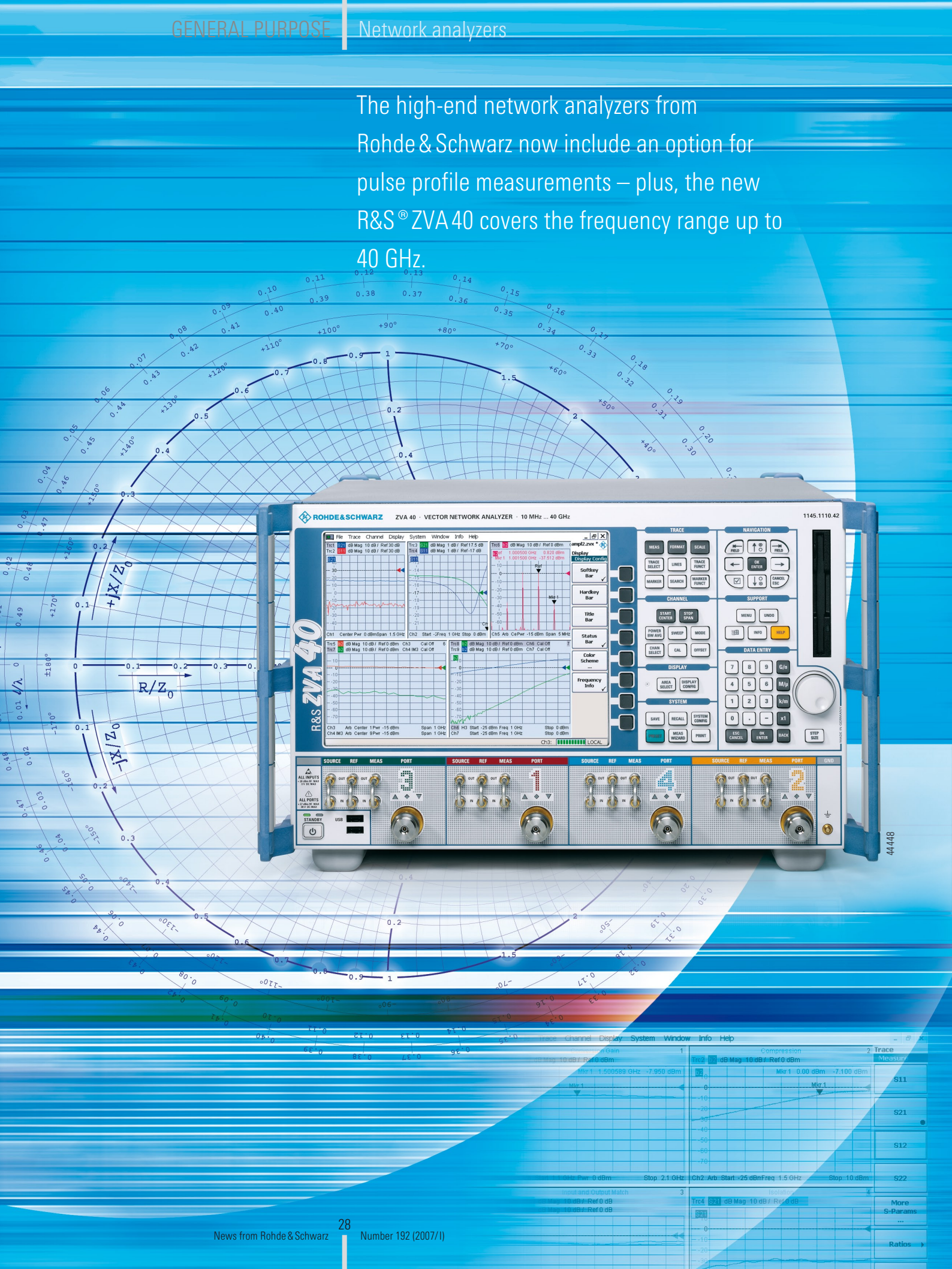
The high-end network analyzers from Rohde & Schwarz now include an option for pulse profile measurements – plus, the new R&S® ZVA 40 covers the frequency range up to 40 GHz.



Easy-to-use pulse profile measurements up to 40 GHz

Equipped with the new R&S®ZVA-K7 pulsed measurements option, the R&S®ZVA and R&S®ZVT network analyzers test the time-dependent characteristics of amplifiers and mixers under pulsed conditions and measure the absolute power, magnitude, and phase of S-parameters with a resolution of 12.5 ns.

Why make things more difficult …

In a wide range of applications, DUTs must be characterized by using pulsed signals instead of CW signals. This procedure reduces the average power in on-wafer measurements to prevent thermal destruction of the DUT. Moreover, power amplifiers in mobile phones or radar output stages only exhibit the desired qualities under pulsed stimulus conditions. The DUT behavior often changes during the pulse duration (FIG 4). The pulse widths for these applications vary between some 100 ns and several microseconds. To test the behavior of the pulsed components as a function of time, i.e. to perform a pulse profile measurement, the network analyzer must feature a time resolution that is significantly higher than the pulse duration.

The time resolution of conventional network analyzers ranges from 3 µs to 20 µs for measurements in the frequency or time domain. To achieve resolutions in the nanosecond range, additional external hardware and software were previously required. This old technique chops the pulsed signals to be measured again, and the pulse profile is calculated offline in accordance with the average pulse method. Such elaborate test setups are expensive and difficult to operate. Moreover, measurement speed, accuracy, and dynamic range are intrinsically limited.

… when they can be so simple

Equipped with the new R&S®ZVA-K7 pulsed measurements option, the network analyzers of the R&S®ZVA family [1] and the R&S®ZVT network analyzer [2] analyze pulses with widths of less than 1 µs at high resolution. In this article, we will use the R&S®ZVA 40 as an example. The measurements allow intuitive and easy operation and are outstanding for their high measurement speed. The option uses the large IF bandwidth of the R&S®ZVA receivers plus special hardware (FIGs 1 and 2).

The method in detail

The R&S®ZVA samples the IF-converted signal at a rate of 80 MHz. A digital signal processor usually filters the collected data before the main processor calculates the error-corrected S-parameters and displays them on the screen. In addition to the sampling time, there is a data processing time of 1 µs to 2 µs between two test points, which used to be the bottleneck when it came to high-resolution measurements in the time domain. To avoid this bottleneck, the sampled raw data is first stored during the pulse profile measurement without filtering, ensuring that no delay occurs between the samples of the individual test points. When the recording process is finished, the analyzer software further processes this data; i.e. in this mode, the main processor of the network analyzer performs digital filtering in addition to error correction.

The R&S®ZVA 40 is a high-end network analyzer with two or four test ports and a frequency range from 10 MHz to 40 GHz. Its exceptionally high output power of more than 13 dBm, a power sweep range up to 50 dB, a dynamic range exceeding 135 dB, and the short measurement time of 3.5 µs per test point make the R&S®ZVA 40 the ideal tool for research and development applications in the microwave range. The high output power and the second internal source of the four-port instrument ensures fast and accurate compression, intermodulation, and hot S-parameter measurements on amplifiers and mixers also under pulsed conditions.

Because the sampling rate of the A/D converter is 80 MHz, a measurement result is output every 12.5 ns, i.e. the time resolution is 12.5 ns. The large memory depth of the R&S®ZVA allows a recording time of 3 ms for all wave quantities. The trigger signal, which is usually derived from the rising edge of the pulse, determines the zero point in time. It is thus possible to display events that start prior to the trigger point, and an exact time correlation between the trigger signal and the RF pulse can be established (FIG 3). Such a correlation is especially important for determining the correct trigger delay in point-in-pulse measurements versus frequency or power.

Owing to this progressive method, the R&S®ZVA performs extremely fast pulsed measurements. With more than 10 sweeps/s at 1001 test points, DUTs can easily be adjusted during the pulse profile measurement (FIG 4). The pulse profile measurement performed with the R&S®ZVA is not limited to periodic signals, as is the case with conventional measurement methods – it is also suitable for analyzing single and double pulses as well as user-defined pulse trains.

DUTs with very short group delay

Measuring the S-parameters of DUTs with group delays that are of the same order as the pulse width is often difficult or even impossible, because a signal may no longer be present at the DUT input by the time the network analyzer can measure this signal at the DUT's output. However, the value of s_{21} is only correct for measurements with a phase of temporal signal overlapping. FIG 5 shows the measurement of the wave quantities and S-parameters of a DUT with a group delay of 100 ns. The R&S®ZVA solves this issue by means of a time offset: Before calculating the S-parameters, it mathematically shifts the wave quantities by the DUT's group delay. Each wave quantity can be assigned a specific time delay, depending on the stimulating port (FIG 6). After the delayed signal has been offset, the R&S®ZVA correctly displays the gain s_{21} versus the entire pulse duration (FIG 7).

Measurements with pulse-modulated input signals

For applications where the DUT requires a pulse-modulated input signal, a generator with pulse modulation such as the R&S®SMA100A or R&S®SMR can be used. By directly accessing the generator path by means of the R&S®ZVA-B16 option, the pulse-modulated RF signal of the generator (instead of the CW signal) is directly applied to the R&S®ZVA test set (FIG 8). This setup is also suitable for pulsed measurements versus frequency and power, as the R&S®ZVA controls external generators via LAN or IEC/IEEE bus. Because the pulsed signal passes the internal coupler, it is also measured by the reference receiver, thus permitting system-error-corrected s_{11} and s_{21} measurements. A system error or power calibration recorded

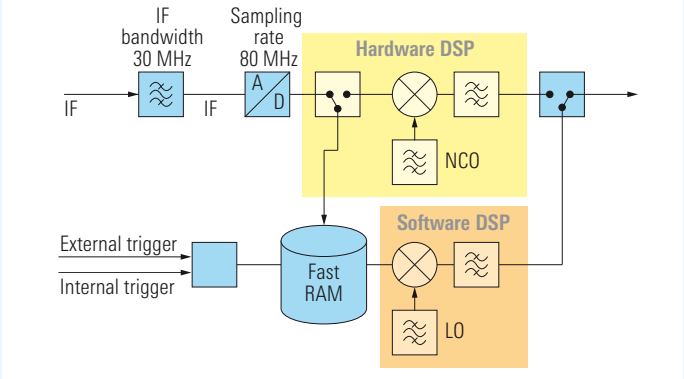


FIG 1 Signal flow during pulse profile measurements using the R&S®ZVA-K7 option.

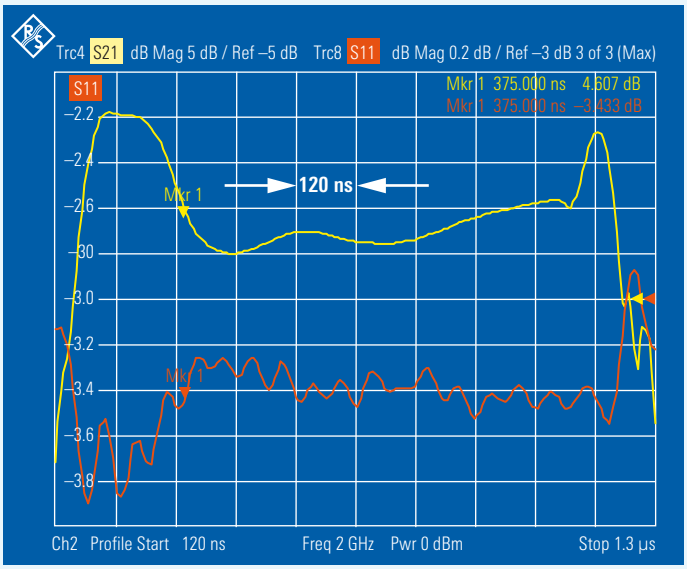


FIG 4 Pulse profile of the S-parameters of an amplifier.

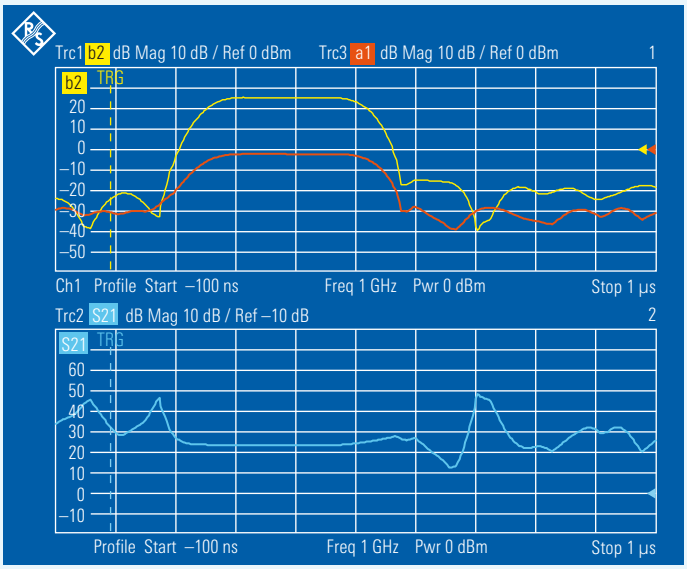


FIG 7 Measurement result after a time offset of the output signal b2 by 100 ns.

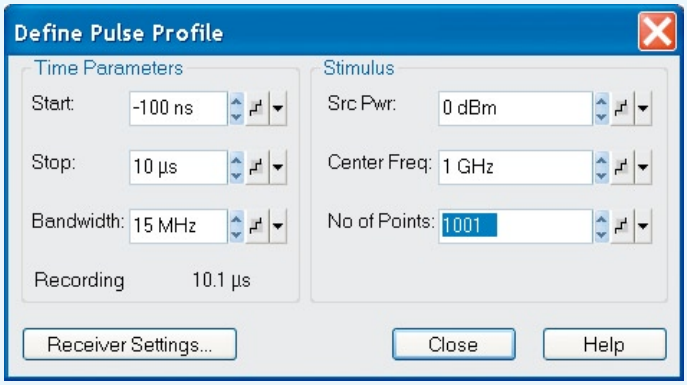


FIG 2 Dialog for configuring the pulse profile measurement.

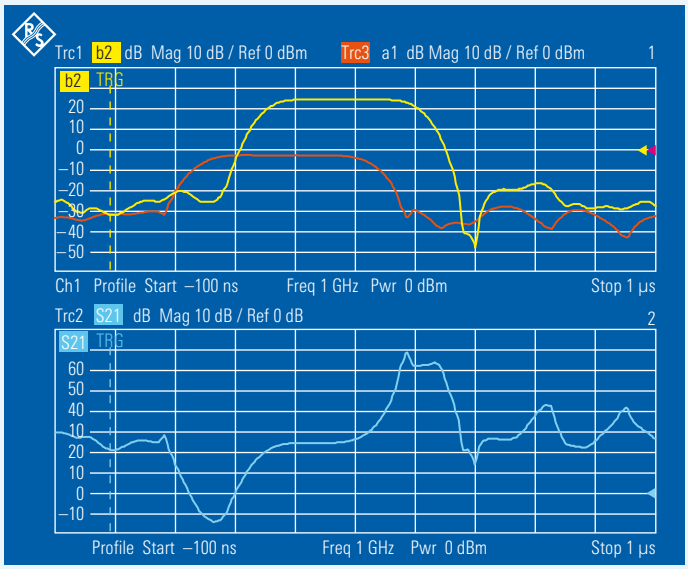


FIG 5 DUT with 100 ns group delay: input signal (red), output signal (yellow), and s_{21} (blue).

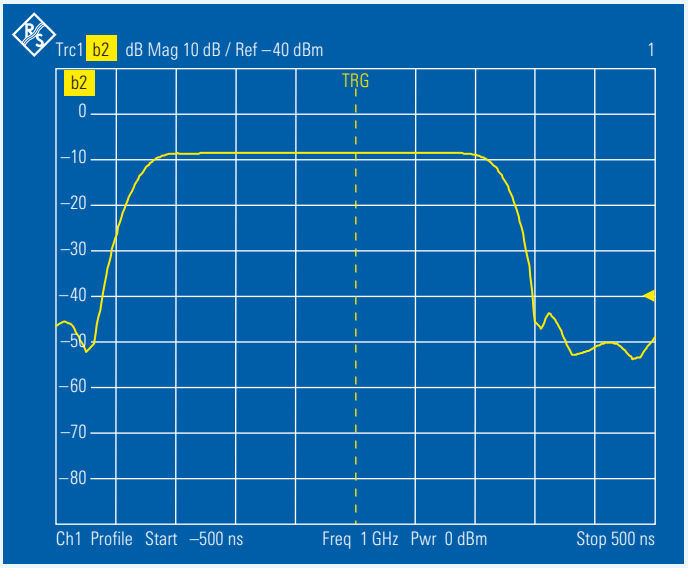


FIG 3 Pulse profile of a wave quantity with trigger signal.

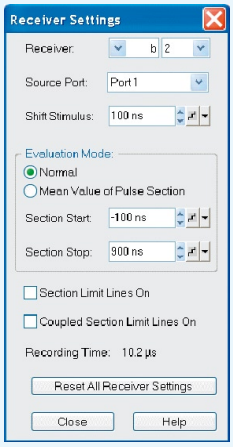
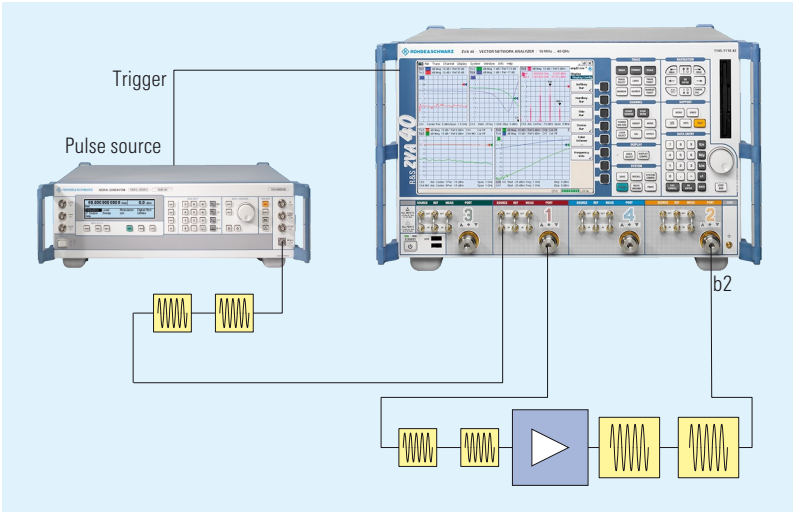


FIG 6 Dialog for delay compensation.



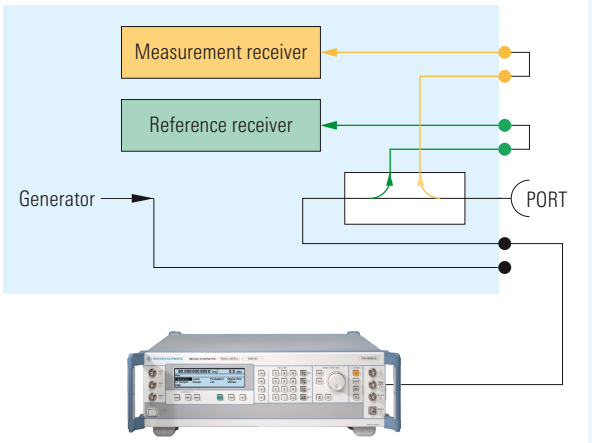


FIG 8 Test setup with an external generator with pulse modulation.

under CW conditions thus also applies under pulsed conditions and need not be repeated even when the duty cycle is changed.

Instead of the external pulse generator, a pulse modulator can be inserted into the generator path (FIG 9), enabling bidirectional measurements and thus also complete two-port calibrations. With a modulator connected to port 1, the forward parameters s_{11} and s_{21} are measured under pulsed stimulus conditions, and the reverse parameters s_{12} and s_{22} under non-pulsed stimulus conditions. If pulsed signals are to be used for both measurements, a second modulator is connected to port 2. Only an additional arbitrary waveform generator is required for a pulsed DUT (FIG 10).

Frequency-converting measurements such as the conversion loss of mixers can also be performed. In this case, the second internal source of the R&S®ZVA is the ideal local oscillator.

Summary

The R&S®ZVA-K7 option allows the time-dependent behavior of amplifiers and mixers to be analyzed with a resolution of 12.5 ns. Operation and test setup are mere child's play. Further benefits include a wide dynamic range and high measurement speed. The option processes single pulses, periodic pulses, and user-defined pulse trains.

Thilo Bednorz

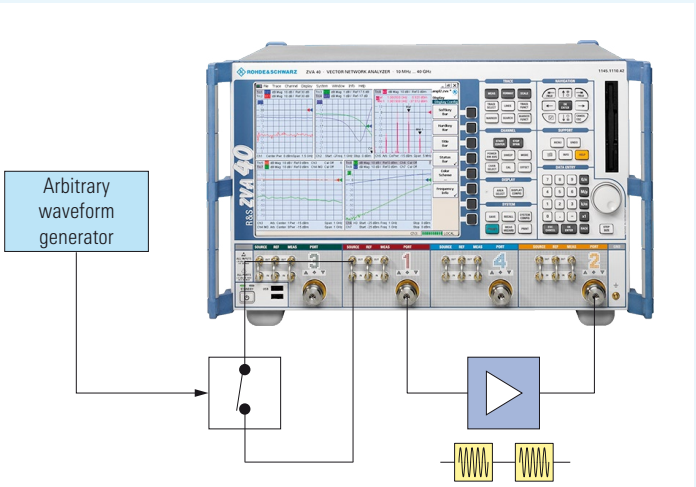


FIG 9
Test setup with pulse modulator.

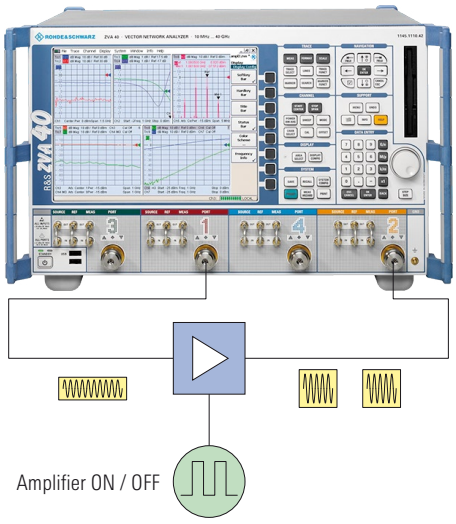


FIG 10
Test setup with pulsed DUT.

More information and data sheet at www.rohde-schwarz.com (search term: ZVA / ZVT)

REFERENCES
[1] Vector Network Analyzer R&S®ZVA: High-end network analyzer – future-proof and extremely fast. News from Rohde & Schwarz (2005) No. 188, pp 26–31
[2] Vector Network Analyzer R&S®ZVT8: Unrivaled: up to eight test ports in a single unit. News from Rohde & Schwarz (2006) No. 189, pp 26–29