



Predstavitev Omicron lab Bode 100, Bode 500, BAS – EMC delavnica 2026

Tomaž Rus, Amiteh d.o.o. tomaz@amiteh.com

Traditional Vector Network Analyzer

- First VNA from R&S in 1950
- Today's VNA starting tens kHz to THz
- S-Parameter only
- Designed for RF and telecommunication engineers
- Cheap USB VNAs to \$\$\$\$\$



Our Approach

Low-Frequency Vector Network Analyzer

- Great tool for power electronics engineers
 - VNA, FRA & Impedance Analyzer
 - Applies VNA principles from mHz to MHz
 - Applicable to nearly **all** electronic systems (except RF of modern telecommunications)
 - Very easy to use & price-effective
- Makes it a **must-have** for **many**, many **engineers**...



“Every electronic engineer needs a Bode-device in his lab!”

OMICRON Lab



Every electronic engineer!



IEEE has 486.000 members

US: 288.000 electrical and electronic engineers

≈ 1 Bode per 100 employees (1%)

26 Million people work in electrical industry **world-wide**

→ 1 % case - **260.000 Bodes**

→ 2 ‰ case - **52.000 Bodes**

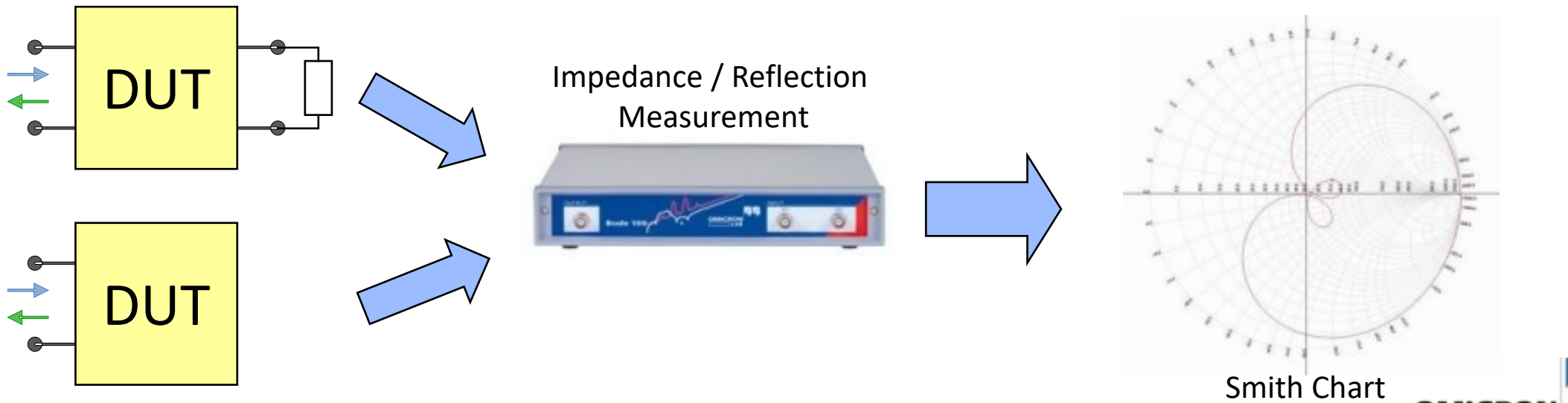


What is it about?

Which key problems do we solve? Bode helps with...

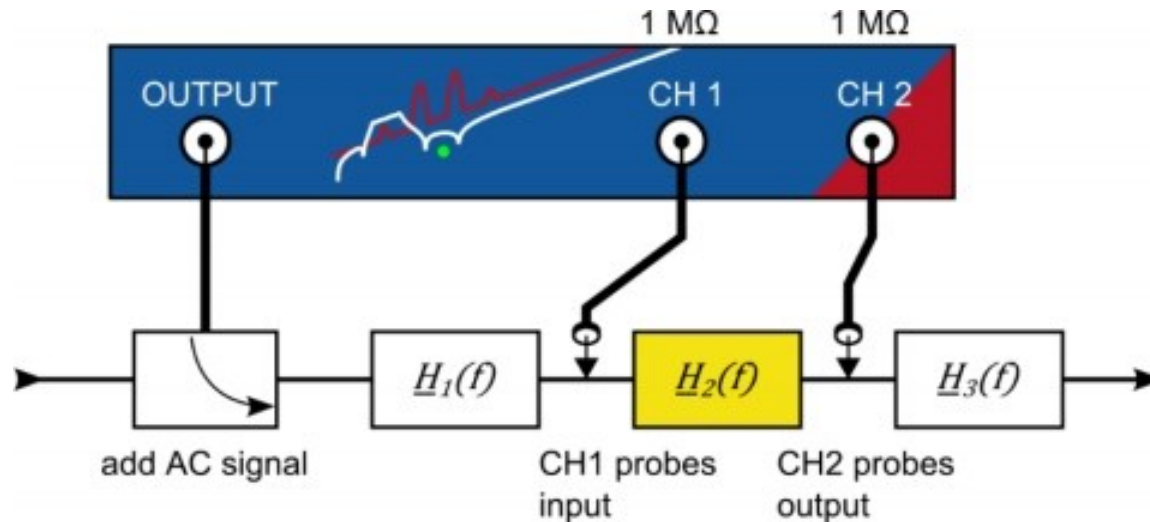
- Troubleshooting power integrity issues
- Designing compensators for switching power converters
- Optimizing a signal conditioning chain
- Measuring frequency response of electronic components
- Analyzing the dynamic behavior of control systems
- Designing EMI filters
- Creating automated test systems
- etc...

Functions of Bode 100



Measuring Transfer Functions (Gain/Phase)

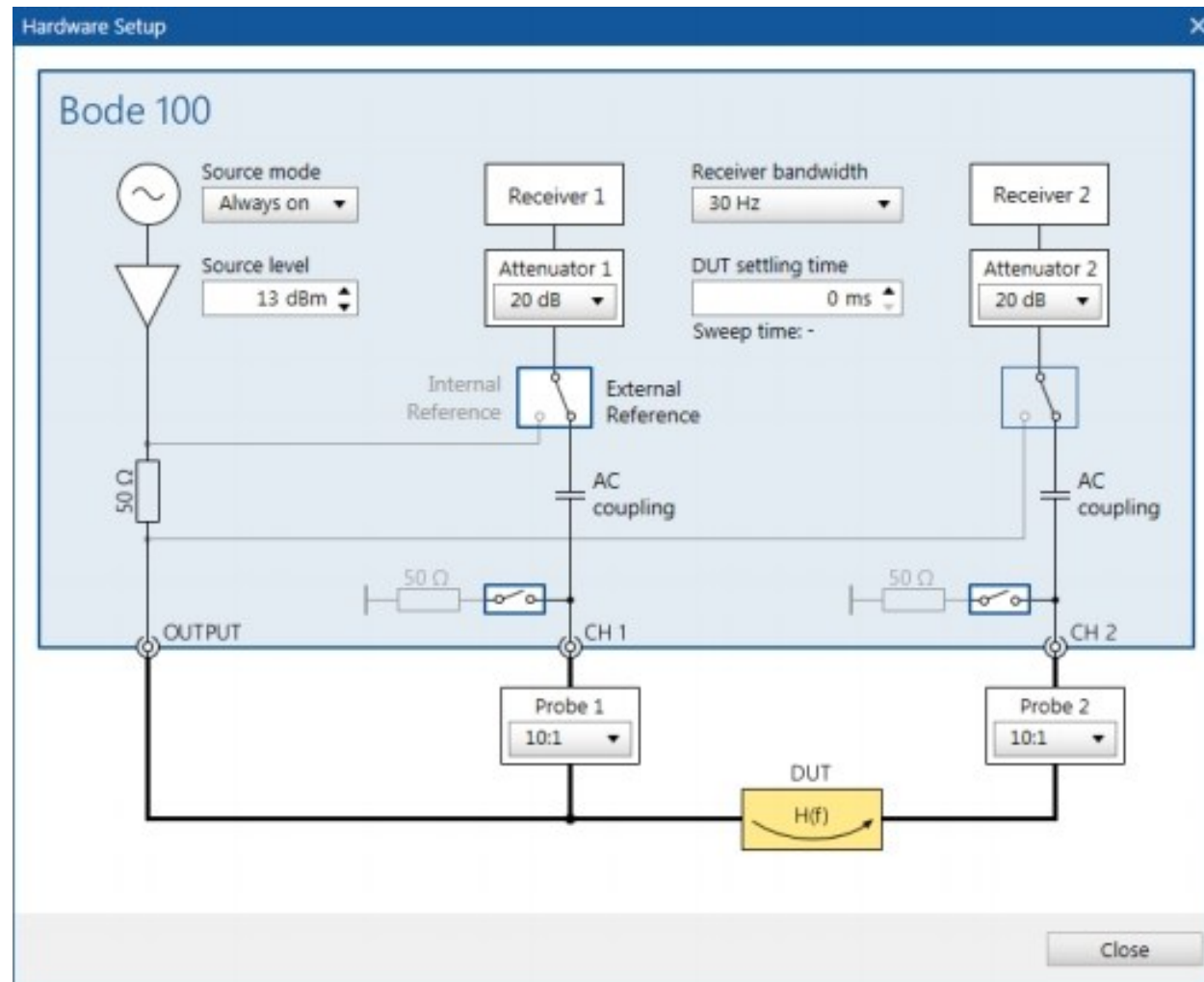
Bode 100 measures the transfer function \underline{H}_2 from CH1 to CH2



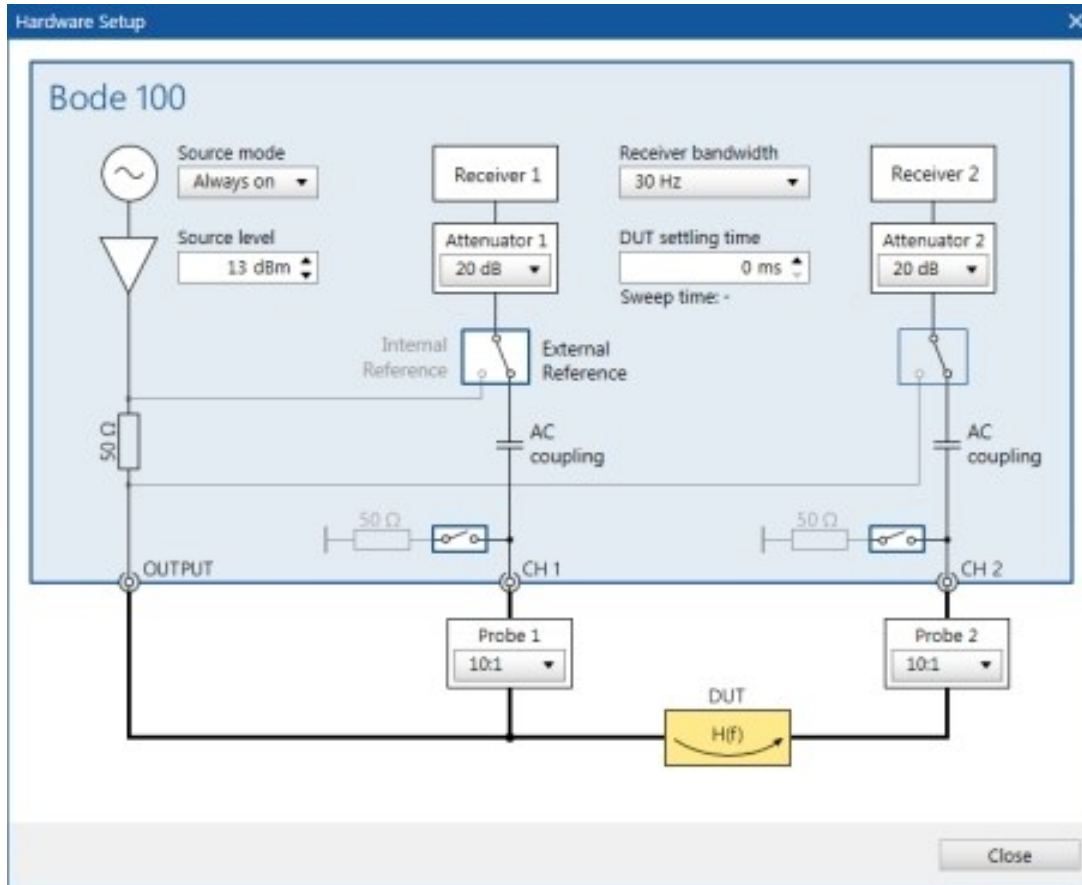
$$Gain = \frac{V_{CH2}}{V_{CH1}}$$

- Measure a filter (low-pass, high-pass, anti aliasing, etc.)
- Measure a control loop (i.e., dc/dc converter)
- Measure an amplifier (audio, power, operational, etc.)

Bode 100 - Frequency Response Analyzer

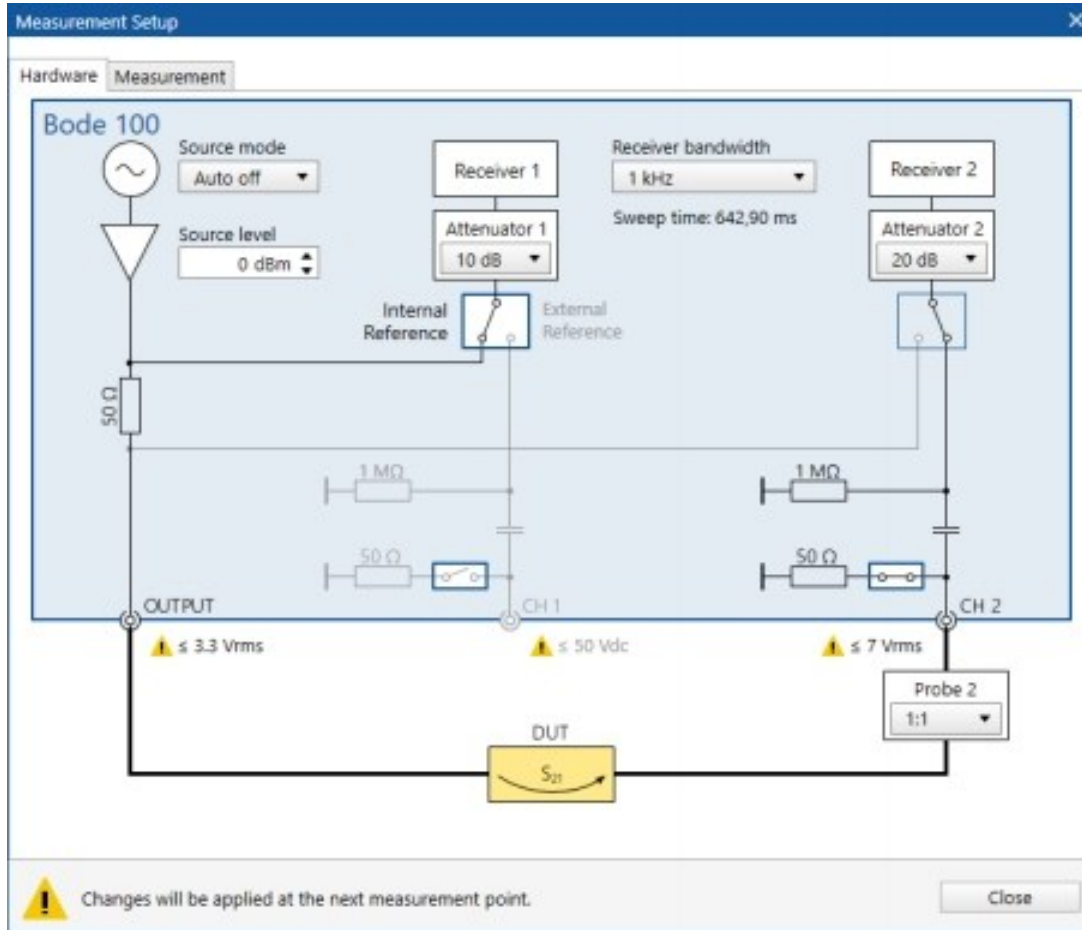


Bode - Frequency Response Analyzer



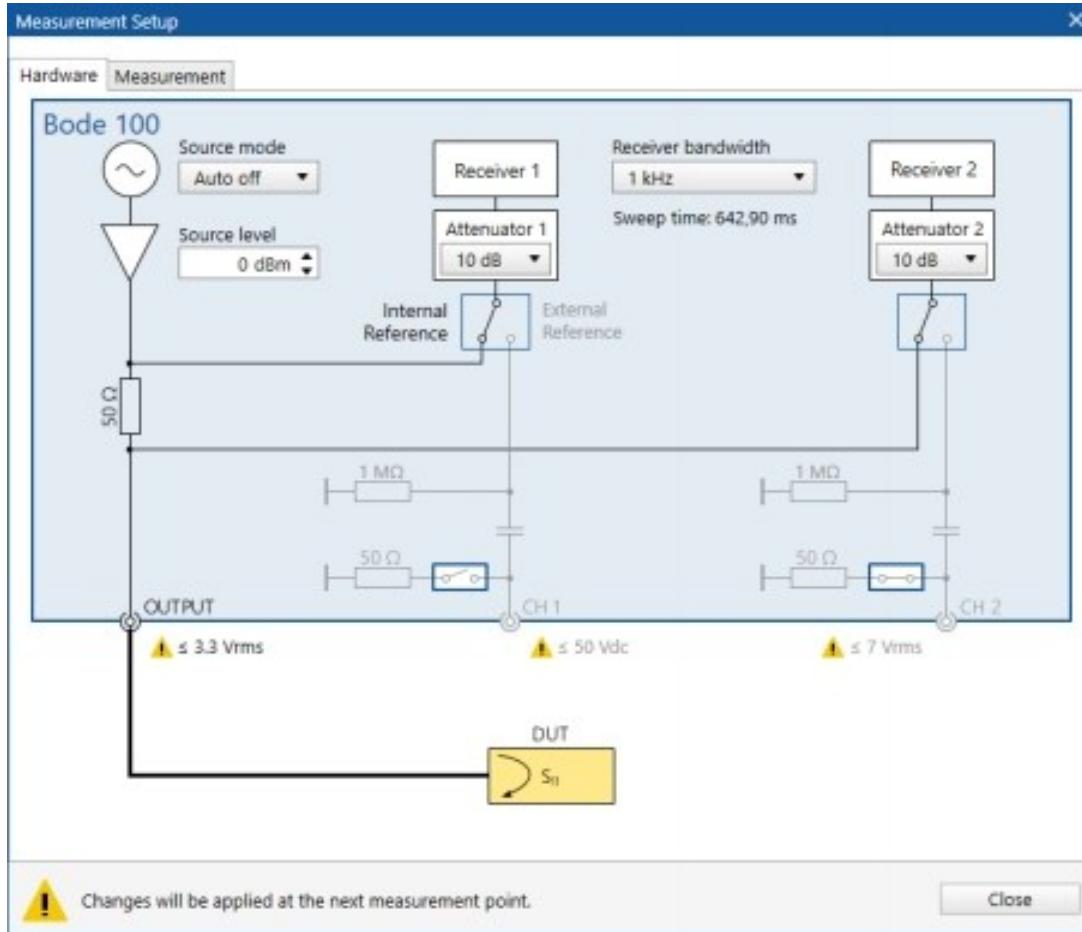
- Voltage Transfer Function
- Loop Gain
- Impedance Measurements (B-WIC, B-SMC, Voltage/Current Method,...)

Bode - VNA



- S-Parameter measurement (50 Ω – System)
- Transmission S₂₁

Bode - VNA



- S-Parameter measurement (50 Ω – System)
- Transmission S₂₁
- Reflection S₁₁

Bode – Impedance Analyzer

The screenshot displays the 'Welcome, please select a measurement type...' screen of the Bode Impedance Analyzer. The interface includes a left-hand navigation menu with options: New measurement, Open, Recent, Save, Save as, Export, Options, About, Read user manual, and Exit. The main area is titled 'Vector Network Analysis | Impedance Analysis | Advanced' and features three primary measurement methods, each with a diagram and a 'Select measurement' button:

- One-Port:** Measure impedance/reflection at the output port. Recommended impedance range: 500 m Ω ... 10 k Ω . Warning: Do not exceed 3.3 V_{rms} at the output (50 Ω).
- Impedance Adapter:** Measure impedance using the B-WIC or B-SMC component test fixtures. Recommended impedance range: 20 m Ω ... 600 k Ω . Note: Calibration (open, short, load) is required.
- Shunt-Thru:** Measure impedance with the Shunt-Thru method. Recommended impedance range: 1 m Ω ... 100 Ω . Warnings: Do not exceed 3.3 V_{rms} at the output (50 Ω); Do not exceed 7 V_{rms} at Channel 2 input (50 Ω).

Below these are additional measurement options: Shunt-Thru with series resistance, Series-Thru, Voltage / Current, and External Bridge.

- Internal Setup depends on measurement method
 - FRA (3 ports)
 - VNA (1 or 2 ports)
- 7 Different Measurement Methods
- $\mu\Omega$ to M Ω

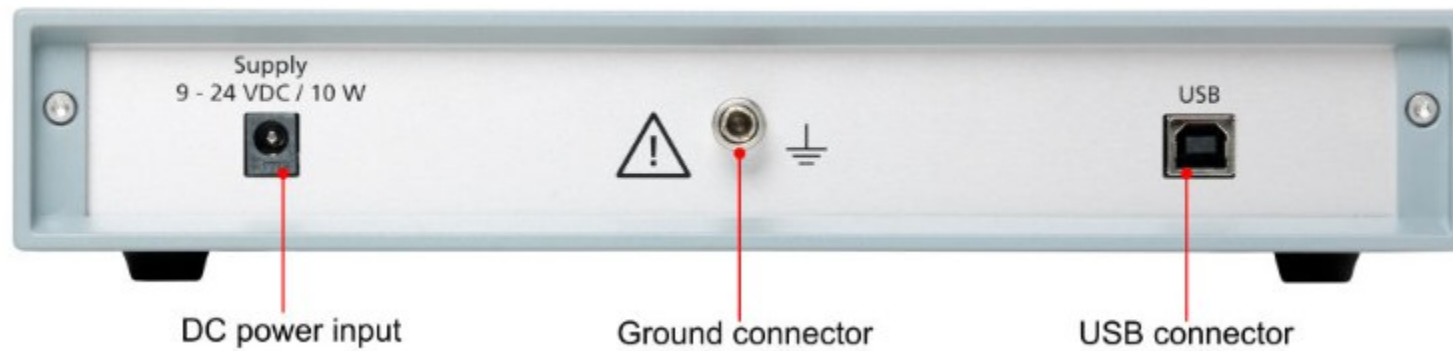
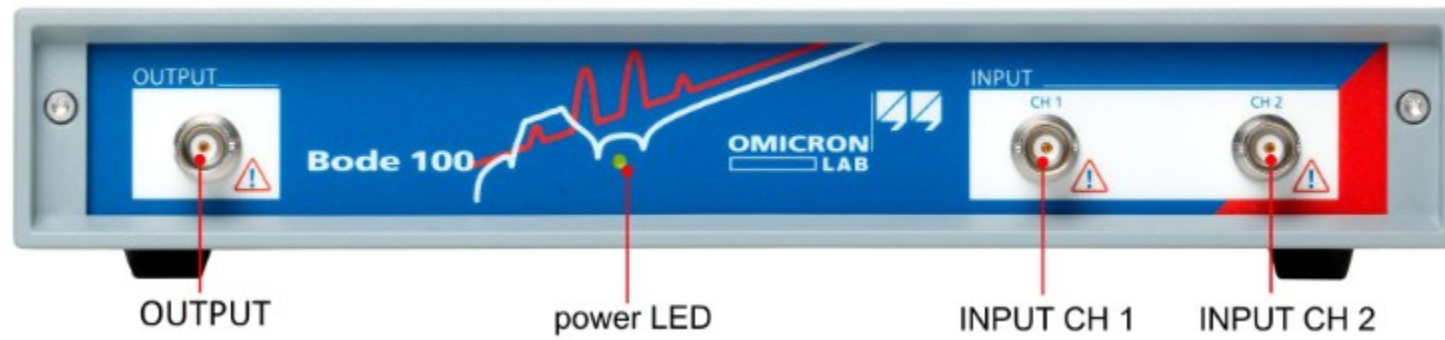


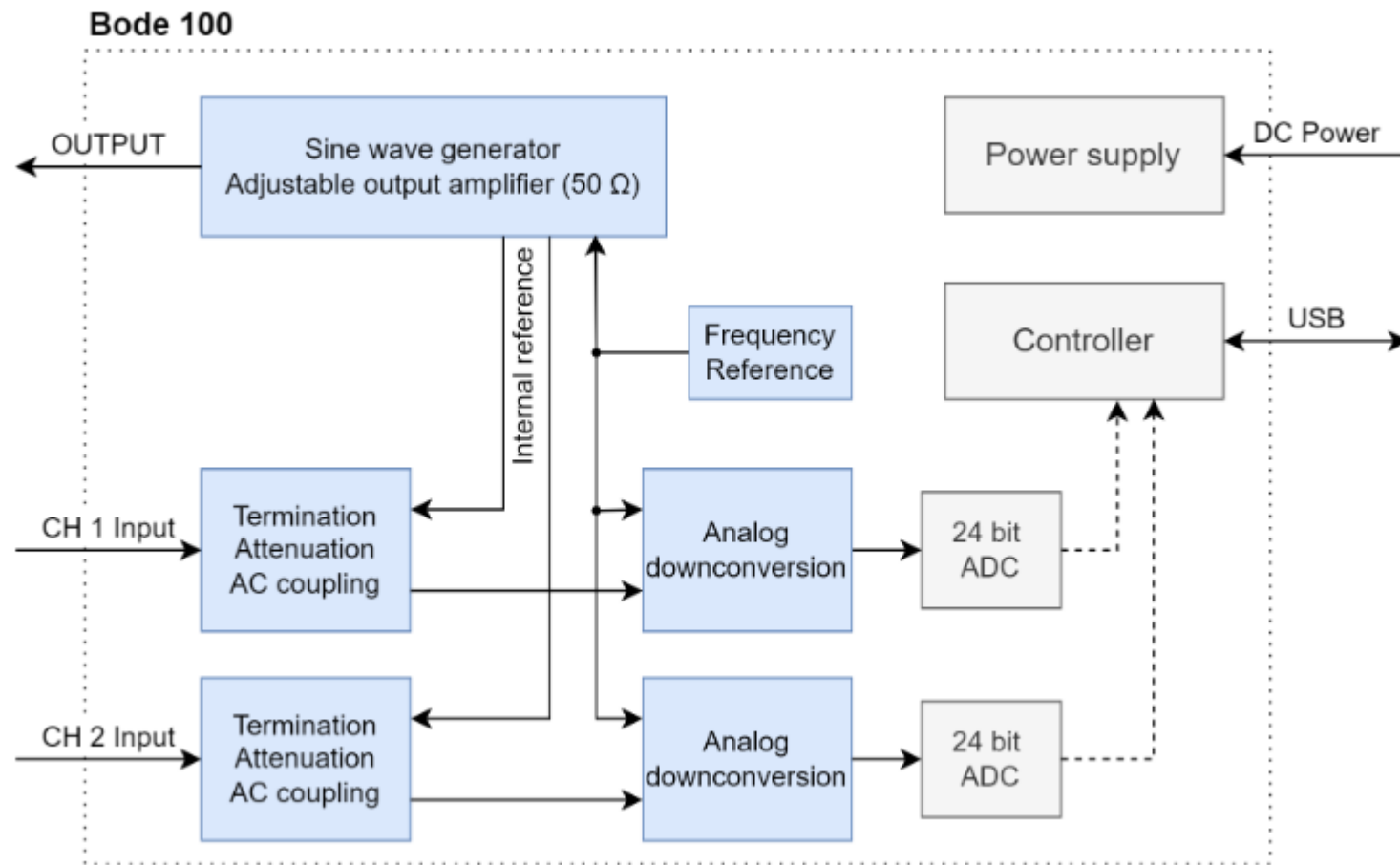
Bode 100, Bode 500

Osnovne tehnične lastnosti



LF-VNA (Bode 100)





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)
Warm-up time (3τ)	62 min*
Gain Error (User-Range calibrated)	< 0.1 dB
Phase Error (User-Range calibrated)	< 0.5°

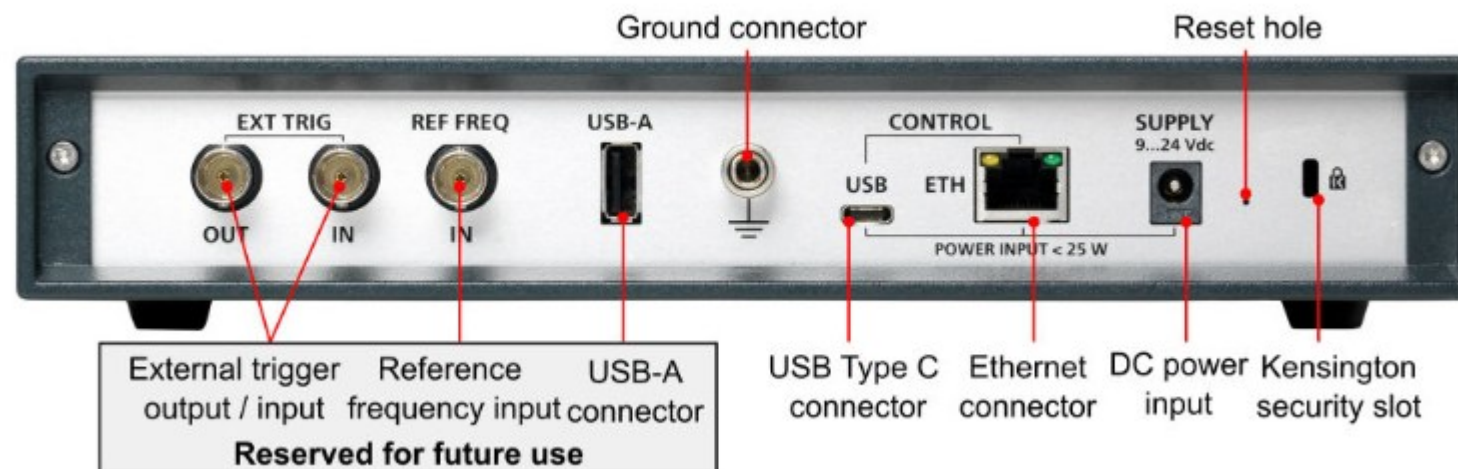
Characteristic	Rating
OUTPUT, CH1, CH2 connector type	BNC
USB interface connector	USB type B socket
*...specifications are valid after device has warmed up and reached a stable temperature	
Bode 100 power requirements	
Supply voltage range	+9 VDC to +24 VDC
Power demand	< 10 W
Connector type	Coaxial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

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)

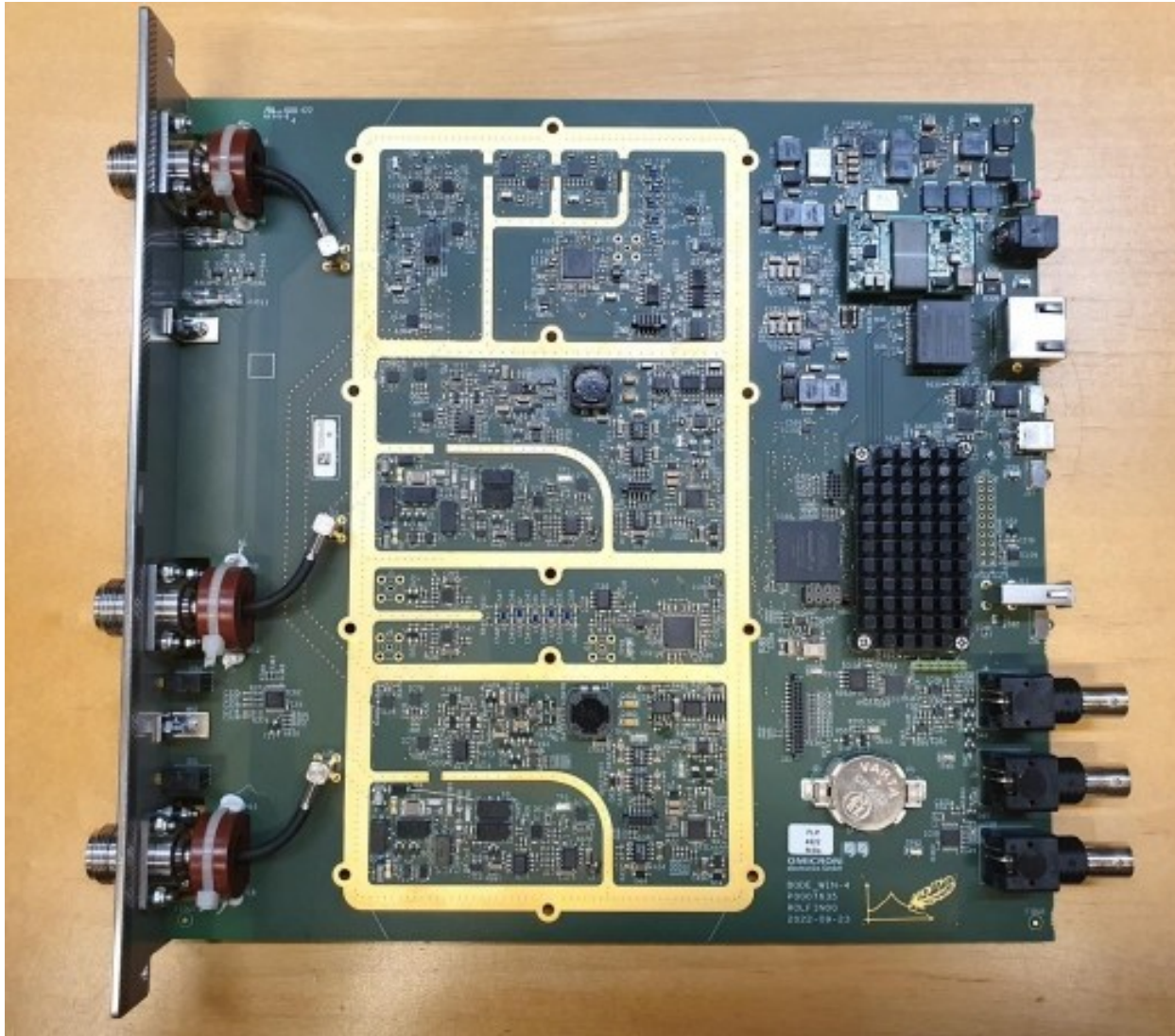


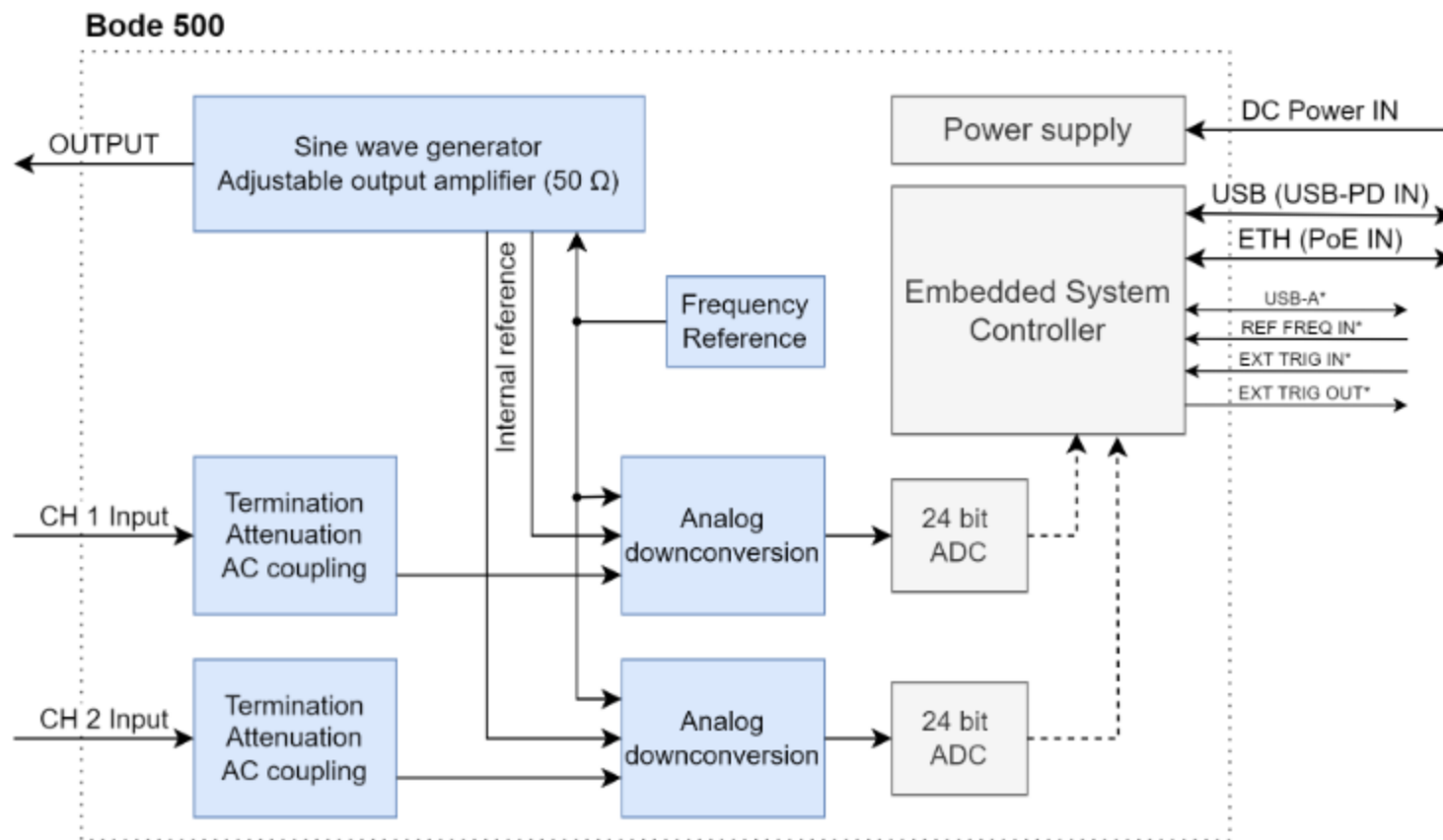
Bode 500

Osnovne tehnične lastnosti



Sneak Peek into the Internals





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	1 MΩ ± 0.5 % (ac-coupled)
Input capacitance	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
Warm-up time (3T)	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

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)

Bode 100 vs. Bode 500

Characteristic	Bode 100	Bode 500
Frequency range	1 Hz ... 50 MHz	10 mHz ... 450 MHz
Dynamic range	> 100 dB	> 120 dB (typ.)
Signal source	-30 dBm ... 13 dBm	-50 dBm ... 16 dBm
Connector type	BNC	N
Source impedance	50 Ω	50 Ω
Channel termination	50 Ω / 1 M Ω AC-coupled	50 Ω / 1 M Ω AC-coupled
Input AC measurement range	up to 10 Vrms	up to 10 Vrms
S-Parameter measurements (VNA)	✓	✓
Frequency Response Analysis	✓	✓
Impedance Analysis	✓	✓
Bode Analyzer Suite User Interface	✓	✓
Standalone SCPI interface	X	✓
USB connector	Type B	Type C
Ethernet connection	X	✓
Network capability	X	✓
Web interface	X	✓
Powered via USB-PD	X	✓
Powered via Ethernet (PoE+)	X	✓
Signal source indicator	X	✓
Channel termination indicator	X	✓
External reference frequency input	X	(future use)
External trigger input	X	(future use)
External trigger output	X	(future use)
USB-A host interface	X	(future use)
Passive cooling (fan-less)	✓	✓



Programska oprema BAS

Osnovne lastnosti

Bode Analyzer Suite 3.50

New measurement

Recent

- Bode100_ImpAdapt_Inductor.bode3
C:\Users\BriLan00\AppData\Roamin...
- Bode100_OnePort_Quartz_Filter.bode:
C:\Users\BriLan00\AppData\Roamin...
- Bode100_TransRef_IF_Filter.bode3
C:\Users\BriLan00\AppData\Roamin...
- Bode500_TransRef_IF_Filter.bode3
C:\Users\BriLan00\AppData\Roamin...

Open other file

Read user manual

Options

About

Welcome, please select a measurement type...

Vector Network Analysis | Impedance Analysis | Advanced

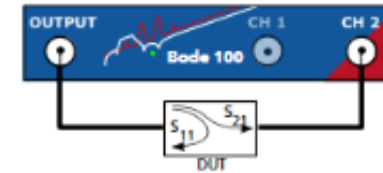
Transmission / Reflection

3.

Measure S-parameters (S_{21} , S_{11}) with $50\ \Omega$ termination.
Measure Gain with internal or external reference.

- Do not exceed $3.3\ V_{rms}$ at the output ($50\ \Omega$).
- Do not exceed $7\ V_{rms}$ at Channel 2 input ($50\ \Omega$).

Select measurement

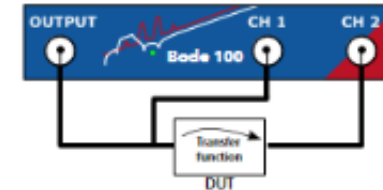


Gain / Phase

Measure transfer function (Gain/Phase) from CH1 to CH2.

- By default, the inputs are set to high impedance and are ac-coupled.
- Do not exceed $50\ V_{dc}$ at the inputs.
- Do not exceed $3.3\ V_{rms}$ at the output ($50\ \Omega$).

Select measurement



> Reflection with external coupler

Select the device to use:

ML723D

1.

Set default startup

BAS 3.50 Bode 500 Support

The image displays the Bode Analyzer Suite 3.50 software interface, divided into two main sections: Hardware Setup and Measurement Selection.

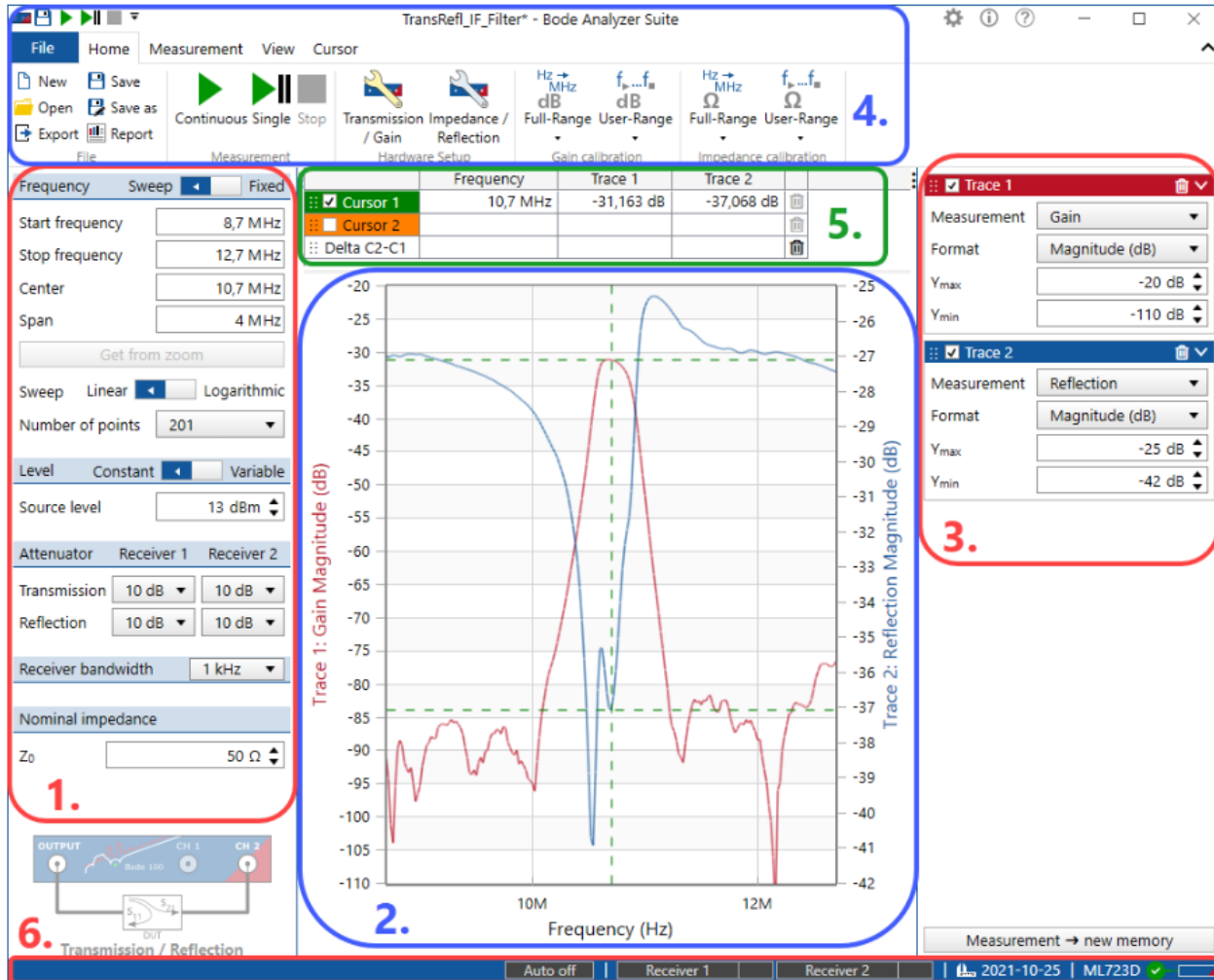
Hardware Setup (Bode 500):

- Source mode:** Auto off
- Source level:** 0 dBm
- Receiver bandwidth:** 1 kHz
- DUT settling time:** 0 ms
- Path switch settling time:** 50 ms
- Sweep time:** 1.22 s
- Attenuator 1:** 0 dB
- Attenuator 2:** 0 dB
- Probe 2:** 1:1
- Warnings:** $\leq 3.3 \text{ V}_{\text{rms}}$ at output, $\leq 50 \text{ V}_{\text{dc}}$ at CH 1, $\leq 7 \text{ V}_{\text{rms}}$ at CH 2.

Measurement Selection:

- Transmission / Reflection:** Measure S-parameters (S_{21} , S_{11}) with 50 Ω termination. Measure Gain with internal or external reference. Do not exceed 3.3 V_{rms} at the output (50 Ω). Do not exceed 7 V_{rms} at Channel 2 input (50 Ω).
- Gain / Phase:** Measure transfer function (Gain/Phase) from CH1 to CH2. By default, the inputs are set to high impedance and are ac-coupled. Do not exceed 50 V_{dc} at the inputs. Do not exceed 3.3 V_{rms} at the output (50 Ω).
- Reflection with external coupler:** (Option partially visible)

At the bottom of the measurement selection window, there is a dropdown menu for "Select the device to use:" set to "102377723" and a "Set default startup" button.



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 140.

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. Learn more about how to configure traces and memories in [10.4 Using the memory traces](#) on page 153 and [10.5 Working with measurement and math traces](#) on page 157.

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 148.

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.

Curve Fitting of an Inductor



Impedance Result Formats

<input checked="" type="checkbox"/> Trace 1		Magnitude: Displays the magnitude of the measured impedance in Ohms.
Measurement	Impedance	Magnitude (dB): Displays the magnitude of the measured impedance in dBΩ.
Format	Magnitude (dB)	Phase (°): Displays the phase of the measured impedance in degrees.
Y _{max}	Magnitude	Phase (rad): Displays the phase of the measured impedance in radians.
Y _{min}	Magnitude (dB)	Tg: Displays the group delay of the measured impedance in seconds (see Gain result equations for details).
<input checked="" type="checkbox"/> Trace 2		Polar: Displays the measured impedance in a polar chart.
Measurement	Polar	Real: Displays the resistance of the measured impedance in Ohms.
Format	Real	Imaginary: Displays the reactance of the measured impedance in Ohms.
Y _{max}	Rs	Rs: Displays the equivalent series resistance (ESR) of the measured impedance in Ω. This value equals the Real part of impedance.
Y _{min}	Ls	Ls: Displays the equivalent series inductance (ESL) of the measured impedance in Henry.
	Cs	Cs: Displays the equivalent series capacitance (ESC) of the measured impedance in Farad.
	Q	Q: Displays the Q-factor of the measured impedance (see Impedance result equations for details).
	Nyquist	Nyquist: Displays the measured impedance in a Nyquist chart
	Q(Tg)	Q(Tg): Displays the Q-factor derived from group delay. This value is used for NISM (see Cursor calculations for details).
	tan(δ)	tan(δ): Displays the tan(δ) of the measured admittance. (see Impedance result equations for details).

Admittance Result Formats

<input checked="" type="checkbox"/> Trace 1		Magnitude: Displays the magnitude of the measured admittance in Siemens.
Measurement	Admittance	Magnitude (dB): Displays the magnitude of the measured admittance in dB _S .
Format	Magnitude (dB)	Phase (°): Displays the phase of the measured admittance in degrees
Y _{max}	Magnitude	Phase (rad): Displays the phase of the measured admittance in radians
Y _{min}	Magnitude (dB)	Tg: Displays the group delay of the measured admittance in seconds (see Gain result equations for details).
<input checked="" type="checkbox"/> Trace 2		Polar: Displays the measured admittance in a polar chart.
Measurement	Polar	Real: Displays the conductance of the measured admittance in Siemens.
Format	Real	Imaginary: Displays the susceptance of the measured admittance in Siemens
Y _{max}	Rp	Rp: Displays the equivalent parallel resistance of the measured admittance in Ohms.
Y _{min}	Lp	Lp: Displays the equivalent parallel inductance of the measured admittance in Henry.
	Cp	Cp: Displays the equivalent parallel capacitance of the measured admittance in Farad.
	Q	Q: Displays the Q-factor of the measured admittance (see Impedance result equations for details).
	Nyquist	Nyquist: Displays the measured admittance in a Nyquist chart.
	Q(Tg)	Q(Tg): Displays the Q-factor derived from group delay (see Cursor calculations for details).
	tan(δ)	tan(δ): Displays the tan(δ) of the measured admittance. (see Impedance result equations for details)

Circuit Fitting Feature of BAS 3.50

The screenshot displays the 'Circuit Fit 1' dialog box in the BAS 3.50 software. The 'Start Fit' button is highlighted with a red circle. The 'Equivalent circuit model' section shows a circuit diagram with a capacitor (C), inductor (L), and resistors (Rs, Rp, R0). The 'Fit results' section displays a table of parameters and two plots: 'Relative Error' and 'RMSRE: 9.459 %'.

Fit results table:

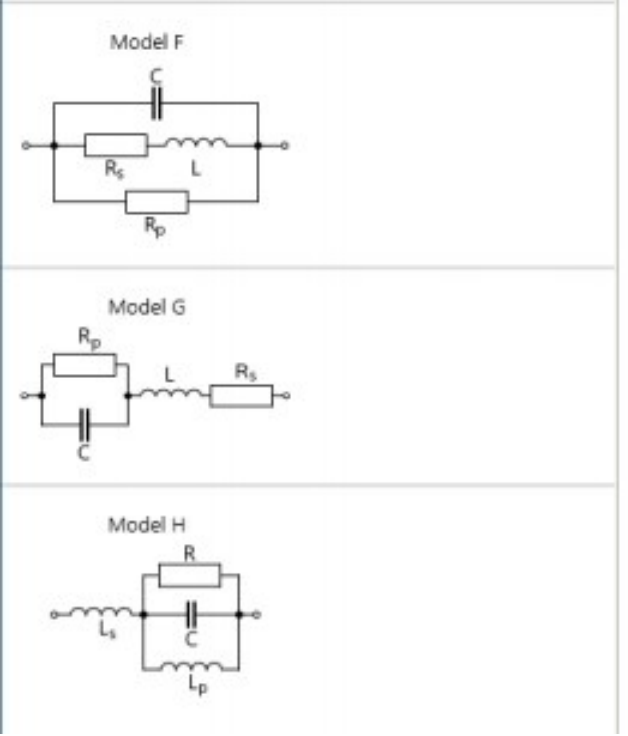
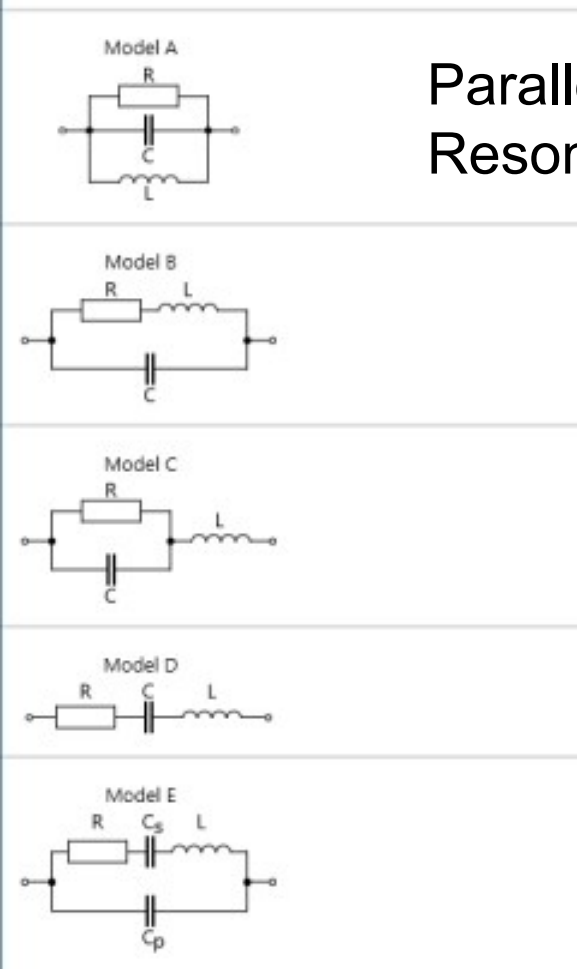
Parameter	Value
Rp	7.567 kΩ
Rs	213.292 mΩ
L	132.728 μH
C	11.214 pF

Relative Error Plot: Shows Error (%) vs Frequency (Hz) on a log-log scale. The error is low (around 5%) until approximately 100 kHz, where it rises to about 25% at 1 MHz and continues to increase towards 100 MHz.

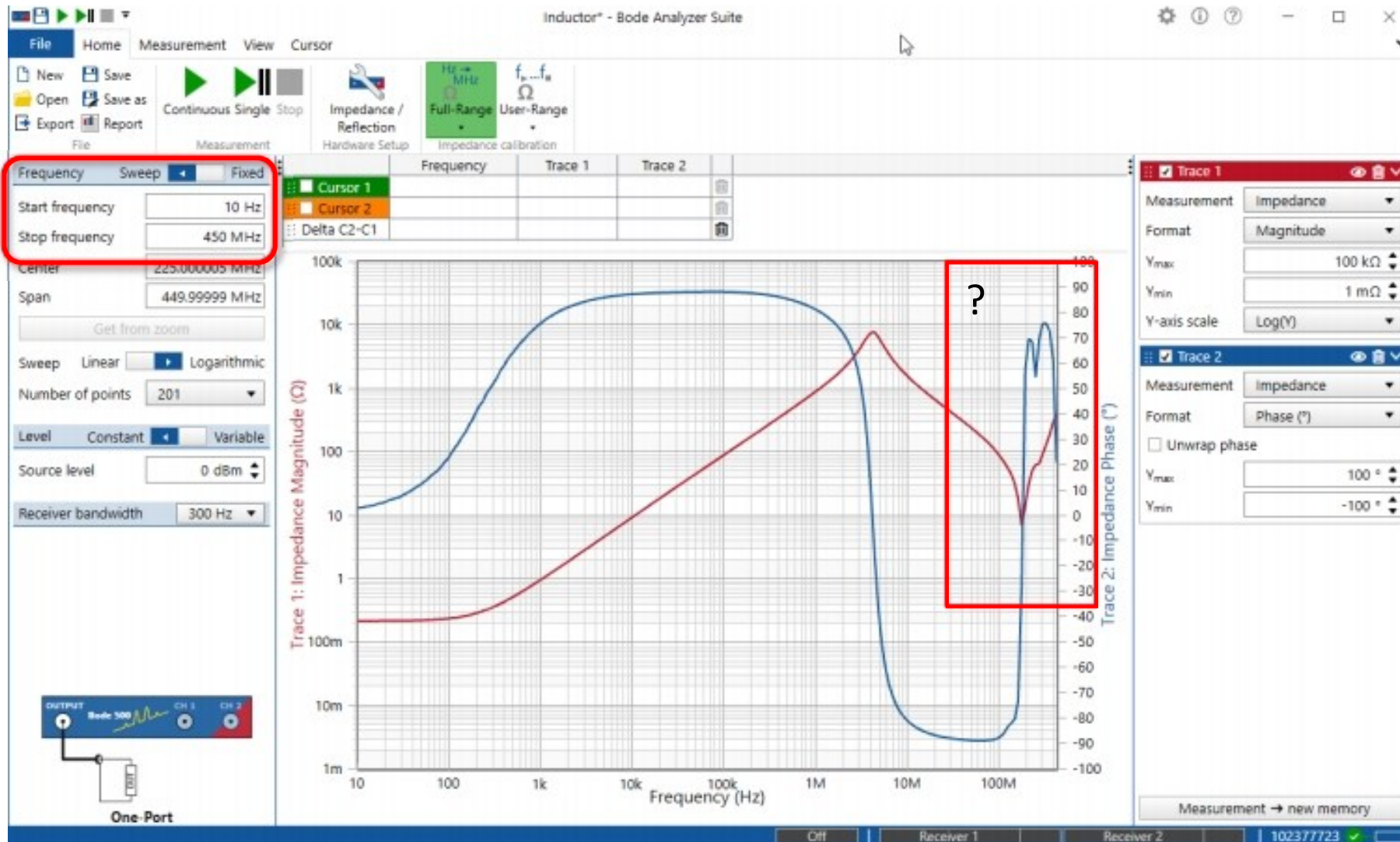
RMSRE: 9.459 % Plot: Shows Magnitude (Ω) and Phase (°) vs Frequency (Hz) on a log-log scale. The magnitude plot shows a peak around 100 kHz, and the phase plot shows a corresponding shift.

Available Models

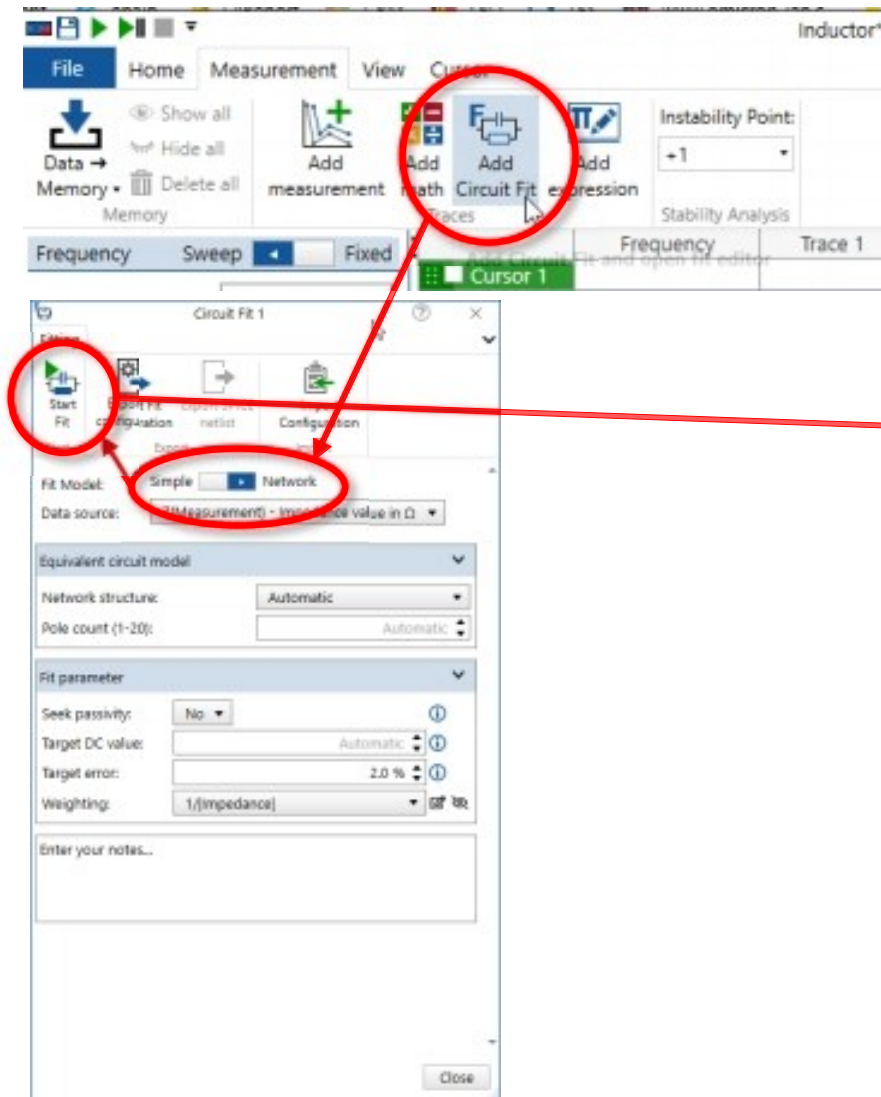
Parallel Resonator



But What Now?



Network Fitting



The 'Circuit Fit 1' dialog box displays the following information:

Fit Model: Simple Network

Data source: Z(Measurement) - Impedance value in Ω

Equivalent circuit model

Network structure: Parallel

Pole count (1-20): Automatic

The equivalent circuit model diagram shows a parallel network with components: C_0 , R_0 , L_1 , R_1 , R_s , L_2 , C_2 , and R_p . The poles are labeled as Real Pole a_1 and Complex Pole a_2 .

Fit parameter

Seek passivity: No

Target DC value: Automatic

Target error: 15.0 %

Weighting: 1/[Admittance]

Fit results

Transfer function representation: Circuit components

Absolute DC value at 0 Hz: 214.9644 mΩ

Pole count:

$$Z = \frac{1}{\frac{1}{R_0} + sC_0 + \frac{1}{sL_1 + R_1} + \frac{1}{sL_2 + R_2} + \frac{1}{R_s + sL_2 + 1/(1/R_p + sC_2)}}$$

R_s	23.533 Ω
C_0	294.101 fF
R_1	214.971 mΩ
L_1	132.44 μH
R_2	-24.297 Ω
L_2	-701.282 pH
R_p	-846.227 Ω
R_s	15.715 Ω
L_2	72.933 nH
C_2	9.479 pF

Relative Error

Plot of Error (%) vs Frequency (Hz) on a log scale. The error is generally low, with a significant spike around 10 MHz.

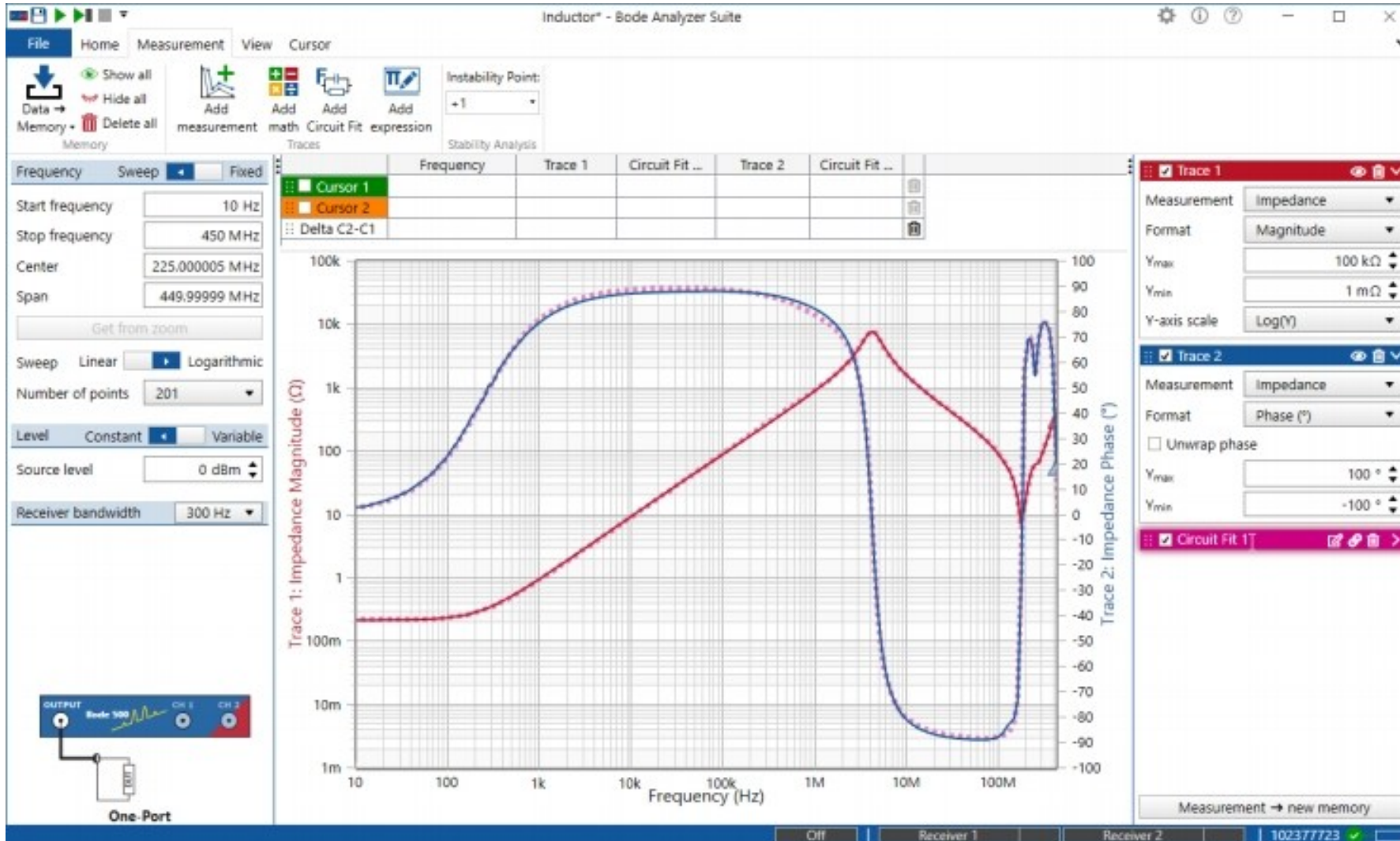
Magnitude/Phase

Plot of Magnitude (Ω) and Phase (°) vs Frequency (Hz) on a log scale. The magnitude plot shows a peak around 10 MHz. The RMSRE is 9.242 %.

Enter your notes...

Fitting complete!

5% Target Error -> 8 poles



Possibilities

- Transfer function export (copy -> paste)
 - Partial fractions
 - Polynomial
 - Factorized (Pole-Zero)
 - Circuit Components
- Spice netlist export for simulator import
- Search for Passivity
- Target DC value can be configured
- Weighting can be manually changed

$$Z = \frac{1}{D + sE + \frac{c_1}{s-a_1} + \frac{c_2}{s-a_2} + \frac{c_3}{s-a_3} + \frac{\bar{c}_3}{s-\bar{a}_3}}$$

$$Z = \frac{a_0 + a_1s + a_2s^2 + a_3s^3 + a_4s^4}{b_0 + b_1s + b_2s^2 + b_3s^3 + b_4s^4 + b_5s^5}$$

$$Z = \frac{1}{k} \cdot \frac{(s - a_1)(s - a_2)(s - a_3)(s - \bar{a}_3)}{(s - z_1)(s - \bar{z}_1)(s - z_2)(s - \bar{z}_2)(s - z_3)(s - \bar{z}_3)}$$

$$Z = \frac{1}{R_0 + sC_0 + \frac{1}{s \cdot L_1 + R_1} + \frac{1}{s \cdot L_2 + R_2} + \frac{1}{Rs_3 + s \cdot L_3 + 1/(1/Rp_3 + s \cdot C_3)}}$$

```

Inductor_Circuit Fit 1_2023-11-07T20_09_44.cir  variant_map.xml
1  .SUBCKT Circuit_Fit_1 _IN _OUT
2  C0 _IN _OUT 9.4855315481236574E-002
3  R0 _IN _OUT 1.6251389781385120E-010
4  L1 _IN N1 -4.8906660210553214E-021
5  R1 N1 _OUT -1.6944446029849314E-010
6  L2 _IN N2 7.4388629568445440E-016
7  R2 N2 _OUT 1.2074390408402216E-012
8  L3 _IN N3 4.1014555954137731E-019
9  Rs3 N3 N4 9.1710192112811248E-011
10 C3 N4 _OUT 1.6823475547857594E+000
11 Rp3 N4 _OUT -4.4760810482417102E-009
12 .ENDS Circuit_Fit_1
13 .END
    
```

Applications

- Everything the Bode 100 can do and more...
- Small component impedance measurements
- EMI filter measurements above 30-50 MHz
- PDN measurements (power distribution networks) for power integrity verification



P2102A

2-Port Probe for Impedance and Step Load Testing



Bode 500 – Key Features

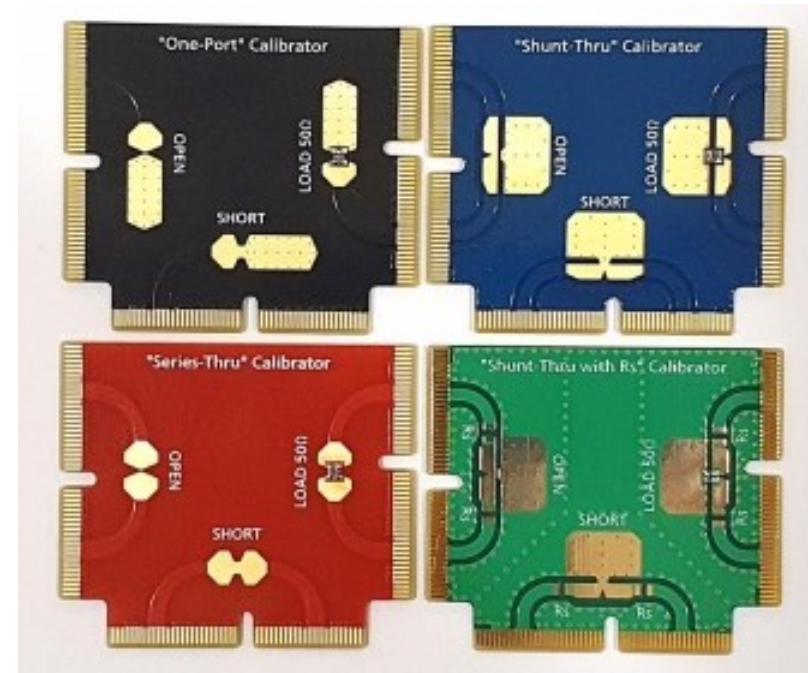
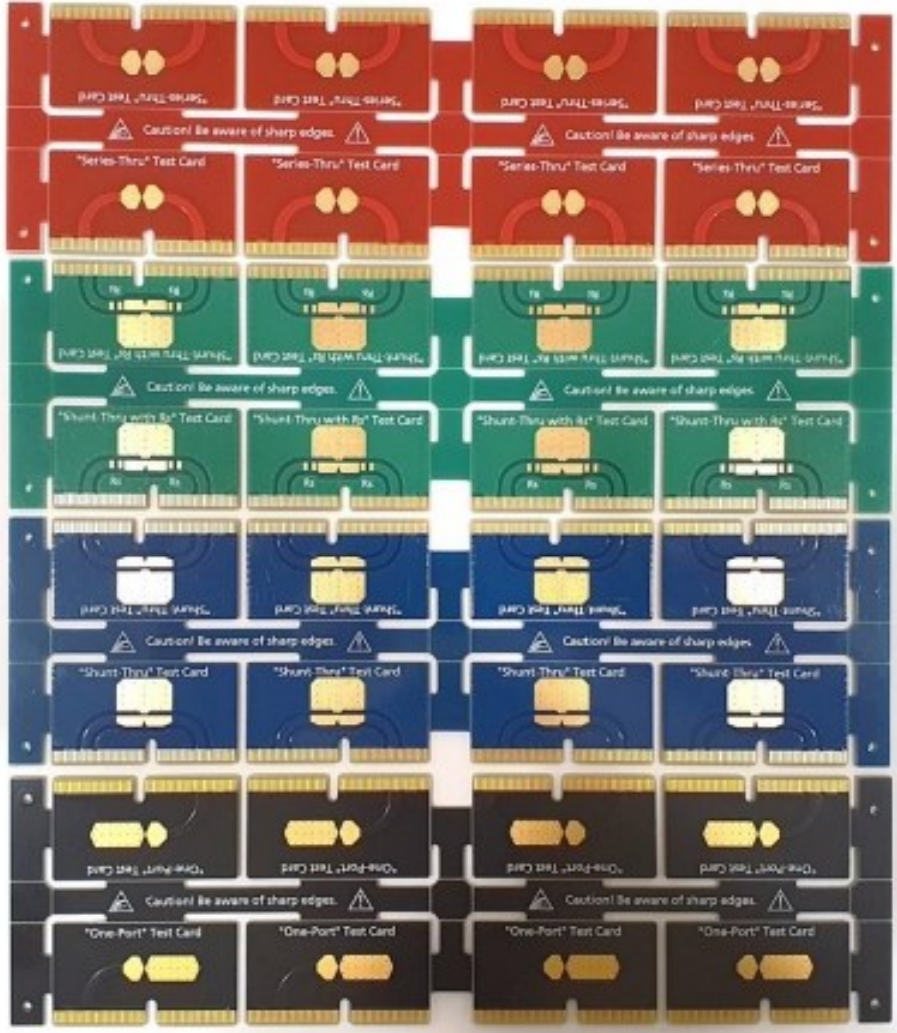
- Small, portable, fan-less design
- USB-PD, PoE, dc power inputs
- External reference frequency locking
- Can be accessed via SCPI commands without the need of a computer with Bode Analyzer Suite installed
- Frequency Range: 1 Hz – 450 MHz (10mHz – 450 MHz)
- Dynamic Range: 125 dB
- Signal Source: -50 dBm ... +16 dBm
- Lower trace noise than Bode 100

B-TCA Impedance Test Fixture

- Supports four measurement modes
 - One-Port Reflection
 - 2-Port Shunt-Thru
 - 2-Port Series Thru
 - Extended 2-Port Shunt-Thru
- Suitable up to 450 MHz •
- Designed for SMD components
- Simple card-edge connection



Color-Coded Test Cards & Calibrators





Accessories

for the Bode 100 & 500

B-WIT 100 (Wideband Injection Transformer)

- Optimized for signal insertion into control loops
- Extremely wide usable frequency range: 1 Hz – 10 MHz
- Highest linearity & lowest insertion loss
- Safe measurements (Isolation rated to 600V CAT II)

List price € 530,- / \$ 590,-



B-LFT 100 (Low-Freq. Injection Transformer)

- Injects up to 15 dBm at 1 Hz without attenuation (B-WIT 100 attenuates – 20 dB @ 1 Hz)
- Provides safe 600 V CATII secondary to primary isolation
- Designed for low-frequency measurements such as
 - PFC voltage loop (crossover around 5 Hz - 7 Hz)
 - Other slow control loops < 30 kHz (mechanical systems)

List price € 730,- / \$ 790,-



B-AMP 12 (External Amplifier)

- Amplifies Bode 100's output power by +12 dB to reach a total power of +25 dBm (8 Vrms or 22 Vpp open-source)
- Features impedance measurement signal connectors
- Applications:
 - Low impedance measurements
 - shunt-thru measurement
 - Impedance with higher signals
 - chip capacitance measurement
 - More injection power

List price: € 930,- / \$ 1050,-

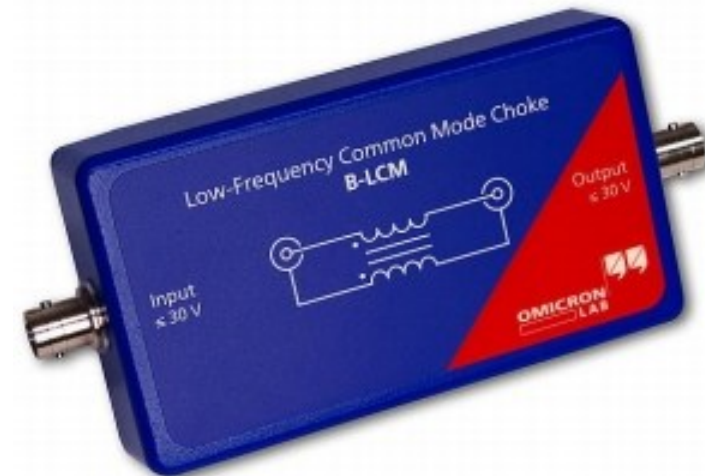


B-LCM (Low-Freq. common mode choke) •

Reduces ground-loop error in Shunt-Thru measurements

- Reduce/suppress common-mode signals
- Quasi-isolate an input channel for high frequencies

List price: € 530,- / \$ 590,-



B-WIC & B-SMC

- Optimized for RLC-Q measurements of all common passive electronic components
- Fast DUT exchange
- Gold-plated electrodes for low contact resistance and reproducible results
- 1 Hz – 50 MHz wide frequency range

List price B-WIC & B-SMC: € 630,- / \$ 690,-



B-TCA

- Designed to simplify the measurement task of SMD components
- Easily measure $m\Omega$ to $M\Omega$
- DC – 450 MHz wide frequency range

List price: € 930,- / \$ 1050,-

Test Card Set (each Set of 32 pcs.): € 130,- / \$ 150,-



B-RFID Test Fixtures

Designed for contactless resonance-frequency and Q-factor measurement of 13,56 MHz RFID cards.

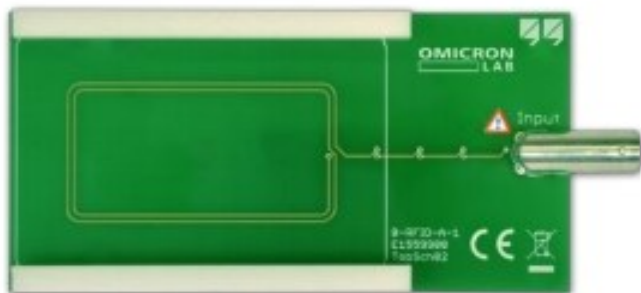
Test fixtures are optimized for measurements on ISO 14443-1:2008 smart cards.

List price: € 110,- / \$ 120,- each.

List price Kit: € 270,- / \$ 310,-

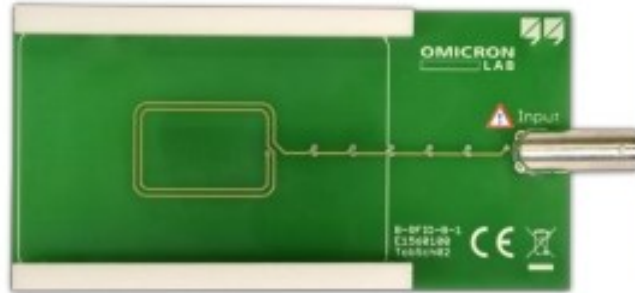
B-RFID-A

For Class 1 cards



B-RFID-B

For Class 3 cards



B-RFID-C

For Class 6 cards



Carrying Case

A colorful box for the Bode 100 featuring a custom cut-out foam interior.

It has been **redesigned** to hold the Bode 100 or Bode 500, more space for cables, the power supply, a B-WIT 100, B-SMC and B-WIC or B-TCA and a B-AMP 12.

List price: € 110,- / \$ 120,-



PML110 (10:1 passive probe)

- Designed for Bode 100 inputs
- Low-noise probes
- 1 M Ω design →
 - reduced crosstalk
 - more accurate gain measurements
 - best protection of Bode 100 inputs against DC voltage and overvoltage



List price: € 210,- / \$ 230,-

PHV 1000-O Passive 100:1 Probe

- Designed for Bode 100
- 50 M Ω || 7.5 pF Impedance
- Exchangeable spring tip
- Attenuation ratio: 100:1
- Maximum working voltage 2000 V



List price: € 490,- / \$ 560,-

Differential Probe TT-SX 9001

- Enables measurements in circuits with high voltages up to 700 V
- Avoids grounding problems
- CAT III rated inputs
- Bandwidth: DC to 30 MHz (-3 dB)
- Attenuation ratio: 1/10 or 1/100
- Powered by USB-C or AA batteries



List price: € 550,- / \$ 650,-

Power Electronics Engineers



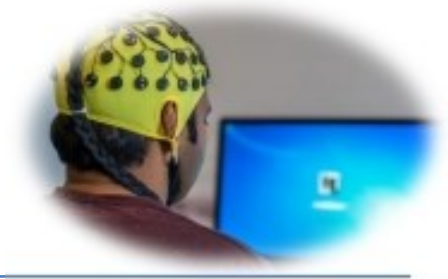
Should measure what Loop	Why?
Gain of the control loop	To ensure a stable control loop. This is important in analog and digital control loop design for high power converters and also LDOs to improve performance To avoid input filter stability problems
Input Impedance & Filter output impedance	
Component Impedance	To analyze components where data is missing or to prove manufacturer's data.
EMC Filter Insertion Loss	Avoid unaccounted parasitics degrading the EMC filter
Leakage Inductance & coupling factor of transformers	Important for Flyback (step-down converter) design and wireless power design

General Electronics Engineers



Should measure what	Why?
Filter Transfer Function	To check if parasitics change filter behavior
LDO Output Impedance	To ensure stable operation of the linear voltage regulator for good system performance
Power Supply Stability	Good power supply regulation and stability causes less problems in the system
Component Impedance	To check if the components behave as expected
EMC Filters	To reduce EMC testing effort
Amplifier Gain	Check if amplifier has needed bandwidth

Sensor Manufacturer



Who	Should measure what	Why?
Design engineer	Sensor capacitance	For capacitive sensor design
	Sensor inductance	For inductive sensor design
	Resonance frequency	For resonance effect sensors (piezo or other)
Test engineer	Same as above	For quality assurance during production using Automation Interface
Purchase engineer	Component impedance	For quality assurance during purchase process of essential sensor components

- Distance sensors
- Ultrasonic and subsonic (sonar applications)

Cable Manufacturer



Who	Should measure what	Why?
Design engineer	Cable characteristic impedance	Important design property
	Cable attenuation	Good cable -> low loss
	Cable crosstalk	Crosstalk in multi-pair cables can cause problems
Test engineer	Same as above	For quality assurance during production using Automation Interface

Applies mainly to cables used for frequencies < 50 MHz

- DSL cables
- Cat 1-4 twisted pair cables

Piezo or Quartz Manufacturer & User



Who	Should measure what	Why?
Design engineer	Capacitance	Important design parameter
	Resonance frequency	For resonance effect sensors
	Damping factor	For low and high-Q systems
Test engineer	Same as above	For quality assurance during production using Automation Interface

- Ultrasound transmitters / receivers
- Micromechanical systems
- Sonar applications

Capacitor Manufacturer



Who	Should measure what	Why?
Design engineer	Capacitance	Main parameter
	ESR, Parasitic inductance	Important for some customer applications (power electronics)
Test engineer	Same as above	For quality assurance during production using Automation Interface

Inductor / Magnetics Manufacturer



Who	Should measure what	Why?
Design engineer	Inductance	Main parameter
	AC resistance	Estimate frequency dependent loss
	Parasitic capacitance	Important design parameter
	Leakage inductance	Important for Flyback Transformer
	Coupling factor	Important for Transformers
Test engineer	Same as above	For quality assurance during production using Automation Interface

RFID Tag/Chip Manufacturer



Who	Should measure what	Why?
Design engineer	Contactless resonance frequency	Design requirement
	Contactless Q-factor	High Q -> higher operating range
Test engineer	Same as above	For quality assurance during production using Automation Interface

- 13.56 MHz RFID and NFC transponders / smartcards
- 125 kHz RFID transponders (e.g. animal identification implants)
- 27 MHz RFID systems

Agenda

15th Power Analysis & Design Symposium - April 29th, 2026



	Central European Summer Time (CEST/UTC +2) (Vienna, Berlin)	Eastern Daylight Time (EST/UTC-4) (New York)	Hong Kong Time (HKT/UTC+8)
<i>Welcome and introduction</i>	09:00 / 09:00 am	03:00 am	15:00 / 03:00 pm
Trade Secrets of the Flyback Converter by Christophe Basso - Future Electronics	09:10 / 09:10 am	03:10 am	15:10 / 03:10 pm
<i>10 min break</i>			
Unleash the Power of the Smith Chart: An Intuitive Guide for RF and Non-RF Engineers by Arturo Mediano - University of Zaragoza	10:20 / 10:20 am	04:20 am	16:20 / 04:20 pm
<i>10 min break</i>			
"Capacitances" of Nonlinear Capacitors by Sam Ben-Yaakov - IRP Systems	11:20 / 11:20 am	05:20 am	17:20 / 05:20 pm
<i>1 h break</i>			
Hands-On Challenges and Solutions in Bidirectional GaN Switch Design by Milan Marjanovic - Electronicdesign-Marjanovic	13:10 / 01:10 pm	07:10 am	19:10 / 07:10 pm
<i>10 min break</i>			
DC Biased Impedance Measurements by Florian Hämmerle - OMICRON Lab	14:10 / 02:10 pm	08:10 am	20:10 / 08:10 pm
<i>10 min break</i>			
Practical EMC Debugging of Power Supplies: Measurements, Ringing, and Noise Sources by Ali Shirsavar - Biricha Digital	15:10 / 03:10 pm	09:10 am	21:10 / 09:10 pm
<i>10 min break</i>			
Unveiling the Mathematics Behind NISM: A New Path to Power Integrity Stability by Steve Sandler - Picotest	16:10 / 04:10 pm	10:10 am	22:10 / 10:10 pm



Hvala.