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FIG 1 The R&S®NRP-Zxx power sensors are standalone measuring instruments capable of communicating with a PC via USB, and thus an ideal choice also for measurements on antenna systems.

EIRP measurements in the receive path of satellite links present a special challenge for T&M equipment in commercial satellite communications – and a new field of applications for the R&S®NRP-Zxx series of power sensors (FIG 1). The sensors measure EIRP at the detached antenna system of a Eutelsat earth station – with high accuracy and speed and excellent long-term and temperature stability, and remotely controlled via USB.

R&S®NRP Power Meters

Smart solution for satellite level monitoring

Satellite signals – subject to a variety of influences

Satellite links are indispensable in sound and TV broadcasting and in worldwide communications via telephone, the Internet, or mobile radio. Smooth, round-the-clock operation must therefore be ensured in particular for commercial systems.

However, if satellite signals arrive at an earth station with insufficient field strength, this may cause serious problems. The bit error ratio (BER) increases rapidly, to an extent that a communications link may be rendered useless. Such detrimental effects are attributable to a variety of causes. In many cases, atmospheric influences affect wave propagation: fog, clouds, and precipitation attenuate signals and also increase noise. Errors in antenna alignment may result in only part of the available power being picked up. This applies in particular to large, high-directivity parabolic antennas. Close attention must also be paid to the ambient conditions under which receiving systems have to operate: Many satellite antennas are installed in the open, i.e. they have to withstand humidity, extreme temperatures, and mechanical stress caused by wind load. This also has a negative effect on signal qual-

ity, which is aggravated by the effects of wear and tear that occur over the course of time.

Although the above effects increase attenuation on the transmission path by a few decibels only, this may easily exceed the capabilities of the background correction algorithms. This is due to the fact that only relatively low headroom is provided for the carrier-to-noise (C/N) ratio. This is by no means a planning error, but the result of economic considerations. Because, if the level of the incoming signal – which arrives at the antenna at approx. –115 dBm – were increased by a mere 3 dB in the interest of higher safety, either the satellite transmit power would have to be doubled or the diameter of the receiving antenna enlarged by 50 %. The more meaningful approach therefore is to invest in appropriate alternative strategies to make full use of the existing, scarce resources. This includes the continuous monitoring of the receive power in order to prevent creeping degradation of the system.

EIRP: the power that matters

To obtain comparable results of the receive power independently of the receive antenna characteristics, the equivalent isotropic radiated power (*EIRP*) of the satellite is calculated from the receive power. The *EIRP* is the power the satellite must radiate so that the measured receive power is obtained. For this calculation, it is assumed that an isotropic transmit antenna is used, i.e. an antenna that uniformly radiates in all directions.

$$\frac{EIRP}{\text{dBW}} = \frac{P_{RX}}{\text{dBm}} + \frac{G_r}{\text{dB}} + \frac{a}{\text{dB}} - 30$$

where P_{RX} is the receive power, G_r the gain of the receive antenna, and a the nominal path attenuation in the order of 200 dB. Comparing the *EIRP* values thus obtained with the satellite's specified *EIRP* will yield a measure of the current quality of the radio link.

How receive power is measured

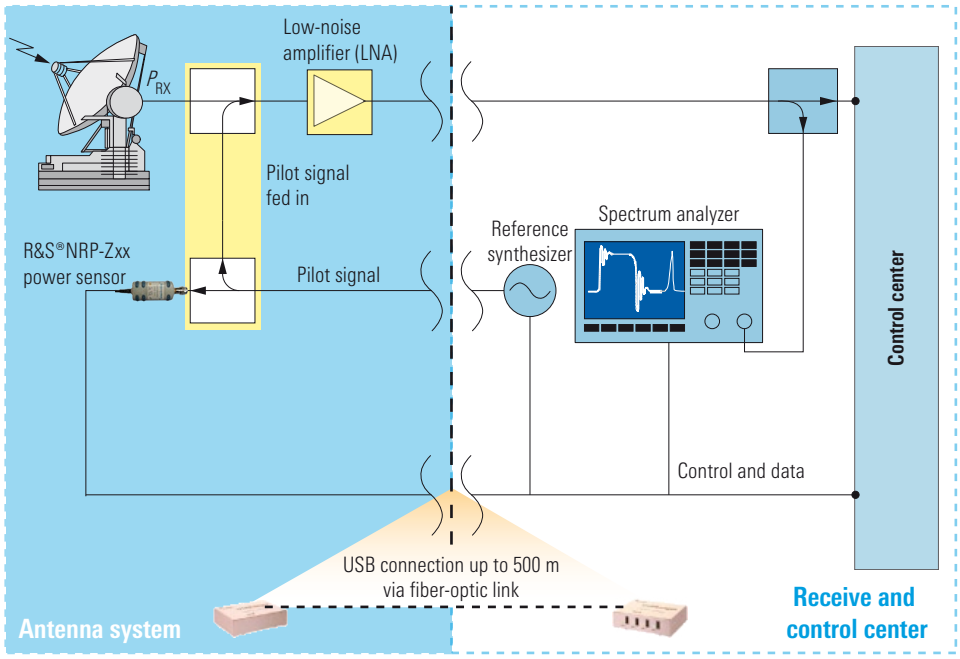
Optimal measurement point

The optimal measurement point is located between the antenna output and the input of the first, extremely low-noise amplifier (LNA), which is flange-mounted on the antenna. While signal level is lowest at this point, achievable measurement accuracy is highest. Measuring power at the receive and control center would cause uncertainties as a result of inadequate stability of the gain provided by the LNA and the attenuation introduced by the – possibly very long – antenna cable. As the receive level at the antenna output is very low – i.e. approx. 50 dB below the measurement limit of a diode power sensor – it must be measured indirectly.

The trick with the pilot signal

FIG 2 shows the measurement setup. A reference pilot signal with a known level is fed in at the measurement point. Like the signal from the satellite, the pilot signal travels through the entire transmission path up to the receive and control center, where a spectrum analyzer is used to determine the level difference between the two signals. Along the entire transmission path, both signals undergo the same amplification and attenuation, as their frequencies are almost identical. This means that the level difference measured at the spectrum analyzer is identical to the level difference at the measurement point, and thus the receive level at the antenna output is known. This is subject to the limitation, however, that the power sensor does not measure the pilot signal level directly at the feed-in point but some distance ahead where the pilot level is significantly higher. This level difference is due to the attenuation introduced by the intermediate, tightly connected passive components. Since the

FIG 2 Test setup for *EIRP* measurement in the receive path of a satellite-to-earth radio station configured for R&S®NRP-Z21 power sensors.



attenuation can be assumed to be stable in the long run, it needs to be measured only once. The resulting value is then subtracted from the value displayed on the power meter.

The critical point: the power meter

The actual measurement challenge, however, has to be met by the power sensor itself. It has to deliver accurate results under extreme temperature conditions and at a long distance from the base unit. Attempts to solve this measurement challenge have repeatedly been made using classic power meters, with varying outcome, however. The reason for this lies in the basic operating principle of these power meters, which use an internal 50 MHz reference signal. Since a reference signal is indispensable in order to perform accurate measurements – especially at the limits of the operating temperature range – a reference must also be provided for the pilot signal measurement. While this makes the test setup considerably more complex – involving additional switches and cable connections – it still does not yield the desired performance.

Always perfectly calibrated: power sensors from Rohde & Schwarz

The R&S®NRP-Zxx power sensors are tailor-made for this measurement task. They require only a simple measurement setup, deliver accurate results even without a reference signal, and considerably cut the costs of purchasing and maintenance. This is due to the sensors' design concept. The R&S®NRP-Zxx power sensors are standalone, remote-controllable instruments offering the complete functionality of a power meter. They are factory-calibrated to provide highly accurate measurements across their entire level, frequency and temperature range. They require no reference signal.

This concept has fully proven itself in over four years of field use. The power sensors have exhibited such excellent long-term stability that recalibration is actually unnecessary. As to the lack of a reference source in this application, it might be objected that it is not possible to detect defective sensors without a reference. While this is correct, the levels in this application are so low that any damage caused by overload can be ruled out. Failures of the sensors due to other causes are very rare, as they have an MTBF of over 300 000 hours (in accordance with IEC 1709, continuous operation at 50 °C ambient temperature).

The showstopper: the remote-control interface

Another difficulty that has to be overcome in this application is bridging the relatively large distance between the receive and control station and the antenna system. The power sensors must be capable of remote control over a distance of several hundred meters. Here, the high versatility of the power sensors really becomes apparent. Their standardized USB digital interface allows them to be used together with a wide range of favorably priced accessories. To enable operation beyond the USB-specific five-meter limit, active extenders are used. They are either based on conventional wired lines (e.g. economy-priced LAN cables) or fiber-optic links, the latter allowing distances up to 500 m to be bridged. The application described here uses a glass-fiber-based product from Icron® Technologies Corporation [*]; the power sensor is remotely controlled from a PC in the receive and control center. Eutelsat uses the R&S®Power Viewer software, which is a small application available free of charge for the R&S®NRP.

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

REFERENCES

[*] USB extenders, USB Ranger Series, Icron® Technologies Corporation, http://www.icron.com/company/contact.php