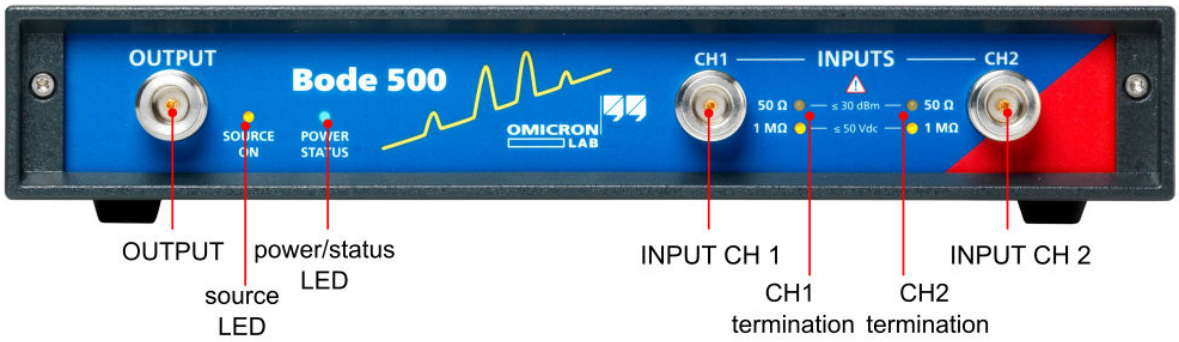


Figure 3-3: *Bode 500* front view

WARNING

Death or severe injury can occur if hazardous voltages are connected to the Bode 500.

Bode 500 is a SELV device (SELV = Safety Extra Low Voltage according to IEC 60950-1), also known as protection class III or ES1 equipment according to IEC 62368-1).

► Do not apply voltage levels > 50 V DC or > 25 V AC to the inputs of *Bode 500*.

► When working with external voltage or current sources in the test setup, ensure that they can not exceed the SELV levels and provide appropriate isolation to other hazardous circuits, such as the AC line voltage supply.

Bode 500 provides the following connectors at the rear panel:

- CONTROL USB: USB-C device port to connect *Bode 500* to a computer
- CONTROL ETH: RJ45 network interface
- Supply power input for DC voltages from 9 Vdc to 24 Vdc (5.5 mm coaxial plug with 2.5 mm pin)
- ⏚: Ground connector for external ground connection (4 mm banana-socket)
- Kensington security lock slot
- EXT TRIG OUT: External trigger output*
- EXT TRIG IN: External trigger input*
- REF FREQ IN: External frequency reference input*
- USB-A: USB host port*

*...reserved for future use, no function in current software version.

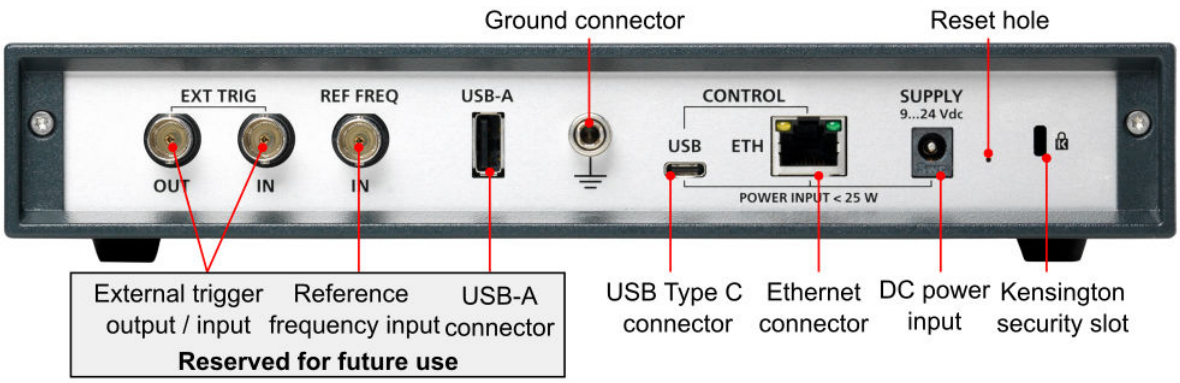


Figure 3-4: *Bode 500* rear view

NOTICE

Risk of permanent damage of the device.

Exceeding the absolute maximum ratings will result in equipment damage.

► The AC-coupled inputs represent a high impedance for DC signal. Before using passive probes, check out 8.5 Using external probes & injection transformers on page 100.

NOTICE

Risk of permanent damage of the device.

Connecting a charged DUT to the *Bode 500* can damage the input and output ports.

► Always discharge the DUT (e.g. piezo or capacitor) before connecting it to the *Bode 500*.

3.3 Block diagram

Bode 100 and *Bode 500* are flexible devices with a similar structure. The main difference is in the digital system architecture and the frequency range of the measurement. *Bode 100* features a minimal digital control circuit, the digital signal processing is performed on the computer running the *Bode Analyzer Suite*. *Bode 500* includes a complete embedded system executing the digital signal processing on the device. In the following, the block diagram of both devices is shown in detail.

Bode 100 block diagram

The *Bode 100* device is composed of the following main building blocks:

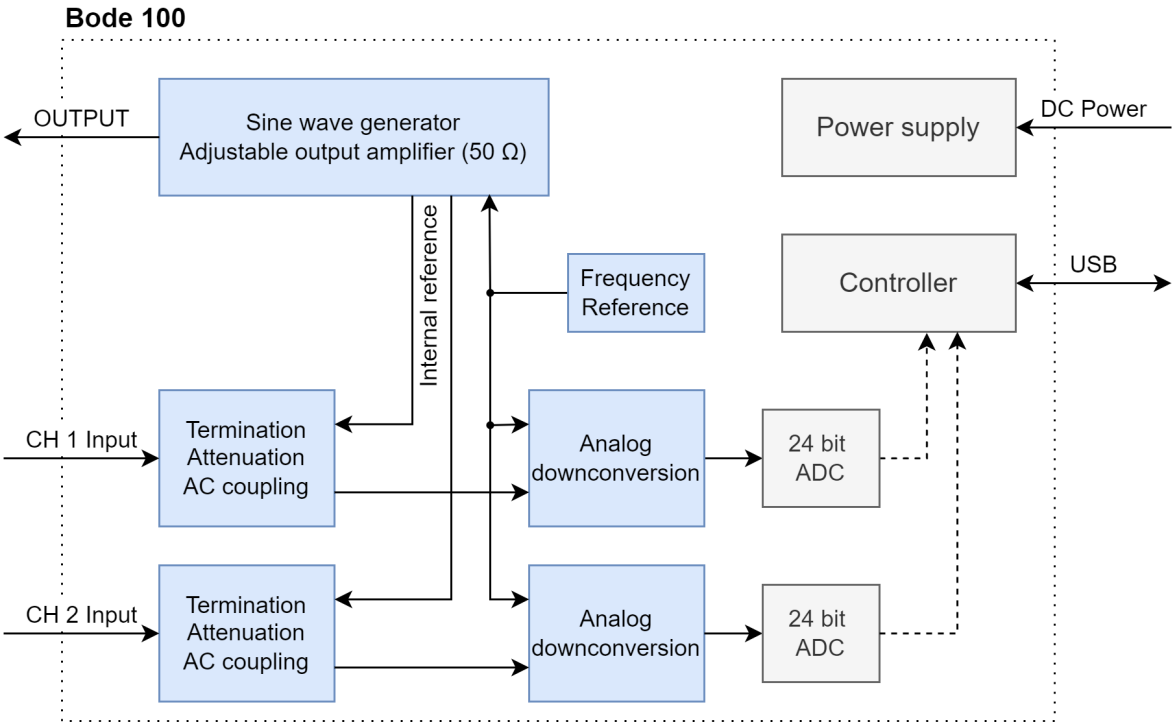


Figure 3-5: *Bode 100* block diagram

- **Signal source:**
  The signal source of *Bode 100* consists of an adjustable DDS sine-wave generator and the adjustable output amplifier. The output impedance is 50 Ω. More information can be found in Signal Source Settings on page 97. Internal reference connections allow to directly connect the source signal to the input channels during transmission and reflection measurements.
- **Channel inputs:**
  Each of the *Bode 100* inputs features an adjustable attenuator (see Choosing the receiver attenuator on page 95) and software-switchable termination. Channel termination can be either 50 Ω or 1 MΩ. Without 50 Ω terminations the inputs are AC coupled, representing a very high impedance at DC.

- **Down-conversion & sampling:**
  The input signal is down-converted to an intermediate frequency and sampled by a 24 bit ADC. The sampled data is sent to the PC and evaluated by the *Bode Analyzer Suite*.

More details on the hardware configuration and the available measurement modes can also be found in Bode 100 hardware setup on page 91.

Bode 500 block diagram

The *Bode 500* device includes the same main elements as *Bode 100* but features a complete embedded system. The architecture of the device is shown below:

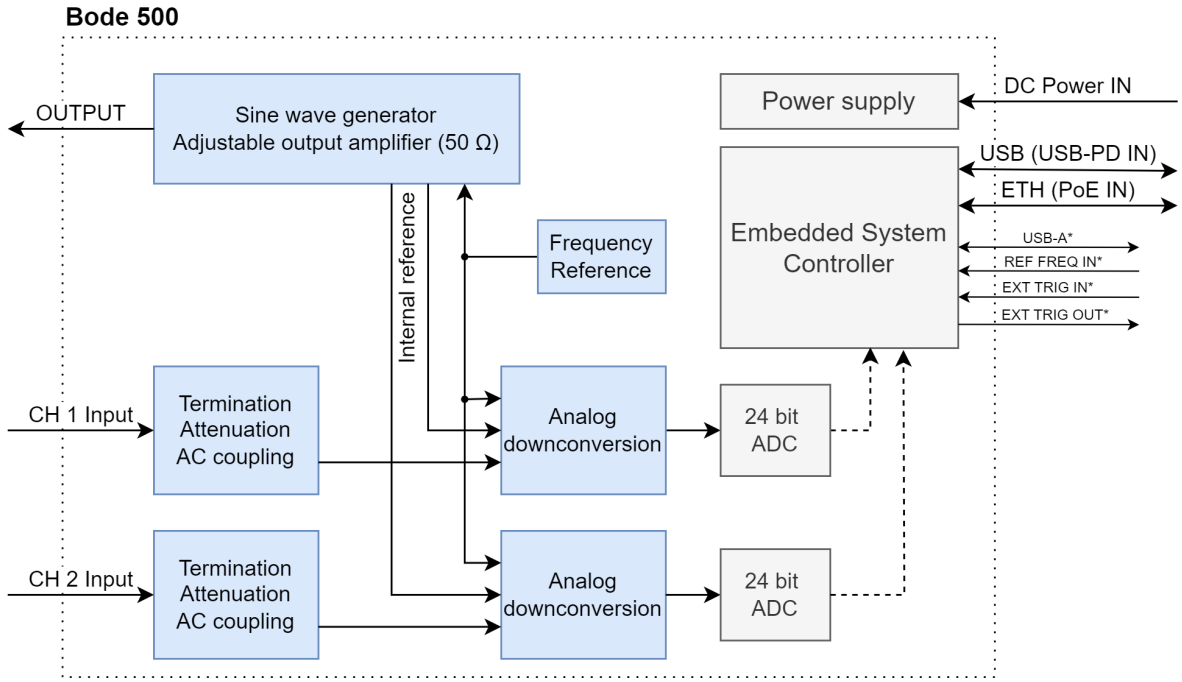


Figure 3-6: *Bode 500* block diagram

- **Signal source:**
  The signal source of *Bode 500* consists of an adjustable DDS sine-wave generator and the adjustable output amplifier. The output impedance is 50 Ω. More information can be found in Signal Source Settings on page 97. Internal reference connections allow to directly connect the source signal to the receivers during transmission and reflection measurements.
- **Channel inputs:**
  Each of the *Bode 500* inputs features an adjustable attenuator (see Choosing the receiver attenuator on page 95) and software-switchable termination. Channel termination can be either 50 Ω or 1 MΩ. Without 50 Ω terminations the inputs are AC coupled, representing a very high impedance at DC.

- **Down-conversion & sampling:**
  The input signal is down-converted to an intermediate frequency and sampled by a 24 bit ADC. The embedded system controller evaluates the sampled data and provides the measurement results to the client device via USB or Ethernet. The client device can either be a computer running *Bode Analyzer Suite* or any SCPI capable software client.

More details on the hardware configuration and measurement modes can also be found in Bode 500 hardware setup on page 92.

3.4 Bode 100 hardware revisions

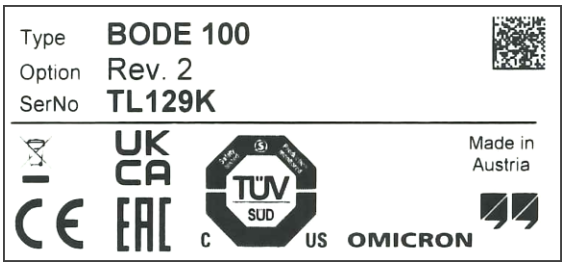
Currently there are two major hardware revisions of *Bode 100* in the field. Revision 1 and Revision 2. To find out if you are using a *Bode 100 R1* or a *Bode 100 R2*, check the identification plate on the bottom of the device.

Bode 100 R1 has been manufactured from 2006 to 2017.
Bode 100 R2 is in production since 2017.

Below typical identification plates or name plates for a *Bode 100 R1* and a *Bode 100 R2* are shown. The name plate of a *Bode 100* can be found on the bottom of the device.

Bode 100 R1

Bode 100 R2



If **Option** is **Rev. 2**, you are using a *Bode 100 R2*. If **Option** is empty, you are using a *Bode 100 R1*.

Your identification plate might look slightly different due to different declaration logos or other reasons.

3.5 Delivered items

Delivered items with Bode 100

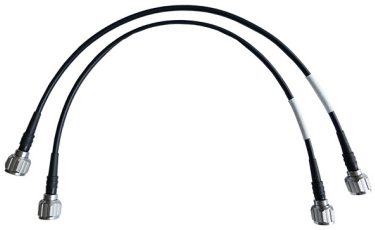
 *Bode 100* multi-functional measurement device	 18 V, 18 W wide-range AC power supply including mains input plugs for different national standards	 USB-A to USB-B Cable
 4 pc. BNC 50 Ω cables with 500 mm length (m-m)*	 BNC adapters (straight, T, Short, Load 50 Ω)*	 Test objects (Quartz filter and IF filter) on PCB*
 *Bode 100* Quick Start Guide including multi-language safety instructions	 *Bode Analyzer Suite* on DVD	

The delivered items may vary a bit from the look shown above.

Items marked with * are not included in the *Bode 100* basic set.

We strongly recommend to use the original wide-range AC power supply delivered with *Bode 100*.

Delivered items with Bode 500

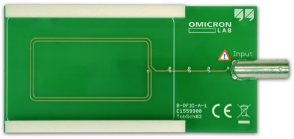
 *Bode 500* multi-functional measurement device	 18 V, 24 W wide-range AC power supply including mains input plugs for different national standards	 USB-A to USB-C cable
 2x N-N (M-M) Cable 50cm	 3x N-BNC (M-M) Cable 50cm	 Adapters: N-Thru (F-F), N-Short (M), N-50Ω Load (M), 2x N-BNC (M-F) and BNC-T (F-F-F)
 Test objects (Quartz filter and IF filter) on PCB with BNC connectors	 *Bode 500* Quick Start Guide including multilingual safety instructions	 *Bode Analyzer Suite* on DVD

The delivered items may vary a bit from the look shown above.

We strongly recommend to use the original wide-range AC power supply delivered with *Bode 500*. If you choose to use a different power supply, make sure that it can provide at least 24 W of power.

3.6 Optional accessories

	**B-WIT 100 Wideband Injection Transformer** **B-LFT 100 Low-Frequency Injection Transformer** **B-WIT 100** and **B-LFT 100** are used to inject signals into control loops. Its main application are the stability analysis of switched mode power supplies and linear voltage regulators. B-WIT 100 order number: P0005758 B-LFT 100 order number: P0005773
	**Passive Probes PML 1110 & PHV 1000-0** **PML 111O** is a passive 10:1 probe designed for precise low-noise transfer function measurements. **PHV 1000-O** is a passive 100:1 high-voltage probe designed for a maximum working voltage of 2000 V. PML 111O order number: B1666600 PHV 1000-O order number: P0008137
	**B-WIC & B-SMC Impedance test fixtures** **B-WIC** and **B-SMC** are designed to extend the impedance measurement range of *Bode 100*. They enable you to easily measure THT or SMD components such as inductors and capacitors. **B-WIC** and **B-SMC** can be also used in conjunction with the *Bode 500* using N-BNC cables. The maximum frequency for B-WIC and B-SMC is 50 MHz. B-WIC order number: P0005760 B-SMC order numer: P0005759
	**B-TCA Wide Frequency Test Fixture** **B-TCA** is designed to perform impedance measurements in a wide frequency range up to 450 MHz using the *Bode 500*. **B-TCA** can be also used in conjunction with the *Bode 100* using two BNC-N cables. B-TCA order number: P0009653
	**B-AMP 12 Amplifier** B-AMP 12 boosts the output signal of *Bode 100 or Bode 500* up to 25 dBm in a frequency range from dc to 50 MHz. Order number: P0005772

	**B-LCM Common Mode Choke** A low-frequency common mode choke to reduce ground-loop errors in e.g. Shunt-Thru measurements. Order number: P0005778
	**B-RFID Measurement Adapters** The B-RFID adapters allow the contact-less measurement of the resonance frequency and Q-factor of 13.56 MHz RFID transponders / chip-cards.

For more information on the above mentioned accessories and other recommended accessories for your *Bode 100 or Bode 500* please check out www.omicron-lab.com.

4 Bode 100 technical data

In this section you can find the most important technical data valid for the *Bode 100 Revision 2* device. You can download a more detailed technical data sheet for *Bode 100 Revision 2* as well as for the older*Bode 100 Revision 1* from the OMICRON Lab website www.omicron-lab.com → Bode 100 → Technical Data.

NOTICE

Risk of permanent damage of the device.

Exceeding the absolute maximum ratings will result in equipment damage.

► Do not exceed the absolute maximum ratings listed below.

4.1 Absolute maximum ratings

Table 4-1: Absolute maximum ratings

Characteristic	Absolute Maximum Rating
dc Power Input	
Max. dc supply voltage	+28 V
Max. dc supply reverse voltage	-28 V
INPUT CH 1, INPUT CH 2 connectors (1 MΩ input impedance selected)	
Maximum dc input signal	50 V
Maximum ac input signal	1 Hz...1 MHz: 50 Vrms 1 MHz...2 MHz: 30 Vrms 2 MHz...5 MHz: 15 Vrms 5 MHz...10 MHz: 10 Vrms 10 MHz ... 50 MHz: 7 Vrms
INPUT CH 1, INPUT CH 2 connectors (50 Ω input impedance selected)	
Maximum input power	1 W
Maximum input voltage	7 Vrms
OUTPUT connector	
Maximum reverse power	0.5 W
Maximum reverse voltage	5 Vrms (≤ 3.3 Vdc recommended)

4.2 Bode 100 specifications

Table 4-2: *Bode 100 Revision 2* specifications:

Characteristic	Rating
Frequency range	1 Hz to 50 MHz
OUTPUT	
Waveform	Sinusoidal
Signal level range	-30 dBm...13 dBm 7 mVrms...1 Vrms (50 Ω load) 14 mVrms...2 Vrms (no load)
Source level accuracy	±0.3 dB (1 Hz to 1 MHz) ±0.6 dB (1 MHz to 50 MHz)
Source level frequency response (flatness)	±0.3 dB (typical, referring to 10 MHz)
Frequency accuracy after adjustment	± 2 ppm ± 0.5 stepsize
Frequency resolution (step size)	6.05 mHz (1 Hz to 100 Hz) 36.32 mHz (100 Hz to 50 MHz)
Source impedance	50 Ω
Return loss (1 Hz to 50 MHz)	>30 dB, >35 dB (typical)
Spurious signals & harmonics	<-25 dBc at full output power (typical)
Maximum reverse signal / power	0.5 W = 5 Vrms (≤ 3.3 Vdc recommended)
INPUT CH 1, INPUT CH 2	
Input impedance (software switchable)	**High**: 1 MΩ (ac-coupled) **Low**: 50 Ω (dc-coupled)
1 MΩ input impedance	1 MΩ ±0.5% || 40...55 pF
50 Ω input impedance return loss	> 28 dB, >35 dB typical (dc to 50 MHz)
Receiver bandwidth (RBW) software selectable	1 Hz, 3 Hz, 10 Hz, 30 Hz, 100 Hz, 300 Hz, 1 kHz, 3 kHz , 5 kHz
Input attenuator (software selectable)	0 dB, 10 dB, 20 dB, 30 dB, 40 dB
Full-scale ac input signal	100 mVrms @ 0 dB input attenuator 316 mVrms @ 10 dB input attenuator 1 Vrms @ 20 dB input attenuator 3.16 Vrms @ 30 dB input attenuator 10 Vrms @ 40 dB input attenuator
Input channel sensitivity (typical)	< 1 µVrms (0 dB attenuator, 10 Hz RBW)
Maximum dc voltage	1 MΩ input impedance: 50 V 50 Ω input impedance: 7 V
Input channels dynamic Range	> 100 dB (@ 10 Hz RBW)
Noise floor (S21 measurement) RBW = 10 Hz, PSOURCE = 13 dBm, Attenuator CH1: 20 dB, CH2: 0 dB	1 Hz to 10 kHz: -115 dB (typical) 10 kHz to 10 MHz: -125 dB (typical) 10 MHz to 50 MHz: -105 dB (typical)
Warn-up time (3τ)	62 min*
Gain Error (User-Range calibrated)	< 0.1 dB
Phase Error (User-Range calibrated)	< 0.5°

Characteristic	Rating
OUTPUT, CH1, CH2 connector type	BNC
USB interface connector	USB type B socket
*…specifications are valid after device has warmed up and reached a stable temperature	
Bode 100 power requirements	
Supply voltage range	+9 VDC to +24 VDC
Power demand	< 10 W
Connector type	Coaxial power socket (2.5 mm / 5.5mm) Inner conductor is positive

4.3 System requirements

Table 4-3: System requirements

Characteristic	Minimum PC Configuration
Processor	Intel Core-i Dual-Core (or similar)
Memory (RAM)	2 GB, 4 GB recommended
Graphics resolution	Super VGA (1024x768) higher resolution recommended
Graphics card	DirectX 11 with Direct2D support
USB interface	USB 2.0 or higher
Operating System	Microsoft Windows 10 / 11
Bode Analyzer Suite Software	Bode 100 Revision 2 requires Bode Analyzer Suite 3.00 or newer.
API Software	.NET >= 8.07 or COM or SCPI compatible client  COM is not recommended for new developments. We recommend using the SCPI interface instead.

4.4 Power Adapter requirements

Table 4-4: Wide-range mains power adapter

Characteristic	Rating
Line input voltage / frequency / current	100…240 V / 47…63 Hz / < 0.5 A
Output voltage / current / power	18 Vdc / 1 A / 18 W

4.5 Environmental requirements

Table 4-5: Environmental requirements

Characteristic	Condition	Rating
Temperature	Storage	-35 ... +60 °C / -31...+140 °F
	Operating	+5 ... +40 °C / -41...+104 °F
	For specification	23 °C ±5 °C / 73 °F ±18 °F
Relative humidity	Storage	20 ... 90 %, non-condensing
	Operating	20 ... 80 %, non-condensing

4.6 Mechanical data

Table 4-6: Mechanical data

Characteristic	Rating
Dimensions (w x h x d)	26 cm x 5 cm x 27 cm / 10.25 " x 2 " x 10.65 "
Weight	1.9 kg / 4.2 lb

5 Bode 500 technical data

In this section you can find the most important technical data for the *Bode 500* device. For a more detailed technical datasheet, please check out www.omicron-lab.com → Bode 500 → Technical Data.

NOTICE

Risk of permanent damage of the device.

Exceeding the absolute maximum ratings will result in equipment damage.

► Do not exceed the absolute maximum ratings listed below.

5.1 Absolute maximum ratings

Table 5-1: Absolute maximum ratings

Characteristic	Absolute Maximum Rating
dc Power Input	
Max. dc supply voltage	+26 V
Max. dc supply reverse voltage	-26 V
INPUT CH 1, INPUT CH 2 connectors (1 MΩ input impedance selected)	
Maximum dc input signal	- 50 V...+ 50 V
Maximum peak value for ac + dc signal	- 60 V...+ 60 V
Maximum ac input signal	10 mHz...1 MHz: 40 Vrms 2 MHz...5 MHz: 15 Vrms 5 MHz...10 MHz: 10 Vrms 10 MHz ... 450 MHz: 7 Vrms
INPUT CH 1, INPUT CH 2 connectors (50 Ω input impedance selected)	
Maximum input power	1 W
Maximum input voltage	7 Vrms
OUTPUT connector	
Maximum reverse power	0.5 W
Maximum reverse voltage	5 Vrms (≤ 3.3 Vdc recommended)

5.2 Bode 500 specifications

Table 5-2: *Bode 500* specifications:

Characteristic	Rating
Frequency range	1 Hz to 450 MHz
OUTPUT	
Waveform	Sinusoidal
Signal level range	-50 dBm...16 dBm* 4 mVpp to 8 Vpp (no load) 2 mVpp to 4 Vpp (50 Ω load)
*...linear derating from 16 dBm to 13 dBm (100 MHz to 300 MHz), and to 7 dBm at 450 MHz.	
Source level accuracy	±0.2 dB (dc to 100 MHz) ±0.6 dB (100 MHz to 450 MHz)
Source signal dc offset	Up to 35 kHz: < 5 mV or < 0.2% of Vpp Above 35 kHz: < 2 mV
Frequency accuracy after adjustment	± 0.5 ppm ± 0.5 step size
Frequency resolution (step size)	3.52 µHz
Source impedance	50 Ω
Return loss (1 Hz to 50 MHz)	>30 dB, >35 dB typical (dc to 100 MHz) >26 dB, >30 dB typical (100 MHz to 200 MHz) >23 dB, >28 dB typical (200 MHz to 450 MHz)
Spurious signals & harmonics	<-25 dBc at full output power (typical)
Maximum reverse signal / power	0.5 W = 5 Vrms (≤ 3.3 Vdc recommended)
INPUT CH 1, INPUT CH 2	
Input impedance (software switchable)	**High**: 1 MΩ (ac-coupled) **Low**: 50 Ω (dc-coupled)
1 MΩ input impedance Input capacitance	1 MΩ ± 0.5 % (ac-coupled) 25 pF @ 1 MHz (typical)
50 Ω input impedance return loss	> 28 dB, >35 dB typical (dc to 100 MHz) > 23 dB, >28 dB typical (100 MHz to 450 MHz)
Receiver bandwidth (RBW) software selectable	1 Hz, 3 Hz, 10 Hz, 30 Hz, 100 Hz, 300 Hz, 1 kHz, 3 kHz , 5 kHz, 10 kHz, 15 kHz
Input attenuation (software selectable)	0 dB, 20 dB
Full-scale AC input signal	1 Vrms @ 0 dB input attenuator 10 Vrms @ 20 dB input attenuator
Input channel sensitivity (typical)	< 1 µVrms (@ 0 dB attenuator, 10 Hz RBW, 3 kHz to 100 MHz)
Maximum dc voltage	1 MΩ input impedance: 50 V 50 Ω input impedance: 7 V
Input channel dynamic range (typical)	> 120 dB (@ 10 Hz RBW, 3 kHz to 100 MHz)
Noise floor (S21 measurement) RBW = 10 Hz, PSOURCE = 16 dBm, Attenuator CH2: 0 dB	1 Hz to 10 kHz: -120 dB (typical) 3 kHz to 100 MHz: -130 dB (typical) at 300 MHz: -115 dB (typical) at 450 MHz: -105 dB (typical)

Characteristic	Rating
Warn-up time (3τ)	84 min*
OUTPUT, CH1, CH2 connector type	N
Control (and supply) USB connector	USB-C
Control (and supply) Ethernet connector	RJ45
USB-Host interface connector	USB-A**
External reference input connector	BNC**
External trigger input/output connector	BNC**
*...specifications are valid after device has warmed up and reached a stable temperature. **...reserved for future use.	
Bode 500 power requirements	
Maximum power requirement	24 W
Coaxial Power socket	+9 Vdc to +24 Vdc Type: 2.5 mm / 5.5mm Inner conductor is positive
Power over Ethernet	PoE+, class 4
USB-PD (Powered over USB) demand	20 V / 1.25 A or 15 V / 1.75 A

5.3 System requirements

Table 5-3: System requirements

Characteristic	Minimum PC Configuration
Processor	Intel Core-i Dual-Core (or similar)
Memory (RAM)	2 GB, 4 GB recommended
Graphics resolution	Super VGA (1024x768) higher resolution recommended
Graphics card	DirectX 11 with Direct2D support
USB interface	USB 2.0 or higher
Operating System	Microsoft Windows 10 / 11
Bode Analyzer Suite Software	Bode 500 requires Bode Analyzer Suite 3.50 or newer.

5.4 Power adapter requirements

Table 5-4: Wide-range mains power adapter

Characteristic	Rating
Line input voltage / frequency / current	100…240 V / 47…63 Hz / < 0.5 A
Output voltage / current / power	18 Vdc / 1.33 A / 24 W

5.5 Environmental requirements

Table 5-5: Environmental requirements

Characteristic	Condition	Rating
Temperature	Storage	-35 ... +60 °C / -31...+140 °F
	Operating	+5 ... +40 °C / -41...+104 °F
	For specification	23 °C ±5 °C / 73 °F ±18 °F
Relative humidity	Storage	20 ... 90 %, non-condensing
	Operating	20 ... 80 %, non-condensing

5.6 Mechanical data

Table 5-6: Mechanical data

Characteristic	Rating
Dimensions (w x h x d) without connectors	26 cm x 5 cm x 27.5 cm / 10.25 " x 2 " x 10.85 "
Weight	2.2 kg / 4.9 lb

6 Bode Analyzer Suite introduction

In this section you will learn the basics of the *Bode Analyzer Suite 3.50*. The window structure and the main functionality is explained.

Step-by-step examples

Get a quick introduction to the *Bode Analyzer Suite* and how to use *Bode 100* or *Bode 500* by following the **step-by-step examples**. For the examples and features described in this User Manual the *Bode 100* is used. If you use the *Bode 500* the steps for connecting to the device, performing a calibration or measurement are similar. Please keep in mind that the hardware setup, measurement ranges and default settings differ. The following examples are included in this document:

- Perform a Transmission / Reflection measurement on the IF filter DUT, see Transmission / Reflection measurement example on page 61.
- Perform a one-port impedance measurement on the Quartz filter DUT, see One-Port measurement example on page 69.
- Measure impedance of an inductor using the B-WIC impedance adapter, see Impedance Adapter example on page 78.

6.1 Start Screen

After the *Bode Analyzer Suite* has started, you will see the Start Screen shown below. If more than one Bode device is connected locally to your computer or you are using the *Bode 500* via network, the Device Selection will be shown.

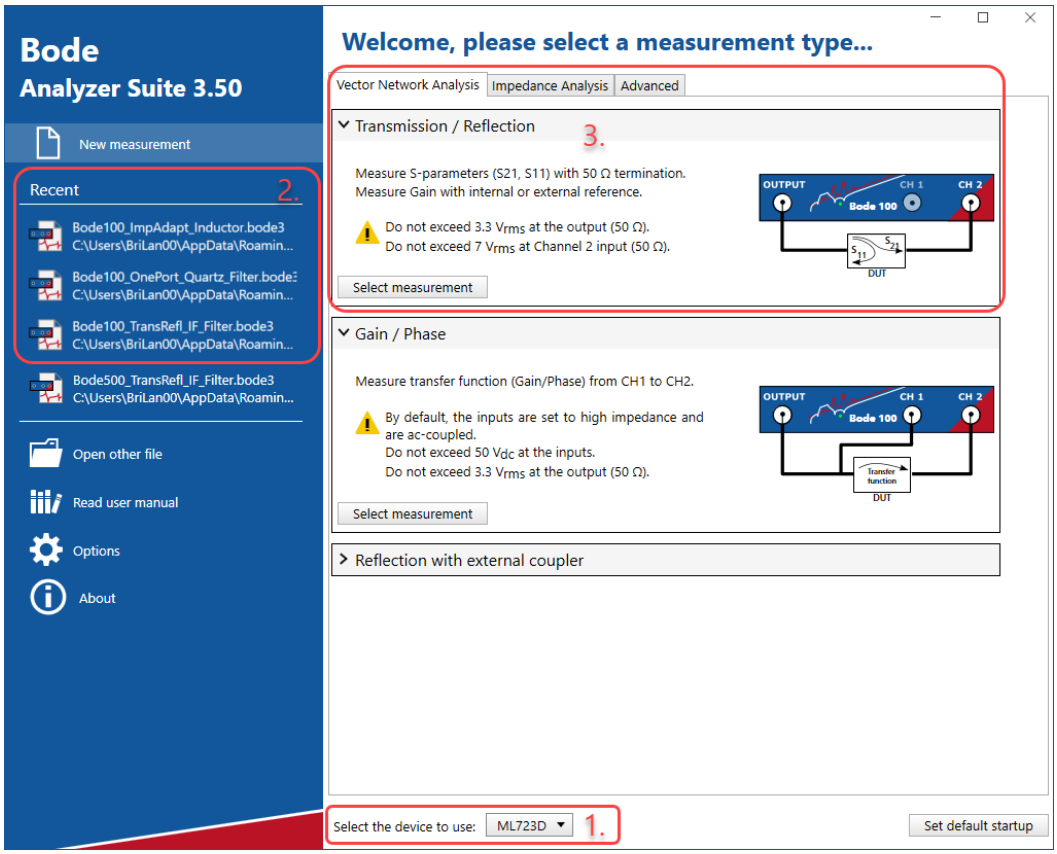


Figure 6-1: *Bode Analyzer Suite* Start screen with a *Bode 100* device selected

- Select the device to use (**1.**). This field is only visible if you have a connection to *Bode 100* or *Bode 500*. If no serial number / device is available for selection, please check out Troubleshooting.
- To start your first measurement open one of the available *Bode 100* demo file, for example **Bode100_TransRefl_IF-filter.bode3** from the Recent list (see **2.**). For more explanations about the demo files check out the Examples section.
- Or alternatively select an empty **Transmission / Reflection** measurement from the **Vector Network Analysis** measurement mode list (**3.**) to start a measurement.

If you cannot see the file **Bode100_TransRefl_IF-filter.bode3** in the Recent list, use the **Open other file** function and enter "%appdata%\OMICRON_Lab\BodeAnalyzerSuite\DemoFiles" to navigate to the demo files.

Hint: If you prefer to automatically select a measurement instead of entering the Start screen, choose your default startup measurement mode by clicking on **Set default startup** and choosing your preferred startup mode. You can also choose a custom .bode3 file to be your default startup configuration.

6.2 Device Detection and Selection

If more than one *Bode 100* or *Bode 500* is connected locally via USB or remotely via network, the Device Selection dialogue opens before the Start Screen will appear. In the Device Selection dialogue you can select the device to use for your measurement.

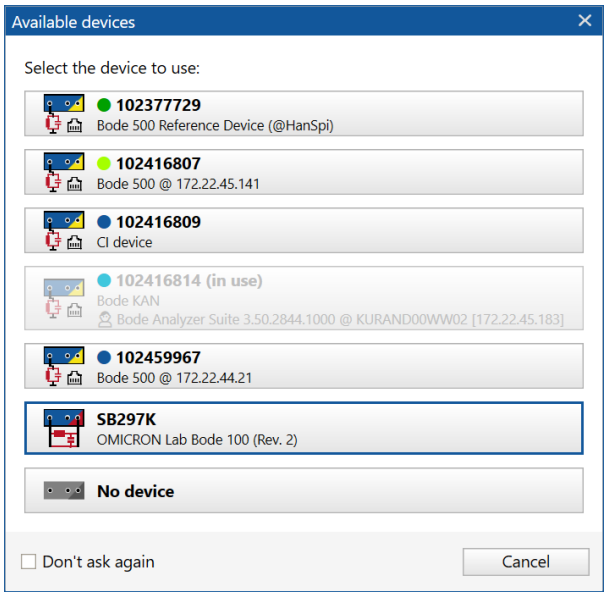


Figure 6-2: Device selection with a *Bode 100* device pre-selected

Each device in the list shows:

- Device serial number (9-digit number for *Bode 500* and 6-digit combination of letters and numbers for *Bode 100*
- Device information about the device type and which instance/user is currently connected to a device. In case of a *Bode 500*, the IP address of the connection is shown.

If a device shows "In use", it is already connected to a different client like a second instance of *Bode Analyzer Suite* or an automation or SCPI client.

If no device is available for connection,"No device" is pre-selected. "No device" is always available in the device detection and selection dialogue. A selected "No device" does not allow to open a new Measurement but allows to open an existing Bode file without the need to connect any physical Bode device.

The device detection and selection dialogue is updated in a regular time basis to check if there are new devices available or "in use". You can hide the dialogue by activating the "Don't ask again" check box. You can revert your decision under Options → General → Common.

6.3 Main window

After selecting a measurement, the main window of the *Bode Analyzer Suite* is opened. When you have a Bode device connected in the main window, it is "in use" and it cannot be connected to any other client. Depending on the selected device type (*Bode 100* or *Bode 500*), the measurement provides different default settings, parameter ranges and hardware setup options.

A measurement can only be opened with the **same device type** it was **generated** with. The image in the left hand bottom corner shows the device type that can be used with the file. You cannot connect a *Bode 500* to a measurement file that has been generated with a *Bode 100* and vice versa. All measurement files generated with 3.50 carry the extension **.bode3* independent on the used device type.

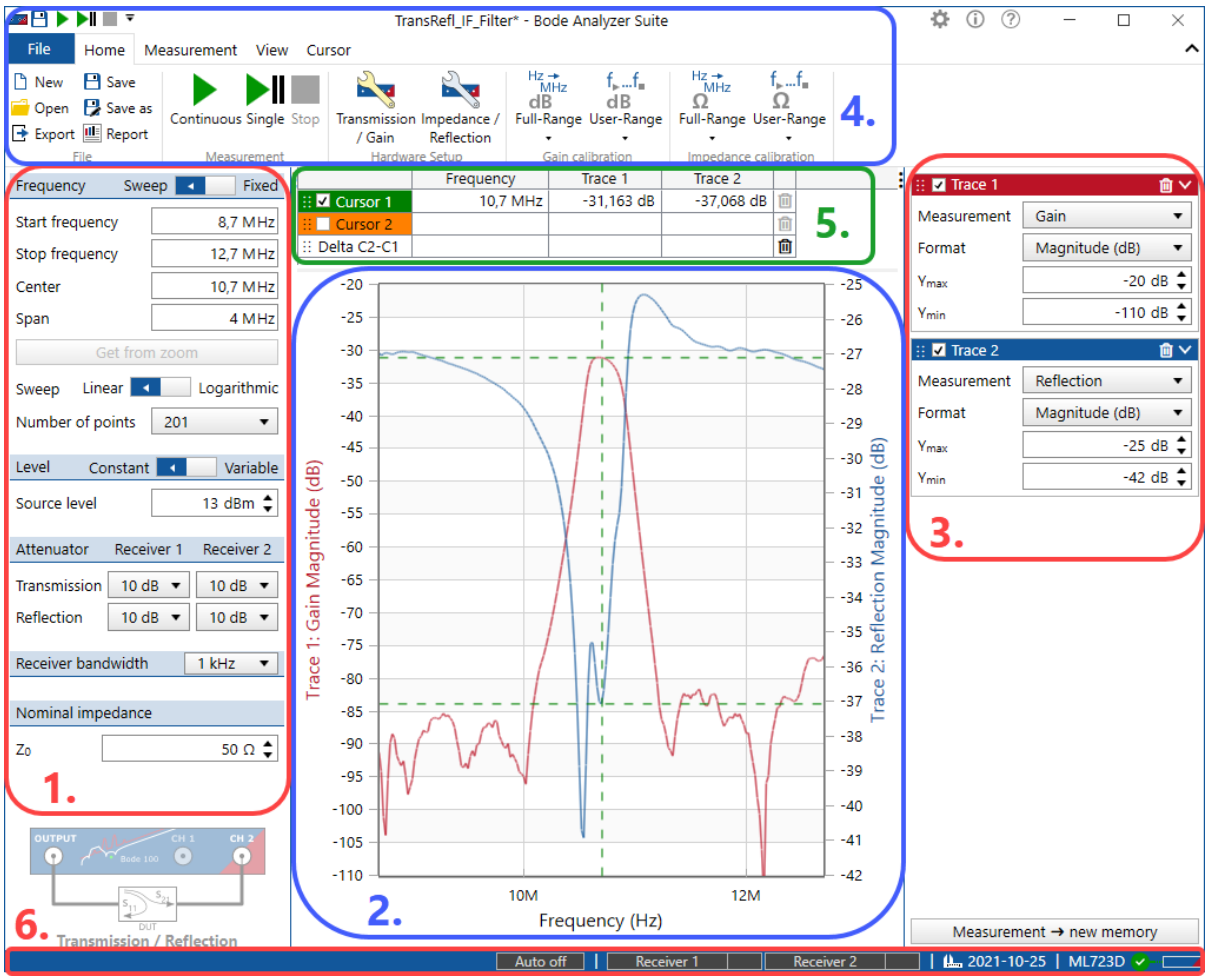


Figure 6-3: *Bode Analyzer Suite* Main window with a *Bode 100* device connected

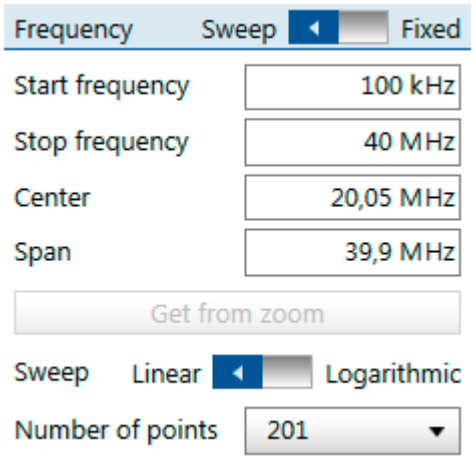
The Main window is structured into six main regions:

1. Measurement configuration
   The measurement configuration allows to configure the measurement frequencies and some hardware setup elements such as the source level, the channel attenuator value and the receiver bandwidth.
2. Chart region
   In the chart region the measurement results are displayed. You can use the Trace settings on the right hand side to choose the result that shall be displayed. Different formats such as Magnitude or Phase as well as different diagrams such as Polar, Nyquist or Smith can be selected. To learn more about the result diagrams, have a look at 10.2 Using the interactive chart on page 138.
3. Trace settings
   Choose what measurement and which result format is displayed in a trace. Additional memory traces or math traces are also controlled in this region. Lear more about how to configure traces and memories in 10.4 Using the memory traces on page 151 and 10.5 Working with measurement and math traces on page 155.
4. Ribbon bar & Quick-Access
   The ribbon bar contains the file operation commands as well as the buttons to start and stop a measurement. Further possibilities are the hardware setup, calibration, view settings, memory operations and cursor commands.
5. Cursor table
   The cursor table displays the values of the movable cursors that are attached to the traces shown in the result diagrams. To learn more about how to use the cursors, check out 10.3 Working with cursors and the cursor table on page 146.
6. Status bar

   The status bar shows the connection state of the hardware and the receiver levels. Further possibilities are signal source control and internal device calibration control.

6.3.1 Measurement configuration

Depending on the selected device (*Bode 100* or *Bode 500*), the structure of the measurement contains different default settings, parameter ranges and hardware setup.

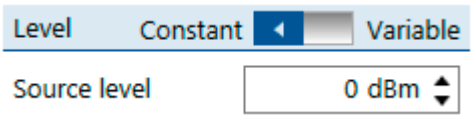


Frequency
In **Frequency sweep** mode you can change either Start frequency and Stop frequency or Center and Span.

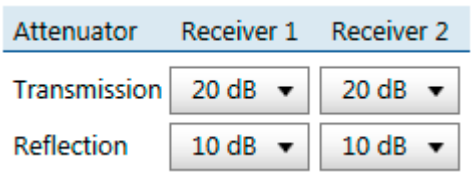
Get from zoom updates Start frequency and Stop frequency with the current zoom window range.

The **Sweep** mode can be **Linear** or **Logarithmic** and the **Number of points** in the sweep can be selected or entered.

In **Fixed Frequency** mode a continuous wave, constant frequency signal can be generated. In this case a vector chart instead of a frequency dependent chart will be shown.



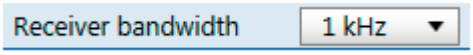
Source level
Choose between a constant or variable output level (shaped level) and set the source level. The variable output level feature is only available in the Frequency sweep measurement. It allows to define different source levels for different frequency points. To learn more about the source control, refer to 8.4 Signal source settings on page 97.



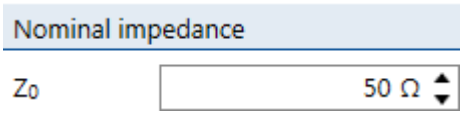
Attenuator
Set the input attenuator for Receiver 1 (Channel 1) and Receiver 2 (Channel 2). If the measurement mode supports two measurements (Transmission and Reflection) you can define the attenuator for each measurement. Depending on your device type different attenuator settings are possible:

- *Bode 100*: 0 dB, 10 dB, 20 dB, 30 dB and 40 dB
- *Bode 500*: 0 dB and 20 dB

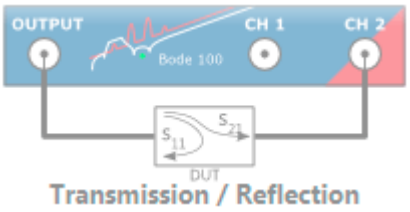
Increase the attenuator when you experience a receiver overload, reduce the attenuator to improve signal to noise ratio (see also Choosing the receiver attenuator on page 95).



Receiver bandwidth
Set the maximum Receiver bandwidth used for the measurement. Receiver bandwidth will be reduced internally if the measurement frequency is smaller than the Receiver bandwidth setting.
Select a high Receiver bandwidth to increase measurement speed. Reduce Receiver bandwidth to reduce noise and to catch high-Q, narrow-band resonances.
More details can be found in Receiver Bandwidth on page 93.



Nominal impedance
The nominal impedance or characteristic impedance value is used to calculate the Reflection factor. See also 7.2 Impedance measurement introduction on page 55.
Note that this field is only visible if a reflection measurement is performed.

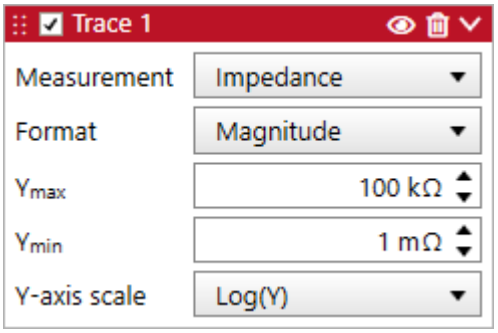


Measurement mode
Shows what measurement mode is currently used and what device type can be used. All available measurement modes are explained in 7 Measurement types and applications on page 52.

6.3.2 Trace configuration

In a Frequency Sweep measurement, the right hand side of the *Bode Analyzer Suite* shows the Trace configuration. The Trace configuration allows to choose what measurement (Gain, Impedance, Reflection, Admittance) is performed and how it is displayed in the chart.

Trace configuration box:



The **Trace configuration box** displays the trace-name and allows to configure:

Use the checkbox to the left of the trace name to disable the trace (including the corresponding axis / chart).

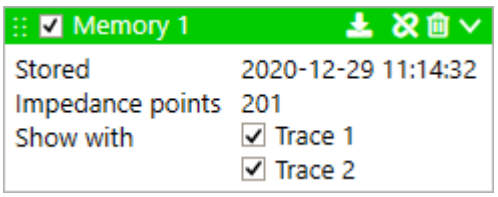
Click to hide the measurement curve of Trace 1 without deactivating the corresponding axis and Memory traces.

Click to delete Trace 1.

Click and hold to drag the trace to re-order traces & charts or to move the data from one file to another.

Measurement: Impedance, defines that Trace 1 measures & displays impedance.
Format: Magnitude, defines that Trace 1 displays the Magnitude of Impedance.
Ymax: 100 kΩ, The upper limit of the y-axis displayed in the diagram.
Ymin: 1 mΩ, The lower limit of the y-axis displayed in the diagram.
Y-axis scale : Log(Y), Currently the y-axis is set to a logarithmic scaling.
Learn more about the trace configuration box in 10.5 Working with measurement and math traces on page 155.

Memory configuration box:



The **memory configuration box** allows to control the memory curves:

Use the checkbox to the left of the memory name to disable (hide) the memory trace.

Click to copy the current measurement data to Memory 1.

Click to delete the Memory 1 trace.

Click to link the cursors to Memory 1.

Click and hold to drag the memory trace for re-ordering of the traces or to move the data from one file to another.
Furthermore it can be selected via the "Show with" checkbox in which diagram the memory data is shown.

Learn more about the memory curves in 10.4 Using the memory traces on page 151.

Hint: By clicking the inner border of the Measurement configuration or Trace configuration you can collapse these configuration areas to create a bigger chart area. You can fold out the configurations anytime by clicking the respective areas at the side of the chart area. For more details refer to the figure below.

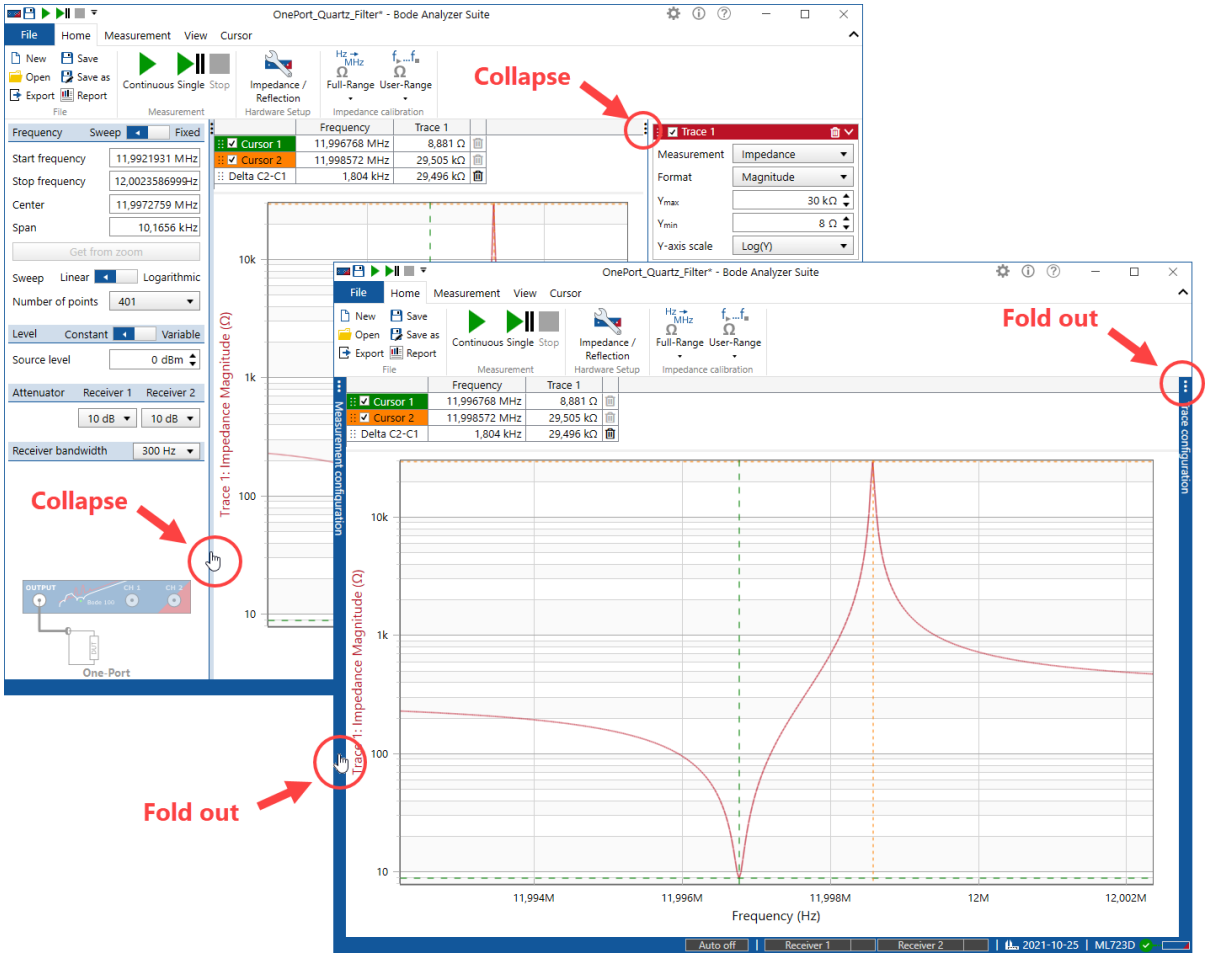


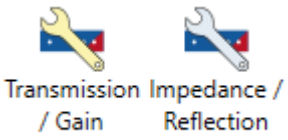
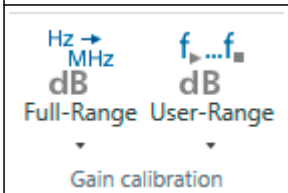
Figure 6-4: Collapsing the measurement and trace configuration areas

The width of the right trace settings region can be adjusted as desired by click and drag of the frame. If you have long trace names or memory names, you can increase the width of the trace configuration region.

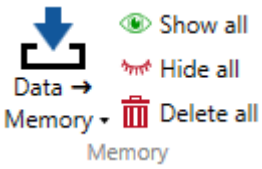
6.3.3 Ribbon controls

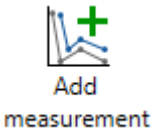
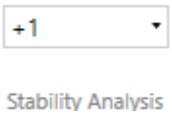
The *Bode Analyzer Suite* ribbons feature the following commands:

Home ribbon

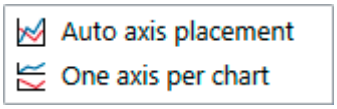
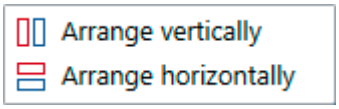
	• New: Create a new measurement • Open: Open a different measurement file • Save: Save the current file • Save as: Choose a different file name to save file • Export: Export measurement data • Report: Create a PDF print-report A detailed explanation on the single file operations can be found in 10.1 Exporting and saving measurement data or settings on page 129.
	• Continuous: Starts a continuous measurement • Single: Performs one single measurement • Stop: Stops a running measurement
	• Transmission/Gain: Configure the gain measurement setup • Impedance/Reflection: Configure the impedance measurement setup For more information regarding the hardware setup, please check out Hardware setup .
	• Full-Range: Perform a Full-Range calibration • User-Range: Perform a User-Range calibration For more information regarding the calibration, please check out 9 Calibration / Correction on page 104
	• Port-extension or port shifting can be used to mathematically move the reference plane in a reflection measurement. For more information, please check out: Port extension.

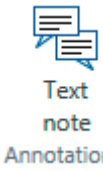
Measurement ribbon

	• Store the current measurement data to a new or existing memory trace. • **Show all** available memory traces in the diagram. • **Hide all** available memory traces. They will not be shown in the diagram. • **Delete all** memory traces.

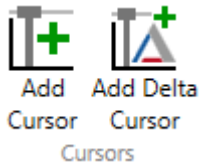
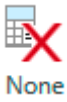
   	• **Add measurement**: Adds a *Measurement trace*. • **Add math**: Adds a *Math trace* for basic operations (+-*/). • **Add Expression**: Adds an *Expression trace* for advanced mathematical operations. • **Add Circuit Fit**: Adds a *Circuit Fit trace* for performing an impedance fit. For more information about this feature see Circuit Fit Trace. The Circuit Fit Trace is a Preview Feature. You can find information about the preview license in the General Software Licence Terms. Each Measurement, Math or Expression trace comes with it's **own axis**. A maximum of 2 axes can be combined in one chart using the **Auto axis placement** function in the **View** ribbon. If you prefer to have only one axis per chart, activate **One axis per chart** in the **View** ribbon. The Circuit Fit trace does not have his own axis. It has the same charting functions as a Memory trace. You can find more information about the use of Measurement, Math and Expression traces in 10.5 Working with measurement and math traces on page 155.
	Select +1 or -1 to be the instability point or positive feedback point for the stability margin calculation or the closed-loop gridlines in the Nichols chart. In a standard loop gain measurement with voltage injection, the positive feedback point appears at +1.

View ribbon

	• Auto axis placement attempts to show two axes (traces) in one diagram. • One axis per chart shows a separate diagram for each trace. You can find more information in 10.2.1 Configure the diagrams on page 138. Select your preferred default setting in the options menu.
	• Arrange multiple diagrams side by side. • Arrange multiple diagrams from top to bottom other.
	Activate averaging. More details can be found in 10.8 Averaging on page 171.

	Open a text field to add text notes to the current measurement.

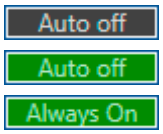
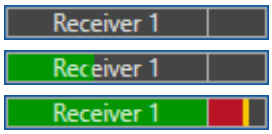
Cursor ribbon

	Add a cursor or a delta cursor. Each cursor will create a new line in the cursor table.
	Activate a cursor calculation. For more details please check out cursor calculations.
	Activate cursor linking. Cursor linking maintains a constant distance between two cursors. By moving one cursor, the second one will follow automatically. Use this feature to e.g. measure the slope at crossover frequency in a bode plot. You can select either decade (x10) or octave (x2) or constant linear distance which will maintain the current frequency delta value.

You can find more information about how to work with cursors in 10.3 Working with cursors and the cursor table on page 146.

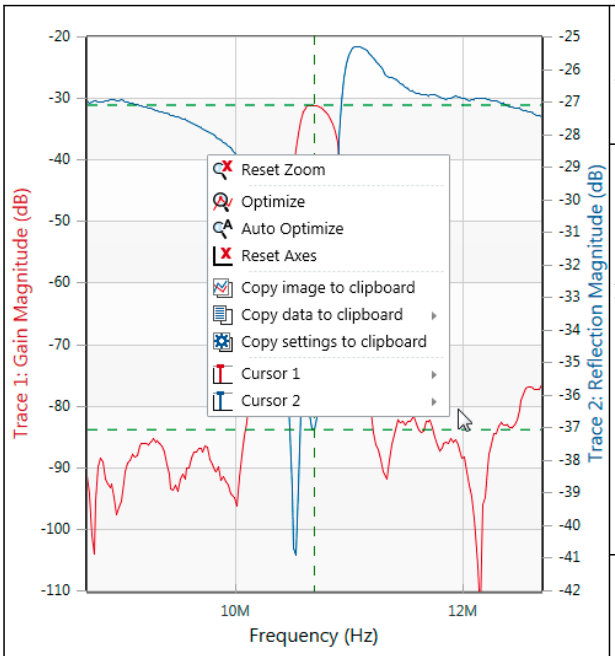
6.3.4 Status bar

The Status bar has several displays and interactive control elements. These are:

	**Source indicator** The source indicator shows if the signal source of *Bode 100 or Bode 500* is switched on. By **moving the mouse over the indicator**, a pop-up allows to change between **Auto off** and **Always on** setting. More details regarding the source setting can be found in 8.4 Signal source settings on page 97.
	**Overload indicators** The overload indicators show the signal level at the receivers of *Bode 100 or Bode 500*. Red color indicates an overload respectively clipping of the receiver. An overload warning will be shown in the chart in such a case. Please increase the attenuator or reduce the signal level to avoid clipping and wrong measurement results. More details about the overload indicator can be found in 8.3 Choosing the receiver attenuator on page 95.
	**Internal device calibration indicator** Shows the date of the last performed internal device calibration of your *Bode 100*. **Move the mouse over the indicator** in order to perform a new internal device calibration. More details about the internal device calibration can be found in 9.1 Internal device calibration on page 104.
	**Device connection indicator** Displays the serial number of the connected device. If no device is connected, "No device" is shown. **Move the mouse over the indicator** in order to search or re-connect to a *Bode 100 or Bode 500* device.

6.3.5 Chart context menu

By right clicking into the chart you get access to a context menu that allows quick access to several functions:



Reset Zoom: Resets the x-axis to the start and stop frequency and the y-axis to the predefined Ymin and Ymax values. See 10.2.2 Zooming the measurement curve on page 140 for details.

Optimize: Optimizes the Ymin and Ymax values once to ensure that the current measurement curve fills the chart area in an optimum way.

Auto Optimize: Optimizes the Ymin and Ymax values continuously to ensure that the measurement curve always fills the chart area in an optimum way.

Reset Axes: Resets the Y-axes to their pre-defined startup values.

See 10.2.3 Optimize the axis scaling / autoscale on page 143 for detail on these functions.

Copy image to clipboard: Copies a image of the current chart to the clipboard.

Copy data to clipboard: Copies all measurement points of Trace 1 or Trace 2 to the clipboard for further processing in a spreadsheet software.

Copy settings to clipboard: Copies all measurement settings to the clipboard in text format.

See 10.1.2 Use the clipboard functions to export data on page 130 for details on these functions.

Cursor 1 & Cursor 2: Allows to access several cursor functions to position the cursors to the maximum, minimum or zero crossing of the measurement traces.

See 10.3 Working with cursors and the cursor table on page 146 for details on these functions.

6.4 Options menu

The Options menu allows you to modify several functions of the *Bode Analyzer Suite*. You can access the Options menu by either clicking the icon in the top right corner of the *Bode Analyzer Suite*'s main window or by clicking **File** → **Options**.

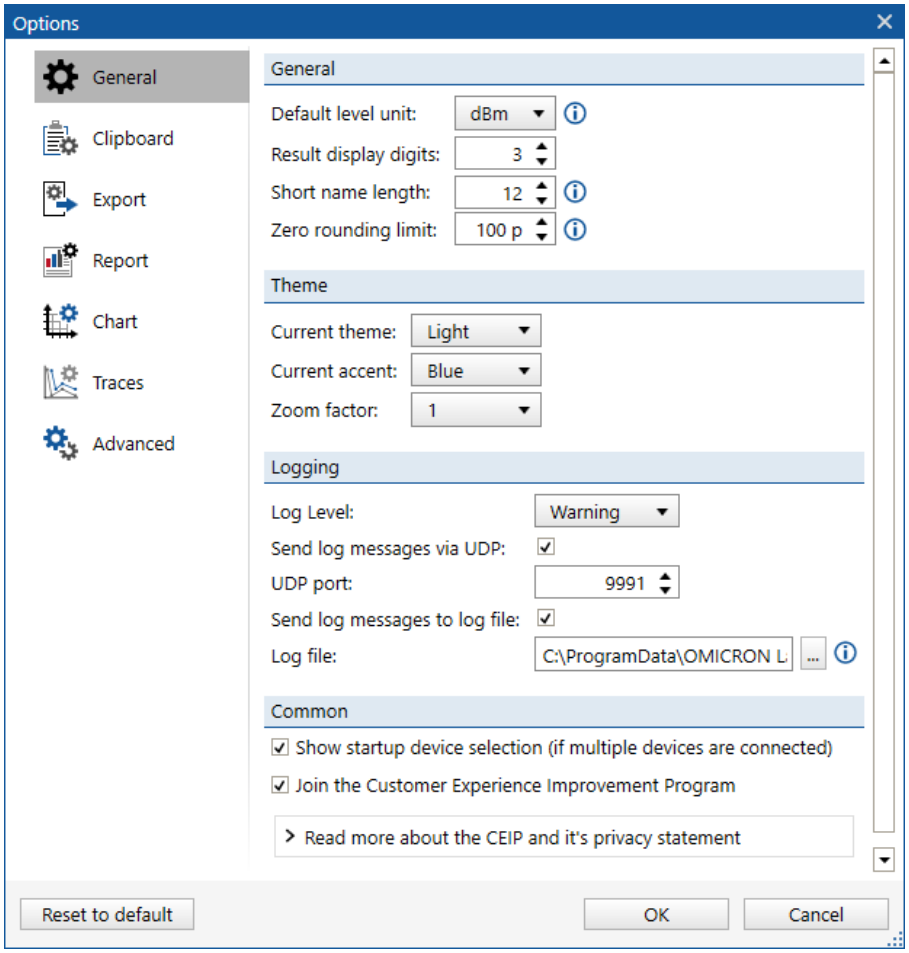


Figure 6-5: *Bode Analyzer Suite* Options menu

The options menu allows you to configure the following settings:

General	***General:*** **Default level unit:** allows you to change the unit for *Bode 100 or Bode 500*'s source level setting. You can choose dBm, Vpp or Vrms. dBm defines the power dissipated into 50 Ω load. Vpp and Vrms are the voltage output levels present when a 50 Ω load is connected at the output. Due to the source's output impedance the output voltage will change depending on the impedance of the connected load. See more in 8.4 Signal source settings on page 97. **Result display digits:** Defines the number of digits behind the decimal separator for values shown in the cursor grid and used for reporting. **Short trace-name length:** This number defines how many letters are used for the name of a measurement or memory trace in the cursor grid, report and clipboarding. **Zero rounding limit:** Values below this number will be displayed as zero. This setting applies to Phase (°) and Magnitude dB.
	Theme: Use the **Current theme** setting to switch between light and dark theme. Select your preferred accent color in **Current accent**. With the **Zoom factor**you can increase the size of the GUI for use on e.g. high-dpi screens.
	Logging: **Log Level:**This function allows you to define the severity level of the events stored in the log-file. Default is **Warning**. Do not use the log-levels Verbose or Debug, except if told by the OMICRON Lab support team. **UDP Logging:** allows you to enable event **logging via UDP** and to define the used **UDP port**. **Logging to a file:** allows you to enable the logging of events to a **log file** and to define the **location** of the log file on your computer's hard drive.
	Common: Allows you to disable or enable the device selection in the Start Screen and to change your preference in relation to the Customer Experience Improvement Program.

 Clipboard	***Chart:*** In this section you can optimize the **size of the text fonts** and the **thickness** of the measurement **traces** in the exported chart . Further on, you can enable the **inclusion** of the **chart legend** and the **cursor grid**. In addition the **position of the cursor grid** in the exported chart and the image **file format** can be defined.
	Data: In this section you can choose the **decimal separator** and the **field separator** for the clipboard export. Find more information in 10.1.2 Use the clipboard functions to export data on page 130.
 Export	In this section you can define several parameters for the **CSV-Export, Excel-Export** and **Touchstone-Export** of the measured data. These parameters are the default values that will be used for all future exports you perform. Find out more in 10.1.4 Exporting measurement data to CSV or Excel files on page 134.
 Report	Here you can choose if comments, the **cursor table**, the **chart legend** or **shaped level** are included in the report or not. Additionally, you can choose if you want to use a custom report or the standard report. Finally you can select if the report should be opened after its generation and the program that should be used to display the report. Detailed information is available in 10.1.6 Generate a PDF report on page 137.

<table>
<tr><td rowspan="3">  Chart</td><td>The sections in this area allow you to optimize the quality and appearance of the charts displayed in the Bode Analyzer Suite.

General:

Choose if numbers in axis labels are displayed in Engineering format (e.g. 1e3) or with SI prefixes (e.g. 1k).
Use the default axis placement setting to choose if you prefer auto-axis placement or only one axis per chart.</td></tr>
<tr><td>Logging:

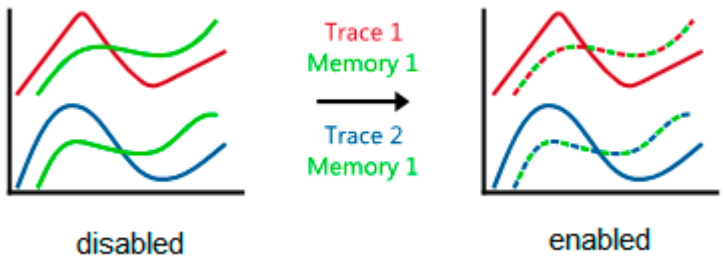
Further on, you can activate a logger that can be useful to find the reason for errors in the chart.
Normally you only need this option when told by the OMICRON Lab support team.</td></tr>
<tr><td>Render Settings:

In case your chart does not show up correctly, please try to change the Chart render mode. Automatic is default and tries to use hardware rendering with DX11. In some rare cases with old graphics cards or problems with the graphics drivers, this can lead to problems. Try using hardware (DX9) or software rendering instead.

  Software rendering can significantly increase the processor usage on your system.</td></tr>
<tr><td rowspan="2">  Traces</td><td>General:

Here you can select the maximum number of memory traces, the default memory line pattern (e.g. solid or dashed) as well as if the deletion of a memory trace needs to be confirmed or not.</td></tr>
<tr><td>Alternating memory trace color mode:

By enabling this mode you can make it easier to find out to which trace a memory belongs. If activated each memory alternates the memory color and the color of the trace it belongs to as shown below:

 
</td></tr>
</table>

 Advanced	***Calibration / Correction:*** You can enable "live update" respectively **"recalculate measurement trace values retroactively"**. This will recalculate the measurement trace values whenever a calibration-related parameter changes. The effect of disabling or enabling a calibration / correction will immediately be shown on the measurement result and not only used for new measurements. You can therefore see the influence of a correction on your results by enabling/disabling a calibration and watching the result change. **Activate port extension** to switch on the Port extension feature. The icon will be shown in the Home ribbon. For more details, please refer to Port extension.

Hint: Click Reset to default to switch back to the default settings of all options at any time.

7 Measurement types and applications

Bode 100 as well as*Bode 500* allow measuring Gain or Impedance, Reflection and Admittance. The following chapters introduce you to the basics of the Gain and Impedance / Reflection / Admittance measurements.

For an easy use, the *Bode Analyzer Suite* supports different measurement types / modes for different applications. The available measurements are listed in the start screen of the *Bode Analyzer Suite* (see 6.1 Start Screen on page 34).

The available measurement modes are grouped in the Vector Network Analysis Tab and the Impedance Analysis Tab:

Vector Network Analysis

The Vector Network Analysis Tab contains the following measurement types:

1. Transmission / Reflection
2. Gain / Phase
3. Reflection with external coupler

Impedance Analysis

The Impedance Analysis Tab contains the following measurement types:

1. One-Port
2. Impedance Adapter
3. Shunt-Thru
4. Shunt-Thru with series resistance
5. Series-Thru
6. Voltage / Current
7. External Bridge

In the following chapters all measurement types are explained in detail.

7.1 Gain measurement introduction

Bode 100 and *Bode 500* offer two different ways of measuring Gain. Either with the internal reference or the external reference. Internal reference means that Receiver 1 is internally connected to the signal source, picking up the internal source voltage. External reference means that Receiver 1 is routed to the front panel input Channel 1.

Depending on the Receiver 1 connection, Gain is measured as shown in the following table:

Receiver 1 is set to internal reference	Receiver 1 is set to external reference
$Gain = \frac{V_{CH2}}{\frac{V_0}{2}}$ Where V_0 is the internal source voltage. If Channel 2 is terminated with 50 Ω (default), Gain equals the scattering parameter S21 of a two-port DUT (Port 1 is connected to *Bode* output and port 2 is connected to *Bode* Channel 2). If Channel 2 is set to high-impedance, a Thru-connection from Output to Channel 2 will result in +6 dB. To normalize to 0 dB you can use Thru-calibration.	$Gain = \frac{V_{CH2}}{V_{CH1}}$ Gain therefore equals the voltage-transfer function of a 2-port DUT if Channel 1 is connected to the DUT input port and Channel 2 is connected to the DUT output port.

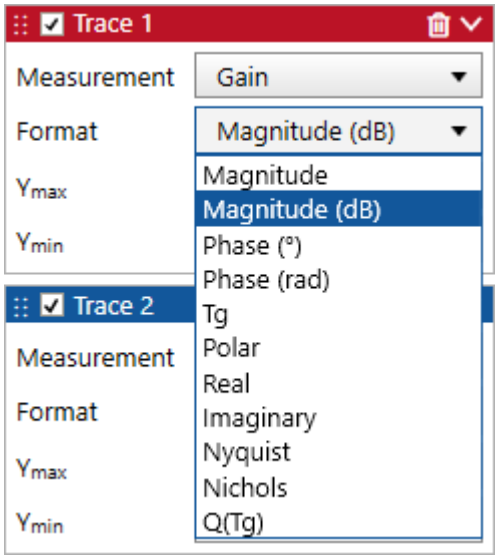
The following two measurement modes can be used to perform a Gain measurement:

1. Transmission / Reflection: This mode allows both, measurements with internal and external reference connection.
2. Gain / Phase: Is used to measure the voltage transfer function from Channel 1 to Channel 2 (Frequency Response Measurement).

Since the gain result is a complex number you can choose how to display the complex value. You can select the result formats by clicking the drop down **Format** in the trace configuration box.

In a gain measurement the following result formats are available:

Gain Result Formats

	**Magnitude:** Displays the linear magnitude of the measured Gain.
	Magnitude (dB): Displays the magnitude of the measured Gain in dB
	Phase (°): Displays the phase of the measured Gain in degrees.
	Phase (rad): Displays the phase of the measured Gain in radians.
	Tg: Displays the group delay of the measured Gain in seconds (see Gain result format equations for details).
	Polar: Displays the measured Gain in a polar chart.
	Real: Displays the real part of the measured Gain.
	Imaginary: Displays the imaginary part of the measured Gain.
	Nyquist: Displays the measured Gain in a Nyquist chart.
	Nichols: Displays Gain over Phase in the Nichols chart. Right-click into the chart to activate closed-loop gridlines.
	Q(Tg): Displays the Q-factor derived from group delay. This value is used for NISM (see cursor calculations on page 164 for details).

Gain result format equations

The Gain results are calculated based on the following equations:

Gain *H*:

$H = h \cdot e^{-j\varphi}$ where *h* is the magnitude of gain *H* and φ the phase of *H*.

ω is the angular frequency $\omega = 2\pi f$ with the frequency *f*.

$$T_g = -\frac{d\varphi}{d\omega}$$ Group delay *Tg* is calculated by symmetric difference quotient

$$Q(T_g) = |\pi \cdot f \cdot T_g|$$ *Q(Tg)* is the quality factor derived from the group delay

7.2 Impedance measurement introduction

Bode 100 and *Bode 500* offer several ways of measuring Impedance, Reflection or Admittance. Impedance, Reflection and Admittance are directly related to each other by the following equations:

$$Y = \frac{1}{Z}$$

Admittance *Y* is the reciprocal of the impedance *Z* and vice versa.

$$Z = \frac{1}{Y}$$

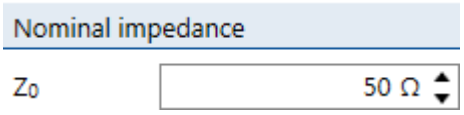
$$\Gamma = \frac{Z - Z_0}{Z + Z_0}$$

The reflection coefficient Γ is calculated from the measured impedance *Z* and the nominal impedance Z_0.

$$Z = Z_0 \frac{1 + \Gamma}{1 - \Gamma}$$

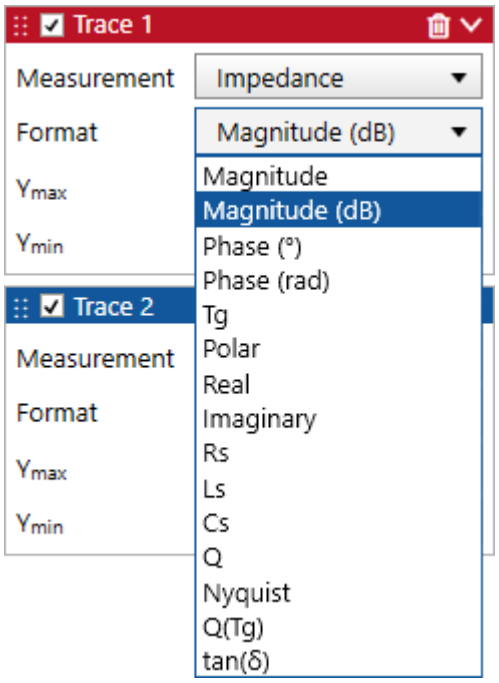
The reflection coefficient Γ can be converted back to impedance *Z* via the nominal impedance Z_0.

Z_0 can be changed by the user in the measurement configuration. The nominal impedance Z_0 field is only visible if a measurement trace is set to Reflection.



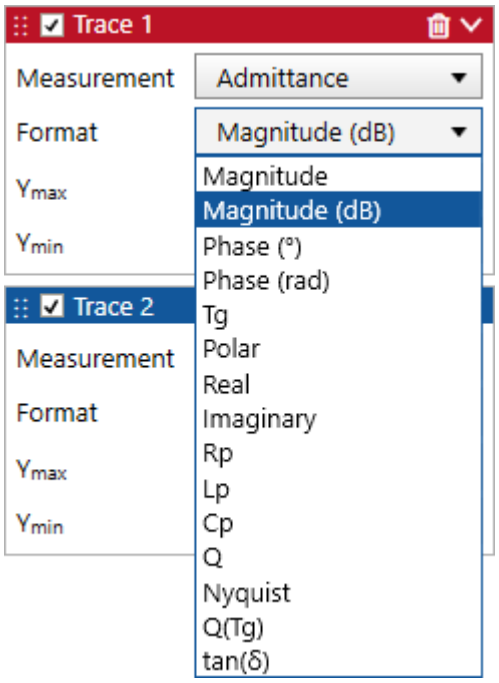
The Impedance Analysis modes allow you to display the measurement results in various formats. You can select the result formats by clicking the drop down **Format** in the trace configuration box. Depending on the chosen measurement the following result formats are available:

Impedance Result Formats



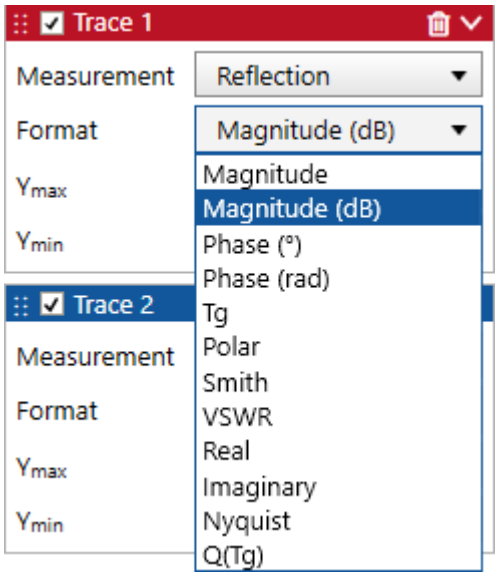
Magnitude: Displays the magnitude of the measured impedance in Ohms.
Magnitude (dB): Displays the magnitude of the measured impedance in dBΩ.
Phase (°): Displays the phase of the measured impedance in degrees.
Phase (rad): Displays the phase of the measured impedance in radians.
Tg: Displays the group delay of the measured impedance in seconds (see Gain result equations for details).
Polar: Displays the measured impedance in a polar chart.
Real: Displays the resistance of the measured impedance in Ohms.
Imaginary: Displays the reactance of the measured impedance in Ohms.
Rs: Displays the equivalent series resistance (ESR) of the measured impedance in Ω. This value equals the Real part of impedance.
Ls: Displays the equivalent series inductance (ESL) of the measured impedance in Henry.
Cs: Displays the equivalent series capacitance (ESC) of the measured impedance in Farad.
Q: Displays the Q-factor of the measured impedance (see Impedance result equations for details).
Nyquist: Displays the measured impedance in a Nyquist chart
Q(Tg): Displays the Q-factor derived from group delay. This value is used for NISM (see Cursor calculations for details).
tan(δ): Displays the tan(δ) of the measured admittance. (see Impedance result equations for details).

Admittance Result Formats



Magnitude: Displays the magnitude of the measured admittance in Siemens.
Magnitude (dB): Displays the magnitude of the measured admittance in dBS.
Phase (°): Displays the phase of the measured admittance in degrees
Phase (rad): Displays the phase of the measured admittance in radians
Tg: Displays the group delay of the measured admittance in seconds (see Gain result equations for details).
Polar: Displays the measured admittance in a polar chart.
Real: Displays the conductance of the measured admittance in Siemens.
Imaginary: Displays the susceptance of the measured admittance in Siemens
Rp: Displays the equivalent parallel resistance of the measured admittance in Ohms.
Lp: Displays the equivalent parallel inductance of the measured admittance in Henry.
Cs: Displays the equivalent parallel capacitance of the measured admittance in Farad.
Q: Displays the Q-factor of the measured admittance (see Impedance result equations for details).
Nyquist: Displays the measured admittance in a Nyquist chart.
Q(Tg): Displays the Q-factor derived from group delay (see Cursor calculations for details).
tan(δ): Displays the tan(δ) of the measured admittance. (see Impedance result equations for details)

Reflection Coefficient Result Formats



Magnitude: Displays the magnitude of the measured reflection coefficient.
Magnitude (dB): Displays the magnitude of the measured reflection coefficient in dB
Phase (°): Displays the phase of the measured reflection coefficient in degrees.
Phase (rad): Displays the phase of the measured reflection coefficient in radians.
Tg: Displays the group delay of the measured reflection coefficient in seconds (see Gain result equations for details).
Polar: Displays the measured reflection coefficient in a polar chart.
Smith: Displays the measured reflection coefficient respectively impedance in a Smith chart.
VSWR: Displays the voltage standing wave ratio of the measured reflection coefficient.
Real: Displays the real part of the measured reflection coefficient.
Imaginary: Displays the imaginary part of the measured reflection coefficient.
Nyquist: Displays the reflection coefficient in a Nyquist chart.
Q: Displays the Q-factor of the measured reflection (see Impedance result equations for details).
Nyquist: Displays the measured reflection in a Nyquist chart.
Q(Tg): Displays the Q-factor derived from the group delay (see Cursor calculations for details).

Result format equations

The Impedance / Admittance / Reflection results are calculated based on the following equations:

Impedance Z:

$Z = R + jX$ where *R* is the real part of the impedance (resistance) and *X* the imaginary part of the impedance (reactance).

ω is the angular frequency $\omega = 2\pi f$ with the frequency *f*.

$R_s = R$	Series equivalent resistance *Rs* equals the real part of impedance
$C_s = -\frac{1}{\omega X}$	Series equivalent capacitance *Cs*
$L_s = \frac{X}{\omega}$	Series equivalent inductance *Ls*
$Q = \frac{\lvert X \rvert}{R}$	Series circuit quality factor *Q*
$\tan(\delta) = \left\lvert \frac{R}{X} \right\rvert$	*tan(d)* of impedance

Admittance Y:

$Y = G + jB$ where *G* is the real part of the admittance (conductance) and *B* the imaginary part of the admittance (susceptance).

ω is the angular frequency $\omega = 2\pi f$ with the frequency *f*.

$R_p = \frac{1}{G}$	Parallel equivalent resistance *Rp*
$C_p = \frac{B}{\omega}$	Parallel equivalent capacitance *Cp*
$L_p = -\frac{1}{\omega B}$	Parallel equivalent inductance *Lp*
$Q = \frac{\lvert B \rvert}{G}$	Parallel circuit quality factor *Q*
$\tan(\delta) = \left\lvert \frac{G}{B} \right\rvert$	*tan(d)* of admittance

Reflection Coefficient Γ:

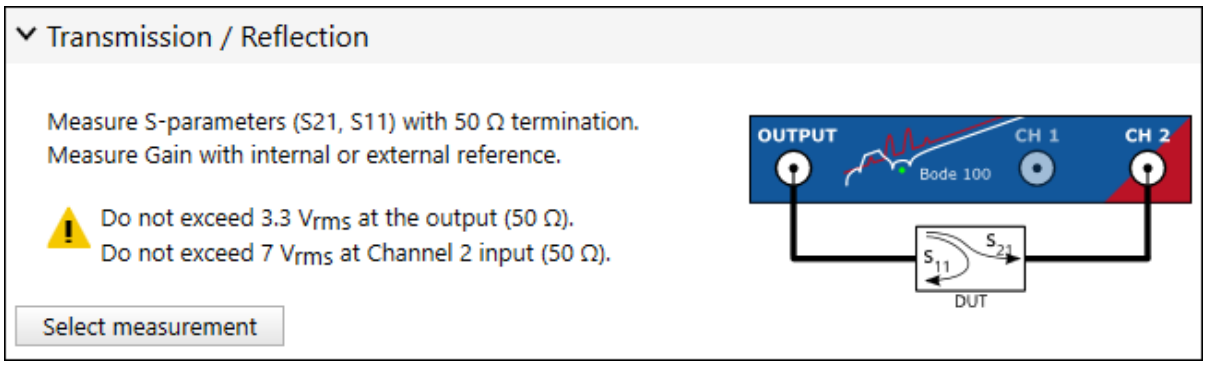
$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$ Voltage Standing Wave Ratio VSWR

Tg as well as Q(Tg) are calculated in the same way as for the gain measurement (see 7.1 Gain measurement introduction on page 53).

7.3 Vector Network Analysis

7.3.1 Transmission / Reflection

The Transmission / Reflection measurement mode is designed to measure the S-parameters S21 and S11 in the 50 Ω domain. For this example a *Bode 100* is used. You can perform the same measurement with the *Bode 500*.



The Transmission / Reflection measurement mode allows to measure both, Transmission (Gain) and Reflection (Impedance). It is possible to select e.g. a Gain measurement in Trace 1 and an Impedance measurement in Trace 2. *Bode 100* or *Bode 500* will then sequentially measure Gain and Impedance.

Therefore some hardware settings like the measurement setup dialog are available twice. Once for the Gain measurement and once for the Impedance measurement.

For details on how the Gain is calculated, please check 7.1 Gain measurement introduction on page 53.

Calibration in the Transmission / Reflection measurement mode

The Transmission / Reflection measurement mode does not require calibration to perform a measurement. However, to remove the influence of your connection cables the measurement mode offers Gain (Thru) as well as Impedance (Open, Short, Load) calibration. Gain calibration applies to a Gain measurement and Impedance calibration applies to a Impedance/Reflection/Admittance measurement. When measuring at high frequency or with long cables it is strongly recommended to perform a calibration. For more details regarding the Gain calibration please refer to 9 Calibration / Correction on page 104.

Typical applications

Typical applications for the Transmission / Reflection measurement mode are:

- Measuring Transmission and Reflection of filters such as IF filters or EMI filters.
- Comparing results from measurements with internal and external reference connection (the Transmission / Reflection measurement mode is the only measurement mode that allows changing the Receiver 1 connection).
- Measuring Gain of RF amplifiers in the 50 Ω domain.

Transmission / Reflection measurement example

Follow the steps described below to perform a Transmission / Reflection measurement. For this step-by-step example a *Bode 100* is used. You can perform the same steps using a *Bode 500*.
Connect the test object "IF Filter" to *Bode 100* using the device specific delivered BNC cables or BNC-adapter cables as shown in the figure below.

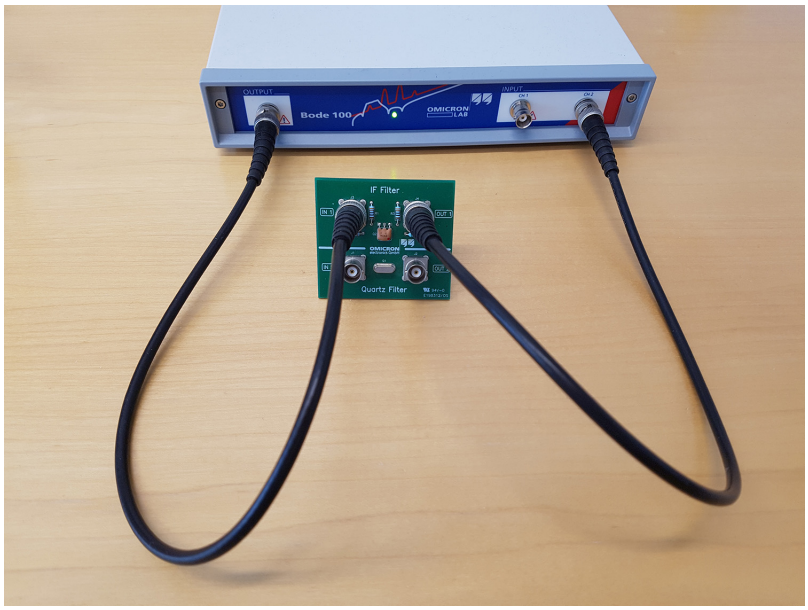
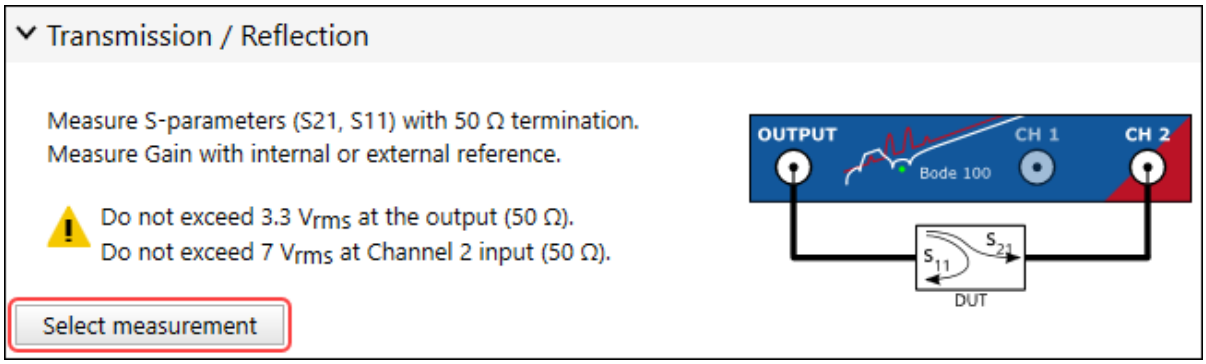
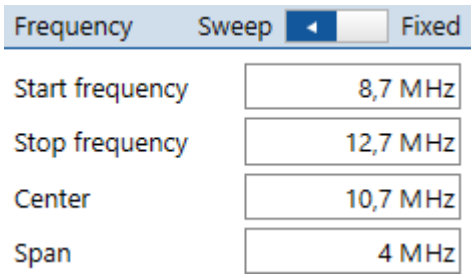


Figure 7-1: Connecting the test object IF Filter to *Bode 100*

Now start the *Bode Analyzer Suite* and enter the Transmission / Reflection measurement mode by clicking on Select measurement.



Before starting the measurement set the Start and Stop frequency to the values shown below:



After setting the Start and Stop frequency the Center frequency as well as the frequency Span are set automatically. Alternatively you can enter the Span and Center and the Start and Stop frequency are updated accordingly

Now you are ready to start your first measurement. Simply click ▶ in the home ribbon. As a result you will see a first measurement comparable to the one shown in the figure below.

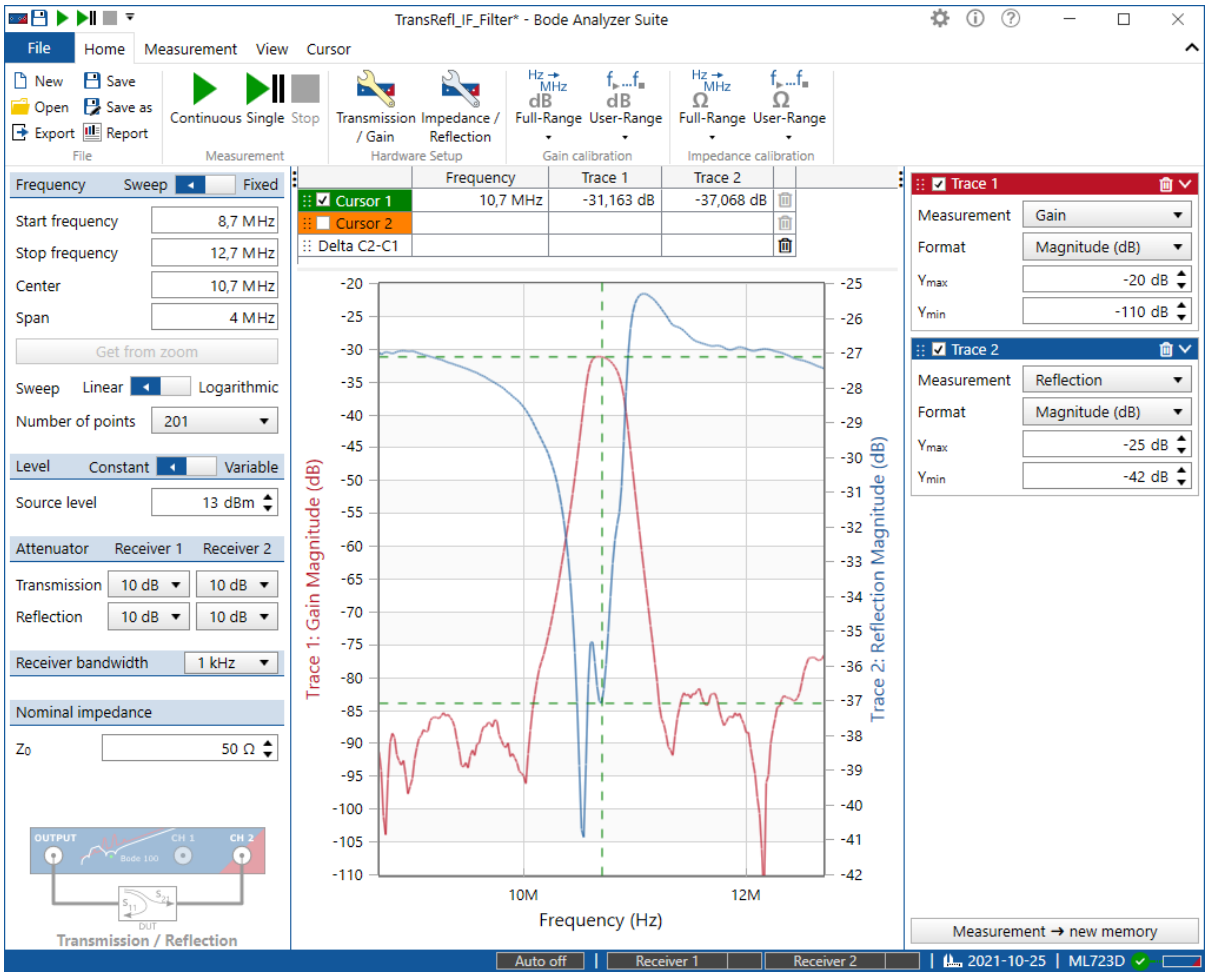


Figure 7-2: S-Parameter measurement of a 10.7 MHz IF filter

Trace 1 (red curve) shows the Magnitude of the Gain (= Magnitude of S21) while Trace 2 (blue curve) shows the Magnitude of Reflection (= Magnitude of S11). You can change Format for both traces to display other results such as Phase or Real and Imaginary components

To optimize the chart you can right click onto the chart and select **Optimize** as shown below. For more information on the chart's context menu check out 6.3.5 Chart context menu on page 46.

Figure 7-3: Context menu of chart

Further on you can use the cursors to perform measurements. To do so simply drag the cursors to the point you want to measure (**1.**) and check out the results in the cursor grid (**2.**) as shown in 7-4 on page 65. For more cursor functions visit 10.3 Working with cursors and the cursor table on page 146.

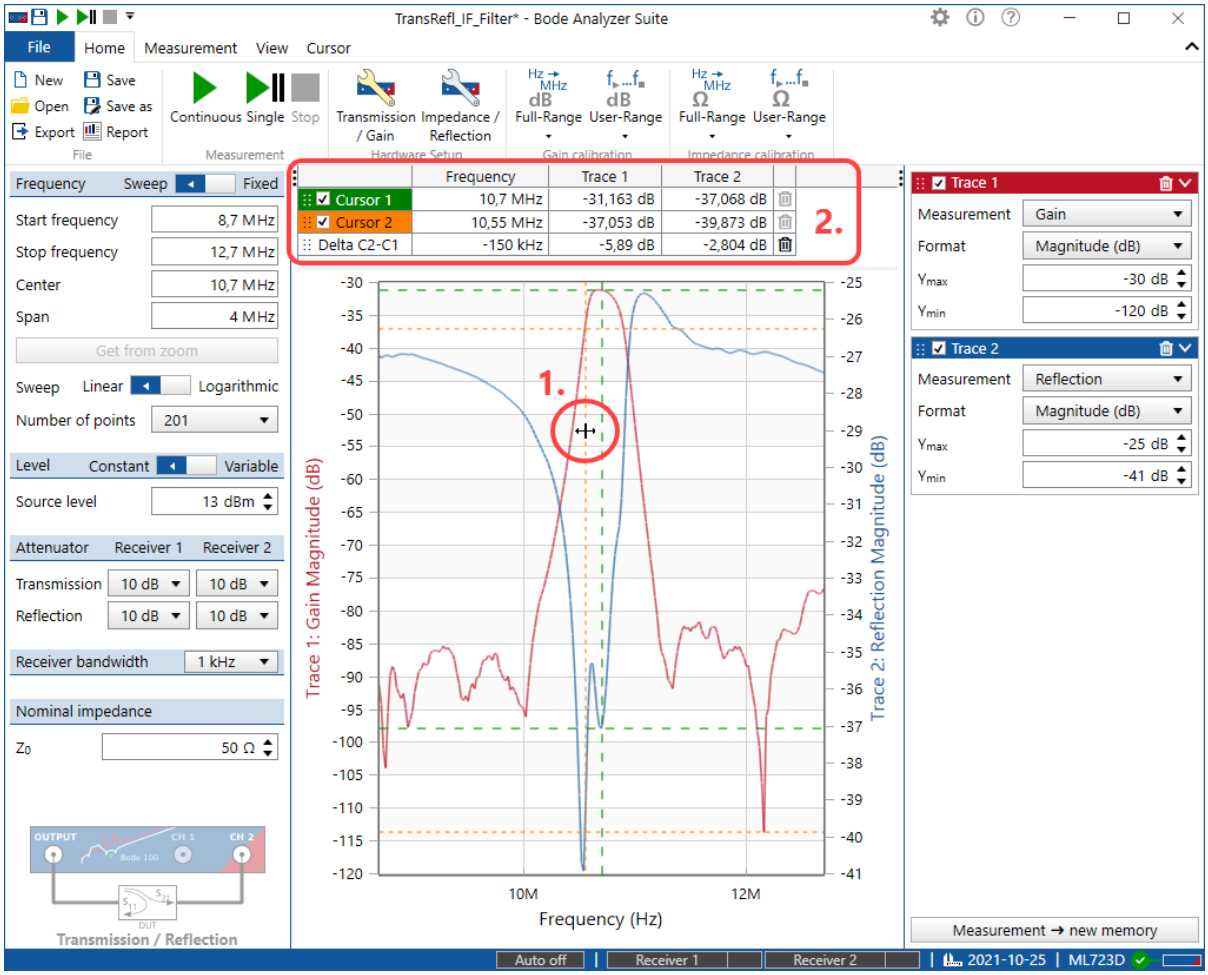


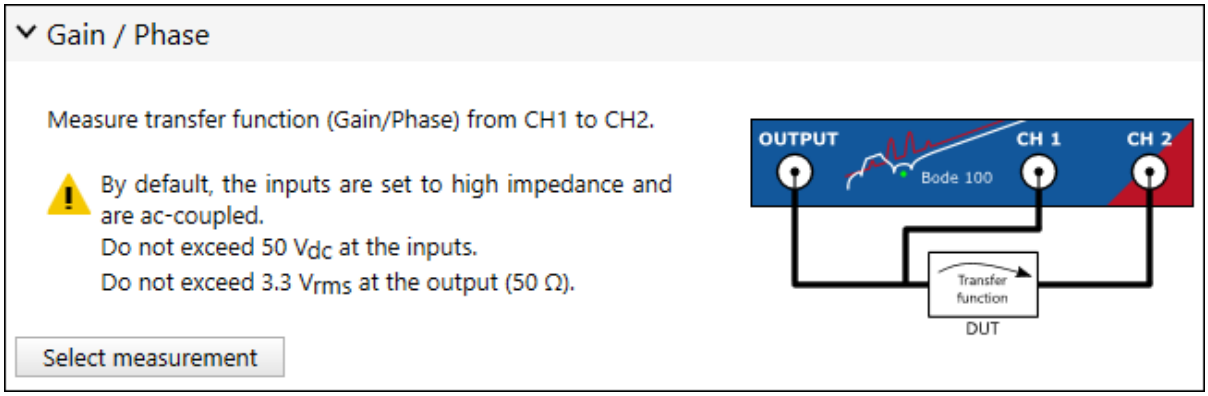
Figure 7-4: Use of cursors and cursor grid

Congratulations you have performed your first measurement with the *Bode 100 or Bode 500*. You can load the settings for the measurement by clicking File → Open → and then navigating to: *"%appdata%\OMICRON_Lab\BodeAnalyzerSuite\DemoFiles"*. The file you will need is: **Bode100_TransRefl_IF-Filter.bode3** or **Bode500_TransRefl_IF-Filter.bode3**

Hint: The Transmission / Reflection is the most flexible measurement setup for the *Bode 100 or Bode 500*. By selecting this setup you can switch between internal and external reference. Further on, you can switch the input impedance of input CH1 and input CH2 between 50 Ω and high impedance.

7.3.2 Gain / Phase

The Gain / Phase measurement mode is designed to measure the transfer function of a DUT using the external reference connection. This means that both Channel 1 and Channel 2 are active.



The Gain Measurement

Bode 100 or Bode 500 measures

$$Gain = \frac{V_{CH2}}{V_{CH1}}$$

Gain therefore equals the transfer function of a 2-port DUT if Channel 1 is connected to the DUT input port and Channel 2 is connected to the DUT output port. The inputs Channel 1 and Channel 2 are set to 1 MΩ by default.
Details on the gain measurement can be found in 7.1 Gain measurement introduction on page 53.

Calibration

The Gain / Phase measurement mode does not require calibration to perform a measurement. However, to remove the influence of probes and cables Gain (Thru) calibration is recommended. For more details regarding the Gain calibration please refer to 9 Calibration / Correction on page 104.

Typical applications

Typical applications for the Gain / Phase measurement mode are:

- Measuring the transfer function of filters or other circuits.
- Measuring in-circuit transfer functions using high-impedance probes.
- Measuring the transfer function of amplifiers etc.
- Measuring loop stability of power supplies.

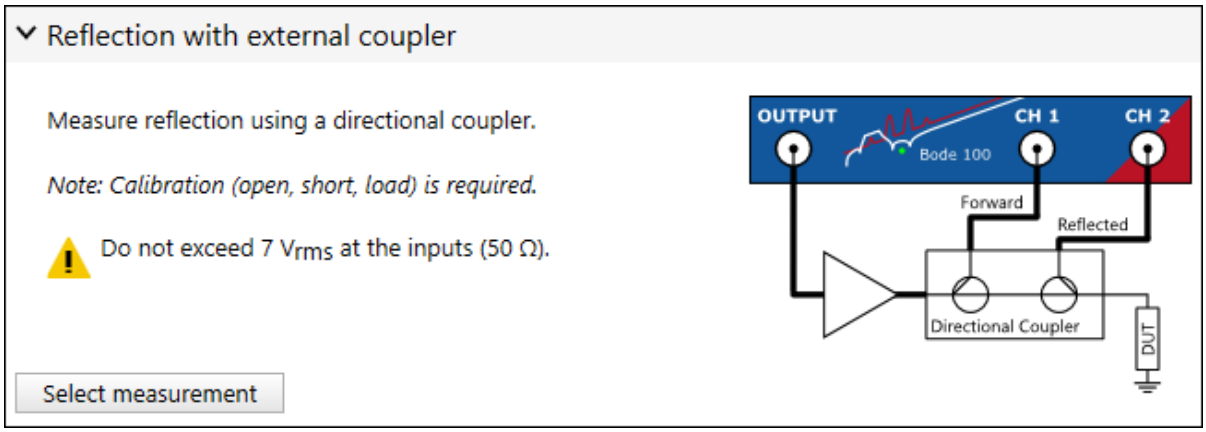
Measurement example

For detailed measurement examples using the Gain / Phase measurement mode, please check out the application notes at www.omicron-lab.com/BodeManualAppNotes. The following application notes use the Gain / Phase measurement mode:

- DC/DC Converter Stability Measurements
- Bipolar Transistor AC Current Gain Measurement
- Op-Amp measurements
- PSRR Measurement
- And many more...

7.3.3 Reflection with external coupler

The External coupler measurement mode is designed to measure reflection using an external coupler. This offers the possibility to use an external amplifier and protect the inputs of *Bode 100 or Bode 500* by using an external directional coupler. For this example a *Bode 100* is used. You can perform the same measurement for the *Bode 500*.



Calibration

Please note that the external coupler measurement mode requires an impedance calibration (Open, Short, Load). For more details on how to perform an impedance calibration see 9.3.2 Calibrating an External Coupler or External Bridge measurement on page 115.

Typical applications

Typical applications for the external coupler measurement mode are:

- Measuring medium-wave antennas.
- Measuring impedance with high-power amplifiers.

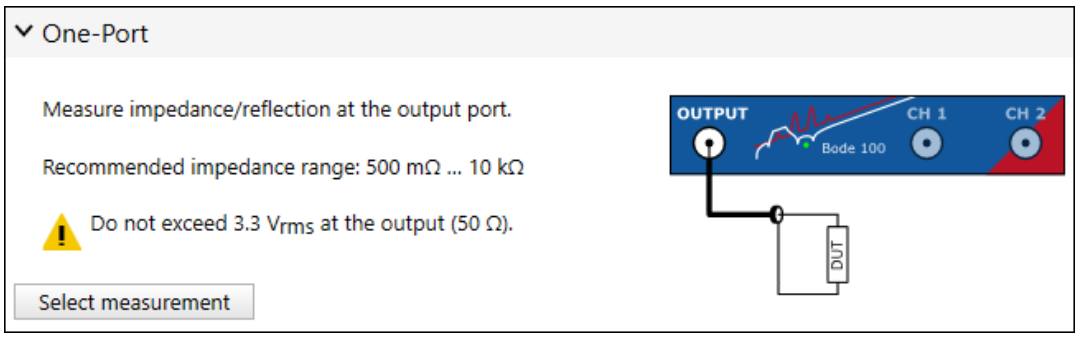
Measurement example

For a detailed measurement example using the external coupler measurement mode, please check out the medium wave antenna measurement application note at www.omicron-lab.com/BodeManualAppNotes.

7.4 Impedance Analysis

7.4.1 One-Port

The One-Port measurement mode is designed to perform quick impedance, admittance and reflection measurements. One advantage of the One-Port impedance measurement mode is that no external calibration is required. *Bode 100 or Bode 500* can measure impedance directly at the output port.



Measurement information

Bode 100 or Bode 500 derives the impedance by evaluating the internal source voltage and the output voltage. Receiver 1 as well as Receiver 2 are internally connected. General details on impedance measurements with *Bode 100 or Bode 500* can be found in 7.2 Impedance measurement introduction on page 55.

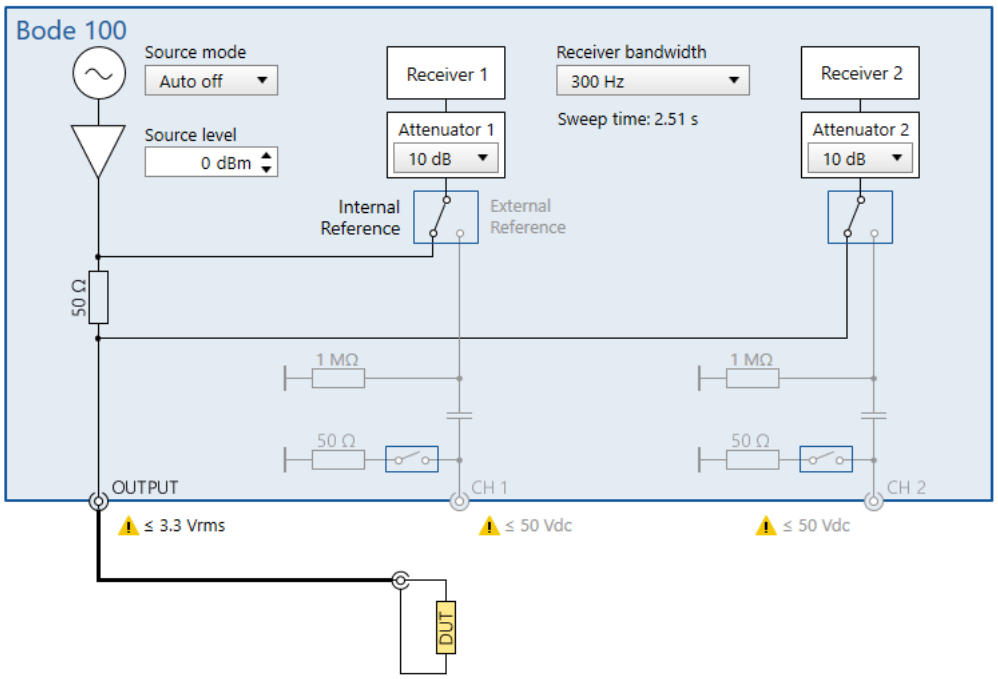


Figure 7-5: Hardware setup of the One-Port measurement mode on the example of the *Bode 100*

Since the output impedance of *Bode 100 or Bode 500* is 50 Ω, the one-port measurement provides highest sensitivity for a DUT having an impedance close to 50 Ω. The method is generally suitable to measure impedance values between roughly 500 mΩ and 10 kΩ. For measurements close to the limits of this method it is highly recommended to perform a careful User-Range calibration to achieve best results.

Calibration

The One-Port impedance measurement mode does not require calibration to perform a measurement. However, to achieve highest accuracy a calibration is recommended. Furthermore a calibration allows to move the reference plane from the output port of *Bode 100 or Bode 500* to the end of a connection cable. This compensates the effect of the connection cable. For more details on how to perform an Impedance calibration please refer to 9.3.1 Calibrating a Reflection or One-Port Impedance measurement on page 113.

Typical applications

Typical applications for the One-Port impedance measurement mode are:

- Measuring impedance of passive components.
- Measuring impedance of cables, piezo-elements or any one-port DUT.

One-Port measurement example

In this measurement example we will determine the series and parallel resonance frequency of a 12 MHz quartz filter. Further on, we will display the quartz filter's reflection curve in a Smith chart. For this step-by-step example a *Bode 100* is used. You can perform the same steps for the *Bode 500*.
Connect the input **IN 2** of the test object "Quartz Filter" to the OUTPUT of *Bode 100 or Bode 500* using the device specific delivered BNC cables or BNC-adapter cables . Further on, connect a BNC short to the corresponding output **OUT 2**. The complete setup is shown in the figure below.

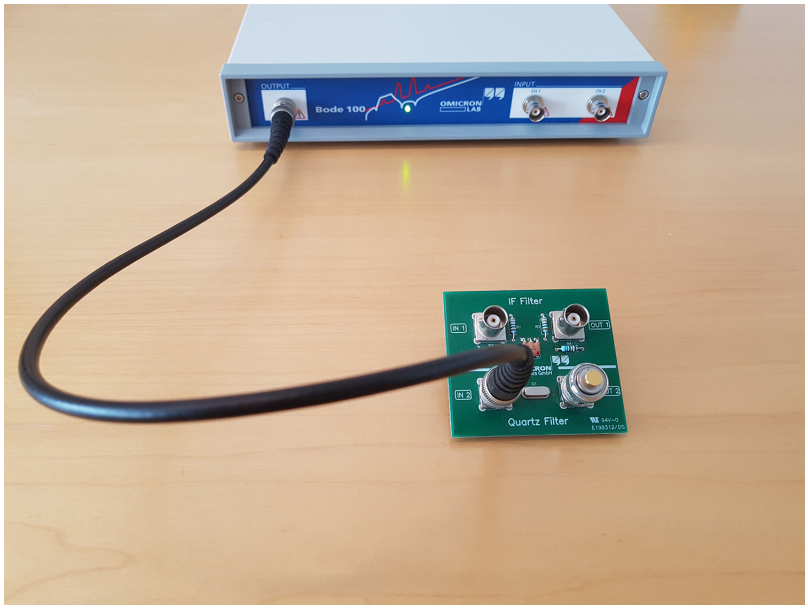
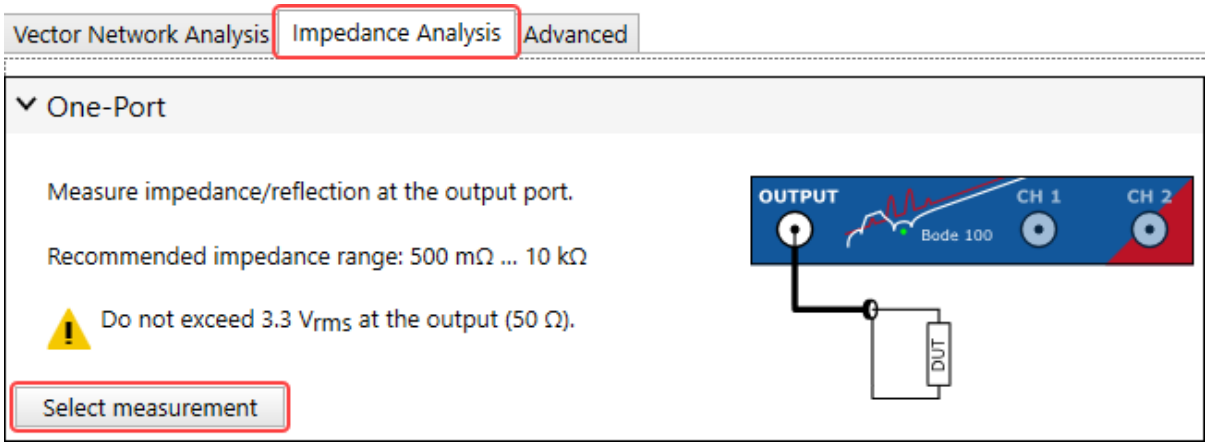


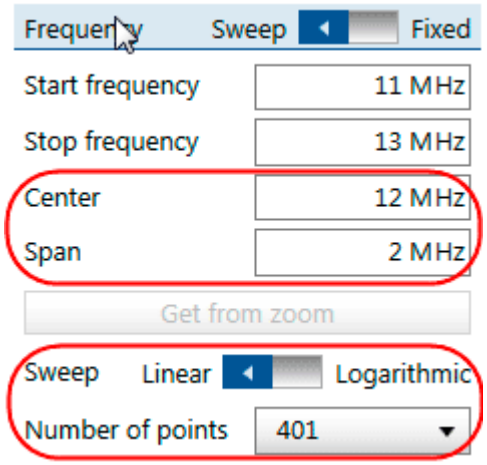
Figure 7-6: Connecting the test object Quartz Filter to *Bode 100*

Now start the *Bode Analyzer Suite* and enter the One-Port measurement mode by clicking Impedance Analysis and then Select measurement.



Before starting the measurement set the **Center frequency**, **frequency Span** and the **Number of points** to the values shown below.

Further on, select **sweep linear**:



Now click  in the home ribbon. As a result you will see a first measurement comparable to the one shown in the figure below.

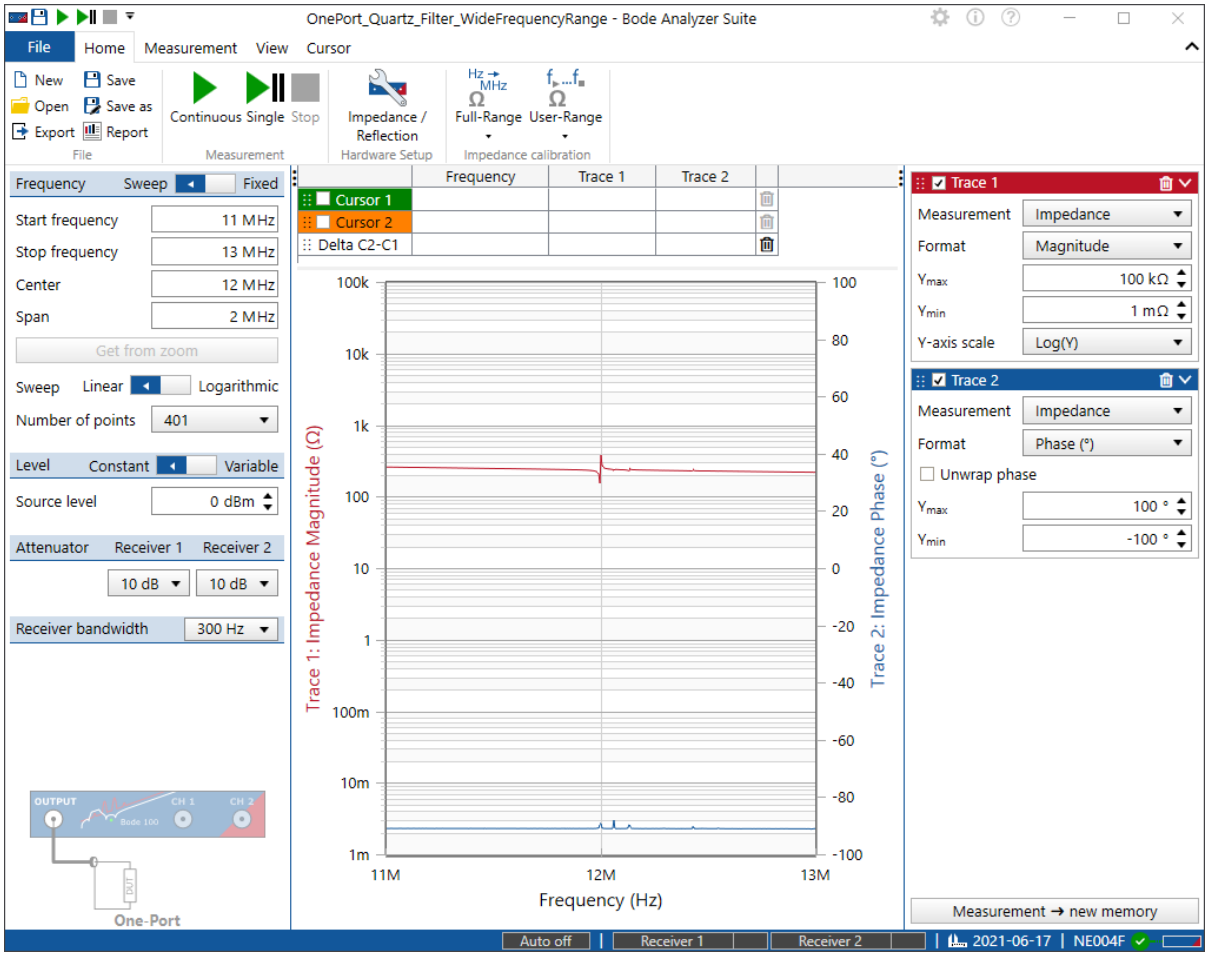
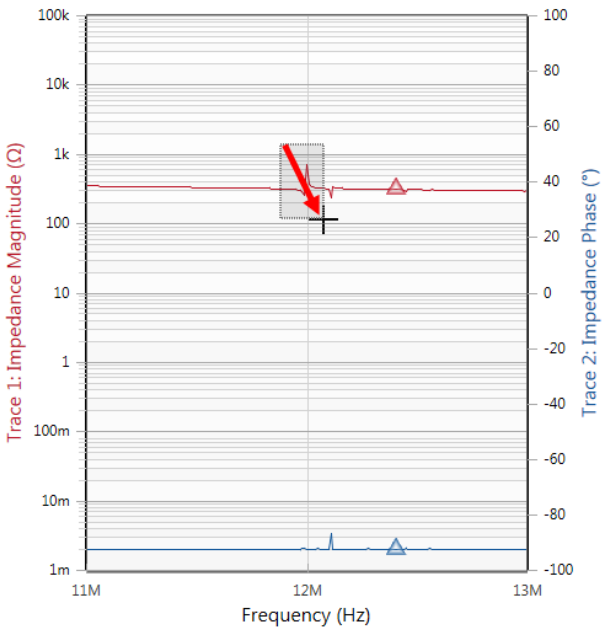


Figure 7-7: Impedance measurement of the test object Quartz Filter

Trace 1 (red curve) shows the Magnitude of the Quartz Filter's impedance while Trace 2 (blue curve) shows the Phase of the Quartz Filter's impedance.

Before continuing the measurement please switch off Trace 2 by unchecking the corresponding check box 

.



To determine the parallel and series resonance of the Quartz filter we need to zoom in. You can do this by clicking into the chart on the top left corner of the intended zoom area, keep the mouse button pressed and pull it to the lower right corner of the intended zoom area as shown.

In the zoomed window you will see that you are not having enough frequency points. By pressing Get from zoom you can set the start and stop frequency of the measurement to match the zoomed window. Right Click into the chart and select **Optimize**. Repeat these steps until you achieve a chart as shown in 7-8 on page 72

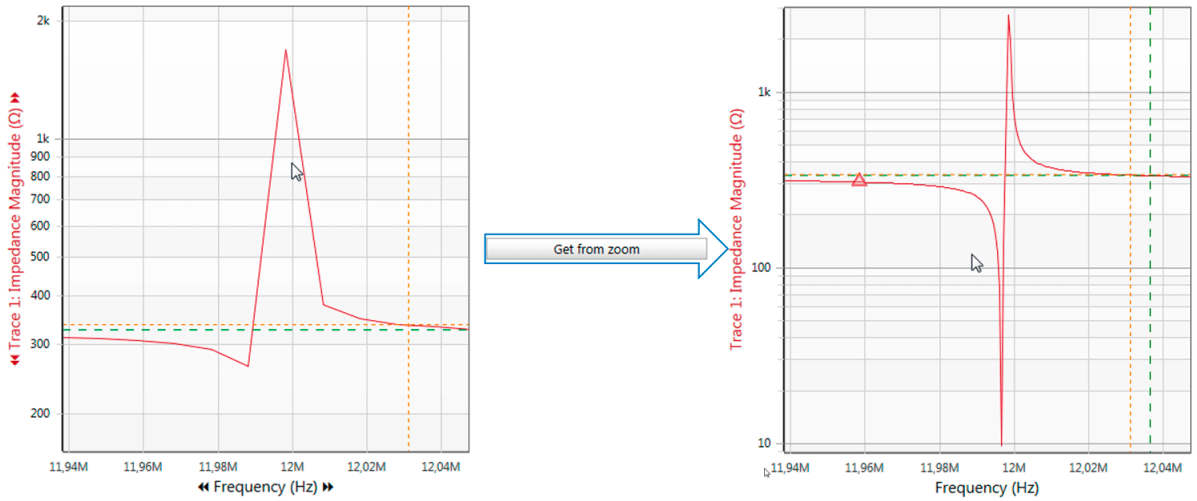


Figure 7-8: Optimizing the frequency resolution with Get from zoom

For more information on the zoom functions and optimizing check out 10.2.2 Zooming the measurement curve on page 140 and 6.3.5 Chart context menu on page 46.

After you have optimized the chart you can measure the series resonance and parallel resonance using the cursors. To do so right-click into the chart area close to the red curve and choose **Cursor 1** and then **Jump to Min (Trace 1)**. Then right-click into the chart area once more and choose **Cursor 2** and then **Jump to Max (Trace 1)**

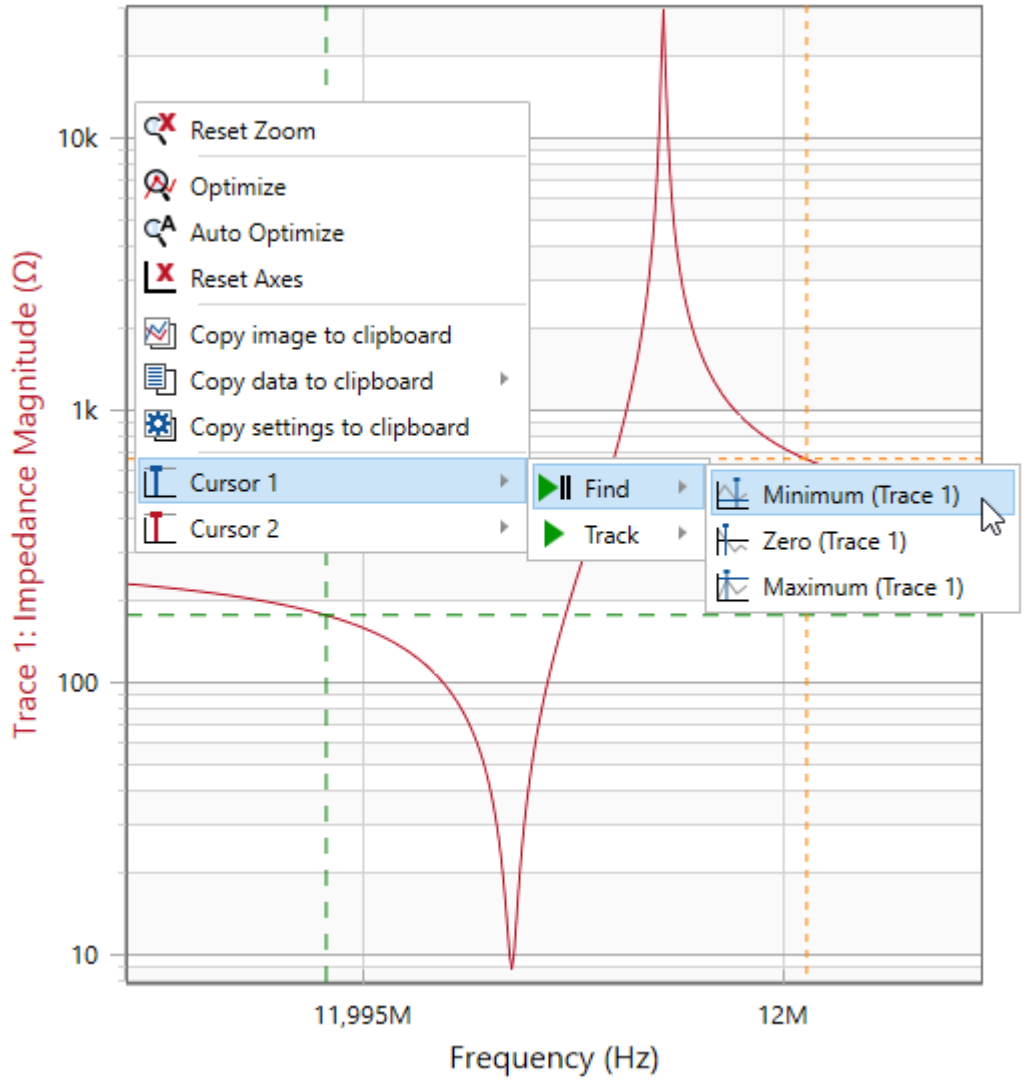


Figure 7-9: Using the cursor jump functions

For more information on cursor functions visit 10.3 Working with cursors and the cursor table on page 146.

Now let's have a look at the measurement result:

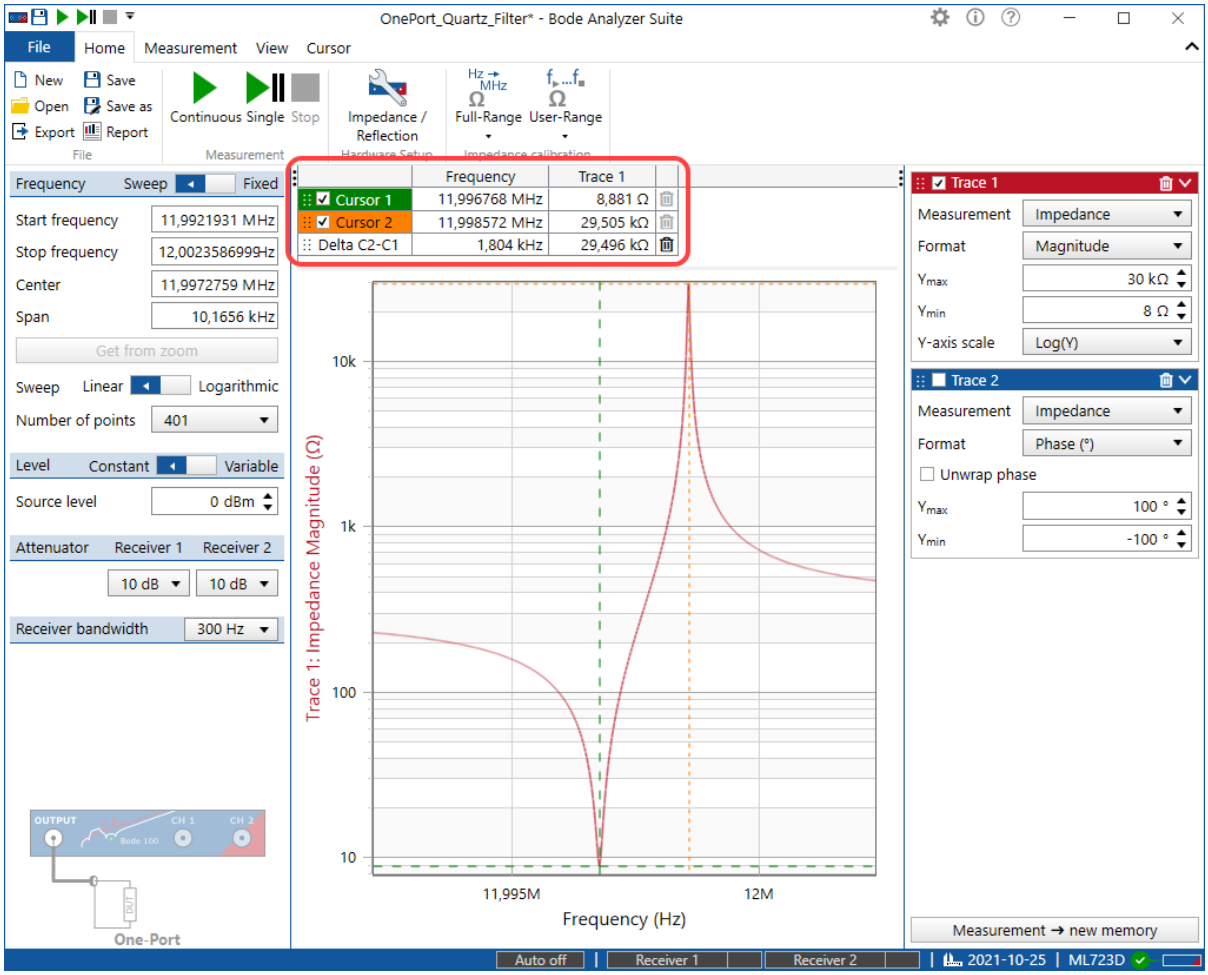


Figure 7-10: Series and parallel resonance frequency of the quartz filter

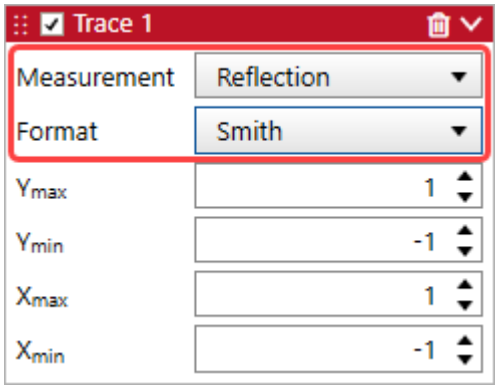
To determine the series and parallel resonance frequencies check out the cursor grid as shown in 7-8 on page 72:

- Series resonance frequency (Cursor 1 - green): 11.996768 MHz
- Parallel resonance frequency (Cursor 2 - orange): 11.998572 MHz
- Offset between the series and parallel resonance frequency (Delta C2-C1): 1.8 kHz

Your measurement results can be slightly different since each quartz filter behaves a little bit different.

One characteristic of resonance frequencies is that the inductances and capacitances compensate each other. This means that at the series and parallel resonance the impedance of our quartz filter should be purely resistive. An elegant way to check this is to display the quartz filters reflection curve as a Smith chart.

Smith charts were developed at a time when it was still difficult to directly measure the frequency swept impedance of measurement objects. The Smith chart is used to determine the impedance at a certain point of the reflection curve. To display the Smith chart of our quartz filter's impedance apply the settings shown below to Trace 1:



After applying the settings a smith chart like the one shown below will be displayed:

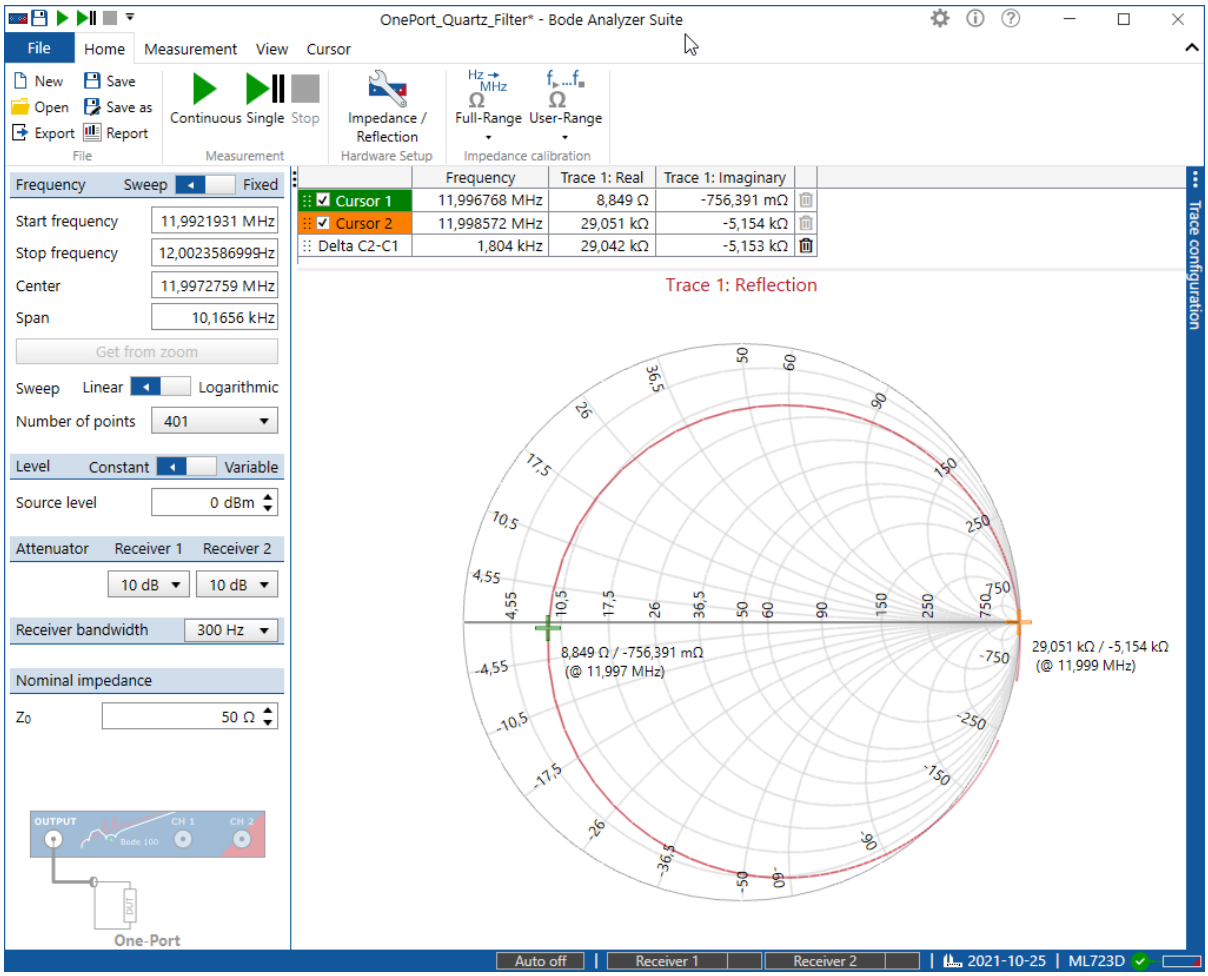


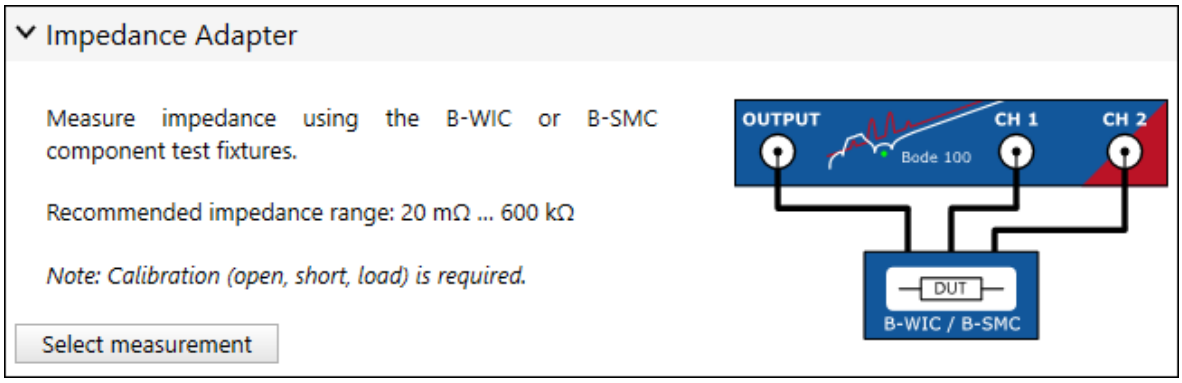
Figure 7-11: Smith chart of the 12 MHz Quartz Filter

As you can see both cursors are very close to the horizontal (=resistive) axis of the Smith chart. However, you can also see that the imaginary part for both measurements is not exactly 0 Ω. The reason for this is the chosen number of frequency points and the frequency resolution resulting from it. Feel free to use more points and zooming to determine the exact frequencies at which the imaginary part of the impedance becomes 0 Ω

Congratulations!
You have performed your impedance measurement with the *Bode 100 or Bode 500*. You can load the settings for the measurement by clicking File → Open → and then navigating to: "%appdata% \OMICRON_Lab\BodeAnalyzerSuite\DemoFiles" . The file you will need is: **Bode100_OnePort_Quartz-Filter.bode3**.

7.4.2 Impedance Adapter

The impedance adapter measurement mode is especially designed for measurements with the OMICRON Lab impedance test fixtures *B-WIC* and *B-SMC*. The impedance adapter measurement mode ensures that *Bode 100 or Bode 500* is configured correctly to achieve best results when measuring with both *B-WIC* and *B-SMC*. For this step-by-step example a *Bode 100* is used. You can perform the same steps for the *Bode 500*



Calibration

The impedance adapter measurement mode requires impedance (open, short, load) calibration. For more details on how to calibrate the *B-WIC* or *B-SMC* impedance adapter, please refer to 9.3.3 Calibrating an Impedance Adapter measurement on page 117.

Measurement information

With *B-WIC* and *B-SMC*, the dynamic range of both input channels is used. This widens the usable impedance measurement range spanning from 20 mΩ to 600 kΩ.

The maximum measurement frequency of *B-WIC* and *B-SMC* is 50 MHz. We don't recommend using *B-WIC* and *B-SMC* for frequencies above 50 MHz.

It is recommended to use the 0.5 m device specific BNC cables or BNC-adapter cables delivered with *Bode 100 or Bode 500* to connect *B-WIC* or *B-SMC* to the *Bode 100 or Bode 500*.
B-WIC and *B-SMC* are designed to measure physically small DUTs. Stray-fields between the DUT and the grounded housing of the impedance adapters might introduce a systematic measurement error. The error is negligible when measuring physically small objects. To measure physically big DUTs it is recommended to use a grounded measurement configuration such as shown in 7.4.1 One-Port on page 68.

Typical applications

Typical applications for the impedance adapter measurement mode are:

- Measuring impedance of capacitors, inductors and other passives (THT and SMC).
- Measuring impedance piezo-elements or quartz elements.

Impedance Adapter measurement example

In this measurement example we will determine the inductance (Ls) and the equivalent series resistance (Rs) of an inductor using the *B-WIC* impedance measurement adapter for through-hole-type components. For this step-by-step example a *Bode 100* is used. You can perform the same measurement using a *Bode 500*.

When using a *Bode 500* we recommend to limit the frequency range to a maximum frequency of 50 MHz. *B-WIC* and *B-SMC* are not designed for frequencies above 50 MHz.

Connect the *B-WIC* to *Bode 100* using three device specific delivered BNC cables or BNC-adapter cables as shown below.

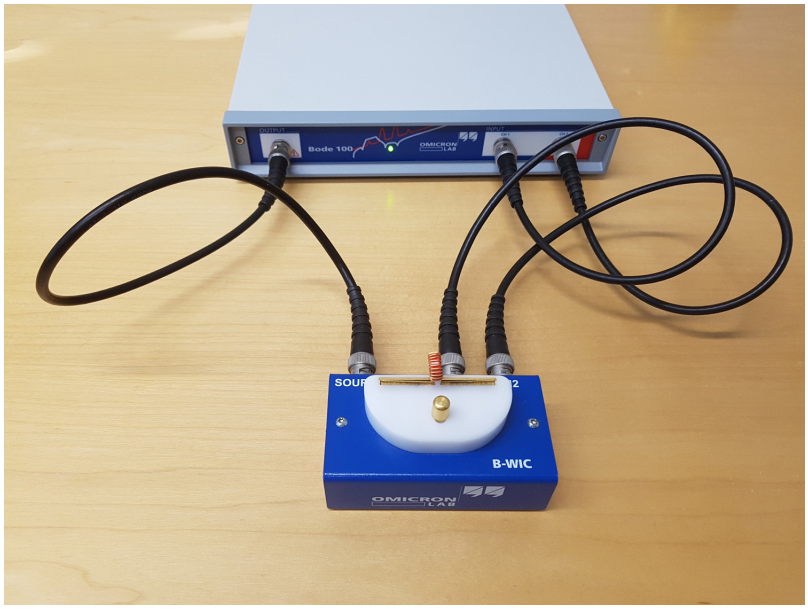
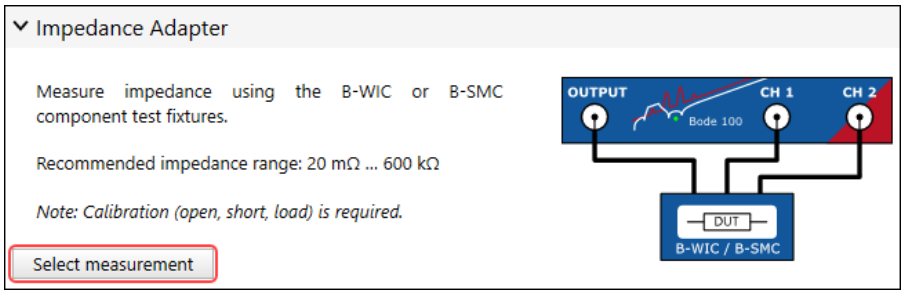


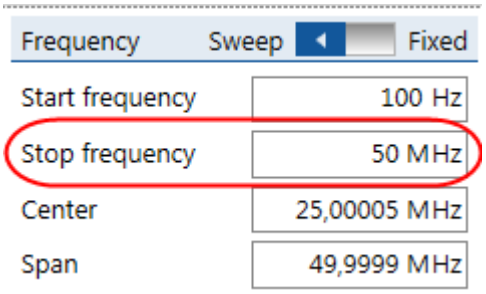
Figure 7-12: Connecting the *B-WIC* to *Bode 100*

Now start the *Bode Analyzer Suite* and enter the Impedance Adapter measurement mode by clicking Impedance Analysis and then Select measurement.



Before you can start a measurement you have to perform a **calibration**. To do so please follow the steps described in Impedance Adapter Calibration on page 117.

After having performed the calibration please put the inductor you want to measure into the impedance measurement adapter as shown in 7-12 on page 78.
Since it is not known in what frequence range the examined inductor is working please change the stop frequency to 50 MHz.



Now click  in the home ribbon. As a result you will see a first measurement comparable to the one shown in the figure below. For sure your result will look different since you are using a different inductor.

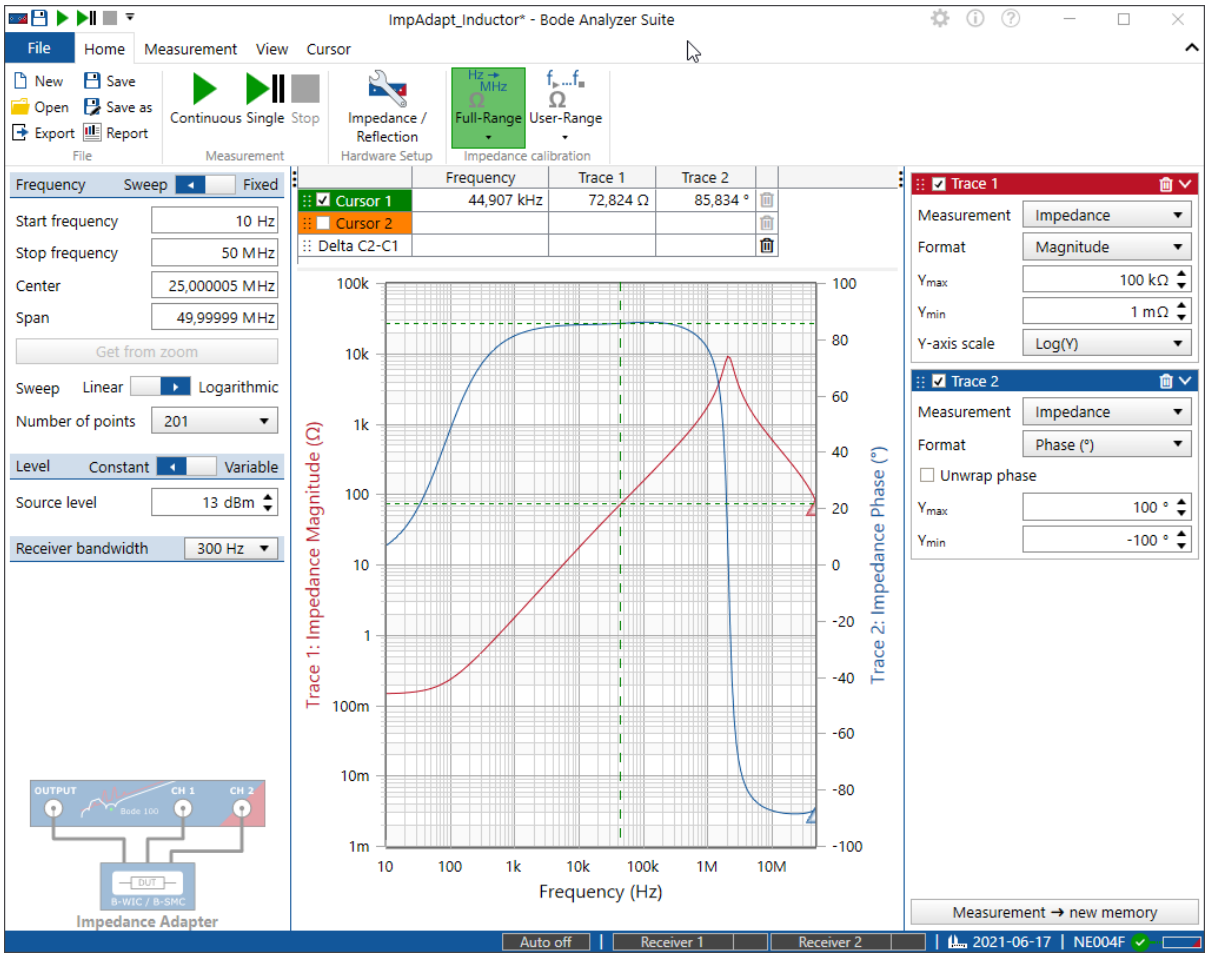
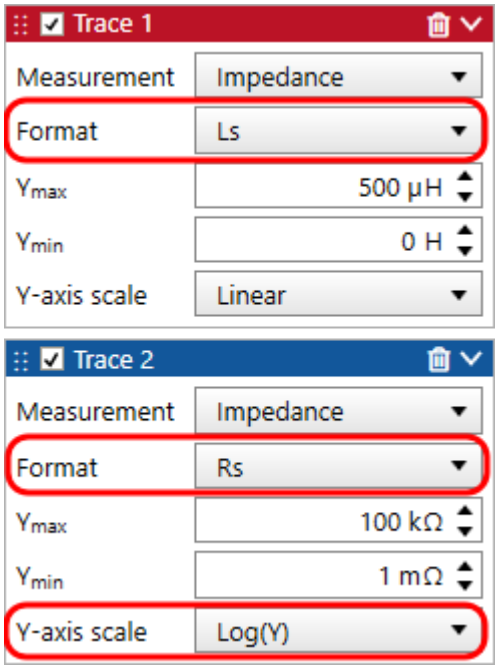


Figure 7-13: Impedance measurement of an Inductor

Trace 1 (red curve) shows the Magnitude of the inductor's impedance while Trace 2 (blue curve) shows the phase of the inductor's impedance. The magnitude curve is rising with 20 dB per decade, this indicates that we are really measuring an inductor. To measure the resistance Rs and inductance Ls of the inductor simply change the format for Trace 1 and Trace 2 as shown.



To get a better view on the Ls and Rs it is recommended to **switch to two diagrams**. To do so follow the instructions described in 10.2.1 Configure the diagrams on page 138.

Well, and now we have our result:

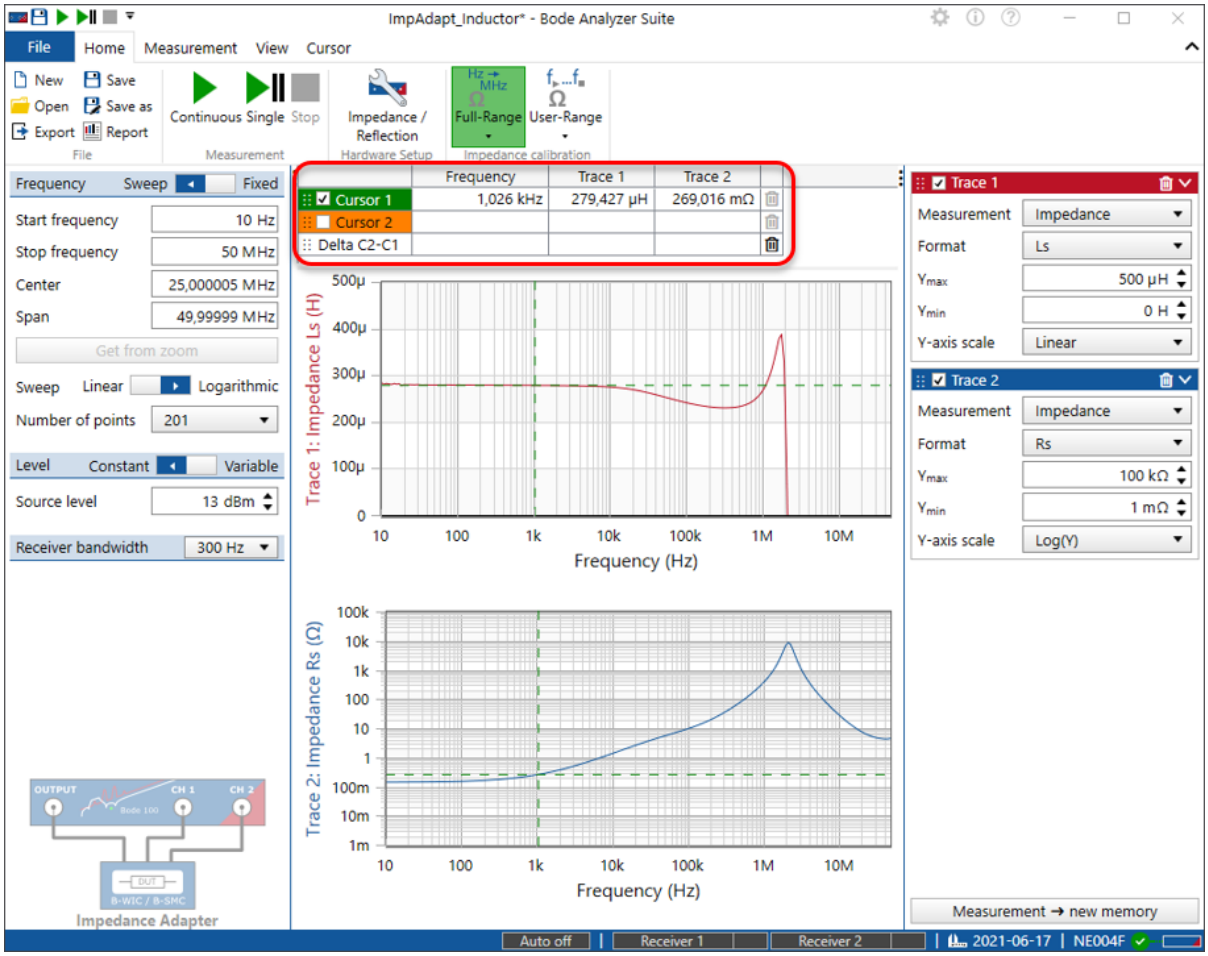


Figure 7-14: Measurement of a 280 µH inductor with the B-WIC impedance adapter

By using the cursors we can gather the following information on the measured inductor:

- The inductor has an inductance of **280 µH** up to roughly **10 kHz**
- The resistance of the inductor starts around **147 mΩ** and rises up to **10 Ω** at **100 kHz**.
- Above 10 kHz the inductance starts to drop and at roughly 2 MHz the inductor has its self-resonance frequency. Above the self-resonance frequency, the capacitive behavior dominates.

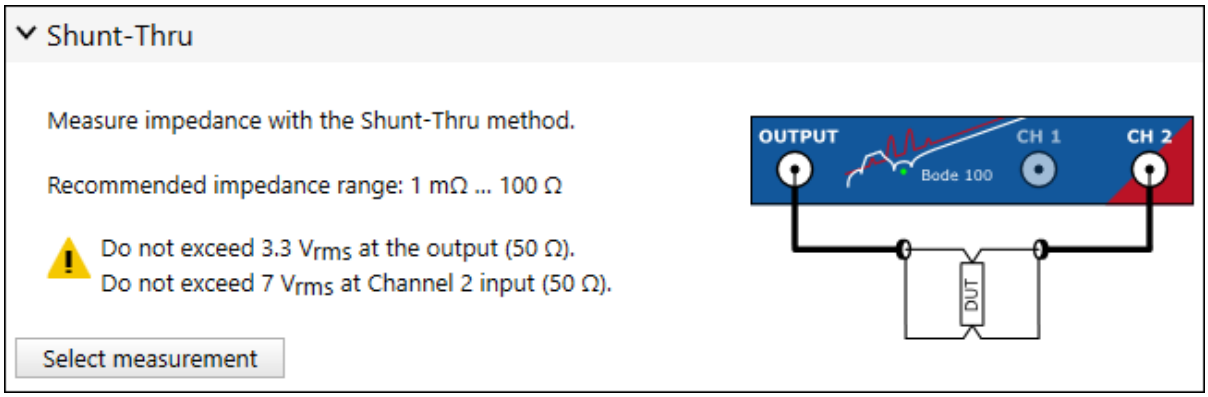
Congratulations you have successfully used the *B-WIC* impedance measurement adapter with the *Bode 100 or Bode 500*. You can load the settings for the measurement by clicking File → Open → and then navigating to: "%appdata%\OMICRON_Lab\BodeAnalyzerSuite\DemoFiles". The file you will need is: **Bode100_ImpAdapt_Inductor.bode3**.

Attention: Since your setup will be different the file should only be used to explore the different, measurement formats offered by *Bode 100 or Bode 500*. Before you execute a new measurement, you will have to **perform a new calibration**.

For a detailed measurement example using the impedance adapter measurement mode to measure capacitors, please check out the ESR measurement application note at www.omicron-lab.com/BodeManualAppNotes

7.4.3 Shunt-Thru

The Shunt-Thru measurement mode is especially suitable to measure very small impedance values. It is basically an S21 transmission measurement in a special configuration. The impedance is calculated from the measured S21 parameter. For this document a *Bode 100* is used. You can perform the same measurement with the *Bode 500*.



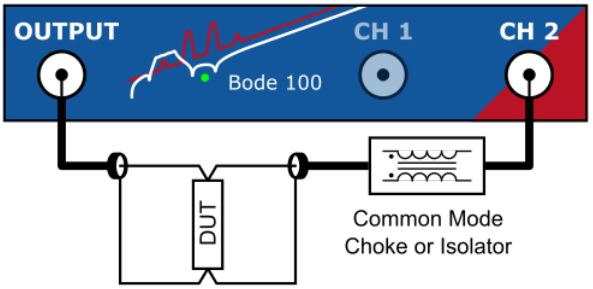
Measurement information

Bode 100 or Bode 500 measure *S21* gain and calculate impedance *Z* using the equation:

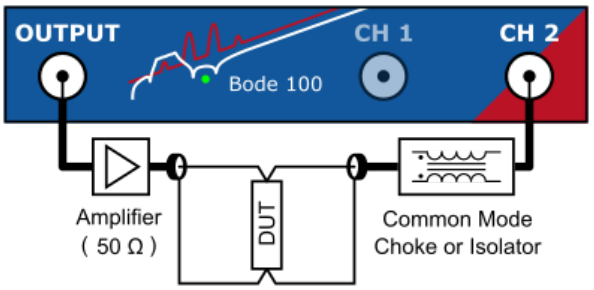
$$Z = 25\Omega \frac{S_{21}}{1 - S_{21}}$$

The Shunt-Thru measurement configuration emulates a 4-wire kelvin connection. The output drives a current thru the device under test that is shunted between the output signal and GND. Channel 2 measures the voltage drop that occurs at the DUT. This measurement mode offers highest sensitivity for low-impedance value DUT.
The recommended impedance measurement range starts at roughly 1 mΩ. With care, using amplifiers or pre-amplifiers, µΩ measurements can be performed. It is not recommended to measure impedance values in the kΩ range or above.

The Shunt-Thru configuration inherently suffers a ground-loop error at low frequencies. The current flowing thru the cable shield of the connection to Channel 2 ground introduces a measurement error that can become significant at frequencies below 10 kHz to 100 kHz when measuring very low impedance values. To suppress respectively reduce the ground-loop error at low frequencies, use a common-mode choke or common-mode transformer or an active isolation device. Note that the Shunt-Thru transformation from S21 to impedance assumes 50 Ω as source impedance and input impedance.



To improve signal to noise ratio for very low impedance measurements, you can use a 50 Ω amplifier at the Output of *Bode 100 or Bode 500* as shown in the image below. Use calibration to remove the amplifier gain and phase shift.



Calibration

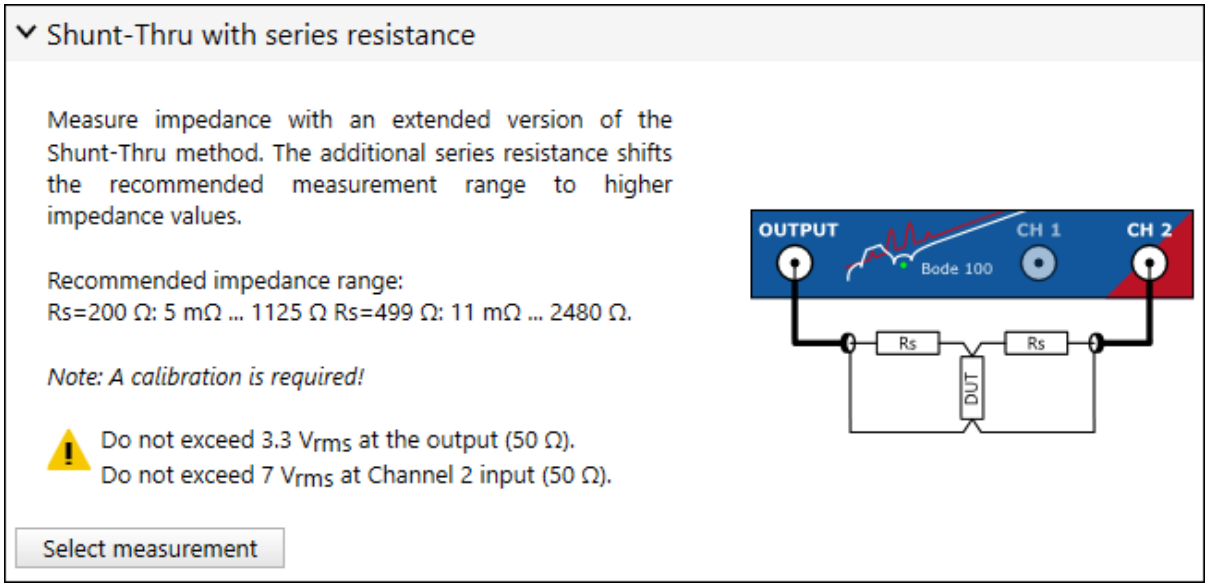
The Shunt-Thru measurement is basically a Gain measurement that is transformed to an impedance. Therefore **two** calibrations are possible. Either a Thru-calibration or an Open, Short, Load calibration. Thru calibration calibrates the underlying S21 measurement and removes the gain/phase shift of the cable connection, common mode choke or amplifier.
Open, Short, Load calibration shifts the reference plane directly to the calibration plane.
For more details on calibrating a Shunt-Thru measurement, please refer to 9.3.4 Calibrating a Shunt-Thru or Series-Thru measurement on page 119.

Typical applications

A typical application for the Shunt-Thru measurement mode is the ESR measurement of ultra-low ESR decoupling caps.

7.4.4 Shunt-Thru with series resistance

Shunt-Thru with series resistance is very similar to the normal Shunt-Thru measurement mode. For more details regarding the normal Shunt-Thru measurement mode, please see 7.4.3 Shunt-Thru on page 82. For this document a *Bode 100* is used. You can perform the same measurement with the *Bode 500*.



Measurement information

Bode 100 or *Bode 500* measure *S21* gain and calculate impedance *Z* using the equation:

$$Z = \frac{50\Omega + Rs}{2} \frac{S_{21}}{1 - S_{21}}$$

Compared to the normal Shunt-Thru measurement mode, the series resistors increase the maximum measurable impedance and protect the ports from external voltage. This is an advantage when one needs to measure from roughly 10 mΩ to some kΩs or when output impedance of a PDN network is measured and the voltage exceeds the maximum allowed limits.
The higher the series Resistors *Rs* are chosen, the higher the maximum recommended impedance is. However, at the same time the lower impedance limit rises.

The following table shows some *Rs* values and their influence on the impedance measurement range:

Series Resistor Rs	Lower Z Limit	Upper Z Limit
200 Ω	5 mΩ	1125 Ω
450 Ω	10 mΩ	2250 Ω
499 Ω	11 mΩ	2480 Ω
950 Ω	20 mΩ	4500 Ω

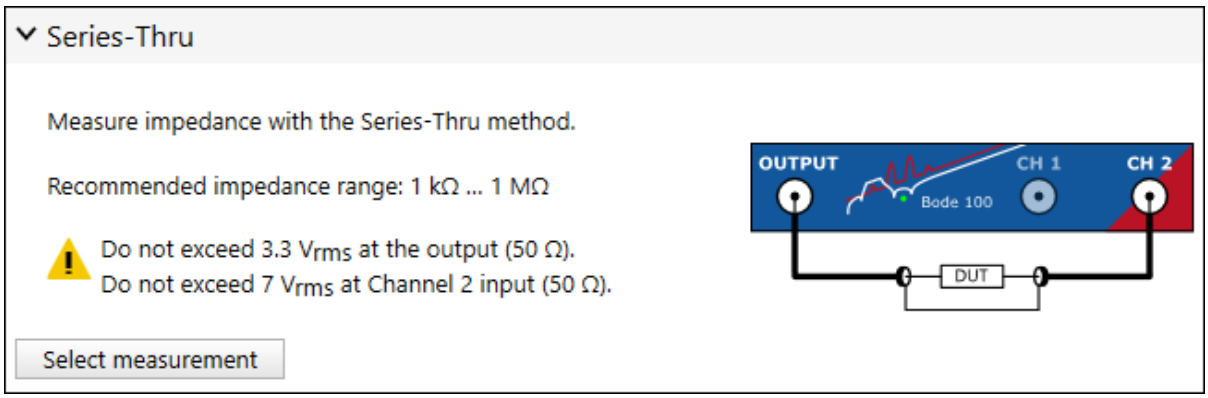
The Shunt-Thru with series resistor configuration suffers from the same systematic error as the normal Shunt-Thru configuration. Please refer to 7.4.3 Shunt-Thru on page 82 for more details about the cable-braid-error.

Calibration

The Shunt-Thru with series resistor measurement requires at least one Thru calibration.
Thru calibration must be performed with the series resistors included.
For more details on calibrating a Shunt-Thru measurement, please refer to 9.3.4 Calibrating a Shunt-Thru or Series-Thru measurement on page 119.

7.4.5 Series-Thru

The Series-Thru measurement configuration is especially suitable to measure very high impedance values. It is basically an S21 transmission measurement in a special configuration. The impedance is calculated from the measured S21 parameter. For this document a *Bode 100* is used. You can perform the same measurement with the *Bode 500*.



Measurement information

Bode 100 or Bode 500 measures *S21* gain and calculates impedance *Z* using the equation:

$$Z = 100\Omega\frac{1 - S_{21}}{S_{21}}$$

The Series-Thru configuration offers high sensitivity for high-impedance DUTs. Impedance values in the MΩ region can be measured. Using an output amplifier further increases the upper impedance measurement limit.
Series-Thru measurement configuration is not suitable for low-impedance DUTs. It is not recommended to measure impedance values below roughly 1 kΩ.
One advantage of the series-thru connection is that a shielded test-setup can easily be constructed.

Calibration

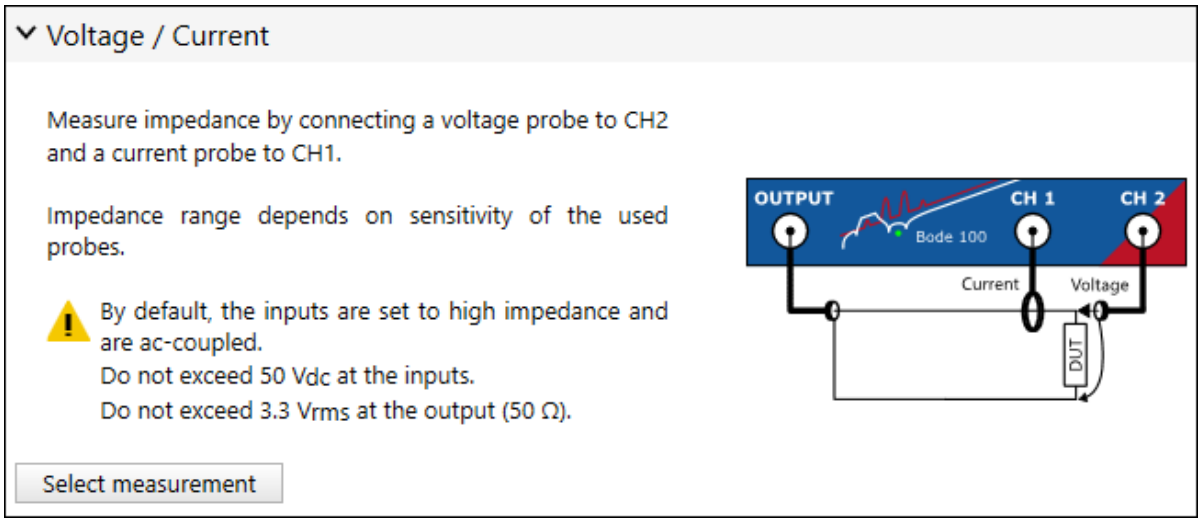
The Series-Thru measurement is basically a Gain measurement that is transformed to an impedance. Therefore **two** calibrations are possible. Either a Thru-calibration or an Open, Short, Load calibration. Thru calibration calibrates the underlying S21 measurement and removes the effect of the cable connection to the DUT.
Open, Short, Load calibration shifts the reference plane directly to the calibration plane.
For more details on calibrating a Series-Thru measurement, please refer to 9.3.4 Calibrating a Shunt-Thru or Series-Thru measurement on page 119.

Typical applications

A typical application for the Series-Thru measurement is the measurement of DUTs with low conductivity (high impedance).

7.4.6 Voltage/Current

The Voltage/Current measurement mode is basically a Gain measurement with external reference similar to the Gain/Phase measurement mode. However, the fact that the Gain is treated as an impedance result offers all impedance result formats such as L, C and Q calculations. For this document a *Bode 100* is used. You can perform the same measurement with the *Bode 500*.



Measurement information

Bode 100 or Bode 500 measure Gain and transform it directly to impedance *Z* using:

$$Z = \frac{V}{I} = \frac{V_{CH2}}{V_{CH1}} = Gain$$

The voltage/current measurement is very flexible. The usable impedance measurement range cannot be generalized since it strongly depends on the used probes and connections. Using highly sensitive current sensing, very high impedance values can be measured. Using very sensitive voltage measurements, very low impedance values can be measured.

Calibration

The Voltage/Current measurement is basically a Gain measurement that is transformed to an impedance. Therefore **two** calibrations are possible. Either a Thru-calibration **or** an Open, Short, Load calibration.

Thru calibration calibrates the underlying gain measurement and removes gain and phase shifts of the probes. A 1 Ω resistor is needed to perform a Thru calibration in the Voltage/Current measurement mode.
Open, Short, Load calibration shifts the reference plane directly to the calibration plane.
For more details on calibrating a Voltage/Current measurement, please refer to 9.3.5 Calibrating a Voltage/Current measurement on page 121.

Typical applications

The Voltage/Current measurement is suitable for a high variety of measurement applications. It is the mode of choice for every impedance measurement that measures voltage and current separately.
Typical measurements are:

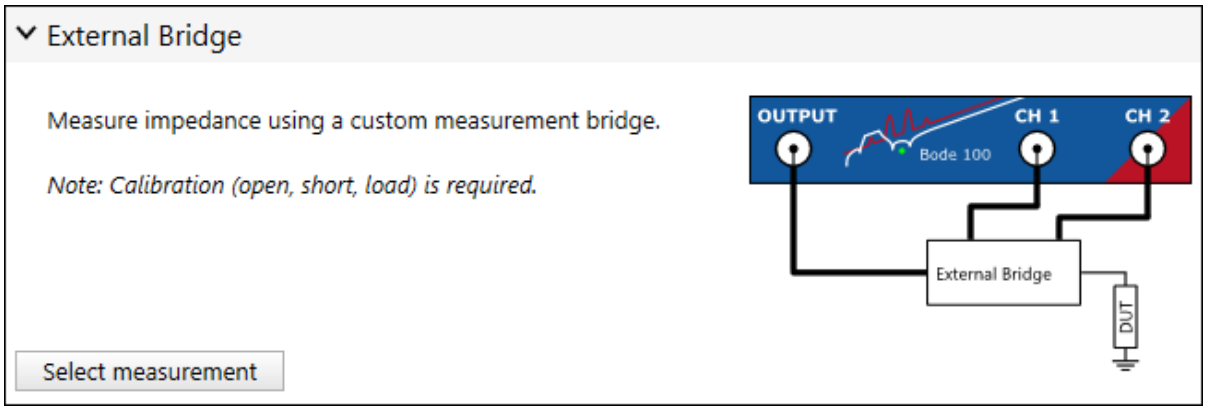
- Input impedance measurement of active circuits such as power supplies.
- Output impedance measurement of active circuits such as power supplies.

Measurement example

For detailed measurement examples using the voltage/current measurement mode, please check out the Non-Invasive stability application note at www.omicron-lab.com/BodeManualAppNotes.

7.4.7 External Bridge

The external bridge measurement mode offers you the possibility to use an arbitrarily designed impedance measurement bridge specifically designed for your special purpose. For this document a *Bode 100* is used. You can perform the same measurement with the *Bode 500*.



Calibration

The external bridge measurement mode requires impedance (open, short, load) calibration.
For more details on how to calibrate an external bridge, please refer to 9.3.2 Calibrating an External Coupler or External Bridge measurement on page 115.

Measurement information

The external bridge measurement mode is similar to the Impedance Adapter measurement mode but allows you to change the channel termination and input attenuators to adjust them according to your needs.

Measurement example

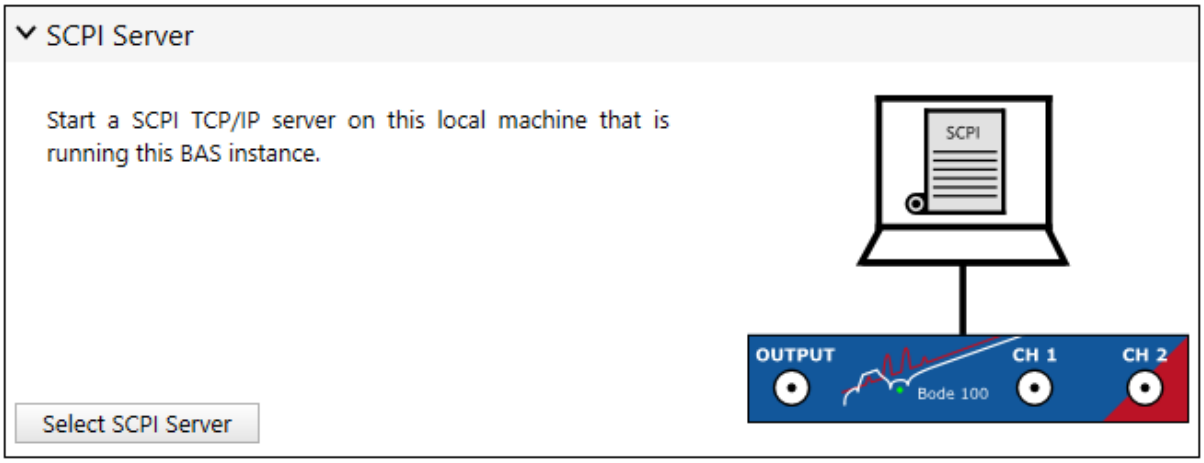
For a detailed measurement example using the external bridge measurement mode, please check out the High-impedance measurement application note at www.omicron-lab.com/BodeManualAppNotes.

7.5 Advanced

7.5.1 SCPI server

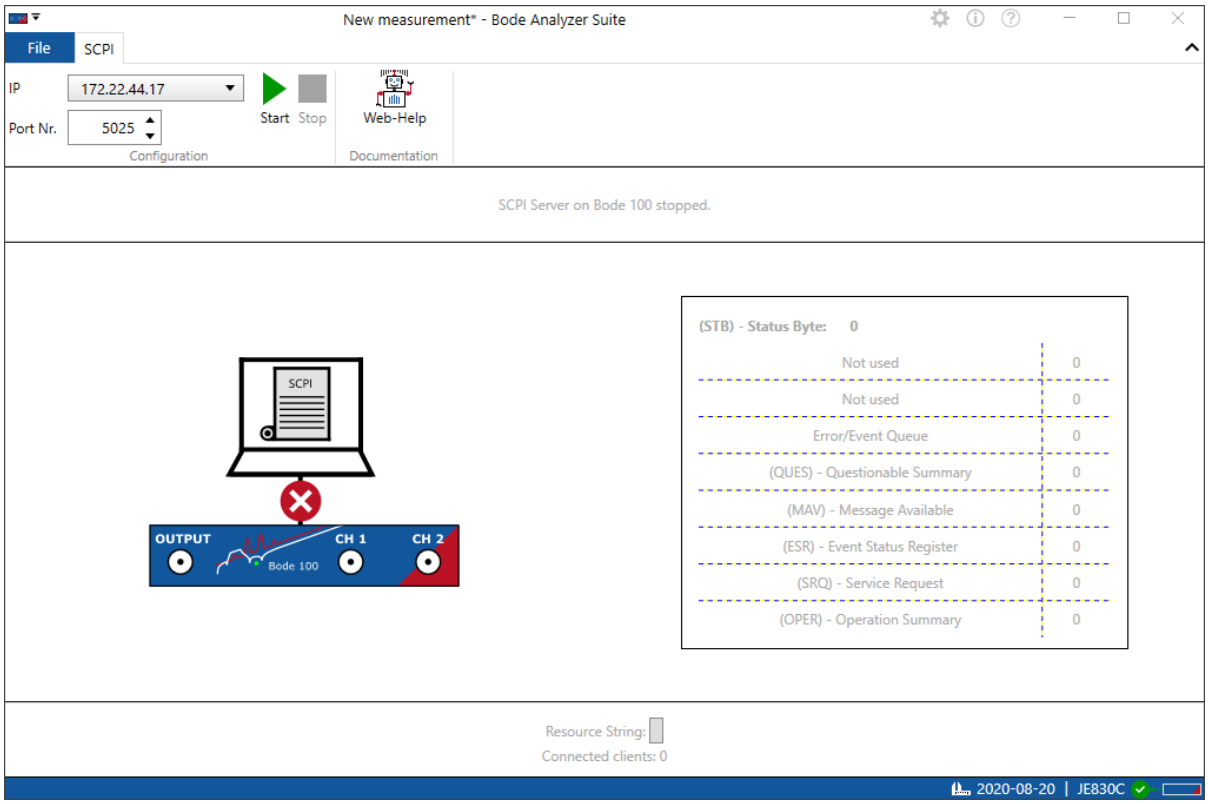
In contrast to the *Bode 100*, the SCPI server is part of the *Bode 500*. The SCPI server on the *Bode 500* is started per default. Thus, we recommend accessing the SCPI server directly on the *Bode 500* device, since it does not require the *Bode Analyzer Suite* installed on your client device (e.g. PC).

For more information on the SCPI server and its differences for *Bode 100* and *Bode 500* and how to perform automated measurements using SCPI or our Bode Automation Interface, please refer to 11 Automating measurements on page 183.
The SCPI Server mode allows you to start a localhost SCPI server that offers you an SCPI interface to control the *Bode 100 or Bode 500*.



The SCPI localhost server allows you to control the *Bode 100 or Bode 500* via SCPI commands. Please note that BAS 3.50 does not offer any GUI related features. This means that you can configure measurements, execute them and receive single-trace, single-channel data that you can then further process in your software application.

Server configuration



In the SPCI Server control window, you can start the server, see if it is running and configure the port-number used. Furthermore, SCPI status-byte information from the device is shown.

The BAS 3.50 SCPI interface is not a remote control of the Bode Analyzer Suite. If an SCPI server is running, you cannot control the *Bode 100 or Bode 500* via *Bode Analyzer Suite* at the same time.

8 Measurement and Device settings

This chapter focuses on settings and options that are required to achieve good measurement results. Details such as configuring the right attenuator or the correct signal source level are discussed in the following.

8.1 Measurement setup and Hardware setup

By clicking on the setup icon  , the measurement setup dialog is opened.
The measurement setup dialog is divided in two parts, the Hardware setup and the Measurement setup. The Hardware tab shows the internal connections of *Bode 100* or *Bode 100* as well as the external connections to the DUT. The Measurement tab shows other sweep time relevant settings.

Hardware setup

Depending on the selected measurement mode, some of the following settings in the Hardware setup tab can be changed:

- **Source mode:** Choose between *Auto off* or *Always on*. More details on the source behavior of *Bode 100* and *Bode 500* can be found in 8.4 Signal source settings on page 97.
- **Source level:** Set the constant source level or the reference level when the shaped level function is used.
- **Receiver bandwidth:** Select the receiver bandwidth used for the measurement.
- **Attenuator 1 and Attenuator 2:** Select the receiver input attenuation.
- **Reference switch:** Receiver 1 and Receiver 2 can be connected either internally or externally, depending on the measurement mode.
- **Termination switch:** When switched on, the Channel 1 and Channel 2 inputs are terminated with 50 Ω. If the switch is open, the input impedance is 1 MΩ, ac-coupled.
- **Probe 1 and Probe 2:** Some measurement modes allow you to manually enter a probe factor. For more details on using probes see 8.5 Using external probes & injection transformers on page 100.

Measurement setup

In the Measurement setup tab some sweep time relevant settings are available. The **Sweep time** shown in this window is calculated depending on the Frequency Sweep parameters and the settings in this dialog.

- **DUT settling time:** Time between applying the measurement signal and starting to measure at the receiver. A DUT settling time is needed if the DUT introduces a significant time delay before the output reaches its final reaction to the input stimulus. And example could be a surface acoustic wave filter with a significant time delay.
- **Filter periods:** The filter periods setting defines the number of signal periods used for the result evaluation in the narrow-band receiver filter. It can be adjusted between 4 and 10 filter periods. Default is 6 filter periods. Lower filter period values increase the measurement speed but reduce accuracy and noise rejection. More filter periods can improve noise rejection.
- **Path switch settling time:** Time delay when switching the internal path. This settings helps to stabilize the values in fast sweep measurements. Default value is 50 ms. This setting is only available for the *Bode 500*

Bode 100 hardware setup

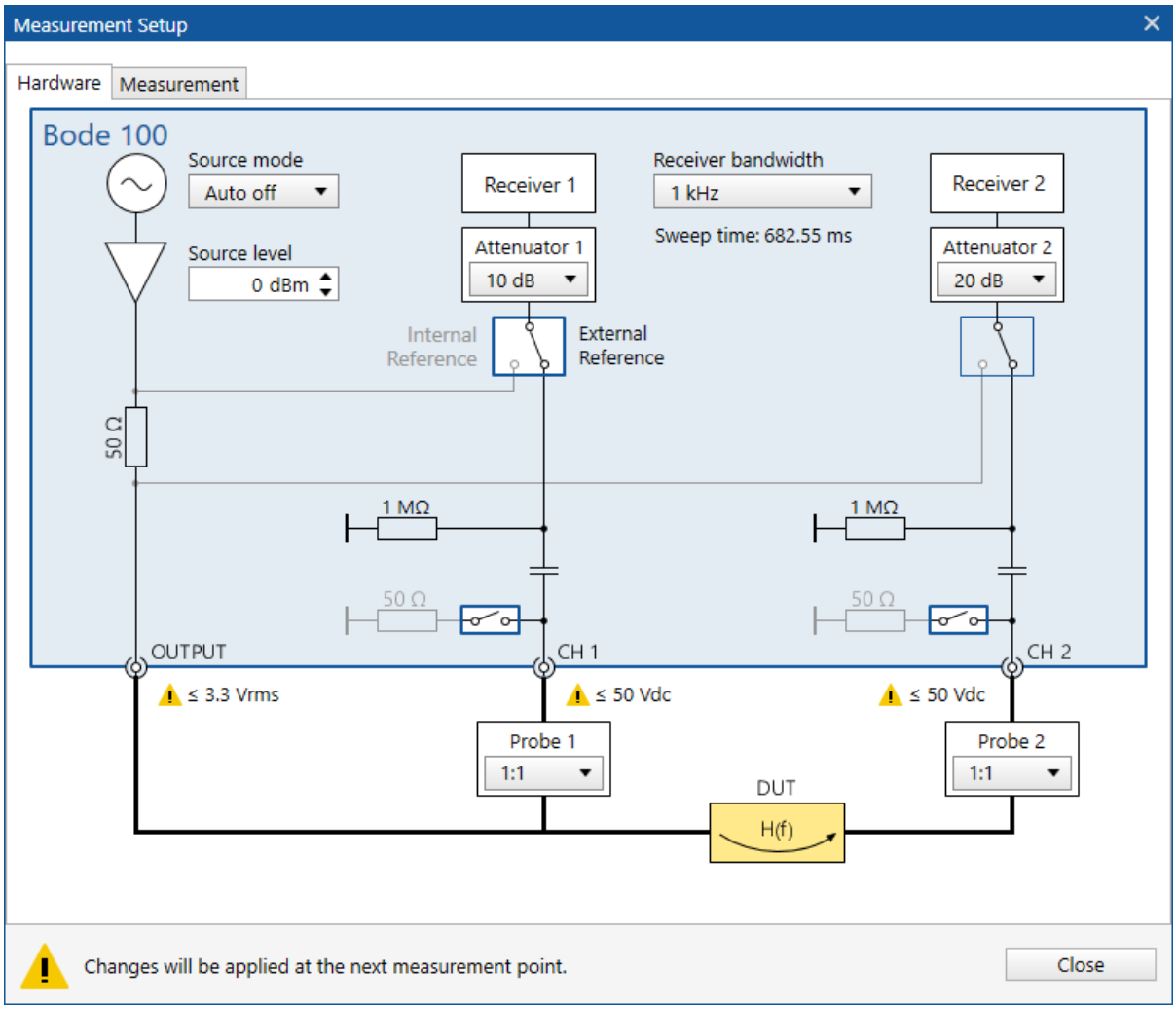


Figure 8-1: *Bode 100* hardware setup dialog in Gain/Phase measurement mode.

Bode 500 hardware setup

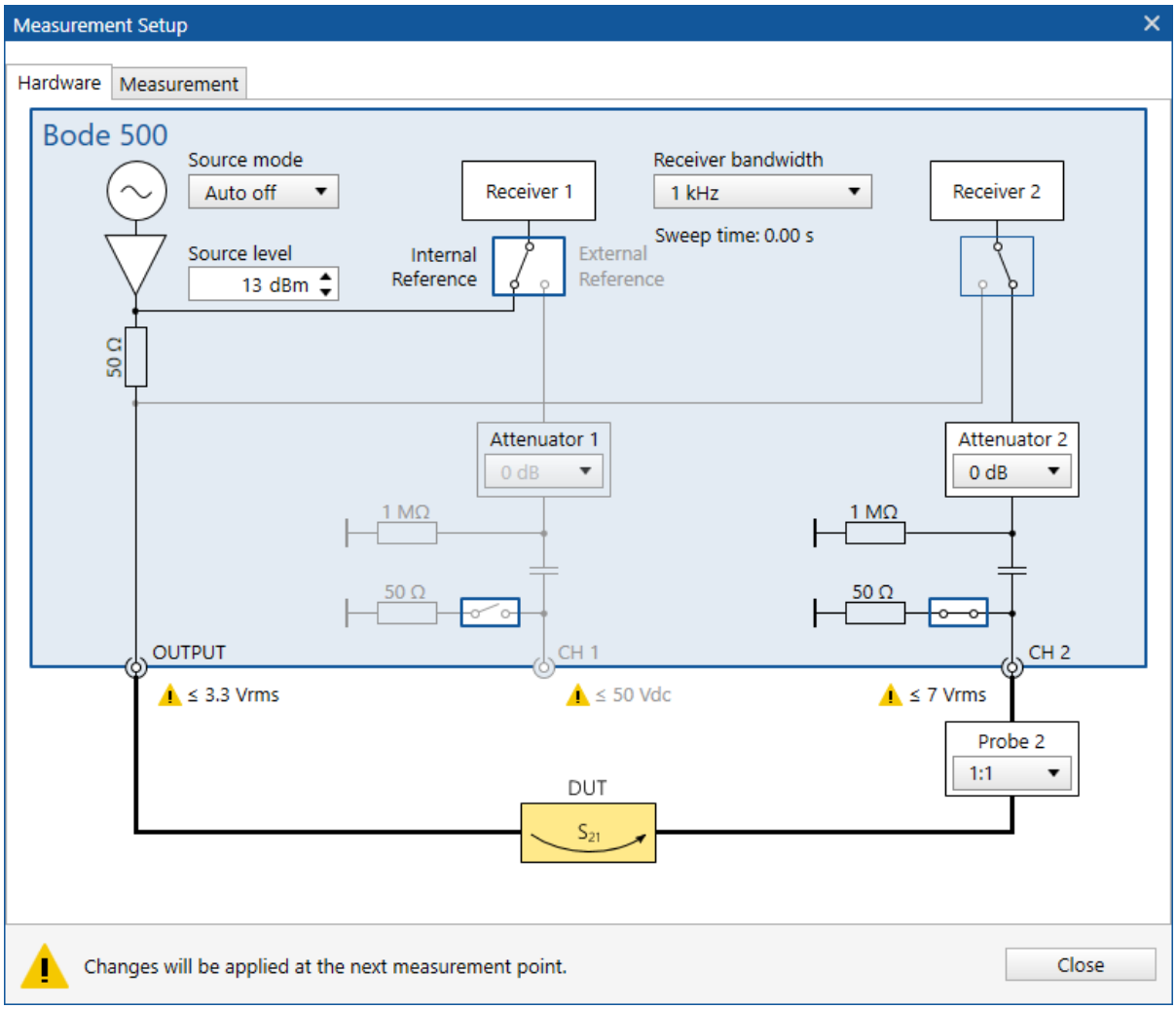


Figure 8-2: *Bode 500* hardware setup dialog in Transmission / Reflection measurement mode.

8.2 Receiver Bandwidth

A Vector Network Analyzer (VNA) measurement is a narrow-band or frequency-selective measurement. Only one frequency of interest is analyzed at a time. To do so, the receiver is configured to be sensitive to exactly the same frequency that is currently generated by the signal generator. All other frequencies or side-bands are neglected. In reality, there is always some finite side-band content that will be included in the measurement result. The RBW setting (Receiver Bandwidth or Resolution Bandwidth) defines the width of the narrow-band filter used to generate the result.
A high RBW value, will result in a fast measurement but more noise. The wider bandwidth results in more noise-energy included in the measurement and therefore in a higher noise-floor level. A low RBW value offers more noise-rejection but it will increase the measurement time.

The following picture shows the shape of the frequency-selective receiver filter for different RBW values:

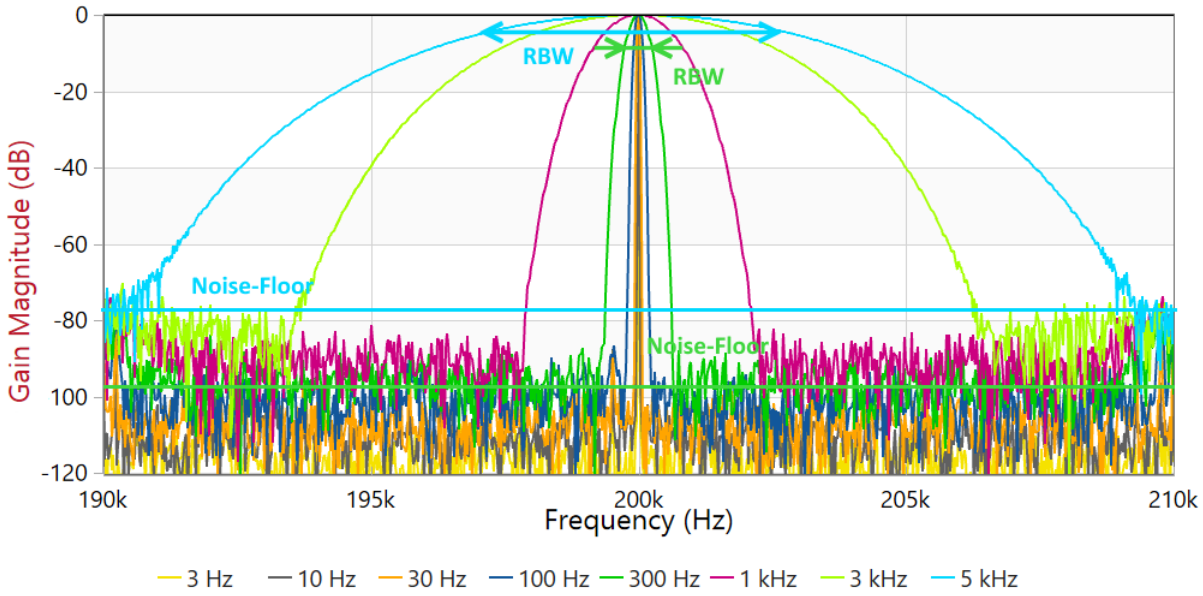


Figure 8-3: Graphical representation of the different RBW values.

The Receiver Bandwidth setting in the *Bode Analyzer Suite* is actually a **maximum RBW** setting. The system will automatically reduce the RBW value when it measures at a frequency below the max. RBW value. It is impossible to measure e.g. at 10 Hz using a receiver bandwidth setting greater than 10 Hz.

Use the 

setting to adjust the maximum RBW used during the measurement.

The measurement times for a single point depending on the RBW setting with 6 filter periods are shown below:

Receiver bandwidth	Theoretical single-point measurement time
1 Hz	2.8 s
3 Hz	940 ms
10 Hz	280 ms
30 Hz	95 ms
100 Hz	30 ms
300 Hz	10 ms
1 kHz	3.8 ms
3 kHz	2.1 ms
5 kHz	1.7 ms
10 kHz	1.3 ms
15 kHz	1.2 ms

When measuring only one single point, the real measurement time will be higher. Initialization and connection latency can significantly impact fast measurements.

Besides the RBW setting, the receiver attenuator plays an important role to improve the signal to noise ratio (SNR).

8.3 Choosing the receiver attenuator

The *Bode Analyzer Suite* allows to configure the receiver attenuator of the device by selecting it in the measurement configuration on the left hand side of the main window or in the hardware setup screen.

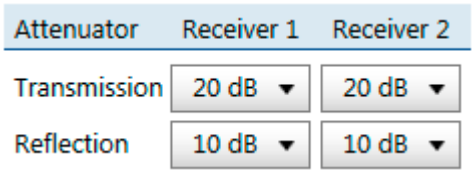


Figure 8-4: Choose the attenuator setting for Receiver 1 or Receiver 2 in the configuration area.

The receiver attenuator reduces the signal level that arrives at the receiver. This leads to a higher full-scale measurement range when using higher attenuator values. The following table shows the relation between attenuator value and full-scale input range:

Attenuator setting	***Bode 100* full-scale input measurement range**	***Bode 500* full-scale input measurement range**
0 dB	100 mVrms	1 Vrms
10 dB	316 mVrms	-
20 dB	1 Vrms	10 Vrms
30 dB	3.16 Vrms	-
40 dB	10 Vrms	-

Depending on the signal size/level that needs to be measured, the input attenuator must be chosen.

Try to use the lowest possible input attenuator that does not result in an **overload** warning. This will give you the best possible signal to noise ratio.

Receiver level indicator

The receiver level indicators in the status bar show the signal level arriving at the receiver. Best is a level close to the full-scale but no Overload.

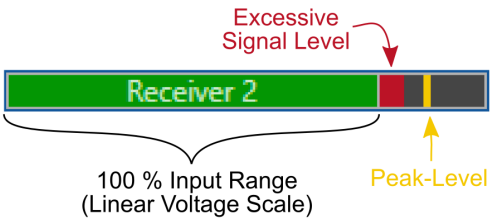


Figure 8-5: Receiver level indicator showing excessive signal causing an overload.

If an overload occurs, the measurement result will be wrong due to clipping in the receiver and the *Bode Analyzer Suite* will show a text warning in the chart as well as shaded areas where the overload did occur as shown in the image below:

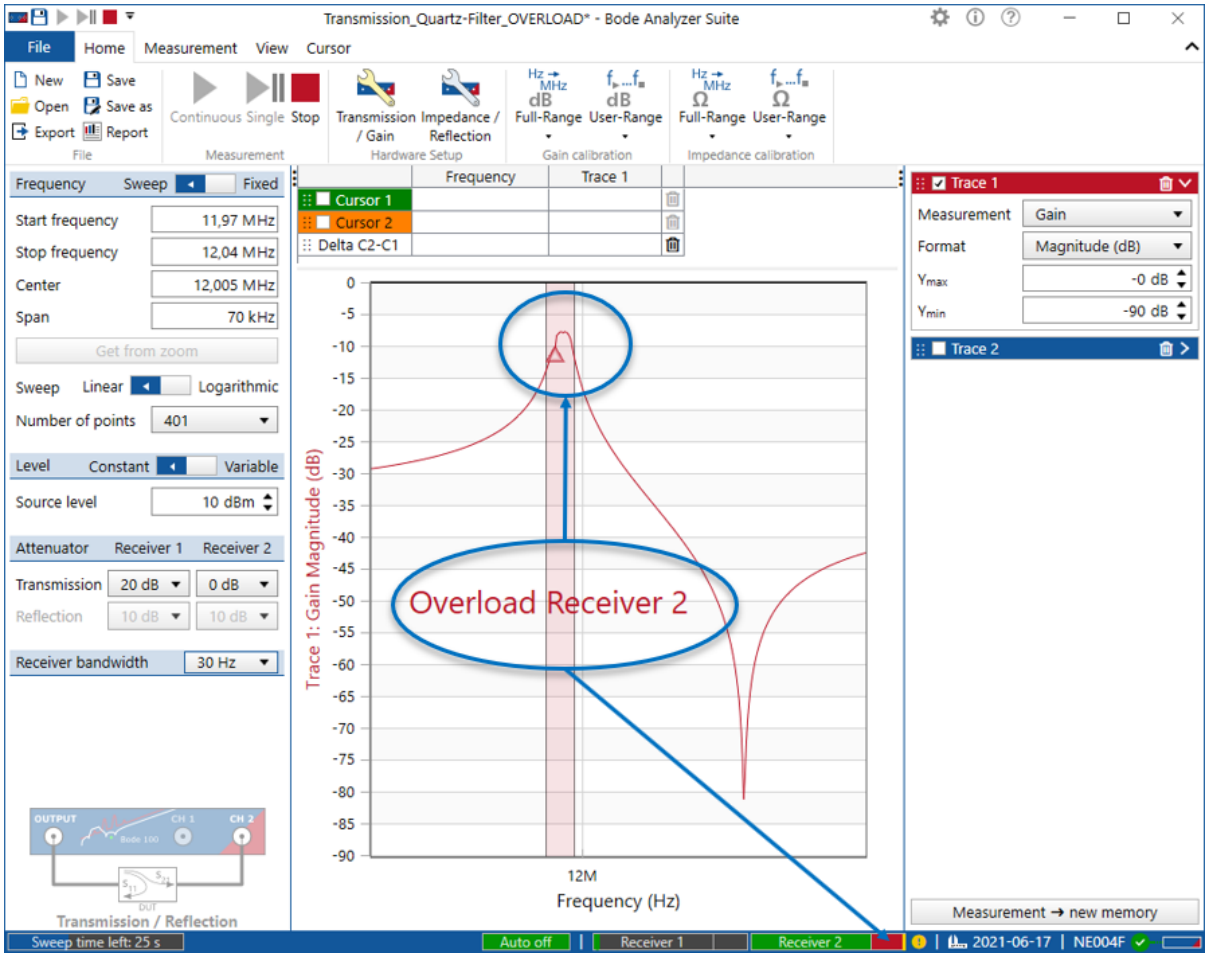


Figure 8-6: The overload at resonance is shown in the level bar in the status bar and as a text warning in the chart. The curve contains a shaded area that shows exactly at which frequencies the overload did occur.

8.4 Signal source settings

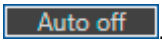
Signal source mode

The signal source of *Bode 100 or Bode 500* can be set to different operation modes:

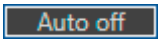
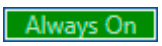
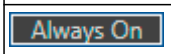
1. Auto off (default)
2. Always On

In **Auto off** mode, the source will be automatically turned off whenever it is not used, respectively when a measurement is stopped.

In **Always On** mode the signal source stays on after a measurement has finished. For example the last frequency point in a sweep measurement defines the signal source frequency and level.

You can change the source mode either in the hardware setup  or by moving the mouse over the source indicator in the status bar  .

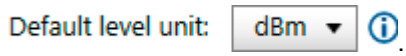
The source indicator shows both, the current setting and if the source is on or off. A gray background indicates that the source is switched off. A green background color indicates that the signal source is running. The following states are possible:

	Source mode is 'Auto off' and source is currently off
	Source mode is 'Auto off' and source is currently on
	Source mode is 'Always On' and source is on
	Source mode is 'Always On' but source is still in off-state. Source will be switched on as soon as the next measurement has been executed.

Output level unit

Bode 100 or Bode 500 use dBm as the default output level unit. 1 dBm equals 1 mW at 50 Ω load.

You can also choose Vrms or Vpp as output unit however, don't forget that the real output voltage of *Bode 100 or Bode 500* depends on the impedance connected to the output. The inner 50 Ω source impedance introduces a voltage drop that depends on the impedance connected at the output port.

The output level unit can be changed in the options. Click on  and select the default level unit of your choice:  .

You can choose Vrms which is the root mean square of the output voltage at 50 Ω load. Again the real output voltage depends on the load you connect to the output. The internal source voltage is 2 times higher than the displayed value. Choose Vpp to display the output voltage in peak-to-peak voltage. Again, the value is valid when a 50 Ω load connected to the output.

Changing the level unit only affects new files / measurements that are created after changing the unit. The level unit is part of the settings stored in the .bode3 file.

Output level range

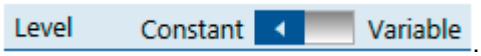
The signal source of the *Bode 100 or Bode 500* can be adjusted within its minimum and maximum signal level. The minimum and maximum values are shown in the table below:

Setting	Bode 100	Bode 500
Minimum source level (dBm)	-30 dBm	-50 dBm
Minimum source level (Vrms)	7 mVrms	0.7 mVrms
Maximum source level (dBm)	13 dBm	16 dBm
Maximum source level (Vrms)	1 Vrms	1.4 Vrms

The maximum signal level of *Bode 500* depends on frequency. At frequencies above 100 MHz the source level will be gradually reduced to 13 dBm at 300 MHz and further reduced to 7 dBm at 450 MHz.

Shaped level

The shaped level feature allows changing the output level over frequency.

To use the shaped level feature, click on the slider selector to switch between constant and variable level 

.

After switching to variable, the Output level text field changes its name to Reference level and the Shape level button appears: 

.

Click on the Shape level button to enter the shaped level dialog shown in the figure below:

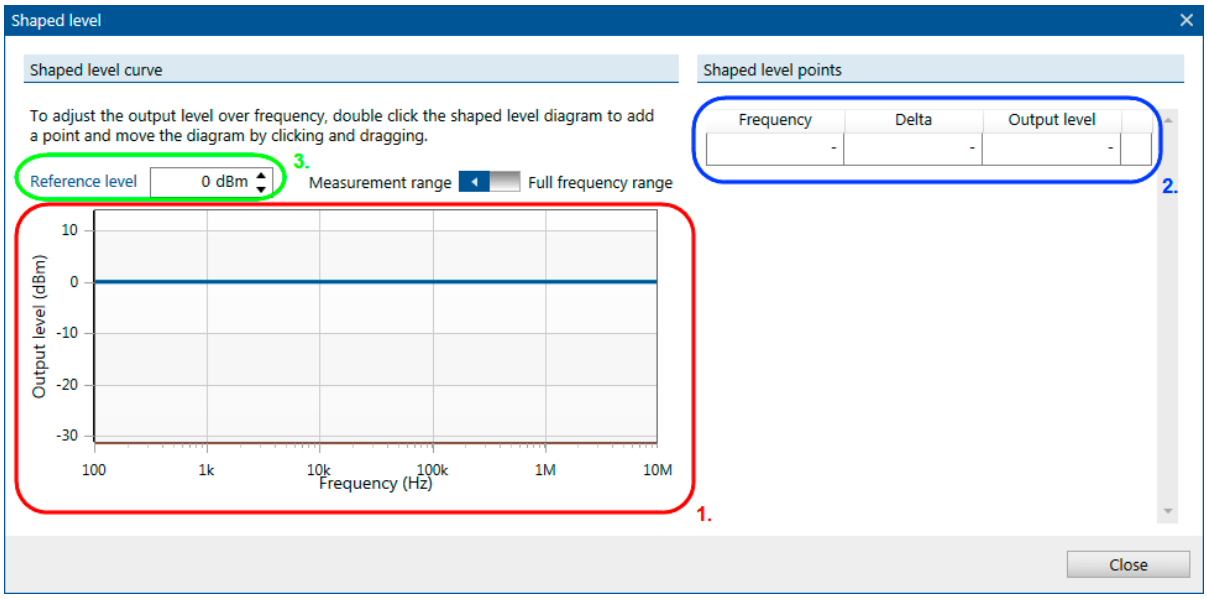


Figure 8-7: Shaped level dialog

In the shaped level dialog you can perform the following actions:

1. Interactive shaped level diagram
   Shows the shaped level curve. Use your mouse to enter new shaped level points by double-clicking or right-clicking into the diagram. Shaped level points can be moved by drag-and-drop in the diagram. The blue line in the diagram shows the reference level line which allows you to shift the entire shaped level curve up and down.
2. Shaped level points table
   The table contains all shaped level points. Points added via mouse click into the diagram will show up in the table. You can also use the table to enter new points manually.
3. Reference level
   The reference level allows you to shift the entire shaped level curve up and down by either entering a different reference level value or by moving the blue reference level line in the diagram.

The output level is calculated by the equation:
Output level = Reference level + Delta

When changing the reference level it might happen that the calculated Output level is higher than the maximum output level of *Bode 100 or Bode 500* or lower than the minimum output level. In such a case the level is automatically limited to the device limits.

This is indicated by an orange limit line and an orange cell color in the shaped level dialog as shown in the following figure:

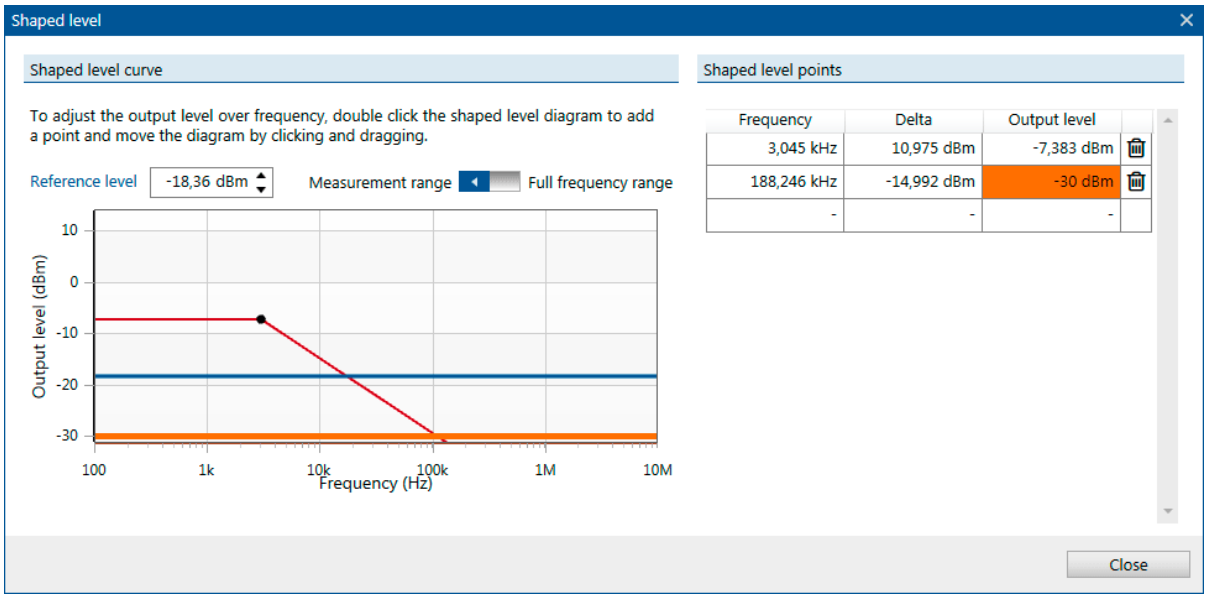


Figure 8-8: Output level limited to the minimum output level of the device

8.5 Using external probes & injection transformers

External probes

You can use external probes with *Bode 100 or Bode 500* that do not require a proprietary interface but offer a standard coaxial connector. The use of external probes can have the following advantages:

- Reduction of the capacitive loading added by connecting the input channels of *Bode 100 or Bode 500* to your circuit.
- Easier in-circuit probing possibilities when no coaxial connectors are available on the DUT.
- Being able to measure currents by using an active current probe or a wideband current monitor.
- Protection of *Bode 100 or Bode 500* from hazardous voltages if **isolating probes** are used.

When using a passive 10:1 voltage probe, the use of a 1 MΩ 10:1 probe is recommended. A 1 MΩ probe features the divider in the probe-tip which lowers the DC voltage as well when used with *Bode 100 or Bode 500*. A standard 10 MΩ oscilloscope probe will not divide the DC voltage when used with the AC-coupled inputs of *Bode 100 or Bode 500*. Furthermore, a 1 MΩ probe provides a lower impedance path that reduces channel to channel crosstalk and noise. OMICRON Lab recommends using the PML-111O passive probe from PMK for the use with *Bode 100 or Bode 500*.

WARNING

Death or severe injury due to hazardous voltage levels possible.

Connecting the ground of a probe or cable to a hazardous live potential will cause this potential to be present at touchable parts of the *Bode 100 or Bode 500* because all grounding is internally connected.

► Ensure that voltage and current probes used with the *Bode 100 or Bode 500* are properly grounded in accordance with their manufacturer's guidelines.

► When working with voltage or current probes, always connect the ground terminal of the *Bode 100 or Bode 500* to the ground terminal in the laboratory, using a solid connection of at least 3.6 mm² cross-section and not longer than 10 m.

NOTICE

Risk of permanent damage of the device.

The inputs of the *Bode 100 or Bode 500* are AC coupled with a maximum allowed DC voltage of 50 V DC. A standard 10:1 passive probe will not divide the DC voltage when connected to the *Bode 100 or Bode 500*.

► Use suitable probes when measuring at DC levels above 50 V.

► Do not use standard 10:1 oscilloscope probes with the *Bode 100 or Bode 500*.

Injection transformers

You can use injection transformers or isolators with *Bode 100 or Bode 500* for measurements in active circuits like control loops of power electronic systems. Make sure the isolation of the injector is safe to use for your application.

WARNING

Death or severe injury due to hazardous voltage levels possible.

If the isolation of the injection transformer fails, the DC potential of the equipment under test will be present at touchable parts of the *Bode 100 or Bode 500*.

- ► Only use injection transformers, isolated for the application's maximum working voltage and overvoltage.
- ► Always connect the ground terminal of the *Bode 100 or Bode 500* to the ground terminal in the laboaratory, using a solid connection of at least 3.6 mm² cross-section and not longer than 10 m.

Probe factor

If a probe has a different probe factor than 1:1, you can configure the probe factor in the Hardware tab of the Measurement setup dialog for each channel separately. For the following description the *Bode 100* is used as an example. To change the probe factor, click on the Setup icon in the home ribbon  and open the Hardware tab.

The following figure shows the Hardware view of the Measurement setup dialog for a Gain / Phase measurement of the a *Bode 100*. In this example two external probes (Probe 1 and Probe 2) can be configured.

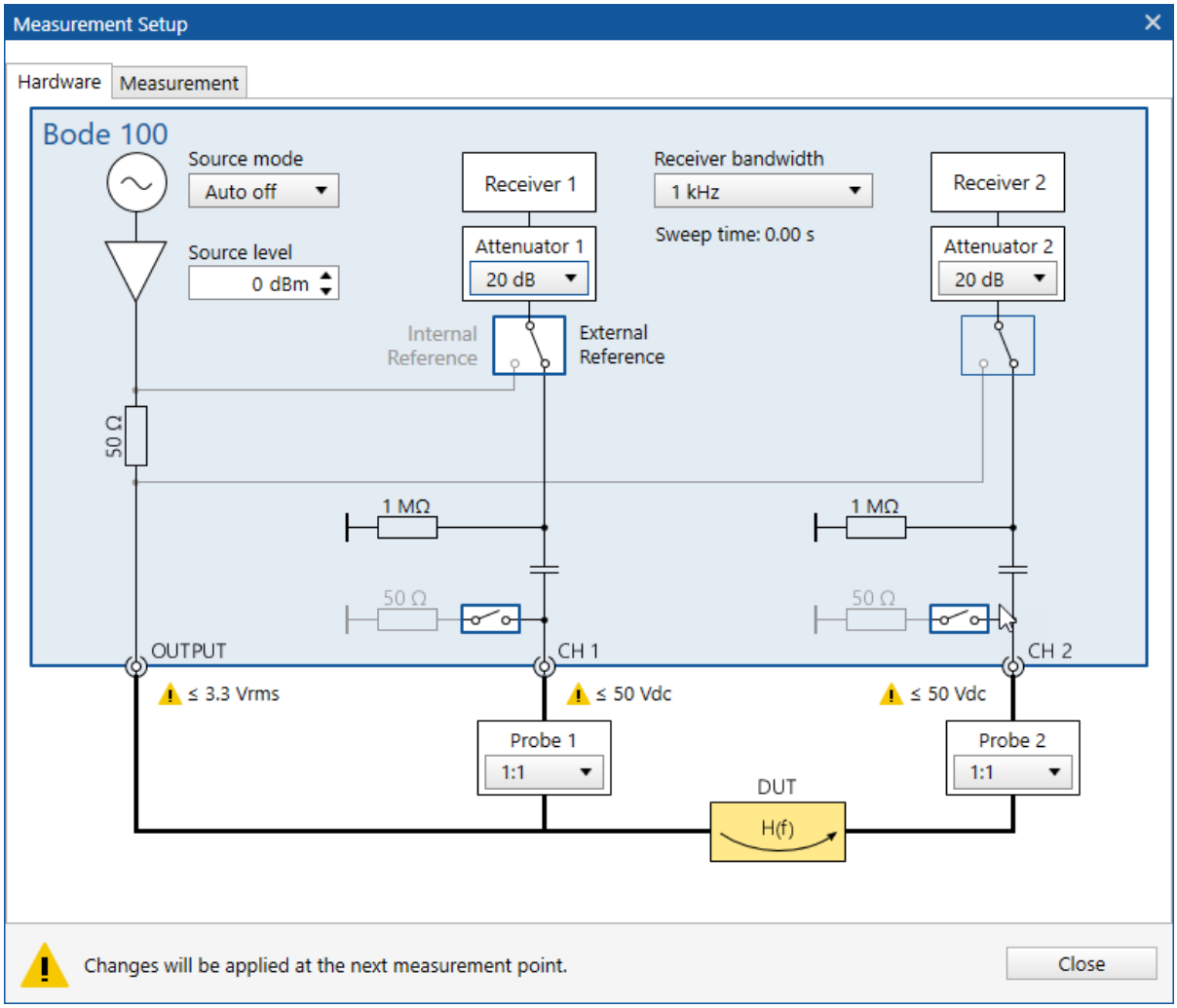
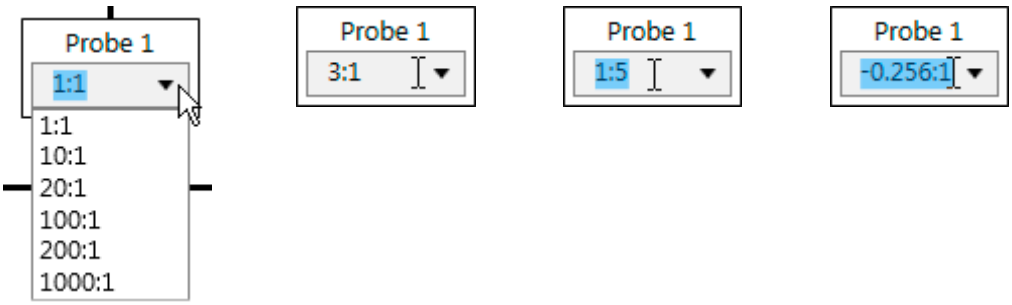


Figure 8-9: Probe configuration in the *Bode 100* Measurement setup dialog

To configure the probe factor, you can use the combo-box. Click on the arrow and select one of the pre-defined probe factors. Alternatively you can enter an **arbitrary** probe factor by marking the text and entering your probe ratio as shown in the examples below:



The probe factor is directly influencing the measurement result. However, as soon as you perform a User-Range calibration or a Full-Range calibration, the probe factor has no direct effect on the gain measurement result anymore. An external calibration compensates the gain and phase response of the probes and therefore overrides the probe factor setting.

9 Calibration / Correction

This section explains how to compensate unwanted effects of the measurement setup and how to improve the accuracy of your measurement results. *Bode 100 or Bode 500* offer the following possibilities to calibrate a test setup or the device itself:

Factory calibration / adjustment

Bode 100 or Bode 500 can be adjusted / re-calibrated at OMICRON. For details regarding this factory calibration, please contact the OMICRON Lab support or your local OMICRON Lab contact.

Internal device calibration

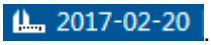
In addition to the external software calibration *Bode 100* features an internal device calibration that compensates the device-internal signal path drift by performing internal measurements.

External calibration / correction

External calibration can be used to compensate the frequency response of probes, cables or the test setup. Depending on the used measurement mode *Bode 100 or Bode 500* offer Gain calibration as well as Impedance calibration.

Hint: To achieve maximum accuracy, **do not change** the attenuators **after** having performed an external calibration.

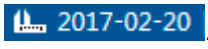
9.1 Internal device calibration

Internal device calibration is required by the system and is automatically performed at the first use of a *Bode 100* on a computer. *Bode 100* performs an internal path compensation based on stable reference elements in the device. The correction data is evaluated and stored on the PC for future measurements. In the *Bode Analyzer Suite* the date of the last internal device calibration is shown in the status bar 

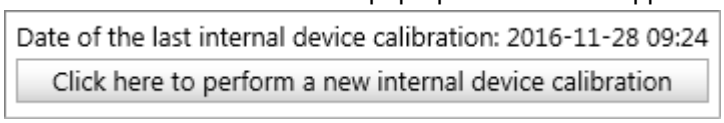
.
Bode 500 does not require an internal device calibration. All required correction values are stored on the device and have already been generated during calibration at the factory.

It is recommended to perform the internal device calibration on a regular basis to improve measurement accuracy especially when no external calibration is performed. Furthermore it is recommended to start a new internal device calibration whenever the environmental conditions, such as temperature, change.
Internal device calibration takes roughly 1 minute when executed. If no internal device calibration is available, the execution will be automatically triggered. This can lead to a time delay on the first use of *Bode 100* on a computer also in an automated setup.

Manually starting a new internal device calibration

To perform a new internal device calibration, move the mouse over the calibration indicator in the status bar 

. A pop-up with a button appears:



Press the button **Click here to perform a new internal device calibration** and the device will start a new internal calibration. The calibration takes roughly 1 minute. During the calibration you cannot perform any measurements with *Bode 100*.

9.2 Performing a Gain Calibration / Normalization

Gain calibration (also called Thru calibration or normalization) is used to remove the gain and phase error introduced by the connections between the measurement instrument and the DUT in a gain or transmission measurement.

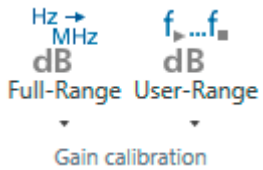
To achieve maximum accuracy, **do not change** the attenuators **after** having performed an external calibration.

Thru calibration can also be used in impedance measurements that are based on a gain measurement. These measurement modes are e.g. Shunt-Thru, Series-Thru or Voltage/ Current. When performing a Thru calibration in such a mode, the underlying gain measurement is calibrated and afterwards the calibrated gain result is transformed to impedance.

Performing the calibration

In order to calibrate a gain measurement, please proceed as follows:

1. Build up the calibration setup. For details on the calibration setup, please see 9.2.1 Calibrating a Transmission (S21) measurement on page 107 or 9.2.2 Calibrating a Gain/Phase measurement on page 108.
2. In the *Bode Analyzer Suite*, click on the Gain calibration icon (either User-Range or Full-Range). To learn more about the difference between User-Range and Full-Range calibration please check 9.3.6 Difference between Full-Range and User-Range calibration on page 122.



3. The calibration dialog opens and the calibration state shows **Not Performed**.

4. Ensure that the calibration setup is connected properly and press **Start**.

5. Wait until the calibration has completed and the calibration state shows **Performed**.

6. Close the calibration dialog.

7. The calibration icon now shows a green background fill.

   This means calibration is activated.

8. You can now connect your DUT and perform a calibrated measurement.

9.2.1 Calibrating a Transmission (S21) measurement

This section shows how to calibrate a Gain, Transmission or S21 measurement performed in the **Transmission / Reflection measurement mode**.

The Transmission / Reflection mode offers the possibility to measure Transmission and Reflection sequentially.
Note: The Gain or Thru calibration is only applied to the gain measurement. If you want to calibrate the Impedance, Reflection or Admittance measurement, refer to 9.3.1 Calibrating a Reflection or One-Port measurement (see page 113).

In the Transmission / Reflection measurement mode Channel 1 is not in use by default. Receiver 1 is connected internally to the signal source through the internal reference. The Channel 2 termination is set to 50 Ω, therefore by default the Gain result equals the transmission S-parameter S21 from the OUTPUT port to the CH2 port. If you choose to measure with the External reference connection, please refer to 9.2.2 Calibrating a Gain/Phase measurement on page 108.

The following picture shows a typical transmission calibration setup. The DUT is replaced by a Thru-connector.

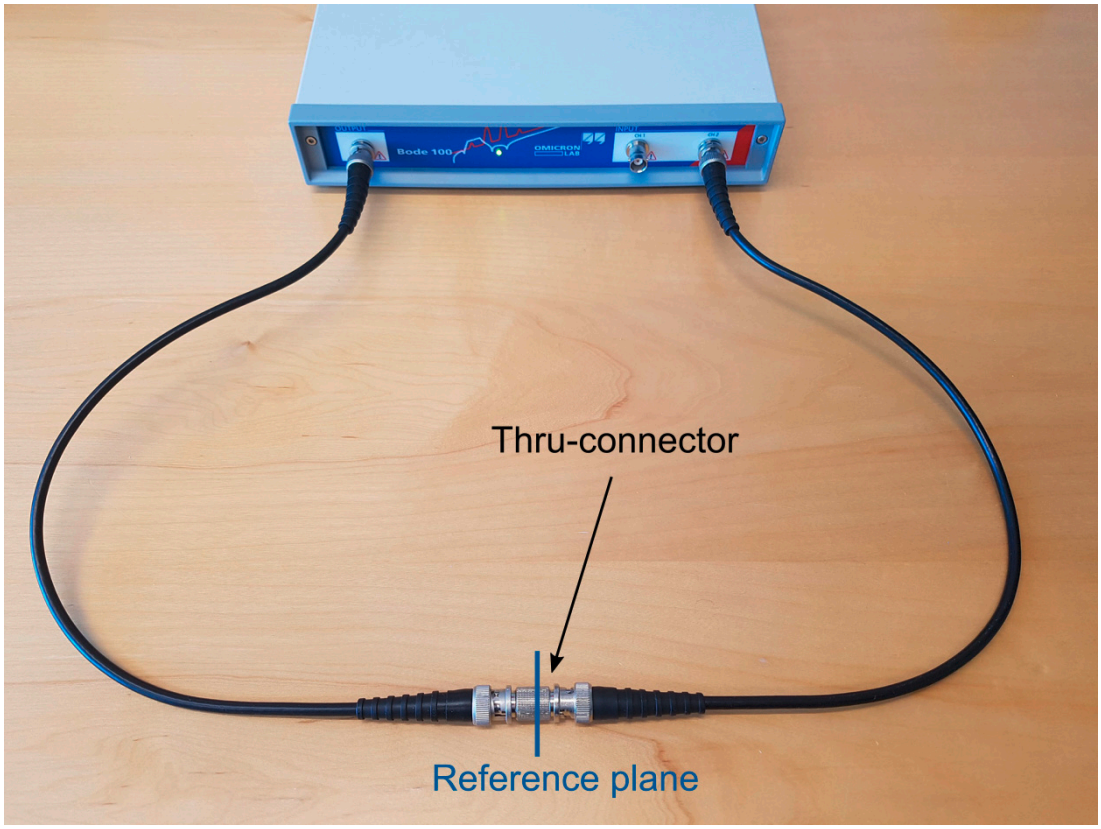


Figure 9-1: Gain, respectively Thru calibration setup in a transmission measurement and *Bode 100*.

The factory calibration of *Bode 100 or Bode 500* moves the reference plane exactly between two cables of 0.5 m length. So you can measure S21 using the delivered cables having a calibrated test-setup.

9.2.2 Calibrating a Gain/Phase measurement

In this section you learn how to calibrate a gain measurement in the **Gain/Phase measurement mode**.

The Gain/Phase measurement mode uses Channel 1 and Channel 2 of *Bode 100 or Bode 500* to measure the transfer function of a DUT. Channel 1 must be connected to the input of the DUT and Channel 2 to the output of the DUT. The transfer function of the DUT (complex gain) is then measured by dividing the voltage at Channel 2 by the voltage at Channel 1.
The cables or probes that connect Channel 1 and Channel 2 to the DUT introduce a gain and phase shift to the measurement signal.
The connection introduces a measurement error if the gain and phase shift of the two probes or cables is not identical.
A gain respectively Thru calibration removes the gain and phase error that is caused by non-similar probes or connections.

The following pictures show a typical gain calibration setup with BNC cables. Both channels are connected to the same signal.

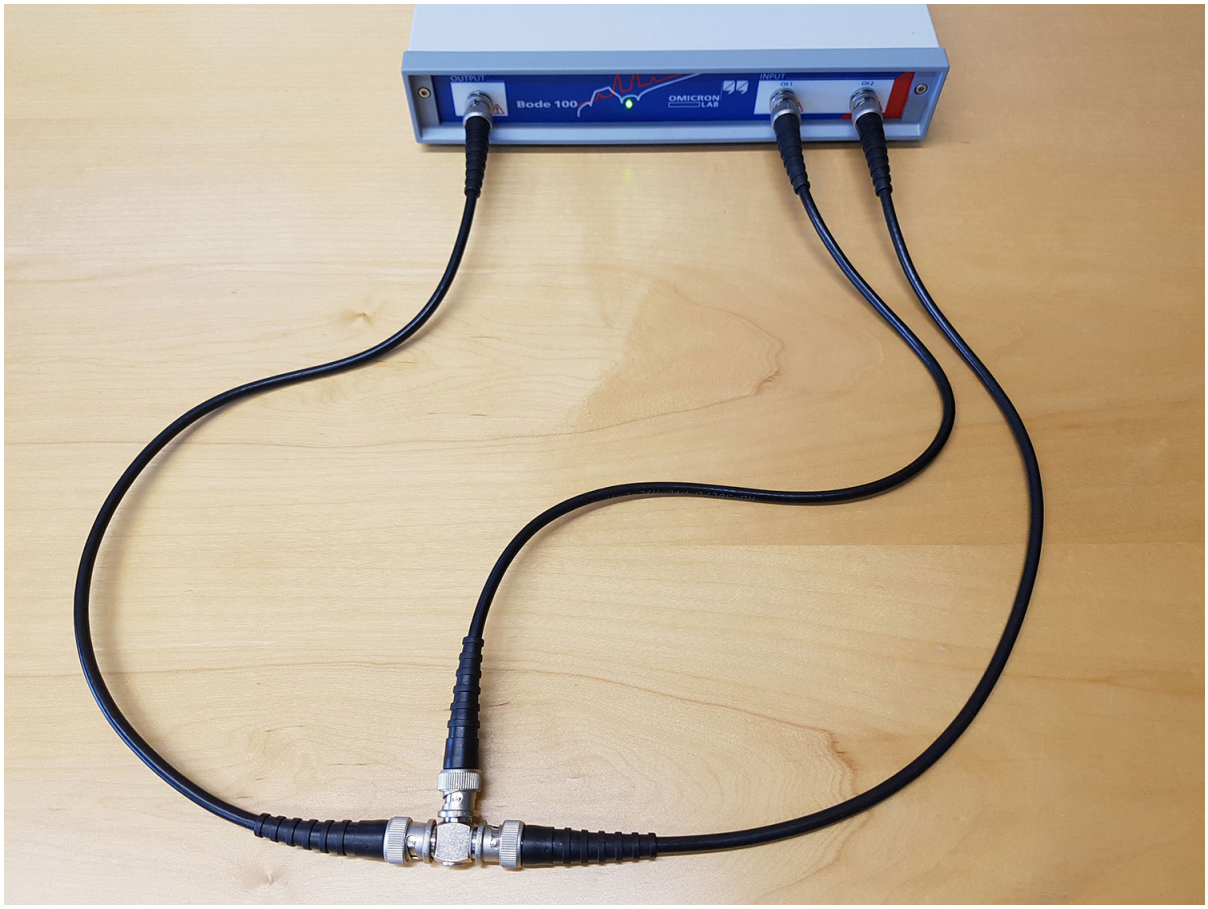


Figure 9-2: Thru calibration setup for gain/phase measurement with BNC cables and *Bode 100*.

The following picture shows a typical gain calibration setup using external voltage probes. Both probes must be connected to the same signal during Thru calibration.

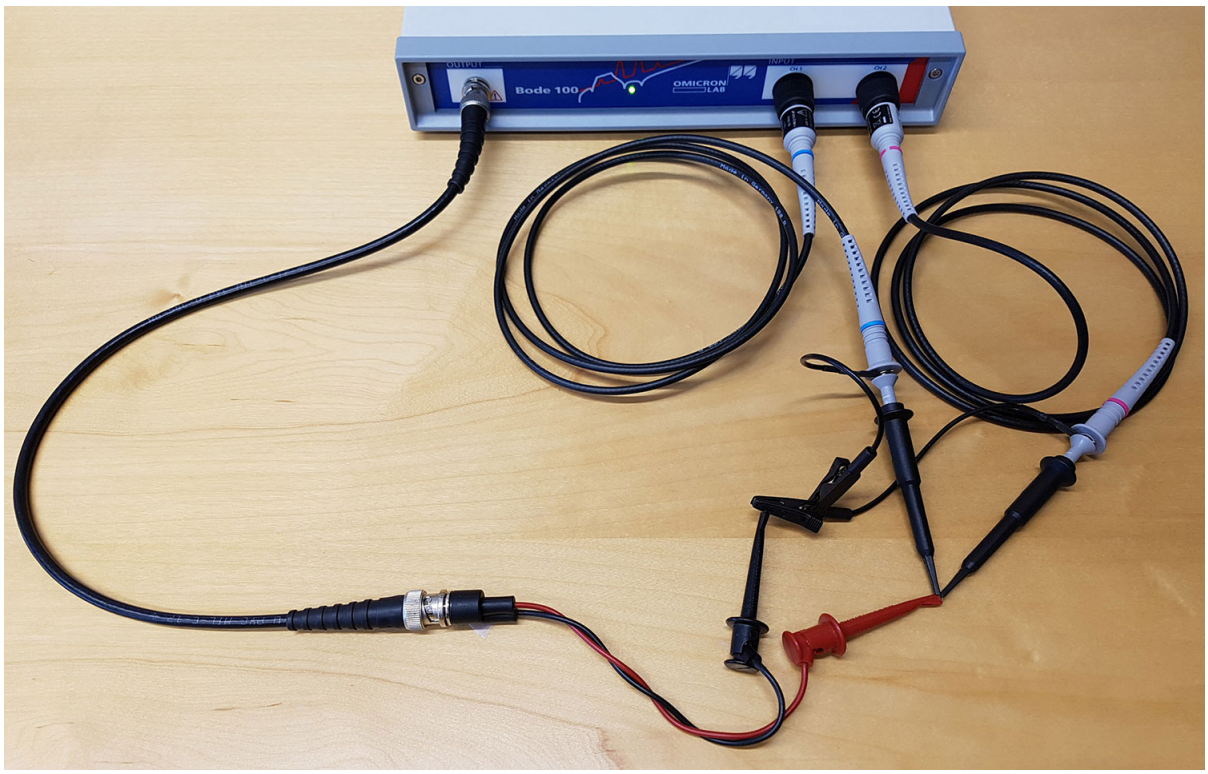


Figure 9-3: Typical Thru.calibration setup for gain/phase measurement using scope probes on *Bode 100*.

Hint: If you use external scope probes, you can also adjust the probes manually using the compensation screw at the probe tip. To do so, perform a continuous gain/phase sweep over the frequency range of interest and adjust the probe compensation until you receive a flat 0 dB and 0 ° line. Mark the probes with Channel 1 and Channel 2 such that you can re-use the similarly adjusted probes.

Hint: When measuring a transfer function directly in a circuit you can always check your calibration by connecting both probes to the same point in the circuit. The result must show 0 dB and 0 °. Please note that this measurement might be influenced by additional noise from the circuit.

9.3 Performing an Impedance Calibration

Impedance calibration (also called Open/Short/Load calibration or OSL calibration) can be used to compensate the parasitics of a measurement setup such as an external directional coupler or a measurement bridge. Furthermore it can be used to shift the reference plane of a one-port reflection measurement from the *Bode 100 or Bode 500* output port to the end of a cable of arbitrary length. This is achieved by measuring known Open, Short and Load elements.

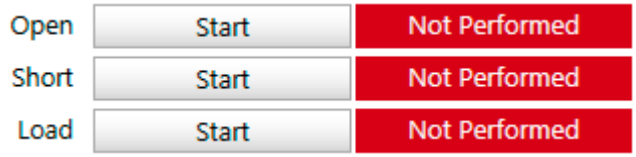
To achieve maximum accuracy, **do not change** the attenuators **after** having performed an external calibration.

Performing a Open/Short/Load calibration

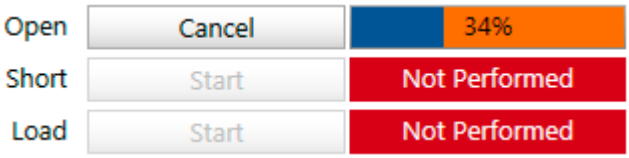
In order to perform an Open/Short/Load calibration please proceed as follows:

1. Build up the calibration setup. For details on the correct calibration setup, please check the following chapters.
2. In the *Bode Analyzer Suite*, click on an Impedance calibration icon (either User-Range or Full-Range). To learn more about the difference between Full-Range and User-Range calibration please see 9.3.6 Difference between Full-Range and User-Range calibration on page 122.

3. In the calibration dialog, the calibration state shows **Not Performed** for all three calibration points.



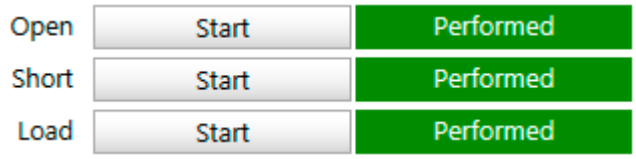
Connect the Open calibrator and press **Start**.



Wait until the Open calibration has completed and the calibration state shows **Performed**.

4. Connect the Short calibrator and press Start.
5. Connect the Load calibrator and press Start.

6. Close the calibration dialog after Open, Short and Load have been performed.

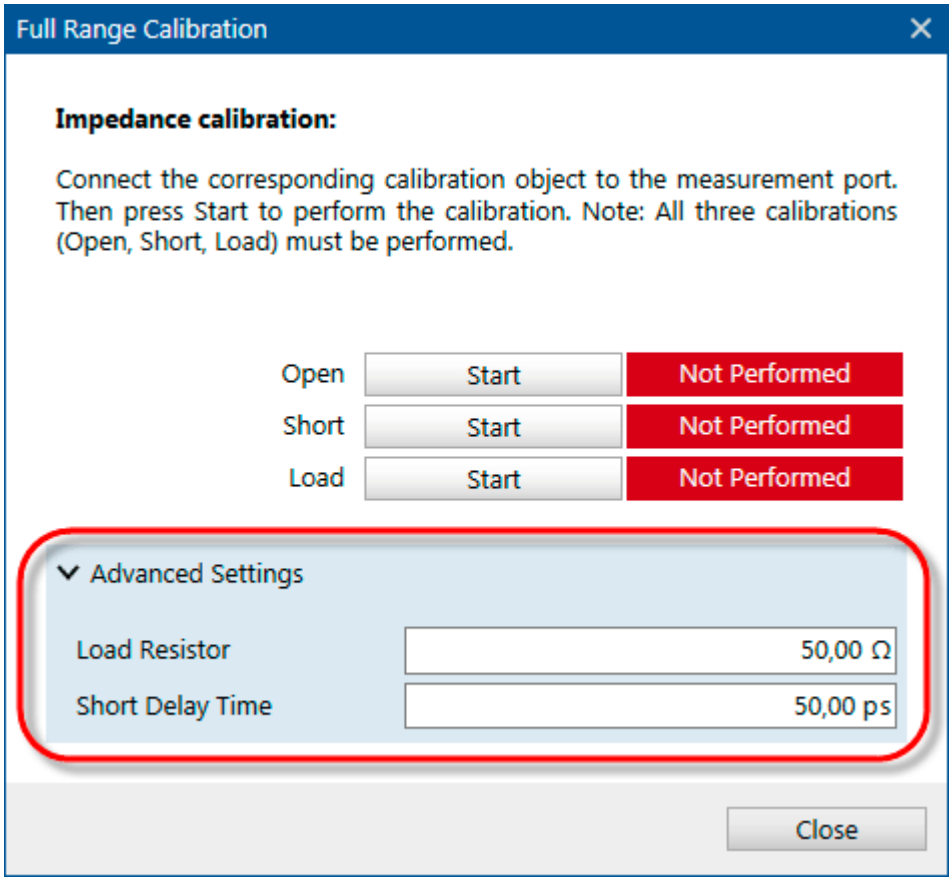


7. The calibration icon now shows a green background fill.

This means that the calibration is active now. You can connect your DUT and perform a calibrated measurement.

Advanced Settings in Open/Short/Load calibration

The calibration dialog offers an Advanced Settings region that can be unfolded by clicking on the arrow ›.



In the Advanced Settings region you can change the following values:

1. The Load Resistor value represents the value of the resistor used for Load calibration.
2. Short Delay Time is the time delay of the Short element used for Short calibration.

- The default settings for Load Resistor and Short Delay Time depend on the measurement mode and the used device.
- If you change a value from its default a warning sign will be shown

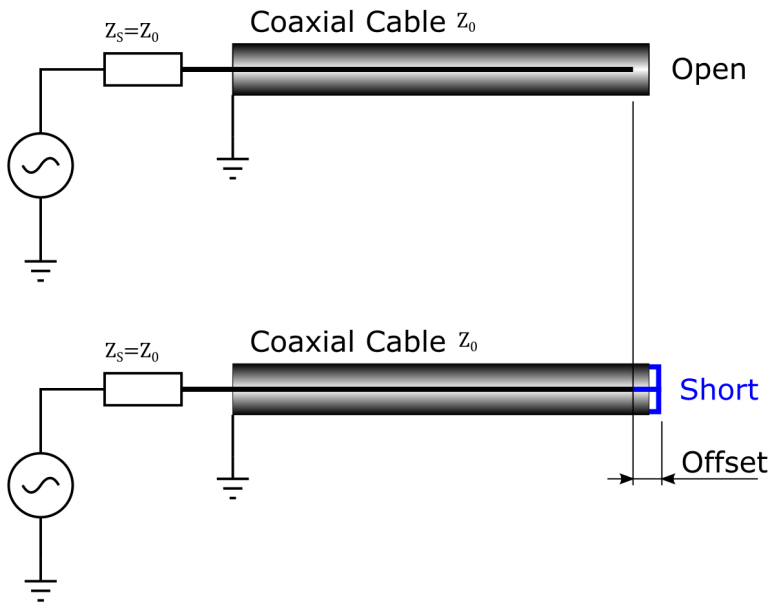
  > Advanced Settings ⚠

- Changing Load Resistor or Short Delay Time will delete the corresponding calibration!

Short Delay Time

The shorting cap used for Short calibration is not an ideal short but adds an additional time-delay to the signal. This time-delay adds an additional phase shift to the measured reflection coefficient at short

$$\Gamma_S = -e^{-j\omega T_s}$$



For small values of Ts, the short delay time can be translated into an equivalent inductance of

$$L \approx 25 \cdot T_s$$

Take care when measuring small inductance values in the nH range. The short-delay time or parasitic inductance of the short will have a strong impact on a low-inductance respectively a low impedance measurement.

9.3.1 Calibrating a Reflection or One-Port Impedance measurement

In this section you learn how to calibrate an Impedance, Reflection or Admittance measurement in the **Transmission / Reflection measurement mode** or in the **One-Port impedance measurement mode**.

The Transmission / Reflection mode offers the possibility to measure Transmission and Reflection sequentially. Please note that the Impedance (Open/Short/Load) calibration is only applied to a Impedance, Reflection or Admittance measurement. If you want to calibrate a Gain measurement please refer to 9.2.1 Calibrating a Transmission (S21) measurement (see page 107).

In the **Transmission / Reflection measurement mode** or in the **One-Port impedance measurement mode** both receivers are internally connected to the 50 Ω source resistance. *Bode 100, Bode 500* are internally calibrated such that the Impedance/Reflection is measured directly at the OUTPUT port of the device. The reference plane is directly at the OUTPUT port connector.

When connecting a DUT with a coaxial cable, the cable introduces additional impedance and time-delay. To compensate these effects, the reference plane can be moved to the end of the cable by performing an Open/Short/Load calibration at the end of the cable.

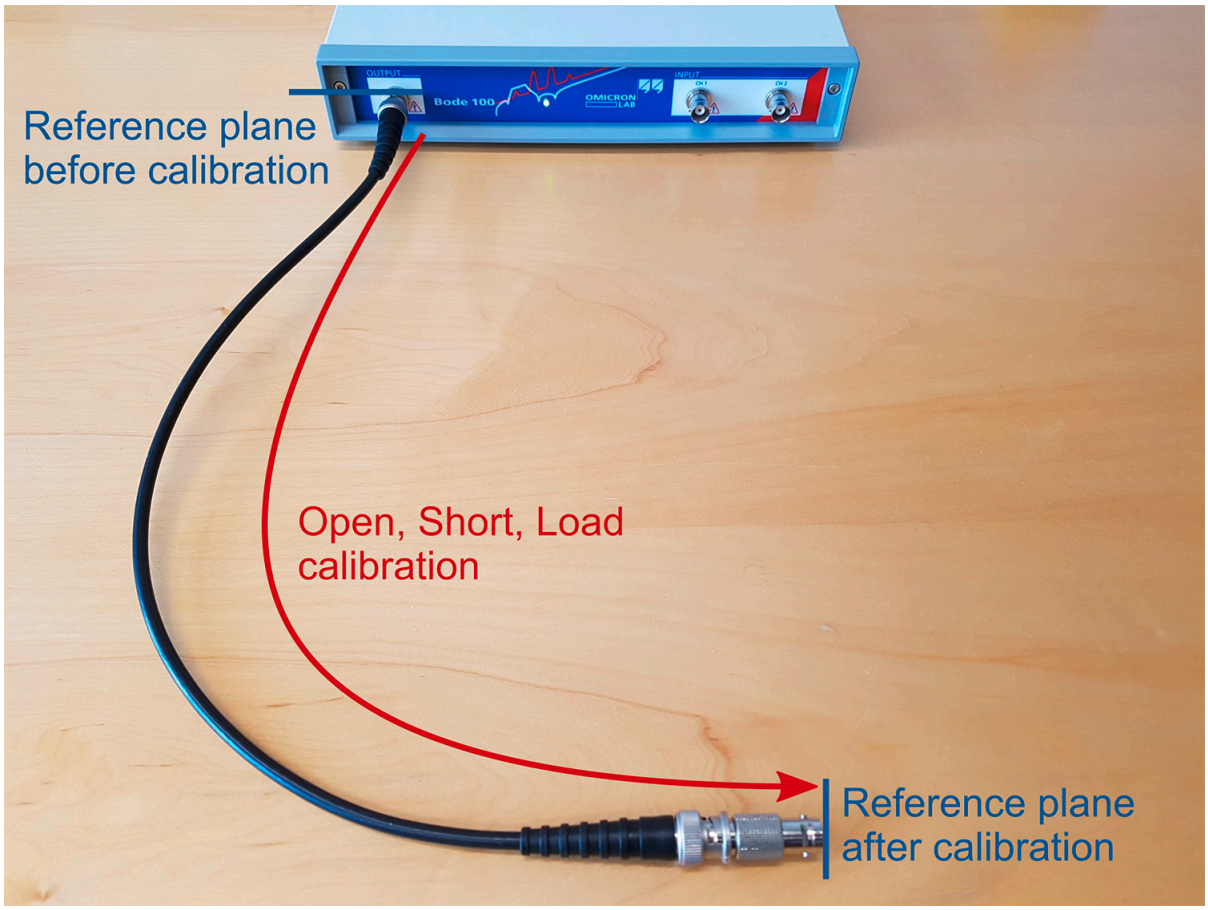


Figure 9-4: Shifting the reference plane by performing Open, Short and Load Calibration shown on *Bode 100*.

To do so, perform Open, Short and Load calibration.
An example using *Bode 100* with the standard BNC calibration elements are shown in the pictures below:

Connect Open and press **Start**.

Wait until the Open calibration has been performed.

Check if your Short element fits to the Short Delay Time Setting (50 ps default).

Connect Short and press **Start**.

Wait until the Short calibration has been performed.

Check if your Load element fits the Load Resistance Setting (50 Ω default).

Connect Load and press **Start**.

Wait until the Load calibration has been performed.

Hint: The load delivered with the Bode 100 is marked with its exact impedance. You can improve the calibration accuracy by entering this value in the Advanced Settings area.
The Short Delay Time in the Advanced Settings area has been chosen to match the Short elements delivered with *Bode 100 or Bode 500*. If your short is marked with *Rosenberger* you can set the Short Delay Time to 40 ps, if it is marked with *Radiall* to 60 ps.
The Short Delay Time for the N-type shorting cap delivered with *Bode 500* is 43 ps.

9.3.2 Calibrating an External Coupler or External Bridge measurement

In this section you learn how to calibrate an Impedance, Reflection or Admittance measurement in the **External Coupler measurement mode** or in the **External Bridge impedance measurement mode**.

In the **External Coupler measurement mode** and the **External Bridge impedance measurement mode** both receivers are connected to the input Channel 1 and Channel 2. Therefore all three ports of *Bode 100 or Bode 500* must be used in these measurement modes.
A directional coupler or a resistive measurement bridge is never ideal and therefore introduces errors caused by e.g. the frequency response of the coupler or bridge. By using Open, Short and Load calibration, a Reference plane at the output of the coupler or bridge can be established such that all frequency dependencies of the coupler or bridge are compensated. In the following example we show how to remove an external measurement bridge by performing Open, Short and Load calibration at the measurement port of the bridge. The same method can be applied to a directional coupler having forward and reflected ports.

The External Coupler measurement mode as well as the External Bridge measurement mode require an impedance calibration. You cannot start a measurement without having performed Open, Short and Load calibration.

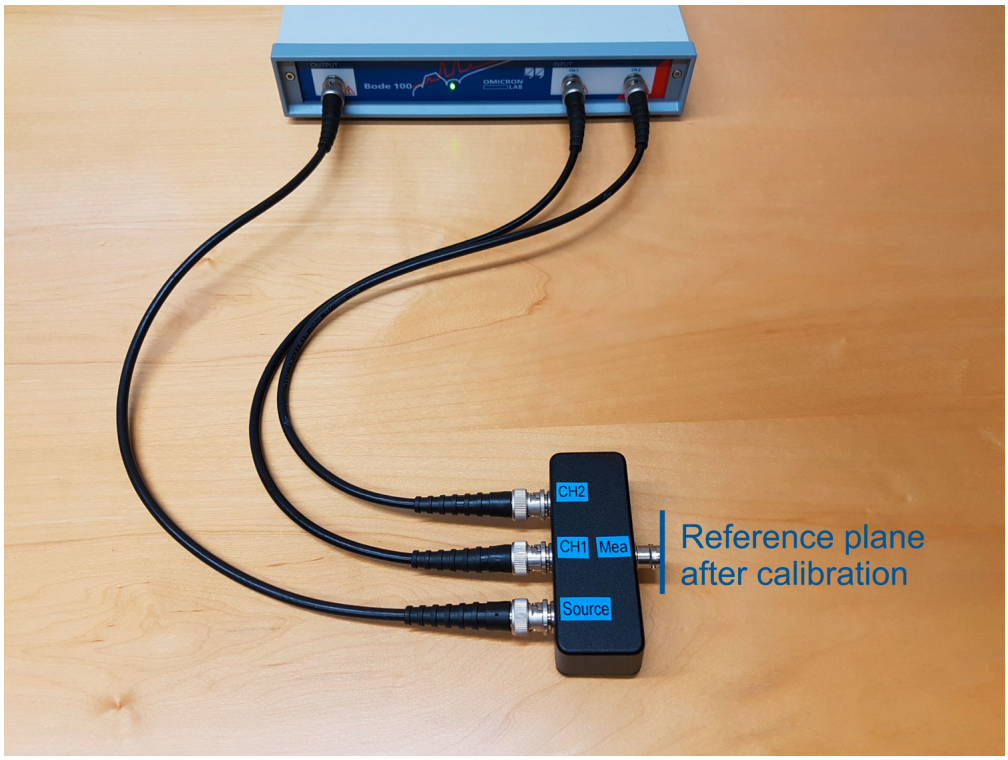


Figure 9-5: Removing a coupler / bridge by performing Open, Short and Load Calibration

Connect Open and press **Start** .

Wait until the Open calibration has been performed.

Open | Start | Performed

Check if your Short element fits to the Short Delay Time Setting (50 ps default).

Connect Short and press **Start**.

Wait until the Short calibration has been performed.

Short | Start | Performed

Check if your Load element fits the Load Resistance Setting (50 Ω default).

Connect Load and press **Start**.

Wait until the Load calibration has been performed.

Load | Start | Performed

9.3.3 Calibrating an Impedance Adapter measurement

In this section you learn how to calibrate an Impedance, Reflection or Admittance measurement in the **Impedance Adapter measurement mode**.

In the **Impedance Adapter measurement mode** both receivers are connected to the input Channel 1 and Channel 2 at the front panel of *Bode 100 or Bode 500*. Therefore all three ports of *Bode 100 or Bode 500* must be connected.

The Impedance Adapter measurement mode is designed for component impedance measurements performed with the *B-WIC* and *B-SMC* impedance test-fixtures from OMICRON Lab.
B-WIC and *B-SMC* contain a resistive measurement bridge, which is specifically optimized for *Bode 100*.

The Impedance Adapter measurement mode requires impedance calibration. You cannot start a measurement without having Open, Short and Load calibration performed.

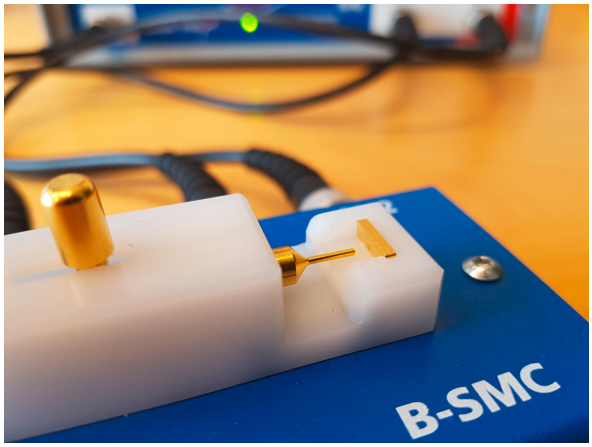
Figure 9-6: Calibrating the B-WIC impedance test fixture by performing Open, Short and Load Calibration

B-WIC and *B-SMC* are designed for the use with *Bode 100* up to 50 MHz. It is not recommended to measure at frequencies above 50 MHz using *B-WIC* and *B-SMC*. If you want to measure above 50 MHz, we recommend using *Bode 500* with coaxial connection or the *B-TCA*.

The following pictures show how to perform Open, Short and Load calibration steps for the *B-WIC* and *B-SMC* impedance test fixtures. Note that in the Impedance Adapter measurement mode the default value for Load Resistor is 100 Ω and the default value for Short Delay Time is 0 ps.

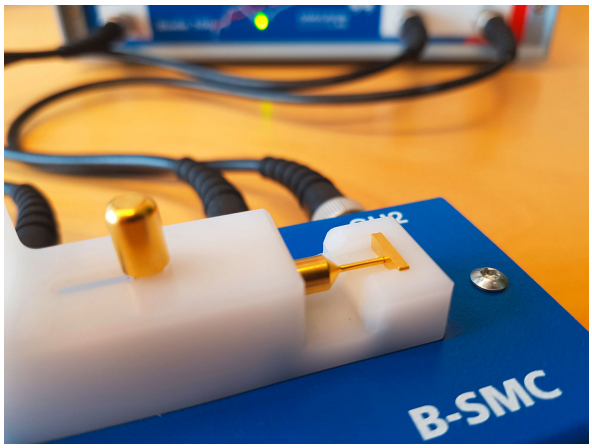
Open (B-WIC)

Open (B-SMC)

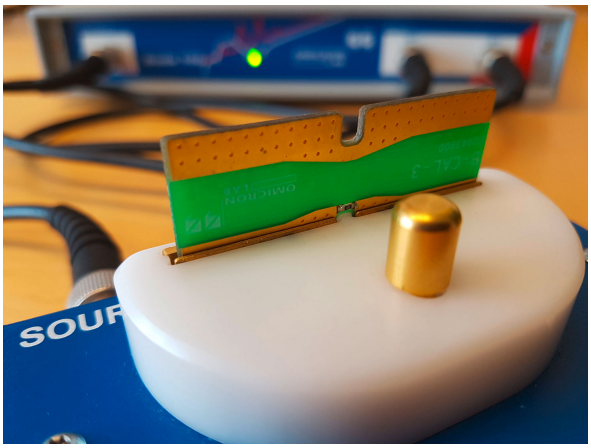


Short (B-WIC)

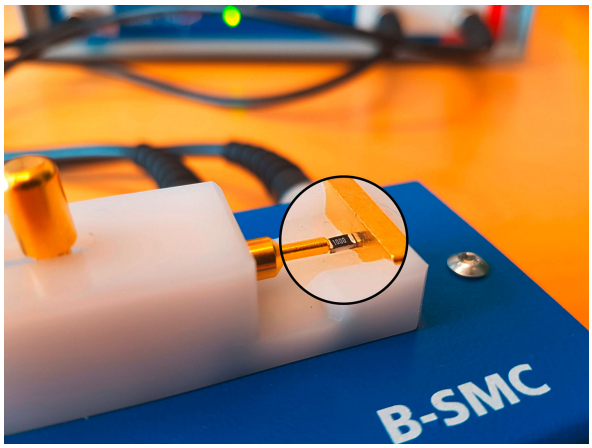
Short (B-SMC)



Load (B-WIC)



Load (B-SMC)

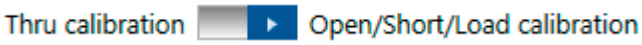


9.3.4 Calibrating a Shunt-Thru or Series-Thru measurement

In this section you learn how to calibrate an Impedance, Reflection or Admittance measurement in the **Shunt-Thru** or **Series-Thru measurement mode**.

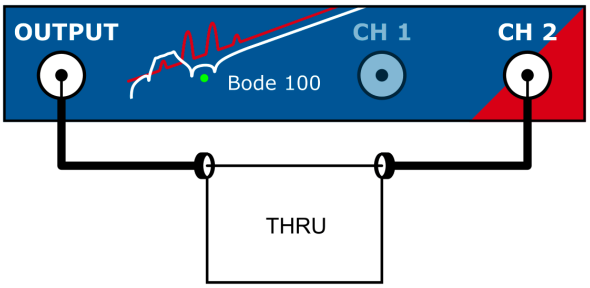
Shunt-Thru and Series-Thru are based on a S21 Transmission measurement. *Bode 100, Bode 500* measure S21 and the *Bode Analyzer Suite* calculates impedance from the S21 measurement. Details on the calculation can be found in 7.4.3 Shunt-Thru on page 82 and 7.4.5 Series-Thru on page 85. You can either calibrate the underlying S21 measurement using Thru calibration **or** you can use Open/Short/Load calibration to move the reference plane directly to the DUT.

Shunt-Thru and Series-Thru allow **both**, Thru **or** Open/Short/Load calibration.
However, only one calibration can be active at a time!
Even if both calibrations have been performed only one calibration is applied.
You must select the calibration you want to apply using the slider in the calibration dialog.
If the arrow points to the left, Thru calibration is applied.
If the arrow points to the right, Open/Short/Load calibration is applied (see example below).



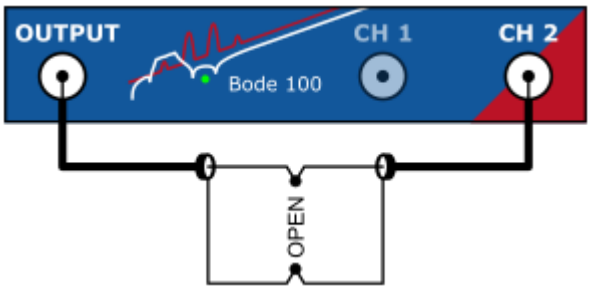
Shunt-Thru calibration connections

Calibrating Thru:

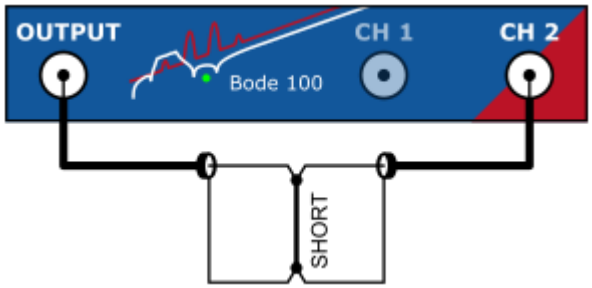


Thru calibration can e.g. remove the gain and phase error introduced by the connection cables including a coaxial common mode transformer that is generally used in this measurement to suppress the cable-braid error.

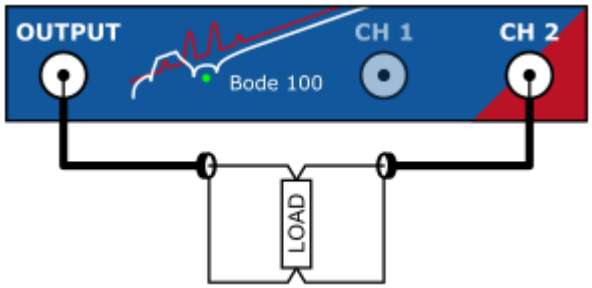
Calibrating Open/Short/Load:



Open calibration.



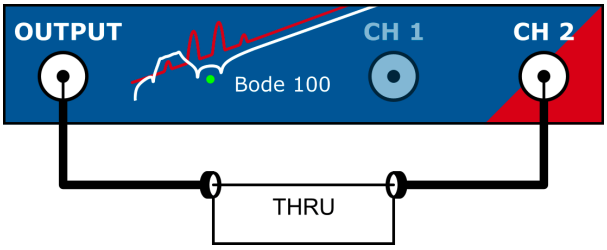
Short calibration.
Note that the inductance of the short connection is assumed to be zero. Short Delay Time is 0 s by default. This means that inductance of the short connection will be subtracted from the measurement result. This might be important to consider when you try measuring several nH of parasitic inductance.



Load calibration.
Default Load Resistor value is 50 Ω.

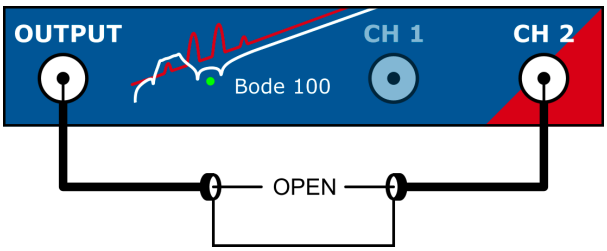
Series-Thru calibration connections

Calibrating Thru:

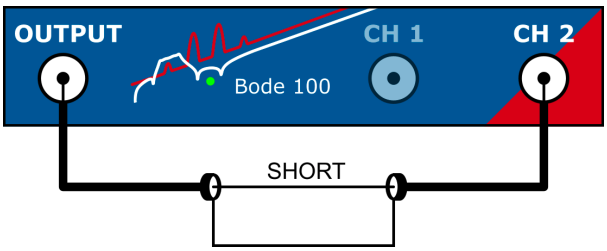


Thru calibration can e.g. remove the gain and phase error introduced by the connection cables.

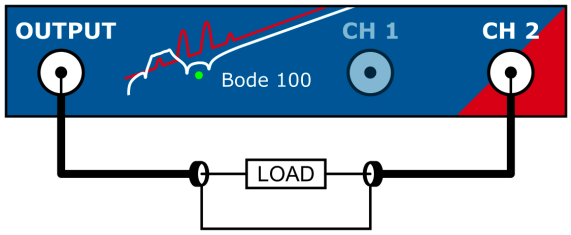
Calibrating Open/Short/Load:



Open calibration.
Note that the capacitance of the Open is assumed to be zero. If you try to measure very low capacitance, the parasitic capacitance of the Open can introduce an error. Try keeping it as small as possible.



Short calibration.
Note that the inductance of the short connection is assumed to be zero. Short Delay Time is 0 s by default.



Load calibration.
Default Load Resistor value is 50 Ω.

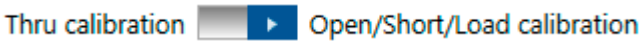
For more details and practical examples on how to perform calibration in the Shunt-Thru or Series-Thru measurement mode, please refer to the corresponding application notes on www.omicron-lab.com.

9.3.5 Calibrating a Voltage/Current measurement

In this section you learn how to calibrate an Impedance, Reflection or Admittance measurement in the **Voltage/Current measurement mode**.

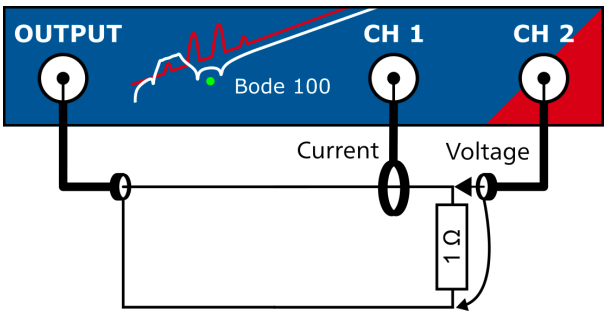
The Voltage/Current measurement mode is based on an Gain measurement. *Bode 100 or Bode 500* measures Gain from Channel 1 to Channel 2. Impedance equals Gain if Channel 1 receives a current signal and Channel 2 receives a voltage signal. The *Bode Analyzer Suite* allows to either calibrate the underlying Gain measurement using Thru calibration or to use Open/Short/Load compensation to move the reference plane directly to the DUT.

The Voltage/Current measurement allows **both**, Thru **or** Open/Short/Load calibration.
However, only one calibration can be active at a time!
Even if both calibrations have been performed only one calibration is applied.
You must select the calibration you want to apply using the slider in the calibration dialog.
If the arrow points to the left, Thru calibration is applied.
If the arrow points to the right, Open/Short/Load calibration is applied (see example below).



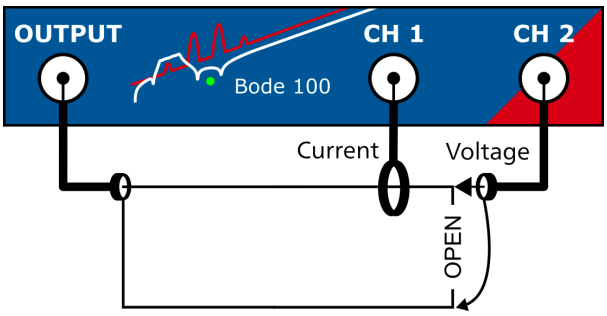
Voltage/Current calibration connections

Calibrating Thru:

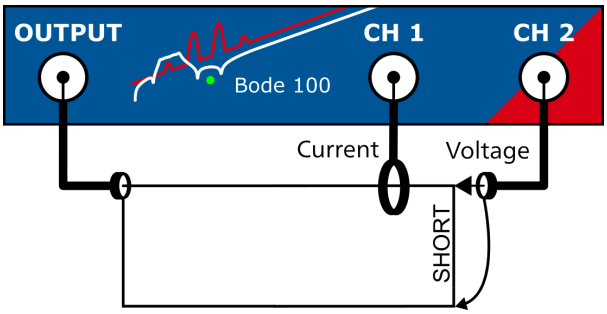


Use a 1 Ω resistor for Thru calibration. 1 Ω results in 1 V/A. Thru calibration can e.g. remove the gain and phase error introduced by the probes. However, it does not correct for systematic measurement errors in the measurement setup such as a voltage drop on the current probe or the current flowing through the voltage probe. These errors cannot be removed by one calibration measurement. In such a case you can use Open/Short/Load calibration to reduce these errors.

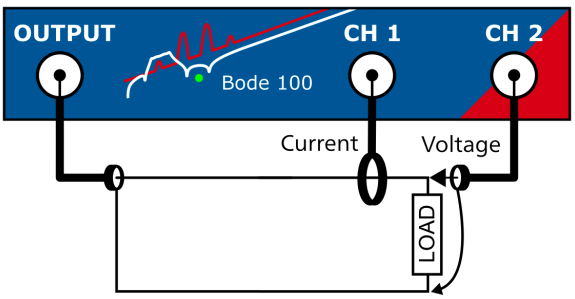
Calibrating Open/Short/Load:



Open calibration.



Short calibration.
Note that the inductance of the short connection is assumed to be zero. Short Delay Time is 0 s by default.



Load calibration.
Default Load Resistor value setting is 50 Ω.

For more details and practical examples on how to perform calibration in the Voltage/Current measurement mode, please refer to the corresponding application notes on www.omicron-lab.com.

9.3.6 Difference between Full-Range and User-Range calibration

Full-Range calibration and **User-Range** calibration differ only in the **frequencies** that are used to measure the correction factors.

Full-Range calibration measures the correction factors over the **"full" frequency range** of the instrument at factory-predefined frequencies.

User-Range calibration measures the correction factors at **exactly** the same **frequency** range and frequency points that are used in the **measurement** currently configured by the user.

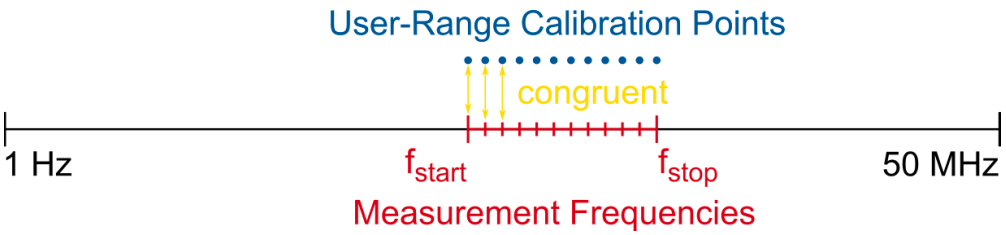


Figure 9-7: User-Range calibration; measurement frequencies and calibration frequencies are congruent.

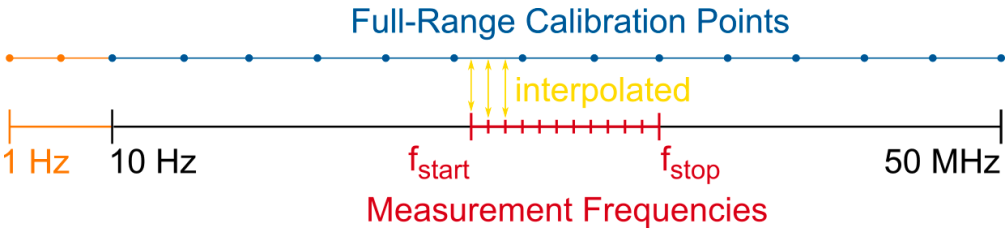


Figure 9-8: Full-Range calibration; correction factors are interpolated at measurement frequencies.

If Full-Range calibration is applied, the correction factors are available at the pre-defined frequencies only. Correction factors for the measurement frequencies are calculated by interpolating between the measured points.

Full-Range calibration on *Bode 100* is performed from 10 Hz to 50 MHz. Full-Range calibration on *Bode 500* is performed from 10 Hz to 450 MHz. If you need to calibrate below 10 Hz, check out 9.3.9 Full-Range calibration below 10 Hz on page 125.
In a single-frequency measurement the User-Range calibration will contain only one frequency.
In a frequency sweep measurement the User-Range calibration contains exactly the same amount of points as the sweep measurement.

Advantage of the Full-Range calibration

Full-Range calibration allows you to change the measurement frequencies without losing the calibration. Since the correction values are interpolated, they can be interpolated for all frequencies chosen in the measurement.

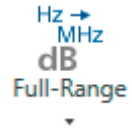
Advantage of the User-Range calibration

User-Range calibration does not use interpolation. The correction values are measured at exactly the same frequencies as used in the measurement. This results in highest accuracy especially when using long cables or narrow-band probes that show significant gain/phase shift in the measurement range.

User-Range calibration is deleted immediately when the measurement frequencies are changed!

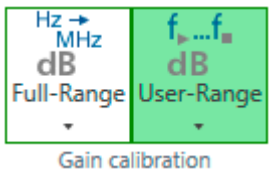
9.3.7 Enabling and disabling a calibration

After a calibration has been performed, the calibration is automatically activated by the *Bode Analyzer Suite*. Since a calibration can be manually enabled or disabled, the calibration icons indicate the current state of a calibration. In the following table the calibration states are explained based on the Gain calibration. The same rules apply to impedance calibration:

	Full-Range Gain calibration is **not performed** (not available) and **not active**. The icon has no background fill and no border.
	Full-Range Gain calibration has been performed and **is active**. The green border indicates that the calibration is available (has been performed). The green background fill indicates that the calibration is activated.
	Full-Range Gain calibration is **enabled** but **not active**. The green border indicates that the calibration is available (has been performed) and was enabled by the user. Since there is no background fill, the calibration is not active. This can happen if a User-Calibration overrules the Full-Range calibration. Both calibrations have been enabled but the software decides to use the User-Range calibration (see information below).
	Full-Range Gain calibration is **available** but **not enabled** and **not active**. The gray border indicates that the calibration is available (has been performed) but it is currently not enabled and therefore also not activated.

User-Range calibration and Full-Range calibration can be performed and activated at the same time. However, if a valid User-Range calibration has been performed, the *Bode Analyzer Suite* will automatically choose the User-Range calibration to be active.

Example:



Both, Full-Range and User-Range Gain calibration have been performed.
Therefore both calibration icons have a green border.
The software however chooses User-Range calibration to be active. This is indicated by the green fill of the User-Range icon. By clicking on the Full-Range calibration icon, the user could force the Full-Range calibration to be active.

9.3.8 Performing and repeating a calibration

A calibration can be performed by clicking on the corresponding calibration icon in the Home ribbon.

- Clicking on a calibration icon (e.g. Full-Range Gain calibration 

) opens the calibration dialog
- The calibration measurement can be started by clicking the start button 

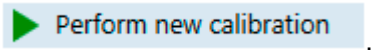
.
- After the calibration is 

the calibration dialog can be closed
- The calibration icon turns green indicating that the calibration is now active 

.

From now on, this calibration is used for the measurement.

A calibration can be disabled and enabled by clicking on its calibration icon.

To repeat a calibration, open the calibration dialog by clicking on the arrow on the bottom of the calibration icon 
. Then select 

. Calibration can then be repeated by pressing the *Start* button.

9.3.9 Full-Range calibration below 10 Hz

Full-Range calibration measures between 10 Hz and the maximum measurement frequency of your *Bode 100 or Bode 500* at factory pre-defined frequencies. Full-Range calibration normally starts at 10 Hz to reduce calibration time.

If you decide that frequencies between 1 Hz and 10 Hz must be included in the Full-Range calibration, you must set the *Start Frequency* to a value <10 Hz before executing the Full-Range calibration.

Alternatively, the User-Range calibration might be more applicable in that case.

Full-Range calibration frequency range:

- If Start Frequency is set ≥10 Hz, then Full-Range calibration will run from 10 Hz to 50 MHz or 450 MHz.
- If Start Frequency is set <10 Hz, then Full-Range calibration will run from 1 Hz to 50 MHz or 450 MHz.

If a Full-Range calibration has been performed at a *Start Frequency* >10 Hz and *Start Frequency* is changed to a value <10 Hz after calibration, the correction value at 10 Hz will be extrapolated to 1 Hz. This is indicated by an **orange** Full-Range calibration icon. Performing the calibration again by pressing the Start button in the calibration dialogue will run the calibration from 1 Hz and the icon will turn green again.
Note, that the calibration takes significantly longer when it starts at 1 Hz.

9.3.10 Automatic deletion of calibration

In order to avoid false measurements or an invalid calibration, the *Bode Analyzer Suite* automatically deletes calibration as soon as a setting makes the calibration invalid. The following lists show which settings will delete a calibration when they are changed.

Deleting User-Range calibration

User-Range calibration is automatically deleted when one of the following settings is changed:

- Measurement frequencies (Start Frequency, Stop Frequency, Center Frequency, Span)
- Sweep Mode (Linear or Logarithmic)
- Number of Points (in the frequency sweep)
- Channel termination (1 MΩ or 50 Ω)
- Reference / receiver connection (Internal or External)
- External probe factor

Deleting Full-Range calibration

Full-Range calibration is automatically deleted when one of the following settings is changed:

- Channel termination (1 MΩ or 50 Ω)
- Reference / receiver connection (Internal or External)
- External probe factor

9.3.11 Saving calibration data

User-Range and Full-Range calibration data is saved to the .bode3 file.
The calibration data (correction values) as well as the calibration states (activated or not) are stored to the file. When opening a bode-file the *Bode Analyzer Suite* attempts to load the external calibration data and calibration states from the file.

The *Bode Analyzer Suite* attempts to load the calibration from the bode-file even when the calibration has been performed with a different *Bode 100 or Bode 500* device.

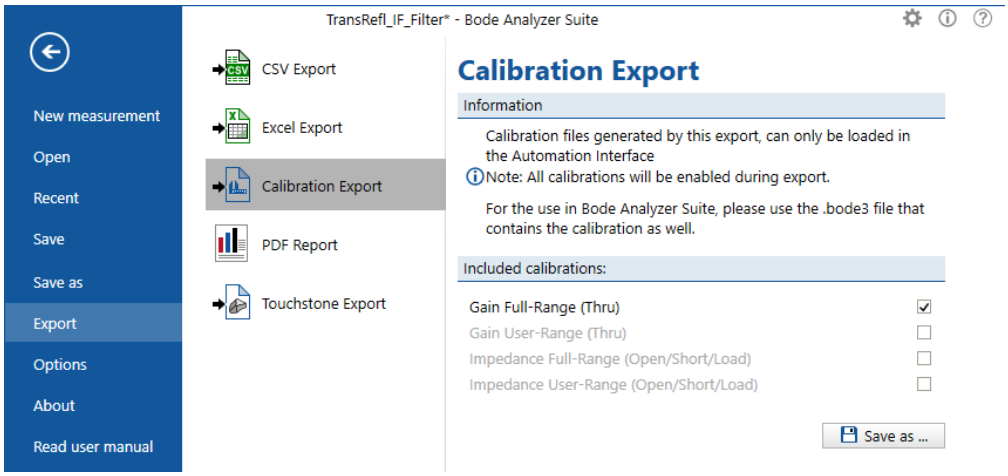
Hardware incompatibilities between *Bode 100* R1 and *Bode 100* R2

- Full-Range calibration from *Bode 100 R1* is not compatible to Full-Range calibration of *Bode 100 R2*. Full-Range calibration will be deleted automatically when opening a bode-file created with a different hardware revision.
- User-Range calibration is not compatible in the frequency range from 3 kHz to 30 kHz. A User-Range calibration that contains frequencies in that range will be deleted automatically when opening a bode-file created with a different hardware revision.

9.3.12 Exporting calibration data

User-Range and Full-Range calibration data can be exported to a .mcalx file for the use in the Automation Interface.

To do so, click on the export icon Export in the **File** ribbon File. This will open the export pane where you can select the calibration export Calibration Export. The following picture shows the export settings:



In the calibration export pane, you can select any available calibration to be exported. A .mcalx file can contain more than one calibration. When loading in the Automation Interface, any usable calibration will be loaded and activated if possible. Please make sure that the device settings in the *Automation Interface* match the settings in the *Bode Analyzer Suite*.

The .mcalx file can be loaded **only** via the Automation Interface or via SCPI commands (see: 11 Automating measurements on page 183 !
To save a calibration for use in the *Bode Analyzer Suite*, please simply save the measurement file (.bode3) that contains the calibration as well.

10 Bode Analyzer Suite software features

The following chapters contain information about important features of the *Bode Analyzer Suite*. Read through these chapters to learn how to use *Bode 100 or Bode 500* efficiently.

10.1 Exporting and saving measurement data or settings

The *Bode Analyzer Suite* supports a variety of possibilities to save measurement configurations and measurement data. In the following these are explained in detail.

10.1.1 Loading and saving the equipment configuration

You can store all settings of *Bode 100 or Bode 500* including the device configuration, measurement settings, calibration and measurement data and the graphical display settings by clicking the Save toolbar button.

This functionality allows you to store multiple equipment configurations for repetitive measurement tasks. With the equipment configurations stored, you can load the respective files for each measurement instead of setting the *Bode 100 or Bode 500* manually.

A file saved by the *Bode Analyzer Suite* version 3.00 or higher has the file extension **.bode3**.

A **.bode3** measurement file generated with a given device type (*Bode 100*, *Bode 500*) can only be opened and used with a device of the same type. This means, a **.bode3** file generated with a *Bode 100* cannot be opened with a *Bode 500* and vice versa but you can always open any **.bode3** without a connected device to review and export measured data.

The *Bode Analyzer Suite* version 3.00 or higher supports loading files with the following file extensions:

- **.bode3** files created with *Bode Analyzer Suite* 3
- **.bodex** files created with *Bode Analyzer Suite* 2.42 or 2.43
- **.bodz** files created with *Bode Analyzer Suite* 2.41
- **.bode** files created with *Bode Analyzer Suite* 2.41 or older

You can save and load .bode3 files on different *Bode 100* devices. Note, however, that calibration data might be deleted when opening the .bode3 file with a different hardware revision (R1, R2) of *Bode 100*. More details can be found in Hardware incompatibilities between Bode 100 R1 and Bode 100 R2 on page 127.

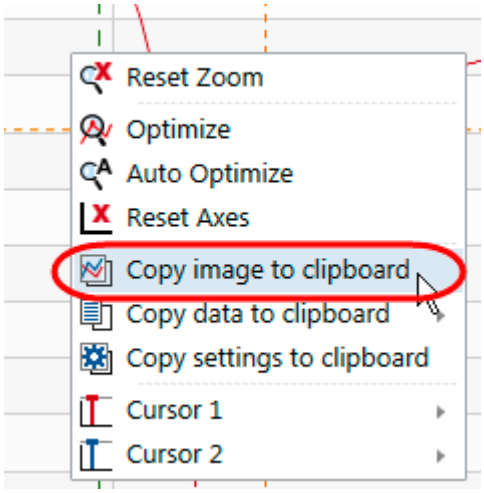
10.1.2 Use the clipboard functions to export data

The *Bode Analyzer Suite* offers several possibilities to quickly export data via the clipboard. The following information can be copied to the clipboard to ease your documentation work:

- An image file of the result diagram
- The measured trace data
- The equipment settings in form of text

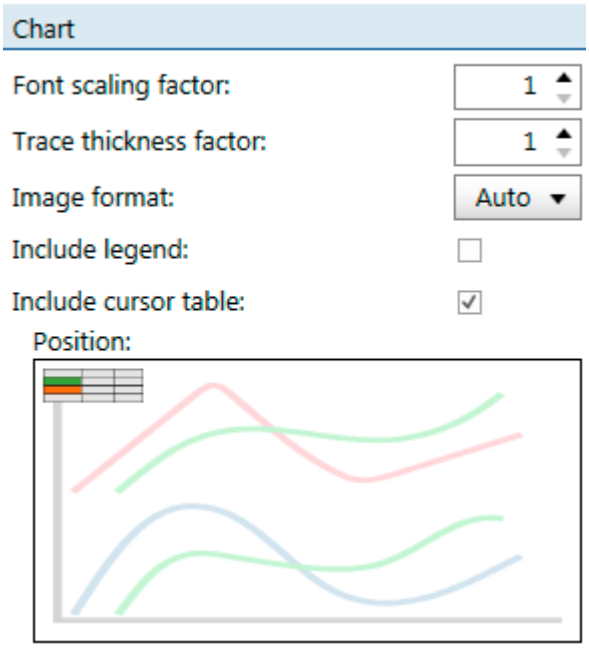
Copy a chart image to the clipboard

Right-click the chart or diagram you want to copy and select Copy image to clipboard.



This will place an image file of the clicked diagram to the Microsoft Windows clipboard that can be pasted to e.g. Microsoft Word. All frequency sweep charts, fixed frequency charts and the shaped level chart can be copied as an image to the clipboard.

You can configure how the chart image looks like by using the Options → Clipboard.



Font scaling factor: Use this number to increase the font size of axis labels in the copied diagram.

Trace thickness factor: Use this number to increase the weight of the trace line in the copied diagram.

Image format: *Bode Analyzer Suite* will use the vector graphics format EMF for the diagram image if possible. In case you experience issues with the EMF files, you can also change the image format to PNG.

Include legend: Activate the checkbox to include a legend. This is an advantage when multiple traces are present in the diagram.

Include cursor table: Activate the checkbox to include the cursor table in the copied image. In addition you can specify the position of the cursor table in the interactive picture below the checkbox.

Copy trace data to the clipboard

Right-click either in the chart or directly on the trace name to copy the measured data to the clipboard. Copy data to clipboard Copied data can directly be pasted in a spreadsheet program for further data processing or can be pasted as a memory trace into another instance / measurement of *Bode Analyzer Suite*.

To move data from one measurement file to another, you can also use drag & drop by grabbing a memory or measurement trace at the dotted area in the trace header.

You can configure the decimal separator and the field separator under Options → Clipboard.

Copy settings to the clipboard

Right-click in the chart and select Copy settings to clipboard. This will copy a text block to the clipboard that contains the current equipment settings. The text block is similar to the settings header included in the CSV or Excel file export.

10.1.3 Use the clipboard to import data

You can use the clipboard to import data into a measurement file. There are two possible sources for the data:

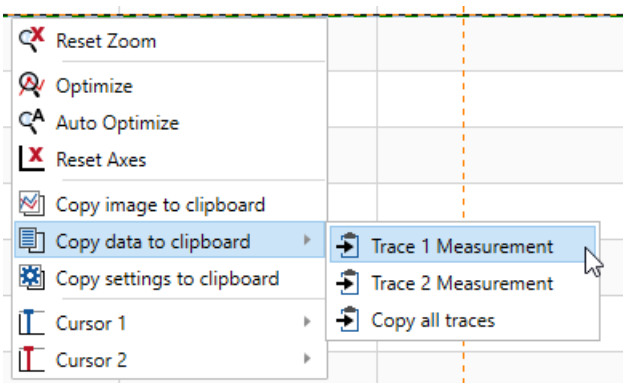
1. A measurement trace or memory trace from another .bode3 file / Bode Analyzer Suite.
2. User-specific data from a spreadsheet program.

In any case, the data will be imported as a memory trace inside the *Bode Analyzer Suite*.

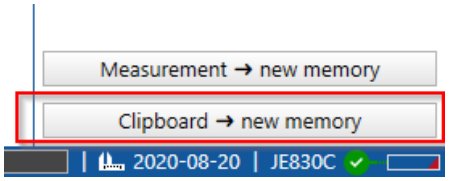
Paste trace data from another .bode3 file / Bode Analyzer Suite

Before you can paste data from another .bode3 file, you must copy the data into the clipboard. Right-click the trace you want to copy, use Copy data to clipboard and select the corresponding trace.

You can only paste single traces. If you use "Copy all traces" you cannot paste the data into another file.



After you have copied the trace data to the clipboard, the *Bode Analyzer Suite* will show a "Clipboard → new memory" button on the right-hand lower corner:



Click the button to paste the trace data into any .bode3 file.

Bode Analyzer Suite does not check for data validity. You can mix Gain and Impedance data. Please make sure to copy and paste the right data. If your measurement has Gain and Impedance data, *Bode Analyzer Suite* will show a selection possibility which data to paste.

Paste / import data from a spreadsheet program

You can also import data from i.e. a spreadsheet program as a memory trace into the *Bode Analyzer Suite*. To do so, you must copy data into the clipboard that can be interpreted as trace data. Please consider the following rules:

- The first column is always interpreted as the frequency in Hz.
- The first line (header) will be skipped if it does not contain numerical data.
- The second column is interpreted as the real part of the complex number.
- The third column is interpreted as the imaginary part of the complex number.
- The complex number is always interpreted as either a Gain value or as an Impedance value.
- Use the same field separator and decimal separator as configured in the options! You can find them under Options → Clipboard.

The following table shows an example of data that can be imported if the decimal separator is chosen to be the dot and the field separator the tab.

Frequency	Real	Imaginary
1001.56	50.6	1e-6
10005.98	60.9999	100.89E-8
100700	0.777E02	0.00000125

You can also use five columns, then the interpretation follows the order Frequency, Gain, Impedance:

Frequency	Gain		Impedance	
	Real	Imaginary	Real	Imaginary
data	data	data	data	data

There might be a situation where the amount of data in the clipboard does not fit the amount of available measurements in a .bode3 file. In such a case, *Bode Analyzer Suite* will show a selection possibility where you can choose to select Gain or Impedance data or choose to paste data as Gain or Impedance.

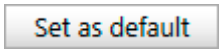
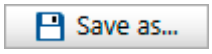
10.1.4 Exporting measurement data to CSV or Excel files

If you need to further process the measurement data the *Bode Analyzer Suite* offers to save the measurement data either as a CSV file or in form of an Microsoft Excel compatible spreadsheet file. To save your measurement data as a .csv or .xlsx file, click on the Export Icon in the Home ribbon 

.

Exporting a CSV file

In the CSV export pane you can choose the following options:

Include settings header	Include a header in the csv file that contains device settings. **Note:** The height of the header is not constant. Please take care when parsing the csv file automatically.
Include active memory traces	All memories that are currently visible in the *Bode Analyzer Suite* will be exported to the csv file.
Include output level	Includes the output level as the second column (after frequency) of the csv file. Might be important for shaped level measurements.
Include real & imaginary values	Real and Imaginary are included independently of the currently chosen display format in the GUI.
Decimal separator	Choose your decimal separator of choice.
Field separator	Configure the separator between two values / fields.
Open file after saving	Activate this function to open the exported file with an external program. When activated a text box appears that allows you to choose your program file. Leave the text box empty to use the default Windows program.
	Press this button to store your settings for future exports. You can find the default settings also in the options dialog accessible in the main window via  .
	Press the **Save as** button to specify a file name and save your export file.

Exporting an Excel file

In the Excel export pane you can choose the following options:

Include settings header	Include a header in the csv file that contains device settings. **Note:** The height of the header is not constant. Please take care when parsing the csv file automatically.
Include active memory traces	All memories that are currently visible in the *Bode Analyzer Suite* will be exported to the csv file.
Include output level	Includes the output level as the first column of the csv file. Might be important for shaped level measurements.
Include real & imaginary values	Real and Imaginary are included independently of the currently chosen display format in the GUI.
Open file after saving	Activate this function to open the exported file with an external program. When activated a text box appears that allows you to choose your program file. Leave the text box empty to use the default windows program.
Set as default	Press this button to store your settings for future exports. You can find the default settings also in the options dialog accessible in the main window via  .
Save as...	Press the **Save as** button to specify a file name and save your export file.

10.1.5 Generating a Touchstone file

Bode Analyzer Suite 3.00 or higher offers the possibility to create Touchstone files from the measured data. This offers you the possibility to use measured data directly in simulators that provide Touchstone import. You can find the Touchstone export using the Export icon in the Home ribbon.

The Touchstone export pane offers the following options:

Network parameter	Choose between S, Y and Z parameters.
Number of ports	Either 1-Port or 2-Port touchstone file can be created.
Network data	Select the measurement trace or memory trace data that corresponds to the network parameter. *Bode Analyzer Suite* does not check if the data is valid. Please take care that you choose the correct measurement for your network parameters. If the frequencies of the traces or memories are not equally spaced, they cannot be selected since Touchstone only allows one frequency column for all network parameters.
Network data format	MA...Magnitude and Angle (Default) DB...Magnitude in dB and Angle RI...Real and imaginary
Frequency unit	Select Hz, kHz, MHz or GHz. Hz is default.
Touchstone version	Default is Touchstone V2. A Touchstone V2 file can be saved under the extension .ts, .s1p or .s2p depending on the number of ports. The file extension .ts is default. A Touchstone V1 file has either the .s1p or .s2 extension.
Number format	Choose SixDigitsFixed or SixDigitsScientific
Open file after saving	Activate this function to open the exported file with an external program. When activated a text box appears that allows you to choose your program file. Leave the text box empty to use the default Windows program.
Set as default	Press this button to store your settings for future exports. You can find the default settings also in the options dialog accessible in the main window via .
Save as...	Press the **Save as** button to specify a file name and save your export file.

10.1.6 Generate a PDF report

If you need to print a measurement report or save it as a PDF document, you can use the PDF export. To do so, click the Report icon in the Home ribbon.

The PDF report pane offers the following options:

General report elements	
Choose your Logo	You can select a logo file different than the default OMICRON Lab logo for your PDF report. Use a PNG image with 2:1 width to height ratio for optimal results.
Printer Page Size	Select between A4 and Letter format.
Include Charts Include Legend Include Device Configuration Include Hardware Configuration Include Calibration/Correction Include Port-extension Include Text Note	Choose which of the General report elements you want to include in your report.
Sweep report elements	
Include Cursor Table Color Cursor Table Include Sweep Configuration Include Shaped Level chart Include Expressions Include Circuit Fit Include Cursor Calculation Include Averaging	Select the report elements you want to include in a frequency sweep measurement report.
Fixed frequency report elements	
Include Measurement Configuration Includes Result Table	Select the report elements you want to include in a fixed frequency measurement report.
Open file after saving	Is activated by default. If you don't enter a program path in the text field below, the default Windows program for PDF files will be used to open your saved PDF report.
Set as default	Press this button to store your settings for future exports. You can find the default settings also in the options dialog accessible in the main window via .
Save as...	Press the **Save as** button to specify a file name and save your report.

10.2 Using the interactive chart

The interactive chart region of the *Bode Analyzer Suite* offers many useful functions to analyze measurement results and how to display them in an optimum way. In the following sections the most important features are presented.

10.2.1 Configure the diagrams

A normal diagram with frequency on the x-axis can have two y-axes. Allows the display of two measurement traces in one diagram as shown in the figure below:

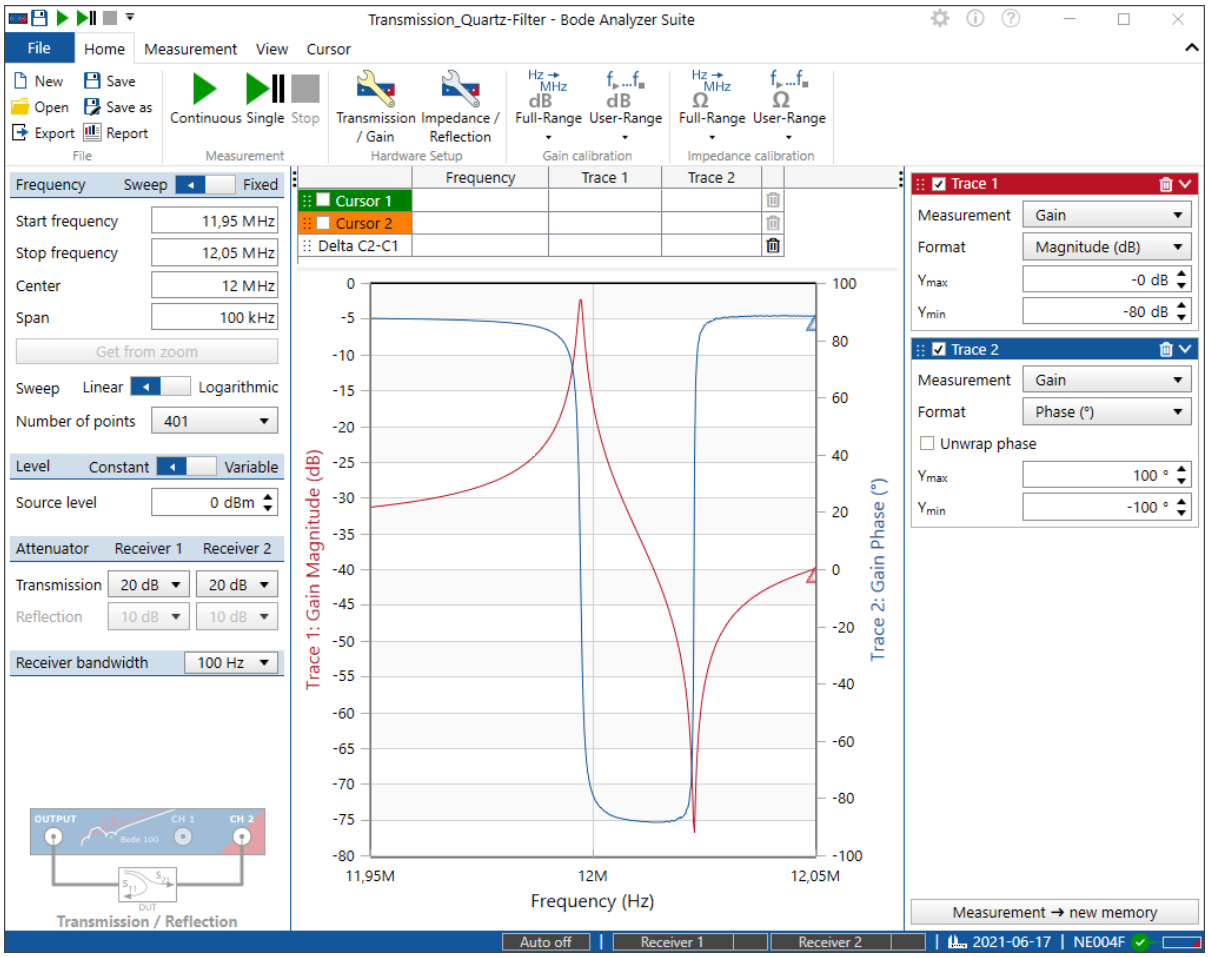
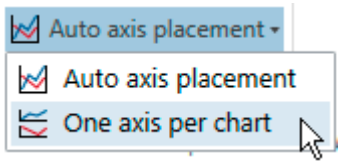


Figure 10-1: Two measurement traces in one diagram using two axis (left and right)

It is not always possible to display two traces in one diagram. If one of the two traces is set to a Polar, Smith, Nyquist or Nichols diagram, automatically two diagrams will be displayed.

You can also choose to show the two curves in two separate diagrams. To do so, click on the View ribbon and select **One axis per chart** as shown below.



This results in two separate diagrams as shown below.

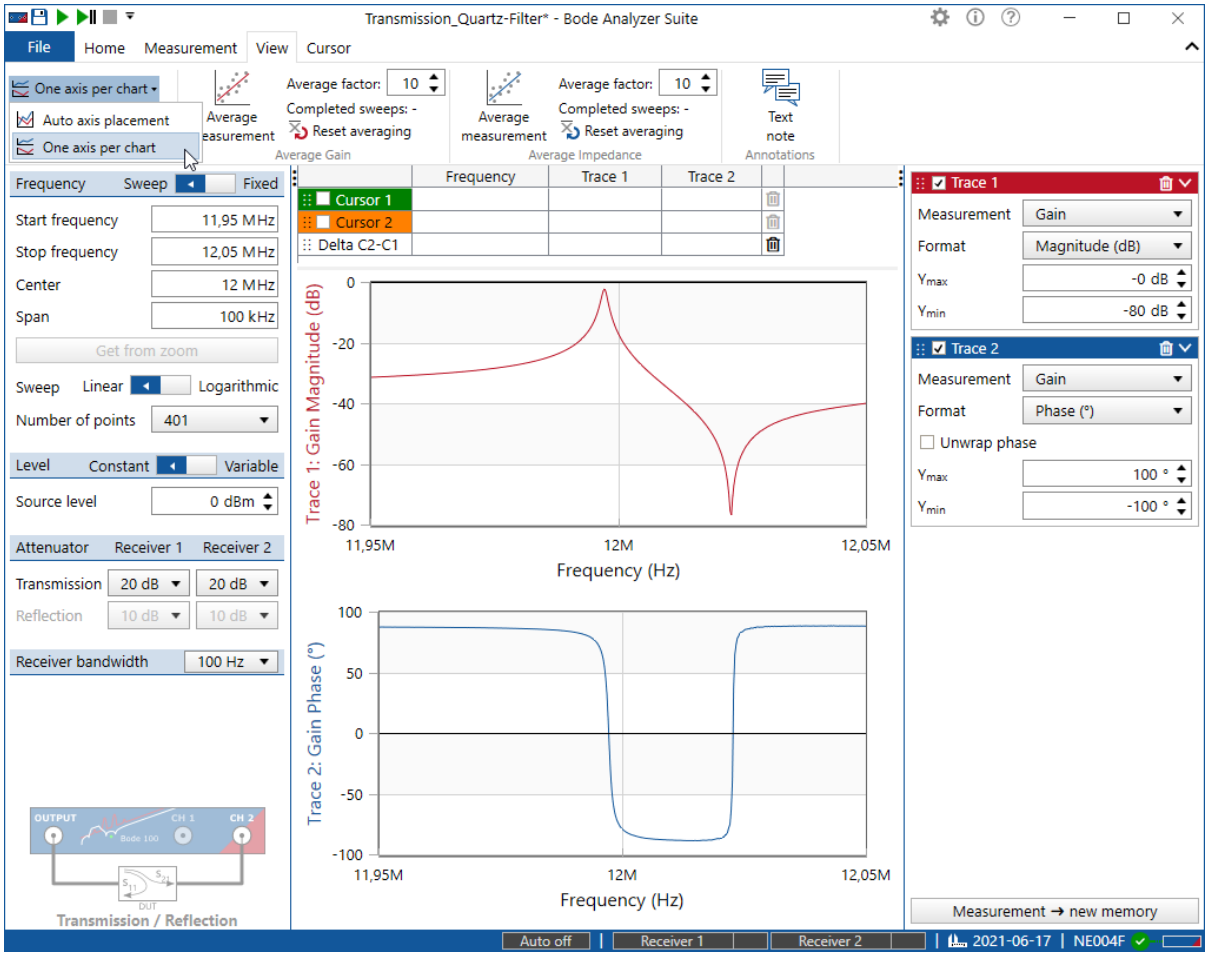


Figure 10-2: Displaying two traces in a separate diagram setting the chart setup to **One axis per chart**

You can configure your preferred style in the options menu under the Chart Settings.

10.2.2 Zooming the measurement curve

Zoom into a measurement curve

To zoom into an interesting part of your measurement curve, click into the chart and hold the mouse clicked to drag a zoom window from **top-left** to **bottom-right** as shown in the following figure:

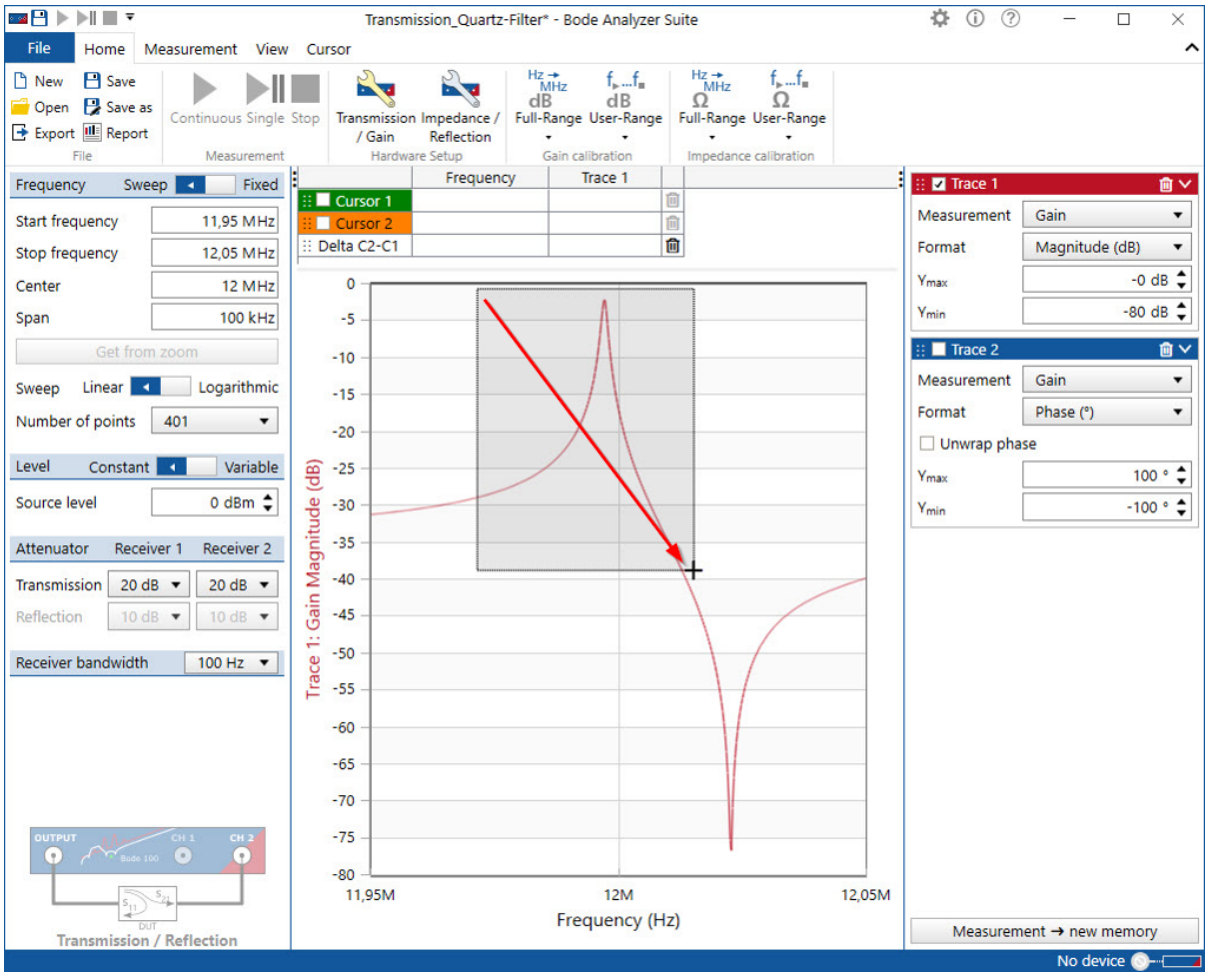
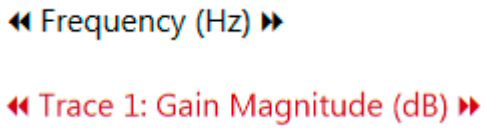


Figure 10-3: Zooming in by click and drag from top-left to bottom right

Whenever you have zoomed in the diagram, the axis label shows additional arrows to indicate that a zoom is active.



Zoom out

To zoom out, click into the chart and drag from **bottom-right** to **top-left** as shown in the figure below:

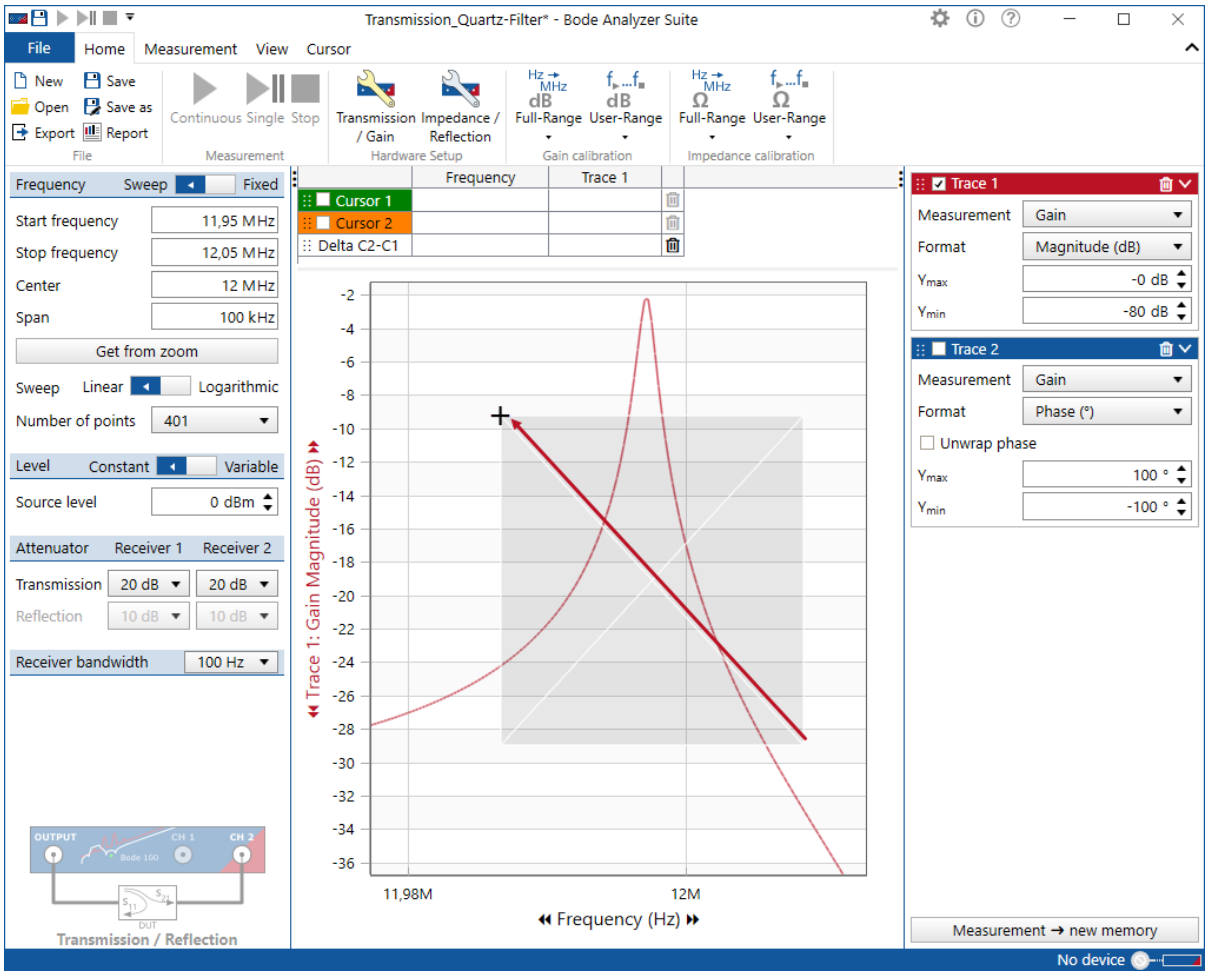
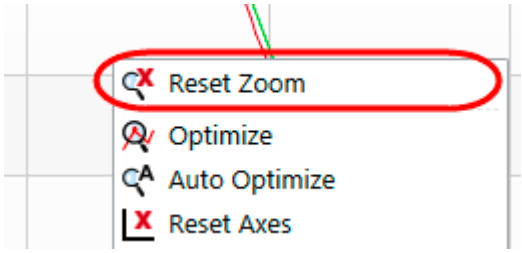


Figure 10-4: Zooming out by click and drag from bottom-right to top-left

Alternatively you can right-click into the chart and use the Reset Zoom function in the context menu of the chart as shown below.



Get from zoom

Zooming helps to check an interesting part of a measurement curve. However, zooming into the curve does not increase the number of measured points which can lead to insufficient frequency resolution.

To achieve a better frequency resolution you can either increase the number of points in the sweep or press the Get from zoom button.

By clicking **Get from zoom**, the start and stop frequency fields are updated with the maximum and minimum frequency of the current zoom window.

After clicking on Get from zoom you can start a new sweep with the full number of points in the current zoom window. The following figure shows the effect in case of a narrow resonance. The green memory trace shows the measurement result before clicking Get from zoom. After clicking Get from zoom, the resonance is captured nicely. After pressing Get from zoom, the zoom is not active anymore and the button is disabled.

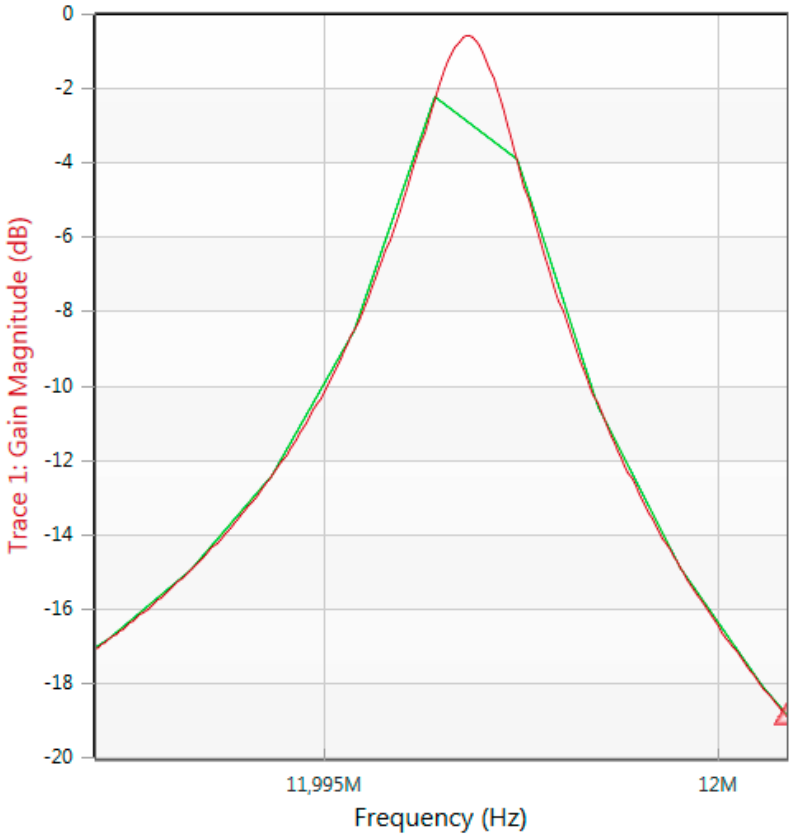


Figure 10-5: Increasing the frequency resolution in a zoom window using **Get from zoom**

10.2.3 Optimize the axis scaling / autoscale

Manually configuring the chart axes

Every measurement trace of the *Bode Analyzer Suite* has axis settings.
A normal diagram with frequency on the x-axis has two y-axis settings (Ymax and Ymin) as shown below:

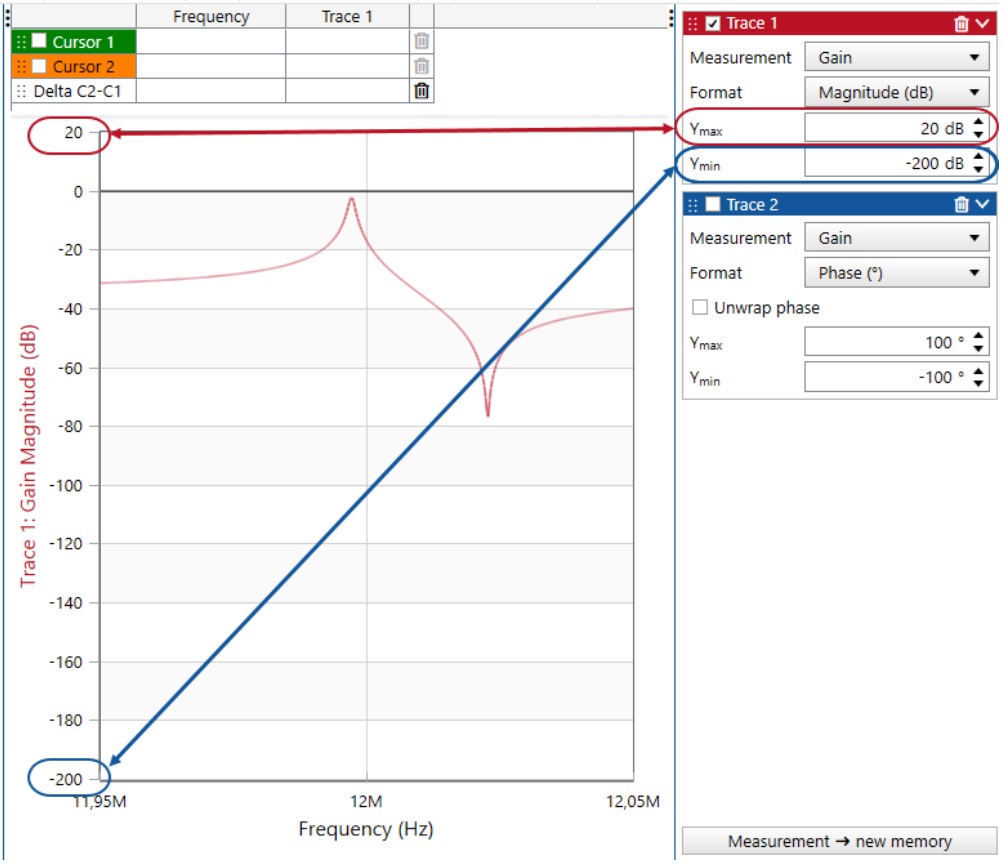


Figure 10-6: Manually configuring the axis limits via the trace configuration

Diagrams such as Polar, Nyquist or Smith have more axis settings to choose the visible range in the diagram.

Use Optimize to automatically optimize the axis scaling

To automatically optimize the axes of your measurement curve, right-click into the chart and click Optimize.

After clicking optimize the axis settings are automatically adjusted as shown below:

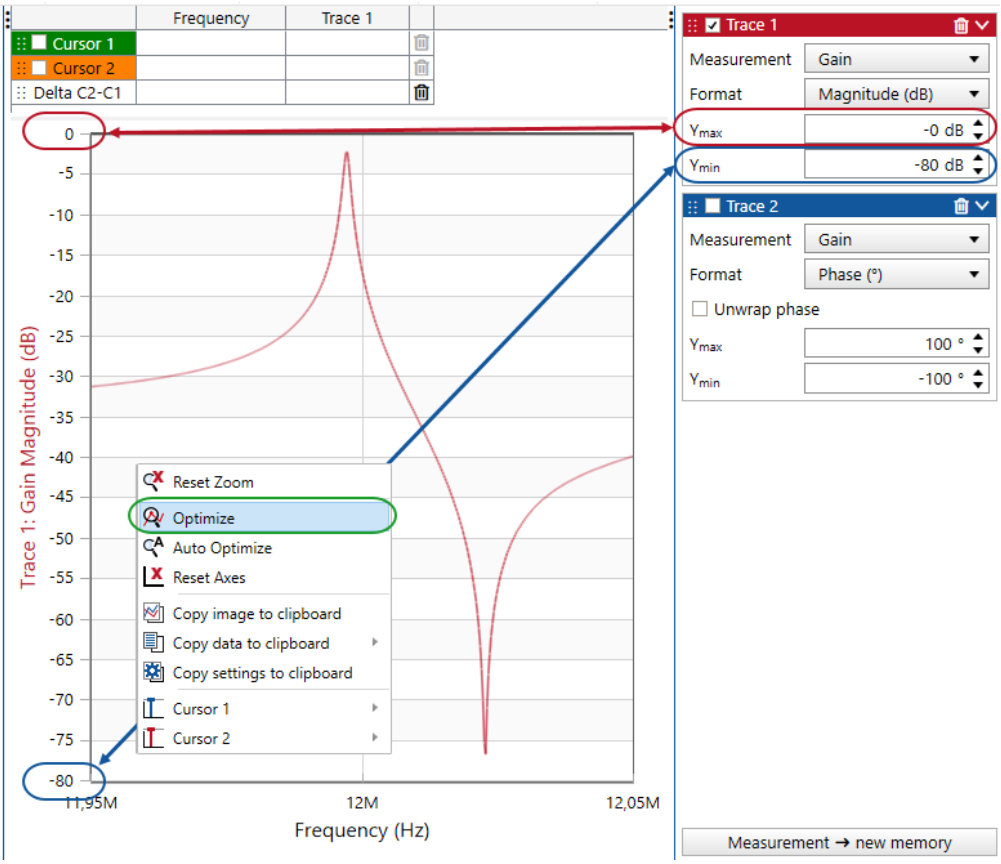
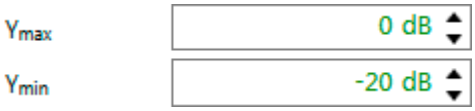


Figure 10-7: Use Optimize to automatically adjust the axis settings

Use Auto-Optimize

If you don't want to click Optimize every time the measurement curve changes, you can use the Auto Optimize function available in the context menu of the chart.

When activated, ☑ Auto Optimize automatically adjusts the axis limits whenever the measurement results change. To display that the Auto Optimize is activated, the Ymax and Ymin text color is changed to green :



Each of the following user interactions will deactivate the Auto-Optimize:

- Zooming in the diagram
- Clicking Reset Zoom
- Clicking Optimize
- Manually adjusting the axis in the trace configuration
- Using Reset axes

Reset axes

If you want to reset the chart axes to the default values, right-click into the chart and use Reset Axes .

10.3 Working with cursors and the cursor table

The *Bode Analyzer Suite* offers cursors (markers) to read the exact value of a trace at a specific frequency. In the following, a short overview on the functionality of cursors is given.

10.3.1 The cursor table

The cursor grid respectively cursor table shows the values of normal value-cursors and delta-cursors. A delta-cursor can be configured to show the difference between two cursors whereas a normal value-cursor shows the value of a trace at a specific frequency.

	Frequency	Trace 1	
Cursor 1	10,4 MHz	-55,74 dB	
Cursor 2	10,8 MHz	-33,112 dB	
Delta C2-C1	400 kHz	22,628 dB	

The cursor table offers the following interactive functions:

- Switch cursors on and off by clicking on the checkbox besides the cursor name  .
- Delete a cursor by clicking on the recycle-bin icon in the last column. Note that a cursor cannot be deleted if it is used by some other function such as a delta-cursor. Then the recycle-bin icon is greyed out.
- Move the cursor up or down in the cursor table by clicking on the dotted area left to the checkbox and drag it to the desired position holding the mouse clicked.

Cursor 1	10,4 MHz	-55,74 dB
Cursor 2	10,8 MHz	-33,112 dB
Delta C2-C1	400 kHz	22,628 dB

- Set the cursor frequency by clicking into the frequency field and manually entering a frequency

	Frequency
Cursor 1	11,997 MHz

- Move the cursor to a specific measurement result by entering the desired value in the Trace column

	Frequency	Trace 1
Cursor 1	11,997 MHz	-905,561 mdB

- You can also enter a delta value and the second cursor will try to find a frequency where the delta value can be achieved.

If an entered value cannot be found, the following information is shown.

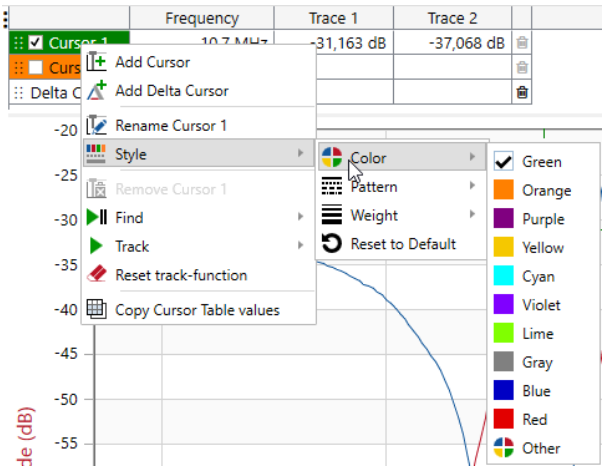
ency	Trace 1
97 MHz	-905,561 mdB

Value not found in visible field!

If multiple solutions are present (e.g. more than one zero-crossing and you entered 0 into the cursor grid), you can right click into the cursor grid and click Jump to next to search the next solution from the current frequency to right (higher frequency).

Changing the cursor line style

You can modify the cursor line style by right-clicking the colored cursor field and using the context menu as shown in the following figure.



Further cursor features in the context menu

By right-clicking a cursor in the cursor table the cursor context menu allows you to use the following features:

- **Add Cursor** and **Add Delta Cursor** to add a new cursor in the cursor table.
- **Rename Cursor** to give a cursor a custom name.
- **Find** or **Track** to search a maximum, minimum or zero-crossing of a trace either once or repetitively after every sweep.
- **Reset track-function** stops tracking a maximum or minimum or zero crossing.
- **Copy Cursor Table values** allows you copy all cursor result into the clipboard at once and paste them e.g. in a spreadsheet program.

10.3.2 Using cursors in the chart

Moving cursors in the chart via mouse drag

You can move the cursors in the chart via the mouse. Simply move the mouse cursor close to the cursor you would like to move until the mouse cursor changes to ↔, then click and drag the cursor to the position you like. Alternatively you can use the left and right arrow keys of your keyboard to move the cursors. Note, this will always move the cursor that was last moved using the mouse.

Find or Track Maximum, Minimum or Zero-crossing in a trace

To find a maximum, minimum or zero crossing of a curve, you can use the functions in the context menu.

Right-click a curve in the diagram. Then select Cursor n, Jump to Max to position Cursor n to the maximum of the clicked curve. In our example we have selected Cursor 1.

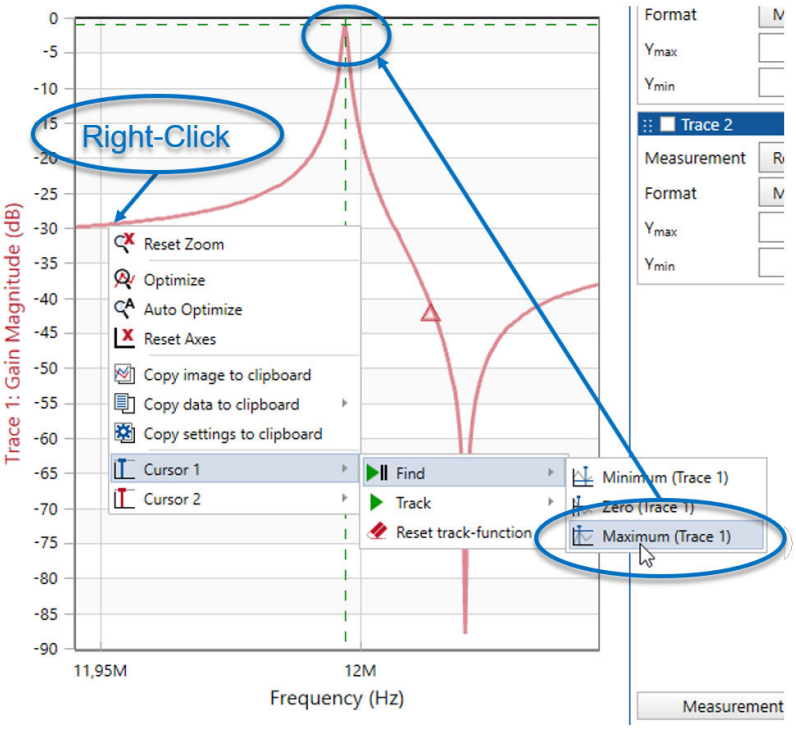


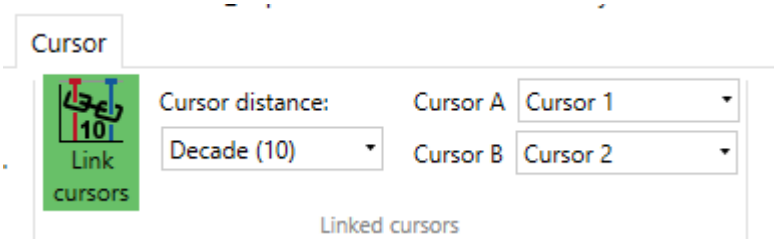
Figure 10-8: Use cursor function Find Maximum

Hint: Find max or min always searches the global max or min in the visible chart region. To find a local max or min, you can zoom into that region and re-perform Jump to Max.

Hint: If you use **Track** instead of **Find**, the maximum, minimum or zero crossing will be automatically searched every time a sweep as completed. This is especially useful when you use fast sweeps.

10.3.3 Link cursors

Two cursors can be linked in terms of the distance on the frequency-axis by clicking on Link cursors. If you move Cursor A with the mouse, Cursor B will follow at the defined distance or factor.



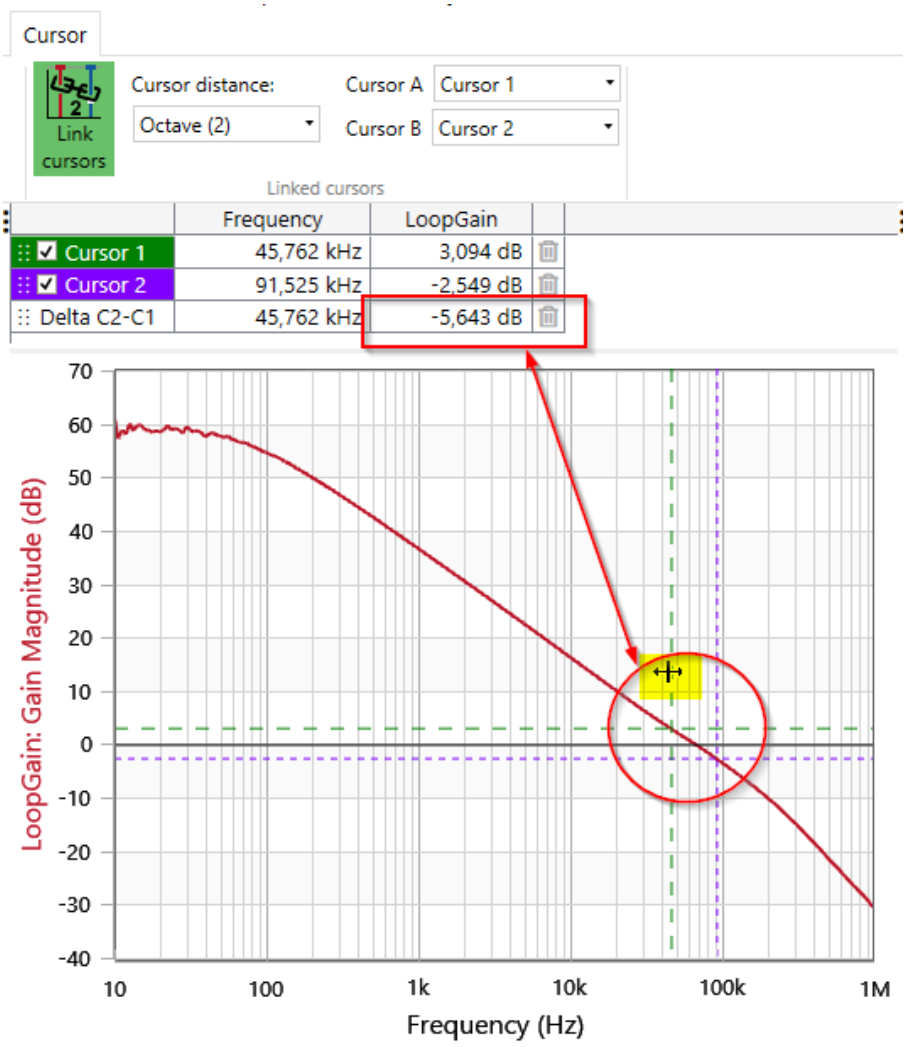
The linking features the following settings:

- Decade...the distance between Cursor A and Cursor B will be kept constant at one decade (linear factor of 10).
- Octave...the distance between Cursor A and Cursor B will be kept constant at one octave (linear factor of 2).
- Linear Distance...the distance between Cursor A and Cursor B will be kept at the current distance in Hz.

Cursor A and Cursor B need to be selected accordingly in the drop-down boxes in the ribbon.

Application examples

With this feature, the slope of a trace can be measured. This can be especially helpful in double-logarithmic diagrams when analyzing e.g. the slope at crossover frequency in a loop-gain measurement (should be around -20dB/decade) or when checking for an inductive or capacitive slope (±20dB/decade or ±6dB/octave).
The following picture shows an example of a measured loop gain where the slope at crossover is -5.7dB/octave and therefore close to the ideal -6dB/octave.



By using the mouse, the cursors can be moved from one frequency to another and the slope can be directly read in the cursor grid since the second cursor automatically follows at a defined distance.

10.4 Using the memory traces

The *Bode Analyzer Suite* offers you the possibility to compare multiple measurements with each other. To copy a current measurement result to a memory trace, use either the

Measurement → new memory button or click the Data → Memory icon in the Memory ribbon.

This will lead to a new curve in the diagram as shown in the figure below.

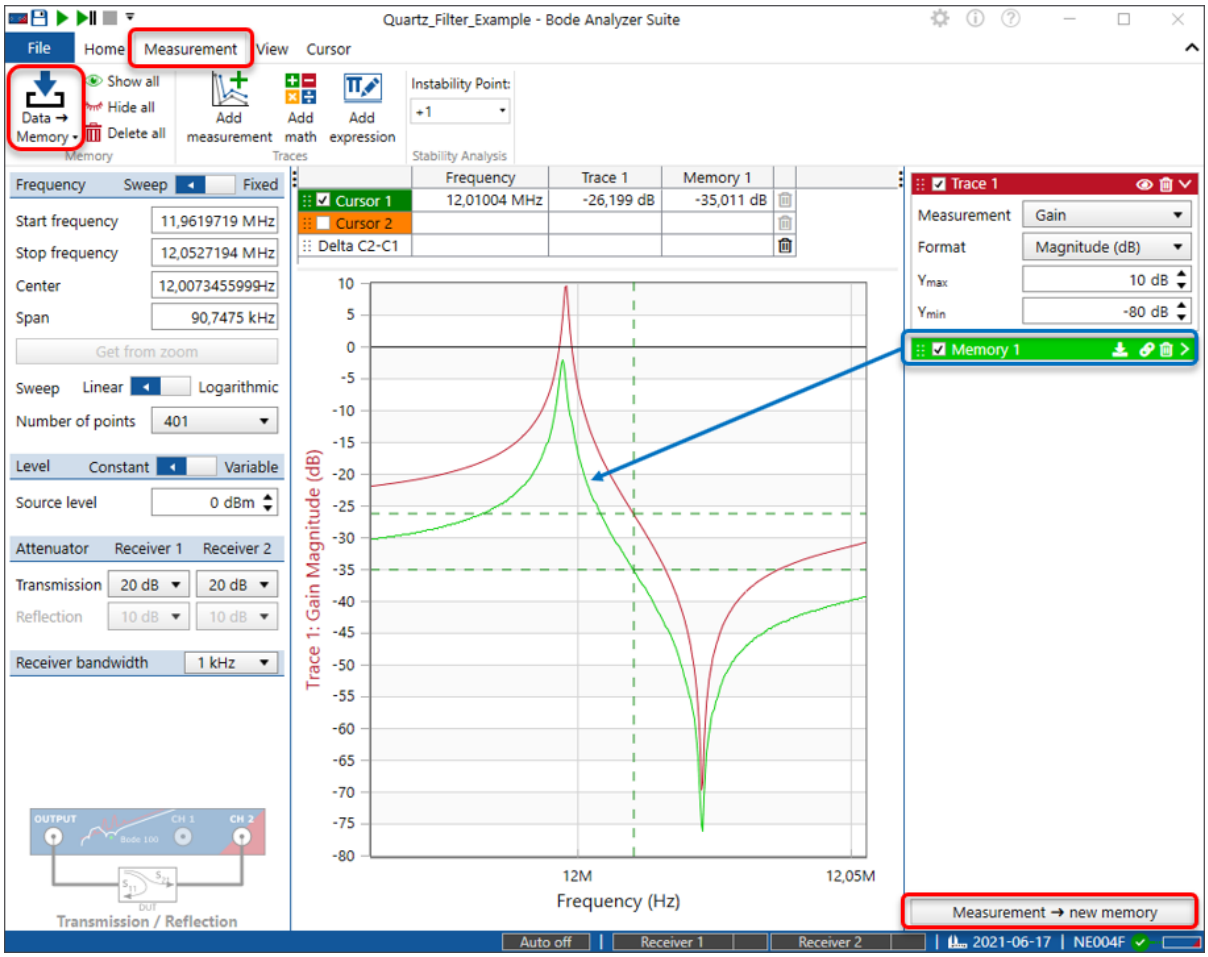


Figure 10-9: Using memory curves to see changes in the measurement and to compare different curves

When you use averaging, a second button is available that allows you to copy the averaged value or the measured value to a memory trace.

Measurement → new memory

Averaged → new memory

You can use multiple memories to determine the change of your DUT depending on a parameter. The following figure shows an example of how the parallel resonance frequency of the quartz filter changes when touching it.

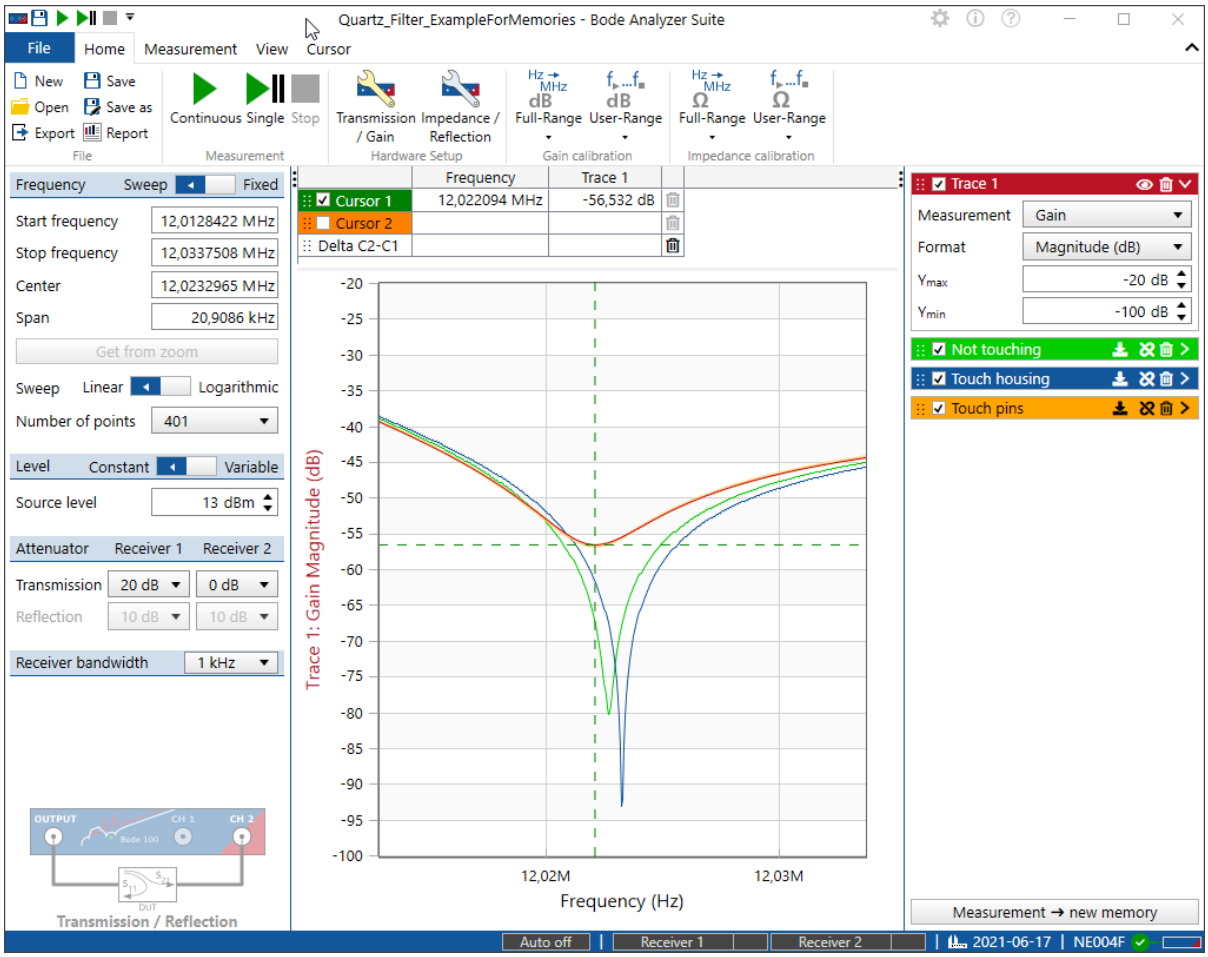
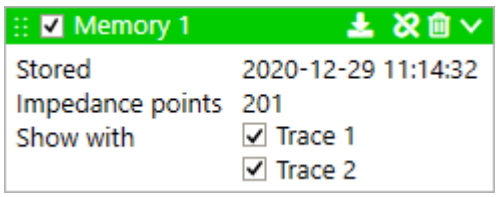


Figure 10-10: Using the memories to compare different measurements

Hints:

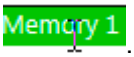
- Double-clicking the Memory name allows you to change the name of the memory.
- When you hover over the memory name on the memory configuration box, the corresponding memory curve will be highlighted in the diagram.

The memory configuration box gives you information on when the memory was stored and allows you to control the memory curves.



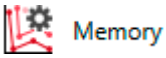
The following actions can be taken:

- Click the checkbox 

next to the name to switch the memory curve on or off.
- Right-click the green area and use the context menu to change the memory style or color.
- Rename the memory by double-clicking on its name 

.
- Update the memory data with the current measurement data by clicking  .
- Delete the memory trace by clicking on  .
- Attach the cursors to the memory trace by clicking on  .
- Use the **Show with** check-boxes to decide if the memory data shall be shown only with one trace or on both.
- Use the  icon to re-order memory traces in a measurement or to copy the data from one measurement file to another by drag-and-drop the trace from one *Bode Analyzer Suite* instance into another *Bode Analyzer suite* instance.

Options

The following options can be configured in the memory options. Go to the options dialog  and select the memory options 

:

- **Maximum number of memory traces:** The maximum number of memory traces is by default limited to 10. If you need more memory curves increase this number.

  Increasing the number of memory traces might impact your software performance. Especially when you use a high number of points and many memory traces.

- **Confirm the deletion of memory traces:** When this checkbox is checked, the software will ask for confirmation when deleting a memory trace.
- **Default memory line pattern:** Change the memory line styles according to your preference.
- **Alternating memory trace color mode:** Activate this option to color-code the memory curves with the corresponding trace color. With this mode it is easier to distinguish between multiple memories when more than one trace is shown in a diagram.

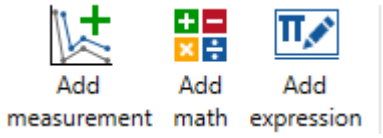
10.5 Working with measurement and math traces

Please also check out 6.3.2 Trace configuration on page 40 to learn more about using the trace configuration. Furthermore, please refer to the previous chapter 10.4 Using the memory traces on page 151 on how to store a measurement trace to a memory trace.
Besides the memory traces, the *Bode Analyzer Suite* offers the following trace types:

- **Measurement traces** show the measured data
- **Math traces** allow simple math operations between measurement traces and memory traces
- **Expression traces** can handle more complex mathematical expressions

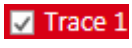
Add an additional trace

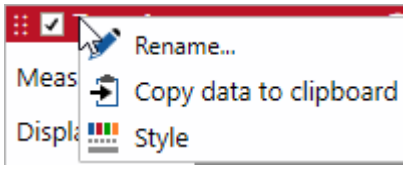
You can add additional measurement traces, math traces or expression traces by clicking on the corresponding icon under the **Measurement** ribbon.



Each of the above mentioned traces comes with its own axis respectively its own chart / diagram.
If the chart setup is set to "one axis per chart", each trace will be shown in a separate chart / diagram.

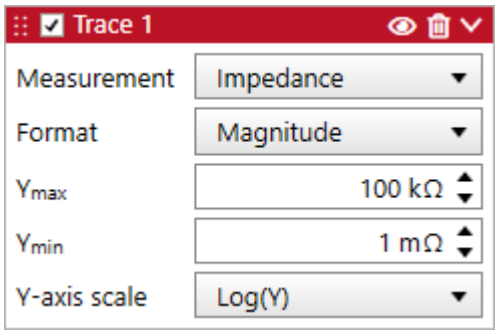
Each trace brings its own trace configuration box on the right hand side of the *Bode Analyzer Suite*. The trace configuration allows you to configure how the data of the trace is displayed in the chart. The following table shows the trace configuration settings which are available for all trace types. Trace-specific settings are described in the following sections.

Format	Choose the desired format how to display the complex data. You can i.e. choose to select Magnitude or Phase(°) and so on. For more details on the available result formats, please refer to Gain Result Formats on page 54 and Impedance Result Formats on page 56.
Ymax, Ymin, etc...	Configure the axis limits of the trace axis (diagram). Please check out: 10.2.3 Optimize the axis scaling / autoscale on page 143. You can also right-click into the diagram and click **Optimize**. This will auto-scale the available axis.
Y-axis scale:	Choose either a linear Y-axis or a logarithmic Y-axis. In addition you can set it to Log(|Y|) to avoid the logarithms of negative numbers.
	Use the checkbox left of the trace name to disable or enable the trace.
	Rename the trace by double-clicking on the trace name.

	Use the context menu to: • Rename the trace • Change the trace style (color, line style, trace markers) • Copy the trace data to the clipboard
	Collapse the configuration box if you have too many traces and need more space.
	Click on the bin icon to delete the corresponding trace. **Note:** This will also remove the corresponding chart axis or chart!
	Click, hold mouse and drag to re-order the traces at the right-hand side of the Bode Analyzer Suite window. This will also re-order the corresponding axis and diagrams. Use drag and drop to move the measurement trace data from one measurement into another.

10.5.1 Measurement traces

In the following the settings that are specific to a **Measurement trace** are described. The **Measurement trace** configuration box is shown in the figure below. It allows you to configure what measurement is performed and how the measurement results are displayed.



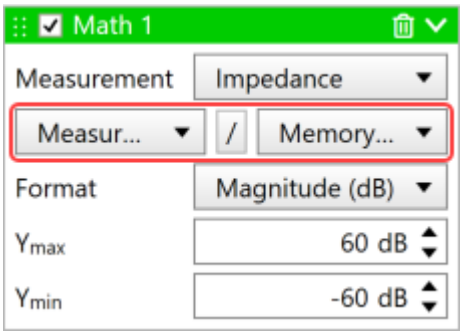
Measurement	Configure what measurement the trace performs. Depending on the measurement mode you can select between Gain, Impedance, Reflection and Admittance. If a measurement mode allows only one specific measurement (Gain), the selection will be disabled.
	Use the eye icon to hide the measurement data in a chart. **Note:** If you disable the a trace using the checkbox, the corresponding axis or chart will be removed as well.

10.5.2 Math traces

For simple mathematical operations you can use the **Math trace** feature of the *Bode Analyzer Suite*. You can choose the two operands and the operator. The available **operands** are either the measurement data or memory data. The available operators are: **+, -, *, /**.
Use the **Math trace** to perform simple calculations such as the sum of two measurements or the difference between a measurement and a memory trace.

Note that the mathematical operation of a math trace is always performed on the complex value selected in the **Measurement** setting. The result is then shown as selected in the **Format** setting.

The configuration box of a **Math trace** set to a *divide operation*, is shown below:



Some notes on the math trace:

- A **division** equals a **subtraction** in **logarithmic** domain. So if you choose *Measurement / Memory 1*, in the Magnitude(dB) plot you will see the difference between Measurement and Memory 1 in dB.
- A **multiplication** equals an **summation** in **logarithmic** domain. So if you choose *Measurement * Memory 1*, in the Magnitude(dB) plot you will see the sum of Measurement and Memory 1 in dB.
- If the frequency points of the two operands don't match, an info icon will be shown in the trace header . Either linear interpolation will be used to find the needed operand values or the values will be skipped.
- A **Memory** cannot be created from of a **Math trace** .

10.5.3 Expression traces

For complex mathematical operations you can use the **Expression Trace** feature of the *Bode Analyzer Suite*.
Adding an **Expression trace** automatically opens the **Expression Editor** in a separate window. The expression editor window can be moved around so that the resulting expression trace can be seen in the background as shown in the figure below.

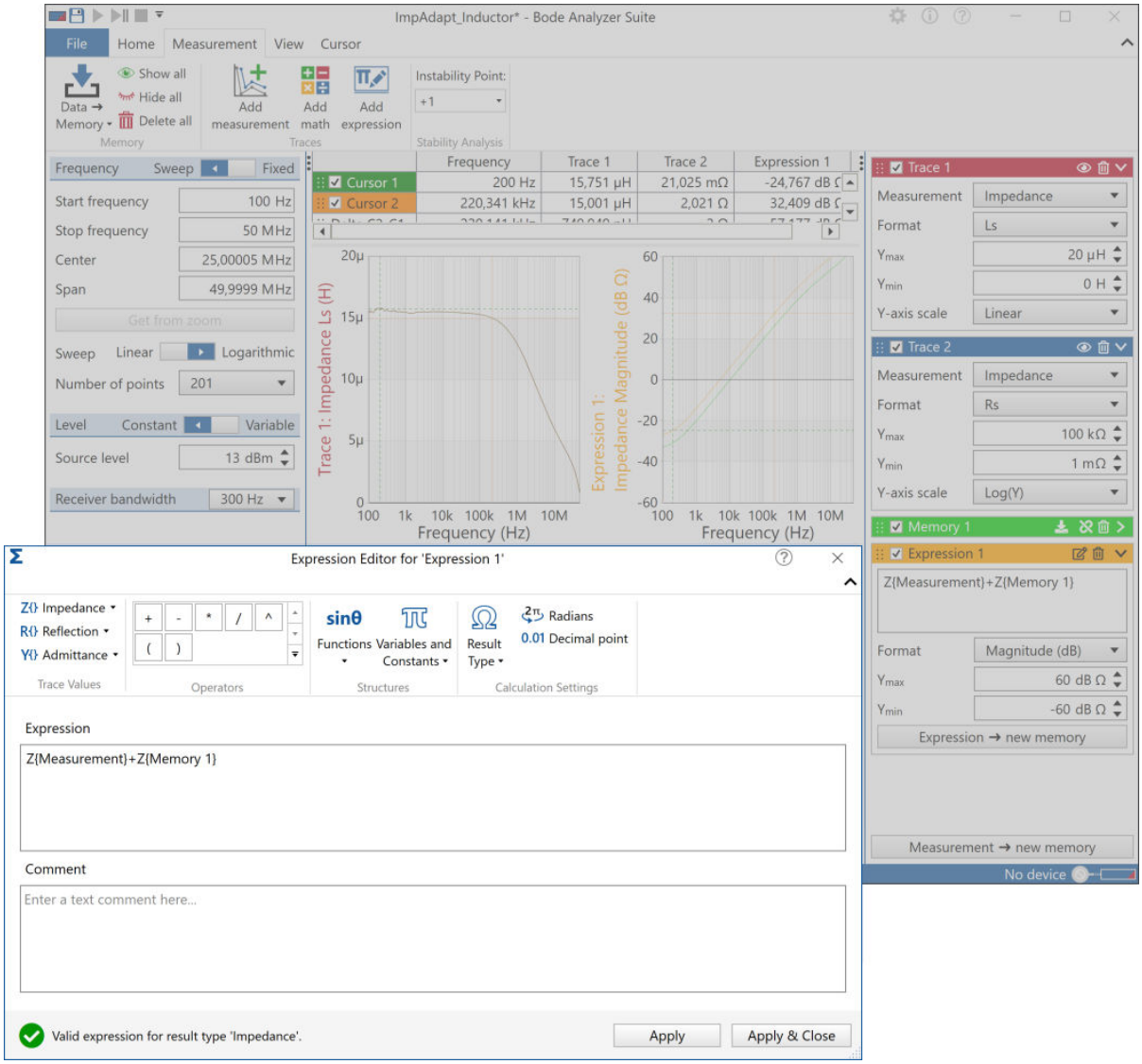


Figure 10-11: An example expression creating the sum of two impedance values plotting the result in the second chart.

In case a **Measurement trace** is used in an expression, the expression result will be updated simultaneously with the running measurement.

Expression Editor

The **Expression Editor** allows you to enter a custom mathematical expression. It offers various functions, variables and operators for simple calculations, to plot a transfer function or to perform advanced manipulation of the measured data.

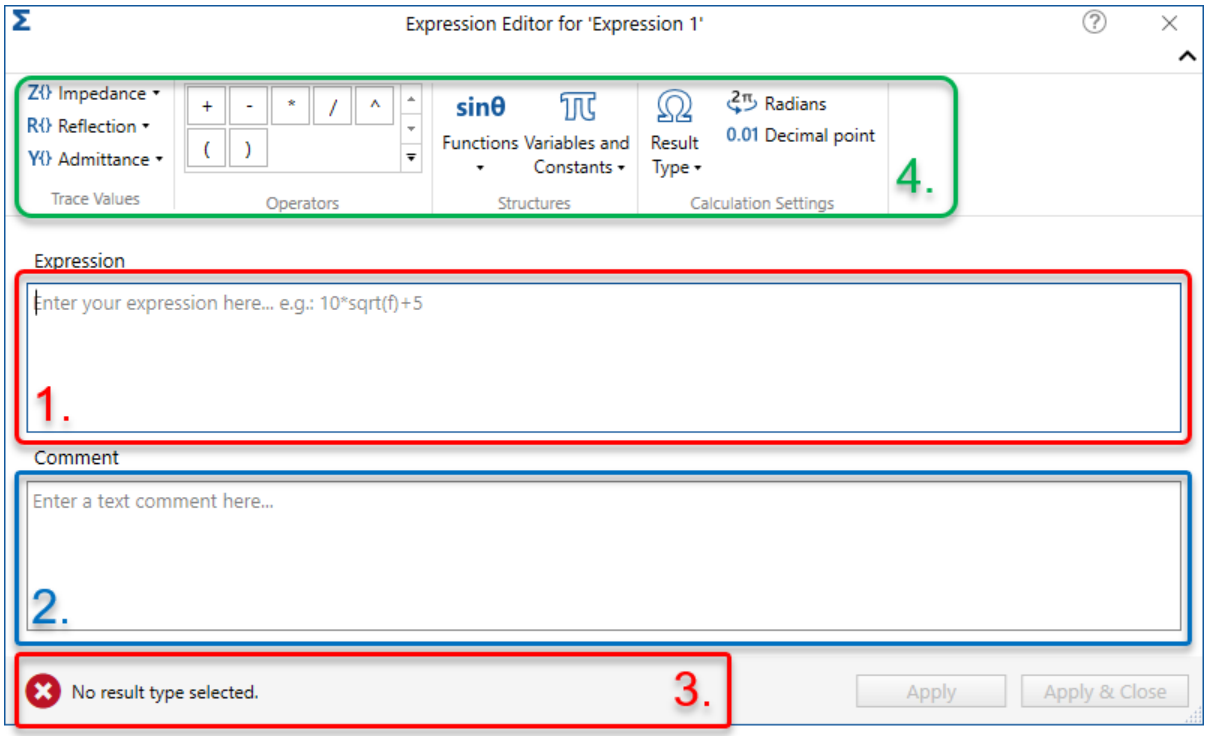


Figure 10-12: Expression editor window

The Expression editor window is structured into four main regions:

1. Expression field- Here you can enter your mathematical expression to be evaluated.
2. Comment field - In this field you can enter a text note for documentation purpose. You could for example describe the expression you have entered.
3. Status bar - See if your expression has been successfully evaluated or if an error appears. If the evaluation is successful, you will see a green checkmark icon  . If there is an error, the following icon will be shown: 
4. Expression toolbar - Here, you can find the available variables, operators, constants and settings you can use in the expressions.

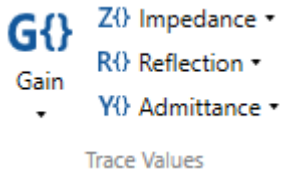
Add an Expression

To apply an expression trace you must at least:

1. **Enter** the **expression** in the expression field
2. Select the right **result type**
3. Click **Apply & Close**

In the following, you can find an overview on the functions of the expression toolbar:

Trace Values

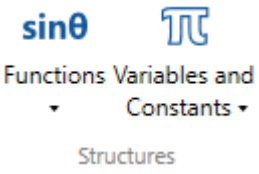


Depending on the available measurement traces and memory traces, you can select the trace data as input for your expressions.
To use for example the impedance data of the measurement, you can select Impedance → Z{Measurement}.
If you want to use the Gain data of the Memory 1 trace, enter: G{Memory 1}.

Operators

The expression editor supports several **operators**. The most common ones are available for selection as shown in the image to the left.

Functions, Variables & Constants



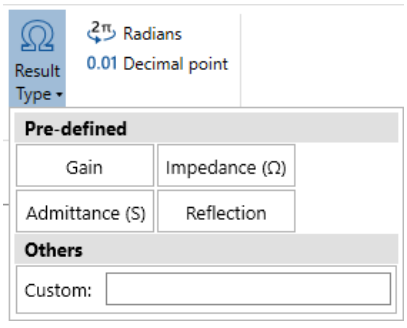
The following **functions** are available via the menu:

- General functions: log()...natural logarithm, log10()...10-base logarithm, sqrt()...square root
- Complex functions: abs()...magnitude, real()...real part of a complex number, imag()...imaginary part of a complex number, arg()...angle of a complex in radian, conj()...conjugate of a complex number
- Trigonometric functions: sin(), cos(), tan(), arcsin(), arccos(), arctan()

The following **variables** & **constants** are available via the menu:

- Variables: f...frequency in Hz, w...angular frequency in rad/s, j...imaginary number, s...complex frequency (jw), Z0...nominal impedance as set in BAS
- Constants: pi...π (3.141...), e...Euler's number, u0...permeability of free space, e0...permittivity of free space, c...speed of light

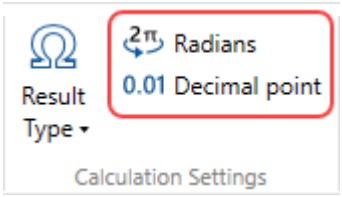
Result Type



A **Result Type** for the expression result must be selected before the expression can be evaluated. This is required for the correct display of the expression results since no automatic unit-calculation is included in the expression parser.

The result type can be chosen from one of the pre-defined result types Impedance, Admittance, Reflection, Gain or a custom result type can be selected. When selecting custom, the unit can be entered in the text field or left empty for a unit-less value.

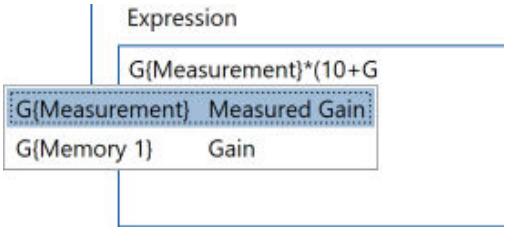
Radius and Decimal point



Please consider:

- The **angle** unit is always **radian**
- The radix character is always a **decimal point**. For example 2.5 equals two and a half.

Expression field



The expression is entered in the expression field. Operands and operators can be selected from the ribbon elements or directly entered in the expression field.
A Search function will show the available elements during typing.

Apply & Close

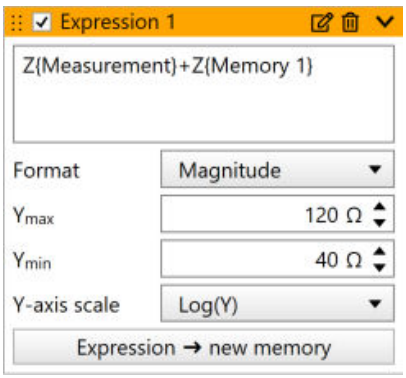
After an expression has been successfully parsed , the expression can be applied using one of the two buttons at the lower right-hand corner:

- **Apply** will calculate the results values without closing the editor window.
- **Apply & Close** will calculate the result values & close the editor window.

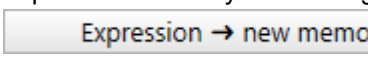
In both cases the resulting expression curve is shown in the corresponding chart in the *Bode Analyzer Suite* main window.

Expression trace configuration

The **Expression trace** and its chart view can be configured using the trace configuration box. The **Expression trace**, has the following specific options:



The expression entered in the editor is shown in the Expression field.
The result of an Expression trace can be copied to a Memory trace using the button



.
The editor window can be opened again by clicking the pen icon or by clicking into the expression field.
If the frequency points of the used operands differ, an info icon will be shown in the trace header . Either linear interpolation will be used to find the needed operand values or the values will be skipped.

10.6 Port extension

The Port extension feature allows you to mathematically move the reference plane of a reflection or impedance measurements. This can be useful if Open/Short/Load calibration cannot be performed directly at the point of connection of the DUT. There could be a short transmission line on a PCB but the Open/Short/Load calibration has been performed at the point of the cable-connector.
Port extension allows you to enter a physical length L and the propagation speed respectively the velocity factor VF. The velocity factor VF is the ratio between the speed of light c and the propagation speed of the signal on the transmission line / cable. It is a number between zero and one. The time needed for the signal to travel along that transmission line can then be calculated by:

$$T = \frac{L}{c \cdot VF}$$

Assuming zero loss, the reflection factor at the end of that transmission line can be calculated as:

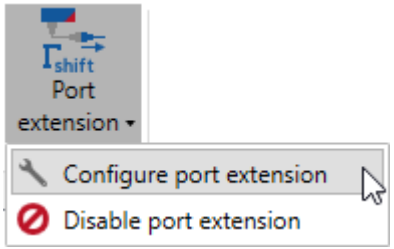
$$\Gamma_{\text{shift}} = \Gamma \cdot e^{j2\omega T}$$

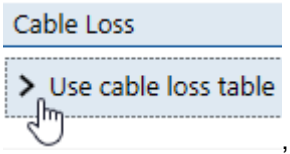
Using port extension

To use Port extension the first time, you must enable it in the Options dialog. You can find the option in the options menu under the **Advanced** section.
After having Port extension enabled, you will find the Port extension icon in the Home ribbon besides the calibration icons.
You can enable or disable Port extension by clicking on the icon. A green icon indicates that the Port extension calculation is active.

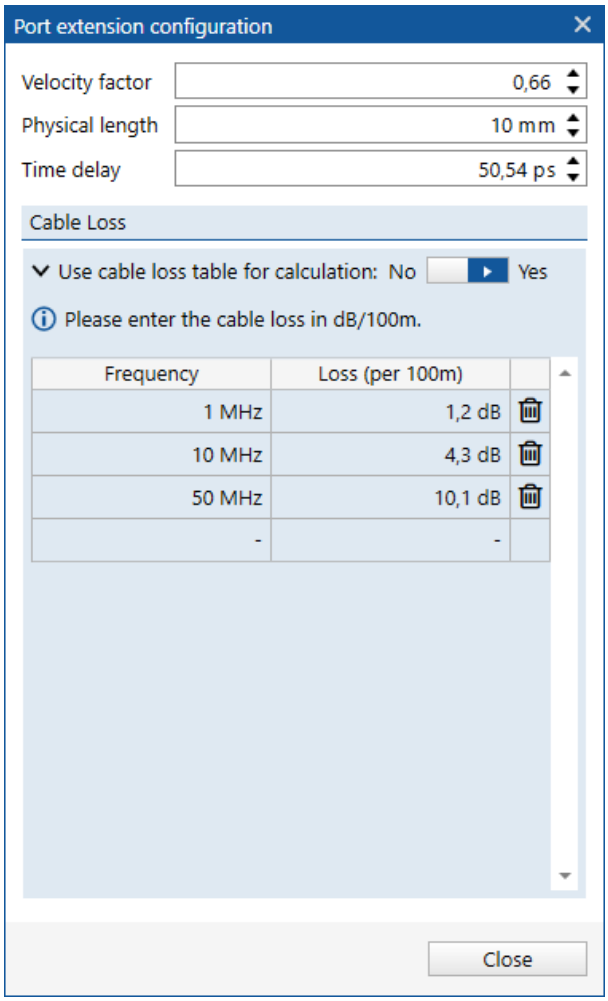
	
Port extension is not active (no colored background).	Port extension is active (green colored icon background).

By clicking on the lower part of the icon  you can open the port extension configuration window. To do so, click on configure port extension as shown below.



In the Port extension configuration window you can enter the physical length as well as the velocity factor or the time delay directly. By clicking on the arrow besides Cable Loss 

, a table appears that allows to enter loss over frequency in dB per 100 m. In the example below, a 10 mm long RG58 cable shall be compensated. The physical length as well as the velocity factor and the cable loss are entered.



10.7 Cursor calculations

Bode Analyzer Suite allows you to perform the following calculations / evaluations based on cursors:

- Non-Invasive Stability Measurement based on output impedance (basic & advanced)
- Resonance-Frequency and Q measurement based on the shape of a resonance peak
- Stability margin calculation based on a loop-gain measurement (bode-plot)

10.7.1 Non-Invasive Stability Measurement

Non-Invasive-Stability-Measurement (NISM) is a method to determine the phase margin of a voltage regulator via the closed-loop output impedance. The advantage of this method is that only the output of the power supply needs to be accessed and no control loop needs to be broken.

Bode Analyzer Suite offers the following two NISM calculations:

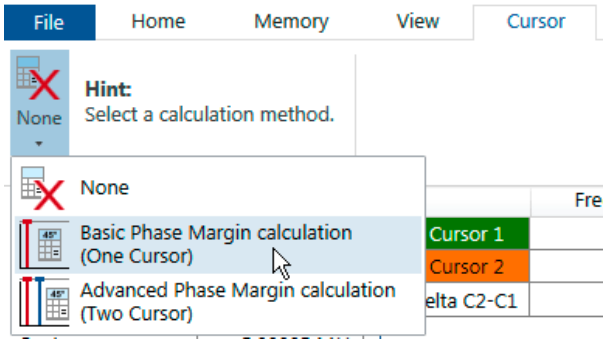
1. Basic phase margin calculation (one-cursor)
2. Advanced phase margin calculation (two-cursors)

NISM is based on the fact that the phase response is very sensitive to the quality factor of a resonator. Assuming a second-order closed loop feedback system, the quality factor of the output impedance resonance peak is directly related to the phase margin of the control loop according to equation (9.25) in "Fundamentals of Power Electronics" by Robert W. Erickson and Dragan Maksimovic.

$$Q = \sqrt{\frac{\cos \varphi_m}{\sin \varphi_m}}$$

Basic phase margin calculation (one-cursor)

To measure the phase margin of a voltage regulator, you first need to measure the output impedance over frequency. Then go to the cursor ribbon and select the Basic phase margin calculation method as shown below:



As a next step, follow the instruction in the GUI and place Cursor 1 to the peak in the Q(Tg) result. The phase margin calculation method shows the phase margin result in the cursor ribbon as shown in the following figure:

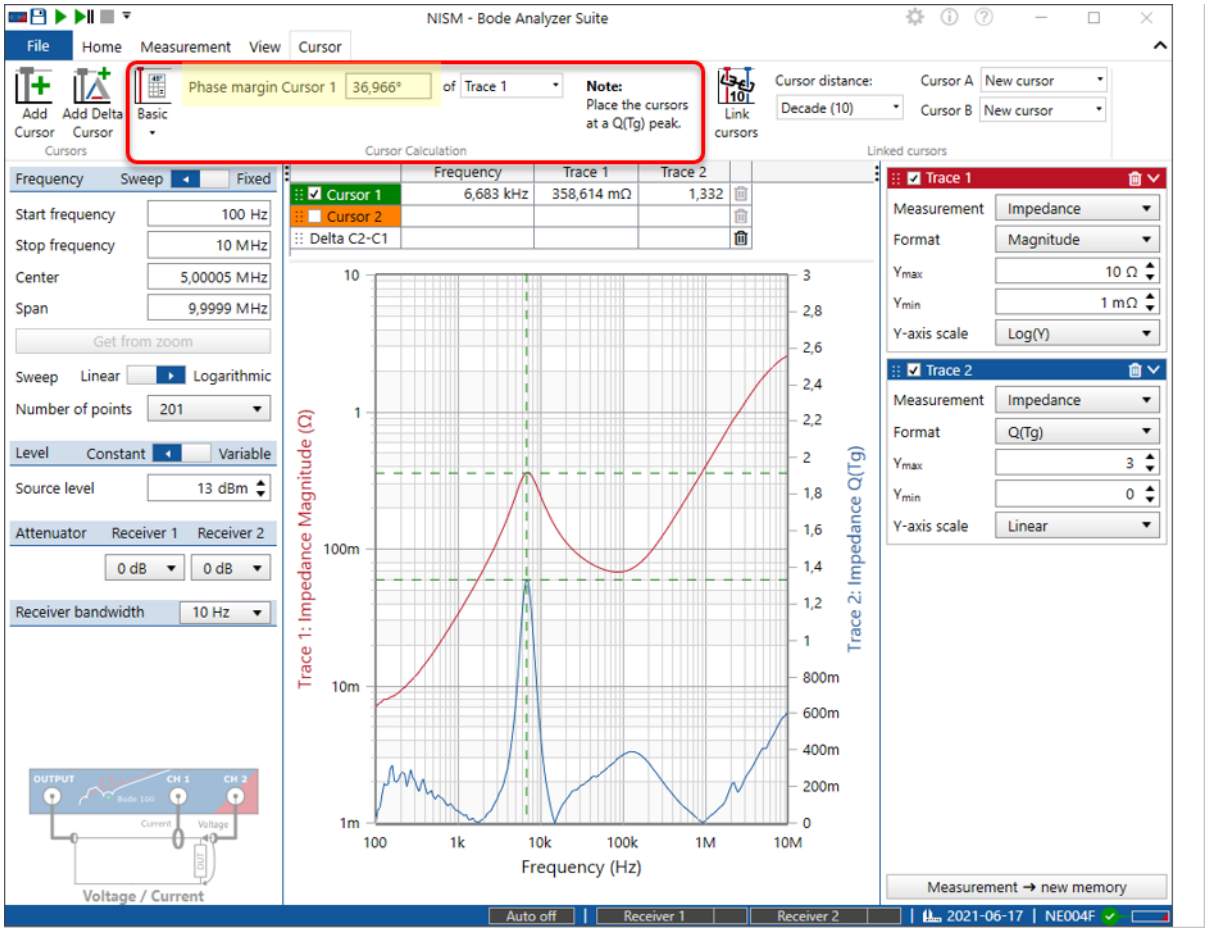


Figure 10-13: Basic phase margin calculation on output impedance of a linear regulator

The result shows a phase margin of nearly 37° (yellow) after placing cursor 1 to the peak in Q(Tg).

Advanced phase margin calculation (two cursors)

The advanced phase margin calculation uses a proprietary method developed by Steven Sandler (Picotest.com). The advantage of the advanced phase margin measurement method is that it includes the output filter damping factor and therefore generates more accurate results for highly damped systems.

If you measure output impedance of a regulator with low Q respectively high phase margin, the peak of Q(Tg) and the peak in impedance are not at the same frequency anymore. The higher the phase margin, the higher the distance between the impedance peak and the Q(Tg) peak.

The advanced phase margin calculation uses two cursors that need to be placed on both peaks in order to give a more accurate result for high phase margin values. To do so, select Advanced Phase margin calculation and place Cursor 1 at the peak in the Q(Tg) curve and Cursor 2 at the peak of the impedance magnitude curve.

To learn more about the non-invasive-stability measurement, please refer to the corresponding application note available at www.omicron-lab.com/BodeManualAppNotes.

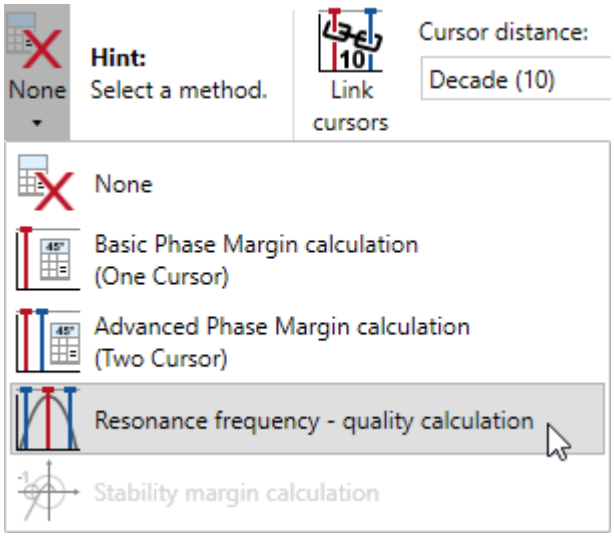
10.7.2 Fres-Q Calculation

For a fast and easy contactless measurement of the resonance frequency (Fres) and quality factor (Q) of RFID and NFC transponders *Bode Analyzer Suite* includes the Fres-Q cursor calculation. By automatically placing three cursors to the resonance peak, *Bode Analyzer Suite* automatically calculates the resonance frequency and quality factor based on the shape of the resonance curve.

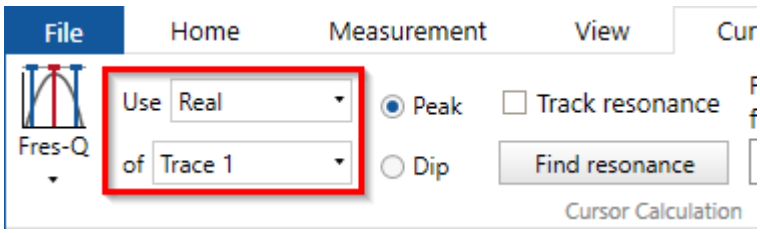
Fres-Q calculation works as follows: *Cursor 2* is placed to the maximum y-value the curve which must correspond to the resonance peak. *Cursor 1* is placed to half the y-value at a lower frequency. *Cursor 3* is placed to half the y-value at higher frequency.
The *Cursor 2* frequency then equals the resonance frequency f_{res}.
The distance between *Cursor 1* and *Cursor 3* equals the bandwidth B.
The quality factor Q is then calculated by:

$$Q = \frac{f_{res}}{B}$$

To measure the resonance frequency and Q-factor of a resonance curve, go to the **cursor ribbon** and select the Fres-Q calculation method as shown below:



As a next step, select the format (Real, Magnitude or Phase) and trace you want to use for the cursor calculation from the ribbon interface as shown in the example below:



In this example we want to calculate the resonance frequency and Q-factor based on the Real part of the values in Trace 1. As an alternative the Magnitude or Phase can be used. If multiple traces contain values or if a memory is linked to the cursor table, then the calculation can also be applied to these curves.

To start the calculation, click either on the button Find resonance or activate the checkbox ☑ Track resonance. Track resonance will automatically evaluate the calculation and search the resonance peak after each completed sweep.
As a result you should see the three cursor positioned correctly at the resonance curve and the result in the ribbon:

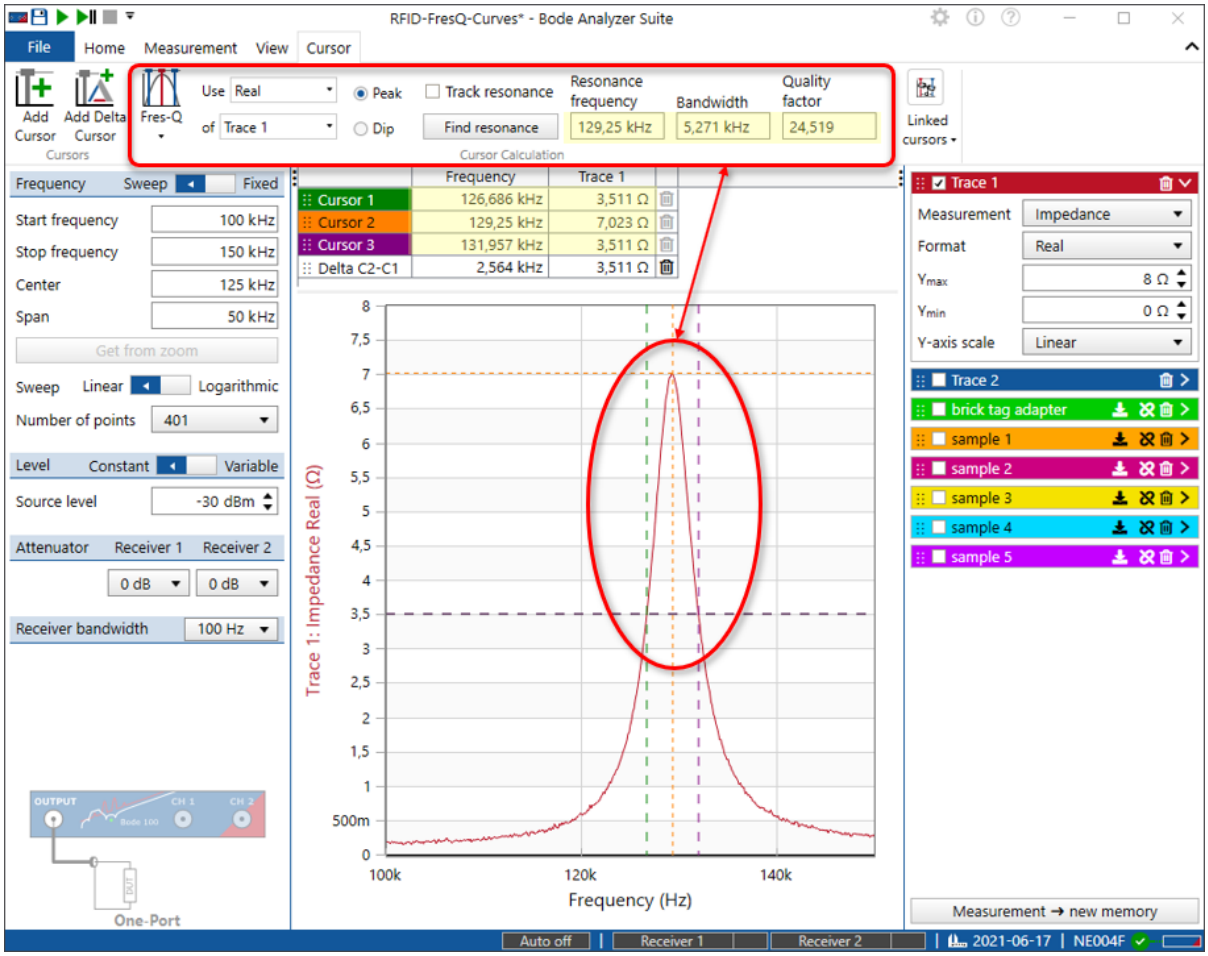


Figure 10-14: Contactless resonance frequency and q-factor measurement of a 125 kHz RFID tag

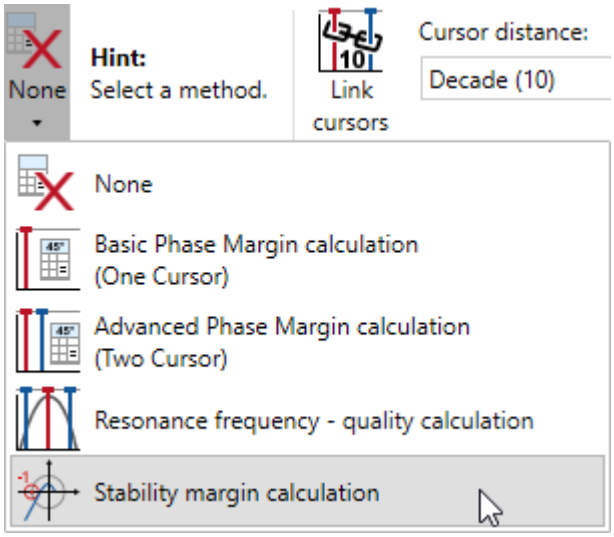
The result in this example indicates a resonance frequency of 129.25 kHz and a Q-factor of 24.5.

To learn more about contactless resonance frequency and Q-factor measurements of RFID transponders, please refer to the corresponding application note available at www.omicron-lab.com/BodeManualAppNotes.

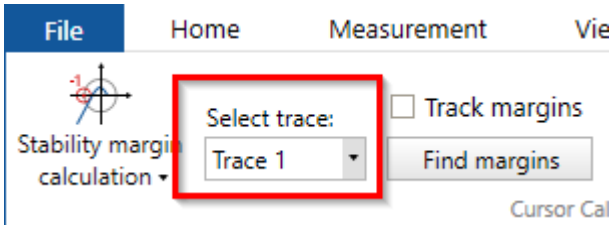
10.7.3 Stability margin calculation

To get quicker stability margin results, *Bode Analyzer Suite* can automatically determine *Phase Margin*, *Gain Margin* & *Vector Stability Margin* using the Stability margin cursor calculation.

To activate stability margin calculation, go to the **cursor ribbon** and select the stability margin calculation method as shown below:



As a next step, select the trace you want to use to derive the stability margin information from. If you want to calculate stability margin from a memory trace, please link the cursor to the memory using the link cursor icon in the memory trace. In the following example we want to calculate the stability margin of the measurement curve in Trace 1:



To start the calculation, click either on the button Find margins or activate the checkbox ☑ Track margins. Track margin will automatically search the stability margins after each completed sweep.
As a result you can see the three cursor positioned at the frequencies of Phase margin, Gain margin and Stability margin. The results are shown in the cursor table and in the cursor ribbon:

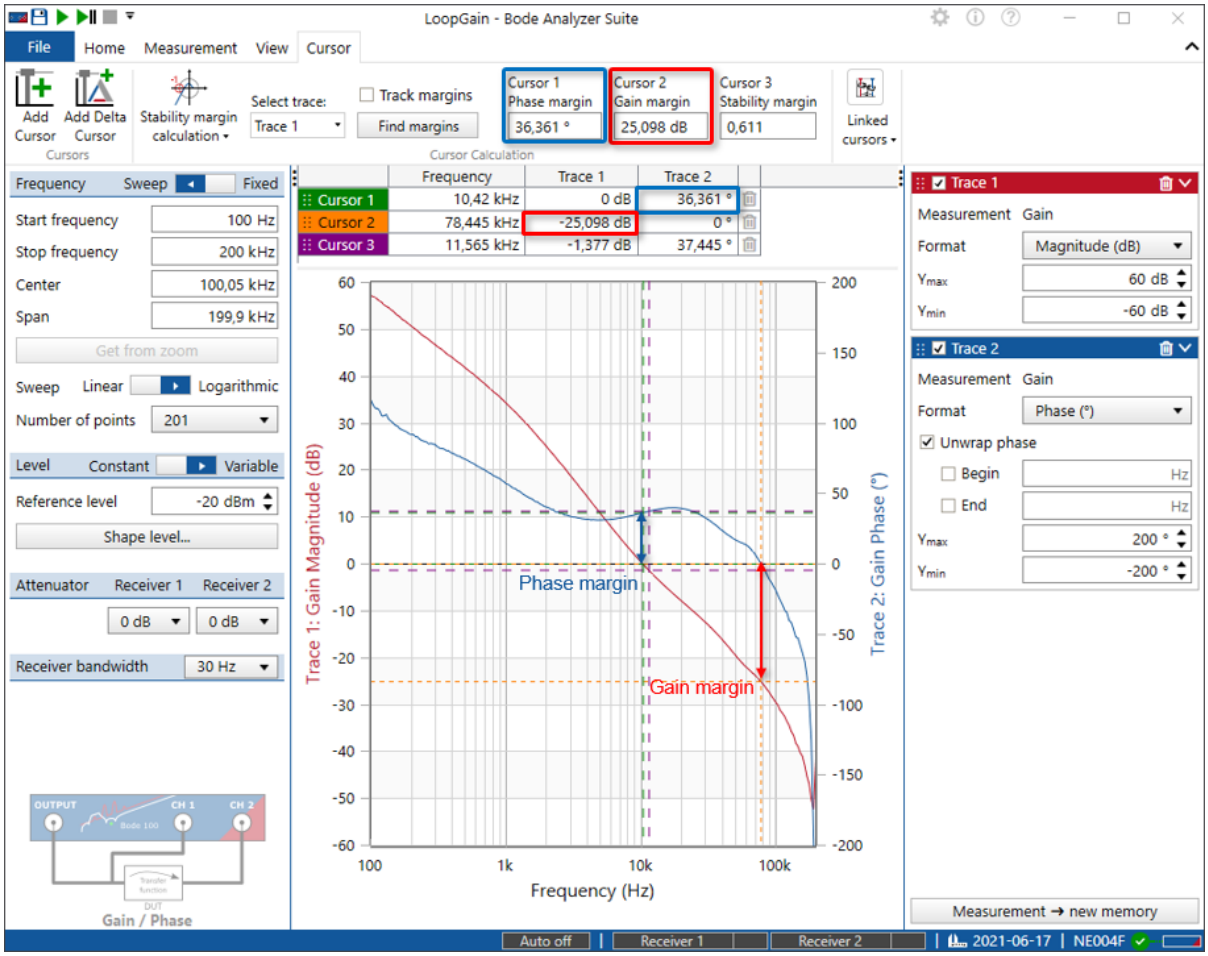


Figure 10-15: Stability margins displayed in the loop gain bode plot of a step-down dc/dc converter.

Besides the Bode diagram, the stability margins are clearly visible in the Nyquist diagram. See next page.

Nyquist Diagram

The stability margins can easily be seen in the Nyquist chart. Set Trace Format to Nyquist to display the Nyquist chart.

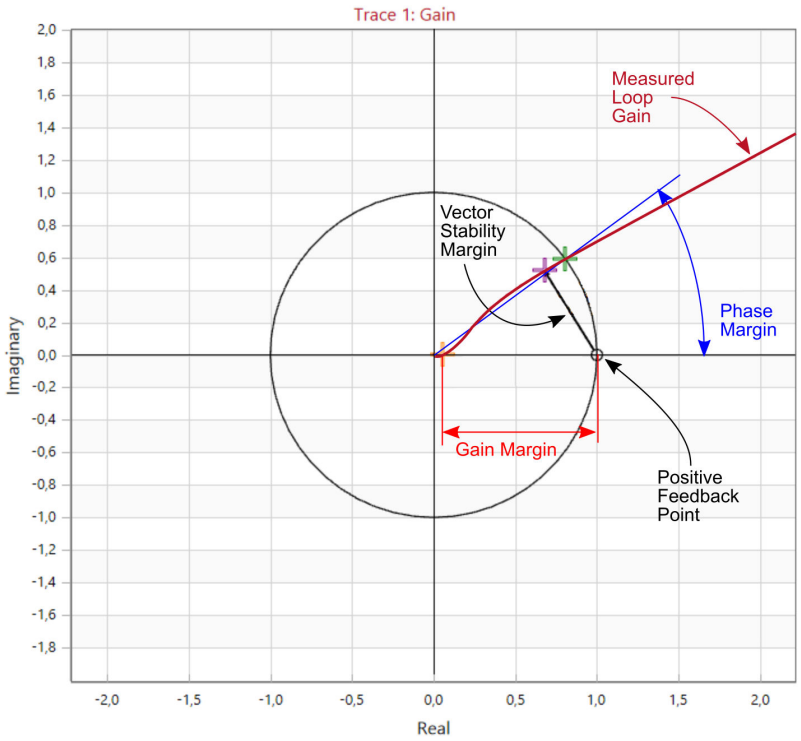


Figure 10-16: Stability margins displayed in the Nyquist chart. Note that the "instability point" is marked at +1.

When measuring loop gain of a negative feedback system using the voltage injection method, 0° measured phase indicates positive feedback. The reason is that the measured signal generally also travels thru the inverting error amplifier, getting an additional 180° phase shift. This is why the instability point is displayed at +1. If you have a case, where the instability point should be at -1, Go to the **Measurement** ribbon and set **Instability Point** to -1.
To learn more about loop gain measurements and stability margin measurements, please check out our webpage: www.omicron-lab.com/BodeManualAppNotes.

10.8 Averaging

Bode Analyzer Suite offers **averaging** to **reduce** measurement **noise**.

Averaging can be activated by clicking on the Average measurement icon  in the **View** ribbon.
When averaging is active, the icon turns green.
The **average factor** influences the averaging method. A **higher** average **factor** offers a **higher noise reduction** but requires more sweeps to complete.
The following figure shows an example where a Gain measurement is averaged (Green icon) and 4 sweeps have already been completed. The average factor is set to 10. Six more sweeps should be completed to achieve the full noise reduction in this case.

You can **increase** or **decrease** the **average factor** during averaging without losing previous measurements.

The following equation shows the implemented averaging algorithm:

$$\bar{x}_n = \frac{x_n}{N} + \left(\bar{x}_{n-1} \cdot \frac{N-1}{N}\right)$$

The new averaged result is calculated using the new measured value and the previous averaged result. N is the average factor that must be ≥2.

The influence of an old measurement will become lower and lower but will never completely disappear (exponentially decaying moving average).
If your measurement result has changed, you can use Reset averaging to restart the averaging and remove the influence of previous measurement results.

Averaging is performed sweep to sweep. This means that at least 2 sweeps are necessary to calculate an averaged result.
Averaging is calculated using the complex measurement result.

Averaging needs to be activated for **Gain** and **Impedance** measurements **separately**!

Memory traces

Whenever you activate averaging, two memory buttons are available to copy data to the memory traces.

Measurement → new memory will copy the measured result to a new memory trace.
Average → new memory will copy the averaged result to a new memory trace.

10.9 Unwrapped phase

The Phase shift between two sine-waves can only be measured between -180° and +180° respectively -π and +π in radians. If the phase shift of a DUT exceeds -180° or +180°, this fact causes a strange-looking phase jump in the diagram.

The following figure shows the Gain and Phase curve of the IF filter DUT delivered with *Bode 100* and *Bode 500*:

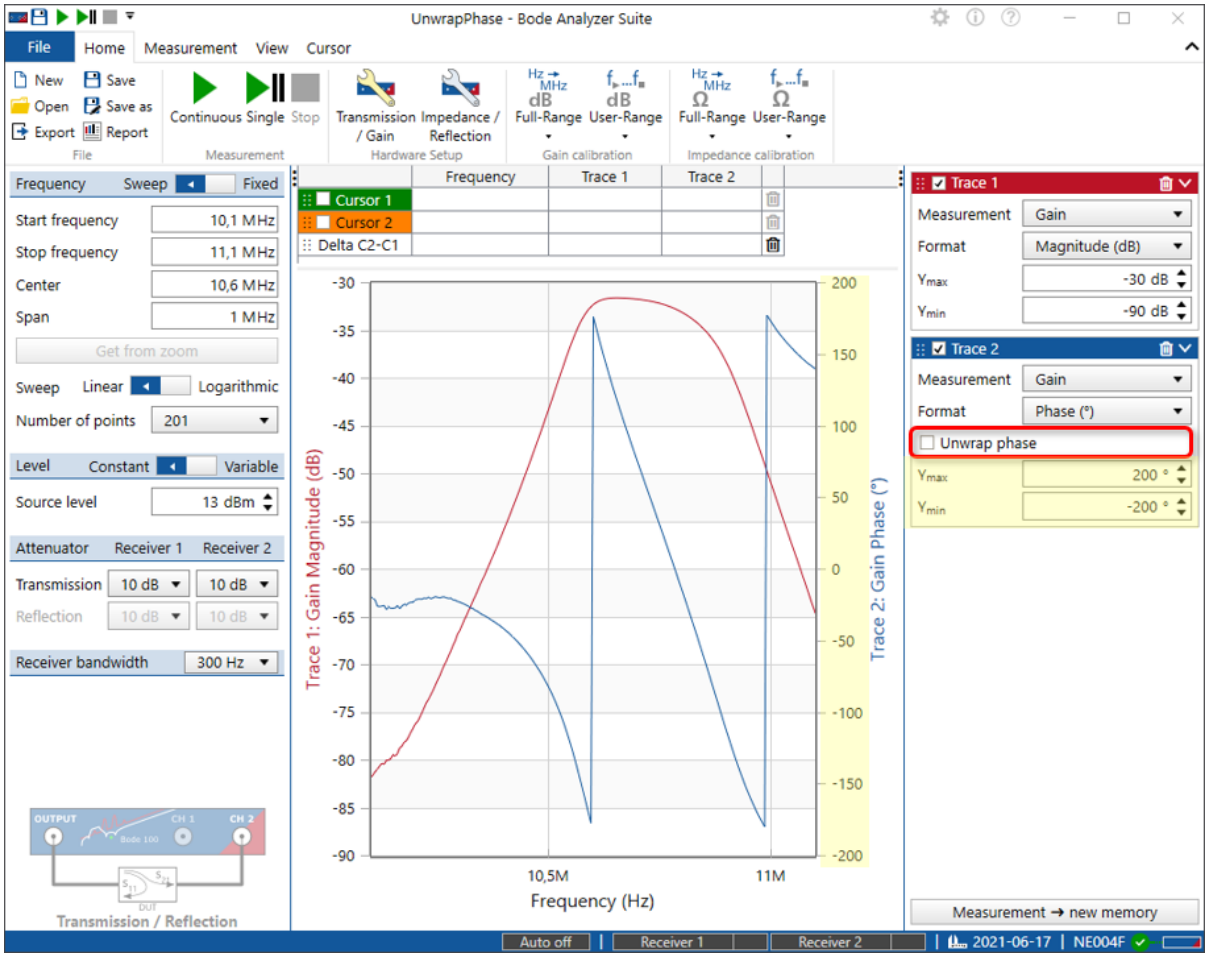


Figure 10-17: Phase-wrap effect caused by the fact that phase can only be measured between -180° and +180°

In some applications, such as the measurement of the total phase shift of a filter, it is useful to continuously display the phase. To do so, activate the Unwrap phase function by clicking the **Unwrap phase** checkbox in the Trace configuration box ☑ Unwrap phase . This leads to an continuos phase display as shown below:

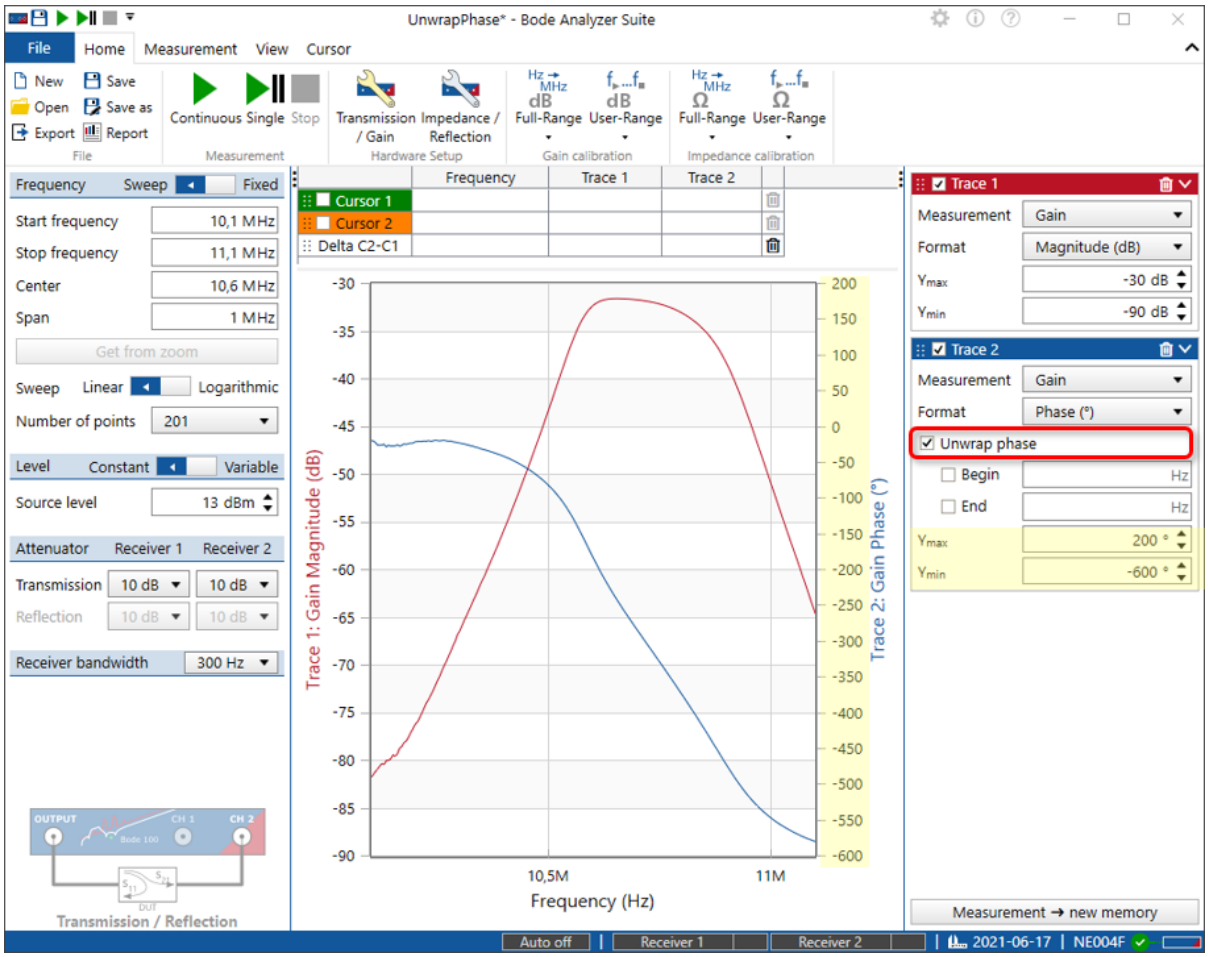


Figure 10-18: Unwrapped phase result shows the total phase shift of the IF filter DUT

Hint: Optionally you can limit the unwrapping to a specific frequency range. Use the Begin and End check boxes and corresponding entry fields to define a frequency range in that the phase shall be unwrapped. This is especially useful when the phase result contains a lot of noise in a specific frequency range.

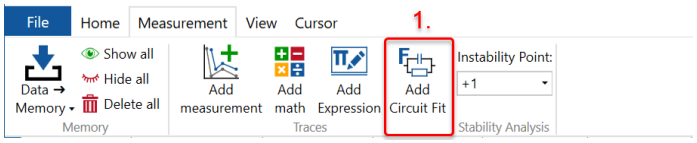
10.10 Circuit Fit

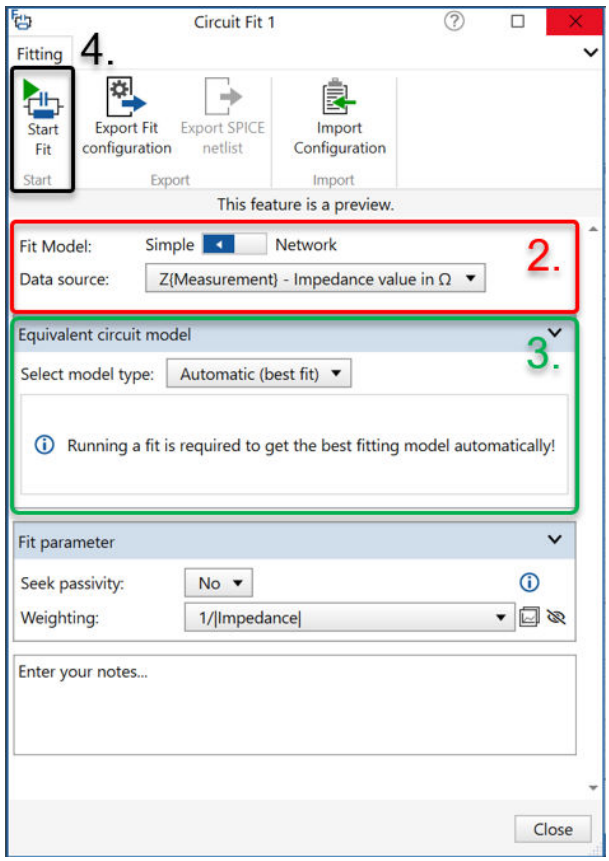
The **Circuit Fit** feature allows you to fit an equivalent circuit model to a measured impedance or admittance curve. The equivalent circuit can either be a **simple model** or a more complex **generic network structure**. This section gives an overview about how to create a circuit fit for impedance or admittance curves using the *Bode Analyzer Suite* and the most important circuit fit functions and calculations.

Let's start with a simple example showing how to fit a simple model to an impedance curve. If you don't have an impedance measurement available, you can use a demo file via File → Open → and then navigating to: "%appdata%\OMICRON_Lab\BodeAnalyzerSuite\DemoFiles". The file we have used here is: **Bode100_ImpAdapt_Inductor.bode3**.

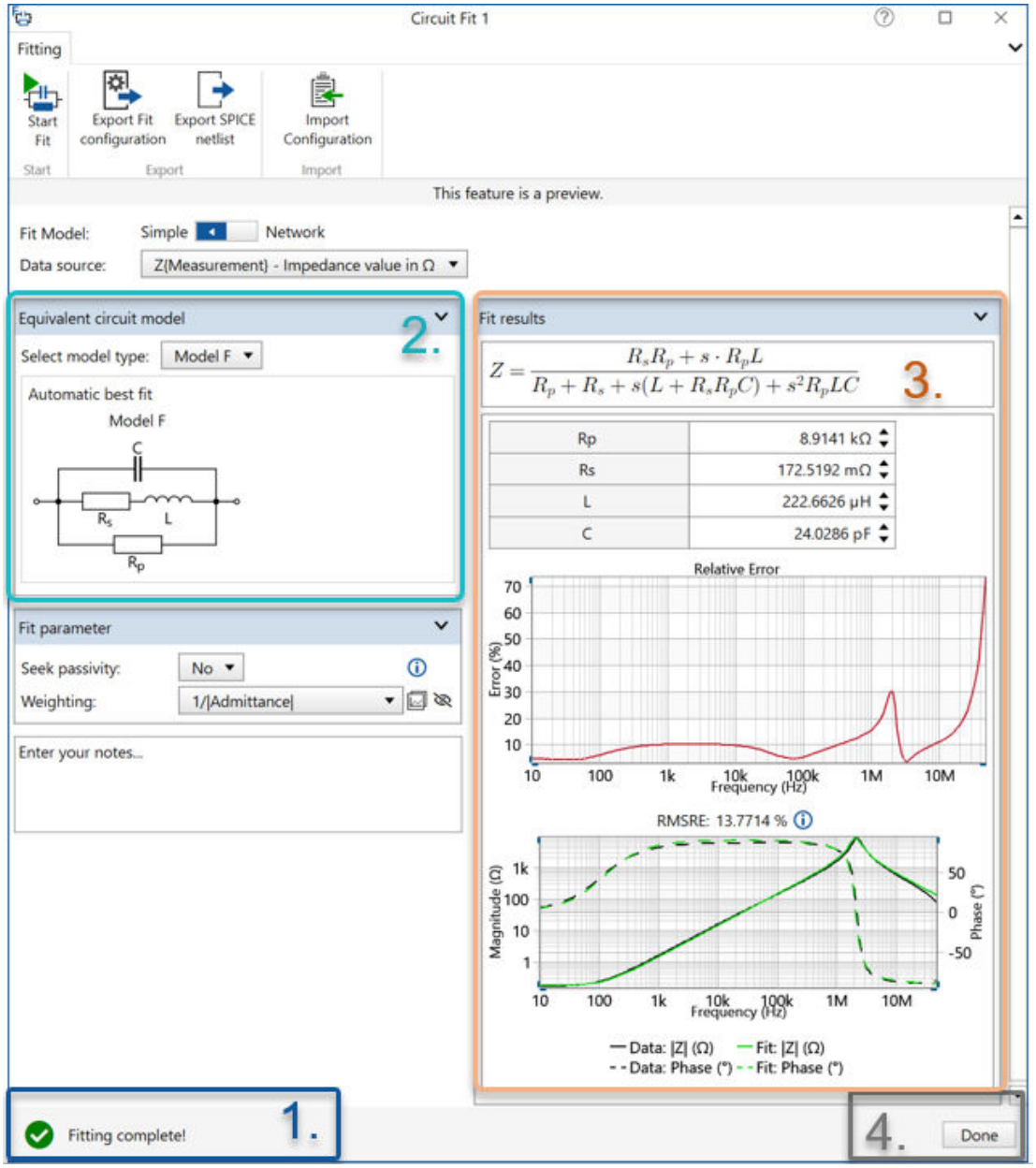
Perform your first simple Circuit Fit

To perform a **Circuit Fit**, go to the **Measurement** ribbon and add a new **Circuit Fit trace** by clicking on the corresponding icon in the ribbon. This automatically opens the circuit fit dialogue and will add a Circuit Fit trace.





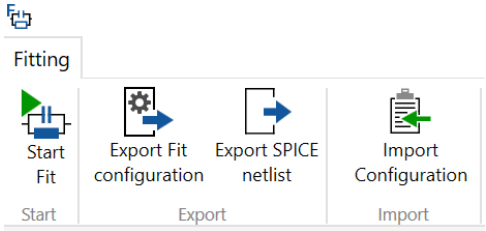
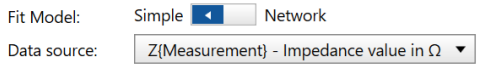
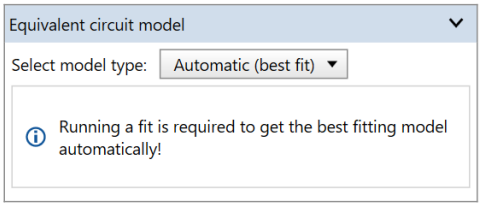
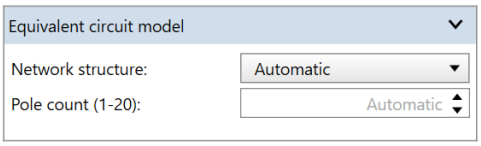
1. Click the **Add Circuit Fit** icon in the Measurement ribbon.
2. Leave the **Fit Model** on **Simple** and select your desired impedance or admittance curve from the **Data Source** list box.
3. For a first try, we recommend to leave the **Model type on Automatic (best fit)**. The algorithm will automatically choose the option of the available pre-defined simple models. For more information on the pre-defined models follow this link.
4. Trigger the circuit fit calculation by pressing the **Start Fit button** on the top of the window.

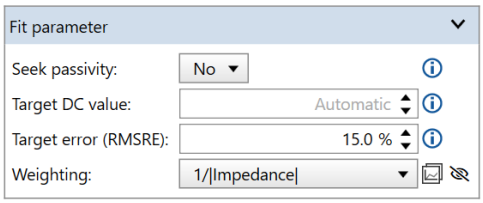


1. A green checkmark is shown in the **Status Bar** if no error has occurred.
2. The model with the smallest **RMSRE Error** will be selected and shown automatically as best fit. For more information of the error calculation see RMSRE Error Calculation.
3. The **Fit Results** are shown on the right side of the dialogue as transfer function representation, result table, relative error chart, RMSRE error and fit result chart to compare with the selected data source. You can adjust the model parameters by changing them in the result table if needed.
4. If you are happy with the result, press **Done**. The Circuit Fit window will be closed, and the circuit trace will be shown in the chart (BAS main window).

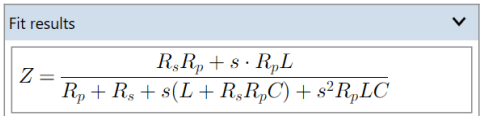
The fit calculation is done in the cloud and requires an active internet connection as well as a connected *Bode 100* or *Bode 500* device.

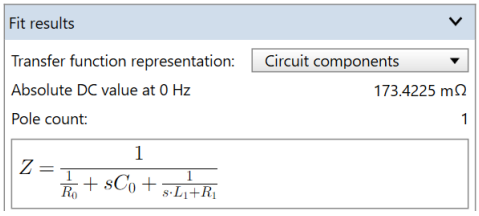
Circuit Fit settings

Ribbon elements 	**Start Fit button** to perform a fit and to get the fit results. The settings are sent to an external circuit fit server (Azure), which calculates the corresponding fit and sends the results for further calculations back to the *Bode Analyzer Suite*.
	Export Fit Configuration button to save the fit settings (without measurement and result) to a .fit file.
	Export SPICE Netlist button to export a fitted circuit model to a SPICE netlist.
	Import Configurations button to import a .fit configuration setting file.
General settings 	**Fit Model:** Select between **pre-defined** (**Simple**) models and a generic **Network** structure
	Data Source: Depending on the available Measurement and Memory traces, select the impedance {Z} or admittance {Y} data as input for your circuit fit. Expression and Math traces cannot be selected as data source. Copy their results to a Memory first if you want to use them as base for a Circuit Fit. A trace needs Impedance/Admittance results to be used in the Circuit Fit.
Simple equivalent circuit models 	**Select model type:** • **Automatic (best fit):** Returns the best fit based on the model with the smallest **RMSRE Error**. • **Alternatively,** select one of the **pre-defined models Model A-H** to perform a fit on a specific model.
Network-structure model 	**Network structure:** • **Automatic:** Returns the structure with the lowest **RMSRE Error**. • **Alternatively,** choose between a **Parallel or Series Network** structure to perform a fit on a specific structure.
	Pole count (1-20): Defines the number of poles used for the network fit. • **Empty field = Automatic:** The fitting algorithm increases the number of poles automatically until the target error is achieved.

	• **Alternatively,** enter a pole count number between 1 and 20 to define the model complexity. In this case no target error is needed.
Fit parameter 	**Seek passivity:** If seek passivity is active (Yes), the fitting algorithm tries to make all components of the equivalent circuit positive. The fit will be better if you allow negative values.
	Target DC value: Target DC value is the desired value of the model at 0 Hz. • **Empty field = Automatic:** The resulting DC value will be shown in the Fit results view. • **Alternatively,** enter a DC value in Ω to give the algorithm a target value. For capacitor fitting, enter a high value, for inductor fitting, enter the DC resistance.
	Target error (RMSRE): Define the Target RMSRE Error for the automatic pole count. Target error only available for Network fitting if the Pole Count setting is set to Automatic.
	Weighting: The weighting curve can be shown as diagram by pressing the eye button next to the weighting selection. • **Pre-defined weighting methods** are available: 1/|Data|; 1/(|Data|)^2; 1/sqrt(|Data|). • **Alternatively,** define your own weighting curve over frequency. To do so, select **Manual weightingor press the Copy Current Selected Weighting Curve button**. In both cases the weighting chart will be shown automatically. Points can be added by double clicking on the chart. Added points can be moved by mouse-dragging or deleted using the mouse over context menu. The *Equivalent Circuit Model type* defines if Impedance or Admittance is used as base for the weighting.
	Comment field: A text field to your enter notes.

Circuit Fit result view

Transfer function for simple model 	The result of the Simple circuit model is presented as a transfer function of the model with the circuit components. The unit of the transfer function depends of the selected Data Source (Impedance Z or Admittance Y).
Transfer function for network structure	The transfer function of the network model can be shown in the following forms:



- Circuit components
- Partial fraction
- Polynomial
- Factorized (Zero-Pole)

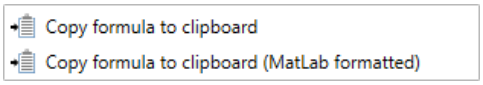
The unit of the transfer function depends of the selected Data Source (Impedance Z or Admittance Y).

The transformation from one format to the other can slightly change the results.

Absolute DC value at 0 Hz: Shows the result of the transfer function at DC (0 Hz).

Pole count: Shows the number of poles in the resulting model.

Copy transfer function to clipboard



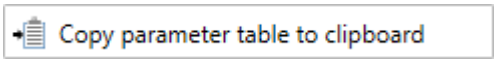
Right mouse click on the transfer function equation opens context menu to **copy the transfer function** formula for further processing.

Fit result table

Rp	8.9141 kΩ
Rs	172.5192 mΩ
L	222.6626 µH
C	24.0286 pF

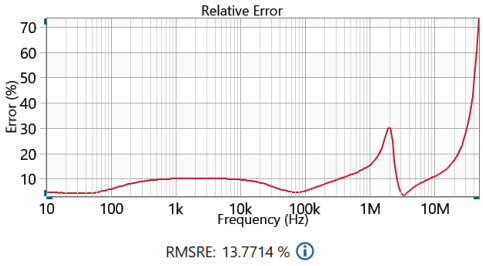
The **Fit result table** shows the values of the transfer function parameters.

Right mouse click on the result table opens the context menu to copy to copy the result parameter to clipboard.



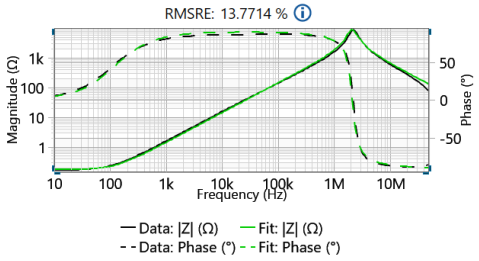
The values can be modified using the up/down arrows or by entering a value.

Relative Error chart



The **Relative Error chart** shows the relative error between data and model in % over frequency.

Fit Result chart



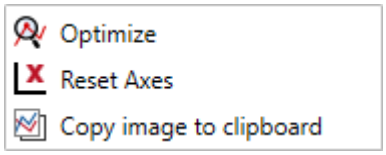
The **Fit Result chart** shows the Bode diagram of the data source and the fitted model by overlaying two curves.

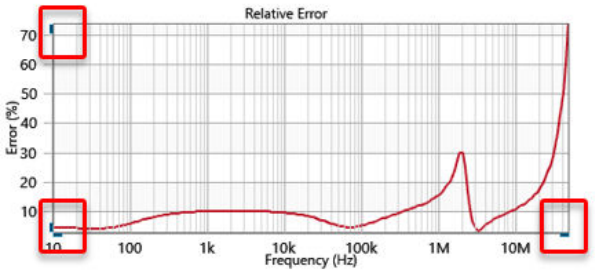
Additionally, the **RMSRE Error** is shown above the chart. See RMSRE Error Calculation for more information

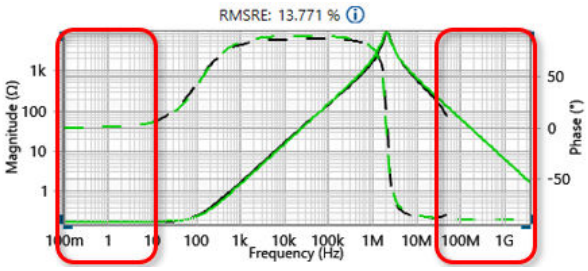
Chart configuration options

The following interactions are available for the weighting chart, the relative error chart and the fit result chart via the context menu or direct mouse-interaction:

- **Zooming** (for more information see the following example on "How to zoom a measurement curve")
- **Optimize** the chart axes range
- **Reset Axes** to the default settings
- **Copy image to clipboard**
- Modify the **Axes** Xmin/Xmax and Ymin/Ymax by mouse via the rectangles at the axis start and end points







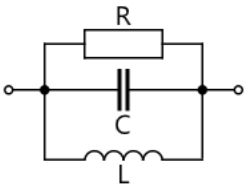
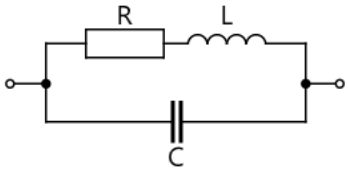
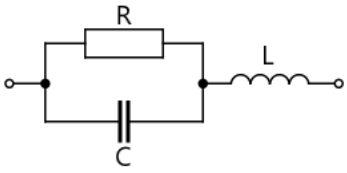
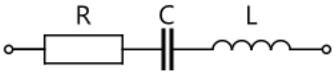
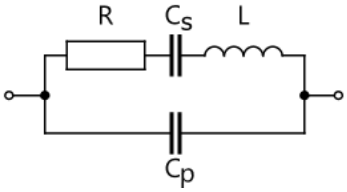
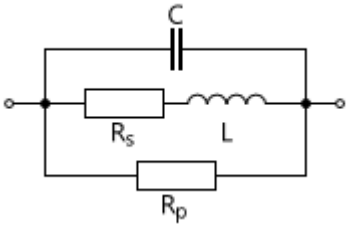
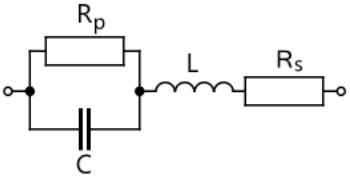
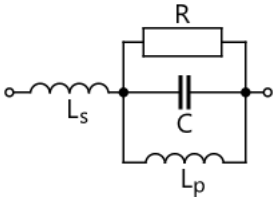
The fit result curve is calculated for two decades below the start frequency and above the stop frequency. Use the mouse to look outside the frequency range of the data source.

RMSRE error calculation

To find a good fit, the fitting feature uses a **Root Mean Square Relative Error (RMSRE)** as a measure for the total error between the data source and the model result. It is calculated as follows:
Assuming the measured complex points are $Z_1,\ldots,Z_n$ with n measured frequency points at frequencies $f_1,\ldots,f_n$. The function g is the fitted function which approximates the measured complex points. The Root Mean Square Relative Error is then calculated by:

$$RMSRE = \sqrt{\sum_{i=1}^{n}\left(\frac{|Z_i - g(f_i)|}{|Z_i|}\right)^2 / n}$$

Pre-defined simple model types

Model A		Simple parallel equivalent circuit model with one parallel loss resistor. Can be used to model a parallel resonator showing an impedance peak. Typically used for inductors with high core loss.
Model B		Parallel equivalent circuit model with one series resistor as loss element in series with the inductor. Can be used to model resistors or inductors
Model C		Series resonance circuit with one parallel resistor as loss element in parallel with the capacitor. Can be used to model high value resistors.
Model D		Series resonator with one series loss resistor. Typically used to model low-loss capacitors.
Model E		Quartz resonator equivalent circuit used to model crystals and ceramics with two resonance frequencies.
Model F		Parallel equivalent circuit model with series and parallel loss element. Often used to model inductors.
Model G		Series equivalent circuit model with series and parallel loss element. Often used to model capacitors.
Model H		Resonator model with three storage elements and one parallel loss element.

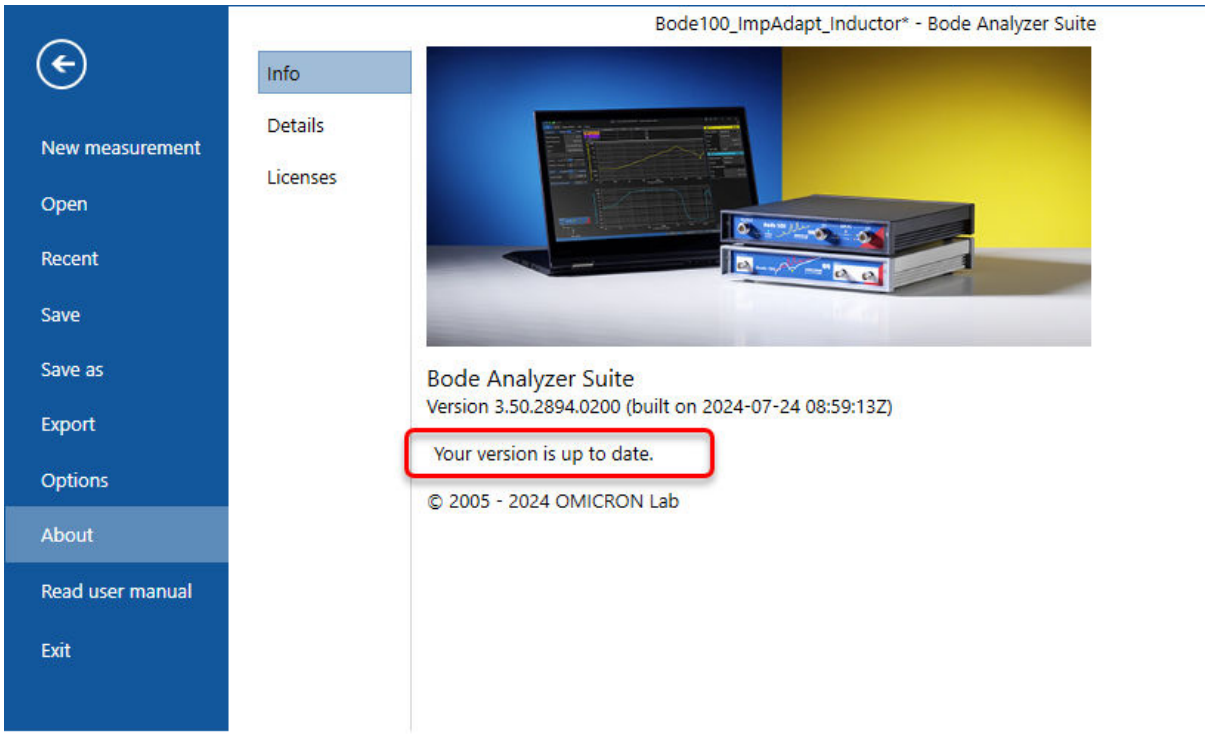
10.11 Shortcuts

The following table gives an overview about the available shortcuts for **Bode Analyzer Suite**.

Command	Shortcut Key(s)
Create a new measurement (.bode3 file)	CTRL+N
Open existing bode file	CTRL+O
Export current measurement settings and results This command opens the export dialogue with different export options available in the Bode Analyzer Suite.	CTRL+E
Save current measurement to .bode3 file. Opens the save as dialogue if the measurement is saved for the first time.	CTRL+S
Open the report setting dialogue to generate a PDF report	CTRL+R
Start "Single" measurement	F6
Start "Continuous" measurement	F5
Stop currently running measurement	F7
Create memory from current measurement results (add new Memory trace)	CTRL+M
Delete Measurement trace data (clear results)	CTRL+D

10.12 Check for updates

To check if your *Bode Analyzer Suite* is up to date, click on the info icon . This will enter the info pane and check for available updates. If your version is up to date, this will be indicated as shown below:



If a newer version is available, the *Bode Analyzer Suite* will inform you by showing an information screen.

11 Automating measurements

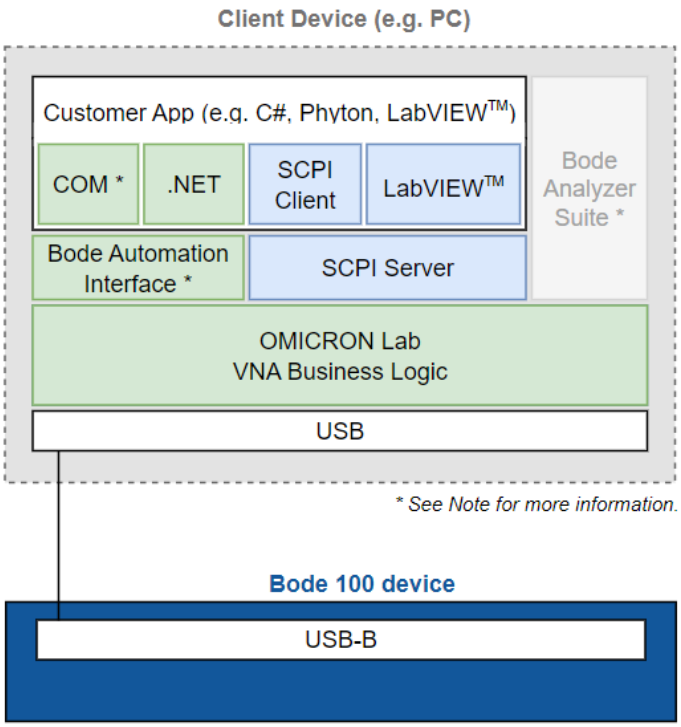
Besides using the *Bode Analyzer Suite*, the *Bode 100* and *Bode 500* can also be controlled via different interfaces to automate your measurement. For more details on measurement automation, please also refer to the our online documentation at: www.omicron-lab.com/BodeAutomationInterfaceHelp

Automating Measurements using the Bode 100

The *Bode 100* can either be accessed via it's proprietary Automation Interface or via a SCPI interface. The Automation Interface is a object oriented API written in .NET, available for .NET programming languages as well as OLE COM compliant programming languages on Windows.

Accessing the Automation Interface via COM is not recommended for new developments, since .NET technology is evolving away from COM.

The *Bode 100* requires a client computer with the OMICRON Lab VNA business logic and the required USB drivers installed. The USB drivers are required to enable communication between the client computer and the *Bode 100* hardware. The OMICRON Lab VNA business logic is needed to generate measurement results and controls the *Bode 100* hardware via USB.
On a Windows computer, the *Bode Analyzer Suite* installer will automatically install the necessary USB drivers and VNA business logic. The installer is available on our OMICRON Lab Bode Analyzer Suite Download Area. On a Linux-based computer, you need to install the USB drivers and VNA business logic manually. You can download a Linux package from the OMICRON Lab Bode Analyzer Suite Download Area.
The following diagram shows the software architecture and structure of the available interfaces for automated measurements using the *Bode 100*.



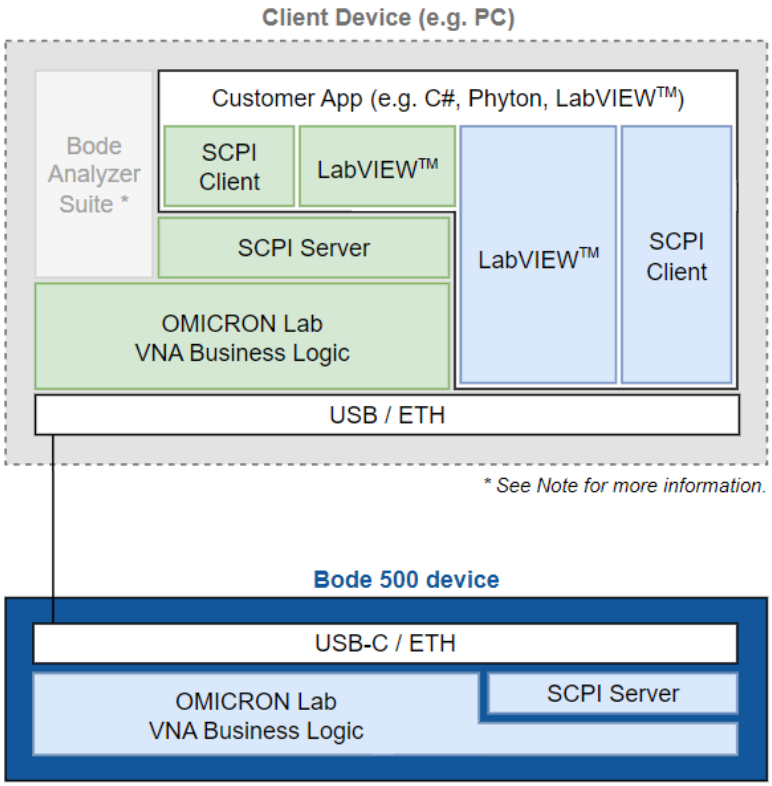
The following options are available for controlling your *Bode 100* device and performing automated measurements:

- **SCPI Interface** (Standard Commands for Programmable Instruments): The SCPI server can be started on the client computer, providing an interface to control the *Bode Analyzer Suite* using SCPI commands.
- **Bode Automation Interface**: Access the automation interface natively from any .NET programming language or via the Windows COM interface.
- **LabVIEW™** software

- *Bode Analyzer Suite* and Bode Automation Interface are only available for Windows.
- Using COM is not recommended for new developments. We recommend using the SCPI interface instead.

Automating Measurements using the Bode 500

The *Bode 500* can be accessed via the SCPI interface.
The OMICRON Lab VNA business logic is part of the *Bode 500*device. This allows direct control of the *Bode 500* without the need for additional OMICRON Lab software to be installed on the client device.
The following diagram shows the software architecture for automated measurements using the *Bode 500*.



The following options are available to control your *Bode 500* device and perform automated measurements:

- **SCPI Interface** (Standard Commands for Programmable Instruments): The SCPI server is part of the *Bode 500* device. It is started per default. If needed, you can start or stop the SCPI server using the*Bode 500 Web-interface* on page 186.
- **LabVIEW** ™ software

- We recommend accessing the SCPI server directly on the *Bode 500* device (see image - highlighted in blue), since it does not require the OMICRON Lab VNA Business Logic installed on the client device.

Bode Automation Interface

The *Bode Automation Interface* is a software interface that allows you to control *Bode 100* via an object-oriented API from .NET based programming languages. You can use the Automation Interface in form of the NuGet package **OmicronLab.VectorNetworkAnalysis.AutomationInterface**.
Besides native .NET access, the *Bode Automation Interface* can also be accessed via the Microsoft inter-process communication technology COM, using any COM compliant programming language.

- Using **COM** is not recommended for new developments. We recommend using the **SCPI interface** instead.
- *Bode Automation Interface* is not available for *Bode 500* devices. Use the SCPI interface for automating measurements on the *Bode 500*.

SCPI Interface

Bode 100 as well as *Bode 500* can be controlled using SCPI commands. For more information on the SCPI functions, please refer to www.omicron-lab.com/BodeAutomationInterfaceHelp.
Using SCPI offers the possibility to control the *Bode 100* as well as *Bode 500* from e.g. Linux without the need to use .NET or COM. For more information on that, please contact us (see: Support).

No GUI functions are included in the SCPI interface. Only the raw measurement data can be accessed. Only single Channel and single Trace measurements are possible.

LabVIEW ™

A LabVIEW ™ instrument driver is available for the *Bode 100*. Please use the latest driver 3.50 or newer. The driver is available from www.ni.com.
A driver for *Bode 500* is under development. Please contact us for more information (see: Support).

12 Bode 500 web interface

The *Bode 500* device includes a web interface that can be used to configure settings like:

- Network configuration (Ethernet and USB).
- Device name and description.
- LED color and brightness.
- Password protection, and more...

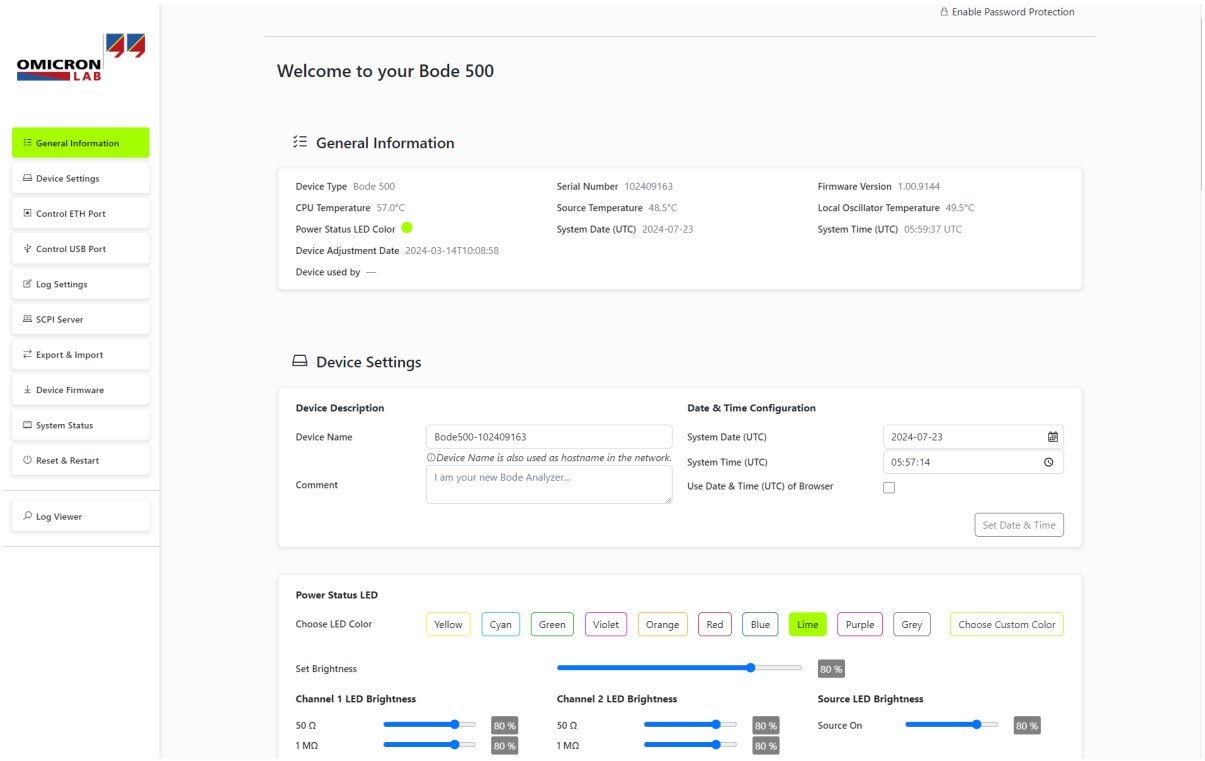
Reach the web interface

To reach the web interface of your *Bode 500*, follow the steps outlined below:

1. Connect the *Bode 500* to your client device or network using the USB or Ethernet connection.
2. Enter the URL **http://*Hostname*** in the address bar of your web browser and press enter. Hostname is the human-readable identifier for the *Bode 500* device. Each *Bode 500* device comes with the default hostname: **Bode500-*SerialNumber*** where ***SerialNumber*** is the 9-digit serial number of your *Bode 500*.
3. This should lead you to the web-interface of your *Bode 500* device.

To avoid possible connection interferences, use only **one** connection (USB or Ethernet) and do not switch between USB and Ethernet during a session.
In case of any connection problems check out *Bode 500* Troubleshooting.

After accessing the *Bode 500* Web Interface you will see the following screen:

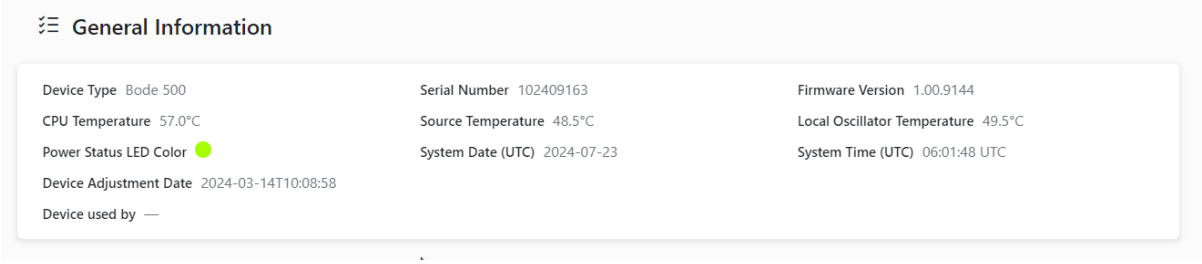


If needed, you can enable a password protection by setting a password. This function is available in the top-right corner of the *Bode 500* Web Interface. The password protection is disabled per default.

- After disabling the password protection, a new password will be required to enable the protection again.
- Changes of the configurations and parameters will be only valid after saving. A **Save** button is visible in the right bottom corner of the web browser window if unsaved changes are available.
- If necessary, reset your changes using the Factory Reset option. This resets all changes including the Device Name (=Hostname) and brings the device back to the factory delivery state.

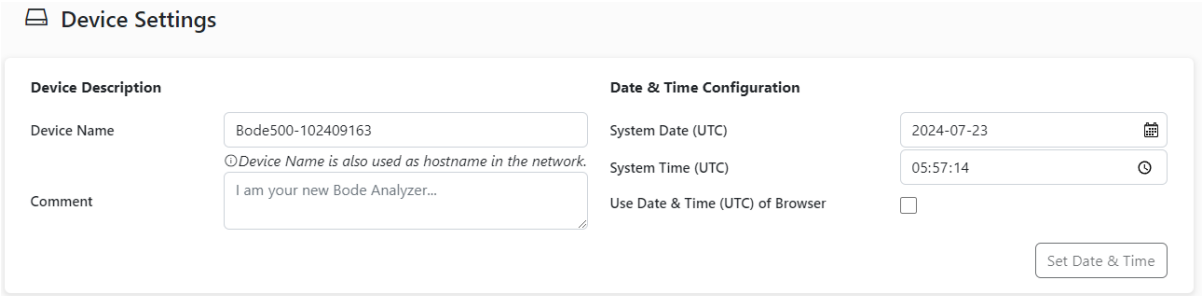
General Information section

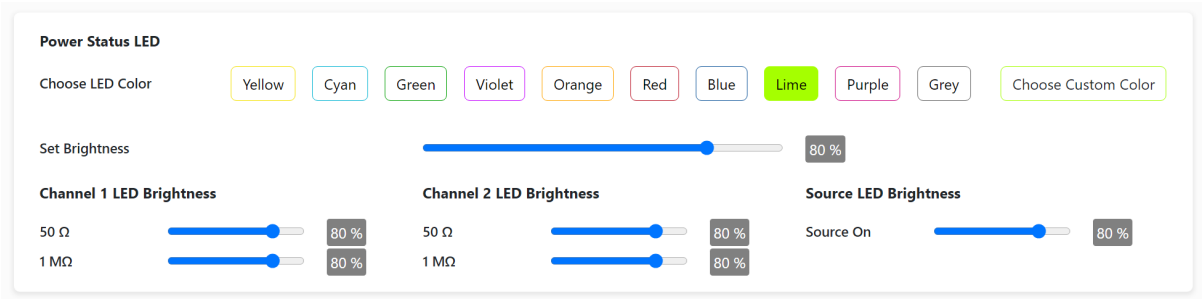
This section includes information about your *Bode 500*, such as serial number, firmware version, device temperatures and the device adjustment date. The data in this section is read only and cannot be changed.



Device Settings section

The **Device Settings** section includes the following settings:





Device Name	Each *Bode 500* device comes with the **default Device Name**: **Bode500-*SerialNumber***, where ***SerialNumber*** is the 9-digit serial number of your *Bode 500*. The **Device Name** is also used as the **Hostname**. The hostname is the human-readable identifier for your *Bode 500* and it can be used to access the web interface instead of using the IP address. You can change the **Device Name** but please note, that this change affects the URL address for accessing your *Bode 500* web-interface.
Device Date & Time	• **System Date (UTC):** Date of your *Bode 500* device in UTC. • **System Time (UTC):** Time of your *Bode 500* device in UTC. System date and time changes are only saved on the *Bode 500* device if the **Set Date & Time** button is pressed.
Comment	The Comment text is shown in the *Device Detection and Selection* dialogue of the *Bode Analyzer Suite*.
LED Configuration	• **Power Status LED:** Customizes the color or brightness of the power status LED. The color is used as indicator for your *Bode 500* shown in the *Device Detection and Selection* dialogue of the *Bode Analyzer Suite* • **Channel and Source LED:** Customizes the brightness of the *Bode 500* Channel 1 LED, Channel 2 LED or Source LED. The LEDs are located on the front panel of the *Bode 500* device. For more information on the meaning of the LEDs see *Bode 500 Connectors*.

Control ETH and USB Port

These two sections allow you to change the IPv4 settings of the network interfaces (ETH and USB).

Please be careful when changing the network interface settings as you could lose connection to the device.

Log Settings

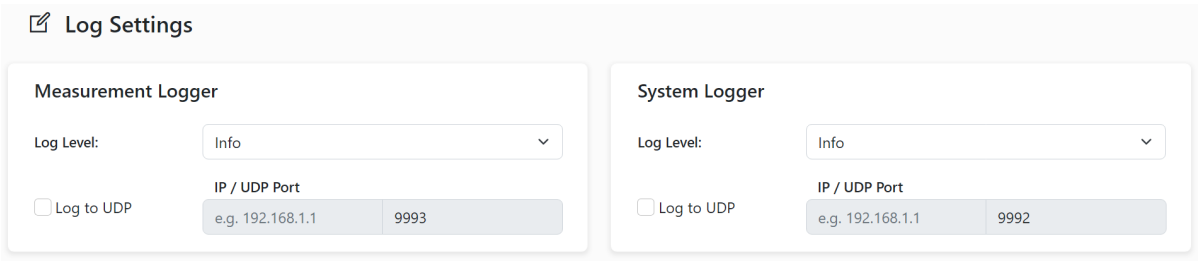
The **Log Settings** section allows to customs the logging of the *Bode 500*.

Two different loggers are available:

- **Measurement Logger**, which includes all measurement relevant log events.
- **System Logger**, which includes all device and system relevant log events.

For each logger it is possible to set a specific log level such as information, warnings or error.

The Measurement and System Log files are stored on *Bode 500* device RAM. The log files are deleted if the *Bode 500* device is restarted.



SCPI Server

The SCPI server is part of the *Bode 500* device. It is enabled and thus started per default. If needed, stop the SCPI server by disabling the SCPI server setting.

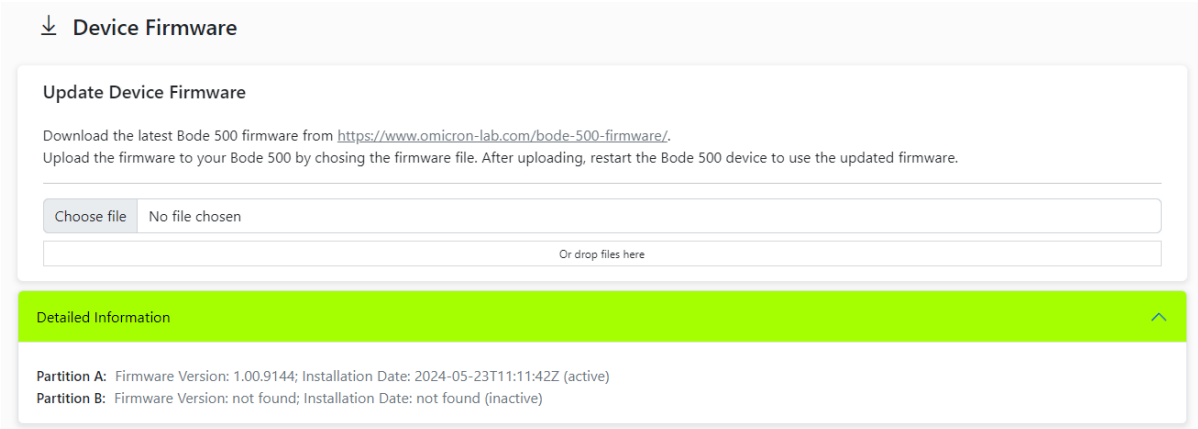
The SCPI server will be started or stopped immediately after changing and saving the SCPI server setting. The SCPI server is reachable on port number 5025 via the IPv4-address of the Control ETH or USB Port.

Export & Import

This section allows to export or import the configuration and user data of your *Bode 500* as a file. The configuration includes all settings from the web-interface. The user data includes calibration data from a calibration that has been stored on the device using the corresponding SCPI command.

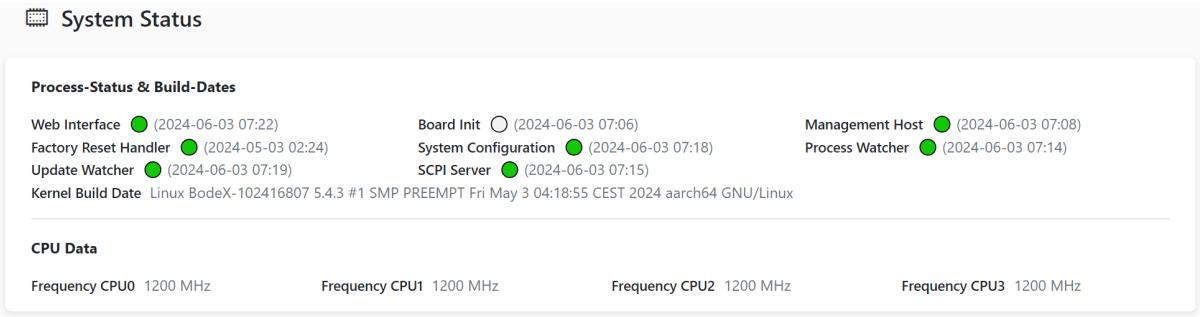
Device Firmware

The **Device Firmware** section offers the possibility to update the device firmware of your *Bode 500*. Before updating, download the latest *Bode 500* firmware update bundle from https://www.omicron-lab.com/bode-500-firmware.
After you have downloaded the update bundle to your computer, you can initiate the firmware upload from the web-interface by choosing the firmware file.
After a successful firmware upload you need to restart the *Bode 500* device.
There are two partitions available, A and B. The new uploaded firmware is always loaded to the inactive partition. After a successful upload and restart the just updated partition will get active and the previously used one will get inactive.



System Status

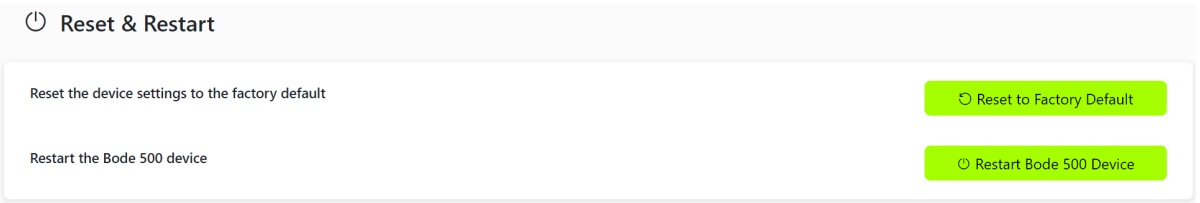
This section includes system status information of your *Bode 500* such as CPU data, build dates and process status. This information read only and cannot be changed.



Reset & Restart

This section allows to

- **Reset** the *Bode 500* device to the default factory settings.
- **Restart** the *Bode 500* device.



The **Reset** operation **resets all changes including the Device Name (=Hostname)** and brings the device back to the factory delivery state.

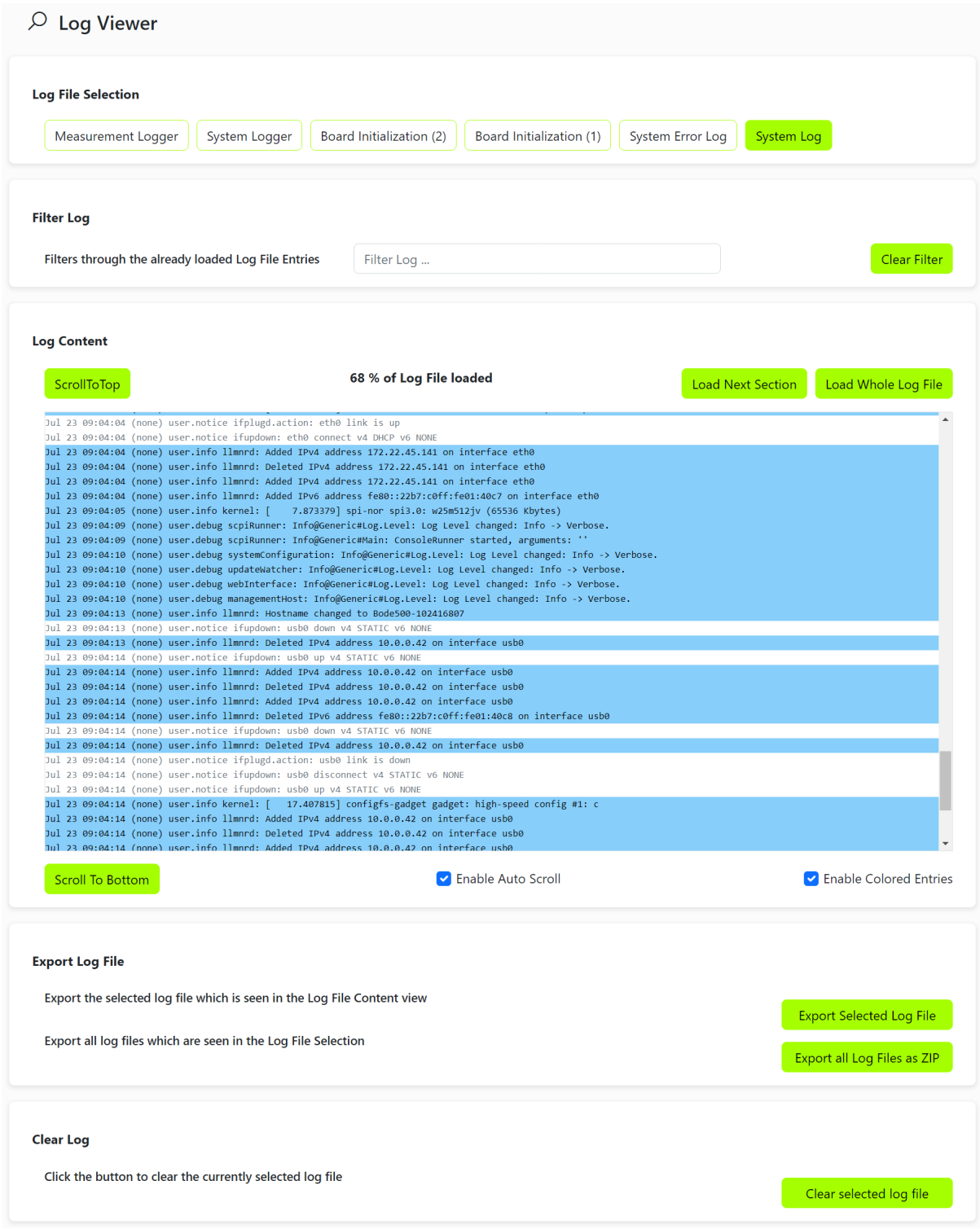
Log Viewer

The **Bode 500 Web Interface** comes with its own **Log Viewer**. It can be accessed by clicking on the **Log Viewer** button in the left navigation bar. Different log viewer functions are available here:

- List of log files (**Log File Selection**) available on your *Bode 500* device to select for analysis

  The Measurement and System Log files are stored on *Bode 500* device RAM. The log files are deleted if the *Bode 500* device is restarted.

- Filter function (**Filter Log**) to search for a specific log file entry of the selected and loaded log file
- **Log Content** view of selected log file with different scrolling and highlighting (coloring) functionalities
- **Export** the currently selected log file or all log files available in the log file list
- **Clear** the currently selected log file to empty the log content view


Log Viewer
Log File Selection
Measurement Logger
System Logger
Board Initialization (2)
Board Initialization (1)
System Error Log
System Log
Filter Log
Filters through the already loaded Log File Entries
Filter Log ...
Clear Filter
Log Content
ScrollToTop
68 % of Log File loaded
Load Next Section
Load Whole Log File
Jul 23 09:04:04 (none) user.notice ifplugd.action: eth0 link is up
Jul 23 09:04:04 (none) user.notice ifupdown: eth0 connect v4 DHCP v6 NONE
Jul 23 09:04:04 (none) user.info llmnrd: Added IPv4 address 172.22.45.141 on interface eth0
Jul 23 09:04:04 (none) user.info llmnrd: Deleted IPv4 address 172.22.45.141 on interface eth0
Jul 23 09:04:04 (none) user.info llmnrd: Added IPv4 address 172.22.45.141 on interface eth0
Jul 23 09:04:04 (none) user.info llmnrd: Added IPv6 address fe80::22b7:c0ff:fe01:40c7 on interface eth0
Jul 23 09:04:05 (none) user.info kernel: [7.873379] spi-nor spi3.0: w25m512jv (65536 Kbytes)
Jul 23 09:04:09 (none) user.debug scpiRunner: Info@Generic#Log.Level: Log Level changed: Info -> Verbose.
Jul 23 09:04:09 (none) user.debug scpiRunner: Info@Generic#Main: ConsoleRunner started, arguments: ''
Jul 23 09:04:10 (none) user.debug systemConfiguration: Info@Generic#Log.Level: Log Level changed: Info -> Verbose.
Jul 23 09:04:10 (none) user.debug updateWatcher: Info@Generic#Log.Level: Log Level changed: Info -> Verbose.
Jul 23 09:04:10 (none) user.debug webInterface: Info@Generic#Log.Level: Log Level changed: Info -> Verbose.
Jul 23 09:04:10 (none) user.debug managementHost: Info@Generic#Log.Level: Log Level changed: Info -> Verbose.
Jul 23 09:04:13 (none) user.info llmnrd: Hostname changed to Bode500-102416807
Jul 23 09:04:13 (none) user.notice ifupdown: usb0 down v4 STATIC v6 NONE
Jul 23 09:04:13 (none) user.info llmnrd: Deleted IPv4 address 10.0.0.42 on interface usb0
Jul 23 09:04:14 (none) user.notice ifupdown: usb0 up v4 STATIC v6 NONE
Jul 23 09:04:14 (none) user.info llmnrd: Added IPv4 address 10.0.0.42 on interface usb0
Jul 23 09:04:14 (none) user.info llmnrd: Deleted IPv4 address 10.0.0.42 on interface usb0
Jul 23 09:04:14 (none) user.info llmnrd: Added IPv4 address 10.0.0.42 on interface usb0
Jul 23 09:04:14 (none) user.info llmnrd: Deleted IPv6 address fe80::22b7:c0ff:fe01:40c8 on interface usb0
Jul 23 09:04:14 (none) user.notice ifupdown: usb0 down v4 STATIC v6 NONE
Jul 23 09:04:14 (none) user.info llmnrd: Deleted IPv4 address 10.0.0.42 on interface usb0
Jul 23 09:04:14 (none) user.notice ifplugd.action: usb0 link is down
Jul 23 09:04:14 (none) user.notice ifupdown: usb0 disconnect v4 STATIC v6 NONE
Jul 23 09:04:14 (none) user.notice ifupdown: usb0 up v4 STATIC v6 NONE
Jul 23 09:04:14 (none) user.info kernel: [17.407815] configfs-gadget gadget: high-speed config #1: c
Jul 23 09:04:14 (none) user.info llmnrd: Added IPv4 address 10.0.0.42 on interface usb0
Jul 23 09:04:14 (none) user.info llmnrd: Deleted IPv4 address 10.0.0.42 on interface usb0
Scroll To Bottom
Enable Auto Scroll
Enable Colored Entries
Export Log File
Export the selected log file which is seen in the Log File Content view
Export Selected Log File
Export all log files which are seen in the Log File Selection
Export all Log Files as ZIP
Clear Log
Click the button to clear the currently selected log file
Clear selected log file

13 Troubleshooting

This chapter describes solutions for different troubleshooting scenarios. If the following hints don't help you resolve your issues and you are still experiencing problems, please contact us. We are looking forward to supporting you. Check out OMICRON Lab Support for further information on how to contact us.

13.1 General tips

Software problems

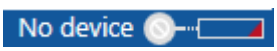
In case you run into software issues such as **crashes** or unexpected behavior, please contact the OMICRON Lab Support.
To help the support team, please include the **log file** of the *Bode Analyzer Suite* in your support request. By default, the log file is located at: *C:\ProgramData\OMICRON_Lab\BodeAnalyzer\Logs\BodeAnalyzerSuite.log*. Note that C:\ProgramData is typically a hidden folder on your computer. For the *Bode 500* the log files can be accessed via the web-interface (see web-interface description).

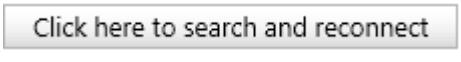
Sometimes graphics card driver issues cause problems in rendering the charts correctly. If you experience chart rendering issues, please update the drivers of your graphics hardware. If this does not resolve your issues, try switching to **software rendering** in the options of *Bode Analyzer Suite*.

Connection issues

In case you are not able to connect to your *Bode 100 or Bode 500*, please perform the following steps:

1. Check if the Power LED at the front panel is on. In case that the LED is not lit, execute the following steps:
   a. Check if the wide-range AC power supply is plugged correctly into the mains socket.
   b. Check if the coaxial DC power connector of the wide-range AC power supply is properly plugged into the *Bode 100 or Bode 500*.
   c. Check the output voltage of the DC connector using a volt-meter. The power supply included in the delivery should provide a voltage of 18 VDC.
2. Check if the communication between the *Bode Analyzer Suite* and the *Bode 100 or Bode 500* has been successfully established. To do so, check if the serial number of your *Bode 100 or Bode 500* is displayed in the start screen (see 6-1 on page 34, or in the right bottom corner of the measurement screen 

(see 6-3 on page 36). If you cannot see the serial number, please check the following:
   a. Check if the communication cable (USB or Ethernet) is properly plugged into your computer and the *Bode 100 or Bode 500*.
   b. Try disconnecting and re-connecting the communication cable and make sure you use the USB cable included in the delivery if you use a USB connection.
   c. Move the mouse over the icon 

in the bottom right corner of the status bar and then click 

.
3. Try re-starting your computer and the *Bode 100 or Bode 500*.

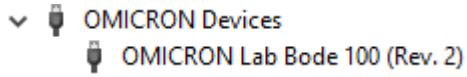
13.2 Tips for Bode 100

If the above mentioned general hints don't help you resolve your issues using your *Bode 100*, please check out the hints below.

Bode 100 specific connection issues

If you still have issues connecting to your *Bode 100*, please check:

1. Try re-installing *Bode Analyzer Suite*. Note that you will need admin rights to install the required USB drivers.
2. Connect your *Bode 100* to the computer and open device manager. You should find the *Bode 100* under OMICRON Devices. If there is a **question mark** or a **warning triangle** icon besides the *Bode 100*, try to right-click it and select **update driver**. This should re-install the USB driver. If the driver is successfully installed, it looks as shown below:



3. Avoid the use of USB hubs and plug your *Bode 100* directly into an USB port of your computer.
4. Try to connect *Bode 100* to a different USB port or a different computer. Some USB 3 ports cause issues with older *Bode 100* Revision 1 devices.
5. The older generation *Bode 100* Revision 1 devices don't work on computers with AMD Ryzen processors. If you face this issue, please use a different computer or contact the OMICRON Lab Support.

13.3 Tips for Bode 500

If the above mentioned general hints don't help you resolve your issues using your *Bode 500*, please check out the hints below.

General issues

If you experience general issues using your *Bode 500*, please check that you use a power supply capable of delivering 24 W. If you use a power supply with less power capability, your *Bode 500* might not start correctly or might occasionally reset if power demand exceeds supply.

The power supply delivered with *Bode 100* is not sufficient to supply a *Bode 500* ! Use only the power supply delivered with your *Bode 500* or a similar device capable of delivering 24 W.

Bode 500 specific connection issues

In case you are still having issues to connect *Bode Analyzer Suite* to your *Bode 500*, we recommend to check if you can reach the web-interface of *Bode 500* by entering the URL **http://*Hostname*** in the address bar of your Internet Explorer.
Each *Bode 500* device came with the same default ***hostname***: **Bode500-*SerialNumber***.
SerialNumber is the 9-digit serial number of your *Bode 500*.
This should lead you to the web-interface of the device.
In the web-interface you can check / change / reset the IP settings of *Bode 500* and configure your *Bode 500* accordingly.

If you cannot reach the web-interface, please check:

1. Try using a different connection interface. If you have used USB, try using Ethernet or vice versa.
2. If none of the interfaces work, check the IP settings of your computer. Note that the following hints are valid for a *Bode 500* in factory-default configuration. If *Bode 500* has been reconfigured, a **factory-reset** might help.
   a. If you connect *Bode 500* to a network via Ethernet, there must be a DHCP server in the network which assigns a valid IP configuration to *Bode 500* and your computer.
   b. If you are connected via USB cable, a virtual network connection (RNDIS) will be established. This interface must be configured to use DHCP. *Bode 500* runs a DHCP server and will assign the IP address to your computer.
   c. If you try to connect *Bode 500* directly to your computer via Ethernet (point-to-point), your computer must act as a DHCP server to enable a connection.

In case you are still having issues to connect *Bode Analyzer Suite* to your *Bode 500*, please remove power from your *Bode 500* and wait for 30 s before you re-power *Bode 500*. During booting of *Bode 500*, please check the following:

1. Check if the green Power / Status LED at the front panel is on and starts to blink after a couple of seconds. The first blinking indicates that the operating system of *Bode 500* has started.
2. As soon as the *Bode 500* is completely initialized, the Power / Status LED switches color and stays on continuously.
3. If the above sequence does not work as described or the re-start did not resolve your connection issues, we recommend that you perform a **factory reset** of your *Bode 500*.

The factory reset will **revert all settings** to it's factory defaults and **delete all user data** stored on the device.

To perform a factory reset of *Bode 500*, follow the steps outlined below:

- Locate the reset button, hidden behind the reset hole at the rear of the device.
- Put a straightened paperclip into the reset hole. Press and hold the switch for a duration of 5 s.
- Release the button and wait until the *Bode 500* restarts.

If all these hints did not help to resolve your issues please contact us. Check out OMICRON Lab Support for further information on how to reach us.

14 Support

When you are working with our products we want to provide you with the greatest possible benefits. If you need any support, we are here to assist you!

Technical Support - Get Support

www.omicron-lab.com/support

support@omicron-lab.com

At our technical support hotline, you can reach well-educated technicians for all of your questions. Competent and free of charge.

Make use of our technical support hotlines:

Americas:	+1 713 830-4660 or +1 800-OMICRON
Asia-Pacific:	+852 3767 5500
Europe / Middle East / Africa:	+43 59495

Additionally, you can find the OMICRON Lab Service Center or Sales Partner closest to you at www.omicron-lab.com → Contact.

OMICRON Lab
OMICRON electronics GmbH, Oberes Ried 1, 6833 Klaus, Austria. +43 59495.

15 Multilingual Safety Instructions

Български – Указания за безопасност, предназначение и квалификации на оператора

Указания за безопасност:

- Bode 100 и Bode 500 представляват БСНН устройства (БСНН = безопасно свръхниско напрежение в съответствие с IEC 60950-1), известни също така като съоръжения с клас на защита III или съоръжения ES1 в съответствие с IEC 62368-1.
- Не прилагайте нива на напрежение > 50 V DC или > 25 V AC към входовете на Bode 100 или Bode 500.
- Имайте предвид, че Bode 100 няма индикатор, който да показва, че изходът е активен. Това е от особено значение, ако към Bode 100 са свързани усилватели.
- Когато работите с външно напрежение или източници на ток в тестова среда, се уверете, че те не могат да надвишават нивата на БСНН и осигурете подходяща изолация на другите опасни вериги, като мрежовото захранване с променливо напрежение.
- Уверете се, че измервателните клещи за напрежение и ток, които използвате с Bode 100 или Bode 500, са правилно заземени, в съответствие с инструкциите на производителя.
- Когато работите с измервателни клещи за напрежение или ток или инжекционни трансформатори винаги свързвайте заземяващата клема на Bode 100 или Bode 500 със заземяващата клема в лабораторията, като използвате стабилна връзка от поне 3,6 mm² напречно сечение и не по-дълга от 10 m.
- Използвайте само инжекционни трансформатори, изолирани за максималното работно напрежение и пренапрежение на приложението.
- Не работете с Bode 100 или Bode 500 при наличие на експлозиви газове или изпарения.
- Не работете с Bode 100 или Bode 500 в околна среда извън границите на температурата и влажността, посочени в документацията за потребителя.

Предназначение:

- Bode 100, Bode 500 и техните аксесоари са специално създадени за измерване на амплитуда/фаза, S параметър и импеданс на електрически вериги в лабораторни и производствени условия.

Квалификация на оператора:

- Изпитванията с Bode 100 или Bode 500 може да се извършват само от упълномощен и квалифициран персонал.
- Служителите, които се обучават или инструктират за работата с Bode 100 или Bode 500, трябва да бъдат под постоянния надзор на опитен оператор, докато работят с апаратурата. При извършване на изпитвания с Bode 100 или Bode 500 трябва да се спазват вътрешните указания за безопасност и допълнителни приложими документи.

中文-安全说明、指定用途和操作人员资格

安全说明：

- Bode 100 和 Bode 500 均为 SELV 设备（根据 IEC 60950-1，SELV = 安全特低电压）,又称防触电安全等级 III 或 ES1 设备（根据 IEC 62368-1）。
- 请勿向 Bode 100 或 Bode 500 的输入端施加超过 50 V DC 或 25 V AC 的电压。
- 请注意，Bode 100 没有用于显示输出是否处于激活状态的指示灯。如果 Bode 100 连接有放大器，则这一点尤其重要。
- 在测试设置中使用外部电源或电流来源时，请确保其不会超出 SELV 水平，并且提供与其他危险电路（例如 AC 线路电压电源）的适当隔离。
- 确保 Bode 100 或 Bode 500 使用的电压和电流探头根据设备制造商指南正确接地。
- 在使用电压探头、电流探头或注入变压器的情况下，请始终使用横截面积至少 3.6 mm² 且长度不超过 10 m 的牢固连接线将 Bode 100 或 Bode 500 的接地端连接到实验室的接地端。
- 仅使用针对应用的最大工作电压和过电压进行隔离的注入变压器。
- 请勿在有易爆气体或蒸汽的环境下操作 Bode 100 或 Bode 500。
- 请勿在超过用户文档中所列温度和湿度限值的环境条件下操作 Bode 100 或 Bode 500。

设计用途：

- Bode 100、Bode 500 及其附件专门用于在实验室和制造环境下测量电子电路的增益/相位、S-参数和阻抗。

操作人员资质：

- 采用 Bode 100 或 Bode 500 的测试必须由符合资质且获得授权的技术人员完成。
- 接受 Bode 100 或 Bode 500 训练、指示、指导、培训的人员在使用该设备时，必须在有经验的操作人员的监督下进行。采用 Bode 100 或 Bode 500 的测试必须满足内部安全规定以及其他相关文件的要求。

Čeština – Bezpečnostní pokyny, určené použití a kvalifikace operátora

Bezpečnostní pokyny:

- Bode 100 a Bode 500 jsou zařízení SELV (SELV = Safety Extra Low Voltage [bezpečné velmi malé napětí] podle IEC 60950-1), známá také jako zařízení třídy ochrany III nebo ES1 podle IEC 62368-1.
- Na vstupy zařízení Bode 100 nebo Bode 500 neaplikujte úrovně napětí >50 V DC či >25 V AC.
- Upozorňujeme, že zařízení Bode 100 nedisponuje žádným indikátorem aktivního výstupu. To by mohlo být obzvláště kritické, pokud jsou k zařízení Bode 100 připojeny zesilovače.
- Při práci s externími zdroji napětí nebo proudu ve zkušební sestavě se ujistěte, že nemohou překročit úrovně SELV, a zajistěte odpovídající izolaci od jiných nebezpečných obvodů, například od síťového zdroje střídavého napětí.
- Ujistěte se, že napěťové a proudové sondy používané se zařízením Bode 100 nebo Bode 500 jsou řádně uzemněny v souladu s pokyny výrobců.
- Při práci s napěťovými a proudovými sondami nebo injekčními transformátory vždy připojte zemnicí svorku zařízení Bode 100 nebo Bode 500 k zemnicí svorce v laboratoři pomocí pevného spoje o průřezu alespoň 3,6 mm² a ne delšího než 10 m.
- Používejte pouze injekční transformátory izolované pro maximální pracovní napětí a přepětí dané aplikace.
- Nepoužívejte zařízení Bode 100 nebo Bode 500 v přítomnosti výbušných plynů nebo výparů.
- Nepoužívejte zařízení Bode 100 nebo Bode 500 v okolních podmínkách, které překračují teplotní a vlhkostní limity uvedené v uživatelské dokumentaci.

Určené použití:

- Zařízení Bode 100, Bode 500 a jejich příslušenství jsou navržena zejména pro měření předstihu/fáze, S parametru a impedance elektronických obvodů v laboratorním a výrobním prostředí.

Kvalifikace operátora:

- Testování se zařízením Bode 100 nebo Bode 500 smí provádět pouze kvalifikovaný, odborně zkušený a oprávněný personál.
- Personál, který podstupuje školení, instruktáž, poučení nebo vzdělávání ohledně zařízení Bode 100 nebo Bode 500, musí být při práci se zařízením pod neustálým dohledem zkušeného operátora. Testování se zařízením Bode 100 nebo Bode 500 musí vyhovovat interním bezpečnostním předpisům a dalším relevantním dokumentům.

Dansk – Sikkerhedsanvisninger, tilsigtet brug og operatørkvalifikationer

Sikkerhedsanvisninger:

- Bode 100 og Bode 500 er SELV-apparater (SELV = Safety Extra Low Voltage iht. IEC 60950-1), der også kaldes udstyr i beskyttelsesklasse III eller ES1-udstyr iht. IEC 62368-1.
- Tilslut ikke spændingsniveauer > 50 V DC eller > 25 V AC til indgangene på Bode 100 eller Bode 500.
- Vær opmærksom på, at Bode 100 ikke har en indikator, der viser om udgangen er aktiv. Det kan især være afgørende, hvis der er forstærkere forbundet til Bode 100.
- Ved arbejde på eksterne spændings- eller strømkilder i testopsætningen skal det sikres, at de ikke overskrider SELV-niveauerne, og at de yder den nødvendige isolation i forhold til andre farlige kredsløb såsom AC-linjespændingsforsyningen.
- Det skal sikres, at de spændings- og strømsensorer, der anvendes sammen med Bode 100 eller Bode 500, har en passende jordforbindelse i henhold til producentens retningslinjer.
- Ved arbejde med spændingssensorer, strømsensorer eller indsprøjtningstransformatorer, skal jordforbindelsen for Bode 100 eller Bode 500 altid forbindes med jordforbindelsen i laboratoriet ved hjælp af en solid forbindelse med et tværsnit på mindst 3,6 mm² og en længde på ikke over 10 m.
- Brug kun indsprøjtningstransformatorer, der er isoleret i overensstemmelse med apparatets maksimale driftsspænding og overspænding.
- Anvend ikke Bode 100 eller Bode 500, hvis der er eksplosive gasser eller dampe til stede.
- Anvend ikke Bode 100 eller Bode 500, der overskrider de temperatur- og fugtighedsgrænser, der er angivet i brugermanualen.

Tilsigtet brug:

- Bode 100, Bode 500 samt tilbehør er specialdesignet til Gain/Phase, S-parameter og impedansmålinger af elektroniske kredsløb i laboratorie- og produktionsmiljøer.

Operatørkvalifikation:

- Tests med Bode 100 eller Bode 500 skal altid udføres af autoriseret og kvalificeret personale.
- Personale, der modtager oplæring, anvisninger, instruktioner eller er under uddannelse til at arbejde med Bode 100 eller Bode 500, skal være under konstant opsyn af en erfaren operatør, mens de arbejder med udstyret. Test med Bode 100 eller Bode 500 skal være i overensstemmelse med de interne sikkerhedsforskrifter samt supplerende relevante dokumenter.

Deutsch – Sicherheitshinweise, bestimmungsgemäße Verwendung und Qualifikation des Bedienpersonals

Sicherheitshinweise:

- Bode 100 und Bode 500 sind Sicherheitskleinspannungsgeräte gemäß IEC 60950-1 (sogenannte „SELV-Geräte“, von SELV = Safety Extra Low Voltage), auch als Geräte der Schutzklasse III oder ES1-Geräte gemäß IEC 62368-1 bekannt.
- An die Eingänge des Bode 100 oder Bode 500 dürfen keine Spannungen > 50 V DC oder > 25 V AC angelegt werden.
- Beachten Sie, dass das Bode 100 keine Anzeige hat, aus der hervorgeht, ob der Ausgang aktiv ist. Dies kann besonders beim Anschluss von Verstärkern an das Bode 100 kritisch sein.
- Wenn Sie im Prüfaufbau mit externen Spannungs- oder Stromquellen arbeiten, stellen Sie sicher, dass diese die SELV-Pegel nicht überschreiten können, und sorgen Sie für eine angemessene Trennung von anderen gefährlichen Stromkreisen, wie z. B. der AC-Spannungsversorgung.
- Stellen Sie bei Verwendung von Spannungstastköpfen und Stromzangen mit dem Bode 100 oder Bode 500 sicher, dass sie gemäß den Richtlinien des jeweiligen Herstellers korrekt geerdet sind.
- Sorgen Sie beim Arbeiten mit Spannungstastköpfen, Stromzangen oder Einspeise-Übertragern dafür, dass der Erdungsanschluss des Bode 100 oder Bode 500 immer mit dem Erdungsanschluss im Labor verbunden ist. Für diese Verbindung ist eine solide Erdungsleitung mit einem Querschnitt von mindestens 3,6 mm² zu verwenden, die nicht länger als 10 m ist.
- Verwenden Sie ausschließlich Einspeise-Übertrager, die für die maximale Betriebsspannung und Überspannung der jeweiligen Anwendung isoliert sind.
- Betreiben Sie das Bode 100 oder Bode 500 niemals in der Nähe von explosionsfähigen Gasen oder Dämpfen.
- Betreiben Sie das Bode 100 oder Bode 500 niemals unter Umgebungsbedingungen, die die in den Nutzungsinformationen aufgelisteten zulässigen Bereiche für Temperatur und Feuchtigkeit über- bzw. unterschreiten.

Bestimmungsgemäße Verwendung:

- Das Bode 100 und das Bode 500 sowie deren Zubehör sind speziell für die Messung der Verstärkung und des Phasenverhaltens von elektronischen Schaltungen sowie von deren Streuparametern und Impedanzen konzipiert. Sie sind ausschließlich für die Verwendung in Labor- und Fertigungsumgebungen vorgesehen.

Qualifikation des Bedienpersonals:

- Prüfungen mit dem Bode 100 oder Bode 500 dürfen nur durch autorisierte, qualifizierte und dafür ausgebildete Personen durchgeführt werden.
- Personen, die das Bode 100 oder das Bode 500 im Rahmen einer Schulung, Einweisung oder anderweitigen Ausbildung bedienen, müssen dabei durchgängig von einer erfahrenen Person beaufsichtigt werden. Prüfungen mit dem Bode 100 oder Bode 500 müssen immer unter Beachtung der internen Sicherheitsvorschriften und aller sonstigen relevanten Dokumente erfolgen.

English – Safety Instructions, Designated Use and Operator Qualification

Safety Instructions:

- Bode 100 and Bode 500 are SELV devices (SELV = Safety Extra Low Voltage according to IEC 60950-1), also known as protection class III or ES1 equipment according to IEC 62368-1.
- Do not apply voltage levels > 50 V DC or > 25 V AC to the inputs of the Bode 100 or Bode 500.
- Be aware that the Bode 100 has no indicator to show if the output is active. This could be especially critical if amplifiers are connected to Bode 100.
- When working with external voltage or current sources in the test setup, ensure that they can not exceed the SELV levels and provide appropriate isolation to other hazardous circuits, such as the AC line voltage supply.
- Ensure that voltage and current probes used with the Bode 100 or Bode 500 are properly grounded in accordance with their manufacturer's guidelines.
- When working with voltage probes, current probes or injection transformers always connect the ground terminal of the Bode 100 or Bode 500 to the ground terminal in the laboratory, using a solid connection of at least 3.6 mm² cross-section and not longer than 10 m.
- Only use injection transformers, isolated for the application's maximum working voltage and overvoltage.
- Do not operate Bode 100 or Bode 500 in the presence of explosive gas or vapours.
- Do not operate Bode 100 or Bode 500 under ambient conditions that exceed the temperature and humidity limits listed in the user documentation.

Designated Use:

- Bode 100, Bode 500, and their accessories are especially designed for Gain/Phase, S-Parameter and Impedance measurements of electronic circuits in laboratory and manufacturing environments.

Operator Qualification:

- Testing with the Bode 100 or Bode 500 may only be carried out by qualified, skilled and authorized personnel.
- Personnel receiving training, instructions, directions, or education on a Bode 100 or Bode 500 must be under constant supervision of an experienced operator while working with the equipment. Testing with the Bode 100 or Bode 500 must comply with the internal safety regulations as well as additional relevant documents.

Ελληνικά – Οδηγίες ασφαλείας, προβλεπόμενη χρήση και προσόντα χειριστών

Οδηγίες ασφαλείας:

- Οι Bode 100 και Bode 500 είναι συσκευές SELV (SELV = Εξαιρετικά χαμηλή τάση ασφαλείας σύμφωνα με το πρότυπο IEC 60950-1), γνωστές επίσης ως εξοπλισμός κατηγορίας III ή ES1 σύμφωνα με το πρότυπο IEC 62368-1.
- Μην εφαρμόζετε τάσεις επιπέδου >50 V DC ή >25 V AC στις εισόδους των Bode 100 ή Bode 500.
- Λάβετε υπόψη ότι η Bode 100 δεν διαθέτει ένδειξη ενεργής εξόδου. Αυτό μπορεί να έχει ιδιαίτερα κρίσιμη σημασία αν συνδέονται ενισχυτές στην Bode 100.
- Όταν εργάζεστε με εξωτερικές πηγές τάσης ή έντασης ρεύματος στο σύστημα δοκιμής, πρέπει να βεβαιώνεστε ότι δεν μπορούν να υπερβούν τα επίπεδα SELV και να παρέχετε κατάλληλη απομόνωση για τα άλλα επικίνδυνα κυκλώματα, όπως η γραμμή παροχής τάσης AC.
- Πρέπει να βεβαιώνεστε ότι οι ανιχνευτές τάσης και έντασης ρεύματος που χρησιμοποιούνται με τις Bode 100 ή Bode 500 είναι σωστά γειωμένοι σύμφωνα με τις οδηγίες του κατασκευαστή τους.
- Όταν εργάζεστε με ανιχνευτές τάσης, ανιχνευτές έντασης ρεύματος ή μετασχηματιστές διοχέτευσης, πρέπει πάντα να συνδέετε τον ακροδέκτη γείωσης της Bode 100 ή της Bode 500 στον ακροδέκτη γείωσης του εργαστηρίου με συμπαγές καλώδιο σύνδεσης διατομής τουλάχιστον 3,6 mm² και μήκος που δεν υπερβαίνει τα 10 m.
- Πρέπει να χρησιμοποιείτε μόνο μετασχηματιστές διοχέτευσης με μόνωση κατάλληλη για τη μέγιστη τάση λειτουργίας της εφαρμογής και τη μέγιστη υπέρβαση τάσης.
- Μην χρησιμοποιείτε την Bode 100 ή την Bode 500 παρουσία εκρηκτικών αερίων ή αναθυμιάσεων.
- Μην χρησιμοποιείτε την Bode 100 ή την Bode 500 σε συνθήκες περιβάλλοντος που υπερβαίνουν τα όρια θερμοκρασίας και υγρασίας που αναφέρονται στα έγγραφα τεκμηρίωσης για τον χρήστη.

Προβλεπόμενη χρήση:

- Η Bode 100, η Bode 500 και τα παρελκόμενά τους έχουν σχεδιαστεί ειδικά για μετρήσεις της απολαβής/φάσης, της παραμέτρου S (σκέδασης) και της σύνθετης αντίστασης ηλεκτρονικών κυκλωμάτων σε εργαστηριακά και βιομηχανικά περιβάλλοντα παραγωγής.

Προσόντα χειριστών:

- Οι δοκιμές με την Bode 100 ή την Bode 500 πρέπει να εκτελούνται μόνο από πιστοποιημένο, ειδικευμένο και εξουσιοδοτημένο προσωπικό.
- Το προσωπικό που εκτελεί πρακτική εξάσκηση ή λαμβάνει εντολές, οδηγίες ή εκπαίδευση σχετικά με την Bode 100 ή την Bode 500 πρέπει να βρίσκεται υπό τη συνεχή επίβλεψη ενός έμπειρου χειριστή όταν εργάζεται με τον εξοπλισμό. Η εκτέλεση δοκιμών με την Bode 100 ή την Bode 500 πρέπει να συμμορφώνεται με τους εσωτερικούς κανονισμούς ασφαλείας και με οποιαδήποτε επιπρόσθετα σχετικά έγγραφα.

Español – Instrucciones de seguridad, aplicación prevista y cualificación del operador

Instrucciones de seguridad:

- El Bode 100 y el Bode 500 son dispositivos SELV (SELV = tensión extrabaja de seguridad según la norma IEC 60950-1), también conocidos como equipos ES1 o con clase de protección III según la norma IEC 62368-1.
- No aplique niveles de tensión > 50 V CC o > 25 V CA a las entradas del Bode 100 o del Bode 500.
- Tenga en cuenta que el Bode 100 no tiene ningún indicador que muestre si la salida está activa. Esto podría ser especialmente crítico si los amplificadores están conectados al Bode 100.
- Cuando trabaje con fuentes externas de tensión o corriente en la configuración de prueba, asegúrese de que no puedan superar los niveles SELV y proporcione el aislamiento adecuado a otros circuitos peligrosos, como la alimentación de tensión de la línea de CA.
- Asegúrese de que las sondas de tensión y corriente utilizadas con el Bode 100 o el Bode 500 están correctamente conectadas a tierra de acuerdo con las directrices de su fabricante.
- Cuando trabaje con sondas de tensión, sondas de corriente o transformadores de inyección, conecte siempre el terminal de tierra del Bode 100 o del Bode 500 al terminal de tierra del laboratorio, utilizando una conexión sólida de al menos 3,6 mm² de sección y no más de 10 m de longitud.
- Utilice únicamente transformadores de inyección, aislados para la sobretensión y la tensión máxima de trabajo de la aplicación.
- No utilice el Bode 100 o el Bode 500 junto a gases explosivos o vapores.
- No utilice el Bode 100 o el Bode 500 en condiciones ambientales que sobrepasen los límites de temperatura y humedad que se indican en la documentación del usuario.

Uso previsto:

- El Bode 100, el Bode 500 y sus accesorios están diseñados especialmente para mediciones de ganancia/fase, parámetro S e impedancia de circuitos electrónicos en entornos de laboratorio y de fábrica.

Cualificación del operador:

- Solo el personal cualificado, experimentado y autorizado puede realizar pruebas con el Bode 100 o el Bode 500.
- El personal no experimentado en el manejo del Bode 100 o del Bode 500 y que esté en plena formación debe encontrarse en todo momento bajo la supervisión de un operador experimentado mientras trabaja con el equipo. Al realizar pruebas con el Bode 100 o el Bode 500 se deben cumplir todas las normativas de seguridad internas, así como las instrucciones proporcionadas en cualquier otro documento que resulte pertinente.

Eesti keel – Ohutusjuhised, kasutusotstarve ja kasutaja kvalifikatsioon

Ohutusjuhised:

- Bode 100 ja Bode 500 on maandamata kaitseväikepingega (Safety Extra Low Voltage, SELV) seadmed (kooskõlas standardi IEC 60950-1 nõuetega), mida teatakse ka kui III kaitseklassi seadmeid või ES1 seadmeid kooskõlas standardiga IEC 62368-1.
- Ärge kasutage seadme Bode 100 või Bode 500 sisendis > 50 V alalisvoolu või > 25 V vahelduvvoolu pinget.
- Pange tähele, et seadmes Bode 100 ei ole näidikut, mis näitaks, kas väljund on aktiivne. Seda on äärmiselt oluline jälgida, kui seade Bode 100 on ühendatud võimenditega.
- Töötades väliste elektripinge- või vooluallikatega katsetingimustes, veenduge, et need ei ületaks SELV-i tasemeid, ja tagage sobiv isolatsioon teistele ohtlikele vooluringidele, nagu vahelduvvoolu liinidele.
- Veenduge, et seadmega Bode 100 või Bode 500 kasutatavad elektripinge ja -voolu andurid oleks õigesti maandatud kooskõlas andurite maaletootja juhistega.
- Töötades elektripingeandurite või sisendtrafodega, ühendage alati seadme Bode 100 või Bode 500 maandusklemm labori maandusklemmiga, kasutades pidevühendust, mis on ristlõikes vähemalt 3,6 mm² ja mitte pikem kui 10 m.
- Kasutage ainult sisendtrafosid, mis on isoleeritud rakenduse maksimaalse tööpinge ja ülepinge jaoks.
- Ärge kasutage seadet Bode 100 või Bode 500 kohas, kus leidub plahvatusohtlikke aineid, gaase või aure.
- Ärge kasutage seadet Bode 100 või Bode 500 keskkonnatingimustes, mis ületavad vastavas kasutusjuhendis esitatud temperatuuri- ja niiskuspiiranguid.

Ettenähtud kasutus:

- Bode 100, Bode 500 ja nende lisatarvikud on mõeldud selleks, et mõõta võimendust/faasi, S-parameetrit ja takistust elektriahelates labori- ja tööstuskeskkonnas.

Kasutaja kvalifikatsioon:

- seadmega Bode 100 või Bode 500 testimist võivad läbi viia üksnes kvalifitseeritud, kogenud ja volitatud töötajad.
- Töötajad, kes läbivad seadme Bode 100 või Bode 500 kasutamise väljaõpet või koolitust või keda juhendatakse selles valdkonnas, peavad seadmega töötamise ajal olema kogenud kasutaja pideva järelevalve all. Seadmega Bode 100 või Bode 500 testimine peab toimuma ettevõttesiseste ohutusnõuete ja asjaomaste lisadokumentide kohaselt.

Suomalainen – Turvallisuusohjeet, käyttötarkoitus ja käyttäjän pätevyys

Turvallisuusohjeet:

- Bode 100 ja Bode 500 ovat SELV-laitteita (SELV = ”pienoisjännitteinen perus- ja vikasuojausehdon täyttävä järjestelmä” IEC 60950-1 -standardin mukaisesti). Luokan muita nimityksiä ovat suojausluokka III ja ES1-laiteluokka IEC 62368-1 -standardin mukaisesti.
- Älä käytä Bode 100- tai Bode 500 -laitteen syöttöliitännöissä vaarallisia jännitetasoja > 50 V DC tai > 25 V AC.
- Huomaa, ettei Bode 100 -laite ilmoita aktiivisesta lähdöstä millään tavalla. Tämä voi olla kriittistä erityisesti silloin, kun Bode 100 -laitteeseen on kiinnitetty vahvistimia.
- Kun käsittelet testilaitteiston ulkoisia jännite- tai virtalähtöjä, varmista, etteivät ne voi ylittää SELV-tasoja ja että ne tarjoavat riittävän eristyksen muihin vaarallisiin piireihin, kuten vaihtovirtalinjan jännitelähteeseen.
- Varmista, että Bode 100- tai Bode 500 -laitteen jännite- ja virta-anturit on maadoitettu valmistajan ohjeiden mukaan.
- Kun käytät jänniteantureita, virta-antureita tai syöttömuuntajia, kytke Bode 100 tai Bode 500 aina laboratorion maadoitusliitäntään kaapelilla, jonka poikkipinta-ala on vähintään 3,6 mm² ja jonka enimmäispituus on 10 m.
- Käytä vain syöttömuuntajia, jotka on eristetty käyttökohteen enimmäiskäyttöjännitteestä ja ylijännitteestä.
- Älä käytä Bode 100- tai Bode 500 -laitetta ympäristössä, jossa on räjähtäviä kaasuja tai höyryjä.
- Älä käytä Bode 100- tai Bode 500 -laitetta ympäristössä, jonka lämpötila ja kosteus poikkeavat käyttöoppaassa mainituista rajoista.

Käyttötarkoitus:

- Bode 100, Bode 500 ja niiden lisävarusteet on suunniteltu nimenomaisesti elektroniikkapiirien vahvistus/vaihe-, S-parametri- ja impedanssimittaukseen laboratorioissa ja tuotantoympäristöissä.

Käyttäjän pätevyys:

- Bode 100- tai Bode 500 -laitteen testaukseen osallistuvilla henkilöillä tulee olla asianmukainen pätevyys, ammattitaito ja valtuutus.
- Henkilöiden, joille annetaan Bode 100- tai Bode 500 -laitetta koskevaa koulutusta, ohjeistusta, opastusta tai valmennusta, tulee olla kokeneen käyttäjän jatkuvan valvonnan alaisina käsitellessään laitteistoa. Bode 100- tai Bode 500 -laitteella suoritettavan testauksen täytyy noudattaa sisäisiä turvallisuusohjeita sekä muita asianmukaisia asiakirjoja.

Français – Consignes de sécurité, utilisation prévue et qualifications des opérateurs

Consignes de sécurité :

- Le Bode 100 et le Bode 500 sont des appareils de type TBTS (Très Basse Tension de Sécurité, en accord avec la norme CEI 60950-1), également connus sous le nom d'équipements de protection de classe III ou d'équipements ES1, en accord avec la norme CEI 62368-1.
- Ne pas appliquer de tensions supérieures à 50 V CC ou 25 V CA aux entrées du Bode 100 ou du Bode 500.
- Noter que le Bode 100 ne possède pas de voyant indiquant si la sortie est active. Être particulièrement vigilant dans le cas où des amplificateurs sont connectés au Bode 100.
- Lors de l'utilisation de sources de tension ou de courant externes dans un montage de test, s'assurer qu'elles ne dépassent pas les niveaux TBTS et isoler de manière appropriée les autres circuits dangereux, tel que l'alimentation électrique en alternatif.
- Veiller à ce que les sondes de tension et de courant utilisées avec le Bode 100 ou le Bode 500 soient convenablement mises à la terre conformément aux consignes de leur fabricant.
- Lors de l'utilisation de sondes de tension, de sondes de courant ou de transformateurs d'injection, toujours connecter la borne de terre du Bode 100 ou du Bode 500 à la borne de terre du laboratoire, à l'aide d'une liaison d'une section minimale de 3,6 mm² et d'une longueur maximale de 10 m.
- Utiliser uniquement des transformateurs d'injection isolés par rapport à la tension de service et la surtension maximales de l'application.
- Ne pas utiliser le Bode 100 ou le Bode 500 en présence de vapeurs ou de gaz explosifs.
- Ne pas utiliser le Bode 100 ou le Bode 500 dans des conditions ambiantes de température et d'humidité supérieures à celles indiquées dans la documentation d'utilisation.

Utilisation prévue :

- Le Bode 100, le Bode 500 et leurs accessoires sont spécialement conçus pour mesurer le gain/phase, le paramètre S et l'impédance des circuits électroniques dans les laboratoires et les usines.

Qualifications des opérateurs :

- Les essais effectués à l'aide du Bode 100 ou du Bode 500 doivent exclusivement être réalisés par du personnel qualifié, compétent et agréé.
- Le personnel recevant une formation, des instructions ou des directives quant à l'utilisation d'un Bode 100 ou d'un Bode 500 doit rester sous la supervision permanente d'un opérateur expérimenté pendant l'utilisation de l'équipement. Les tests effectués à l'aide du Bode 100 ou du Bode 500 doivent être conformes aux réglementations de sécurité internes et à tout autre document relatif.

Hrvatski – Sigurnosne upute, predviđena namjena i kvalifikacije rukovatelja

Sigurnosne upute:

- Bode 100 i Bode 500 su SELV uređaji (engl. SELV = Safety Extra Low Voltage, tj. sigurnosni izrazito niski napon u skladu s normom IEC 60950-1), poznati i kao zaštitna oprema III. klase ili ES1 oprema u skladu s normom IEC 62368-1.
- Nemojte dovoditi napon > 50 V DC ili > 25 V AC na ulaze uređaja Bode 100 ili Bode 500.
- Imajte na umu da na uređaju Bode 100 ne postoji indikator koji pokazuje da je izlaz aktivan. Ovo može biti osobito kritično ako su na Bode 100 priključeni pojačivači.
- Pri radu s vanjskim izvorima napona ili struje u kompletu za ispitivanje, osigurajte da vanjski izvori ne mogu prijeći granice SELV-a i osigurajte odgovarajuću izolaciju na drugim opasnim strujnim krugovima, npr. na vodu za napajanje izmjeničnom strujom.
- Uvjerite se da su naponske i strujne sonde koje se upotrebljavaju uz Bode 100 ili Bode 500 pravilno uzemljene u skladu sa smjernicama njihovih proizvođača.
- Pri radu s naponskim sondama, strujnim sondama ili transformatorima za ubrizgavanje, uvijek povežite terminal za uzemljenje uređaja Bode 100 ili Bode 500 s terminalom za uzemljenje u laboratoriju vodičem minimalnog poprečnog presjeka od 3,6 mm² i ne duljim od 10 m.
- Upotrebljavajte samo transformatore za ubrizgavanje izolirane za maksimalni radni napon primjene i prenapon.
- Nemojte upotrebljavati uređaj Bode 100 ili Bode 500 blizini eksplozivnih plinova ili isparavanja.
- Nemojte upotrebljavati uređaj Bode 100 ili Bode 500 u okolišnim uvjetima koji prekoračuju ograničenja temperature i vlažnosti navedena u korisničkim priručnicima.

Predviđena namjena:

- Uređaji Bode 100 i Bode 500 te njihova dodatna oprema osmišljeni su izričito za mjerenja parametara pojačanje/faza, parametra S i električne impedancije elektroničkih krugova u laboratorijima i proizvodnim okolinama.

Kvalifikacije rukovatelja:

- Uređaj Bode 100 ili Bode 500 smiju koristiti samo kvalificirani, stručni i ovlašteni zaposlenici.
- Zaposlenici koji prolaze izobrazbu, instrukcije, poduku ili tečaj o uređaju Bode 100 ili Bode 500 moraju biti pod stalnim nadzorom iskusnog rukovatelja prilikom rada s opremom. Ispitivanje uređajem Bode 100 ili Bode 500 mora biti u skladu s unutarnjim sigurnosnim propisima i dodatnim relevantnim dokumentima.

Magyar – Biztonsági utasítások, rendeltetésszerű használat és kezelői szakképesítési követelmények

Biztonsági utasítások:

- A Bode 100 és Bode 500 ún. SELV (SELV = biztonsági törpefeszültség az IEC 60950-1 szabvány szerint), más jelölés szerint III. érintésvédelmi osztályú, avagy IEC 62368-1 szabvány szerinti ES1 készülékek.
- A Bode 100 és Bode 500 bemeneteire tilos 50 V (egyenáramú, DC) vagy 25 V (váltakozó áramú, AC) feszültségnél nagyobb jelszintet kapcsolni.
- Vegye figyelembe, hogy a Bode 100 nem rendelkezik állapotjelzővel az aktív kimenet jelzésére. Ez különösen akkor lehet kritikus fontosságú, ha a Bode 100 kimenetére erősítők csatlakoznak.
- Ha a vizsgálati rendszerben külső feszültség- vagy áramforrásokkal végeznek munkát, gondoskodni kell róla, hogy azok értéke ne léphesse túl a SELV szintjeit, az egyéb veszélyes áramköröket pedig, mint például a vonali AC tápfeszültség, megfelelő szigeteléssel kell ellátni.
- Gondoskodjon arról, hogy a Bode 100 vagy Bode 500 készülékhez feszültség- és árammérés céljából csatlakoztatott mérőfejek a gyártói útmutatások szerint megfelelően földelve legyenek.
- A feszültség- és árammérőfejekkel vagy betápláló transzformátorokkal végzett munka során minden esetben legalább 3,6 mm² keresztmetszetű és legfeljebb 10 méter hosszú kábel segítségével alakítson ki szilárd csatlakozást a Bode 100 és Bode 500 földelőcsatlakozója és a laboratórium földelőcsatlakozója között.
- Csak az alkalmazás maximális üzemi feszültségének és túlfeszültségének megfelelően szigetelt betápláló transzformátort használjon.
- Tilos a Bode 100 és Bode 500 készüléket robbanásveszélyes gáz vagy gőzök jelenlétében használni.
- Ne üzemeltesse a Bode 100 és Bode 500 készüléket olyan környezeti feltételek esetén, amikor a hőmérséklet és a páratartalom értékei túllépik a felhasználói dokumentációban felsorolt határértékeket.

Rendeltetésszerű használat:

- A Bode 100 és Bode 500, valamint tartozékaik különösen elektronikai áramkörök erősítésének, fázisának, szórásparaméterének és impedanciájának laboratóriumban és gyártási környezetekben végzett mérésére szolgálnak.

Kezelői képesítések:

- A Bode 100 és Bode 500 segítségével végzendő méréseket csak szakképzett, gyakorlattal rendelkező és ezzel megbízott személyek végezhetik.
- A Bode 100 és Bode 500 kezelésére vonatkozó betanításban, utasításokban, útmutatásban vagy oktatásban részesülő személyeket a készülék használata során folyamatosan felügyelnie kell egy tapasztalt kezelőnek. A Bode 100 és Bode 500 segítségével végzendő vizsgálatok során be kell tartani a belső biztonsági szabályokat és a további vonatkozó dokumentumokban foglaltakat.

Italiano – Istruzioni di sicurezza, utilizzo previsto e qualifiche degli operator

Istruzioni di sicurezza:

- Bode 100 e Bode 500 sono dispositivi SELV (SELV = Safety Extra Low Voltage, vale a dire a bassissima tensione di sicurezza, secondo IEC 60950-1), denominati anche apparecchi con classe di protezione III o apparecchi ES1 secondo IEC 62368-1.
- Non applicare livelli di tensione >50 V CC o >25 V CA agli ingressi di Bode 100 o Bode 500.
- Considerare che Bode 100 non è dotato di un indicatore in grado di mostrare se l'uscita è attiva. Questo può comportare problemi soprattutto in caso di collegamento di amplificatori a Bode 100.
- Quando si lavora con sorgenti di tensione o di corrente esterne nell'impianto di prova, assicurarsi che non superino i livelli SELV e che forniscano un isolamento appropriato da altri circuiti pericolosi, come l'alimentazione di tensione della linea CA.
- Le sonde di tensione e di corrente impiegate con Bode 100 o Bode 500 vanno collegate a terra in modo corretto, secondo le istruzioni del rispettivo produttore.
- Quando si lavora con sonde di tensione, sonde di corrente o trasformatori di iniezione, collegare sempre il terminale di terra di Bode 100 o Bode 500 al terminale di terra del laboratorio, utilizzando un collegamento solido con sezione trasversale minima di 3,6 mm² e di lunghezza non superiore a 10 m.
- Utilizzare esclusivamente trasformatori di iniezione isolati per la tensione massima di esercizio e la sovratensione dell'applicazione.
- Evitare di utilizzare Bode 100 o Bode 500 in presenza di gas o vapori esplosivi.
- Non utilizzare Bode 100 o Bode 500 in condizioni ambientali con temperatura e umidità superiori ai limiti indicati nella documentazione utente.

Utilizzo previsto:

- Bode 100, Bode 500 e i loro accessori sono appositamente progettati per le misurazioni di guadagno/fase, parametro-S e impedenza nei circuiti elettronici del laboratorio e degli ambienti di produzione.

Qualifiche degli operatori:

- Le prove con Bode 100 o Bode 500 devono essere condotte solo da personale esperto autorizzato e qualificato.
- Quando utilizza l'apparecchiatura, il personale che riceve addestramento, istruzioni o formazione su Bode 100 o Bode 500 deve trovarsi sotto la costante supervisione di un operatore esperto. Le prove eseguite con Bode 100 o Bode 500 devono rispettare le regole di sicurezza interne e i relativi documenti aggiuntivi.

日本語 - 安全上のご注意、用途および使用者資格

安全のために：

- Bode 100 および Bode 500 は SELV 機器（SELV = Safety Extra Low Voltage（安全超低電圧回路）、IEC 60950-1 準拠）であり、IEC 62368-1 準拠の保護クラス III または ES1 機器としても知られています。
- Bode 100 または Bode 500 の入力には、50 V DC または 25 V AC を超える電圧レベルを印加しないでください。
- Bode 100 には、出力がアクティブかどうかを示すインジケーターがないことに注意してください。これは、アンプが Bode 100 に接続されている場合、特に重要です。
- 試験装置で外部の電圧源や電流源を使用する場合、それらが SELV レベルを超えないようにし、AC ライン電圧供給源など、他の危険な回路に対して適切な絶縁を行ってください。
- Bode 100 または Bode 500 で使用する電圧プローブおよび電流プローブが、製造元のガイドラインに従って適切に接地されていることを確認してください。
- 電圧プローブ、電流プローブ、またはインジェクショントランスを使用する場合は、必ず、断面積 3.6 mm²以上、10 m 以下の距離で、Bode 100 または Bode 500 のアース端子と実験室のアース端子を確実に接続してください。
- アプリケーションの最大使用電圧と過電圧に対して絶縁されたインジェクショントランスのみを使用してください。
- 爆発性ガスや蒸気がある場所では、Bode 100 または Bode 500 を使用しないでください。
- ユーザーマニュアルに記載されている温度と湿度の制限を超える周囲条件下で Bode 100 または Bode 500 を使用しないでください。

使用目的：

- Bode 100、Bode 500 とそのアクセサリは、特に実験室や製造環境における電子回路のゲイン/位相、S パラメータ、インピーダンス測定用に設計されています。

作業者の資格：

- Bode 100 または Bode 500 を使用した試験は、資格があり、熟練し、認可を受けた担当者のみが実施できます。
- Bode 100 または Bode 500 に関するトレーニング、指示、指令、または教育を受けている者は、装置を使用して作業している間は常に経験豊富なオペレーターの監督下にいなければなりません。Bode100 または Bode500 を使用した試験は、社内安全規定および追加の関連文書に準拠する必要があります。

Lietuvių – Saugos nurodymai, numatomasis naudojimas ir operatoriaus kvalifikacija

Saugos nurodymai

- „Bode 100“ ir „Bode 500“ yra SELV įrenginiai (SELV – saugi žemiausioji įtampa pagal standartą IEC 60950-1), taip pat žinomi kaip III apsaugos klasės arba ES1 įranga pagal standartą IEC 62368-1.
- Prie „Bode 100“ arba „Bode 500“ įėjimų nejunkite pavojingos įtampos (>50 V (nuol. Sr.) arba >25 V (kint. sr.)).
- Atminkite, kad „Bode 100“ neturi indikatoriaus, rodančio, ar išėjimas yra aktyvus. Šis reikalavimas ypač svarbus, jei prie „Bode 100“ jungiami stiprintuvai.
- Dirbdami su išoriniais įtampos ar srovės šaltiniais konfigūruodami bandymą įsitikinkite, kad jie neviršija SELV lygių, ir užtikrinkite tinkamą izoliaciją nuo kitų pavojingų grandinių, pavyzdžiui, kintamosios srovės linijos įtampos šaltinio.
- Pasirūpinkite, kad su „Bode 100“ arba „Bode 500“ naudojami įtampos ir srovės bandikliai būtų tinkamai įžeminti, kaip nurodyta jų gamintojo parengtose taisyklėse.
- Prieš dirbdami su įtampos, srovės bandikliais arba injekcijos transformatoriais, būtinai prijunkite „Bode 100“ arba „Bode 500“ įžeminimo gnybtą prie laboratorijos įžeminimo gnybto, naudodami tvirtą ne mažesnio kaip 3,6 mm² skerspjūvio ir ne ilgesnę kaip 10 m ilgio jungtį.
- Naudokite tik injekcijos transformatorius, izoliuotus atsižvelgiant į didžiausią programos darbinę įtampą ir viršįtampį.
- Nenaudokite „Bode 100“ arba „Bode 500“, jei aplinkoje yra sprogių dujų arba garų.
- Nenaudokite „Bode 100“ arba „Bode 500“ tokiomis aplinkos sąlygomis, kai viršijamos naudotojo dokumentacijoje nurodytos ribinės temperatūros ir drėgnio vertės.

Numatytasis naudojimas

- Bode 100, Bode 500 ir jų priedai specialiai skirti laboratorijose ir gamyklose matuoti elektroninių grandinių stiprinimo koeficientui, fazei, S parametrui ir pilnutinei varžai.

Operatoriaus kvalifikacija

- Bandymus su „Bode 100“ ir „Bode 500“ leidžiama atlikti tik kvalifikuotiems, įgudusiems ir įgaliotiems darbuotojams.
- Darbuotojai, kurie mokomi, instruktuojami, kuriems nurodoma arba pasakojama, kaip dirbti su „Bode 100“ arba „Bode 500“, turi būti nuolat, kol dirbama su įranga, prižiūrimi patyrusio operatoriaus. Bandymai su „Bode 100“ arba „Bode 500“ turi būti atliekami laikantis vidaus saugos instrukcijų ir papildomų aktualių dokumentų.

Latvijas – Drošības instrukcijas, paredzētā izmantošana un operatora kvalifikācija

Drošības norādījumi

- Bode 100 un Bode 500 ir SELV ierīces (SELV = sevišķi zema sprieguma (drošības) ierīce saskaņā ar IEC 60950-1), kas atbilst arī III aizsardzības klases vai ES1 aprīkojumam saskaņā ar IEC 62368-1.
- Nepievadiet Bode 100 vai Bode 500 ieejām spriegumu, kas pārsniedz 50 V līdzstrāvu vai 25 V maiņstrāvu.
- Ņemiet vērā, ka Bode 100 nav indikatora, kas parāda, vai izeja ir aktīva. Tas ir īpaši svarīgi, ja Bode 100 ir pievienoti pastiprinātāji.
- Strādājot ar ārējiem sprieguma vai strāvas avotiem testa režīmā, pārliecinieties, ka tie nevar pārsniegt SELV līmeni, un nodrošiniet atbilstošu izolāciju citām bīstamām shēmām, piemēram, maiņstrāvas līnijas sprieguma padevei.
- Pārliecinieties, ka ar Bode 100 vai Bode 500 izmantotie sprieguma un strāvas devēji ir pareizi iezemēti atbilstoši to ražotāju norādēm.
- Strādājot ar sprieguma devējiem, strāvas devējiem vai inžekcijas transformatoriem, vienmēr savienojiet Bode 100 vai Bode 500 zemējuma spaili ar zemējuma spaili laboratorijā, izmantojot stabilu savienojumu, kura šķērsgriezums ir vismaz 3,6 mm² un garums nepārsniedz 10 m.
- Izmantojiet tikai tādus inžekcijas transformatorus, kas izolēti pret maksimālo darba spriegumu un pārspriegumu attiecīgajos lietošanas apstākļos.
- Neekspluatējiet Bode 100 vai Bode 500 sprādzienbīstamas gāzes vai tvaiku tuvumā.
- Neekspluatējiet Bode 100 vai Bode 500, ja vides apstākļi pārsniedz lietotāja dokumentācijā norādīto temperatūras un mitruma robežvērtību.

Paredzētā izmantošana

- Bode 100, Bode 500 un to piederumi ir īpaši paredzēti pastiprinājuma/fāžu, S parametra un pilnās pretestības mērījumiem laboratorijas un ražošanas vides elektroniskajās shēmās.

Operatora kvalifikācija

- Testēšanu ar Bode 100 vai Bode 500 atļauts veikt tikai atbilstoši pilnvarotiem un kvalificētiem darbiniekiem ar nepieciešamajām prasmēm.
- Strādājot ar aprīkojumu, darbiniekiem, kas piedalās apmācībās, saņem instrukcijas, norādījumus vai izglītojošu informāciju par Bode 100 vai Bode 500, jābūt pastāvīgā pieredzējuša operatora uzraudzībā. Testēšanai ar Bode 100 vai Bode 500 jāatbilst iekšējiem drošības noteikumiem un attiecīgajiem papildu dokumentiem.

Nederlands – Veiligheidsinstructies, beoogd gebruik en kwalificaties van de bediener

Veiligheidsinstructies:

- Bode 100 en Bode 500 zijn SELV-apparaten (SELV = Safety Extra Low Voltage volgens IEC 60950-1), ook wel bekend als een apparaat van beschermingsklasse III of ES1-apparatuur volgens IEC 62368-1.
- Plaats geen spanningsniveaus > 50 V DC of > 25 AC op de invoeraansluitingen van de Bode 100 of Bode 500.
- Houd er rekening mee dat de Bode 100 niet aangeeft wanneer de uitvoer actief is. Dit kan vooral van belang zijn indien er versterkers op de Bode 100 zijn aangesloten.
- Als in de testopstelling met externe spannings- of stroombronnen wordt gewerkt, moet ervoor worden gezorgd dat deze de SELV-niveaus niet overschrijden en moeten deze bronnen juist zijn geïsoleerd van andere gevaarlijke circuits, zoals de AC-netspanning.
- Zorg ervoor dat de spannings- en stroomtestkabels die met de Bode 100 of Bode 500 worden gebruikt, correct zijn geaard, in overeenstemming met de richtlijnen van de fabrikant.
- Sluit bij het werken met spannings- en stroomtestkabels of injectietransformatoren altijd de aardklem van de Bode 100 of Bode 500 op de aardklem in het laboratorium aan. Maak hiervoor gebruik van een stevige kabel die een diameter van minstens 3,6 mm² heeft en niet langer is dan 10 m.
- Gebruik alleen injectietransformatoren met isolatie die bestand is tegen de maximale werkspanning en overspanning van de toepassing.
- Gebruik de Bode 100 of Bode 500 niet in de buurt van explosief materiaal, gevaarlijke gassen of dampen.
- Gebruik de Bode 100 of Bode 500 niet bij omgevingsomstandigheden die de temperatuur- en vochtigheidslimieten overschrijden welke zijn gespecificeerd in de gebruikersdocumentatie.

Beoogd gebruik:

- De Bode 100, Bode 500 en de bijbehorende accessoires zijn speciaal ontwikkeld voor het uitvoeren van metingen van amplitudeversterking/faseverschuiving, S-parameters en impedantie van elektronische circuits in laboratorium- en productieomgevingen.

Kwalificaties van de bediener:

- Tests met de Bode 100 of Bode 500 mogen alleen worden uitgevoerd door ervaren, gekwalificeerd en hiertoe bevoegd personeel.
- Personen die via een training, een cursus, instructies of aanwijzingen bekend worden gemaakt met het gebruik van de Bode 100 of Bode 500, moeten continu onder toezicht van een ervaren bediener staan wanneer ze met de apparatuur werken. Het testen met de Bode 100 of Bode 500 moet aan de interne veiligheidsregels en aanvullende veiligheidsrelevante documenten voldoen.

Polski – Instrukcje bezpieczeństwa, przeznaczenie i kwalifikacje operatora

Instrukcje bezpieczeństwa:

- Bode 100 i Bode 500 to urządzenia niskonapięciowe SELV (ang. Safety Extra Low Voltage – bardzo niskie napięcie bezpieczne, zgodnie z normą IEC 60950-1), określane również jako wyposażenie o klasie ochronności III lub ES1 zgodnie z normą IEC 62368-1.
- Do wejść urządzeń Bode 100 i Bode 500 nie wolno przykładać napięć powyżej 50 V DC lub 25 V AC.
- Pamiętaj, że urządzenie Bode 100 nie ma wskaźnika, który sygnalizowałby, że wyjście urządzenia jest aktywne. Może to być szczególnie istotne, gdy do urządzenia Bode 100 podłączone są wzmacniacze.
- Podczas pracy z zewnętrznymi źródłami napięcia lub prądu wchodzącymi w skład konfiguracji testowej upewnij się, że nie przekraczają one poziomów napięcia SELV i zapewnij odpowiednią izolację od innych niebezpiecznych obwodów, takich jak obwód zasilania napięciem linii AC.
- Upewnij się, że sondy napięciowe i prądowe używane z urządzeniami Bode 100 i Bode 500 są prawidłowo uziemione zgodnie z wytycznymi ich producenta.
- Podczas pracy z sondami napięciowymi, sondami prądowymi i transformatorami „wstrzykującymi” zawsze podłączaj zacisk uziemiający urządzenia Bode 100 lub Bode 500 do zacisku uziemiającego w laboratorium, używając do tego celu przewodu drutowego o przekroju co najmniej 3,6 mm² i długości nie większej niż 10 m.
- Używaj wyłącznie transformatorów iniekcyjnych z izolacją dostosowaną do maksymalnego napięcia roboczego i przepięć, które mogą występować przy danym zastosowaniu.
- Nie używaj urządzeń Bode 100 i Bode 500 w obecności wybuchowych gazów lub oparów.
- Nie używaj urządzeń Bode 100 i Bode 500 w warunkach środowiskowych przekraczających dopuszczalne zakresy temperatury i wilgotności podane w dokumentacji użytkownika.

Przeznaczenie:

- Urządzenia Bode 100, Bode 500 oraz ich osprzęt służą do pomiarów wzmocnienia/fazy, parametru S i impedancji obwodów elektronicznych w warunkach laboratoryjnych i produkcyjnych.

Kwalifikacje operatora:

- Testy za pomocą urządzeń Bode 100 i Bode 500 może wykonywać wyłącznie wykwalifikowany i autoryzowany personel mający odpowiednie umiejętności.
- Pracownicy odbywający szkolenie, zapoznający się z instrukcjami, wytycznymi i obsługą urządzenia Bode 100 lub Bode 500 muszą się znajdować pod stałym nadzorem doświadczonego operatora podczas pracy ze sprzętem. Testy przeprowadzane przy użyciu urządzeń Bode 100 i Bode 500 muszą być zgodne z wewnętrznymi przepisami bezpieczeństwa oraz dodatkowymi obowiązującymi dokumentami.

Portugues do Brasil – Instruções de segurança, uso designado e qualificações do operador

Instruções de segurança:

- O Bode 100 e o Bode 500 são dispositivos SELV (SELV = tensão de segurança extrabaixa de acordo com a IEC 60950-1), também conhecidos como equipamento de proteção classe III ou ES1 de acordo com a IEC 62368-1.
- Não aplique níveis de tensão >50 VCC ou >25 VCA às entradas do Bode 100 ou do Bode 500.
- Lembre-se de que o Bode 100 não tem indicador para mostrar se a saída está ativa. Isso pode ser especialmente crítico se os amplificadores estiverem conectados ao Bode 100.
- Ao trabalhar com fontes de corrente ou tensão externas na configuração de teste, garanta que elas não possam exceder os níveis SELV e forneça isolamento adequado para outros circuitos perigosos, como a fonte de alimentação da linha CA.
- Certifique-se de que as alicates de tensão e alicates de corrente utilizadas com o Bode 100 ou o Bode 500 estejam devidamente aterradas de acordo com as diretrizes do fabricante.
- Ao trabalhar com alicates de tensão, os alicates de corrente ou os transformadores de injeção sempre se conectam ao terminal de aterramento do Bode 100 ou do Bode 500 ao terminal de aterramento no laboratório usando uma conexão sólida de uma seção transversal de pelo menos 3,6 mm² e não mais de 10 m.
- Use apenas transformadores de injeção isolados para a tensão de operação e sobretensão máxima da aplicação.
- Não opere o Bode 100 ou o Bode 500 na presença de gases ou vapores explosivos.
- Não opere o Bode 100 ou o Bode 500 em condições ambientais que excedam os limites de temperatura e umidade listados na documentação do usuário.

Uso designado:

- O Bode 100, o Bode 500 e seus acessórios são especialmente projetados para medições de ganho/fase, parâmetro de dispersão e de impedância de circuitos eletrônicos em ambientes laboratoriais e de fabricação.

Qualificação do operador:

- Testes com o Bode 100 ou o Bode 500 devem ser realizados apenas por pessoal autorizado, capacitado e qualificado.
- Pessoal em fase de treinamento, instrução, orientação ou aprendizado sobre o Bode 100 ou o Bode 500 deve permanecer sob a constante supervisão de um operador experiente ao trabalhar com o equipamento. O teste com o Bode 100 ou o Bode 500 deve estar em conformidade com os regulamentos de segurança internas, além de com os documentos relevantes adicionais.

Română – Instrucțiuni de siguranță, destinația de utilizare și calificările operatorului

Instrucțiuni de siguranță:

- Bode 100 și Bode 500 sunt dispozitive SELV (SELV = Safety Extra Low Voltage conform IEC 60950-1), cunoscute și ca echipamente din clasa de protecție III sau echipament ES1 conform IEC 62368-1.
- A nu se aplica niveluri de tensiune > 50 V CC sau > 25 V CA pe intrările Bode 100 sau Bode 500.
- Vă rugăm să rețineți că Bode 100 nu are niciun indicator care să arate dacă ieșirea este activă. Acest aspect poate avea importanță critică dacă sunt conectate amplificatoare la Bode 100.
- În condiții de lucru cu tensiune externă sau surse de curent în configurația de test, asigurați-vă că acestea nu depășesc nivelurile SELV și realizați izolația adecvată față de alte circuite periculoase, precum sursa de tensiune a liniei CA.
- Asigurați-vă că sondele de tensiune și curent utilizate cu Bode 100 sau Bode 500 sunt împământate corect conform instrucțiunilor producătorului.
- În cazul utilizării sondelor de tensiune, a sondelor de curent sau a transformatoarelor de injecție conectați întotdeauna terminalul de împământare al Bode 100 sau Bode 500 la terminalul de împământare din laborator, folosind o conexiune solidă cu o secțiune de cel puțin 3,6 mm² și o lungime de maximum 10 m.
- Folosiți doar transformatoare de tensiune izolate pentru tensiunea și supratensiunea maximă de utilizare a aplicației.
- Nu operați Bode 100 sau Bode 500 în prezența gazelor sau vaporilor cu risc de explozie.
- Nu operați Bode 100 sau Bode 500 în condiții ambientale care depășesc limitele de temperatură și umiditate listate în documentația utilizatorului.

Destinația de utilizare:

- Bode 100, Bode 500 și accesoriile acestora sunt proiectate special pentru măsurători de amplificare/fază, parametri de dispersie și impedanță ale circuitelor electronice în medii de laborator sau de producție.

Calificările operatorului:

- Testarea cu Bode 100 sau Bode 500 trebuie efectuată doar de către personal calificat, instruit și autorizat.
- Personalul în curs de instruire, dirijare și educare privind Bode 100 sau Bode 500 trebuie să se afle sub supravegherea permanentă a unui operator experimentat în timpul utilizării echipamentului. Testarea cu Bode 100 sau Bode 500 trebuie să respecte reglementările de siguranță internă, precum și documentația suplimentară relevantă.

Slovenský – Bezpečnostné pokyny, určené použitie a kvalifikácia obsluhy

Bezpečnostné pokyny:

- Bode 100 a Bode 500 sú zariadenia SELV (SELV = bezpečnostné mimoriadne nízke napätie podľa IEC 60950-1), známe aj ako zariadenia triedy ochrany III alebo ES1 podľa IEC 62368-1.
- Na vstupy zariadenia Bode 100 alebo Bode 500 neprivádzajte napätie > 50 V DC alebo > 25 V AC.
- Majte na pamäti, že Bode 100 nemá žiadny indikátor, ktorý by ukazoval, či je výstup aktívny. Táto skutočnosť by mohla byť zvlášť kritická pri pripojení zosilňovačov k zariadeniu Bode 100.
- Pri práci s externými zdrojmi napätia alebo prúdu v testovacej zostave zabezpečte, aby nemohli prekročiť úrovne SELV, a zabezpečte vhodnú izoláciu od iných nebezpečných obvodov, ako je napríklad sieťový zdroj striedavého napätia.
- Uistite sa, že napäťové a prúdové snímače používané so zariadením Bode 100 alebo Bode 500 sú riadne uzemnené podľa pokynov výrobcu.
- Pri práci s napäťovými sondami, prúdovými sondami alebo injektážnymi transformátormi vždy pripojte uzemňovaciu svorku Bode 100 alebo Bode 500 k uzemňovacej svorke v laboratóriu pomocou pevného spojenia s prierezom najmenej 3,6 mm² a nie dlhšieho ako 10 m.
- Používajte len injektážne transformátory izolované na maximálne pracovné napätie a prepätie aplikácie.
- So zariadením Bode 100 alebo Bode 500 nepracujte za prítomnosti výbušných plynov alebo výparov.
- Nepoužívajte zariadenie Bode 100 alebo Bode 500 pri podmienkach prostredia, ktoré prekračujú teplotné a vlhkostné limity uvedené v používateľskej dokumentácii.

Určené použitie:

- Zariadenia Bode 100, Bode 500 a ich príslušenstvo sú špeciálne navrhnuté na merania zosilnenia/fázu, S-parametra a impedancie elektronických obvodov v laboratóriách a výrobných prostrediach.

Kvalifikácia obsluhy:

- Testovanie pomocou zariadenia Bode 100 alebo Bode 500 môže vykonávať len vyškolený, skúsený a oprávnený personál.
- Na pracovníkov, ktorí momentálne absolvujú školenie, zaúčajú sa alebo sa vzdelávajú v súvislosti so zariadením Bode 100 alebo Bode 500, musí pri práci so zariadením vždy dohliadať skúsený operátor. Testovanie pomocou zariadenia Bode 100 alebo Bode 500 sa musí vykonávať v zhode s internými bezpečnostnými predpismi, ako aj ďalšou príslušnou dokumentáciou.

Slovenščina – Varnostna navodila, predvidena uporaba in kvalifikacije upravljavca

Varnostna navodila:

- Bode 100 in Bode 500 sta napravi z napetostjo SELV (SELV = varna zelo nizka napetost v skladu s standardom IEC 60950-1), znani tudi kot oprema z zaščitnim razredom III ali ES1 v skladu s standardom IEC 62368-1.
- Na vhodih naprave Bode 100 ali Bode 500 ne uporabljajte napetosti > 50 V DC ali > 25 V AC.
- Zavedajte se, da naprava Bode 100 nima indikatorja, ki bi pokazal, ali je izhod aktiven. To je še posebej pomembno, če so na napravo Bode 100 priključeni ojačevalniki.
- Pri delu z zunanjimi viri napetosti ali toka v nastavitvi preizkusa poskrbite, da ne presegajo ravni SELV, in zagotovite ustrezno izolacijo drugih nevarnih tokokrogov, kot je omrežno napajanje z izmeničnim tokom.
- Zagotovite, da so sonde za napetost in tok, ki se uporabljajo z napravo Bode 100 ali Bode 500, pravilno ozemljene v skladu z navodili proizvajalca.
- Pri delu s sondami za napetost in tok ali dovodnimi transformatorji ozemljitveni priključek naprave Bode 100 ali Bode 500 vedno povežite z ozemljitvenim priključkom v laboratoriju, pri čemer uporabite priključitev s prerezom vsaj 3,6 mm² in ne daljšo od 10 m.
- Uporabljajte samo dovodne transformatorje, izolirane za največjo delovno napetost in prenapetost aplikacije.
- Naprave Bode 100 ali Bode 500 ne uporabljajte v bližini eksplozivnih plinov ali hlapov.
- Naprave Bode 100 ali Bode 500 ne uporabljajte v okoljskih pogojih, v katerih so presežene omejitve temperature in vlage, navedene v uporabniški dokumentaciji.

Predvidena uporaba:

- Napravi Bode 100 in Bode 500 ter njuna dodatna oprema so izdelane posebej za merjenje ojačevalnega/faznega razločka, parametra razpršenosti in impedance elektronskih vezij v laboratoriju in proizvodnih okoljih.

Kvalifikacija upravljavca:

- Preizkušanje z napravo Bode 100 ali Bode 500 lahko izvaja samo kvalificirano, usposobljeno in pooblaščeno osebje.
- Osebje, ki se usposablja, prejema navodila ali se izobražuje o napravi Bode 100 ali Bode 500, mora biti med delom z opremo pod stalnim nadzorom izkušenega upravljavca. Preizkušanje z napravo Bode 100 ali Bode 500 mora biti v skladu z notranjimi varnostnimi predpisi in dodatnimi ustreznimi dokumenti.

Svenska – Säkerhetsinstruktioner, avsedd användning och användarkvalifikationer

Säkerhetsinstruktioner:

- Bode 100 och Bode 500 är SELV-enheter (SELV = Safety Extra Low Voltage (säkerhet extra låg spänning) enligt IEC 60950-1), även känd som skyddsklass III- eller ES1-utrustning enligt IEC 62368-1.
- Anslut inte spänningsnivåer > 50 V DC eller > 25 V AC till ingångarna på Bode 100 eller Bode 500.
- Var medveten om att Bode 100 inte har någon indikator som visar om utgången är aktiv. Detta kan vara särskilt kritiskt om förstärkare är anslutna till Bode 100.
- När du arbetar med externa spännings- eller strömkällor i testutrustningen, ska du se till att de inte kan överskrida SELV-nivåerna och ge lämplig isolering till andra farliga kretsar, såsom nätspänningsförsörjningen.
- Kontrollera att spännings- och strömsonder som används med Bode 100 eller Bode 500 har jordats ordentligt i enlighet med deras tillverkares anvisningar.
- Vid arbete med spänningssonder, strömsonder eller matningstransformatorer, ska jordterminalen på Bode 100 eller Bode 500 alltid anslutas till jordterminalen i laboratoriet, med en fast anslutning med minst 3,6 mm² i tvärsnitt och som inte är längre än 10 m.
- Använd endast matningstransformatorer som är isolerade för tillämpningens maximala arbetsspänning och överspänning.
- Använd inte Bode 100 eller Bode 500 i närvaro av explosiva gaser eller ångor.
- Använd inte Bode 100 eller Bode 500 i förhållanden som ligger utanför de temperatur- och fuktighetsgränser som anges i användarmanualerna.

Avsedd användning:

- Bode 100, Bode 500 och enheternas tillbehör har tagits fram specifikt för förstärkning/fas-, S-parameter- och impedansmätningar på elektroniska kretsar i laboratorie- och tillverkningsmiljöer.

Användarkvalifikation:

- Test med Bode 100 eller Bode 500 ska endast utföras av kvalificerad, kunnig och auktoriserad personal.
- Personal som får utbildning, instruktioner, anvisningar eller undervisning om Bode 100 eller Bode 500 måste vara under ständig övervakning av en erfaren operatör medan de arbetar med utrustningen. Test med Bode 100 eller Bode 500 måste följa interna säkerhetsföreskrifter, samt ytterligare relaterade dokument.

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