

# R&S®FSx-K91/-K91n, R&S®FSW/FSQ-K91ac WLAN Application Firmware

## WLAN TX measurements with Rohde & Schwarz analyzers



# R&S®FSx-K91/-K91n R&S®FSW-K91ac/ R&S®FSQ-K91ac WLAN Application Firmware At a glance

The R&S®FSx-K91/-K91n and the R&S®FSW/FSQ-K91ac application firmware packages expand the application range of the R&S®FSx signal and spectrum analyzers by adding the capability to perform spectrum and modulation measurements on signals in line with the WLAN IEEE 802.11a/b/g/j/n/ac standard.

The R&S®FSx-K91 application firmware covers standard-related tests as well as further evaluations for in-depth analysis in development for signals in line with the WLAN IEEE 802.11 a/b/g/j standard. The R&S®FSx-K91n application firmware extends the functionality of R&S®FSx-K91 to include spectrum and modulation measurements in accordance with the IEEE 802.11n standard. For measurements in line with the IEEE 802.11ac standard, the R&S®FSx-K91ac application firmware is needed.

R&S®FSx-K91/-K91n and R&S®FSW/FSQ-K91ac are versatile tools for all established WLAN IEEE 802.11 standards.

All WLAN measurement applications are fully remote-controllable via the IEC/IEEE bus or LAN, using SCPI commands. The operating concepts of the different analyzers are largely identical, including the IEC/IEEE bus commands. The analyzers provide a consistent platform for a wide scope of applications. They are ideal for development, design, verification and production applications. Users who are familiar with one of the analyzers can quickly master operation of the other analyzers.

## Key facts

- Analysis at the RF level or in the analog/digital baseband (optional)
- Demodulation bandwidth of 160 MHz with the R&S®FSW (equipped with R&S®FSW-B160 option)
- Modulation formats for IEEE 802.11a/g/j/n/ac: BPSK, QPSK, 16QAM, 64QAM, 256QAM
- Modulation formats for IEEE 802.11b: DBPSK, DQPSK, CCK, short PLCP, long PLCP
- Very low residual EVM down to -54 dB
- Legacy/mixed/Greenfield mode of IEEE 802.11n signals
- Support of very high throughput (VHT)

# R&S®FSx-K91/-K91n R&S®FSW-K91ac/ R&S®FSQ-K91ac WLAN Application Firmware Benefits and key features

## R&S®FSx-K91 WLAN application firmware

- Expands the R&S®FSW/FSQ/FSG/FMU/FSL/FSV signal and spectrum analyzers by adding the capability to perform spectrum and modulation measurements on signals in line with the IEEE802.11 a/b/g/j standard
- Provides complex WLAN measurements at a keystroke (automatic setting of modulation format)
- Performs measurements in the RF/IF range and in the baseband (analog and digital)
- Offers the ideal solution for a wide scope of WLAN applications
- Optimally designed for research, design, verification and production applications
- Allows remote control of all functions via IEC/IEEE bus or LAN

▷ [page 4](#)

## R&S®FSx-K91n WLAN application firmware

- Expands the R&S®FSW/FSQ/FSG/FSV/FSL signal and spectrum analyzers by adding the capability to perform spectrum and modulation measurements on WLAN IEEE802.11n signals
- Maximum analysis bandwidth of 40 MHz with the R&S®FSW (equipped with R&S®FSW-B40 option) and the R&S®FSQ (equipped with R&S®FSQ-B72 option) or the R&S®FSV signal and spectrum analyzers (equipped with R&S®FSV-B70 option)
- Support of legacy/mixed/Greenfield mode of IEEE802.11n signals

▷ [page 6](#)

## R&S®FSW-K91ac/R&S®FSQ-K91ac WLAN application firmware

- Adds the capability to perform spectrum and modulation measurements on WLAN IEEE802.11ac signals to the R&S®FSW or the R&S®FSQ signal and spectrum analyzers
- Maximum analysis bandwidth of 160 MHz with R&S®FSW signal and spectrum analyzer (equipped with R&S®FSW-B160 option)
- Maximum analysis bandwidth of 80 MHz with the R&S®FSQ signal and spectrum analyzer (equipped with R&S®FSQ-B72 option)
- Supports very high throughput (VHT) and 256QAM

▷ [page 7](#)

## Analyzers supporting WLAN measurements

Rohde&Schwarz offers a wide range of signal and spectrum analyzers for WLAN measurements:

- The R&S®FSx-K91/-K91n/-K91ac WLAN options provide the same user interface for a wide range of different spectrum and signal analyzers, offering optimal solutions for every application. No additional time is needed to transfer T&M equipment from R&D to production
- Analyzers equipped with R&S®FSx-K91/-K91n/-K91ac WLAN options are one-box solutions, which makes remote control easy. Test setups are straightforward and space-saving

▷ [page 8](#)

# R&S®FSx-K91

## WLAN application

### firmware

#### TX measurements on WLAN signals in line with IEEE 802.11a/b/g/j

The WLAN application firmware for the R&S®FSW, R&S®FSQ, R&S®FSG, R&S®FMU, R&S®FSV and R&S®FSL expands the application range of these analyzers by spectrum and modulation measurements on signals in line with the WLAN IEEE 802.11a/b/g/j standards. The outstanding analysis and evaluation capabilities of the R&S®FSW, R&S®FSQ's and R&S®FSG enable measurements beyond the scope of the standard, making them ideal for applications in development and verification. The R&S®FSV signal and spectrum analyzer with the R&S®FSV-K91 option is a favorably priced mid-range instrument for measurements in development and production of high-end components. The R&S®FSL spectrum analyzer with its unbeatable price is the optimal solution for production and is also ideal for service and maintenance applications because of its battery option.

#### Measurement results

##### IEEE 802.11a/g/j, IEEE 802.11 turbo mode (with R&S®FSQ only)

- | Spectrum mask with limit lines and pass/fail (17.3.9.2) and user-editable spectrum mask
- | Spectrum flatness with limit lines and pass/fail (17.3.9.6.2)
- | Constellation error, EVM (17.3.9.6.3)
- | Selectable tracking: phase, level, timing
- | RF carrier leakage (17.3.9.6.1)
- | Carrier frequency and symbol clock error (17.3.9.4, 17.3.9.)
- | Adjacent channel power
- | Constellation diagram for all carriers or a single carrier
- | Constellation overview
- | EVM versus carriers, EVM versus symbols
- | Group delay
- | Time-gated spectrum (FFT)
- | CCDF (also time-gated) and crest factor
- | Bit stream

##### IEEE 802.11b, IEEE 802.11g-CCK/DSSS

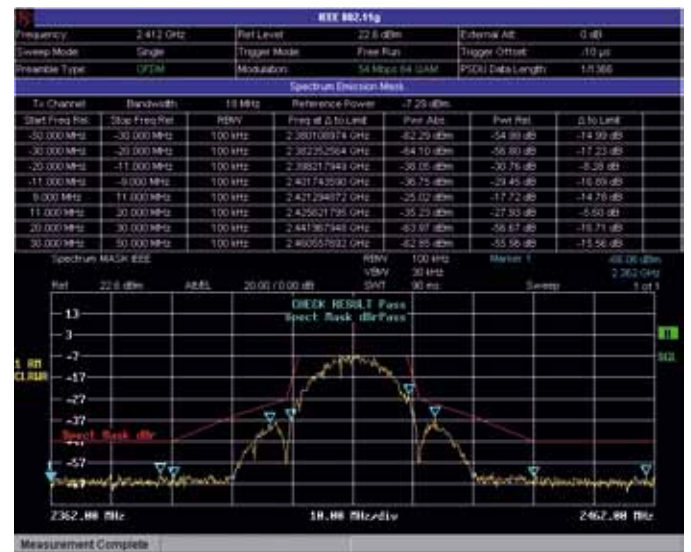
- | TX power level (18.4.7.1)
- | TX spectrum mask with limit lines and pass/fail (18.4.7.3)
- | Transmit power-on and power-down ramp (18.4.7.8)
- | TX modulation accuracy, EVM, EVM versus symbols (18.4.7.8)
- | RF carrier leakage (I/Q offset) (18.4.7.7)
- | Carrier frequency and chip clock error (18.4.7.4, 18.4.7.5)
- | Constellation diagram
- | Gain imbalance, quadrature error
- | CCDF (also time-gated) and crest factor
- | Bit stream
- | Adjacent channel power

##### General

- | Analysis at the RF, IF, inverted IF
- | Analysis in the analog I/Q baseband (requires R&S®FSQ-B71 option)
- | Analysis in the digital I/Q baseband (requires R&S®FSx-B17 option)
- | Autoselection of demodulation
- | Display of header information



The result summary displays the most important parameters for characterizing WLAN signals detected within the recording period.



Spectrum emission mask with standard-compliant limit lines for a signal in line with IEEE802.11b.



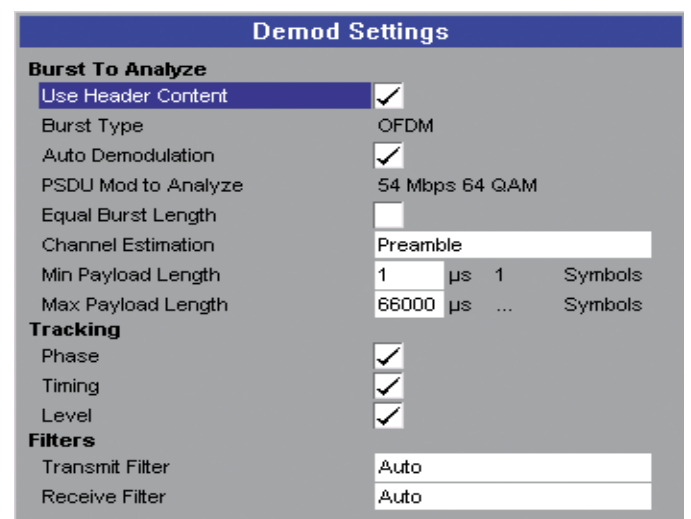
Constellation diagram of all or selectable single carriers.



Setup tables provide a quick overview of the selected settings and quick access to the setting parameters.



Signal field content is used for automatic setting of modulation and can be displayed for further evaluation.



# R&S®FSx-K91n WLAN application firmware

## TX measurements on WLAN signals in line with IEEE802.11n

The R&S®FSx-K91n option is a firmware upgrade to the R&S®FSx-K91 option for the R&S®FSW, R&S®FSQ, R&S®FSG, R&S®FSV and R&S®FSL signal and spectrum analyzers and enables R&S®FSx-K91 users to quickly measure signals in line with IEEE802.11n.

WLAN solutions based on the IEEE 802.11n standard will operate in the 2.4 GHz or 5 GHz radio band, or both bands, offering backward compatibility with existing IEEE 802.11a/b/g deployments.

IEEE802.11n has the following main benefits:

- ▮ Increased data throughput
- ▮ Increased reliability of wireless LANs

This has been achieved by three primary innovations:

- ▮ Packet aggregation
- ▮ Channel bonding (40 MHz channels)
- ▮ Multiple input multiple output (MIMO) technology

## R&S®FSx-K91n features

The R&S®FSx-K91n option supports modulation measurements on signals in line with the IEEE802.11n WLAN standard up to a maximum bandwidth of 40 MHz<sup>1)</sup>.

All IEEE802.11n modes are supported:

- ▮ Legacy (support of IEEE802.11a, g)
- ▮ Mixed mode: high throughput (HT) and legacy
- ▮ Greenfield mode: HT only

Users of the R&S®FSx-K91n option get the same results as with the R&S®FSx-K91 application firmware and can use the same features.

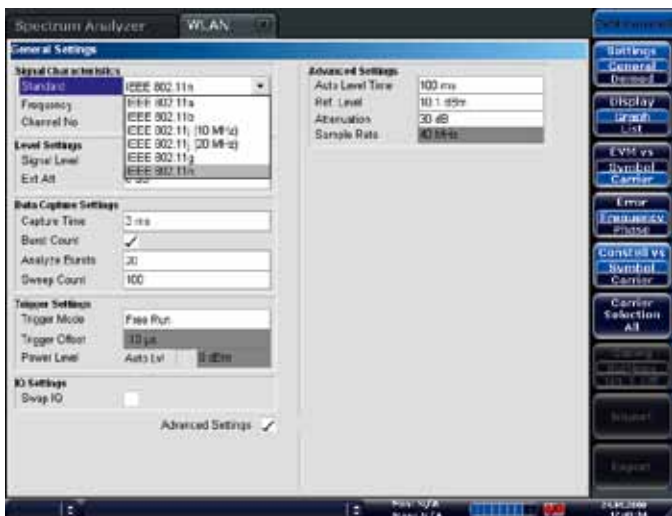
The R&S®FSx-K91n option makes tests on WLAN signals an easy task because it offers the following advantages:

- ▮ Scalable solution
- ▮ Easy and intuitive user interface

<sup>1)</sup> For measuring signals with 40 MHz bandwidth, the R&S®FSW-B40 option is required for the R&S®FSW, the R&S®FSV-B70 option is required for the R&S®FSV and the R&S®FSQ-B72 option for the R&S®FSQ.

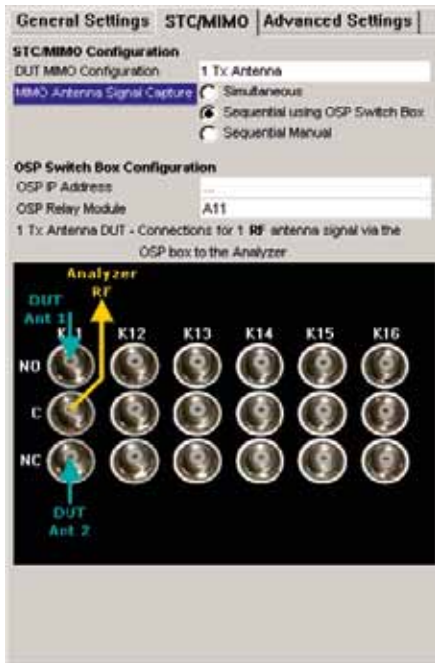


Spectrum flatness and group delay of the 104 occupied carriers of a 40 MHz wide IEEE802.11n signal (Greenfield mode).



In the setup table of the R&S®FSV signal and spectrum analyzer, all relevant WLAN standards can be selected.

# R&S®FSW-K91ac/ R&S®FSQ-K91ac WLAN application firmware



As with the R&S®FSx-K91n option several R&S®FSW or R&S®FSQ analyzers can be connected to perform MIMO measurements while simultaneously capturing I/Q data. If repetitive signals are available, spatial streams can be sequentially captured, either manually or the using the OSP box.



Measurement of a WLAN IEEE802.11ac signal with 256QAM modulation. The capture buffer, the constellation diagram and the result summary table are shown.

## TX measurements on WLAN signals in line with IEEE802.11ac

The R&S®FSW-K91ac option is a firmware upgrade to the R&S®FSW-K91 option for the R&S®FSW signal and spectrum analyzer. The R&S®FSW-K91 option must be installed on the R&S®FSW.

The R&S®FSQ-K91ac option is a firmware upgrade to the R&S®FSQ-K91n option for the R&S®FSQ spectrum and signal analyzer. The R&S®FSQ-K91 and R&S®FSQ-K91n options must be installed on the R&S®FSQ. The R&S®FSW-K91ac and R&S®FSQ-K91ac extend the functionality of R&S®FSW-K91 and R&S®FSQ-K91n respectively to include spectrum and modulation measurements in line with WLAN IEEE 802.11ac.

The WLAN IEEE802.11ac physical layer is based on the well-known orthogonal frequency division multiplexing (OFDM) used for IEEE802.11a and IEEE802.11n and provides backward compatibility with IEEE802.11a and IEEE802.11n devices operating in the 5 GHz band.

IEEE802.11ac devices are required to support 20 MHz, 40 MHz and 80 MHz channels and one spatial stream. Several optional features are also defined such as wider channel bandwidth (80 MHz + 80 MHz and 160 MHz), 256QAM and up to eight spatial streams to achieve data rates of 3.5 Gbps.

## R&S®FSW/FSQ-K91ac features

The R&S®FSW-K91ac and the R&S®FSQ-K91ac application firmware support modulation measurements on signals in line with the WLAN IEEE802.11ac standard up to a maximum bandwidth of 160 MHz with the R&S®FSW and 80 MHz with the R&S®FSQ<sup>2)</sup>.

IEEE802.11ac enhancements are supported:

- Channel bandwidth of 20 MHz, 40 MHz, 80 MHz, 80 MHz + 80 MHz<sup>3)</sup> and 160 MHz
- 256 QAM modulation format
- VHT operating mode
- Up to four spatial streams

R&S®FSQ-K91ac users get the same results as with the R&S®FSx-K91/-K91n application firmware and can use the same features.

<sup>2)</sup> For measuring signals with 160 MHz bandwidth, the R&S®FSW with R&S®FSW-B160 option is required. For measuring signals with 80 MHz bandwidth with the R&S®FSQ, the R&S®FSQ-B72 option is required.  
<sup>3)</sup> Measuring each 80 MHz frequency segment as single channel bandwidth signal.

# Analyzers supporting WLAN measurements

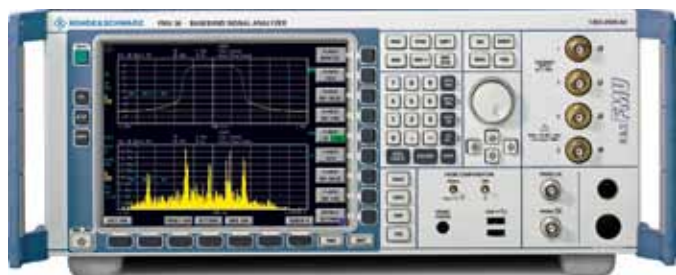
The uniform operating concept and largely identical functionality of the different analyzers facilitate instrument operation and allow application programs to be transferred.



The R&S®FSW – the new standard in RF performance and usability.



The R&S®FSQ – high-end signal analysis.



The R&S®FMU – universal baseband analyzer.

## The R&S®FSW signal and spectrum analyzer – the new standard in RF performance and usability

The very high-performance R&S®FSW signal and spectrum analyzer was developed to meet demanding customer requirements – with low phase noise, wide analysis bandwidth and straightforward and intuitive operation, making measurements fast and easy. The R&S®FSW offers up to 160 MHz analysis bandwidth.

Featuring a touchscreen user interface, a flat menu structure and straightforward result presentation, the R&S®FSW offers exceptional ease of operation. Various measurements can be displayed simultaneously in separate windows on the large 12.1" screen, which greatly facilitates result interpretation. The R&S®FSW also scores top marks when it comes to measurement speed. Providing 1000 sweep/s in remote operation and delay-free switching between instrument setups, the R&S®FSW ranks top among the signal and spectrum analyzers available on the market.

The R&S®FSW offers extremely low inherent and phase noise, unrivaled low residual EVM, high dynamic range, as well as outstanding accuracy, which makes it the ideal high-end tester for development applications where tolerances and limit values often have to be narrower than specified in the standard.

The available spurious-free dynamic range (SFDR) also plays an eminent role when analyzing I/Q data. With an SFDR well over 100 dBc, the R&S®FSW offers unprecedented accuracy when it comes to linearizing amplifiers and measuring EVM.

## The R&S®FSQ signal and spectrum analyzer – high-end signal analysis

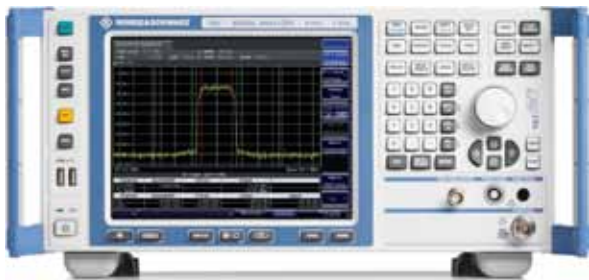
The R&S®FSQ combines a spectrum analyzer up to 40 GHz with a signal analyzer in a single box. Equipped with the R&S®FSQ-B71 hardware option, it can also analyze analog baseband signals. The R&S®FSQ-B17 option is required for analyzing digital baseband signals. The R&S®FSQ-B72 broadband option permits the analysis of 40 MHz signals in line with IEEE802.11n, of 80 MHz signals in line with IEEE 802.11ac and of multicarrier scenarios with bandwidths of up to 120 MHz. The R&S®FSQ is a solution for all applications in development and production.

Similar to R&S®FSW, the R&S®FSQ with its high-end RF performance is also an ideal high-end tester for development applications.

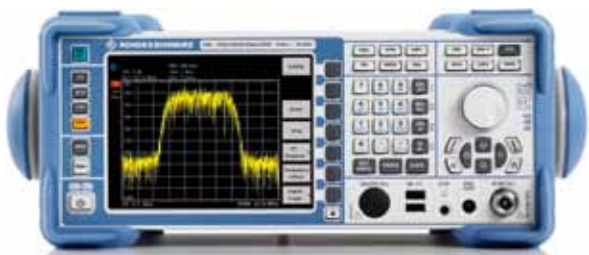


### The R&S®FMU signal and spectrum analyzer – universal baseband analyzer

The R&S®FMU is a universal analyzer for analog baseband signals. Moreover, it is ideal for applications with low RF that require high sensitivity. The R&S®FMU is equipped with baseband inputs that may either be balanced or unbalanced. The analyzer is equipped as standard with the vector signal analysis application firmware. The R&S®FSQ-K91/-K91n options permit modulation measurements on WLAN OFDM and WLAN DSSS/CCK signals.



The R&S®FSV – the new standard in the mid-range class.



The R&S®FSL – compact spectrum analysis.



The R&S®FSG – spectrum analysis for wideband communications technologies.

### The R&S®FSV signal and spectrum analyzer – the new standard in the mid-range class

Featuring a demodulation bandwidth of up to 40 MHz, a measurement uncertainty of less than 0.4 dB up to 7 GHz and a measurement speed that is more than five times faster than that of other mid-range analyzers, the R&S®FSV signal and spectrum analyzer is the new industry benchmark in this class. It is well suited for analysis of all WLAN signals due to the wide demodulation bandwidth of 40 MHz, which is needed for the IEEE 802.11n standard. Its unrivaled speed and its optimal price/performance ratio make it the ideal instrument for production. However, as a multipurpose instrument, the R&S®FSV is the right analyzer for general applications in development and service. The touchscreen and an intuitive user interface make working with the instrument an easy task. Features and functions as well as remote control are compatible with all other Rohde & Schwarz analyzers. Instruments can be changed easily.

### R&S®FSL spectrum analyzer – compact spectrum analysis

The R&S®FSL spectrum analyzer is an extremely light-weight and compact analyzer for a wide variety of applications in development, service and production. It offers functions that previously were provided only by high-end spectrum analyzers and has an outstanding price/performance ratio. Featuring a tracking generator and a demodulation bandwidth of 28 MHz, the R&S®FSL is unrivaled in its class. It is the ideal choice for performing spectrum and modulation measurements on every developer's workbench or in production. The optional battery makes it an ideal instrument for service and maintenance as well.

### R&S®FSG spectrum analyzer – spectrum analysis for wideband communications technologies

The R&S®FSG spectrum analyzer is ideal for mobile and wireless applications in development and production. It supports frequencies up to 13.6 GHz and features high measurement speed and performance. Owing to its 28 MHz I/Q demodulation bandwidth it is also suitable for wideband standards such as WLAN, WiMAX™ or 3GPP LTE.

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# Specifications in brief

|  | R&S®FSW   | R&S®FSQ                              | R&S®FSG              | R&S®FSV                             | R&S®FSL  | R&S®FMU   |
|--|---|--------------------------------------|----------------------|-------------------------------------|--|---|
| <b>RF performance</b>  |   |                                      |                      |                                     |  |   |
| Frequency range  | 2 Hz to 8/13.6/26.5 GHz                                     | 20 Hz to 3.6/8/26.5/40 GHz           | 9 kHz to 8/13 GHz    | 20 Hz to 3/7/13/30 GHz              | 9 kHz to 3/6/18 GHz  | DC to 36 MHz                                    |
| Resolution bandwidth   | 1 Hz to 10 MHz, 80 MHz (with R&S®FSW-B8 option)             | 1 Hz to 50 MHz                       | 1 Hz to 10 MHz       | 1 Hz to 40 MHz                      | 1 Hz to 20 MHz   | 0.5 Hz to 20 MHz                                |
| Phase noise at 10 kHz offset                                 | typ. -140 dBc (1 Hz)  | typ. -133 dBc (1 Hz)                 | typ. -114 dBc (1 Hz) | typ. -106 dBc (1 Hz)                | typ. -103 dBc (1 Hz)   | typ. -143 dBc (10 MHz)                          |
| Overall measurement uncertainty                              | < 0.4 dB (8 GHz)  | 0.3 dB (f < 3.6 GHz)                 | 0.3 dB (f < 3.6 GHz) | 0.4 dB (f < 7 GHz)                  | 0.5 dB (f < 3 GHz)   | 0.3 dB  |
| DANL   | typ. -159 dBm (at 2 GHz, with R&S®FSW-B13 option, 1 Hz RBW) | -158 dBm (at 1 GHz, 1 Hz RBW)        | -154 dBm             | -152 dBm                            | -117 dBm (at 1 GHz, 300 Hz RBW), -152 dBm (at 1 GHz, 1 Hz RBW, preamplifier) | -151.5 dBm                                      |
| TOI  | typ. +30 dBm (f < 1 GHz)                                    | typ. 27 dBm                          | typ. 21 dBm          | typ. 17 dBm                         | typ. 15 dBm  | -   |
| <b>I/Q demodulation</b>                                      |   |                                      |                      |                                     |  |   |
| I/Q demodulation bandwidth                                   | 10 MHz, 160 MHz (R&S®FSW-B160 option)                       | 28 MHz, 120 MHz (R&S®FSQ-B72 option) | 28 MHz               | 28 MHz, 40 MHz (R&S®FSV-B70 option) | 28 MHz   | 72 MHz  |
| I/Q memory   | 400 Msample   | 16 Msample, 235 Msample, 705 Msample | 4 Msample            | 200 Msample                         | 512 ksample  | 16 Msample, optionally 235 Msample, 705 Msample |
| I/Q baseband inputs, analog                                  | •   | • R&S®FSQ-B71                        | -                    | -                                   | -  | •   |
| I/Q baseband inputs, digital                                 | •   | •                                    | •                    | •                                   | -  | •   |
| LXI Class C conformant                                       | •   | •                                    | •                    | •                                   | •  | •   |
| <b>WLAN</b>  |   |                                      |                      |                                     |  |   |
| Residual EVM (averaged over 20 bursts, f = 2.4 GHz or 5 GHz) | -54 dB <sup>1)</sup>  | -46 dB <sup>1)</sup>                 | -46 dB <sup>1)</sup> | -45 dB <sup>1)</sup>                | -40 dB <sup>1)</sup>   | -   |
| ACLR with noise correction                                   | typ. 80 dB  | typ. 80 dB                           | typ. 80 dB           | typ. 70 dB                          | typ. 58 dB   | typ. 69 dB                                      |
| IEEE802.11n  | •   | •                                    | •                    | •                                   | •  | -   |
| IEEE802.11ac   | •   | •                                    | -                    | -                                   | -  | -   |

<sup>1)</sup> Level: -30 dBm to +15 dBm, channel estimation: preamble and payload.

For data sheet, see PD 0758.1435.22 and [www.rohde-schwarz.com](http://www.rohde-schwarz.com)

# Ordering information

| Designation  | Type          | Order No.    |
|--|---------------|--------------|
| <b>Base units</b>  |               |              |
| Signal and Spectrum Analyzer, 2 Hz to 8 GHz  | R&S®FSW8      | 1312.8000.08 |
| Signal and Spectrum Analyzer, 2 Hz to 13.6 GHz   | R&S®FSW13     | 1312.8000.13 |
| Signal and Spectrum Analyzer, 2 Hz to 26.5 GHz   | R&S®FSW26     | 1312.8000.26 |
| Signal and Spectrum Analyzer, 20 Hz to 3.6 GHz   | R&S®FSQ3      | 1155.5001.03 |
| Signal and Spectrum Analyzer, 20 Hz to 8 GHz   | R&S®FSQ8      | 1155.5001.08 |
| Signal and Spectrum Analyzer, 20 Hz to 26.5 GHz  | R&S®FSQ26     | 1155.5001.26 |
| Signal and Spectrum Analyzer, 20 Hz to 40 GHz  | R&S®FSQ40     | 1155.5001.40 |
| Spectrum Analyzer, 9 kHz to 8 GHz  | R&S®FSG8      | 1309.0002.08 |
| Spectrum Analyzer, 9 kHz to 13.6 GHz   | R&S®FSG13     | 1309.0002.13 |
| Baseband Signal and Spectrum Analyzer, DC to 36 MHz                                    | R&S®FMU36     | 1303.3500.02 |
| Signal and Spectrum Analyzer, 9 kHz to 3 GHz   | R&S®FSV3      | 1307.9002.03 |
| Signal and Spectrum Analyzer, 9 kHz to 7 GHz   | R&S®FSV7      | 1307.9002.07 |
| Signal and Spectrum Analyzer, 9 kHz to 13 GHz  | R&S®FSV13     | 1307.9002.13 |
| Signal and Spectrum Analyzer, 9 kHz to 30 GHz  | R&S®FSV30     | 1307.9002.30 |
| Signal and Spectrum Analyzer, 10 Hz to 40 GHz  | R&S®FSV40     | 1307.9002K40 |
| Spectrum Analyzer, 9 kHz to 3 GHz  | R&S®FSL3      | 1300.2502.03 |
| Spectrum Analyzer, 9 kHz to 3 GHz, with tracking generator                             | R&S®FSL3      | 1300.2502.13 |
| Spectrum Analyzer, 9 kHz to 6 GHz  | R&S®FSL6      | 1300.2502.06 |
| Spectrum Analyzer, 9 kHz to 6 GHz, with tracking generator                             | R&S®FSL6      | 1300.2502.16 |
| Spectrum Analyzer, 9 kHz to 18 GHz   | R&S®FSL18     | 1300.2502.18 |
| <b>Recommended options and extras</b>  |               |              |
| 28 MHz Analysis Bandwidth, for the R&S®FSW   | R&S®FSW-B28   | 1313.1645.02 |
| 40 MHz Analysis Bandwidth, for the R&S®FSW   | R&S®FSW-B40   | 1313.0861.02 |
| 80 MHz Analysis Bandwidth, for the R&S®FSW   | R&S®FSW-B80   | 1313.0878.02 |
| 160 MHz Analysis Bandwidth, for the R&S®FSW  | R&S®FSW-B160  | 1313.1668.02 |
| Digital Baseband Interface, for the R&S®FSW  | R&S®FSW-B17   | 1313.0784.02 |
| I/Q Baseband Inputs, for the R&S®FSQ   | R&S®FSQ-B71   | 1157.0113.02 |
| I/Q Bandwidth Extension to 120 MHz, for the R&S®FSQ                                    | R&S®FSQ-B72   | 1157.0336.02 |
| Digital Baseband Interface, for the R&S®FSQ  | R&S®FSQ-B17   | 1163.0063.02 |
| Digital Baseband Interface, for the R&S®FSG  | R&S®FSQ-B17   | 1163.0063.02 |
| Digital Baseband Interface, for the R&S®FMU  | R&S®FSQ-B17   | 1163.0063.02 |
| 40 MHz Analysis Bandwidth, for the R&S®FSV   | R&S®FSV-B70   | 1310.9645.02 |
| <b>Firmware/software</b>   |               |              |
| 802.11a/b/g Measurement Application, for the R&S®FSW                                   | R&S®FSW-K91   | 1313.1500.02 |
| 802.11n Measurement Application, for the R&S®FSW; requires R&S®FSW-K91                 | R&S®FSW-K91n  | 1313.1516.02 |
| 802.11ac Measurement Application, for the R&S®FSW; requires R&S®FSW-K91                | R&S®FSW-K91ac | 1313.4209.02 |
| WLAN IEEE 802.11 a/b/g/j TX Application Firmware, for the R&S®FSQ, R&S®FSG and R&S®FMU | R&S®FSQ-K91   | 1157.3129.02 |
| R&S®FSQ-K91 Upgrade to IEEE 802.11n, for the R&S®FSQ, R&S®FSG and R&S®FMU              | R&S®FSQ-K91n  | 1308.9387.02 |
| R&S®FSQ-K91 Upgrade to IEEE 802.11ac, for the R&S®FSQ                                  | R&S®FSQ-K91ac | 1308.9170.02 |
| WLAN IEEE 802.11 a/b/g/j TX Application Firmware, for the R&S®FSV                      | R&S®FSV-K91   | 1310.8903.02 |
| R&S®FSV-K91 Upgrade to IEEE 802.11n, for the R&S®FSV                                   | R&S®FSV-K91n  | 1310.9468.02 |
| WLAN IEEE 802.11 a/b/g/j TX Application Firmware, for the R&S®FSL                      | R&S®FSL-K91   | 1302.0094.02 |
| R&S®FSL-K91 Upgrade to IEEE 802.11n, for the R&S®FSL                                   | R&S®FSL-K91n  | 1308.7903.02 |
| <b>Upgrades</b>  |               |              |
| Analysis Bandwidth Upgrade from 28 MHz to 40 MHz <sup>1)</sup>                         | R&S®FSW-U40   | 1313.5205.02 |
| Analysis Bandwidth Upgrade from 40 MHz to 80 MHz <sup>1)</sup>                         | R&S®FSW-U80   | 1313.5211.02 |
| Analysis Bandwidth Upgrade from 80 MHz to 160 MHz <sup>1)</sup>                        | R&S®FSW-U160  | 1313.5754.02 |

<sup>1)</sup> In order to measure WLAN signals with a given channel bandwidth (CBW)  $\in$  { 5, 10, 20, 40, 80, 160} MHz, the R&S®FSW requires an analysis bandwidth option greater or equal to this CBW. I.e. the channel bandwidth CBW of the WLAN signal to be measured  $\leq$  max. installed R&S®FSW analysis bandwidth option.