NEWS

220/18

ROHDE&SCHWARZ

High performance

Challenging applications require top-class T&M instruments. New models combine excellent specifications with a rich feature set and extraordinary ease of operation.

Wireless

New signal generator options for designing and testing 5G base stations

Automotive

The recently introduced eCall automotive emergency call system already has a successor

General purpose

New oscilloscope software simplifies testing of DDR3 memory interfaces

NEWS

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Cover feature

The success of a measurement depends not least on the quality of the T&M instruments. For reliable results, the instruments have to be up to the task and all settings must be correct. High-end T&M instruments make things easier in this respect. Their performance qualifies them for virtually any challenge that modern technology can pose. Wizards, automatic functions and software for many special tasks help users prevent mistakes and get answers quickly. A capable and efficient high-end instrument also has a certain flair that makes it a pleasure to work with – no small matter considering how much they are used in everyday lab work. Many of the instruments featured in this issue fall in this category. With the R&S®RTP oscilloscopes, Rohde & Schwarz has entered the high-performance segment of this instrument class (page 42). Initially available up to 8 GHz, they are ideal for measurements on fast buses and complex embedded designs. The R&S®RTP is the first oscilloscope that can compensate for impairments caused by components in the signal path through realtime hardware deembedding, ensuring consistently reliable measurement results. The R&S®FSW signal and spectrum analyzer has been on the market for a while and has built up a reputation as a reference instrument. Now it has been further enhanced (page 58). With its 2 GHz internal analysis bandwidth, 800 MHz real-time bandwidth and low phase noise, it is the benchmark when it comes to evaluating wideband communications systems and high-resolution radars. The brand new, midrange R&S®FSV3000/FSVA3000 analyzers are also a good choice for demanding measurements. They offer surprisingly innovative automatic features such as an event driven GUI and a synchronizing function for connected generators – and the performance data to match (page 64).

Overview
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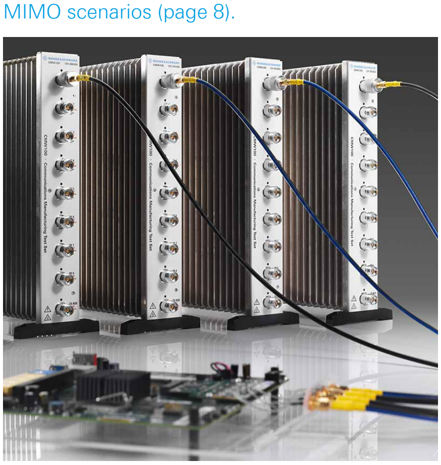
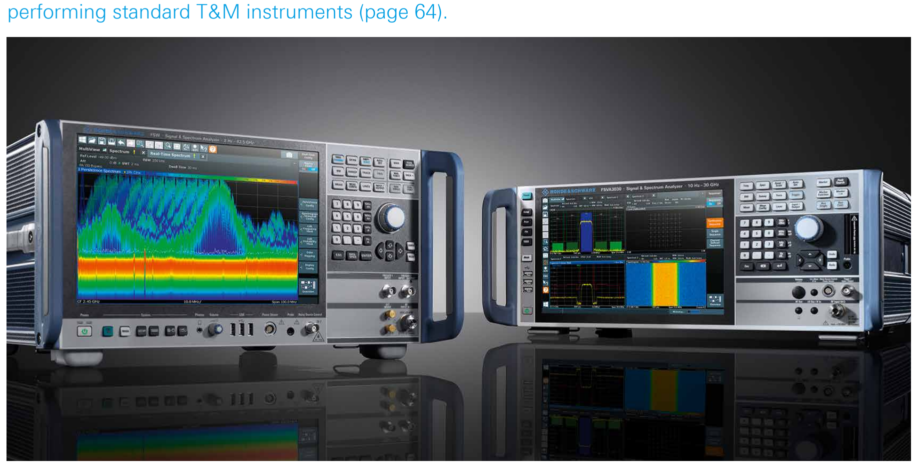
The R&S®CMW100 communications manufacturing test set now supports all common WLAN MIMO scenarios (page 8).



New signal and spectrum analyzers: The R&S®FSW (left) maintains its leading position by offering enhanced specifications and features (page 58). The R&S®FSV3000 and R&S®FSVA3000 are top-performing standard T&M instruments (page 64).



The R&S®AdVISE video based monitoring and analysis system automatically and completely detects malfunctions during EMC testing (page 40).

The latest generation R&S®OSP switch and control platform features fully redesigned hardware and software and a state-of-the-art operating concept (page 66).

New network scanners ready for 5G NR

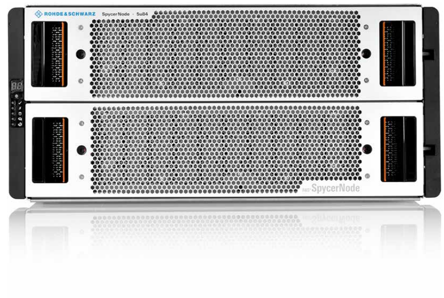
In-vehicle and backpack systems are used to measure the quality of mobile networks. Backpack systems should be as small and light as possible – and that depends on the T&M equipment used. This equipment consists of test smartphones for connection and quality of service measurements as well as network scanners that accurately determine the local RF conditions (field strength, interference). A computer and a battery pack that can last an entire day in the field are also needed. Smartphones cannot be made any smaller, but it is possible to reduce the size of the other components and increase their performance at the same time. The new R&S®TSME6 (the small instrument on top) and R&S®TSMA6 (the middle instrument, which is resting on the battery pack) show what is possible. The R&S®TSME6 is a pure scanner, while the R&S®TSMA6 includes a high-performance computer. Both seamlessly cover the frequency range between 350 MHz and 6 GHz and therefore also the sub 6 GHz range of 5G NR. Up to ten standards can be implemented and simultaneously measured. The instruments (even different models) can be easily cascaded to perform complex measuring tasks such as 4×4 MIMO or channel aggregation. A click system ensures that the instruments are securely mechanically connected. The instruments are designed in such a way that additional hardware can be integrated, for instance a downconverter for measurements in the 5G millimeterwave bands. The well-established R&S®ROMES4 drive test software or API-connected software control the instruments and analyze the results.

Handheld spectrum analyzer now up to 31 GHz

The R&S®Spectrum Rider FPH, which was previously available up to 4 GHz, is being expanded into a family of instruments. With three new base models and license keys for frequency extensions, instruments are available from 5 kHz to 2/3/4/6/8/13.6/20/26.5 and 31 GHz. The measurement functions and other features are the same on all models and – if not already included in the base package – can be activated with a keycode. The instruments can be remotely operated from a browser via LAN or USB (standard) and options can be added to activate a receiver mode, connect a power meter, analyze interference (suitable antennas are available as accessories) and perform pulse measurements on radar signals (with the microwave models). For standardized installation and service measurements on transmitter stations, a wizard ensures error-free sequencing of the measurement steps and correct documentation. The analyzer's field-optimized operation that combines hardkeys and a touchscreen also works well in the test lab where, thanks to its solid RF performance, the R&S®FPH can replace a stationary instrument. Accessories such as a near-field probe set for EMC diagnostic measurements are also available. The R&S®Spectrum Rider FPH can be purchased directly from Rohde & Schwarz or specialist distributors.

Improved over-the-air measuring system

Introduced at the end of 2016, the R&S®NRPM was the first measuring system for determining the transmit power of 5G and wireless gigabit components over the air (OTA). The system consists of remote antenna modules with integrated diode sensor connected to a signal processing module that communicates with a computer. The antenna frontends have been replaced by a new generation. The new R&S®NRPM-A90 and R&S®NRPM-A90D models step up performance. The frequency range has been extended in both directions and now covers 18 GHz to 90 GHz, which includes all frequency bands specified for automotive radar. Measurement uncertainty is below 0.7 dB (absolute) and below 0.1 dB (relative) over the entire range, with a dynamic range of 50 dB. The R&S®NRPM-A90D model has two Vivaldi antennas positioned at right angles to each other and can measure the polarization at two levels. The R&S®NRPM provides users in development, verification and production with an easy-to-use, low-cost measuring system for calibrating the output power of the DUT and testing the DUT's beamforming function. When testing beamforming, an unlimited number of spatially distributed antennas can be interconnected.



High-performance memory for media workflows

The requirements most frequently requested by operators of media data memories are reliability, performance and ease of use. The new R&S®SpycerNode memory solution meets these requirements better than any other solution on the market. Based on an enterprise hardware platform, it is the first solution to make high-performance computing features available to the media and entertainment market. Its extreme reliability with an MTTDL of up to 200 million years is the result of full hardware redundancy combined with the most advanced software data backup mechanisms provided by the IBM Spectrum Scale RAID file system based on erasure coding. And the I/O performance is just as impressive as the data security. Millions of IOPS and bandwidths of up to 12 Gbyte per second and unit are achieved via four parallel 100 Gbit/s Ethernet ports, and an unlimited number of units can be bundled in the same namespace under one URL. Three chassis versions with storage capacities ranging from 92 Tbyte to several Pbyte can be configured to meet all start-up requirements. The configuration can be expanded at any time, even during system operation. It is even possible to combine different models. It is easy to enter all settings with the browser based device manager, which can also be used to manage other Rohde & Schwarz products in the network, such as the R&S®Venice media server.

First signal generator for full duplex (FDX) DOCSIS®

Cable network providers usually offer connected households both TV programs and fast Internet access. The data over cable service interface specification (DOCSIS) standard that is widely used in the USA and other parts of the world provides the technical basis. Using coaxial cables for the "last mile" to the end user ensures that the transmission speed in cable TV networks is considerably higher than in competing DSL networks. Even with DOCSIS 3.1, downstream rates up to 10 Gbit/s and upstream rates up to 1 Gbit/s were possible. Full duplex (FDX) DOCSIS tops this performance by balancing the transmission and making 10 Gbit/s available in the upstream as well. This brings interactive broadband applications like virtual reality within reach. Rohde & Schwarz has offered test solutions for the DOCSIS standard for many years. One of these solutions is the R&S®CLGD cable load generator. The new R&S®CLGD-K400 option adds FDX DOCSIS capability. R&S®CLGD-K400 software option can be installed on all previously supplied instruments.

DOCSIS® is a registered trademark of CableLabs.

Portable emergency TV transmitter

TV transmission outages that viewers would notice are a rare occurrence. This is thanks to the high reliability of today's transmission technology and also due to the fact that all major components are redundant. Should a link along the signal chain actually fail, a "spare part" is usually inserted automatically. Terrestrial broadcasters use various redundancy concepts – but only for large broadcast stations because redundancy costs money. In heavily fragmented broadcast areas with a large number of low-power transmitters, network operators tend to rely on the robustness of the transmitters and, in the unlikely event of a failure, use mobile emergency transmitters to tide them over until a replacement has been obtained or the defective transmitter has been repaired. Rohde & Schwarz offers suitable transmitters with an power output up to 1.15 kW based on the R&S®TLU 9 or R&S®TMU 9evo families. The transmitters are housed in a sturdy plastic case. A shockmount protects them from jolts and vibrations. All electrical connections are located on the rear interface panel, which makes installation quick and easy. The station only has to provide power, the program feed, a bandpass filter and the antenna. The transmitters are wideband and can be used on any UHF frequency. Emergency transmitters (in this case R&S®TMV 9 transmitters) are also available for DAB and DAB+.

New WLAN test solutions

Every new WLAN standard extends the list of properties that have to be measured. The testers in the R&S®CMW family provide developers and production specialists with all the measurement functions they need.

MIMO measurements on WLAN radio components

MIMO multi-antenna technology helps modern radio systems achieve higher data throughput provided that all RF paths perform as intended. The R&S®CMW100 communications manufacturing test set supports all common measurement methods needed to analyze the performance of WLAN radio components.

The use of multi-antenna systems can increase the coverage range and boost the data throughput compared to single-antenna systems. MIMO transmitters simultaneously send different signals (streams) on the same frequency via separate antennas (Fig. 1). Successful decoding of these signals on the receiving end requires relatively spatially independent transmission channels between the transmitting and receiving antennas, such as is the case with multipath propagation. In order for the complex mathematical algorithms to be able to reconstruct the signal, certain minimum requirements must be satisfied with regard to the spectral purity of the transmitters and the sensitivity of the receivers. Both must be tested in development and also to some extent in production. For transmitter testing, there are three methods that differ in terms of test depth and equipment complexity. All of these methods are supported by the R&S®CMW100 communications manufacturing test set (model K06).

Basic multi-antenna system

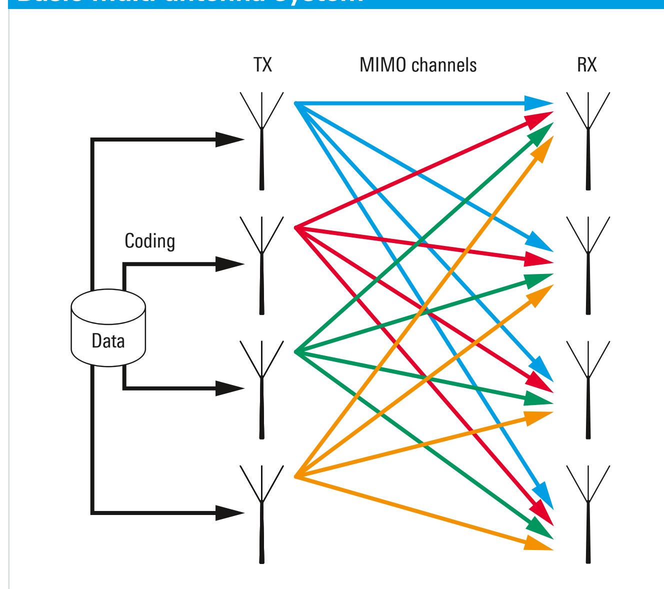


Fig. 1: 4 × 4 MIMO systems have 16 transmission channels that can be used to increase the data rate for a single user or to simultaneously provide coverage for multiple users.

Receiver testing

The MIMO receiver test is performed simultaneously on all receiving antennas. Each antenna is connected to a separate signal generator – a vector signal generator or the R&S®CMW100 tester's internal generator. The ARB waveform files required for each generator can be created on a PC with the R&S®WinIQSIM2 software tool. Once all of the generators have been synchronously started, a packet error rate measurement is performed. Suitable remote control programs determine whether the device under test (DUT) successfully decodes the data packets in non-signaling mode.

Transmitter testing

For transmitter tests, three methods are available for verifying the RF properties in non-signaling mode, depending on the desired test depth.

Composite MIMO TX measurement

With this method, all MIMO signals transmitted in parallel (up to eight) are combined in a power combiner and the sum signal is transmitted to an R&S®CMW100 for analysis (Fig. 2). Although the MIMO antennas transmit different bit

Fig. 2: Test setup for the composite MIMO TX measurement. A WLAN device with four antennas is connected to the R&S®CMW100 via a power combiner.

Freq: 2412.0000000 MHz Ref.Lvl: 0.00 dBm Std: 802.11n (Switched MIMO) Green Field 40MHz

TX Measurement (Scalar)

MCS Index	30			
Spatial Streams	4			
Space Time	4			
Data Symbols	38			
Statistics	**Current**	**Average**	**Max**	**StdDev**
Overview				
EVM All [dB]	-44.14	-44.03	-43.67	0.12
EVM Data [dB]	-44.11	-43.98	-43.62	0.13
EVM Pilot [dB]	-44.74	-44.90	-44.41	0.17
Power Total [dBm]	-7.27	-7.27	-7.27	0.00
Symbol Clock Error [ppm]	-0.049	0.014	-0.544	0.185
Center Frequency Error [Hz]	69.66	71.19	80.47	3.05
Streams				
EVM All 1 [dB]	-43.90	-43.89	-43.36	0.20
EVM Data 1 [dB]	-43.86	-43.85	-43.30	0.21
EVM Pilot 1 [dB]	-44.78	-44.71	-43.88	0.38
EVM All 2 [dB]	-44.10	-44.04	-43.19	0.20
EVM Data 2 [dB]	-44.10	-44.00	-43.13	0.21
EVM Pilot 2 [dB]	-44.08	-44.87	-44.00	0.38
EVM All 3 [dB]	-44.36	-44.20	-43.14	0.20
EVM Data 3 [dB]	-44.32	-44.15	-43.06	0.21
EVM Pilot 3 [dB]	-45.18	-45.09	-44.19	0.38
EVM All 4 [dB]	-44.20	-43.99	-42.96	0.20
EVM Data 4 [dB]	-44.16	-43.94	-42.89	0.21
EVM Pilot 4 [dB]	-45.02	-44.94	-43.99	0.38
Antenna				
Power TX1 [dBm]	-13.42	-13.42	-13.42	0.00
Power TX2 [dBm]	-13.64	-13.64	-13.64	0.00
Power TX3 [dBm]	-13.07	-13.07	-13.07	0.00
Power TX4 [dBm]	-13.06	-13.07	-13.06	0.00
IQ Offset TX1 [dB]	-72.26	-66.06	-61.94	2.78
IQ Offset TX2 [dB]	-59.61	-59.42	-57.25	1.16
IQ Offset TX3 [dB]	-70.30	-70.61	-67.49	1.77
IQ Offset TX4 [dB]	-72.39	-71.36	-68.03	2.30

Statistic Count 100 / 100 Out of Tolerance 0.00 %

Fig. 3: Results of a switched 4 × 4 MIMO TX measurement.

Fig. 4: Test setup for the switched MIMO TX measurement. Each antenna in the DUT is connected to a port on one R&S®CMW100. The ports are switched in rapid succession to the test set's analyzer.

sequences, the analyzer is able to determine the transmitted power of each antenna from the sum signal in a single measurement step (if the DUT is suitably configured) and provide a quality assessment for the sum signal in the form of the error vector magnitude (EVM) value. The composite MIMO TX measurement is the method of choice for production because it quickly verifies MIMO performance without a lot of test equipment and finds faulty antenna connections.

Switched MIMO TX measurement

For the switched MIMO TX measurement, each transmitting antenna is connected to a port on one R&S®CMW100. All antennas are switched in rapid succession and analyzed individually (Figs. 3 and 4). The antennas continuously transmit different bit sequences, but the same sequence for each channel. These bit sequences are the basis for detailed analysis of the RF properties on all transmit paths. Even an 8 × 8 MIMO TX system can be analyzed with just one instrument.

True MIMO TX measurement

In contrast to the sequential switched measurement, the true MIMO TX measurement is performed simultaneously on all channels. It is therefore not necessary to repeatedly transmit the bit sequences. However, the speed advantage comes at a high hardware cost since a separate R&S®CMW100 is required for each transmitting antenna (Fig. 5). The measurement results are consolidated by the control PC connected to the system.

Fig. 5: The true MIMO TX measurement requires a separate R&S®CMW100 for each MIMO antenna. A control and evaluation PC for managing the test sets is always required (not shown here).

Multi-user MIMO and beamforming

Instead of simultaneously sending multiple MIMO data streams to a single user to boost the data throughput, the data streams can be distributed among multiple users – a scenario that can be analyzed with both the switched and the true MIMO TX measurement (Fig. 6).

To implement multi-user MIMO (MU-MIMO), the receiver requires as many receiving antennas as in the single-user case to ensure reliable channel separation. For smartphones that have a maximum of two MIMO antennas due to their compact size, this would limit MU-MIMO to two users. One possible solution is to use beamforming to augment or suppress the propagation of individual signals in certain directions by exploiting the radiation patterns of multi-antenna systems (Fig. 7). Each user then receives only their intended data stream with high field strength. Based on this technique, even a user with only one receiving antenna can successfully decode their intended data stream in an 8×8 MU-MIMO scenario.

Summary: The R&S®CMW100 offers the right measurement solution for receiver and transmitter testing in every MIMO scenario.

Thomas A. Kneidel

Freq: 2412.00 MHz Ref.Lvl: 0.00 dBm Std.:802.11 ax Switched MIMO 40MHz

TX Measurement (Scalar) | Signal Fields Info | OFDMA Results

No of Users	4			
No of RUs	1			
Statistics	Current	Average	Max	StdDev
EVM All [dB]	−10.11	−10.11	−10.11	0.00
EVM Data [dB]	−9.96	−9.96	−9.96	0.00
EVM Pilot [dB]	−50.21	−50.21	−50.21	0.00
RU 1	RU Size: 484 RU Index: 1 RU26 Index: 1			
Power Ant1	−10.67	−10.67	−10.67	0.00
Power Ant2	−11.34	−11.34	−11.34	0.00
Power Ant3	−10.55	−10.55	−10.55	0.00
Power Ant4	−10.43	−10.43	−10.43	0.00
Power Ant5	−10.82	−10.82	−10.82	0.00
Power Ant6	−10.67	−10.67	−10.67	0.00
Power Ant7	−10.50	−10.50	−10.50	0.00
Power Ant8	−10.64	−10.64	−10.64	0.00
User 1	MCS: 1 DCM: 0 NSTS: 4 STA-ID: 11 TxBf: −1 Coding: LDPC			
EVM All [dB]	−52.64	−52.64	−52.64	0.00
EVM Data [dB]	−52.68	−52.68	−52.68	0.00
EVM Pilot [dB]	−51.50	−51.50	−51.50	0.00
Stream 1	−52.03	−52.03	−52.03	−52.03
Stream 2	−53.60	−53.60	−53.60	−53.60
Stream 3	−52.73	−52.73	−52.73	−52.73
Stream 4	−52.34	−52.34	−52.34	−52.34
User 2	MCS: 2 DCM: 0 NSTS: 2 STA-ID: 22 TxBf: −1 Coding: LDPC			
EVM All [dB]	−51.84	−51.84	−51.84	0.00
EVM Data [dB]	−51.98	−51.98	−51.98	0.00
EVM Pilot [dB]	−48.95	−48.95	−48.95	0.00
Stream 1	−52.00	−52.00	−52.00	−52.00
Stream 2	−51.69	−51.69	−51.69	−51.69
User 3	MCS: 9 DCM: 0 NSTS: 1 STA-ID: 33 TxBf: −1 Coding: LDPC			
EVM All [dB]	−1.08	−1.08	−1.08	0.00
EVM Data [dB]	−0.93	−0.93	−0.93	0.00
EVM Pilot [dB]	−50.62	−50.62	−50.62	0.00
User 4	MCS: 11 DCM: 0 NSTS: 1 STA-ID: 44 TxBf: −1 Coding: LDPC			
EVM All [dB]	−52.02	−52.02	−52.02	0.00
EVM Data [dB]	−52.20	−52.20	−52.20	0.00
EVM Pilot [dB]	−48.60	−48.60	−48.60	0.00

Fig. 6: Measurement results for an 8×8 MU-MIMO scenario with four WLAN stations: user 1 is supplied with four data streams, user 2 with two data streams and users 3 and 4 with one data stream each.

Beamforming

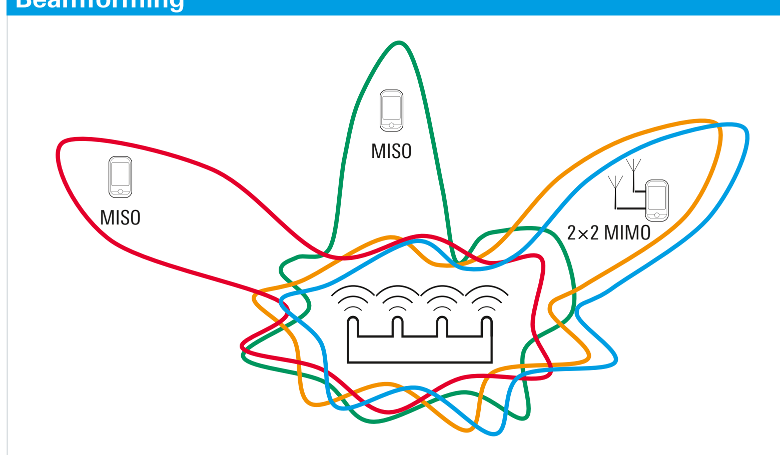


Fig. 7: MU-MIMO system with spatial multiplexing based on beamforming.

Signaling tests on WLAN 802.11ax devices

Unlike production applications where calibration and testing of a WLAN product's transmitter and receiver can be performed in non-signaling mode, measurements in signaling mode are an absolute must in development and quality assurance. Such measurements are now possible for the new IEEE 802.11ax standard.

In non-signaling mode, the device under test (DUT) is remote controlled via an electrical cable. This special operating mode supports time-optimized calibration and testing of the transmitter and receiver. These tests require a suitable T&M instrument equipped with a signal generator and analyzer, such as the R&S®CMW100 communications manufacturing test set. When using this time-optimized test and measurement method, it is understood that a custom remote control program is required for each chipset to be tested, that a wired remote control interface must be available, and that the test is not performed under real operating conditions. There is a clear risk that the device could behave differently during subsequent normal operation. This risk can be minimized by first testing the WLAN radio component in signaling mode during development and quality assurance. The T&M instrument emulates either an access point (AP) or a WLAN station (STA), and the DUT connects to the emulated AP or STA like it would under normal operating conditions. Contact is generally made with a coaxial cable via the antenna connection. Using standard-compliant signaling, the DUT can be placed in any desired operating state required for the measurements. Typical examples include:

- Verification of receiver quality based on a packet error rate (PER) measurement
- Determination of the transmitter's RF properties by measuring the transmitted power and analyzing the modulation accuracy (EVM)
- Performance measurements (data throughput)
- Protocol analyses [1]

Such measurements were also required by earlier WLAN standards. The latest version (IEEE 802.11ax) has introduced a number of new methods involving additional test requirements [2] that require the use of a flexible tester that supports signaling, such as the R&S®CMW270 or R&S®CMW500.

One of WLAN's weak areas is related to the carrier sense multiple access with collision avoidance (CSMA/CA) method as previously implemented up to the 802.11ac standard. The objective of this method is to ensure interference-free operation of multiple WLAN stations with one AP by only allowing a single station to transmit at any one time. An STA may transmit only if the channel is not in use for a specified wait time. This method is also known as listen-before-talk (LBT). However, there is still a risk of the transmission colliding with the transmission of another concurrently waiting station that also thought the channel was free. A collision leads to data loss, which leads to a repetition of the procedure and a new transmission. The more WLAN stations involved, the more drastic the increase in the wait times and the lower the efficiency of the available radio channel. The orthogonal frequency division multiplexing access (OFDMA) method, which with 802.11ax can also be used for WLAN, provides a significant improvement. The available bandwidth is divided into resource units (RU) that the access point dynamically assigns to its allocated stations on demand (Fig. 1).

The AP also informs the STA about the modulation coding scheme (MCS) to be used. For T&M instruments that assume the AP role, it is now possible for the first time to restrict the transmitter measurement for a WLAN station to a specific MCS in signaling mode.

Uplink OFDMA synchronization

One of the prerequisites for efficient parallel operation of multiple WLAN ax stations is proper synchronization. Triggered by the AP, all stations must start transmitting within ±0.4 µs, (Fig. 2). Compliance with this tolerance must be measured.

Multi-user channel distribution

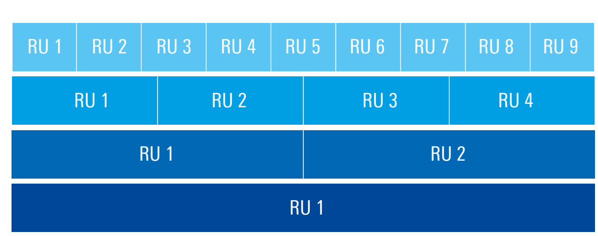


Fig. 1: In multi-user mode, a 20 MHz channel (for example) is divided into resource units (RU) that can be combined in different sizes.

Unused tone error

To minimize mutual interference during parallel operation of multiple STAs, the IEEE has set upper limits for the permissible spurious emissions in the adjacent spectrum. Similar to an adjacent channel leakage ratio (ACLR) measurement for cellular technologies, compliance with these limits must be verified with an unused tone error measurement.

Dynamic power control

Dynamic power control is also new in the 802.11ax standard. Excessive field strength differences between the different STAs at the AP receiving antenna would hinder proper OFDMA operation. This problem can be prevented if the STAs adjust their transmitted power so that all signals arrive at the AP with approximately the same field strength. The AP lets the STAs know what power it is transmitting, and the STAs then perform a receiver signal strength indication (RSSI) measurement. Based on the result, each STA can derive the path attenuation on the link to the AP. The AP also tells all stations the desired target RSSI at its receiving antenna. The STAs then send their data packets with the desired signal strength plus the calculated path attenuation. When multiple STAs transmit in parallel to the AP, the transmitted power of each STA is adapted continuously to the prevailing conditions.

Uplink OFDMA synchronization

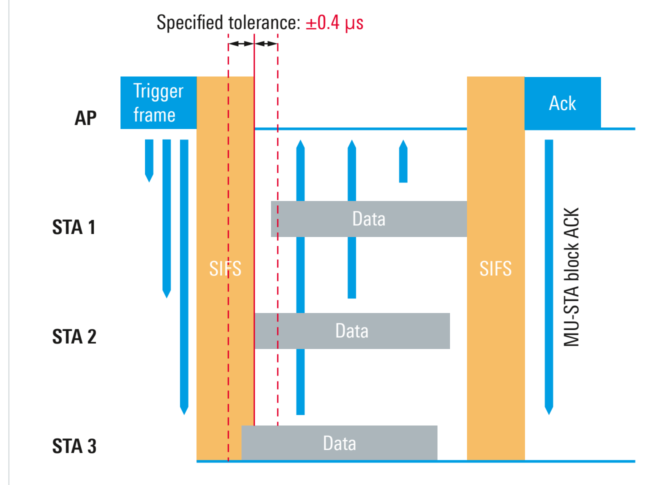


Fig. 2: Starting with the AP's trigger signal, all STAs must synchronously transmit their data packets to the AP within a time of departure accuracy of 0.4 µs.

Whereas until now WLAN stations mostly transmitted statically with the maximum allowable power for their country, the transmit level range has increased significantly in 802.11ax – with consequences for the calibration of transmitted power in production. Not only has the dynamic range for the transmit level increased, WLAN 11ax also has more stringent requirements for the accuracy of the transmitted power and RSSI measurement depending on whether the device is low-cost or high-end (the standard distinguishes between two quality classes: A and B).

New test solution for 802.11ax

When verifying the new WLAN features introduced with 802.11ax, developers are faced with tests and measurements they cannot adequately perform in non-signaling mode. What they need is a tester that can configure the DUT via signaling. Equipped with the R&S®CMW-KS657 software option, an R&S®CMW270 or R&S®CMW500 can emulate an 802.11ax access point with up to 80 MHz bandwidth in SISO mode and test STA in all operating modes (single-user and multi-user). The previous WLAN tests as well as the specialized 11ax measurements are supported. The R&S®CMWmars message analyzer can also be used to record and monitor all protocol messages exchanged between the tester and DUT in real time.

The use of 802.11ax will provide a clear boost in efficiency, especially in locations with high WLAN user density such as airports, exhibition halls, sports stadiums and shopping centers. This decisive advantage should help speed up acceptance of the new standard and write another chapter in the WLAN success story.

Thomas A. Kneidel

References
[1] Thomas A. Kneidel: WLAN signaling with the R&S®CMW270 and R&S®CMW500 testers. NEWS (2011) No. 204, pp. 6 to 8.
[2] Dr. Michael Simon: WLAN 802.11ax speeds up communications in multi-user scenarios. NEWS (2017) No. 217, pp. 24 to 29.

Tools for designing and testing 5G base stations

Millimeterwave frequencies and wideband signals require new approaches to designing 5G base stations. The R&S®SMW 200A vector signal generator provides the necessary support.

Measurement based development of Doherty amplifiers

Doherty amplifiers, especially those with two independently driven inputs, promise significantly better energy efficiency in 5G base station transmitters and similar applications. A new software option for the R&S®SMW200A vector signal generator helps designers realize the full potential of their amplifier designs.

Power amplifiers in base stations constitute 30 % to 60 % of the cost and 20 % to 60 % of the energy consumption of the transmitter infrastructure, making their optimal design a key focus for RF power semiconductor and infrastructure vendors alike (base stations, radio relay transmitters).

The most effective ways to reduce amplifier power dissipation have been known for a long time, but only in the last few years has it been possible to implement them in practice. That's because energy-efficient operation comes at the cost of nonlinearities that have to be compensated by upstream or downstream measures – non-trivial measures such as digital predistortion that are only possible with advanced circuit technology.

On the infrastructure side, conventional Doherty power amplifier designs have established themselves in the market, whereas envelope tracking dominates on the device side. In envelope tracking, the supply voltage of the power transistors is dynamically adapted to the signal envelope. The Doherty method splits the input signal into two parallel amplifier paths. The main amplifier handles the base load and is permanently operated at energy-efficient full modulation. If the input signal rises above a certain level, the second amplifier switches on and handles only the load peaks. This task sharing is particularly promising for digital signals with their high crest factor. Many years of R&D effort were necessary to make this theoretically attractive concept possible in practice. It will take even more years to migrate it to high millimeterwave frequencies and wideband applications such as 5G and SatCom.

Every implementation of a Doherty amplifier is always an approximation since perfect Doherty operation is a theoretical concept that cannot be achieved in practice. Nevertheless, even with rough approximations, performance is usually better than the baseline class AB amplifier at low operating frequencies and small bandwidths. However, the technique becomes less tolerant to rough approximations and hence less efficient as operating frequency, bandwidth and output power increase. New and repeatable design processes are required to harness the full potential of the technique. The R&S®SMW200A vector signal generator together with the R&S®FSW signal and spectrum analyzer can provide very effective support.

Doherty designers have to design two halves, the input side and the output side. The input side is where the performance differentiation and cost battle is won and lost. The output side with the combiner determines the maximum potential.

The signal to be amplified must be split in order to drive the two amplifier paths. There are different approaches to implementing this split. Classic implementations perform this split in the analog domain. Dual-input solutions perform the split in the digital domain (Fig. 3). Studies published in the peer review literature suggest that dual-input split implementations could realize as much as 60 % more RF output power and 20 % more energy efficiency over a 50 % wider bandwidth than a classic Doherty implementation. The challenges remain the same regardless of whether the amplifier is being developed for 5G and SatCom transmitters or for other applications that require demanding high performance and reproducibility. Designers want to ensure that they get the maximum possible performance from the design under the intended operating conditions as efficiently as possible. Unfortunately, these are mutually contradictory goals, and one can only be achieved at the expense of the other. It is necessary to find an operating point and a parameter set that minimize these costs. In order to do this, the sensitivity of the design to frequency, phase and level variations in the amplifiers paths must be known. The current development process, which heavily relies on reference designs and manual fine-tuning of prototypes, makes it difficult to explore beyond a few local optima. Due to a lack of insight into the sensitivities of the chosen design, the designer typically specifies conservative metrics to accommodate part-to-part variations in a production environment. The result is usually suboptimal because the true potential of the design was not fully explored and specified.

Doherty amplifier development with the R&S®SMW200A and R&S®FSW

Only by stimulating the two amplifier inputs with a range of different signals is it possible to identify and understand the performance trade-offs and sensitivities (Fig. 1). Dual-input Doherty amplifier designs benefit especially from this approach. Even classic designs such as fixed RF input splitter, programmable RF input splitter and dispersive input splitter benefit from such measurements.

A key requirement for this innovative measurement based development process is a vector signal source that is able to produce two precisely aligned signals. The dual-path R&S®SMW200A vector signal generator is the perfect fit. It is able to generate two signals whose relative phase, timing, amplitude and absolute input power can be finely and reproducibly adjusted. This precise alignment of the two signals remains stable over a long period without the need for elaborate calibration procedures since the two paths share the same internal clock. The R&S®SMW200A is able to generate two RF signals of the highest quality, each with a frequency up to 20 GHz, bandwidth up to 2 GHz and up to +18 dBm RF output power. A solution for up to 40 GHz using an additional R&S®SGS100A/R&S®SGU100A RF extension unit is also available.

The R&S®SMW-K546 digital Doherty software option makes it easy to fully explore the performance potential of all Doherty

Parameter spaces of a Doherty amplifier path

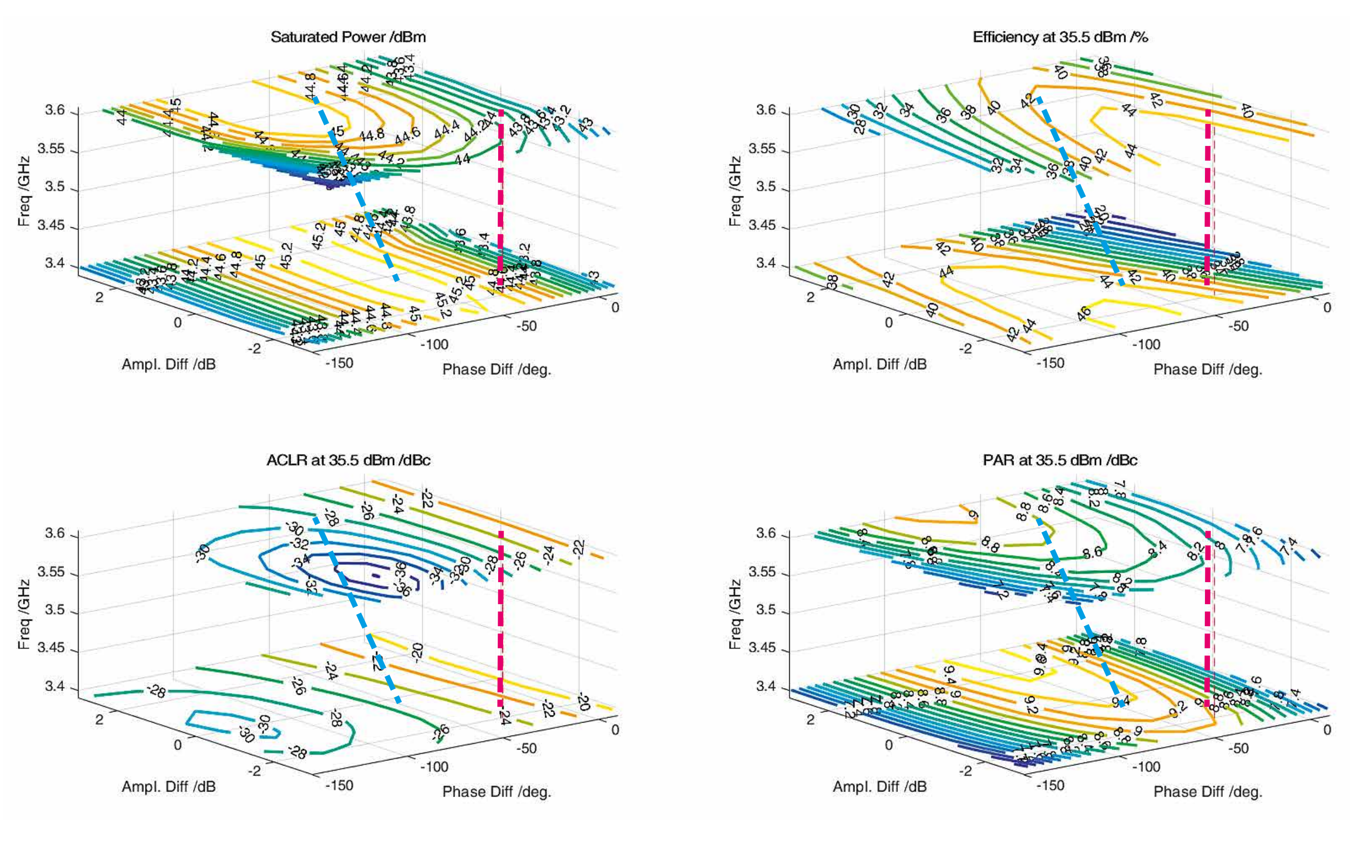


Fig. 1: The entire Doherty amplifier path parameter space with the dimensions of frequency, amplitude difference and phase difference can be filled with measurement data within a few minutes using the presented measurement solution. The dashed red line shows a possible suboptimal operating point that might be chosen with the conventional method due to a lack of information. The measurement suggests, for example, operating parameters according to the blue dotted line (visualization with MATLAB®).

amplifier designs (Figs. 2 and 3). Shaping functions, level and phase adjustments as well as digital predistortion can be easily configured in just seconds and applied in real time using the intuitive GUI. Time-consuming waveform recomputation after each change of parameter settings is not required due to the real-time functionality. This allows the designer to explore the impact of various parameters on the performance of their Doherty designs in real time and quickly find the input split settings and shaping functions that yield the best performance. The R&S®FSW signal and spectrum analyzer equipped with the R&S®FSW-K18 amplifier measurements software option provides the corresponding measurements, capturing not only scalar quantities such as spectral regrowth and EVM, but also vectors such as AM-AM and AM-PM.

Gareth Lloyd, Dr. Patrick Agyapong

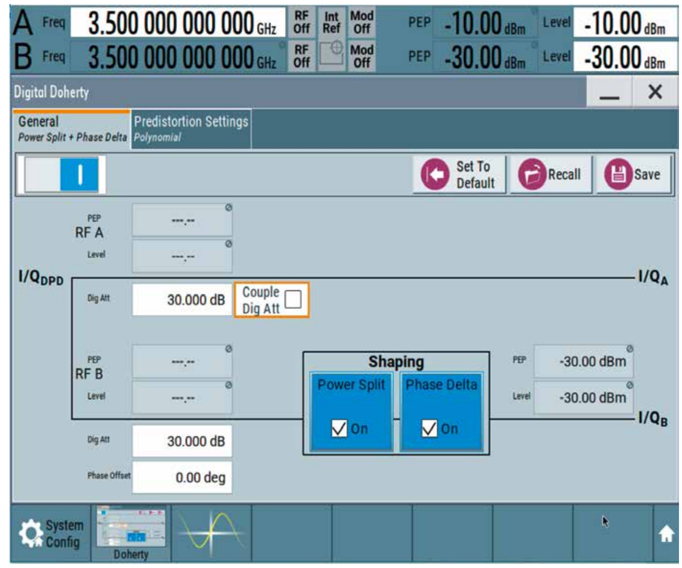


Fig. 2: The R&S®SMW-K546 digital Doherty software option provides an easy-to-use interface to fully explore the performance potential of Doherty amplifier designs. Relative phase offsets, level offsets, shaping functions and digital predistortion can all be configured and applied in real time to the input signals.

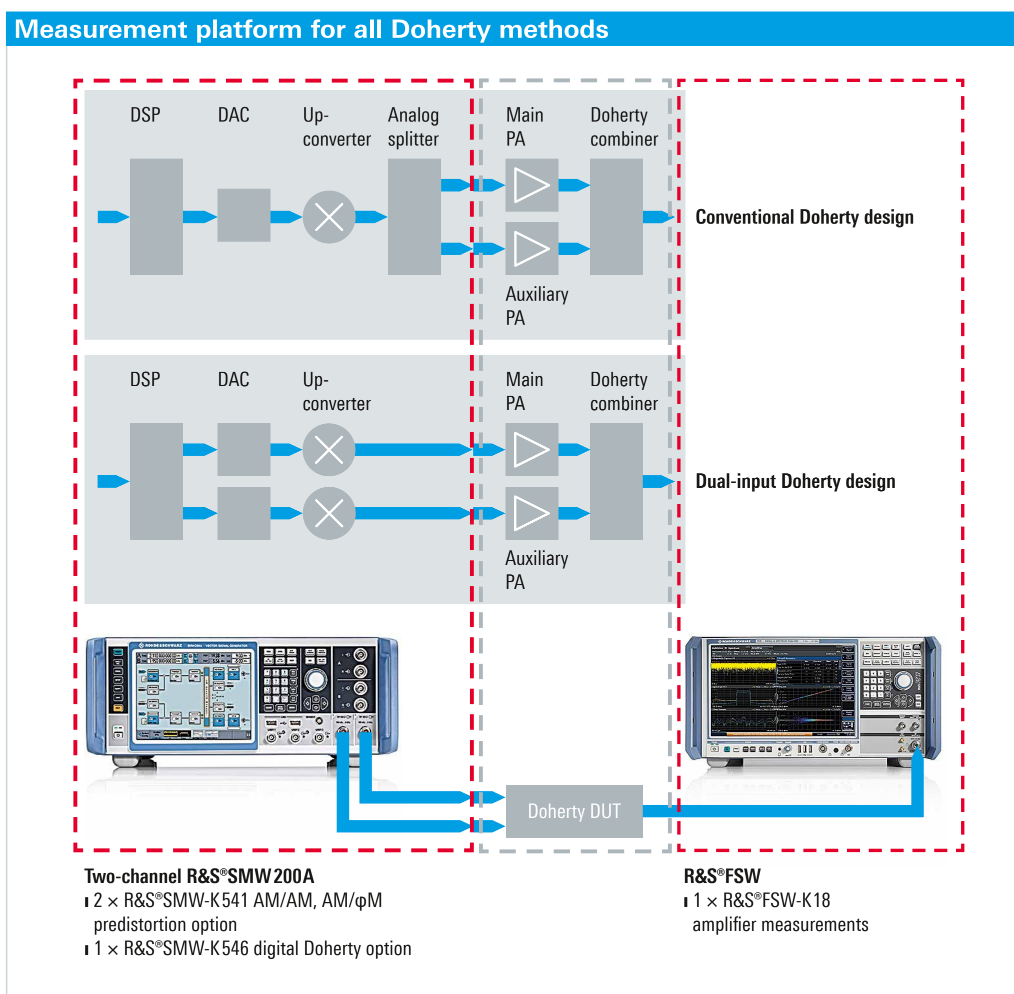


Fig. 3: The R&S®SMW200A vector signal generator produces the path signals for all possible Doherty amplifier designs, and together with the R&S®FSW signal and spectrum analyzer all the data necessary for design optimization.

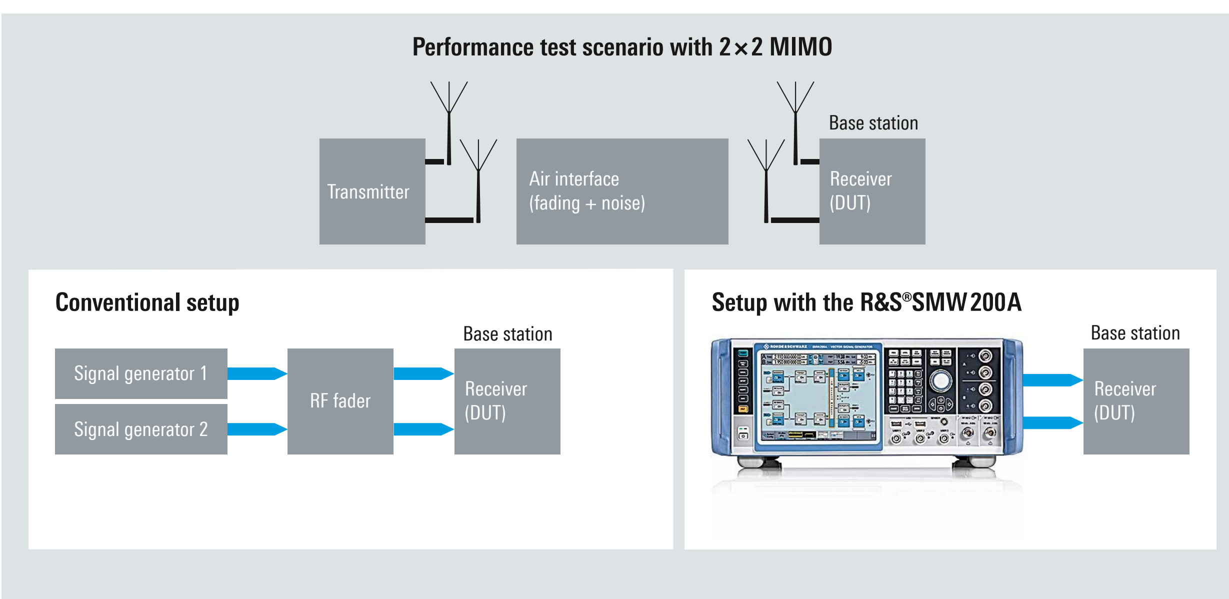
Performance tests on 5G NR base stations

The R&S®SMW200A vector signal generator with the optional integrated fading simulator is the industry benchmark for performance tests on LTE base stations. With the new R&S®SMW-B15 hardware option, the wideband version of the generator now also fades wideband millimeterwave signals in compliance with 5G NR Release 15.

The 3GPP 5G NR Release 15 set of standards was adopted in June 2018. The included specifications TS 38.141-1 and TS 38.141-2 are particularly relevant for base station manufacturers. They define general requirements for transmitters, receivers and base station performance. The requirements for transmitters and receivers target compliance with the spectrum usage conditions specified by the regulatory authorities. On the other hand, the performance requirements focus on data reception under real conditions, which makes simulation of propagation conditions necessary in the test setup.

The R&S®SMW200A vector signal generator with the optional R&S®SMW-B14 fading simulator was already the industry-leading single-box solution for performance tests on LTE base stations as well as on components for other standards, such as Wi-Fi. The sub-6 GHz requirements of 5G NR can also be easily addressed with this configuration. However, fading hardware with more bandwidth is needed for the 5G millimeterwave range with its large specified bandwidths. That is now available with the R&S®SMW-B15 option. The new fader can be installed in the wideband version of the R&S®SMW200A and meets the high demands of the test specifications for 5G NR Release 15 signal sources.

Comparison of setups



The R&S®SMW200A offers a compact, user-friendly setup for performance tests on base stations.

A new standard with new test requirements

Performance tests require highly precise transmit signals as well as simulation of propagation conditions. The physical layer features of the air interface standard dictate the nature of the transmitted signal. Unlike LTE, which only supports frequency bands up to 6 GHz, 5G NR extends into the millimeterwave range, placing new demands on signal generators. Furthermore, the maximum carrier bandwidth of 20 MHz per individual subscriber with LTE pales in comparison to the bandwidths of 100 MHz below 6 GHz and 400 MHz in the millimeterwave range foreseen with 5G NR. Channel models that ensure realistic simulation of propagation conditions over a much wider frequency range are also available for 5G NR. Together with higher carrier frequencies, larger signal bandwidths and higher-order MIMO (up to 8 × 8), they significantly increase the computational load on fading simulators compared to LTE.

Along with the usual conducted tests in the range below 6 GHz, the 5G NR performance tests introduce another innovation: over-the-air (OTA) tests at frequencies below 6 GHz and in the millimeterwave range. This makes test setups more complicated and imposes considerably higher requirements on the signal quality and RF output power of signal generators and fading simulators.

Compact and easy to operate

Compared to a conventional setup with separate signal generators and RF fading simulators, the R&S®SMW200A is more compact, easier to set up and to operate, and covers a much wider frequency range (see figure). It does not cause any signal conversion losses, which typically occur with RF faders. The generator produces extremely pure signals with high output power, and their levels can be set precisely without additional calibration effort. This is particularly beneficial for OTA tests.

R&S®SMW-B15 fading hardware for 5G NR

The R&S®SMW-B15 fading simulation hardware for the wideband version of the R&S®SMW200A is equipped with even more processing power. It currently offers a fading bandwidth of 200 MHz, which for example is necessary for 5G NR performance tests in the millimeterwave range conforming to Release 15, and in the future it will support even larger bandwidths in line with the evolution of the standard. The R&S®SMW-B15 can also be used in scenarios already covered by the R&S®SMW-B14, for example for MIMO fading and routing (initially up to 16 fading channels; soon up to 8 × 8 MIMO) or carrier aggregation. Furthermore, it supports the new 5G NR Release 15 channel model as well as many channel models also supported by the R&S®SMW-B14, including OTA MIMO fading.

Key features of the R&S®SMW200A (standard and wideband versions)

- Frequency range: 100 kHz to 40 GHz (44 GHz pending)
- Output power: up to +18 dBm
- Optional integrated fading and AWGN generator
- MIMO, carrier aggregation, multistandard channel models and signal generation for 5G NR, LTE, Wi-Fi and many other common standards
- 8 × 4 MIMO with just one generator (below 6 GHz; additional R&S®SGT100A generators required for more than two RF signals)

Standard version with optional R&S®SMW-B10 (ARB generator) and R&S®SMW-B14 (fading) fading hardware

- Up to 160 MHz RF bandwidth
- Up to 160 MHz fading bandwidth

Wideband version with optional R&S®SMW-B9 (ARB generator) and R&S®SMW-B15 (fading) fading hardware

- Up to 2 GHz RF bandwidth
- Up to 200 MHz fading bandwidth

Summary: The R&S®SMW-B15 hardware option equips the wideband version of the R&S®SMW200A vector signal generator with powerful fading simulation for performance tests on base stations in compliance with 5G NR Release 15 – with the same form factor and ease of use that have made it an industry standard.

Dr. Patrick Agyapong

Radar sensors on the test bench

Proper operation of radar sensors used in driver assistance systems is a safety-critical issue. Each sensor needs to be tested during manufacturing and when installed in the vehicle. A new radar echo generator plays a key role.

Radar sensor tests call for echo simulators

Radar based driver assistance systems, e.g. collision avoidance systems, rely on proper operation of their radar sensors. Whether a specific sensor in the fully assembled vehicle will correctly measure the distance, size, direction and speed of an object depends on the sensor's performance and quality and on its mounting position in the vehicle. Both aspects are relevant to safety, making functional tests necessary in sensor production at the supplier and on the vehicle manufacturer's assembly line. To assess the performance and radar compatibility of sensor radomes, Rohde & Schwarz recently launched the R&S®QAR automotive radome tester (see NEWS No. 219, pp. 24 to 29). In addition, the digital ARTS9510C automotive radar test system has been available for some time for thoroughly testing radar sensors during development, simulating in particular moving targets. Once the sensor and radome for a given vehicle model have reached the stage of production maturity with the aid of the above test equipment, all that needs to be done during series production is to verify that key parameters comply with predefined limit values.

The new R&S®AREG100A automotive radar echo generator performs these production tests conveniently and reliably (Figs. 1 and 2).

The R&S®AREG100A provides reliable testing of current and future radar sensors both in the 24 GHz ISM band and in the 77 GHz/79 GHz E band. It is made up of two components to provide a high degree of flexibility and ease of use:

1. The base unit includes all components necessary to simulate up to four objects at fixed distances, with user-definable values for radar cross section and radial velocity. When placing the order, customers can specify any four fixed distances for the simulated objects to obtain a solution matched to their test scenarios.
2. The remote frontend converts the signal emitted by the radar sensor to a lower, intermediate frequency (IF) band. The base unit generates the echoes. The signal is then converted back into the radar band and retransmitted to the radar sensor.

In the E band, the R&S®AREG100A already supports bandwidths up to 4 GHz and can simulate object distances as short as 4 meters when the user chooses an air gap of 0.8 meters between the frontend and the DUT. These capabilities make the instrument a future-proof solution for testing short range and long range radars.

Fig. 2: The R&S®AREG100A and the R&S®ATS1500A shielded chamber form a system solution for testing radar sensors, in particular during series production.

Fig. 1: The R&S®AREG100A automotive radar echo generator consists of a base unit and a remote frontend, which can be selected to match the radar band used.

Radar sensors must be resistant to interference

Until recently, mutual interference between automotive radar sensors was not considered a serious issue since only very few luxury cars were equipped with radar based driver assistance systems. Now that these systems are becoming increasingly popular in mid-size and compact cars, the situation is changing. In addition, the number of radar based systems and sensors per vehicle is growing. Both trends increase the probability of mutual interference between radar sensors. As a consequence, appropriate immunity tests need to be performed. The European Radio Equipment Directive (RED), which became effective in June 2017, and associated standards such as ETSI EN 303396 define performance requirements that need to be demonstrably complied with. To verify the robustness of radar sensors against interference, Rohde & Schwarz offers a reference solution based on the R&S®AREG100A (Fig. 3). The R&S®AREG100A frontend converts the generated echo signals, together with an interfering signal supplied by a signal generator, up into the radar band. A signal generator with an upper frequency limit of 6 GHz is adequate for this purpose.

Since RED stipulates tests with CW interfering signals only, an analog signal generator such as the R&S®SMB100B is sufficient to deliver RED-compliant signals. It is also possible to simulate more challenging interference scenarios, e.g. with FM chirp sequences, which are typically encountered in radar applications. Using simulation software such as R&S®Pulse Sequencer in combination with a vector signal generator such as the R&S®SMW200A is a good choice. Together with the R&S®AREG100A, a test setup is obtained that allows even very complex interference scenarios to be simulated.

RED-compliant characterization of radar sensors during final functional testing in production

RED also specifies an upper limit for the transmit power. The calibrated receive paths of the R&S®AREG100A make it possible to verify compliance with this limit during final functional sensor testing in production. Conversion of the radar signal from the ISM band or E band to an IF band in the R&S®AREG100A frontend considerably simplifies the test setup. To measure the equivalent isotropic radiated power (EIRP), the user simply connects an R&S®NRP8S power meter to the calibrated IF output of the R&S®AREG100A. A signal and spectrum analyzer, such as the R&S®FSW8, can be connected to another IF output of the R&S®AREG100A to simultaneously measure key parameters such as occupied bandwidth, chirp linearity and chirp duration.

Dr. Alois Ascher, Dr. Rainer Lenz, Volker Bach

Reference solution for RED-compliant testing of automotive radar sensors

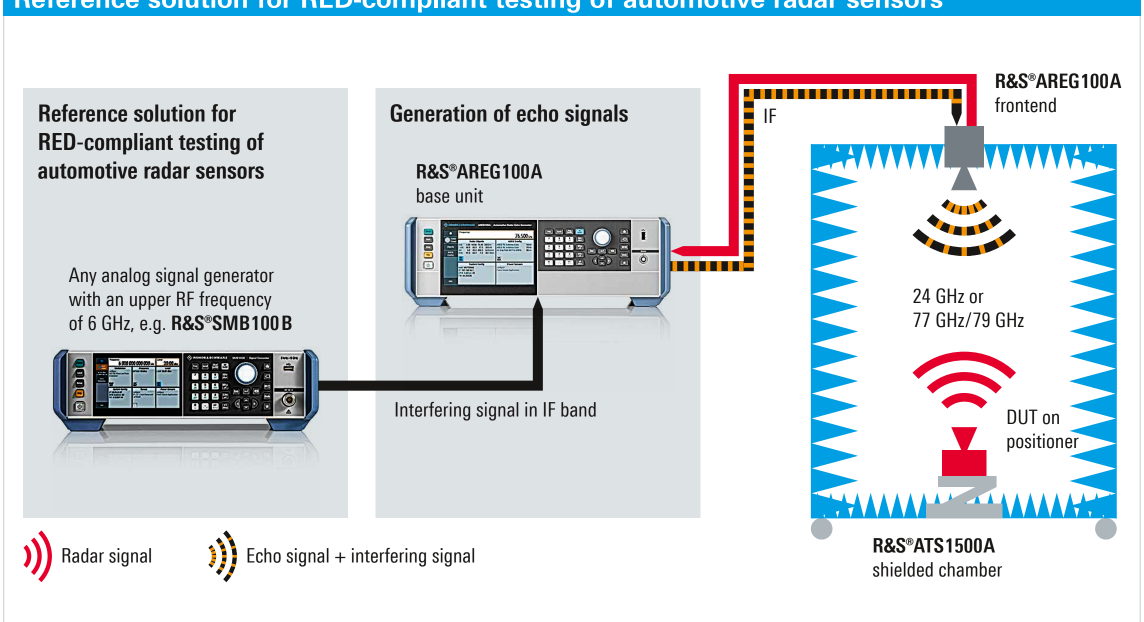


Fig. 3: RED-compliant sensor interference immunity tests can easily be performed using a setup with the R&S®AREG100A, the R&S®ATS1500A shielded chamber and an analog RF signal generator such as the R&S®SMB100B.

The introduction of eCall, the automatic car emergency call system, was preceded by years of discussion and coordination at the European level. Since March 2018, it has been mandatory for all new homologated car models in the EU. It has only been installed in relatively few vehicles, yet it is already technologically obsolete. Its successor is waiting in the wings.

When a serious accident occurs, eCall automatically contacts the public safety answering point (PSAP) via mobile telephony. The in-vehicle electronics determine whether or not a serious accident has taken place. Airbag actuation is a typical indicator of the seriousness of an accident. The system can also be manually triggered using an SOS button to report a different kind of emergency or an accident involving other vehicles.

Existing eCall installations are based on ETSI and CEN standards. Development of these standards began about 15 years ago. The system uses an in-band modem to acoustically transmit (using peep tones similar to a fax machine) the eCall minimum set of data (MSD) to the 112 emergency number over a GSM voice channel. This technologically outdated solution was chosen because at the time only GSM appeared to provide the necessary international coverage. It made good sense back in the planning phase, but the pace of mobile phone development now calls it into question. The German insurance industry estimates that near-complete market penetration of eCall will not be reached until 2035. But by then, some European countries will no longer have GSM networks since the frequencies are desperately needed for LTE and 5G. Already today, more than 95% of the European population has access to an LTE network. So the question is: What will happen to eCall? Network operators cannot be forced to maintain a GSM infrastructure just to keep this service going. The solution will probably be hybrid. eCall based on GSM and a modern successor system will coexist in in-vehicle telematics systems so that functionality is maintained wherever the car is.

From eCall to NG eCall

The successor to eCall is next generation eCall (NG eCall), and it has already been specified. Naturally NG eCall will not use modulated tones for data transmission in the IP-based LTE system. But it will still use voice transmission since eCall doesn't just transmit data, but also establishes a voice link to the accident vehicle. The LTE IP multimedia subsystem (IMS) acts as a service enabler. IMS is a transmission technology for IP-based multimedia applications in landline and mobile telephony networks. One of its main purposes is to enable telephony, which in LTE is known as voice over LTE (VoLTE).

IMS is not new. It was developed in the early 2000s and is based on older industry standards developed by ETSI (TISPAN) and 3GPP (IMS). The IMS framework became established with the introduction of LTE. It is used for voice transmission, video telephony, SMS service and much more. IMS is also the perfect basis for NG eCall and was suitably adapted. Release 14 of 3GPP specifies a network support indicator that tells the network whether NG eCall is supported or if legacy eCall has to be used. This ensures that eCall and NG eCall can coexist (Fig. 1).

Coexistence of eCall and NG eCall

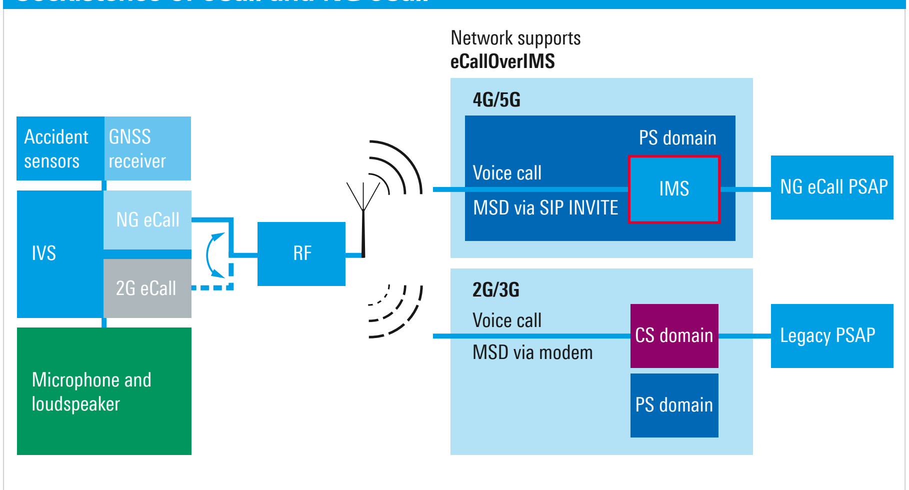
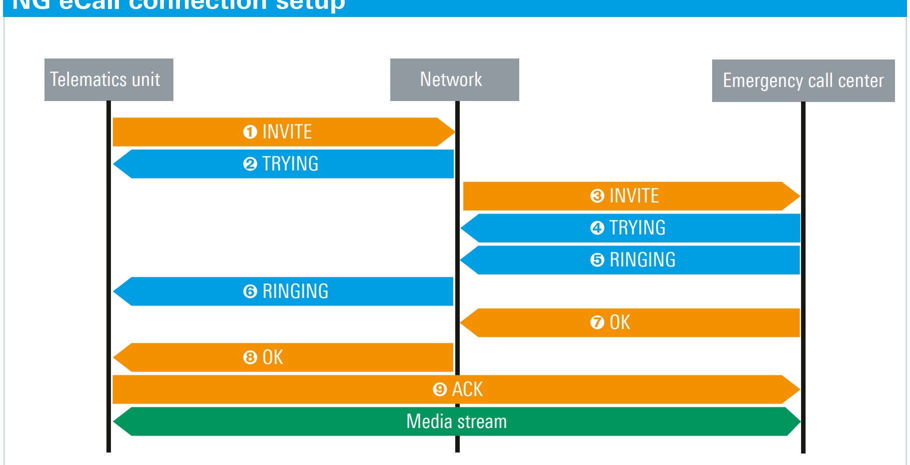


Fig. 1: In an LTE network, a network support indicator determines whether NG eCall is supported or if a legacy eCall needs to be placed.

NG eCall connection setup



❶	SIP INVITE message (including MSD).
❷ bis ❻	The network and the PSAP (emergency call center) answer with TRYING and RINGING.
❼ bis ❾	As soon as the PSAP receives the MSD, it sends OK, which the caller acknowledges with ACK. The call connection is now established and all media data such as voice, video or other data can be transmitted.

Fig. 2: Details of establishing an NG eCall connection between the telematics unit, network and emergency call center.

How does NG eCall work?

If an accident occurs while the vehicle is connected to an LTE network, the telematics system evaluates the network support indicator for NG eCall. If NG eCall is supported, the vehicle can place an emergency call via IMS using the session initiation protocol (SIP) and session description protocol (SDP). If NG eCall is not supported, there needs to be a handover (circuit switch fallback) to the GSM network in order to make a legacy eCall over the GSM in-band modem. Fig. 2 shows how the connection is established.

Routing of the call to the PSAP is controlled by the resource name in the transmitted SIP. The following uniform resource names have been defined:

- urn: service: sos.ecall.manual: manual eCall
- urn: service: sos.ecall.automatic: automatic eCall
- urn: service: test.sos.ecall: test call

So as not to lose any time, the MSD is transmitted to the PSAP while the call is being established. The dataset is presently limited to 140 bytes. But the data volume can easily be increased in the LTE network.

Fig. 3 shows a comparison of eCall and NG eCall.

Advantages of NG eCall

Since NG eCall sets up a fast data connection, the system can transmit data other than the MSD, data that might be helpful in an emergency situation, for example driver health data, which could be supplied by a smart watch connected to the vehicle by Bluetooth®. If there is a connected dashcam, a video link can be set up so that the call center has visual information. In the other direction, it is conceivable that the emergency call center could send remote control commands to the vehicle, for example to unlock the doors or turn off the ignition. Notwithstanding the data privacy and IT security aspects of such features, the fact remains that NG eCall has substantially more potential functionality than the technologically outdated legacy eCall. This is one reason that eCall services are likely to become increasingly divided – between the public system that uses the 112 emergency number and manufacturers' proprietary systems that call private emergency call centers. Manufacturers are required to install standard eCall, but can also implement their own fee based services. If they do, they still have to let the vehicle operators choose which system they want to use and also ensure that if the proprietary system is unavailable, the vehicle will automatically switch to public eCall.

Why start now with NG eCall?

Even though the EU Commission has not yet made any binding directive concerning NG eCall, it can be safely assumed that it will. Once a sufficient number of network operators configure their LTE IMS for NG eCall, the automotive industry can use it with suitably designed telematics systems, including for private emergency call services. It does not need to, and definitely will not, wait for legislation to force the issue.

Even where NG eCall functionality has already been implemented in a mobile network, testing telematics systems in real networks can be difficult and time-consuming. And reproducibility is never achievable in field tests. It is also hard to obtain test results on the IMS since it is part of the network infrastructure that is inaccessible to the user. But a custom-designed test and measurement system can deliver the necessary data easily and reliably.

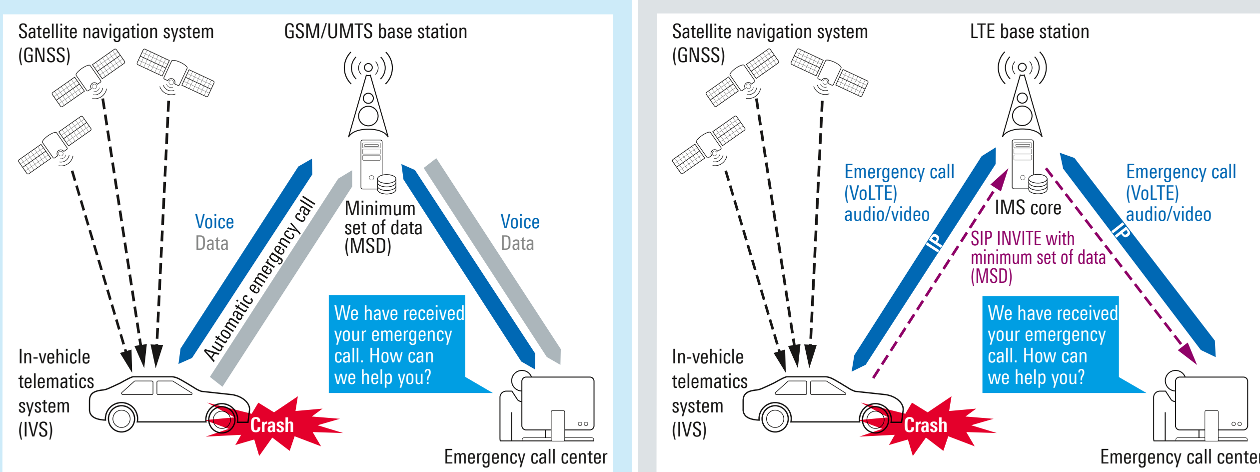
T&M solution

Rohde & Schwarz has long offered a comprehensive test solution for GSM-based eCall (Fig. 4). The system's design is so universal that it can even

eCall versus NG eCall

The first, and currently used, version of eCall is based on circuit-switched voice telephony and uses an in-band modem.

Next generation eCall uses the IP multimedia subsystem (IMS) of packet switched telecommunications networks



- Accident
- IVS calls 112 via GSM
- Establishment of voice connection
- MSD transfer via in-band modem
- Voice connection between vehicle and emergency call center

- Accident
- IVS calls 112 via VoIP/VoLTE and sends the MSD during call setup
- Establishment of voice channel between vehicle and emergency call center
- Optional transmission of additional multimedia data (video or sensor data)

Fig. 3: NG eCall (right) can use the capabilities of a fast IP network to transmit large data volumes.

be used for the Russian emergency call system ERA-GLONASS – and now also NG eCall. To handle NG eCall, the R&S®CMW-KA096 has been added to the PC test software suite. The R&S®CMW500 wideband radio communication tester as a mobile network simulator and the R&S®SMBV100A GNSS simulator already have all the necessary capabilities.

The R&S®CMW-KA096 software simulates an NG eCall capable emergency call center and remotely controls the R&S®CMW500, which replicates an LTE mobile network and the necessary IMS infrastructure.

With a test setup consisting of a control computer and the R&S®CMW500, it is possible to verify whether the onboard NG eCall electronics (IVS) can trigger an NG eCall, choose the right network, transmit the correct MSD data and establish voice communications with a voice-over-LTE call to the emergency call center. The data in the MSD is available in RAW format and in a decoded format. If an R&S®SMBV100A vector signal generator with GNSS option is incorporated into the test setup, it is also possible to check the GNSS position accuracy of the MSD entry.

NG eCall standards	Specification
IP Multimedia Subsystem (IMS) emergency session	3GPP TS 23.167
IP Multimedia Call Control Protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP)	3GPP TS 24.229
Next-Generation Pan-European eCall	IETF rfc8147
Additional Data Related to an Emergency Call	IETF rfc7852
Next-Generation Vehicle-Initiated Emergency Calls	IETF rfc8148
Intelligent transport systems – eSafety – eCall High level application Protocols (HLAP) using IMS packet switched networks	CEN TS 17184
ECall end to end conformance testing for IMS packet switched based systems	**CEN TS 17240**

NG eCall is based on a series of standards (list incomplete) that are met by the test solution described here.

The test procedure can be easily expanded to multi-cell scenarios. Such scenarios are used in interoperability testing to simulate the vehicle entering a zone where NG eCall is not supported. In this case, it is necessary to test whether the telematics system can correctly place the emergency call using the legacy eCall backup system.

Christian Hof

Video

Fig. 4: All vehicle emergency call systems can be tested for acceptance with this setup.

Troubleshooting in automotive Ethernet networks

For driver assistance systems to operate reliably, the sensor data must reach the control units unimpaired. The details of communications between sensors and control units are regulated by the new automotive Ethernet standard. However Ethernet protocol analysis by itself is usually not sufficient if there are signal transmission problems. In such cases, the new trigger and decode solution for the R&S®RTO and R&S®RTE oscilloscopes can help.

Reliable Ethernet communications is essential for driver assistance systems

Automotive Ethernet is being increasingly used as a fast bus system for onboard driver assistance systems, infotainment systems and more. The automotive industry has therefore developed the 100BASE-T1 Ethernet interface, which is based on BroadR-Reach technology and standardized by IEEE working group 802.3bw. 100BASE-T1 implements a full-duplex Ethernet connection over an unshielded twisted pair (twisted-pair Ethernet). The 100BASE-T1 signals are PAM-3 modulated with differential signal levels between –1 V and +1 V. The data rate of 100 Mbit/s is significantly higher than with

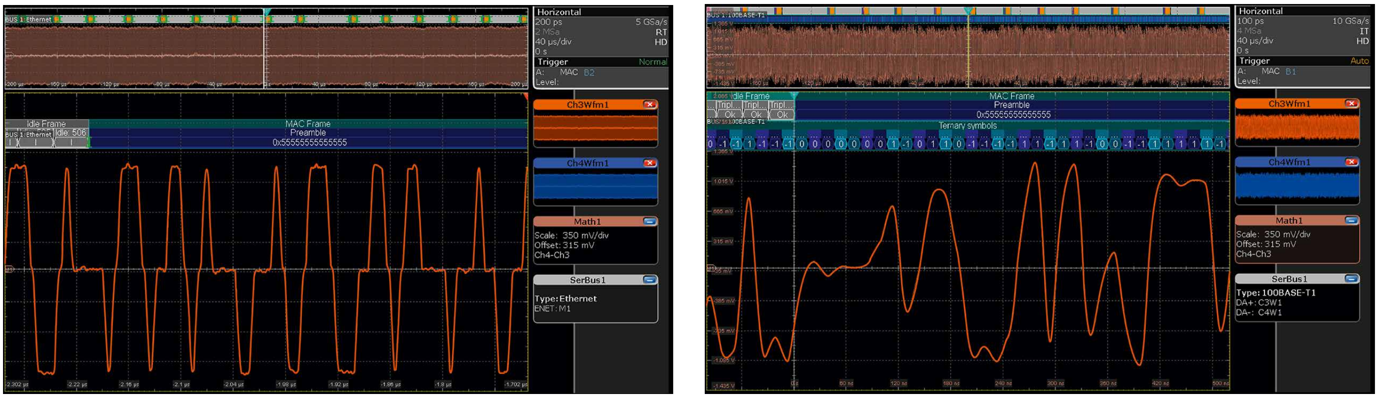


Fig. 2 On the left is a differential 100BASE-TX signal. The three levels and steep transition edges are clearly visible. An automotive 100BASE-T1 signal is shown on the right for comparison. Due to predistortion in the equalizer, the levels of the PAM-3 signal are not always clearly recognizable.

conventional automotive buses such as the CAN bus. This enables the development of driver assistance systems where large data volumes, such as occur in camera signals and radar signals, can also be transmitted reliably and with sufficiently short latency.

To ensure reliable transmission over the unshielded cable with minimum RF leakage, the transmitter uses an equalizer to shape the frequency response of the signals. The 100BASE-T1 PHY chips measure the frequency response of the cable when a connection is established and determine the appropriate signal predistortion. Compared to standard 100BASE-TX Ethernet, which works without equalizers, the signals in the 100BASE-T1 system are highly distorted and therefore the signal quality cannot be read directly from an analysis of the signal levels, for example in an eye diagram (Fig. 2).

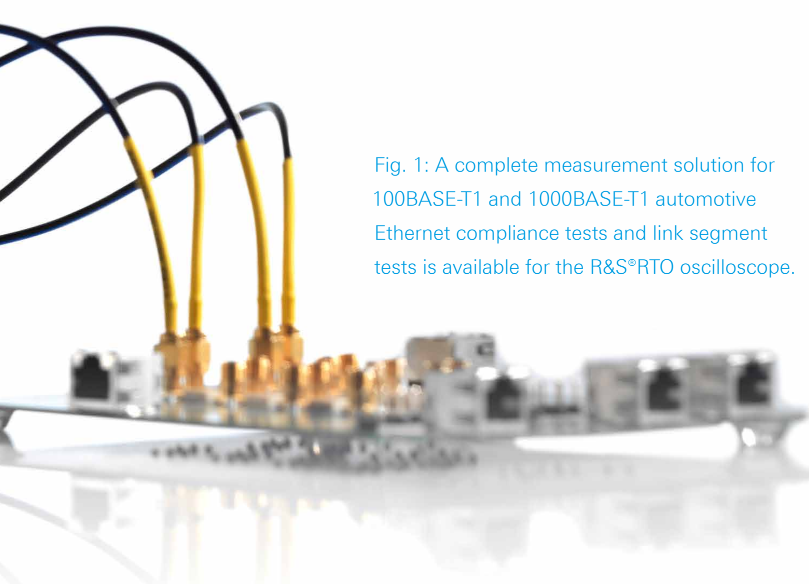


Fig. 1: A complete measurement solution for 100BASE-T1 and 1000BASE-T1 automotive Ethernet compliance tests and link segment tests is available for the R&S®RTO oscilloscope.

Testing automotive Ethernet interfaces

The automotive industry association Open Alliance has defined detailed specifications for Ethernet interface tests. In the compliance tests for the physical layer (PMA tests in the Open Alliance Automotive Ethernet ECU Test Specification), the electrical properties of the interfaces are measured in the lab using an oscilloscope and a network analyzer. The compliance tests only check the electrical properties of the transmitter (using test signals). No tests are performed on the receiver. The quality of communications between two control units is simply measured indirectly by reading out the signal quality parameters of the PHY chips.

Tools such as Vector CANoe or Wireshark are usually used to verify that the control unit application communicates correctly. These software tools perform extensive analyses of the protocol content by acquiring all Ethernet data traffic with special interface modules. However, they only indicate transmission errors as data packet errors. If the data packet errors are caused by coupled-in interference for example, a more detailed analysis is not possible with these software tools. In such cases, an oscilloscope with suitable trigger and decode functions is commonly used.

The new solution for triggering and decoding on 100BASE-T1 buses for the R&S®RTO (Fig. 1) and R&S®RTE oscilloscopes makes it possible for the first time to analyze data packet content correlated with the electrical bus signals. Troubleshooting becomes nearly as simple as on conventional CAN buses.

Decoupled signal acquisition

If the signals on the twisted pair are tapped directly using an oscilloscope probe, the superimposed signals traveling in both directions are acquired. However, protocol analysis is not possible without separating these signals. The R&S®RT-ZF5 Ethernet probing fixture (Fig. 3) uses directional couplers to separate the signals, allowing decoupled acquisition of 100BASE-T1 communications with an oscilloscope (Fig. 4). The maximum additional attenuation of the signals is 1 dB, which does not affect data transmission.

Since the 100BASE-T1 transmitter's equalizer highly distorts the acquired signals, the signals are equalized by complex algorithms before decoding in the oscilloscope. The R&S®RTO displays the decoded data packets and idle frames as color-coded bus signals and in a table (Fig. 6). Time correlation of the 100BASE-T1 electrical signal levels with the transmitted protocol content enables detailed analysis of bus communications and data packet errors. Users can also trigger on data packet errors or on data packets with specific transmit or target addresses.

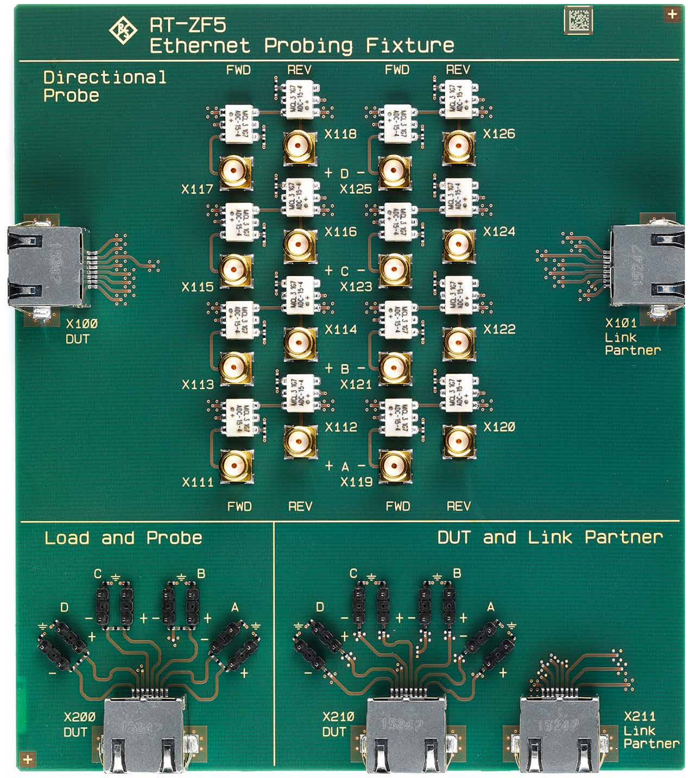
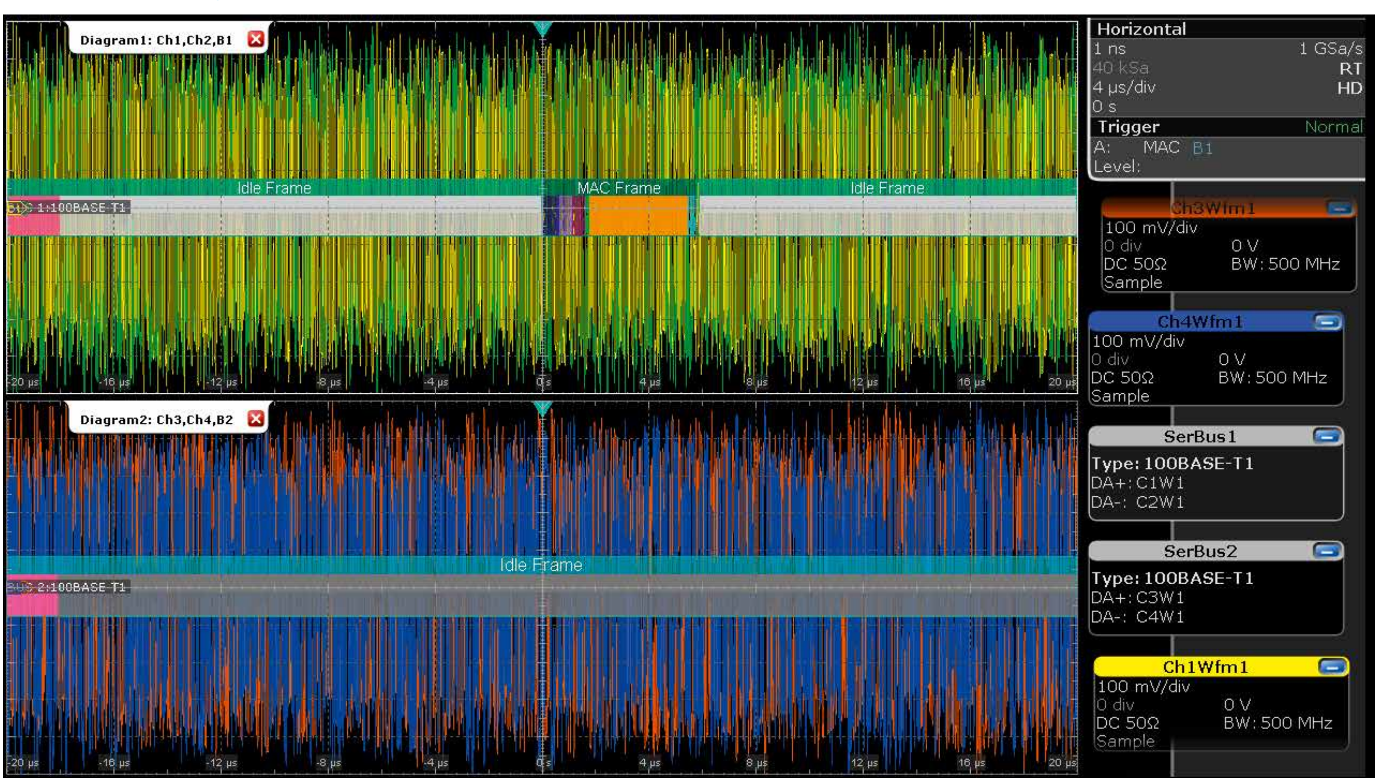


Fig. 3: The directional couplers in the R&S®RT-ZF5 Ethernet probing fixture allow decoupled acquisition of both data streams in full-duplex 100BASE-T1 communications.

Fig. 4: 100BASE-T1 decoding of both data streams in full-duplex communications. The MAC frame is highlighted in orange, the continuously transmitted idle frames are shaded gray.



Analyzing data packet errors

100BASE-T1 decoding can be used to show the timing of bus communications relative to other signals. For example, the start-up time of a control unit can be determined by triggering the oscilloscope on the 12 V supply voltage. The start-up time is the time between power-up and when the first valid data packet appears.

Intermittent bus errors caused by coupled-in interfering signals are difficult to find without simultaneously analyzing bus communications and 100BASE-T1 electrical signal levels. Decoding allows bus communications to be analyzed time-correlated over all seven OSI communications layers, which allows the source of the coupled-in interfering signal to be identified (Fig. 5).

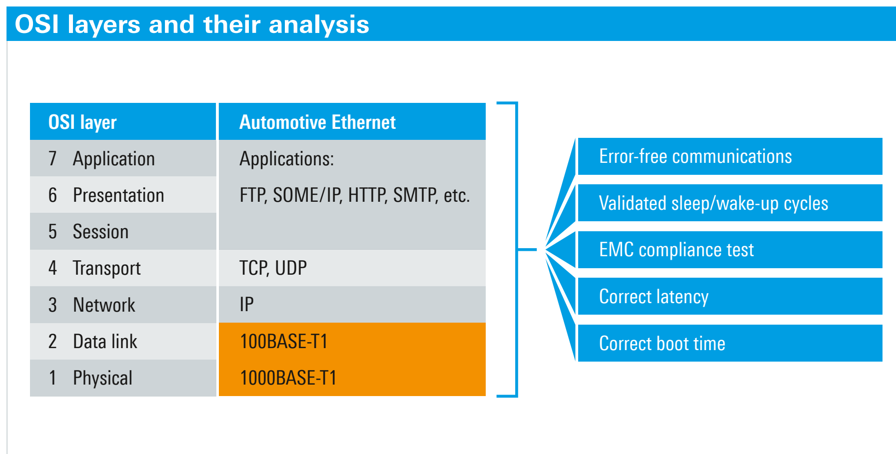
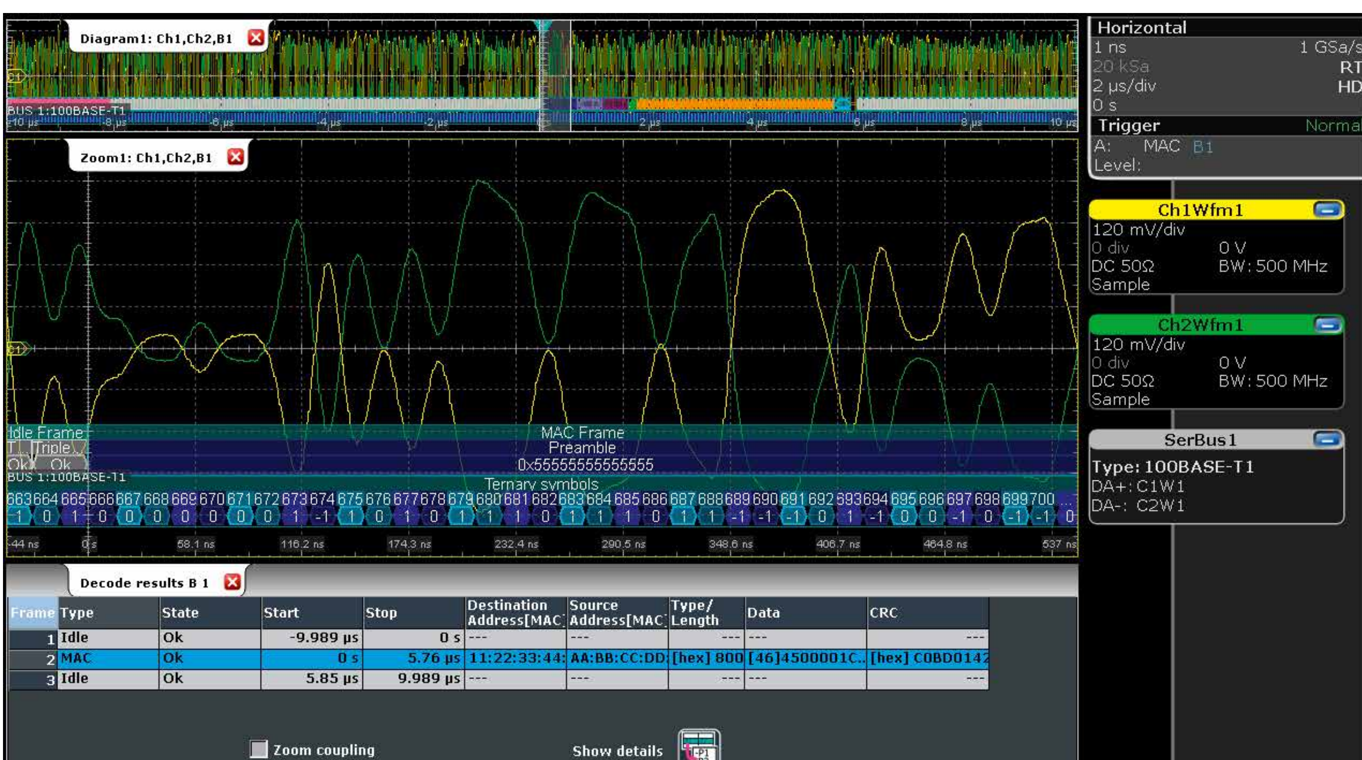


Fig. 5: The oscilloscope with the trigger and decode option analyzes all seven OSI layers of Ethernet communications.

Fig. 6: Decoding 100BASE-T1 electrical signal levels. The two levels of the 100BASE-T1 differential signal and the decoded data packet content are clearly visible.



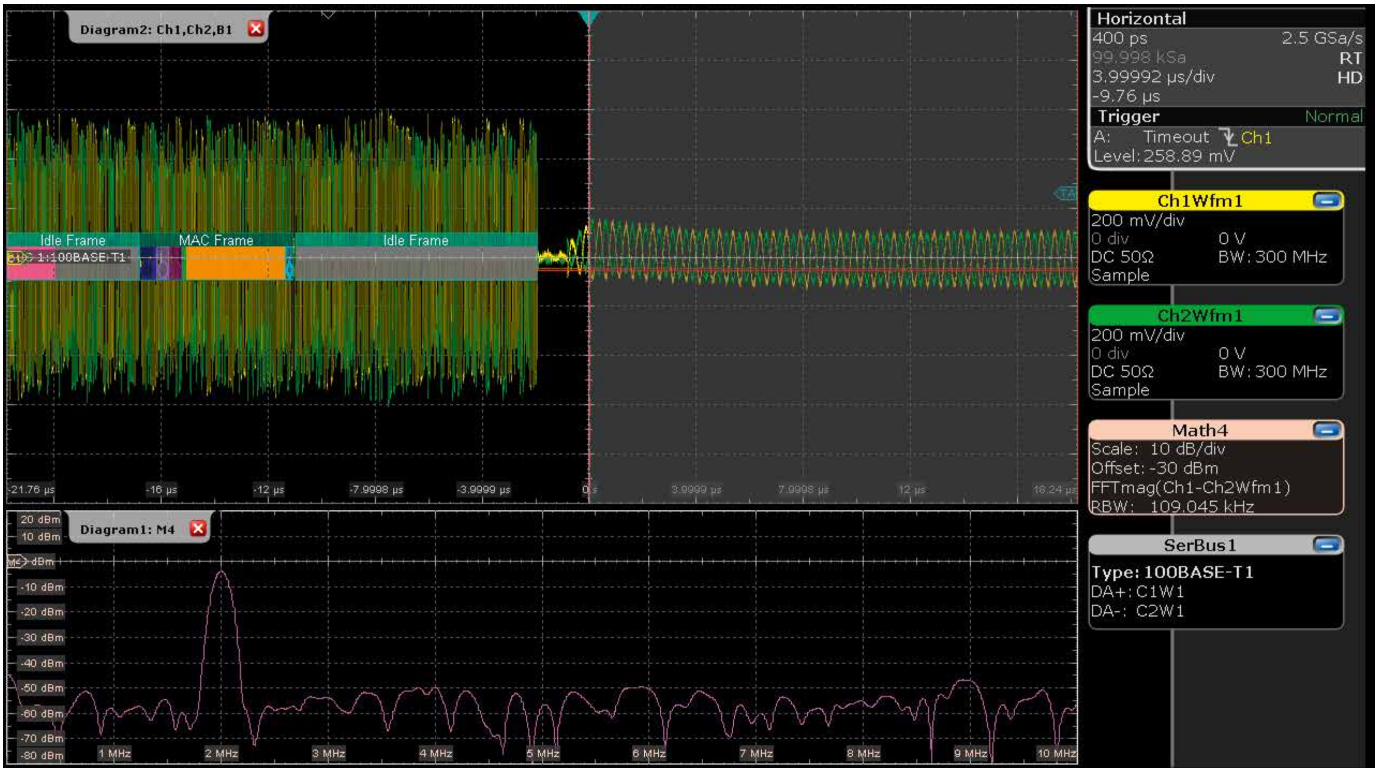


Fig. 7: Combining protocol analysis and frequency analysis to investigate an intermittent interruption of bus communications.

In the measurement in Fig. 7, for example, the MAC frame and the idle frames are transmitted correctly at the start of the acquisition. However, the data stream abruptly stops in the middle of the acquisition. The bottom window shows the frequency spectrum of the faulty time slice (the area shaded gray at the upper right). A spike at 2 MHz is clearly visible. This interfering signal is apparently responsible for the bus problem. Troubleshooting such problems is simplified by combining decoding with the oscilloscope's other analysis tools, such as frequency analysis. Problems that would otherwise be difficult to track down can be recognized at a glance with the oscilloscope.

Required oscilloscope configuration

- Oscilloscope: **R&S®RTO2004**
  (4 channels, ≥ 600 MHz bandwidth)
  or R&S®RTE1054
  (4 channels, ≥ 500 MHz bandwidth)
- **R&S®RTO-K57 or R&S®RTE-K57 option** to support 100BASE-T1
- **R&S®RT-ZF5 Ethernet probing fixture** for channel separation

Additionally recommended:

- R&S®RTE-TDBNDL option for serial trigger and decode functionality
- R&S®RTO-K24 100BASE-T1 compliance test option
- R&S®RTO-K87 1000BASE-T1 compliance test option
- R&S®ZND vector network analyzer

Summary

For the development of control units with an automotive Ethernet interface, Rohde&Schwarz offers a complete 100BASE-T1 trigger and decode solution, including an Ethernet probing fixture, for decoupled signal acquisition. It enables analysis of bus communications across all seven OSI communications layers. Extensive functions for triggering and displaying transmitted data packets facilitate the analysis of protocol content and identification of the causes of bus errors.

A dedicated option is available for 100BASE-T1 and 1000BASE-T1 automotive Ethernet compliance tests and link segment tests.

Dr. Ernst Flemming

In brief

Two-quadrant power supply unit with convenient touchscreen

The new R&S®NGL200 power supplies are specialists for challenging applications in development labs and production test systems.

Modern electronic circuits, such as those in mobile and IoT devices, are sensitive and demanding when it comes to the power supply. A power supply used in their development must allow current changes from a few microamperes in standby mode to the ampere range during transmit mode – within microseconds and without overshoots. The precision, stability and smoothness of the set current and voltage values are just as important. The new R&S®NGL200 power supply family does an excellent job of meeting these requirements. The power supplies are packed full of features that make the R&S®NGL201 (single-channel) and R&S®NGL202 (two cascadable channels) models ideal for many challenging tasks in lab and ATE applications. Thanks to the two-quadrant architecture, the 6.5 digit power supplies function as both source and sink and can be used for tasks such as controlled charging and discharging of batteries. The properties of simulated battery types can be reproduced using the variable internal impedance. Current/voltage characteristics can be precisely programmed – with dwell times per value ranging from 1 ms to several hours. The power supplies offer numerous interfaces for ATE applications, including WLAN. An impressive operating feature is the high-resolution 5" touchscreen, which not only clearly displays the measured values but also provides easy access to the many device functions.

Key features	R&S®NGL201	R&S®NGL202
Output channels (electrically isolated, floating, short-circuit-proof)	1	2
Max. output power per channel	60 W	
Output voltage per channel	0 V to 20 V	
Max. output current per channel	≤ 6 V: 6 A, > 6 V: 3 A	
Load transient recovery time	< 30 µs	
Max. power values per channel when used as load	60 W, 3 A	

Easy measurement of radar pulse stability

The higher the amplitude and phase stability within a radar pulse, the more information a radar system can extract from the received signal. Making stability measurements with the required level of sensitivity used to be complex and costly. A new option for the R&S®FSWP phase noise analyzer and VCO tester now makes these measurements easy and straightforward.

Radars not only receive echoes from the targets they are intended to detect, but also from surrounding objects such as trees, buildings and ocean waves. These incidental echoes, which are referred to as clutter, are of no interest to radar operators, plus they impair radar performance. However, signal processing in advanced radar systems can detect and suppress unwanted reflections by comparing the phases and amplitudes of successive echoes and displaying only moving targets, for example. The higher the phase and amplitude stability of the transmitted pulses, the better the results of signal processing. With high-quality signals, it can be assumed that any phase and amplitude variations are attributable to the target and not to instabilities in the transmitter system. Knowing the phase and amplitude stability of transmitted pulses is therefore crucial when assessing the sensitivity of a radar system. In particular, the power amplifiers in the transmitters can negatively affect stability. Precise measurement of these components is necessary in order to maximize overall system sensitivity and to allow the detection of targets with a very small radar cross section such as micro aerial vehicles.

Fig. 1: Residual measurement of the phase and amplitude stability of pulses on an amplifier. The R&S®FSWP feeds the pulsed signal to the amplifier and analyzes the amplifier's output signal.

Simple setup for a complex measurement

High-sensitivity measurements of the phase and amplitude stability of pulses, especially on amplifiers, previously required complicated test setups involving multiple instruments. The R&S®FSWP-K6P option for the R&S®FSWP phase noise analyzer and VCO tester now greatly simplifies these measurements. The new option is an enhancement to the R&S®FSWP-K6 pulse measurements option and is intended specifically for characterizing pulse stability. The R&S®FSWP-K6P option takes advantage of the R&S®FSWP hardware, which is optimized for very low phase noise and measures phase and amplitude stability with higher sensitivity than a spectrum analyzer. The R&S®FSWP can also generate pulses like a radar system, feed the pulses to a DUT such as an amplifier, and analyze the DUT's output signal. Since the phase noise of the supplied pulses and that of the local oscillator in the R&S®FSWP are identical or correlated, the phase noise can be effectively suppressed, leaving only the phase change caused by the DUT. This residual measurement delivers sensitivity of < –80 dB for pulse-to-pulse phase and amplitude stability measurements. The dB values for phase stability are calculated as follows:

$$\textit{Phase stability} = 10 \times \log \left[\frac{1}{N-1} \sum_{i=1}^{N-1} (\theta_{i+1} - \theta_i)^2 \right]$$

where θ_i is the phase at a sampling point of the ith pulse given N pulses. An average pulse-to-pulse phase deviation in the order of 0.1 mrad corresponds to –80 dB. This analogously applies to amplitude stability. Fig. 1 shows the test setup. The amplifier input and output are connected directly to the R&S®FSWP. For this complex and highly sensitive measurement, the test setup couldn't be any simpler. As a matter of course, the R&S®FSWP offers users the flexibility to insert their own source as a local oscillator for this measurement. This is helpful in cases where the source in the R&S®FSWP is not adequate for a given application.

Typical radar applications, however, do not use simple pulses. Instead, they employ bursts (Fig. 2) or complex pulse

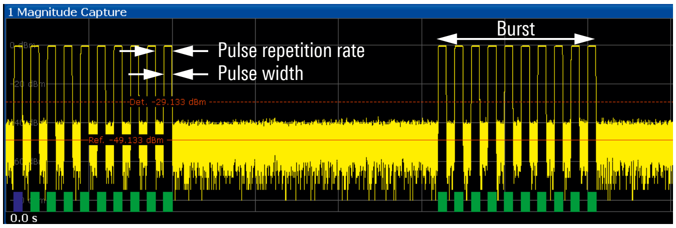


Fig. 2: Burst signal: ten pulses are followed by a longer pause up to the next burst.

sequences. Consequently, burst signals are also required when testing radar components, since the components heat up during the on-phase of the burst signal, which has a strong impact on phase and amplitude stability. The R&S®FSWP can generate pulse sequences and bursts, which are also taken into consideration during result evaluation and presentation.

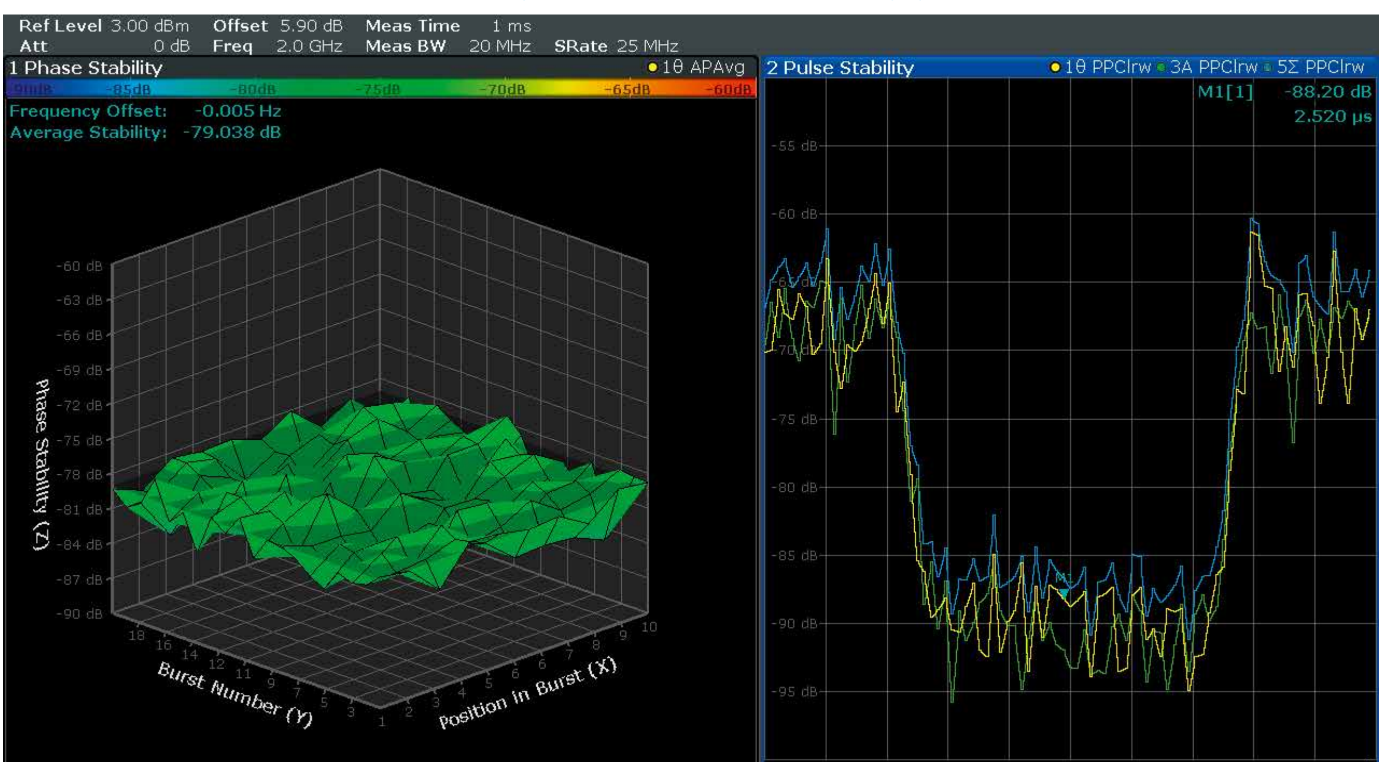
Presentation of results

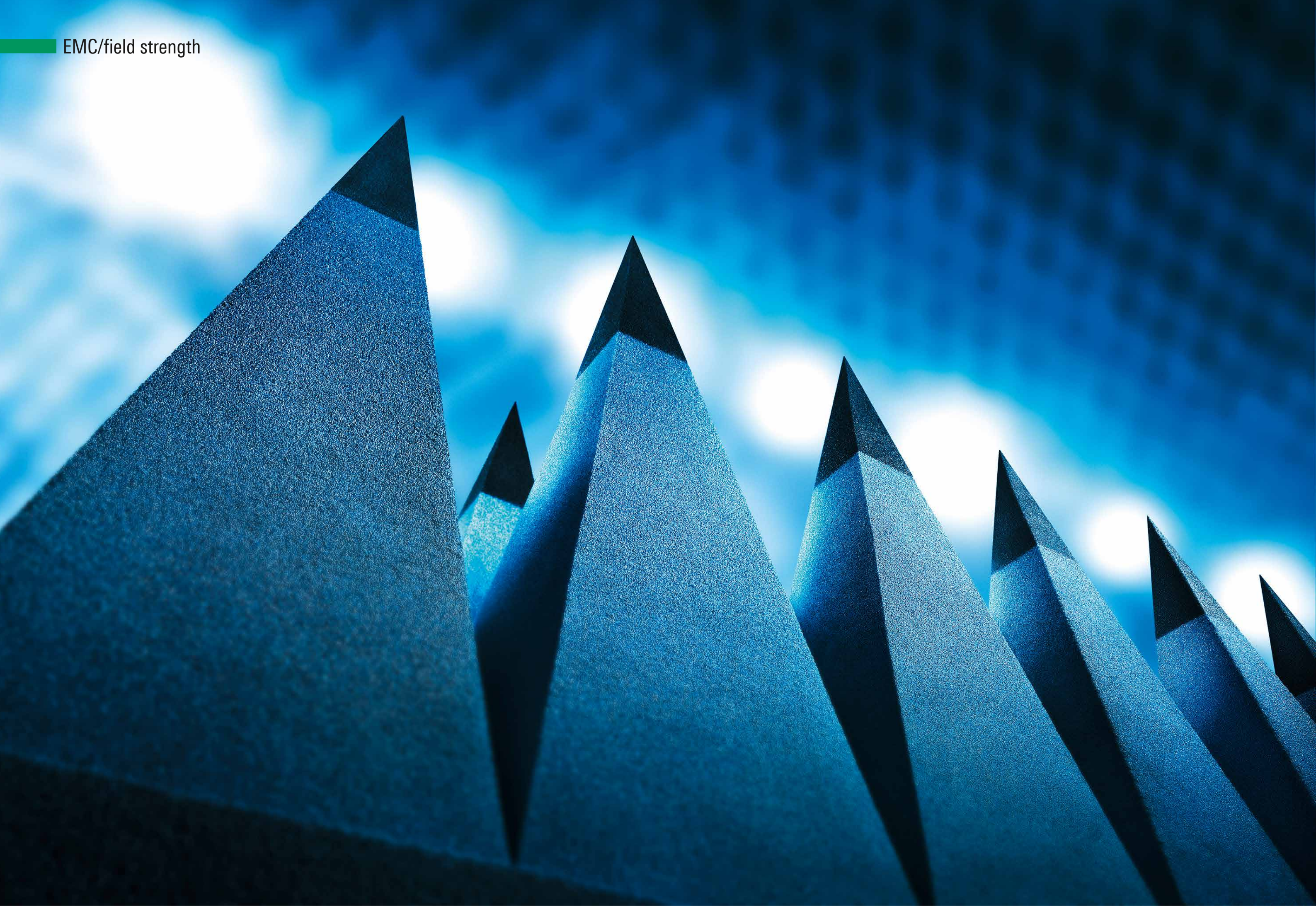
With the R&S®FSWP-K6P option, users can choose whether to make measurements using the more broadband hardware of the spectrum analyzer or the significantly more sensitive hardware of the phase noise tester. In the latter case, users have the option of directly measuring the pulsed signal or employing the residual test mode with internally generated pulses to stimulate the DUT.

The phase and/or amplitude stability can be displayed for each individual pulse. The deviation at each sampling point in a pulse from the average amplitude and phase in this pulse is calculated and displayed. The R&S®FSWP can also average the values over an entire burst, or only calculate the difference from pulse to pulse, delivering pulse-to-pulse phase and amplitude stability. Both of these averaging techniques produce smoother, more conclusive traces (Fig. 3).

Dr. Wolfgang Wendler

Fig. 3: Pulse-to-pulse phase and amplitude stability of a burst signal during testing of a passive attenuator. Left: waterfall display of the phase deviation from the average value of each pulse for all recorded bursts. Heating effects causing instability within a burst are clearly visible. Right: difference measurement, showing pulse-to-pulse phase stability (yellow) and amplitude stability (green), plus the sum of the two signals (blue) averaged over all pulses. The difference between the absolute values in the two diagrams is due to the use of different averaging techniques.





R&S®ELEKTRA has evolved

The R&S®EMC32 EMC software deployed worldwide is gradually being replaced by R&S®ELEKTRA. The successor software now supports automation and control of EMI systems and contains high-performance modules for EMS measurements.

Developing complex and exceptionally versatile EMC test software such as R&S®ELEKTRA is not a trivial task. The first modules were unveiled in 2017 (see NEWS (2017) No. 217, pp. 15 to 17). The base module described there (which now has the type designation R&S®ELEMI-E) is aimed at developers who test the electromagnetic interference (EMI) of their prototypes before EMI certification.

EMI certification in line with all current standards

The new R&S®ELEMI-A and R&S®ELEMI-S modules for EMI measurements expand the range of applications for product testing and certification. The software controls the measurement of conducted and radiated disturbances in line with commercial, automotive and military standards (Fig. 1). It allows users to choose the depth of automation. Everything is configurable – from manual interactive measurements to virtually fully automatic test sequences. Not only can R&S®ELEKTRA remotely control turntables and masts from all current manufacturers, it can also search for peaks in EMI measurements and perform final measurements fully automatically with exact peak searching by varying the frequency, mast and turntable settings. Convenient functions for scheduling test scenarios and generating test reports boost efficiency and throughput in the test lab.

Automated EMS measurement and disturbance level calibration

To measure electromagnetic susceptibility (EMS), the EUT is exposed to defined electromagnetic disturbance and tested to see if it also functions flawlessly under unfavorable ambient conditions, such as occur in the vicinity of large electric motors or radio equipment. R&S®ELEKTRA operates in line with the commercial standards IEC/EN 61000-4-3 and 61000-4-6.

For accurate test results, the field strength of the disturbance field must be as uniform as possible. Each test setup is therefore subjected to extensive, standardized calibration of field strength and field uniformity. R&S®ELEKTRA performs this calibration and subsequent evaluation largely automatically. The user only has to position the field probe. After successful calibration, the generator produces signals with the right level under all conditions, taking into account the antenna characteristic, amplifier characteristic, losses in cables and RF switches, and anechoic chamber attenuation.

During the test, the EUT is monitored from outside the chamber to verify that it behaves as intended. For this purpose, besides monitoring USB or LAN interfaces it is often necessary to also check status lamps, displays or screens using video systems in the anechoic chamber. This is handled by the R&S®AdVISE software, which is perfectly matched to R&S®ELEKTRA for video evaluation and recording (see the following article) and relieves users of the tedious task of constant visual monitoring.

R&S®ELEKTRA – and what's coming next

R&S®EMC32 is the globally leading EMC test software, with a market share in the high two-digit range. This success story and the worldwide proliferation of the mature software in the industrial and research sectors makes it imperative for Rohde & Schwarz to constantly enhance and extend this software in line with technological progress and adapt it to amended standards.

These efforts gave rise to the new R&S®ELEKTRA EMC test software, which in its present configuration does not yet cover all use cases of R&S®EMC32. Based on a modern development platform, high-performance graphic libraries and an integrated database, R&S®ELEKTRA provides a convenient user interface for fast navigation through all steps of EMC test procedures. The software is scalable on all output devices and resolutions, supports touchscreens and split-screen operation, and noticeably simplifies tasks in EMC test labs with convenience functions such as automatic recognition and configuration of connected system devices. Now the EUT is the focus of configuration, execution and result presentation. Since multiple EMC tests are usually necessary for an EUT, they are preconfigured in a test plan and jointly documented at the end.

EMI standard	Description
CISPR 11	Industrial, scientific and medical (ISM) radio frequency equipment – Electromagnetic disturbance characteristic – Limits and method of measurement
CISPR 12	Vehicles, boats and internal combustion engine driven devices – Radio disturbance characteristic – Limit and methods of measurement for protection of receivers except those installed in the vehicle / boat / device itself or the adjacent vehicle / boat / device
CISPR 14	Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus
CISPR 15	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
CISPR 25	Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers
CISPR 32	Electromagnetic compatibility of multimedia equipment – Emission requirements (replaced CISPR 13 and CISPR 22)
MIL-STD-461	Requirements for the control of electromagnetic interference characteristics of subsystems and equipment (CE102, RE102)
ISO 11451	Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy
ISO 11452	Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy

Fig. 1: Examples of EMI standards for radiated and conducted emission measurements currently supported by R&S®ELEKTRA.

Convenience functions boost efficiency

Extensive libraries in R&S®ELEKTRA provide information about the required test setup and components dependent on the test standard. The software automatically recognizes T&M instruments and system components if they are connected to the computer or the network. This minimizes the number of settings necessary to get tests up and running. For prior checking of the correctness of all settings, the process can be simulated in the software without occupying physical instruments or an anechoic chamber.

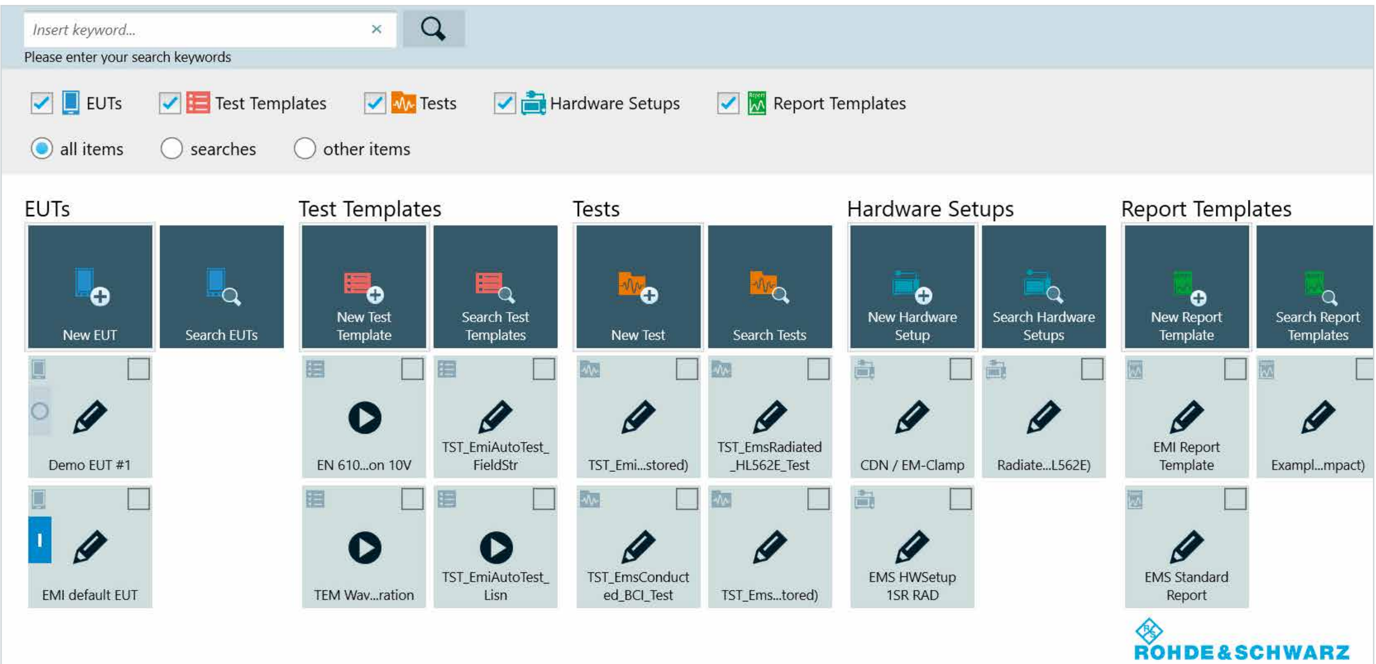
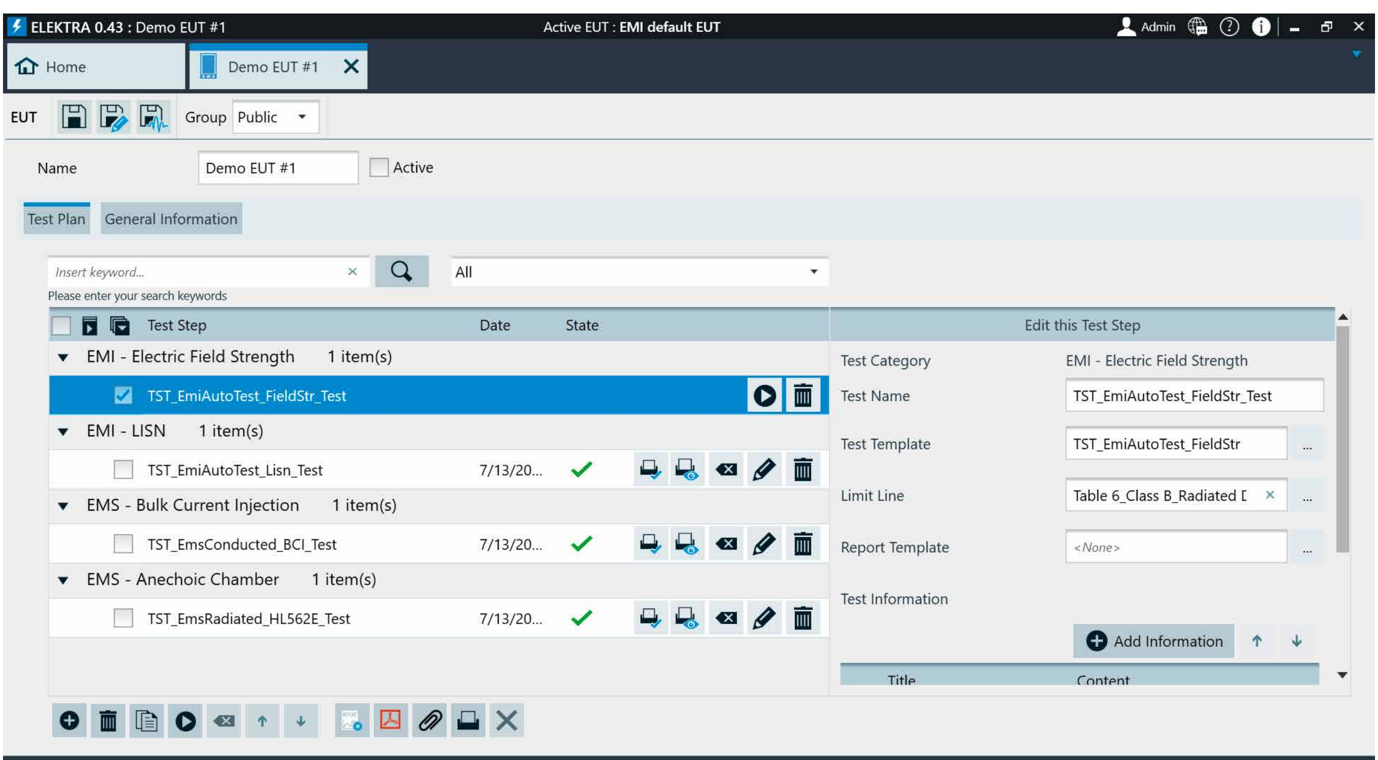


Fig. 2: Control center for complex measurements: the dashboard with tiled symbols for fast access.

Fig. 3: Test plan with various subtests.



The user pins all link tiles necessary for the measurement task to the dashboard (Fig. 2). Filter functions, for example for frequency bands, keywords or standards, reduce the display to the essentials. Important settings and parameters for a test can be viewed and edited at any time. Is there an error in a limit line? That can easily be corrected in the test sequence description. A power meter not connected? Also no problem; it can simply be added to the hardware setup during the test.

Working on other things during a measurement process, such as creating reports, defining tests or comparing results, is also supported. To help maintain an overview, test plans provide support for extensive test sequences. For each EUT, they specify in advance which tests must be performed (Fig. 3) and show the status of individual measurements. A mouse click creates an overall report that can be optimized with structuring and formatting functions in R&S®ELEKTRA or edited using external word processing programs.

R&S®ELEKTRA supports third-party hardware with the generic device driver already used successfully in R&S®EMC32. Users configure the necessary remote control commands in a dialog window.

A migration wizard simplifies the switch from R&S®EMC32 to R&S®ELEKTRA by importing existing hardware setups and test templates. Naturally, both software packages can be installed on the same PC – including multiple versions of R&S®ELEKTRA. If necessary and to enable proper handling of specific situations, all R&S®ELEKTRA versions are available on demand, for example when the end customer's certification only supports a specific version.

Summary

With the new modules and functions, R&S®ELEKTRA has evolved from a tool for EMI measurements during the development process into a control center for the automation and control of complex certification systems. For EMS measurements, R&S®ELEKTRA together with R&S®AdVISE now also handles susceptibility measurements and EUT monitoring for commercial standards. The software is continuously refined and updated and will support additional standards in the future.

Reiner Götz

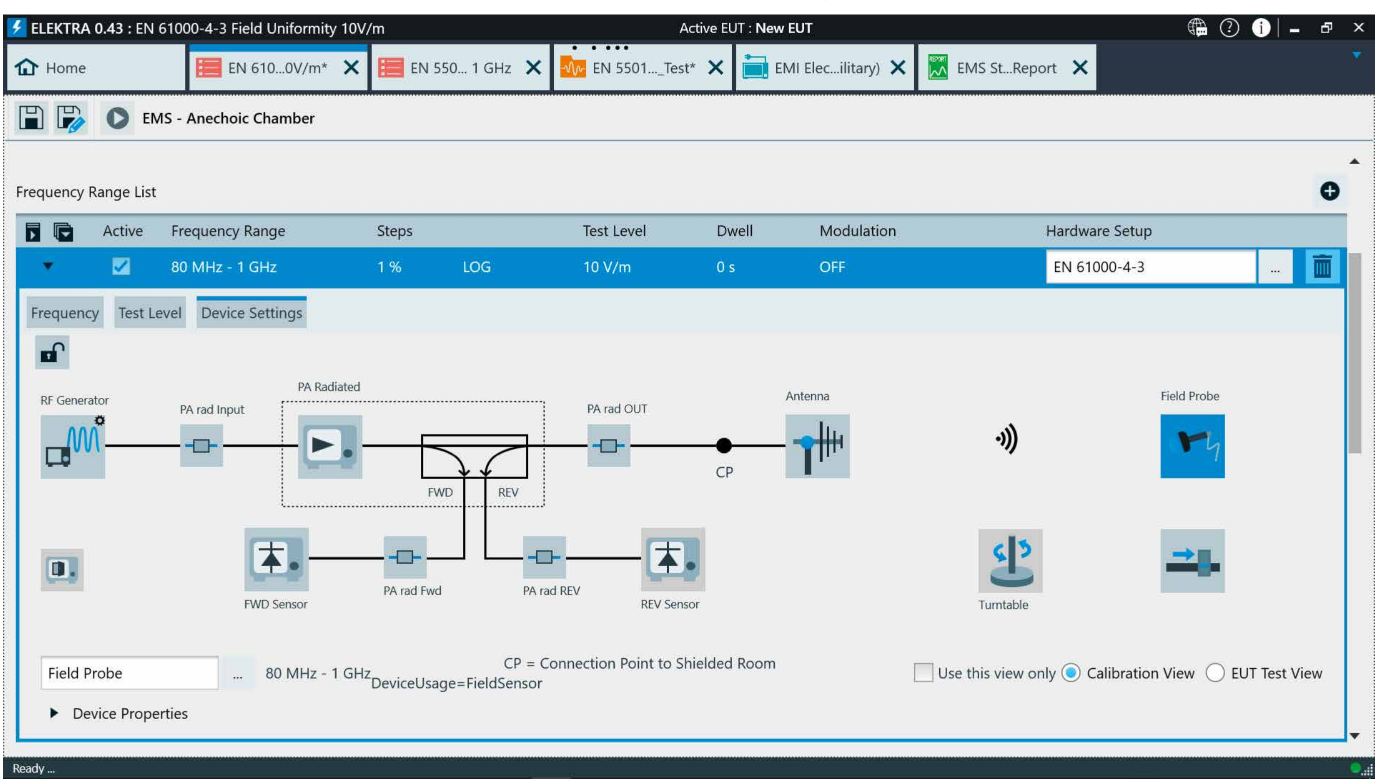


Fig. 4: Graphic presentation with interactive symbols facilitates quick alteration of test configurations at any time.

More reliable than the human eye: fully automated visual inspection

The R&S®AdVISE video based monitoring and analysis system detects malfunctions, automatically and completely, during electromagnetic susceptibility measurements. It eliminates human inattentiveness from the test process, ensures reproducible test results and simplifies documentation.

R&S®AdVISE is the ideal choice wherever EUT characteristics need to be visually monitored. This includes electronic entertainment equipment, displays in vehicles, professional devices and systems in an early stage of development. In the new version 3, the software has been completely redesigned. It contains new features, expansions to the remote control interface and operating improvements.

A typical R&S®AdVISE application is to measure electromagnetic susceptibility (EMS) using the R&S®EMC32 or R&S®ELEKTRA EMC test software (Fig. 1).

An electromagnetically shielded HDTV camera films the EUT in the anechoic chamber during the test cycle. R&S®AdVISE evaluates the video signal in real time based on defined requirements and reports deviations to the measurement software, which generates a test log. R&S®AdVISE records the evaluated video and creates an event list.

During the test, the EMC test software can transfer test parameters such as frequency, disturbance level, modulation and antenna position to R&S®AdVISE, where they are superimposed on the recorded video. This makes it possible to assign events to specific test conditions (Fig. 2).

By clicking entries in the event list of the integrated video player, the user can select and view critical situations, and incorporate clips or stills into the documentation.

If desired, R&S®AdVISE can be integrated into the user's own control program via the remote control interface. Measurements can also be controlled manually, and logs can be generated on the basis of the internal event list.

Anechoic chamber with optical monitoring system

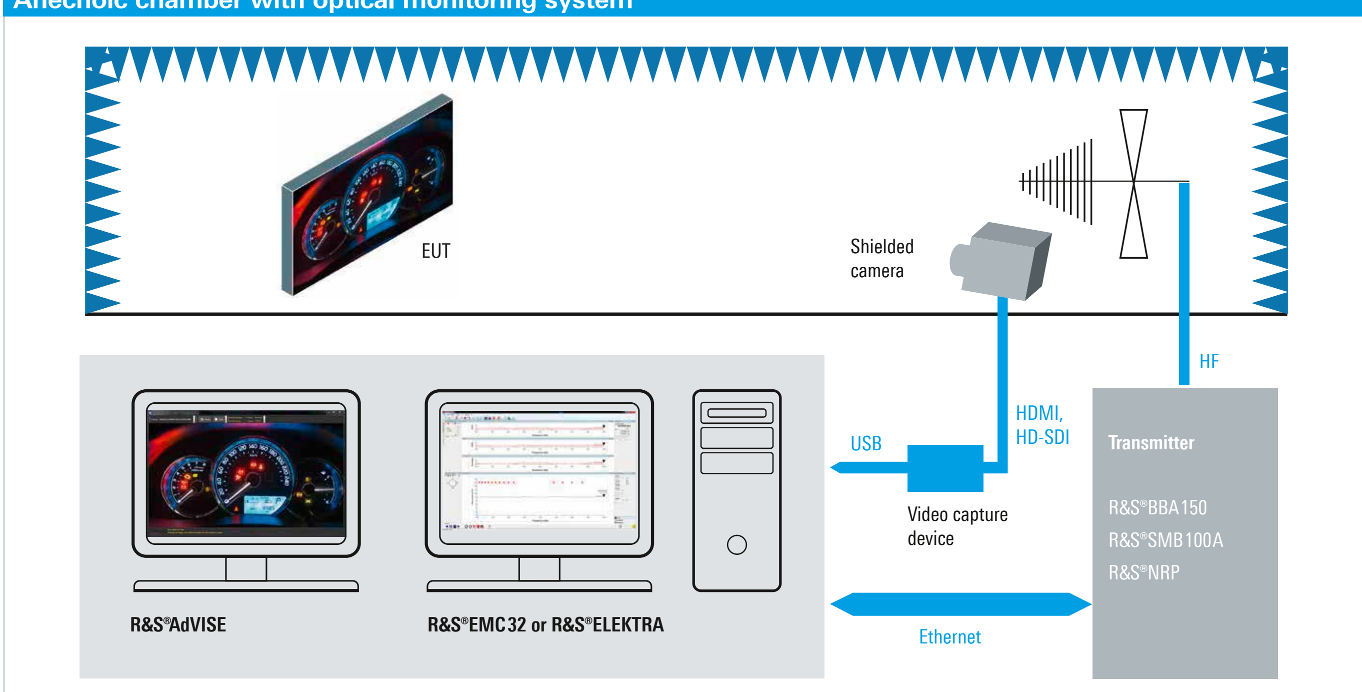


Fig. 1: R&S®AdVISE in an EMS test system controlled by the R&S®EMC32 or R&S®ELEKTRA EMC test software.

Images are analyzed using regions of interest (ROI), which the user marks in the video image and assigns to a suitable analysis method (Fig. 3). Up to 32 ROIs can be monitored simultaneously (R&S®ADV-K1032 option). This leaves enough computing power to run the R&S®EMC32 or R&S®ELEKTRA EMC test software on the same platform.

The analysis engine will consider all typical display elements, such as signal lights, flashing lights, background illumination, moving elements, analog indicators, symbols, numbers, warnings and running lights. They can be individual elements, or displayed on a screen.

In addition to analyzing camera signals, R&S®AdVISE can use the R&S®ADV-K1050 virtual camera option to evaluate existing video recordings.

R&S®AdVISE runs on any PC with Windows™ 7/10 that meets the minimum requirements. No special interface is needed for feeding the video signal. It goes through a standard USB 3 interface with upstream off-the-shelf portable capture device. This makes the system usable with any camera equipped with an HDMI or HD-SDI interface.

Summary: After just a few minutes of configuration work, the current version of the R&S®AdVISE visual monitoring system handles time-consuming tasks automatically and makes sure that not even the smallest undesired events go unnoticed.

Harald Ibl; Doug Jones

Fig. 2: Test view with superimposed information from an EMS test. All display elements are declared as ROIs and are monitored for changes.

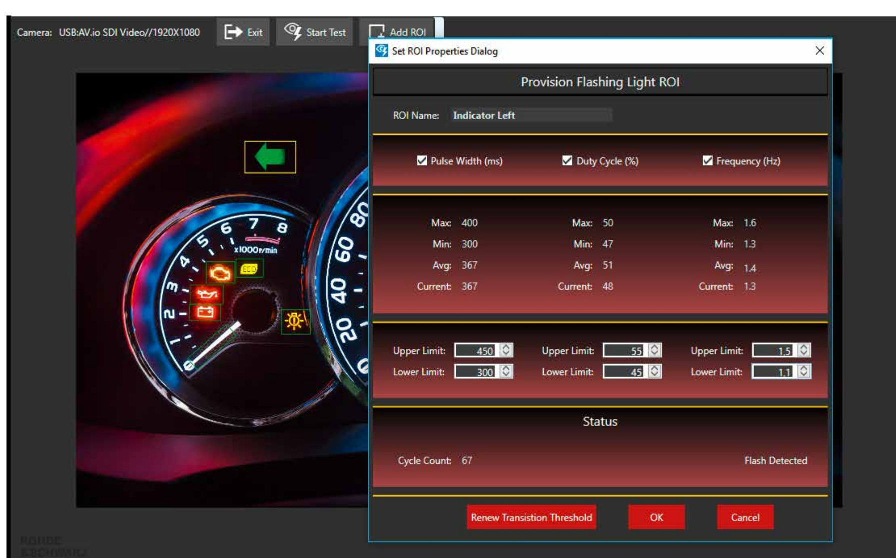


Fig. 3: Monitoring a flashing element with the ROI flashing lights method.

Signal integrity in real time with the new R&S®RTP oscilloscope family

The new R&S®RTP high-performance oscilloscopes offer outstanding measurement accuracy, speed and functional diversity, making them ideal for debugging during development. Their capabilities and performance characteristics are tailored to the requirements of fast digital interfaces, wideband wireless interfaces and sophisticated embedded designs.

Fig. 1: R&S®RTP oscilloscopes set new performance standards in their class with ASICs developed inhouse and real-time hardware signal processing.

Multitalent for everyday lab tasks

The R&S®RTP oscilloscopes – available in three bandwidths from 4 GHz to 8 GHz– are versatile T&M tools for lab use. They are a combination of multiple measuring instruments in a compact format (Figs. 1 and 2).

Their four analog channels address time domain measurements on fast interfaces, clock signals and wideband transmitters. The input signals can also be analyzed in the frequency domain. Operation is similar to a spectrum analyzer, with the typical configuration parameters of start frequency, stop frequency and resolution bandwidth. Searching for intermittent EMI is simplified by the high acquisition rate and functions such as logarithmic axis scaling and the waterfall diagram (spectrogram). Detailed signal analysis can be performed with the R&S®VSE vector signal explorer software option.

The up to 16 digital channels with 400 MHz bandwidth are ideal for analyzing relatively slow protocol based control and programming interfaces such as I²C, SPI and CAN.

A generator option with two arbitrary 100 MHz analog outputs and eight digital function generator channels is also available. If the oscilloscope is equipped with the R&S®RT-ZVC option, up to 16 additional 1 MHz channels with a vertical resolution of 18 bit are available for high-precision voltage and current measurements.

Key features

- Bandwidth (4 analog channels)
  - R&S®RTP084: 8 GHz
  - R&S®RTP064: 6 GHz
  - R&S®RTP044: 4 GHz
- Sampling rate: 20 Gsample/s per channel
- Acquisition memory:
  - 50 Msample per channel
  - 2 Gsample max.
- Mixed signal oscilloscopes (MSO) with16 digital channels
  - 400 MHz bandwidth
  - 5 Gsample/s sampling rate
  - 200 Msample memory depth

As a special feature, a differential pulse source for pulses with a rise time of 22 ps and a bandwith of 16 GHz can be installed and used as a stimulus source for DUTs or for transmission and reflection tests (TDT/TDR) on signal lines.

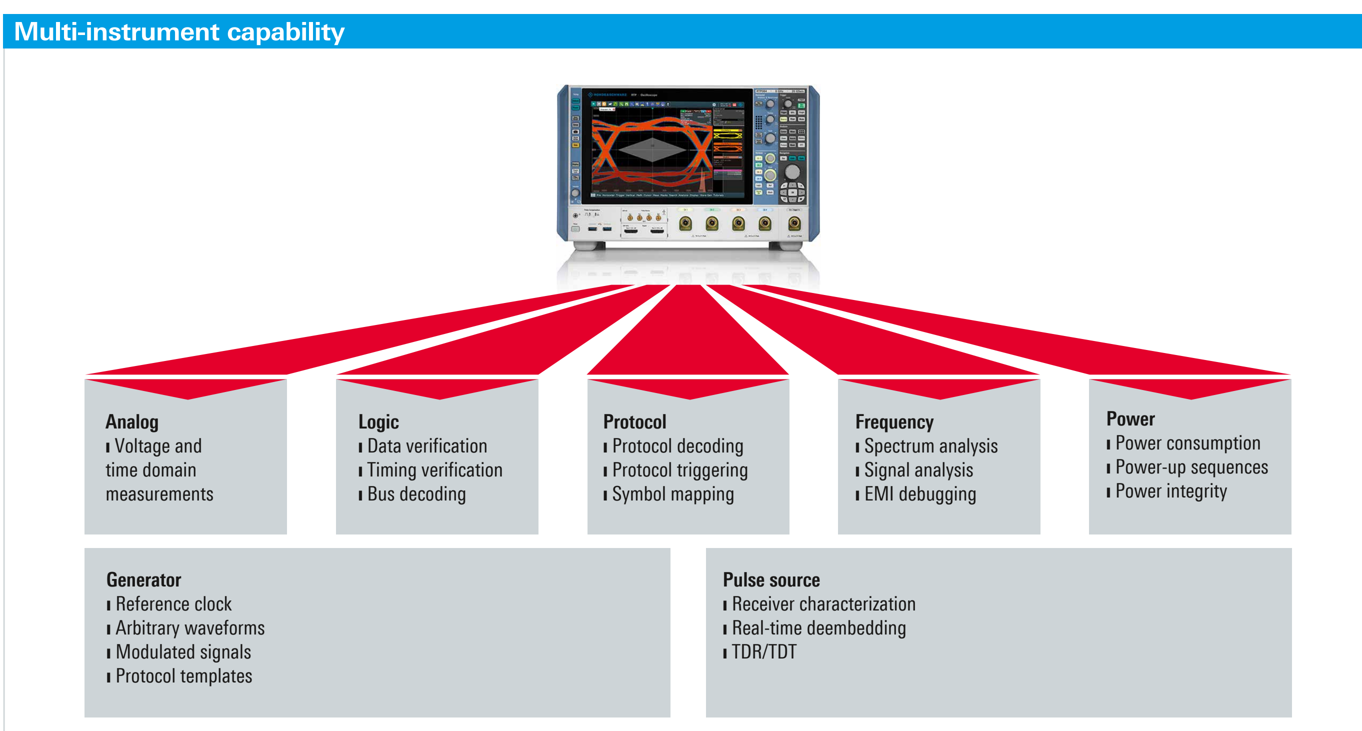


Fig. 2: R&S®RTP oscilloscopes are a combination of multiple measuring instruments in a compact format that save space on the lab bench.

Signal integrity in real time

The high measurement accuracy of the R&S®RTP is due in part to the analog input components developed inhouse. The input amplifiers, samplers and A/D converters are specifically designed for high sensitivity and large dynamic range. Special filters directly after the A/D converter optimize measurement accuracy in real time. This special feature offers, for example, the advantage of minimum vertical scaling down to 1 mV/div at full bandwidth for small-signal measurements. It is also the reason for the extremely flat frequency response of ±0.25 dB with a spurious-free dynamic range (SFDR) of less than 45 dBc for accurate measurement of wideband signals in the time and frequency domains.

The unique correction in real time is the basis for the high acquisition rate, the ultra precise trigger functions and the innovative real-time correction for signal path elements such as cables, connectors and PCB structures (deembedding).

High acquisition rate for debugging

The R&S®RTP is ideal for debugging because it uses a special ASIC for signal acquisition and processing that processes the waveforms in parallel faster than is possible with PC resources. This significantly reduces the blind time compared to conventional oscilloscopes – and rare or sporadic errors are detected faster and more reliably (Fig. 6).

The maximum acquisition rate of the R&S®RTP is nearly one million traces per second. This does not require a special measurement mode with functional restrictions and should not be confused with segmented mode, where the acquisition memory can only be filled one time by a limited number of waveforms with a short blind time. The high acquisition

Truly practical deembedding

Deembedding for correction of transmission losses is common practice with wideband oscilloscopes. The acquired waveforms are postprocessed with correction filters to compensate for errors such as reflections at junctions or losses due to inductive or capacitive loads. But postprocessing calculations usually take a long time, which makes the oscilloscope slow to respond and discourages users from using the deembedding function.

Rohde & Schwarz takes a new approach to deembedding in the R&S®RTP (see the application card “Real-time deembedding with the R&S®RTP”). The filter structures for real-time deembedding directly after the A/D converter are flexibly configurable, allowing the transmission characteristics to be adapted to individual test setups. Operation is straightforward. The user first specifies the individual elements of the transmission path in the configuration dialog. Components such as cables, adapters and test fixtures can be selected in this dialog (Fig. 3).

The next step is to load the S-parameters that describe the transmission losses and impedance matching (Fig. 4). In the final step, the deembedding software collects the transmission characteristics of the entire signal chain and computes a corresponding correction filter, which is loaded in the hardware.

Subsequent measurements benefit from real-time deembedding. The waveforms are displayed without transmission losses exactly as they occur on the DUT and without any delays due to time-consuming postprocessing calculations (Fig. 5).

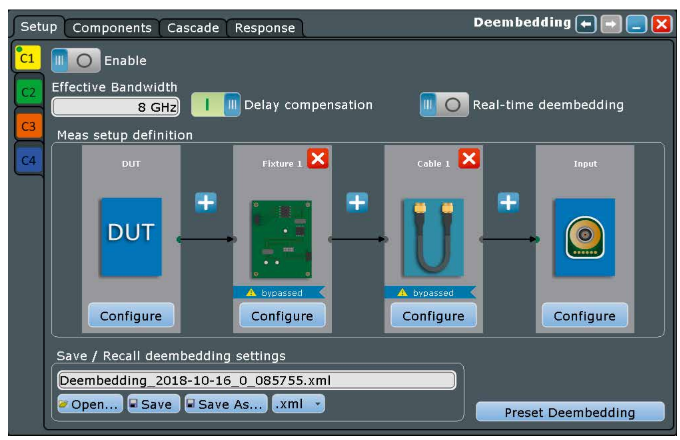
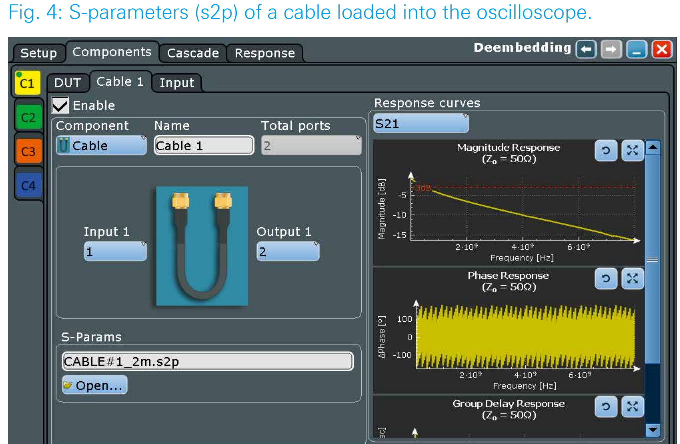


Fig. 3: Signal path configuration with transmission components between the DUT and the oscilloscope input.

Fig. 4: S-parameters (s2p) of a cable loaded into the oscilloscope.



The deembedding architecture of the R&S®RTP with real-time deembedding

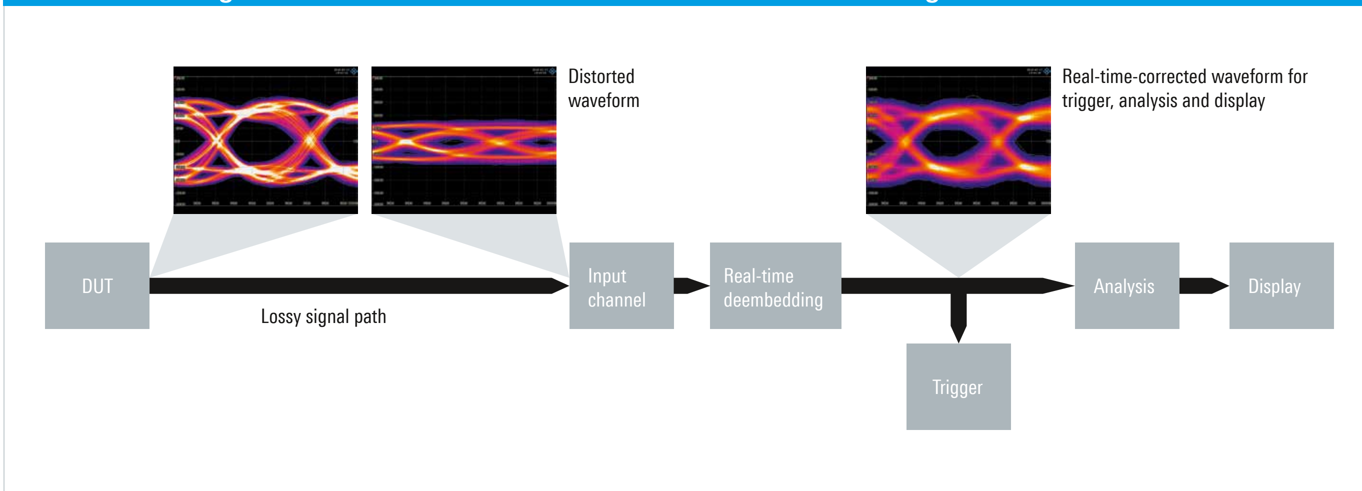


Fig. 5: The deembedding function displays the waveforms without transmission losses and without delays due to time-consuming postprocessing calculations.

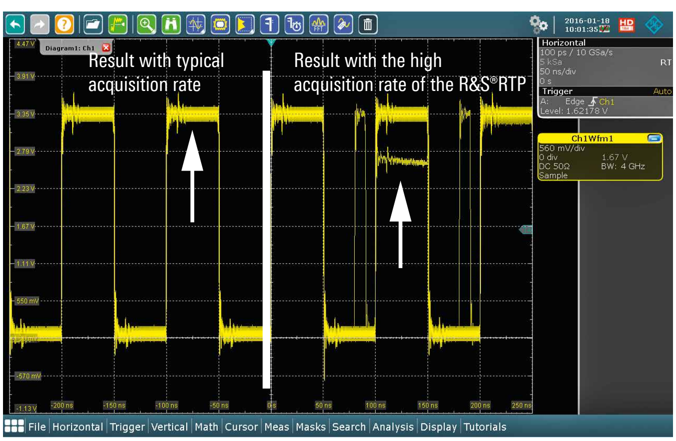
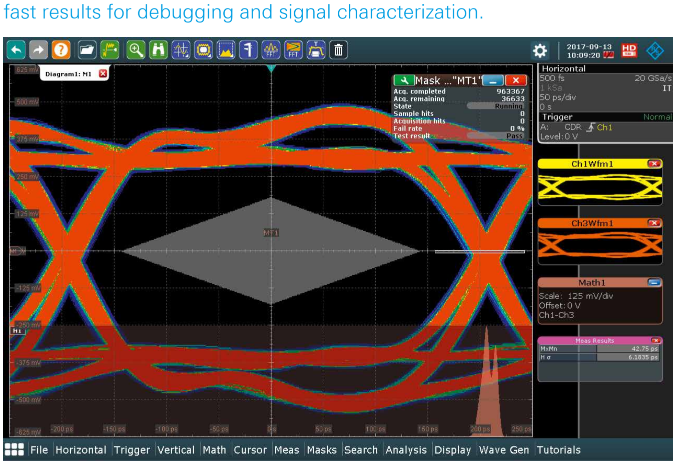


Fig. 6: With its acquisition rate of up to 1 million traces per second, the R&S®RTP quickly detects even intermittent faults.

Fig. 7: The high acquisition rate for mask tests and histograms delivers fast results for debugging and signal characterization.



rate of the R&S®RTP is also available for analysis tools such as zoom or cursor as well as for mask tests and histograms. This makes it easy to track down errors and analyze the static characteristics of a signal (Fig. 7).

Precise triggering

For debugging and targeted signal analysis, it is generally desirable to focus on specific signal properties. This can be achieved with custom trigger conditions. This is difficult with conventional oscilloscopes due to the limited sensitivity of their trigger system and their limited bandwidth for complex trigger forms. The only option with such oscilloscopes is to acquire a long trace with the edge trigger and then search through it.

The R&S®RTP has the same familiar digital trigger system as other Rohde & Schwarz oscilloscopes. This system uses the samples from the A/D converter and always works with the current waveform. It can react to all trigger events up to the full device bandwidth and with a time resolution of 125 fs (Fig. 8). For example, the R&S®RTP084 8 GHz model reliably triggers on pulse widths down to 50 ps. In combination with a hysteresis that is continuously adjustable from 0 div to 5 div, it is possible to trigger on extremely small signal amplitudes with minimal hysteresis. A larger hysteresis can be used for stable triggering on noisy signals.

Since the trigger system taps the signals after the real-time deembedding filters, it is possible for the first time to trigger on signals that have been corrected using deembedding. In 16 bit high-definition acquisition mode, the trigger system can also use the increased vertical resolution.

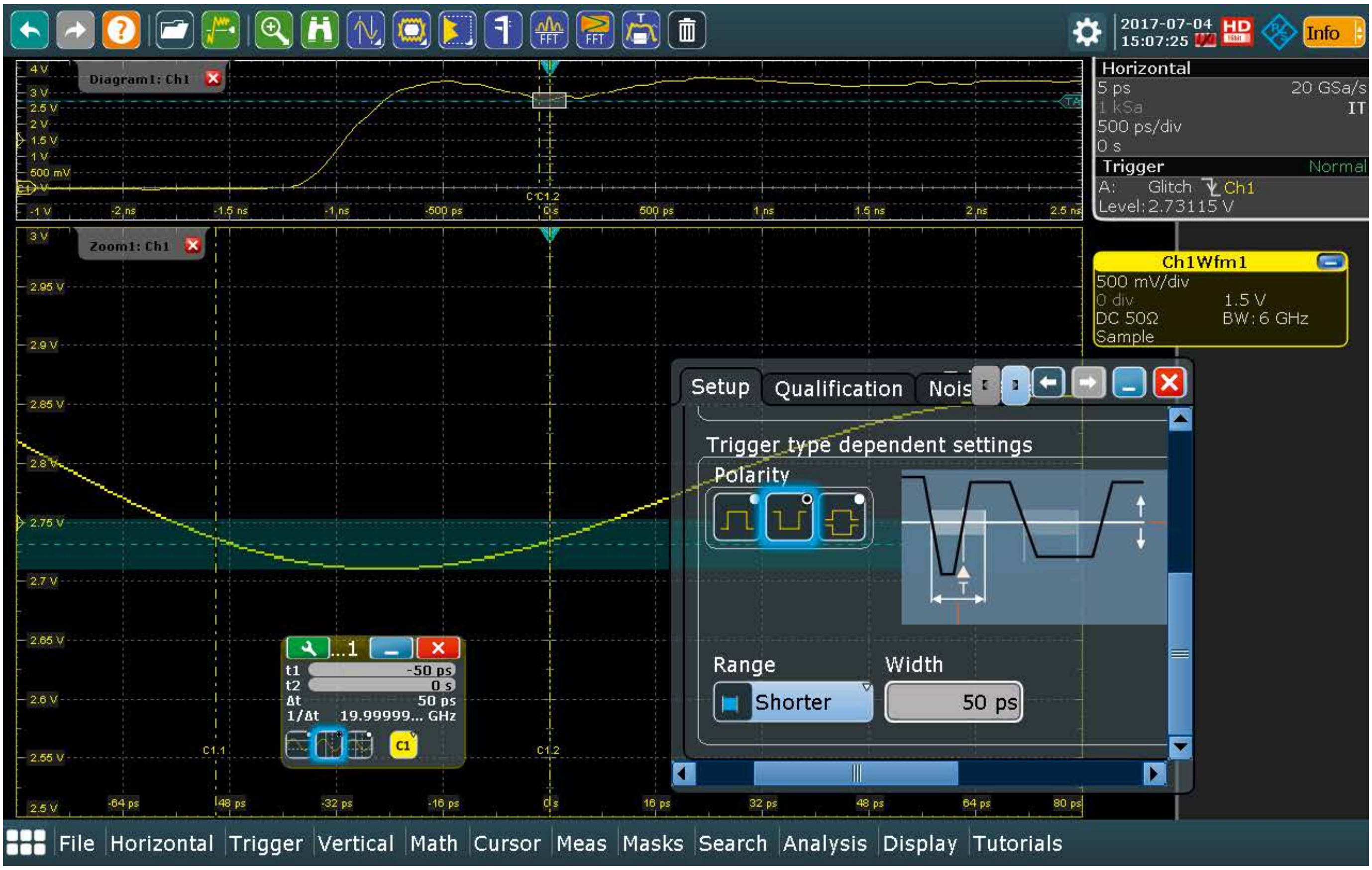


Fig. 8: The digital trigger system of the R&S®RTP allows all trigger types to be used up to the full instrument bandwidth – for example, a pulse trigger with a minimum width of 50 ps.

These outstanding features of the trigger system open up numerous options for targeted signal analysis. It is possible to precisely trigger on wireless signals as well as on fast digital signals.

Analysis in the frequency domain

The four R&S®RTP analog input channels can easily be used for signal analysis in the frequency domain. Users benefit from the measurement accuracy provided by the outstanding properties of the frontend. The FFT calculations are performed so fast that even intermittent signal components can be captured in the spectrum.

Configuration of the spectrum analysis function is simple. After the user enters the frequency span and desired resolution bandwidth, the oscilloscope software automatically scales the acquisition interval (Fig. 9). Standard tools such as cursors and automatic frequency domain measurements are available for signal evaluation. The optional spectrogram function, peak list function and logarithmic axis scaling extend the analysis options (Fig. 10).

EMI debugging with mask tests and zone triggers

Analyzing electronic circuits for electromagnetic interference is an important part of the development task. An oscilloscope such as the R&S®RTP is useful for debugging mutual interference between components and testing isolation or decoupling measures. The R&S®RTP is also helpful for preparing for EMC approval tests. It can be used for precompliance testing in the development lab, increasing the level of confidence for EMC testing in the dedicated EMC lab.

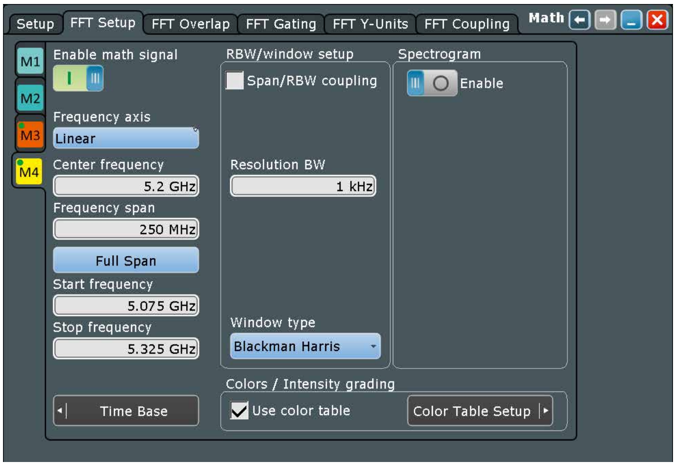


Fig. 9: FFT input dialog with typical spectrum analyzer parameters.

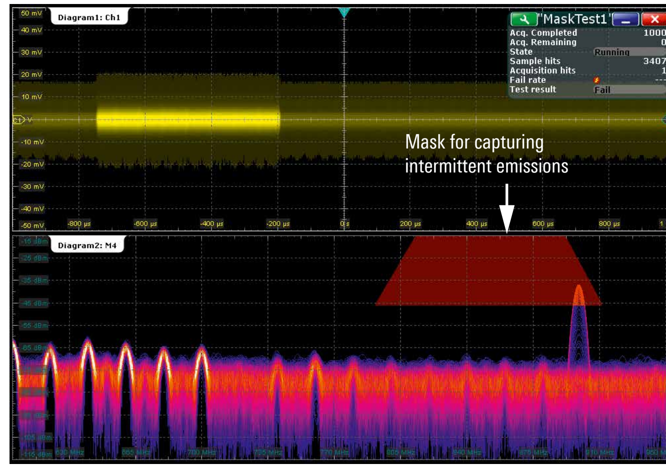


Fig. 11: Mask test in the spectrum for EMI debugging and EMC precompliance testing.

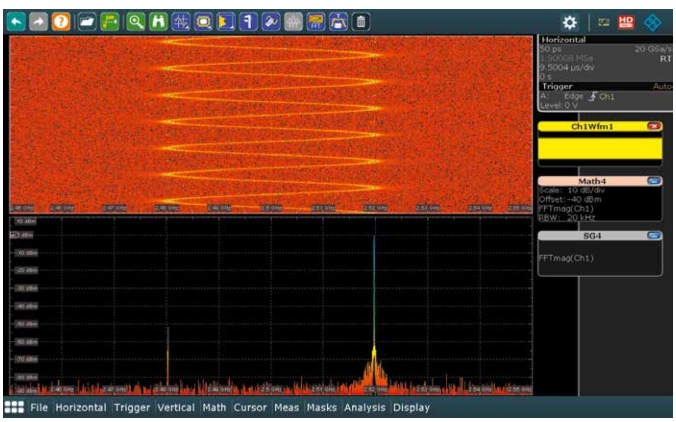


Fig. 10: Analysis of a frequency modulated signal with the spectrogram option.

Fig. 12: The history function allows you to access all waveforms in the acquisition memory for subsequent analysis.

The mask test is an important function for these tasks. It can be used to define areas on the screen where the spectrum must not be violated (Fig. 11). Even intermittent faults can be found quickly, since the R&S®RTP oscilloscopes acquire and process signals very quickly. The zone trigger is another powerful function for EMI debugging. It also uses areas (zones) defined on the screen. Depending on the configuration, a waveform is only displayed if the zone is violated or not violated.

If multiple waveforms are recorded, they can be displayed later with the history function for subsequent analysis (Fig. 12). Analyses over very long time periods are possible since the R&S®RTP can optionally have up to 2 Gsample memory depth per channel.

Multichannel wideband RF signal analysis

Thanks to its outstanding measurement accuracy and input sensitivity, the R&S®RTP is ideal for synchronous multichannel measurements on RF signals up to 8 GHz. This applies to wireless signals such as WLAN IEEE 802.11ac and the upcoming 5G New Radio as well as to radar signals for automotive, aviation and military applications (Fig. 13).

The oscilloscope can be combined with the R&S®FSW signal and spectrum analyzer for measurements at higher carrier frequencies up to 85 GHz. An effective analysis bandwidth of up to 5 GHz can be achieved.

The optional R&S®VSE vector signal explorer software can be used to analyze digitally modulated RF signals. The base option includes generic I/Q analysis functions and supports

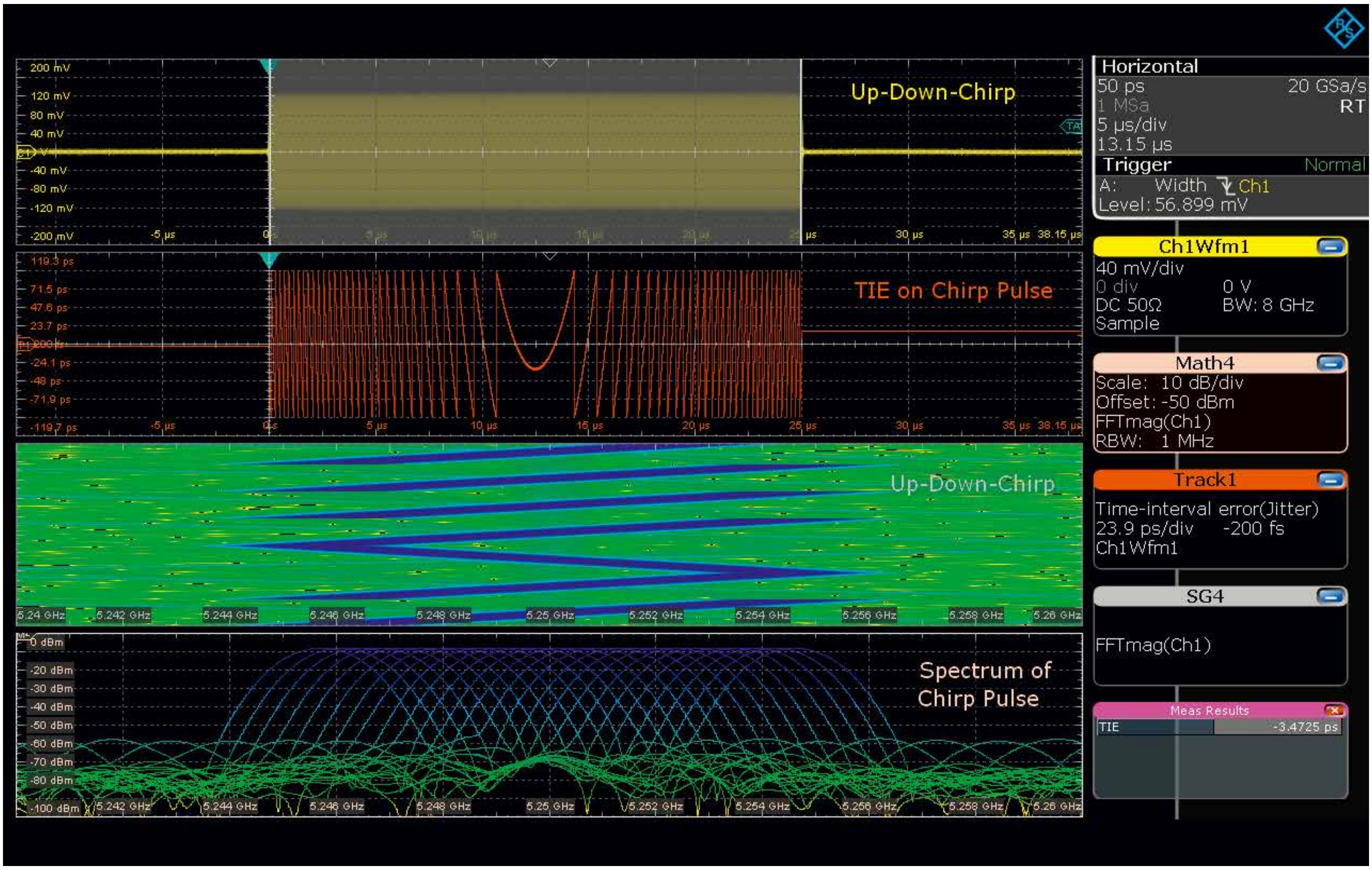


Fig. 13: Pulse analysis of up/down chirps in the time and frequency domains.

analog demodulation. The Windows based software can be used on the oscilloscope and on a separate PC.

The base software can be modularly expanded:

- R&S®VSE base software: I/Q analyzer
- R&S®VSE-K6: pulse analysis
- R&S®VSE-K7: AM/FM/PM modulation analysis
- R&S®VSE-K60: transient analysis
- R&S®VSE-K70: vector signal analysis
- R&S®VSE-K96: OFDM analysis

Users of proprietary modulation protocols can connect the R&S®RTP to external analysis tools such as MATLAB® for maximum flexibility.

Enough space on the lab bench

Considering its capabilities and performance, the R&S®RTP has a very compact footprint and is very quiet. That makes it ideal for use in the lab. To keep pace with changing user requirements, it comes with two option slots on the front panel and two option slots on the rear panel. These slots can be used for a 16-channel, 400 MHz mixed signal option, a universal generator option with two arbitrary 100 MHz channels and eight digital channels, or the previously mentioned differential pulse source.

Software options are available for many applications. The portfolio includes trigger and decode options for slow and fast protocols (I²C, UART, CAN-FD, Ethernet, USB 3.1, etc.), compliance tests (PCI Express, DDR3, etc.), general analysis options (jitter, deembedding, etc.) and RF signal analysis options (Figs. 14 and 15).

Memory depth and bandwidth can also be easily upgraded with software licenses. The standard memory can be expanded from 50 Msample per channel to 2 Gsample maximum. In the currently available bandwidth range, the R&S®RTP models can be expanded from 4 GHz to 6 GHz or 8 GHz. Additional models with higher bandwidths in the same instrument format are planned for 2019.

Summary

The high-performance R&S®RTP family extends the Rohde & Schwarz oscilloscope portfolio. These high-bandwidth models address the increasing requirements for fast bus interfaces and wideband wireless signals in embedded applications in a wide range of customer segments. The compact oscilloscopes combine accuracy, speed, functional diversity and future-readiness, making them ideal for everyday measurements in the lab.

Guido Schulze

R&S®RTP compliance test options	
Interface standard	**Option**
USB	
1.0 / 1.1 / 2.0 / HSIC	R&S®RTP-K21
Ethernet	
10 / 100 Mbit	R&S®RTP-K22
1 Gbit	R&S®RTP-K22
2.5G / 5GBASE-T	R&S®RTP-K25
10 Gbit	R&S®RTP-K23
10M / 100M / 1GBASE-T Energy Efficient Ethernet	R&S®RTP-K86
Automotive Ethernet	
100BASE-T1 BroadR-Reach®	R&S®RTP-K24
1000BASE-T1	R&S®RTP-K87
PCI Express	
1.1 / 2.0 (up to 2.5 GT/s)	R&S®RTP-K81
MIPI	
D-PHY	R&S®RTP-K26
Memory	
DDR3 / DDR3L / LPDDR3	R&S®RTP-K91

Fig. 14: The R&S®RTP compliance test options cover numerous interfaces.

Fig. 15: Automatic PCI Express compliance test: An additional monitor that can be operated in split screen mode is often helpful for everyday tasks.

Troubleshooting DDR3 memory interfaces

When designing circuits with DDR3 SDRAM modules, developers need solutions for checking the signal integrity on high-speed data lines. The new R&S®RTO-K91/ R&S®RTP-K91 oscilloscope option offers several valuable tools: decoding of read and write cycles, display and analysis of eye patterns, and automated compliance testing for the DDR3, DDR3L and LPDDR3 standards.

The signal integrity challenge when using DDR3 SDRAM

The DDR3 standard was published in 2007 by the JEDEC consortium. DDR4 memory has been on the market for several years, and the DDR5 standard is being worked on intensively. Nevertheless, DDR3 memory is still attractive for many applications because it costs less, is very reliable and compact, and offers high data volume as well as adequate data rates. For optimized power consumption, e.g. for mobile battery-powered applications, versions conforming to the DDR3L and LPDDR3 standards are also available.

The DDR3 standard specifies memory components with data rates from 800 Mbit/s to 2133 Mbit/s. These fast data rates are often new for industrial, medical and automotive applications, and the design and test requirements of the highly integrated electronic modules are demanding.

First of all, the memory components need a stable supply voltage that complies with the specified tolerances and does not pick up interfering signals from other functional units. Attention must also be given to the correct design of the memory interface signal lines, which have to support the high data rates. This includes, for example, an adequately dimensioned bandwidth over the entire transmission path (including the transitions at vias, connectors or relays), matching the line lengths of data and clock signals, and protecting lines with high data rates against crosstalk from other interfaces or functional units.

Finally, comprehensive test capabilities for evaluating the signal integrity and troubleshooting the DDR3 memory interface are indispensable when designing circuits.

Oscilloscopes are the first choice for measurements in this area because they offer many options for signal integrity testing, such as dynamic voltage and timing tests in line with JEDEC specifications (compliance tests) as well as the eye diagram test as an important analysis tool.

Eye diagram test

DDR3 interfaces use a parallel bus structure in which each set of eight single-ended data lines (DQ 0 to DQ 7) is clocked by a differential strobe signal (DQS) (Fig. 1). In the eye diagram of the individual DQ signals, the transmitted bits correspond to the rising and falling edges of the DQS clock signal.

The quality of many transmission parameters can be read from the eye diagram. For example, the eye opening time and jitter at the eye edges (bit transitions) can be seen on the horizontal axis, and the vertical eye opening and noise can be seen on the vertical axis.

The R&S®RTO and R&S®RTP (see page 42) oscilloscopes offer many analysis options for eye diagrams, including automatic eye diagram measurements, horizontal and vertical histograms for jitter and noise analysis, and masks for long-term stability tests (Fig. 2). They acquire waveforms much faster than other oscilloscopes on the market, capturing several million bits within seconds and displaying them as an eye diagram.

To create eye diagrams from the bits of a long acquisition period, the R&S®RTO-K91/R&S®RTP-K91 DDR3 signal integrity debugging and compliance test software option provides the DDR eye diagram function (Fig. 3). This

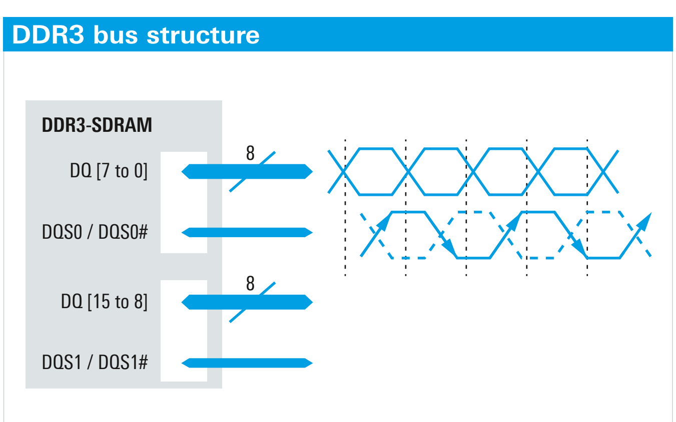


Fig. 1: Parallel bus structure of DDR3 SDRAM with eight single-ended data lines and a differential strobe signal (cyclic clock) for each link.

Fig. 2: Eye diagram of DDR3 write cycles with mask test and histogram.

software uses the edges of the DQS signal to break down the DQ signal into bits for the eye diagram display and offers numerous options for specific analyses, such as gate qualifiers and bit sequence filters.

In combination with the read/write decoding function, which is also part of the R&S®RTO-K91/R&S®RTP-K91 option and is described in more detail below, eye diagrams for read and/or write cycles can be displayed.

Targeted triggering on read and write cycles

The DDR3 data interface uses bidirectional lines for single-ended DQ data signals and differential DQS signals. To distinguish between read and write cycles, the edges of the DQ signal are transmitted with a different phase than the edges of the DQS signal. In the read cycle (when the memory sends data to the processor), the edges occur at the same time. In the write cycle (when the processor sends data to the memory), the DQ data edges are offset by half a bit width (Fig. 4).

This clock offset, which is important for memory functionality, makes it difficult to display simple eye diagrams and measure time parameters such as setup&hold time. It is therefore necessary to observe read and write cycles separately in signal integrity analysis (see the application card "Triggering read and write cycles of DDR3 memories"). This is accomplished through targeted triggering on the start of the read and write cycles. The R&S®RTO and R&S®RTP offer many options for precise triggering. Their unique digital trigger system supports complex A-B-R trigger sequences (trigger events A, B and reset), and thanks to their digital architecture, they respond reliably to small signal changes and pulse widths < 50 ps.

The different preambles for the read and write cycles (Fig. 5) are a signal property of DDR3 memory interfaces that can be used for triggering.

Figs. 6 and 7 show example trigger configurations for read and write cycles, respectively. For triggering on the negative read preamble, which is somewhat longer than one bit width, a correspondingly configured pulse trigger can be used. In the example in Fig. 6, a negative pulse trigger > 1 ns was chosen for a DDR3 component with a data rate of 1333 Mbit/s (about 750 ps bit width).

For triggering on write cycles (Fig. 7), an A-B-R trigger sequence was defined that looks for write preambles (slightly larger than one bit width). In this example, the A trigger is set as a pulse width trigger with negative polarity and a width > 2 ns to find the start of write cycles. The B trigger is set to the positive pulse width of the write preamble (> 750 ps). If no valid B trigger event is found after an A trigger event, the R trigger (set to 2 ns) resets the trigger system to search for A.

The R&S®RTO-K91/R&S®RTP-K91 zone trigger option offers another method for targeted triggering of read or write cycles. It allows the user to define zones that must be either passed through or avoided for valid triggering. Fig. 8 shows an example for triggering on read cycles. The first zone in the DQS signal responds to the read preamble. The other two zones in the DQS and DQ signals target edges that occur at the same time.

Decoding of read and write cycles

The R&S®RTO-K91/R&S®RTP-K91 option's decoding function provides another way to detect read and write cycles. This function is selected from the protocol menu. It marks the read and write cycles within an acquisition of DQS and DQ signals based on the phase shift of the signal edges. Fig. 9 shows the setup dialog. The user simply selects the channel assigned to the DQ and DQS signals and then uses the Auto function to set the thresholds and hysteresis values.

As described in the eye diagram section, the DDR eye diagram function (Fig. 10) can use this decoding function. Another powerful tool is the eye stripe that marks mask violations in the time domain in red on the time axis and allows the user to use zoom coupling to conveniently navigate between mask violations.

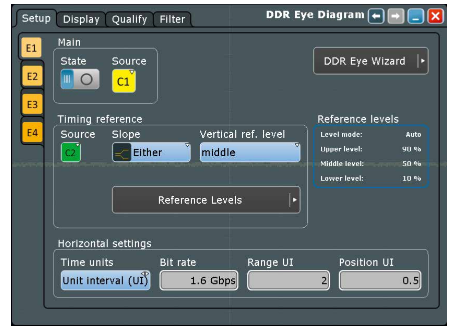


Fig. 3: Setup dialog for the DDR eye diagram function.

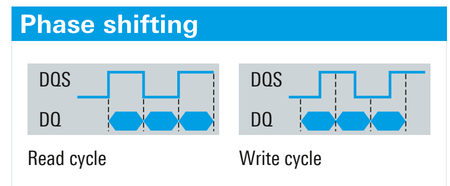


Fig. 4: Synchronization of DQ and DQS signals for read and write signals.

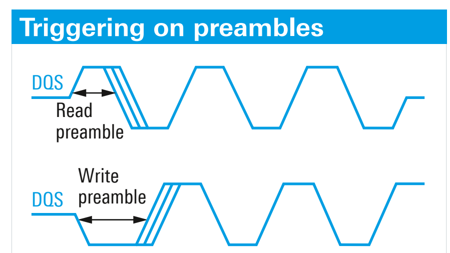


Fig. 5: Preamble of the DQS signal for DDR3 read and write cycles.

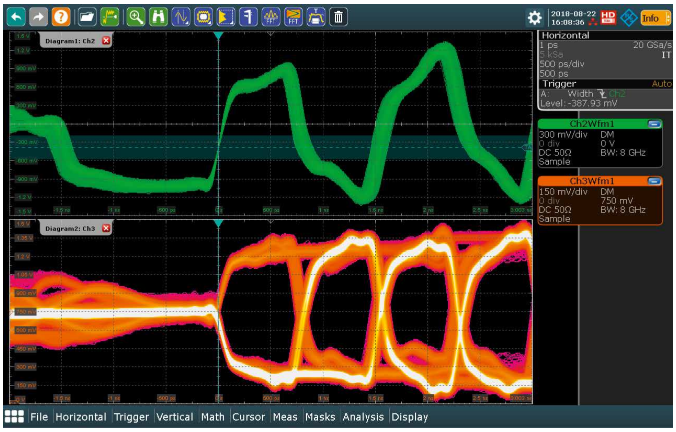


Fig. 6: Triggering on the read preamble with a negative pulse trigger.

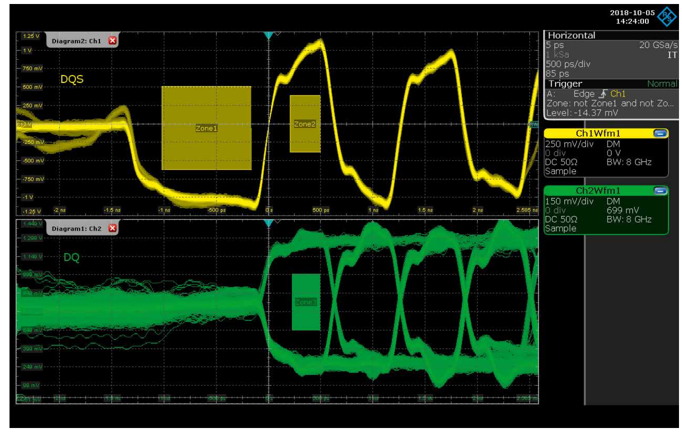


Fig. 8: Triggering on read cycles with a combination of zones.

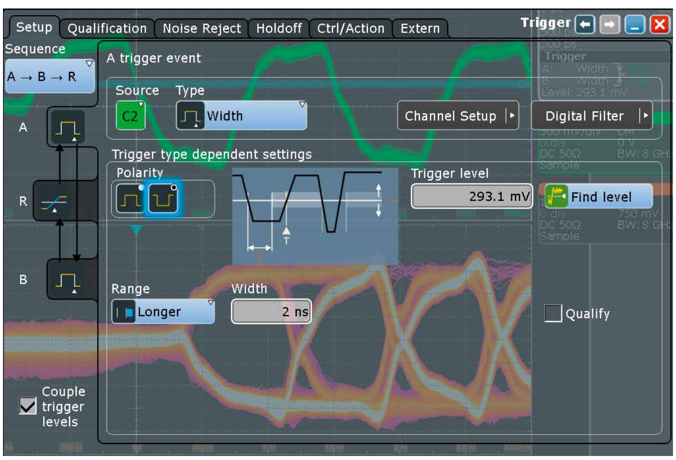


Fig. 7: Triggering on the write preamble with a composite trigger condition (A-B-R pulse trigger).

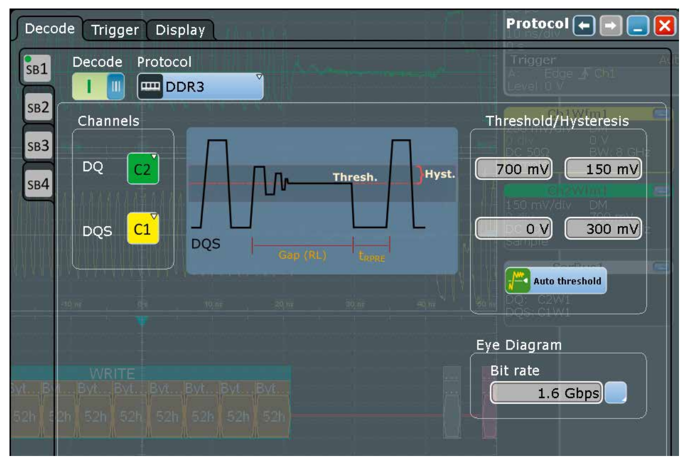
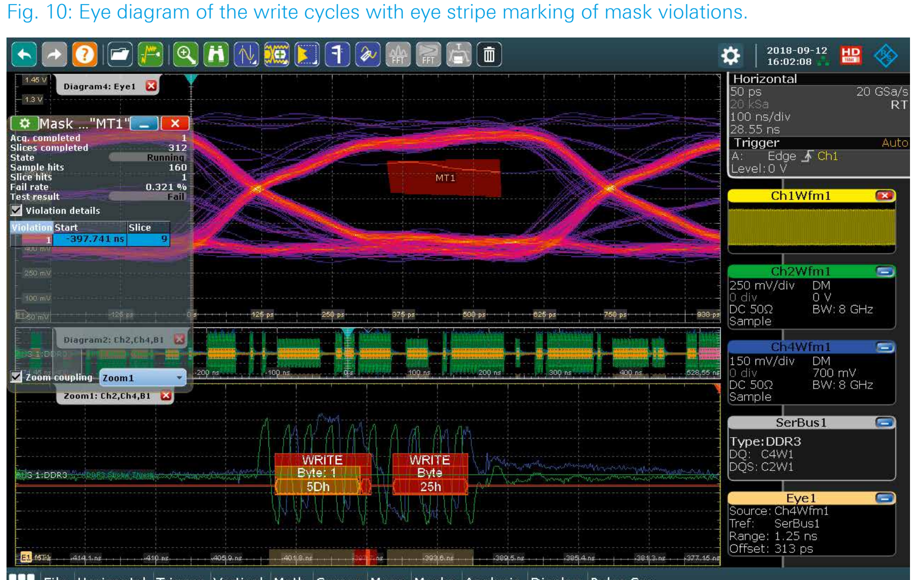


Fig. 9: Configuration of read/write decoding with the R&S®RTO/R&S®RTP-K91option.

Fig. 10: Eye diagram of the write cycles with eye stripe marking of mask violations.



Compliance tests for DDR3 standards

Compliance tests compare measured values with the specifications described in the standard. Powerful basic measurement functions such as setup&hold are helpful, but true convenience and efficiency can only be achieved with an automated solution. An automated solution provides detailed instructions for signal contacting, automatically configures the oscilloscope, acquires and measures the necessary waveforms, and issues a report with a summary

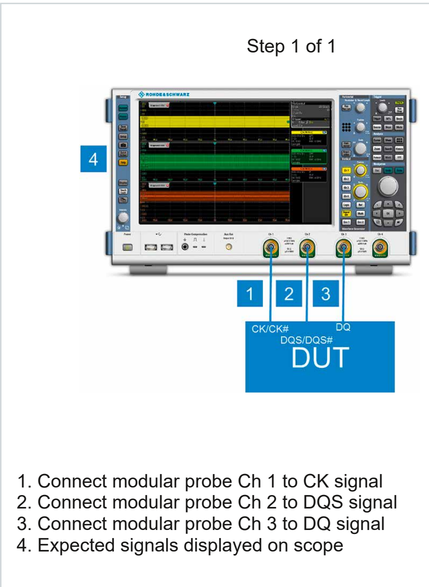


Fig. 11: Example of step-by-step instructions for the compliance test in the data timing test.

Fig. 12: The detailed results of each test can be viewed by expanding the rows.

of the results. The benefits increase when more measurements are required on different data lines and for different data cycles. R&S®ScopeSuite automatically solves the problem of separating the read and write cycles, and provides support for derating setup&hold measurements.

The R&S®RTO/R&S®RTP-K91 option does all of this. It checks DUTs for compliance with the DDR3 (JESD79-3), DDR3L (JESD79-3-1 and JESD79-3-1A.01) and LPDDR3 (JESD209-3C) standards. Using images and text, it conveniently guides the user through the measurements and indicates which channels of the oscilloscope should be connected and which measurement signals should be visible (Fig. 11).

The results are presented in a way that gives the user a quick overview and also allows quick access to the details without having to generate a report (Fig. 12).

Derating

The derating function determines a positive or negative adjustment of the measurement limit value based on the actual slew rate of the DQ and DQS signals. The slew rate is measured on the rising and falling edges of the DQS and DQ signals for each setup&hold measurement. The derating value is then determined by interpolating between the reference values defined in the JEDEC standard.

Fig. 13 shows an example of the results of the setup time (tDS) measurement. The slew rates of the DQS and DQ signals are shown together with the actual measured values. The resulting derating in this example is 50.226 ps, which is taken into account in the tDS limit.

The R&S®RTO/R&S®RTP-K91 option automatically and efficiently performs measurements with derating. First it separates the cycles in the DDR3 signal into read and write cycles. Then it activates the relevant measurements over the defined signal time, graphically presents the results for the worst measured value, and summarizes them in a report (Fig. 14).

Timing tests

The JEDEC DDR3 standard divides the interface tests into timing tests and electrical tests. The timing tests contain specifications that describe the time behavior of the individual signals. For example, the strobe timing defines the time response of the strobe signal to the clock and data signals. And the tRPRE timing measurement ensures that the read preamble is longer than 90 % of a clock cycle. The start time of the preamble is approximated by linear interpolation of the falling strobe signal crossing zero. The end point is determined by the next time a rising edge of the strobe signal crosses zero. Fig. 15 shows the measurement details in a zoomed-in view of the read cycle.

Additional Information

Measurement	Value	Limits
Bursts processed	1559	
tDS(derate) min	218.712 ps	x >= 80.226 ps
DQS Slew Rate	4.090V/ns	
DQ Slew Rate	1.505V/ns	
Derating	50.226 ps	

Fig. 13: Results of setup time (tDS) measurement with derating. The calculated derating in this example is 50.226 ps.

Similar tests are required for other signals. Many of the measurements are similar, but not identical. The R&S®RTO/R&S®RTP-K91 option's compliance tests cover all of the specified timing tests (Fig. 17).

Electrical tests

The electrical tests, as the name suggests, check the electrical properties of the signals. In the case of differential signals, the properties of the individual lines referenced to ground (V+, V–) are checked separately. Fig. 16 shows an overview. Unlike the timing tests, only one signal is observed for these measurements. However, in some cases additional DQ and DQS signals are necessary to determine the read and write cycles

Fig. 18 shows a simple example of a DQS signal from the report for the VIHdiff(AC) parameter. It shows the high logic voltage of the differential DQS signal, which is determined using a histogram.

Contacting the test points

The JEDEC DDR3 specification refers to signals directly on the DRAM component, which is why the test points should be contacted as close as possible to the memory component during troubleshooting and signal integrity tests.

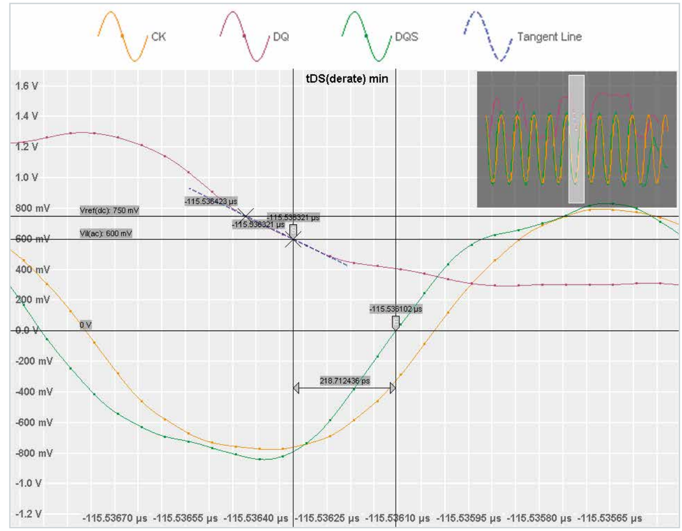


Fig. 14: Report for setup time measurement with derating.

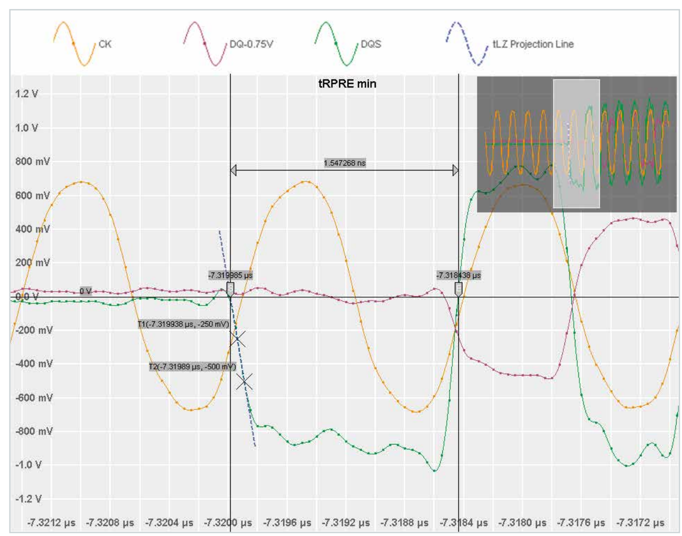


Fig. 15: Determining the intercept point for timing measurements (here a tRPRE measurement). The DQ signal (violet) is only needed to separate the read and write cycles.

- Electrical Tests
  - Single-Ended Measurements
    - Input Slew Rate for ADD and CMD (8.5, 13.5)
    - Input Slew Rate for DQ and DM (8.5, 13.6)
    - AC & DC Input Levels for ADD and CMD (8.1.1)
    - AC & DC Input Levels for DQ and DM (8.1.2)
    - AC Input Levels for CK and DQS (8.3.3)
    - Output Slew Rate for DQ (9.3)
    - AC & DC Output Levels for DQ (9.1)
    - AC Overshoot & Undershoot for ADD and CMD (9.6.1)
    - AC Overshoot & Undershoot for CK, DQ, DQS and DM (9.6.2)
  - Differential Measurements
    - AC Input Levels for CK and DQS (8.3)
    - AC Differential Cross Point Voltage for CK and DQS (8.4)
    - Differential Output Slew Rate for DQS (9.4)
    - Differential AC Output Levels for DQS (9.2)

Fig. 16: List of electrical tests that the R&S®RTO/R&S®RTP-K91 compliance test option can perform.

- Clock Timing (12.1)
- Data Timing (4.13.2, 13.4, 13.6)
- Strobe Timing (4.13.2, 4.14.2, 8.3.1)
- Command Timing (13.5)
- Address Timing (13.5)
- Chip Select Timing (13.5)

Fig. 17: List of timing tests provided with the R&S®RTO/R&S®RTP-K91 option.

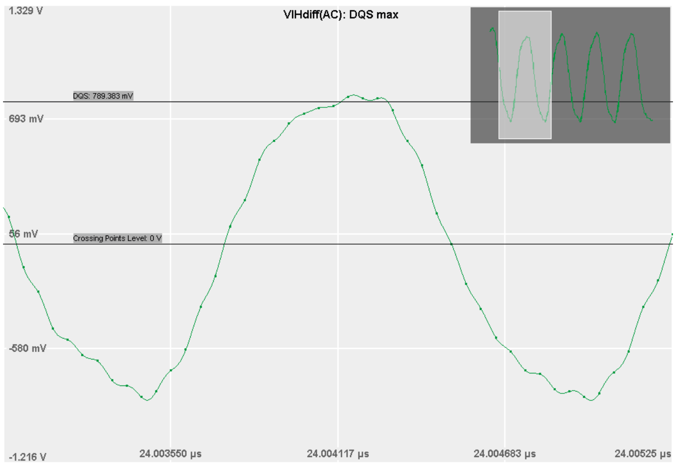


Fig. 18: Determination and display of the maximum VIHdiff(AC) value of a DQS signal.

DDR3 memory components usually have a ball grid array (BGA) package and are either soldered directly on the PCB or on a dual inline memory module (DIMM). It is usually not possible to directly contact the balls on the underside of the package. With single-sided circuit boards or DIMMs, vias can be used to access the signal lines (Fig. 19).

If contacting on the back of the board is not practical, it is possible to insert an interposer between the DIMM and the SDRAM component. The interposer feeds out specific signal lines for probe contacting. Fig. 20 shows an example of a modified DIMM with an interposer from Nexus Technology (www.nexustechnology.com). A DRAM component was unsoldered from the DIMM, and a raiser and an interposer were inserted between the DIMM substrate and the DRAM component.

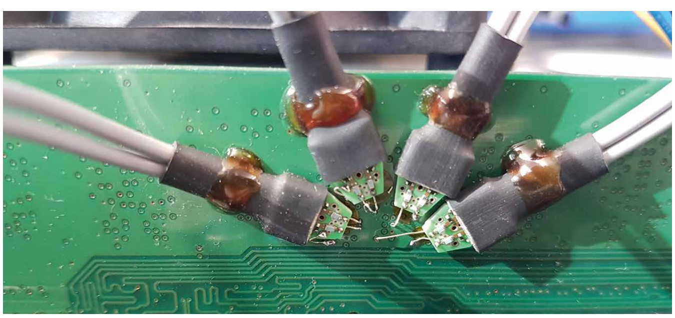


Fig. 19: Using vias to contact DQ and DQS signals on the back of the printed circuit board.

Rohde & Schwarz offers modular wideband probes with numerous tip modules for signal contacting. For example, the R&S®RT-ZMA10 solder-in tip module can be used to connect the probe to the test point. The R&S®RT-ZMA40 browser tip module offers other flexible contact options.

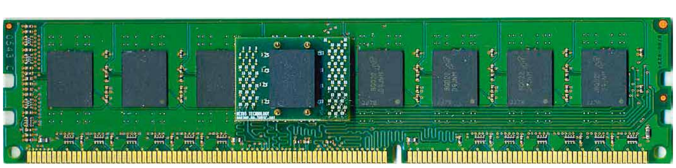


Fig. 20: DIMM with interposer for using a solder-in probe tip module to contact DDR3 signals .

As a general rule for all contact methods, the contacts should be kept as short as possible to minimize additional inductance and capacitance. For example, the solder contacts on the R&S®RT-ZMA10 should not exceed two to three millimeters in length.

The multimode capability of the R&S®RT-ZM modular probes provides great flexibility when measuring differential, single-ended or common-mode voltages. To measure differential signals such as the clock signal or DQS signal, the probe contacts the differential inputs V_P and V_N and ground (Fig. 21). In multimode, it is then easy to switch between differential mode and single-ended mode for the electrical tests.

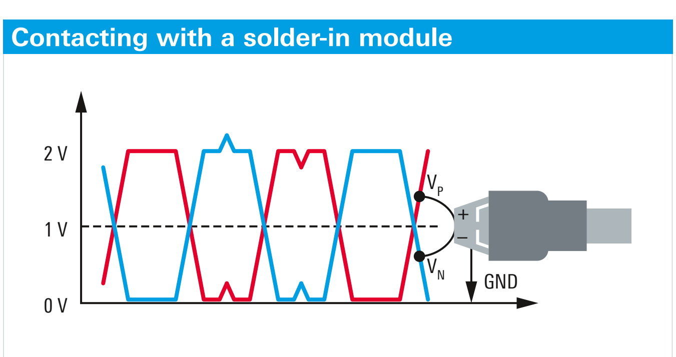
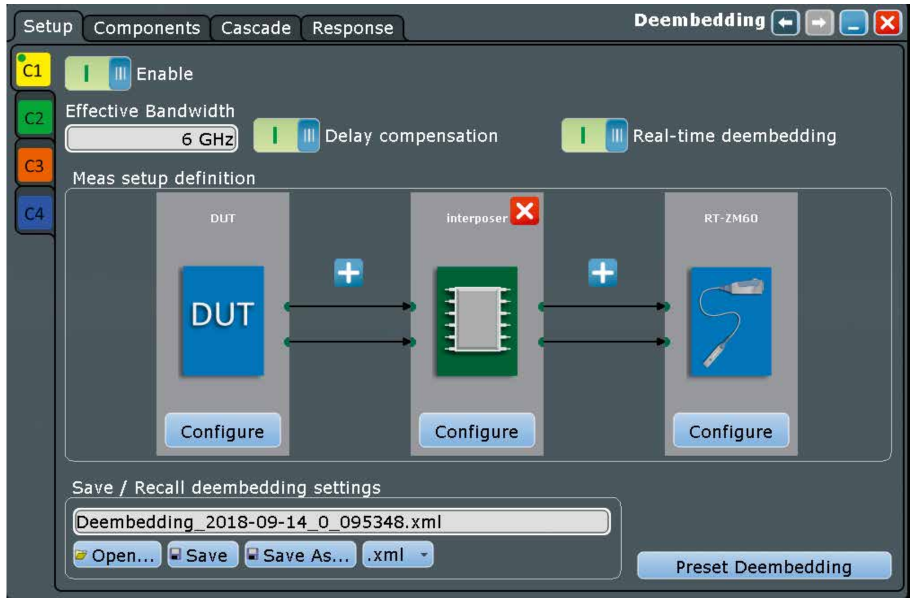


Fig. 21: Solder contacts of the R&S®RT-ZMA10 solder-in probe tip module.

Fig. 22: Setup dialog for the deembedding function.



The best signal fidelity for the single-ended DDR data signals or control signals is obtained when the differential probe inputs (V_P and V_N) are used without additional ground contacts.

Deembedding compensates for transmission losses

Signal transmission through the probe (from the contact point of the DDR data line to the oscilloscope) is not perfect. The signal is distorted by transmission losses, making comparison with the specification more difficult. These losses are increased by additional test components such as interposers.

The R&S®RTO and R&S®RTP oscilloscopes support deembedding, which is the common method used to compensate for these transmission losses. The R&S®RTO-K121/RTP-K121 deembedding option calculates a compensation filter based on S-parameters and applies it to the acquired waveforms. Fig. 22 shows the setup dialog for defining the signal path. An S-parameter file describing the transmission characteristics can be loaded for each element. When deembedding is activated, the characteristics of the overall path (including the oscilloscope input) are determined once and a compensation filter is calculated.

With the R&S®RTP-K122 option, hardware-accelerated deembedding can be performed in real time on an R&S®RTP. The user can utilize the oscilloscope's high acquisition rate of up to 1 million waveforms per second to quickly and reliably capture rare events during troubleshooting. The trigger system also benefits from real-time compensation since it acts on the compensated and therefore correct signal.

Summary

The integration of DDR3 memory devices presents circuit designers with very specific design and test challenges that can best be addressed with a customized, oscilloscope based measurement solution. The R&S®RTO-K91/R&S®RTP-K91 option has all the necessary capabilities: functions for effective troubleshooting such as DDR3 eye diagrams and read/write decoding as well as conveniently guided standard compliance tests. The real-time deembedding function of the R&S®RTP automatically eliminates distortion effects from the measurement setup, improving the reliability of analysis results and increasing the efficiency of measurements.

Guido Schulze, Johann Tost

Signal and spectrum analysis: new models for upscale requirements

When it comes to investigating wideband communications systems or high-resolution radars, you need top-rank analyzers. New models in the top and upper middle class raise the bar even higher.

Making the reference instrument even better

For years, the R&S®FSW family of analyzers has defined the technological leading edge of the market. They now offer enhanced specifications, features and operation in a brand new look.

Improving an instrument that is already at the upper end of the performance scale is a very difficult task. With the R&S®FSW (Fig. 1), that has succeeded in several aspects:

Better specifications

The phase noise – a decisive parameter for many high-end applications – is now typically –140 dBc/Hz at 1 GHz and 10 kHz carrier offset or –133 dBc/Hz at 10 GHz and 10 kHz offset.

Improved features and functionality

- The touchscreen is now capacitive and understands new gestures.
- All models at 26 GHz and above now support up to 2 GHz internal analysis bandwidth; if you want to demodulate signals up to 5 GHz with the aid of an R&S®RTO oscilloscope, you can do this with selected models.
- The real-time bandwidth can be expanded to a maximum of 800 MHz. Signals with bandwidths up to 512 MHz can be streamed over the I/Q interface and recorded, for example by the new R&S®IQW I/Q recorder (see the brief profile on page 63).
- Generating remote control programs is very easy with the SCPI recorder. This tool converts manual operator actions directly into remote control commands and offers further aids for automatic program generation.
- In addition to the previous 1 mm connector, the top model R&S®FSW85 now has a second input with the more robust 1.85 mm connector for measurements up to 67 GHz, as well as higher measurement sensitivity above 50 GHz.

800 MHz real-time analysis for accurate signal level detection with extremely short signals

In the development and characterization of frequency agile radar systems and communications solutions, it is essential to acquire signals seamlessly, detect extremely short signals and record relatively long sequences without interruptions. This is only possible with a real-time analyzer. Regulatory authorities need real-time analyzers too, in order to track down undesirable or unlicensed signals.

Even for relatively simple applications, real-time analysis is also a helpful tool. With sweeping analyzers, it is difficult and

Fig. 1: Analytics powerhouse: key specifications of the R&S®FSW have been further improved.

time-consuming to investigate intermittent or brief events in the frequency domain, the spectral behavior of signal sources during frequency switching, or the influence of digital circuits on RF signals.

Whereas the previous version of the R&S®FSW was able to analyze spectra up to 512 MHz bandwidth in real time, the new instrument generation now offers an analysis window width up to 800 MHz with the R&S®FSW-B800R option. The FFT length is adjustable between 32 and 16384 to achieve different resolution bandwidths. Signals as short as 0.46 µs are detected with correct signal levels with a probability of intercept (POI) of 100 %, and signals lasting only a few nanoseconds are still reliably detected but not necessarily with correct signal levels. More than 2 million spectra per second go into the evaluation. Since the human eye can only process at most 30 images per second, the R&S®FSW offers displays that enable the user to see all events, such as the persistence spectrum and the spectrogram (Fig. 2). A frequency mask trigger (FMT) automatically evaluates all 2.34 million spectra per second and responds to user-defined events, even if they only last for a few nanoseconds.

If you want to record real-time spectra over extended periods for evaluation later on, for example during field measurements, or if you want to use a signal generator to feed in a realistic environment in a lab scenario, the measurement data can be streamed to an I/Q recorder (such as the new R&S®IQW; see page 63) with the R&S®FSW-B517 option installed. If the full streaming bandwidth of 512 MHz is used, sequences lasting more than 40 minutes can be recorded; with smaller bandwidths, the sequences can be significantly longer.

Wideband analysis of radar or communications signals with 2 GHz internal bandwidth

Complex radar applications and the latest communications standards require very large analysis bandwidths, but they do not necessarily need to be available in real-time mode. For example, up to 400 MHz bandwidth is necessary for the analysis of 5G NR signals, or as much as 2 GHz for WLAN 802.11ad signals. If digital preemphasis is used for 5G NR to increase transmission quality, at least one adjacent channel on each side must be included in the measurement. This alone requires 1.2 GHz bandwidth.

The R&S®FSW not only offers up to 2 GHz internal analysis bandwidth to meet these requirements, but also the matching application software in the instrument for automatic measurement of the modulation quality of 5G or WLAN signals (Fig. 3). The R&S®FSW67 model can acquire WLAN 802.11ad signals in the 60 GHz band without supplementary converters.

If 2 GHz is not enough

The only substitute for bandwidth is even more bandwidth. The next generation of automotive radar sensors will work with chirp signals with a bandwidth of 4 GHz. The new WLAN 802.11ay standard already requires at least 5 GHz to analyze two channels. Similar trends can be seen in the A&D sector.

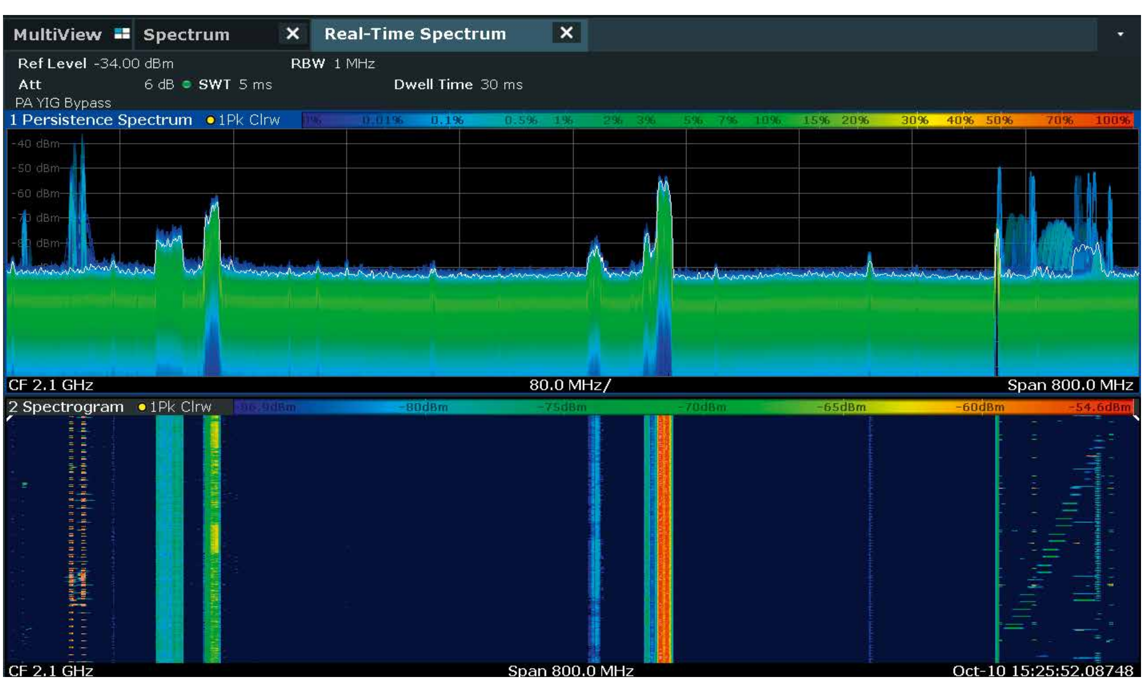


Fig. 2: Real-time analysis with 800 MHz bandwidth at a center frequency of 2.1 GHz, allowing simultaneous acquisition of ISM and LTE bands. The persistence spectrum at the top color-codes the spectra according to their frequency of occurrence, while the spectrogram below shows the spectral history.

The R&S®FSW equipped with the B5000 option and an R&S®RTO2064 oscilloscope provides up to 5 GHz analysis bandwidth. Unlike other solutions, the frequency response of this combination is fully deemphasized and the user can start working right away without worrying about calibration. If the B5000 option is installed in the top model, R&S®FSW85, next generation automotive radar signals with a bandwidth of 4 GHz can be acquired directly at 79 GHz and analyzed (Fig. 4). The frequency response of the R&S®FSW85 extends to 90 GHz; measurement up to 85 GHz is possible with pre-selection. On the other hand, if measurements at frequencies below 67 GHz are on the agenda, the instrument has a second front-panel RF input with the more robust 1.85 mm connector available for that purpose.

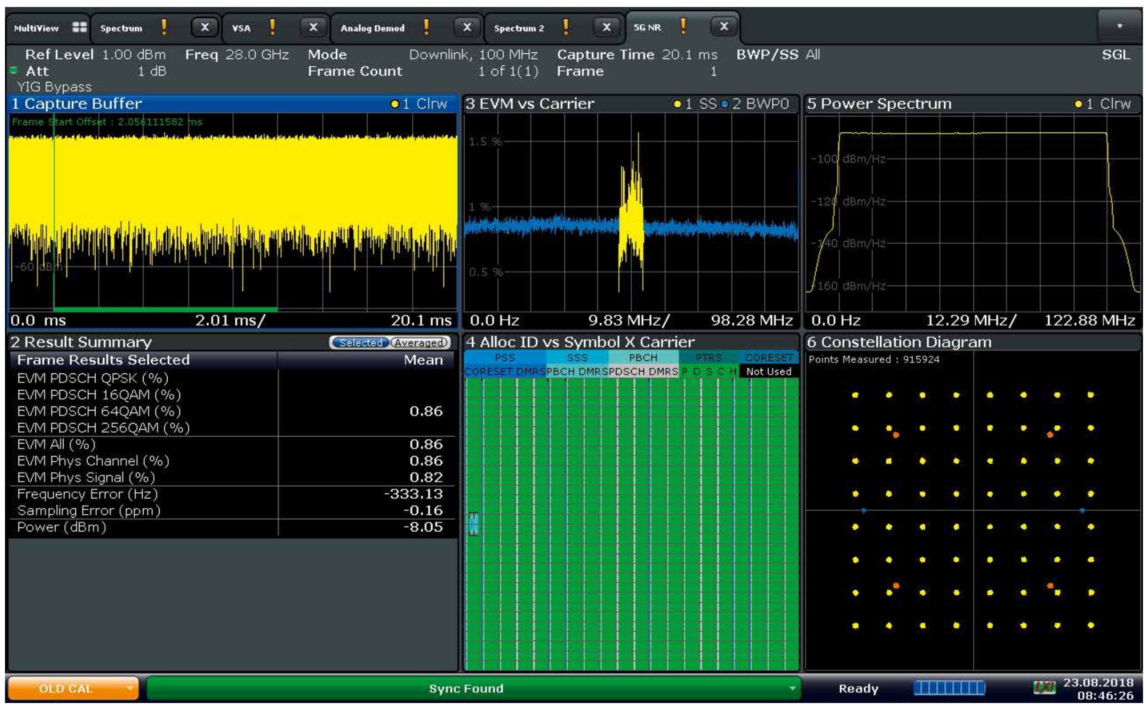


Fig. 3: Analysis of a 5G NR downlink signal at 28 GHz with the R&S®FSW-K145 option. Various views, such as EVM vs. carrier, the constellation diagram and tabular listing of all important parameters enable fast characterization or optimization of the 5G application.

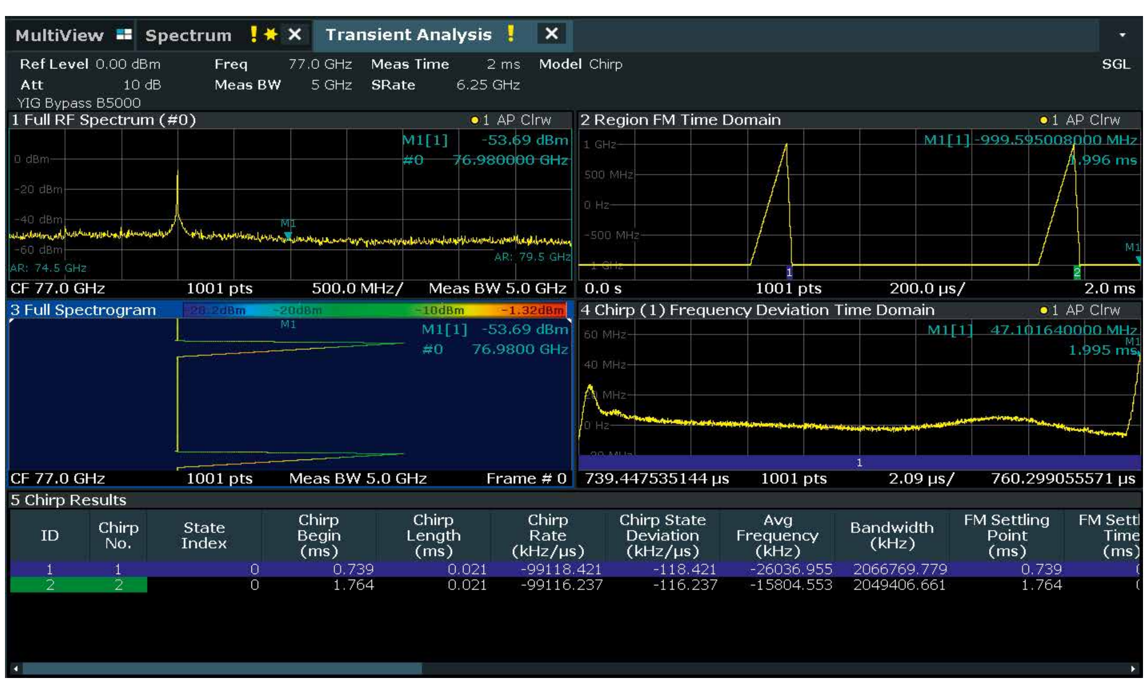


Fig. 4: Measuring the short chirp of a radar signal with a bandwidth of 2 GHz, using a 5 GHz measurement bandwidth. The quickly declining frequency chirps were the main focus of this measurement and were therefore selected. The spectrogram shows that there are no undesired sidelines outside the band.

Analysis of very pure signals and sources

The quality of a signal analyzer or spectrum analyzer is essentially determined by the phase noise of the internal local oscillator. Low phase noise helps with accurate measurement of modulation quality and spectral measurements close to the carrier – for example, measuring the adjacent channel power of narrowband transmission systems or checking spectral masks. It is also indispensable for characterizing components such as VCOs or synthesizers.

Consequently, the phase noise performance of the R&S®FSW has been further improved. With –140 dBc/Hz at 10 kHz offset and 1 GHz receive frequency or –133 dBc/Hz at 10 GHz, it outshines all current competitors. In combination with the R&S®FSW-K40 option, this performance enables phase noise measurements that previously required top-notch phase noise measurement stations (Fig. 5). Using a digital PLL, in I/Q mode the R&S®FSW can track the drift of the DUT, enabling characterization of VCOs close to the carrier.

Fig. 5: Phase noise measurement on a high-grade oscillator at 10 GHz with the R&S®FSW-K40 measurement application. The measurement results for various offset frequencies are shown at the bottom.

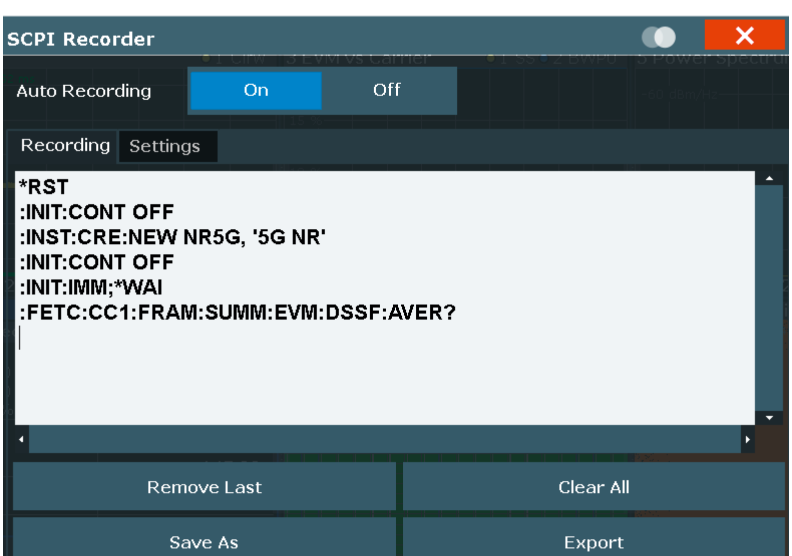
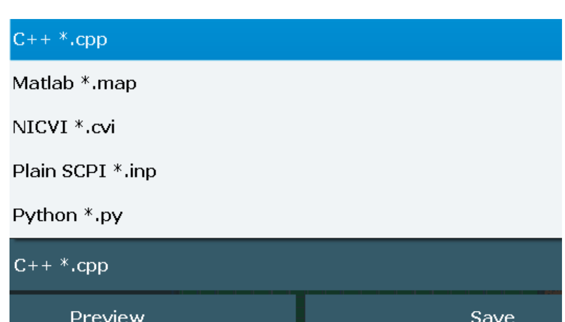


Fig. 6: The SCPI recorder notes what the user does. Here it activates the 5G NR option, performs a measurement and then queries the EVM. The script can be exported in various formats.



SCPI recorder and new touch gestures simplify operation

Developing an instrument remote control program can be a long and difficult process. Users have to study the manual to find the right SCPI commands and figure out what the parameters mean. The online manual available on the instrument does not help much. Now the R&S®FSW with its standard SCPI recorder enables quick and easy program generation. Users switch on the recorder and manually execute their measurement sequence. The instrument automatically converts user entries into a command sequence, taking parameter configuration into account (Fig. 6). Specific result queries can be added from a table by touching the table until a menu appears and then selecting the exact parameters to be copied. The finished script file can even be exported to C++, MATLAB® or Python. Synchronization sequences can also be inserted automatically. Creating a program to control a signal and spectrum analyzer has never been easier – even novice programmers can quickly do the job.

Even more important than easy program generation is convenient manual operation. Touchscreens have long since become standard on measuring instruments because they provide distinct gains in convenience and efficiency, both for device configuration and for presenting results. Now the R&S®FSW has a capacitive touchscreen that is just as sensitive as a smartphone screen. Changing the frequency or the reference level with a gesture, or zooming in on a trace with two fingers, has an immediate effect. Users can also choose whether or not critical settings, such as the input attenuation, can be altered with a swipe gesture.

In summary: With its improved specifications, features and options, the R&S®FSW is still at the head of the pack. Along with the largest internal analysis bandwidth in normal and real-time operation, it offers key RF parameters such as phase noise that are unmatched by any other instrument. Moreover, operation and programming of the instrument are even easier now.

Dr. Wolfgang Wendler

Recording and playing back long signal sequences

Top-end analyzers such as the R&S®FSW can analyze signals with multi-gigahertz bandwidth, but with their onboard resources they can only do this either live or based on very short internally stored sequences. Especially with high bandwidth measurements, the data rates are so high that only the fastest SSDs at the professional level can handle them – and even then only if the entire data flow architecture is designed accordingly. External high-performance recorders, such as the new R&S®IQW, can remedy this situation. Connected to the HS digital I/Q interface of the R&S®FSW, the R&S®IQW can seamlessly record long signal sequences with bandwidths up to 512 MHz and 16 bit I/Q resolution. With an input signal at this maximum bandwidth, which corresponds to a transfer rate of 2.5 Gbyte/s, a 6.4 Tbyte swappable SSD is good for 42 minutes. Recording times of several hours are possible with lower bandwidth. A typical application for the R&S®IQW is recording real-world RF scenarios with an R&S®FSW as the frontend. The integrated GPS module allows the data to be coordinated with the recording location. In the lab, the recorded baseband signal is converted back to the RF domain by an attached R&S®SMW200A vector signal generator to provide realistic signals for test setups. Of course, the recorder can also be useful in pure lab applications. It can be operated easily and conveniently via the touchscreen or a computer connected over the LAN, especially because a wizard helps with the settings. For use in sensitive areas, such as the A&D environment, the swappable SSD can be secured to prevent removal.

The R&S®IQW can seamlessly record long signal sequences with bandwidths up to 512 MHz and 16 bit I/Q resolution.

A breath of fresh air in the mid-range segment

Most signal and spectrum analysis tasks do not require top of the range T&M equipment. Today's upper mid-range instruments offer features that just a few years ago were reserved for the premium segment. Two brand new models are the proof.

A new instrument generation is expected to outperform its predecessors and clearly demonstrate the technical advances that have been made since the previous generation. The R&S®FSV3000 and R&S®FSVA3000 signal and spectrum analyzers meet this expectation in all respects (Fig. 1). With better RF data, higher measuring speed and impressive features, they are ideal high-quality standard T&M instruments for use in the lab and automated test environments (ATE). They even master complex measuring tasks in wideband communications and A&D applications.

Very good or even better

The R&S®FSV3000 and R&S®FSVA3000 models are identical in appearance and operation, but differ in their performance data and application focus.

The R&S®FSV3000 has been developed to perform complex measurements quickly and easily. Its high measuring speed and easy operation make it the right instrument for the lab and the production line. With an analysis bandwidth of up to 200 MHz, it can capture and analyze two 5G NR carriers simultaneously.

With an analysis bandwidth of up to 400 MHz, a high dynamic range and a phase noise of –120 dBc/Hz (at 1 GHz, 10 kHz offset), the R&S®FSVA3000 is moving beyond mid-range. Its range of applications includes linearization of power amplifiers, acquisition of short events and characterization of frequency agile signals.

Automatical capturing of rare events

The event driven GUI of the R&S®FSV3000 and R&S®FSVA3000 makes it easy to capture rare events. The user simply has to select a triggering criterion such as an ACLR or limit line violation from a dropdown menu and then specify an action to be performed, for instance a screenshot or saving I/Q data (Fig. 2). The action is executed only if the event occurs, and recorded in a journal for later analysis.

The new one-button measuring function shortens instrument set-up time. At the press of a button, the parameters relevant for display, e.g. center frequency, span and level range, are adjusted to the applied signal; for a pulsed signal, the gate sweep parameters are also adjusted. For standard compliant measurements such as ACLR or spectrum emission mask (SEM) on communications signals, the one-button measuring function selects the appropriate standard-specific settings for channel spacing, channel bandwidth, measuring duration, etc.

For complex measuring cycles in an automated production line, SCPI programs on external PCs control the measuring instruments. The built-in SCPI recorder speeds up the programming of these control scripts considerably. All manual user entries are translated into SCPI commands that can be saved natively or exported in the syntax of commonly used programming languages and tools such as C++, Python and MATLAB®.

Fig. 1: The R&S®FSV3000 and R&S®FSVA3000 are redefining the mid-range segment. Their best-in-class performance data and ease of operation are setting new standards.

Many RF measuring tasks require a combination of signal generator and spectrum analyzer, whereby the settings of the two instruments often need to be coordinated. If, for example, the characteristics of an amplifier need to be measured for certain mobile signals, then the generator and analyzer must have the same frequency and level settings. The intelligent signal generator control unit of the R&S®FSV3000 and R&S®FSVA3000 automatically performs this synchronization. The analyzer directly controls the generator* via the coupling manager. Changes in frequency and level on the analyzer are transferred to the generator. The generator's GUI can be displayed and operated on the analyzer so that the user can access the entire setup from one instrument. In addition, the instruments' SCPI recorders can be coupled to create a combined remote control program.

High-speed analysis

The R&S®FSV3000 and R&S®FSVA3000 have been developed for measuring applications in automated test systems. They are extremely fast at performing spectrum measurements, modulation analyses and changing modes and frequencies. FFT-based ACLR and SEM measurements are faster than swept measurements and do not have a negative effect on the dynamic range. The portfolio of demodulation options covers the very latest standards, including 5G NR (Fig. 3), LTE and WLAN 802.11ac and ax. Universal measuring applications such as noise figure, phase noise, vector signal demodulation and amplifier measurements are also available.

In cloud based test systems, signal analysis is performed on servers. This requires large quantities of I/Q data to be transferred. The R&S®FSV3000 family has also been optimally designed for this operating mode. Its signal processing architecture and the optional 10 GBit/s LAN interface make it possible to transfer I/Q data to the network even at the high sampling rates required for large analysis bandwidths.

Summary: The R&S®FSV3000 and R&S®FSVA 3000 provide many attractive functions for measuring tasks in the lab and production as well as unrivaled RF performance and measuring speed for this class. Thanks to autoconfiguration, event based actions and an SCPI recorder, the analyzers simplify today's increasingly complex everyday measurement tasks. As a frontend in an ATE with cloud based signal analysis, the analyzers stream wideband I/Q data to the cloud computer via the 10 Gbit/s LAN interface.

Martin Schmähling

* Currently possible with the R&S®SMW200A and R&S®SMBV100B generators.

The R&S®FSV3000/FSVA3000 will be available starting March 27, 2019.

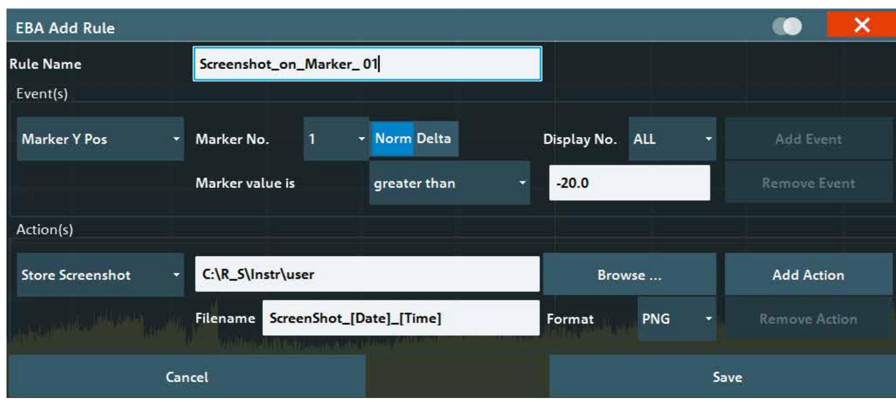
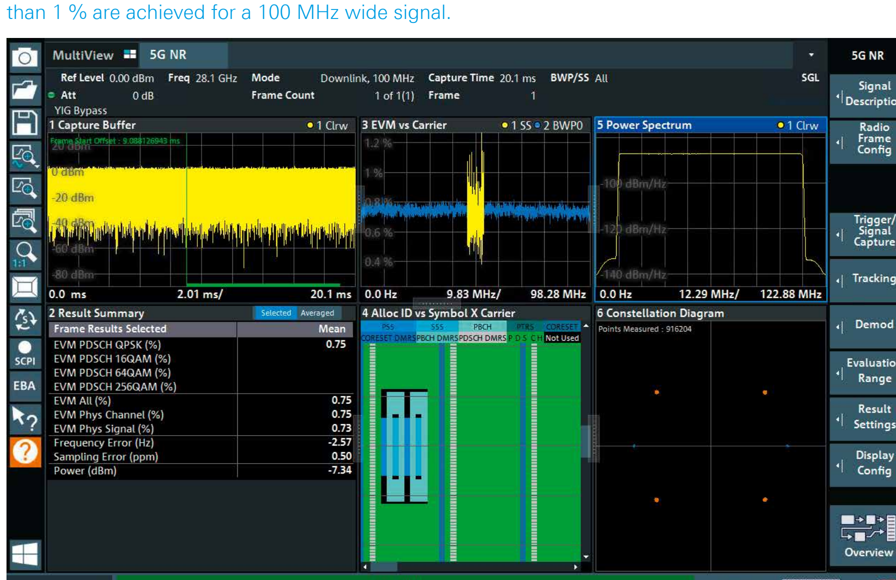


Fig. 2: The event based action function enables efficient troubleshooting. User-defined rules for triggering actions, e.g. a screenshot, are conveniently defined on the screen.

Fig. 3: The R&S®FSV3000 and R&S®FSVA3000 are ready for 5G NR. At 28 GHz, EVM values of better than 1 % are achieved for a 100 MHz wide signal.



New switch and control center

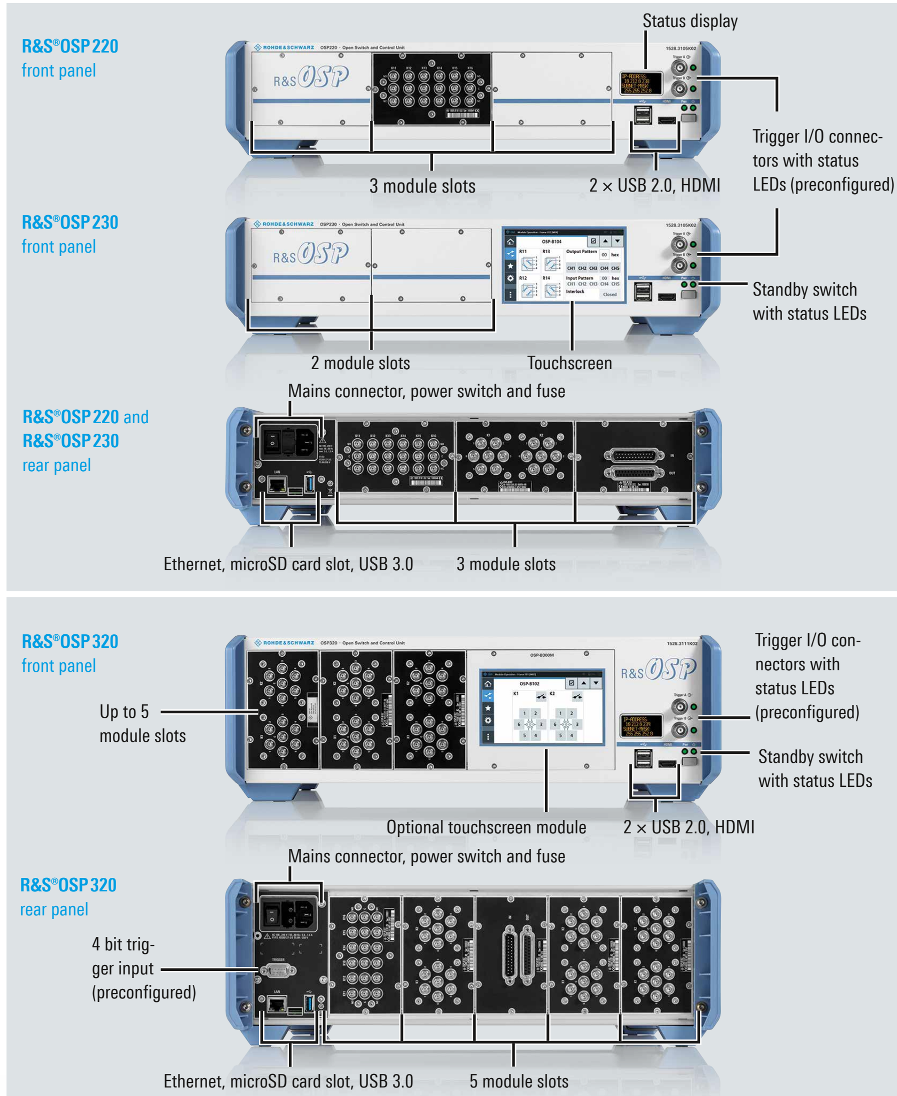
Based on ten years of experience with the R&S®OSP switch and control platform, the next generation of this product family has now been developed. The result is a state-of-the-art yet backward compatible platform, allowing legacy switch and control modules to be used with the new units.

New technologies such as 5G and advanced radar technology can be challenging for switch and control equipment as they require wider frequency ranges and shorter switching times. With these requirements in mind, the R&S®OSP switch and control platform was entirely redesigned both in terms of hardware and software and provided with a state-of-the-art operating concept. With three models (R&S®OSP220 / 230 / 320, Figs. 1 and 2) and a detached satellite box (R&S®OSP-B200S2), the new platform supports universal applications, ranging from benchtop configurations for laboratory measurements all the way through integration into complex, rack-mounted test systems.

The performance and functional range of the R&S®OSP models have been substantially increased:

- All models have module slots on the front and rear panels to provide maximum cabling flexibility.
- Each model can now manage and control up to 16 modules, including connected satellites. The output power of the power supply has been increased for switching electromechanical RF relays.
- For convenient configuration in a network, the R&S®OSP models come with a status display or a touchscreen showing the TCP/IP address and host name.
- Units equipped with a touchscreen can be configured and operated manually without external accessories.

Fig. 2: The R&S®OSP switch and control platform – models and interfaces.



Virtually unlimited expandability

All R&S®OSP models can be combined via Ethernet into a corporate or global network in a master/slave configuration. This substantially expands the potential applications of the R&S®OSP units, in combination with their trigger and path control functions. New requirements can be subsequently supported.

In addition to networking multiple R&S®OSP units, the compact R&S®OSP-B200S2 satellite box can be used to bring switch and control functions close to the DUT or the antennas (Fig. 3). This reduces the number of long RF cables required while improving the RF performance of the cabling and cutting costs.

Fig. 1: The module slots on the front and rear panels of the new R&S®OSP switch and control units can accept a wide variety of modules to implement versatile wiring configurations.

Intuitive web interface

The R&S®OSP models come with a built-in web interface for local operation via the touchscreen or a PC browser. No extra configuration software is required.

In the case of browser based control, the resolution of the displayed content is automatically adapted to the screen size of the touchscreen, smartphone, connected monitor or PC screen (Fig. 4).

Keeping what is proven

Tried and tested components were retained, including:

- Reliable **Linux operating system** with its substantially lower risk of virus attacks

Typical combinations of R&S®OSP units and R&S®OSP-B200S2 satellite boxes

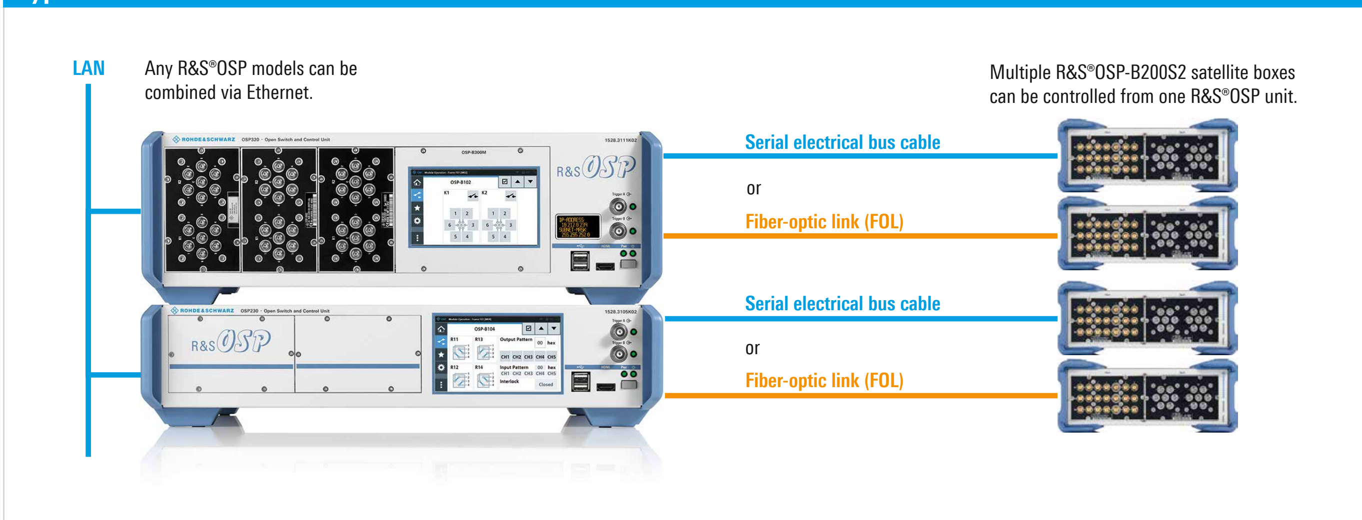
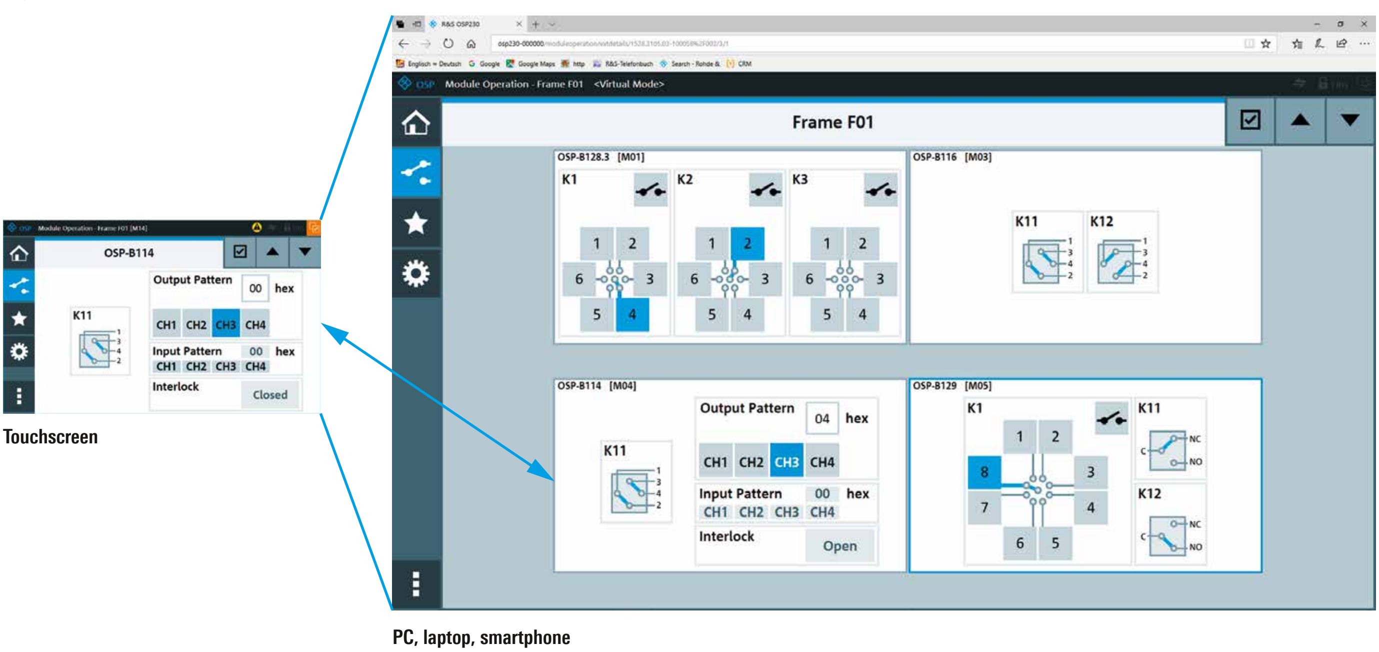


Fig. 3: The R&S®OSP-B200S2 satellite boxes bring switch and control functions close to the DUT.

Fig. 4: With web browser based control, the resolution of the displayed content is automatically adapted to the screen size of the display or monitor used.



- **USB and HDMI interfaces** for manual control using an external monitor and a keyboard and mouse
- **Path control** using combined relay switching states to simplify control and programming of complex wiring configurations
- **Virtual mode** allowing devices and paths to be preconfigured without having all of the units / modules available – a benefit when configuring complex systems
- **Flexible module buses and combinable module slots** for versatile configurations – useful especially with larger, application-specific modules
- **Compatibility of the module buses**, allowing all available R&S®OSP modules (new and legacy, Fig. 5) with their different relay types and variants to be used:
  - All basic types of RF relays (SPDT, SPnT, DPDT)
  - Electromechanical coaxial relays up to 67 GHz in different versions (failsafe, latching, terminated, non-terminated)
  - Solid-state relays (SSR)
  - Digital I/O modules and multiplexer module

Fast switching with trigger option

The integrated trigger unit is an important new feature that is activated with the R&S®OSP-K100 option, which will be available soon. It allows predefined paths to be switched via external trigger inputs. Hardware based switching significantly boosts switching speed compared with LAN-based control. This capability is required especially for fast switching between different antennas, radar modules, etc. using solid-state relays.

Depending on the trigger mode, the front-panel trigger connectors can be configured as inputs or outputs, e.g. for sequentially switching predefined paths or toggling between two different states. The R&S®OSP320 additionally has a digital address input on its rear for direct control of predefined paths.

Gert Heuer

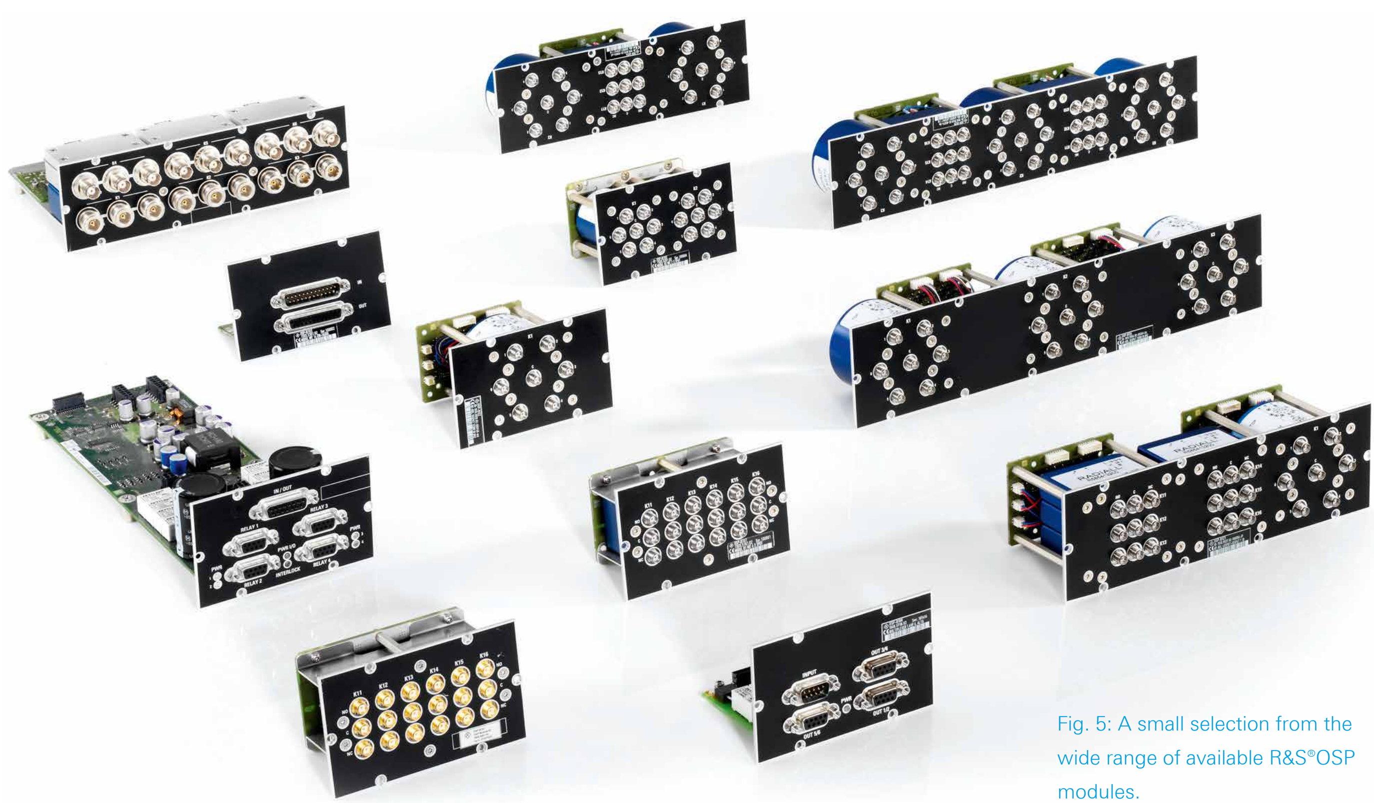


Fig. 5: A small selection from the wide range of available R&S®OSP modules.

A protocol for live transmission over the internet

Conventional point-to-point connections for the distribution of live media content via satellites or content delivery networks are expensive and have several disadvantages. The Rohde & Schwarz subsidiary GMIT offers a proven solution for transmission over the public internet that is far more cost-effective and flexible.

If media providers want to achieve long-term success, they must provide their audience with appropriate content as quickly and inexpensively as possible. The transmission paths to customers are a source of savings potential. Thanks to increasingly high online bandwidths between continents, data centers and end points, the public internet can be used to broadcast live events, provide TV content to a wide audience and add new programs to online TV services.

A distinction is generally made between content contribution and content distribution (Fig. 1). In both cases, technical obstacles need to be overcome in order to reliably broadcast live content over the unmanaged internet around the clock with high bit rates and minimal delays. This level of performance has only recently been achieved.

The internet protocol is everywhere

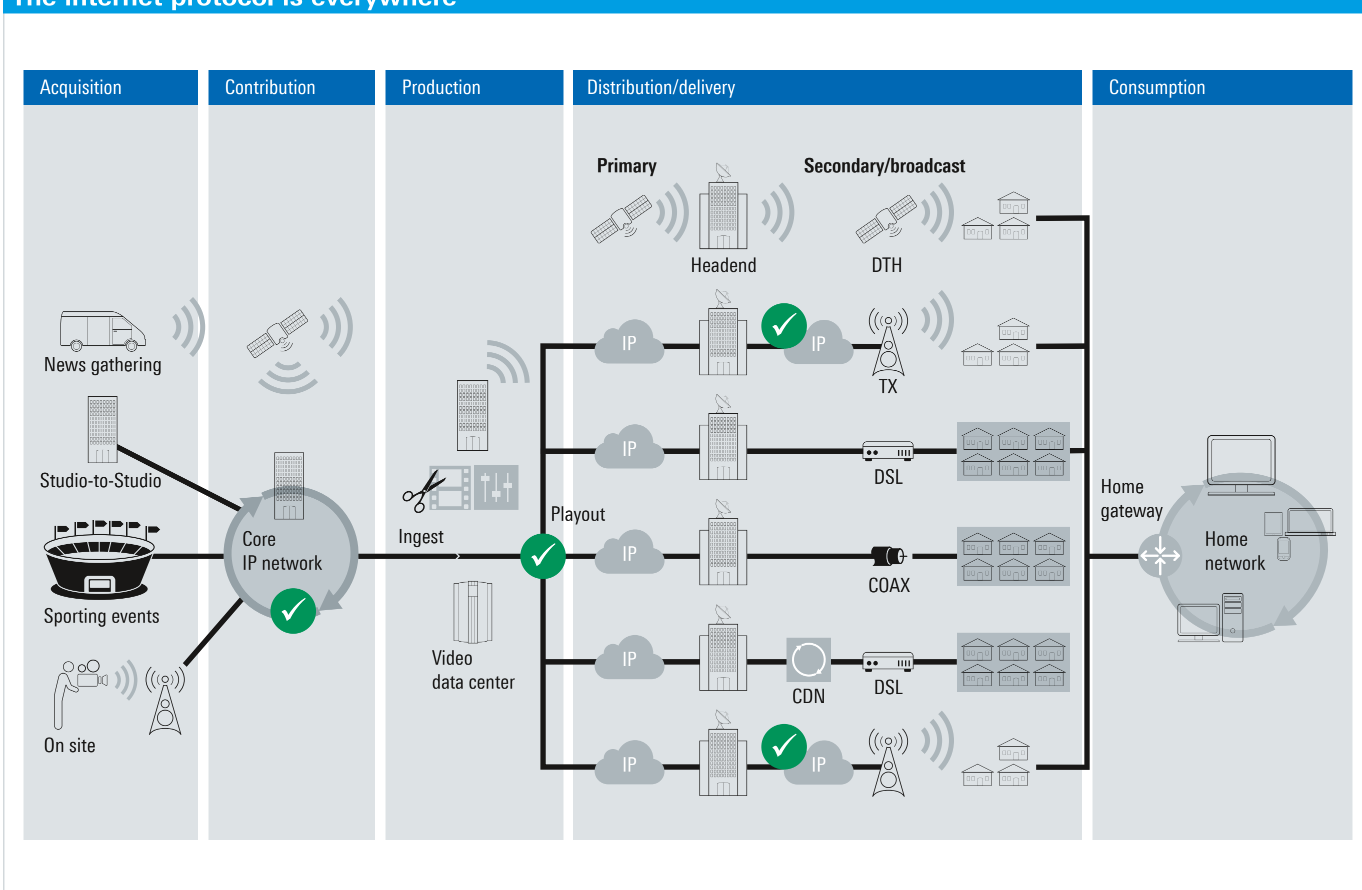


Fig. 1: From acquisition to consumption: IP contribution and IP distribution take place at all media production interfaces.

Conventional point-to-point connections

Teleports

For a long time, satellites were used to feed and distribute live content over long distances. Signals are sent to satellites via teleports and then forwarded to other teleports before being distributed via dedicated, managed optical networks. This process has the disadvantages of very high initial/operating costs and a lack of flexibility when establishing new connections.

Content delivery networks

Content delivery networks (CDN) are another way to distribute content. These networks consist of internet servers in multiple data centers. The size of the network depends on the provider. The servers are connected over the public, unmanaged internet or over managed virtual overlay networks, or in some cases over private optical networks that offer better quality of service. Content is mirrored, i.e. identical copies are stored on these servers. Conventionally, CDNs mirror entire websites by copying their content to servers in different regions. When users access a website via an internet browser, the content (text, graphics, etc.) is delivered by one of the CDN servers closest to the user. Closest refers to the distance on the internet, which is measured in round trip time, for example.

HLS streaming in CDN

In recent years, many established CDN operators have also entered the streaming market. The de facto standard for smartphones and smart TVs is the HTTP live streaming (HLS) protocol developed by Apple, which splits on-demand video content and live streams into "chunks" consisting of MPEG-TS files, each of which is a few seconds long. HLS can handle adaptive streaming. The content is available at various bit rates. The streaming client chooses the most suitable resolution for each chunk in accordance with the bandwidth available at that moment.

Since HLS is based on HTTP, the familiar protocol used to transmit websites to browsers, internet streams can be received in the same way as other web content, even behind firewalls. This is also known as over the top (OTT) because it uses the existing internet infrastructure to distribute audiovisual content – at least over the last mile, i.e. the path to the end user's streaming client.

Disadvantages of CDN

CDNs are currently the most widely used technology, but they have disadvantages. In addition to high cost, one of the main problems is their high latency. Due to content mirroring, many CDN providers incur a delay of 30 and 60 seconds for live streaming with HLS. Very few providers can achieve a latency of only a few seconds, something that was possible with satellite transmissions.

Another disadvantage is that customers themselves are largely responsible for feeding their live streams into the CDN themselves. The content also needs to be reliably transmitted to the nearest network access point. In countries or regions where the CDN cannot offer an access point in a nearby data center, providers will need to revert to a satellite connection or a dedicated optical network.

Purely internet based infrastructures can be problematic

The omnipresent internet with its constantly increasing bandwidth is virtually the only option for transporting media content. The problem is that due to the purely packet based and connectionless nature of this medium, universal quality of service (QoS) cannot be ensured. Packet loss during the handling of internet traffic by routers, and even brief stream dropouts due to routing changes, are common. Every missing data packet causes picture distortion or audio gaps, and every brief dropout causes an interruption in live playback.

The solution: RelayCaster – only available from Rohde & Schwarz

The goal of streaming specialist Motama GmbH was to compensate for the erratic nature of the internet with intelligent processes. The company was a pioneer in this field and presented its RelayCaster product at the 2010 IBC international trade show in Amsterdam. The Rohde & Schwarz Berlin based subsidiary GMIT GmbH acquired the Motama technology in 2017, thereby expanding its product portfolio, particularly in the area of interference-free transmission of audio and video content over IP networks. Rohde & Schwarz has since revamped the product, which is now known as R&S®RelayCaster. The enhanced version allows feeding and encoding of SDI/HDMI data streams. This integrated functionality further improves the cost-efficient platform for transmitting live content.

The idea: a unique protocol

The UDP and TCP protocols dominate online. While UDP may be excellent for transmitting live streams, it is inherently unreliable. This leads to packet losses with intermittent audio dropout or video errors (block artifacts) that can range from minor to serious.

TCP, on the other hand, is 100 % reliable, but that is also why it is unfortunately not suitable for transmitting bandwidth-hungry live streams over large internet distances (long round trip times and many internet hops). Even minor packet losses cause TCP to decrease the bandwidth, causing the live stream to freeze. This problem occurs with all TCP-based protocols such as HTTP, and therefore streaming protocols such

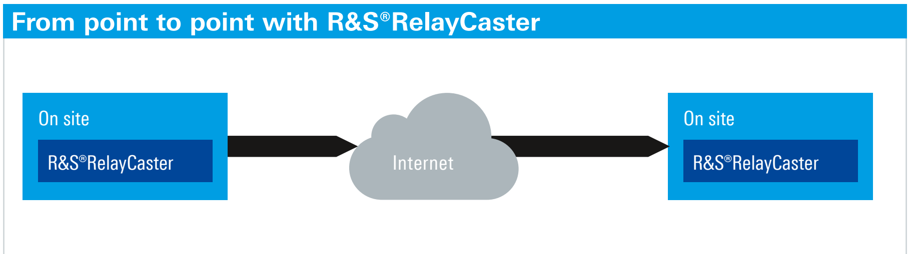


Fig. 2: An R&S®RelayCaster server transmits a live data stream via the public internet to an R&S®RelayCaster receiver. A special protocol ensures reliable transmission and low latency.

as HLS. It causes HLS to switch to a lower bit rate in the case of packet loss, reducing audio and video quality.

The solution from Motama uses two R&S®RelayCaster instances (Fig. 2) for live, error-free transmissions online. The unique R&S®RelayCaster streaming protocol (RCSP) is used between the two instances. One instance sends the live stream from the local network via public internet to another R&S®RelayCaster instance at any internet-accessible location. The receiver forwards the live signal to its own local network, where e.g. a terrestrial broadcast distributes it to the content takers (B2C in Fig. 4).

RCSP solves problems such as packet loss in unmanaged areas of the internet. It can bridge large internet distances, compensate for packet loss and is fully internet-compatible. Optional encryption with the Advanced Encryption Standard (AES) keeps content secure.

RCSP is based on UDP and achieves its quality of service by combining several methods, such as optimized retransmission of lost packets. The protocol combines the good characteristics of the two dominant internet protocols UDP and TCP and operates with a very low latency of about 1 second.

The QUIC protocol developed by Google is also based on UDP, but unlike RCSP where real-time capability takes precedence over reliability, it is designed for absolutely reliable data transmission.

RCSP can transmit a single stream or several streams with any desired bandwidths, provided that the input and output bandwidths are available at the transmitter and receiver, respectively. Based on experience, a margin of 20 % additional bandwidth should be planned in to accommodate strong fluctuations in line quality.

Various versions

Various versions of R&S®RelayCaster are available, which allows almost infinitely scalable networks to be set up. In addition to several server types (Fig. 3), there is also an inexpensive, portable embedded device version and pure software versions for use on leased servers in external data centers and on virtual machines of cloud providers such as Amazon AWS and Microsoft Azure (Fig. 4).

Hybrid solutions that combine existing transmission technologies with new internet based contribution and distribution solutions are a good idea for many projects. Sending

Fig. 3: R&S®RelayCaster is available as a server solution, as a small embedded device and as a pure software solution.

Setting up networks with R&S®RelayCaster

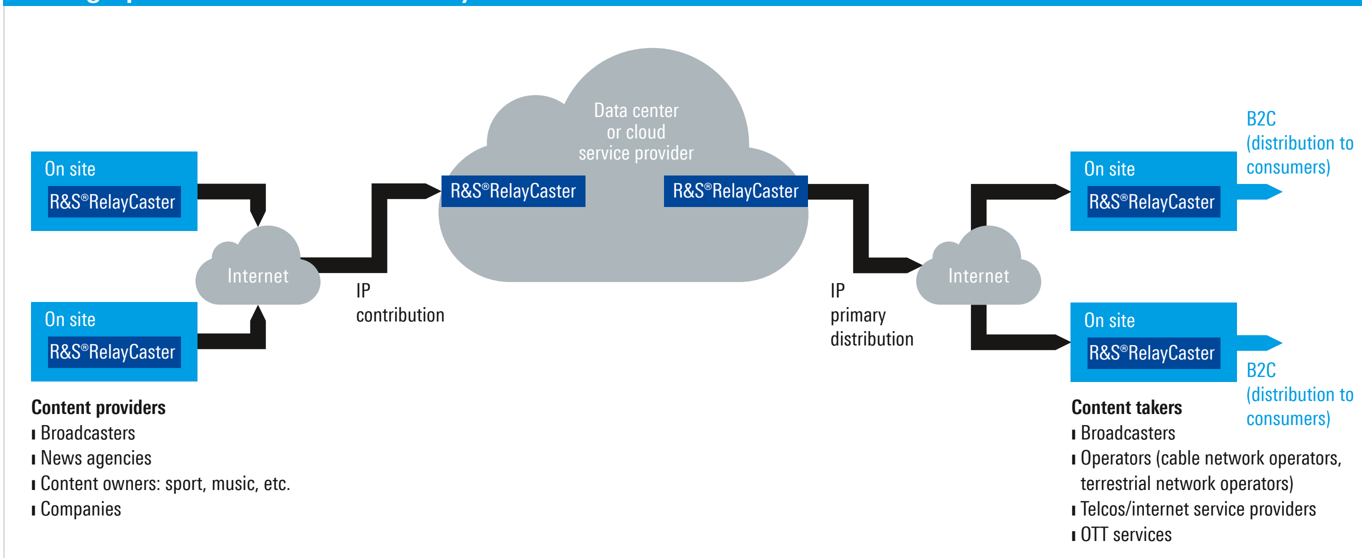


Fig. 4: R&S®RelayCaster can be used to set up extensive contribution and distribution networks that connect content providers to content takers and are almost infinitely scalable thanks to cloud based resources.

live content to satellite teleports and bridging the gap from teleports to CDN feed points are just two of many possible applications.

Summary

Today, the mature internet based IP transmission technology offers a stable and considerably more affordable alternative to conventional dedicated point-to-point connections for content distribution. R&S®RelayCaster fulfils the QoS conditions required for interruption-free transmission via public, unmanaged IP networks. IP-based transmission means that users are no longer reliant on expensive satellite connections, dedicated connections or CDN providers. R&S®RelayCaster is not limited to specific regions or data centers. The solution enables content to be distributed over any distance and to any location that has an internet connection. It is ideal for producers and live content aggregators as well as providers of live content streaming and OTT streaming. This innovative platform allows users to set up their own flexible, scalable content delivery networks and to utilize the internet to reduce their operating costs to an unprecedented extent.

Rohde & Schwarz with its comprehensive broadcasting portfolio, cybersecurity expertise and global presence is a reliable partner in this new, universal IP-based era.

Dr. Marco Lohse

Network solution provider LANCOM now part of the Rohde & Schwarz company group

Rohde & Schwarz has increased its majority stake in LANCOM Systems, the leading German manufacturer of network infrastructure solutions for business customers and public authorities, to 100 percent. The acquisition is an important step on the way to becoming the largest European provider of network and cybersecurity solutions. LANCOM Systems will operate as an independent subsidiary within the company group and, together with Rohde & Schwarz Cybersecurity GmbH, form the Networks & Cybersecurity Division that will be headed by LANCOM founder Ralf Koenzen. Koenzen will continue to manage LANCOM's business together with previous Co-Managing Director Stefan Herrlich.

LANCOM cloud solution puts wind underneath Air Zermatt's wings

Every second counts in mountain rescue, which is why the Upper Valais helicopter company Air Zermatt relies on a cloud based network from LANCOM Systems. The long-standing aviation company uses this network during its rescue missions to make sure that all necessary operation data is collected and made available extremely quickly. Swiss IT service provider Seabix is responsible for ensuring that everything functions smoothly.

Air Zermatt, which apart from rescue missions also operates transport and tourist flights, has moved its IT network to a cloud.

The hardware – routers, switches, WLAN access points – and the network management solution are from LANCOM. Management of the infrastructure has been outsourced to managed service provider Seabix AG, who manages and monitors the entire network from any location via a simple internet connection (software defined networking). Unlike conventional network management approaches, this allows fast remote intervention in the event of a crisis. The "made in Germany" solution provides maximum data protection and data security.

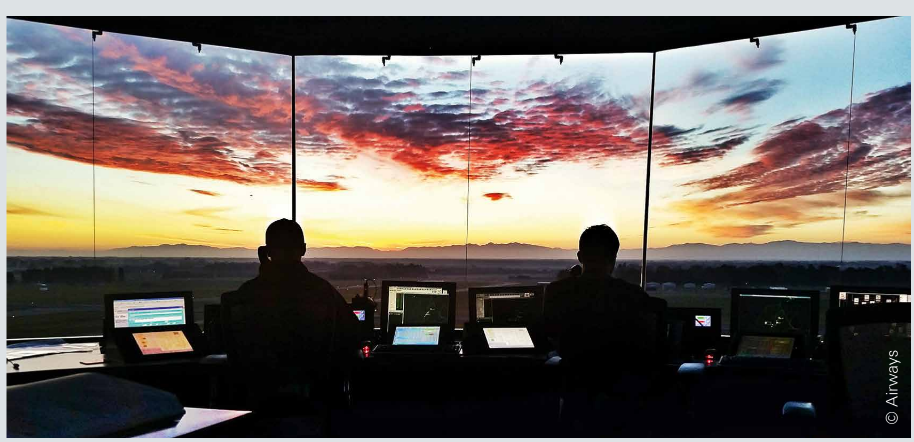
Help arrives quickly: Air Zermatt mountain rescuers quickly arrive at the accident scene thanks to the fast alert notification via the LANCOM network.

New Zealand's ATM provider chooses Rohde & Schwarz as its modernization partner

Over the next few years, New Zealand's air navigation service provider Airways will be modernizing the country's entire air traffic management (ATM) infrastructure. It has selected Rohde & Schwarz as the supplier for the voice communications system – the heart of the ATM.

In two tranches, the nationwide air traffic management locations will be equipped with four redundant IP-based R&S®VCS-4G communications systems. Tranche 1 consists of the equipment for the air traffic management centers in Auckland and Christchurch. Tranche 2 (scheduled for 2021) will upgrade another 22 locations across the country.

The overall project includes delivery, implementation and lifelong support of over 200 controller workstations, new ATC radios and various ground-to-ground communications links. Rohde & Schwarz Australia will manage the project.



Paradise for air traffic controllers: the view from the Christchurch tower stretches to the distant horizon. State-of-the-art ATC radio technology will make it an even more exciting place to work.

Rohde & Schwarz partner of Netflix Production Technology Alliance

At the IBC trade show in 2018, Netflix launched its Production Technology Alliance Product (PTAP) program. Rohde & Schwarz is involved with its R&S®CLIPSTER mastering station, which is used in the post production and playout of many original Netflix productions. The PTAP program includes products that meet current and future Netflix specifications. The PTAP logo informs Netflix post production partners that the product complies with Netflix requirements. As a member of the Alliance, Rohde & Schwarz has access to the Netflix technical roadmap and can continue to develop products with the desired functions.

Highly advanced EMC anechoic chambers opened in Vietnam

Rohde & Schwarz Asia (RS Asia) has built an EMC test center commissioned by the Authority of Radio Frequency Management (ARFM) of the Ministry of Information and Communication. RS Asia has equipped the center with all T&M equipment required for standard-compliant EMC measurements.

At the opening ceremony, Doan Quang Hoan (Director General of ARFM) praised the cooperation with Rohde & Schwarz. The highly advanced anechoic chamber meets the highest requirements that domestic and foreign compliance standards place on a test environment.

The new anechoic chamber was opened in Ho Chi Minh City in a ceremony attended by high-ranking customer representatives.

FM is alive

Despite all digitization trends, in many countries FM is holding its own as a robust, standard radio technology. The necessary broadcasting infrastructures are being upgraded or built. Two recent examples:

Record-breaking FM transmitter delivered

The largest FM transmitter system ever built by Rohde & Schwarz is being installed in Peru. The media group CRP Medios y Entretenimiento S.A.C. has constructed a new building specifically to house this transmitter system. In April 2018, the customer chose the Rohde & Schwarz solution because of its compact design. The six meter wide system consists of eight 30 kW R&S®THR9 transmitters that each broadcast a single program and a 20 kW standby transmitter. Rohde & Schwarz is the only manufacturer that offers liquid-cooled VHF FM transmitters. These transmitters are not only compact, they are also extremely energy efficient, quiet and low maintenance.

The most compact transmitter of its type, but still enormous. Nine racks are needed to provide the required output power, including standby capacity.

FM transmitter for the highest building in Turkey

Çamlıca Tower in Istanbul, the tallest building in Turkey at 369 meters, is currently under construction. After its completion, it will broadcast radio and TV programs to the metropolitan area. Rohde & Schwarz is supplying the FM transmitters. Eighty 5 kW transmitters from the R&S®THR9 family will broadcast all local programs. Ten more will serve as standby transmitters. Once again, the compactness and energy efficiency of the liquid-cooled R&S®THR9 transmitters were the deciding factors for winning the order.

The futuristic Çamlıca Tower (shown here as a computer graphic) will dominate the Istanbul skyline.