Bode 100

User Manual

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Contents

Using This Manual

This User Manual provides detailed information on how to use all functions of the *Bode 100* vector network analyzer properly and efficiently. The Bode 100 User Manual is intended for all users of the *Bode 100*, providing instructions on the operation, usage, and measurement procedures.

Any user of the *Bode 100* should have fundamental working knowledge of basic electronics, general measurement techniques, and the use of PC-based applications running under a Windows® environment.

Conventions and Symbols Used

In this manual, the following symbol indicates paragraphs with special safety relevant meaning:

Symbol	Description
	Equipment damage or loss of data possible.

Related Documents

The following documents complete the information covered in the Bode 100 User Manual:

Title	Description
Automation Interface Object Hierarchy and Automation Interface Reference available in the Automation subdirectory of the *Bode Analyzer Suite* directory	Provide detailed information on the *Bode Analyzer Automation Interface*.

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1 Introduction

1.1 Overview

The *Bode 100* is a multifunctional test & measurement instrument designed for professionals such as scientists, engineers and teachers engaged in the field of electronics. Its concept – universal hardware controlled by the *Bode Analyzer Suite* software running on a PC – makes the *Bode 100* an efficient and flexible solution for a wide spectrum of applications including:

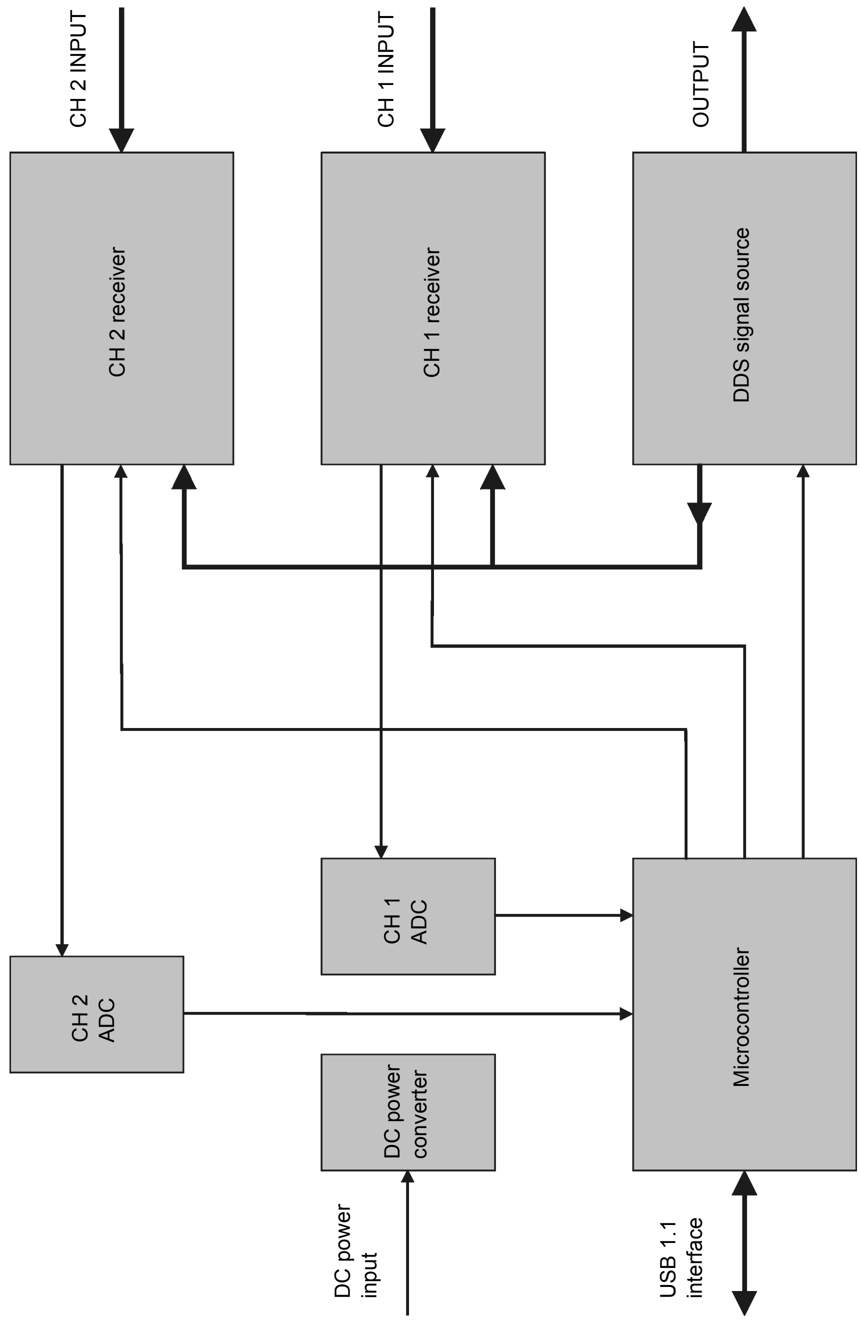
- **Gain/Phase** measurements
  The *Bode 100* measures the gain and phase of passive and active electronic circuits as well as complex electronic systems such as closed-loop control systems, video systems and RF equipment.
- **Impedance/Reflection** measurements
  The *Bode 100* measures impedance, admittance and reflection coefficient of passive and active electronic circuits. An internal bridge allows performing measurements by just connecting the device under test (DUT) to the *Bode 100*'s source.
- **Frequency Sweep** measurements
  In addition to single frequency measurements, the *Bode 100* performs measurements in the **Frequency Sweep** mode.
  In this measurement mode, the *Bode 100* is capable of measuring the gain, reflection coefficient and impedance of the DUT. The results are displayed as a function of the frequency in various display formats such as group delay curves or Smith charts.

The measurement results are available on your PC for processing and/or documentation.

The *Bode 100* includes a DDS (direct digital synthesis) signal source with adjustable level and frequency for excitation of the DUT, two receivers processing the DUT's response and a microcontroller. A DC power converter generates voltages for powering the circuitry involved. The *Bode Analyzer Suite* software runs on a PC connected to the *Bode 100* via USB interface.

1.2 Block Diagram

Figure 1-1:
Block diagram



1.3 Connectors

Caution: To avoid damage of the *Bode 100*, check 10.3 "Absolute Maximum Ratings" on page 102 for maximum input signals at the CH 1 INPUT and CH 2 INPUT connectors and maximum reverse power at the OUTPUT connector.

The *Bode 100* provides the following connectors:

- OUTPUT (signal source output) on the front panel
- CH 1 INPUT (channel 1 input) on the front panel
- CH 2 INPUT (channel 2 input) on the front panel
- DC power input on the rear panel
- USB connector on the rear panel

Figure 1-2:
Bode 100 front view

Figure 1-3:
Bode 100 rear view

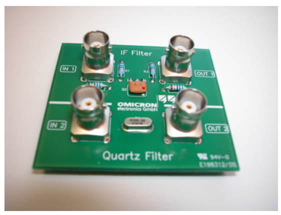
1.4 Standard Compliance

The *Bode 100* complies with the following standards:

Table 1-1:
Standard compliance

Standard	**Description**
IEC 61326: Class B equipment Performance criterion B	EMC requirements
Universal Serial Bus (USB) Specification, Revision 1.1 and Revision 2.0	USB interface

1.5 Delivery

 *Bode 100* multifunctional vector network analyzer	 *Bode 100* CD-ROM	 Wide-range AC power supply including mains input plugs for different national standards
 Test objects on a PCB: Quartz filter, IF filter	 USB cable	 4 × BNC 50 Ω cable (m–m)
 BNC straight adapter (f–f)	 BNC T adapter (f–f–f)	 BNC short circuit (m)
 BNC 50 Ω load (m)	 Bode 100 User Manual	The delivered items may differ slightly from the picture.

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2 Installation

Caution: Before installing the *Bode 100*, check the environmental and power requirements (see 10 "Technical Data" on page 101).

2.1 Installing the *Bode Analyzer Suite*

Caution: Install the *Bode Analyzer Suite* on the delivered CD-ROM before using the *Bode 100*.

The *Bode Analyzer Suite* software on the delivered CD-ROM controls the operation of the *Bode 100*. Install the *Bode Analyzer Suite* first, before you connect the *Bode 100* to the PC. Put the *Bode 100* CD-ROM in the CD-ROM drive and follow the instructions on the screen. Please check the OMICRON Lab website www.omicron-lab.com for installation support or contact your nearest support center (see "Contact Information / Technical Support" on page 105).

2.2 Powering the *Bode 100*

Caution: Before powering the *Bode 100* using a DC power supply not delivered with the *Bode 100*, check the polarity of its output voltage (see 10.2 "Power Requirements" on page 102).

The *Bode 100* is powered with an external wide-range AC power adapter. Before powering the *Bode 100*, select the adapter's mains input plug fitting your power outlet. Plug the adapter's DC output connector into the *Bode 100*'s DC power input on the rear panel and the mains input plug into the power outlet. Alternatively, you can power the *Bode 100* with any DC power supply meeting the power requirements specified on page 102.

2.3 Connecting the *Bode 100* with the PC

The *Bode 100* communicates with the PC via USB interface (see 10.4 "PC Requirements" on page 103). Connect the *Bode 100*'s USB connector on the rear panel to the USB connector of your PC using the USB cable delivered with your *Bode 100*.

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3 Gain/Phase Mode

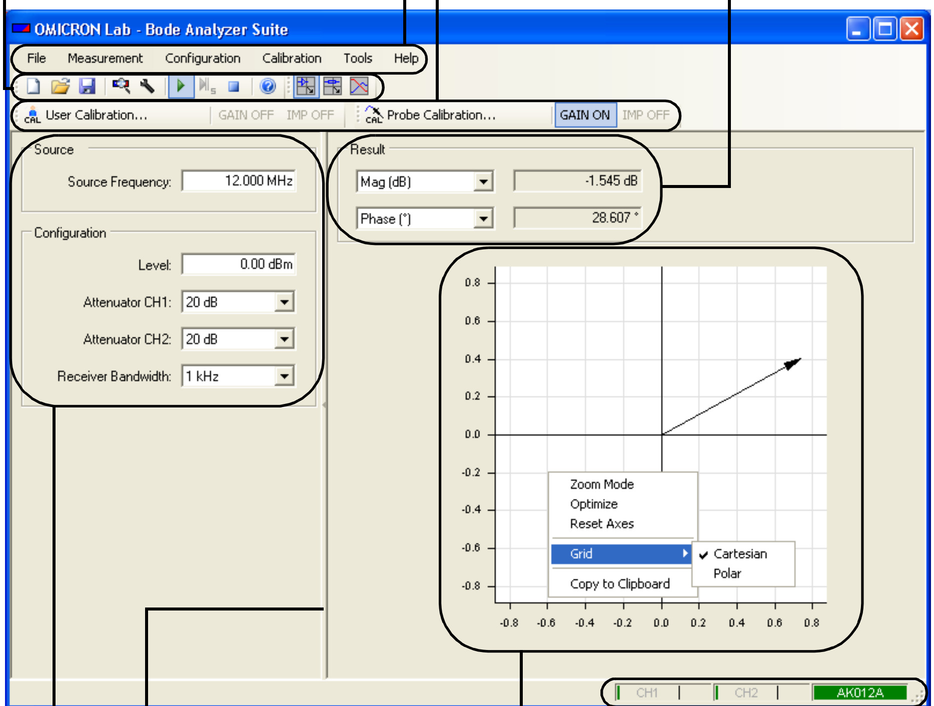
Figure 3-1:
Gain/Phase mode window

Menu bar
Allows access to all *Bode 100* functions. See Table 3-1: "Menus and commands" on page 16.

Calibration toolbar
Choose the calibration mode.
Switch the calibration on and off.
See Figure 3-3: "Calibration toolbar" on page 17.

Toolbar
Contains shortcuts to the most important *Bode 100* functions.
See Figure 3-2: "Toolbar" on page 17.

Results
Select the result format and get result values.
See Figure 3-5: "Gain/Phase mode results" on page 18.



Split bar
Drag the split bar to resize the panes.

Configuration and measurement setup
See Figure 3-4: "Configuration and measurement setup" on page 18.

Overload and connection indicators
See Figure 3-7: "Overload and connection indicators" on page 19.

Graphical display of measurement results
Use the context menu to optimize the display.
See Figure 3-6: "Graphical display of measurement results" on page 19.

Table 3-1:
Menus and commands

Menu	Command	Description
File	**New**	Opens the `NewBodeMeasurement.Bode` file containing default settings.
	Open	Opens a `*.Bode` file containing saved settings and measurement data.
	Save	Saves the device configuration, measurement settings, calibration and measurement data and the graphical display settings.
	Save As	
	Exit	Closes the *Bode Analyzer Suite*.
Measurement	**Gain/Phase**	Selects the **Gain/Phase** measurement mode.
	Impedance/Reflection	Selects the **Impedance/Reflection** measurement mode.
	Frequency Sweep	Selects the **Frequency Sweep** measurement mode.
	Continuous Measurement	Starts continuous measurements.
	Single Measurement	Starts a single frequency sweep measurement.[1]
	Stop Measurement	Stops measurement. The last result remains displayed.
Configuration	**Device Configuration**	Allows setting the device configuration.
	Connection Setup	Shows the connection of the DUT to *Bode 100*.
	Search and Reconnect Device	Connects *Bode 100* with the PC.

[1]Only available in the **Frequency Sweep** mode

Menu	Command	Description
Calibration	**User Calibration**	Starts the user calibration (see 6 "Calibrating the Bode 100" on page 59).
	Probe Calibration	Starts the probe calibration (see 6 "Calibrating the Bode 100" on page 59).
Tools	**Options**	Allows setting the startup configuration and the CSV export options (see 7.1 "File Operations" on page 73).
Help	**Contents**	Opens the online help.
	About	Displays the *Bode Analyzer Suite* version.

Figure 3-2:
Toolbar

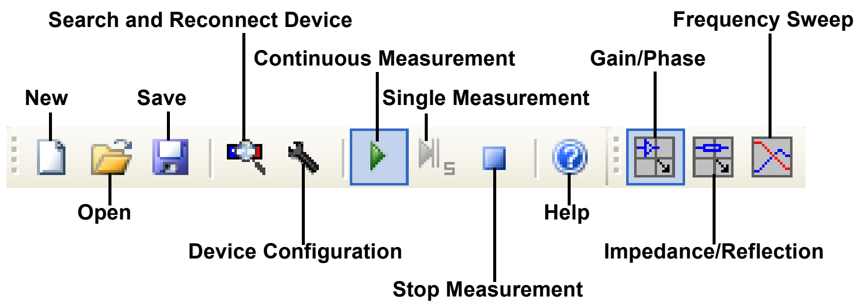


Figure 3-3:
Calibration toolbar

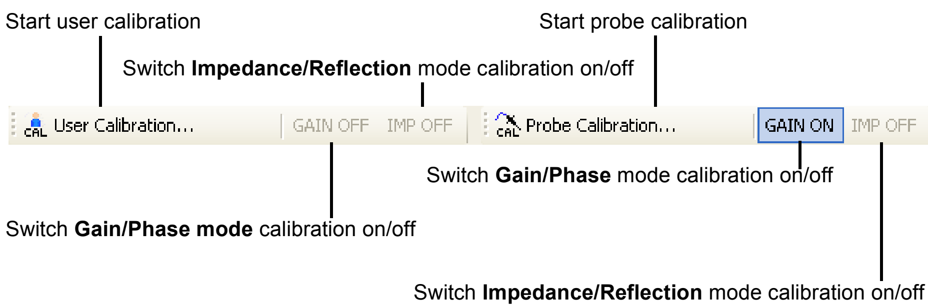
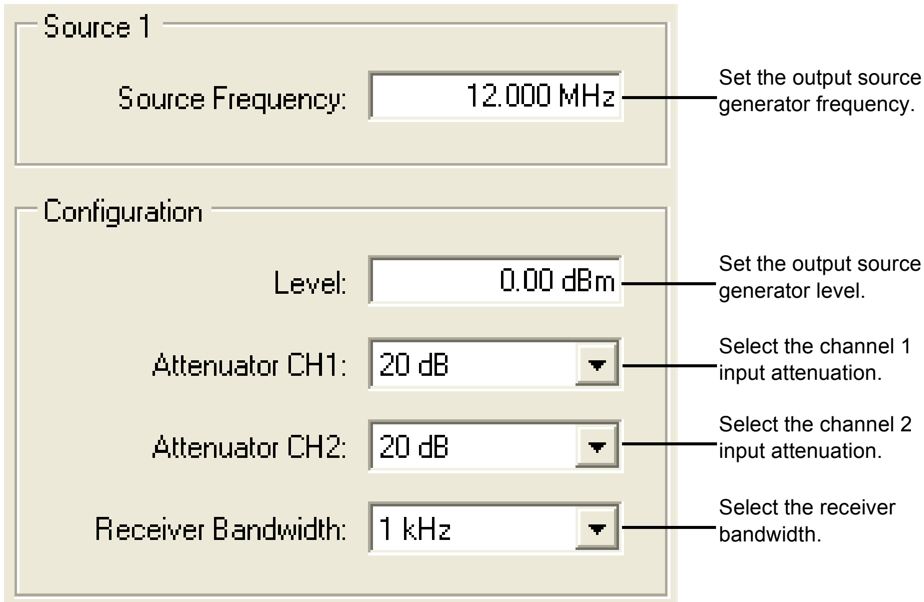


Figure 3-4:
Configuration and measurement setup



Hint: A higher receiver bandwidth allows faster measurements, a lower receiver bandwidth increases the measurement accuracy.

Figure 3-5:
Gain/Phase mode results

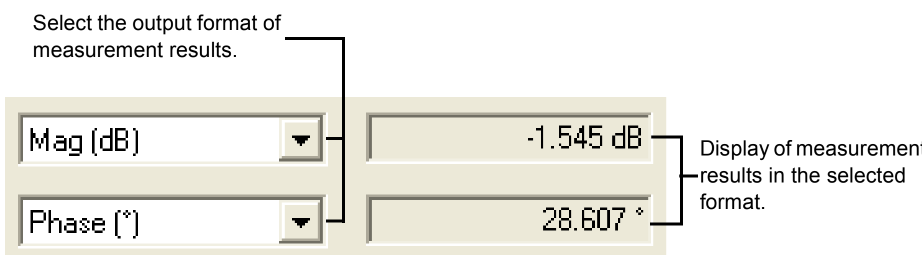
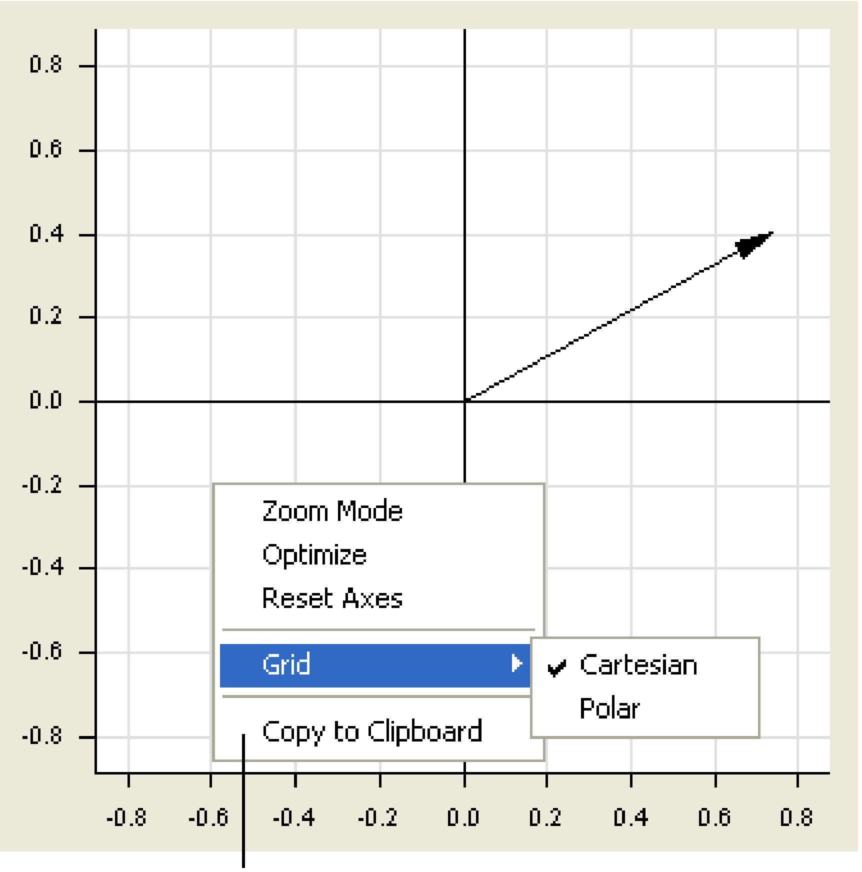


Figure 3-6:
Graphical display of
measurement results



Right-click in the diagram to open the context menu.
Use the context menu to optimize the diagram, select the grid and zoom in the diagram. After having zoomed in, click **Optimize** to get back to an optimized diagram.

Hint: Using the **Copy to Clipboard** function you can easily export your diagram into other Windows® applications.

Figure 3-7:
Overload and
connection indicators

Overload indicators for the channel 1 and channel 2 inputs. If you see a red bar, increase the attenuation of the respective channel to prevent the overload.

Serial number of the *Bode 100*

Hint: If the serial number field in the status bar displays "No Device" on red background, check whether the *Bode 100* is powered and connected with your PC, and then click the toolbar button to reconnect the *Bode 100*.

3.1 Basics

The gain and phase of the DUT is calculated from the measurement data obtained using the reference channel 1 and the measurement channel 2. You can connect the signal source to the reference channel internally or externally as described in 3.2 "Choosing the Reference Connection" on page 22.

The basic definitions and formulas related to the gain/phase measurements are summarized below:

$$|\underline{H}(f)| = \mathrm{abs}\{\underline{H}(f)\} \qquad \text{(Eq. 3-1)}$$

$$\phi(f) = \arg\{\underline{H}(f)\} \qquad \text{(Eq. 3-2)}$$

$$T_g(f) = -\frac{1}{2\pi} \bullet \frac{\mathrm{d}}{\mathrm{d}f}\phi(f) = -\frac{\mathrm{d}}{\mathrm{d}\omega}\phi(\omega) \qquad \text{(Eq. 3-3)}$$

where
$\underline{H}(f)$ …displayed gain/phase function
$|\underline{H}(f)|$ …magnitude of $\underline{H}(f)$
$\phi(f)$ …phase of $\underline{H}(f)$
$T_g(f)$ …group delay of $\underline{H}(f)$

$$\underline{S}_{ji}(f) = 2 \bullet \frac{\underline{V}_{OUT}}{\underline{V}_0},\ i \neq j \qquad \text{(Eq. 3-4)}$$

$$\underline{H}_T(f) = \frac{\underline{V}_{OUT}}{\underline{V}_{IN}} \qquad \text{(Eq. 3-5)}$$

where
$\underline{S}_{ji}(f)$ …S parameter from port *i* to port *j* $(i \neq j)$ of the DUT
$\underline{H}_T(f)$ …transfer function of a two-port device, $\underline{H}_T(f)$ depends on the load of the port where $\underline{V}_{OUT}$ is measured
$\underline{V}_{OUT}$ …voltage at the DUT's output
$\underline{V}_0$ …open-circuit voltage of the source
$\underline{V}_{IN}$ …voltage at the DUT's input
$\underline{V}_{CH1}$ …voltage at the channel 1 input
$\underline{V}_{CH2}$ …voltage at the channel 2 input
$\underline{Z}_{IN}$ …input impedance of the DUT
R_S …50 Ω source resistance

Assumptions for measuring $\underline{S}_{ji}(f)$:

- The source with resistance R_S = 50 Ω is connected to port *i.*
- 50 Ω load (receiver resistance) at port *j* measuring $\underline{V}_{OUT}$, any other ports of the DUT are terminated with 50 Ω.
- Connections are made with 50 Ω cables.

3.1.1 Internal Reference Connection

The basic formulas for the internal reference connection are summarized below.

Table 3-2: Formulas for Internal Reference Connection

Channel 2 Input Resistance	
50 Ω	**High Impedance**
$\underline{V}_{CH1} = \frac{\underline{V}_0}{2}$ (Eq. 3-6)	$\underline{V}_{CH1} = \frac{\underline{V}_0}{2}$ (Eq. 3-7)
$\underline{V}_{CH2} = \underline{V}_{OUT}$ (Eq. 3-8)	$\underline{V}_{CH2} = \underline{V}_{OUT}$ (Eq. 3-9) $\underline{V}_{IN} = \underline{V}_0 \bullet \frac{\underline{Z}_{IN}}{(\underline{Z}_{IN} + R_S)}$ (Eq. 3-10)
$\underline{H}(f) = \frac{\underline{V}_{CH2}}{\underline{V}_{CH1}} = 2 \bullet \frac{\underline{V}_{OUT}}{\underline{V}_0}$ $= S_{ji}(f)$ of the DUT (Eq. 3-11)	$\underline{H}(f) = \frac{\underline{V}_{CH2}}{\underline{V}_{CH1}} = 2 \bullet \frac{\underline{V}_{OUT}}{\underline{V}_0}$ $= 2 \bullet \frac{\underline{V}_{OUT}}{\underline{V}_{IN}} \bullet \frac{\underline{Z}_{IN}}{(\underline{Z}_{IN} + R_S)}$ (Eq. 3-12) $\underline{H}(f) = 2 \bullet \underline{H}_T(f) \bullet \frac{\underline{Z}_{IN}}{(\underline{Z}_{IN} + R_S)}$ (Eq. 3-13)
If you make a through connection from the source to CH 2: 0 dB gain will be displayed since $\underline{V}_{CH2} = \underline{V}_0/2$	If you make a through connection from the source to CH 2: +6 dB gain will be displayed since $\underline{V}_{CH2} = \underline{V}_0$

3.1.2 External Reference Connection

Independent of the selected input impedance at the channel 1and channel 2 inputs, the following formulas apply:

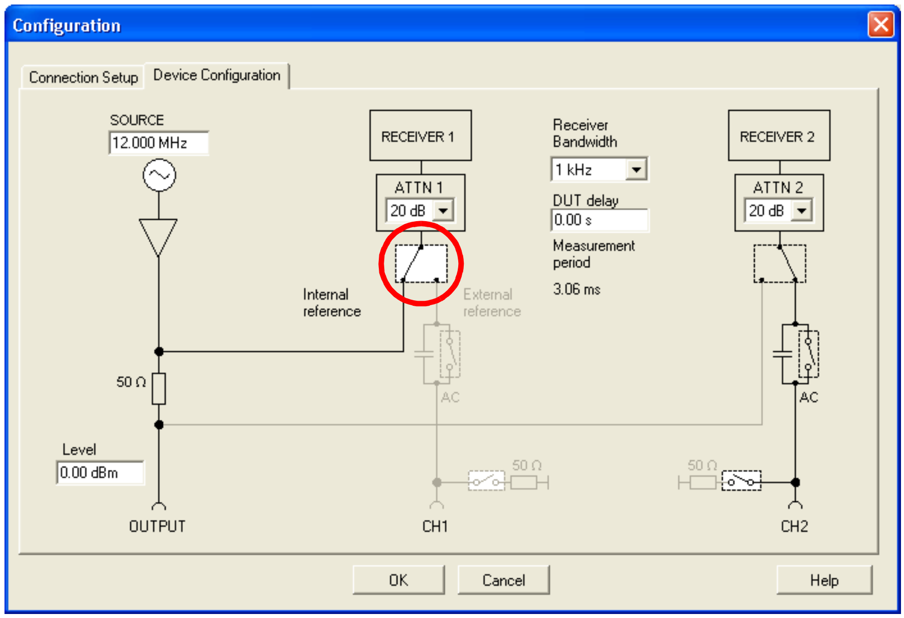
$$\underline{V}_{CH1} = \underline{V}_{IN} \quad \text{(Eq. 3-14)}$$

$$\underline{V}_{CH2} = \underline{V}_{OUT} \quad \text{(Eq. 3-15)}$$

$$\underline{H}(f) = \underline{H}_T(f) = \frac{\underline{V}_{CH2}}{\underline{V}_{CH1}} = \frac{\underline{V}_{OUT}}{\underline{V}_{IN}} \quad \text{(Eq. 3-16)}$$

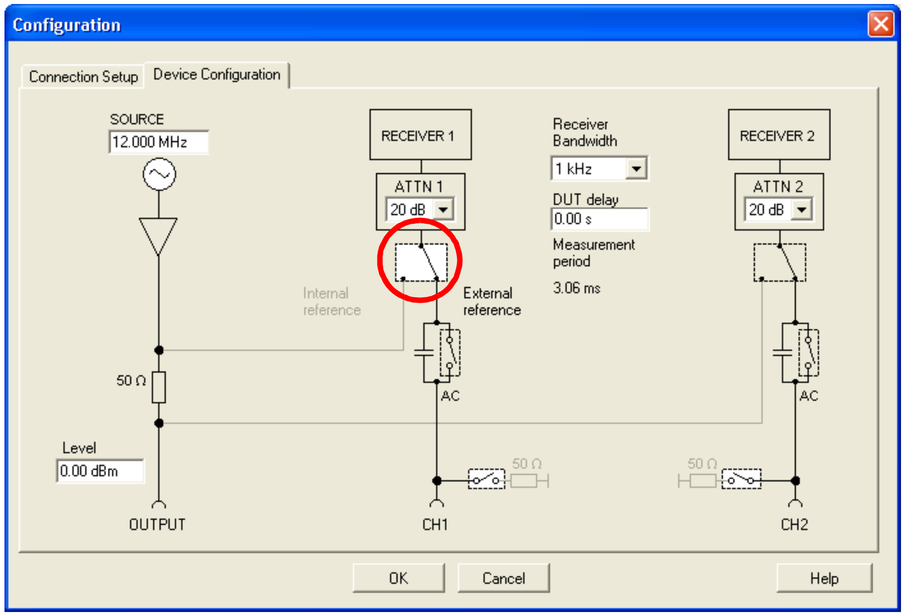
3.2 Choosing the Reference Connection

Open the **Configuration** window by clicking **Device Configuration** on the **Configuration** menu or the  toolbar button (see 3.3 "Example: Gain/Phase Measurement" on page 24). By default, the **Device Configuration** tab is selected. To connect the reference internally, set the marked configuration field as shown below.



Note: The source signal is internally connected to the channel 1 input in front of the 50 Ω source resistor (channel 1 voltage $\underline{V}_0$ as defined in 3.1 "Basics" on page 20).

To connect the reference externally, set the marked configuration field as shown below, and then connect the OUTPUT connector to the CH 1 INPUT connector using a cable.



Note: The source signal is externally connected to the channel 1 input behind the 50 Ω source resistor (channel 1 voltage $\underline{V}_{IN}$ as defined in 3.1 "Basics" on page 20).

3.3 Example: Gain/Phase Measurement

Expected example duration: 20 minutes.

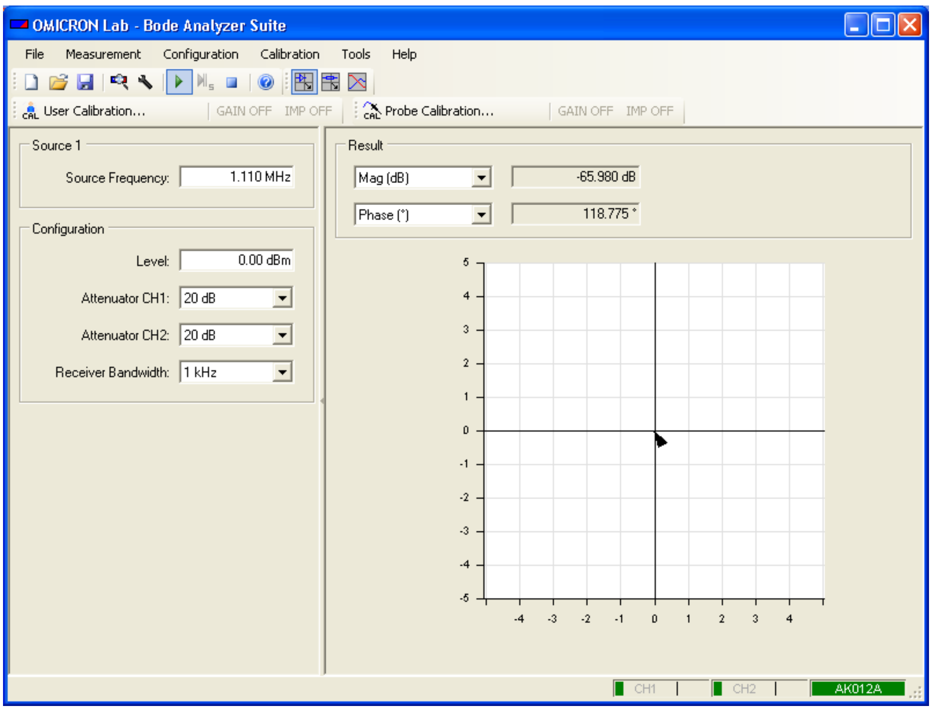
In this example you will learn step by step how to use the **Gain/Phase** mode of the *Bode 100*. How to:

- measure gain and phase of a sinusoidal signal at a certain frequency
- set bandwidth, attenuators and amplitudes of the generator
- optimize the diagram
- compensate the connection cables in the **Gain/Phase** mode

Question: What magnitude in dB does the delivered test object IF filter have at 10.7 MHz?

These types of 10.7 MHz filters are used in FM radios.

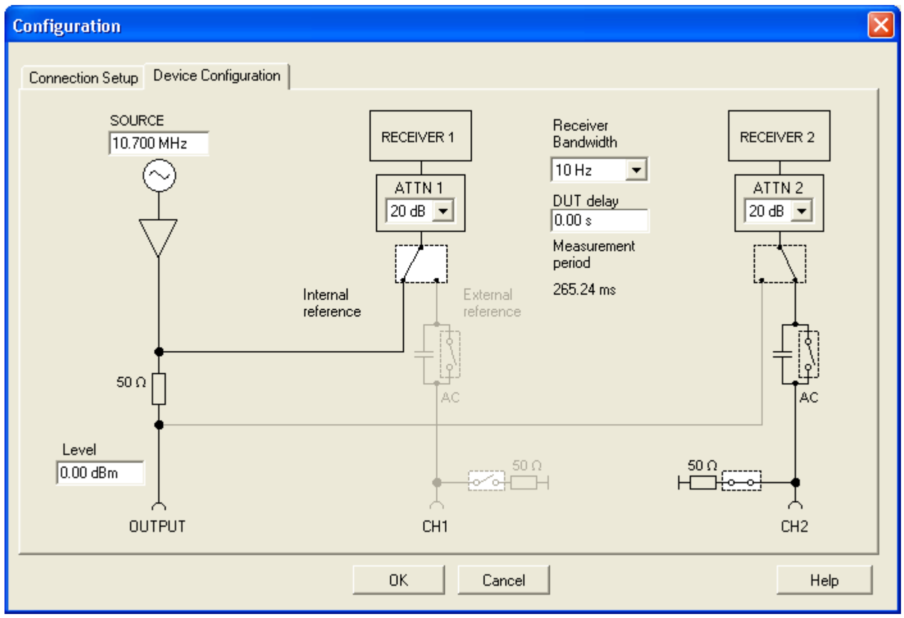
1. Connect the *Bode 100* and start the *Bode Analyzer Suite* software. Select the **Gain/Phase** mode.



Hint: If you see a serial number e.g. 

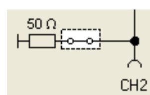
in the status bar on the lower right side of the window then the *Bode Analyzer Suite* communicates with the *Bode 100*. If you cannot see the serial number check whether your *Bode 100* is connected and powered properly, and then click the  toolbar button.

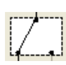
2. Click the  toolbar button to configure the **Gain/Phase** mode.



3. Set:

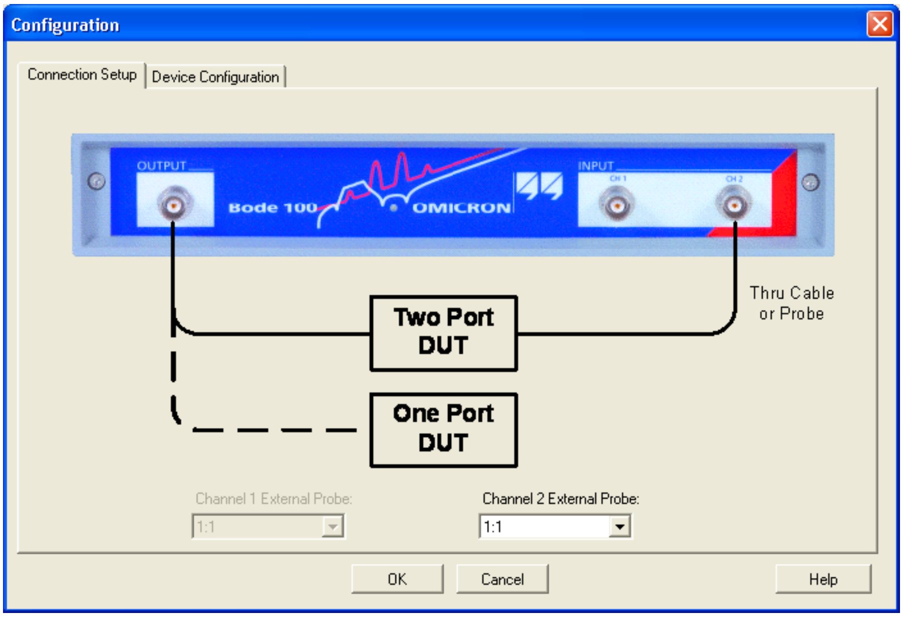
- CH2: 50 Ω ON (click on switch as shown)



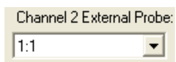
- SOURCE: 10.7 MHz
- Receiver bandwidth: 10 Hz
- ATTN 1 (channel 1 input attenuator): 20 dB
- ATTN 2 (channel 2 input attenuator): 20 dB
- The switch  (before ATTN1) to the internal source as reference
- Level: 0 dBm

Hint: Setting the receiver bandwidth to 10 Hz makes the readout more stable but also makes the measurement slower.

4. Click the **Connection Setup** tab.

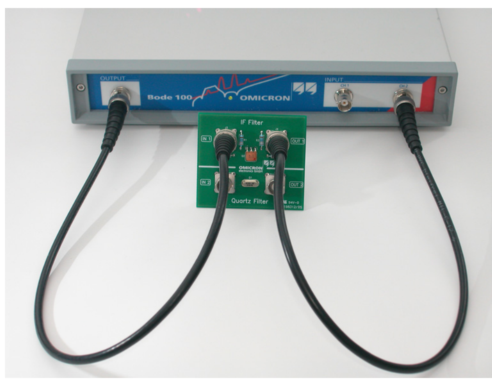


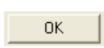
The picture shows you how to connect the DUT.

Hint: Use the 

box to set the voltage ratio when a probe is used instead of cable connection (see 7.3 "Advanced Sweep Options" on page 88).

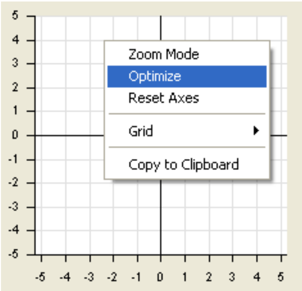
5. Connect the test object (IF filter) to the *Bode 100* as shown.

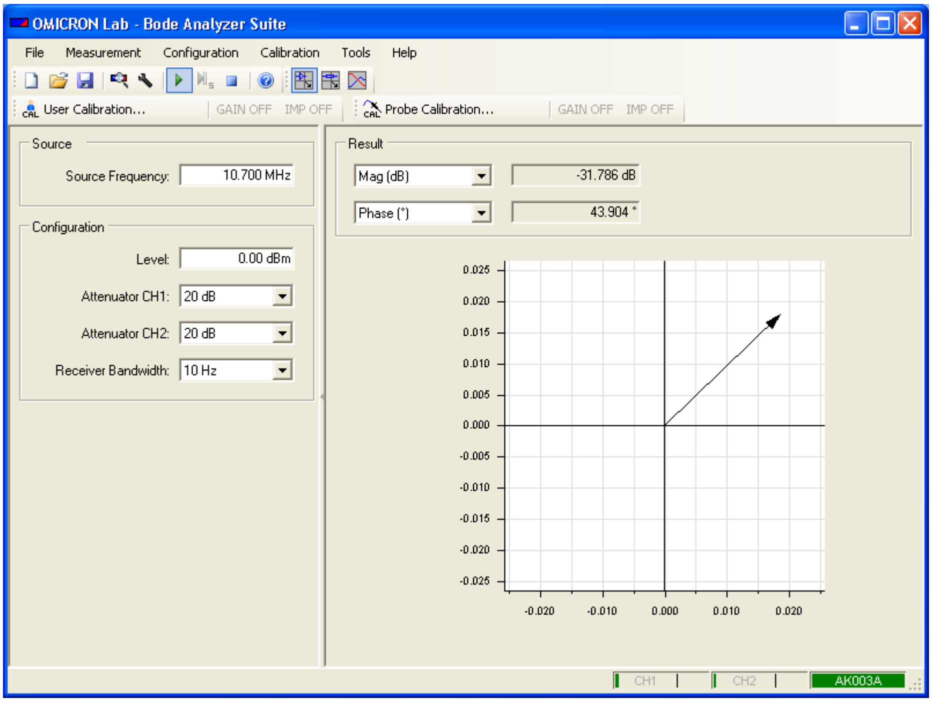


6. Click 

to close the **Configuration** window and to get back to the **Gain/Phase** mode window.

7. For a better view of the **Gain/Phase** vector in the complex plane, right-click in the diagram, and then click **Optimize**.



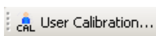


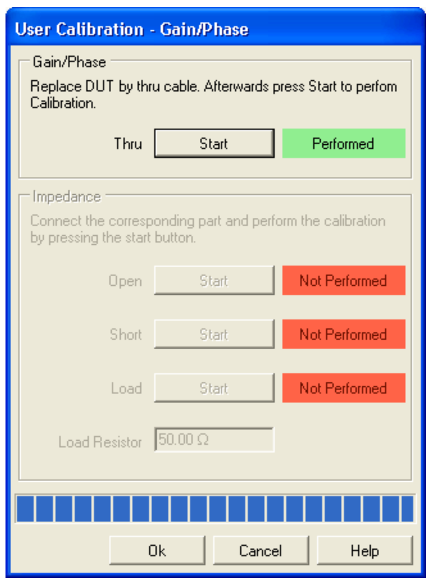
Result: The IF filter has a magnitude of –31.79 dB at 10.7 MHz. Your result may differ because each IF filter is slightly different.

The phase readout is not the value you want to measure because it is the sum of the phase shift of the cables and of the IF filter. To get the value of the IF filter alone, use the **Gain/Phase** calibration to compensate the phase shift of the cables.

Continue the example and calibrate the *Bode 100* to get a usable phase measurement.

1. Replace the test object IF filter with the BNC straight adapter (f–f).

2. Click the  toolbar button to open the calibration window.
3. In the **User Calibration - Gain/Phase** window, click **Start**.

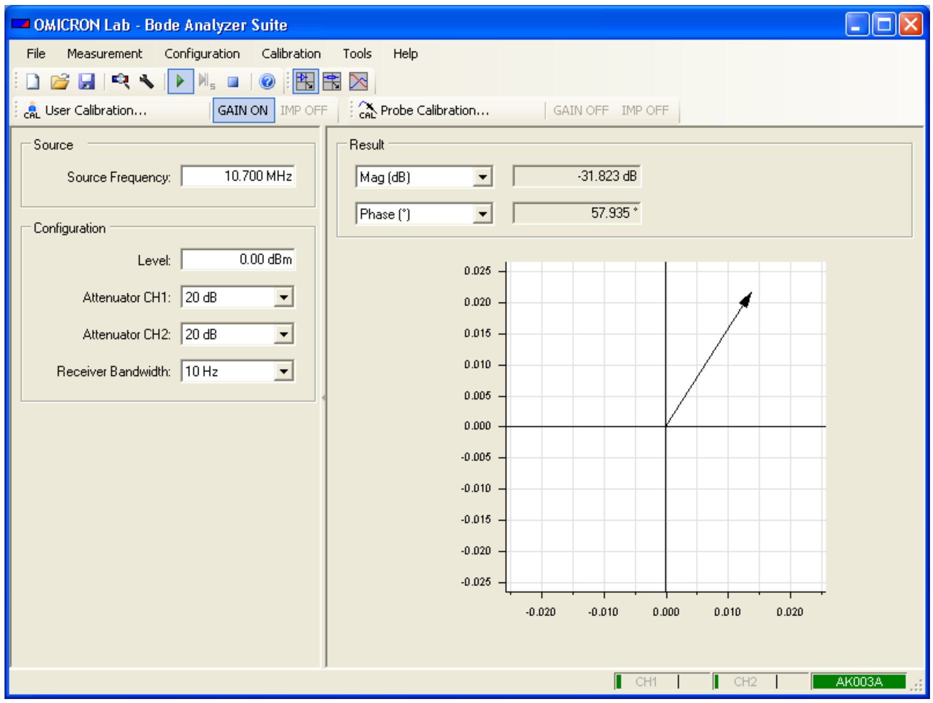


The calibration takes only a few seconds. The **Gain/Phase** mode is now calibrated for the current specific measurement setup.

Note: The **Impedance** calibration is unavailable because it cannot be used in the **Gain/Phase** mode.

4. Click OK.
5. Reconnect the test object (IF filter).

Hint: If you change settings the user calibration has to be repeated. If you use the probe calibration Probe Calibration... instead you can change settings without repeating the calibration. For more information, see 6 "Calibrating the Bode 100" on page 59.



Result: The transfer function of the IF filter has a magnitude of –31.82 dB and a phase shift of 57.9º at 10.7 MHz.

Again, your results may differ because every IF filter and measurement setup is slightly different.

Hint: You can toggle between the measurement results with calibration and without calibration by clicking the GAIN ON toolbar button.

As OMIfuzius said: Only applied knowledge changes the world. We are responsible to change it to the better.

Congratulation! In this example you learned how to use the **Gain/Phase** mode.

How to:

- measure gain and phase shift of a DUT using a sinusoidal signal at a certain frequency
- set bandwidth, attenuators and amplitude of the generator
- optimize the diagram
- compensate the connection cables in the **Gain/Phase** mode

Go back to the overview chart at 3 "Gain/Phase Mode" on page 15 and try different settings to check out their effect on the measurement.

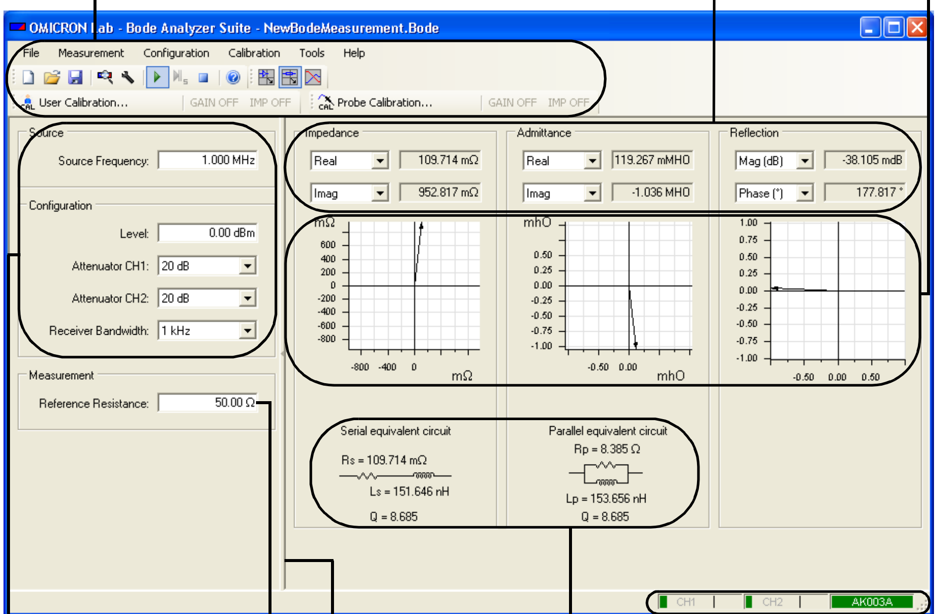
4 Impedance/Reflection Mode

Figure 4-1:
Impedance/Reflection mode window

For the description of the menu bar, toolbar and calibration bar, see 3 "Gain/Phase Mode" on page 15.

Graphical display of measurement results
Use the context menu to optimize the display. See Figure 3-6: "Graphical display of measurement results" on page 19.

Results
Select the result format and get result values. See Figure 4-2: "Impedance/Reflection mode results" on page 32.



Split bar
Drag the split bar to resize the panes.

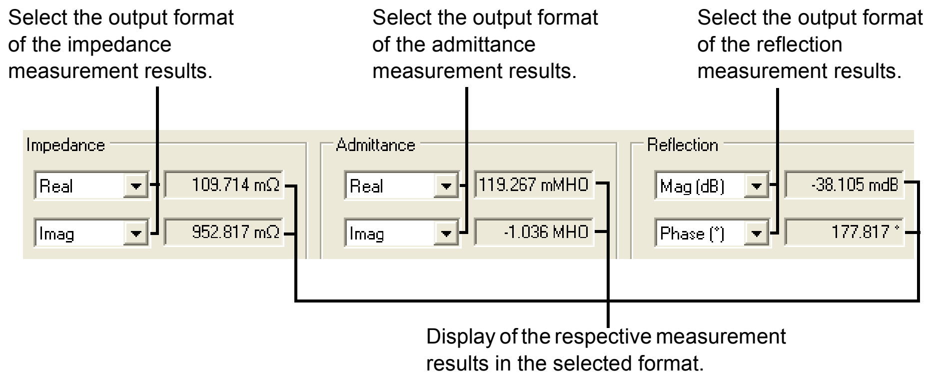
Equivalent circuits
View the equivalent circuits (see 4.1.2 "Equivalent Circuits" on page 33).

Reference resistance
Set the reference resistance (see 4.1.1 "General Formulas" on page 32).

Overload and connection indicators
See Figure 3-7: "Overload and connection indicators" on page 19.

Configuration and measurement setup
See Figure 3-4: "Configuration and measurement setup" on page 18.

Figure 4-2:
Impedance/Reflection
mode results



4.1 Basics

4.1.1 General Formulas

The general formulas related to the **Impedance/Reflection** measurements are summarized below:

$$\underline{Z} = \frac{\underline{V}}{\underline{I}} \qquad \text{(Eq. 4-1)}$$

$$\underline{Y} = \frac{\underline{I}}{\underline{V}} = \frac{1}{\underline{Z}} \qquad \text{(Eq. 4-2)}$$

$$\underline{r} = \frac{\underline{Z} - R_0}{\underline{Z} + R_0} = \frac{G_0 - \underline{Y}}{G_0 + \underline{Y}} \qquad \text{(Eq. 4-3)}$$

$$R_0 = \frac{1}{G_0} \qquad \text{(Eq. 4-4)}$$

where

$\underline{V}$ …voltage at the reference plane
$\underline{I}$ …current at the reference plane
$\underline{Z}$ …impedance
$\underline{Y}$ …admittance
$\underline{r}$ …reflection coefficient
R_0 …reference resistance
G_0 …reference conductance

Note: The reference resistance R_0 can be set in the **Measurement** area of the **Impedance/Reflection** mode window.

4.1.2 Equivalent Circuits

The basic formulas for the serial equivalent circuit are:

$$\underline{Z} = \mathrm{Real}(\underline{Z}) + j\mathrm{Imag}(\underline{Z}) = R_s + jX_s \qquad \text{(Eq. 4-5)}$$

$$R_s = \mathrm{Real}(\underline{Z}) \qquad \text{(Eq. 4-6)}$$

If $\mathrm{Imag}(\underline{Z}) < 0$:

$$C_s = \frac{1}{\omega|\mathrm{Imag}(\underline{Z})|} \qquad \text{(Eq. 4-7)}$$

If $\mathrm{Imag}(\underline{Z}) > 0$:

$$L_s = \frac{|\mathrm{Imag}(\underline{Z})|}{\omega} \qquad \text{(Eq. 4-8)}$$

where
R_s …series resistance
X_s …series reactance
C_s …series capacitance
L_s …series inductance

The basic formulas for the parallel equivalent circuit are:

$$\underline{Y} = \mathrm{Real}(\underline{Y}) + j\mathrm{Imag}(\underline{Y}) = \frac{1}{R_p} + j\left(\frac{-1}{X_p}\right) \qquad \text{(Eq. 4-9)}$$

$$R_p = \frac{1}{\mathrm{Real}(\underline{Y})} \qquad \text{(Eq. 4-10)}$$

If $\mathrm{Imag}(\underline{Y}) < 0$:

$$L_p = \frac{1}{\omega|\mathrm{Imag}(\underline{Y})|} \qquad \text{(Eq. 4-11)}$$

If $\mathrm{Imag}(\underline{Y}) > 0$:

$$C_p = \frac{|\mathrm{Imag}(\underline{Y})|}{\omega} \qquad \text{(Eq. 4-12)}$$

where
R_p …parallel resistance
X_p …parallel reactance
L_p …parallel inductance
C_p …parallel capacitance

Depending on the regional settings of your PC the elements of the serial and parallel equivalent circuits are displayed according to the **IEC** (International Electronic Commission) or **ANSI** (American National Standards Institute) standards as shown below.

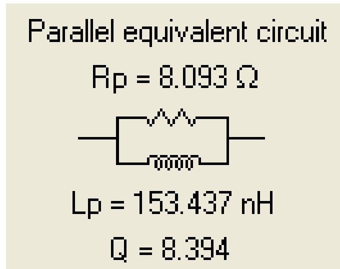


Figure 4-3:
Resistor and inductor according to ANSI

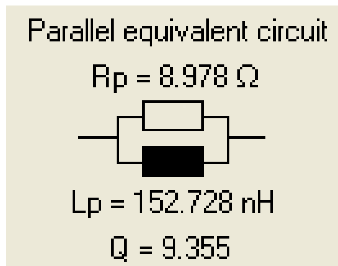


Figure 4-4:
Resistor and inductor according to IEC

Note: Capacitors have the same symbol  according to both standards.

4.1.3 Quality Factor

An ideal inductor will be lossless irrespective of the amount of current flowing through the winding. An ideal capacitor will be lossless irrespective of the voltage applied to it. However, real inductors have winding resistance due to the metal wire forming the coils and real capacitors have a resistance due to the used insulation material. These resistances cause a loss of inductive or capacitive quality. For serial equivalent circuits, the quality factor Q is defined as the ratio of the reactance to the resistance at a given frequency. For parallel equivalent circuits, the quality factor Q is defined as the ratio of the resistance to the reactance at a given frequency.The Q factor is a measure of the inductor's and capacitor's efficiency. The higher the Q factor of a capacitor or inductor, the closer the capacitor/inductor approaches the behavior of an ideal, lossless component.

The Q factor calculated using the serial equivalent circuit is given by

$$Q = \frac{|\mathrm{Imag}(\underline{Z})|}{\mathrm{Real}(\underline{Z})} = \frac{|X_s|}{R_s} \qquad \text{(Eq. 4-13)}$$

and using the parallel equivalent circuit is given by

$$Q = \frac{|\mathrm{Imag}(\underline{Y})|}{\mathrm{Real}(\underline{Y})} = \frac{\frac{1}{|X_p|}}{\frac{1}{R_p}} = \frac{R_p}{|X_p|} \qquad \text{(Eq. 4-14)}$$

4.2 Example: Impedance/Reflection Measurement

Expected example duration: 20 minutes.

In this example you will learn step by step how to use the **Impedance/Reflection** mode of the *Bode 100*.

How to:

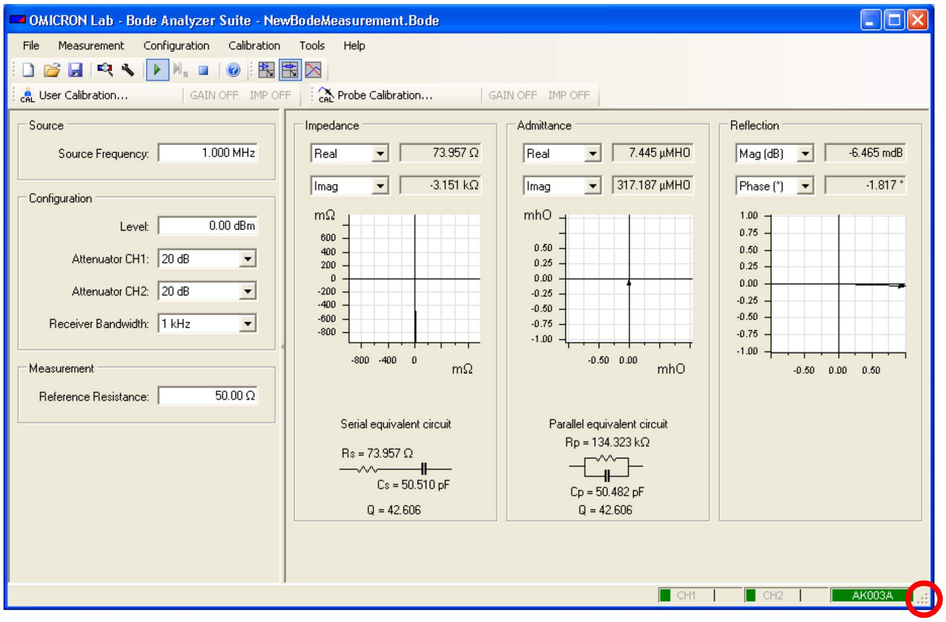
- measure the reflection coefficient at a certain frequency
- set bandwidth and amplitudes of the generator
- connect the DUT for the impedance and reflection measurement
- optimize the diagrams
- deal with the serial and parallel equivalent circuits

Question: What is the reflection coefficient in dB of the delivered IF filter input at 10.7 MHz?

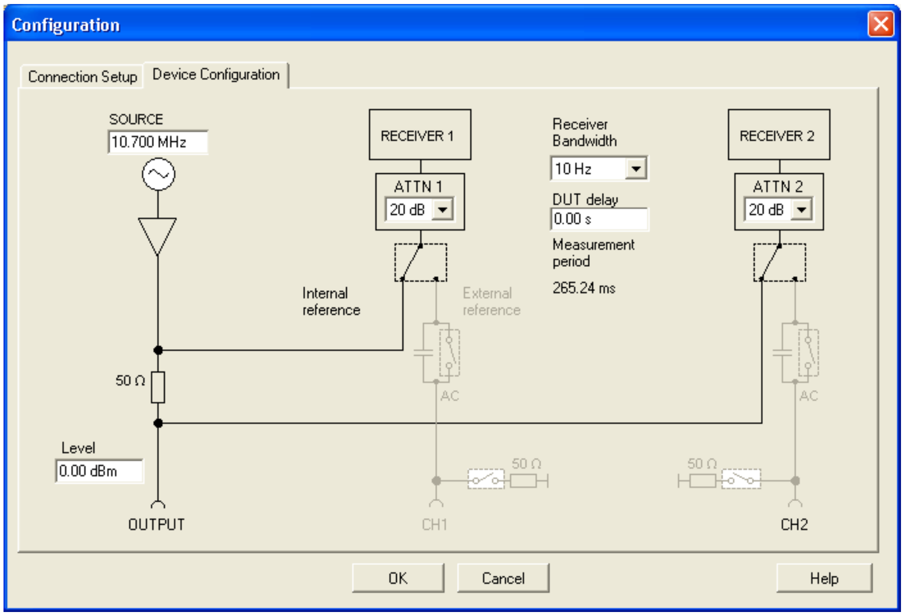
1. Connect the *Bode 100* and start the *Bode Analyzer Suite* software.

Hint: If you see the serial number of your *Bode 100* on the lower right side of the status bar then your *Bode 100* is working properly.

2. Click the toolbar button to switch to the **Impedance/Reflection** mode.
3. If necessary, adjust your window size. Move the mouse to the lower right corner of the window. By dragging the corner you can adjust the window.



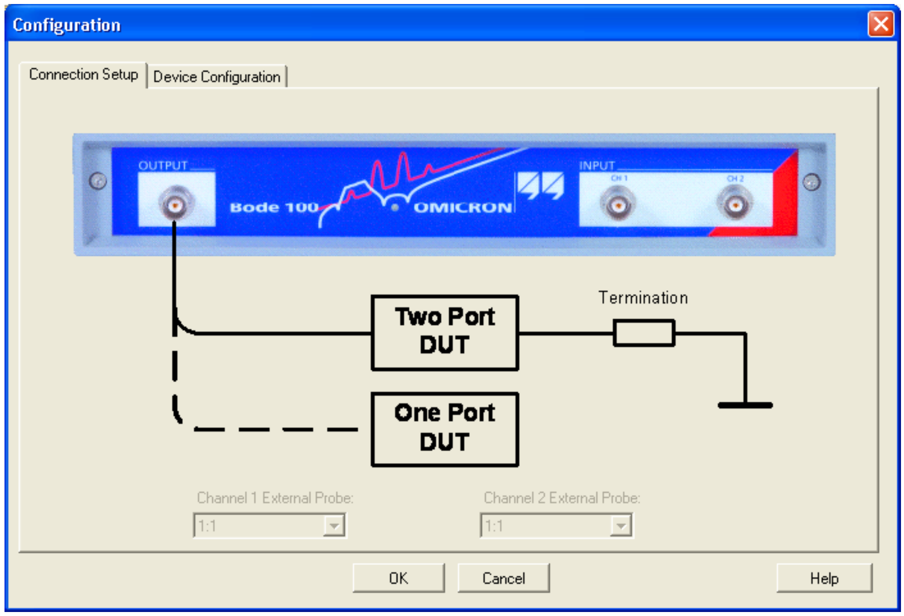
4. Click the  toolbar button to configure the **Impedance/Reflection** mode.



5. Set:

- SOURCE: 10.7 MHz
- Receiver Bandwidth: 10 Hz
- Level: 0 dBm

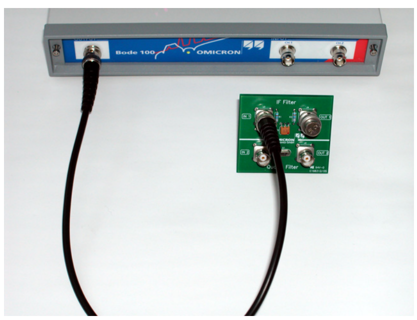
6. Click the **Connection Setup** tab.

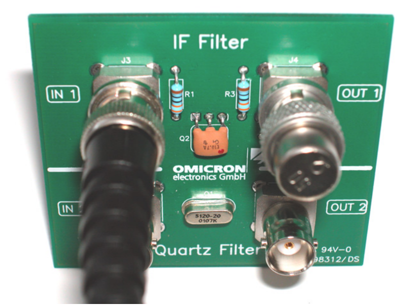


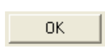
This picture shows you how to connect the DUT.

Hint: In the **Impedance/Reflection mode** the channel 1 and channel 2 inputs are not used. Consequently, the **External Probe** boxes are unavailable.

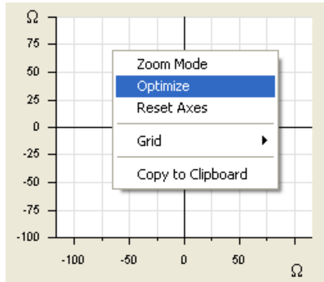
7. Connect the output of the *Bode 100* to the DUT (IF filter) input and connect the BNC 50 Ω load to the output of the DUT as shown.



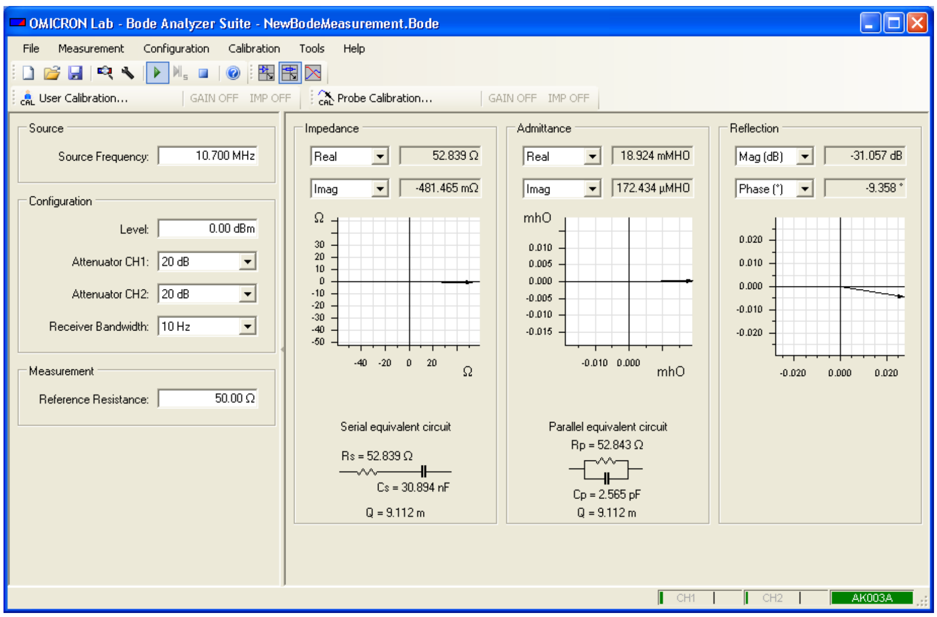


8. Click  to close the **Configuration** window.

9. For a better view of the impedance, admittance and reflection vectors in the complex plane, right-click in the respective diagrams, and then click **Optimize**.



10. View the results.



Result: The measured values of the IF filter at 10.7 MHz are:

- Reflection coefficient: –31.1 dB
- Impedance: nearly 50 Ω

Hint: If you cannot see the result then make the window bigger or move the separator bar to the left window border by clicking on it. To restore the left pane, click on the separator bar again.

Usually, the reference resistance of 50 Ω is used to calculate the reflection coefficient. The **Reference Resistance** box allows you to enter other reference resistance values if required.

The parallel and serial equivalent circuits give us an indication of the electrical components that would be required to rebuild the electrical characteristics of your DUT at the measurement frequency. In our example you would require a 31 nF capacitor and a 52 Ω resistor to build the series equivalent circuit.

Try it out, get yourself the required components and repeat the measurement. If the results do not match 100% keep in mind that you are using real components with a Q factor on their own.

For information on how to calibrate the *Bode 100* in the **Impedance/Reflection** mode, see 6.4 "Calibration in the Impedance/Reflection Mode" on page 66.

Congratulation! In this example you learned how to use the **Impedance/Reflection** mode.

How to:

- measure the reflection coefficient at a certain frequency
- set bandwidth and amplitudes of the generator
- connect the DUT for the impedance and reflection measurement
- optimize the diagrams
- understand serial and parallel equivalent circuits

After this example get a glass of water to increase your reflection mode and your attention bandwidth. Then try things out and right-click and left-click to everything that does not move on the screen.

Go back to the overview chart at 4 "Impedance/Reflection Mode" on page 31 and try things out.

5 Frequency Sweep Mode

Figure 5-1:
Frequency Sweep mode window

Sweep settings
Set frequency sweep.
See Figure 5-2: "Sweep settings" on page 42.

Cursor settings
Set cursors and view measurement results.
See Figure 5-3: "Cursor settings" on page 42.

Trace settings
Define measurement format and display options.
See Figure 5-4: "Trace settings" on page 43.

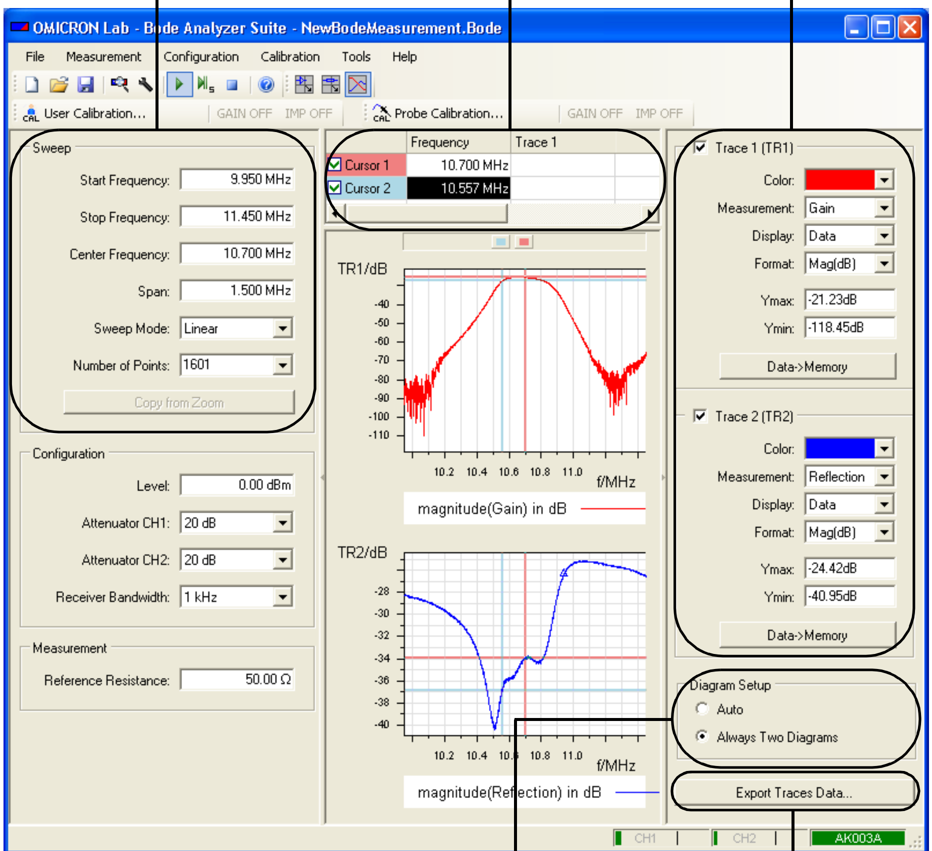


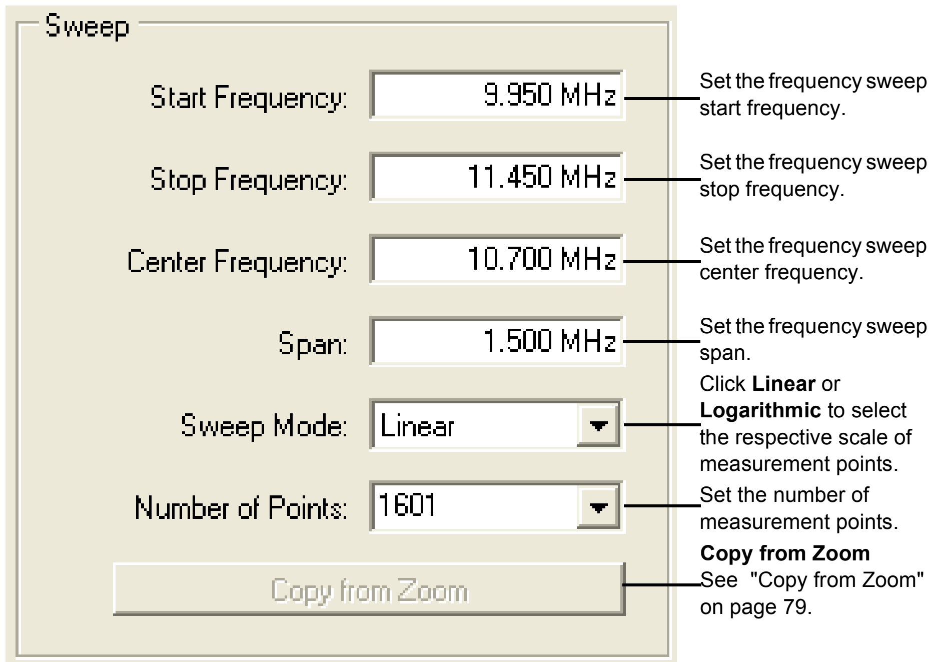
Diagram setup
See Figure 5-5: "Diagram setup" on page 44.

Export traces data
Export traces as CSV file.
See 7.1.2 "Exporting Measurement Data" on page 74.

Note: Only window areas specific for the **Frequency Sweep** mode are explained. For window areas common to other measurement modes, see Figure 3-1: "Gain/Phase mode window" on page 15 and Figure 4-1: "Impedance/Reflection mode window" on page 31.

In the **Frequency Sweep** mode you can perform a sequence of **Gain/Phase** and/or **Impedance/Reflection** measurements and examine the results in different types of diagrams.

Figure 5-2:
Sweep settings



Hint: The start frequency, stop frequency, center frequency and span are mutually dependent. After one of them has been changed, the others settings are recalculated by the *Bode Analyzer Suite*.

Figure 5-3:
Cursor settings

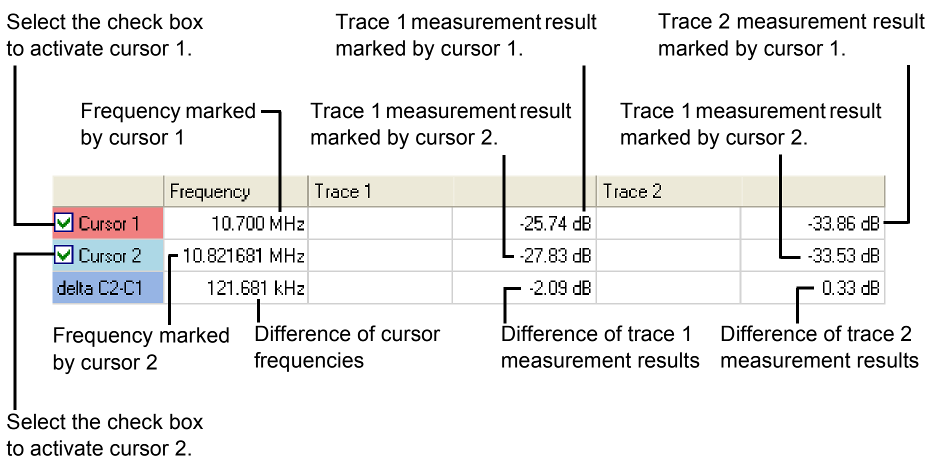
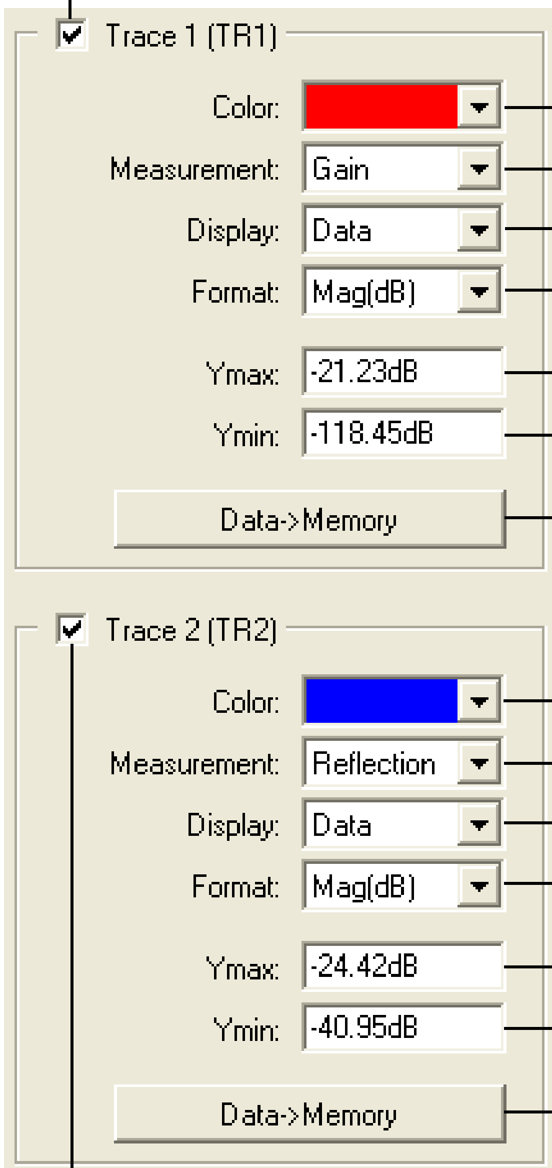


Figure 5-4:
Trace settings

Select the check box to activate trace 1.



Set the color of trace 1.

Click **Gain**, **Reflection**, **Impedance** or **Admittance** to select the respective trace 1 measurement.

Display
See "Data and Memory" on page 83.

Select the output format of trace 1 measurement results.

Set the maximum value on the trace 1 Y-axis.

Set the minimum value on the trace 1 Y-axis.

Data –> Memory
See "Data and Memory" on page 83.

Set the color of trace 2.

Click **Gain**, **Reflection**, **Impedance** or **Admittance** to select the respective trace 2 measurement.

Display
See "Data and Memory" on page 83.

Select the output format of trace 2 measurement results.

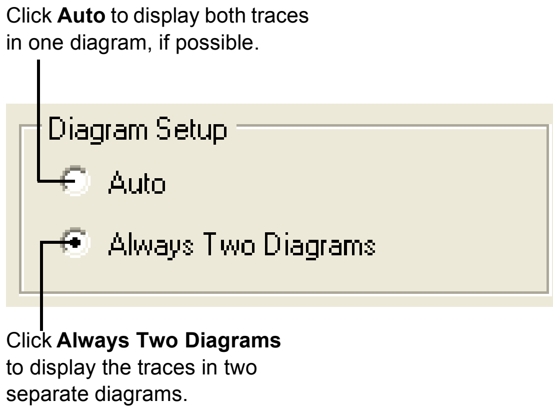
Set the maximum value on the trace 2 Y-axis.

Set the minimum value on trace 2 the Y-axis.

Data –> Memory
See "Data and Memory" on page 83.

Select the check box to activate trace 2.

Figure 5-5:
Diagram setup



Note: Diagram Setup is available only if both traces are activated.

5.1 Example: Frequency Sweep Measurement

Expected example duration: 30 minutes.

In this example you will learn step by step how to use the **Frequency Sweep** mode of the *Bode 100*.

How to:

- visualize measurement data in a graph
- set configuration parameters like the input resistor and bandwidth
- set sweep parameters like start and stop frequencies
- use cursors to read single measurement points
- calibrate and compensate the cables

Let's examine the12 MHz quartz filter on the delivered printed circuit board (PCB).

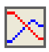
Questions:

- How does the gain of the quartz look like as a function of frequency, displayed in dB?
- How does the reflection of the quartz look like in the Smith chart?
- What are the series resonance and the parallel resonance frequencies?
- What is the attenuation of the quartz filter at the series resonance?
- What is the series resistance R_s of the quartz filter?

Measurement Procedure:

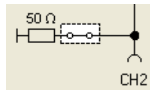
1. Connect the *Bode 100* to the PC and start the *Bode Analyzer Suite* software.

Hint: If you see the serial number of your *Bode 100* on the lower right side of the status bar then your *Bode 100* is working properly.

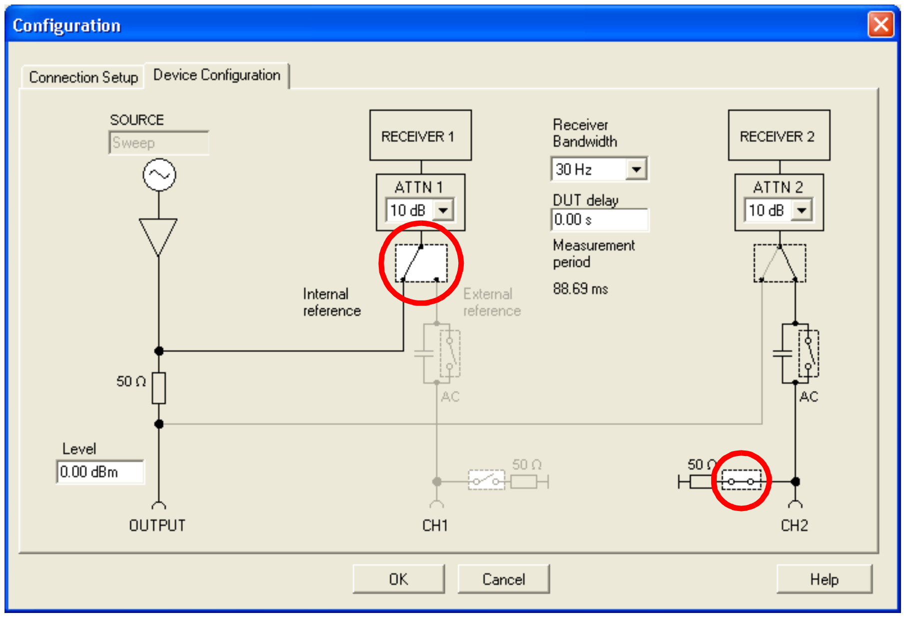
2. Click the  toolbar button to switch to the **Frequency Sweep** mode.
3. Click the  toolbar button to configure the **Frequency Sweep** mode.
   We want to measure the quartz filter with 50 Ω load.

4. Set:

- CH2: 50 Ω ON (click on switch as shown)



- The switch  (before ATTN1) to the internal source as reference

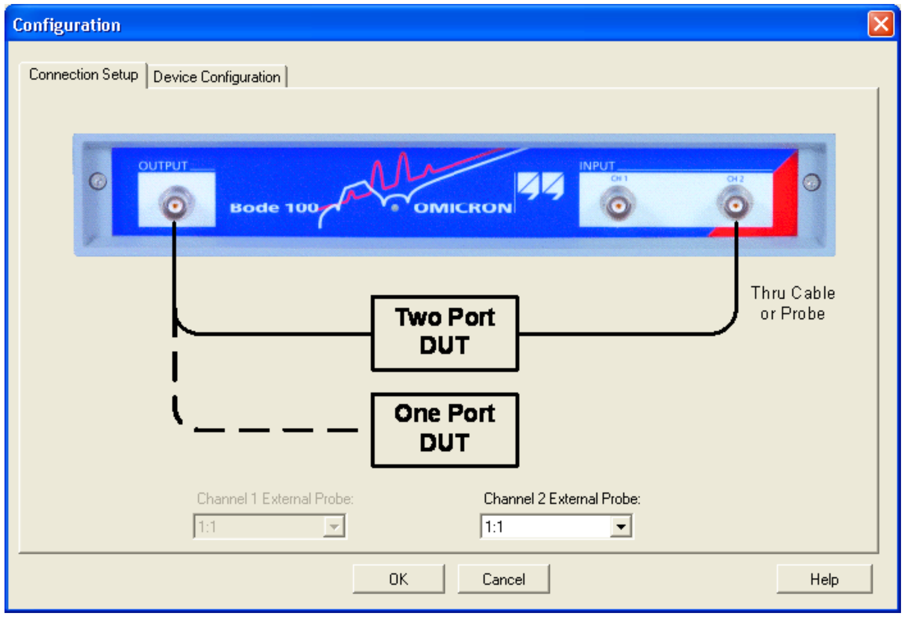


Hint: The following settings can be made either in the **Configuration** window or in the **Configuration** area on the left side of the **Frequency Sweep** mode window.

- ATTN 1 (channel 1 input attenuator): 10 dB
- ATTN 2 (channel 2 input attenuator): 10 dB
- Receiver bandwidth: 30 Hz
- Level: 0 dBm

Hint: With a narrow receiver bandwidth like 30 Hz, the measurement is very selective. Only little noise will affect the measurement and, consequently, the measurements will be more stable but the sweep will be slow. The receiver bandwidth of 3 kHz will perform the fastest sweep.

5. Click the **Connection Setup** tab.



This picture shows you how to connect the DUT (quartz filter).

Hint: Use the Channel 2 External Probe: 1:1 box to set the voltage ratio when a probe is used instead of cable connection (see 7.4 "Using Probes" on page 92).

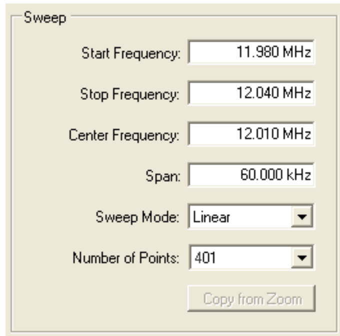
6. Connect the quartz filter to the *Bode 100* as shown.

7. Click OK to close the **Configuration** window and to get back to the **Frequency Sweep** mode window.

8. Set the sweep frequencies:

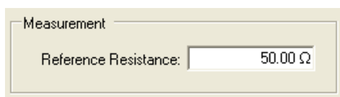
- Start frequency: 11.98 MHz
- Stop frequency: 12.04 MHz
- Number of points: 401

The other settings will be automatically calculated and the **Sweep** area of the **Frequency Sweep** mode window should now look like below.



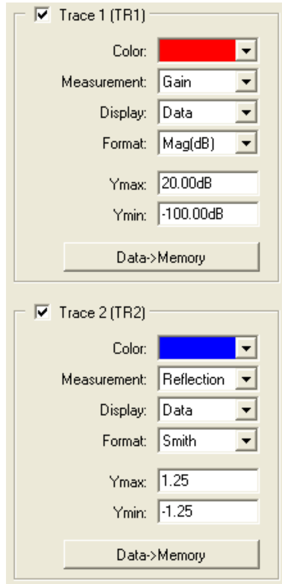
Hint: A setting which results in an out-of-range frequency for any other parameter will be corrected to ensure that all sweep frequencies (start, stop, center) are within the range of 10 Hz…40 MHz.

9. Set the reference resistance.
   Default: 50 Ω



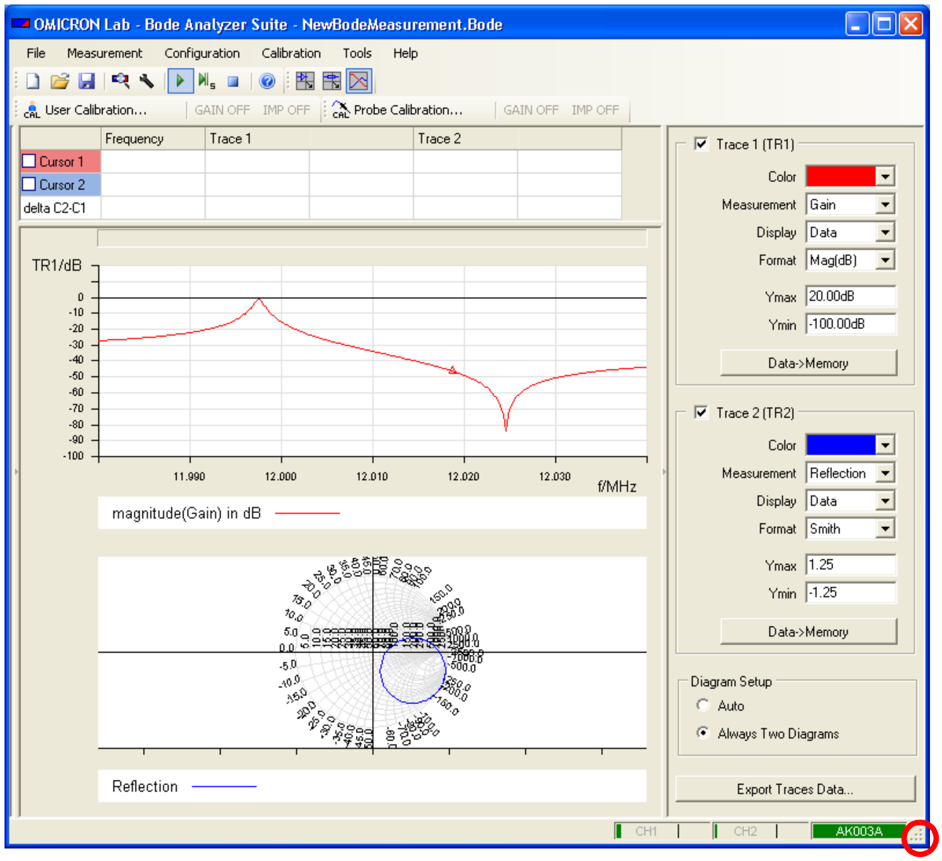
The reference resistance is used to calculate the reflection coefficient.

10. Activate both traces and set the parameters as shown below.



11. If you have a bigger screen then you can adjust your window size. Move the mouse to the lower right corner of the window . and drag the corner.

Hint: In addition to resizing the window, you can click on the split bar to hide the left and right panes to increase the size of the diagrams.

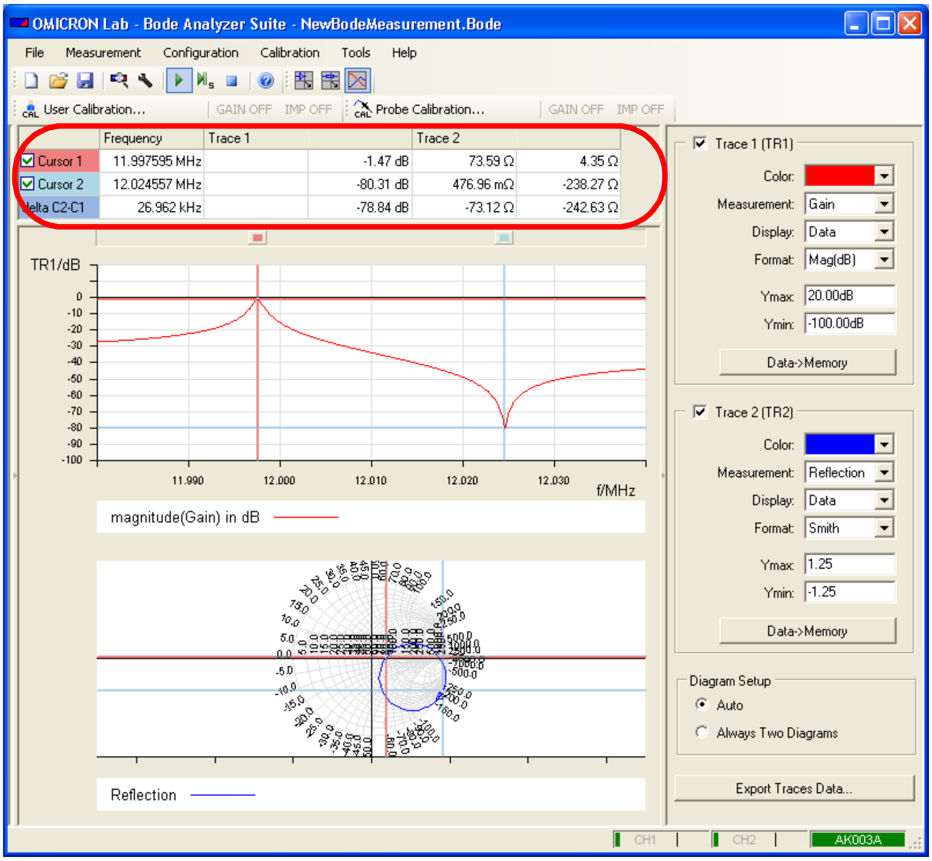


In the upper graph you see the gain of the quartz filter. You can use the cursors to measure the series and parallel resonance frequencies.

12. Select the **Cursor 1** and **Cursor 2** check boxes to activate cursors.

13. To find the series resonance frequency of the quartz filter, drag the cursor 1 to the peak of the upper graph.

14. To find the parallel resonance frequency of the quartz filter, drag the cursor 2 to the lowest value (notch) of the upper graph.
In the marked area of the **Frequency Sweep** mode window, the series and parallel resonance frequencies and the corresponding measurement data are displayed.

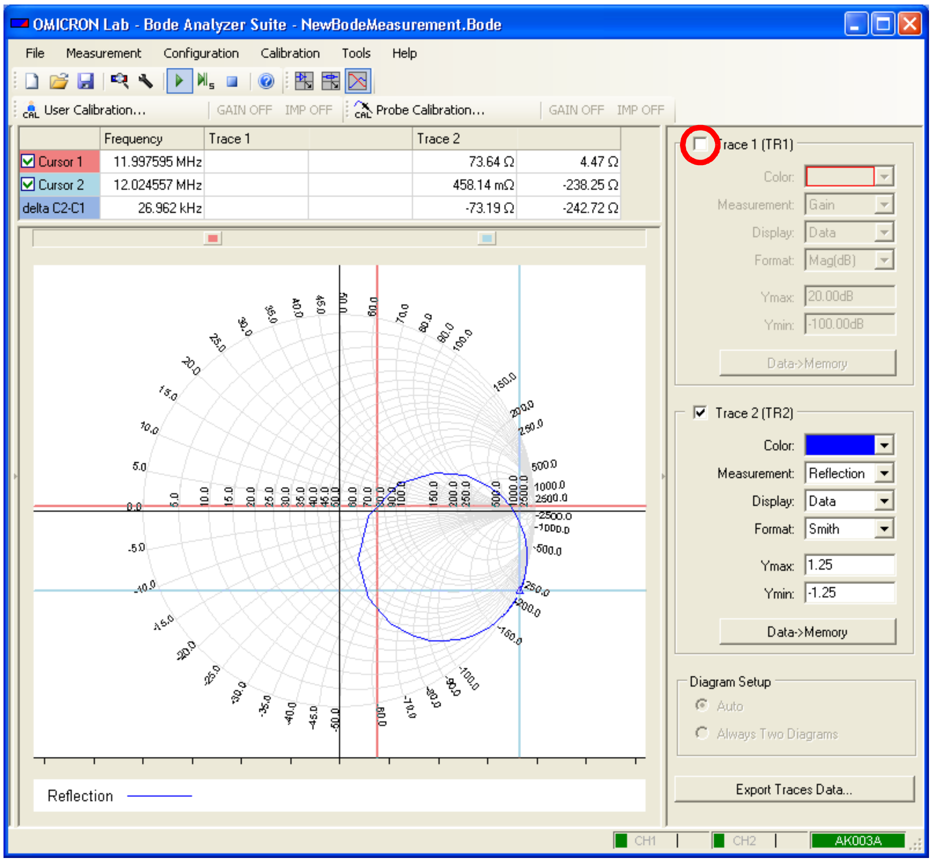


Results: Cursor 1 marks the series resonance frequency of 11.998 MHz and an attenuation at the series resonance frequency of 1.47 dB.
Cursor 2 marks the parallel resonance frequency of 12.025 MHz and an attenuation at the parallel resonance frequency of 80.31 dB.

For the measurement of the series resistance of the quartz filter we will use the Smith chart. The Smith chart displays the reflection coefficient (see (Eq. 4-3) on page 32) in the complex plane. The horizontal axis represents the real component and the vertical axis the imaginary component of the DUT's reflection coefficient. The central point of the Smith chart corresponds to the case when the DUT's impedance equals the reference resistance and, consequently, the reflection coefficient is zero.

Additionally, the Smith chart contains circles with constant resistance (R) and constant reactance (X). This diagram format allows an easy "translation" of any point of the reflection coefficient curve into the corresponding DUT's impedance. The cursor values displayed in the Smith chart format are the real and imaginary components of the corresponding DUT's impedance. For more information on the Smith chart, refer to the relevant technical literature.

15. In the lower graph you see the Smith chart showing the reflection coefficient of the quartz filter. To display only this chart, clear the **Trace 1** check box to deactivate trace 1.

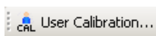


Since the output of the DUT (quartz filter) is connected to the channel 2 input, the measured impedance is the quartz impedance plus the 50 Ω input impedance of the *Bode 100*.

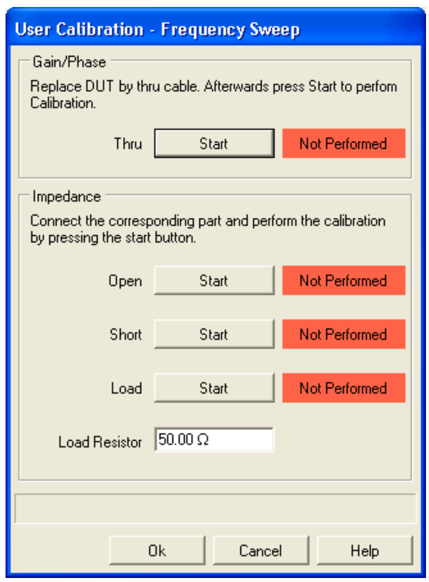
For an idle quartz, the trace should be nearly symmetrical against the real axis. The reason why it is not is as follows: We have used a cable to connect the quartz to the *Bode 100* and therefore we measure a phase shift of the reflected voltage (twice the shift of the cable itself). We can remove this unwanted phase shift by using the **Impedance/Reflection** calibration. By calibrating the *Bode 100* we move the **Impedance/Reflection** reference plane to the end of the cable connected to the input of the DUT.

5.2 Impedance/Reflection Calibration

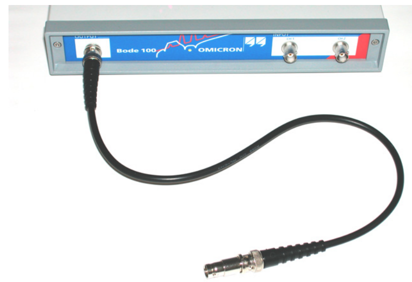
Now we perform the **Impedance/Reflection** calibration. This type of calibration is also described in 6.4 "Calibration in the Impedance/Reflection Mode" on page 66.

1. Click the 

toolbar button to open the calibration window.



2. Connect the cable you want to use for the measurement to the OUTPUT connector of the *Bode 100*. Plug the BNC straight adapter on the other end of the cable.



3. Click the **Start** button next to **Open** in the **Impedance** area of the calibration window. After the calibration has been completed, the field on the right displays **Performed** on green background.

With the measurement settings the calibration may take about 35 seconds.

Hint: You can reduce the calibration time by setting fewer measurement points, a wider receiver bandwidth, or by choosing the probe calibration.

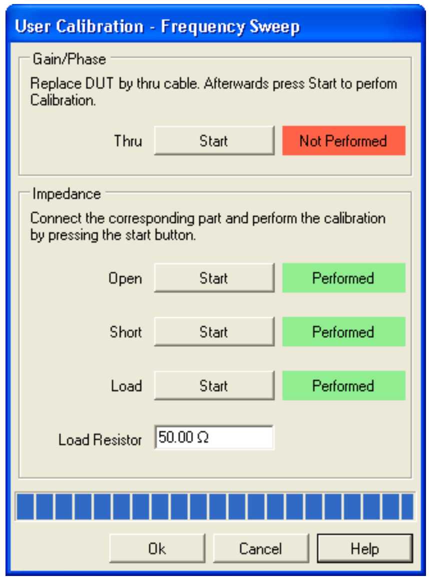
4. Plug the BNC short circuit on the straight adapter connected to the cable.

5. Click the **Start** button next to **Short** in the **Impedance** area of the calibration window. After the calibration has been completed, the field on the right displays **Performed** on green background.

6. Replace the BNC short circuit with the BNC 50 Ω load.

7. Click the **Start** button next to **Load** in the **Impedance** area of the calibration window. After the calibration has been completed, the field on the right displays **Performed** on green background.

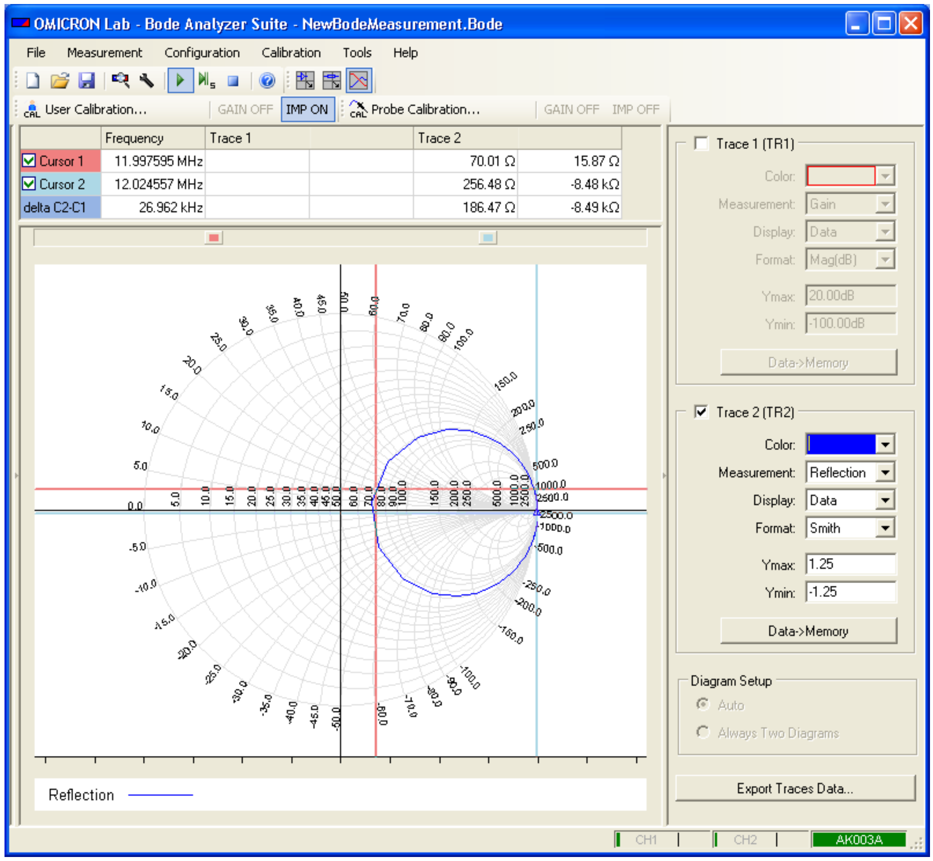
8. Measure the value of the load resistor with an accurate ohmmeter and enter the exact value in the **Load Resistor** box.



9. Click OK. You have done the **Impedance/Reflection** calibration for the **Frequency Sweep** mode.

10. Reconnect the quartz filter to the *Bode 100* as shown below.

11. View the calibrated Smith chart.



12. Calculation of the series resistance R_s at the series resonance frequency:
To calculate the series resistance of the quartz filter you need to subtract 50 Ω from the real part measured with cursor 1. The reason is that the reflection measurement circuit "sees" the quartz filter in series with the 50 Ω termination of the channel 2 input.
The **Trace 2** columns of the table display the real and imaginary parts of the measurement results at the frequencies marked by the cursors.

Result: R_s = 70.01 Ω – 50 Ω = 20.01 Ω

Your result may slightly differ because every quartz filter and measurement setup is different.

Frequency sweepers have an easier time to get the picture.

Congratulation! In this example you learned how to use the **Frequency Sweep** mode.

How to:

- visualize measurement data in a graph
- set configuration parameters like the input resistor and bandwidth
- set sweep parameters like start and stop frequencies
- use cursors to read single measurement points
- calibrate and compensate for the cable

Go back to the **Frequency Sweep** mode window in 5 "Frequency Sweep Mode" on page 41 and try things out.

6 Calibrating the *Bode 100*

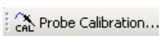
The *Bode 100* can compensate errors caused by the measurement setup like cables and probes. Also the overall accuracy may be improved by calibrating the *Bode 100* (e.g. if the operating temperature exceeds the range specified in 10.5 "Environmental Requirements" on page 103).

6.1 Calibration Methods

The *Bode 100* supports two calibration methods: the probe calibration optimized for measurements which require frequent changes of measurement settings and the user calibration for most accurate results.

Note: During start up, the *Bode 100* executes an internal calibration algorithm. During this calibration, internal attenuators and amplifiers are measured and calibrated.

6.1.1 Probe Calibration



The probe calibration of the *Bode 100* allows you to change several measurement parameters without the need of recalibration. During the probe calibration, calibration factors are determined at the factory defined frequencies within the complete frequency range. The calibration factors for the frequency points defined by the current measurement settings are then obtained by interpolation.

Hint: The probe calibration compensates cables and broad-band probes. If you want to compensate frequency selective probes or if your cable length exceeds 10 m it is recommended to use the user calibration (see 6.1.2 "User Calibration" on page 60).

The probe calibration allows **changing** the following **parameters without the need of recalibrating** the *Bode 100*:

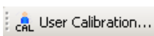
- Frequency values
- Sweep mode (linear/logarithmic)
- Number of measurement points (in the **Frequency Sweep** mode)
- Source level
- Attenuator 1 and attenuator 2
- Receiver bandwidth
- Zoom **with & without** the **Copy from Zoom** function
  (see "Copy from Zoom" on page 79)

The **probe calibration** will be **switched off automatically** if the following parameters are changed:

- Reference mode (internal/external reference)
- Conversion ratio of external probes (see 7.4 "Using Probes" on page 92)
- Input resistance of the channel 1 and/or channel 2 (low/high impedance)

Hint: Use the probe calibration if measurement parameters have to be changed often during the measurements. You will save time because you do not need to recalibrate the *Bode 100* each time you changed the parameters.

6.1.2 User Calibration



The user calibration is the most accurate calibration method available with the *Bode 100*. The user calibration is performed at the exact measurement frequencies. In the **Gain/Phase** and **Impedance/Reflection** measurement modes, the *Bode 100* is calibrated at the source frequency. In the **Frequency Sweep** mode, the calibration is performed at the exact frequencies specified by the measurement points.

The user calibration allows **changing** the following **parameters without the need of recalibrating** the *Bode 100*:

- Source level
- Attenuator 1 and attenuator 2
- Receiver bandwidth
- Zoom **without** the **Copy from Zoom** function (see "Copy from Zoom" on page 79)

The **user calibration** will be **switched off automatically** if one of the following parameters is changed:

- Frequency values
- Sweep mode (linear/logarithmic)
- Number of measurement points (in the **Frequency Sweep** mode)
- Reference mode (internal/external reference)
- Conversion ratio of external probes (see 7.4 "Using Probes" on page 92)
- Input resistance of the channel 1 and/or channel 2 (low/high impedance)
- Zoom **with** the **Copy from Zoom** function (see "Copy from Zoom" on page 79)

Hint: Use the user calibration for the highest accuracy of measurement results or if you want to compensate for highly frequency selective components in your measurement setup such as narrow-band measurement probes.

6.1.3 Hierarchy of Calibration Methods

The *Bode 100* allows you to activate the user calibration and the probe calibration at the same time (see Figure 6-1: "Activating user and probe calibration" below).

Figure 6-1: Activating user and probe calibration

If both the user calibration and the probe calibration are activated, the more accurate user calibration is used. If measurement parameters are changed and the user calibration becomes void the *Bode 100* switches automatically to the probe calibration; the user calibration is then switched off until the *Bode 100* is recalibrated.

6.2 Calibration in the Gain/Phase Mode (Internal Reference)

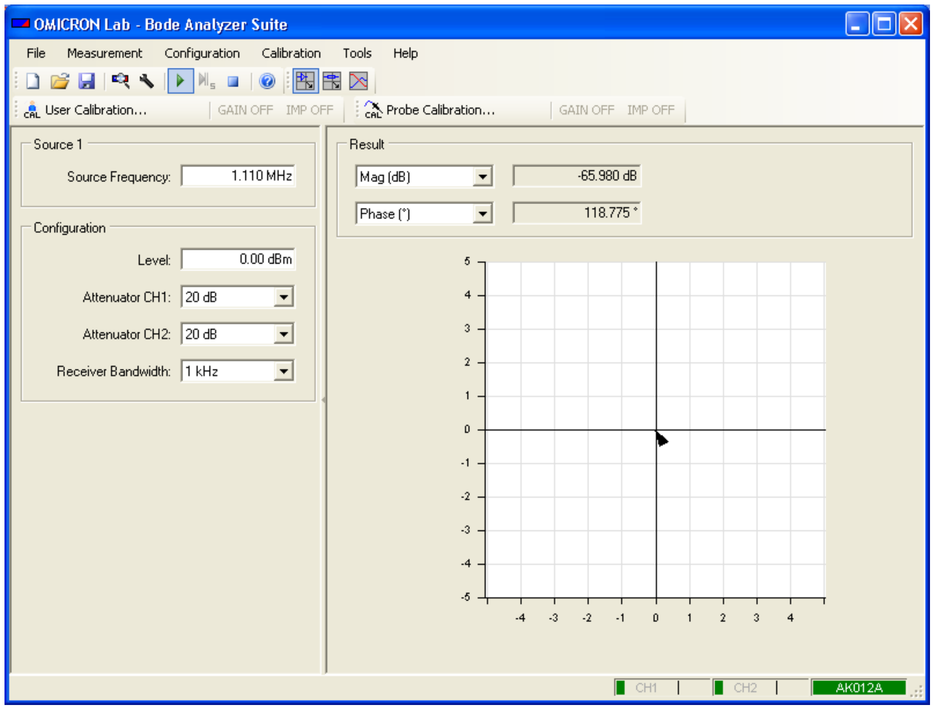
For calibrating the *Bode 100* in the **Gain/Phase** mode you find a practical example in 3.3 "Example: Gain/Phase Measurement" on page 24.

Note: The probe calibration is performed in the same way as the user calibration.

6.3 Calibration in the Gain/Phase Mode (CH1 Reference)

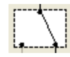
To compensate for the cable and connection error in the **Gain/Phase** mode follow the following step-by-step procedure:

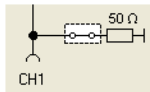
1. Connect the *Bode 100* and start the *Bode Analyzer Suite* software.
   Select the **Gain/Phase** mode.

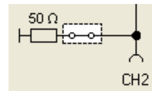


2. Click the  toolbar button to open the **Configuration** window.
   In the **Configuration** window, set the parameters for your measurement. In our example we have chosen the following settings.

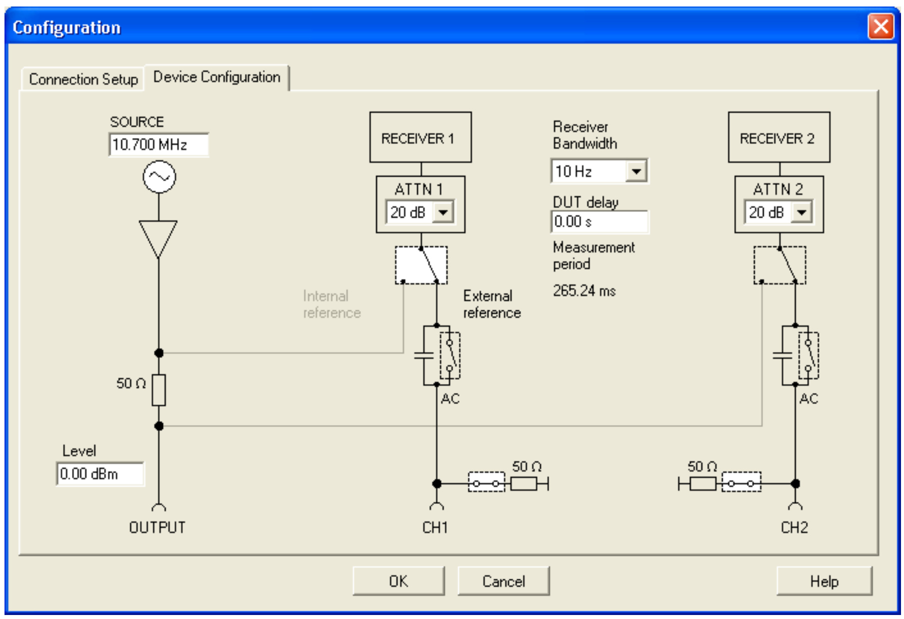
3. Set:

- External reference CH1 (Click on the switch symbol  .)
- CH1 and CH2: 50 Ω (Click on the switch symbols.)

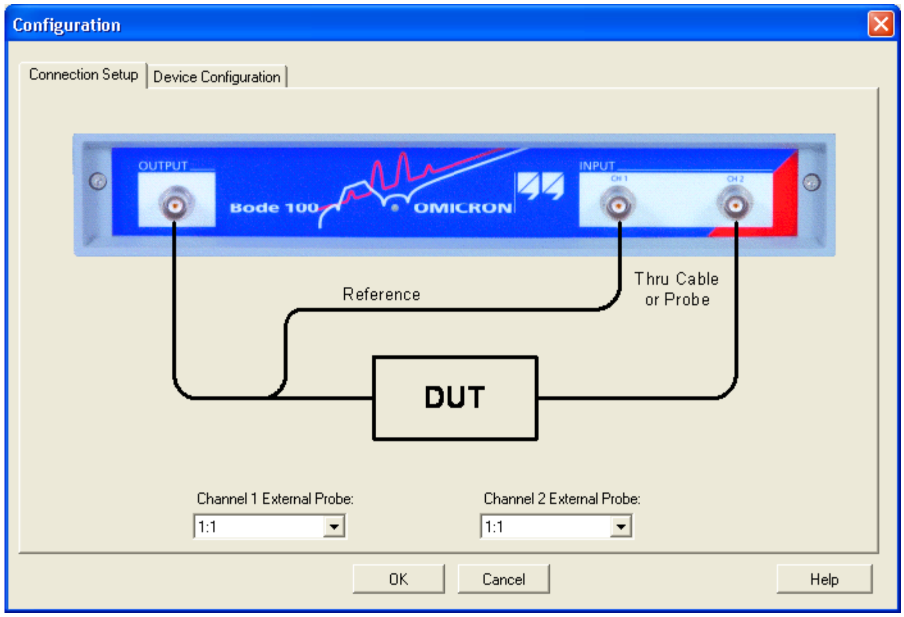




- SOURCE: 10.7 MHz
- Receiver bandwidth: 10 Hz
- ATTN 1: 20 dB
- ATTN 2: 20 dB
- Level: 0 dBm

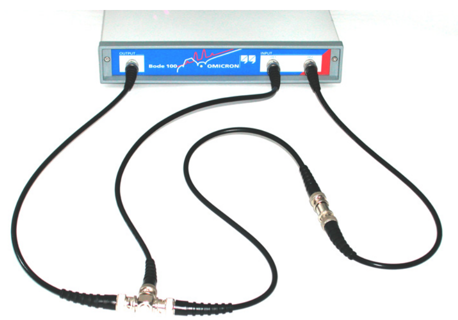


4. Click the **Connection Setup** tab.



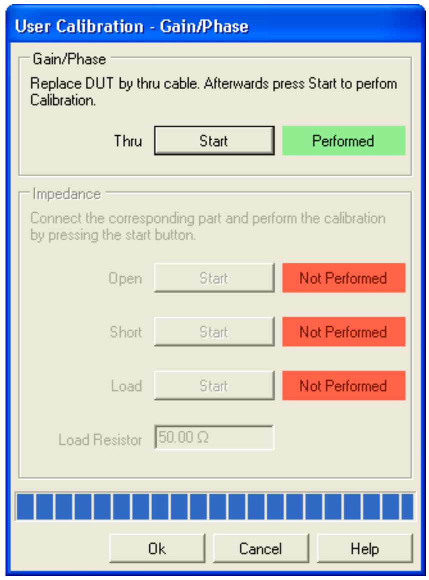
This picture shows how to connect the DUT.

5. Connect the cables you want to use for the measurement as shown below.

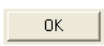


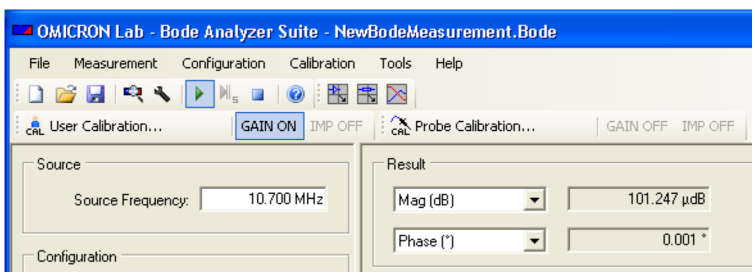
6. Click OK to close the **Configuration** window.
7. Choose either the probe calibration or the user calibration and click the respective toolbar button.

8. In the respective calibration window, click **Start**  to perform the calibration



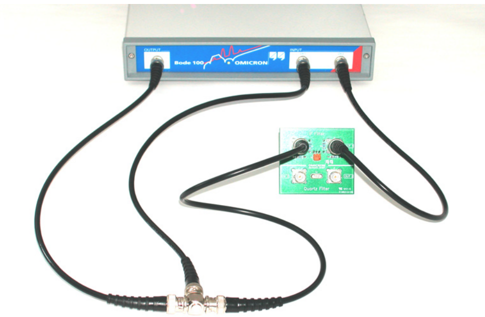
For the **Gain/Phase** measurement, the **Impedance/Reflection** calibration is not necessary. The **Gain/Phase** mode is now calibrated for the current specific measurement setup. Refer to 6.1 "Calibration Methods" on page 59 to learn in which cases you have to repeat the calibration if a parameter is changed.

9. Click 
.



In our case we read 101 µdB (0.000101 dB) and 0.001°. Because we are close to zero your results may differ from this example. Nevertheless the displayed values should be very small.

10. The calibration is done and you can connect replace the BNC straight adapter with your DUT as shown below.



6.4 Calibration in the Impedance/Reflection Mode

If you want to exceed the accuracy of the measurement results in the **Impedance/Reflection** mode you can compensate for the connection setup. Without calibration the reference plane of the impedance measurements is at the BNC connector of the source. Therefore if a DUT is connected with a cable, the impedance is not measured at the DUT input but at the input of the cable.

Example: Measure the input impedance of the IF filter at the BNC connector of the PCB (and not the impedance at the input of the cable used for connection of the filter).

Expected example duration: 20 minutes.

In this example you will learn step by step how to use the calibration of the *Bode 100* in the **Impedance/Reflection** mode.

How to:

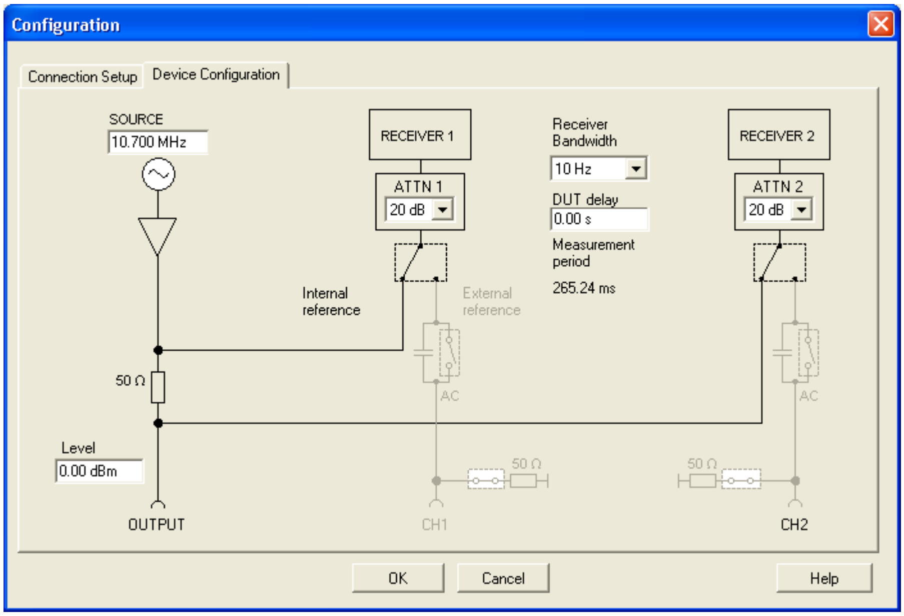
- eliminate the influence of the cable
- connect the cable in the open, short and load condition
- connect the DUT

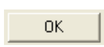
Questions:

- What is the real part of the impedance in Ω?
- What is the reflection coefficient in dB?

1. Click the  toolbar button to switch to the **Impedance/Reflection** mode.
2. Click the  toolbar button to open the **Configuration** window.
3. Because we want to test the 10.7 MHz IF filter, set:

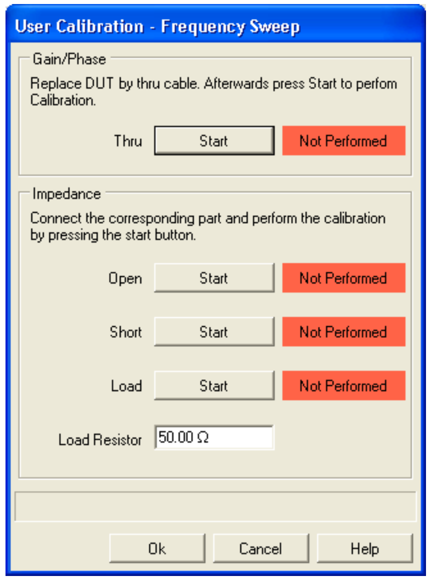
- SOURCE: 10.7 MHz
- Receiver bandwidth: 10 Hz
- Level: 0 dB



4. Click 

.

5. Choose either the probe calibration or the user calibration and click the respective toolbar button.



6. Connect the cable you want to use for the measurement to the OUTPUT connector of the *Bode 100*. Plug the BNC straight adapter on the other end of the cable to have the same reference plane.

7. Click the **Start** button next to **Open** in the **Impedance** area of the calibration window. After the calibration has been completed, the field on the right displays **Performed** on green background.

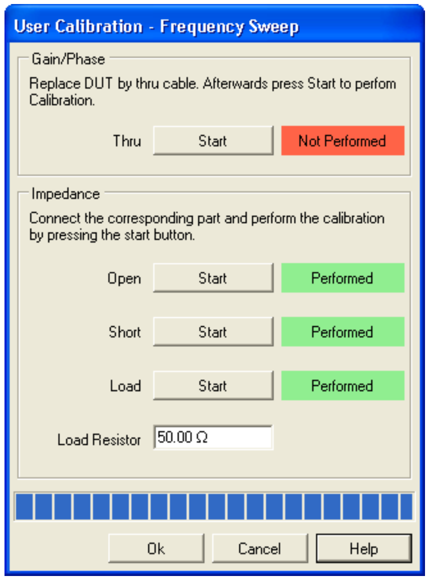
8. Plug the BNC short circuit on the straight adapter connected to the cable.

9. Click the **Start** button next to **Short** in the **Impedance** area of the calibration window. After the calibration has been completed, the field on the right displays **Performed** on green background.

10. Replace the BNC short circuit with the BNC 50 Ω load.

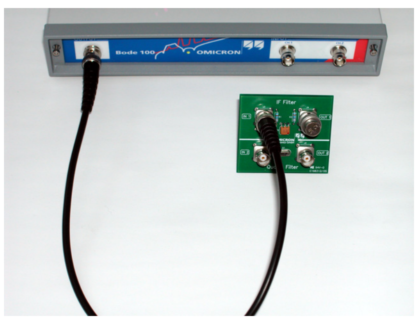
11. Click the **Start** button next to **Load** in the **Impedance** area of the calibration window. After the calibration has been completed, the field on the right displays **Performed** on green background.

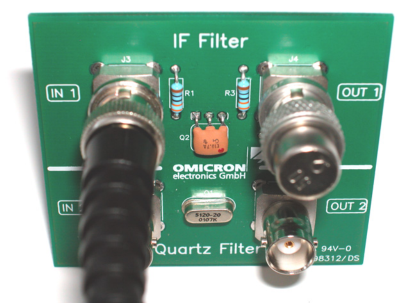
12. Measure the value of the load resistor with an accurate ohmmeter and enter the exact value in the **Load Resistor** box.



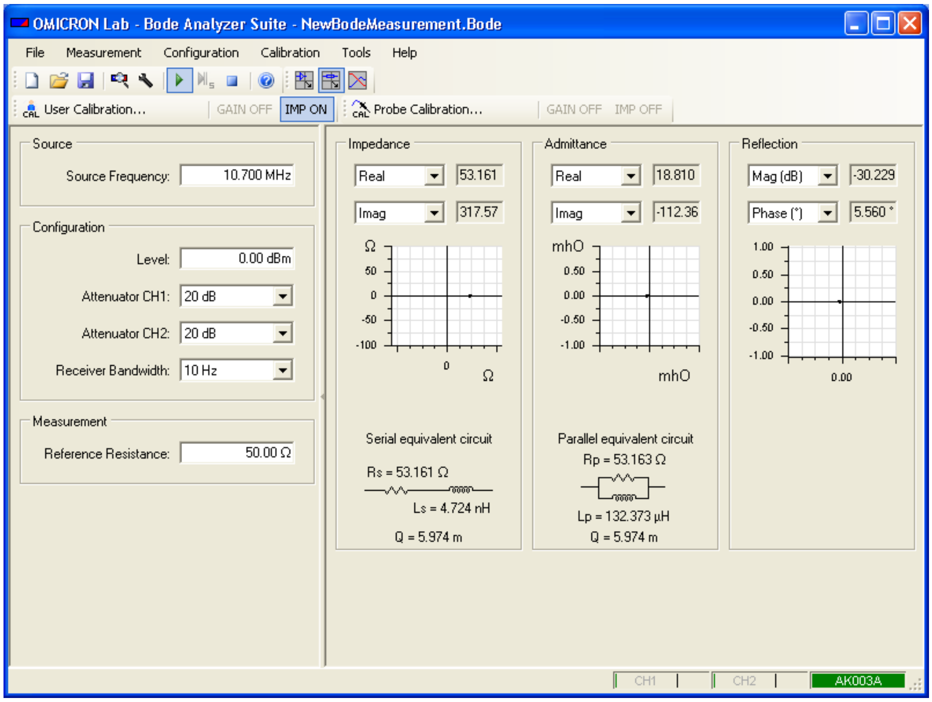
13. Click OK. You have done the **Impedance/Reflection** calibration.

14. Connect the test object.





15.Read the results.



Answer:

- The real part of the Impedance is 53.2 Ω.
- The magnitude of the reflection is –30.2 dB.
- The results may differ because every IF filter and measurement setup is slightly different.

Congratulation! In this example you learned the calibration of the *Bode 100* in the **Impedance/Reflection** mode.

How to:

- eliminate the influence of the cable
- connect the cable in the open, short and load condition
- connect the DUT

I had my first cable problem when I was born but luckily the midwife solved that problem.

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7 Advanced Functions

The *Bode 100* provides additional features extending the functionality described in sections 3 to 6 of this User Manual. This section describes these advanced functions which will make your daily measurement tasks with the *Bode 100* even easier.

7.1 File Operations

The *Bode 100* supports the following file operations.

7.1.1 Loading and Saving the Equipment Configuration

You can store all settings of the *Bode 100* including the device configuration, measurement settings, calibration and measurement data and the graphical display settings by clicking the toolbar button (see Table 3-1: "Menus and commands" on page 16).

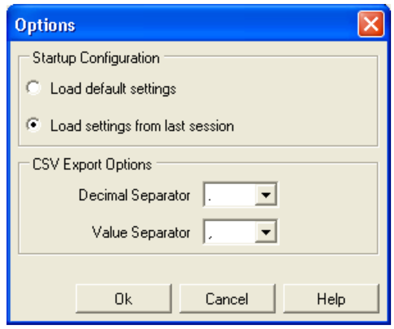
Hint: This functionality allows you to store multiple equipment configurations for repetitive measurement tasks. With the equipment configurations stored, you can load the respective files for each measurement instead of setting the *Bode 100* manually.

A saved file containing the *Bode 100* settings has the extension `*.Bode`. The file is stored in XML format and can be viewed with standard web browsers or a simple text editor tool.

In the **Frequency Sweep** mode, after loading a `*.Bode` file, the stored measurement data (including memory) is displayed. To preserve these values, the measurement is held (the toolbar button is activated). In this state you can change display options and use cursors to read measurement data. To continue with your measurement, click the toolbar button.

Hint: To ensure that your *Bode 100* starts with the same configuration as in your last session, click **Options** on the **Tools** menu, and then select the respective check box in the **Options** dialog box (see Figure 7-1: "Setting the startup configuration" below).

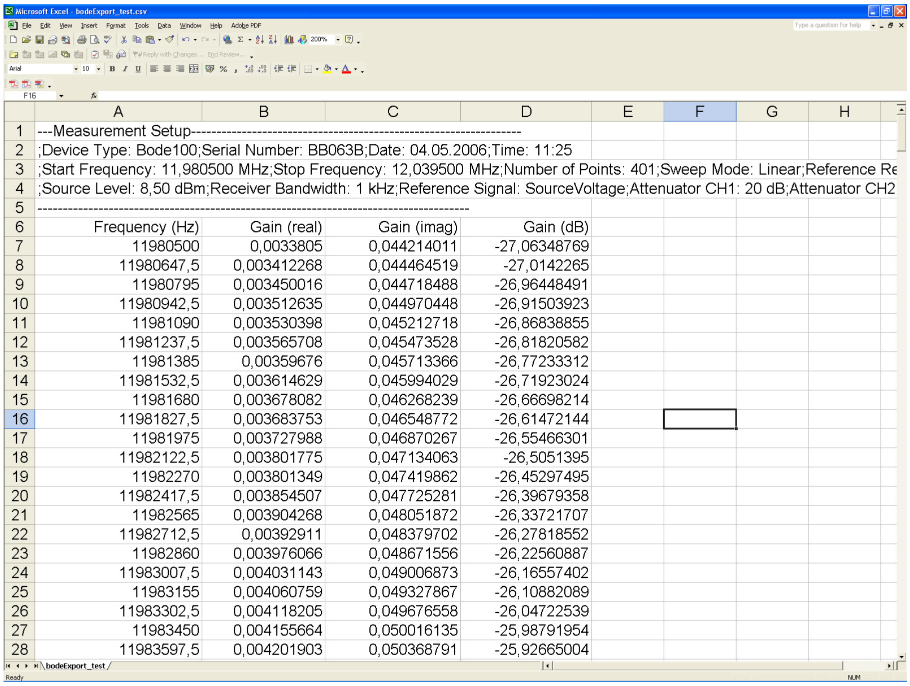
Figure 7-1:
Setting the startup configuration



7.1.2 Exporting Measurement Data

In the **Frequency Sweep** mode you can export the measurement data by clicking the Export Traces Data... button. In addition to the trace (measurement) data, all equipment settings are exported into a comma separated file (`*.csv`). This file format can be easily processed by standard spread-sheet analysis tools such as Excel®. Depending on the chosen measurement, the CSV file always contains the real and imaginary part of the gain and/or the reflection. Additionally, the measurement data in the selected output format is displayed as shown in Figure 7-2: "Displayed CSV file data" below.

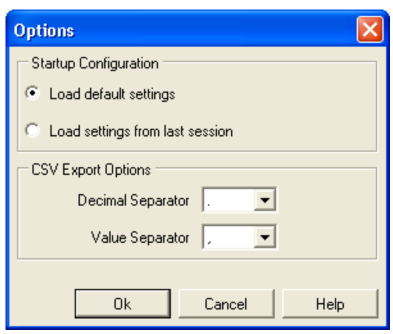
Figure 7-2:
Displayed CSV file data



	A	B	C	D
1	---Measurement Setup---			
2	;Device Type: Bode100;Serial Number: BB063B;Date: 04.05.2006;Time: 11:25			
3	;Start Frequency: 11,980500 MHz;Stop Frequency: 12,039500 MHz;Number of Points: 401;Sweep Mode: Linear;Reference Re			
4	;Source Level: 8,50 dBm;Receiver Bandwidth: 1 kHz;Reference Signal: SourceVoltage;Attenuator CH1: 20 dB;Attenuator CH2			
5	---			
6	Frequency (Hz)	Gain (real)	Gain (imag)	Gain (dB)
7	11980500	0,0033805	0,044214011	-27,06348769
8	11980647,5	0,003412268	0,044464519	-27,0142265
9	11980795	0,003450016	0,044718488	-26,96448491
10	11980942,5	0,003512635	0,044970448	-26,91503923
11	11981090	0,003530398	0,045212718	-26,86838855
12	11981237,5	0,003565708	0,045473528	-26,81820582
13	11981385	0,00359676	0,045713366	-26,77233312
14	11981532,5	0,003614629	0,045994029	-26,71923024
15	11981680	0,003678082	0,046268239	-26,66698214
16	11981827,5	0,003683753	0,046548772	-26,61472144
17	11981975	0,003727988	0,046870267	-26,55466301
18	11982122,5	0,003801775	0,047134063	-26,5051395
19	11982270	0,003801349	0,047419862	-26,45297495
20	11982417,5	0,003854507	0,047725281	-26,39679358
21	11982565	0,003904268	0,048051872	-26,33721707
22	11982712,5	0,00392911	0,048379702	-26,27818552
23	11982860	0,003976066	0,048671556	-26,22560887
24	11983007,5	0,004031143	0,049006873	-26,16557402
25	11983155	0,004060759	0,049327867	-26,10882089
26	11983302,5	0,004118205	0,049676558	-26,04722539
27	11983450	0,004155664	0,050016135	-25,98791954
28	11983597,5	0,004201903	0,050368791	-25,92665004

To adapt the CSV file to your requirements, you can chose between different decimal and value separators. To select the separators you want to use, click **Options** on the **Tools** menu, and then select the decimal and value separators in the **Options** dialog box (see Figure 7-1: "Setting the startup configuration" below).

Figure 7-3:
Selecting the separators



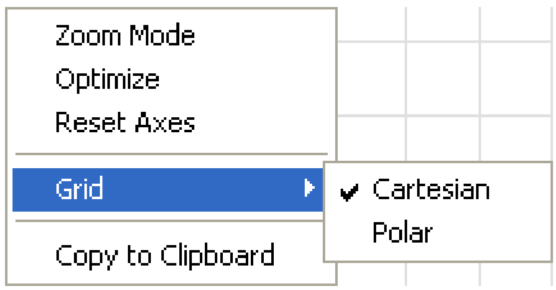
7.2 Advanced Display Options

In all measurement modes, the *Bode Analyzer Suite* provides several possibilities to visualize the measurement results according to your needs. These advanced display options are accessible via the context menu. To open the context menu, right-click in a diagram in the graphical display.

7.2.1 Gain/Phase and Impedance/Reflection Mode Context Menu

The context menu in the **Gain/Phase** and **Impedance/Reflection** mode is shown below.

Figure 7-4:
Gain/Phase and **Impedance/Reflection** mode context menu



Optimize

The **Optimize** command allows you to optimize the diagram by scaling both axes so that you can see the complete measurement result in the highest possible resolution.

Figure 7-5:
Diagram with default settings

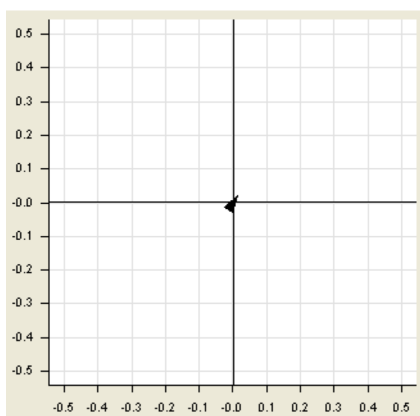
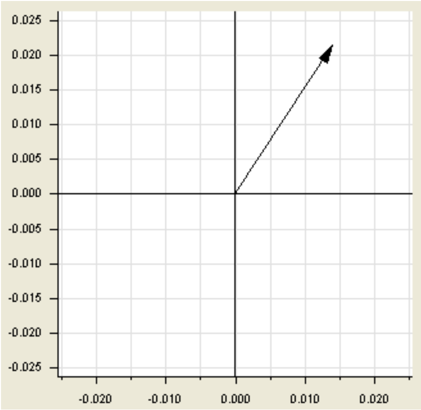


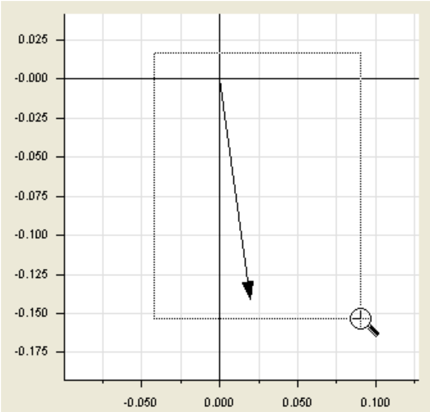
Figure 7-6:
Diagram after applying
Optimize



Reset Axes The **Reset Axes** command resets both axes of the diagram to the factory default values.

Zoom Mode After clicking **Zoom Mode**, the pointer changes to a magnifying glass when you move it over the diagram. Press and hold the left mouse button to select the zoom area. After releasing the left mouse button, the diagram is rescaled to display the zoomed area.

Figure 7-7:
Selecting zoom area



To switch off the zoom mode, click **Zoom Mode** on the context menu to cancel the selection.

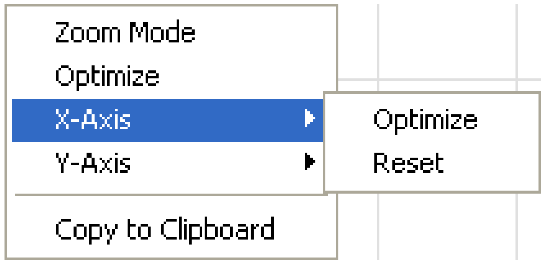
To zoom out, click **Reset Axes** on the context menu. To optimize the graphical display, click **Optimize** on the context menu.

Copy to Clipboard By clicking **Copy to Clipboard** you copy the complete diagram to the clipboard. Thereafter you can insert the diagram into all Windows® software applications which support the clipboard function.

7.2.2 Frequency Sweep Mode Context Menu

The context menu in the **Frequency Sweep** mode is shown below.

Figure 7-8:
Frequency Sweep
mode context menu



For the **Optimize**, **Reset Axes** and **Copy to Clipboard** commands, see 7.2.1 "Gain/Phase and Impedance/Reflection Mode Context Menu" on page 76.

Zoom Mode

In the **Frequency Sweep** mode, using the **Zoom Mode** command you can optimize and reset the X-axis and the Y-axis separately. This is especially handy when exiting the **Zoom Mode.** The zoom function is a nice way to inspect particular parts of the measurement curve without having to change the measurement parameters.

Figure 7-9:
Selecting zoom area

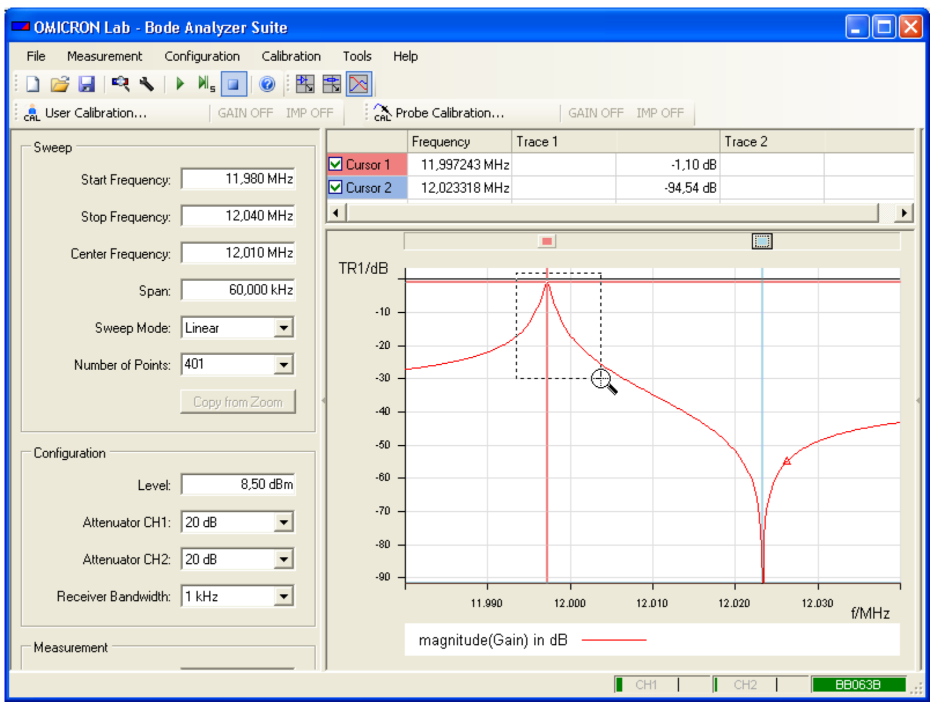
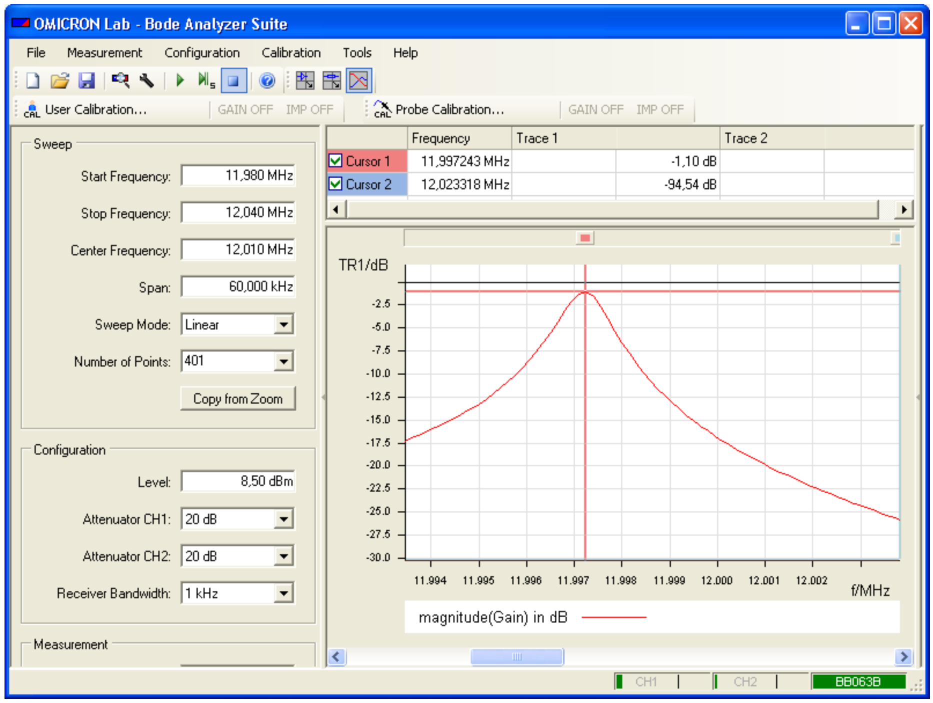


Figure 7-10:
Displaying zoom area



In the **Zoom Mode**, the measurement is still performed in the whole frequency range (span); the zoom area applies only to graphical display. (Compare the sweep settings in Figure 7-9: "Selecting zoom area" and Figure 7-10: "Displaying zoom area" above – they are identical.)

To optimize the graphical display in both axes, click **Optimize** on the context menu. Alternatively, you can reset the axes separately. To reset an axis, point to **X-Axis** or **Y-Axis** on the context menu, and then click **Optimize** or **Reset** to optimize or to zoom out respectively the selected axis.

Copy from Zoom

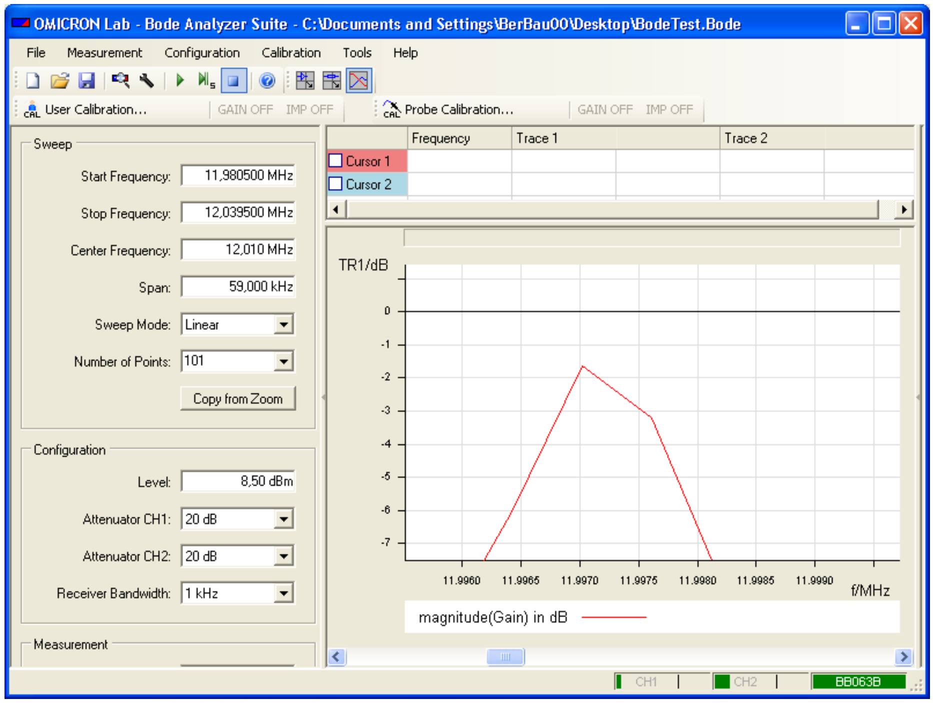
The Copy from Zoom button allows you to copy the start and stop frequencies of the zoom area to the sweep settings, keeping the number of measurement points constant. This function is especially useful to measure a detail of a curve with a higher resolution.

Note: The **Copy from Zoom** command is available only in the **Zoom Mode**.

Figure 7-11: "Measured curve with initial sweep settings" below shows a zoom area of an measurement. Due to the low number of measurement points in the area, the displayed curve is not smooth. By applying the **Copy from Zoom** function the frequency span is narrower, resulting in a higher resolution of the measured curve (see Figure 7-12: "Measured curve with sweep settings copied from the zoom area" on page 81).

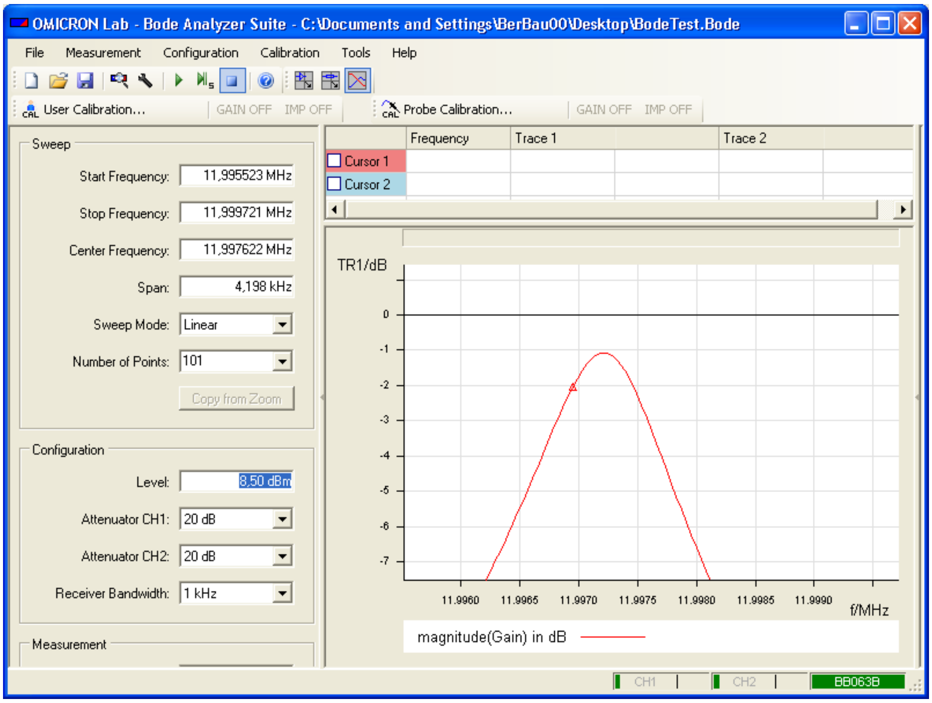
Note: After using the **Copy from Zoom** function, the original sweep settings are lost. If used, the user calibration is switched off, too.

Figure 7-11: Measured curve with initial sweep settings



Hint: Compare the frequency sweep settings before (see Figure 7-11: "Measured curve with initial sweep settings" above) and after (see Figure 7-12: "Measured curve with sweep settings copied from the zoom area" on page 81) applying the **Copy from Zoom** function.

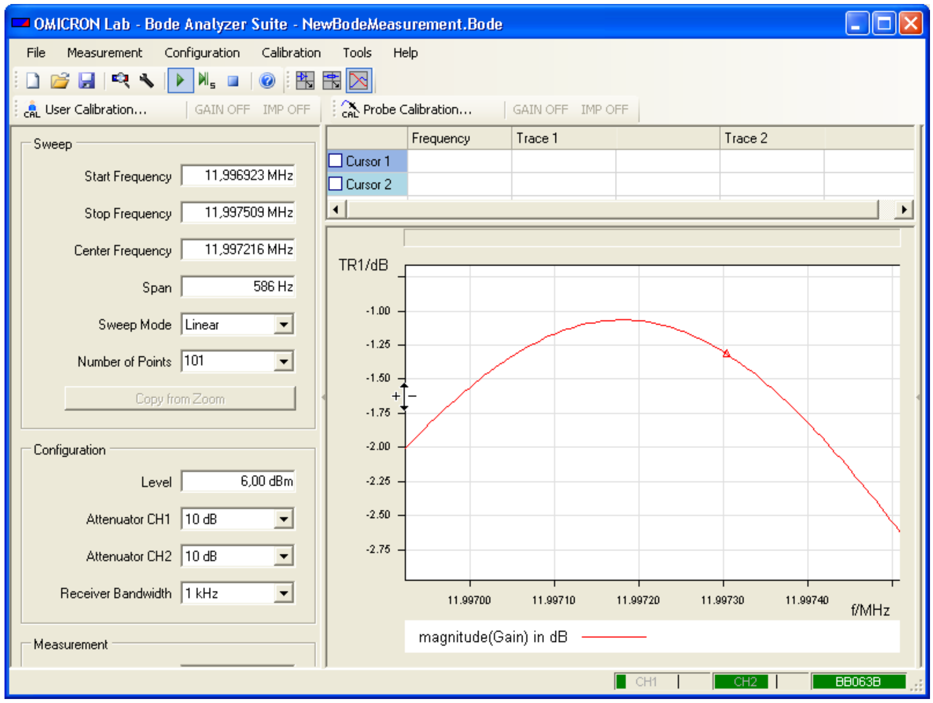
Figure 7-12:
Measured curve with sweep settings copied from the zoom area



Special Zoom Function

In the **Zoom Mode**, when moving the pointer over an axis the pointer becomes a double-headed arrow. Then click the left mouse button to zoom in and the right mouse button to zoom out respectively.

Figure 7-13:
Special zoom function applied on Y-axis



Hint: This function is also available in the **Gain/Phase** and the **Impedance/Reflection** mode.

Data and Memory

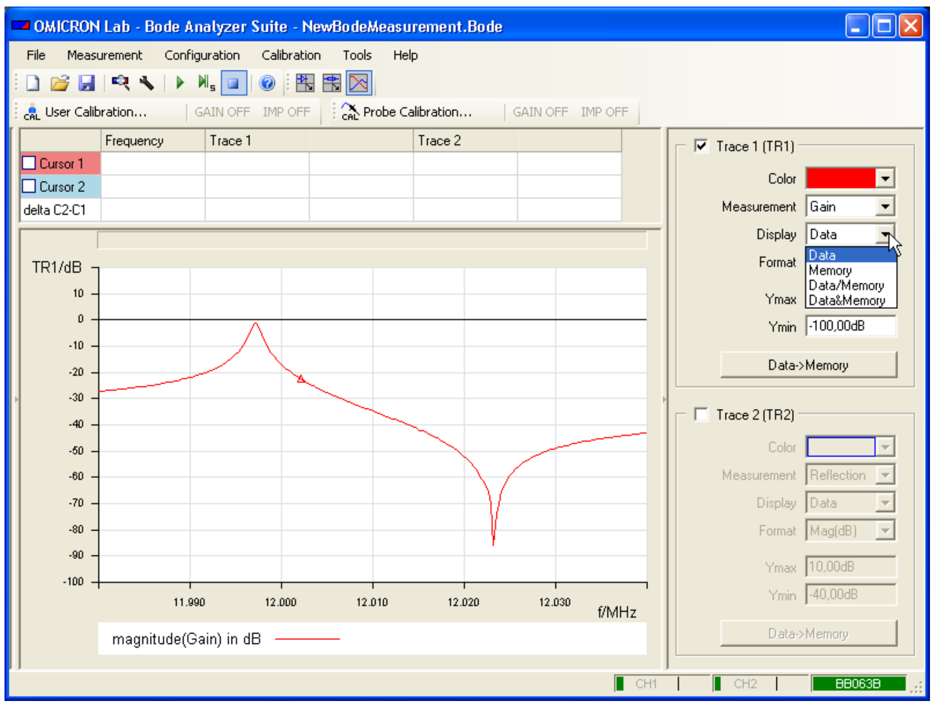
The *Bode 100* allows you to copy the current measurement data into the trace memory and to display it.

To store and display the measurement data:

1. Click the Data->Memory button to store the current measurement data into the trace memory.
2. In the **Display** list, select one of the following:
   - **Data** to display the current measurement data
   - **Memory** to display the stored measurement data
   - **Data/Memory** to display the difference between the current and the stored measurement data
   - **Data & Memory** to display the current and stored measurement data together

Hint: The **Data/Memory** option is particularly useful to compare two electrical components of the same type because even smallest differences in the frequency behavior can be detected easily.

Figure 7-14: Selecting **Display** function



Example: Using the data and memory functions

Example duration: 15 minutes

In this example you will learn step by step how to use the data and memory display function in the **Frequency Sweep** mode.

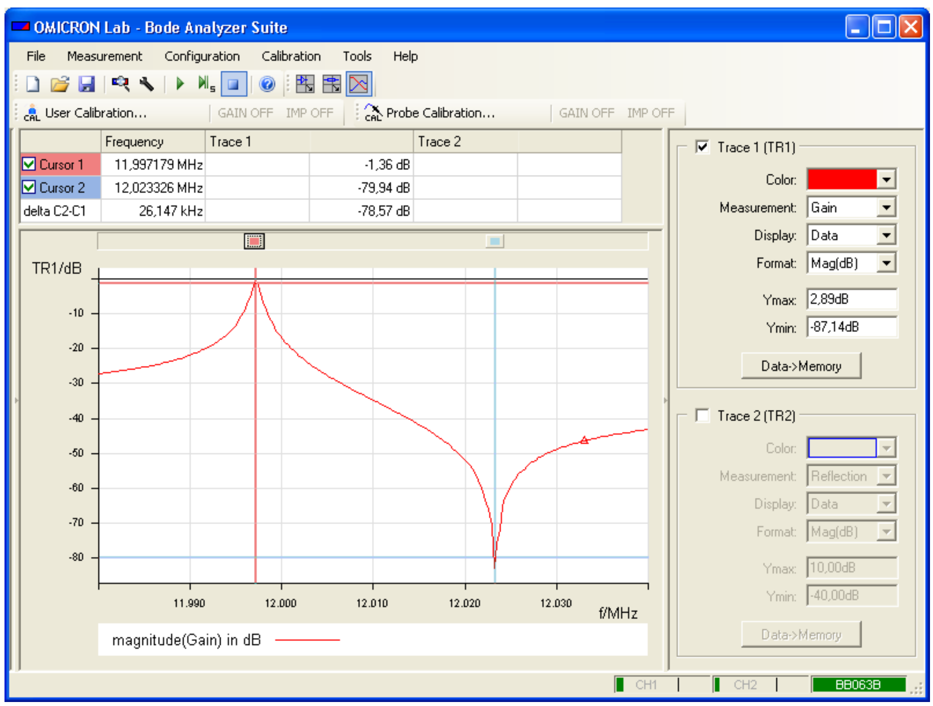
How to:

- copy the current measurement data to the trace memory
- compare the frequency responses
- detect even smallest differences between the current and stored measurement data by using the **Data/Memory** display function

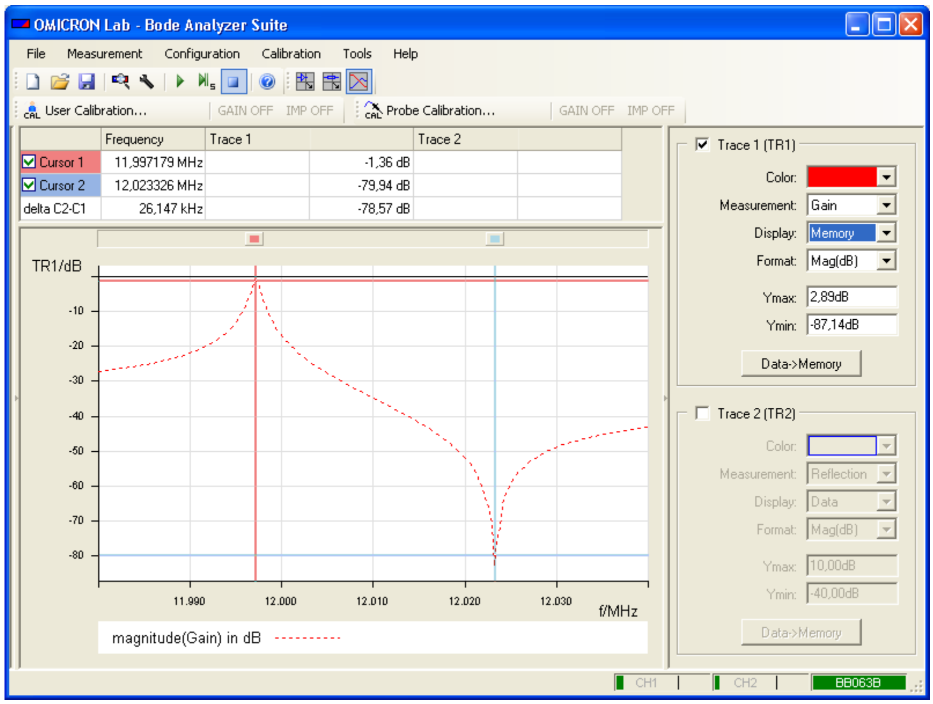
Question: How big is the influence on the measurement, when you touch the housing of the quartz filter on the sample PCB?

To find the answer, proceed as follows:

1. Follow steps 1 to 14 of the example outlined in 5.1 "Example: Frequency Sweep Measurement" on page 44.
2. Clear the **Trace 2** check box.
   Your screen should now look like this:

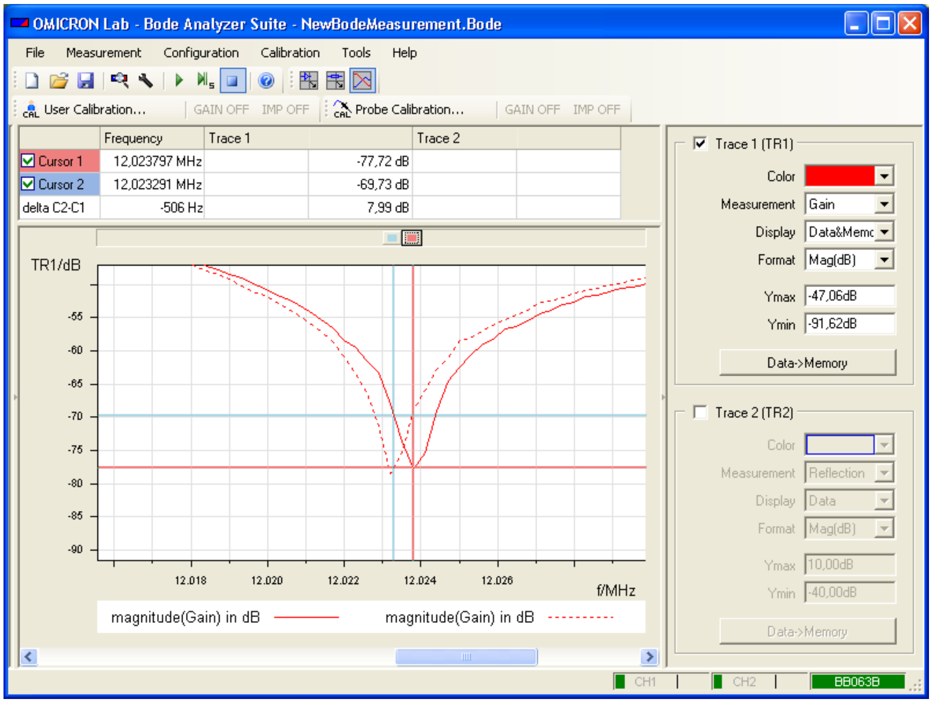


3. Click the Data->Memory button to store the measurement data.
4. In the **Display** list, select **Memory**.
   The stored data is displayed as a dashed line.



5. In the **Display** list, select **Data & Memory**, and then touch the housing of the quartz filter with your finger.
   By doing this you shift the parallel resonance frequency of the filter.
6. Mark the new parallel resonance frequency with the cursor 1.
   You can now measure the effect of touching the quartz filter using the **delta C2-C1** function.

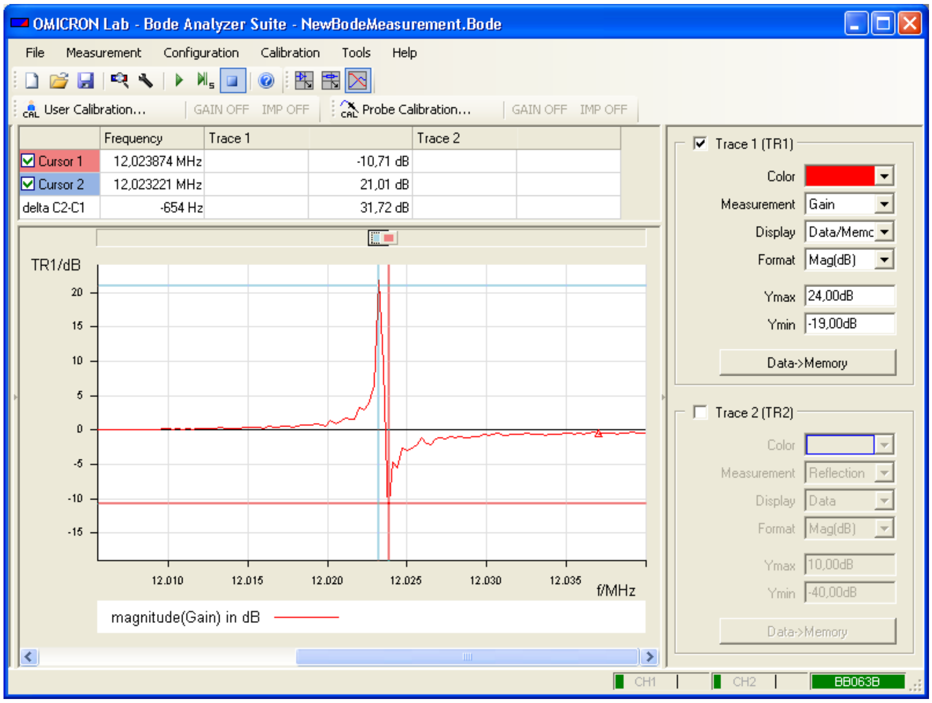
Hint: Use the **Zoom Mode** function to get a better view. The figure below shows a zoomed diagram showing the effect of touching the quartz filter housing.



Result: Touching the quartz housing shifts the parallel resonance frequency by 506 Hz. You might measure different values with your quartz filter.

7. In the **Display** list, select **Data/Memory**, and then touch the filter.

8. Optimize the Y-axis.
   The diagram now displays the difference between the actual measurement data and the stored data.



If the curve is above the 0 dB line the current measured data is higher than the stored measurement data. If the curve is below the 0 dB line the currently measured data is below the stored measurement data

Hint: The **Data/Memory** function allows you to detect even smallest differences between different parameters of the same component type (e.g. comparison of two quartz filters of the same type).

Congratulation! In this example you learned how to use the data and memory functions in the **Frequency Sweep** mode.

How to:

- copy the current measurement data to the trace memory
- compare the frequency responses
- detect even smallest differences between the current and stored measurement data by using the **Data/Memory** display function

7.3 Advanced Sweep Options

In the **Frequency Sweep** mode, you can choose between continuous sweep ▶ and single sweep ▶|S measurements. In most applications, the continuous sweep measurement is used since all measurement data is periodically updated.

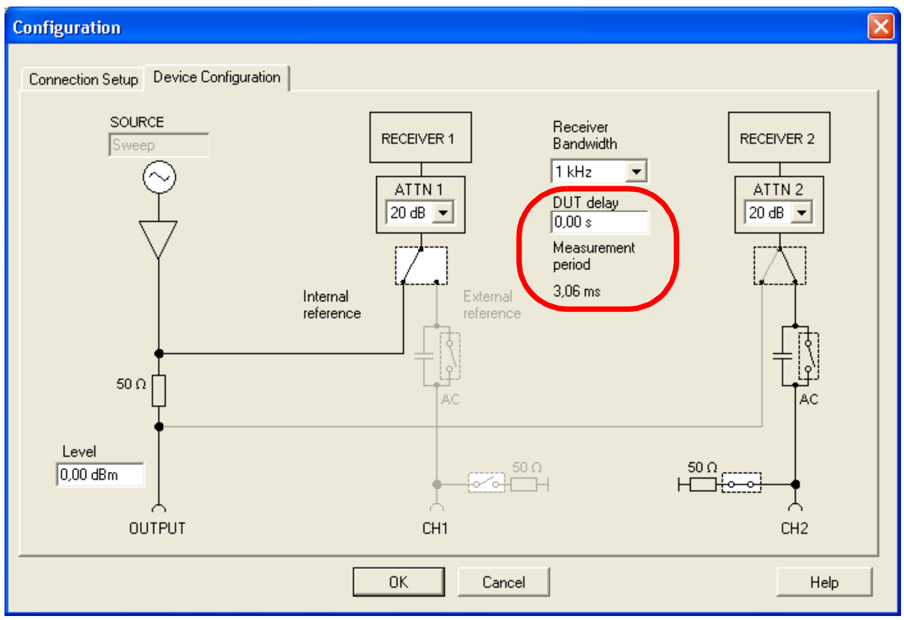
Single Sweep

The single sweep ▶|S measurement can be used to capture one-time events or to produce a stable curve before using the **Copy to Clipboard** function.

DUT Delay, Measurement Period

In the **Configuration** window, you can find the **DUT delay** and **Measurement period** fields.

Figure 7-15: **DUT delay** and **Measurement period** fields



The measurement period indicates the time the *Bode 100* requires to perform measurement at one frequency point. By multiplying this value with the selected number of measurement points you can get an estimate of the expected sweep time.

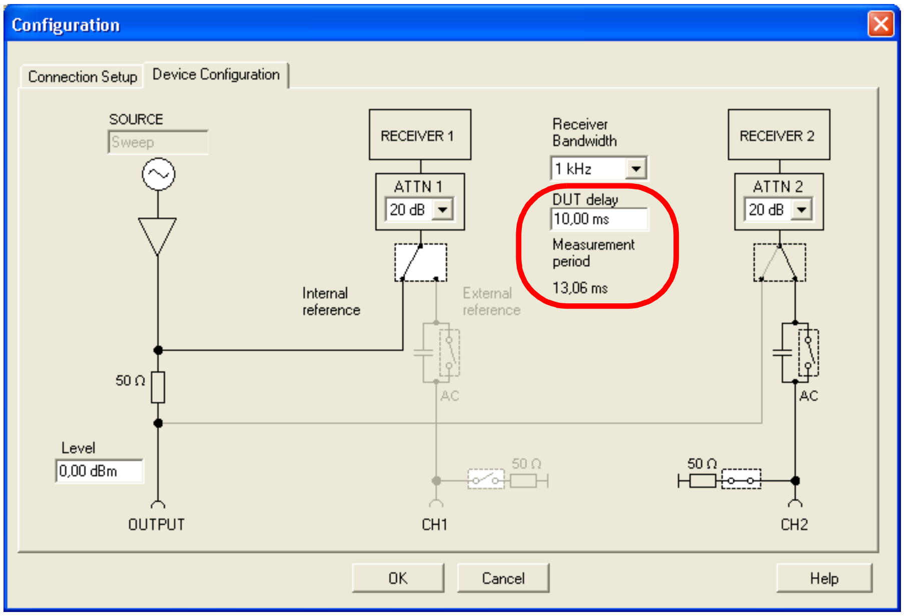
Example: Expected sweep time for 401 points and a measurement period of 3.06 ms

sweep time = 3.06 ms • 401 frequency points = 1.2 s

Some devices under test require a settling time when the input frequency has been changed (e.g. phase-lock loops). The DUT delay allows setting this waiting time.

Let's assume our DUT requires a 10 ms settling time each time the input frequency has changed. To allow for this waiting time, we enter 10 ms in the DUT delay box.

Figure 7-16:
Setting the DUT delay



The measurement period is automatically updated. When using the same number of measurement points as before, the sweep time is now much longer.

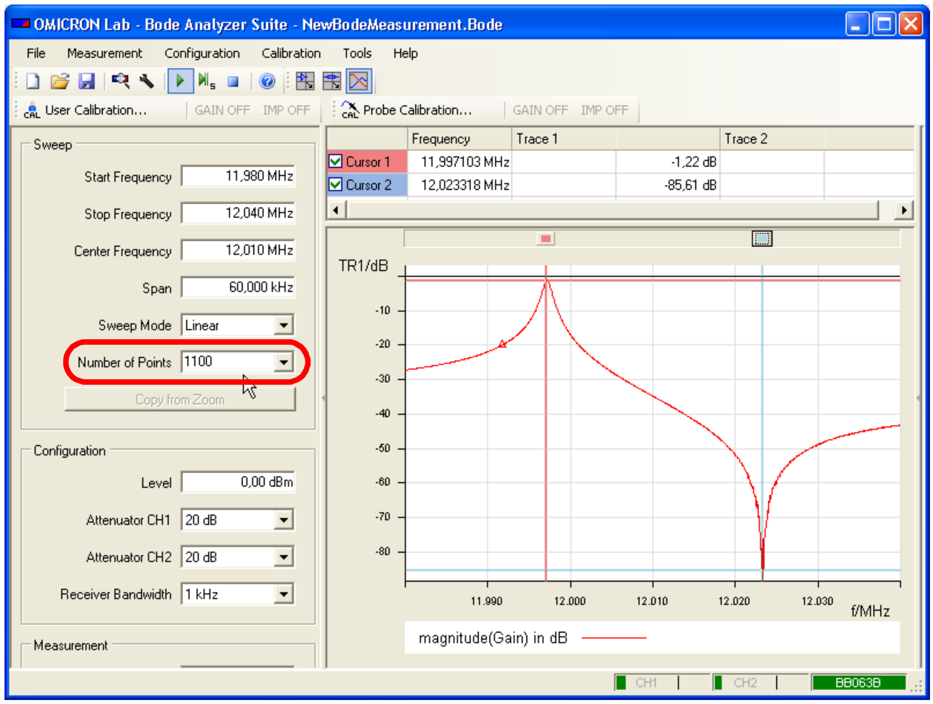
sweep time = 13.06 ms • 401 frequency points = 5.23 s

Hint: Set the DUT delay to zero after your measurement is completed to ensure the shortest sweep time possible for new measurements.

Number of Measurement Points

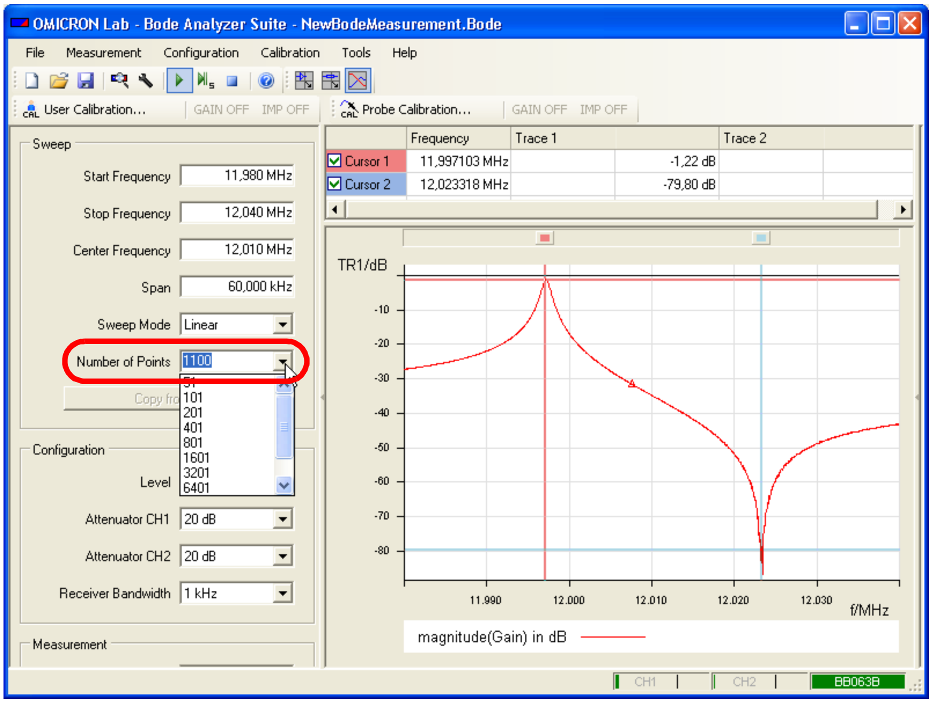
Sometimes a very specific number of measurement points is required. The *Bode 100* allows you to set any number of measurement points in the range 10…16501. To set the number of measurement points, click in the **Number of Points** box, and then enter the number of points you wish to use for your measurement.

Figure 7-17: Entering the number of measurement points



To get back a predefined number of measurement points, click the corresponding entry in the **Number of Points** list.

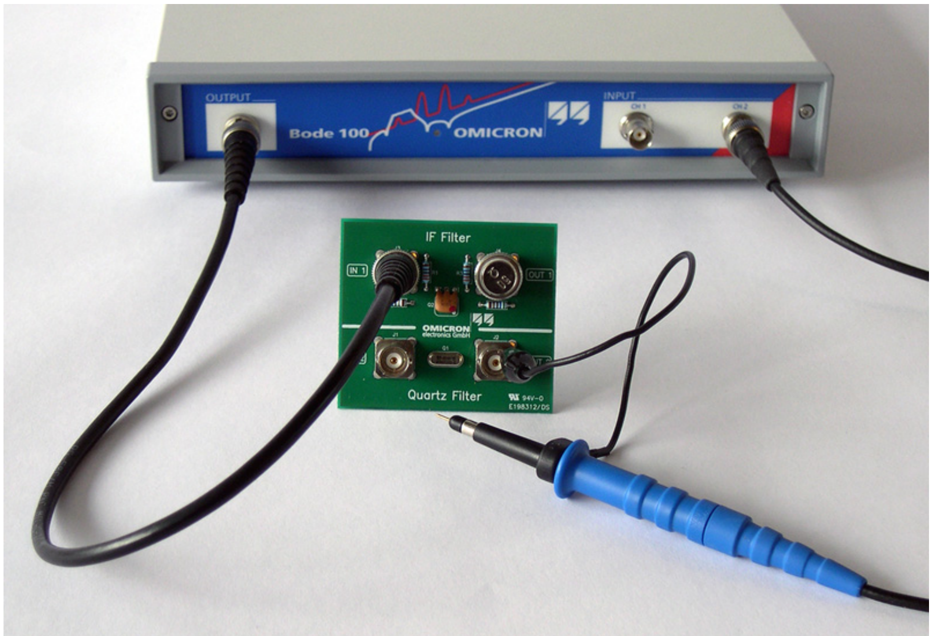
Figure 7-18: Selecting a predefined number of measurement points



7.4 Using Probes

The *Bode 100* allows you to use measurement probes for input channel 1 and input channel 2.

Figure 7-19:
Using a probe



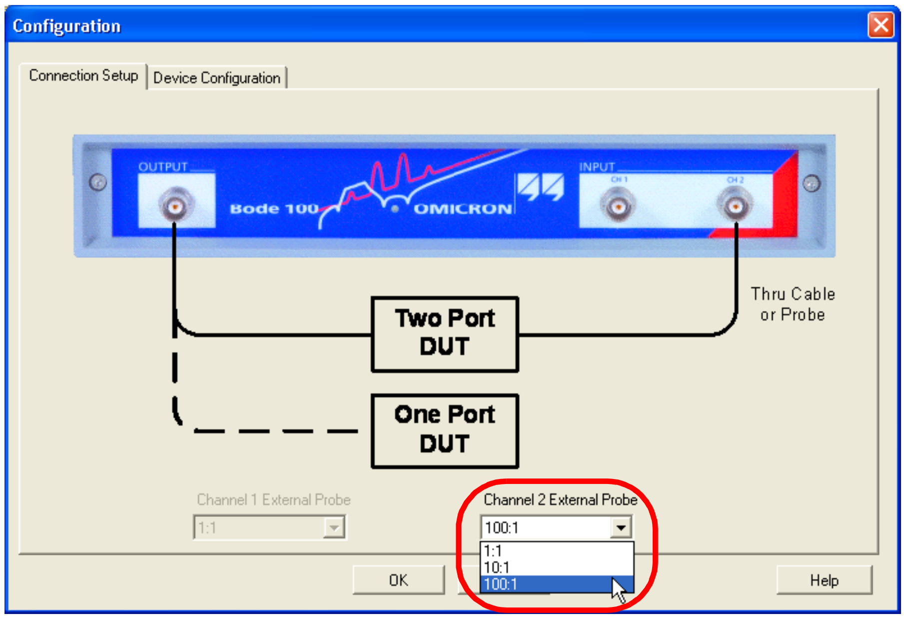
The use of probes is recommended for the following applications:

- Measurements at points in the DUT circuitry which are not accessible with BNC cables
- Measurements of devices under test which are sensitive to capacitive or resistive influences (e.g. resonant circuits)

When using a probe, consider the following instructions:

1. Always set the correct probe ratio in the **Connection Setup** tab of the **Configuration** window.
   You can choose between 1:1, 10:1 or 100:1.

Figure 7-20:
Setting the probe ratio

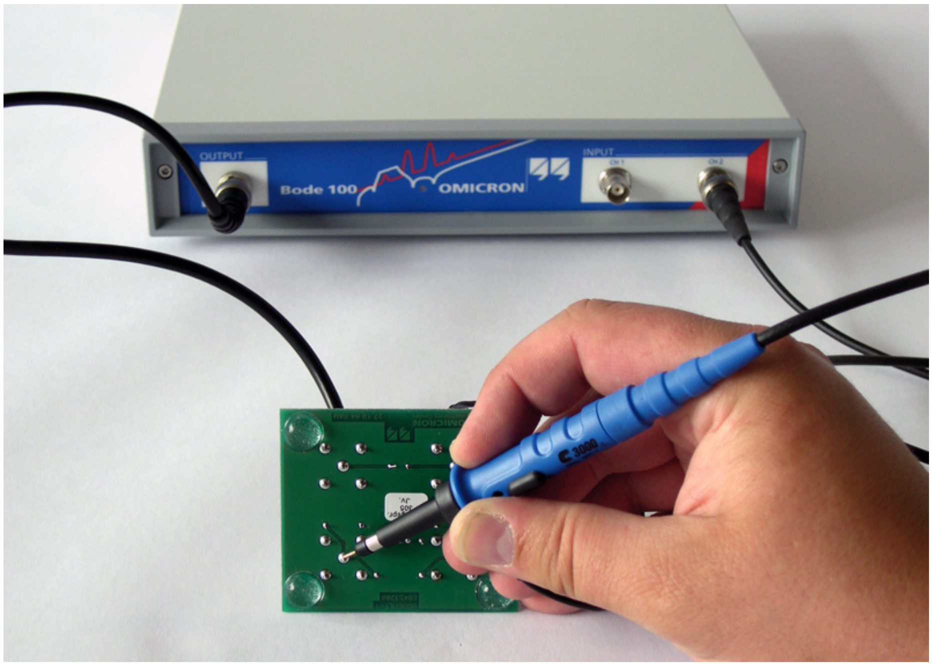


2. Ensure that your DUT is terminated correctly.

Hint: When using a probe with a DUT which requires a 50 Ω termination, you can simply connect the BNC 50 Ω load delivered with your *Bode 100* to the output of the DUT.

3. To obtain accurate measurement results, calibrate the *Bode 100* as follows:
4. Connect the ground of the probe with the ground of the DUT and touch the DUT's input with the probe tip.
5. Now, perform the calibration in the **Gain/Phase** mode as described in 3.3 "Example: Gain/Phase Measurement" on page 24.

Figure 7-21:
Touching the DUT's
input with the probe's tip



Hint: Ensure that the probe's tip is in contact with the DUT's input all the time until the calibration is finished.

6. After having calibrated the probe, start your measurement at any point of the DUT using the probe.

The first time I used my measurement **probe** to **zoom** into an electrical circuit will always remain in my **memory**.

Congratulation! You learned how to use the advanced functions of the *Bode 100*.

How to:

- load and save the equipment configuration
- export measurement data
- use context menus and advanced sweep options
- use probes

8 Automation Interface

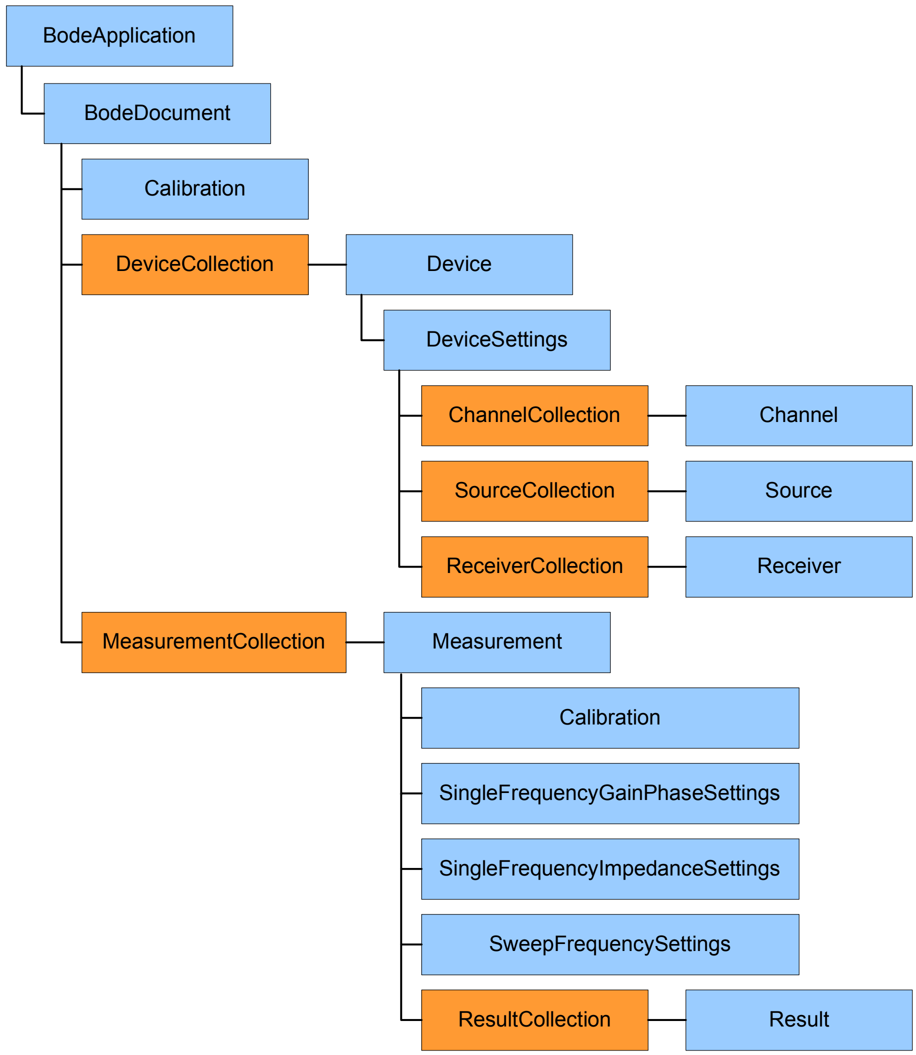
So far you have worked with the *Bode 100* by using the graphical user interface (GUI) of the *Bode Analyzer Suite*. Beside this very comfortable user interface for laboratory use, the *Bode 100* provides also an all-purpose application programming interface (API) which allows other software to communicate directly with the *Bode 100*.

The *Bode Analyzer Automation Interface* supports OLE automation and allows quick access of the *Bode 100* using OLE compatible controllers such as Excel® or programming languages like Visual C++®. This allows simple integration of the *Bode 100* into automated measurement setups.

The *Bode Analyzer Automation Interface* is automatically installed during the *Bode Analyzer Suite* installation and is available for use as soon as a *Bode 100* unit is connected to your PC. (You do not need to start the *Bode Analyzer Suite* to access the *Bode Analyzer Automation Interface*).

Figure 8-1: "Object hierarchy overview" on page 96 shows an overview of the command structure for the *Bode Analyzer Automation Interface*.

Figure 8-1:
Object hierarchy
overview



Hint: You can find a detailed overview of the *Bode Analyzer Automation Interface* object hierarchy in the Automation subdirectory of the *Bode Analyzer Suite* directory.

Figure 8-2: "Example of code segment for accessing the Bode Analyzer Automation Interface" on page 97 shows a typical code segment used to access functions of the *Bode Analyzer Automation Interface*. In this example, a *Bode 100* unit is searched for and, after a device has been found, measurement parameters are set.

Figure 8-2:
Example of code segment for accessing the *Bode Analyzer Automation Interface*

Example

Visual Basic

```
Public Sub Main()
    Dim myBodeApp As New BodeAnalyzer.BodeApplication
    Dim myDocument As BodeAnalyzer.BodeDocument

    Set myDocument = myBodeApp.Document

    myDocument.Devices.ScanForDevices

    If myDocument.Devices.Count > 0 Then
        ' select the first device
        myDocument.Devices(1).SelectAndInit
        ' set default device settings
        myDocument.SelectedDevice.DeviceSetup.Bandwidth = Bandwidth_Hz100
        myDocument.SelectedDevice.DeviceSetup.DUTDelay = 0.000012 ' 12 µs
        myDocument.SelectedDevice.DeviceSetup.Channels(2).Termination50Ohm = True
        myDocument.SelectedDevice.DeviceSetup.Channels(2).Probe = ExternalProbe_Probe10to1
        myDocument.SelectedDevice.DeviceSetup.Receivers(1).Attenuator = Attenuator_dB0
        myDocument.SelectedDevice.DeviceSetup.Receivers(2).Attenuator = Attenuator_dB10
        myDocument.SelectedDevice.DeviceSetup.Sources.Level = 20 ' 20 dBm aren't possible, is changed to 13dBm (max. Level)
        myDocument.SelectedDevice.DeviceSetup.Sources(1).On = True
        myDocument.SelectedDevice.DeviceSetup.Sources(2).On = False

        MsgBox "Device (Id: " & dev.DeviceId & " , Serial: "
                 & dev.SerialNumber & ") selected and ready to use."
    Else
       ' No device connected
        MsgBox "No device connected."
        End
    End If

    myBodeApp.Quit
End Sub
```

See Also

Device Members

For a complete description of the *Bode Analyzer Automation Interface*, see the Bode Analyzer Automation Interface Reference available in the Automation subdirectory of the *Bode Analyzer Suite* directory.

Congratulation! In this chapter you:

- learned basics about the *Bode Analyzer Automation Interface*
- got an overview on the object hierarchy of the used command structure
- learned where to look for further information on the *Bode Analyzer Automation Interface*

Shout "OLE" to celebrate your new knowledge about the *Bode Analyzer Automation Interface*.

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9 Troubleshooting

9.1 USB Cable and/or Power Supply to the *Bode 100* Is Missing

If the serial number field in the status bar displays "No Device" on red background then the *Bode Analyzer Suite* software does not have a connection to the *Bode 100*.

Solution: Connect the USB cable to the PC and the *Bode 100* and check the power supply. Then click the **Search and Reconnect Device** toolbar button to connect the *Bode 100* with the PC.

9.2 Lost Communication

The loss of the *Bode 100* power supply and other events can cause loss of communication. In this case, the serial number field in the status bar displays "No Device" on red background.

Solution: Click the **Search and Reconnect Device** toolbar button to connect the *Bode 100* with the PC.

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10 Technical Data

10.1 *Bode 100* Specifications

Table 10-1:
Bode 100 specifications

Characteristic	Rating
Frequency range	10 Hz…40 MHz
OUTPUT connector	
Output impedance	50 Ω
Connector	BNC
Wave form	Sinusoidal signal
Output voltage	0.01…1 Vrms into 50 Ω load –27 dBm…13 dBm
CH 1 INPUT, CH 2 INPUT connectors	
Input impedance	Low or high impedance selectable
Low impedance	Input impedance 50 Ω
High impedance	Input impedance 1 MΩ ±2% Input capacitance 40…55 pF
Connectors	BNC
Receiver bandwidth	10 Hz, 30 Hz, 100 Hz, 300 Hz, 1 kHz, 3 kHz
Input attenuator	0 dB, 10 dB, 20 dB, 30 dB, 40 dB
Input sensitivity	100 mV full scale for input attenuator 0 dB
Dynamic range	> 100 dB at 10 Hz receiver bandwidth
Gain error	< 0.1 dB (calibrated)
Phase error	< 0.5º (calibrated)
USB interface	
Connector	Type B

10.2 Power Requirements

Table 10-2:
Power requirements

Characteristic	Rating
AC power adapter	
Input voltage/frequency	100…240 V / 47…63 Hz
DC power supply	
Output voltage/output power	+10…24 V / 10 W
Inner connector	+10…24 V
Outer connector	Ground
Inner diameter	2.5 mm
Outer diameter	5.0 mm

10.3 Absolute Maximum Ratings

Table 10-3:
Absolute maximum ratings

Characteristic	Absolute Maximum Rating
DC power input	
DC supply voltage	+28 V
DC supply reverse voltage (device does not work)	–28 V
CH 1 INPUT, CH 2 INPUT connectors (high impedance)	
Maximum AC input signal	50 Vrms for 10 Hz…1 MHz 30 Vrms for 1 MHz…2 MHz 15 Vrms for 2 MHz…5 MHz 10 Vrms for 5 MHz…10 MHz 7 Vrms for 10 MHz…40 MHz
CH 1 INPUT, CH 2 INPUT connectors (low impedance)	
Maximum input power	1 W (= 7 Vrms)
OUTPUT connector	
Maximum reverse power	0.5 W

10.4 PC Requirements

Table 10-4:
PC requirements

Characteristic	Requirement
Minimum configuration	Pentium 500 MHz, 256 MB RAM, CD-ROM drive
Recommended configuration	Pentium 1 GHz, 256 MB RAM, CD-ROM drive
Interface	USB 1.1 or USB 2.0
Operating system	Windows® 2000 or Windows® XP

10.5 Environmental Requirements

Table 10-5:
Environmental requirements

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

10.6 Mechanical Data

Table 10-6:
Mechanical data

Characteristic	Rating
Dimensions (w × h × d)	26 × 5 × 26.5 cm / 10.25" × 2" × 10.5"
Weight	< 2 kg / 4.4 lbs

Hint: You can find more technical data on the OMICRON Lab website www.omicron-lab.com.

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Contact Information / Technical Support

E-Mail:	support@omicron-lab.com
Web:	www.omicron-lab.com

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Alternatively, please see our website www.omicron-lab.com for customer service centers in your area.

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