



**ROHDE & SCHWARZ**

Meas BW  
Att  
Input (QPK) 9 kHz  
1 Bargraph 10 dB  
Max Peak 1 DC  
3 IF Analysis  
24.70 dB $\mu$ V  
Meas Time 10  
Preamp  
PS



POWER SYSTEM  
PRE-SET MODE SETUP



The R&S®ESW EMI test receiver offers outstanding performance in terms of dynamic range, speed and accuracy. With its integrated preselection filters, 20 dB preamplifier and highly linear frontend, it meets the requirements of all relevant commercial and military EMC standards, including CISPR, EN, MIL-STD-461, DO-160 and FCC, as well as the special requirements posed by the automotive and aerospace&defense (A&D) sectors. The instrument comes in three models, from 2 Hz to 8 GHz, 26 GHz and 44 GHz.

### EMI tests take time – although less than ever with the R&S®ESW

Conventional measuring receivers scan a frequency range of interest in many small, sequential steps. Completing a standard-compliant measurement can take several hours. Recent advances in digital signal processing, however, have brought forth solutions that speed up these measurements by many orders of magnitude. FFT-based time domain scans can be performed so efficiently today that the stringent level accuracy requirements defined in the EMC standards can be met without any problems. Even the CPU-intensive digital weighting filters in EMI detectors no longer represent a performance obstacle. FFT-based measurements have been officially approved for CISPR compliance measurements since 2010, when the industry presented proof of their suitability using appropriate measuring instruments. The R&S®ESU, which preceded the R&S®ESW, was the first commercially available test receiver that supported the FFT-based approach. The R&S®ESW now performs EMC compliance measurements even faster thanks to FPGA-based signal processing (unlike the R&S®ESU, which used the on-board CPU). Frequency scans in the CISPR bands require just a few milliseconds, and conducted disturbances can be measured in realtime with the option of running CISPR detectors (quasi-peak and CISPR-average) in parallel. Spectral signal components with a bandwidth of up to 30 MHz are covered without any time gaps. With a virtual step size of  $\frac{1}{4}$  of the resolution bandwidth and FFT windows overlapping by  $> 90\%$ , the R&S®ESW achieves level measurement accuracy significantly better than that required by CISPR 16-1-1.\*

\* A comparison of the two modes is presented in a white paper, "Comparison of time domain scans and stepped-frequency scans in EMI test receivers," found under search term 1EE24 at [www.rohde-schwarz.com](http://www.rohde-schwarz.com).

#### Product highlights

- ▮ Extremely fast time domain scan thanks to FPGA-based signal processing
- ▮ Widest available dynamic range (1 dB compression point of +15 dBm)
- ▮ Numerous configurable preselection filters, including notch filters for the suppression of ISM bands, plus optional highpass filters
- ▮ Conventional heterodyne (standard) and realtime spectrum analysis (option)
- ▮ Extremely sensitive measurements starting at 2 Hz for automotive and A&D applications
- ▮ Large touchscreen with MultiView function to display multiple operating modes, showing all relevant information at a glance

Speed is a crucial factor when testing devices that can be operated, or measured, only during a short period of time – either because they change their behavior (fluctuating or drifting disturbances), or because extended operation might be destructive, or because their operating cycle calls for high speed (as in the case of power window regulators in motor vehicles). The extremely fast time domain scan delivers results very quickly, making it easy to handle such scenarios.

#### Scan tables for fast results

In receiver mode, disturbance measurements are controlled by the settings in the scan table. The scan parameters are presented in a table and can be individually configured for each task and DUT with up to ten independently defined subranges. The same scan table is used for the time domain scan function, where the step size is set to  $\frac{1}{4}$  of the resolution bandwidth by internal coupling. In this mode, the receiver delivers standard-compliant measurement results for the entire CISPR band B after two seconds, using two CISPR detectors, this period including the required settling time of one second. This means that a complete standard-compliant measurement takes a total of four seconds for single-phase and eight seconds for three-phase DUTs, translating into virtually no delays attributable to the instrument (Fig. 1 and Fig. 2).

Band	Frequency	Resolution bandwidth	Measurement time	CISPR detectors	Total measurement time
CISPR band B	150 kHz to 30 MHz	9 kHz	100 ms	peak	110 ms
CISPR band B	150 kHz to 30 MHz	9 kHz	1 s	quasi-peak and CISPR-average	2 s
CISPR band C/D	30 MHz to 1000 MHz	120 kHz	10 ms	peak	620 ms
CISPR band C/D	30 MHz to 1000 MHz	9 kHz	10 ms	peak	840 ms
CISPR band C/D	30 MHz to 1000 MHz	120 kHz	1 s	quasi-peak	80 s
CISPR band C/D	30 MHz to 1000 MHz	9 kHz	1 s	quasi-peak and CISPR-average	67 s

Fig. 1: Measurement times for standard settings in different CISPR bands.

Since the R&S®ESW delivers an overview of the disturbance scenario within seconds, disturbance signals that vary over time or intermittent disturbance signals with low repetition rates can be detected already during the development phase by performing repeated measurements. The observation period can be extended in order to better capture disturbances that change with time. A small investment in measurement time produces reliable results, even for difficult-to-capture signals.

### Maximum protection against overload

EMI measurements of unknown disturbances call for the highest possible RF dynamic range in order to prevent overloading caused by wideband disturbances or high carrier signal levels. Preselection filters (bandpass filters), which are

typically included as standard in EMI test receivers – including, of course, the R&S®ESW – provide protection against overloading by allowing only a defined range of the RF spectrum through to the mixer. The CISPR/EN standards cover conducted disturbances starting from 150 kHz. Measurements are not performed below 150 kHz, as this range is inundated with AC line disturbances (an exception are the military and automotive sectors, where measurements are performed even though not expressly required by the standards). However, the levels below 150 kHz are sufficient to overload test instruments and make measurements impossible. CISPR therefore recommends a steep-edge 150 kHz highpass filter that suppresses the frequencies below 150 kHz by up to 60 dB, allowing measurements from 150 kHz to 30 MHz without overloading the test equipment. In addition to an impulse-protected input with 21 “normal” preselection filters, the



Fig. 2: Configurable R&S®ESW scan table with up to 10 subranges.

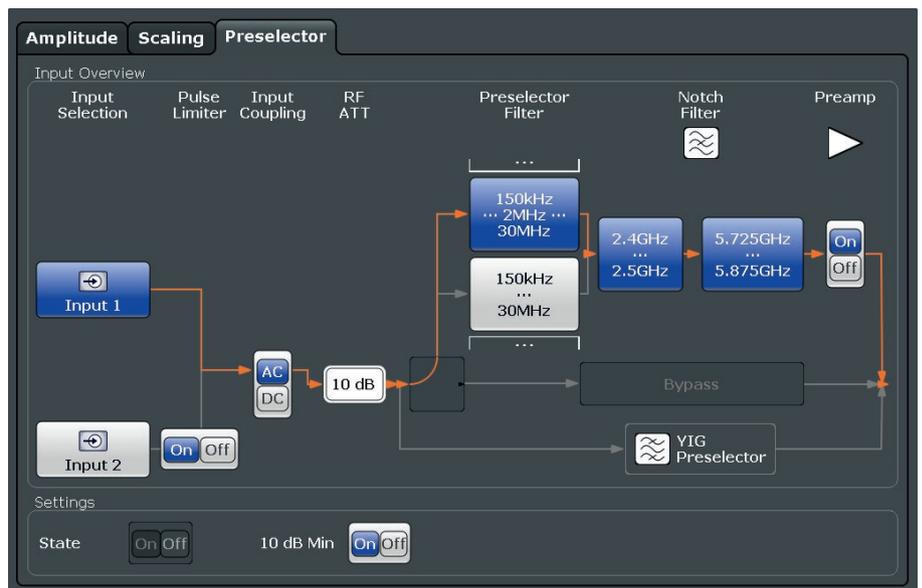


Fig. 3: Configurable preselection filters protect against overloading; special filters permit extremely sensitive measurements.

R&S®ESW offers a 150 kHz highpass filter as recommended by the standard as well as a 2 MHz highpass filter that prevents, for example, disturbance signals from switched-mode power supplies from reaching the sensitive frontend (Fig. 3).

High-level carrier signals are also present in the upper frequency ranges, e.g. in the license-free ISM bands where

WLAN networks and Bluetooth® devices operate, such signals significantly limiting instrument dynamic range for the typical measurement tasks up to 6 GHz (CISPR 22/32 for DUTs used in IT). The R&S®ESW comes with high-end notch filters to suppress these bands at 2.4 GHz and 5.8 GHz, making it possible to measure the remaining frequency ranges better and with greater sensitivity (Fig. 4).

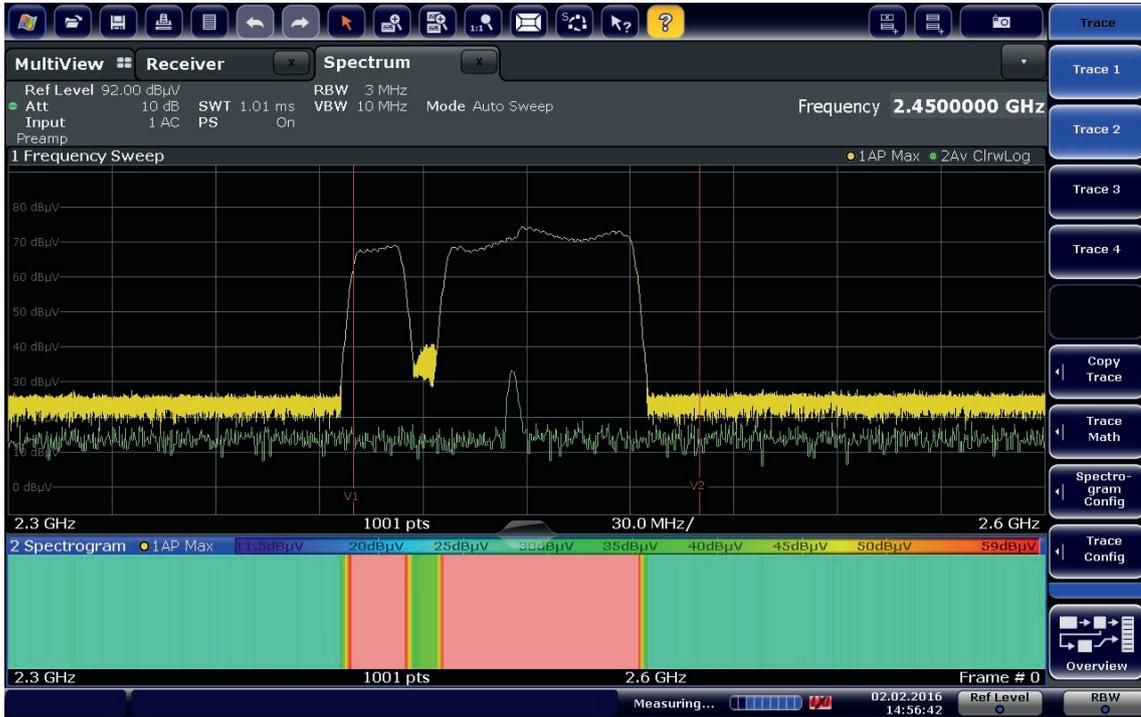
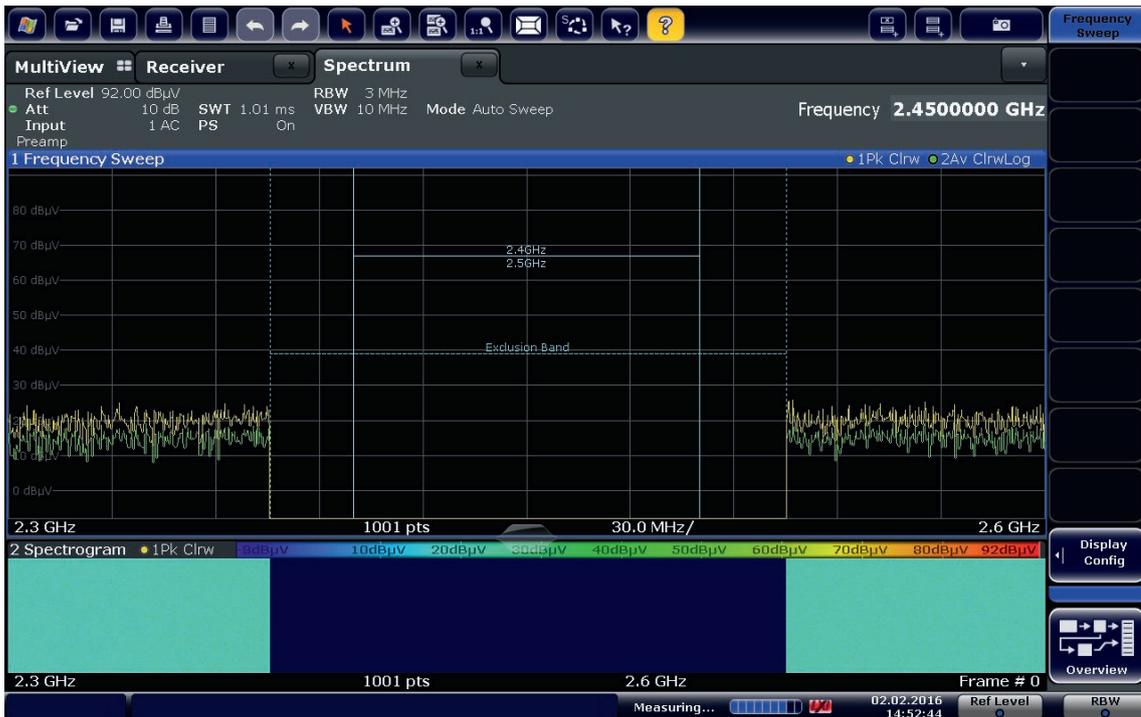


Fig. 4: Spectrum around the 2.4 GHz ISM band. Top: With the notch filter deactivated, a strong WLAN signal reaches the mixer. Bottom: When activated, the notch filter keeps the spectral ISM band component away from the IF stage.



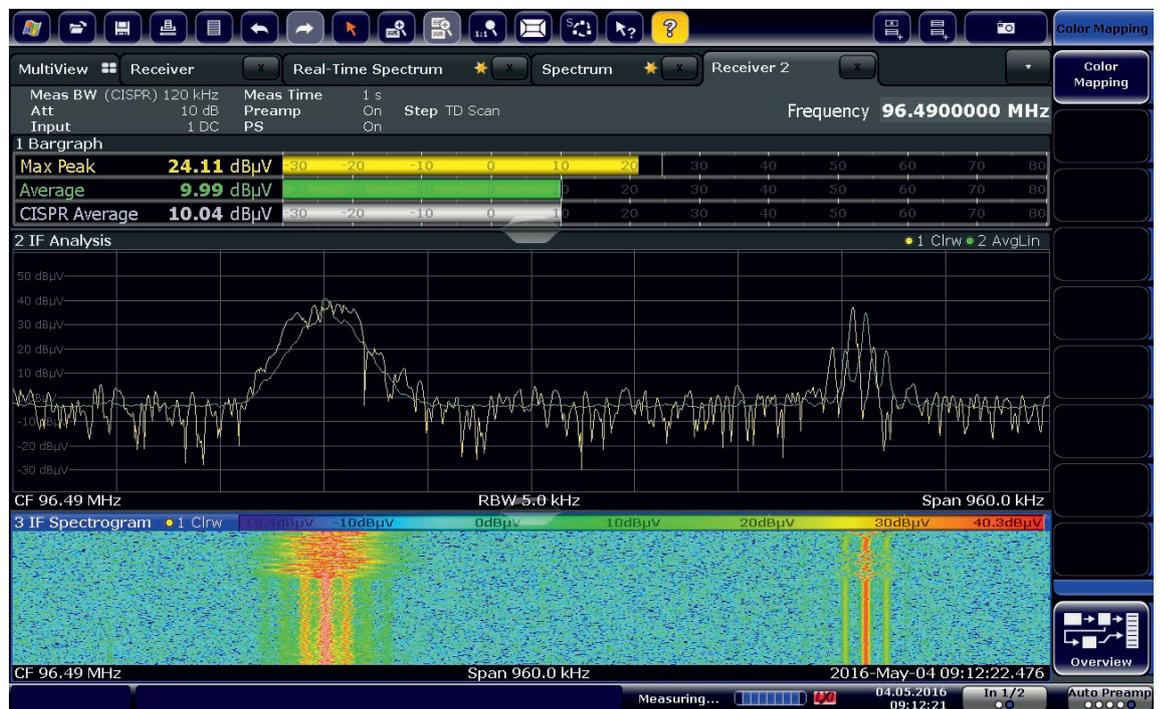


Fig. 5: IF spectrum display coupled to preview diagram via marker, plus spectrogram display.

### IF analysis with spectrogram

The IF analysis function of the R&S®ESW provides a spectral display of an RF input signal in a selectable range around the EMI receive frequency. The IF spectrum display can be coupled to the bargraph display for the current receive frequency. Alternatively, the IF spectrum can be displayed together with the stored results from the preview measurement. The marker in the preview diagram can be used to control the center frequency of the IF spectrum (marker track function). The center frequency of the IF spectrum always corresponds to the current receive frequency. The test receiver can therefore be tuned to the signal of interest accurately and quickly. Any received signals can be quickly classified as disturbance signals or wanted signals. AM or FM audio demodulation can be activated in parallel, making it easier to identify detected signals, e.g. to recognize and exclude ambient interferers in open-area measurements. An IF spectrogram can be generated in parallel with the IF spectrum, making it easier to capture time-varying, sporadic or drifting disturbance signals (Fig. 5).

### Spectrum analyzer included

The R&S®ESW is not only an EMI test receiver, but also a full-featured spectrum analyzer as is needed in labs for countless measurement tasks, including EMI analysis during development. With preselection activated, the R&S®ESW can even perform standard-compliant EMI measurements in spectrum analyzer mode, offering a third option beyond a classic test

receiver and a time domain analyzer that users can take advantage of depending on preference and application.

Markers can be placed on the frequencies of EMI signals to carry out targeted analysis. Markers can be coupled with CISPR weighting detectors to enable direct comparison with limit values. The spectrum can also be displayed along a logarithmic frequency axis, which simplifies result analysis across a wide frequency range and displays limit lines in compliance with relevant standards. Critical frequencies are presented in a peak list and are used for fast, standard-compliant comparison of EMI signals with limit lines. In spectrum analyzer mode, the R&S®ESW measures with a resolution of up to 200001 points. In classic test receiver mode with user-defined step size, the instrument captures and saves up to four million points per trace.

### Realtime spectrum analysis with up to 80 MHz bandwidth

The realtime spectrum analysis function of the R&S®ESW (R&S®ESW-K55 option) facilitates rapid detection of sporadic and transient EMI signals, such as those caused by switching operations. These signals are difficult and time-consuming to detect using conventional methods. The realtime analysis window with a bandwidth of up to 80 MHz displays spectral events without time gaps, ensuring that no event is missed. This is achieved by means of special display modes that make the time behavior of disturbance signals immediately visible.

### Spectral histogram for clear identification of pulsed and continuous disturbances

The R&S®ESW offers a spectrogram function (spectrum over time) that allows users to analyze the behavior of disturbance signals in the time domain in all operating modes (stepped-frequency scan, time domain scan, IF analysis, sweep and

realtime mode). Each spectrum is presented as a horizontal line with different levels assigned different colors. The individual spectral lines are joined continuously. Recording is seamless at a rate of up to 10000 lines per second. In persistence mode, the R&S®ESW writes the spectra into a single diagram. The color of each pixel indicates how often a specific

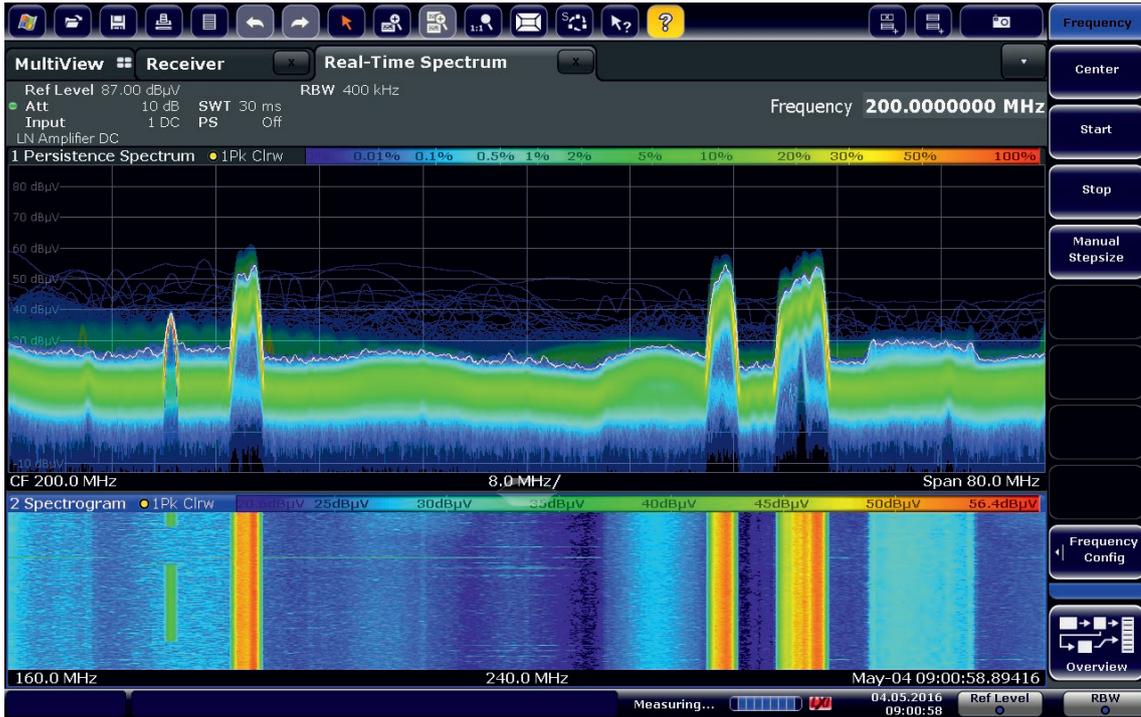


Fig. 6: Realtime spectrum with wanted and disturbance signals, shown in persistence mode.



Fig. 7: Big screen: The MultiView display mode delivers a running display of multiple operating modes on one screen.

amplitude occurs at a specific frequency. Frequently occurring signals are shown in red, for example, and sporadic ones in blue. If signals no longer occur at a specific frequency with a specific amplitude, the corresponding pixel disappears after a user-definable persistence period. This allows users to clearly distinguish between pulsed disturbances, which occur only for very brief periods, and continuous disturbances (Fig. 6). Different pulsed disturbances can easily be distinguished from one another.

### MultiView: display of multiple operating modes

The MultiView function (Fig. 7) brings the measurement results from various operating modes together onto the 12.1" screen, greatly facilitating their comparison – e.g. the frequency spectrum in sweep mode together with a single-frequency measurement using the IF analysis function including a spectrogram display. Four independent single-frequency measurements can be displayed at a time, for example.

### Outstanding sensitivity starting at 2 Hz

The emergence of electromobility creates new EMI test requirements in the automotive sector. In particular, the connection between a vehicle and a charging station involves high currents and long, unfiltered cable links – scenarios that prompt manufacturers and suppliers to perform EMI measurements starting at a frequency as low as 5 Hz. With a specified lower frequency limit of 2 Hz, the R&S®ESW is ideal for these applications (Fig. 8). Thanks to baseband conversion, signals up to 30 MHz are sampled right at the instrument input, completely eliminating the effect of the local oscillator in this frequency range. This results in high sensitivity of, for example, typ. –110 dBm below 10 Hz and typ. –120 dBm between 10 Hz and 100 Hz, meaning that the test receiver meets even the most stringent requirements.

### Documentation made easy

Certification measurements must be carefully and fully documented so that evidence of conformance can be furnished when required. The report generator of the R&S®ESW turns this into an easy task. All information that is necessary to track a measurement can be integrated into the report, including the description of the measurement task, the standards applied, the test procedure used, specific user-defined procedures, any applied transducers and limit lines, plus result graphs from the preview measurement, different DUT load states, final measurement results in tabular form and a graph of the final measurement. Sufficient space is provided for individual interpretation and commenting. Reports can be saved as templates and reused. Different templates can be defined, for example with individual customer logos.

### Summary

As a market and technology leader, Rohde&Schwarz has long proven its expertise in the development of EMI test receivers. The existing high-end models R&S®ESIB and R&S®ESU have stood the test of time and are internationally acknowledged reference instruments. The new flagship R&S®ESW surpasses its predecessors not only in terms of measurement speed, but also offers a wider dynamic range, lower inherent noise and extremely high accuracy. Various operating modes, including conventional stepped-frequency scan, FFT-based time domain scan, IF analysis, frequency sweep and realtime spectrum analysis (all of which can be combined with a spectrogram display) support users in performing complex measurement tasks. And last but not least, there are the large, flexibly configurable touchscreen as well as convenient report configuration and generation.

Volker Janssen

Fig. 8: Electromobility expands the test scenarios for the automotive industry, adding EMI measurements starting as low as 5 Hz.

