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, AM², FM², I/Q, I/Q²
- Audio filters: notch, noise suppression, bandpass
- Dual-channel analog video output (AM, FM)
- ITU measurements
- LAN interface (SCPI)
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)
  - qM
  - 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, FM)
- 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
  - qM 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 **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, AM², FM², I/Q, and I/Q² functions makes it possible to visualize the demodulated spectrum. In the AM³ and FM³ modes, most digitally modulated signals can be identified, and further measurements performed as, for example, the following:

- Symbol rate
- Chip rate of DSSS transmissions

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-RSM182/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 programmable 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
- **Frequency resolution**: 1 Hz
- **Frequency accuracy**: $\leq 1 \times 10^{-7}$
- **Aging per year**: $\leq 1 \times 10^{-7}$
- **Input for external reference**: 10 MHz

#### Phase noise
- $\leq -130$ dBc (1 Hz) at 1 kHz offset, typ. $-140$ dBc (1 Hz)

#### BFO
- Settable, 0 kHz to ±8 kHz

#### Antenna input
- BNC socket, 50 $\Omega$

#### VSWR
- $\leq 2.5$

#### Input level
- (-137 dBm to +10 dBm) $f = 400$ kHz to 32 MHz
- (-137 dBm to +6 dBm) $f < 400$ kHz

#### Preselection
- 9 kHz to 400 kHz lowpass filter
- 400 kHz to 32 MHz switchable highpass/lowpass filters

#### Immunity to interference
- **Aliasing suppression**: $\geq 90$ dB, typ. 120 dB
- **Inherent spurious signals**: $\leq -110$ 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**: $\geq$30 dBm, typ. 35 dBm (low distortion mode), f = 1 MHz to 32 MHz, $\geq$20 dBm, typ. 25 dBm (normal mode), f = 1 MHz to 32 MHz

#### Noise figure
- $\leq$15 dB, typ. 12 dB (normal mode), f = 400 kHz to 30 MHz
- $\leq$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 $f_{\text{ref}} = 1$ kHz, $m = 0.5$
- **FM**: bandwidth = 15 kHz, SINAD = 20 dB $f_{\text{ref}} = 1$ kHz, deviation = 5 kHz
- **LSB/USB**: bandwidth = 2.4 kHz, SINAD = 10 dB $\leq$0.5 $\mu$V ($\leq$-113 dBm), f = 400 kHz to 30 MHz

#### CW
- **bandwidth**: 600 Hz, **SINAD**: 10 dB
- $\leq$0.25 $\mu$V ($\leq$-119 dBm), f = 400 kHz to 30 MHz

#### Demodulation modes
- AM, FM, PM, PULSE, I/Q (all IF bandwidths)
- USB, LSB, CW (IF bandwidth 5 kHz), ISB (IF bandwidth 2 kHz)

#### IF bandwidths
- For demodulation, level and offset measurement (3 dB bandwidth)
- 30 filters [100/150/300/600 Hz]
- 1/2/2.4/2.7/3.1/4/4.8/6/9/12/15/30/50/120/150/250/300/500/800 kHz
- 1/2.5/5/10 MHz
- **Shape factor**: (3 dB - 60 dB)
  - $\leq$1.6 for 100 Hz to 5 MHz filters
  - $\leq$1.3 for 10 MHz filter
- **Audio filters**: notch/noise suppression/bandpass
  - 300 Hz to 3.3 kHz

#### Squelch (level squelch)
- $-30$ dB$mV$ to $+130$ dB$mV$, settable in 1 dB steps

#### Gain control
- AGC, MGC, $-30$ dB$mV$ to $+130$ dB$mV$
- AGC modes: FAST/DEFAULT/SLOW
- MGC settable in 1 dB steps

#### Automatic frequency control (AFC)
- Automatic returning for frequency-unstable signals ± 1/5 IF bandwidth (100 Hz to 10 MHz)

#### ADC resolution
- 16 bit

#### Level and offset measurement
- **Signal level**: $-30$ dB$mV$ to $+130$ dB$mV$, resolution 0.1 dB
- **Indication errors**: max. ±1.5 dB, typ. ±1.0 dB
- **Level indication mode**: AVG, PEAK, FAST, RMS
- **Offset**: up to ± 1/5 IF bandwidth (100 Hz to 10 MHz), resolution 1 Hz

#### IF panorama
- (with R&S®EMS10SU 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®EM500M option)
- **AM (modulation index)**
  - AM, AM+, AM–, m = 0 % to 999.9 %; resolution 0.1 %
  - $f_{\text{max}} = 4$ MHz
- **Indication error**: $<5$ % with bandwidth $\leq$1 MHz
  - $<7$ % with bandwidth $>$1 MHz
  - ($S/N > 40$ dB, $AF = 1$ kHz, measurement time $<1$ s)
- **FM (FM deviation)**
  - FM, FM+, FM–
  - $\Delta f = 0$ Hz to 4 MHz, resolution 0.001 kHz
  - $f_{\text{max}} = 4$ MHz ($f_{\text{ref}} +$ deviation)
- **Indication error**: $<2$ % of used IF bandwidth (absolute)
  - ($S/N > 40$ dB, $AF = 1$ kHz, measurement time $<1$ s)
- **qM**
  - $\Delta \theta = 0$ rad to 12.5 rad;
  - resolution 0.01 rad
  - $f_{\text{max}} = 4$ MHz ($f_{\text{ref}} +$ 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**

| 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 ≤55 MHz)
- **I/Q digital** LAN (bandwidth ≤1 MHz), FPDP (bandwidth ≤10 MHz)
- **Audio analog** headphone connector: 0 V to ≥2 V
  - 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)
  - Rₗ = 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)
  - Rₗ = 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, ETSIEN 301 499-22 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)
- **DC** 12 V/24 V typ. 45 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**

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