# NEWS

206/12

ROHDE&SCHWARZ


# Focus on AV interfaces

**Two new testers put analog and digital audio / video interfaces such as HDMI and MHL™ through their paces – from protocol tests to realtime analysis of media content.**

WIRELESS TECHNOLOGIES

**RF switch matrix boosts productivity in wireless device manufacturing**

GENERAL PURPOSE

**Expanded oscilloscope family: new models and new probes**

GENERAL PURPOSE

**Power sensors for production: fast, reliable and cost-effective**

## NEWS

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# Cover feature

Set-top boxes, tablet PCs, smartphones – all these devices have analog or digital audio / video interfaces such as HDMI and MHL™ that have to undergo numerous interoperability and application tests during development and production.

The two new audio / video test platforms from Rohde&Schwarz – one for development (photo) and a compact version for manufacturing applications – are the first on the market capable of carrying out all required measurements. They not only perform protocol tests and audio / video measurements, they also analyze media content in realtime. Test modules allow users to tailor the testers to their specific tasks. Manufacturers benefit from a test platform that provides simpler, more cost-effective testing than other setups.

# Overview

# NEWS 206/12

## WIRELESS TECHNOLOGIES

### Testers





### Coverage measurement systems



### Spectrum / signal analyzers



The R&S®TSMW universal radio network analyzer and the R&S®ROMES4 drive test software are an unbeatable pair for analysis and optimization work on TETRA networks (page 8). And they help answer the question in which cells of a mobile radio network investment in LTE MIMO pays off (page 13).

## GENERAL PURPOSE

### Oscilloscopes



### Power meters / voltmeters





EMC / FIELD STRENGTH



BROADCASTING



The R&S®VTE video tester and the R&S®VTS compact video tester test analog and digital audio / video interfaces such as HDMI and MHL™ on consumer electronics equipment – from protocol tests to realtime analysis of media content (page 32).





MISCELLANEOUS

# R&S®CMWS: increased efficiency in wireless device production

Shorter production times and lower costs are critical as the complexity of wireless devices continues to grow. The right solution: the R&S®CMWS advanced RF switch matrix. Together with the R&S®CMW500 wideband radio communication tester, it helps to considerably boost productivity in manufacturing environments.

## Reducing the test time

As more and more tests are required on wireless devices, test time must be minimized as much as possible in order to manage the costs generated in production. In terms of the required time for transmitter tests, the savings potential has already been largely exploited, although further optimization is possible with the multi-evaluation list mode option (R&S®CMW-KM012) for the R&S®CMW500 wideband radio communication tester.

It is much more productive to concentrate on receiver tests, especially on bit error ratio (BER) measurements. They can be shortened by performing the measurements simultaneously on as many devices under test (DUTs) as possible. The key is the new R&S®CMWS advanced RF switch matrix: It simultaneously distributes the test signal from the R&S®CMW500 via its 24 RF ports in non-signaling mode to up to 24 DUTs (Figs. 1 and 2).

## Suitable for production: versatile and straightforward

The R&S®CMWS ideally adapts to the user's production and test run requirements. Two different RF switch boards are available as options and – depending on the actual requirements – one to a maximum of three of these units can be integrated into the switch matrix. The R&S®CMW500 directly controls the R&S®CMWS. The main benefit is straightforward operation when using all the tester's non-signaling features. Moreover, everything runs automatically and in realtime since control of the R&S®CMWS is integrated into the software of the R&S®CMW500.

## Suitable for production: easy to calibrate

Mobile phone production is mass production, involving intensive use of test instruments along with space shortages and


Fig. 1 Boosting efficiency in production: the R&S®CMW500 wideband radio communication tester with the R&S®CMWS advanced RF switch matrix. The R&S®CMWS simultaneously distributes the test signal from the R&S®CMW500 via its 24 RF ports to up to 24 DUTs.

significant wear and tear on cables and adapters, which results in increased calibration requirements. The R&S®CMWS advanced RF switch matrix is ideal for this environment as it supports convenient calibration of the entire system. The paths the RF signals follow from the R&S®CMW via the R&S®CMWS and the cables to the mobile phone adapter can be calibrated individually in a frequency-dependent manner (Fig. 3). This simplifies regular use and provides the benefits of high measurement accuracy and high yield in production.

## Summary

The R&S®CMWS advanced RF switch matrix helps to significantly boost the productivity of the R&S®CMW500 wideband radio communication tester in wireless device production. Adaptation of multiple DUTs to an R&S®CMW500 using changing setups with discrete RF components or plain RF switching matrices is now a thing of the past.

Gottfried Holzmann

**R&S®CMWS: block diagram**

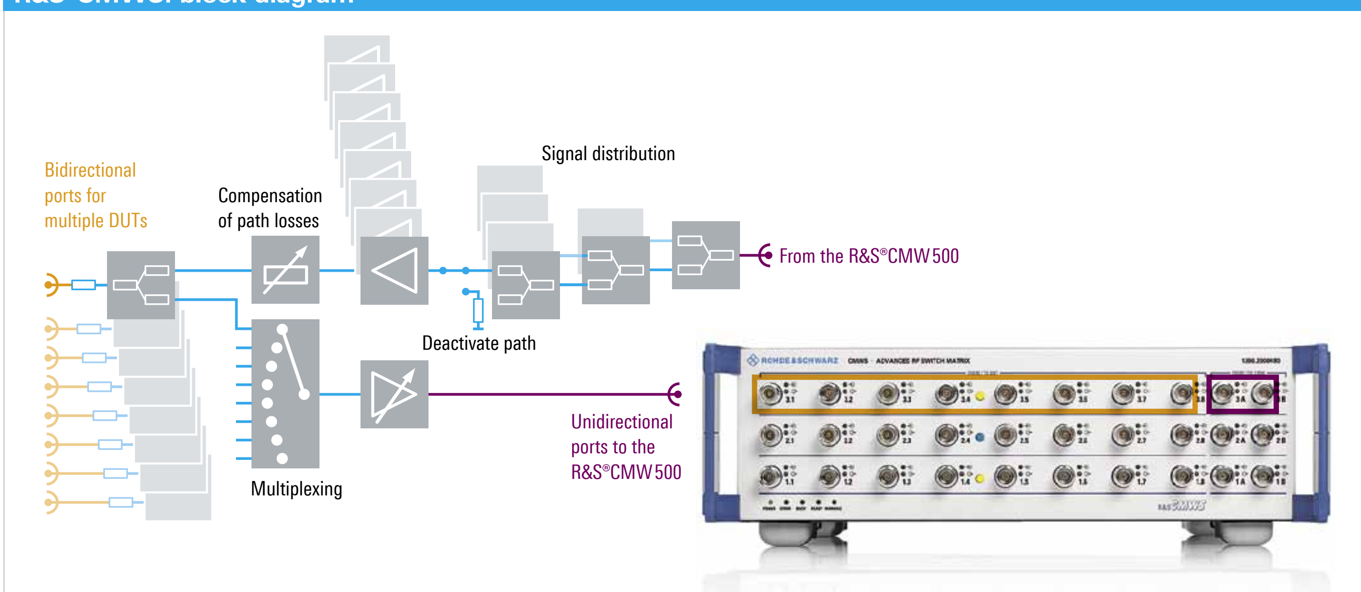



Fig. 2 Operating principle of the R&S®CMWS advanced RF switch matrix.

**Switching example**

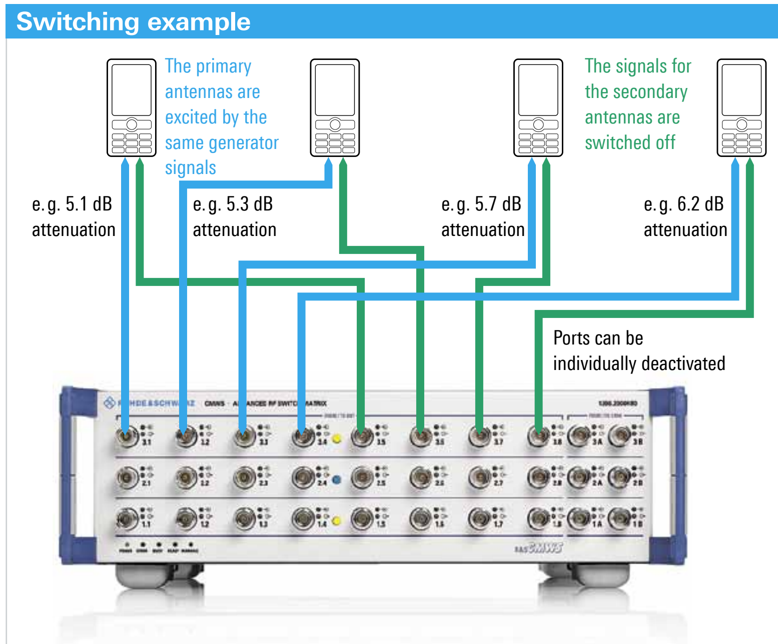



Fig. 3 Four mobile phones on one R&S®CMWS-B81A RF switch board. Path losses are individually compensated.

# Comprehensive and uncompromising: drive test system analyzes TETRA networks

The new drive test system allows assessment of the coverage and quality of service of TETRA networks. The system consists of the R&S®TSMW universal radio network analyzer and the R&S®ROMES4 drive test software. It handles all aspects of mobile measurement data acquisition and presentation, including in-depth analysis. This is one of the prerequisites for top operational reliability and availability of these networks for professional applications.

## Extremely high availability is a must

TETRA communications networks for government authorities and industry must provide operational reliability and availability at all times. Suitable T&M equipment is therefore very important in the planning and setup phase as well as during subsequent operation, and also is a key element for preventing problems. Drive tests provide information about the actual conditions prevailing in the network and especially on the air interface. There are three categories of tests that overlap to some extent and are best combined as part of a measurement campaign:

- Coverage measurements
- Quality of service measurements
- Troubleshooting measurements

See page 13 for a description of how the R&S®TSMW universal radio network analyzer and the R&S®ROMES4 drive test software help in LTE systems to assess where it will pay off to invest in additional network equipment.


Fig. 1 The R&S®TSMW universal radio network analyzer and the R&S®ROMES4 drive test software are an unbeatable pair for analysis and optimization work on TETRA networks — both during network setup and also for ensuring troublefree operation over the long term.

## Ensuring radio coverage

Coverage measurements provide exact, reproducible verification of the TETRA mobile radio coverage in a region or a country. Drive tests are performed to record the transmitted power for all cells along the drive, as well as qualitative properties of the TETRA signals and parameters of the radio channel. These measurements are passive and do not have any influence on the network. They provide valuable data for the following applications:

- Comparison of actual radio coverage with planned radio network and infrastructure specifications
- Frequency coordination with adjacent networks
- Investigation of signal-to-noise ratios and multipath propagation

Coverage measurements are frequently performed during network setup. However, they are also useful in the long term for ongoing network optimization in order to ensure sustainable, high-quality radio coverage in the area.

Rohde & Schwarz has developed compact and extremely powerful T&M equipment for such applications: The R&S®TSMW universal radio network analyzer (Fig. 1) works with the R&S®TSMW-K26 TETRA option and the R&S®ROMES4 drive test software to determine all relevant parameters — with unmatched accuracy and speed. During coverage measurements, the R&S®TSMW uses its two 20 MHz wide frontends to scan one or two TETRA bands, each containing up to 600 adjacent channels, several times per second. Besides the signal power for each cell that is detected, the following additional parameters are determined:

- Frequency, carrier and main carrier
- Mobile country code (MCC), mobile network code (MNC) and location area (LA)
- Channel power and received signal power (including correction of transducer factors and cable losses)
- Signal-to-noise ratio (SNR)
- Timeslot number (TN), TDMA frame number (FN), TDMA multiframe number (MFN)
- Various bit error rates (BER)
- Frequency errors and phase errors
- Delay spread
- Inband spectrum
- Constellation diagram (QPSK)
- Channel impulse response (CIR) for multipath propagation
- Co-channel interference

In addition, the drive test system determines the system information for all cells by demodulating the non-crypted elements of the protocol data units (PDU).

After the drive test, the network coverage can be analyzed during the postprocessing phase using the R&S®ROMES4N15 network performance analyzer software option (coverage plug-in) to obtain coverage statistics. The network coverage analyzer aggregates the data of multiple measurement campaigns and allows convenient analysis of coverage and interference within the network, or from neighboring networks (Fig. 2). For comparison purposes, the TETRA network's planning data plots can be overlaid on the map. The software can automatically generate reports for all the analyses in Excel, HTML or PDF format.

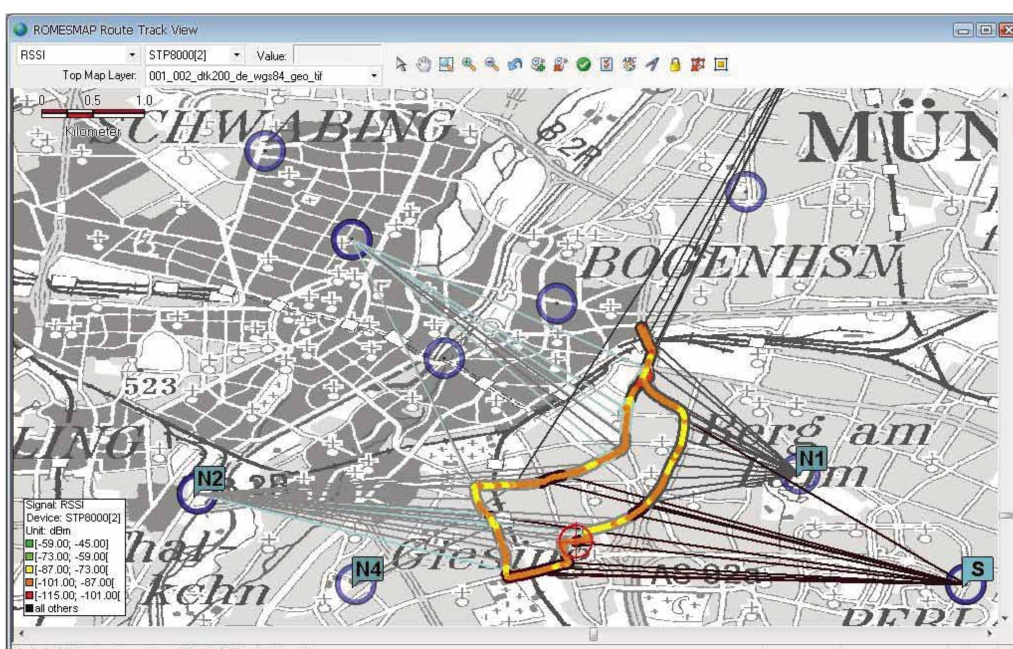



Fig. 2 Map display and TETRA terminal behavior.

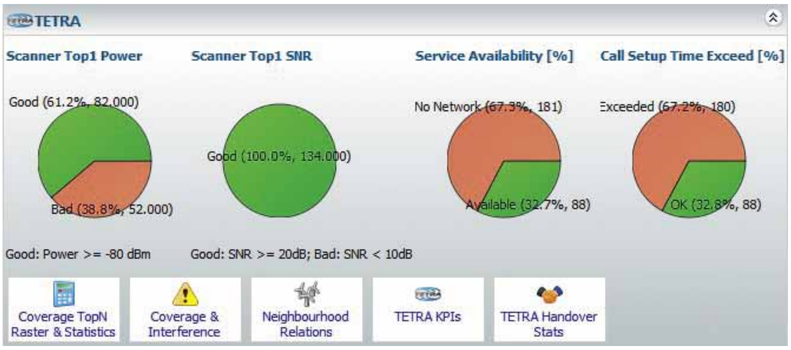



Fig. 3 Analysis of quality of service.

## Quality of service measurements for dependable network quality

Quality of service from the user's perspective is measured based on specifications in order to enable reproducible comparisons in area and time. Unlike coverage measurements, quality of service measurements are active, meaning they participate in TETRA network operation to obtain the required data. The European Telecommunications Standards Institute (ETSI) specified most of these measurements. However, there are often other parameters that need to be measured which the infrastructure provider or user must verify on an individual basis.

Quality of service measurements (Fig. 3) assess a number of trigger points during productive operation and use this data to compute certain quality of service parameters. These parameters are then compared with the agreed service level for a given network. These measurements help in the following cases:

- Verification of agreed specifications for the network
- Evaluation of network quality (also from user's perspective)
- Identification of spots where disruptions frequently occur

Since these measurements reflect the actual user perception in TETRA networks, they cover intrinsic network properties and end-to-end quality parameters during network operation for group calls and individual calls as well as the short data service (SDS). During the automatic measurements as part of the drive tests, however, certain quality of service measurements cannot be conducted reasonably (such as emergency and assistance calls, tactical status messages and alarms) since they could have unacceptable consequences in an operational network.

TETRA terminals that are controlled by the R&S®ROMES4 software are used exclusively for quality of service measurements. The terminals assess a large amount of signaling information as well as the voice quality in line with ITU P.862.

As in coverage measurements, the results of the quality of service measurements undergo postprocessing. In this case, the network performance analyzer software (NPA, R&S®ROMES4N11 option) is used to determine the wquality of service (QoS) parameters. Users can customize numerous possible settings that go beyond the selected standard to perform individual evaluation of the service level for all time points and in all regions.

## Troubleshooting

Any interference occurring in the network must be detected and corrected as quickly as possible. Problems may have diverse reasons, but the main trouble sources in TETRA are:

- Interference in a TETRA network due to insufficient planning or overreach
- Shadow effects and multipath propagation
- Interference caused by other networks
- Interference caused by external emissions
- Interference caused by faulty network components (e.g. repeaters, terminals, base station amplifier output stages)
- Problems in the core network (not covered here)

Rohde&Schwarz is well positioned to analyze interference in TETRA networks due to the company's extensive experience with GSM technology which has similar signal characteristics. Detecting and analyzing the causes of interference in a fast and pinpoint manner requires the ability to combine the measurement data from the scanner and terminal.

In principle, detection of interference in the field is handled in a similar manner to coverage and quality of service measurements with a vehicle, PC, software, radio network analyzer and terminals. Analysis is performed using the R&S®ROMES4N17 software option (handover and neighborhood analysis) for the network performance analyzer. It shows all the locations designated as "problem spots" based on adjustable criteria. These locations are divided into different categories (Fig. 4):

- Coverage problems
- Interference problems
- Handover problems
- Network problems
- SDS problems

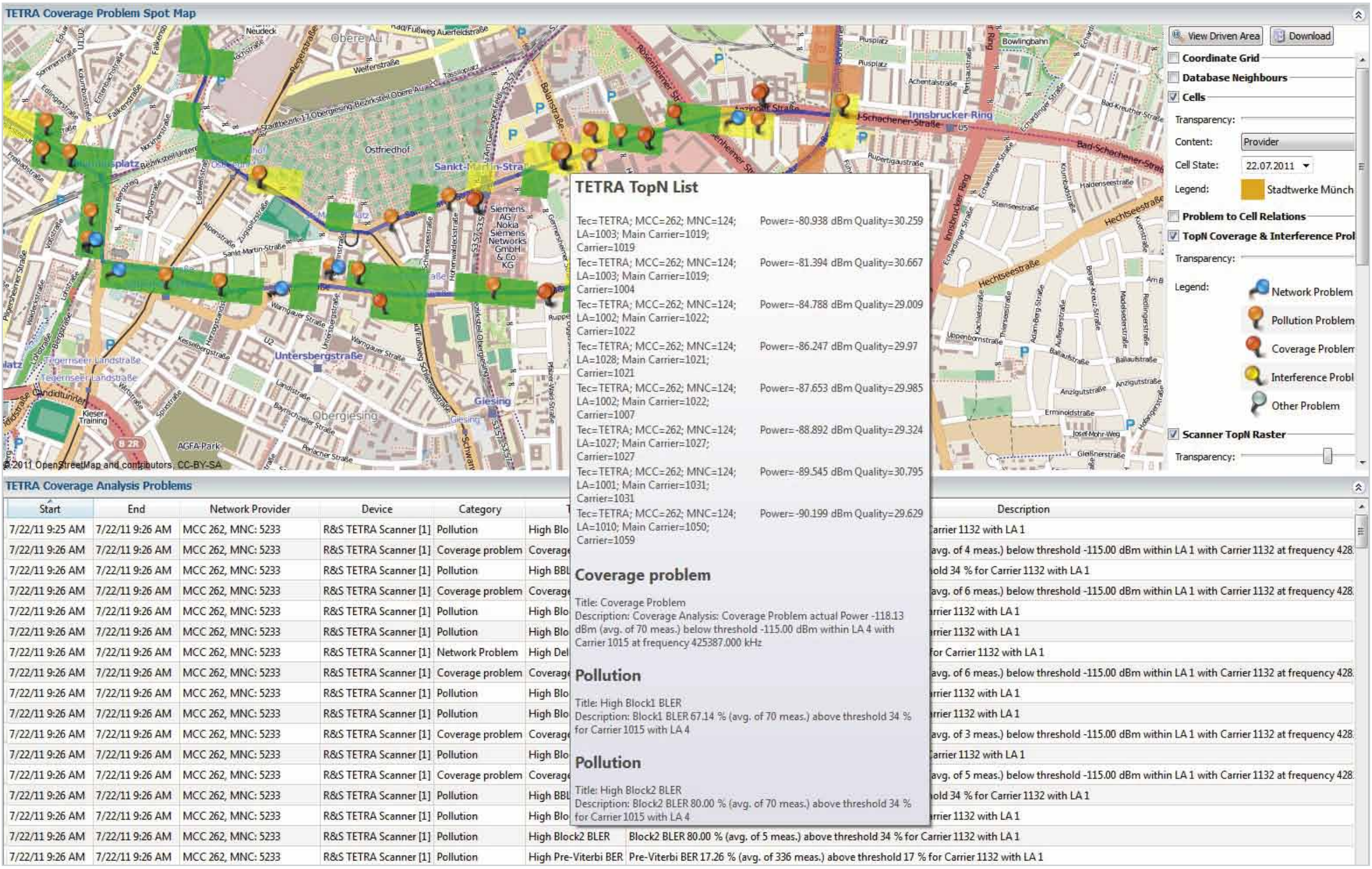
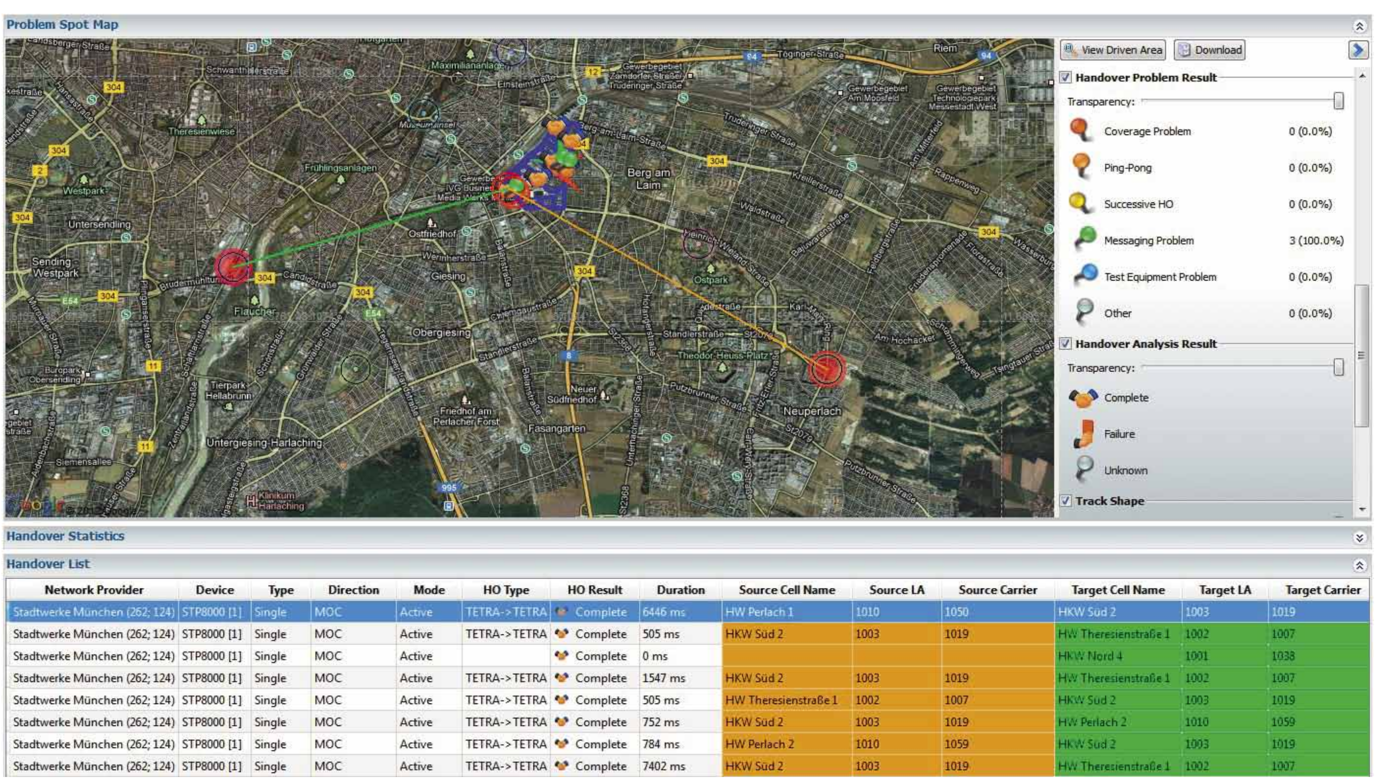



Fig. 4 TETRA problem analysis.

Fig. 5 TETRA handover analysis.



Handover analysis (Fig. 5) and neighborhood analysis are very powerful modules. They provide all relevant information about each individual handover or the neighborhoods along with possible causes of any problems that were identified.

The scanner and terminal signaling information is used to determine all sources of interference. This information is provided with as much detail as possible for each of the problem spots. Most problems can be identified with the information obtained by the drive test system, meaning that final, intensive and specific measurements in the field are often not required.

## Special measurements

As an option for coverage measurements, the R&S®TSMW can also estimate the position of TETRA base stations (Fig. 6). The analyzer saves all the cells it finds in a database. As an addition to the drive tests, the Rohde & Schwarz R&S®DDF0xA and R&S®DDF0xE direction finders can be used to determine the position of base stations and terminals.

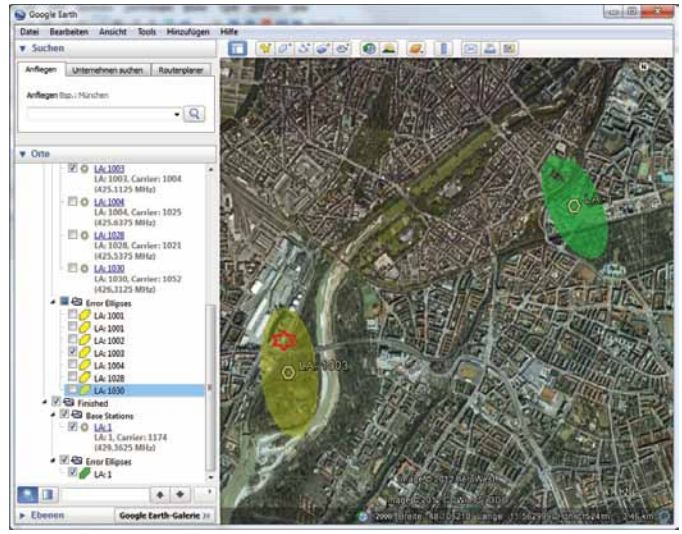


Fig. 6 Estimation of the position of TETRA base stations.

In principle, measurement of TETRA cells assigned to airborne operation is similar to measurements made using a vehicle. However, it is somewhat more difficult to integrate the measuring system into the aircraft and to select and mount the necessary antennas. The flight path and altitude are recorded using GPS.

The TETRA enhanced data service (TEDS) can be tested using a scanner and the R&S®TSMW-K26Q option. Suitable terminals are not yet available for quality of service measurements within R&S®ROMES4. This option extends the scanner's parameters to include TEDS-specific parts such as:

- Modulation type
- Code rate
- Burst, header and pilot modulation error rate
- Data message erasure rate
- SICH, AACH and data error rate
- Expansion of the constellation diagram

LTE is already available as a broadband expansion for TETRA. It will further boost the requirements for quality and operational reliability in these networks. Rohde & Schwarz is already a leader in the field of drive test systems for commercial LTE networks. These strengths can be ideally exploited in combined TETRA and LTE drive tests. The R&S®TSMW measures TETRA on the first RF channel and LTE independently on the second RF channel. Terminals that implement the respective mobile radio standards are used for the quality of service measurements.

Direct mode operation (DMO) and indoor measurements have been hot topics for TETRA users in recent times. The R&S®TSMW-K26D DMO option will be available for the R&S®TSMW in September 2012. It is supported by R&S®ROMES.

The R&S®TSMW-K27 option enables spectrum analysis in parallel to the scanner measurements. This is particularly relevant on the TETRA uplink and downlink bands. A waterfall display of the spectrum is especially helpful for visually identifying interference.

## Summary

The R&S®TSMW universal radio network analyzer and the R&S®ROMES4 drive test software are an unbeatable pair for analysis and optimization work on public and private TETRA networks — both during network setup and also for ensuring troublefree operation over the long term. In the future, too, Rohde & Schwarz measuring systems will retain their cutting-edge position in drive testing for terrestrial trunked radio, providing a comprehensive, integrated solution for all types of network problems at any time.

Wolf Seidl

# In which cells of a mobile radio network does investment in LTE MIMO pay off?

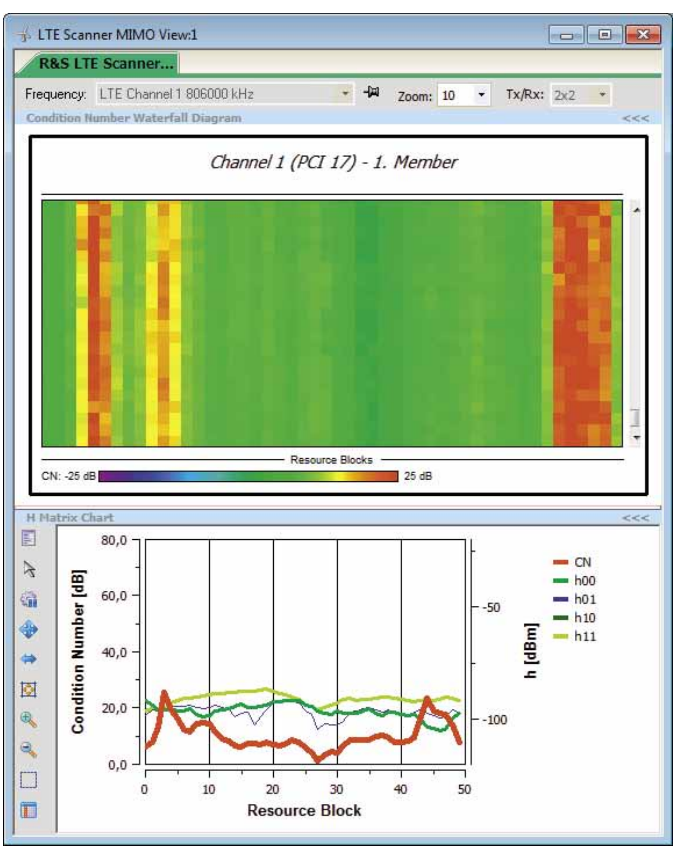
This is a question many network operators ask themselves. A Rohde & Schwarz drive test system can help with the answer: the R&S®TSMW universal radio network analyzer used together with the R&S®ROMES 4 test software. This system can measure MIMO channels without the use of a test mobile phone. It also enables operators to assess the quality of a channel, find out where MIMO works best and, most importantly, evaluate where an investment in additional network equipment pays off.

## MIMO: not always a guarantee for higher data throughput

Using multiple-antenna technologies such as MIMO does not always guarantee higher data rates. If network operators want to know where an investment in MIMO pays off, they have to analyze the channel condition – a task that requires a lot of experience.

The following example illustrates how difficult it is to assess the MIMO characteristics of a radio channel: When headlights approach in the darkness, it is at first impossible for the naked eye to recognize if it is a car or a motorbike, i.e. if it is a vehicle with one or two headlights. Only when the vehicle comes closer is it possible to discern between the two. The same is true for MIMO receivers: From what distance is a MIMO signal clearly identifiable and can therefore help to increase data throughput? This question has to do with what is known as the condition.

Fig. 1 Display of the condition number versus resource blocks (horizontal) and time (vertical).




## A question of condition

The mathematical term "condition" describes certain properties of a matrix. The matrix of a MIMO channel consists of the amplitude and phase of each signal path (a total of four paths for 2 × 2 MIMO). The R&S®TSMW universal radio network analyzer can measure the paths' amplitude and phase and use them to calculate the condition. A good condition allows reliable separation of the signals (similar to differentiating between one or two headlights as described in the above example). If the condition is poor, the receiver is unable to make this distinction.

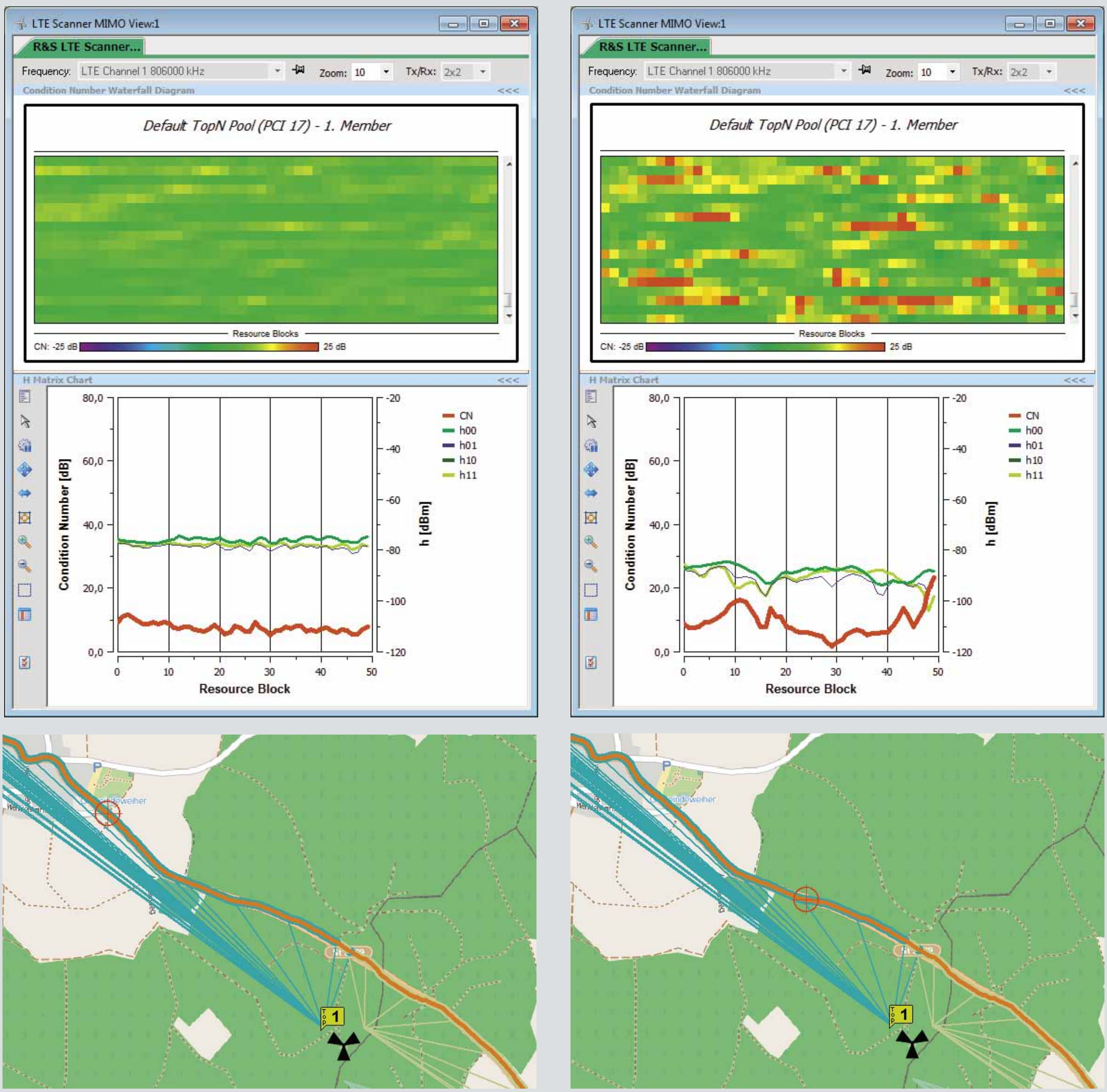
The condition is described by the condition number in dB. The R&S®ROMES 4 test software can display this number per cell and per resource block. This means that the MIMO capability within an up to 20 MHz wide LTE signal can be measured across the spectrum. Measurements prove that a bandwidth of this size is required (Fig. 1). For background information and details on calculating the condition number and understanding its significance, see Application Note 1SP18 from Rohde & Schwarz (available for download on the Rohde & Schwarz website).

### A real-world example

Practice has shown that the MIMO capability of a channel depends, for example, on whether there is a line-of-sight (LOS) connection to the base station or not (non-line-of-sight, NLOS). With a LOS connection, the MIMO channel quality is hardly affected by reflections. If the LOS connection is lost, the radio link is usually maintained. However, the quality of the MIMO channel decreases because it becomes frequency-selective due to multipath propagation and the resulting reflections.

Fig. 2 compares LOS and NLOS connections. The upper section shows the condition number as a waterfall diagram. For each timestamp there is a line consisting of multiple measurement results per resource block (up to 100 at 20 MHz). The more red areas there are in the waterfall diagram, the less suitable the channel is for MIMO. The diagram underneath shows the condition number (red) and the power values of the channel matrix (e.g. h00).

Fig. 2 In LOS operation (left), cross-polarized transmit and receive antennas ensure a good and, more importantly, frequency-independent MIMO channel condition. Although the MIMO channel condition is no worse in NLOS operation (driving through a forest, right), it becomes frequency-selective as a result of multipath propagation.



## Optimizing MIMO mobile radio networks

Mobile radio standards such as GSM/WCDMA mostly use SISO together with transmit and receive diversity. The performance quality of the radio channel and the theoretical channel capacity can be determined. Channel capacity is determined by the known bandwidth and the measurable signal to interference and noise ratio (SINR). This is also true for MIMO, where, however, the MIMO channel quality as well as the SINR must be taken into account.

It is possible for a MIMO link to have low data throughput even though it has a large SINR or for a MIMO link with a low SINR to have high data rates – it depends on how suitable a channel is for MIMO. The suitability depends on the distance to the LTE base station, on antenna geometry and multipath propagation. In general, the SINR is a measure of a signal's interference, and the condition number is a measure of a channel's MIMO capability.

The Rohde&Schwarz drive test system helps network operators gain experience in these complex relationships and find answers to the questions of where MIMO works best and how far away from the base station the receiver can be located. There is a significant difference, for instance, between a macro (outdoor) and a micro (indoor) cell, and between their MIMO channels. The experience gained helps when expanding LTE networks and, most of all, when positioning new LTE cells.

Another important planning parameter other than a cell's positioning is antenna geometry. MIMO data streams in a 2×2 MIMO LTE system are generally separated with the help of different polarizations (cross-polarization at ±45 °). Sufficient orthogonality can also be achieved with line-of-sight connections and small antenna housings. In order for the R&S®TSMW to measure the channel like a test mobile phone, MIMO reference antennas are used, because they can make the best use of the special properties of MIMO.

## Summary

The Rohde&Schwarz drive test system, consisting of the R&S®ROMES4 test software and the R&S®TSMW universal radio network analyzer, enables testing of LTE and MIMO under real-world conditions. The system makes it easier to understand MIMO's efficiency and helps maximize the performance of an LTE mobile radio network. With its optimized wizard, R&S®ROMES4 can be configured within seconds; the measurement system is put into operation quickly and easily.

Stefan Schindler

### Key features

- LTE MIMO measurements are possible in all current and future frequency bands
- At the same time, measurements can be performed in other mobile radio standards such as GSM/WCDMA, CDMA2000®/EV-DO, TETRA and WiMAX™; spectrum scans can also be carried out
- The R&S®TSMW universal radio network analyzer automatically recognizes the LTE signal bandwidth
- The MIMO channel matrix can be exported to Excel
- Existing R&S®TSMW universal radio network analyzers can be software-upgraded in the field for LTE MIMO testing

### Application examples

- Sensible positioning of LTE base stations at rollout
- Optimizing the performance of LTE networks
- Testing LTE base stations before and after software updates
- Measuring MIMO antennas
- Reproducing MIMO channels with a fading simulator

### Required options

- R&S®ROMES test software version 4.65 or later
- R&S®TSMW with the R&S®TSMW-K29 and R&S®TSMW-K30 options
- R&S®TSMW-Z7 (700 MHz) or R&S®TSMW-Z8 (multiple frequency bands) MIMO reference measurement antenna

# At the push of a button: signal analysis in line with WLAN 802.11ac

The R&S®FSW signal and spectrum analyzer can measure signals in line with the IEEE 802.11ac WLAN standard with an accuracy that was previously unattainable in these bandwidths. In order to do this, it needs to be equipped with the R&S®FSW-K91 / -K91AC options.

## All measurements for the new WLAN standard

Today's laptops and smartphones support the IEEE 802.11g or 802.11n standard for WLAN access to the Internet. However, more recent applications, such as video transmission in HD quality, require higher data rates than can be achieved with previous methods. To meet this demand, the IEEE 802.11 task group started defining the 802.11ac [1] standard about four years ago. This standard provides for significantly faster data rates, is backward compatible with older standards such as 802.11a and 802.11n and, like these older standards, also works in the 5 GHz band.

In order to achieve all of these objectives, the 802.11ac standard is based on orthogonal frequency division multiplexing (OFDM), as are 802.11a and 802.11n. However, 802.11ac delivers four times the bandwidth of 802.11n (up to 160 MHz) with the OFDM method. 256QAM modulation and up to eight multiple input multiple output (MIMO) data streams are also available. These expansions as well as more efficient information transmission make it possible to achieve data rates of up to 3.5 Gbits/s.

Semiconductor manufacturers are currently developing the first functional chipsets for the 80 MHz bandwidth. Commercially available WLAN modules for the new standard are expected at the end of this year, and 160 MHz modules will come on the market approximately one year later. During this start-up phase there is a high demand for suitable test equipment – both in development labs and also for the production of first small-scale batches.

To ensure that transmitters work in line with the 802.11ac standard, a comprehensive range of measurements is required. Whereas spectral properties such as spectrum emission mask (SEM) or adjacent channel leakage ratio (ACLR) can be measured with a mid-range spectrum analyzer, it is a special challenge to measure the modulation characteristics – because the signal, with its entire bandwidth of up to 160 MHz, has to be recorded and demodulated. A signal analyzer has to have an analysis bandwidth of 160 MHz, its frequency response must be as linear as possible across this range, and it must have an excellent dynamic range in order to measure, for example, the error vector magnitude (EVM), a parameter that describes the modulation quality. For 256QAM, for instance, the standard specifies a minimum EVM of –32 dB. In order to reliably measure this, the residual EVM of the measuring instrument, i.e. the error vector that is generated by the instrument itself, should be at least 10 dB better. The residual EVM is caused by the phase noise of the local oscillator, unwanted interference and other internal noise sources such as amplifiers and switches. An EVM of < –40 dB at a bandwidth of 160 MHz is difficult to achieve

The R&S®FSW signal and spectrum analyzer was the first analyzer on the market to offer a signal analysis bandwidth of 160 MHz. Its measurement functions, such as the multistandard radio analyzer, are essential to developers of mobile radio base stations in line with multiple standards or frequency-hopping radio systems and their components. Developers and manufacturers in the A&D segment will particularly appreciate the R&S®FSW's low phase noise, the signal analysis bandwidth and the pulse measurement option. And everyone will appreciate the convenient touchscreen operation.
A detailed article about the R&S®FSW can be found in NEWS (2011) No. 204, starting on page 32.

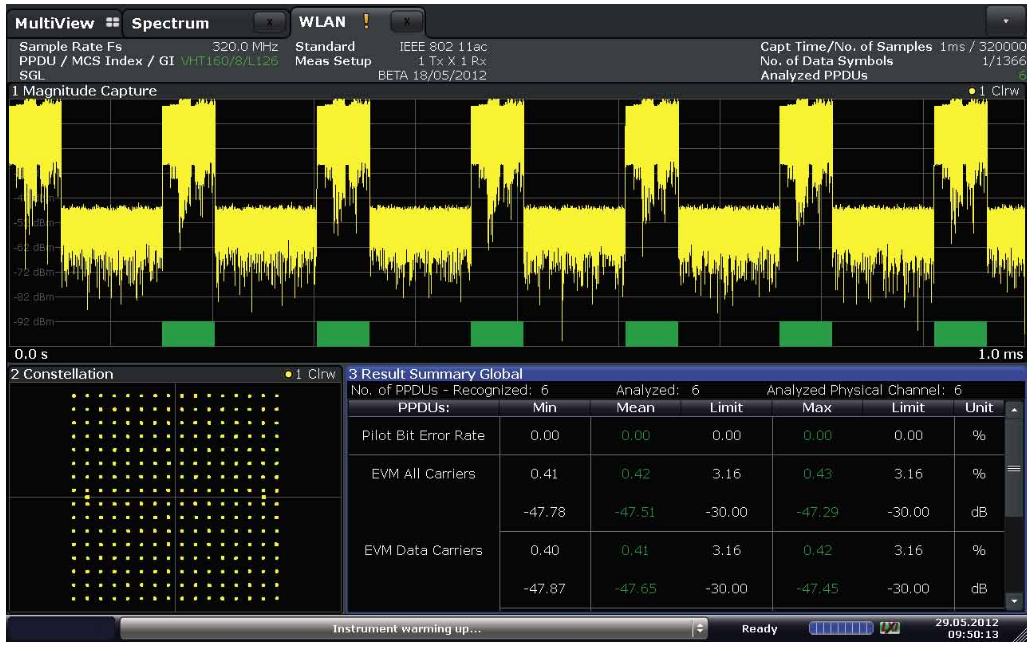



Fig. 1 Typical measurement of an 802.11ac WLAN signal. The user can conveniently configure the screen display in order to see the signal in the time domain where valid bursts are highlighted in green, to view a tabular list of modulation characteristics, and to look at the constellation diagram or other measuring parameters such as EVM versus frequency or time.


Fig. 2 802.11ac WLAN signal with an EVM of –32 dB.

with mid-range analyzers. Developers of chipsets, components and modules for IEEE 802.11ac therefore require high-end test and measurement equipment in their labs.

The R&S®FSW signal and spectrum analyzer can measure these signals at the push of a button when equipped with the R&S®FSW-K91 (measurements in line with 802.11a / b / g) and R&S®FSW-K91AC (measurements in line with 802.11ac) options. It can also be used to perform all spectral measurements defined in the standard. Equipped with the R&S®FSW-B160 option, it can record and demodulate an up to 160 MHz wide 802.11ac signal and measure its modulation quality and other I/Q-based parameters such as spectrum flatness, I/Q frequency error and center frequency error. It also has no problems with a residual EVM of < –45 dB thanks to its outstanding RF characteristics.

Measurements are extremely easy to perform: Simply set the transmit frequency and push a button to start the measurement. The R&S®FSW automatically determines the other parameters, such as the bandwidth and modulation type. Fig. 1 shows a typical measurement of an 802.11ac signal with 160 MHz bandwidth. The user can conveniently configure the versatile screen display. This flexibility makes it

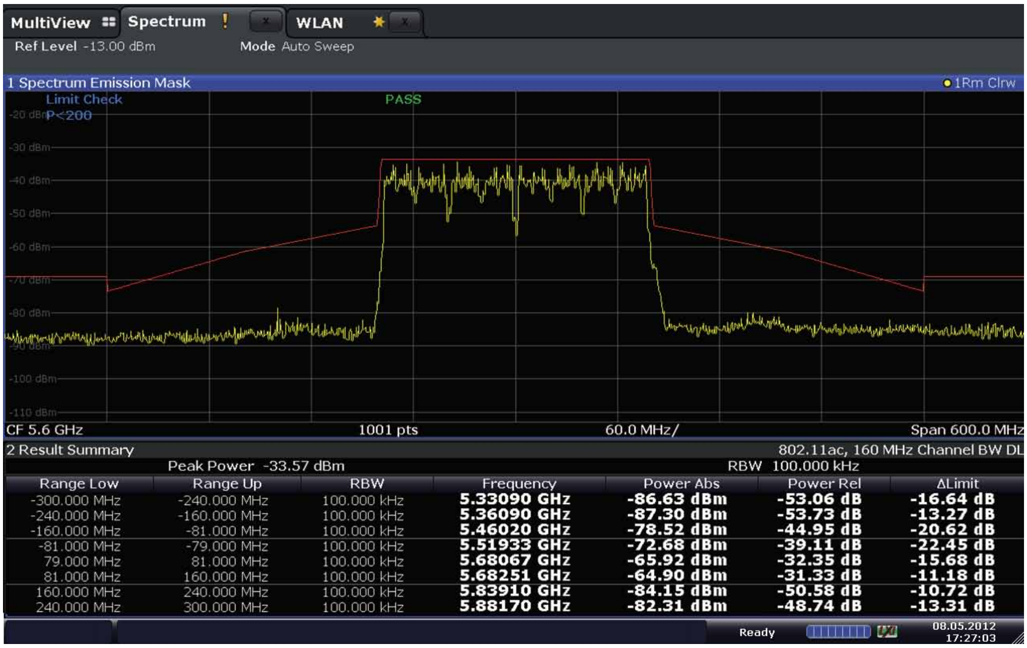



Fig. 3 Spectrum emission mask measurement on a WLAN transmitter.

possible to choose how results are displayed to show all important measurement parameters at a glance. It is no longer necessary to switch between different windows or measuring modes. The R&S®FSW features an extremely low residual EVM. In the example, a value of –46 dBc was measured on an 802.11ac signal originating from Rohde & Schwarz signal generators.

As a comparison, Fig. 2 shows a signal with an EVM of –32 dB. The points in the constellation diagram are significantly more scattered, and further deterioration of the signal quality would lead to bit errors. A measuring instrument with a too high residual EVM would display a worse reading, and would classify the properly functioning WLAN module in this example as inadequate. Mistakes of this kind cannot happen with the R&S®FSW signal and spectrum analyzer. The analyzer performs this measurement in less than 50 ms, making it extremely interesting for use in production.

As a spectrum analyzer it can use the spectral masks defined in the standard in order to measure whether a WLAN application interferes with other transmission standards (Fig. 3). It can also be used to determine whether the adjacent channel power is correct to minimize mutual interference within the band. The R&S®FSW measures the signal in line with the measurement limits specified in the standard. After the signal is demodulated, the bandwidth and performance class are selected automatically.

To examine several transmission paths, e.g. for MIMO signals, multiple R&S®FSW can measure in parallel and then analyze the signal. In the case of repetitive signals, the analyzer can sequentially record the signals from each transmit antenna and then analyze them, and the measurement paths can be changed either manually or automatically using an R&S®OSP switch and control platform.

## Summary

160 MHz analysis bandwidth combined with previously unattainable measuring quality make the R&S®FSW a unique tool for measuring signals in line with IEEE 802.11ac, a tool that is also extremely easy to use. Rohde & Schwarz also offers signal generators for generating 160 MHz wide signals in line with this standard [2], providing a complete measuring package for this new standard.

Dr. Wolfgang Wendler

References

[1] Rohde & Schwarz Application Note 1MA192: 802.11ac Technology Introduction, White Paper.
[2] IEEE 802.11ac standard: WLANs break through the Gigabit barrier. NEWS (2011) No. 204, pp. 16–17.

# Expanded R&S®RTO oscilloscope family opens up new applications

New models, new probes: Rohde&Schwarz continues to systematically broaden its oscilloscope portfolio, opening up new frequency ranges and applications in development, service and production.

## R&S®RTO: models from 600 MHz to 4 GHz

The R&S®RTO oscilloscopes combine high measurement accuracy, high measurement speed and powerful analysis capabilities in a compact format. Rohde&Schwarz now adds new models to its product family: two 600 MHz models with two and four channels for universal use in labs where high sensitivity, high acquisition rates and comprehensive analysis tools play an important role. The new 4 GHz, four-channel model is designed to meet demand for higher bandwidths when developing digital, analog and RF designs, and is the ideal solution for general research, medical technology and the development of RF chipsets.

## Low-noise frontends for measurements on low-voltage signals

The frontends of an oscilloscope must be equipped with low-noise amplifiers to enable accurate measurements on low voltage signals. The 4 GHz model offers a specified noise voltage of < 240 µV at the smallest vertical scaling (1 mV/div). Since noise also depends on the bandwidth, the noise of the 600 MHz model is correspondingly lower: < 80 µV. These excellent values make it possible for the R&S®RTO oscilloscopes to measure with full bandwidth even in the smallest vertical range. Other commercial instruments need to reduce the measurement bandwidth below 10 mV/div to ensure that the waveform noise remains low (Fig. 1).

## High acquisition rate even at 4 GHz

Another unique characteristic of the R&S®RTO oscilloscopes is their high acquisition and analysis rate of up to 1 million waveforms per second. The 4 GHz model also features this high rate thanks to its integrated, extremely powerful ASIC: 8-bit A/D converters sampling at a maximum of 20 Gsample/s deliver data at a rate of 160 Gbit/s, data that the ASIC has to process and write to memory.

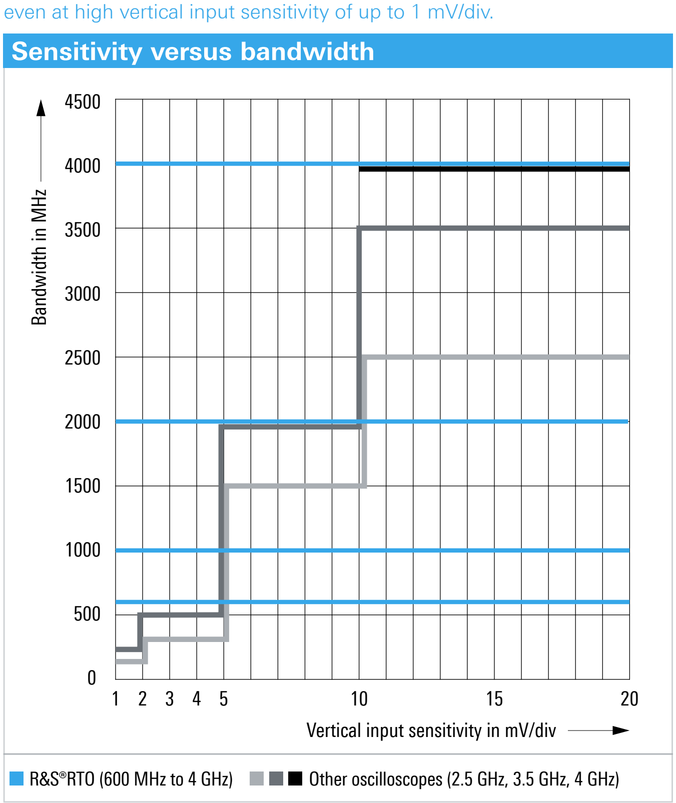
Oscilloscopes are indispensable for debugging, both in development and in service. Therefore, they must be able to observe a signal as often as possible to detect even sporadic faults. The high acquisition rate of the R&S®RTO oscilloscopes can also be fully utilized for analysis functions such as histogram and mask tests, and allows high-speed signal integrity tests up to 4 GHz.

The article starting on page 23 shows an R&S®RTO feature that is unique on the market: the new I/Q data interface.

## Indispensable: analysis in the frequency domain

Compared with time domain measurements, analysis in the frequency domain delivers additional information about the spectral composition of a measurement signal. This can be useful, e.g. to identify interfering components and interfering sources.

Fig. 1 The R&S®RTO oscilloscopes offer full measurement bandwidth, even at high vertical input sensitivity of up to 1 mV/div.



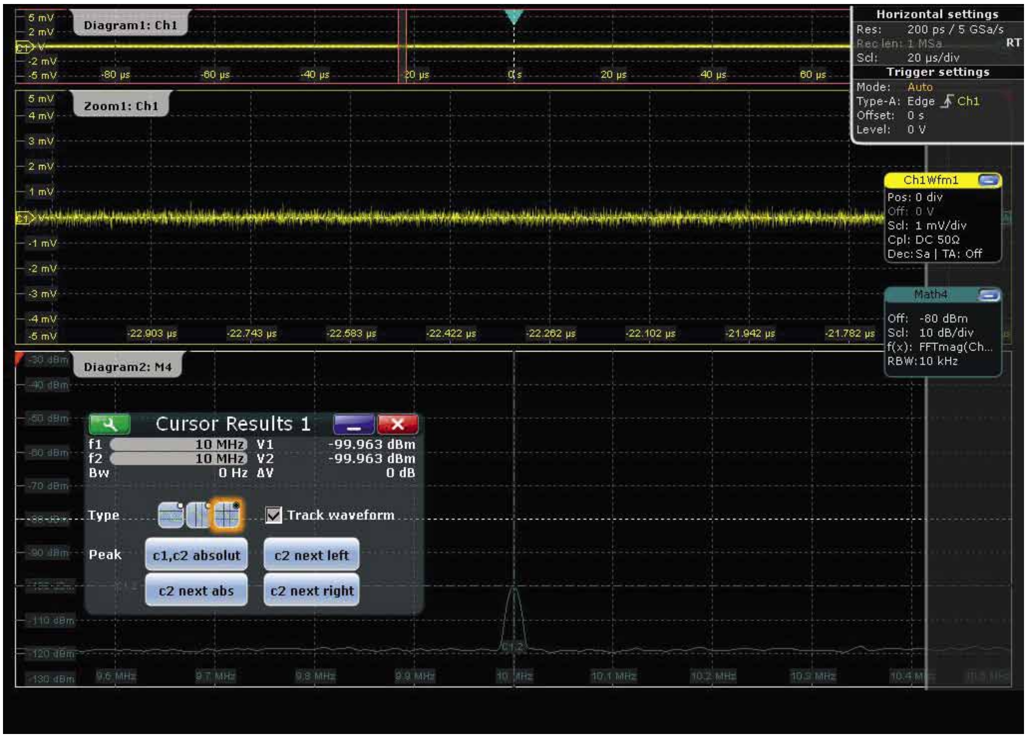



Fig. 2 Thanks to its high dynamic range, the R&S®RTO detects even signals with a level of –100 dBm in the frequency domain.

Many oscilloscopes available on the market can convert waveforms from the time domain into the frequency domain using the FFT function. The advantage of the R&S®RTO is that these calculations are hardware-supported: digital downconversion is used to reduce the data volume for the FFT calculation. The resulting speed advantage enables users to detect and analyze rapid signal changes, sporadic signal interference and weak superimposed signals.

Particularly when analyzing low-voltage signals in the frequency domain, the R&S®RTO oscilloscopes benefit from their low-noise frontend and precise A/D converters. The converters provide an outstanding dynamic range of > 7 bit (ENOB) that can be fully utilized up to 4 GHz (Fig. 2).

Operation in FFT mode is based on the convenient and easy-to-understand spectrum analyzer concept. Many additional functions, such as up to four FFTs on different parts of the time domain waveform, automated measurements, mask tests in the FFT diagram and cursors with automatic peak search, make the FFT function a powerful tool for debugging and signal analysis in the frequency domain.

## Additional logic and protocol analysis

The increasing integration of various technologies, i.e. embedded design, previously required the use of different T&M instruments. Apart from analog oscilloscope channels used to display signals in the time domain (e.g. measurements on analog signals or signal integrity tests on digital interfaces) and the FFT function for RF signals, additional channels are often required to perform logic analysis on digital data. The ability to decode data on serial programming and data interfaces such as inter-integrated circuits ($I^2C$) or serial peripheral interfaces (SPI) is just as important as the triggering on protocol content to facilitate debugging or verify circuit designs.

Rohde & Schwarz has implemented all these different functions in its R&S®RTO oscilloscopes. This simplifies data analysis for any design and allows synchronous measurements on analog, digital and RF signals. The R&S®RTO-B1 mixed signal option provides the R&S®RTO models with 16 additional digital channels. The R&S®RTO-K1 to R&S®RTO-K4 software options add protocol triggering and decoding (e.g. $I^2C$, SPI, RS-232 or CAN) on analog and digital channels.

Fig. 3 shows an example of measurements on an SPI programmable voltage controlled oscillator (VCO) whose frequency is changed from 825 MHz to 845 MHz. Analyzing the switching behavior is easy with the R&S®RTO. The user

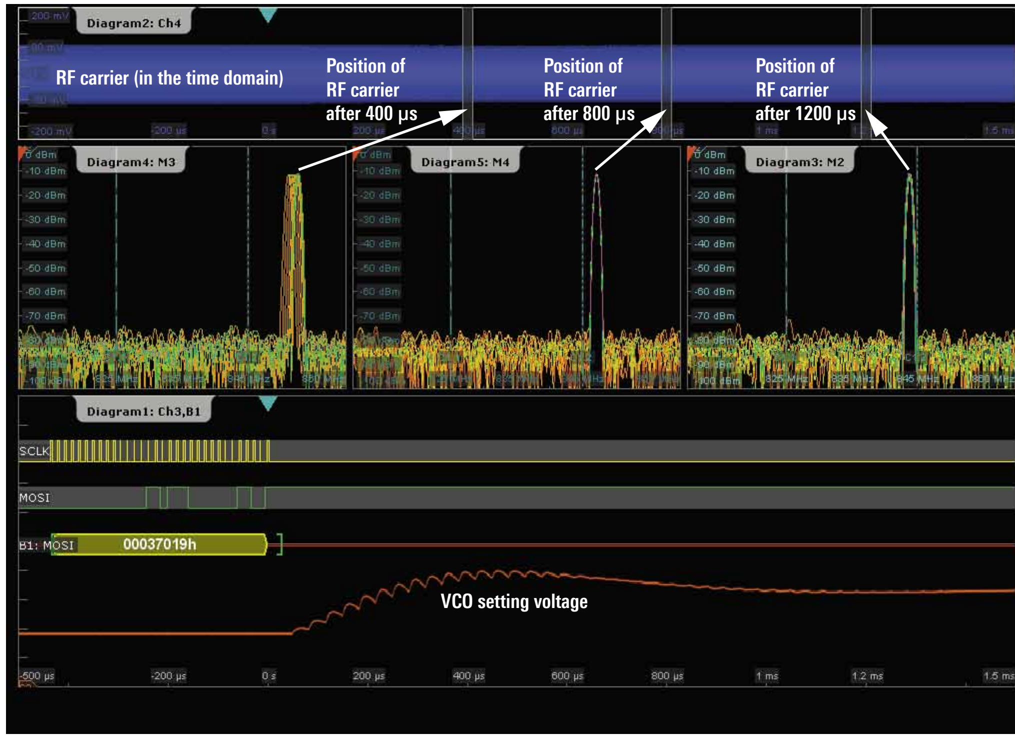



Fig. 3 VCO frequency switching example: The R&S®RTO supports synchronous measurements on the input and output of the VCO and on the SPI control line. Triggering is on an SPI data word that is recorded over digital channels. Various gated FFT functions are performed on the RF signal (blue trace).

triggers on the corresponding data word on the SPI bus (for example via connected digital oscilloscope channels) and is then able to observe the transient response of the RF signal via an analog oscilloscope channel. The FFT function allows users to simultaneously evaluate the various frequencies at different times on the signal in the time domain. The VCO setting voltage can be displayed via an additional analog channel.

## New, compact differential probe

The increasing use of serial high-speed interfaces creates a growing need for the right T&M equipment. One of the main tasks is to measure differential and ground-referenced signals. Edge transitions for differential clock signals, for example, must be accurately assigned to obtain measurement results that correspond to the differential signal behavior in the circuit. This is not possible with two single-ended probes. Measurements of typically low-amplitude differential signals also require a wide dynamic range and a minimal load on the DUT's operating point.

The differential probes designed for the R&S®RTO oscilloscopes are ideal for such tasks. The new R&S®RT-ZD40 differential probe has an upper frequency limit of 4.5 GHz. Together with the 4 GHz oscilloscope, it provides an unchanged system bandwidth of 4 GHz (Fig. 4).

**Comparison of frequency responses**

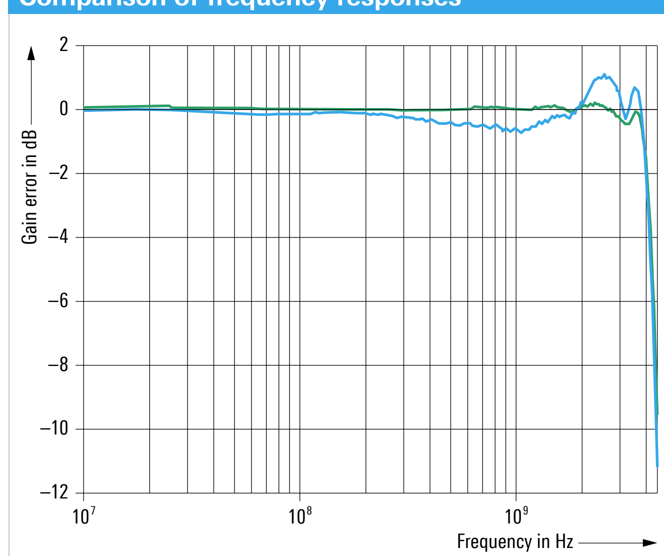



Fig. 4 Frequency response of the 4 GHz R&S®RTO alone (green), and together with the 4.5 GHz R&S®RT-ZD40 probe (blue).

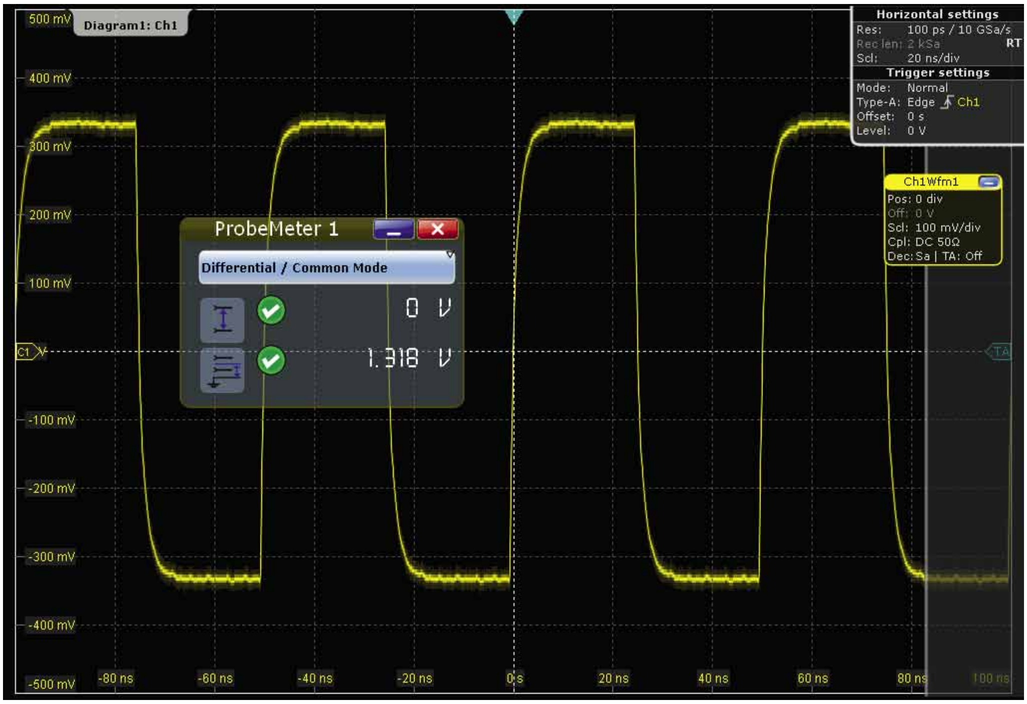



Fig. 5 Independent DC measurement of differential and common mode voltage using the R&S®ProbeMeter on the R&S®RT-ZD probe (differential clock signal with $V_{com}$ = 1.318 V and $V_{diff}$ = 350 mV).

Rohde&Schwarz probes have very low noise (typ. 3 mV) and an extremely wide dynamic range, enabling exact measurements on even weak signals. Their wide dynamic range of ±5 V allows measurements on fast, large amplitude signals (e.g. on single-ended memory interfaces) and prevents distortion. With a DC input impedance of 1 MΩ and low input capacitance (0.4 pF with the R&S®RT-ZD40), the probes ensure minimum load on the DUT.

Like the single-ended R&S®RT-ZS probes, the probe tip features an integrated micro button enabling users to easily control the oscilloscope from the probe. Functions such as Run / Stop, Autoset or Save Image can be assigned to this button. The probe tip also accommodates the R&S®ProbeMeter, which delivers DC measurement results for common mode and differential voltage regardless of the base unit's settings. This is the first time that a differential probe enables the user to determine the common mode operating point during a differential measurement (Fig. 5).

Fig. 6 R&S®RT-ZC20 current probe for a peak current of 50 A and a bandwidth of 100 MHz.

## Current probes for power measurements

Current probes for direct AC and DC current measurements on signal lines are a new addition to the Rohde&Schwarz product portfolio. Using these probes, the R&S®RTO oscilloscopes can perform, for example, power measurements on switching power supplies. The R&S®RT-ZC10 and R&S®RT-ZC20 current probes allow a maximum peak current of 500 A and 50 A, respectively. The R&S®RT-ZC20 current probe (Fig. 6) has a bandwidth of 100 MHz and a noise floor of 2.5 mA (RMS). The R&S®RT-ZC10 current probe has a maximum bandwidth of 10 MHz and a noise floor of 25 mA (RMS).

Guido Schulze

# R&S®RTO oscilloscope with state-of-the-art signal analysis software

The R&S®RTO from Rohde&Schwarz is the only oscilloscope on the market equipped with an interface to transfer I/Q data to analysis software. Together with the R&S®RTO-K11 software option, the oscilloscope acquires digitally modulated signals and exports the corresponding I/Q data, with an adjustable sampling rate, to analysis software such as MATLAB® oder LabVIEW. Using special Rohde&Schwarz tools, it analyzes OFDM and NFC signals to the last detail.

## Operating principle of the R&S®RTO I/Q sampling mode

The new R&S®RTO-K11 I/Q software interface supports the following signals input to the R&S®RTO:

- Real RF signals
- IF signals in complex I/Q format
- Complex I/Q baseband signals

After A/D conversion, the R&S®RTO converts modulated real RF signals from the carrier frequency to the baseband using a numerically controlled oscillator (NCO) (Fig. 1). The signal is lowpass-filtered and then resampled to the set sampling rate. The resulting I/Q data is stored in memory. Since each input signal requires a separate oscilloscope channel, a four-channel model can acquire up to four real RF signals in parallel.

The oscilloscope operates in a similar way for complex I/Q signals in the IF band. Such signals are processed by low IF receivers, for example. These components are used e.g. in TVs to receive digitally modulated signals. They convert the received RF signal to a low IF to prevent problems with the DC offset of the A/D converter. After digitization, the digital back end of the low IF receiver converts the signal to the baseband.

The R&S®RTO downconverts these types of signals from IF to baseband, where they are lowpass-filtered and converted to the required sampling rate (Fig. 2). In contrast to processing real RF input signals, two oscilloscope channels are required for each input signal: one channel for the in-phase component (I) and another channel for the quadrature component (Q).

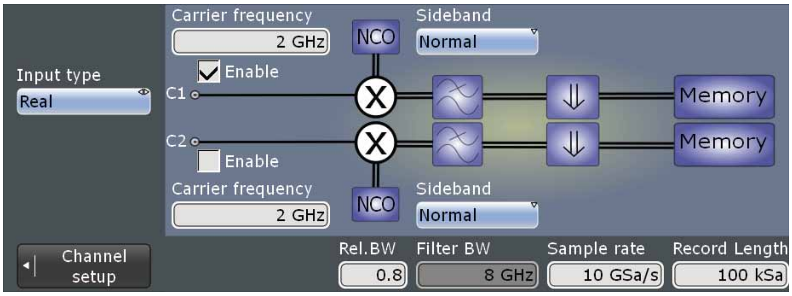



Fig. 1 Processing steps for a real RF input signal in the R&S®RTO I/Q sampling mode.

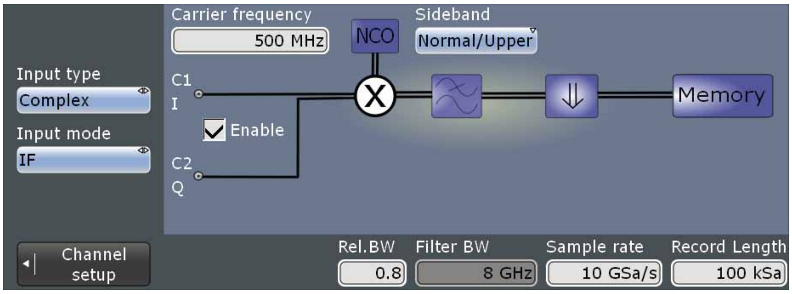



Fig. 2 For IF signals already in complex I/Q format, the processing steps of the R&S®RTO-K11 option are identical to those for real RF signals.

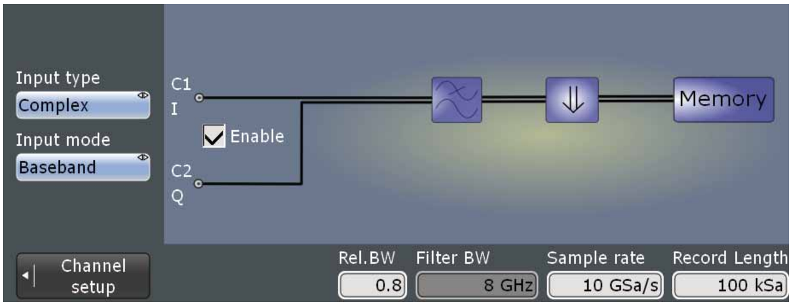



Fig. 3 If an input signal is in the baseband, no frequency conversion is necessary. The signal is lowpass-filtered and converted to the required sampling rate.

I/Q signals in the complex baseband are present, for example, when the user performs measurements on a baseband chip. Using the R&S®RTO-K11 software option, these signals can be acquired and converted to the required sampling rate for further analysis. No downconversion is required. The signal only has to be lowpass-filtered and converted to the sampling rate (Fig. 3). Two oscilloscope channels are required for each baseband; one for I and another one for Q. A four-channel R&S®RTO can process two baseband signals simultaneously.

## Generic I/Q interface for signal analysis

Commercially available oscilloscopes output only the input signal sampled by the A/D converter. Prior to the actual I/Q analysis, users have to make sure that the signal is down-converted to the baseband, and then filtered and converted to the required sampling rate – steps that are error-prone and time-consuming.

With the R&S®RTO oscilloscope, this process is faster and easier: The R&S®RTO-K11 I/Q software interface extracts the I/Q data from the input signal and provides this data at a user-definable sampling rate. Users simply have to export the data into the analysis tool and can immediately start demodulating. Its wide range of analysis functions and convenient operation make the MATLAB® software the ideal tool for analyzing I/Q data. Other programming environments such as LabVIEW can also be used.

For data transmission, users make the required settings in R&S®RTO-K11 with a few simple remote-control commands or by manually operating the software. The data can be saved on a USB stick or on the R&S®RTO hard disk in various formats such as CSV and XML.

For special analysis tasks, Rohde & Schwarz offers the R&S®FS-K96 OFDM vector signal analysis software and the R&S®FS-K112 near field communications (NFC) analysis software. Both options support Rohde & Schwarz spectrum analyzers such as the R&S®FSW and R&S®FSV, or the R&S®RTO oscilloscope with installed R&S®RTO-K11 I/Q software interface, during signal acquisition.

## Long acquisition time due to hardware-supported frequency downconversion

On the way to I/Q data, R&S®RTO-K11 converts input signals from the RF or IF to the complex baseband. In the R&S®RTO, this task is hardware-implemented and therefore faster than software-based calculations. The resulting sampling rate can be relatively low since after frequency downconversion only signals in the baseband have to be sampled. This enables users to acquire signals over long periods of time without having to manage large volumes of data.

An example: A signal with a bandwidth of 80 MHz and a carrier frequency of 3 GHz is to be demodulated and analyzed. When using the R&S®RTO-K11 I/Q software interface, the bandwidth can be up to 80 % of the Nyquist bandwidth. Therefore, after the hardware-based downconversion to the baseband, a sampling rate of 100 Msample/s suffices. R&S®RTO-K11 supports a maximum memory depth of 10 Msample which corresponds to an acquisition time of 100 ms for the I/Q data of the signal in the example.

Commercially available oscilloscopes that use software-based frequency downconversion need a minimum sampling rate of 6.1 Gsample/s for the same signal. An acquisition time of 100 ms requires 610 Msample. Such a large volume of data forces users to invest in expanding memory depth (if possible) or to make do with shorter acquisition times.

## Example: analysis of an 802.11ac signal

The 802.11ac standard is part of the 802.11 wireless LAN standard and is mainly based on 802.11n. Due to higher-order modulation schemes (264QAM) and higher bandwidths (80 MHz / 160 MHz), 802.11ac achieves higher data throughput in the 5 GHz band.

The R&S®RTO can be used to acquire the data to demodulate 802.11ac signals during transmitter tests if the WLAN signal is in the baseband or IF band. The R&S®FS-K96 OFDM vector signal analysis software can be used to demodulate and analyze the signal. The option includes standard-compliant configuration files for OFDM-based communications standards such as IEEE 802.16 (WiMAX™) and IEEE 802.11a / g / n / ac (WLAN). Proprietary OFDM signals, as used in military applications for example, can also be analyzed.

Figs. 4 and 5 show the analysis results of a 80 MHz wide 802.11ac signal acquired by the R&S®RTO and analyzed with the R&S®FS-K96 software. Thanks to the outstanding characteristics of the R&S®RTO frontend, the overall EVM of –42 dB is excellent, practically on the level of a mid-range signal analyzer.

Sylvia Reitz

| Item | Min | Mean | Mean Limit | Max | Max Limit | Unit |
|---|---|---|---|---|---|---|
| EVM All | -42,62 | -42,53 | | -42,41 | | dB |
| EVM Data | -42,52 | -42,42 | | -42,28 | | dB |
| EVM Pilot | -44,90 | -44,59 | | -44,37 | | dB |
| I/Q Offset | -78,43 | -76,02 | | -73,87 | | dB |
| Gain Imbalance | 0,00 | 0,00 | | 0,00 | | dB |
| Quadrature Error | 0,00 | 0,00 | | 0,00 | | ° |
| Frequency Error | 55,90 | 56,17 | | 56,39 | | Hz |
| Sample Clock Error | 1,10 | 1,11 | | 1,12 | | ppm |
| Frame Power | -4,78 | -4,77 | | -4,76 | | dBm |
| Crest Factor | 10,03 | 10,74 | | 11,17 | | dB |

Fig. 4 The R&S®FS-K96 OFDM vector signal analysis software lists the most important numerical measurement results in tables. The analysis of a 802.11ac signal with a bandwidth of 80 MHz acquired with the R&S®RTO delivers an excellent overall EVM of –42 dB.

Fig. 5 The R&S®FS-K96 OFDM vector signal analysis software offers a wide range of measurements, e.g. constellation diagram or EVM over all OFDM carriers. The graphical display of results makes signal analysis easier.

# Power sensors for production: fast, reliable and cost-effective

For measuring instruments used in production, a compromise between technical characteristics and purchasing costs must often be made. For this reason, Rohde&Schwarz has developed two power sensors that are optimized for production applications. They cover the frequency ranges to 8 GHz and to 18 GHz, offer a wide dynamic range and are suitable for both continuous wave (CW) and modulated signals.

## Multipath diode power sensors – tailored for use in production

Diode power sensors from Rohde&Schwarz deliver very accurate results even at extremely low power levels. They have been successful on the market for more than 10 years, due to their outstanding characteristics and their patented multipath technology featuring three measurement paths (see box).

For use in production, not all these outstanding characteristics are necessarily required. Rather, costs play a crucial role in this special environment. To provide attractive measuring equipment for such use as well, Rohde&Schwarz offers a good compromise with its new R&S®NRP-Z211 and R&S®NRP-Z221 power sensors (Fig. 1): Equipped with only two measurement paths, these sensors have a favorable purchasing price yet still ensure a good dynamic range that fully suffices for most production applications. Although other two-path sensors are available on the market, the new Rohde&Schwarz power sensors and their patented multipath technology offer significant advantages.

Fig. 1 R&S®NRP-Z211 power sensor.

## Patented multipath technology ensures high measurement speed

The R&S®NRP-Z211 and R&S®NRP-Z221 power sensors use two measurement paths having six series-connected diodes each. The two paths together cover a dynamic range of 80 dB. The more sensitive path extends from –60 dBm to –4 dBm, the second path from –33 dBm to +20 dBm. Unlike conventional two-path sensors, where changing the measurement path requires a hard switchover, the new Rohde&Schwarz power sensors do not perform any switchover. Instead, measurements are always made in parallel in both measurement paths, and the result is determined using a patented weighting algorithm. Consequently, the path transition is smooth and hysteresis-free, avoiding the "hard" switchover point and the associated delay of about 25 ms as with competitive products. In addition, the noise contribution of the less sensitive path in the transition region is reduced by a factor of four (6 dB). As a result, assuming the same uncertainty contribution, a measurement speed 16 times faster is possible. The

**Diode power sensors: fast and accurate**

Diode power sensors are state of the art: They offer high measurement speed and precise power measurements over a wide dynamic range. With measurements on modulated signals, however, they may reach their limits, because the dynamic range of a single measurement path usually does not suffice. For these measurements, the entire signal level range – from the minimum to the maximum – must fit into the square-law region of the diode characteristic, because this is the only region in which the power detector behaves linearly and allows exact determination of the power average without additional measurement errors.

**Remedy: more paths and more diodes per path**

Diode power sensors with multipath architecture get around this problem. Due to their staggered measurement paths, they offer an expanded dynamic range. Each path covers a different level range and operates exclusively in the square-law region of the detectors. To further increase the dynamic range, each measurement path includes a number of series-connected diodes, distributing the measurement voltage over multiple diodes. The square-law region of each measurement path becomes larger and, as a result, so does the power sensor's overall dynamic range.

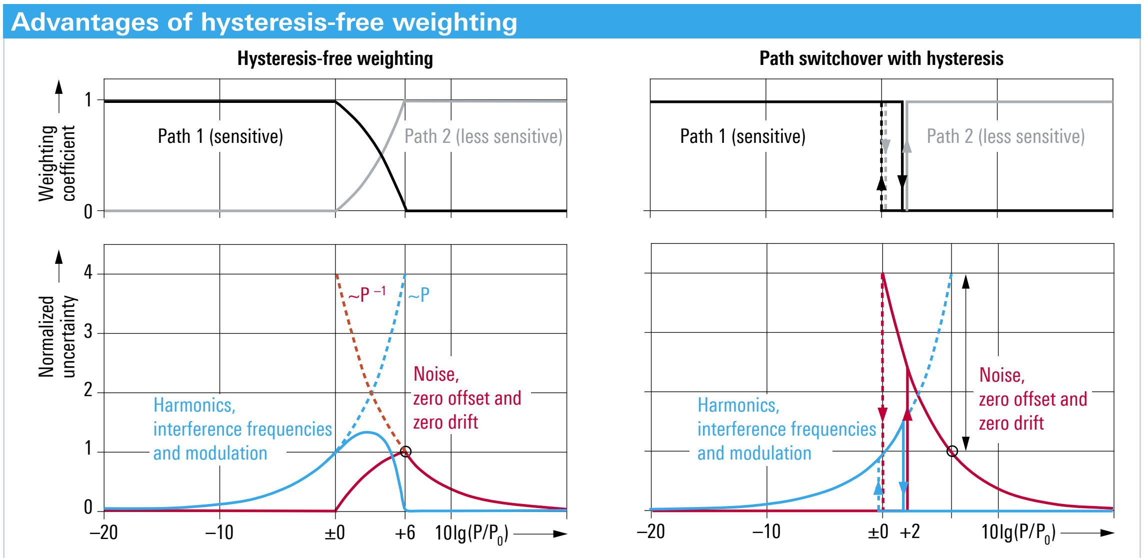
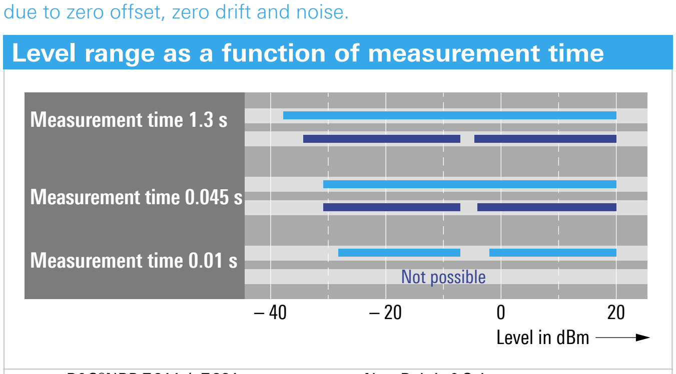



Fig. 2 Left: Simultaneous measurement of both paths and the patented weighting algorithm from Rohde&Schwarz decrease noise by a factor of four (6 dB). Right: Result with hard path switchover with sequential measurement.

power sensors from Rohde&Schwarz therefore provide a distinct overall advantage. Of particular interest in production applications with stringent requirements in terms of measurement speed and accuracy is the considerably larger continuous level range of Rohde&Schwarz power sensors (Fig. 3).

If especially high measurement speeds are required, the new power sensors can be operated in a measurement mode in which they store up to 1024 measurement results internally in a buffer memory and, to save time, subsequently transfer these results in one block to the control computer.

Fig. 3 Comparison of the R&S®NRP-Z211 / -Z221 power sensors and a non-Rohde&Schwarz power sensor. The diagram shows the usable level range as a function of the measurement time, based on 0.5 % uncertainty due to zero offset, zero drift and noise.




## Minimal space requirement in automatic test systems

Since the space available in automatic test system racks is limited, a major advantage is that the sensors can be operated without a base unit. The compact R&S®NRP-Z211 / -Z221 two-path diode power sensors can be connected to a control host via the R&S®NRP-Z4 USB adapter and controlled via a measurement program.

## Optimum conditions for interruption-free production

The R&S®NRP-Z211 / -Z221 power sensors feature an extremely low failure rate: The computed mean time between failures (MTBF) is approximately 100 years (assuming operation eight hours a day, five days a week) – a definite advantage in everyday production. The recommended calibration interval of two years also contributes to production that is as interruption-free as possible.

## Summary

The R&S®NRP-Z211 and R&S®NRP-Z221 two-path diode power sensors offer the market´s best price/performance ratio of their class. Their high measurement speed, their level measurement range optimized for production purposes and their excellent reliability as well as low initial and lifetime cost make them the power sensors of choice when it comes to applications in production.

Michael Kaltenbach

# R&S®EMC32 EMC measurement software: completely reworked and now even more versatile

With almost 3000 licenses installed around the globe, the R&S®EMC32 EMC measurement software is the market leader for automatic testing in all relevant sectors and standardization areas. The newly released version 9 has been completely reworked to take advantage of the full potential of the latest hardware and operating systems. Two new options for measurements during development work help to make the software even more versatile.

## User interface: now even more convenient

The user interface of the R&S®EMC32 EMC measurement software had a complete overhaul in version 9 to deliver further improvements (Fig. 3). The Explorer includes some new functions such as fast access to important test templates (Fig. 1). Operating dialogs are displayed only if they are currently relevant. This creates room to display the ongoing measurement and the parameters to be monitored. New options for arranging graphics on the screen – including even a second monitor – help to provide a better overview and allow the user to concentrate on the essential graphics.

## Higher efficiency: R&S®EMC32-K10 EMI auto test option

EMC laboratories are under constant pressure to increase their test throughput and efficiency. The improved R&S®EMC32-K10 EMI auto test option helps to meet this requirement: It accelerates measurements by up to 25 % and provides new functions:

### Clear visual presentation of measurement and accessories

Two new dialog windows on the left side of the R&S®EMC32 application window provide an overview of the current measurement status and the position of the accessories. The "Testing Process" window (Fig. 2 and also ❷ in Fig. 3) shows the active test steps along with details of the current measurement. The "Accessories" window (❶ in Fig. 3) clearly shows all the antennas and transducers used in a measurement with their frequency ranges as well as the accessories and their current position.

### Convenient management of critical frequencies

The software compiles the critical disturbance frequencies in a table (❸ in Fig. 3) which also includes a listing of important

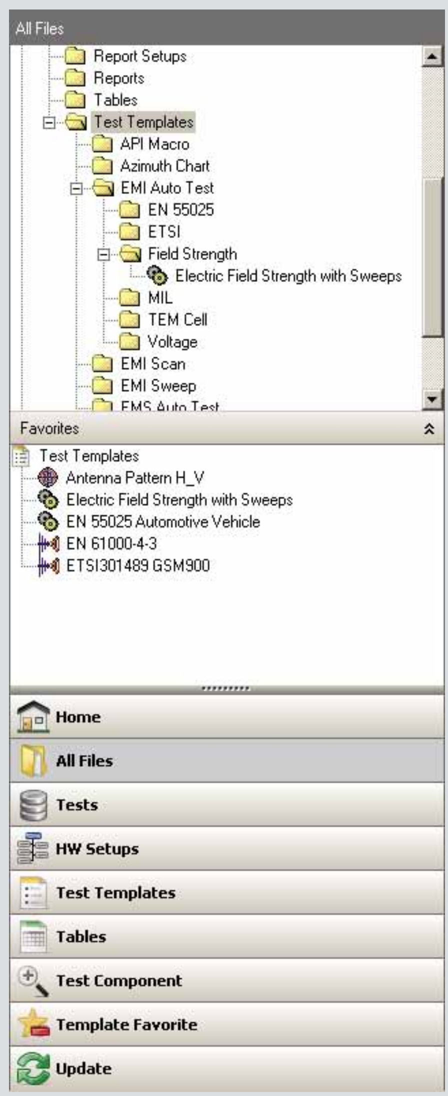



Fig. 1 Explorer in R&S®EMC32 with window for test template favorites.

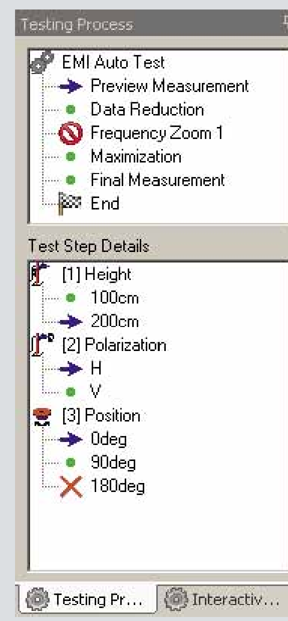


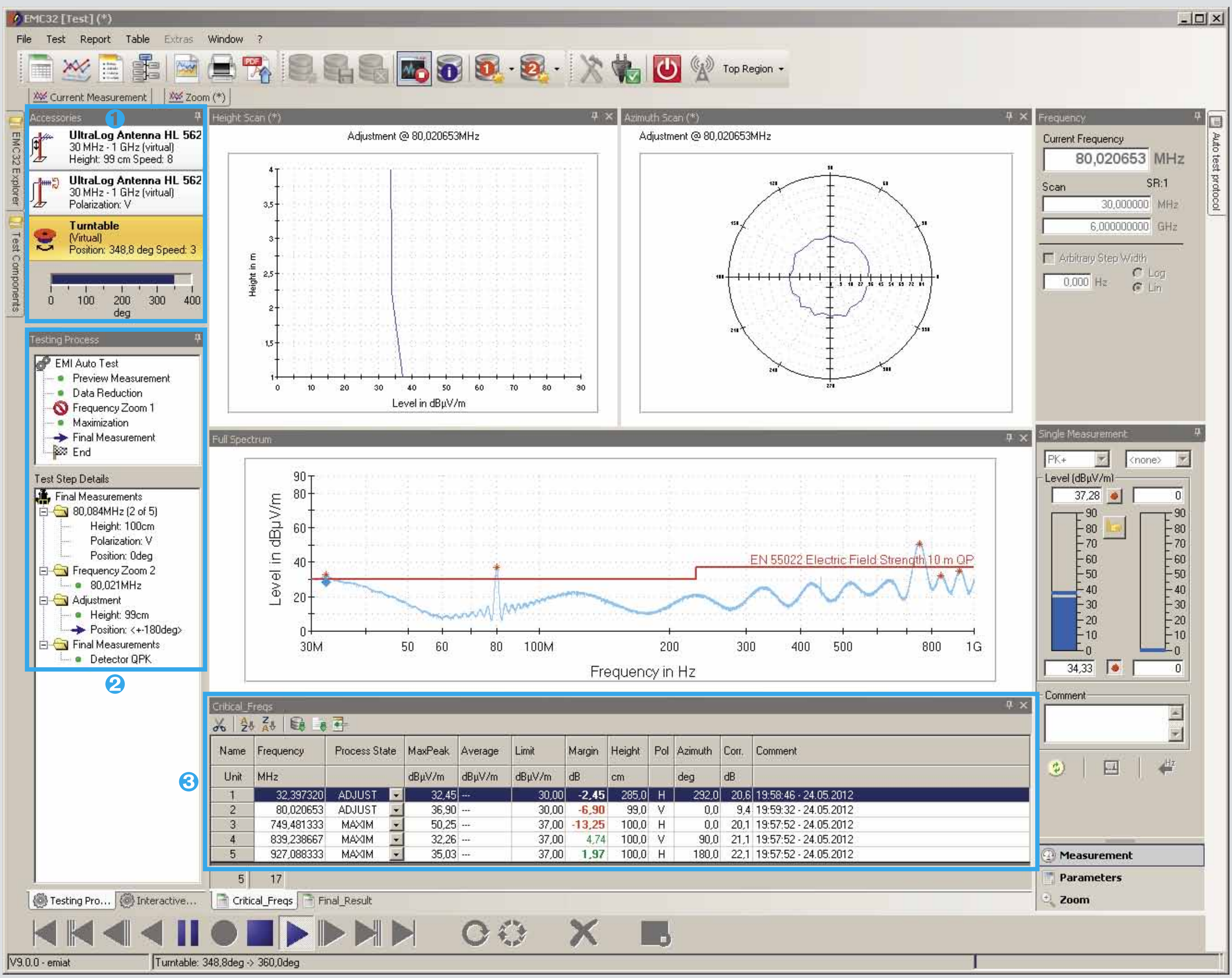

Fig. 2 Testing Process dialog in EMI auto test (here, preview measurement).

Fig. 3 New user interface of the R&S®EMC32 EMC measurement software.
❶ Interactive measurement with control of accessories.
❷ Testing process, final measurement.
❸ Table with critical frequencies.

information such as the margin with respect to the limit. These frequencies are automatically determined during the measurement as part of data reduction or are inserted from a predefined frequency list (e.g. harmonics). The user can also add them via drag&drop from the measurement graphics or via keyboard input. Another table ("Final_Result") contains the measurement results from the final measurement at the critical frequencies along with the most important information such as the limit value, the margin with respect to the limit and the position of the accessories. Tabbed windows allow fast switching between the different table views. The "Full Spectrum" window is positioned in the center of the R&S®EMC32 application window, and temporary graphics can be placed above this window during the measurement.

**Visual presentation of adjustment measurements with azimuth and height scan graphics**

Depending on the measurement method the software clearly presents the values from the adjustment measurement in a diagram for the height scan (level vs. mast height) and azimuth scan (level vs. turntable position). For postprocessing the results from this automatic measurement, the graphics that are generated temporarily during the measurement can be saved optionally as files in WMF format. This allows better verification of the plausibility of the measurement results and makes additional information available for the test report.



## 3D visualization of radiation patterns

During development of a new product, the device's exact radiation pattern must frequently be determined at specific frequencies. Using the new R&S®EMC32-K23 software option, the results of these measurements can be presented in 3D format with great clarity and level of detail (Fig. 4). The graph is generated by simply dragging and dropping the critical frequency from the spectrum graph or using the toolbar function provided in the "Final_Result" and "Critical_Freqs" tables. In the case of electric field strength measurements, the data from the preview measurement or maximization measurement is presented in cylindrical coordinates. The software presents the results of radiated spurious emission (RSE) measurements on wireless communications equipment in spherical coordinates.

The radiation diagram can be rotated and scaled on the screen to meet user requirements. For better visualization of the diagram, intermediate values can be interpolated in different stages. Each view can be saved as a JPG file for use in the test report.

## Interactive measurements with EMI auto test

At the end of an automatic test routine during compliance testing or measurements during development, it is recommended to verify the measurement results or repeat the measurement at some critical frequencies after modifying the device under test. The new R&S®EMC32-K24 interactive measurement option simplifies this process. It provides excellent flexibility during automatic testing and allows the user to interactively control the test system. This option expands the R&S®EMC32-K10 EMI auto test software to include the following new functions:

### Simple adaptation of the test routine without modifying the test template

Using the new "Testing Process" dialog window (Fig. 2), the test routine defined by the test template can be adapted without having to modify the template. For example, it is easy to deactivate individual test steps such as the zoom 1 measurement or individual accessory positions (e.g. for the turntable) during the preview measurement. Moreover, it is possible to select the test step where to begin or continue the measurement.

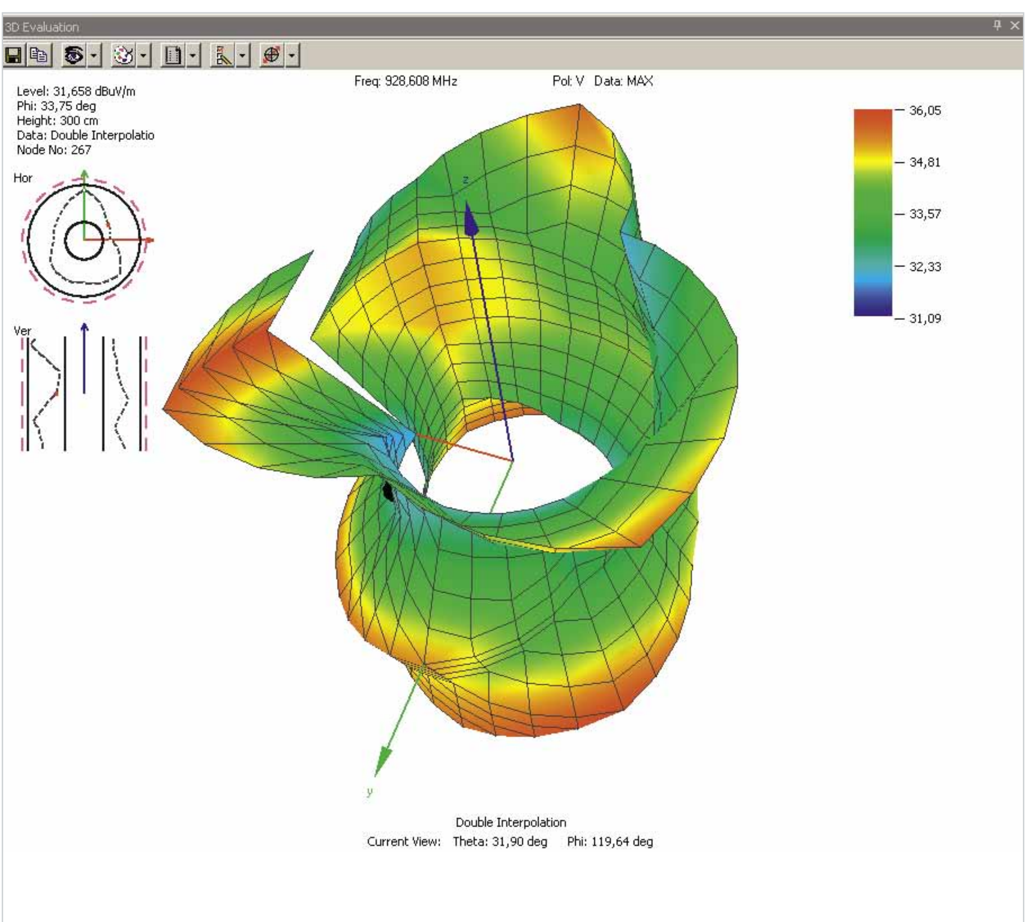



Fig. 4 3D display generated with the new R&S®EMC32-K23 option.

### Interactive final measurement at critical frequencies

Interactive final measurements are based on the "Process State" column in the table of critical frequencies, or on values that the user adds interactively. The interactive final measurement function provides a high degree of flexibility and saves time by making it possible to focus only on the critical frequencies. This function allows repetition of the automatic test routine at selected frequencies (e.g. reset value of adjustment measurement to preview measurement).

### Interactive verification of measurement results

The new function for interactive single measurements makes it possible to verify individual frequencies from the "Final_Results" and "Critical_Freqs" tables on a fully interactive basis. Accessories such as the mast and turntable that are used in measuring the electric field strength are first moved to the position where the maximum value was found during the automatic test routine, and then a cyclical receiver measurement is launched. The user can now interactively change the position of the accessories and tune the receive frequency in order to determine the maximum radiation at this frequency. In addition, the current receive frequency and the current accessory positions can be saved as a new entry in the corresponding result table. Each frequency is provided with a timestamp to allow complete documentation of the measurement. The critical frequency can also be determined more precisely using a partial scan around the frequency (interactive zoom measurement) in order to compensate for any drift in the disturbance frequency vs. time.

## Summary

Version 9 of the R&S®EMC32 EMC measurement software has a fully revamped user interface with many new options for arranging the graphical windows and tables. Further optimizations such as the new Explorer functions round out the upgrade of the basic packages for measuring EMS and radiated emission.

The tried-and-tested R&S®EMC32-K10 EMI auto test option has been extensively redeveloped and now provides faster measurement speed combined with optimized management of critical frequencies and intuitive visual display of the test and the measurement data.

Fig. 5 provides an overview of the modules available for R&S®EMC32. Two new options for R&S®EMC32-K10 provide new graphical functions for 3D visualization of data generated during radiated measurements (R&S®EMC32-K23) as well as interactive support for measurement result verification and measurements during development (R&S®EMC32-K24). These advances will allow the R&S®EMC32 EMC measurement software to continue to meet future requirements while consolidating the product's market-leading position.

Robert Gratzl; Xaver Sutter

Detailed information at www.emc32.rohde-schwarz.com

| Module | Application |
|---|---|
| **R&S®EMC32-S** | **Basic package for EMS measurements** |
| R&S®EMC32-K1 | Enhanced EMS functionality for automotive / A&D measurements |
| R&S®EMC32-K2 | Measurement of audio breakthrough and spurious emissions in wireless communications |
| R&S®EMC32-K3 | Susceptibility measurements in reverberation chambers in line with EN 61000-4-21 (R&S®EMC32-K4 also required) |
| R&S®EMC32-K4 | EMS auto test functionality |
| R&S®EMC32-K6 | Measurements in line with MIL-STD-461E/F CS103/4/5 |
| R&S®EMC32-K7 | Generic drivers for RF generators, power meters and oscilloscopes |
| R&S®EMC32-K8 | Database interface to laboratory management systems |
| **R&S®EMC32-EB** | **Basic package for EMI measurements** |
| R&S®EMC32-K10 | EMI auto test functionality |
| R&S®EMC32-K11 | Test plan generation and automatic control with test sequencer |
| R&S®EMC32-K21 | Automation of additional measurement tasks using macro language |
| R&S®EMC32-K22 | Measurement of RF radiation patterns of antennas and EUTs |
| R&S®EMC32-K25 | TD-SCDMA option for R&S®EMC32-K2 |
| R&S®EMC32-K26 | LTE option for R&S®EMC32-K2 |
| R&S®EMC32-K33 | EMI measurements in reverberation chambers in line with EN 61000-4-21 (R&S®EMC32-K10 also required) |
| R&S®EMC32-K51 | EMI evaluation with flexible scan sequences (e.g. in line with GMW 3091/3097) |
| R&S®EMC32-K56 | EMI measurement in line with MIL-STD: transmitter in transmit mode |
| R&S®EMC32-K23 | 3D evaluation for R&S®EMC32-K10 EMI auto test |
| R&S®EMC32-K24 | Interactive measurement for R&S®EMC32-K10 EMI auto test |
| R&S®EMC32-U9E | Update to version 9 for R&S®EMC32-EB basic package |
| R&S®EMC32-U9S | Update to version 9 for R&S®EMC32-S basic package |

Fig. 5 Basic packages and expansion modules for the R&S®EMC32 EMC measurement software (blue: new).

# Putting audio / video interfaces through their paces

Set-top boxes, tablet PCs, smartphones – all these devices have analog or digital audio/video interfaces such as HDMI and MHL™ that have to be thoroughly tested. Two new testers now provide all the testing performance needed. Besides performing standard interface protocol tests, they analyze media content in real-time during application tests on consumer electronics equipment.

### R&S®VTE video tester – universal AV interface test platform for R&D and quality assurance

The R&S®VTE video tester (Fig. 1) is a versatile platform for testing audio and video (AV) interfaces on consumer electronics equipment in R&D and quality assurance. This highly compact, universal tester (3 HU, ½ 19") accommodates up to three test modules, which provides flexibility for future expansions and upgrades. The R&S®VTE has a capacitive 7-inch touchscreen to enable intuitive, straightforward operation. Audio signals applied to the instrument's test inputs can be monitored via the headphones output and the built-in loudspeaker.


Fig. 1 The R&S®VTE video tester (top) and the R&S®VTS compact video tester (bottom) rely on the same modular concept. By employing appropriate interface test modules and software options, users can optimally configure the testers to meet the requirements of different applications in development and manufacturing.


### R&S®VTS compact video tester – the perfect test platform for manufacturing applications

The R&S®VTS compact video tester (Fig. 1) has been devised for testing AV interfaces in manufacturing applications, where cost and footprint play significant roles. The R&S®VTS comes without a touchscreen and is therefore extremely compact (1 HU, ½ 19"). As a result, it requires little space in test systems. It accommodates one test module and, thanks to the built-in PC, it can also be operated as a standalone unit. The tester can be controlled locally using a USB mouse and keyboard and an external monitor, or remotely over a LAN.

### An operating concept you will not want to miss

The R&S®VTE and the R&S®VTS use identical functional software, featuring the same intuitive and self-explanatory GUI (Fig. 2) for local operation and for remote control from a PC. The user selects the desired test application by pressing a tab on the touchscreen. Graphics can be displayed in full-screen mode to make them easier to view. Syntax errors and limit violations are clearly marked. In end-to-end tests, generator and analyzer applications can be run in parallel – and these are just a few of the many advantages afforded by the testers' convenient operating concept, which supports multiple languages (English, Chinese, Korean and Japanese). Running on Windows 7, the two testers also support capabilities provided by standard PCs, such as data transfer and network integration.

### Test automation made easy

The R&S®VTE and the R&S®VTS have a VXI-11 remote control interface that accepts standard commands for programmable instruments (SCPI). This makes it easy to integrate the instruments into test systems. The integrated R&S®AVBrun test sequencer greatly simplifies automation of even complex test setups without the need to create source code. Composing test cases is very convenient using the tester's GUI on a PC to compile the individual test steps in the desired order. The tester then runs the test case fully automatically. Ready-to-run test cases are also available for specific applications.

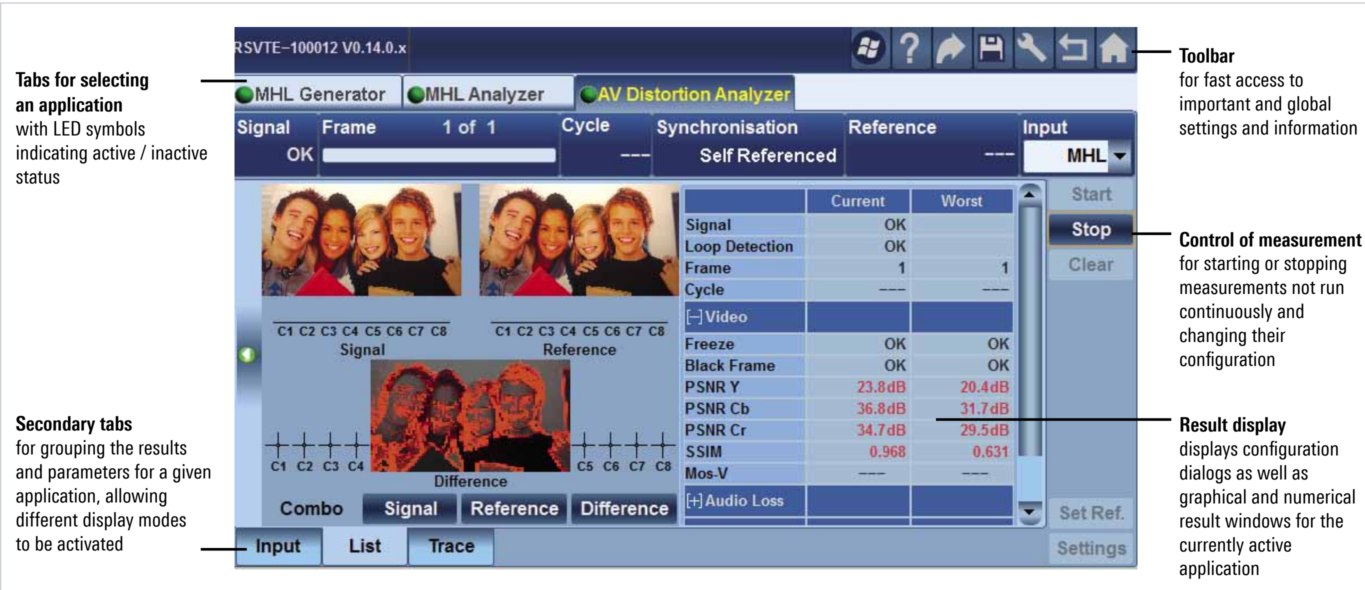



Fig. 2 Innovative graphical user interface (GUI) – shown here with the difference picture analysis function, which detects video degradation and analyzes it using suitable metrics.

## Test module for mobile high-definition link (MHL™) testing

Modern smartphones and tablets can record video content with their built-in HD cameras and receive video streams via mobile radio. To replay such audio and video content on high-definition multimedia interface (HDMI) flatscreen TVs – to view the content with friends, for example – a new video interface has been defined: the mobile high-definition link (MHL™). The mobile device's micro USB port is used as the physical MHL interface. While video is output to the flatscreen TV, the mobile device is charged via this interface.

The new interface requires numerous protocol and application tests in development and production. To support these tests, Rohde & Schwarz has developed the optional R&S®VT-B 2350 MHL RX / TX module for the R&S®VTE and R&S®VTS video testers. Equipped with this module, the testers can perform protocol tests on MHL Version 1.2 source and sink interfaces. Audio and video are output in realtime on the tester or played out to a TV set over the tester's HDMI output. All relevant protocol parameters are presented in a straightforward manner:

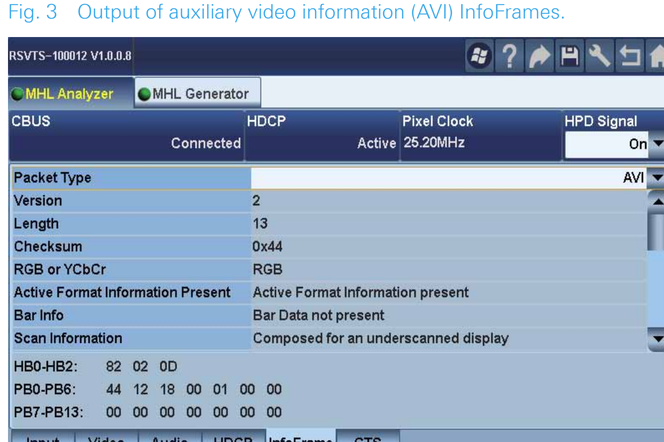
- Video timing parameters such as pixel clock and resolution in line with CEA-861
- Audio data
- High-bandwidth digital content protection (HDCP) status along with the keys used
- Auxiliary video information (AVI) InfoFrame (Fig. 3), audio InfoFrame, source product description (SPD) and MPEG InfoFrame

To test MHL sinks, user-defined multicolor patterns with resolutions in line with the MHL specification can be played out via the tester's generator output (Fig. 4). In addition to performing realtime measurements, the R&S®VT-B 2350 MHL RX / TX module also provides raw test modes (additional software option) for MHL source and sink system tests in line with the MHL Compliance Test Specification Rev. 1.2 (Figs. 5 and 6).

## Test modules for any requirements: from MHL and HDMI to analog interfaces

The RX / TX test module for the MHL interface is the first module implemented for the R&S®VTE and R&S®VTS testers, with

Fig. 3 Output of auxiliary video information (AVI) InfoFrames.



many others to follow. Test modules for the HDMI 1.4c interface standard are scheduled to be available in the second half of 2012. Among other features, ultra-definition (UD) resolutions (4k × 2k) offered by high-end screens will be supported. In addition to routine protocol tests, these modules will enable tests in line with the MHL compliance test specification as well as application tests. An analog audio/video interface test module will be available for analyzing SD and HD composite and component signals. The testers will be equipped with two audio inputs for measuring audio parameters.

## Video and audio content analysis opens up completely new applications

Besides carrying out protocol tests and displaying the transmitted video and audio content, the R&S®VTE and R&S®VTS can optionally analyze the content received via any of their MHL, HDMI or analog AV inputs.

The R&S®VT-K2100 video analysis software option measures the timing and level of each video signal component in realtime (Fig. 7). This can be used to verify correct transmission of color signals, for example. The R&S®VT-K2110 AV inspection and R&S®VT-K2111 AV distortion analysis options are available to analyze picture quality (see box on page 36). They present results in graphical form and deliver objective results in realtime, including peak signal-to-noise ratio (PSNR), structural similarity (SSIM) and the mean opinion score (MOS-V) derived from SSIM. Plus, they detect visible errors in the video image as well as the picture failure point (PFP). R&S®VT-K2110 and R&S®VT-K2111 are available exclusively for the R&S®VTE video tester. An audio analysis option will be available in the second half of 2012 to deliver conclusive results on audio level, frequency, phase, signal-to-noise ratio (SNR), distortion, crosstalk and other relevant parameters.

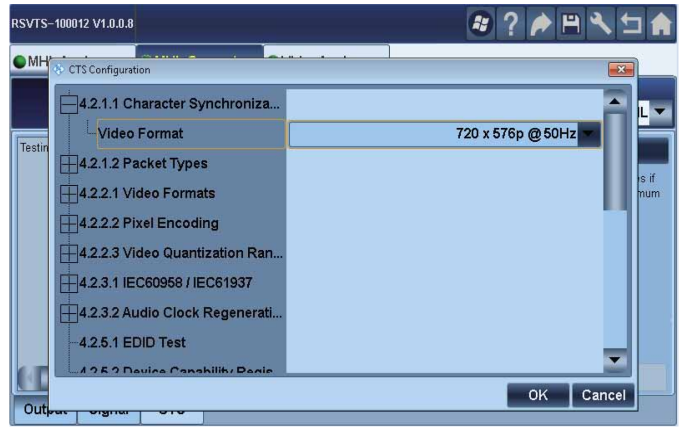



Fig. 5 The tester can optionally output TMDS raw data, which is required for sink system tests in line with the MHL compliance test specification (CTS).

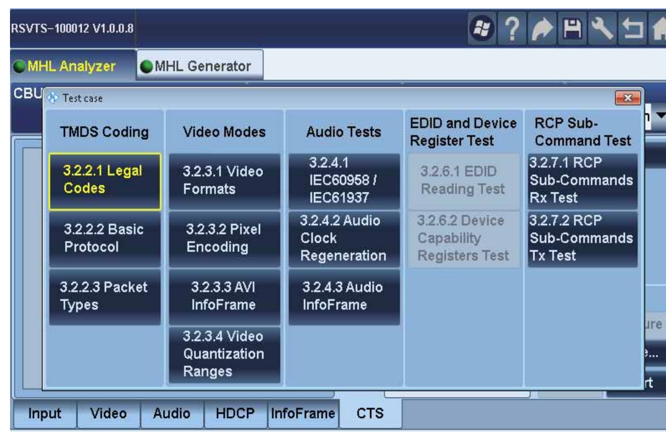



Fig. 6 The tester can optionally analyze TMDS raw data during source system tests (for example on smartphones) in line with the MHL compliance test specification (CTS).

Fig. 4 Realtime output of user-defined multicolor patterns with resolutions in line with the MHL specification.

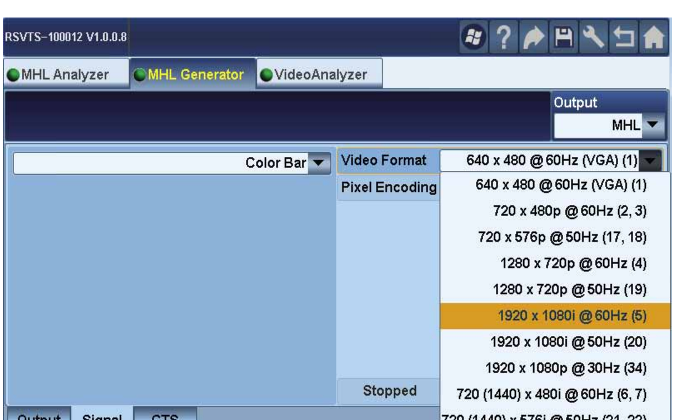
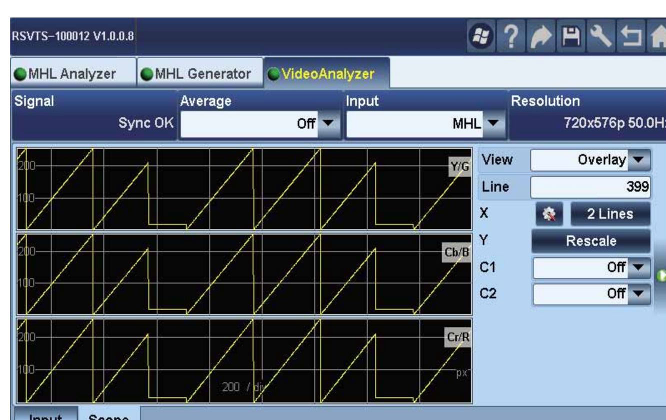



Fig. 7 The level and timing of the digital component signal can be measured in the time domain.



## Detecting and analyzing video degradation

The R&S®VT-K2110 AV inspection and R&S®VT-K2111 AV distortion analysis options detect video degradation as is typically caused by transmission errors. Examples of such degradation include blocking, picture freeze and picture loss.

### Testing terminal equipment

When testing the RF frontend of terminal equipment for immunity to interference during AV transmissions at the development stage, for example, there is a need for automatic detection of video degradation. The AV inspection and AV distortion analysis options rely on difference picture analysis to accomplish this: The picture sequence to be analyzed is compared in realtime with the corresponding picture sequence of an ideal reference signal. For mobile phones, the test is carried out as follows (see Fig. 8):

1. A looped video signal is transmitted over an undisturbed link, decoded in the mobile phone's receiver and transferred to the test module via the phone's AV outputs. The video tester stores the undisturbed signal as a reference signal.
2. In a second step, defined interference is superimposed on the transmission link. The disturbed video signal is fed to the tester's analysis unit in order to verify how it affects the mobile phone's video decoding performance.
3. The video tester synchronizes the disturbed video signal and the ideal reference signal and displays differences between the two signals in graphical form, plus it calculates numerical results for them using suitable metrics.

### Difference picture analysis

In difference picture analysis, the tester calculates the difference between two pictures and presents the results graphically, with differences marked red. Plus, mathematical evaluation is carried out based on two metrics commonly used in the industry: peak signal-to-noise ratio (PSNR) and structural similarity (SSIM). This makes the evaluation process reproducible and suitable for automation.

The video tester calculates the PSNR and SSIM metrics for individual pictures in each case. To determine visible degradation across a sequence of pictures, temporal masking effects can be taken into account by defining thresholds for a given sequence. This makes it possible to automatically analyze a picture sequence for visible degradation as well as for the type of degradation that various test standards refer to as the picture failure point (PFP).

More information about video degradation detection and analysis, especially for video over LTE applications, can be found in the webinar "Video over LTE – testing the next step in the end user experience" at **EETimes.com**.

### Video over LTE testing

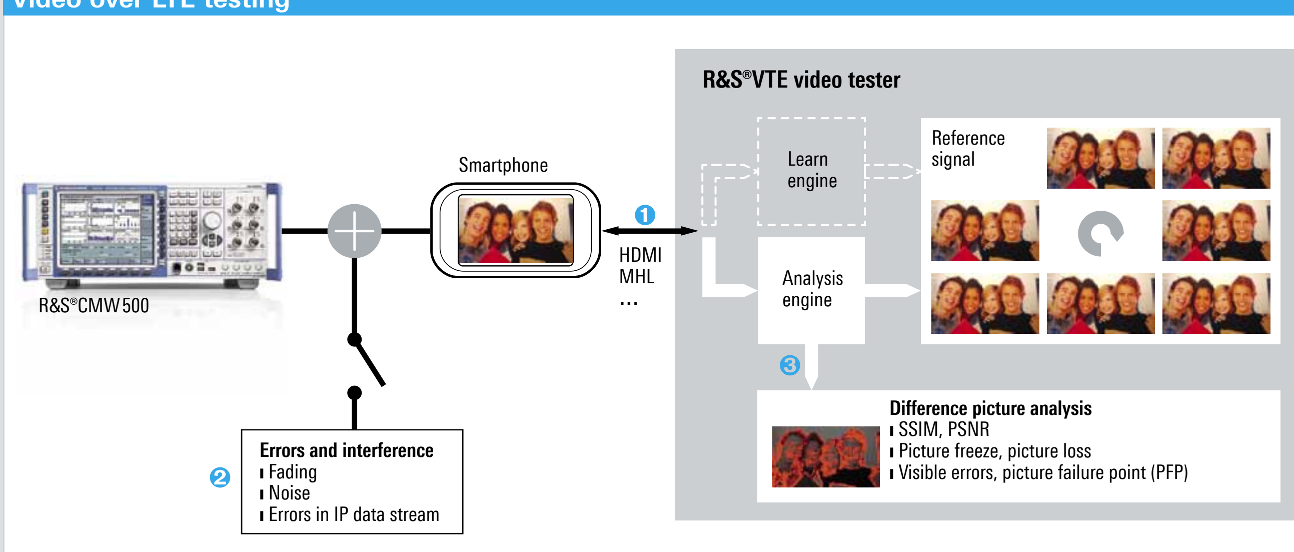



Fig. 8 Schematic representation of video degradation analysis for video over LTE transmissions.


Fig. 9 Test setup with an R&S®CMW500 tester and an R&S®VTE video tester for carrying out application tests on smartphones.

## Applications

### Testing digital AV interfaces for conformance with standards

The protocol on the AV interfaces of consumer electronics equipment is tested for standard-compliant behavior during development and certification to ensure the equipment's interoperability with other components. Especially at the development stage, it is crucial for test equipment to be able to display protocol parameters in realtime, with simultaneous decoding and analysis of the media content.

One special application is testing in line with the MHL compliance test specification (CTS) as a final interoperability test. CTS tests call for raw data analysis. The R&S®VTE and R&S®VTS now make it easy to perform this task.

### End-to-end (E2E) testing of video over LTE

The LTE mobile radio standard enables applications such as video conferencing and video streaming on mobile devices. To check the mobile device's immunity to interference for video transmissions, interference is superimposed on the transmitted signal. This is done by embedding errors in the IP data stream or by introducing noise or fading to degrade RF signal transmission over the air interface.

The mobile phone decodes the incoming video data and outputs it to the R&S®VTE via the MHL or HDMI interface. The R&S®VTE reliably detects video degradation – either operator-controlled or using automatic test routines – and supports the operator in objectively assessing video quality.

Fig. 9 shows a typical setup for end-to-end testing of video over LTE. In the second half of 2012, the R&S®VTE video tester will also be available as an option for the R&S®CMW-PQA performance measurement system for testing the robustness of cellular video transmissions.

## Summary

The R&S®VTE video tester and the R&S®VTS compact video tester from Rohde&Schwarz are setting new trends in the development and manufacturing of consumer electronics equipment with AV interfaces. The two testers are already available, as is a first test module (for the MHL standard). Two more modules (for HDMI and analog AV interface testing) plus another base unit are to follow in the second half of 2012. The new base unit and modules will be presented in a future issue of NEWS.

Harald Gsödl

# At home in the world's broadcasting towers

Broadcasting equipment from Rohde&Schwarz

All around the globe, Rohde&Schwarz transmitter systems ensure reliable broadcasting coverage. And new ones are constantly being added, for example in Turkmenistan, where Rohde&Schwarz specialists installed advanced broadcasting equipment in a new TV tower under difficult conditions. Another example is Kazakhstan, where three major cities have now entered the world of digital TV.

### Long-term cooperation

For many years now, the Republic of Turkmenistan's Ministry of Communication has been a valuable Rohde&Schwarz customer. In 2009 the ministry had commissioned the company with the setup of a nationwide network of analog TV transmitters as part of its "Channel 5" project. The positive experiences gained from that project paved the way to another large order. This is above all due to the high availability and robustness of Rohde&Schwarz products — two features that the ministry values very highly.

The new agreement, which was signed in April 2011, commissioned Rohde&Schwarz as the exclusive supplier of 159 transmitters for the nationwide analog TV/FM broadcasting network within the framework of the "Channel 6" project. In addition, a total of 28 digital and analog TV transmitter systems (DVB-T2 / ATV) as well as DAB/FM radio transmitter systems (Figs. 2 and 3) were ordered for the new TV tower near Ashgabat.

The order included the design and delivery of all equipment required for operating the transmitters. This also included the installation of the complete power distribution and monitoring systems for the transmitters. In the planning phase, Rohde&Schwarz drafted detailed installation plans, defined the interfaces, and collaborated closely with the construction company.

◁ Fig. 1 The "Turkmenistan TV Tower" is the country's new national landmark. It is located approximately 10 km southwest of the national capital of Ashgabat on a mountain top at an elevation of 800 meters in the Kopet Dag mountains.

### State-of-the-art broadcasting equipment for the country's landmark

One particularly challenging task was the timely installation of the transmitters in the "Turkmenistan TV Tower," the country's new national landmark (Fig. 1). The tower's transmitter room on the 31st floor is on the same level as the observation decks — 150 m above the ground. The tower's base building houses 13 television studios and other transmission facilities. Beyond that, the tower is home to seven TV stations and six radio stations. Consequently, this broadcasting center, is probably one of the largest in Central Asia.

Fig. 2 Some of the R&S®NR8205E VHF FM transmitters that were successfully installed on the 31st floor.

Photo: Robert Bleicher

There was only an extremely brief period available for installing the broadcasting equipment in the tower. The first transmitter was to enter trial operations on October 18, 2011, the 20th anniversary of the country's declaration of independence, and the Turkmen president, Gurbanguly Berdimuhamedow, was scheduled to open the tower personally on that date.

Besides the very limited timeframe, the numerous other obstacles the Rohde&Schwarz team had to overcome while installing the broadcasting equipment in the tower were special challenges. For instance, there was not enough space to set up the standard heat exchangers for the liquid-cooled ATV/DVB and DAB transmitters. Deploying special heat exchangers featuring a customized compact design was the only way to ensure reliable cooling of the transmitters.

The installation technicians and craftspeople — with up to 3000 of them present during peaks — needed a lot of creativity and improvisation skills in order to work alongside each other on this giant construction site without getting in each other's way. Keeping cool was another key goal for the Rohde&Schwarz team, since construction of the transmitter room had not yet been completed in mid-September 2011, just four weeks before the date for the initial trial run. The raised floor and the suspended ceiling above the transmitter room were completely missing. It seemed nearly impossible for the construction company to complete the transmitter room during the remaining two weeks to the extent required to begin installation of the transmitter and combiner systems as well as of the mains distribution units at the beginning of October 2011.

Fig. 3 A small portion of the extensive array of transmitters that was installed in the "Turkmenistan TV Tower" (here the R&S®NA8506 / R&S®NH8603 DAB / ATV high-power transmitters). The entire transmitter system is controlled using the R&S®TS4570 broadcast network monitoring and control software. The monitoring of the forward and reflected power at the switching matrix RF outputs is accomplished by the R&S®TS4506 RF power monitoring system. All the information gained from the monitoring systems can be accessed on a PC in the operator room.

Photo: Robert Bleicher

Photo: Robert Bleicher

Fig. 4 Combiner system with DVB-T transmitters.

Nevertheless, the Rohde&Schwarz project managers refused to be discouraged and focused on ensuring precise coordination of the transportation of the transmitters to Turkmenistan. This was important, because putting such a large amount of equipment into intermediate storage was not an option. Altogether, 44 tons of air cargo had to be flown to Baku in Azerbaijan, where the load was transferred to trucks for the ferry trip across the Caspian Sea before traveling onward to Ashgabat by land.

The extra effort required to perfect the timing and coordination of the material deliveries proved to be worthwhile: In the meantime, the construction workers had accomplished the nearly inconceivable; they had prepared the transmitter room sufficiently to allow installation of the transmitters to begin in the second week of October 2011. Timed almost like clockwork, the Rohde&Schwarz broadcasting equipment arrived at the tower on schedule for installation. The systems had to be transported to the tower cab 150 m above the ground during the evening and night hours, because only one elevator was in operation, and it was not possible to disturb the construction work being performed by the other companies. Up there, the team needed to keep cool heads in order not to be distracted from their complicated installation work by the busy construction work going on all around them: Technicians were still working everywhere to install the air conditioning and sprinkler systems. One level higher, workers were even still pouring concrete for part of the platform.

## On air, on time

Perhaps it was precisely these unusual challenges that motivated the Rohde&Schwarz team to reach top levels of performance and not give up. In this way, right on time for the anniversary, an ATV transmitter was put on air for a trial run just as desired. In the weeks that followed, the team installed the rest of the 27 transmitters, which were set up in a 1+1 standby configuration in the TV tower, and it was able to make the complete transmitter system operational by December 9, 2011, for the handover.

This project was a great success and a special experience: Never before had Rohde&Schwarz installed and commissioned so many transmitters at a single station and under such difficult conditions.

By the way, the 21 high-power and medium-power transmitters that were distributed across the country as part of this project were also put into operation on time. After all, for Rohde&Schwarz as a market leader, setting up transmitter networks of all sizes, power classes and transmission standards very quickly all around the world is almost a routine job.

Robert Bleicher; Franz Maurus

## DVB-T2 transmitters for Kazakhstan


Photo: Ricardo Rauch, Rohde&Schwarz

In October 2011, the Kazteleradio public broadcasting company in Kazakhstan commissioned Rohde&Schwarz to deliver and install turnkey transmitter systems for the cities of Almaty, Astana and Karaganda. Rohde&Schwarz won the order, because the reliable and robust transmitters impressed the customer.

The systems for these three cities have similar configurations and include:

- Two DVB-T high-power transmitters (3.7 kW)
- Headends with encoders, multiplexers and inserters for local programs and commercial broadcasts
- Satellite reception and decoding systems
- Multiscreen systems for operational monitoring
- Measurement and RF monitoring systems

There was very little time to complete the work, because the systems had to go on air by December 15, 2011. These systems marked the country's start into digital TV, and plans called for an inauguration ceremony with the country's president.

Due to the tight timeframe, precise coordination with other companies that the customer had tasked with delivering additional components, such as the electrical systems, was also important for this project. The Rohde&Schwarz installation team also managed to take a relaxed approach to the temperatures, which can be as low as –40 °C during this time of year, and to the language barrier (with Kazakh and Russian as the state and official languages of Kazakhstan).

The transmitter systems were installed during the required time period and to the customer's complete satisfaction. And this good work might also benefit the Rohde&Schwarz team when the country takes its next steps: installation of a nationwide digital TV network.

Husam Hassan

## Topping-out ceremony at Rohde & Schwarz in Munich

Rohde & Schwarz is expanding its headquarters in Munich. The global, family-owned company is investing close to EUR 60 million in a new office complex near the Munich-East train station. As part of the traditional dedication ceremony for the now complete shell, the topping-out wreath was hoisted atop the roof by crane. The new multifunctional building is due to be completed by March 2013.

Friedrich Schwarz (left), President of Rohde & Schwarz Immobilien GmbH & Co. KG, gave the opening speech. Christian Ude (right), the Mayor of Munich, and Jürgen Engel (center), President of KSP Jürgen Engel Architekten architectural office, also spoke to ceremony attendees.

## Expansion of the Singapore site

Rohde & Schwarz is investing EUR 35 million (about SGD 58 million) in a new building at Changi Business Park in Singapore. To mark the occasion of this strategic milestone, an official groundbreaking ceremony took place in April 2012. The new building will be home to Rohde & Schwarz Asia Pte. Ltd. and the Rohde & Schwarz regional headquarters. The new construction project is due to be completed by the fourth quarter of 2013. Rohde & Schwarz Asia is a global hub for R&D and production. The Rohde & Schwarz regional headquarters coordinates business activities in the eastern hemisphere.


Representatives of Rohde & Schwarz GmbH & Co. KG, JTC Corporation, Rohde & Schwarz Asia Pte. Ltd. and R&S Immobilienmanagement GmbH joined the German ambassador to Singapore for the groundbreaking ceremony at the site of the new global hub.

## EASA certifies Rohde & Schwarz airborne transceiver

In March 2012, the R&S®MR 6000 A VHF / UHF airborne transceiver was approved for the Airbus A400M transport aircraft. The European Aviation Safety Agency (EASA) granted the certification as part of the civil certification process for the A400M. For the first time, the approval was based on the civil development processes for avionics equipment in line with RTCA/DO-178B (software) and RTCA/DO-254 (hardware). Rohde & Schwarz passed the required functional safety tests for the transceiver.

This civil certification will allow the first aircraft to be delivered to France, where it will be put into service in December 2012.

Successful certification: Dr. Jürgen Foag (third from right), A400M V/UHF Transceiver Project Leader, and Dr. Rainer Storn (front, center), Head of R&D for Airborne Radio Software, with his team and representatives from EASA and the customer.

## TV transmitters from Rohde&Schwarz in the Australian outback

The Australian network operator Imparja TV has commissioned Rohde&Schwarz Australia with the delivery of several low-power transmitters of the R&S®SLx8000 family. Imparja operates the digital TV network in the outback together with Southern Cross Austereo (SCA). The rollout is currently underway at 28 stations, each having three TV transmitters that will provide service to around 700,000 residents distributed over an area of five million $km^2$. The unmanned stations are monitored using the R&S®DVMS1 monitoring system, which forwards all relevant RF and MPEG parameters to the network control centers located in Alice Springs and Townsville.

## ATC system for Parchim International Airport

The Parchim airport in Mecklenburg-Vorpommern is currently undergoing expansion, with a focus on development for international airfreight activities. Baltic Airport Mecklenburg GmbH, the airport operator, has placed an order with Rohde&Schwarz Systems GmbH for a state-of-the-art turnkey ATC system. Its main features include the IP-based R&S®VCS-4G voice communications system, which uses TCP/IP protocol to accommodate VoIP-capable radios and communications systems.

## Mexican oil company uses Rohde&Schwarz radios

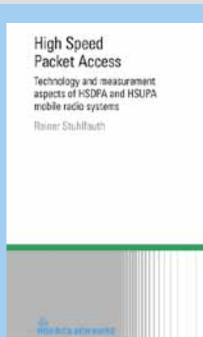
In the future, the Petroleos Mexicanos (PEMEX) oil company will use a Rohde&Schwarz communications system to manage the supply of materials and the transportation of passengers to six off-shore drilling rigs. The main components are the fully IP-based R&S®VCS-4G voice communications system as well as VoIP-capable R&S®Series4200 radios. PEMEX staff at the control center located in Ciudad del Carmen will use the new system to issue orders to the helicopters and maintain contact with the pilots during flight. Backup systems, each equipped with an extra radio, are installed for emergencies.

Rohde&Schwarz radios in the Gulf of Mexico.

## Mobile ATC tower for Indonesia

Rohde&Schwarz has delivered a fully equipped R&S®MX400 mobile air traffic control tower to the Indonesian air traffic control authority (Directorate General Civil Aviation, DGCA). The tower will be deployed throughout the country wherever an ATC communications infrastructure needs to be set up quickly. For example, the mobile tower can be used to coordinate relief flights in disaster areas where the local ATC infrastructure is no longer available. In addition to the Rohde&Schwarz equipment, the tower features a meteorological information system and interfaces for connecting to the local telecommunications infrastructure.

Fully equipped R&S®MX400 mobile air traffic control tower for the Indonesian ATC authority.




**High Speed Packet Access** – *Technology and measurement aspects of HSDPA and HSUPA mobile radio systems* is the new book by Rohde&Schwarz author Reiner Stuhlfauth. It can be purchased in bookstores (ISBN 978-3-939837-14-5) or directly from the Rohde&Schwarz webshop (www.books.rohde-schwarz.com). Price: EUR 64.

## New R&S®THU9 transmitter family for TV in Colombia

Next year, Colombia will be the first country in Latin America to go on the air with a DVB-T2 TV network. The network will use R&S®THU9 high-power transmitters from Rohde&Schwarz. Upon introducing DVB-T in 2010, the Consorcio Canales Nacionales Privados (CCNP) decided in favor of 24 transmitters from Rohde&Schwarz. These transmitters will gradually be updated to DVB-T2 in the coming months with the R&S®TSE800 transmitter system extension. During the next phase, eight more transmitter stations will be set up in major cities, providing 50 percent of Colombians with access to the new broadcasting network.

## New painting system for production services

With a new painting system, Rohde&Schwarz Messgerätebau GmbH in Memmingen has expanded its production services for customers outside the Rohde&Schwarz group of companies. Customers from the automotive, wireless communications and aerospace sectors in particular have their modules coated with protective paint to protect them from harmful environmental factors such as high humidity, condensation and salt spray. The new acquisitions also include two automated bonding systems for the production of radio frequency modules up to 110 GHz.

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