Vector Network Analyzer R&S®ZVA

High-end network analyzer – future-proof and extremely fast

The new R&S®ZVA generation of high-end network analyzers offers high measurement speed, maximum dynamic range and extremely high versatility and accuracy – ideal prerequisites for present and future measurement tasks. On top of this, the user benefits from an easy and intuitive operating concept.

Sophisticated hardware concept

The high end Network Analyzer R&S®ZVA (FIG 1) is available in two models up to 8 GHz and 24 GHz with two or four test ports each. Like the R&S®ZVR predecessor model, the R&S®ZVA employs the tried-and-tested fundamental mixing concept, which ensures maximum sensitivity and dynamic range. The analyzer features extremely fast synthesizers, which make for minimum measurement times. Each test port is equipped with a measurement receiver and a reference receiver, and a separate generator is provided for each pair of test ports; the generator signals can be applied sequentially or in parallel as required (FIG 2). This enables parallel measurements on DUTs.

Multitalent opening up unique opportunities for designers

Unparalleled versatility …

New technologies and increasingly shorter innovation cycles mean that designers in development labs are faced with continuously changing requirements. A scenario like this calls for highly versatile test equipment that can be used for a variety of DUTs. In this sce-
The R&S®ZVA proves to be a real multitalent: The basic version already provides measurements on balanced and unbalanced passive components as well as on amplifiers. Frequency-converting measurements on mixers and amplifiers as well as time domain measurements are provided optionally.

... combined with utmost convenience
The intuitive operating concept of the Network Analyzer R&S®ZVA does away with the tedious studying of a manual. For more complex settings as are required, for example, for measuring balanced or other multiports, a wizard is available that guides the user step by step through a desired setup and queries all necessary inputs. Even highly complex measurement settings can thus be made quickly and easily without any in-depth knowledge about the instrument (FIG 3).

Typical applications

Measurements on base station filters
Base station filters are characterized by very high attenuation in the stopband and low attenuation in the passband. To perform $S_{21}$ measurements on such filters, the instrument must have a wide dynamic range. Moreover, segmented sweeps have to be used, which allow parameter settings to be optimally matched to the passband and the stopband (FIGs 4 and 5).

For the filter stopband, a narrow IF bandwidth (minimum 1 Hz) is set in order to achieve maximum sensitivity. The longer measurement time involved in this approach can be compensated by reducing the number of test points, thus providing a wide dynamic range at an acceptable speed.

In the passband, the main requirements are high resolution and low trace noise. A large number of test points is, there-
fore, selected for this range in order to enable an accurate analysis of the filter ripple — which is the ratio of the maximum to the minimum power level in the passband. To prevent the receiver section of the analyzer from being overdriven because of the low filter attenuation, an output power of −10 dBm is selected, for example (FIG 4).

Characterization of amplifiers
The R&S®ZVA offers a wide range of amplifier measurements. To measure the transmission characteristics of an amplifier with high accuracy and without interruption, it is desirable to use the widest possible level range without having to switch any attenuators. Featuring electronic level switching over a range of typically 50 dB, the R&S®ZVA is ideally suited for measuring the transmission and compression characteristics of amplifiers (FIG 6).

Measuring the small signal behavior sometimes calls for extremely small levels. Optional mechanical attenuators are available to reduce the analyzer output level to ≤−100 dBm. Measuring compression, by contrast, calls for output levels as high as possible; the R&S®ZVA offers +15 dBm.

Measuring active DUTs requires DC voltage, which can be fed at the bias-tee inputs on the R&S®ZVA rear panel. The DC voltage is applied to the DUT via the analyzer’s inner conductor. The DC inputs on the R&S®ZVA make it possible to measure the supply voltage or the current proportional to this voltage, from which the power added efficiency (PAE), i.e. the ratio of output minus input power to DC power of the amplifier, is determined.

To ensure highly accurate amplifier measurements, the analyzer’s output power is calibrated, which also eliminates the effects of the test setup. This is done by means of an R&S®NRP power sensor, which is connected to the R&S®ZVA and controlled via its USB interface. By means of this power sensor, the R&S®ZVA calibrates the generator versus level or frequency. Calibration can be carried out in iterative steps or down to a predefined minimum level tolerance.

Intermodulation measurements on amplifiers
The R&S®ZVA four-port model comes with two internal generators. These can generate a two-tone signal, which is required for intermodulation measurements. An external generator is not needed (FIG 7). The low phase noise of the R&S®ZVA’s internal generators and the very good power-handling capability of its receivers are optimum prerequisites for measuring high intercept points.

Hot S-parameter measurements on power amplifiers
To characterize a power amplifier, its output matching ($S_{22}$) must be measured under real conditions, i.e. under full load, which is known as hot S-parameter measurement. This is the only way to optimally match an amplifier to the load at its output. The problem encountered in this measurement is that the high output signal of the amplifier is superimposed on the signal generated by the analyzer at test port 2. The problem is solved by introducing a small frequency offset between the signal at the amplifier output and the signal generated by the analyzer for measuring $S_{22}$. This, however, requires very high receiver selectivity as well as robust level control — features which are of course provided by the R&S®ZVA.

Frequency-converting measurements on mixers
The R&S®ZVA analyzer concept features independent synthesizers. This is necessary for performing measurements on mixers and frequency converters, as it allows the generators and receivers to sweep at different frequencies. The LO signal for the mixer can be supplied by an external generator or by the second generator provided in the R&S®ZVA four-port model (FIG 8).

Intermodulation measurements on mixers can be performed using an external generator, which is controlled via the analyzer’s LAN or IEC/IEEE bus interface. Mixers are mainly characterized by their conversion loss, matching, group delay, isolation, compression and intermodulation — the R&S®ZVA measures all these quantities and provides a straightforward overview of results (FIG 9).

Optimized production sequences
The principal requirement in production is high throughput. Whether high production throughput can be achieved depends on the speed of the measuring instruments and, in automated sequences, on the time required for data transfer to the controller.

Record holder in speed
The R&S®ZVA sets new standards in measurement speed since, due to its fast synthesizers, it requires less than 5 ms for a frequency sweep over 201 test points. In the CW sweep mode, a measurement time of less than 3.5 µs per test point can be achieved. This makes the R&S®ZVA the fastest network analyzer currently available on the market.

To minimize measurement time, the IF bandwidth should be as large as possible. At the same time, dynamic range should not be unduly reduced and trace noise should be kept to a minimum. The R&S®ZVA’s is optimally suited for this as it features an excellent dynamic range of typically 135 dB between test ports, which is extended up to 150 dB with direct receiver access (option), and trace noise as low as typically 0.0008 dB at an IF bandwidth of 1 kHz.
FIG 4 Settings for measurements on a base station filter.

FIG 5 Transmission measurements on a base station filter.

FIG 7 Test setup for intermodulation measurements without an external generator.

FIG 8 The second internal generator supplies the LO signal for mixer measurements.

FIG 6 Characterization of an amplifier.
Measurement speed can be further optimized by using segmented sweeps, where test parameters such as the IF bandwidth, number of test points and the generator level can be defined separately for each segment. Measurements can thus be focused on segments of interest, and carried out with the dynamic range and frequency resolution optimally adapted for each segment.

Data transfer in virtually no time
The R&S®ZVA hardware concept makes it possible to transfer data measured during the first sweep to the controller already during the second sweep via the analyzer’s IEC/IEEE bus or LAN interface. This means that data transfer time is practically insignificant, which substantially cuts down on measurement time.

To further speed up automated test sequences, the R&S®ZVA provides channel bits at its trigger I/O port. The channel bits synchronize the DUT with the network analyzer, allowing limit values to be queried or external hardware to be controlled.

Fast switching between instrument setups
Previously, when measuring several DUTs, the required instrument setups had to be loaded from hard disk each time the DUT was changed. The R&S®ZVA can load various setups including calibration data into RAM and switch between these setups in less than 10 ms. To select the desired setup window, simply use the mouse in manual production applications; in automated test sequences, switchover is made by IEC/IEEE bus or LAN control (FIG 10).

True parallel measurements
The R&S®ZVA hardware concept allows true parallel measurements since the analyzer’s internal generators can be switched to all test ports at the same time. For example, the R&S®ZVA four-port model can analyze two two-port DUTs in parallel or measure the reflection of four one-port DUTs at its four ports in parallel.

Direct generator and receiver access
For some applications, external amplifiers, filters or attenuators have to be included in the test setup. This is possible by using the “Direct Generator / Receiver Access” option. This option in conjunction with the generator and receiver attenuator options turn the R&S®ZVA into an instrument that provides utmost flexibility in creating test setups.

Another positive effect of the direct access mode is that dynamic range increases to 150 dB (at 1 Hz IF bandwidth) since the internal couplers are bypassed. This is of interest when measuring high-blocking filters, for example.

Numerous calibration techniques
It goes without saying that a high-end network analyzer should provide a large number of calibration techniques. This is ensured by the R&S®ZVA hardware concept, which features a measurement and a reference receiver for each test port. This means that, in addition to classic TOSM calibration, modern 7-term calibration techniques can be used. These include TOM, TRL/LRL, TRM and TNA, some of which are of interest in particular for carrying out calibration in test fixtures or on wafers.

Manual calibration techniques are, however, time-consuming and error-prone especially where multiports are concerned. To solve this problem, Rohde & Schwarz offers an automatic calibration unit that comes in various models (FIG 11). Controlled by the network analyzer, the calibration unit performs complete four-port calibration in less than 30 seconds, for example. Apart from saving time, automatic calibration units offer the advantage that they have to be connected only once to carry out a complete calibration. This means less wear to the connectors and thus an extended life. And, last but not least, automatic calibration practically excludes operator errors.

Summary
Superior RF performance combined with versatile use and extendability — these are the current requirements in the development and production of state-of-the-art components and modules. The R&S®ZVA from Rohde & Schwarz perfectly meets these requirements and, moreover, is easy to operate.

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**FIG 9**
Characterization of a mixer (conversion gain, matching, isolation and intermodulation).

**FIG 10**
You can switch between setups in no time – simply by means of the mouse or via the IEC/IEEE bus.

**Condensed data of the R&S® ZVA**

- **Number of test ports**: 2 or 4
- **Frequency range**: 300 kHz to 8 GHz (R&S® ZVA B), 10 MHz to 24 GHz (R&S® ZVA 24)
- **Measurement time per test point**: <3.5 µs
- **Measurement time (201 test points)**: 4.5 ms
- **Data transfer time (201 test points)**:
  - Via IEC/IEEE bus: <2.9 ms
  - Via VX111 (LAN with 100 Mbit/s): <1.3 ms
  - Via RSIB (LAN with 100 Mbit/s): <0.7 ms
- **Switching time**:
  - Between channels: <1 ms
  - Between instrument setups: <10 ms
- **Dynamic range at 10 Hz measurement bandwidth**:
  - Between test ports: >130 dB, typ. 135 dB
  - With direct receiver access: >145 dB
- **Output level at test port**: >+13 dBm, typ. +15 dBm
- **Level sweep range**: >40 dB, typ. 50 dB
- **IF bandwidths**: 1 Hz to 1 MHz
- **Number of channels, diagrams, traces**: >100 each (depending on available RAM capacity)
- **Number of test points per trace**: 2 to 20000
- **Operating system**: Windows XP Embedded

**FIG 11**
The automatic Calibration Unit R&S® ZV-Z51 saves time and prevents errors.