Version 01.00

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R&S®ESMD Wideband Monitoring Receiver

Radiomonitoring from 9 kHz to 26.5 GHz

- Realtime spectrum monitoring
- Detection and monitoring of almost any type of signal
- Fast search in user-selectable frequency ranges
- Direction finding of emissions
- Reliable location of interference sources
- Recording of signals
- Audio monitoring of emissions
- Signal analysis (online and offline)
- Spectrum and waterfall display
- Output of complex baseband data
- 8.4" XGA display (1024 × 768 pixels)
- 20 MHz realtime bandwidth
- Demodulation up to 20 MHz bandwidth
- 31 IF filters from 100 Hz to 20 MHz
- RF spectrum with user-definable frequency range, up to 70 GHz/s scan speed
- IF spectrum, display range from 10 kHz to 20 MHz
- Video spectrum
- Scanning capabilities: frequency scan, memory scan, panorama scan
- Two LAN interfaces (1 Gbit each)

ROHDE&SCHWARZ

Overview

The R&S®ESMD is designed for signal search, radiomonitoring, spectrum monitoring applications in line with ITU recommendations, etc.

The R&S®ESMD stands out from the crowd due to its wide frequency range of 9 kHz to 26.5 GHz, outstanding receive characteristics, 20 MHz realtime bandwidth, wealth of functionalities and large (8.4") XGA color display.

It is also prepared to meet future requirements in the fields of receiver and signal analysis engineering. Using the available options, the receiver can be optimally adapted to the tasks at hand. Free slots and spare capability for signal processing allow the instrument to be expanded for future tasks.

The R&S®ESMD can be upgraded to a full-featured, single-channel direction finder.

The receiver is remote-controlled via its LAN interface. It can be easily integrated into new or existing systems since the protocol used on the remote-control interface is compatible with other receivers from Rohde&Schwarz.

The receiver is equally well suited for mobile and stationary applications.

Brief description

The basic version of the R&S®ESMD covers a wide frequency range from 20 MHz to 3.6 GHz. Optional plug-in modules make it possible to expand the frequency range down to 9 kHz and up to 26.5 GHz.

The receiver's operation and functionality are optimized for monitoring tasks. Yet its adaptable functions also mean that it can be used in other areas, especially when realtime analysis of signals is required.

The receiver is equipped with comprehensive preselection, which reduces the signal sum load in scenarios involving many powerful transmitters.

All of the receiver's functions can be remote-controlled via the LAN interface. All measurement results (including spectrum and I/Q data) are output via this interface.

The R&S®ESMD is particularly well suited to perform the following tasks:

- Quick overview of activities in a user-definable frequency range
- Monitoring of predefined frequencies
- Storage of up to 10000 frequencies
- Search in a frequency range with user-definable start/stop frequency and fixed step width
- Search for and analysis of interfering signals
- Detection of illegal transmitters
- Monitoring of security-relevant radio and navigation services
- Monitoring of self-conducted radiocommunications training exercises in a specific frequency band
- Monitoring of selected emissions
- Radiomonitoring for tactical and strategic intelligence
- Radiomonitoring for internal and external security
- Monitoring in line with ITU guidelines
- Coverage measurements and monitoring of networks
- Storage of spectra or digital baseband data, internal and external
- Analysis of digital signals

Digital signal processing

All signal processing is performed by means of powerful signal processors and field programmable gate arrays (FPGAs).

The R&S®ESMD has a realtime bandwidth of 20 MHz. Thus, the FFT panorama also allows the analysis of broadband signals and of the signal environment up to a bandwidth of 20 MHz.

To ensure processing of the different signals with an optimum signal-to-noise ratio, the receiver has 31 IF filters with bandwidths from 100 Hz to 20 MHz. Demodulation with output of the digital baseband and video data can be performed at all bandwidths.

The data obtained can be made available on many different interfaces in both analog and digital formats for post-processing or further processing. The R&S®ESMD is thus also suitable for integration into complex monitoring systems.

Operation

Different R&S®ESMD models are available:

- Model .02
  Base unit, front panel without display and control elements, solely for remote-control operation
- Model .03
  With display and control elements, for manual operation via the front panel and remote-control operation

The operating concept of the R&S®ESMD meets the requirements placed on a state-of-the-art radiomonitoring receiver.

If the receiver is operated from its front panel, all essential functions such as selection of bandwidths, demodulation modes, detectors, etc. can be accessed directly by using labeled keys.

Menus structured by priority provide quick access to further functions and settings, making it possible to quickly adapt operation to the task at hand.

Measurement results as well as spectrum and waterfall diagrams are output on a straightforward 8.4" XGA color display. This display can be configured as desired.

For remote control, a software application is supplied that can be installed on an external PC. This software also allows the models .02 and .03 to be operated from a PC.

Scan capabilities

RF spectrum (panorama scan)
In this mode, the desired frequency range is scanned in 20 MHz steps. For each step, a 20 MHz wide FFT is computed. The spectrum of the selected frequency range is presented in realtime on the display.

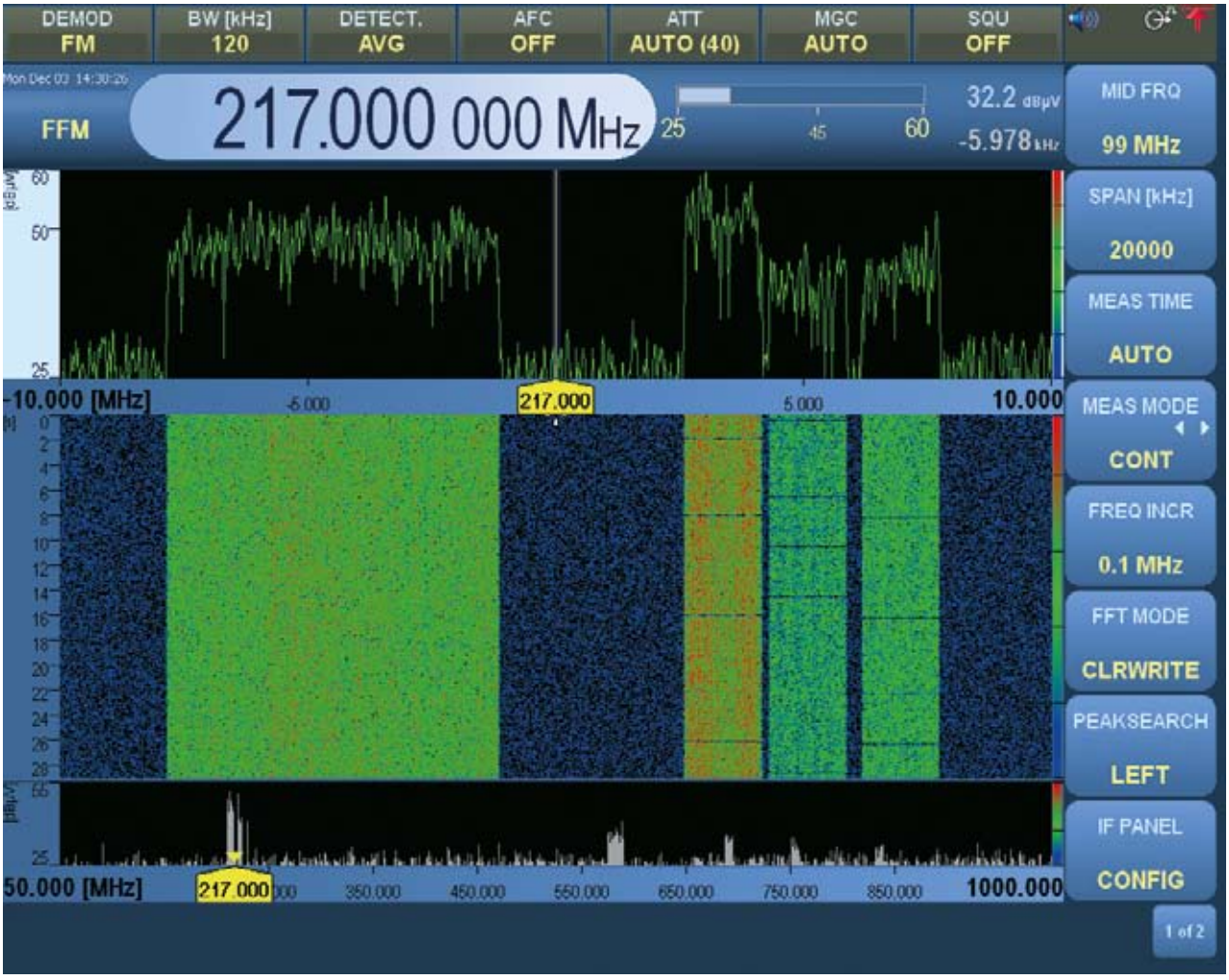
Frequency scan
In this mode, a frequency range can be defined to which a complete data record can be assigned. The data record contains the receiver settings as well as scan parameters such as start/stop frequency and step width.

Memory scan
The R&S®ESMD contains 10000 definable memory locations. A complete receive data record including frequency, demodulation mode, bandwidth, squelch level, etc., can be assigned to each memory location.

IF panorama

To enable more in-depth analysis of the signal spectrum and signal environment, the receiver is equipped with an IF panorama. The current receive frequency is at the center of the spectrum display. The span can be set between 1 kHz and 20 MHz for optimal adaptation to the task at hand. MINHOLD, MAXHOLD and AVERAGE displays are also possible, allowing an even broader scope of applications.

Detection and analysis of a radar pulse



Clear presentation of results and associated settings on the large display

Video panorama

The spectrum of the demodulated signal is displayed by means of the built-in video panorama.

Various display modes are provided for the measurement and visual analysis of signal parameters such as baud rate and chip rate (for DSSS signals).

Data output

A variety of data is output via the LAN interface:

- Complex baseband data (I/Q data) up to 10 MHz bandwidth
- Digital video data (demodulated signal) up to 5 MHz bandwidth
- Digital audio up to 12.5 kHz bandwidth
- Spectra of panorama scan
- Spectra of IF panorama
- Spectra of video panorama
- Level reading
- Offset reading
- Field strength reading
- Modulation index, FM and phase deviation
- Bandwidth

Remote control

All receiver functions can be remote-controlled via the LAN interface. To ensure reliable transmission at high data rates (baseband data, scan data) and of control commands, the receiver is equipped with two 1 Gbit LAN interfaces.

The protocol on the LAN interface is compliant with the standard commands for programmable instruments (SCPI) syntax.

Application examples

Quick scan of a frequency range
The Panorama Scan function enables the R&S®ESMD to perform a high-speed scan of a user-definable frequency range. It thus provides a fast overview of the spectrum occupancy. This makes it possible to immediately detect changes caused by illegal radio services, interferences, temporary emissions, etc. The receiver can be switched to Listen mode simply by pressing a key. The marker function is used to select the signal of interest for demodulation and analysis.

The resolution of the FFT computation can be set to suit the channel spacing used by various radio services.

The advantages of this FFT scan are its fast scan rates plus high sensitivity and small resolution bandwidth.

Scan using channel spacing
The Frequency Scan function is used to search in the frequency range with fixed channel spacing. The receiver scans the frequency range and analyzes every channel for occupancy. If a signal is above the threshold, the receiver dwells at the signal's frequency for the predefined hold time, and the signal can be demodulated and processed. In the case of analog methods, the demodulated signal can be monitored on the loudspeaker or headphones.

The Frequency Scan function is designed especially for monitoring radio services that use fixed (frequency) channel spacing.

Scan at specific frequencies
The Memory Scan function is used to scan previously defined channels in sequence and check whether they are occupied. If a signal is above the threshold, the receiver dwells at the signal's frequency for the predefined hold time, and the signal can be demodulated and processed. In the case of analog methods, the demodulated signal can be monitored on the loudspeaker or headphones.

In this mode, parameters such as frequency, demodulation mode, bandwidth, squelch levels, etc., can be set individually for each channel.

The content of each memory location can be transferred to the receiver manually by using the RCL key. The settings can also be changed and then stored in the memory by means of the SAVE key.

The parameters for multiple channels can be set by calling up a display table.

This type of scan is particularly useful for scanning individual frequencies that do not have a fixed channel spacing or for periodically scanning frequency blocks (e.g. f1, f2, f3, f1, f2, f3, etc.).

Demodulation and analysis
Analog modulated signals are demodulated in the receiver. The signal can be monitored with the built-in loudspeaker or via headphones.

A PC-based software (R&S®GX430) is available for analyzing complex signals. This software includes a number of signal detection and analysis functions such as classification (detection of the modulation mode), vector analysis, bit stream analysis and decoding.

For online analysis, digital data are transferred in realtime via LAN from the receiver to the PC. For offline analysis, the software accesses data saved internally in the receiver, or external data.

Interference search
Due to its compact design and many special functions, the R&S®ESMD is ideally suited for detecting all types of radio interference. Special functions such as an adjustable measurement time and continuous or periodic level output have been integrated for these tasks. Since these functions also work in the HF spectrum, it is easy to find even non-periodic interferers which would otherwise be difficult to detect due to their irregular appearance in a quickly changing spectrum. As a result, the source of interference can be quickly detected and eliminated – an aspect that is extremely important in security-critical radio traffic (e.g. airborne communications, air traffic control, ATC).

Rear view of the R&S®ESMD

Detection of frequency-agile signals, hoppers
The large realtime bandwidth and high scan rates of the receiver ensure reliable detection even of signals with quickly varying frequencies. Even hoppers with hop rates of up to 2000 hops/s are detected.

When using the MAXHOLD function, the occupied frequency range of the transmitter is displayed quickly.

Detection of burst signals, radar emissions
Due to the receiver's large realtime bandwidth (20 MHz), even very narrow bursts such as those emitted by radar equipment can be detected and analyzed.

Using the IF panorama, parameters such as pulse duration can be measured.

Data recording
Data can be recorded/stored using the following media (receiver model with front panel for manual operation):

- 2 Gbyte on internal compact flash card
- External storage via USB 2.0

Digital data can also be output in realtime via the LAN interface and recorded externally (e.g. PC hard disk).

The recording time is limited only by the capacity of the storage medium.

Recording can be done in various formats.

Civil monitoring in line with ITU guidelines
Featuring excellent performance, the R&S®ESMD meets all requirements for measurements in line with ITU-R recommendations and the ITU spectrum monitoring handbook (2002).

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

- Frequency and frequency offset in line with ITU-R SM.377
- Field strength in line with ITU-R SM.378
- Modulation in line with ITU-R SM.328
- Spectrum occupancy on the control PC in line with ITU-R SM.182/SM.328
- Bandwidth in line with ITU-R SM.443
- Detection of mono and stereo transmissions from FM broadcast transmitters

Radio data system (RDS) analysis
The signal content is demodulated and decoded. The results are output on the display or external PC and are also made available via LAN. Information such as station name, frequency lists and traffic information is visible at a glance.

TV picture as a bitmap
A special TV mode is used to demodulate analog TV transmissions. The receiver calculates a black-and-white bitmap picture and displays it via the user interface. Simultaneously, the original sound is audible. The color TV picture is available for a video monitor (or video projector) in realtime at the AM video output.

Selective call/pager analysis
The R&S®ESMD-SL option is available for decoding selective call methods and for demodulating pagers.

The following selective call methods are supported:
CCIR1, CCIR7, CCITT, EEA, EIA, EURO, DCS, DTMF, CTCSS, NATEL, VDEW, ZVEI1, ZVEI2.

The results are output on the display or via remote interface.

Direction finding of emissions
In addition to detecting signals, the direction from which they arrive is also important in radiolocation and radiomonitoring.

The R&S®ESMD-DF upgrade kit turns the R&S®ESMD into a single-channel direction finder.

The upgrade kit consists of an hardware modul for the receiver and the corresponding Firmware. The DF antenna is not part of the upgrade kit.

Built-in test equipment

The receiver's most important parameters are continuously monitored by built-in test equipment. Additionally, it is possible to perform a dynamic test of the entire interception processing channel. Deviations from the nominal values appear as an error message on the user interface.

The defective module is thus reliably identified and downtime is reduced to a minimum.

Specifications

Frequency	
Frequency range	20 MHz to 3.6 GHz 9 kHz to 26.5 GHz (optional)
Frequency resolution	1 Hz
BFO	0 Hz to ±8 kHz
Frequency accuracy	≤1×10^{-7}
Input for external reference	10 MHz
Synthesizer setting time	typ. 1 ms, ≤5 ms (any step width)
Oscillator phase noise	
HF	≤–130 dBc/Hz at 1 kHz offset, typ. –140 dBc/Hz
VHF/UHF	≤–120 dBc/Hz at 10 kHz offset (f = 640 MHz)
Antenna inputs	
HF	2 inputs, N female, 50 Ω
VHF/UHF	2 inputs, N female, 50 Ω
HF/VHF/UHF (combined)	1 input, N female, 50 Ω (internal switching)
VSWR	≤2.5, f ≤ 1000 MHz ≤3, f > 1000 MHz
Input level	–137 dBm to +10 dBm
Max. input level (non-destructive)	+15 dBm
Oscillator reradiation at antenna input	≤–107 dBm, typ. –120 dBm
Input selection	
9 kHz to 400 kHz	lowpass filter
400 kHz to 32 MHz	highpass/lowpass filter, switchable
20 MHz to 215 MHz	bypass for broadband application, switchable
20 MHz to 1500 MHz	tracking preselection
1500 MHz to 3600 MHz	highpass/lowpass, switchable
Switchable attenuation	manual or automatic 25 dB in 5 dB steps from 9 kHz to 32 MHz (HF tuner) 40 dB in 1 dB steps from 20 MHz to 3.6 GHz (VHF/UHF tuner)
Interference rejection	
Image rejection	
9 kHz to 32 MHz	direct reception (no image frequency present)
20 MHz to 3600 MHz	≥90 dB
IF rejection	
9 kHz to 32 MHz	direct reception (no IF present)
20 MHz to 3600 MHz	≥90 dB

Linearity	
2nd order intercept point	
9 kHz to 32 MHz (HF)	≥50 dBm, typ. 65 dBm (normal mode) >70 dBm, typ. 75 dBm (low distortion mode) f = 1 MHz to 32 MHz
20 MHz to 3600 MHz	typ. 55 dBm (low distortion mode) typ. 50 dBm (normal mode)
3rd order intercept point	
9 kHz to 32 MHz (HF) [1]	≥20 dBm, typ. 25 dBm (normal mode) ≥30 dBm, typ. 35 dBm (low distortion mode) f = 1 MHz to 32 MHz
20 MHz to 3600 MHz [2]	
In-band	≥8 dBm, typ. 10 dBm (normal mode) ≥17 dBm, typ. 23 dBm (low distortion mode)
Out-of-band	typ. 32 dBm
Noise figure	
9 kHz to 32 MHz (HF)	≤15 dB, typ. 12 dB (normal mode) f = 400 kHz to 32 MHz
20 MHz to 2000 MHz	≤12 dB, typ. 10 dB (low noise mode)
2000 MHz to 3000 MHz	≤15 dB, typ. 12 dB (low noise mode)
3000 MHz to 3600 MHz	≤17 dB, typ. 15 dB (low noise mode)
Sensitivity	measurement using telephone filter in line with ITU-T (low noise mode)
AM: bandwidth = 6 kHz SINAD = 10 dB f_{mod} = 1 kHz, m = 0.5	≤–107 dBm, f ≤ 2000 MHz
	≤–104 dBm, f = 2000 MHz to 3000 MHz
	≤–102 dBm, f = 3000 MHz to 3600 MHz
FM: bandwidth = 15 kHz SINAD = 25 dB f_{mod} = 1 kHz, deviation = 5 kHz	≤–107 dBm, f ≤ 2000 MHz
	≤–104 dBm, f = 2000 MHz to 3000 MHz
	≤–102 dBm, f = 3000 MHz to 3600 MHz
Demodulation modes	
AM, FM, PM, PULSE, I/Q, TV (all IF bandwidths)	
USB, LSB, CW, ISB (IF bandwidths ≤15 kHz)	
IF bandwidths	
Demodulation, level and offset measurement (3 dB bandwidth) 31 filters	100 Hz, 150 Hz, 300 Hz, 600 Hz, 1 kHz, 1.5 kHz, 2.1 kHz, 2.4 kHz, 2.7 kHz, 3.1 kHz, 4 kHz, 4.8 kHz, 6 kHz, 9 kHz, 12 kHz, 15 kHz, 30 kHz, 50 kHz, 120 kHz, 150 kHz, 250 kHz, 300 kHz, 500 kHz, 800 kHz, 1 MHz, 1.25 MHz, 1.5 MHz, 2 MHz, 5 MHz, 10 MHz, 20 MHz

Shape factor (3 dB : 60 dB)	≤1:1.7 for 100 Hz to 2 MHz filter ≤1:1.6 for 5 MHz filter (3 dB : 50 dB) ≤1:1.7 for 10 MHz and 20 MHz filter (3 dB : 50 dB)
Squelch (level squelch)	–30 dBµV to 120 dBµV, settable in 1 dB steps
Audio filter	notch/noise reduction/bandpass 300 Hz to 3.3 kHz
Gain control	AGC, MGC, 130 dB AGC modes: FAST/DEFAULT/SLOW MGC, settable in 1 dB steps
Automatic frequency control (AFC)	automatic retuning for signals with unstable frequency ±½ IF bandwidth (100 Hz to 20 MHz)
ADC resolution	16 bit
Level and offset measurement	
Signal level	–30 dBµV to 120 dBµV resolution 0.1 dB
Display error	max. ±3 dB, typ. ±1.5 dB
Level display mode	AVG, PEAK, FAST, RMS
Frequency offset	up to ±½ IF bandwidth (100 Hz to 20 MHz) resolution 1 Hz
IF panorama	internal FFT (2048 points) internal computation speed up to 6000 FFT/s
Span	1 kHz, 2 kHz, 5 kHz, 10 kHz, 20 kHz, 50 kHz, 100 kHz, 200 kHz, 500 kHz, 1 MHz, 2 MHz, 5 MHz, 10 MHz, 20 MHz
Display modes	ClearWrite, Average, MaxHold, MinHold
Modulation measurement (with the R&S®ESMD-IM option)	
AM (modulation depth)	AM, AM+, AM– m = 0 % to 999.9 % resolution 0.1 % f_{max} = 10 MHz
Indication error	<5 %, for bandwidths ≤1 MHz <7 %, for bandwidths >1 MHz (S/N >40 dB, AF = 1 kHz, measurement time <1 s)
FM (FM deviation)	FM, FM+, FM– Δf = 0 Hz to 10 MHz resolution 1 Hz f_{max} = 10 MHz (f_{mod} + deviation)
Indication error	<2 % of occupied IF bandwidth (absolute) (S/N >40 dB, AF = 1 kHz, measurement time <1 s)
φM (PM)	Δφ = 0 rad to 12.5 rad resolution 0.01 rad f_{max} = 10 MHz (f_{mod} + deviation)
Indication error	<0.1 rad (S/N >40 dB, AF = 1 kHz, measurement time <1 s)
Bandwidth measurement	
	automatic up to 20 MHz bandwidth, x dB and ß % method

Scan characteristics	
Memory scan	10 000 programmable memory locations scan speed up to 1000 channels/s
Frequency scan	user-selectable start/stop frequency and step width scan speed up to 1000 channels/s
Panorama scan (with the R&S®ESMD-PS option)	RF spectrum with user-selectable start/stop frequency, step width: 125 Hz, 250 Hz, 500 Hz, 625 Hz, 1,25 kHz, 2.5 kHz, 3.125 kHz, 6.25 kHz, 12.5 kHz, 25 kHz, 50 kHz, 100 kHz scan speed up to 70 GHz/s or 1.1 million channels/s
Inputs/outputs	
Antenna inputs	
HF	2 inputs, N female, 50 Ω
VHF/UHF	2 inputs, N female, 50 Ω
HF/VHF/UHF (combined)	1 input, N female, 50 Ω (internal switching)
External reference input	10 MHz input level 0 dBm to 10 dBm
Control signals, inputs	GPS, GPS trigger, compass, serial, trigger, blank
Outputs	
IF2	405.4 MHz, BW ≥ 50 MHz (–3 dB), uncontrolled, typ. 11 dB above antenna input (normal mode)
IF3	21.4 MHz, bandwidth = 10 MHz, uncontrolled 57.4 MHz, bandwidth = 20 MHz, uncontrolled
Internal reference output	10 MHz output level 7 dBm to 13 dBm
Video A, video B	video analog, AM (A) and FM (B), DC to ½ IF bandwidth, or: IF analog, controlled, 2 channels, adjustable center frequency 0 Hz to 21.4 MHz, bandwidth ≥2 MHz, level ≥0 dBm
Video, digital	LAN, bandwidth ≤500 kHz
I/Q, digital	LAN, bandwidth ≤10 MHz
Audio, analog	headphone connector: 0 V to ≥2 V R_i = 100 Ω f = 10 Hz to 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 to 300 Hz to 12.5 kHz (depending on IF filter and modulation) AF balanced: 0.4 V ±0.2 V (m = 0.5) R_i = 600 Ω f = 100 Hz to 12.5 kHz
Audio, digital	LAN (bandwidth ≤24 kHz)

Control signals, outputs	signal > squelch threshold, COR, antenna control
Built-in test equipment	check of entire receiver (short or long test), continuous monitoring of test points
Data and control interface	two 1 Gbit LAN interfaces (Ethernet 1000BaseT) control interface: three USB ports for external recording, mouse/keyboard/printer function (model .03 only)
General data	
Climatic conditions	in line with EN 60068-2-1, EN 60068-2-2
Operating temperature range	0 °C to +50° C (model .02) 0 °C to +45 °C (model .03)
Permissible temperature range	–10 °C to +55 °C (model .02) 0 °C to +50 °C (model .03)
Storage temperature range	–40 °C to +70 °C (model .02) –20 °C to +60 °C (model .03)
Humidity	max. 95 %, cyclic test 25 °C/40 °C non condensing (model .02) max. 80 %, cyclic test 25 °C/40 °C non condensing (model .03)
Shock	in line with EN 60068-2-27 MIL-STD-810E, method 516.4 (40 g)
Vibration (sinusoidal)	in line with EN 60068-2-6 (5 Hz to 150 Hz)
Vibration (random)	in line with EN 60068-2-64 (10 Hz to 500 Hz)
Electromagnetic compatibility (EMC)	in line with EN 300339, ETSI EN 301489-1, ETSI EN 301489-22
MTBF (IEC 1709)	>15 000 h (model .03) >20 000 h (model .02)
Power supply	AC: 100 V to 240 V 47 Hz to 440 Hz 100 VA to 250 VA (depending on optional equipment)
Dimensions (W × H × D) (without handles and feet)	426 mm × 176 mm × 450 mm (16.77 in × 6.92 in × 17.71 in) 19", 4 HU
Weight	approx. 18 kg (40 lb)

[1] Frequency spacing between intermodulation signals ≥150 kHz, level of test signals
–6 dBm (low distortion mode)
–17 dBm (normal mode).

[2] Frequency spacing between intermodulation signals ≥2 MHz, level of test signals
–16 dBm (low distortion mode)
–30 dBm (normal mode).

Ordering information

Designation	Type	Order No.	Availability
Wideband Monitoring Receiver, without front control panel	R&S®ESMD	4066.0004.02	available
Wideband Monitoring Receiver, with front control panel	R&S®ESMD	4066.0004.03	available
HF Module, 9 kHz to 30 MHz	R&S®ESMD-HF	4066.4100.02	available
SHF Module, 3.6 GHz to 26.5 GHz	R&S®ESMD-SHF	4066.4200.02	2nd quarter 2008
Panorama Scan (RF spectrum)	R&S®ESMD-PS	4066.4500.02	available
ITU Measurement Software	R&S®ESMD-IM	4066.4400.02	2nd quarter 2008
Selective Call/Pager Decoder	R&S®ESMD-SL	4066.4600.02	available
DC Power Supply	R&S®ESMD-DC	4066.4000.02	3rd quarter 2008
Direction Finding Upgrade Kit (without antenna)	R&S®ESMD-DF	4066.4300.02	2nd quarter 2008

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