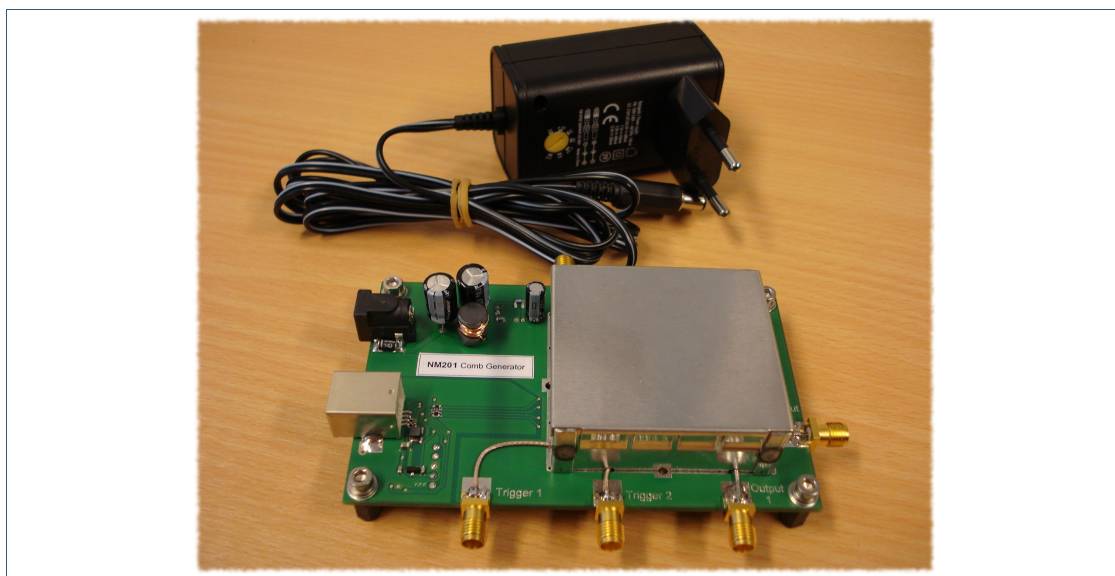# NM310S Nonlinear Starter Kit for your R&S VNA

Make your first steps in the nonlinear world

Do you want to...

➢ learn about the latest large-signal characterisation techniques?

➢ experience the power of large-signal measurements with limited budget?

➢ better understand your RF diodes, transistors under RF conditions?

➢ see why your power amplifier is not performing as predicted?

➢ know how reliable your devices are under realistic conditions?

Introduction

Your nonlinear problem is our business

The business of NMDG is to assist R&D, design, test engineers and instrumentation manufacturers who need to characterise, model and test HF active components and circuits under realistic conditions, especially in nonlinear mode of operation.

NMDG has 20 years of practical experience in high – frequency stimulus-response systems that focus on nonlinear behaviour and is co-creator of the large-signal network analyser (LSNA) technology whom concepts and calibration processes have earned a worldwide recognition.

However, from an engineer's point of view, the LSNA techniques are often new and seem complex. Accordingly, NMDG does consider as one of its primary missions to help engineers to understand and to take benefit of these powerful techniques with minimal risk at an affordable cost.

In this context, NMDG introduces the NM310S, a cost-efficient nonlinear starter kit, allowing you to make your first steps in the nonlinear world with your vector network analyser.

Once acquainted, you will be able to extend, with incremental investment, the capability of your system to perform nonlinear measurements under further realistic conditions, including non-50 Ohm environment using passive or active tuners and to support the design and test efforts of your company or institute.

Extending a VNA to characterise and analyse the nonlinear behaviour of active components
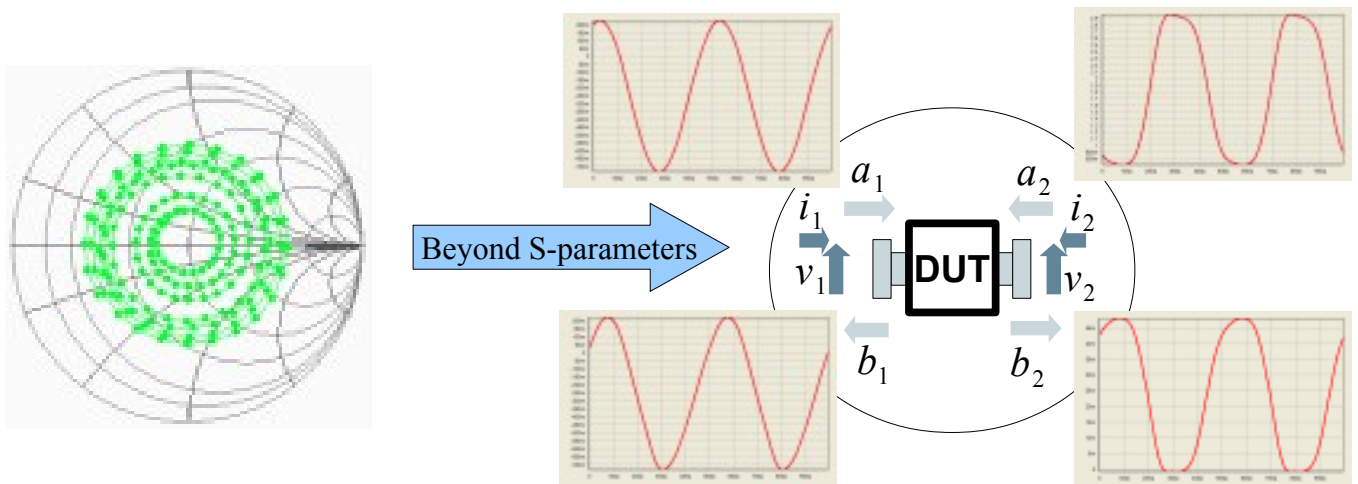
Full harmonic characterisation of nonlinear RF / HF components

The linear behaviour of RF/HF components like filters, interconnects and transistors under small-signal operation is completely characterised by S-parameters, measured using a vector network analyser (VNA). Over time, VNAs evolved from single-ended two-port instruments to multi-port instruments to handle differential linear devices.

Triggered by the growing need for better insight in the nonlinear behaviour of components, VNA manufacturers are adding some "nonlinear" features to some of their models. These competitive features include AM-to-AM, AM-to-PM, harmonic power measurements and mixer characterisation. Unfortunately, these features characterise the component 's nonlinear behaviour only partially.

Complete harmonic characterisation of high-frequency components is now possible thanks to the nonlinear extension kits from NMDG. The NMDG extension kits are a combination of additional hardware and software that runs on top of a selection of vector network analysers.

Key values

➤ Study the **true and complete high-frequency behaviour** of your components under realistic large-signal RF excitation and mismatch conditions

➤ **Eliminate the uncertainty** of the impact of the measurement environment

➤ **Determine the matching circuits** for proper classes of operation directly

➤ **Investigate the reliability** of your components under realistic HF conditions

Key benefits

➤ **One connection** from small-signal to large-signal HF characterisation

➤ **Fast and complete** test capability, even in non-50 Ohm environment

➤ **New insight** in diodes, transistors, amplifiers and fast switching devices

Key capabilities

➤ Complete characterisation of device behaviour at both input and output ports, including **amplitude and phase** spectral content

➤ **Incident and reflected waves** and **voltages and currents** formalism

➤ **Frequency and time domain** representation

➤ **Connectorised** and **on-wafer** calibration and measurement

➤ Overrange detection and **autoranging capability**

➤ **3D dynamic trajectories**, mapping DC and HF conditions

➤ **Derived measurement quantities**, e.g. input and output powers, gain, PAE, input and output impedances at fundamental and harmonics

The NM310S Nonlinear Starter Kit
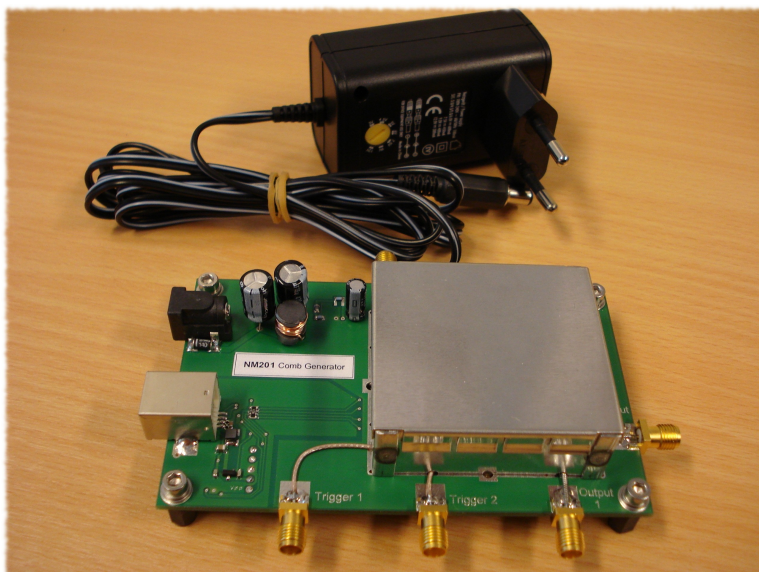
The NM201 Comb Generator

The NM310S nonlinear starter kit aims to guide you step by step into the nonlinear world. With a low investment, you will be able to explore the power of LSNA techniques with a minimal risk.

On top of the standard measurement capabilities of your vector network analyser, the NM310S kit provides calibrated measurement capability of the time waveforms of the incident and reflected waves or voltages and currents at the ports of a component under test. The calibrated waveforms are periodical with a minimal frequency of 20 MHz and with spectral components up to 3 GHz.

Amongst others, the NM310S kit is very suitable to characterise diodes, transistors, amplifiers and fast switching devices.

Key capabilities and Limitations of NM310S Starter Kit

- Measurement of **fundamental and harmonics** under CW conditions
- Characterisation of spectral components **from 20 MHz to 3 GHz**
- Power limited by the linearity of the VNA's receivers. Linearity can be extended up to the maximum power handling of the VNA by using external attenuators

What's in the box

The kit consists of:

- One NM201 double-output Comb Generator (20 MHz - 3 GHz); one output is used as synchroniser enabling the reconstruction of time waveforms while the second output is used as Harmonic Phase Reference (HPR) supporting the required phase calibration
- One SMA connection kit
- One USB stick containing the NMDG's ICE software installer, a ICE 30 day demo license[1], a quick start guide and several tutorials.

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1 The ICE 30 day demo license will allow you to begin immediately your first steps in the nonlinear world. A final license is delivered for your system on demand.

ICE
Reveals the power of LSNA techniques

The NM310S starter kit comes with NMDG's software package, ICE (Integrated Component Characterisation Environment). ICE is an easy-to-use software for nonlinear HF component characterisation, supporting system configuration, absolute calibration and measurement.

ICE aims to characterize the complete nonlinear behaviour of components under realistic conditions with almost real-time feedback. It allows one to combine different instruments and equipments, enabling realistic stimuli – response measurements.

With an easy-to-use graphical user interface, the user configures and calibrates the system to perform accurate harmonic measurements. The data, i.e. incident and reflected waves or voltages and currents at the ports of a device under test, can be visualised and saved in different ways.

Data Displays

Spectral data in frequency domain
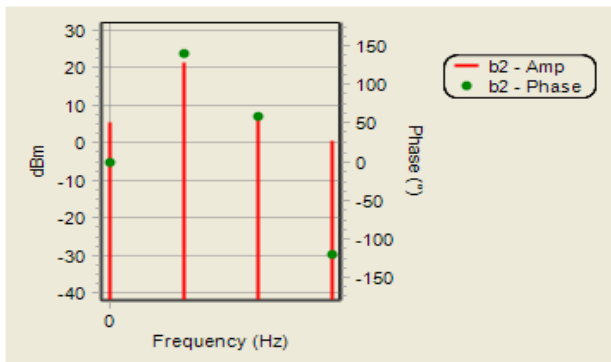
*Amplitude and phase of transmitted waves
in frequency domain*

Similar to a spectrum analyser, the NM310S Starter Kit allows one to visualise the spectral data of the measured quantities in frequency domain.

The unique feature is that the spectral data includes calibrated phase information.

### Input and output impedances on Smith Chart
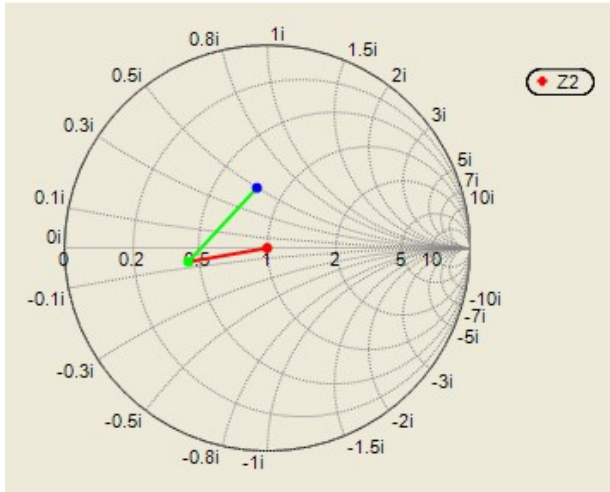
Load impedances presented to the DUT
at fundamental, second and third harmonics

Using measured incident and reflected waves, it is possible to calculate and visualise the impedances at DUT input and the output impedances presented at output of the device, at fundamental and harmonics on Smith Chart representations.

Time-domain waveforms

An oscilloscope is an indispensable tool on the lab bench to probe signals and to diagnose the proper behaviour of circuits. For analogue circuits and components operating at an ever increasing signal frequency and information density, voltage information only is not enough. The advantages of using vector network analysers instead of oscilloscopes have clearly been proven for linear RF and HF applications. The NM310S kit provides the same advantage for nonlinear RF and HF applications.
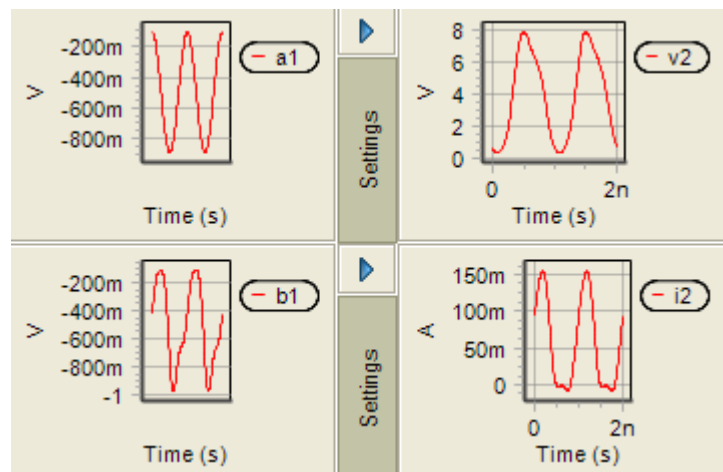
Time domain waveforms
(from top to bottom, left to right: incident wave at input,
reflected wave at input, output voltage, output current)

3D dynamic trajectories
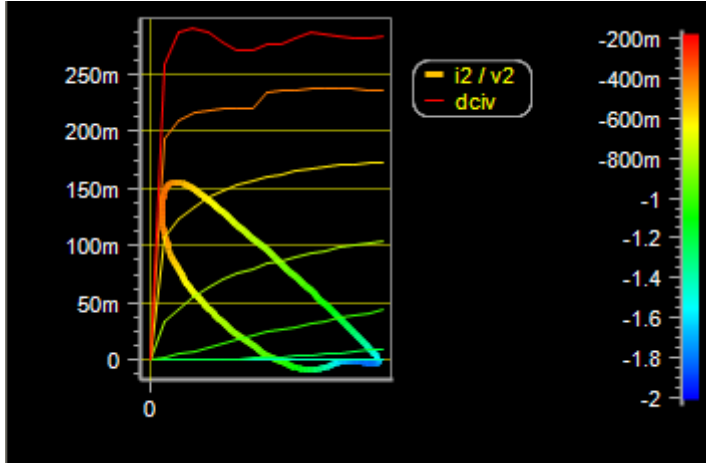
3D dynamic loadline

By combining the measured quantities, it is now possible to visualise, almost in real-time, different dynamic trajectories such as the output current waveform versus output voltage waveform, i.e. the dynamic loadline, on top of DC output characteristics of the device under test.

Furthermore, as both quantities at input and output of the device are measured simultaneously, the NM310S Starter Kit allows one to map, for example, the dynamic excursion of the gate voltage to the static gate voltage, using gradient colours. Different phenomena such as trapping and memory effects or delay between input and output can now be visualised in real-time.

Derived quantities

Thanks to the measurement of the basic quantities, one can easily calculate derived quantities such as gain, delivered input and output powers, efficiency and power added efficiency.

Settings - 1GHz			
Quantity		Value	Unit
b_out(f)/a_in(f)	⌄	19.52893	dB ⌄
PAE	⌄	59.75525	% ⌄
Efficiency	⌄	59.71899	% ⌄
Pdel_in(f)	⌄	-12.89831	dBm ⌄
Pdel_out(f)	⌄	21.11934	dBm ⌄
Zin(f)	⌄	1.37297 - 76.44126i	Ohm ⌄
ZL(f)	⌄	38.10117 + 24.74i	Ohm ⌄
	⌄		⌄

Derived quantities

**Integrate ICE capabilities in your own test environment**

You can benefit of the ICE measurement capabilities in your own test environment thanks to the ICE remote connection.

When your development platform is able to call directly .NET 2.0 assemblies, such as LabVIEW (7 or higher), Mathematica (5.2 or higher) or MATLAB (R2009A or higher), you will be able to integrate directly ICE functionalities in your own application.

Alternatively, ICE can be integrated in development platform able to call C/C++ library. However, you will need to develop an interop library, which bridges unmanaged C/C++ to .NET, to cover your needed API. An example is bundled with the ICE installation to demonstrate the basic principle.

Empowering your R&S VNA for large-signal measurements using the NM310S Starter Kit
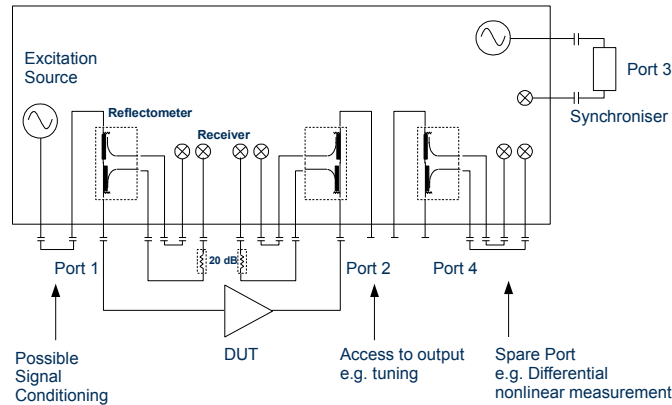
Block diagram of the NM310S Starter Kit connected to a R&S VNA

Presently the NM310S Starter Kit supports the following R&S vector network analyser models:

> ➢ 4-port R&S® ZVA8
> ➢ 4-port R&S® ZVA24
> ➢ 4-port R&S® ZVA40
> ➢ 4-port R&S® ZVA50
> ➢ 4-port R&S® ZVA67
> ➢ R&S® ZVT8 (at least 3 ports)
> ➢ R&S® ZVT20 (at least 3 ports)

with the following options:

> ➢ **Direct generator/receiver Access hardware option** (R&S® ZVAxx-B16 or R&S® ZVTxx-B16)
> ➢ **Frequency conversion software option** (R&S® ZVA-K4)
> ➢ *Optional*: Step attenuator hardware option for measurement receivers at Port 1 and Port 2, allowing automatic range adaptation (R&S® ZVAxx-B31 and -B32 or R&S® ZVT20-B32)
> ➢ R&S ZVAB firmware 2.80 or higher

The user needs also to provide:

- **A R&S® NRP-Z series power sensor** directly connected to the R&S VNA via **a NRP-Z3 (active) or a NRP-Z4 (passive) USB adapter** in order to perform the required power calibration

- **A standard calibration kit**, consisting of a short, open and load, used for the relative calibration (alternatively R&S calibration unit can be used for connectorised setup)

- **RF Test cables** to connect the device under test to the R&S VNA

- **External fixed attenuator and a small RF flexible cable** per port to extend the linearity of the measurement receiver **when the step attenuator option is missing on Port 1 (option B31) and/or Port 2 (option B32)**. Please refer to Table 1 for required attenuation value depending on your R&S VNA model.

- **Adapters** to connect the NM201 double-output comb generator (SMA), depending on your R&S VNA model.

R&S VNA Model	Attenuator value
R&S® ZVA8	20 dB
R&S® ZVA24	25 dB
R&S® ZVA40	30 dB
R&S® ZVA50	25 dB
R&S® ZVA67	35 dB
R&S® ZVT8	20 dB
R&S® ZVT20	25 dB

Table 1: Attenuation value of external fixed attenuator required
when step attenuator option on Port 1 (B31) and/or Port 2 (B32) is not present.

ICE Software Requirements

The ICE software can run on a desktop, a laptop or directly on the R&S vector network analysers.

<u>To use ICE on a desktop or laptop</u>, one needs to consider a PC with:

- ➢ **Supported OS:** Microsoft Windows® XP SP3, Windows Vista® or Windows® 7 (x86 or x64 version)
- ➢ **Recommended Processor:**
  - ‣ Intel® Core™ 2 Duo or Core™ i3 or better
  - ‣ AMD Athlon™ X2 or Phenom™ or better
- ➢ **Recommended Screen Resolution:** 1280 x 1024 or higher
- ➢ **Installed Software:**
  - ‣ VISA I/O Library:
    - ➢ NI-VISA Run-Time (or Full) 4.3 or higher
    - ➢ or Agilent IO Libraries Suite 14.2 or higher
    - ➢ or other VISA compliant library with VISA COM support
- ➢ **External equipments control via:** USB, Ethernet interface or IEC/IEEE-bus controller interface (IEEE-488)

<u>To use ICE on the R&S network analyser itself,</u> please consider:

- ➢ **Supported OS:** Microsoft Windows XP Embedded SP2
- ➢ **External high-resolution screen recommended**: 1280 x 1024 or higher
- ➢ **Installed Software:**
  - ‣ VISA I/O Library:
    - ➢ NI-VISA Run-Time (or Full) 4.3 or higher
    - ➢ or other VISA compliant library with VISA COM support
- ➢ **External equipments control via**: USB, Ethernet interface or IEC/EEE bus by using the **R&S® ZVAB-B44** USB-to-IEC/IEEE Adapter

Extending the NM310S Starter Kit

Extend Frequency Range

NMDG offers different nonlinear extension kits for your VNA with extended frequency range.

Extend Instrument Support

Specific instruments can be integrated in ICE through dedicated plugins.

The Tuner plugin allows one to integrate, and potentially control, different types of impedance tuners in ICE. The plugin contains drivers for a selection of tuner models from tuner manufacturers.

Add Powerful Applications

ICE can be extended with different applications to assist you in your tests and designs.

The ICEBreaker application allows one to perform generic sweep plans such as DC, power and/or load-pull sweeps, and to collect measurement data in an accurate way, using different types of stimuli and receivers in a coherent way, with or without control loops. It provides comprehensive visualisation of measurement data sets for free. For example, the user can analyse the behaviour of its component under multi-harmonic source and load mismatch conditions using source- and load-pull contour plots.

The NM600 Fast Source and Load Pull (FSLP) application enables the characterisation of active components under various input and output mismatch conditions with only your VNA. Within the power capabilities of the VNA, one does not need to invest in a dedicated and costly source- and load-pull setup, based on either passive or active tuning techniques.

The NM700 S-function extraction tool allows to create a measurement-based behavioural model for active components and to verify it. The model can then be exported to different CAE tools.

And More...

Besides the commercialisation of products, NMDG offers characterisation & behavioural modelling services based on Large-Signal Network Analyser (LSNA) technology, resulting in faster realisation of better and more complex HF designs, better testing procedures and faster time to market.

Using its extensive expertise in RF instrumentation, NMDG develops characterisation systems on customer demand.

Finally, as each nonlinear problem is different, NMDG provides consulting services to help customer to understand and solve their problems, and gives training courses on nonlinear characterisation techniques, load-pull techniques and behavioural modelling theory.

Order Information

Designation	Type	Order number
20 MHz-3GHz Nonlinear Starter Kit for R&S VNA	NMDG NM310S-Z	NM310S-Z

More information

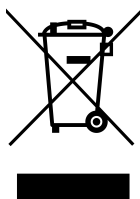NM310S Starter Kit and other NMDG products and services, focusing on nonlinear RF and HF characterisation, behavioural modelling and test:

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Phone: +32 3 890 46 13
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www.nmdg.be

Rohde&Schwarz VNA: www.rohde-schwarz.com

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January 2013 - Product description and specification are subject to change without notice.

Notes

Notes