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The radiomonitoring specialist: versatile, fast, accurate

Fast detection of signals, highly accurate measurements and demodulation, and versatility are the major advantages of the new R&S®ESMD radiomonitoring receiver. Due to these advantages plus other attributes such as a wide frequency range and expandability for use as a direction finder, the R&S®ESMD provides functionalities previously available only with entire systems.

Special characteristics

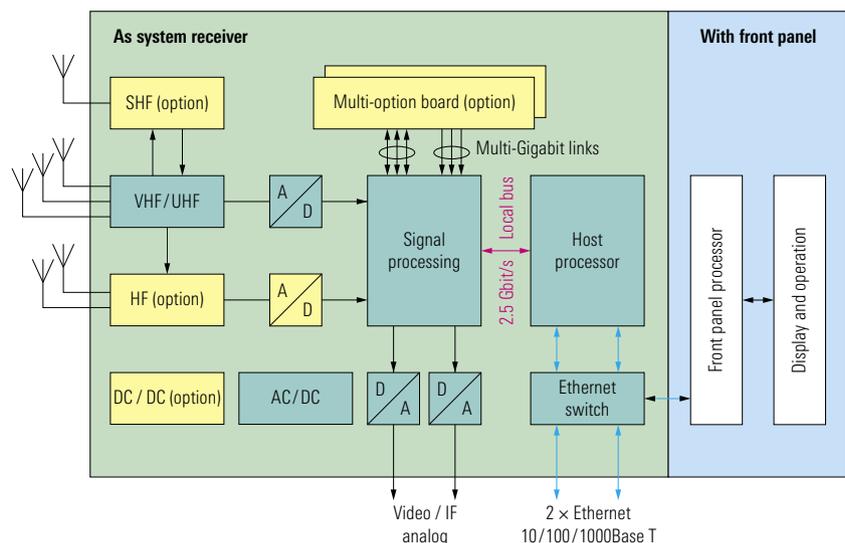
Modern radiomonitoring equipment has to handle a vast array of tasks, including stationary or mobile use, wideband scan or narrowband demodulation, or manual or fully automatic operation. The R&S®ESMD (FIG 1) takes on all of these challenges easily with its wide range of functions, its modular architecture, and its variety of available enhancements (FIG 2) – characteristics that allow users to adapt the receiver optimally to their individual requirements. The special characteristics of the R&S®ESMD are as follows:

- ◆ Demodulation from 100 Hz to 20 MHz (realtime bandwidth)
- ◆ ITU-compliant measurement of signal parameters between 100 Hz and the full realtime bandwidth
- ◆ Analog two-channel IF/video output up to 20 MHz bandwidth
- ◆ Direction finding
- ◆ Standardized 1 Gbit Ethernet data interface
- ◆ Standardized command set (SCPI)
- ◆ Easy serviceability and maintainability

In the base version, the R&S®ESMD detects frequencies from 20 MHz to 3.6 GHz. Two frequency range expansions are available for installation in the instrument. With the expansions for the microwave range (3.6 GHz to 26.5 GHz, SHF option) and the shortwave band (9 kHz to 32 MHz, HF option), the receiver can cover the entire frequency range from 9 kHz to 26.5 GHz. Up to six antennas that are switched internally can be connected in this configuration.

FIG 1 Shortwave or microwave, demodulation or spectrum display, detection of pulsed signals or direction finding: The R&S®ESMD provides all of these capabilities in one compact device.

FIG 2 Simplified block diagram of the R&S®ESMD system architecture.



* Maximum bandwidth that is processed without interruption.

► The R&S®ESMD offers excellent RF performance over the entire receive range (see condensed data on page 67). This is of particular importance in scenarios where very strong and very weak signals occur closely together, or when scanning for signals that are difficult to detect, because the user must be certain that the correct signal is being detected, and not some artifact generated by the receiver itself, for example.

The R&S®ESMD combines outstanding RF characteristics with innovative broadband technology: For example, in the HF range, it functions as a direct receiver. Its carefully designed preselection as well as the absence of mixers, oscillators, and the like, make it a first-class receiver, even in the shortwave range up to 32 MHz.

Even though many radiomonitoring tasks can be carried out automatically these days, manual operation of the receiver

is often indispensable. The R&S®ESMD front panel has been optimized for these types of tasks (FIG 1). All important functions, including frequency entry, bandwidths, demodulation mode, AGC/MGC, and scan parameters, can be set using fixed keys. The smooth-running frequency setting knob makes tuning to signals easy, and the high-resolution TFT display (1024 × 768 pixels) ensures that all device parameters and measurement results are clearly visible (FIG 3).

Whether you wish to monitor specific frequencies or scan for difficult-to-detect signals over a wide frequency range, fast scan modes are a must for every modern radiomonitoring receiver. The R&S®ESMD has three scan modes. The frequency scan is suited for sequential scanning of a frequency band with fixed channel spacing. The memory scan processes up to 10000 channels in any sequence as defined by the operator. Both scan modes achieve speeds of up to 1000 channels/s.

The highest scan rate is offered by the R&S®ESMD in the panorama scan (PSCAN) mode:

Step width (kHz)	Channels (1/s)	Scan rate (GHz/s)
100	200000	20
50	360000	18
25	560000	14
12.5	800000	10
6.25	1000000	6.25

Even at very small resolution bandwidths, the R&S®ESMD achieves a scan rate of up to 20 GHz/s (FIG 4). As a result, the PSCAN is ideal for scanning both for short-duration signals and for frequency hoppers, even over wide scan ranges.

FIG 3 Important tools in radiomonitoring: spectral and waterfall display (spectrogram). The 20 MHz wide spectrum shows four digital broadcast signals, one DVB-T signal to the left and three DAB signals to the right. The high time resolution of the realtime spectrum makes the null symbols in the DAB data streams clearly visible in the waterfall display.

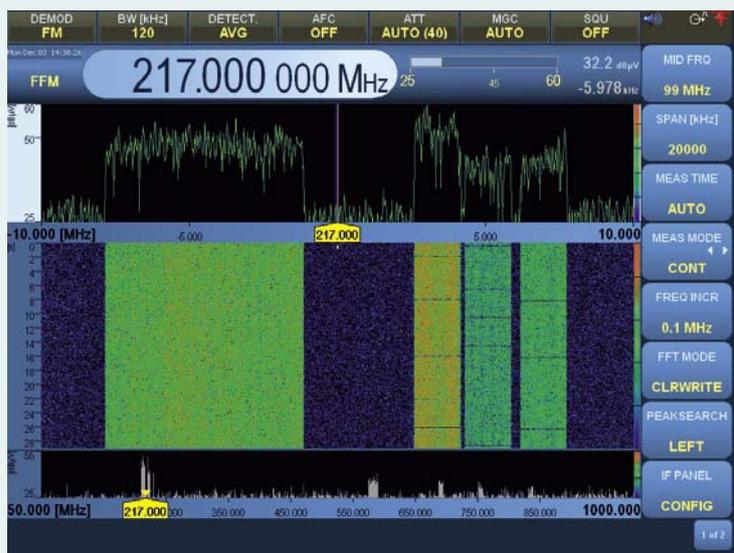
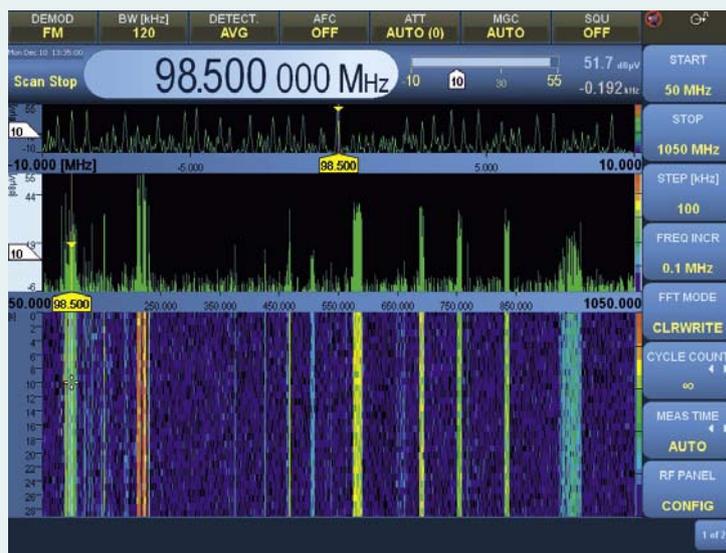


FIG 4 PSCAN from 50 MHz to 1050 MHz: The step width (resolution bandwidth) is 100 kHz. In this setting, the scan range (span) of 1 GHz is run through twenty times per second. The left edge of the spectrum shows the VHF FM broadcast band, and the GSM band at 900 MHz is seen to the right.



Signal processing in realtime

The digital signal processing in the R&S®ESMD consists of two parallel, independently parameterized paths (FIG 5). One path calculates the IF spectrum, while the other path is used for demodulation, automatic gain control (AGC), measurement value calculation, and reversion to an analog signal (video signal). Both paths work

completely without interruption and in realtime.

The spectrum path allows reliable monitoring of the spectral characteristics for even very quickly changing signals. Its effectiveness becomes obvious when monitoring signals with a pulse structure (FIGs 6 to 8). The enormous amount of data obtained during spectrum calculation is difficult for externally connected

systems to handle (FIG 9). Therefore, the device already performs data reduction by means of various weighting filters (Average, MAXHOLD, MINHOLD).

Even at small spectrum bandwidths, the user benefits from the receiver's processing power: The signal processing overlaps the spectrum calculations, which improves the time resolution. Alternatively, a weighted overlap

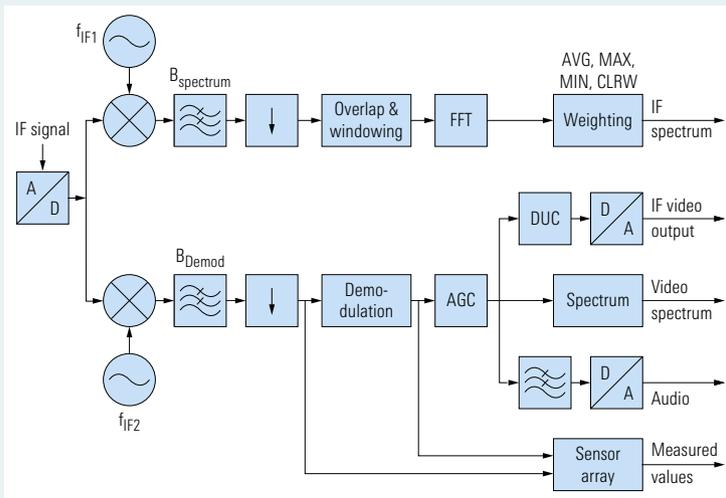
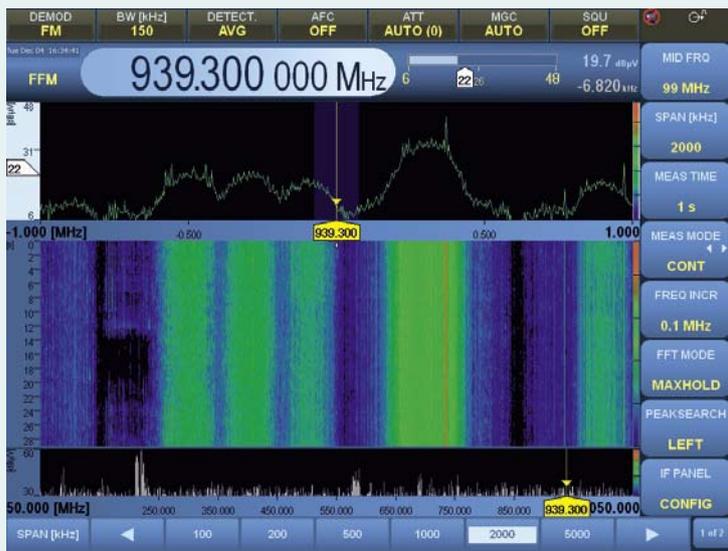
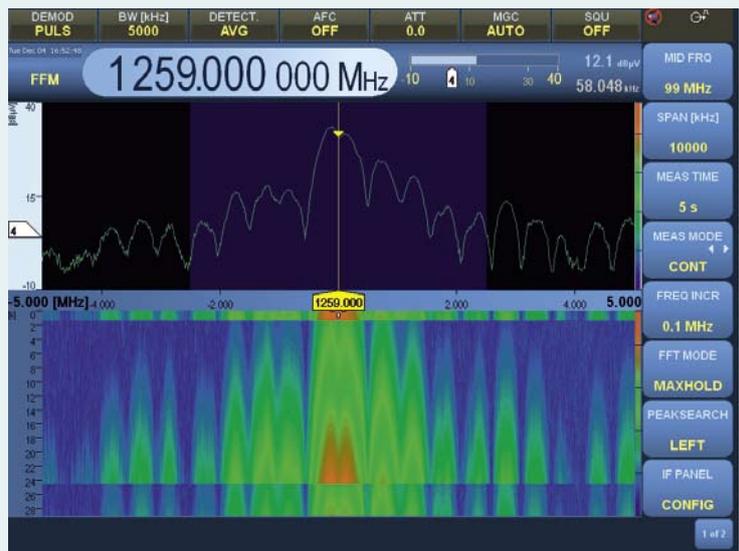


FIG 5 Block diagram of the signal processing in the R&S®ESMD.

FIG 8 Analysis of a GSM signal using the IF spectrum: The signal to the right of the center shows an obvious peak. This is the frequency correction burst (FCB), which spectrally corresponds to a carrier signal. The FCB is emitted only by GSM base stations, lasts 576 μ s, and is repeated every 46 ms or 51 ms.



FIGS 6 and 7 Detection of long-range radar on the antenna: The distance of 500 kHz between the zeroes on the $\sin(x)/x$ -shaped spectrum leads one to suppose a pulse length of about 2 μ s. The supposition is confirmed by measuring the amplitude-demodulated signal (envelope) using an oscilloscope connected to the analog video output of the R&S®ESMD.



- ▶ add (WOLA) spectrum can be calculated that significantly improves the adjacent channel suppression in the spectrum.

The demodulation path is the method of choice when analyzing the time domain characteristics of signals. Because signal processing is carried out in parallel, the user can view radio signals from various angles. The R&S®ESMD simultaneously provides the wideband, demodulated, and gain-controlled signal, as well as a narrowband audio signal, various signal levels, and modulation parameters such as modulation depth and frequency deviation. In addition, it calculates the spectrum of the demodulated signal. This video spectrum is extremely helpful in determining the characteristics of signals (FIG 10), and it can even be useful in discerning some of the characteristics of highly complex, spread-spectrum (DSSS) third-generation mobile signals (FIG 11).

Expandable for use as direction finder

The direction from which an electromagnetic wave arrives at an antenna is information whose importance cannot be overestimated. The equipment needed to determine this angle of incidence is normally both extensive and expensive. Not so with the R&S®ESMD: As the first monitoring receiver from Rohde & Schwarz, it can be upgraded to a full-featured direction finder (R&S®DDF255) without any additional equipment. Either the correlative interferometer method or the Wattson-Watt principle is used to determine the bearing. Up to three DF antennas can be connected directly to the receiver.

Because the DF functionality is fully integrated into the scan sequences, it satisfies the requirements for a variety of scenarios. So whatever the situation – whether cyclical monitoring of distress

frequencies, interception of classic voice communications (FIG 12), or finding the bearing of short-duration signals in the millisecond range – the R&S®ESMD from Rohde & Schwarz is an extremely compact and cost-efficient solution.

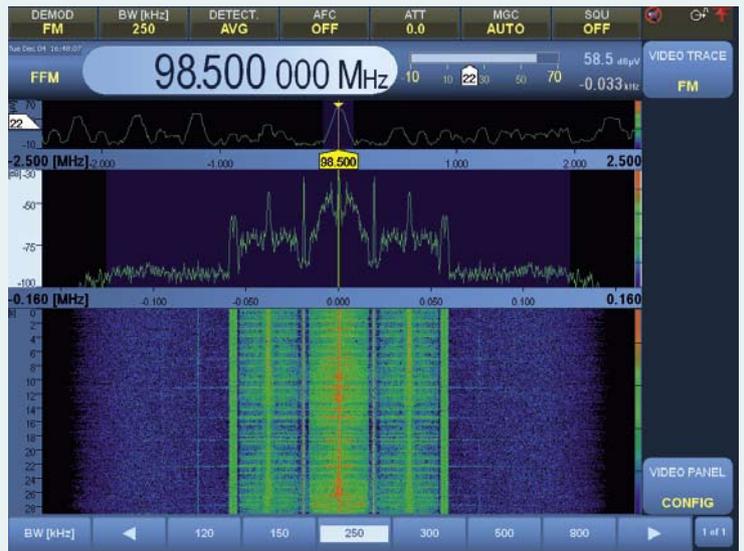
State-of-the-art and compatible: the system interfaces

The R&S®ESMD is equipped with two triple-mode 1 GBit Ethernet interfaces for data output and remote control (10/100/1000BaseT). As a result, backward compatibility with other Rohde & Schwarz monitoring receivers, such as the R&S®EB200, R&S®ESMB, R&S®EM050, R&S®EM550, R&S®EM510, and R&S®PR100, is ensured. And the same applies to data and command formats. Seamless integration in existing monitoring systems is thus no problem at all.

FIG 9 To allow the comparison of the realtime capability of monitoring receivers, a virtual scan speed is frequently specified. This value identifies the scan speed in scan ranges that are smaller than the maximum bandwidth of the receiver. This could also be called a realtime scan because the settling time of the synthesizer is immaterial within the realtime bandwidth of a receiver. At large bandwidths and a fixed frequency resolution, this quantity will only reflect the processing power of a receiver.

Frequency resolution (kHz)	Number of spectra (1/s)	Time resolution (µs)	Scan rate of realtime scan (B = 20 MHz)
12.5	12500	80	250 GHz/s
25	25000	40	500 GHz/s
50	50000	20	1000 GHz/s
100	100000	10	2000 GHz/s

FIG 10 Video spectrum of a frequency-demodulated VHF FM multiplex signal. This view shows the structure of such a signal with 19 kHz pilot tone and RDS subcarrier.



The R&S®ESMD has connections for external accessories, such as GPS or an electronic compass. Like earlier devices, this receiver also offers comprehensive selftests at the module level, ensuring a high degree of serviceability and maintainability. Extensive recalibrations after a module replacement are thus eliminated.

Both the modular design and the multi-option boards that allow implementation of future functionality enable the R&S®ESMD to easily address new developments in radiomonitoring such as larger realtime bandwidths.

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

Summary

Shortwave or microwave, demodulation or spectrum display, detection of pulsed signals or direction finding: The R&S®ESMD provides all of these capabilities in one compact device. Because there are so many device options, this article can offer only a brief overview of the receiver's most important characteristics. The R&S®ESMD and its expansions offer well over one hundred different combinations, making it adaptable to almost any task. An upcoming issue will highlight the most important options.

Condensed data of the R&S®ESMD (typical values)

Frequency range	9 kHz to 26.5 GHz
Noise figure	
HF	12 dB
VHF	10 dB
UHF	12 dB
3rd order intercept point (IP3)	
HF	35 dBm (at input level of -6 dBm)
VHF	23 dBm
UHF	23 dBm
Synthesizer settling time	1 ms
Demodulation modes	AM, FM, φM, I/Q, PULSE, TV, LSB, USB, ISB, CW
ITU-compliant measurement values	frequency, frequency offset, frequency deviation, phase deviation, modulation depth, field strength
Demodulation and measurement bandwidths	31 bandwidths from 100 Hz to 20 MHz
IF spectrum bandwidths	14 bandwidths from 1 kHz to 20 MHz
Data interface	1 Gigabit Ethernet (10/100/1000Base T)
Video /IF output (switchable)	2 channels, gain-controlled, level >0 dBm

FIG 11 Video spectrum of a UMTS signal. For digitally modulated signals whose envelopes are not constant, the baud rate or chip rate in the spectrum of the squared base-band signal can be determined by means of spectral lines that are symmetrical to frequency 0. In this case, this phenomenon occurs at a frequency of 3.84 MHz, which corresponds to the UMTS chip rate.

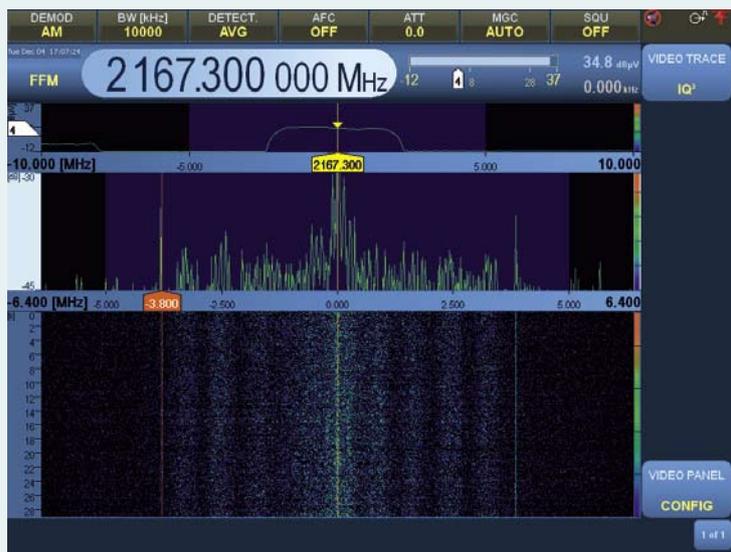


FIG 12 The R&S®ESMD after being upgraded to a direction finder: DF measurement of a voice channel in the aeronautical radio band.

