Signal Analyzers R&S FSQ

Bandwidth and dynamic range for future systems and technologies

The R&S FSQ is fully in line with the trend towards systems with higher data rates (e.g. wireless LAN) and multicarrier signals. With an analysis bandwidth of 28 MHz, the instrument is well prepared for future technologies and systems, without compromising on dynamic range and easily meeting the demands of all transmission standards. Using only complementary firmware applications, without hardware add-ons, the R&S FSQ is easily expanded into a multistandard or multicarrier analyzer.

FIG 1 The new R&S FSQ comes with optimum features for analyzing broadband transmission systems and multicarrier signals.

Solid advances

Similarly to the spectrum analyzers of the R&S FSE family [1] and the signal analyzers of the R&S FSIQ family [2], Rohde&Schwarz is continuing its successful product policy with the Spectrum Analyzers R&S FSU [3] and the new Signal Analyzers R&S FSQ. The R&S FSQ (FIG 1) is available for three different frequency ranges:

- R&S FSQ3 20 Hz to 3.6 GHz
- R&S FSQ8 20 Hz to 8 GHz
- R&S FSQ26 20 Hz to 26.5 GHz

The analog RF section of the analyzer matches for the most part that of the R&S FSU family in design and characteristics, but with extra capability for vector analysis of signals up to 28 MHz RF bandwidth. Similar to the R&S FSU, the R&S FSQ too features high sensitivity (–155 dBm (1 Hz) at 2 GHz), wide dynamic range (25 dBm TOI at 2 GHz) and low phase noise particularly at large carrier offsets (–160 dBc (1 Hz) at 10 MHz). This creates optimum conditions for signal analysis on broadband transmission systems and multicarrier signals.

Multicarrier signals call for an analyzer with extremely wide dynamic range. Power measurement in unused channels must not be affected by inherent noise, inherent intermodulation or phase noise. All three variables tighten the dynamic range. In the case of 4-carrier signals to 3GPP WCDMA, the wide dynamic range and the low inherent noise of –89 dBm

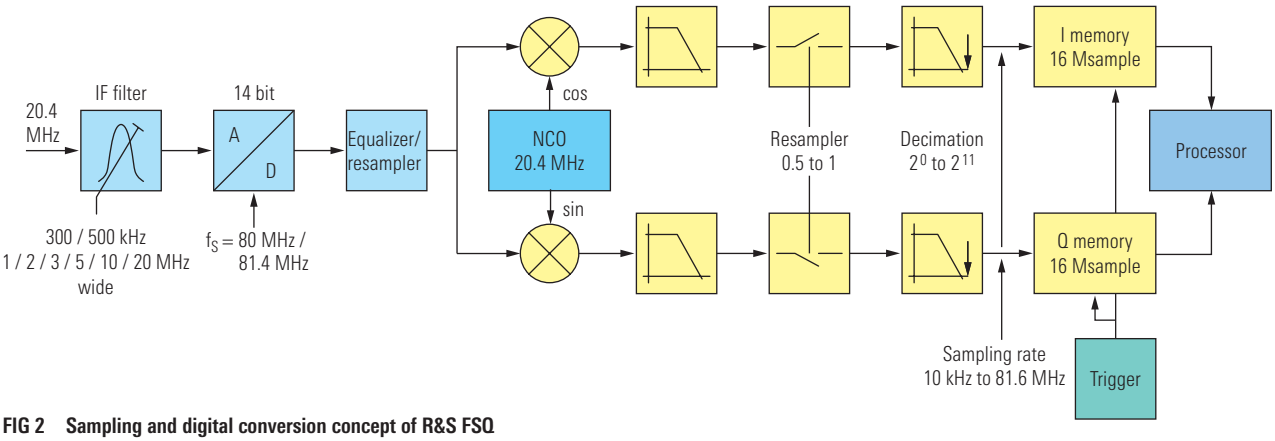


FIG 2 Sampling and digital conversion concept of R&S FSQ

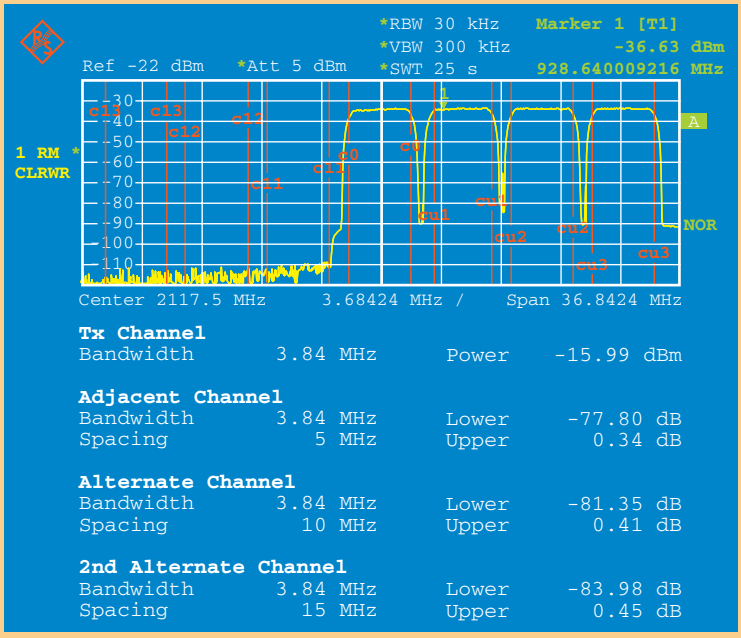
in 4 MHz bandwidth produce a dynamic range of approx. 67 dB in the adjacent channel. The RMS detector and an internal routine for inherent noise compensation allow a boost in dynamic range by as much as 10 dB to approx. 77 dB. With just one WCDMA carrier, level ratios up to 84 dB are possible in the adjacent channel (FIG 3). The R&S FSQ thus achieves the minimum dynamic range of 75 dB in the adjacent channel, which many users require for single carriers, also for WCDMA multicarrier signals.

The wide dynamic range of the analyzer also shows its worth when measuring spurious emissions. The high 1 dB compression point of the input mixer (+13 dBm) requires only a minimum of external filtering for mobile radio transmission systems of both the second and third generation [4]. This does away entirely with the need for tunable notch filters. The selectable number of test points (up to 10000 per trace) in conjunction with the RMS detector allows power measurements in just one sweep over wide frequency bands. So time-consuming division into several partial sweeps is quite unnecessary. The signal analyzer automatically searches for the maximum levels above a definable threshold, lists them in a table or transfers them to a controller by remote control.

The major difference between the R&S FSQ and FSU families is their signal evaluation. A completely new chip set for conversion to the I/Q baseband was developed that, compared to the R&S FSU, offers significantly higher bandwidth and wider dynamic range, more computing power and greater memory depth.

The R&S FSQ digitizes the 20.4 MHz intermediate frequency for conversion to the I/Q baseband with a sampling rate of up to 81.4 MHz (FIG 2). The resolution of the A/D converter is 14 bits, the equivalent RF bandwidth that can be obtained is 28 MHz. Using a digital resampler in the I/Q baseband, the sampling rate can be optimally adapted to the measurement signal. This resam-

FIG 3 Measurement of adjacent channel power on multicarrier WCDMA signals with noise compensation



pler converts the sampling rate of the A/D converter in realtime and without dynamic loss into almost any sampling rate between 10 kHz and 81.4 MHz. That eliminates the time-consuming signal processing routines often used to match the sampling rate to the symbol rate of digitally modulated signals. Considering the time it takes to record up to 16 million samples for the inphase and quadrature signal, measurement time is obviously reduced quite substantially.

The R&S FSQ equalizes the amplitude and group delay distortions of the analog receive channel also in realtime using a complex, digital compensation filter. For this purpose it uses a reference signal with exactly known frequency response and group delay. At a keystroke, it applies the reference signal to the RF input and calculates an appropriate compensation filter that is cut into the I/Q data stream during measurement. The resulting amplitude frequency response, for example, is < 0.2 dB over at least 66 % of the set resolution bandwidth (3 MHz to 50 MHz) or maximally 28 MHz. FIG 4 is an example of the amplitude, phase and group delay distortions measured at 20 MHz resolution bandwidth after correction.

Especially in broadband transmission, both the transmitter and receiver in the system commonly use analog technology for conversion to the baseband. The R&S FSQ can be retrofitted with analog baseband inputs for the analysis of analog I/Q baseband signals.

Sophisticated applications

Scaling and adjustment of multicarrier amplifiers

Output amplifiers for OFDM or CDMA signals and multicarrier amplifiers often take the form of feed-forward amplifiers to increase efficiency if the demands for suppressing adjacent channel power are very high. Amplifier adjustment requires the amplitude and phase information of the transfer function when the service signal is applied. This information can usually be derived from the complex baseband signal. The R&S FSQ measures the data at the amplifier output and outputs them with high bandwidth and dynamic range on the IEC/IEEE-bus or 100BaseT LAN interface. The recording time and sampling rate of the signal can be configured within wide limits.

Analysis of WCDMA signals

The Application Firmware R&S FS-K72 turns the R&S FSQ into a 3GPP signal analyzer for base station signals. It performs all measurements to 3GPP standard and additionally provides valuable data for in-depth analysis of WCDMA signals [5]. Broadband I/Q signal evaluation and the high computing power of the analyzer also enable measurement of multicarrier transmission signals. When, in future, base stations condition several WCDMA RF carriers straight away in the baseband – and possibly

FIG 4 Amplitude, phase and group delay distortion of I/Q data (20 MHz resolution filter)

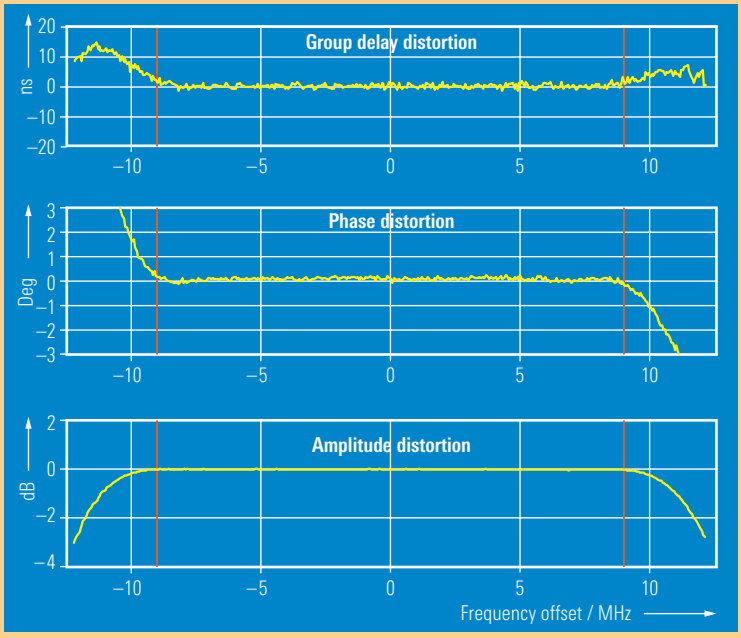
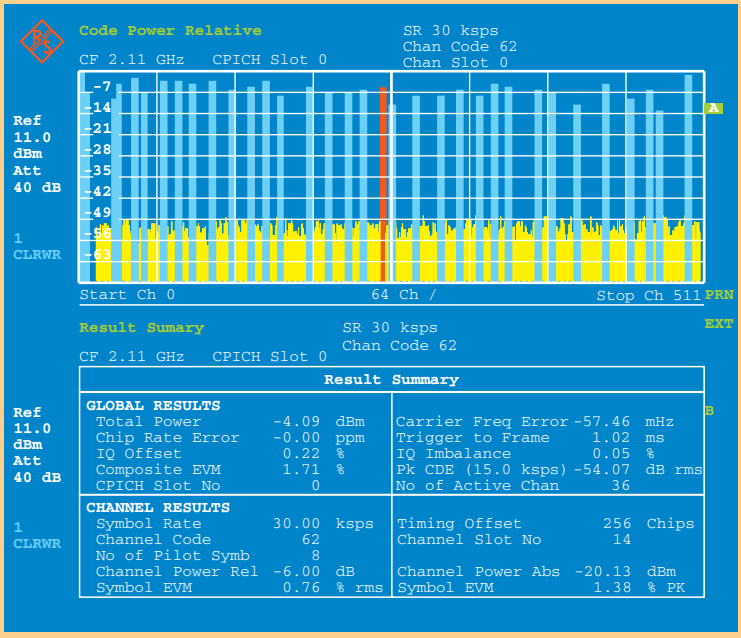


FIG 5 Measurement of WCDMA carrier in code domain



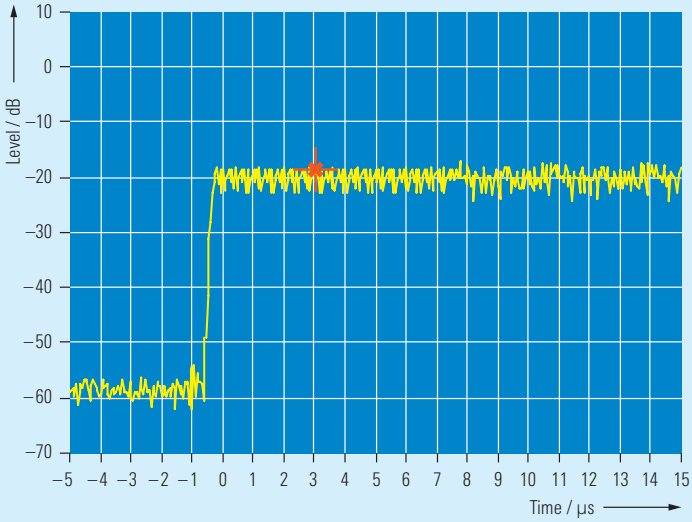


FIG 6 Timing

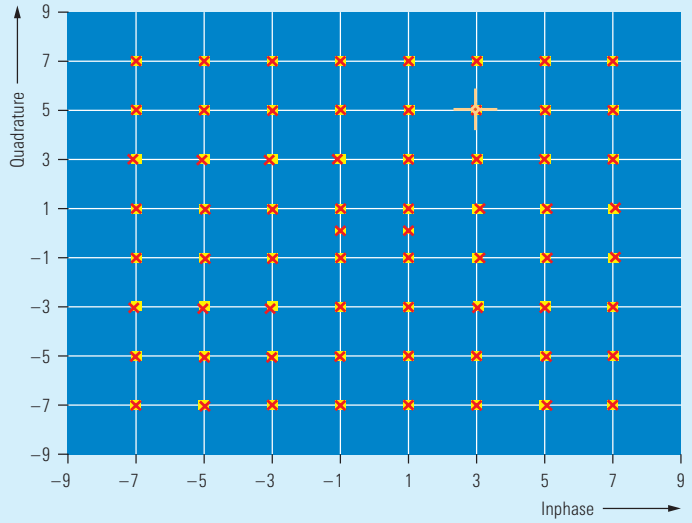


FIG 7 Constellation diagram at transmission rate of 54 Mbit/s (64QAM); red: real signal, yellow: ideal signal

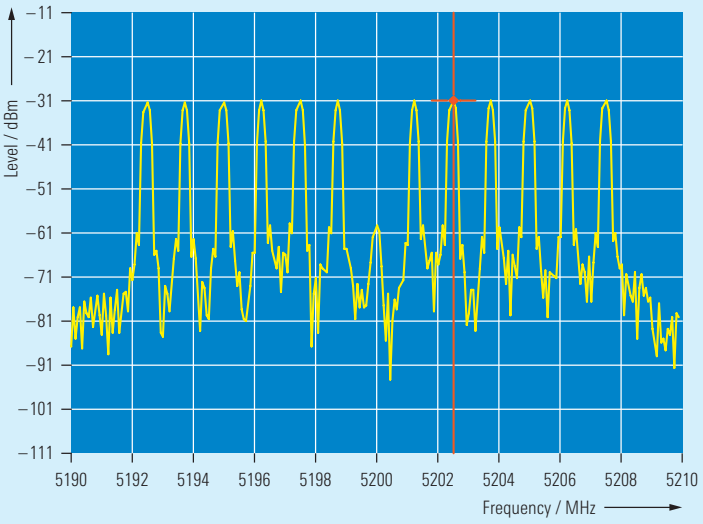


FIG 8 Preamble spectrum

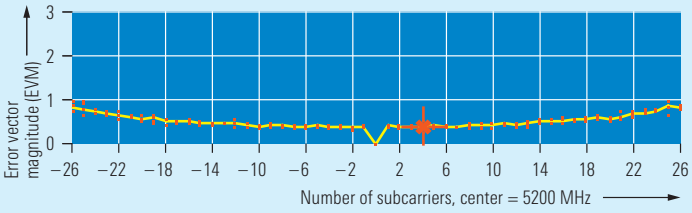


FIG 9 Error vector magnitude of individual OFDM signal carriers

Analysis of WLAN signals to IEEE 802.11a with Signal Analyzer R&S FSQ

Wireless LAN signals to IEEE 802.11a standard are intended for transmission rates of 6 Mbit/s to 54 Mbit/s. Transmission is by OFDM at 20 MHz channel spacing, with 52 carriers spaced at 312.5 kHz. The signal consequently occupies a bandwidth that previous RF spectrum analyzers were unable to process and was therefore the reserve of special-purpose instruments.

Especially for analyzing wireless LAN signals (IEEE 802.11a), the R&S FSQ can load Windows™ software that uses the I/Q data of the RF transmit signal to analyze it. It measures all key parameters of the OFDM signal in the frequency, time and modulation domains for the different transmission rates:

- Spectrum of a selectable section of the RF signal, e.g. preamble
- Amplitude distribution (CCDF) and crest factor
- Transmit spectrum mask
- Frequency error of RF signal and symbol frequency
- I/Q offset and I/Q imbalance
- Constellation diagram (BPSK, QPSK, 16QAM and 64QAM)
- Modulation error (EVM) per OFDM carrier or symbol
- Spectrum flatness
- Bits of payload symbols

FIGs 6 through 9 illustrate some measurements on an IEEE 802.11a signal at a transmission rate of 54 Mbit/s.

even for different kinds of transmission (a mix of 2G and 3G) – analyzers will be faced with new demands that can only be solved by broadband signal processing in the baseband, as is the case with the R&S FSQ. Fitted with the R&S FS-K72 option for example, the analyzer can measure the modulation characteristics of a WCDMA signal in the code domain even in the presence of one or more adjacent carriers. Thanks to its wide dynamic range, it is able to select and analyze a carrier by digital filtering to the exclusion of amplitude or phase distortion (FIG 5).

Both realtime equalization of the RF channel and digital conversion of the sampling rate by hardware to four times the symbol rate of 3.84 MHz significantly contribute to the high measurement speed. The analysis of a complete WCDMA frame thus takes only 1.5 s.

Analysis of WLAN signals

See box on the left.

General applications

For general applications in the lab or in production, the R&S FSQ – like the R&S FSU – provides a wide variety of functions that simplify measurements or help to avoid errors:

- Two independent measurement settings quickly selectable at a keystroke
- Split-screen display with independent measurement settings in both windows
- Four markers or delta markers
- Markers for measuring noise power density
- Markers for measuring oscillator phase noise
- Automatic intermodulation measurement for determining the third-order intercept point
- Frequency counter with 0.1 Hz resolution for a 50 ms measurement period
- Power measurement in the time domain (mean, RMS and peak power)
- Measurement of amplitude distribution (CCDF) and crest factor
- Measurement of occupied bandwidth
- User-definable limit lines (absolute or relative) with selectable margin and pass/fail indication
- Consideration of correction factors (transducers) in level measurement
- Fast measurement of levels with user-definable frequency lists in remote control mode
- Control of external generators for measuring transfer functions (option FSP-B10)

High measurement speed

The R&S FSU already set new standards for spectrum analyzers in terms of measurement speed. The R&S FSQ improves on this again with more powerful signal processing hardware and an even faster main processor. In remote control mode for example, it sends up to 50 measurement traces per second to the controller for a 10 MHz span. At zero span, the number of traces is 75.

Compatible with R&S FSE, FSP and FSU

The R&S FSQ family adds to the measurement functionality offered by Rohde&Schwarz spectrum analyzers. Compatibility plays a special role, in particular for remote control. User investment in test programs is not lost when changing to the R&S FSQ, which is to a large extent command-compatible with the Rohde&Schwarz instruments FSE, FSIQ, FSP [6] and FSU, if they contain the particular function.

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Condensed data of R&S FSQ

Frequency range	20 Hz to 3.6/8/26.5 GHz
Amplitude measurement range	–155 dBm to 30 dBm
Amplitude display range	1 dB, 10 dB to 200 dB in 10 dB steps, linear
Level measurement uncertainty	0.3 dB up to 3.6 GHz
Resolution bandwidths	1 Hz to 30 kHz FFT filter, in steps of 1/2/3/5, 10 Hz to 20 MHz in steps of 1/2/3/5 and 50 MHz, channel filter (100 Hz to 5 MHz)
Detectors	max. peak, min. peak, auto peak, sample, average, RMS, quasi-peak
Display	21 cm (8.4" colour TFT LCD, SVGA resolution)
Remote control	IEC 625-2 (SCPI 1997.0), RS-232-C, 100BaseT LAN

More information, data sheets and application notes at www.rohde-schwarz.com (search term: FSQ)

REFERENCES

[1] Spectrum Analyzer FSEM/FSEK – Fast spectrum analysis now through to 40 GHz. News from Rohde&Schwarz (1996) No. 152, pp 7–9

[2] Signal Analyzer FSIQ – Ready for all measurements on 3GPP base station transmitters. News from Rohde&Schwarz (2001) No. 170, pp 15–17

[3] FSU26: see p 25 in this issue

[4] Application note 1EF45, Spurious Emission Measurement on 3GPP Base Station Transmitters

[5] Data sheet WCDMA 3GPP Application Firmware R&S FS-K72

[6] Spectrum Analyzer FSP – Medium class aspiring to high end. News from Rohde&Schwarz (2000) No. 166, pp 4–7