FIG 1 A powerful team: R&S NRP with 18 GHz Power Sensor R&S NRP-Z21

Microwave power meters are only as good as their sensors, which is why they were the focus of development for the new Power Meter Series R&S NRP. The sensors offer a dynamic range of up to 90 dB for modulated signals of any RF bandwidth, plus time gating, high measurement speed and low measurement uncertainty. Whether used for digital mobile radio, wireless LANs, or classic applications: these sensors set new standards in terms of versatility and accuracy.

Power Meter R&S NRP

Evolution in power measurement – intelligent sensor technology

Intelligent sensors herald a new generation

Digital mobile radio triggered a flood of developments in RF test and measurement engineering, which have also affected power meters. At first, it was the time structure of the test signals that presented new challenges. Today it is the broadband modulation techniques of third-generation mobile radio. And this is only the beginning. Wireless LANs with RF bandwidths of more than 100 MHz are already being discussed.

The problems cannot be solved by conventional sensor designs, especially if you want to keep the great-

est advantage of power meters, their high measurement accuracy. For that reason, Rohde&Schwarz again takes an extremely innovative approach with the new generation, comparable to the introduction of intelligent sensors for the URV5 and NRV models in the early 1980s. All the signal processing is relocated into the sensor, which is the key to exploiting the potential of multiple-path sensor technology. The link to the basic unit or any controller is established via the standard USB interface (universal serial bus). The new family of power meters launches with the universal Sensors NRP-Z11 (-Z21) from 10 MHz to 8 (18) GHz and a basic unit of future-oriented design (FIG 1).

90 dB dynamic range

If it is true that the popularity of a power sensor grows with its dynamic range, then the NRP-Z11 and NRP-Z21 stand a very good chance of becoming real favourites. For the first time, a range of 90 dB for broadband modulated signals has been achieved, while the lower measurement limit (defined by noise and zero offset) remains a very respectable –67 dBm. And this does not change much if the power is to be measured within a single GSM timeslot (FIG 3). Even for signal-triggered measurement of the mean power of single bursts or the generation of a power/time template, a wider dynamic range is available than with conventional designs.

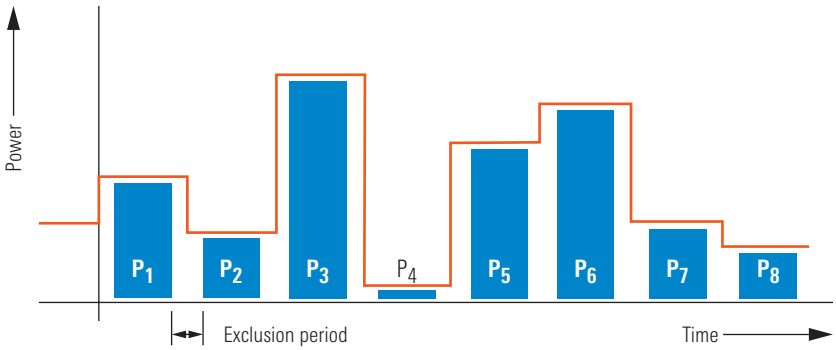

FIG 2 Multislot measurement: for the usual time division methods (e.g. GSM / EDGE, DECT), average power can be measured in all timeslots at the same time.

Signal-synchronized measurements

The NRP-Z11 and NRP-Z21 sensors can measure the average power not only in the classic manner, i.e. continuously without temporal reference to the signal content, but also synchronized with the signal over definable periods of time. Up to 128 intervals (26 when controlled by the basic unit) can be acquired and measured at one go (FIG 2). This allows entire frames of GSM / EDGE signals to be analyzed. Unwanted portions in the transition from one timeslot to the next can be blanked by freely definable exclusion periods at the beginning and end. To measure the power/time template of recurring or non-recurring waveforms (FIG 4), the number of test intervals

Technology ↓ Mode →		Dynamic range for measuring average power Bandwidth of test signal 100 MHz/5 MHz/0 (CW)			
		Continuous	**Timeslot** 1 out of 8 (external trigger)	**Burst** duty cycle 1:8 (internal trigger)	**Power vs. time** 256 points (external trigger)
Thermoelectric sensor		50 / 50 / 50 dB	–	–	
Diode	**Sensor in square-law region**	43 / 43 / 50 dB	–	–	
	CW sensor	43 / 43 / 90 dB	–	–	
	Peak sensor	33 / 50 / 80 dB	– / 50 / 57 dB	– / 33 / 37 dB	– / 50 / 57 dB
	Multiple-path sensor	80 / 80 / 80 dB	–	–	
	R&S smart sensor technology	**90 / 90 / 90 dB**	**85 / 85 / 85 dB**	**60 / 60 / 60 dB**	**70 / 70 / 70 dB**

FIG 3 Dynamic range of various sensor technologies as a function of the RF bandwidth of the test signal (peak-to-average ratio always 7 dB).

(points) can be increased to 1024; signal details down to durations of about 10 µs can thus be resolved. Extensive trigger functions, derived from an external source or the test signal, ensure stable conditions.

High system accuracy

The small measurement uncertainty of broadband power meters will continue to be the decisive argument for their use. In practice, the data sheet specifications of about 2 % (0.09 dB) for unmodulated, spectrally pure signals of well-matched sources can seldom be achieved. This is due to those error sources that relate to the test signal or external circuitry: harmonics and nonharmonics, modulation, mismatch of the source, and the influence of attenuators and directional couplers connected ahead of the sensor for level matching.

The NRP sensors mark a great step towards resolving these problems. The expression *smart sensor technology* (see opposite page) stands for a whole series of measures intended to give the sensors the behaviour characteristic of thermal sensors. This includes very accurate measurement of average power, regardless of modulation (FIG 5), and high immunity to incorrect weighting of harmonics, spurious and other interference signals. The maximum speed of up to 1500 triggered measurements per second nevertheless equals that of diode sensors (in buffered mode, measurement interval 2 x 100 µs).

The effect of mismatched sources is reduced to the extent technically feasible by the sensors' small SWR (max. 1.13 between 30 MHz and 2.4 GHz), which is largely independent of the power to be measured. Despite this, the value given still results in an uncertainty of ±4 % (0.17 dB) on a source with an SWR of 2. This value, which dominates all other errors, can now be reduced to almost zero with the NRP sensors, if the complex reflection coefficient of the source is transmitted to the sensors via the USB data interface. The sensors then correct the matching error, taking into consideration their own impedance mismatch.

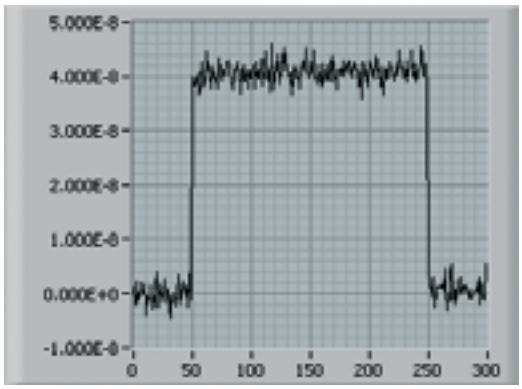

FIG 4 Power/time template of a nonrecurring RF burst for an application in medical electronics, measured with the NRP-Z11 (LabView application without basic unit; readings in W and ms, no averaging).

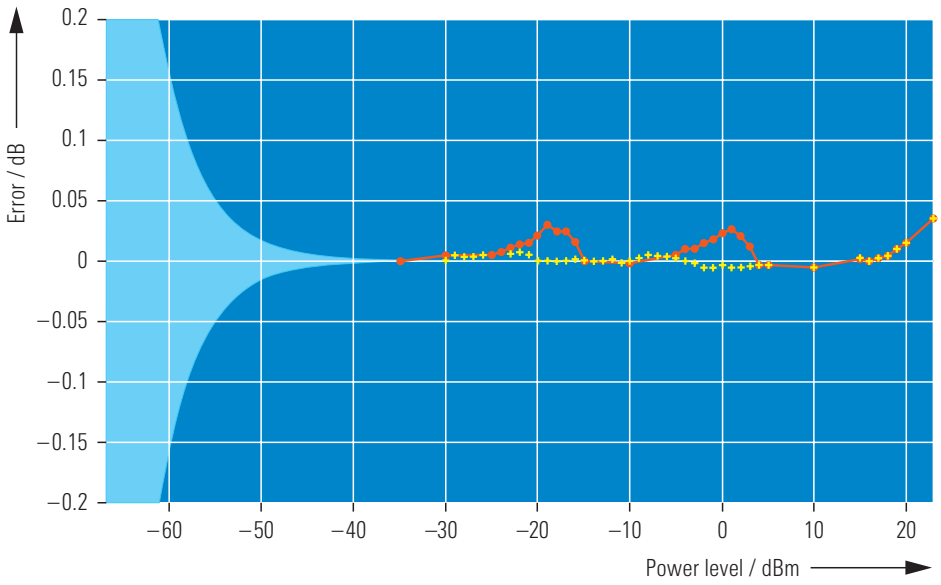

FIG 5 Modulation-related errors of an NRP-Z11 or NRP-Z21 power sensor for a 3GPP test signal (test model 1–64) compared to a CW signal of the same magnitude.
Red: default setting; yellow: transition area between measurement paths shifted by –6 dB; light blue: uncertainty caused by noise (modulation effect below –30 dBm negligible).

There is a similar problem if the sensor cannot be connected directly to the source, and a level-matching attenuator or connecting cable is necessary. In this case, the interactions between three components must be taken into account – a non-trivial bit of mathematics involving complex numbers. Here, too, the user is offered a straightforward, standardizable solution. With the help of a small software tool that runs on any PC, the complete S-parameter data set of the twoport connected ahead can be loaded into the sensor's memory in the common s2p (Touchstone) format, which every vector network analyzer can provide, and is then taken into account in the measurement. After the source's complex reflection coefficient has been transmitted, a perfectly corrected reading of maximum accuracy is obtained.

Costs per measurement halved

The price of a power meter that meets the requirements of modern communications technology is substantial, and is a sizeable part of the total cost of an RF measurement system. Users consequently often save in the wrong place, and shift the job of power measurement to other, less accurate instruments, or keep the number of test points low. There is no need for such compromises with the NRP sensors, since these can be operated directly on a controller, which is usually available anyway, thus saving the cost of the basic unit. One of the two USB adapters (NRP-Z3 or NRP-Z4) and the software tool kit included as a standard accessory are required for controlling by a PC. The software tool kit comes with both a DLL (dynamic link library) for individualized use of the entire sensor functionality under Windows™, and the *Power Viewer*, a virtual power meter with basic measurement functions for the PC workstation (FIG 7).

Universal basic unit

For those applications requiring a basic unit, the R&S NRP offers everything you expect from a modern power meter – and much more. No other instrument is as small, lightweight and rugged, and the optional battery pack ensures several hours of operation without line power. The NRP has a Windows-style menu interface, a high-resolution graphical display, and is operative in seconds, making it a pleasure to use. Depending on requirements, it can be fitted with one, two or four measurement inputs, an IEC/IEEE bus port being provided as standard. The shortest measurement time, from triggering to readout of the result, is 4 ms; only one modulation period is needed to measure very low-frequency modulated signals.

And evolution continues

The new family will be expanded continuously, starting with the extension of the frequency range. Sensors with upstream power attenuators as well as DC-coupled thermal sensors will be available. Since the influence of the basic unit is nonexistent, the latter will be the most accurate power references commercially available. Display of power versus time and remote control via the USB interface or Ethernet (optional) will round off the functionality of the basic unit.

Thomas Reichel

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

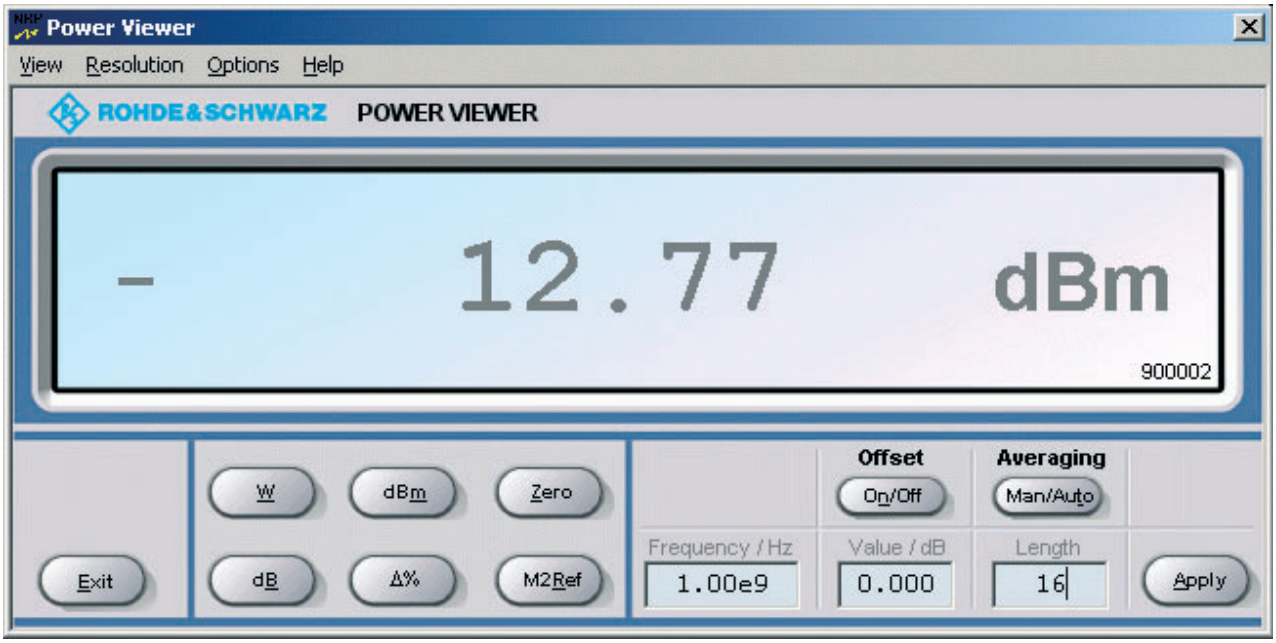

FIG 7 The *Power Viewer* turns any PC (under Windows 98 / 2000 / ME / XP) into a power meter.