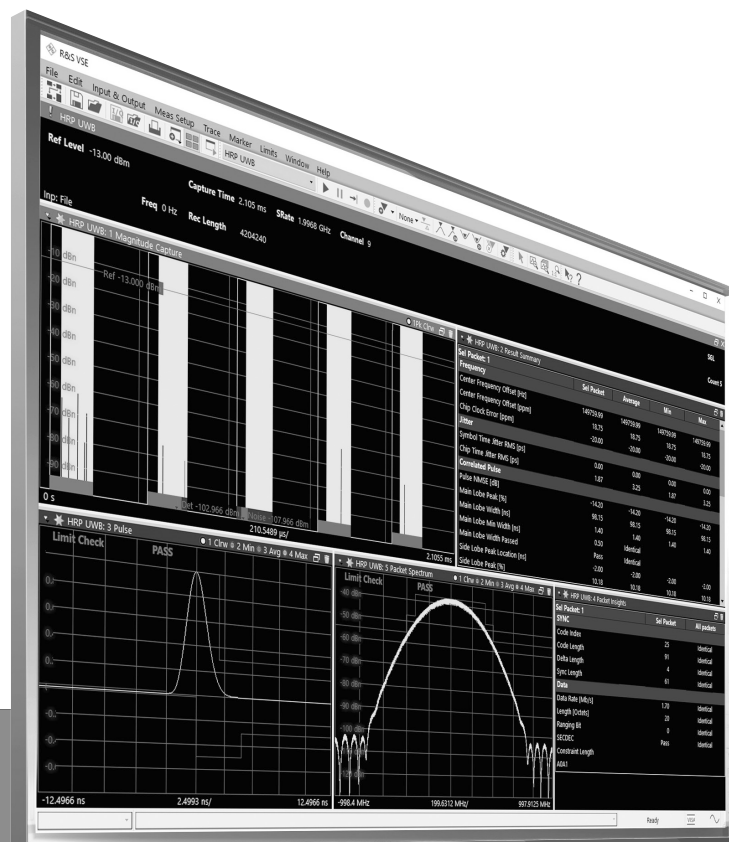# HIGH RATE PULSE REPETITION FREQUENCY ULTRAWIDEBAND MEASUREMENTS

Specifications

R&S®FSW-K149
R&S®VSE-K149

Data Sheet
Version 04.00

ROHDE & SCHWARZ

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CONTENTS

Definitions

General

Product data applies under the following conditions:

- Three hours storage at ambient temperature followed by 30 minutes warm-up operation
- Specified environmental conditions met
- Recommended calibration interval adhered to
- All internal automatic adjustments performed, if applicable

Specifications with limits

Represent warranted product performance by means of a range of values for the specified parameter. These specifications are marked with limiting symbols such as <, ≤, >, ≥, ±, or descriptions such as maximum, limit of, minimum. Compliance is ensured by testing or is derived from the design. Test limits are narrowed by guard bands to take into account measurement uncertainties, drift and aging, if applicable.

Non-traceable specifications with limits (n. trc.)

Represent product performance that is specified and tested as described under "Specifications with limits" above. However, product performance in this case cannot be warranted due to the lack of measuring equipment traceable to national metrology standards. In this case, measurements are referenced to standards used in the Rohde & Schwarz laboratories.

Specifications without limits

Represent warranted product performance for the specified parameter. These specifications are not specially marked and represent values with no or negligible deviations from the given value (e.g. dimensions or resolution of a setting parameter). Compliance is ensured by design.

Typical data (typ.)

Characterizes product performance by means of representative information for the given parameter. When marked with <, > or as a range, it represents the performance met by approximately 80 % of the instruments at production time. Otherwise, it represents the mean value.

Nominal values (nom.)

Characterize product performance by means of a representative value for the given parameter (e.g. nominal impedance). In contrast to typical data, a statistical evaluation does not take place and the parameter is not tested during production.

Measured values (meas.)

Characterize expected product performance by means of measurement results gained from individual samples.

Uncertainties

Represent limits of measurement uncertainty for a given measurand. Uncertainty is defined with a coverage factor of 2 and has been calculated in line with the rules of the Guide to the Expression of Uncertainty in Measurement (GUM), taking into account environmental conditions, aging, wear and tear.

Device settings and GUI parameters are designated with the format "parameter: value".

Non-traceable specifications with limits, typical data as well as nominal and measured values are not warranted by Rohde & Schwarz.

In line with the 3GPP/3GPP2 standard, chip rates are specified in million chips per second (Mcps), whereas bit rates and symbol rates are specified in billion bit per second (Gbps), million bit per second (Mbps), thousand bit per second (kbps), million symbols per second (Msps) or thousand symbols per second (ksps), and sample rates are specified in million samples per second (Msample/s). Gbps, Mcps, Mbps, Msps, kbps, ksps and Msample/s are not SI units.

Specifications

The specifications of the R&S®FSW-K149 and the R&S®VSE-K149 high rate pulse (HRP) repetition frequency ultrawideband (UWB) measurements are based on the data sheet specifications of the R&S®FSW and the R&S®VSE. They have not been checked separately and are not verified during instrument calibration. Measurement uncertainties are given as 95 % confidence intervals. The specified level measurement errors do not take into account systematic errors due to reduced signal-to-noise ratio (SNR).

General remarks

This data sheet covers the R&S®FSW-K149 and the R&S®VSE-K149.

The R&S®FSW-K149 and the R&S®VSE-K149 support the standard revisions IEEE 802.15.4-2020 and IEEE 802.15.4z-2020.

The R&S®FSW-K149 runs on the device itself.

The R&S®VSE-K149 runs on a PC that can be connected to the analyzers, test receiver and oscilloscopes as specified below.

If not stated otherwise, the data sheet values are device-specific, e.g. the same value applies to the R&S®FSW-K149 and the R&S®VSE-K149 with connected R&S®FSW.

For feature tables the following convention applies:

•	feature always supported i.e. with the R&S®VSE-K149 connected to the device and with the corresponding R&S®FSW-K149 option when running directly on the device
• (VSE)	feature supported only with the R&S®VSE-K149 connected to the device; not with the corresponding R&S®FSW-K149 option when running directly on the device
• (FSW-K149)	feature supported only when running directly on the device with the corresponding R&S®FSW-K149 option; not supported in the R&S®VSE-K149
–	feature not supported with this device

Overview

		R&S®FSW	R&S®RTP
R&S®FSW-K149	software that runs on device	•	–
R&S®VSE-K149	PC software that can be connected to device	•	•

HRP UWB measurements

Signal acquisition

	R&S®FSW/R&S®FSW (VSE)	R&S®RTP (VSE)
Maximum capture length	50 ms	50 ms [1]
Maximum number of HRP UWB packets in one capture	1 to 1000 (depending on capture length and packet length)	
Capture oversampling	4, 6, 8, 10, 12	
Sample rates	499.2 MHz × capture oversampling	
Required I/Q bandwidths		
Channels 0, 1, 2, 3, 5, 6, 8, 9, 10, 12, 13, 14 (499.2 MHz)	800 MHz [2]	800 MHz [3]
Channels 4, 11 (1331.2 MHz)	2000 MHz [4]	2000 MHz [3]
Channel 7 (1081.6 MHz)	1750 MHz [2]	1750 MHz [3]
Channel 15 (1354.97 MHz)	2000 MHz [2]	2000 MHz [3]

Supported demodulation parameters

Parameter	User input/auto detection	Options
Channels	user input	all channels defined in standard (0 to 15) including channels with bandwidth higher than 499.2 MHz
PHY modes	user input	• non-ERDEV: IEEE 802.15.4-2020 • ERDEV-BPRF: IEEE 802.15.4z-2020 • ERDEV-HPRF: IEEE 802.15.4z-2020
SHR parameters		
STS packet configuration	user input	• 0: STS off • 1: SYNC/SFD, STS, PHR/PSDU • 2: SYNC/SFD, PHR/PSDU, STS • 3: SYNC/SFD, STS
Code index	auto detection	automatically detected using channel configuration
Delta length	auto detection	4, 16, 64
Sync length	auto detection	• non-ERDEV: 16, 64, 1024, 4096 • HRP-ERDEV BPRF: 16, 64, 1024, 4096 • HRP-ERDEV HPRF: 16, 24, 32, 48, 64, 96, 128, 256
SFD length	auto detection	4, 8, 16, 32, 64
SFD number	auto detection	• non-ERDEV: short/long • HRP-ERDEV BPRF: 0, 2 • HRP-ERDEV HPRF: 1, 2, 3, 4
Length (SI symbols)	auto detection	• short: 8 symbols • long: 64 symbols
STS parameters		
STS active segment length	user input	16, 32, 64, 128, 256
STS active segments	user input	1, 2, 3, 4
STS gap	user input	STS packet configuration 2: 0 to 127
Data parameters		
PHY data rate mode	user input	• for BPRF: DRBM_LP and DRBM_HP • for HPRF: DRHM_LR and DRHM_HR
Maximum HPRF payload size	user input	1023, 2047, 4095
Frame length	auto detection	• non-ERDEV: 0 to 127 • ERDEV: 0 to 4095
Data rate	auto detection	• non-ERDEV: 0.11/0.85/1.70/6.81/27.24 Mbit/s • BPRF: 6.8 Mbit/s • HPRF: 3.9/7.8/15.6/31.2 Mbit/s
Constraint length	auto detection	CL3 or CL7

[1] Depending on software and hardware options of the R&S®RTP. Capture length of 50 ms achievable with e.g. R&S®RTP164 with R&S®RTP-B110 option in waveform mode with 20 GHz instrument sample rate.

[2] Requires R&S®FSW-B1200 1200 MHz analysis bandwidth option or higher.

[3] Bandwidth requirement is met by all R&S®RTP models. R&S®RTP134 or R&S®RTP164 is required to capture UWB signals up to channel 15 at 9484.8 MHz.

[4] Requires R&S®FSW-B2001 2000 MHz analysis bandwidth option or higher.

Detection of packets (burst/sync)

Within the capture buffer, the location and length of the UWB packets is automatically detected.

For convenience, four different detection modes are supported.

The detection mode and detection level to find the bursts containing the UWB packets are user configurable.

Detection mode	Detection level
Absolute	user-defined absolute threshold
Noise	sum of automatically detected noise level and user-defined threshold
Peak	sum of automatically detected peak level and user-defined threshold
Ref level	sum of reference level of measurement and user-defined threshold

Furthermore, the burst detection can be configured by defining the minimum and maximum burst length and also the maximum off-time within bursts.

Evaluation modes (statistics)

Run mode	Range	Covered packets in statistics
Run single	one capture	statistics over all packets in one capture
	fixed count of packets	statistics over user-defined number of packets, either in one capture or in multiple captures, if capture time is too short for all packets
Run continuous	one capture	statistics over all captured packets in all captures
	fixed count of packets	repeated "run single" with "fixed count of packets"

Supported measurements

Displays

Magnitude capture	raw I/Q data with annotation of detected UWB packets
Pulse	measured time domain pulse (including transmit mask limit checks)
Packet spectrum	frequency spectrum of UWB packet (including limit checks)
Correlated pulse	cross-correlation of measured UWB pulse and rood raised cosine (RRC) pulse, in line with IEEE 802.15.4-2020
Chip time jitter	histogram of time jitter of pulses
Chip phase jitter	histogram of phase jitter of pulses
Symbol time jitter	histogram of time jitter of symbols
Symbol phase jitter	histogram of phase jitter of symbols

Result summary table

Frequency	
Center frequency offset (Hz)	estimated frequency offset of SYNC section
Center frequency offset (ppm)	estimated frequency offset of SYNC section relative to carrier frequency
Chip clock error (ppm)	estimated chip clock frequency error of SYNC section
Jitter	
Symbol time jitter RMS (ps)	RMS of the time jitter of symbols of the SYNC section
Chip time jitter RMS (ps)	RMS of the time jitter of chips of the SYNC section
Correlated pulse	cross-correlation of measured UWB pulse and root raised cosine (RRC) pulse, in line with IEEE 802.15.4-2020
Pulse NMSE (dB)	NMSE of the correlated pulse
Main lobe peak (%)	amplitude of main lobe peak
Main lobe width (ns)	main lobe width of pulse at 80 %
Main lobe minimum width (ns)	required minimum width of main lobe, in line with IEEE 802.15.4-2020 (table 15-12)
Main lobe width passed	passed if main lobe width is above minimum main lobe width
Side lobe peak location (ns)	location of side lobe peak relative to main lobe peak
Side lobe peak (%)	amplitude of side lobe peak
Side lobe peak passed	passed if side lobe peak is below 30 %
Time domain pulse	in line with FIRA UWB PHY technical requirements v1.2, section 5.2.5
Pulse mask	passed if time domain pulse meets mask
Pulse rise monotonic	passed if time domain pulse rises monotonically
Pulse rise time (ns)	rise time of pulse
Pulse rise time passed	passed if pulse rise time is smaller than 2.5 ns
SYNC pulse location and polarity [5]	passed if all pulses of SYNC section have correct location and polarity
SFD pulse location and polarity [5]	passed if all pulses of SFD section have correct location and polarity
STS pulse location and polarity [5]	passed if all pulses of STS section have correct location and polarity
EVM	in line with FIRA UWB PHY technical requirements v1.2, section 5.2.6
SHR NRMSE (%)	NRMSE of SHR section (omitting first µs)
PHR NRMSE (%)	NRMSE of PHR section
PSDU NRMSE (%)	NRMSE of PSDU section
STS NRMSE (%)	NRMSE of STS section
PHR pulse level (dB)	pulse level of PHR section relative to SHR section
PSDU pulse level (dB)	pulse level of PSDU section relative to SHR section
STS pulse level (dB)	pulse level of STS section relative to SHR section
Power	
Packet mean (dBm) [5]	mean power of whole packet
Packet peak (dBm) [5]	peak power of whole packet
SHR mean (dBm)	mean power of SHR section
SHR peak (dBm)	peak power of SHR section
PSDU mean (dBm)	mean power of PSDU section
PSDU peak (dBm)	peak power of PSDU section
STS mean (dBm)	mean power of STS section
STS peak (dBm)	peak power of STS section
I/Q offset (dB) [5]	I/Q offset estimated from SYNC section
Spectrum	transmit power spectral density, in line with IEEE 802.15.4-2020, section 15.4.5
Maximum spectral power (dBm/MHz)	maximum spectral power density
Spectrum mask passed	passed if transmit PSD mask limits are met
Ranging	
Ranging marker (ps)	ranging marker position, in line with IEEE 802.15.4-2020 and IEEE 802.15.4z-2020, relative to capture buffer
Ranging marker in STS 1 to 4 (ps)	ranging marker position within STS, in line with IEEE 802.15.4z-2020, relative to capture buffer

Packet insights table

SYNC	
Code index	code index
Code length	corresponding code length
Delta length	delta length
Sync length	number of analyzed symbols in SYNC section of the packet including symbols in settling time
SFD	• non-ERDEV: short/long • HRP-ERDEV BPRF: 0, 2 • HRP-ERDEV HPRF: 1, 2, 3, 4
Data	
PSDU bit rate (Mbit/s)	bit rate, in line with IEEE 802.15.4-2020 (table 15-3) and IEEE 802.15.4z-2020 (table 15-9a and table 15-10b)
PHR bit rate (Mbit/s) [5]	bit rate transmitted in data rate field of PHR, in line with IEEE 802.15.4-2020 (table 15-8)
Chip per burst	non-HPRF: chips per burst, in line with IEEE 802.15.4-2020 (table 15-3)
Hop burst	non-HPRF: hop burst, in line with IEEE 802.15.4-2020 (table 15-3)
Length (octets)	length of payload in octets, including MAC FCS octets
Ranging bit	status of ranging bit
Reserved bit	non-HPRF: status of reserved bit
SECDED	status of SECDED
Constraint length	HPRF mode: CL3 or CL7
A0A1	HPRF mode: values of A0 and A1 are shown
MAC FCS	result of verification of MAC frame check sequence (FCS)
Payload [6]	payload, in line with IEEE 802.15.4-2020 (section 15.2.8) and IEEE 802.15.4z-2020 (sections 15.2.8 and 15.3.4)
STS	
Bitstream1 to bitstream4 [5]	bitstream of STS sections 1 to 4, in line with IEEE 802.15.4z-2020 (section 15.2.9)

Time of flight (ToF)

To estimate the elapsed time between several packets in one capture buffer, the ranging marker in the results summary table for each selected packet can be evaluated.

For convenience, user-defined groups of packets are available to calculate the statistics just across the desired packets in a ToF scenario.

IEEE 802.15.4 and IEEE 802.15.4z required measurements

Requirement	Coverage
Operating frequency bands	support of all channels from 0 to 15
Maximum allowable power spectral density (PSD)	packet spectrum display and result summary table
Baseband impulse response (RRC)	correlated pulse display and result summary table
Power spectral density (PSD) mask	packet spectrum display and result summary table
Chip clock error	result summary table and chip/symbol time/phase error histogram displays
Center frequency error	result summary table

FIRA UWB PHY required measurements

Requirement	FIRA	Coverage
Operating frequency bands	FIRA UWB PHY technical requirements v1.2, section 5.2.2	support of all channels from 0 to 15
Preamble codes	FIRA UWB PHY technical requirements v1.2, section 5.2.3	support of all mentioned preamble codes
Carrier frequency and symbol timing	FIRA UWB PHY technical requirements v1.2, section 5.2.4	result summary table
Baseband impulse response (pulse mask, pulse rise monotonic, pulse rise time)	FIRA UWB PHY technical requirements v1.2, section 5.2.5	result summary table and pulse display
Transmit signal quality (NRMSE and pulse level for all sections)	FIRA UWB PHY technical requirements v1.2, section 5.2.6	result summary table
MAC FCS support	FIRA UWB PHY technical requirements v1.2, section 5.5.1.3	packet insights table

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[5] Not supported in R&S®VSE.

[6] Payload can be queried via SCPI in R&S®VSE and R&S®FSW. Entry in table is not visible in R&S®VSE.

Ordering information

Designation	Type	Order No.
HRP UWB		
HRP UWB measurements	R&S®FSW-K149	1350.6930.02
HRP UWB measurements	R&S®VSE-K149	1345.1463.06
Vector signal explorer		
Base software	R&S®VSE	1320.7500.06
Signal and spectrum analyzers		
Signal and spectrum analyzer, 2 Hz to 26.5 GHz	R&S®FSW26	1331.5003.26
Signal and spectrum analyzer, 2 Hz to 43.5 GHz	R&S®FSW43	1331.5003.43
Signal and spectrum analyzer, 2 Hz to 50 GHz	R&S®FSW50	1331.5003.50
Signal and spectrum analyzer, 2 Hz to 67 GHz	R&S®FSW67	1331.5003.67
Signal and spectrum analyzer, 2 Hz to 85 GHz	R&S®FSW85	1331.5003.85
1.2 GHz analysis bandwidth	R&S®FSW-B1200	1331.6400.14
2 GHz analysis bandwidth	R&S®FSW-B2001	1331.6916.14
4.4 GHz analysis bandwidth	R&S®FSW-B4001	1338.5215.14
6.4 GHz analysis bandwidth	R&S®FSW-B6001	1338.5221.14
8.312 GHz analysis bandwidth	R&S®FSW-B8001	1338.5238.14
Real-time spectrum analyzer 800 MHz, POI ≤ 15 µs	R&S®FSW-B800R	1331.6400.16
RF preamplifier	R&S®FSW-B24	1313.0832.xx
High-performance oscilloscopes		
13 GHz, 50 Msample memory	R&S®RTP134	1320.5007.13
16 GHz, 50 Msample memory	R&S®RTP164	1320.5007.16
Memory upgrade, 1 Gsample per channel	R&S®RTP-B110	1337.9530.02
I/Q software interface	R&S®RTP-K11	1800.6683.02
Service option		
R&S®VSE software maintenance	R&S®VSE-SWM	1320.7622.81

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