

Spectrum and signal analyzers for every requirement – an overview

The introduction of the Handheld Spectrum Analyzer R&S®FSH6 (page 26) expands an already full range of analyzers from Rohde & Schwarz, covering virtually every requirement with regard to level of performance, frequency range and functionality. You can find the right equipment for your development, production or installation needs from among our wide selection of instruments and options. Most of the instruments are identical in functionality and operation, allowing you to easily transfer programs or operating know-how from one instrument to the next.

The world of analyzers from Rohde & Schwarz

Since first entering the spectrum analyzer market, Rohde & Schwarz has continuously expanded its range of analyzers. The R&S®FSH, R&S®FS300, R&S®FSP, R&S®FSU, and R&S®FSQ families of instruments now cover the full scope of performance and frequency ranges. We offer virtually any type of instrument you need, from handheld spectrum analyzers up to high-end signal analyzers. Our instruments are designed for frequencies up to 50 GHz and higher (FIGs 1 and 2). FIG 3 provides an overview of the frequency ranges for the various families of instruments. FIG 4 compares the most important specifications.

New mobility in spectrum analysis – the R&S®FSH

The R&S®FSH is a handheld spectrum analyzer designed for measurement tasks in the field (see [1] and article on page 37). The brand-new model

R&S®FSH6 (page 26) offers a frequency range of 100 kHz to 6 GHz. The strengths of this family of instruments are easy operation, sturdy housing, and low weight. In addition, a built-in tracking generator and an integrated VSWR bridge enable you to perform DTF measurements on cables. You can use these analyzers to check antenna installations such as found at base stations and to analyze the spectrum for interference. The instruments even display antenna matching in vector format in a Smith chart.

The functionality of the R&S®FSH matches that of conventional lab instruments. Each instrument is equipped with an RMS detector for precise power measurements, channel power measurements, and burst power measurements in the time domain, plus an AM/FM audio demodulator, versatile marker functions and a port for connecting a power sensor. An increasingly important application is EMF analysis: The R&S®FSH has been combined with an antenna and software to create a separate test system for this purpose – the new R&S®TS-EMF [2].

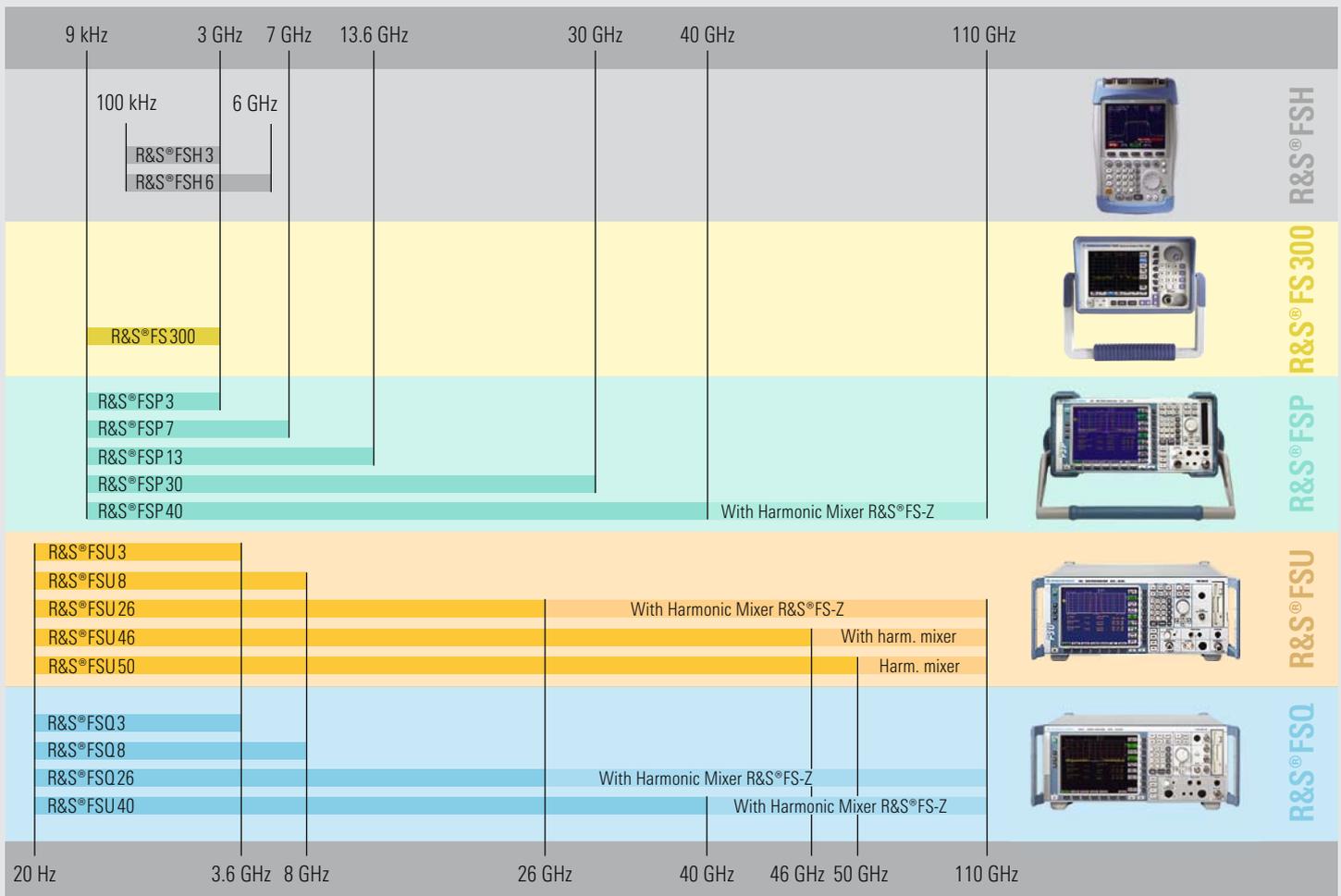
| | |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| R&S®FSH | 3 GHz/6 GHz handheld spectrum analyzer for mobile use in service and installation |
| R&S®FS300 | Economical 3 GHz spectrum analyzer for universal applications in service and production |
| R&S®FSP | Medium-class spectrum analyzer up to 40 GHz for most laboratory applications, service and measurement tasks in production |
| R&S®FSU | Spectrum analyzer with highest dynamic range up to 50 GHz for laboratory applications and for production when dynamic range requirements are high |
| R&S®FSQ | Signal analyzer with integrated spectrum analyzer up to 40 GHz (corresponding to the R&S®FSU) and up to 120 MHz I/Q demodulation bandwidth |

FIG 1 Analyzers from Rohde & Schwarz.



FIG 2 The full range of analyzers from Rohde & Schwarz covers virtually every requirement with regard to level of performance, frequency range and functionality.

FIG 3 Overview of the various frequency ranges.



► For all RF tasks – the R&S®FS 300

The R&S®FS 300 is a compact, universal and economical spectrum analyzer with properties previously found only in more expensive instruments [3]. The maximum permissible signal level is 33 dBm (2 W), which is more than most modern mobile phones are capable of, for example. This means low risk of destruction if power that is too high is unintentionally applied. For remotecontrol operation, this instrument relies on the widely used USB interface, eliminating the need for an IEC/IEEE bus card in the remote controller.

Medium-class instruments redefined – the R&S®FSP

The R&S®FSP is far more than just the right analyzer for general applications in the laboratory, in service and in the field. It is also the fastest RF spectrum analyzer currently available [4]. This makes it of particular interest for use in production and manufacturing. The following benchmarks show its enormous speed potential.

Its sweep rate in manual operation – i.e. the number of possible sweeps per second, including all processing time and return time – is 100 sweeps/s in zero span. This is faster than is necessary even for adjustment purposes. This high speed is useful, for example, if averaging over a large number of sweeps is necessary.

A common benchmark in remotecontrol operation is the sweep rate when transmitting all trace data via the IEC / IEEE bus. Capable of up to 80 sweeps/s in zero span and up to 55 sweeps/s for spans <10 MHz, the R&S®FSP is probably today's fastest analyzer.

In addition, integrated complex measurement and analysis routines significantly speed up measurements. This includes the List mode, which enables you to perform an entire series of measurements at various frequencies and different settings by using a single remotecontrol command. By using this function together with many different kinds of channel filters, the R&S®FSP operates like a very fast, accurate and selective power meter. You can also use the R&S®FSP's Fast ACP function to measure adjacent channel power with channel filters in the time domain. In accordance with the selected standards, the analyzer tunes to different channel frequencies one after the other, where it measures the power in the predefined measurement time using the channel filters specified for each frequency. Compared with conventional integration methods, performing measurements with the channel filters is approx. 10 times faster. The VCO synthesizer concept makes frequency switching so fast that total measurement time is hardly affected.

Both high measurement speed and intelligent analysis routines shorten test times and increase throughput, yielding highly effective production. Reliability is another major concern in production. Instruments must hold up well during continuous operation. The optional electronic attenuator ensures high reliability. It can even cope with the largest of switching cycles without experiencing wear.

The remaining functionality, which is on par with any high-end instrument, makes the R&S®FSP the ideal analysis tool in development if an extremely high dynamic range is not required, for example in the development of mobile phones. When it comes to application-specific firmware, the R&S®FSP is also comparable to the R&S®FSU and R&S®FSQ. For example, firmware is available for mea-

suring code domain power on 3GPP/WCDMA, cdma2000 or TD-SCDMA signals, for measuring the signal parameters of GSM or EDGE signals, and even for measuring EVM on WLAN signals in accordance with IEEE802.11a.

The analyzer is optimally suited for use in the field since its weight is very low for an instrument of its class. With the optional battery power supply, it can also be battery-operated.

High-end for any requirement – the R&S®FSU

The primary difference between the high-end Spectrum Analyzer R&S®FSU [5] and the R&S®FSP is that the R&S®FSU offers an expanded dynamic range and RF performance, right up to the limit of what is feasible. This is evident in its phase noise, intermodulation properties and 1 dB compression point. In the frequency range around 1 GHz and up to 2 GHz, which is important in mobile communications, it reaches a TOI of typically +25 dBm to +27 dBm. These values are well in line with many high-end communications receivers. With a 1 dB compression point of +13 dBm, it can measure signals with a power of up to +5 dBm at an RF attenuation setting of 0 dB, i.e. without impairment of the displayed average noise level. This factor and the instrument's excellent phase noise of -160 dBc (1 Hz) at 10 MHz from the carrier allow the R&S®FSU to measure spurious emissions even on GSM or WCDMA base stations with minimum use of filters. There is no need for expensive, tunable notch filters.

Another example of the advantages of its high dynamic range is its capability to measure adjacent channel power on a 3GPP WCDMA signal. Its value of 77 dB for a four-carrier signal is sufficiently different from the values commonly encountered in base stations and

| | R&S®FSH | R&S®FS300 | R&S®FSP | R&S®FSU | R&S®FSQ |
|---------------------------------------------------------------------|-----------------------------------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|----------------------------------|
| Type | Handheld spectrum analyzer | Universal spectrum analyzer from the Family 300 | General-purpose spectrum analyzer | High-performance spectrum analyzer | High-performance signal analyzer |
| Frequency range | 100 kHz to 6 GHz | 9 kHz to 3 GHz | 9 kHz to 40 GHz | 20 Hz to 50 GHz | 20 Hz to 40 GHz |
| With external mixer | – | – | up to 1.12 THz ¹⁾ | up to 1.12 THz ¹⁾ | up to 1.12 THz ¹⁾ |
| Frequency uncertainty at 1 GHz | 2000 Hz | 2000 Hz | 1000 Hz | 180 Hz | 180 Hz |
| Optional | – | – | 180 Hz | 50 Hz | 50 Hz |
| Resolution bandwidths | | | | | |
| Standard filter | 100 Hz to 1 MHz 1 kHz to 1 MHz (model .13) | 200 Hz to 1 MHz | 10 Hz to 10 MHz | 10 Hz to 50 MHz | 10 Hz to 50 MHz |
| FFT filter | – | – | 1 Hz to 30 kHz | 1 Hz to 30 kHz | 1 Hz to 30 kHz |
| Channel filter | – | – | 100 / 200 / 300 / 500 Hz, 1 / 1.5 / 2 / 2.4 / 2.7 / 3 / 3.4 / 4 / 4.5 / 5 / 6 / 8.5 / 9 / 10 / 12.5 / 14 / 15 / 16 / 20 / 21 / 25 / 30 / 50 / 100 / 150 / 192 / 300 / 300 / 500 kHz, 1 / 1.2288 / 1.5 / 2 / 3 / 5 MHz | | |
| RRC filter | – | – | 18 / 24.3 kHz, 1.28 / 3.84 / 4.096 MHz | | |
| EMI filter | – | – | 200 Hz, 9 kHz, 120 kHz | | |
| Displayed average noise level²⁾ | | | | | |
| At 1 GHz | –114 dBm (1 kHz) | –120 dBm (300 Hz) | –145 dBm (10 Hz) | –148 dBm (10 Hz) | –148 dBm (10 Hz) |
| At 26 GHz | – | – | –128 dBm (10 Hz) | –138 dBm (10 Hz) | –136 dBm (10 Hz) |
| At 40 GHz | – | – | –120 dBm (10 Hz) | –133 dBm (10 Hz) | – |
| Third order intercept (TOI)²⁾ | 13 dBm | 5 dBm | 15 dBm | 27 dBm | 27 dBm |
| Dynamic range for 3GPP ACLR in adjacent channel²⁾ | – | – | 66 dB | 84 dB | 84 dB |
| Phase noise (10 kHz offset)²⁾ | –85 dBc (1 Hz), 30 kHz offset | –90 dBc (1 Hz) | –113 dBc (1 Hz) | –123 dBc (1 Hz) | –123 dBc (1 Hz) |
| Measurement uncertainty | 1.5 dB | 1.5 dB | 0.5 dB | 0.3 dB | 0.3 dB |
| Linearity of display | | | 0.2 dB | 0.1 dB | 0.1 dB |
| Bandwidth of I/Q demodulation | – | – | 8 MHz | 8 MHz | 28 MHz, as option up to 120 MHz |
| I/Q memory | – | – | 128 ksamples | 512 ksamples | 16 ksamples |
| Speed | | | | | |
| Sweep time, span >10 Hz | 100 ms to 1000 s | 100 ms to 1000 s | 2.5 ms to 16000 s | | |
| Zero span | 1 ms to 100 s | 100 µs to 20 s | 1 µs to 16000 s | | |
| Measurement rate on IEC/IEEE bus ³⁾ | – | – | 80/s | 70/s | 70/s |
| Preamplifier | models .03 and .23 | | up to 7 GHz | up to 26 GHz | up to 26 GHz |
| Tracking generator | | | | | |
| Internal | models 13 and 23: up to 3 GHz | – | up to 3 GHz | up to 3.6 GHz | – |
| External | – | – | with External Generator Control R&S®FSP-B10 and signal generators such as the R&S®SMR, R&S®SMP, R&S®SMIQ | | |
| LAN | – | – | optional | standard | standard |
| Battery operation | standard | – | optional | – | – |
| Connector for power sensor | standard | – | optional | optional | optional |

FIG 4 Comparison of the analyzer's main specifications.

- 1) With Rohde & Schwarz Harmonic Mixers R&S®FS-Z60, R&S®FS-Z90 and R&S®FS-Z110 up to 110 GHz.
- 2) Best performance, typical.
- 3) Zero span, 1 sweep including trace data transmission.

- ▶ power amplifiers to yield adequate measurement uncertainty. In the case of one-carrier signals, it can achieve adjacent channel power ratios of up to 84 dB.

If you operate the R&S®FSU together with the application firmware packages for GSM/EDGE, 3GPP or cdma2000, it is the ideal analyzer for base station tests, both in development and in production.

The microwave models R&S®FSU26, R&S®FSU46, and R&S®FSU50 have been optimized for the special requirements in this frequency range. The low displayed average noise level of typ. -148 dBm in a 1 Hz bandwidth at 26 GHz, and -138 dBm (1 Hz) at 46 GHz, supports precise and sensitive measurements. Sophisticated YIG filter corrections, which are critical to high measurement accuracy, ensure the repeatability and stability of measurements.

Broadband communications firmly under control – the R&S®FSQ

The Signal Analyzer R&S®FSQ is based on the R&S®FSU and combines its excellent RF characteristics with the versatility of a broadband signal analyzer. The main difference is the digital signal analysis, which was developed for the large demodulation bandwidth of 28 MHz and provides additional DSP computing capacity.

This large demodulation bandwidth makes the R&S®FSQ precisely the right instrument for measurements on 3GPP WCDMA multicarrier signals, whether for determining the amplitude statistics via the CCDF measurement function or for measuring the code domain power. As for the adjacent channel power ratio, the R&S®FSQ reaches the same values as the R&S®FSU, e. g. 77 dB in the adjacent channel of a four-carrier WCDMA signal.

The R&S®FSQ shows its particular strengths when used together with the general vector analysis option, which is available only for the R&S®FSQ. This option features not only a large bandwidth, as evident from the high symbol rate of up to 25 Msymbol/s. Measurement rates of up to 40 measurements/s on GSM or EDGE signals are also possible. Conventional modulation types up to 256QAM are supplied with the instrument. Special software tools enable you to even design modulation constellations or to use self-designed baseband filters, increasing the instrument's versatility. A new measurement function is particularly of interest to developers of highly linear amplifiers: By analyzing a demodulated signal such as a 64QAM signal, the vector signal analysis option determines the distortion characteristic of the amplifier inserted between a transmitter and the analyzer and then displays it directly as an AM/AM and AM/ ϕ M characteristic.

When performing measurements at the chip level, you often need to analyze baseband signals. You can do this with the R&S®FSQ by adding the baseband input option, whose baseband inputs can be switched between balanced and unbalanced.

You can achieve even higher demodulation bandwidths of 60 MHz (up to 3.6 GHz) or 120 MHz (above 3.6 GHz) by using the baseband expansion option. In vector signal analysis, you can therefore directly measure symbol rates of up to 81.6 Msymbol/s. When operated with this option, the R&S®FSQ26 or the R&S®FSQ40 is optimally suited for analyzing broadband satellite signals and microwave signals.

Functions supplied with the R&S®FSP, R&S®FSU, R&S®FSQ

The R&S®FSP, R&S®FSU and R&S®FSQ all feature the same user interface and remote control commands. This makes important, complex measurement routines the same in all three families. Once you learn one instrument, you know them all. You can also use most programs without making changes.

A short list of functions includes the following:

- ◆ Fast ACP and List mode
- ◆ CCDF measurement
- ◆ Versatile measurement functions for channel and adjacent channel power, including for multicarrier signals with up to 12 payload carriers
- ◆ 23 predefined standards for adjacent channel power measurements
- ◆ Probably the widest choice of filter characteristics available, ranging from FFT and channel filters up to RRC filters
- ◆ Full range of detectors, including RMS and quasi-peak
- ◆ TOI measurement function
- ◆ Rapid frequency counter (1 Hz resolution at a measuring time of 30 ms)
- ◆ Occupied bandwidth
- ◆ Split-screen display with independent measurement settings in both windows
- ◆ Automatic output of all signals in the spectrum as a list, e. g. for spurious measurements
- ◆ Noise and phase noise markers
- ◆ C/N and C/N₀ measurement functions
- ◆ Command-set compatibility with HP 8566A/B und HP 8563

| Standard | Measurements on mobile stations | Measurements on base stations |
|------------------|---------------------------------|-------------------------------|
| GSM/EDGE | R&S®FS-K5 | R&S®FS-K5 |
| WCDMA 3GPP UMTS | R&S®FS-K73 | R&S®FS-K72 |
| HSDPA for 3GPP | R&S®FS-K73 | R&S®FS-K74 |
| cdma2000 | R&S®FS-K83 | R&S®FS-K82 |
| cdma2000 1xEV-DV | R&S®FS-K83 | planned for R&S®FS-K82 |
| cdma2000 1xEV-DO | R&S®FS-K85 | R&S®FS-K84 |
| TD-SCDMA | R&S®FS-K77 | R&S®FS-K76 |

FIG 5
Mobile-radio-specific application firmware packages.

| Application | Type designation | R&S®FSP | R&S®FSU | R&S®FSQ |
|-----------------------------------------------------------|----------------------------------------------------------------------|------------|---------|---------|
| Mobile radio | | | | |
| GSM/EDGE | Modulation and spectrum measurements on mobile and base stations | R&S®FS-K5 | ● | ● |
| 3GPP | Modulation, code domain and spectrum measurements on base stations | R&S®FS-K72 | ●* | ● |
| HSDPA | Expansion for R&S®FS-K72 | R&S®FS-K74 | ●* | ● |
| 3GPP | Modulation, code domain and spectrum measurements on mobile stations | R&S®FS-K73 | ●* | ● |
| TD-SCDMA | Modulation, code domain and spectrum measurements on base stations | R&S®FS-K76 | ● | ● |
| TD-SCDMA | Modulation, code domain and spectrum measurements on mobile stations | R&S®FS-K77 | ● | ● |
| cdma2000 IS-95/cdmaOne | Modulation, code domain and spectrum measurements on base stations | R&S®FS-K82 | ● | ● |
| cdma2000 incl. 1xEV-DV | Modulation, code domain and spectrum measurements on mobile stations | R&S®FS-K83 | ● | ● |
| cdma2000 1xEV-DO | Modulation, code domain and spectrum measurements on base stations | R&S®FS-K84 | ● | ● |
| cdma2000 1xEV-DO | Modulation, code domain and spectrum measurements on mobile stations | R&S®FS-K85 | ● | ● |
| Other wireless applications | | | | |
| <i>Bluetooth</i> | R&S®FS-K8 | ● | ● | ● |
| WLAN 802.11a/b/g/j | R&S®FSQ-K91 | | | ● |
| WLAN 802.11a | R&S®FSP-K90 | ● | | |
| General measurement applications | | | | |
| AM/φM/FM demodulator, including THD and SINAD measurement | R&S®FS-K7 | ● | ● | ● |
| Measurements with power sensors | R&S®FS-K9 | ● | ● | ● |
| Noise factor and gain measurements | R&S®FS-K30 | ● | ● | ● |
| Phase noise measurements | R&S®FS-K4 | ● | ● | |
| General vector signal analysis | R&S®FSQ-K70 | | | ● |

FIG 6 Overview of application-specific options for the R&S®FSP, R&S®FSU, and R&S®FSQ families.

* Requires additional hardware: R&S®FSP-B15/FSP-B70.

- To the extent allowed by the bandwidth, the numerous application-specific firmware packages that are available are also highly similar. They cover all common mobile radio standards (2G, 2.5G, 3G) plus the data rate increase for 3GPP, HSDPA or the new TD-SCDMA standard, as shown in FIG 5. In addition, packages for general-purpose measurement applications are available, e. g. for measuring noise factors, phase noise, or a general-purpose AM/FM/ϕM measurement demodulator. FIG 6 provides a full overview.

Important options

A few of the numerous options available for the analyzers are highlighted here:

External generator control

This option enables you to use commercially available signal generators in scalar network analysis as tracking generators for transmission measurements and – with an additional bridge – for reflection measurements. This expands the frequency range for scalar network measurements beyond the range of installable tracking generators (up to 3 GHz in the R&S®FSP, and up to 3.6 GHz in the R&S®FSU and R&S®FSQ). Since frequency generation in the generator is completely separate from that in the analyzer in such cases, you can easily perform measurements on frequency-converting DUTs with almost any offset. This also enables you to quickly and easily determine characteristics such as filter passband characteristics or cable loss in the microwave range (for example, up to 40 GHz with the R&S®FSP 40 and R&S®SMR 40). You can often use an existing generator since this option supports generators from Rohde & Schwarz and other manufacturers.

Power sensor measurements

This option allows you to connect the Power Sensors R&S®NRP-Z11 and R&S®NRP-Z21 via the USB interface. The measurement result is displayed either by itself in the split-screen mode or, like a marker result, directly on the analyzer display. When you measure absolute power, the high accuracy of the sensors is thus available in the analyzer for applications in which the instrument's own low measurement uncertainty of 0.3 dB (R&S®FSU and R&S®FSQ) is not sufficient. This may be the case, for example, when calibrating the output level of generators. The power sensors enable you to precisely determine the absolute power at a level as a reference and then measure the other level stages with the high linearity of the relative level display of the analyzer (R&S®FSU and R&S®FSQ <0.1 dB).

Analysis in the frequency range above 46 GHz

Frequencies in the high GHz range still require the use of external harmonics mixers even today. You can connect external mixers to the R&S®FSP 40, R&S®FSU 26, R&S®FSU 46, R&S®FSU 50, R&S®FSQ 26, or R&S®FSQ 40 provided that these are equipped with the option LO/IF Ports for External Mixers. Mixers available from Rohde & Schwarz cover the frequency range up to 110 GHz. If you use other suitable mixers, a range of up to 1.1 THz is possible. When you use external mixers, you normally have to determine and suppress unwanted intermodulation products, which can take a lot of effort. The R&S®FSP, R&S®FSU, and R&S®FSQ do this automatically by using a software preselector.

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More information and data sheets at
www.rohde-schwarz.com
 (search term: type designation)

REFERENCES

- [1] Handheld Spectrum Analyzer R&S®FSH 3: New mobility in spectrum analysis. News from Rohde & Schwarz (2002) No. 175, pp 20–25
- [2] Portable System for EMF Measurements R&S®TS-EMF: Even more universal: EMF measurements from 100 kHz to 40 GHz and for UMTS. News from Rohde & Schwarz (2004) No. 181, pp 39–41
- [3] Spectrum Analyzer R&S®FS300: Favourably priced and universal for laboratory, service and production. News from Rohde & Schwarz (2003) No. 177, pp 20–23
- [4] Spectrum Analyzer R&S®FSP: Medium class aspiring to high end. News from Rohde & Schwarz (2000) No. 166, pp 4–7
- [5] Spectrum Analyzer R&S®FSU: Best RF performance – third generation of high-end analyzers. News from Rohde & Schwarz (2001) No. 171, pp 20–25