R&S®NRP-Z81 Wideband Power Sensor

State-of-the-art technology for wireless digital communications

A new sensor for the R&S®NRP power meter now offers the complete functionality required today for high-frequency power measurements: 30 MHz video bandwidth for power envelope analysis, short measurement times, and 80 dB dynamic range for average power measurements.

More and more in demand: power envelope analysis

Measuring electrical power in the RF and microwave range has long been a task for sophisticated T&M equipment. While in the beginning the key requirement was high measurement speed combined with high measurement accuracy, power envelope analysis is now increasingly required. This includes waveform, peak and average values, rise and fall times, and statistical distribution. Once again, the driving force is wireless digital communications technology with its complex RF signals. For example, hundreds of thousands of new base stations are put into operation every year, and their output power has to be tested in production, installation, and as part of routine maintenance. For this task, all manufacturers rely on power meters – and increasingly on those from Rohde & Schwarz.

This latest member of the R&S®NRP instrument family (FIG 1) is another superior-quality power sensor, as it measures all the parameters you expect from a peak power meter, with or without a base unit:

FIG 1
R&S®NRP power meter with R&S®NRP-Z81 wideband power sensor.

◆ Power envelope as a function of time
◆ Statistical power distribution
◆ Average power

The sensor features a frequency range from 50 MHz to 18 GHz, a lower measurement limit of approx. –60 dBm for average power measurements, and approx. –47 dBm for envelope power measurements. This ample functionality is accommodated in a compact box no larger than that of its predecessors and, like them, capable of remote control from a PC via USB. In short: state-of-the-art technology that can handle present and future measurement tasks, unrivaled in functionality, size, and price.

Oscillographic power measurements

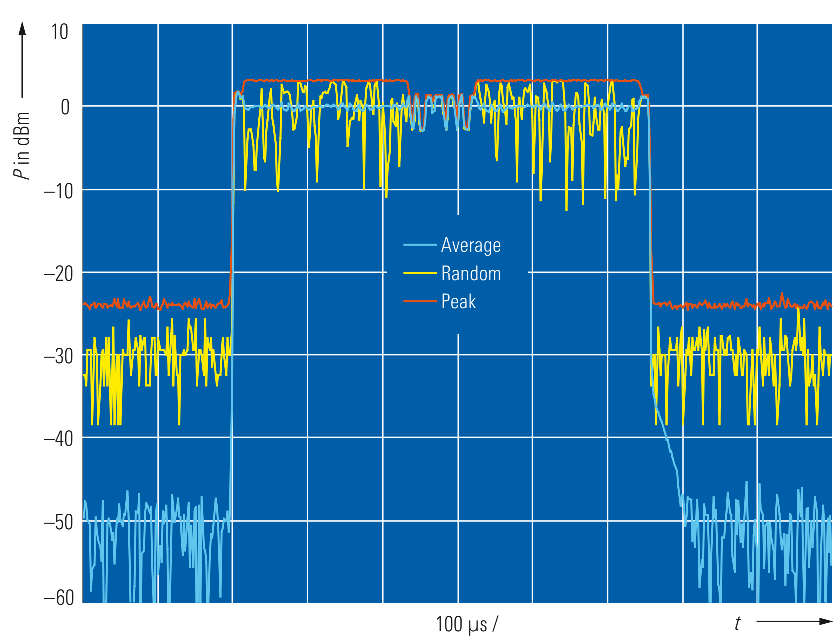
The primary feature that distinguishes the new power sensor from its predecessors – the R&S®NRP-Z11 and the R&S®NRP-Z21 / 22 / 23 / 24 – is its large video bandwidth of 30 MHz for carrier frequencies above 500 MHz. This in conjunction with a continuous sampling rate of 80 million values per second, i.e. a time resolution of 12.5 ns, is sufficient for displaying the envelope power of radar pulses and analyzing all current transmission methods based on digital modulation: TDMA (e.g. GSM/EDGE), OFDM (e.g. WiMAX, IEEE 802.11 a / b / g, 3.9G) and (W)CDMA, as well as RF carriers that are a combination of such signals (multicarriers). It is thus possible to perform oscillographic measurements of the power envelope – with the accuracy that is expected from power meters.

For the display of the power envelope, the fully processed measured data is output as pixels, i.e. measured power can be displayed directly. While 250 pixels are normally sufficient for displaying a trace, the sensor can deliver up to 8192 pixels, which means a safe margin satisfying even exacting demands on display resolution. As each pixel represents a time interval and thus usually comprises many samples, it may be useful to output different values for each pixel in order to characterize the specific time interval. The sensor therefore supplies the following: a random sample representing the waveform characteristic, the average value for a display with reduced noise, and the maximum and the minimum value – all in realtime, without time-consuming post-processing (FIG 2). The display of average values allows even extremely small powers to be measured.

And here is one of the strengths of the new power sensor: Whereas conventional peak power meters fail when it comes to measuring signal details below –30 dBm, the R&S®NRP-Z81 power sensor performs such measurements down to approx. –47 dBm. This is made possible by a chopper that switches synchronously with the signal (see box on page 35). It reduces zero drift and zero offset to a minimum and allows noise reduction to virtually any level by averaging several traces.

An oscilloscope is only as good as its trigger capabilities. Therefore, the new power sensor offers everything that is needed in practice: internal or external triggering on single-shot or repetitive events, and various types of trigger qualification. These include the conventional hold-off, as well as defining a trigger hysteresis or a drop-out parameter, which enables triggering only if the signal is below the trigger threshold for a minimum period of time. Pretriggering can be selected if the trigger event occurs after the signal section to be recorded. The start of a measurement can be shifted to an earlier point by up to 4096 pixels, i.e. a multiple of the recording time with conventional screen display. The video bandwidth can be reduced to 5 MHz, 1.5 MHz, and 300 kHz in order to increase trigger sensitivity and reduce noise.

FIG 2 Power envelope of a GSM EDGE signal, measured with the R&S®NRP-Z81. The three traces display different pixel representations. Blue: average values; yellow: random values; red: peak values.



The wideband power sensor in detail

Analyzing signals with large RF bandwidth often strains the performance limits of conventional diode power sensors: They are not able to follow the rapidly changing signal envelope. The diode detector then outputs a signal from which the profile of the measured quantity can no longer be properly reconstructed. This is aggravated by nonlinear distortion outside the square-law region of the detector diode, rendering even average power measurement impossible.

Therefore, the signal processing chain in a wideband power sensor starts with a diode detector that is designed such that its rise time, and particularly its fall time, are shorter than those of the measured signal. In the case of the R&S®NRP-Z81 sensor (FIGs 3 and 4), the detector is followed by a switch that cyclically reverses the polarity of the detector signal when several measurements are averaged. This process is referred to as chopping. This helps to minimize the zero offset and to change the spectral composition of the display noise so that the noise can be reduced as required by means of averaging. With conventional peak power meters without a chopper, noise can be reduced only to a certain extent due to the 1/f noise component. This means that high-resolution measurements are not possible.

All this is only possible on the basis of powerful digital signal processing, which in turn requires a sufficient input: In the case of the R&S®NRP-Z81 power sensor, this is 80 million samples per second. The R&S®NRP-Z81 immediately calculates the equivalent instantaneous power for each sample depending on the set RF carrier frequency, the current sensor temperature, and the measured signal amplitude. These calculations are based on a comprehensive set of calibration data that is compiled individually for each sensor. The data is so accurate and so finely graduated that the raw detector characteristic is optimally corrected. And because this correction data is valid throughout the life of the sensor, recalibration requires only a normal power calibration system.

FIG 3 Compact, high-precision electronic design: internal circuitry of the R&S®NRP-Z81 wideband power sensor.

Calculating the instantaneous power already constitutes the main step in signal processing. What follows is correct time allocation in the case of triggered measurements, the combination of samples into pixels or average-power values, the extraction of extreme values, and statistical analysis. All this is performed by a highly complex FPGA of the latest generation.

What distinguishes the R&S®NRP-Z81 power sensor from comparable products is that its complete signal processing – from the microwave frontend to the output of results – is integrated in a highly compact box. One of the advantages this affords for the user is absolute immunity to interference, even when the sensor is exposed to strong electromagnetic fields as may occur in EMC tests, for example.

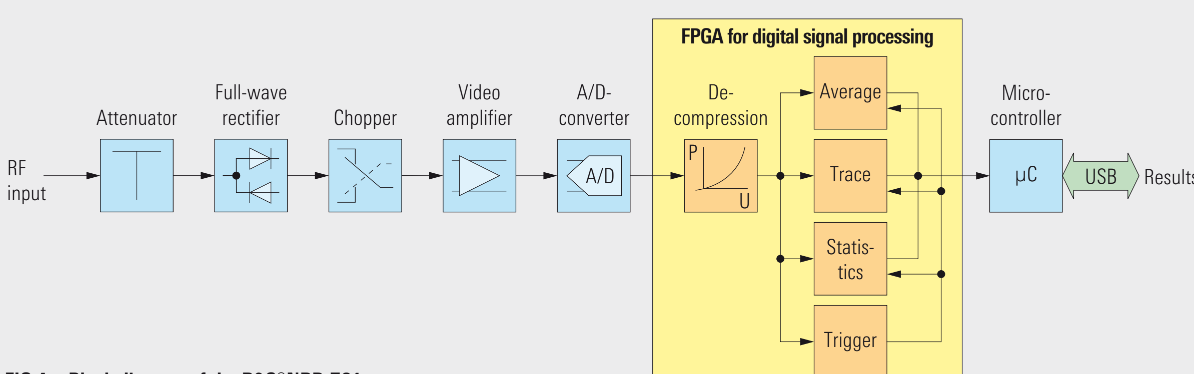


FIG 4 Block diagram of the R&S®NRP-Z81 power sensor.

Statistical analysis

More and more often, high-frequency signals are modulated in such a way that their power envelope assumes a stochastic character, with the result that their representation versus time yields hardly any useful information. Time-domain representation then has to be replaced by statistical analysis. A method commonly employed is, for example, to calculate the complementary cumulative distribution function (CCDF), which indicates the probability of signal peaks occurring above a defined power threshold.

Here, too, speed is what counts, and this has been the difficulty so far. The R&S®NRP-Z81 power sensor solves this problem in realtime, i.e. in less than 25 ms. This is the time it takes for the sensor to record and analyze one million samples. It is thus possible to monitor changes in the signal composition virtually without delay. If a smaller number of samples, i.e. 100 000 values, is sufficient, the process is accelerated accordingly. The video bandwidth can be reduced in this case, too, and the measurement performed synchronously with the signal. Statistical analysis will then cover only a specific signal section, whose position and duration can be exactly defined (FIG 5). The results of statistical analysis are likewise processed such that they can be directly displayed in graphical form. The level range and the number of pixels are user-definable within wide limits; resolution as high as 0.006 dB per pixel can be selected. Instead of a CCDF, the result can be output as a probability density function (PDF).

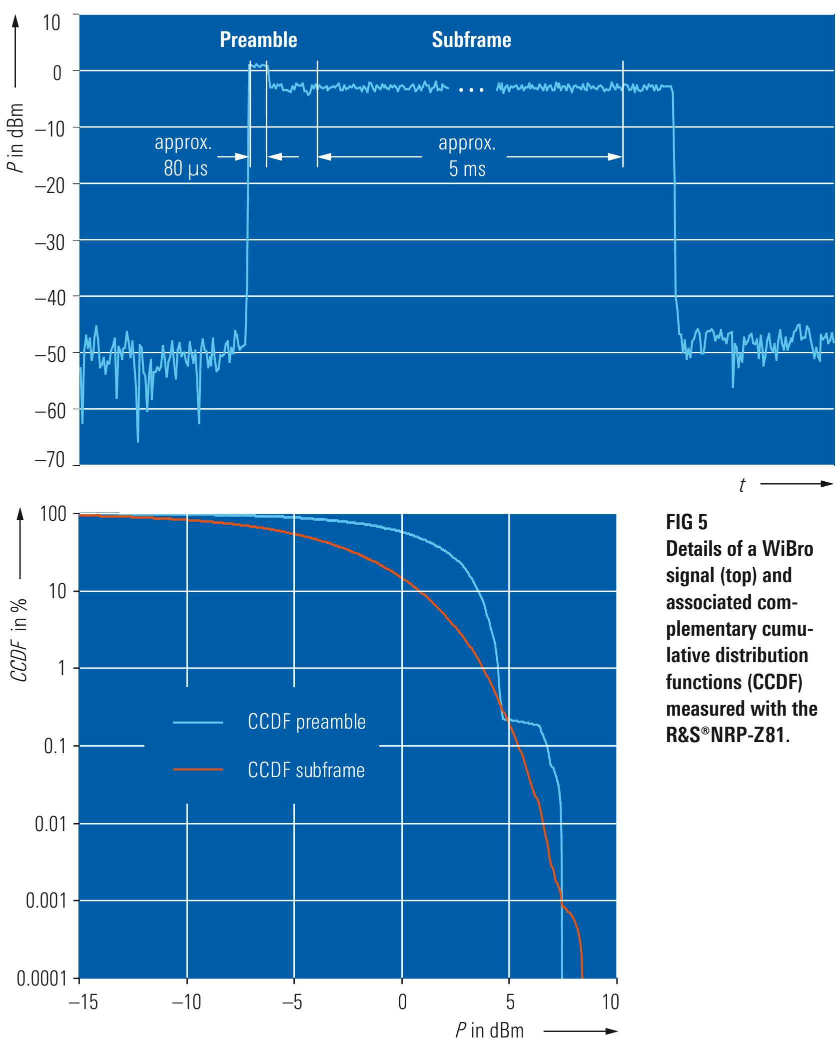


FIG 5 Details of a WiBro signal (top) and associated complementary cumulative distribution functions (CCDF) measured with the R&S®NRP-Z81.

Average power measurement for utmost accuracy

The rule of the golden mean applies also, and especially, to power measurement. For this reason, the R&S®NRP-Z81 offers various functions for measuring average power:

- **Cont Av** Continuous average power
- **Timeslot Av** Average power over signal-synchronized measurement windows (gates)
- **Burst Av** Average power of bursts

The above modes have in common that they determine average power over a defined time interval. In the Cont Av mode, this is done continuously without any reference to the signal, comparable to the operation of a thermal power meter. In the Burst Av mode, the beginning and the end of the measurement are automatically determined by the rising and falling edges of the burst – the ideal function for measuring pulsed signal power with a minimum number of settings. Exclusion periods at the beginning and the end can be defined.

The Timeslot Av mode for signal-synchronized measurements offers even greater versatility. The gate duration can be selected from a range including six decades (50 ns to 100 ms). Exclusion periods can be defined not only at the beginning and the end, but also within a gate. The position and duration of exclusion periods are defined by the user alone. Up to 16 gates can be linked to yield a timeslot structure. It is thus possible to measure power over all timeslots of a TDMA signal in one go.

Actually a matter of course and yet a completely new feature for wideband sensors is the wide dynamic range available for the averaging modes. With continuous averaging, for example, it extends from –60 dBm to +20 dBm – not only for CW signals but also for signals with any type of modulation. This is the logical consequence of a superior concept.

Extras included

It goes without saying that the new sensor includes all the tried and tested features of the R&S®NRP-Zx power sensors already established on the market:

- **Fixed noise mode** for the auto-averaging filter
- **Gamma correction** for increased measurement accuracy with DUTs exhibiting substantial mismatch
- **S-parameter correction** allowing users to easily take into account attenuators, directional couplers or amplifiers connected ahead of the DUT in the measurement result

For the continuous output of results, the output rate can be reduced as far as necessary to prevent overload of the controlling host. This could easily happen in the past when R&S®NRP sensors were operating at their speed limits, for example with very short measurement windows or with sliding averaging. Output rate reduction is therefore also available for the existing range of power sensors. It can be downloaded as part of a free-of-charge firmware update from the Rohde & Schwarz website and installed in only a few seconds.

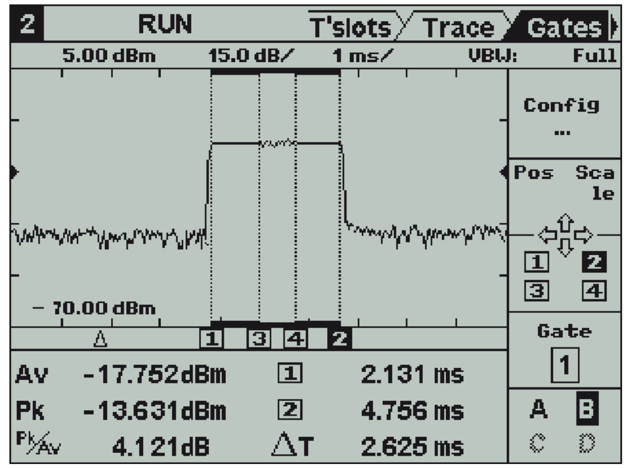


FIG 6 Enlarged area for trace and new softkeys: redesigned user interface of the R&S®NRP in the Trace / Gate mode.

Control and output of results

The new sensor, like all other R&S®NRP sensors, can be controlled from a PC, the R&S®NRP base unit, or any other Rohde & Schwarz instrument. The sensor therefore comes with drivers that support the complete sensor functionality.

The operating concept of the R&S®NRP base unit has been completely redesigned (FIG 6):

- Enlarged waveform display
- Simplified scaling and positioning of waveforms by direct key control
- More directly controllable functions with new softkey bar
- Gate and marker functions now separate; display of peak power and peak-to-average ratio

The existing range of sensors also benefits from the improvements in the control of the base unit. It is therefore advisable to download the current R&S®NRP firmware version from the Internet.

Future developments

The R&S®NRP instrument family will be continuously enhanced with the focus on customer benefit: high quality at an affordable price, always at the forefront of the technological development – true to the motto "just plug and play".

Thomas Reichel

To learn how the R&S®NRP-Zxx power sensors perform EIRP measurements on satellite signals, refer to the next page.

More information at www.rohde-schwarz.com (search term: NRP / NRP-Z81)