Version
01.00

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R&S®EM510 HF Digital Wideband Receiver

Efficient and versatile solution for radiomonitoring

The state-of-the-art R&S®EM510 is a fully digitized HF receiver and covers the frequency range from 9 kHz to 32 MHz.

Excellent RF characteristics and a wide dynamic range combined with powerful digital signal processing are the basis for optimal system solutions.

- Wideband operation
  - I/Q data up to 10 MHz bandwidth
  - Demodulation up to 10 MHz bandwidth
- 30 IF filters (bandwidths from 100 Hz to 10 MHz)
- Panorama scan up to 34 GHz/s or 600 000 channels/s
- Frequency/memory scan up to 1500 channels/s
- IF panorama with up to 9.6 MHz span
- Video panorama, AM, FM, AM^2, FM^2, I/Q, I/Q^2
- Audio filters: notch, noise suppression, bandpass
- Dual-channel analog video output (AM, FM)
- ITU measurements
- LAN interface (SCPI)

ROHDE&SCHWARZ

Overview

The R&S®EM510 digital HF wideband receiver is ideally suited for signal scans, spectrum monitoring in line with ITU recommendations and radio investigation services.

The R&S®EM510 is optimally prepared to meet future requirements in signal reception and analysis technology. It is software-compatible with the R&S®EB200/ESMB/EM550 instrument family and can thus be easily used to upgrade existing radiomonitoring systems.

Description

The R&S®EM510 is a modern direct receiver. After the antenna signal has passed through preselection with highpass/lowpass filters, it is fed directly into the A/D converter. This concept offers a variety of advantages:

- Extremely high scan speed
- No image or IF frequencies (no mixers or local oscillators)
- No local oscillator phase noise
- Excellently suited for wideband applications
- No interference signals from local oscillators or mixers
- High linearity and simultaneously low power consumption
- High MTBF due to low number of critical components

The R&S®EM510 covers the frequency range from 9 kHz to 32 MHz. A large number of IF bandwidths are available for processing the different signals with optimum signal-to-noise ratio. The use of cutting-edge digital signal processing ensures superlative results.

The receiver features digital IF filters with 30 different bandwidths from 100 Hz to 10 MHz. The filter characteristics are optimized for radiomonitoring tasks, allowing top-quality processing of signals up to 10 MHz bandwidth.

Operation

The receiver is controlled via the LAN interface (TCP/IP) on the basis of SCPI syntax and operates in the following modes:

- Fixed frequency mode (FFM)
- Memory scan
- Frequency scan
- Panorama scan (option)
- Test

Data can be output in the following formats:

- Baseband signal (I and Q) in digital form via
  - LAN ($bandwidth_{max}$ = 1 MHz)
  - FPDP ($bandwidth_{max}$ = 10 MHz)
- Video analog, DC up to ½ bandwidth, two channels (AM/FM or I/Q), or IF analog, gain control, variable center frequency 0 Hz to 21.4 MHz, two channels
- Video digital via LAN, two channels, AM/FM ($bandwidth_{max}$ = 250 kHz) or I/Q ($bandwidth_{max}$ = 500 kHz)
- AES3 for recording audio data
- Audio digital via LAN
- Audio analog (600 Ω line and headphones)

Operating modes

In **Fixed Frequency** mode, the receiver is set to a fixed frequency at which the signal is received, filtered and demodulated. The following parameters and functions can be selected:

- Frequency: setting range from 9 kHz to 32 MHz with 1 Hz resolution
- Demodulation modes:
  - FM
  - AM
  - PULSE (AM PULSE)
  - φM
  - USB
  - LSB
  - ISB
  - CW
  - I/Q
- Bandwidth: selectable in 30 steps between 100 Hz and 10 MHz
- Measurement time: automatic or adjustable between 0.5 ms and 900 s
- Detector modes: "continuous" or "periodic"
- Squelch: adjustable in steps of 1 dB in the range from –30 dBµV to +130 dBµV
- Automatic frequency control (AFC): if AFC is on, the receiver frequency is retuned within the IF bandwidth
- Level detector: For level measurements, the detector can be switched to AVG (average), PEAK, RMS or FAST
- Frequency offset detector
- Attenuator: manual mode (0 dB to 40 dB) or automatic mode
- Gain control (GC): automatic (AGC) and manual (MGC); MGC covers an input signal range from –30 dBµV to +130 dBµV
- Video panorama: spectrum of demodulated signal with analysis functions (AM^2, FM^2)
- IF panorama (option): span from 10 kHz to 9.6 MHz
- ITU measurements (option):
  - AM modulation index (AM+, AM–, AM)
  - FM deviation: FM+, FM–, FM
  - φM deviation: 0 π to 4 π
  - Bandwidth: 0 Hz to 9.6 MHz

In **Memory Scan** mode, the receiver settings for monitoring up to 10 000 channels can be configured. These channels can be scanned using the "Memory Scan" command. A single channel can be called with the "Recall" command.

The squelch threshold serves as a criterion for dwelling on a frequency or switching to the next channel. If the signal level exceeds the threshold, the receiver stops for the set dwell time.

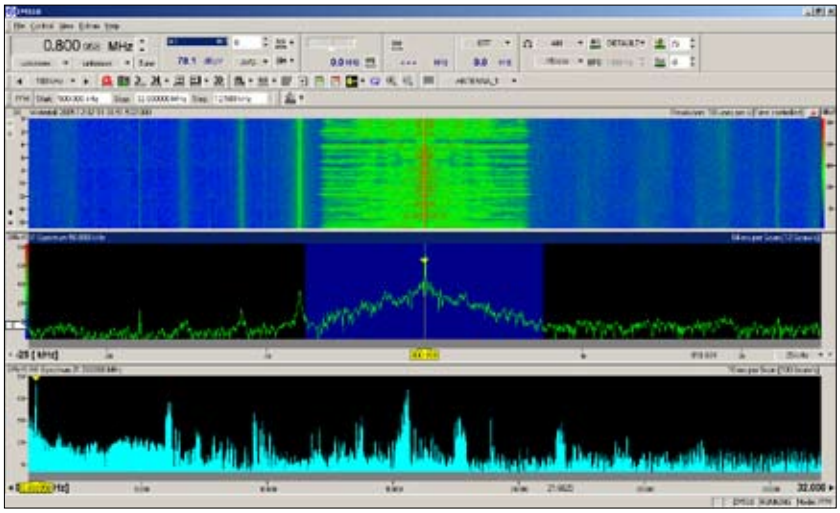
The following parameters can be set for each channel:

- Memory location status
- Frequency
- Demodulation mode
- Bandwidth
- Attenuation
- AFC settings
- Squelch threshold
- Antenna selection

In **Frequency Scan** mode, the start and stop frequency and the step width for monitoring a frequency range are specified.

The squelch threshold acts in the same way as with the memory scan. The receiver settings apply to the entire scan range.

In **Memory Scan** or **Frequency Scan** mode, different selectable measurements (e.g. level offset, AM modulation index, FM deviation, bandwidth) are performed in parallel.



RF panorama, IF panorama and waterfall

In **Panorama Scan** mode, the receiver is tuned from the start to the stop frequency in steps of approx. 10 MHz and performs a high-resolution FFT at each step, allowing extremely high scan speeds of up to 34 GHz/s. The resolution bandwidth can be selected in the range from 125 Hz to 100 kHz.

Operation using standard software and PC

The receiver comes with comprehensive operating software. The software is easily and quickly installed on the control PC, after which the receiver can be operated with full functionality.

Depending on the options installed, the following results are displayed on the PC in realtime:

- Level, offset, modulation parameters, bandwidth
- Frequency scan
- Memory scan
- Spectra
  - RF panorama
  - IF panorama
  - Video panorama
- Waterfall display of spectra

The windows for spectra and waterfall can be adapted to suit different tasks.

Uses

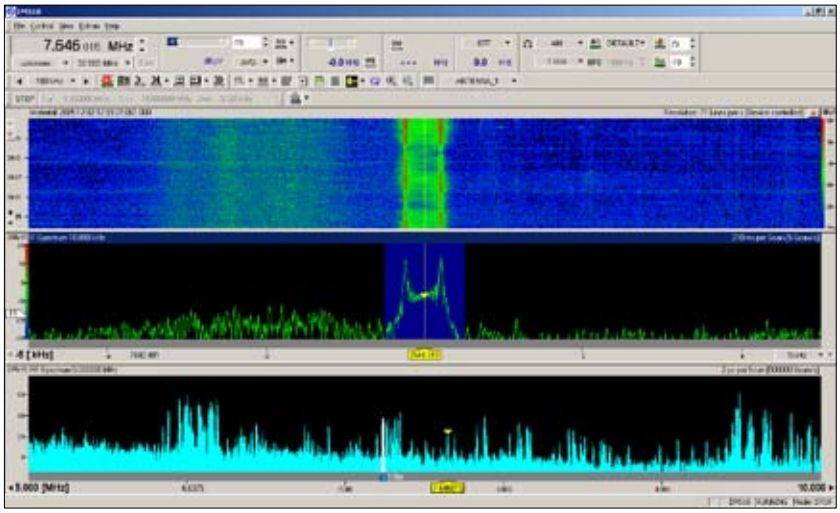
Due to its high scan speed, the receiver is ideally suited for fast, reliable detection of all signal types in the vast field of civil and military radiomonitoring.

From fixed-frequency emissions and signals with rapidly changing frequency (e.g. hoppers) to periodically or non-periodically pulsed emissions, nothing in the scenario is left undetected. The receiver's functionality encompasses the following:

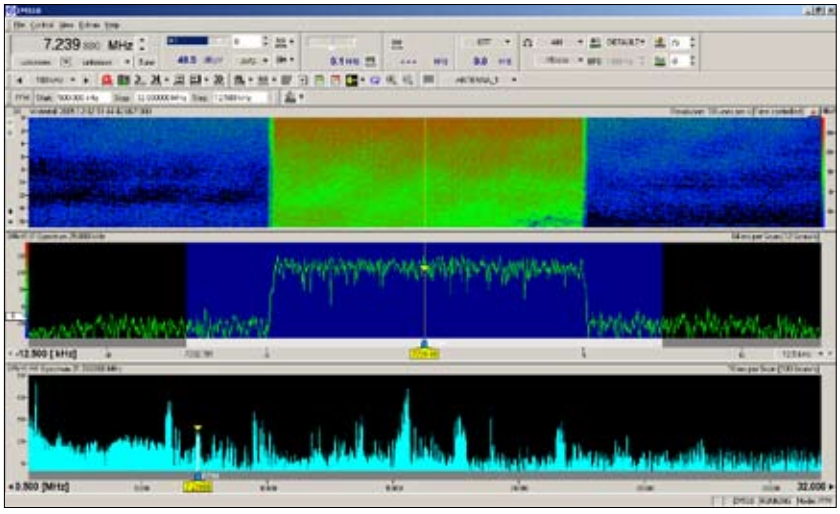
- Detection of signals in the RF spectrum
- Memory scan of up to 10 000 memory channels
- Frequency scan in specified frequency ranges
- Visualization of the signal and the signal environment
- Identification of the signal type (analog or digital)
- Recording of baseband and audio data
- Demodulation of the signal
- Audio monitoring of AM, FM, CW and SSB transmissions
- Signal analysis
- Demodulation of analog hopper signals
- Pulse detection and measurements

The video panorama with AM, FM, AM^2, FM^2, I/Q and I/Q^2 functions makes it possible to visualize the demodulated spectrum. In the AM^2 and FM^2 modes, most digitally modulated signals can be identified, and further measurements performed as, for example, the following:

- Symbol rate
- Chip rate of DSSS transmissions



FSK transmission



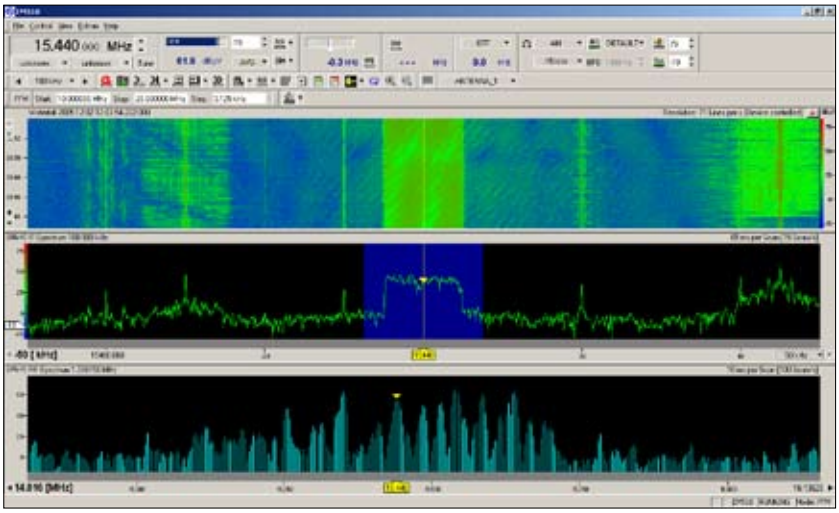
IF spectrum (zoomed) for measurements

Civil monitoring in line with ITU guidelines

Owing to its performance, the R&S®EM510 meets all requirements for measurements in line with the ITU-R specifications (ITU Spectrum Monitoring Handbook, 2002).

If the R&S®EM510IM option is installed, the following measurements can be performed:

- Frequency and frequency deviation in line with ITU-R SM377
- Field strength in line with ITU-R SM378
- Modulation in line with ITU-R SM328
- Spectrum occupancy on the control PC in line with ITU-R SM182/SM328
- Bandwidth in line with ITU-R SM443



Reception of a digital radio mondial (DRM) signal

Customer-specific systems
The R&S®EM510's LAN control interface makes the receiver perfectly suited for configuring customer-specific system solutions. All interfaces are open and well documented. The protocol on the LAN interface is compliant with the standard commands for progammable instruments (SCPI) command syntax. All special functions, such as panorama scan, IF panorama, video panorama and ITU measurements, are integrated in the receiver and therefore require no additional hardware.

Wideband & narrowband
The R&S®EM510 is a wideband receiver for high-speed scanning, monitoring and analysis tasks. Due to its design, it is also ideally suited for narrowband applications.

Rohde&Schwarz also offers the R&S®EM010 digital VXI HF receiver. Due to its design (1 VXI slot), the R&S®EM010 is predestined for multichannel narrowband receive systems (see R&S®EM010 data sheet, PD 5213.5816.32).

Standard-compliant design

The receiver is designed for stationary and mobile use. Thorough shielding and filtering of all input and output lines ensure extremely low EMI as well as high electromagnetic immunity.

For use in vehicles, the receiver can be powered directly from the vehicle's battery via the DC input.

Self-diagnosis
The receiver is continuously monitored by automatic built-in tests (BITs). If deviations from the nominal values are detected, an error message with a code for displaying the error type is generated. For detailed information, the values of the internal test probes, including the upper and lower limits, can be output on the user interface. All out-of-tolerance values are marked.

The complete signal path between the antenna input and the demodulated output can be checked by means of a user-triggered loop test. This test is executed with internally generated and modulated signals.

Specifications

Frequency	
Frequency range	9 kHz to 32 MHz <1 MHz and >30 MHz with reduced performance
Frequency resolution	1 Hz
Frequency accuracy	≤1×10^{-7}
Aging per year	≤1×10^{-7}
Input for external reference	10 MHz
Phase noise	≤–130 dBc (1 Hz) at 1 kHz offset, typ. –140 dBc (1 Hz)
BFO	settable, 0 kHz to ±8 kHz
Antenna input	BNC socket, 50 Ω
VSWR	≤2.5
Input level	–137 dBm to +10 dBm (–30 dBµV to +117 dBµV) f = 400 kHz to 32 MHz –137 dBm to +6 dBm (–30 dBµV to +113 dBµV) f < 400 kHz
Max. input level (nondestructive)	+15 dBm
Preselection	
9 kHz to 400 kHz	lowpass filter
400 kHz to 32 MHz	switchable highpass/lowpass filters
Input attenuation	automatically or manually switchable
Immunity to interference	
Aliasing suppression	≥90 dB, typ. 120 dB
Inherent spurious signals	≤–110 dBm (normal mode)
Linearity	
Measurement level	–6 dBm, LOW DIST –17 dBm, NORM
2nd order intercept point	>70 dBm, typ. 80 dBm (low distortion mode), f = 1 MHz to 32 MHz >50 dBm, typ. 65 dBm (normal mode), f = 1 MHz to 35 MHz
3rd order intercept point	≥30 dBm, typ. 35 dBm (low distortion mode), f = 1 MHz to 32 MHz ≥20 dBm, typ. 25 dBm (normal mode), f = 1 MHz to 32 MHz
Noise figure	≤15 dB, typ. 12 dB (normal mode), f = 400 kHz to 30 MHz ≤26 dB, typ. 22 dB (low distortion mode), f = 400 kHz to 30 MHz
Sensitivity	measurement with telephone filter in line with ITU-T (normal mode)
AM: bandwidth = 6 kHz, SINAD = 10 dB f_{mod} = 1 kHz, m = 0.5	≤1 µV (≤–107 dBm), f = 400 kHz to 30 MHz
FM: bandwidth = 15 kHz, SINAD = 20 dB f_{mod} = 1 kHz, deviation = 5 kHz	≤1 µV (≤–107 dBm), f = 400 kHz to 30 MHz
LSB/USB: bandwidth = 2.4 kHz, SINAD = 10 dB	≤0.5 µV (≤–113 dBm), f = 400 kHz to 30 MHz
CW: bandwidth = 600 Hz, SINAD = 10 dB	≤0.25 µV (≤–119 dBm), f = 400 kHz to 30 MHz
Demodulation modes	AM, FM, PM, PULSE, I/Q (all IF bandwidths) USB, LSB, CW (IF bandwidth ≤9 kHz), ISB (IF bandwidth ≥1 kHz)
IF bandwidths	
For demodulation, level and offset measurement (3 dB bandwidth)	30 filters (100/150/300/600 Hz 1/1.5/2.1/2.4/2.7/3.1/4/4.8/6/9/12/15/30/50/120/150/250/300/500/800 kHz 1/1.25/1.5/2/5/10 MHz)
Shape factor (3 dB : 60 dB)	≤1:1.6 for 100 Hz to 5 MHz filters ≤1:1.3 for 10 MHz filter
Audio filters	notch/noise suppression/bandpass 300 Hz to 3.3 kHz
Squelch (level squelch)	–30 dBµV to +130 dBµV, settable in 1 dB steps
Gain control	AGC, MGC, –30 dBµV to +130 dBµV AGC modes: FAST/DEFAULT/SLOW MGC settable in 1 dB steps
Automatic frequency control (AFC)	automatic retuning for frequency-unstable signals ± ½ IF bandwidth (100 Hz to 10 MHz)
ADC resolution	16 bit
Level and offset measurement	
Signal level	–30 dBµV to +130 dBµV, resolution 0.1 dB
Indication errors	max. ±1.5 dB, typ. ±1.0 dB
Level indication mode	AVG, PEAK, FAST, RMS
Offset	up to ± ½ IF bandwidth (100 Hz to 10 MHz), resolution 1 Hz
IF panorama (with R&S®EM510SU option)	internal FFT (2048 points), typ. 20 pictures/s
Span	10 kHz to 9.6 MHz (10/25/50/100/150/256/300/400/600/800 kHz/1.2/2.4/4.8/9.6 MHz)
Modulation measurement (with R&S®EM050IM option)	
AM (modulation index)	AM, AM+, AM– m = 0 % to 999.9 %; resolution 0.1 % f_{max} = 4 MHz
Indication error	<5 % with bandwidth ≤1 MHz <7 % with bandwidth >1 MHz (S/N > 40 dB, AF = 1 kHz, measurement time <1 s)
FM (FM deviation)	FM, FM+, FM– Δf = 0 Hz to 4 MHz, resolution 0.001 kHz f_{max} = 4 MHz (f_{mod} + deviation)
Indication error	<2 % of used IF bandwidth (absolute) (S/N > 40 dB, AF = 1 kHz, measurement time <1 s)
φM	Δφ = 0 rad to 12.5 rad; resolution 0.01 rad f_{max} = 4 MHz (f_{mod} + deviation)
Indication error	<0.1 rad (S/N > 40 dB, AF = 1 kHz, measurement time <1 s)

Bandwidth measurement	up to 9.6 MHz automatic; >9.6 MHz with external software, xdB and ß% method
Scan characteristics	
Memory scan	10 000 programmable memory locations, scan speed up to 1500 channels/s
Frequency scan	user-selectable start/stop frequency and step width, 100 frequencies suppressible, scan speed up to 1500 channels/s
Panorama scan (with R&S®EM510PS option)	RF spectrum with user-selectable start/stop frequency, step width 125/250/500/625 Hz/1.25/2.5/3.125/6.25/12.5/25/50/100 kHz, scan speed up to 34 GHz/s
Inputs/outputs	
Inputs	
Antenna input	9 kHz to 32 MHz, 50 Ω, BNC socket
External reference input	10 MHz, BNC socket input level 0 dBm to +10 dBm
Outputs	
Video A, video B	video analog, AM (A) and FM (B), DC up to ½ IF bandwidth or: IF analog, controlled, two channels, settable center frequency 0 Hz to 21.4 MHz, bandwidth up to 5 MHz, depending on IF filter and center frequency, level ≥0 dBm
Video digital	LAN (bandwidth ≤500 kHz) FPDP (bandwidth ≤5 MHz)
I/Q digital	LAN (bandwidth ≤1 MHz) FPDP (bandwidth ≤10 MHz)
Audio analog	headphone connector: 0 V to ≥2 V R_i = 100 Ω f = 10 Hz/300 Hz to 12.5 kHz (depending on IF filter and modulation) AF line: 0.5 V ± 0.3 V (m = 0.5) R_i = 100 Ω f = 10 Hz/300 Hz to 12.5 kHz (depending on IF filter and modulation) AF symmetrical: 0.4 V ± 0.2 V (m = 0.5) R_i = 600 Ω f = 100 Hz to 12.5 kHz
Audio digital	LAN AES/EBU interface (ANSI 4.40)
Internal reference output	10 MHz, output level 7 dBm to 13 dBm
Built-in test	monitoring of test signals by means of loop test as short or long test, continuous monitoring of test points
Data and control interfaces	
LAN	ETHERNET 10/100BaseT
Optical data interface	FPDP, 1 Gbit/s
General data	
Climatic conditions	in line with EN 60068-2-1, EN 60068-2-2
Operating temperature range	0 °C to +50 °C
Permissible temperature range	–10 °C to +55 °C
Storage temperature range	–40 °C to +70 °C
Humidity	in line with EN 60068-2-30 max. 95 %, cycl. test at 25 °C/55 °C
Shock	in line with EN 60068-2-27 40 g/11 ms MIL-STD-810E, method 516.4
Vibration	
Sine	in line with EN 60068-2-6, EN 61010-1 MIL-T-28800 D, class 5
Noise	in line with EN 60068-2-64
Electromagnetic compatibility (EMC)	in line with EN 300339, ETSI EN 301489-1, ETSI EN 301 489-22 MIL-STD-461E, CE 102, RE 102, RS 103
MTBF	≥30 000 h (IEC 1709)
Power supply	
AC	100 V to 240 V (47 Hz to 63 Hz) typ. 45 VA
DC	12 V/24 V typ. 33 VA
Dimensions (W × H × D)	19", 2 height units, 426.7 mm × 87.6 mm × 450 mm (without feet or handles)
Weight	8.5 kg 18.74 lb

Ordering information

Designation	Type	Order number
HF Digital Wideband Receiver	R&S®EM510	4065.7728.02
Options		
Panorama Scan (RF Spectrum)	R&S®EM510PS	4065.8430.02
IF Panorama (IF Spectrum)	R&S®EM510SU	4065.8499.02
ITU Measurement Software[1)]	R&S®EM510IM	4065.8401.02
SEL CALL Analysis	R&S®EM510SL	4065.8460.02

[1)] R&S®EM510SU IF panorama is included in the R&S®EM510IM option.

More information at
www.rohde-schwarz.com
(search term: EM510)

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