EMC TEST SOLUTIONS ON THE CUTTING EDGE

White paper | Version 01.00 | Tobias Groß, Jürgen Kausche

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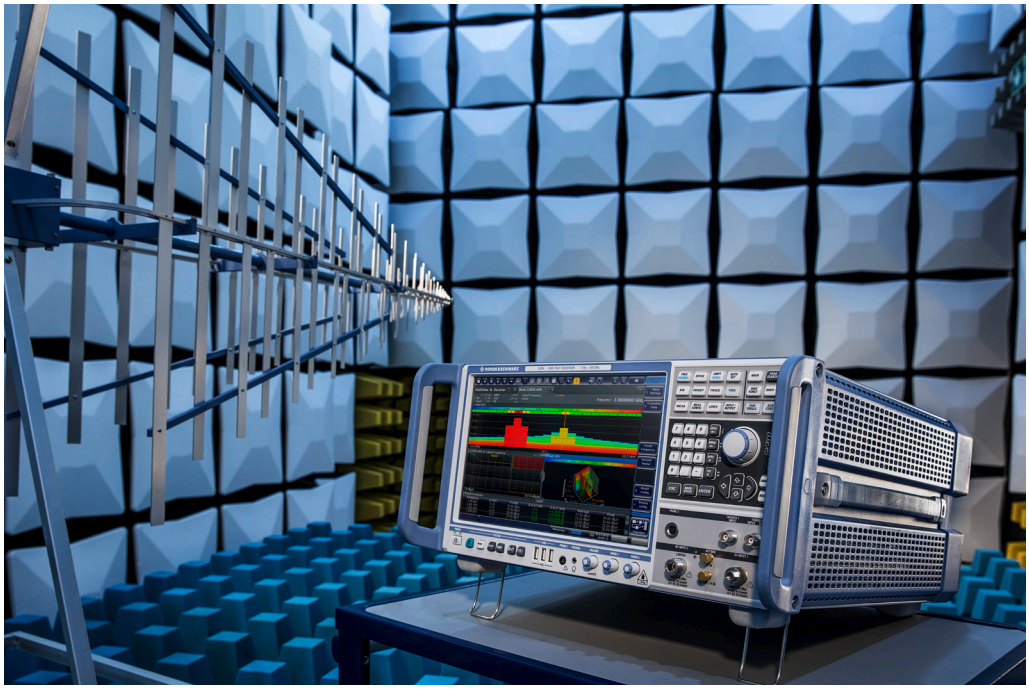
INTRODUCTION

Upcoming technologies such as 5G for wireless communications and the increasing amount of integrated electronic systems in modern vehicles require new solutions for EMC testing. In addition, manufacturers are looking for time saving test routines and intuitive test software that enable fast precompliance and compliance testing.

As a leading manufacturer of EMC T&M solutions, Rohde&Schwarz has a comprehensive portfolio of EMC T&M equipment that ranges from individual instruments to custom turnkey systems. For tracking down interference signals when developing electronic devices, Rohde&Schwarz offers solutions based on spectrum analyzers and test receivers with measurement software for precompliance and certification measurements. The EMC test solutions support all relevant commercial, automotive, military and aerospace standards as well as ETSI and FCC standards for radiated spurious emissions (RSE) and audio breakthrough measurements. One important target market for Rohde&Schwarz is the mobile communications industry. Here, the upcoming 5G technology requires new test solutions.

Fig. 1: The high-end R&S®ESW EMI test receiver with the new APD analysis option



RSE TEST SOLUTION EXTENDED FOR 5G COVERS UP TO 200 GHz

Rohde&Schwarz has therefore extended the widely used R&S®TS8996 test system, which already covers RSE and EMC measurements for conventional wireless technologies, to the new 5G communications standard. The system uses the user-friendly R&S®ELEKTRA EMC test software, which has been updated with 5G measurement and calibration routines. This includes full control of the call with the R&S®CMX500 radio communication tester.

Fig. 2: The R&S®TS8996 RSE test system now also covers 5G

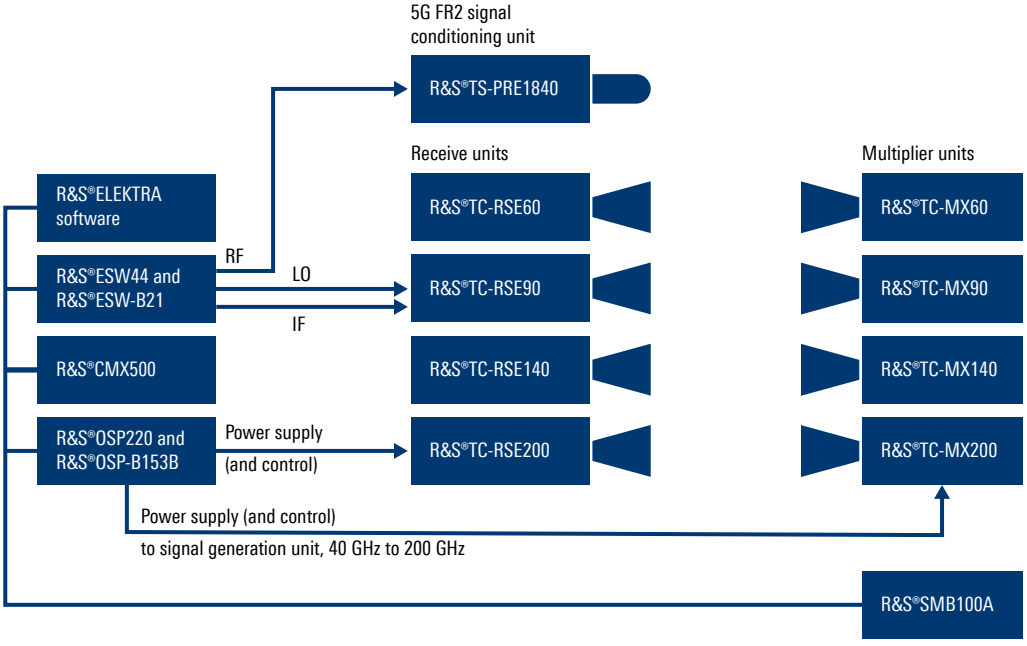
5G supports two frequency ranges: FR1 and FR2. FR1 uses the frequencies known from 4G, but now extends up to 7.125 GHz. The new R&S®OSP-B155G signal conditioning unit supports FR1 and the higher output power of 5G devices. Existing systems can be easily upgraded because the maximum test frequency of 12.75 GHz, 26.5 GHz or 40 GHz – depending on the test standard and carrier frequency – is identical with LTE.

For 5G FR2, the carrier frequencies range from 24.25 GHz to 40 GHz. Therefore, the RSE test frequency range now extends up to 200 GHz, depending on the applied standard. Dedicated R&S®TC-RSE frequency-converting receive units with an excellent sensitivity of typically –40 dBm (1 MHz) extend an existing R&S®ESW test receiver or R&S®FSW spectrum analyzer to these frequencies. Additional multiplier units are also available and allow system checks and calibration up to 200 GHz.

For the 18 GHz to 41 GHz frequency range, where measurement directly around the carrier is required, the new R&S®TS-PRE1840 signal conditioning unit shifts the signal into the ideal dynamic range. This approach is already in use for 5G FR1 and LTE signals.

The R&S®ELEKTRA test software supports optimized, fully automated RSE measurements by using routines for 5G FR2, including prescan, adjustment loop, 2D/3D orthogonal cuts and complete TRP evaluation over the entire frequency range.

Fig. 3: RSE system extension for 5G FR2 up to 200 GHz including system verification



NEW FEATURES OF THE R&S®ESW EMI TEST RECEIVER

With many years of experience in EMC testing, Rohde&Schwarz continually evolves to fulfill the demanding requirements of EMI testing. The efficient and convenient Rohde&Schwarz EMI test receivers use the latest technology to meet changing EMI standards.

The R&S®ESW is the top-of-the-line EMI test receiver in terms of accuracy and versatility for standard-compliant EMI tests. With its outstanding dynamic range and pulse resolution of single pulses (required by the CISPR standard), the R&S®ESW is the ideal choice for EMI compliance testing.

TDS OPTIMIZATION REDUCES TESTING TIME

The latest firmware (version 1.70) optimizes time domain scans (TDS). The new "fast TDS" mode from Rohde&Schwarz allows fast quasi-peak testing up to 1 GHz. Through the resolution of pulses with a repetition frequency of 10 Hz and higher, fast TDS reduces the testing time for precompliance and compliance tests. For the latter, the user must ensure that no pulses with a repetition frequency of less than 10 Hz occur.

In addition to the new fast TDS mode, the standard mode also benefits from time saving optimization. The "automatic TDS" optimization method automatically chooses the best optimization while ensuring compliance with CISPR 16-1-1.

The revised time domain scan in the latest R&S®ESW firmware has significantly improved the measurement speeds for full compliance tests in line with CISPR 16-1-1, thus reducing overall testing time and costs. Table 1 presents measurement times of commonly used CISPR bands.

The 30 MHz to 1000 MHz band with a 9 kHz resolution bandwidth is of special interest, since time-consuming automotive tests include measurements in this band. CISPR 25 defines EMI tests for onboard automotive receivers that are tested using the internal antenna of a vehicle. A distinctive aspect of these tests is the narrow resolution bandwidth of only 9 kHz, whereas other standards use 120 kHz in this frequency band. A narrower resolution bandwidth results in longer testing times and increased computational complexity to calculate the spectrum. The new, optimized time domain scan featured in the R&S®ESW enables previously unattainable fast measurement times for time-consuming tests with a quasi-peak detector. For example, this feature significantly reduces testing time for CISPR 25 measurements.

Table 1: Measurement speeds with normal TDS and fast TDS for the most relevant standards, their detectors and frequency ranges

Fast TDS offers great advantages for testing with CISPR detectors.

Frequency ranges, detectors and standards	Normal TDS (TDS optimization: automatic)	Fast TDS (TDS optimization: fast)
150 kHz to 30 MHz 9 kHz, quasi-peak + CISPR-average, 1 s	2 s	2 s
150 kHz to 30 MHz 9 kHz, peak, 100 ms	110 ms	110 ms
30 MHz to 1000 MHz 120 kHz, peak, 10 ms	380 ms	380 ms
30 MHz to 1000 MHz 9 kHz, quasi-peak + CISPR-average, 1 s	64 s	40 s
30 MHz to 1000 MHz 120 kHz, quasi-peak + CISPR-average, 1 s	50 s	40 s
1 GHz to 6 GHz 1 MHz, peak + CISPR-average, 100 ms	216 s	111 s
1 GHz to 18 GHz 1 MHz, peak, 10 ms	8 s	8 s
1 GHz to 26.5 GHz 1 MHz, peak + CISPR-average, 10 ms	13 s	13 s
1 GHz to 40 GHz 1 MHz, peak, 10 ms	21 s	21 s

MICROWAVE OVEN TESTING: FASTER AND WITH DETAILED INSIGHTS

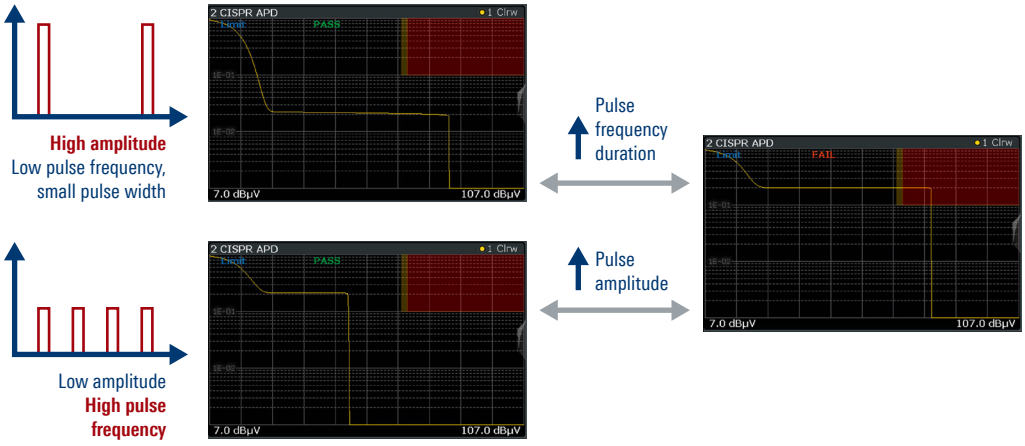
Microwave ovens are a major source of electromagnetic emissions. Their operating frequency is around 2.5 GHz, drifting heavily due to poor quality oscillators that enable attractive prices for consumers. Typically, test engineers use the log average method in line with the CISPR 11 standard. With the latest revision of the standard, the new method known as Multi CISPR APD can be used as an alternative. This method not only reduces the overall testing time significantly, it also provides detailed insights into the emission's characteristics.

THE NEW METHOD: MULTI CISPR APD

The amplitude probability distribution (APD) assesses the influence of interference on digitally modulated signals. The APD test method provides insight into amplitudes and their probability of occurrence within a defined bandwidth and time window. Modern digitally modulated transmissions feature forward error correction coding (FEC). Interferences up to a specific level are therefore acceptable. The FEC can correct the resulting bit errors to achieve an undistorted transmission.

To illustrate this point, consider two pulsed signals: one with a high amplitude and low pulse frequency, and one with a low amplitude and high pulse frequency. Both have the same power, but a different interference influence. The APD easily assesses and visualizes this, as shown in Fig. 4. On the x-axis, the APD shows the amplitude and, on the y-axis, its cumulative probability of occurrence. In other words, the probability of occurrence of each amplitude is shown, including all the smaller amplitudes.

Fig. 4: APD visualizes the probability of occurrence of each amplitude, including all the smaller amplitudes



CISPR 11 defines limit values for the APD testing method that microwave ovens have to comply with. This limit for each band is a two-dimensional point of amplitude and corresponding probability of occurrence. It must not be exceeded in either of the two measurements. There is also a fail area, which is marked in red in the APD plots in Fig. 4. Once the APD function of a measured signal enters the fail area, the test fails. Microwave ovens are the first product for which the Multi CISPR APD applies the CISPR 11 standard. Other products will follow.

The Multi CISPR APD performs the APD test not only on one channel, but also on multiple channels in parallel. This ensures that the EMI test receiver captures drifting interferences with at least one APD channel at a time. Following the CISPR 11 standard procedure, the test engineer can find all the harmonics of the microwave oven up to 18 GHz with a simple and fast peak scan. On each found peak, the Multi CISPR APD evaluates the interference on five channels in parallel: at the peak itself and at ±5 MHz and ±10 MHz.

MULTI CISPR APD WITH AN R&S®ESW

The R&S®ESW is the best performing EMI test receiver for CISPR 11 microwave oven tests. In the new version 1.70 firmware, the Multi CISPR APD application is available as an option for the receiver. This application supports the test engineer with the evaluation and detailed analysis of up to 67 APD channels in parallel. Each channel offers individual limit checking.

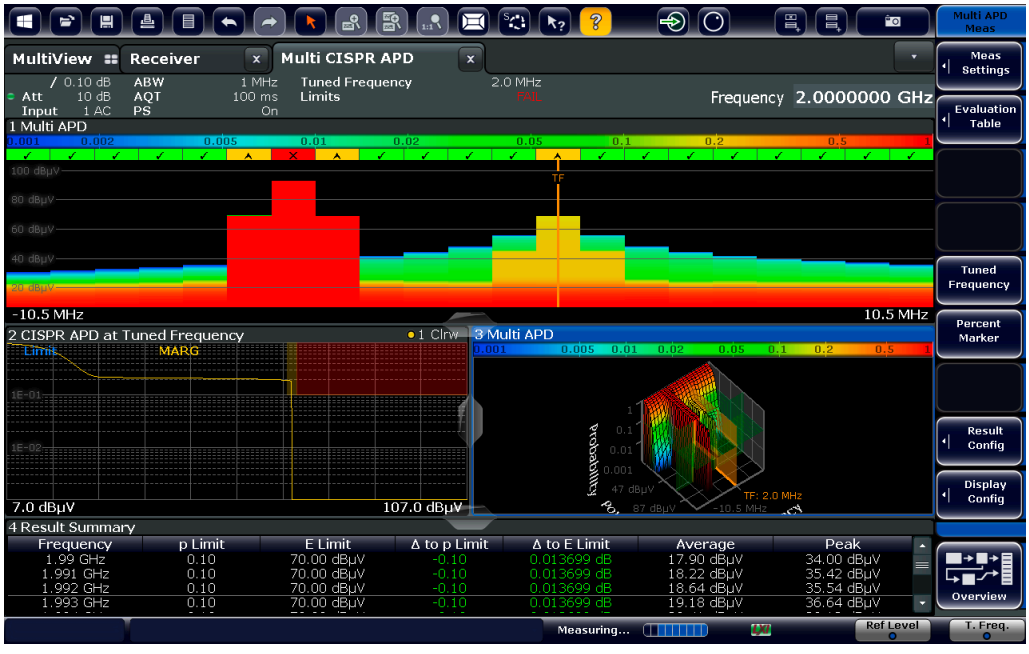
In one clearly arranged display, the Multi CISPR APD application combines 2D and 3D plots of the disturbances of each channel as well as the corresponding limits and the pass/fail indication (Fig. 5). The 3D display supports touch gestures for selecting regions of interest or panning and tilting. The result table presents margins or exceeded limits for every evaluated channel. Use the single-channel APD display at a variable tuned frequency to investigate an individual channel in detail. The R&S®ESW with R&S®ESW-K58 fulfills all CISPR 16-1-1 requirements for measuring receivers with APD measuring functionality.

Key facts

- Maximum number of channels: 67 (ABW ≤ 300 kHz), 21 (ABW = 1 MHz)
- Analysis bandwidth (–6 dB): 1 Hz ≤ ABW ≤ 1 MHz
- Minimum measurable probability: $1 \cdot 10^{-7}$
- Maximum acquisition time: 120 s
- In line with CISPR 16-1-1

Thanks to the APD multichannel measurement function, the EMI test receiver will be able to handle upcoming EMI standards.

Fig. 5: In one clearly arranged display, the Multi CISPR APD application combines 2D and 3D plots of the disturbances of each channel as well as the corresponding limits and the pass/fail indication



CONCLUSION

Rohde&Schwarz has extended its R&S®TS8996 test system, which covers RSE and EMC measurements, to the new 5G communications standard. The new fast TDS enables faster commerical measurements than ever previously achieved for time-consuming tests with a quasi-peak detector. APD analysis precisely shows the effects of interference on digitally modulated wireless signals (WLAN, cellular or Bluetooth®), and in the future it will also be applied to other product standards.

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Rohde & Schwarz

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