Filter Design and Optimization Using the R&S®ZVA/ZVB/ZVT Integrated with AWR® EDA Software

Application Note

Products:

- R&S®ZVA
- R&S®ZVB
- R&S®ZVT
- AWR® Microwave Office® (MWO)
- AWR® Visual System Simulator™ (VSS)
- AWR® TestWave™
- AWR® iFilter™

This application note describes how to integrate R&S®ZVA/ZVB/ZVT vector network analyzers with AWR's electronic design automation (EDA) software. Measured data can be exported using the AWR® Testwave™ tool via GPIB/LAN and verified with simulated data. Basic filter design is simplified with the AWR® iFilter™ filter synthesis wizard, an optimization tool that can be introduced to correlate measured data with simulated data.

Application Note

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ROHDE&SCHWARZ

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1 Introduction

1.1 Overview

For manufacturers of RF devices, reducing the timescale from design to validation is essential to realizing shorter time-to-market cycles for new designs. By changing the design flow, the efficiency of the process can be significantly enhanced. Serial design flow with validation loops can be replaced by a parallel design-validate flow.

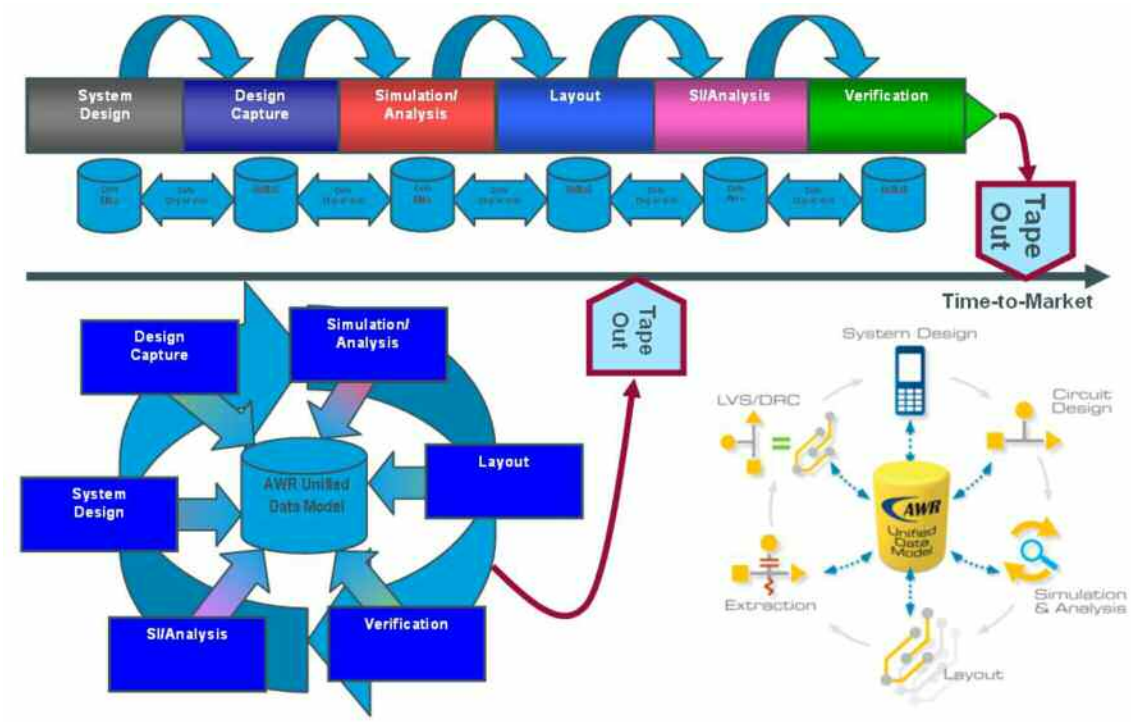


Figure 1: Parallel design-validate flow via AWR's unique Unified Data Model design environment/flow

AWR® employs the Unified Data Model™ (UDM) as the basis for a parallel design-validate flow. This modern design platform enables realtime design concurrency across RF system, circuit, electrical and physical design phases. Because the AWR® UDM is a single data-set approach, it enables multiple views of the circuitry, resulting in unparalleled tool interactivity and enhanced throughput.

In addition, the AWR® Design Environment™ offers the TestWave™ tool [1], which enables users to import real measurement data from, for instance, R&S®ZVA/ZVB/ZVT vector network analyzers and utilize it to address correlation or post-processing issues inside the simulation and design environment. Hence, designs from AWR® Microwave Office® (MWO) and AWR® Visual System Simulator™ (VSS) can be correlated with actual prototype measurements.

1.2 Setup

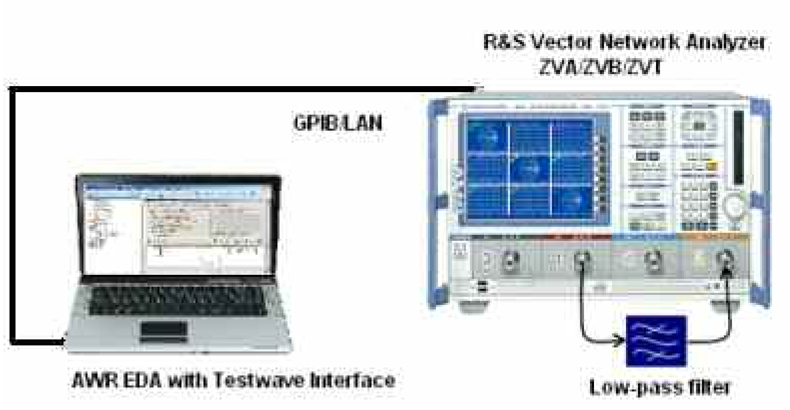


Figure 2: Test setup for filter simulation and validation

In this application note, the simple design cycle of a filter is examined from design and simulation to verification. The filter is measured with an R&S®ZVB vector network analyzer. The AWR® iFilter™ filter wizard [2] is introduced to verify filter design. A standard optimization tool for tuning is also discussed.

Once a design cycle is in AWR® software it needs to be validated with a prototype. The TestWave™ option provides integration with actual measured data from test and measurement instruments. In this application note, an R&S®ZVB vector network analyzer is used to measure filter characteristics such as return loss, pass band, and cut-off frequency, and correlate them with simulated design data from AWR® Microwave Office® and VSS software. Design optimization, based on the correlation of simulation and actual measured data, helps to improve time-to-market and reduce cost intensive design cycles. This facilitates successful designs with a reduced number of design cycles. As a result, resources can be allocated more efficiently, and an earlier market release ensures a competitive edge.

2 Simulation with AWR® Software

2.1 Design

The low-pass filter is a widely used passive component in RF circuitry. A low-pass filter (LPF) can be located after the RF frontend as a preselector or be transformed into a band-pass filter. Here we will examine the design of a basic 4th order Butterworth low-pass filter with a cut-off frequency of 1.87 GHz and 50 Ω impedance rating for both ports. In this application note, the filter prototype will be measured with an R&S®ZVB vector network analyzer. The measured data will be correlated with the filter design done with AWR® Microwave Office®.

Ideally, a Butterworth filter has a gentle cut-off and no gain ripple due to flat amplitude response. Generally, the LPF cut-off frequency indicates the pass-band (rejection towards higher frequencies) and is typically specified by a 3dB insertion loss. A 4th order low-pass Butterworth filter with series-shunt profile can be designed using capacitive and inductive lumped elements according to equations (1) and (2):

Equation (1) & (2):

$$C_i = \frac{1}{\pi F_c Z} \sin\left(\frac{(2i-1)\pi}{2n}\right) \quad \text{where i = odd integers} \quad (1)$$

$$L_j = \frac{Z}{\pi F_c} \sin\left(\frac{(2j-1)\pi}{2n}\right) \quad \text{where j = even integers} \quad (2)$$

Where F_c = *Cut-off frequency*
Z = Source or load impedance
n = Order number

Table 1 shows the results of these equations for the Butterworth filter example.

4th order Butterworth Filter	
Impedance Z = 50 ohm Cut-off frequency Fc = 1.87 GHz Order n = 4	
Element	
Inductive(j)	Capacitive(i)
(2) 7.86 nH	(1) 1.3028pF
(4) 3.257 nH	(3) 3.145 pF

Table 1: Capacitive and inductive elements for the Butterworth filter example

2.1.1 Low-Pass Filter (LPF) Design with AWR® Microwave Office® Software

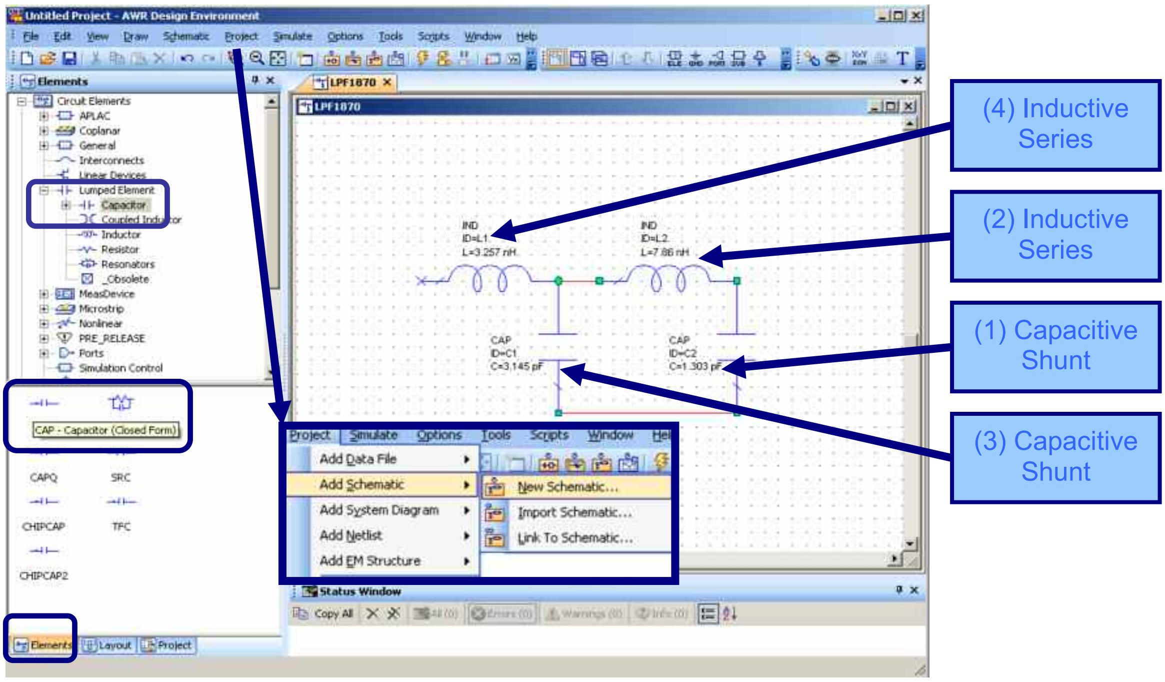


Figure 3: Adding lumped elements into a schematic with values calculated from Table 1

When beginning a new LPF design from scratch, a new project and simulation schematic must be created inside the Microwave Office® design environment. To do this, select [Project] in the taskbar, then [Add Schematic] and [New Schematic]. On the bottom left pane tab, switch to the [Elements] tab and under [Circuit Elements], [Lumped Element], select the [CAP-Capacitor (Closed Form)] and the [IND-Inductor (Closed Form)]. Drag the elements onto the schematic and directly input the necessary parameters. Add ground and ports from the Microwave Office® taskbar by selecting [Draw].

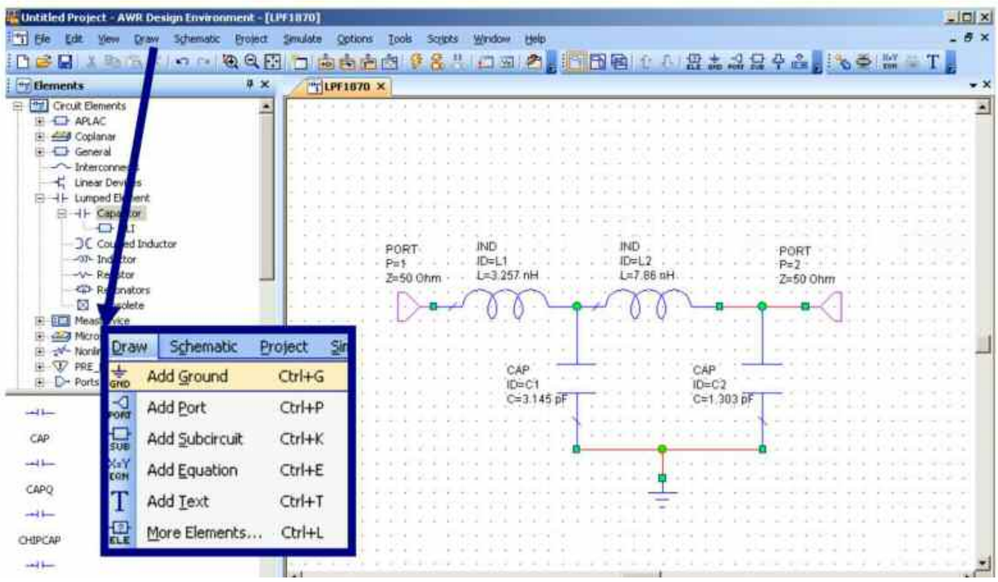


Figure 4: Adding grounds and ports to the circuit

2.1.2 Low-Pass Filter (LPF) Synthesis with AWR® iFilter™ Filter Synthesis Wizard

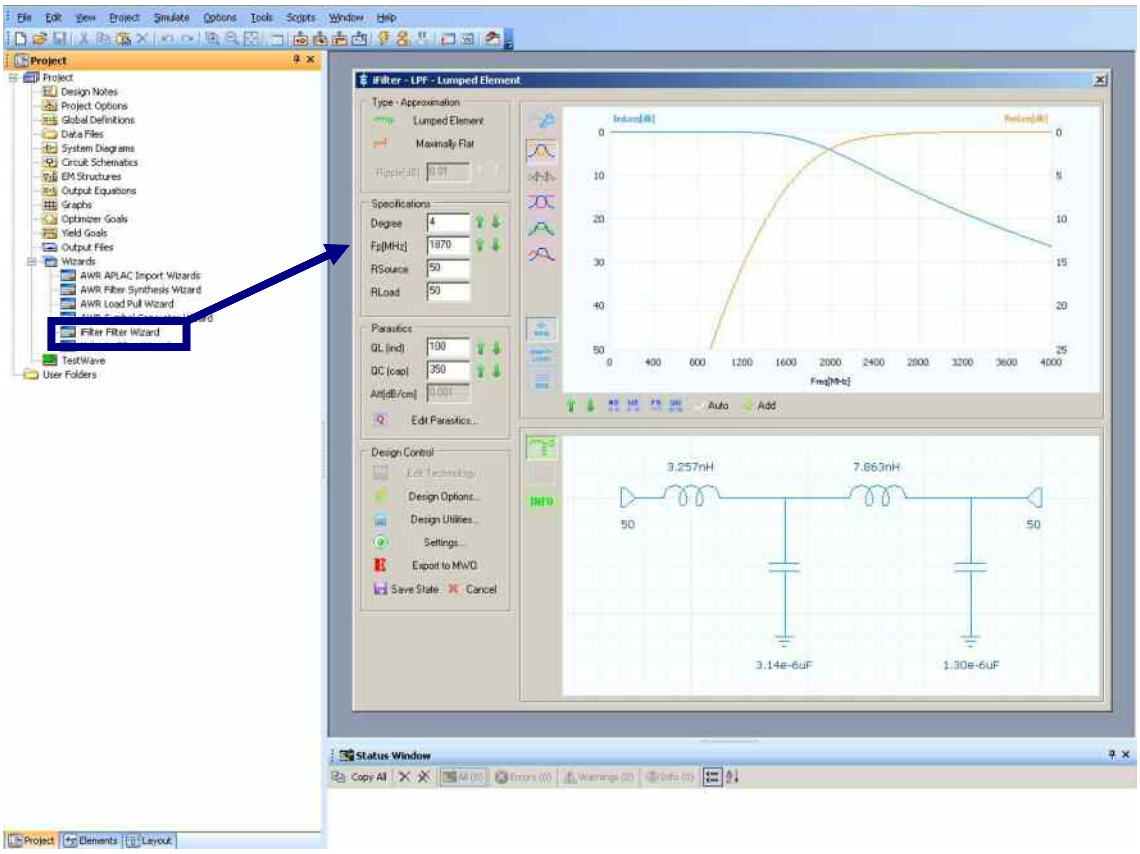


Figure 5: AWR® iFilter™ filter synthesis wizard

The iFilter™ filter synthesis wizard is a filter synthesis program that runs in the AWR® Design Environment™.
As shown in Figure 5, iFilter™ is opened by double-clicking the appropriate icon in the project bar of AWR® Design Environment™. Figure 6 shows the main filter design dialog of the iFilter™ graphical user interface (GUI).

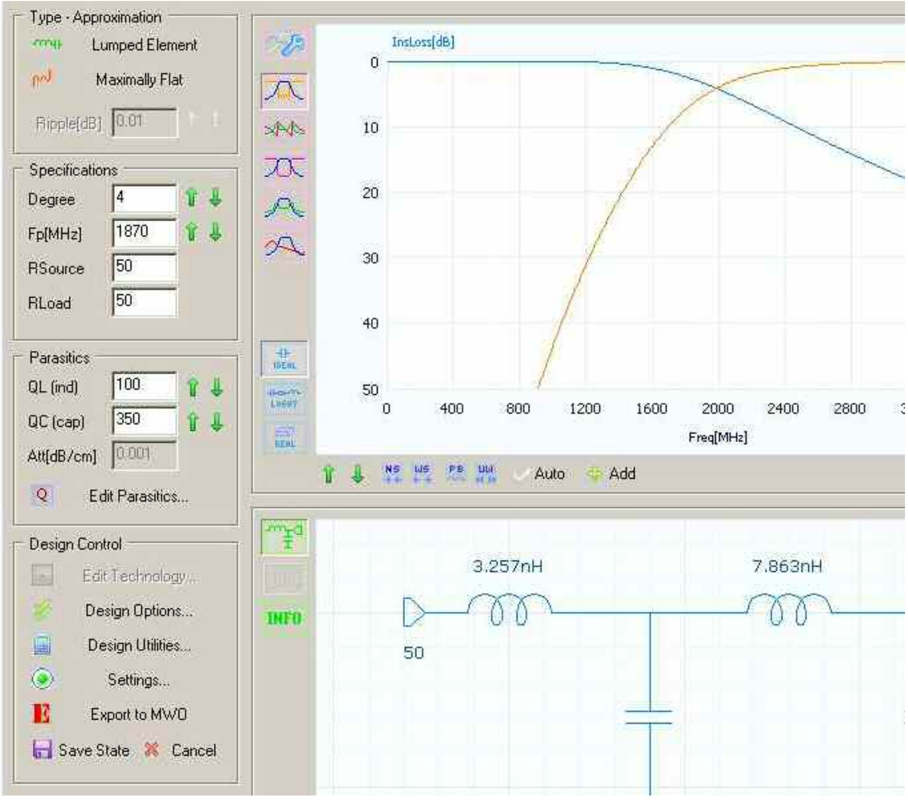


Figure 6: AWR® iFilter™ filter wizard – main filter design dialog

The 4th order Butterworth (maximally flat) low-pass filter is again used as an example. Filter type, specifications and parasitics can be configured on the left-hand side (Figure 6).

In order to model realistic behavior, the vendor libraries (Figure 9) in the "Design Options" menu can be used. Thanks to the AWR® open integration environment, models of capacitors and inductors from many vendors are provided.

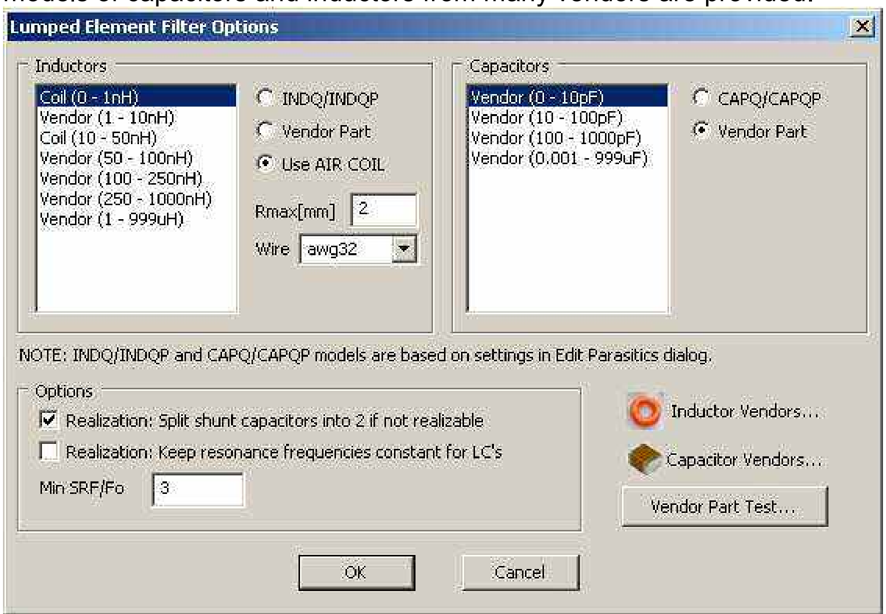


Figure 7: Lumped element filter options

By clicking the "INFO" button in the main window, the parts the iFilter™ tool suggests for the particular design can be seen. As shown in Figure 8, the first CAP should be 3.14e-6 uF, so iFilter™ suggests that two CAPQ of ATC600L-series should be selected.

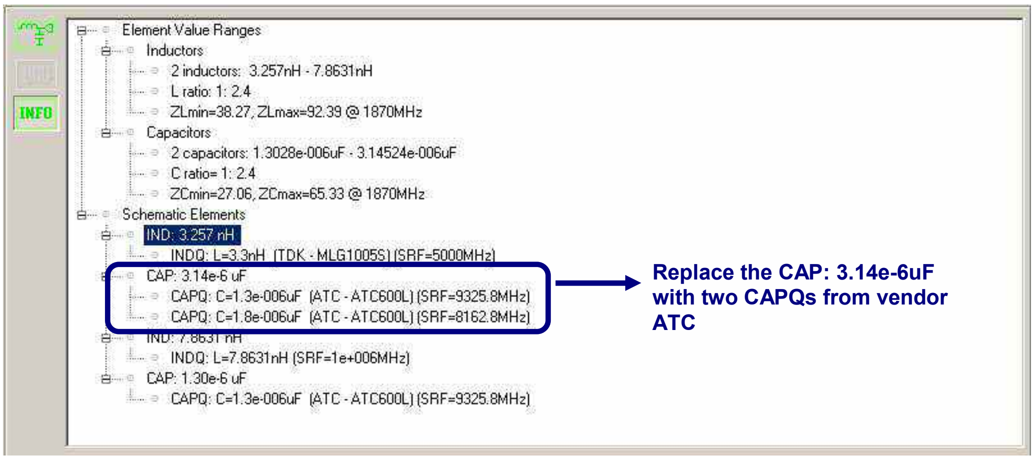


Figure 8: Information on appropriate elements

After finalizing the filter settings, iFilter™ directly indicates the response, and the user is provided with a choice of five preset chart types (Figure 9 to Figure 13).

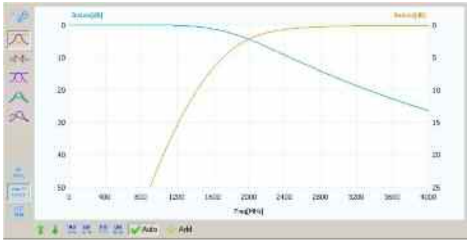


Figure 9: Insertion loss + return loss

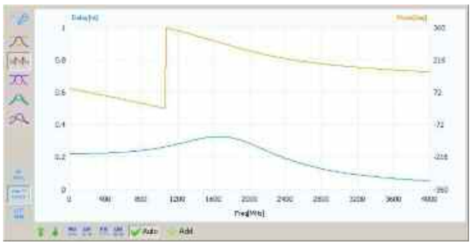


Figure 10: Group delay + insertion phase

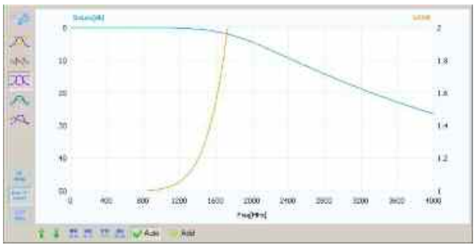


Figure 11: Insertion loss + input VSWR

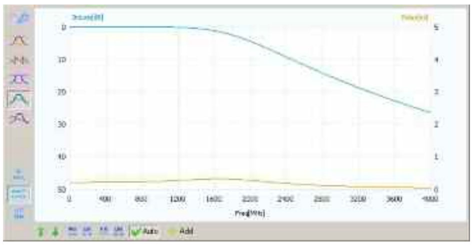


Figure 12: Insertion loss + group delay

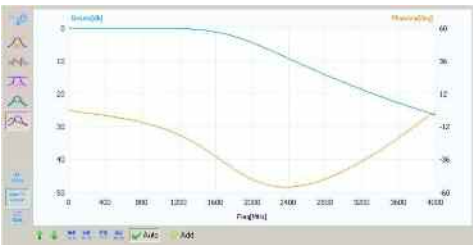


Figure 13: Insertion loss + phase variation

The designer has two options when defining graphs and measurements prior to simulation. Using the export options of iFilter one can define the graphs using the Graphs dialog, the selected measurements will be automatically added to the graphs on export. If this option is turned off, then the designer can use the graph and measurement dialogs available within MWO.

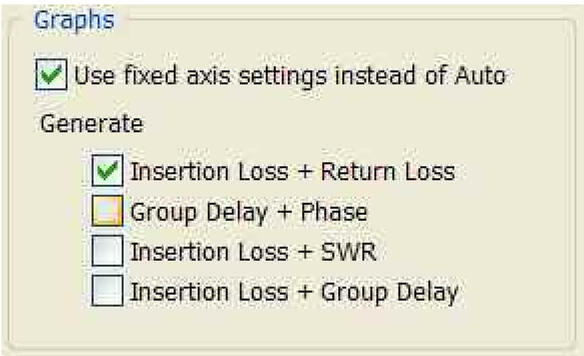


Figure 14: Graphs dialog

iFilter™ enables users to quickly create various filter types with different characteristics. Adjust the desired parameters for modeling parasitics, and choose from a wide variety of vendor models.
The results from the filter simulation can be displayed and evaluated, then transferred into Microwave Office® as a new filter schematic. iFilter™ is a quick and handy tool for RF designers who want to choose from a myriad of filter types and classes for incorporation into their designs and circuits.

2.2 Analysis

2.2.1 Simulated Plots

The AWR® iFilter™ wizard option allows for synthesis of filters. Microwave Office® simulation provides an analytical approach for verifying the results. The analysis and display of results is a seamless series of steps. Setup of graph properties prior to Microwave Office® simulation simplifies analysis.

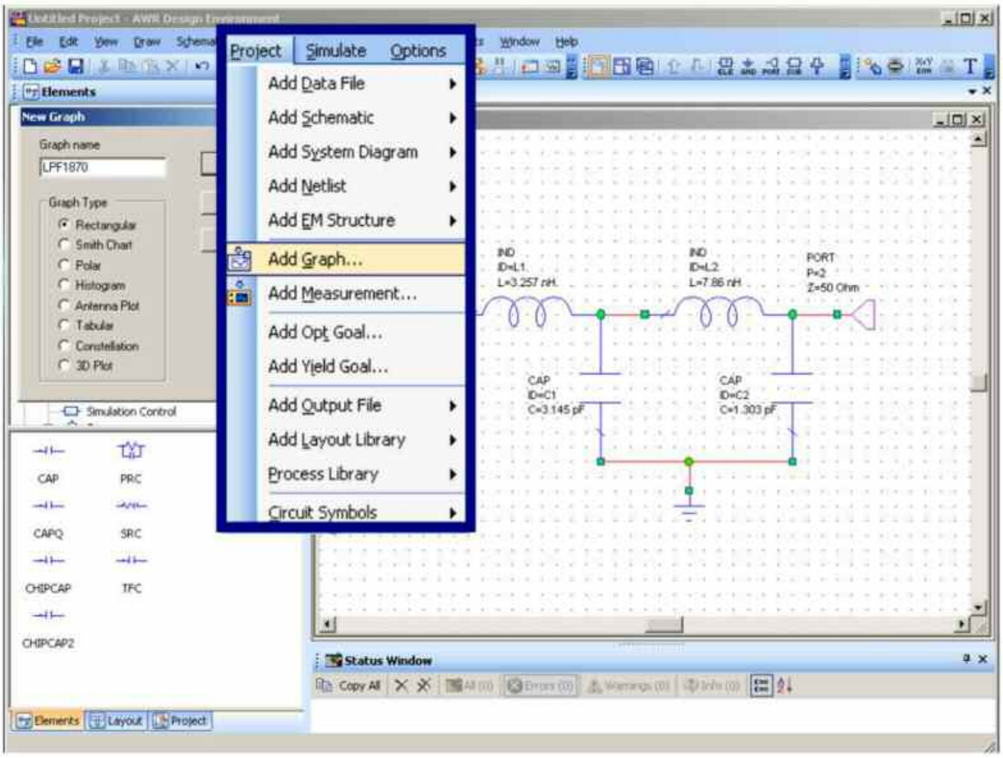


Figure 15: Adding graphs and measurements to plot

From the Microwave Office® taskbar, select [Project], [Add Graph] and [Name Schematic] as “LPF1870”. For S_{11} and S_{21} measurements for the low-pass filter, select the rectangular graph.

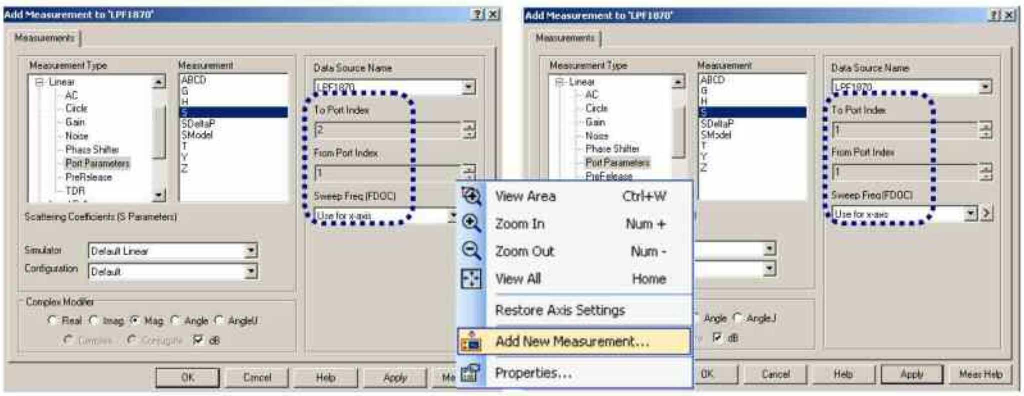


Figure 16: Adding new measurements to the graph by right click

By right-clicking on the graph and selecting [Add New Measurement], S_{11} and S_{21} measurements can be selected. The schematic name “LPF1870” is provided as the data source.

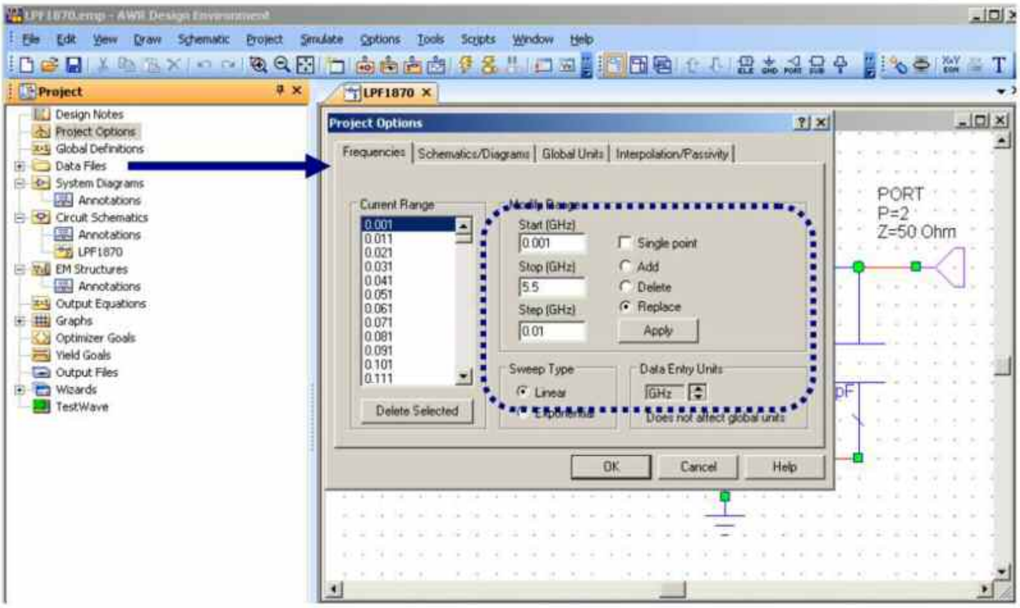


Figure 17: Project options to set frequency range

In order to set a frequency range, on the bottom left pane tab, switch to the [Projects] tab and select [Project Options]. Choose an operating frequency range between 0.001 to 5.5 GHz at steps of 10 MHz. A linear sweep is presumed for this example. On the graph tab, graph scaling options can be accessed by right-clicking and selecting [Properties].The y-axis can be set to “dB” and from a minimum of -70 dB to a maximum of 5 dB. The x-axis can be set to an operating frequency range coinciding with the linear sweep from 0 to 5.5 GHz.

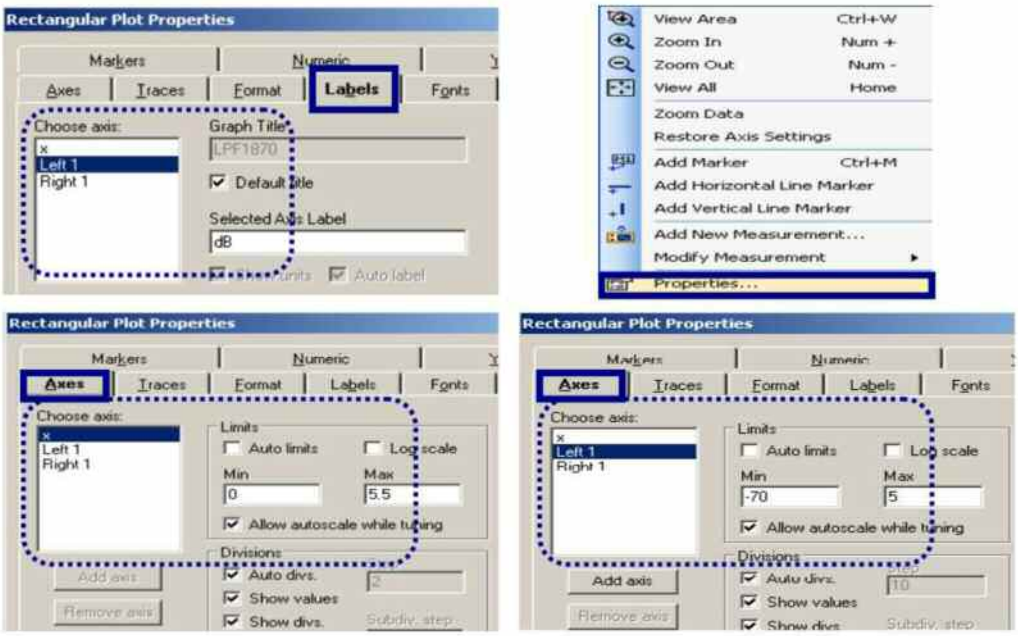


Figure 18: Graph properties for adjusting the scaling and labeling of the axes

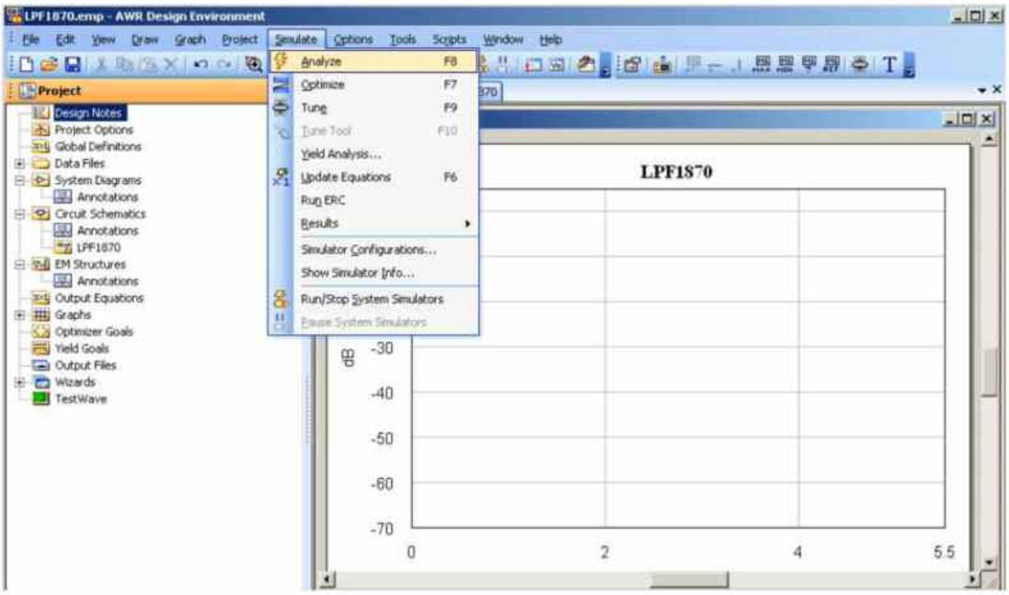


Figure 19: Analyzing the data into a rectangular plot

From the Microwave Office® taskbar, select [Simulate], then [Analyze] for the simulated plot. Both S_{11} and S_{21} measurements will be plotted.
By right-clicking, select [Add Marker] and point the cursor to place a marker on the graph. In the right-hand section of the taskbar, there is a [Marker Search] icon for specific marker placement, as shown in Figure 20.

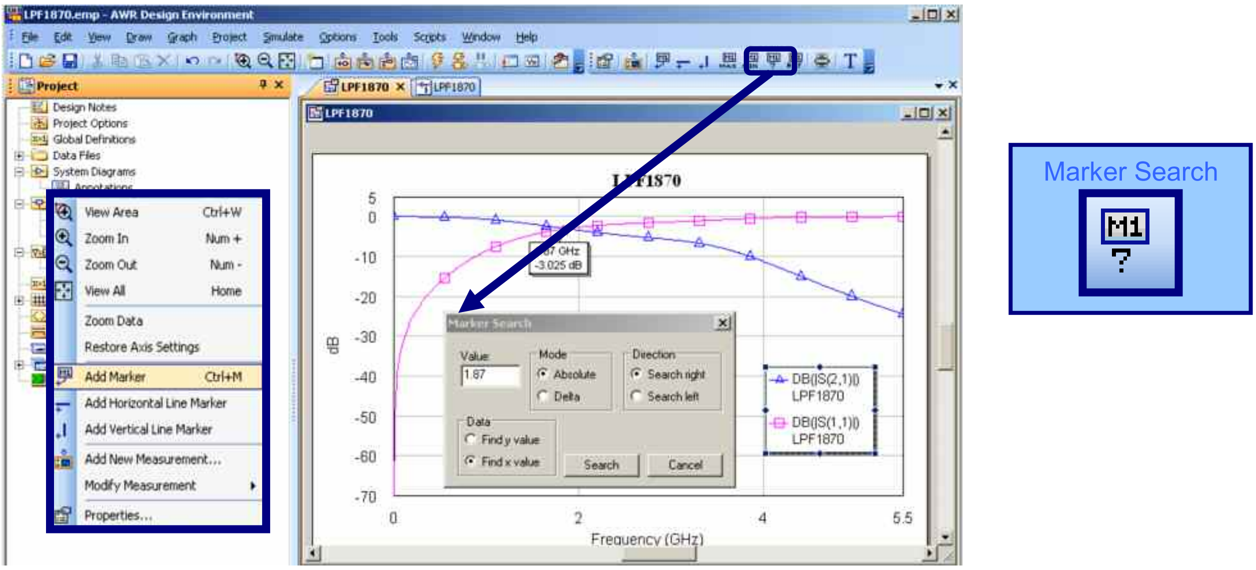
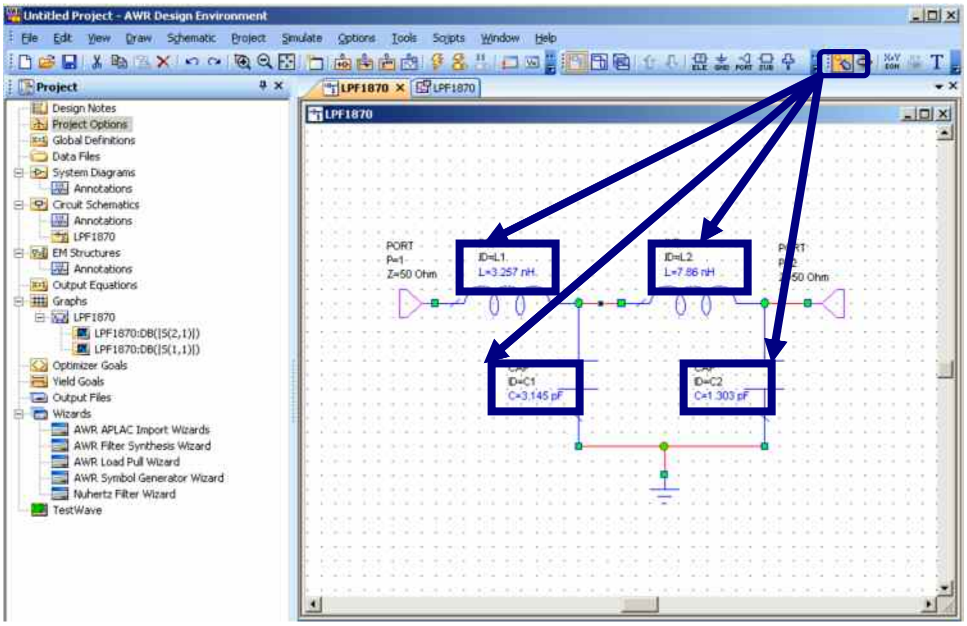


Figure 20: Adding markers and pointing markers to a specified location via "Marker Search"

2.2.2 Tune Tool for Optimization



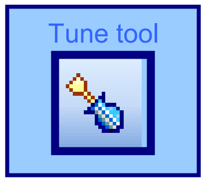
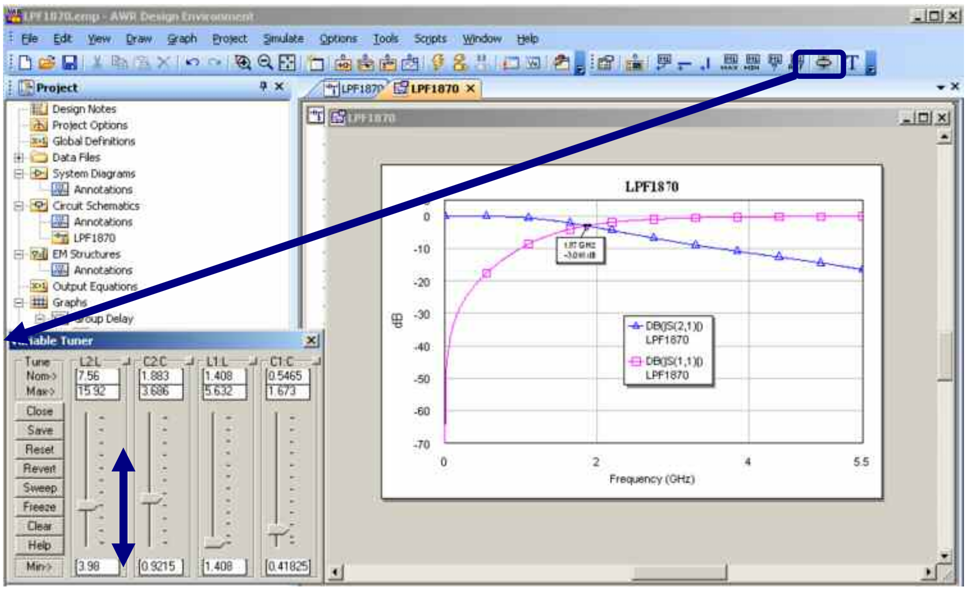


Figure 20: Tune tool for optimization

Switch to the schematic, and select [Tune tool] in the right part of the taskbar (see Figure 21).
Now point to a lumped element and left-click to make the element variable to tune. Tunable elements will now be highlighted in **blue**.



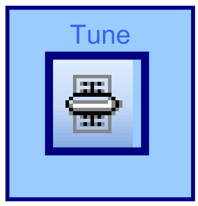


Figure 21: Realtime optimization of parameters

To optimize, select [Tune] on the right part of taskbar and a variable console will appear. This powerful tool performs optimization in realtime without the need to analyze or compile.

3 Verification

Verification involves correlation of simulated versus actual data. Actual data from the prototype filter is measured using the R&S®ZVB vector network analyzer and correlated with the simulated filter design data from Microwave Office®. Prior to calibration, the R&S®ZVB settings must be configured to optimum conditions for measurement (see Table 2).

Setting Parameter	Trade-off	Chosen setting
Start and Stop frequency	Narrow down span to skip range where data is irrelevant	Span between 0-5.5GHz
Number of points	Higher number of points lead to better resolution at the expense of slower calibration time	501 points as an average
Measurement Bandwidth	Low Bandwidth for higher dynamic range at the expense of slower sweep time. High Bandwidth might lead to degraded dynamic range due to noise.	1kHz as an average
Power	Power level can be adjusted in the filter passband to avoid receiver entering its compression region	0dBm

Table 2: Optimum conditions for measurement

A brief overview of important filter measurements is given in Figure 22. This is not an exhaustive list, but shows just the main parameters.

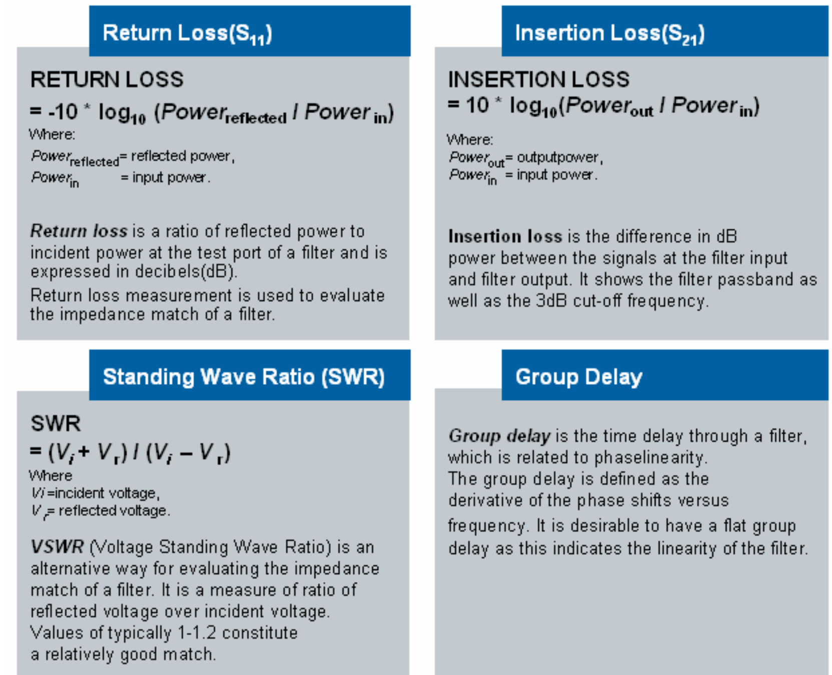


Figure 22: Scorecard for filter measurement

3.1 Calibration of the R&S®ZVB Vector Network Analyzer

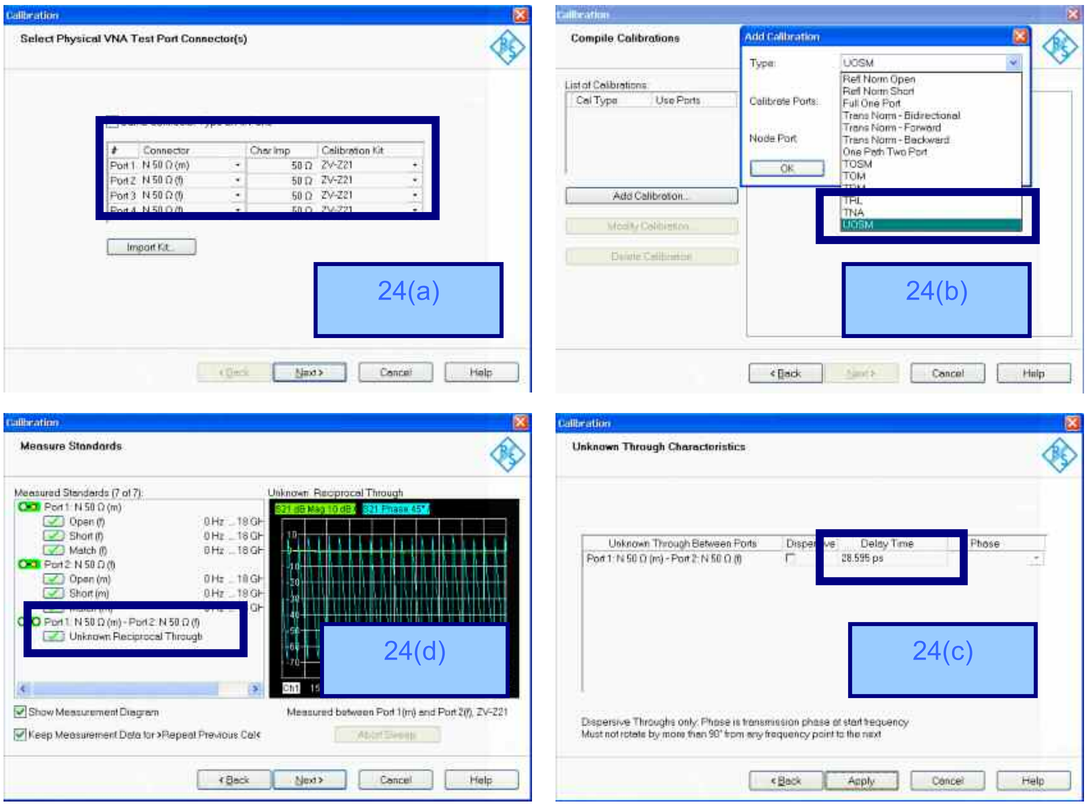


Figure 23: Calibration of R&S®ZVB vector network analyzer using the USOM method

A vector network analyzer is only as useful as the accuracy with which it makes measurements, and this requires the instrument to be calibrated. Employing a technique called vector error correction, error terms are characterized using known standards so that errors can be removed from actual measurements.

The R&S®ZV-Z21 calibration kit contains the necessary precision N standards **T**hrough, **O**pen, **S**hort and **M**atch (male and female). In this application note, the prototype filter has both male and female ports. As such, the Unknown Through (UOSM) method is used since different connector types are used at the test ports [3]. Using the softkeys of the R&S®ZVB*,* select [Cal], [Start Cal], [More (1/2)] and [Other]. As shown in Figure 23(a), select the necessary male/female for the ports and proceed with “Next”. As shown in Figure 23(b), select [add calibration] and select “UOSM”. Proceed with calibrating the reference planes and unknown through, consisting of the female-female N standard through connected to the male-male N standard through. This unknown through has a delay time, as shown in Figure 23(c) and Figure 23(d).

3.2 Data Transfer via AWR® TestWave™

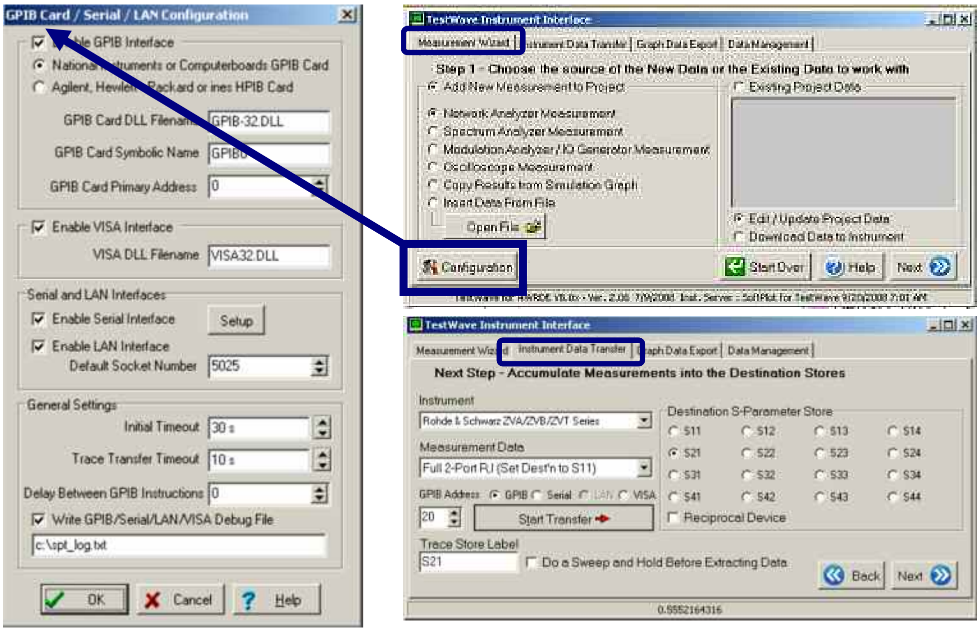


Figure 24: Configuration of transfer via GPIB and type of measurement

Testwave™ enables measured data to be transferred from test equipment to the simulation environment for correlation or post-processing. Once installed, double-click the icon at the bottom of the [Project Tree]. Under [Configuration], modes of data transfer such as GPIB or LAN can be chosen. Under the [Measurement Wizard] tab, select the type of measurement. Proceed to the [Interface Data Transfer] tab and select the type of measurement equipment. Confirm the address and select “Start Transfer” to import data from the test equipment.

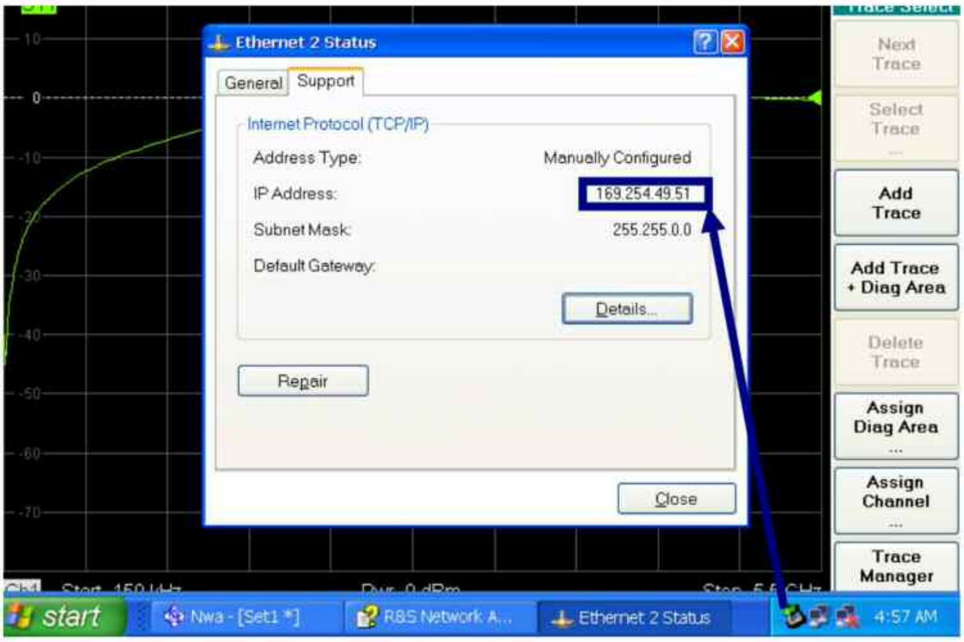


Figure 25: Acquiring the IP address of the R&S®ZVB

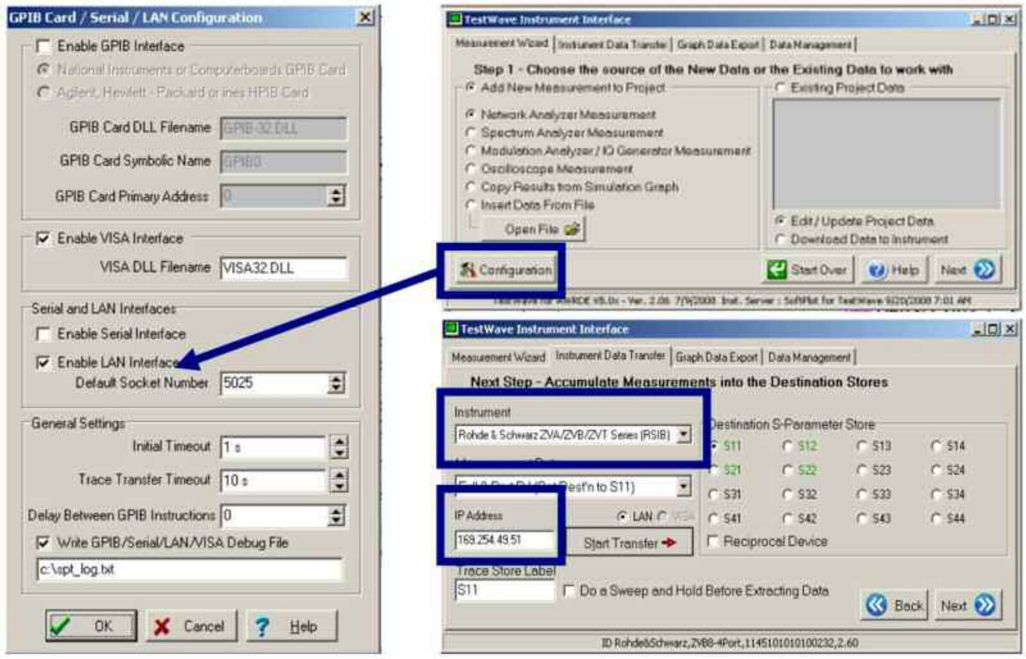


Figure 26: Configuration of transfer via LAN and type of measurement

For LAN setup, acquire the IP address of the equipment as shown in Figure 25. Under the TestWave™ option [Configuration], select [Enable LAN Interface] and [Enable VISA Interface]. The default socket number is “5025”. Select the instrument type, specify the instrument IP address, and select “Start Transfer” to acquire data as shown in Figure 28.
Note: In order to ensure that the data transfers correctly, make sure to select "S11" at the "Destination S-Parameter Store".

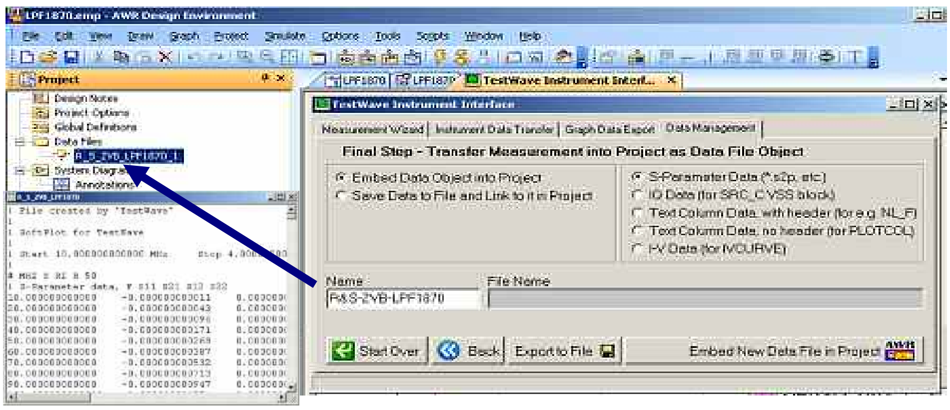


Figure 27: Embedding data into a project as data files

Under the [Data Management] tab, choose “S-parameters” to directly “Embed Data Object into Project”. The name of the data file will appear in the project tree and its content can be viewed by left-clicking it.

3.3 Simulated versus Measured Plot

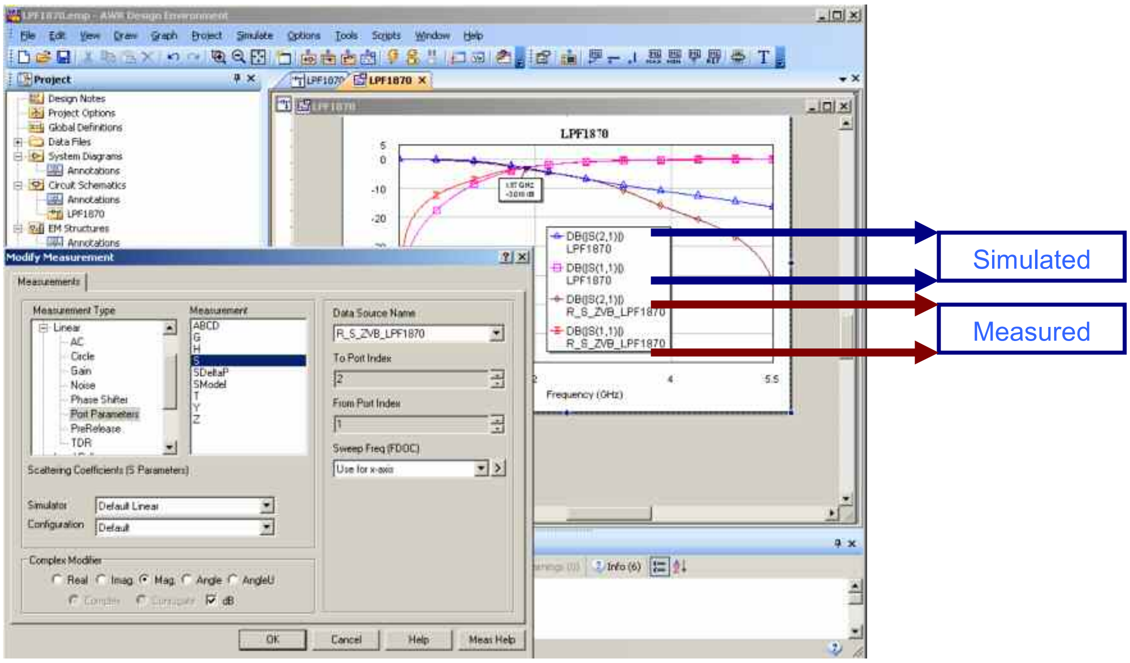


Figure 28: Appending an imported data source into a simulated graph

Right-click on the graph, [Add Measurement] and select the name of the data file to append.
Select S_{11} and S_{21} measurements and "Analyze" again to generate measured plots.

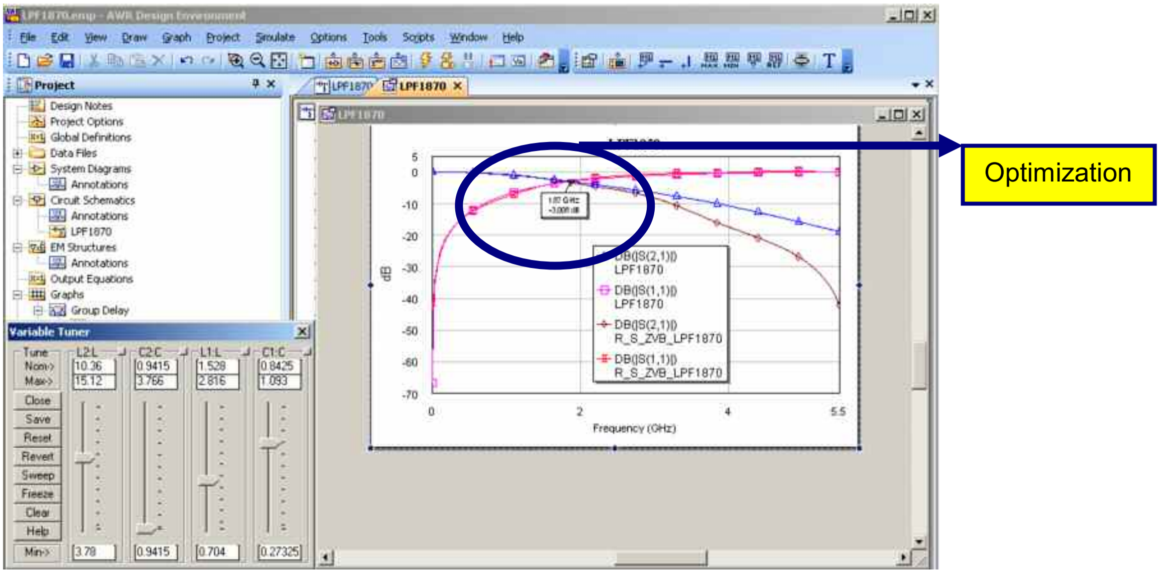


Figure 30: Optimizing simulated lumped elements

Assuming the measured data is a “golden unit” for benchmarking, the simulated data can be optimized for the best fit. Each lumped element that is tuned will automatically change its value in the schematic and the simulation results will be updated accordingly in the graph. Tuning can either be performed manually or automatically with respect to a defined optimization goal, e.g. a maximum deviation of 0.01dB between measured and simulated data for S_{21}.

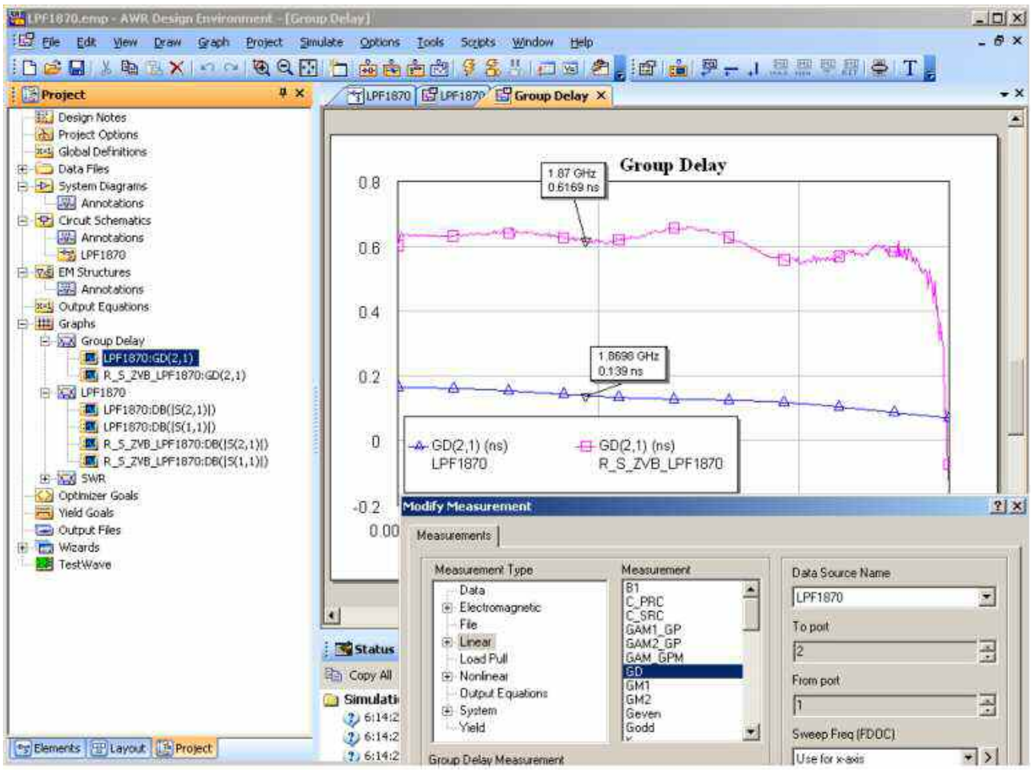


Figure 29: Group delay measurement

For a group delay measurement, right-click on the graph and select [Linear measurement] followed by the acronym “GD” for group delay.

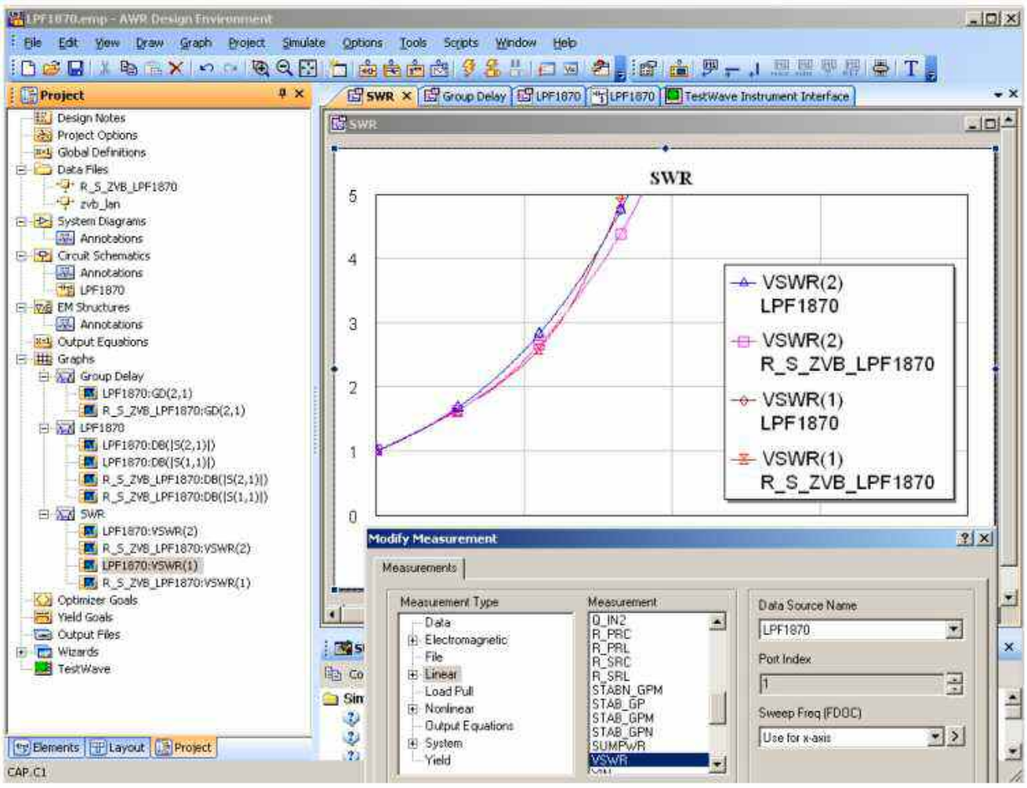


Figure 30: Standing wave ratio

For standing wave ratio measurement, right-click on the graph and select [Linear measurement] followed by the acronym “VSWR” for voltage standing wave ratio.

4 Conclusion

AWR® TestWave™ software seamlessly integrates Rohde & Schwarz test and measurement (T&M) equipment, such as the R&S®ZVA, R&S®ZVB and R&S®ZVT vector network analyzers, with simulation software for communications systems and RF / microwave circuits. It brings circuit- and system-level simulation together with actual measurement data in the same environment.

TestWave™ integrates test and measurement equipment from Rohde & Schwarz with both VSS and Microwave Office® simulators, using RS-232, GPIB or LAN. It is completely integrated into the AWR® Design Environment™, including an icon in the project hierarchy. Together with the simulation software, TestWave™ provides wireless system and RF / microwave circuit designers with a complete design flow, combining schematic simulation, test signal generation, and test and measurement verification. This capability enables designers to perform computer trade-off studies with "hardware-in-the-loop" simulations. Its user interface provides a simple, efficient way to import signals and manage data from Rohde & Schwarz test and measurement equipment.

Accessing these two previously disjointed phases of the development process, hardware design and verification, from the same environment shortens development time. Furthermore, merging simulation and measurement data in one environment through "hardware-in-the-loop" simulations saves design and verification time and increases design accuracy, which, at the same time, reduces the number of design iterations. Thus, combining the two development phases accelerates time to market and provides a competitive edge for RF and microwave designs.

5 Literature

[1] http://web.awrcorp.com/content/Downloads/TestWave-Datasheet.pdf

[2] https://awrcorp.com/download/faq/english/docs/Users_Guide/iFilter.html

[3] Fundamental of Vector Network Analysis, Rohde & Schwarz publication, Michael Hiebel, 2007

6 Ordering Information

Designation	Type	Frequency range	Order No.
Base Unit			
Vector Network Analyzer, 2 Ports, 8 GHz, N	ZVA8	300 kHz to 8 GHz	1145.1110.08
Vector Network Analyzer, 4 Ports, 8 GHz	ZVA8	300 kHz to 8 GHz	1145.1110.10
Vector Network Analyzer, 2 Ports, 24 GHz, 3.5 mm	ZVA24	10 MHz to 24 GHz	1145.1110.24
Vector Network Analyzer, 4 Ports, 24 GHz, 3.5 mm	ZVA24	10 MHz to 24 GHz	1145.1110.26
Vector Network Analyzer, 2 Ports, 40 GHz, 2.4 mm	ZVA40	10 MHz to 40 GHz	1145.1110.43
Vector Network Analyzer, 2 Ports, 40 GHz, 2.92 mm	ZVA40	10 MHz to 40 GHz	1145.1110.40
Vector Network Analyzer, 4 Ports, 40 GHz, 2.4 mm	ZVA40	10 MHz to 40 GHz	1145.1110.45
Vector Network Analyzer, 4 Ports, 40 GHz, 2.92 mm	ZVA40	10 MHz to 40 GHz	1145.1110.42
Vector Network Analyzer, 2 Ports, 50 GHz, 2.4 mm	ZVA50	10 MHz to 50 GHz	1145.1110.50
Vector Network Analyzer, 4 Ports, 50 GHz, 2.4 mm	ZVA50	10 MHz to 50 GHz	1145.1110.52
Vector Network Analyzer, 2 Ports, 67 GHz, 1.85 mm	ZVA67	10 MHz to 67 GHz	1305.7002.02
Options			
Direct Generator/Receiver Access, 2-Port Model, 8 GHz	ZVA8-B16	300 kHz to 8 GHz	1164.0209.08
Direct Generator/Receiver Access, 4-Port Model, 8 GHz	ZVA8-B16	300 kHz to 8 GHz	1164.0209.10
Direct Generator/Receiver Access, 2-Port Model, 24 GHz	ZVA24-B16	10 MHz to 24 GHz	1164.0209.24
Direct Generator/Receiver Access, 4-Port Model, 24 GHz	ZVA24-B16	10 MHz to 24 GHz	1164.0209.26
Direct Generator/Receiver Access, 2-Port Model, 40 GHz	ZVA40-B16	10 MHz to 40 GHz	1164.0209.40
Direct Generator/Receiver Access, 4-Port Model, 40 GHz	ZVA40-B16	10 MHz to 40 GHz	1164.0209.42
Direct Generator/Receiver Access, 2-Port Model, 50 GHz	ZVA50-B16	10 MHz to 50 GHz	1164.0209.50
Direct Generator/Receiver Access, 4-Port Model, 50 GHz	ZVA50-B16	10 MHz to 50 GHz	1164.0209.52
Direct Generator/Receiver Access, 2-Port Model, 67 GHz	ZVA67-B16	10 MHz to 67 GHz	1164.0209.67
Generator Step Attenuator, Port 1, for ZVA8	ZVA8-B21	300 kHz to 8 GHz	1164.0009.02
Generator Step Attenuator, Port 2, for ZVA8	ZVA8-B22	300 kHz to 8 GHz	1164.0015.02
Generator Step Attenuator, Port 3, for ZVA8	ZVA8-B23	300 kHz to 8 GHz	1164.0021.02
Generator Step Attenuator, Port 4, for ZVA8	ZVA8-B24	300 kHz to 8 GHz	1164.0038.02
Generator Step Attenuator, Port 1, for ZVA24	ZVA24-B21	10 MHz to 24 GHz	1164.0109.02
Generator Step Attenuator, Port 2, for ZVA24	ZVA24-B22	10 MHz to 24 GHz	1164.0115.02
Generator Step Attenuator, Port 3, for ZVA24	ZVA24-B23	10 MHz to 24 GHz	1164.0121.02
Generator Step Attenuator, Port 4, for ZVA24	ZVA24-B24	10 MHz to 24 GHz	1164.0138.02
Generator Step Attenuator, Port 1, for ZVA40	ZVA40-B21	10 MHz to 40 GHz	1302.5409.02
Generator Step Attenuator, Port 2, for ZVA40	ZVA40-B22	10 MHz to 40 GHz	1302.5415.02
Generator Step Attenuator, Port 3, for ZVA40	ZVA40-B23	10 MHz to 40 GHz	1302.5421.02
Generator Step Attenuator, Port 4, for ZVA40	ZVA40-B24	10 MHz to 40 GHz	1302.5438.02
Generator Step Attenuator, Port 1, for ZVA50	ZVA50-B21	10 MHz to 50 GHz	1305.5616.02
Generator Step Attenuator, Port 2, for ZVA50	ZVA50-B22	10 MHz to 50 GHz	1305.5622.02
Generator Step Attenuator, Port 3, for ZVA50	ZVA50-B23	10 MHz to 50 GHz	1305.5639.02
Generator Step Attenuator, Port 4, for ZVA50	ZVA50-B24	10 MHz to 50 GHz	1305.5645.02
Generator Step Attenuator, Port 1, for ZVA67	ZVA67-B21	10 MHz to 67 GHz	1305.7077.02
Generator Step Attenuator, Port 2, for ZVA67	ZVA67-B22	10 MHz to 67 GHz	1305.7083.02

Designation	Type	Frequency range	Order No.
Receiver Step Attenuator, Port 1, for ZVA8	ZVA8-B31	300 kHz to 8 GHz	1164.0044.02
Receiver Step Attenuator, Port 2, for ZVA8	ZVA8-B32	300 kHz to 8 GHz	1164.0050.02
Receiver Step Attenuator, Port 3, for ZVA8	ZVA8-B33	300 kHz to 8 GHz	1164.0067.02
Receiver Step Attenuator, Port 4, for ZVA8	ZVA8-B34	300 kHz to 8 GHz	1164.0073.02
Receiver Step Attenuator, Port 1, for ZVA24	ZVA24-B31	10 MHz to 24 GHz	1164.0144.02
Receiver Step Attenuator, Port 2, for ZVA24	ZVA24-B32	10 MHz to 24 GHz	1164.0150.02
Receiver Step Attenuator, Port 3, for ZVA24	ZVA24-B33	10 MHz to 24 GHz	1164.0167.02
Receiver Step Attenuator, Port 4, for ZVA24	ZVA24-B34	10 MHz to 24 GHz	1164.0173.02
Receiver Step Attenuator, Port 1, for ZVA40	ZVA40-B31	10 MHz to 40 GHz	1302.5444.02
Receiver Step Attenuator, Port 2, for ZVA40	ZVA40-B32	10 MHz to 40 GHz	1302.5450.02
Receiver Step Attenuator, Port 3, for ZVA40	ZVA40-B33	10 MHz to 40 GHz	1302.5467.02
Receiver Step Attenuator, Port 4, for ZVA40	ZVA40-B34	10 MHz to 40 GHz	1302.5473.02
Receiver Step Attenuator, Port 1, for ZVA50	ZVA50-B31	10 MHz to 50 GHz	1305.5716.02
Receiver Step Attenuator, Port 2, for ZVA50	ZVA50-B32	10 MHz to 50 GHz	1305.5722.02
Receiver Step Attenuator, Port 3, for ZVA50	ZVA50-B33	10 MHz to 50 GHz	1305.5739.02
Receiver Step Attenuator, Port 4, for ZVA50	ZVA50-B34	10 MHz to 50 GHz	1305.5745.02
Receiver Step Attenuator, Port 1, for ZVA67	ZVA67-B31	10 MHz to 67 GHz	1305.7119.02
Receiver Step Attenuator, Port 2, for ZVA67	ZVA67-B32	10 MHz to 67 GHz	1305.7125.02
Oven Quartz (OCXO)	ZVAB-B4		1164.1757.02
Time Domain (TDR)	ZVAB-K2		1164.1657.02
Frequency Conversion Measurements	ZVA-K4		1164.1863.02
Vector Corrected Mixer Measurements	ZVA-K5		1311.3134.02
True Differential Measurements	ZVA-K6		1164.1540.02
Pulsed Measurements, 3 ms recording time, for all ZVA	ZVA-K7		1164.1511.02
Pulsed Measurements, 25 ms recording time, for all 2-port ZVA	ZVA-B7		1164.1492.02
Pulsed Measurements, 25 ms recording time, for all 4-port ZVA	ZVA-B7		1164.1492.03
Embedded LO Mixer Delay Measurements	ZVA-K9		1311.3128.02
Cable Set for ZVA-K9	ZVA-B9		1311.3134.0x
5 MHz Receiver Bandwidth	ZVA-K17		1164.1070.02
Internal Pulse Generators	ZVA-K27		1164.1892.02
Noise Figure Measurement	ZVA-K30		1164.1828.02
USB-to-IEC/IEEE Adapter	ZVAB-B44		1302.5544.02
Visa I/O Library	VISA I/O BIB		1161.8473.02

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Environmental commitment

- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

Certified Quality System
ISO 9001

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