Vector Signal Analyzer R&S FSQ-K70

Universal demodulation, analysis and documentation of digital radio signals

- For all major mobile radio communication standards:
  - GSM & EDGE
  - WCDMA-QPSK
  - CDMA2000-QPSK
  - *Bluetooth*™
  - TETRA
  - PDC
  - PHS
  - DECT
  - NADC
- For all common digital modulation modes:
  - BPSK, QPSK, OQPSK
  - π/4 DQPSK
  - 8PSK, D8PSK, 3π/8 8PSK
  - (G)MSK
  - 2, 4, (G)FSK
  - 16, 32, 64, 128, 256 (D)QAM
- 20.4 MHz symbol rate
- 28 MHz I/Q demodulation bandwidth
- Optimum representation of results:
  - In-phase and quadrature signals versus time
  - Magnitude and phase versus time
  - Eye diagram
  - Vector diagram
  - Constellation diagram
  - Table with modulation errors
  - Demodulated bit stream
  - Statistical evaluation of modulation parameters
  - Amplifier distortion measurements

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Universal analysis of digital radio signals

The vector signal analyzer option upgrades the high-quality Signal Analyzers R&S FSQ, adding universal demodulation and analysis capability down to bit stream level for digital radio signals. The option supports all common mobile radio communication standards.

Measurement and analysis of digital modulation signals

You want to measure and analyze digitally modulated signals? This can easily be done even up to 26 GHz with the vector signal analyzer option in the R&S FSQ.

In addition to performing standard measurements such as determination of modulation accuracy, carrier leakage or I/Q imbalance, you can also study the information statistics of these parameters such as the standard deviation of carrier frequency error calculated over 10 measurements.

Since the R&S FSQ-K70 can analyze digital signals, it is an ideal tool for use in development and production

Versatile in the lab

You may want to develop future or company standards, use unconventional formats or modify synchronization sequences.

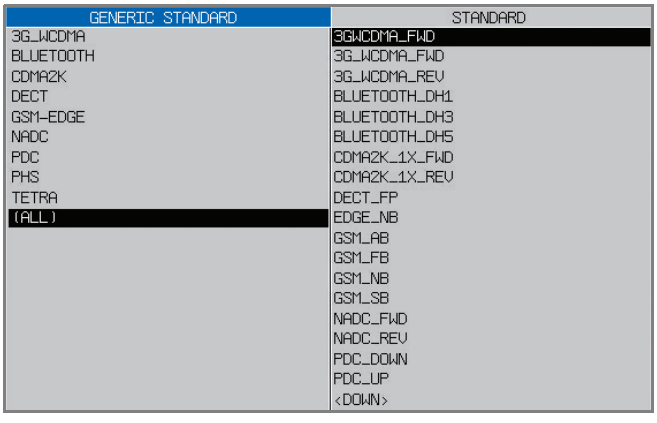
In all these cases, the R&S FSQ with the option R&S FSQ-K70 will support you by providing user-selectable bit and symbol rates, filters, modulation schemes and synchronization sequences. You can even generate and store your own generic standards, save the settings and recall them at any time.

Efficient in production

The high measurement speed of 60 sweeps/s in the analyzer mode and typically 20 measurements/s using the vector signal analyzer function is ideal for applications in production. The high flexibility allows multistandard test systems to be configured for easy adaptation to varying production requirements.

Any mobile radio standard at a key stroke

The high flexibility offered by the analyzer is by no means at the price of complicated operations: all major digital modulation standards can be activated at a key stroke. The instrument is then completely configured for measurements in line with the activated standard. The corresponding synchronization sequences are of course offered along with the standard.



List of standards

Multiple test functions integrated in one unit

The Signal Analyzers R&S FSQ in conjunction with the option R&S FSQ-K70 replace several individual instruments:

- High-grade spectrum analyzer
- Vector demodulator
- Constellation analyzer

Principle of vector signal analysis

The IF signal is digitized by means of a fast A/D converter, allowing purely digital processing of all subsequent analysis steps, thus making them practically error-free and providing high long-term and temperature stability. After A/D conversion, the signal is digitally mixed into the baseband and split into a real and an imaginary component. The complete signal information is thus available for further analysis.

The signal is demodulated down to bit level by a DSP. From the data stream thus obtained, an ideal signal is calculated. This reference signal is compared with the test signal. The resulting difference signal contains all modulation errors (see block diagram below).

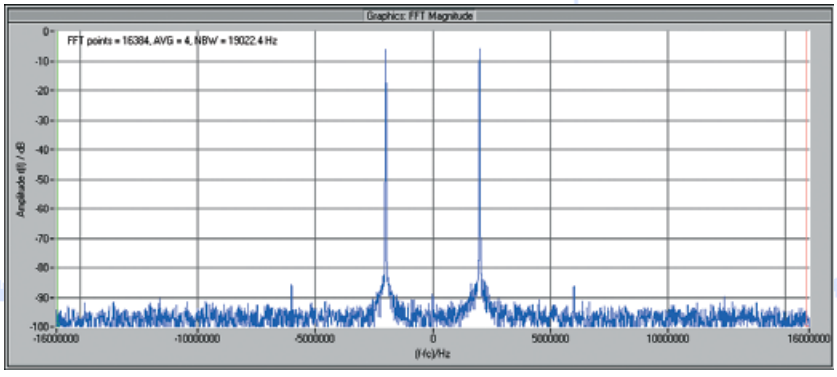
The R&S FSQ features a newly developed digital back end that benefits from the progress in ADC and ASIC development. Time-consuming evaluation algorithms can be implemented directly in hardware – a prerequisite for fast measurement and high accuracy.

- 14-bit A/D converter 81.6 MHz
- Digital hardware resampler to match the sampling rate to a multiple of the symbol rate
- Sampling rate from 10 kHz to 81.6 MHz adaptable to the modulation rate
- SFDR >80 dBfs
- Digital downconversion to baseband with high output bandwidth (28 MHz referred to RF)

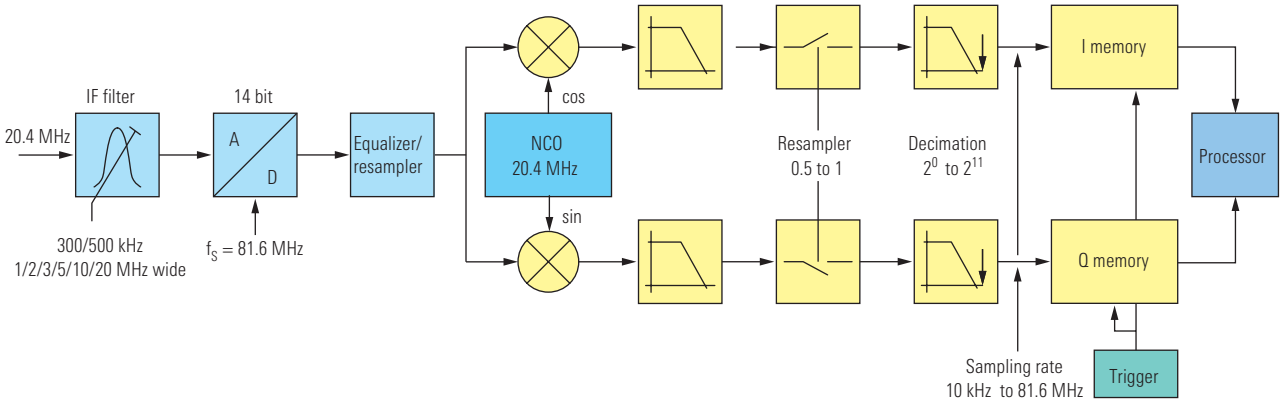
Visualizing amplifier influence on your signal

By analyzing the difference between the reference signal and the signal under test, the analyzer can display the distribution of the amplitude and phase error as a probability density function.

Furthermore, the phase and amplitude errors can be analyzed with respect to signal amplitude. The results can reveal the cause of modulation errors and help finding the optimum operating point for the amplifier.



Intermodulation distortion of I/Q data: a distortion-free transmission range is particularly important for amplifier measurements; the illustration above shows the intermodulation characteristics of the I/Q data of a two-tone signal.



Block diagram of vector signal analysis section in the R&S FSQ

Applications

Measurements on parts of signals (1)
To perform these measurements on TDMA systems such as EDGE in line with standards, a time reference must be established from synchronization sequences to pre- or midamble. This is done in the PATTERN SEARCH mode, in which the analyzer triggers on preset or user-defined synchronization sequences. This not only allows established standards to be measured with high precision, but also modified settings in the case of new developments. Further trigger modes are:

- External
- Burst

Picture 1 shows an example where the modulation quality is measured only on the training sequence of an EDGE signal.

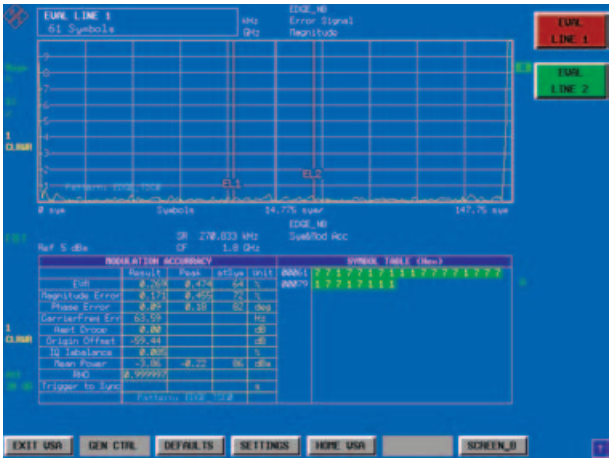
Modulation accuracy measurements on WCDMA mobiles (2 and 3)
The low inherent EVM of <0.6% (rms) of the option R&S FSQ-K70 substantially reduces uncertainty. Tolerances, e.g. an rms EVM error of 17.5% for WCDMA, can thus be allowed practically completely for the DUT, thus widening the DUT tolerance margin.

The SYMBOL TABLE/MODULATION ACCURACY lists the demodulated bits and the errors found. The bit sequences and the errors can be read via the fast IEC/IEEE bus or 100 Mbit LAN connection of the analyzer.

The constellation diagram of the QPSK signal and the probability distribution of the amplitudes are shown below.

Modulation error measurements on EDGE signals (4)
The upper screen (A) shows the EVM versus time of an EDGE signal; the lower screen provides a summary of relevant errors measured over a burst signal and several statistical parameters calculated over 10 bursts.

1



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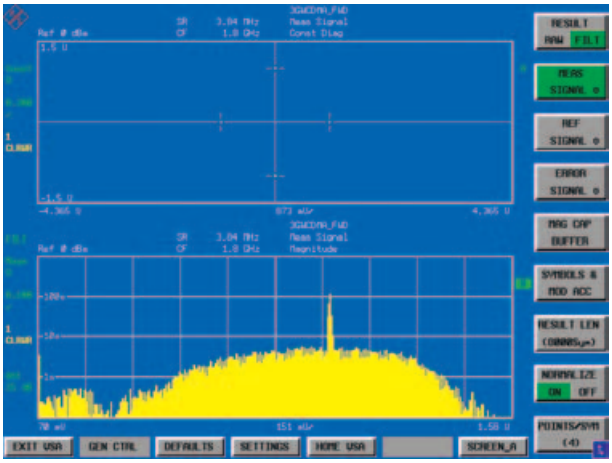

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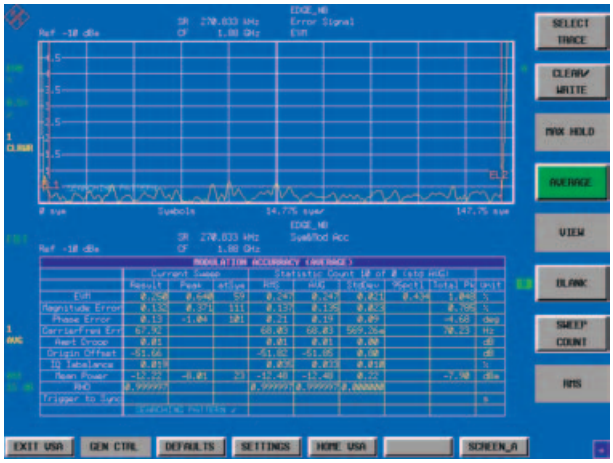

Convenient analysis with vector diagram (5)

The vector diagram enables convenient analysis of the degradation of modulation accuracy caused, for example, by nonlinearities, phase noise or amplitude-dependent phase response of amplifiers, converters, etc. The upper screen (A) shows the complete constellation diagram, the lower screen (B) the probability distribution of the error vector magnitude (EVM).

AM/φM and AM/AM distortion example with a 16 QAM signal (6 and 7)

Picture 6 shows the constellation diagram where the outer constellation points are drawn to the center of the diagram as a result of the amplifier compression. Picture 7 shows the AM/AM and AM/φM conversion curve of the same signal.

WLAN 802.11b constellation diagram (8)

Signals where the modulation format changes the signal quality can be analyzed with the R&S FSQ-K70. The constellation diagram in the upper half of the display is calculated from the QPSK part of an 802.11b signal marked with the red display lines. Due to the Gaussian pulse shaping filter used by the transmitter, the signal is not intersymbol-interference-free and the symbol points are not single points but are distributed in a square.

Specifications for R&S FSQ-K70 see PD 0757.8313.

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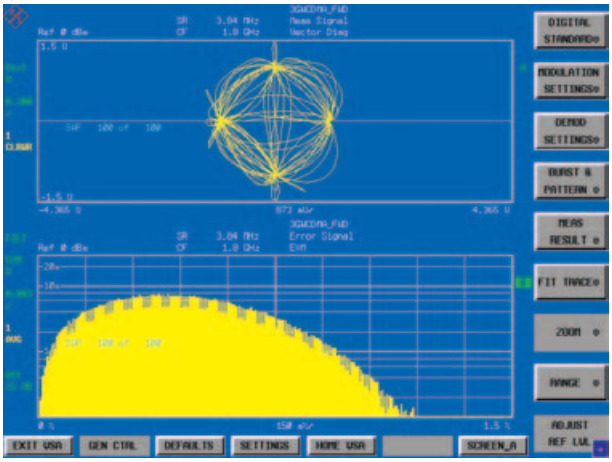

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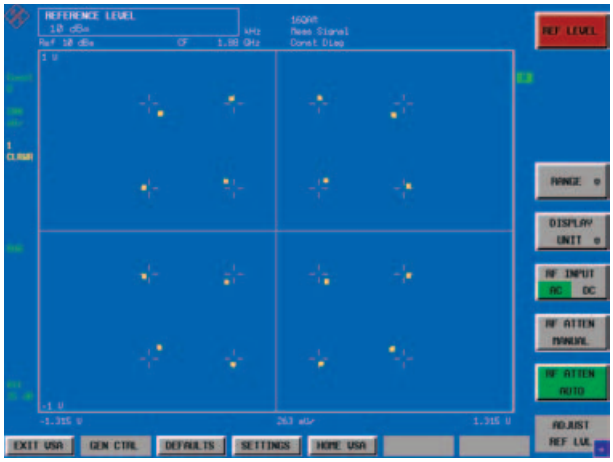

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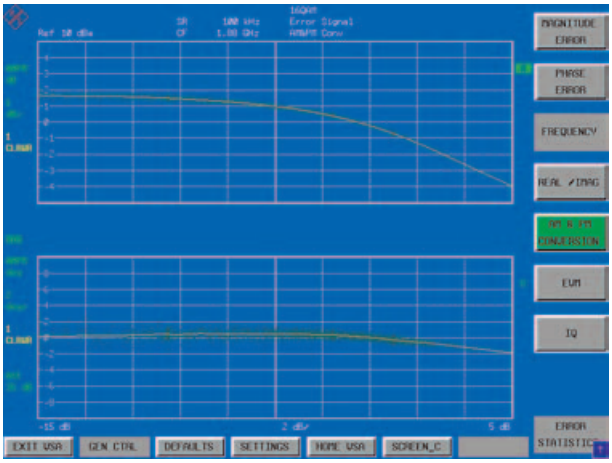

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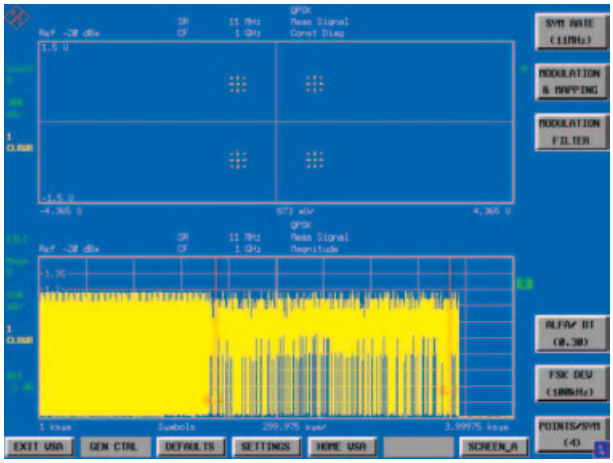

Certified Environmental System
ISO 14001
REG. NO 1954

Certified Quality System
ISO 9001
DQS REG. NO 1954

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Vector Signal Analyzer R&S FSQ-K70

Specifications

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The specifications of R&S FSQ-K70 are based on the datasheet specifications of Signal Analyzers R&S FSQ and have not been checked separately.

Specifications apply under the following conditions:
15 minutes warmup time at ambient temperature, specified environmental conditions met, calibration cycle adhered to and internal calibration performed. Data with tolerances are measurement uncertainties with a confidence level of 95%. Data without tolerances are typical values. The specified level measurement errors do not take into account systematic errors due to reduced S/N ratio.

Signal acquisition

Signal acquisition	Adjustable	Up to 8k symbols
Samples per symbol	1, 2, 4, 8, 16	
Symbol clock	Internally generated	
Carrier lock	Internally locked	
Triggering	 Searches data block for beginning of TDMA burst and performs analysis over detected burst length.	Single Continuous External Burst search
Data synchronization	Predefined patterns User-defined patterns	

Modulation formats

FSK	Including GFSK	2 FSK 4 FSK
MSK	Including GMSK	Yes
PSK	 (EDGE)	BPSK, QPSK, OQPSK, DQPSK, π/4 DQPSK, 8PSK, D8PSK 3π/8 8PSK
QAM Absolute encoding Differential encoding	 16QAM, 32QAM, 64QAM, 128QAM, 256QAM D16QAM, D32QAM, D64QAM, D128QAM, D256QAM	

Predefined standards

Cellular	
3GPP WCDMA (QPSK)	Forward link Reverse link
CDMA2000 1x (QPSK, OQPSK)	Forward link Reverse link
EDGE	Normal burst
GSM	Access burst Frequency correction burst Normal burst Synchronization burst
NADC	Forward link Reverse link
PDC	Downlink Uplink
PHS	Communication burst Control burst

Wireless networking		
Bluetooth™	BLUETOOTH is a trademark owned by Bluetooth SIG, Inc., USA and licensed to Rohde & Schwarz.	DH1 packets DH3 packets DH5 packets
Other		
DECT	Fixed part burst	
TETRA	Control burst downlink Data burst downlink	

Filtering

Filter types	Raised cosine (RC) Root raised cosine (RRC) CDMA2000 compliant Gaussian EDGE None
User- selectable Alpha BxT	 0.1 to 1 0.1 to 1

Symbol rate

Maximum symbol rate Maximum bandwidth	The symbol rate is limited by the max bandwidth. The analyzer automatically selects an appropriate bandwidth for the selected modulation bandwidth. Example: with raised cosine filtering Max. symbol rate 28 MHz/(1+alpha) ≤20.4 MHz	20.4 MHz 28 MHz

Measurement results

Formats other than FSK

Measured signal	Filtered, carrier locked, symbol locked	I/Q versus time Magnitude versus time Phase versus time PDF/CDF
Reference signal	Ideal, computed from detected symbols	I/Q versus time Magnitude versus time Phase versus time PDF/CDF
Error vector signal	Vector difference between measured and reference signal	I/Q versus time Magnitude versus time Phase versus time PDF/CDF
Error signal	Difference between measured magnitude/phase and reference magnitude/phase	Magnitude error versus time Phase error versus time PDF/CDF
Detected symbols	Symbols versus time	
Modulation accuracy	Single sweep based numerical results Statistical results over multiple sweeps	
AM/AM conversion AM/φM conversion	Gain error versus reference signal level Phase error versus reference signal level	

FSK measurement results

Measured signal	Magnitude versus time Instantaneous frequency versus time PDF/CDF	
Reference signal	Magnitude versus time Instantaneous frequency versus time PDF/CDF	
Deviation signal	Difference between instantaneous frequency of measured signal and reference signal	Deviation error versus time
Magnitude error signal	Difference between measured magnitude and reference magnitude	Magnitude error versus time

Display formats

The following trace formats are available for measured data and computed ideal reference data, with complete marker and scaling capabilities and automatic grid line adjustment to ideal symbol or constellation points.

Polar diagrams	Samples displayed only at symbol times Display of trajectory between symbol times with 1, 2, 4, 8, 16 points/ symbol	Constellation Vector
I or Q versus time		
Eye diagrams	Formats other than FSK FSK	I/Q Frequency
Error vector magnitude versus time		
AM/AM conversion AM/φM conversion	For modulation formats with amplitude variations	
Statistical diagrams	PDF CDF	

Error summary

Formats other than FSK

Measured rms and peak values	EVM can be calculated with or without removing I/Q offset I/Q offset	Error vector magnitude Magnitude error Phase error Carrier frequency offset Origin offset Amplitude drop I/Q imbalance Statistics

Error summary (FSK)

Measured rms and peak values	FSK errors can be calculated with measured deviation or ideal deviation	Deviation error Magnitude error Carrier frequency offset

Detected symbols

Symbol table

Symbol formats	Binary Octal Hexadecimal Decimal	
Symbol marker	Symbol mapping is user-definable with additional utility program. **Note:** Synchronization patterns are required to resolve carrier phase ambiguity in non-differential modulation formats.	Synchronization patters shown as inverse video

Measurement uncertainty

Formats other than FSK and OQPSK. Averaging = 10.
Conditions: Specifications apply from 20 °C to 30 °C, for a full-scale signal, fully contained in the selected measurement span, random data sequence;
instrument receiver mode;
RF >20 MHz;
level ≥–25 dBm;
start frequency ≥15% of BW;
alpha/ BT ≥0.3 (0.3 ≤ alpha ≤ 0.7 offset QPSK) and symbol rate ≥1 kHz;
for symbol rates <1 kHz or RF frequency >5 GHz, uncertainty may be limited by phase noise.

Residual errors

(Result = 150 symbols, averages = 10, frequency = 1 GHz)

Residual EVM	Symbol rate ≤100 kHz Symbol rate ≤1 MHz Symbol rate ≤10 MHz Symbol rate >10 MHz <15 MHz	0.5% rms 0.5% rms 1.0% rms 2.0% rms
Residual Magnitude error	Symbol rate ≤100 kHz Symbol rate ≤1 MHz Symbol rate ≤10 MHz Symbol rate >10 MHz	0.3% rms 0.5% rms 1.0% rms 1.5% rms
Residual Phase error	(For modulation formats with equal symbol amplitudes) Symbol rate ≤100 kHz Symbol rate ≤1 MHz Symbol rate ≤10 MHz Symbol rate >10 MHz	 0.3° rms 0.4° rms 0.6° rms 1.2° rms
Frequency error	Added to frequency accuracy, if applicable	Symbol rate/500000
I/Q origin offset	–60 dB or better	

Residual errors for standard measurements

Predefined standard settings and averaging = 10, frequency = 1 GHz

Residual EVM	3GPP WCDMA (QPSK) CDMA2000 EDGE TETRA NADC PDC	0.6% rms 0.4% rms 0.35% rms 0.5% rms 0.4% rms 0.55% rms
Residual Phase error	GSM	0.15° rms
Residual Deviation error	DECT	2.5 kHz rms

Frequency dependency of residual errors

Residual EVM	3GPP WCDMA (QPSK) Frequency 5 GHz 10 GHz 15 GHz 20 GHz 25 GHz	 0.9% 1.4% 2.1% 2.6% 4.0%
Residual EVM	QPSK, symbol rate 15 MHz, alpha = 0.22 Frequency 5 GHz 10 GHz 15 GHz 20 GHz 25 GHz	 1.2% 1.9% 2.3% 2.8% 3.8%

Measurement rate for standard measurements

Predefined standard settings, external trigger, continuous sweep

Measurements	3GPP WCDMA (QPSK) GSM (normal burst) EDGE (normal burst) DECT NADC CDMA2000	10/s 15/s 15/s 15/s 10/s 10/s

Ordering information

Vector Signal Analyzer for R&S FSQ	**R&S FSQ-K70**	**1161.8038.02**
Signal Analyzer 20 Hz to 3.6 GHz	R&S FSQ3	1155.5001.03
Signal Analyzer 20 Hz to 8 GHz	R&S FSQ8	1155.5001.08
Signal Analyzer 20 Hz to 26.5 GHz	R&S FSQ26	1155.5001.26
Recommended extras and options	**See data sheet Signal Analyzer R&S FSQ, PD 0757.7652**	
I/Q Baseband Inputs for Signal Analyzer R&S FSQ	R&S FSQ-B71	1157.0113.02

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