NEWS

210/14

ROHDE&SCHWARZ

Europe's first FM transmitter, built by Rohde&Schwarz, went on the air on February 28, 1949. Its latest successor is giving tried and tested technology new momentum.

European VHF broadcasting turns 65

Wireless technologies

Optimizing wireless networks with miniature high-performance scanners

General purpose

Switch matrices for network analyzers enable measurements on DUTs with up to 48 ports

Broadcasting and audio/video technology

More efficient TV studio production – from ingest and studio playout to content distribution

Always up to date with the NEWS app

Tablet users can now read NEWS in digital form. The R&S®News app for iPad, Android tablets and Amazon Kindle devices can be downloaded free of charge from the respective provider's app store. The app's language can be set internally to English, German, French or Spanish.

Besides the texts in the current print edition, all articles published in the last three years, sorted by topic, are accessible in seconds. The content is enriched by videos. Graphical signs mark which new articles have appeared since the app was last opened, guiding you selectively to the innovations.

Your benefits:

- All articles, sorted by topic, available immediately
- Timely presentation of product innovations, no waiting for the next print edition
- Additional articles that could not be published in the print edition
- Quick access to in-depth, topic-related content (application notes, product brochures, videos, etc.)

You can find the app in the respective app stores, under the key words R&S NEWS or Rohde&Schwarz, or simply by scanning the appropriate QR code.

For iPad

For Android

NEWS

Published by Rohde&Schwarz GmbH&Co. KG
Mühldorfstrasse 15 · 81671 München
www.rohde-schwarz.com

Regional contact

- Europe, Africa, Middle East | +49 89 4129 123 45
  customersupport@rohde-schwarz.com
- North America | 1 888 TEST RSA (1 888 837 87 72)
  customer.support@rsa.rohde-schwarz.com
- Latin America | +1 410 910 79 88
  customersupport.la@rohde-schwarz.com
- Asia/Pacific | +65 65 13 04 88
  customersupport.asia@rohde-schwarz.com
- China | +86 800 810 8228/+86 400 650 5896
  customersupport.china@rohde-schwarz.com

Editor and layout: Redaktion Drexl&Knobloch GmbH (German)
English translation: Dept. GF-MC7
Photos: Rohde&Schwarz
Printed in Germany

Volume 54
Circulation (German, English, French, Spanish and Japanese) 75000
approx. three times a year
ISSN 0028-9108
Supply free of charge through your nearest
Rohde&Schwarz representative

PD 5214.4494.72

Cover feature

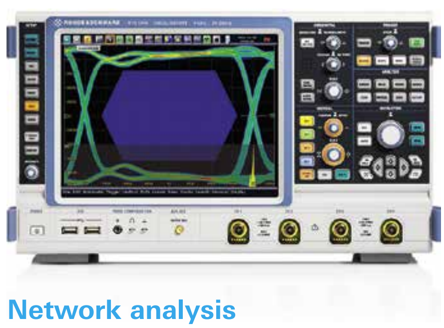
A piece of technological history was written 65 years ago on February 28. Europe's first VHF FM transmitter made its on-air debut after being developed and built by Rohde&Schwarz in record time. This pioneering achievement not only convinced German radio listeners of the superior quality of FM radio. It soon persuaded the international public and launched the rapid expansion of FM technology around the globe. It was the first of many generations of transmitters from Rohde&Schwarz.

In this issue, we present the culmination of this development. Analog broadcasting delivers a convincing grand finale with the new R&S®THR9 FM transmitters for VHF band II (page 40). The adjacent VHF band III is also expected to see further development. Sound and television broadcasting are celebrating a comeback here as the UHF band is increasingly being used by other applications such as wireless communications. The R&S®TMV9 medium-power and R&S®THV9 high-power transmitters now offer network operators state-of-the-art technology in this frequency band (page 46).

Overview NEWS 210/14

Wireless technologies

General purpose



Up to four compact, lightweight R&S®TSME drive test scanners fit in the backpack system so that even systems with 4 × 4 MIMO can be measured on the go (page 6).

Equipped with new switch matrices, the R&S®ZNB vector network analyzer provides up to 48 ports for measurements (page 23).

EMC / Field strength

Broadcasting and audio/video technology

February 28, 1949: Europe's first VHF FM transmitter went into operation. It was supplied by Rohde&Schwarz. Many generations of sound and TV broadcasting equipment have followed in the decades since. Read about the latest transmitters starting on page 40.

Radiomonitoring / radiolocation

Miscellaneous

Fig. 1: Up to four compact, lightweight R&S®TSME drive test scanners fit in the R&S®TSME-Z3 backpack system, so that even systems with 4×4 MIMO can be measured on the go.

Agile on the go: ultracompact, lightweight scanner for network optimization

Drive test scanners measure the quality of radio channels in mobile networks and are essential when planning, setting up and optimizing these networks. The R&S®TSME, an exceptionally compact and lightweight scanner, is now available. It performs measurements for all relevant standards simultaneously and its compact backpack system is ideal for use in buildings.

The app version of this article includes two videos.

Ongoing task: network expansion and optimization

Since the advent of smartphones and tablets on the wide-base market, the use of mobile broadband data services has been rapidly increasing. In 2012 alone, the global mobile data volume grew by 70 %. The telecommunications company Cisco predicts a further increase of 66 % annually in the coming years. [1]

Network operators are forced to respond by further expanding and optimizing their networks. When doing so, they rely on a variety of strategies:

- Allocation of new frequencies
- Implementation of new wireless communications standards and technologies with higher spectral efficiency, such as LTE, LTE-Advanced and multiple input multiple output (MIMO)
- Refarming of frequency blocks, such as using former GSM blocks in the 900 MHz band for WCDMA/UMTS or in the 1800 MHz band for LTE
- Use of small cells
- Increased use of WLAN to reduce network load

Fig. 2: The latest generation of Rohde&Schwarz drive test scanners is now even more compact. Shown here is a complete test system with the R&S®TSME and the R&S®ROMES measurement software.

When expanding network capacity, network operators increasingly take into account that the majority of data traffic is generated in buildings. In 2014, this is expected to be about 80 % of all data traffic (estimate from Nokia Solutions and Networks [2]).

In order to ensure network quality, operators, infrastructure manufacturers and service providers must manage the measurement tasks associated with networks of the future. The new ultracompact, lightweight R&S®TSME drive test scanner (Figs. 2 and 3) from Rohde & Schwarz is ideal for this task. With a measurement bandwidth of 350 MHz to 4.4 GHz, it covers all bands specified for wireless communications standards. In each band, it can simultaneously measure any combination of signals from different wireless communications standards. In Europe, for example, this is a combination of UMTS and GSM in the 900 MHz band, LTE and GSM in the 1800 MHz band, UMTS in the 2100 MHz band and LTE in the 2600 MHz band. Depending on the level of network expansion, it flexibly adapts to the network configuration.

R&S®TSME: very versatile

Coverage planning during spectrum refarming

When planning an additional LTE network for a frequency band in which a UMTS network is already operating, for example, the prevalent propagation conditions must be measured. This data can be used to fine tune the propagation model used in the LTE planning tool (model tuning). Since the UMTS network cannot be turned off for these measurements, a scanner with a high dynamic range is required to detect the signal of a distant radio cell in the neighboring cell's coverage area. The drive test scanners from Rohde & Schwarz perform these measurements easily.

Spectrum reallocation

The shutdown of analog TV channels has made new frequency bands available for wireless communications worldwide. Network operators first need to gain experience with these bands to be able to utilize them optimally. The introduction of LTE in the 800 MHz band, for example, has shown that this band differs significantly from the 900 MHz band. Since the lower frequency significantly extends the range of the LTE 800 cells, the 800 MHz band requires a different interference prevention plan than the 900 MHz band. Interference can occur when too many neighboring cells are received too strongly (pilot pollution).

Network optimization using LTE and MIMO

The use of LTE and MIMO increases the spectral efficiency of a network. LTE is based on OFDM and can therefore be flexibly deployed in different bandwidths. With 64QAM modulation, data rates up to 75 Mbit/s can be achieved in a 20 MHz channel. Under good channel conditions, MIMO can double the data rate without increasing the bandwidth. However, this requires an appropriately optimized network. The network operator can use a scanner during drive tests to determine whether and where there are problems with the radio transmission. Interference measurements are typically performed at the same time.

Even externally induced interference, such as from defective set-top boxes, strong TV transmitters or faulty cable TV lines, can be detected with scanner measurements. The network operator or regulatory authority can then take action against the interference source. Assessing the channel quality of LTE MIMO requires additional special MIMO measurements that the operator can use to optimize the network.

Fig. 3: Two R&S®TSME drive test scanners (rear view) configured for 2×2 MIMO.

Fig. 4: The R&S®TSME-Z3 backpack system can accommodate up to four scanners or two scanners and two mobile phones.

The R&S®TSME is ideal for all these tasks. The instrument is prepared so that up to four scanners can be cascaded to perform MIMO measurements. Essentially, the scanner will be able to grow with the network configuration and be used in systems with 2 × 2 MIMO and 4 × 4 MIMO.

The LTE-Advanced carrier aggregation mode makes it possible to increase the maximum data rate by combining several LTE cells. These cells generally lie in different frequency bands. The wide bandwidth of the R&S®TSME and its big brother, the R&S®TSMW, enables them to measure LTE-A networks with carrier aggregation.

In-building measurements

The greatest volume of data in mobile networks occurs in buildings. Buildings have the highest subscriber density and the highest data service usage. This is why network operators use dedicated infrastructures such as microcells, picocells and distributed antenna systems (DAS) in airports, train stations, trains, event venues (exhibition halls, sports stadiums), shopping centers and office buildings.

Operators increasingly supplement these small-cell networks with WLAN hotspots to reduce the load on mobile networks (WLAN offloading). Scanner measurements are essential for planning, commissioning and optimizing this infrastructure. When planning an in-building network, test transmitters help to determine the signal propagation. After the network has been set up, scanner measurements are used to check the coverage. The high cell density in buildings leads to increased interference. For this reason, network optimization is essential for standards such as UMTS and especially LTE, because it is usually not possible to reserve a specific frequency band for microcells and picocells.

Weighing less than 700 g with a maximum power consumption of 15 W, the R&S®TSME is ideal for these kinds of mobile measurements in buildings. The rugged R&S®TSME-Z3 backpack system (Figs. 1 and 4) accommodates up to four scanners or two scanners and two mobile phones. It can be equipped with two hot-swappable rechargeable batteries. The entire backpack system is extremely quiet during operation – an important requirement for measurements in public spaces.

Summary

The ultracompact R&S®TSME drive test scanner is the ideal network operator tool for performing measurements in all wireless communications standards, and in both today's and tomorrow's frequency bands. Several scanners can be cascaded to carry out MIMO measurements. The R&S®TSME-Z3 backpack system provides an efficient solution for measurements where most data traffic exists: in buildings.

Jordan Schilbach

References

[1] http://www.cisco.com/web/solutions/sp/vni/vni_forecast_highlights/index.html
[2] http://nsn.com/portfolio/services/network-implementation/in-building-solutions

Now easier than ever: analysis of complex wireless protocols

GSM, WCDMA, LTE, WLAN, Bluetooth®, etc.: Today's smartphones support many wireless communications standards and often communicate via several standards simultaneously, which makes analysis of data protocols increasingly complex. Such tasks are easier to accomplish with the new R&S®CMWmars message analyzer. Its powerful tools permit users to understand and graphically analyze signaling sequences.

R&S®CMWmars – the all-rounder for all wireless communications standards

The R&S®CMW500 wideband radio communication tester generates the signals for all common wireless communications standards – from GSM, WCDMA, TD-SCDMA and CDMA2000® all the way to LTE. The tester simulates the radio access network (layers 1 to 3 in the OSI/ISO layer model, i.e. the air interface) as well as the network operator's core network. This makes it possible to thoroughly test wireless devices on all protocol layers, from the physical transport layer to IP applications (Fig. 1).

During the test, the R&S®CMW500 records all signaling messages chronologically in a message log and stores it in a database. Since the introduction of LTE, these message logs have become increasingly complex, so that they now contain hundreds of thousands of messages and can grow into the gigabyte range, such as is the case for data throughput measurements, for example (IP end-to-end throughput).

The R&S®CMWmars message analyzer helps users analyze these complex message logs. The easy-to-use graphical user interface provides a large number of analysis tools for quickly tracking down all types of signaling problems. It has established itself as an indispensable tool for development teams at chipset and mobile phone manufacturers, for interoperability tests at network operators and for certification tests in test houses.

Gain insight – retain oversight

The strength of R&S®CMWmars is that it provides different views of the message log to help users better understand the complex protocol relationships (Fig. 2). The views can be customized, depending on how the various R&S®CMW500 applications (e.g. protocol tests, certification tests) record the logs.

Fig. 1: The R&S®CMWmars message analyzer on the R&S®CMW500 wideband radio communication tester.

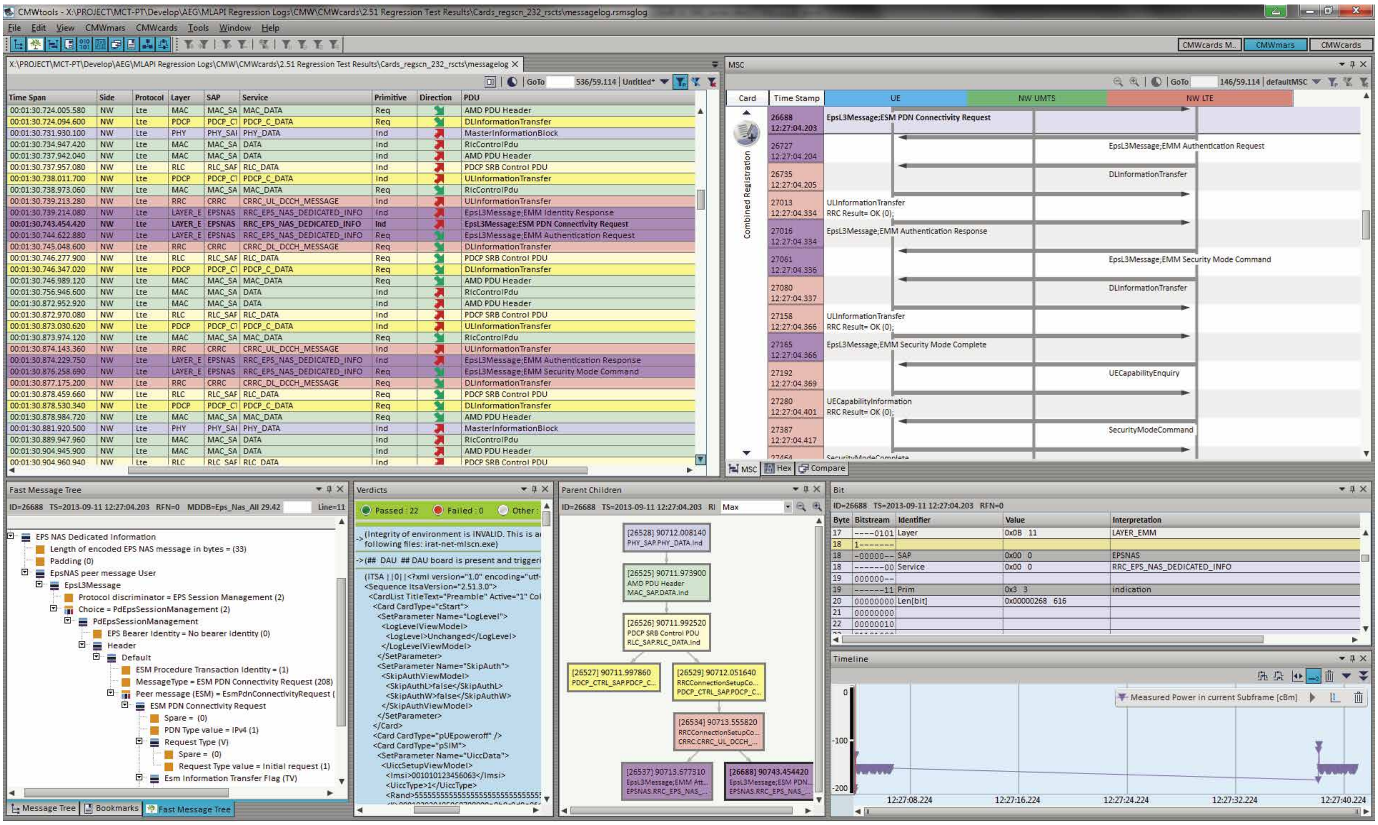


Fig. 2: Different views within the R&S®CMWmars message analyzer make it easier to track down errors in wireless signaling procedures.

Users get an initial overview of a wireless device's behavior during basic protocol tests, such as registration or inter-RAT procedures (pass/fail view). The message sequence chart view displays layer 3 signaling message sequences that are exchanged between the wireless device and the various cells (Fig. 4). The parent/children view illustrates the path a signaling message takes through the various protocol layers. The core of the application is the table view in which all recorded messages are listed in table format and sorted by timestamp, with the option to search and filter them according to defined criteria. All analysis views can be configured as required and are synchronized, so that the user is able to maintain a clear overview of what is going on, even with complex message logs.

Tracking down errors quickly

Network simulation and predefined test case scenarios on the R&S®CMW500 make it possible to reproduce a wide variety of errors in wireless signaling protocols. For example, information elements can be corrupted along the transmission path (coding/decoding errors) or data packets might be

Key characteristics of R&S®CMWmars

- Protocol analysis tool for all R&S®CMW500 applications
- In one message log access to all protocol layers of all wireless communications standards, including the IP data layer
- Various views for different angles – from simple to detailed
- Easy filtering thanks to an optimized user interface
- Comparison of information elements and packets within the application
- Pass/fail view with direct link to error source
- Unique timeline view for graphical analysis of information elements
- Highlighting of information elements and comments using bookmarks
- Offline analysis after completion of tests, as well as simultaneous logging within a test case
- Scripting interface for automated analysis using predefined C# or Python macros

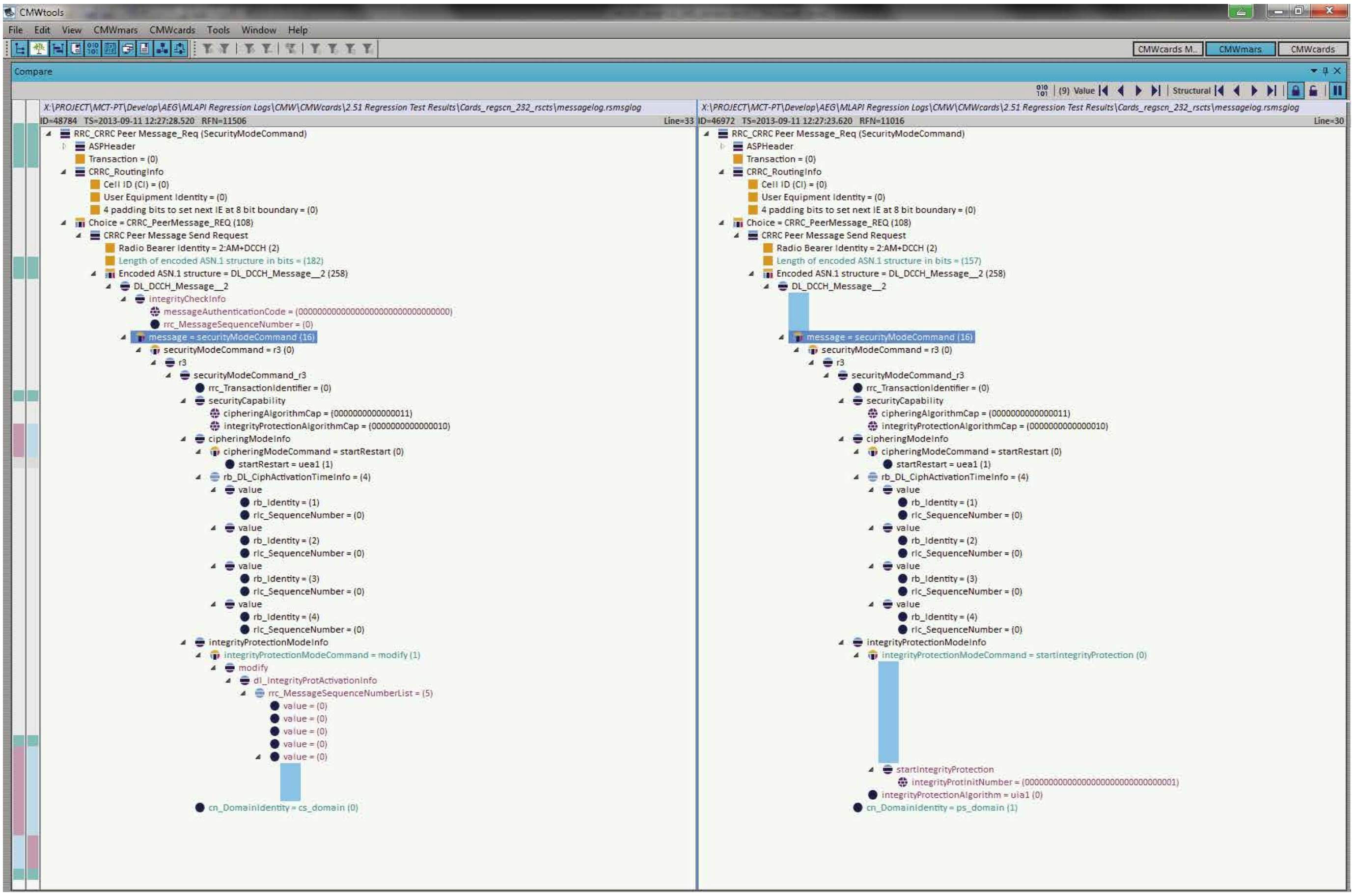
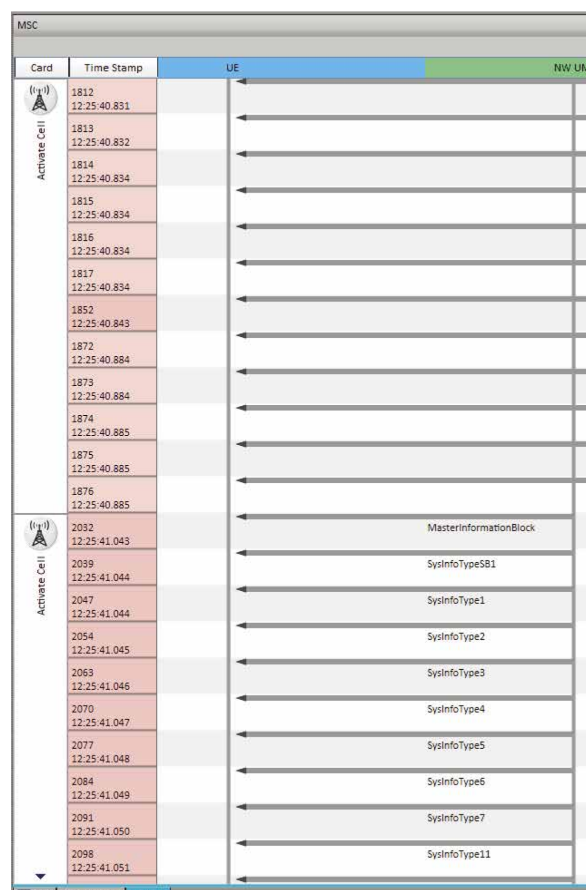


Fig. 3: Compare view for a direct comparison of individual information elements and packets.



received too late or even be lost (timeout errors). Although these protocol errors are difficult to track down, R&S®CMWmars enables users to quickly and efficiently detect them using the R&S®CMW500 without losing sight of the bigger picture.

R&S®CMWmars decodes both the downlink messages sent by the tester and the uplink messages sent by the wireless device (tree view) and displays them at bit level if required (bit view). Message contents or subelements can be compared to quickly identify differences between pass/fail tests (compare view, Fig. 3). The time-line view is used to present any selected information elements graphically over time. Readings from the physical layer and their trends are seen at a glance (Fig. 5).

A powerful scripting interface for C# and Python gives advanced users access to the entire R&S®CMW500 message log database so that they can efficiently automate frequently recurring analysis steps and extend the application's built-in range of features.

R&S®CMWmars and R&S®CMWcards – the perfect team

The R&S®CMWmars message analyzer works perfectly with the R&S®CMWcards* application to permit graphical programming of signaling tests. Both applications run within the same user interface, but offer different perspectives. Users can switch between the development perspective in R&S®CMWcards and the message analyzer perspective at any time to analyze the behavior of a wireless device either immediately during the test or offline after the test is completed. In the message sequence chart, the appropriate R&S®CMWcards playing card is referenced to each signaling message (Fig. 4). In addition, the complete R&S®CMWcards playing card sequence can be reconstructed from a message log file, greatly simplifying troubleshooting in distributed development teams and in customer support.

* R&S®CMWcards simplifies the creation of wireless signaling tests. NEWS (2012) No. 207, pp. 6–8.

Not only R&S®CMWcards applications benefit from the R&S®CMWmars message analyzer. All other R&S®CMW500 applications also support the new analysis tool – from the RF tester (callbox) to interoperability testing (IOT) and performance quality analysis (PQA) to system applications in the R&S®TS8980 RF conformance test systems.

Summary

The innovative R&S®CMWmars message analyzer simplifies the analysis of data protocols within a wide variety of R&S®CMW500 applications. R&S®CMWmars helps to significantly reduce the time required for troubleshooting complex wireless protocols thanks to easy operation of the powerful analysis tools, clear individual views and the possibility to analyze information elements in detail and add proprietary scripts to built-in features.

R&S®CMWmars can be installed on the R&S®CMW500 wideband radio communication tester or on a Windows® PC and is available in three different versions: R&S®CMWmars basic with fundamental analysis tools, R&S®CMWmars advanced for protocol experts and R&S®CMWmars viewer (freeware) that provides users with an initial overview of the R&S®CMW500 message logs.

Thomas Moosburger; Manuel Galozy

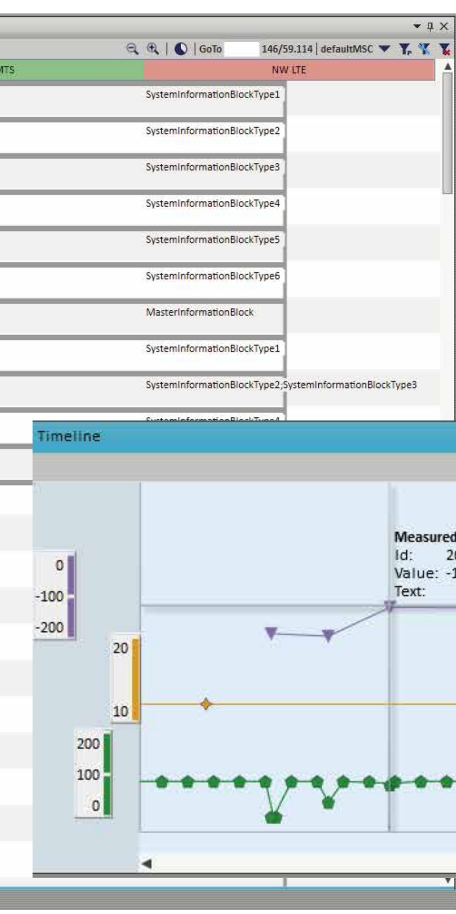


Fig. 4: The message sequence chart creates a compact overview of the signaling between the wireless device and the wireless network.

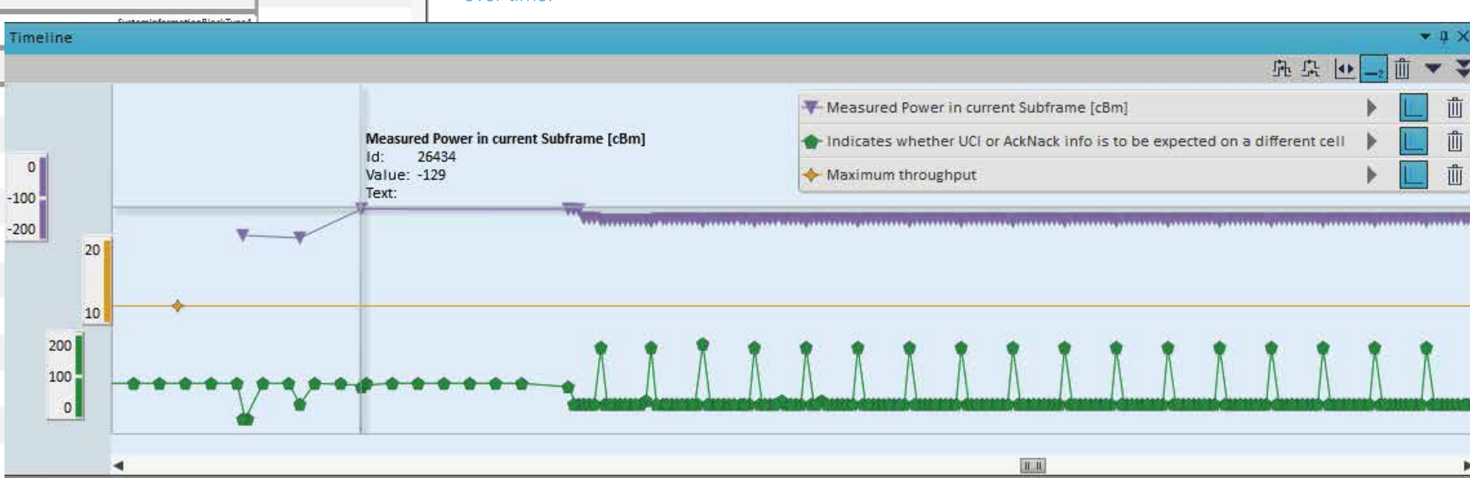


Fig. 5: The timeline view displays information elements graphically over time.

All-in-one solution for efficient amplifier testing including envelope tracking

A major portion of the amplifier power in smartphones dissipates as heat. The envelope tracking (ET) technology significantly improves amplifier efficiency as it allows the amplifier supply voltage to track the envelope of the RF signal. The R&S®SMW 200A vector signal generator combined with the R&S®FSW signal and spectrum analyzer now make comprehensive amplifier testing possible.

Improved amplifier efficiency with envelope tracking (ET) technology

Low battery warnings are all too familiar to smartphone users. In an effort to make these warnings less pervasive, manufacturers have long been working on a way to minimize power consumption. Beyond the processor and the display, a significant percentage of the energy is typically consumed by the amplifiers in the transmit path, which is why research is intense in this area. Amplifier efficiency is significantly improved through envelope tracking (ET).

Amplifiers are most efficient when they operate close to their maximum output power. ET takes advantage of that fact. Instead of receiving a constant supply voltage, the amplifier is fed a voltage from a DC modulator. This voltage is then controlled in such a way that it tracks the envelope of the RF signal. As a result, the amplifier operates at high efficiency most of the time, i.e. close to or in saturation (Fig. 1).

Additional requirements for amplifier testing including envelope tracking

In the case of envelope tracking, the amplifier can no longer be considered in isolation. Instead, its characteristics must always be studied in conjunction with the DC modulator.

Initially, a highly precise synchronization of the modulated supply voltage with the RF input signal (P_{IN}) must be performed on the amplifier. In the case of an LTE signal (with a bandwidth of 20 MHz), deviations in the nanosecond range would cause a significant increase in the error vector magnitude (EVM).

Instead of a strictly linear depiction of the input power on the supply voltage, the envelope signal can be optimized with respect to efficiency or linearity by using shaping functions. Linearity optimization causes a constant amplification over the amplifier's entire power range. Optimization for efficiency changes the gain over the power range (P_{IN}) because the

Comparison of conventional setup and envelope tracking

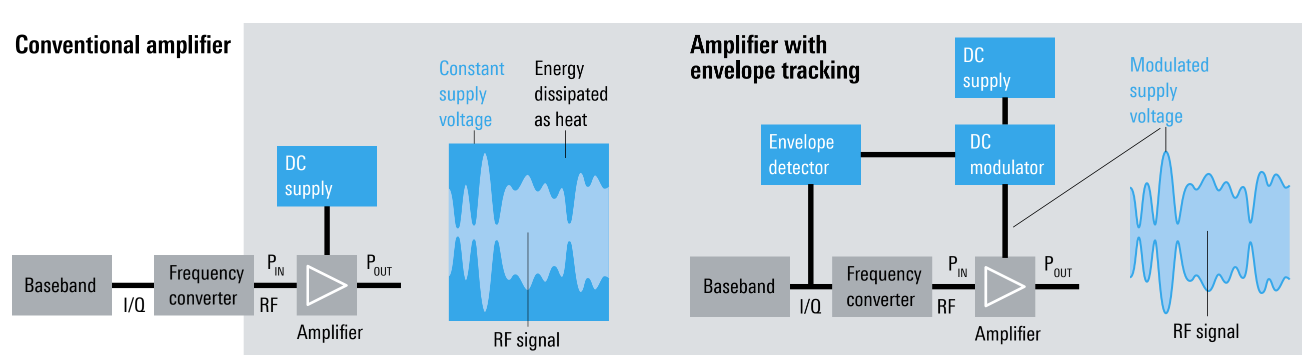


Fig. 1: Comparison of a conventional amplifier with an amplifier with envelope tracking.

amplifier is always operated in compression, i.e. in the nonlinear range. The resulting distortions at the amplifier output are often compensated for by using predistortion.

When characterizing an amplifier, it is important also to determine the power added efficiency (PAE) in addition to standard measurement values such as output power, adjacent channel leakage ratio (ACLR) or EVM. The PAE describes how efficiently an amplifier converts the received DC power into RF power using the following formula:

$$PAE \text{ (in \%)} = \frac{RF\ power_{IN} - RF\ power_{OUT}}{DC\ power} \cdot 100\ \%$$

This measurement displays the efficiency versus time. It requires synchronized recording of the input and output power and also acquisition of the current and voltage trace for the DC modulator.

All-in-one solution from Rohde & Schwarz

Rohde & Schwarz is now offering a customized all-in-one solution to meet the increasing requirements of chipset manufacturers to characterize power amplifiers with envelope tracking. This solution covers signal generation and analysis and is based on the high-end R&S®SMW200A vector signal generator and the R&S®FSW signal and spectrum analyzer (Fig. 2).

RF and envelope signal from a single instrument

Equipped with the new R&S®SMW-K540 envelope tracking option, the R&S®SMW200A easily generates the RF signal and the corresponding envelope signal. Since the vector signal generator calculates the envelope signal from the baseband signals in realtime, any communications standard, including LTE or WLAN, as well as custom RF waveforms can be used on the generator. As both signals come from a single instrument, users do not need to worry about synchronization. They can delay the RF signal and the envelope signal relative to each other in realtime by ±500 ns with 1 ps resolution. This ensures perfect synchronization between the modulated supply voltage and the RF signal. Due to the outstanding generator performance, the R&S®SMW200A delivers an extremely low-noise envelope signal at the analog I/Q output.

A selection of flexible shaping functions allows users to optimize the envelope in realtime (Fig. 3). In addition to a look-up table (LUT), the R&S®SMW200A also provides polynomial functions or detroughing. This gives users complete flexibility for optimizing the DC modulator and amplifier.

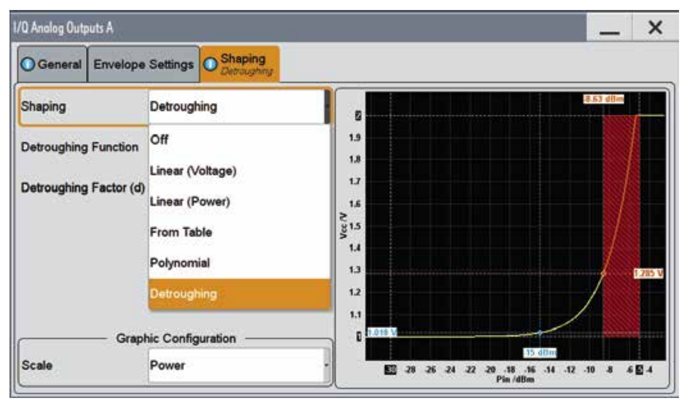


Fig. 3: Shaping functions in the R&S®SMW-K540 envelope tracking option.

Test setup for envelope tracking

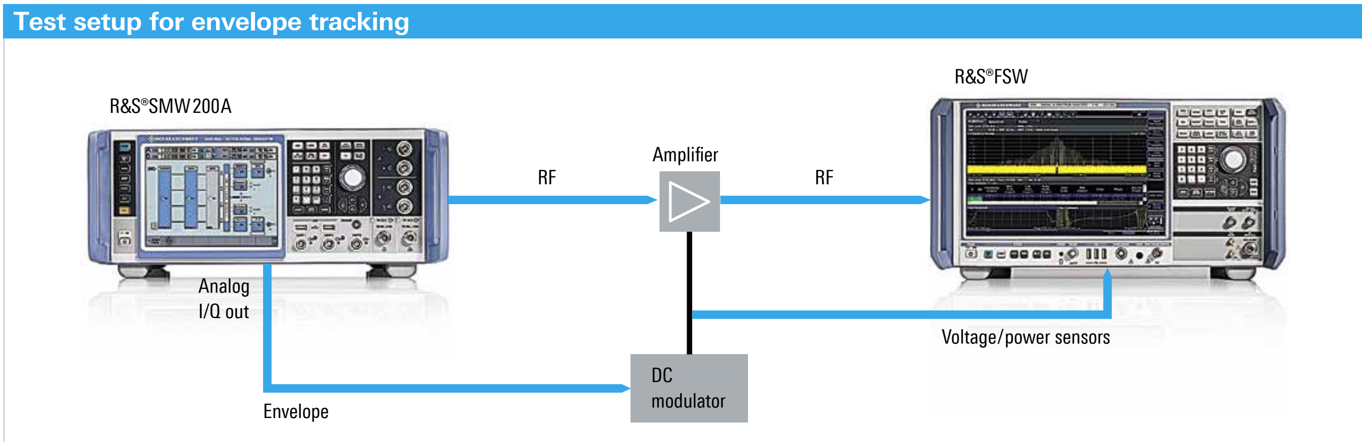


Fig. 2: Complete test setup for envelope tracking with the R&S®SMW200A vector signal generator and the R&S®FSW signal and spectrum analyzer.

All amplifiers are tested over specific power ranges. The auto envelope voltage adaptation mode speeds up the setup and testing time. The user can enter key parameters such as input power (P_{in}), supply voltage (V_{cc}) or DC modulator gain in a clear user interface (Fig. 4). Automatic recalculation of the envelope in realtime based on these values and during power sweeps makes it possible to perform testing over the amplifier's entire power range. This unique functionality significantly reduces testing time and eliminates time-consuming manual recalculation of the envelope at different power levels.

Digital predistortion in realtime

Since amplifiers with envelope tracking usually operate in the nonlinear range, distortion is experienced at the output. To counteract such deterioration in the RF performance, predistortion is often employed.

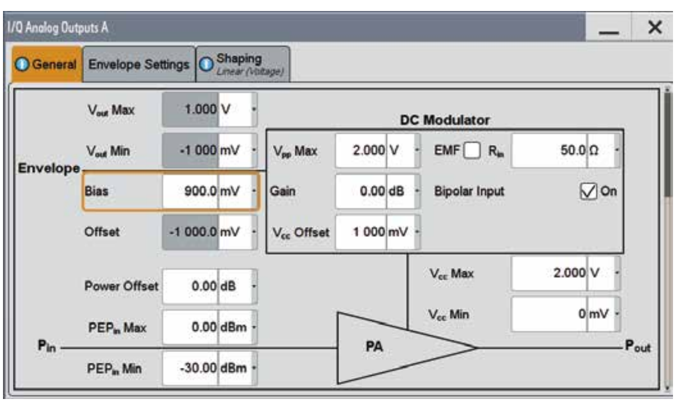
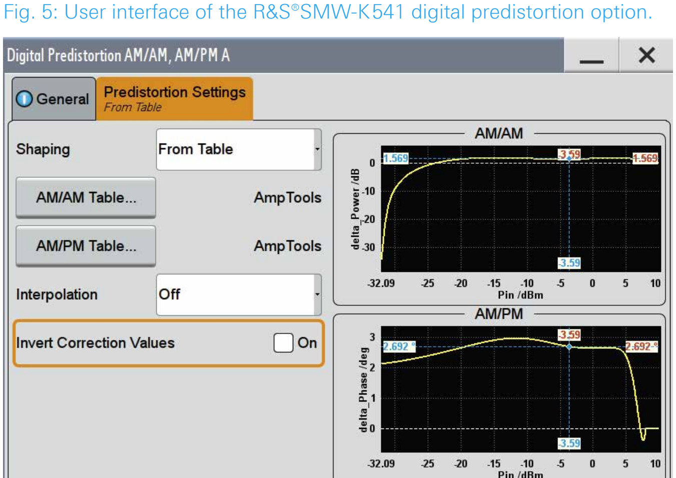


Fig. 4: User interface of the R&S®SMW-K540 envelope tracking option for detailed entry of key parameters.

Fig. 5: User interface of the R&S®SMW-K541 digital predistortion option.



The new R&S®SMW-K541 digital predistortion option (Fig. 5) permits loading of an AM/AM and AM/PM table with the requisite correction values. These delta values are calculated in realtime using the baseband signal. In conjunction with envelope tracking, the configuration can be set so that predistortion is applied only to the RF signal, or that the envelope signal is calculated based on the predistorted signal.

This option also makes it possible to import user-specific predistortion tables. The distortion can alternatively be determined using the R&S®FSW amplifier characterization software application. The associated coefficients for predistortion are then transmitted automatically to the R&S®SMW200A.

Synchronous analysis of envelope signal and RF signal

Equipped with the R&S®FSW-B71 hardware option, the R&S®FSW signal and spectrum analyzer can perform envelope tracking tests. The R&S®FSW-B71 hardware option adds analog I/Q baseband inputs of 40 MHz bandwidth each (the R&S®FSW-B71E option is additionally required for a bandwidth of 80 MHz). The modulator output signal is tapped at one of the inputs (Fig. 2). At the same time, the R&S®FSW receives the amplifier output signal via its RF input. The two signals can then be synchronized, displayed and analyzed. An oscilloscope is no longer required.

The current PAE can be calculated when inserting a small resistor in the circuit between the DC modulator and the power amplifier.

Power amplifiers are typically characterized by also measuring EVM and ACLR. The high-performance R&S®FSW signal and spectrum analyzer is ideal for these measurements: Its residual EVM for a 10 MHz LTE signal is only –48 dB and the WCDMA ACLR dynamic range is 88 dB. The influence of the test instrument on the result is negligible.

Measuring the noise in the output signal is often tricky for power amplifiers operated with envelope tracking and requires a spectrum analyzer with an excellent high dynamic range. The R&S®FSW and its extremely low displayed average noise level of typ. –159 dBm (1 Hz) at 2 GHz without using a preamplifier (when using a preamplifier it is up to 13 dB better) is more suitable than any other instrument for this task.

Thanks to efficient signal processing in the R&S®FSW, standard-compliant measurements are exceptionally fast. For example, a 20 MHz LTE uplink signal is characterized in fewer than 50 ms.

Fig. 6: Measurement of the AM/AM and AM/PM conversion as well as of EVM, peak and RMS power of an LTE UL signal using the R&S®FSW amplifier characterization software application.

All tests performed on one user interface

Testing amplifiers including envelope tracking is especially easy if the setup is controlled by the R&S®FSW amplifier characterization software for Windows. It controls both the R&S®SMW200A and the R&S®FSW, including their ET-related functions, automates the calculation of the AM/AM and AM/PM conversion for the DUT and then transmits relevant data to the generator. The information is then used for real-time digital predistortion (DPD). Since the software always knows the output signal of the generator, it can perform EVM calculations in parallel to AM/AM or AM/PM conversion and other analysis tasks significantly faster than with an unknown signal (Fig. 6).

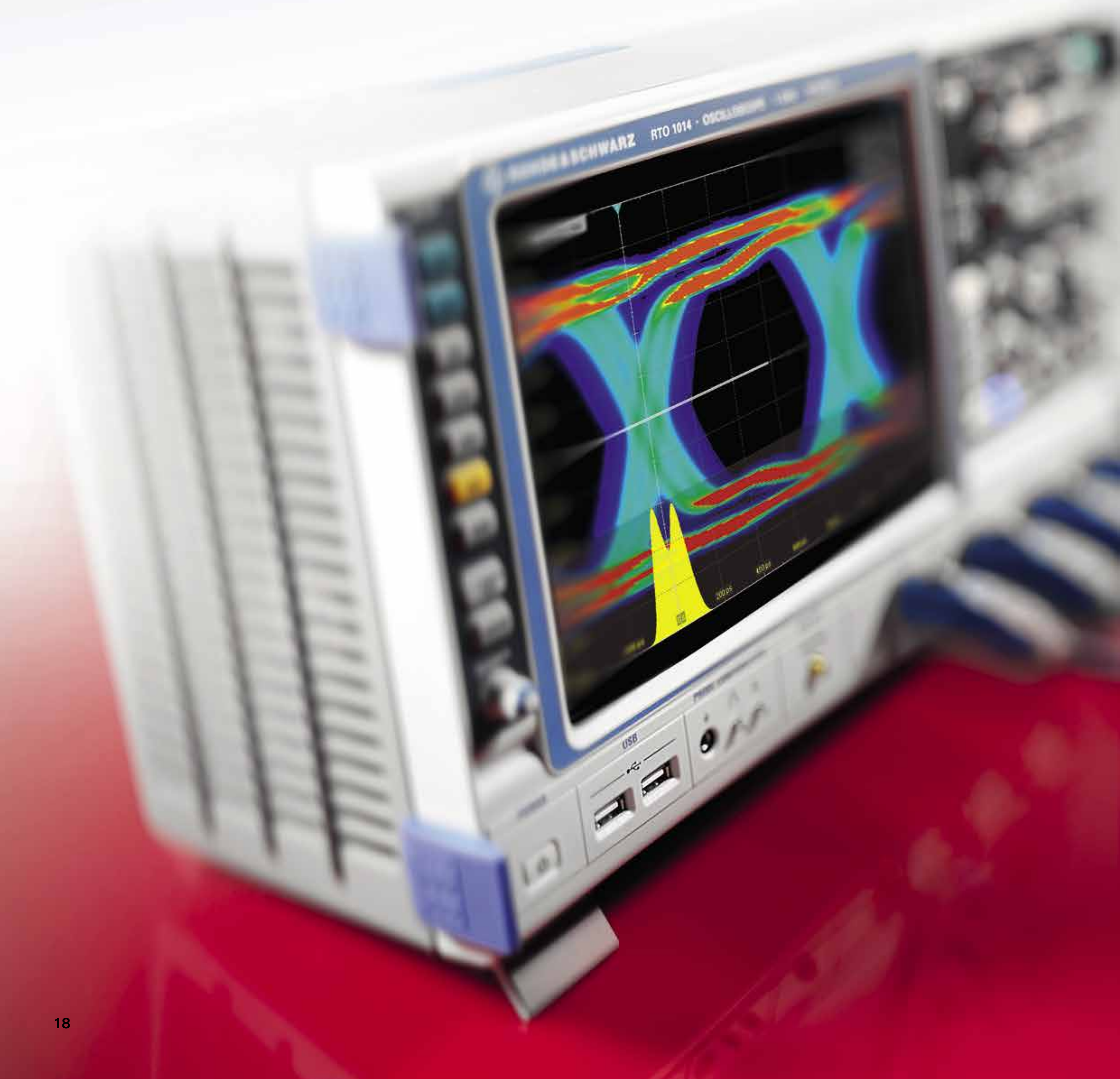
Summary

The simple test setup consisting of only two instruments allows quick startup without additional calibration effort. The testing time is greatly reduced by generating the envelope in realtime and thanks to the customized analysis software. When equipped with the R&S®SMW-K540 envelope tracking and R&S®SMW-K541 digital predistortion options and combined with the R&S®FSW signal and spectrum analyzer featuring synchronous RF and baseband inputs, the R&S®SMW200A vector signal generator is a unique solution for efficiently testing amplifiers including envelope tracking.

Matthias Weilhammer; Johan Nilsson

Jitter analysis with the R&S®RTO oscilloscope

Jitter can significantly impair digital systems and must therefore be analyzed and characterized in detail. The R&S®RTO oscilloscope in combination with the R&S®RTO-K12 jitter analysis option is a convenient tool for this task.



Jitter analysis options in the time and frequency domain

Jitter is a phenomenon that occurs in digital circuits. Jitter is present, for example, on clock signals, which are characteristic of digital systems. Although digital signals are in general more robust and less prone to interference than analog signals, the current trend toward higher data rates is a challenge for the signal integrity. This can be seen with printed boards. To maintain low costs, manufacturers continue to use FR4 printed boards for electronic circuits. However, the material, connectors and vias all impair the transmission characteristics. At data rates above 1 Gbit/s, the effect is no longer negligible. But a detailed signal analysis allows problems to be identified quickly and efficiently.

The data rates for many interface protocols, e.g. PCIe, SATA, USB and DDR, have been increasing over successive generations. Jitter analysis on these types of signals is not limited to data signals, but also includes the embedded clock or reference clock signals.

Jitter analysis can be performed in both the time and the frequency domain. Rohde&Schwarz offers solutions for both domains: R&S®RTO oscilloscopes as well as phase noise testers such as the R&S®FSUP. Oscilloscopes measure in the time domain and are preferred for jitter analysis on circuits that were designed and tested in the time domain. Phase noise testers are used, for example, to characterize oscillators in the frequency domain.

A comparison of the two methods (Fig. 1) typically shows greater accuracy for measurements in the frequency domain due to the higher dynamic range and longer measurement intervals. Measurements in the time domain have the advantage that sporadic unwanted signals can be displayed and analyzed. Nonperiodic signals, such as data signals with an embedded clock, can also be tested.

	Time domain	Frequency domain
Intrinsic measurements	Peak-peak jitter Cycle-cycle jitter Period jitter	RMS phase jitter Phase noise Spectrogram
Benefits	Low clock rates and data-dependent jitter measurable Measurement of jitter over time (track)	Easy detection of spurious and random jitter Typically lower noise floor thanks to higher dynamic range

Fig. 1: Comparison of jitter analysis in the time and frequency domain.

Jitter: definition and components

The International Telecommunication Union (ITU) defines jitter as short-term variations of the significant instants of a timing signal from their ideal positions in time. Jitter does not have a single source. Total jitter (TJ) can be divided into several components (Fig. 2). The two major categories are random jitter (RJ) and deterministic jitter (DJ). For a detailed jitter analysis it is important to understand the causes and sources of the individual components. The histogram, which is a graphical display of the frequency distribution (Fig. 3), shows only the total jitter. The total jitter is calculated by a convolution of the individual probability distribution functions (PDF) of each jitter source.

Random jitter is unbounded. It is described by statistical values such as mean value μ and standard deviation σ, and the PDF is the well-known Gaussian distribution. Caused by thermal noise, shot noise and similar effects, random jitter can be described as phase noise in oscillating signals.

In contrast, deterministic jitter is bounded and cannot be described with phase noise. These jitter components are frequently specified as peak-to-peak values. Deterministic jitter includes period jitter (PJ), data-dependent jitter (DDJ) and duty cycle distortions (DCD).

Period jitter can be caused by crosstalk or PLL instability, for example. Its PDF differs depending on the source. Digital signal crosstalk frequently results in a Dirac PDF, while for purely sinusoidal signals the PDF corresponds to the Doppler power density function.

Data-dependent jitter is caused by intersymbol interference (ISI). The resulting dual Dirac PDF lies symmetrical to the time origin.

Duty cycle distortions originate from nonoptimal decision levels or different rise and fall times and, like data-dependent jitter, can be represented by a dual Dirac PDF.

Jitter sources

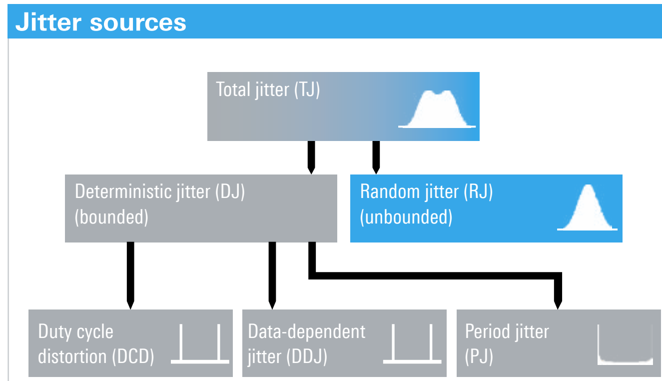


Fig. 2: Jitter sources and corresponding PDF in the histogram.

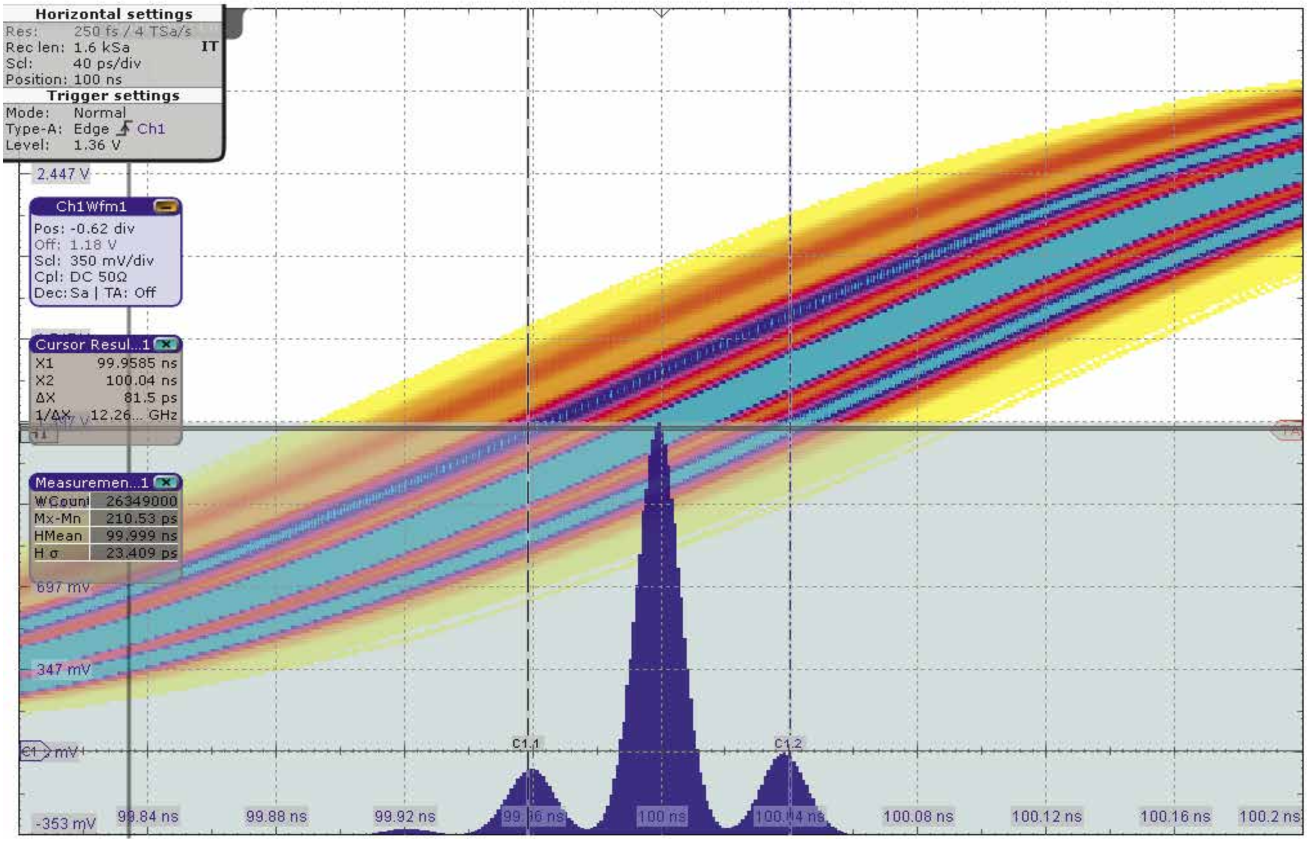
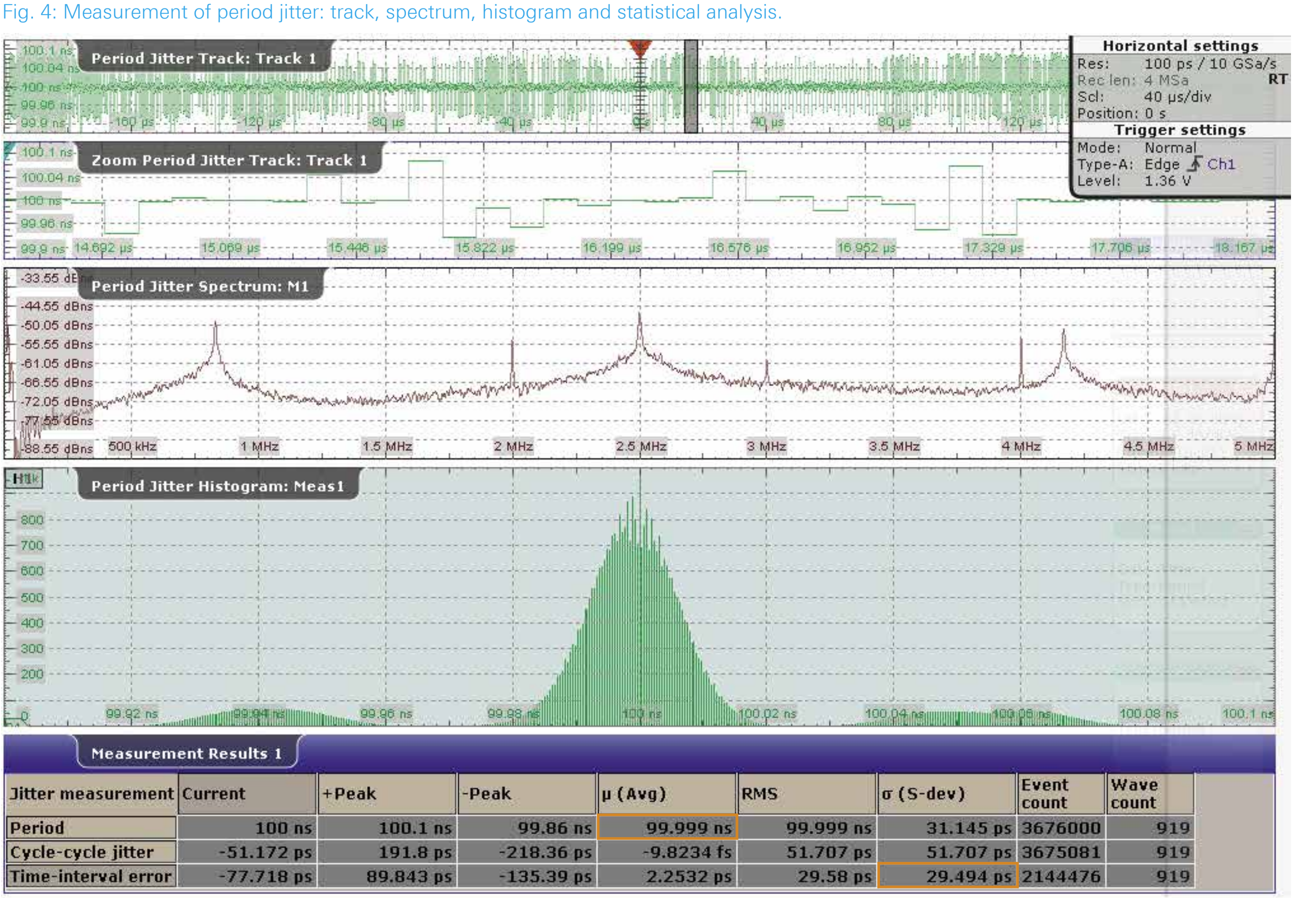


Fig. 3: Jitter analysis on waveforms using histogram and persistence.

Fig. 4: Measurement of period jitter: track, spectrum, histogram and statistical analysis.



Displaying jitter

The R&S®RTO oscilloscope offers a variety of tools for analyzing jitter. Even without a jitter option, the user can display the waveform histogram with persistence for analysis purposes. With this setting, waveforms are accumulated on the display, and the histogram shows the frequency of occurrence of the signals. This makes it easy to determine e.g. the density of signal transitions (Fig. 3). The statistical values for the distribution can be determined by applying the cursor and automatic measurement functions to the histogram.

The R&S®RTO-K12 jitter analysis option adds automated jitter measurements, including calculation of the period jitter and the data rate, and offers a variety of additional display options. The R&S®RTO displays the measurement results in a table, optionally with detailed statistics. The measured values can also be displayed as a histogram. Additionally, with the R&S®RTO-K12 option, jitter values can be tracked over time, which enables the user to create the spectrum of the jitter signal by calculating the FFT. Viewing the jitter signal in the frequency domain has many advantages. First, small deterministic jitter components are visible that would otherwise be obscured by noise (Fig. 4). Second, the user can use the magnitude and behavior of the noise floor as indications about the noise power and the individual noise components.

Measuring jitter

Fig. 5 shows important jitter measurement functions – period jitter, cycle-cycle jitter and time interval error (TIE) jitter – referenced to the measured signal over time. The example shows a digital clock signal that corresponds to a periodic signal. The mathematical analysis of these measurements as a function of the input signal is complex. See the references for more detailed discussions [1]. Here, the measurement functions for period jitter, cycle-cycle jitter and TIE jitter will be introduced and compared using concrete application examples.

The period jitter measurement function enables the user to perform extensive analyses, e.g. to assess the stability of a clock source. The R&S®RTO calculates the period jitter using the difference of successive edge positions of the signal as a reference. For simple clock sources such as crystal oscillators, the track function for period jitter appears as a constant with overlaid noise (track 1 in Fig. 4). Looking at the histogram, it becomes obvious that the mean value of the measurement corresponds to the nominal period duration (99.999 ns in Fig. 4). The noise power of the phase noise signal (29.4 ps in Fig. 4) corresponds to the standard deviation of the measurement result. In addition to this stochastic analysis, the track function can be applied to the period jitter measurement function to display modulated signals. This is ideal for analyzing radar signals, for example. However, it must be noted that this measurement function can only be used on periodic signals.

Definition of jitter measurement functions

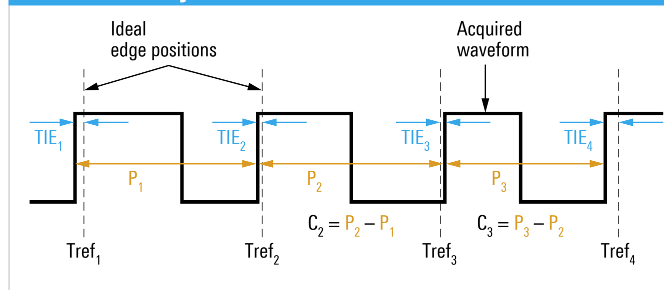


Fig. 5: Definition of jitter measurement functions for period jitter (P_n), cycle-cycle jitter (C_n) and TIE jitter.

The cycle-cycle jitter measurement function (Fig. 5) is very similar to the period jitter measurement function. It calculates the difference between consecutive pulse periods and is also applicable only for periodic signals. It can be used to analyze oscillator stability or the dynamic behavior (PLLs), for example.

The TIE jitter measurement function can be used on clock and data signals. It calculates the difference between the actual edge position and the associated nth ideal edge position (Fig. 5). Although this doesn't precisely match the original ITU definition, it is a commonly used definition of this measurement function in oscilloscopes. The term TIE will be used in this sense for the remainder of this article.

The TIE jitter measurement function is used to evaluate the transmission of a digital data stream with an embedded clock. When measuring the TIE, a measuring instrument has to determine not only the actual edge position, but also the unknown ideal edge position. Oscilloscopes have two methods to do this.

The first and simplest approach is to estimate a constant interval using the least square estimation (LSE) method. The second method uses a PLL or clock data recovery (CDR) to determine the edge positions. This is necessary because the assumption of the first method (i.e. the embedded clock is constant) may not hold true for all signals. The embedded clock may change during the acquisition, e.g. due to a spread spectrum technique (PCIe).

Jitter analysis with an oscilloscope is comparable to sampling the phase noise, where the sampling frequency corresponds to the nominal frequency of the signal. The measurement functions used, e.g. period jitter or TIE jitter, are essentially filters that are used on the sampled signal. Because the sampling rate is limited and the phase noise is not band-limited, aliasing effects can result.

Oscilloscopes typically implement CDR in software. A software-based CDR calculates the ideal edge position for a single acquisition based on the series of previous transitions. This means that a dead time occurs at the start of each acquisition because the CDR must first collect a sufficient number of transitions to compute the ideal edge position with sufficient accuracy. As a result, even in the case of a long acquisition time only a few measurements can be performed. Furthermore, the accuracy of the ideal edge position calculations depends on the sampling rate. Reducing the sampling rate in order to increase the length of the acquisition can cause instabilities in the software-based CDR [2].

These problems are eliminated with the R&S®RTO oscilloscope thanks to its integrated, hardware-based CDR (R&S®RTO-K13 option) that consistently operates at the maximum sampling rate. Instabilities and dead times at the start of every acquisition are prevented.

Summary

Jitter in digital systems can significantly limit the data rate and therefore requires detailed analysis and characterization. Its low intrinsic jitter makes the R&S®RTO oscilloscope an excellent instrument for jitter measurements, and the R&S®RTO-K12 option unlocks its full potential. This option offers a comprehensive set of measurement functions for development and conformance testing.

The additional R&S®RTO-K13 CDR hardware option is a reliable solution for clock recovery, eliminating the weaknesses inherent in a purely software-based implementation.

Dr. Mathias Hellwig

References
[1] D. A. Howe; T. N. Tasset, "Clock Jitter Estimation based on PM Noise Measurements," Boulder, CO 80305, 2003.
[2] A. M. S. Chatwin A. Lansdowne, Measurement Techniques for Transmit Source Clock Jitter for Weak Serial RF Links, Big Sky, MT: Aerospace Conference, IEEE, 2011.

Additional references
– Jitter Analysis with the R&S®RTO Digital Oscilloscope. Application Note from Rohde&Schwarz (search term 1TD03).

Switch matrices for the R&S®ZNB: network analysis now with up to 48 ports

Where the R&S®ZNB vector network analyzer once offered a maximum of 32 RF ports* via switch matrices, the new R&S®ZN-Z84 switch matrices now increase the number of test ports to 48. This makes it possible to quickly and conveniently measure all S-parameters of components with up to 48 ports.

Always enough test ports

The number of RF ports of components in smartphones and tablets is steadily increasing. Rohde&Schwarz has introduced the R&S®ZN-Z84, an external switch matrix (Fig. 1) that permits manufacturers to characterize the RF characteristics of these components using the R&S®ZNB. The R&S®ZN-Z84 offers up to 24 ports and covers the mobile radio frequency range from 10 MHz to 8.5 GHz. Two matrices, each with 24 ports and two VNA ports, increase the number of test ports of a four-port R&S®ZNB to up to 48 ports. All models permit full-crossbar measurements and enable users to determine all S-parameters of a multiport DUT.

* R&S®ZNB: convenient network analysis with up to 32 ports. NEWS (2013) No. 208, pp. 48–50.

The app version of this article contains a video about the R&S®ZN-Z84.

Fig. 1: The R&S®ZNB vector network analyzer with two R&S®ZN-Z84 switch matrices provides up to 48 ports.

Test setup and operation – simple and fast

The intuitive operating concept of the R&S®ZNB makes it especially easy to configure, calibrate and perform complex multiport measurements. The R&S®ZNB automatically detects the matrix type and assigns the port numbers so that users can immediately start measuring (Fig. 2). No additional software is required to control the matrix, evaluate results or run the calibration.

The test parameters are selected in the R&S®ZNB user interface. The clear structure of the user interface allows each parameter to be selected with a maximum of three operating steps, even when testing DUTs with many ports. The large 30 cm (12.1") touchscreen provides straightforward display and easy evaluation of results – even with a large number of traces.

The R&S®ZNB controls the matrices via LAN, USB or the direct control interface. The time required per switching operation is less than 2 ms for control via LAN and less than 1 ms for control via USB (Fig. 3). Direct control bypasses the operating system to use the digital hardware in the R&S®ZNB to directly control the matrices. The switching time is less than 100 µs and thus negligible. Direct control increases measurement speed, especially for setups with few test points and many ports. If controlled via USB or LAN, the many switching operations and associated switching times would make up a significant portion of the total measurement time.

Thanks to their compact design and the use of electronic switches, the R&S®ZN-Z84 switch matrices feature low insertion loss and good test port match. As a result, the instruments offer improved long-term stability, measurement accuracy, output level and dynamic range and reduce trace noise. The high compression point permits measurements on active DUTs with output levels of up to +20 dBm.

A matrix for every application

The R&S®ZN-Z84 is available with two or four VNA ports and either six, 12, 18 or 24 test ports (Fig. 4). Users can select the optimum combination for low attenuation, maximum accuracy and a high number of ports. Partially equipped matrices can be upgraded with additional ports at any time, allowing them to grow as requirements change.

A 24-port system can be created using a matrix with two or four VNA ports (Figs. 5 and 6). Matrix solutions with four VNA ports have the advantage that

Fig. 2: Automatic allocation of test ports in the R&S®ZNB vector network analyzer.

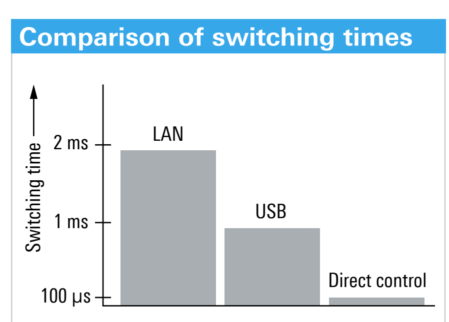


Fig. 3: Comparison of switching times for different control interfaces.

the connected vector network analyzer can measure on four ports of the DUT simultaneously, significantly reducing measurement time, especially in production applications. Matrices with only two VNA ports need to carry out up to three times as many switching operations in order to perform the same number of measurements.

A four-port R&S®ZNB combined with two matrices, each equipped with two VNA ports and 24 test ports, turns into a test system with 48 ports (Fig. 1), making it possible to characterize all 2304 S-parameters of a 48-port DUT.

Summary

Rohde & Schwarz offers new matrices for the R&S®ZNB with six, 12, 18 and 24 ports that can be controlled and configured via the VNA's intuitive user interface. The matrices are supported by two-port and four-port analyzers and permit multiport measurements on DUTs with up to 48 ports. Short switching times and excellent RF characteristics make the matrices especially suitable for time-critical production applications. Thanks to their modular design, additional ports can be added at any time.

Thilo Bednorz

Configuration overview

	VNA ports	Test ports	Configuration
R&S®ZNB with two ports	2	6	R&S®ZN-Z84
	2	12	R&S®ZN-Z84 + opt. 22
	2	18	R&S®ZN-Z84 + opt. 22 + opt. 32
	2	24	R&S®ZN-Z84 + opt. 22 + opt. 32 + opt. 42
R&S®ZNB with four ports	4	12	R&S®ZN-Z84 + opt. 24
	4	18	R&S®ZN-Z84 + opt. 24 + opt. 34
	4	24	R&S®ZN-Z84 + opt. 24 + opt. 34 + opt. 44
	2 × 2	2 × 24	2 × (R&S®ZN-Z84 + opt. 24 + opt. 34 + opt. 44)

Fig. 4: Overview of the matrix configuration for full-crossbar measurements.

Switch matrix with four VNA ports

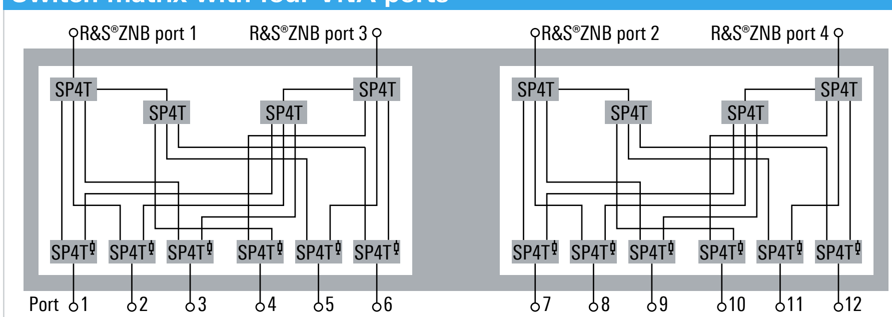


Fig. 5: R&S®ZN-Z84 switch matrix with four VNA ports and 12 test ports.

Switch matrix with two VNA ports

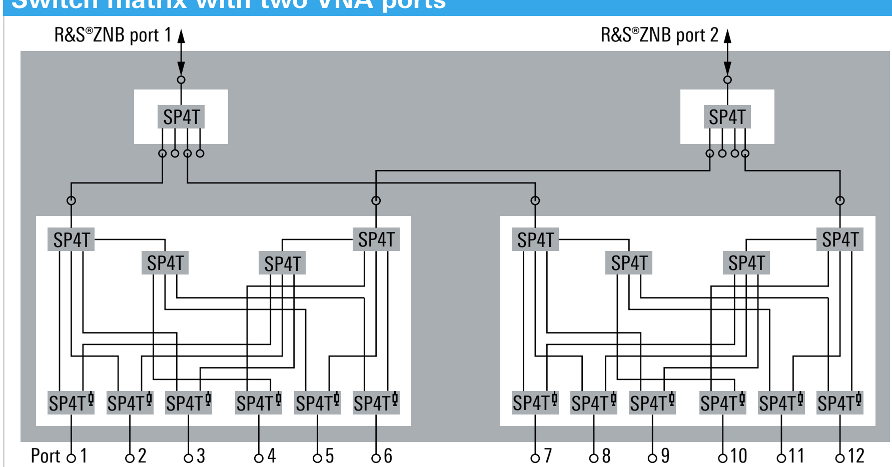


Fig. 6: R&S®ZN-Z84 switch matrix with two VNA ports and 12 test ports.

Fig. 1: The R&S®ZNB vector network analyzer with the R&S®ZN-Z51 automatic calibration unit (N (f) connector).

New calibration units for production and lab

The new R&S®ZN-Z151 is ideal for use in production, where the focus is on cost-effective calibration. The R&S®ZN-Z51 calibration unit is recommended for applications with different connector types or high data security requirements.

Fig. 2: The R&S®ZN-Z51 automatic calibration unit with four ports and 3.5 mm (f) connector.

Even more choices

Besides manual calibration kits, Rohde & Schwarz offers several automatic calibration units with two, four, six or eight ports. The product range is expanded by two new calibration units, the R&S®ZN-Z151 and R&S®ZN-Z51, which are supported by the R&S®ZVA, R&S®ZVT, R&S®ZVB, R&S®ZNB and R&S®ZNC vector network analyzers.

Cost-effective: the R&S®ZN-Z151 calibration unit

In many production sites, vector network analyzers (VNA) are used for component testing. Test setups require regular calibration, e.g. to compensate for attenuation in the lines. Calibration must be fast, easy and above all cost-effective. The R&S®ZN-Z151 automatic calibration unit was developed especially for this application (Fig. 3).

The two-port calibration unit with N (f) connectors covers the frequency range from 100 kHz to 8.5 GHz, which perfectly matches the frequency range of the R&S®ZNB8. The unit can be connected via USB to any of the above-mentioned Rohde & Schwarz VNAs and is automatically detected by the firmware. Users simply need to connect the test cable to the calibration unit as shown in the calibration wizard and start the calibration. The rest is taken care of quickly and automatically.

Versatile and top quality: the R&S®ZN-Z51 calibration unit

The R&S®ZN-Z51 calibration unit (Figs. 1 and 2) covers the frequency range from 100 kHz to 8.5 GHz and features particularly high accuracy. Its lockable USB connectors prevent accidental separation of the cable from the calibration unit, e.g. during calibration.

The unit is available as a two-port or four-port model with either 3.5 mm (f) or N (f) connectors. Models equipped with N (f) connectors can be configured instead with N (m), 3.5 mm (f or m) or 7/16 (f or m) connectors*. Like all calibration units, the R&S®ZN-Z51 is factory-characterized with the selected connectors.

Users can equip the ports of the two new calibration units with their own adapters and characterize them. The characterization data of the R&S®ZN-Z51 can be stored on a removable microSD card. Sensitive data can be protected against unauthorized access simply by removing the card.

Summary

The R&S®ZN-Z151 calibration unit is ideal for users who want fast and easy calibration and are looking for a cost-effective solution. The R&S®ZN-Z51 is available with a variety of connector types and features particularly high accuracy. It also allows users to store characterization data on a removable storage medium.

Tanja Schulze

Automatic calibration

VNAs can be quickly and easily calibrated using automatic calibration units. The calibration unit is connected to a Rohde & Schwarz VNA via USB. The VNA firmware automatically detects the calibration unit, and the characteristic data is transmitted to the analyzer, where the calibration unit is displayed in the menu for selection (Fig. 4).

Once connected to the VNA and the DUT, calibration is performed fully automatically. This saves time compared to a manual calibration because every DUT port has to be connected only once to the calibration unit. It also prevents errors caused by connecting an incorrect calibration standard, for example.

Fig. 4: The calibration menu on the R&S®ZNB vector network analyzer with the selected calibration unit.

* The upper limit frequency for ports with 7/16 connectors is 7.5 GHz.

Fig. 3: The R&S®ZN-Z151 automatic calibration unit is a cost-effective solution for use in production.

Seamless realtime analysis of frequency hopping with the R&S®FSW

A new option has been added to the R&S®FSW high-end signal and spectrum analyzer for realtime applications. It measures the spectrum in a frequency band up to 160 MHz wide, and even detects signals with a duration of only 1.87 µs with 100 % certainty and with accurate level. Infrequent and ultrashort events are made visible thanks to spectrogram displays and persistence mode.

Realtime analysis – vital for measurements on frequency hopping systems

Wireless communications systems that use frequency hopping have the advantage that their data transmission is less susceptible to interference and that diverse applications can share one frequency band. Cordless headsets and microphones, for example, operate very reliably in an extremely small space and in the same frequency band. Frequency hopping is also useful for tactical radios or radar applications in which, among other things, the influence of wanted interference must be minimized. In order to analyze frequency agile systems of this type, it is essential that the signals are displayed accurately and without interruption. This is also a prerequisite for being able to analyze brief interference effects such as those caused by frequency hops or digital circuits and to examine frequency hopping algorithms. Realtime spectrum analysis is ideal for performing these tasks [1, 3, 4].

Realtime spectrum analysis up to 67 GHz with the R&S®FSW

The R&S®FSW-K160R 160 MHz realtime spectrum analyzer option turns the R&S®FSW high-end signal and spectrum analyzer (Fig. 1) into a realtime analyzer. It digitizes a frequency band of up to 160 MHz and calculates up to 600 000 spectra per second (see Fig. 2). In order to achieve different resolution

Fig. 1: The R&S®FSW signal and spectrum analyzer, equipped with the R&S®FSW-K160R option, analyzes almost 600 000 spectra per second in realtime and is twice as fast as competitor products.

Parameter	
FFT length	selectable between 32 and 16384
Realtime analysis bandwidth	up to 160 MHz
Minimum signal duration for 100 % POI	1.87 µs
FFT rate	max. 585938 FFT/s

Fig. 2: The most important specifications of the R&S®FSW-K160R 160 MHz realtime spectrum analyzer option.

bandwidths, the FFT length is adjustable between 32 and 16384. With large resolution bandwidths, the R&S®FSW can detect signals up to a minimum duration of 1.87 µs with accurate level and at a probability of intercept (POI) of 100 %. The seamless spectra overlap by 67 % in the time domain so that the observer does not miss even the smallest of signals.

Because the human eye can only process up to 30 images per second, the analyzer combines several thousand spectra in one detector so that each peak is recognizable. However, this combining leads to loss of the extremely high time resolution. Other display modes, such as the persistence spectrum and the spectrogram, or the frequency mask trigger (FMT), solve this problem. The FMT can automatically evaluate all 600000 spectra per second and respond to certain user-defined events, even if these are only a few nanoseconds long.

Persistence mode displays color-coded signal frequency

In persistence mode, the analyzer seamlessly writes all spectra on top of each other in a diagram, color-coded according to their probability of occurrence. For example, it marks signals that occur very frequently in red, and those that occur rarely in blue. If a signal no longer occurs, it disappears after the selected persistence time. This allows the user to

Fig. 3: WLAN and Bluetooth® share the ISM band at 2.4 GHz. Sometimes weak signals cannot be detected with a spectrum analyzer. They are hidden by stronger signals (top). A weaker signal can only be detected in the persistence spectrum display (bottom).

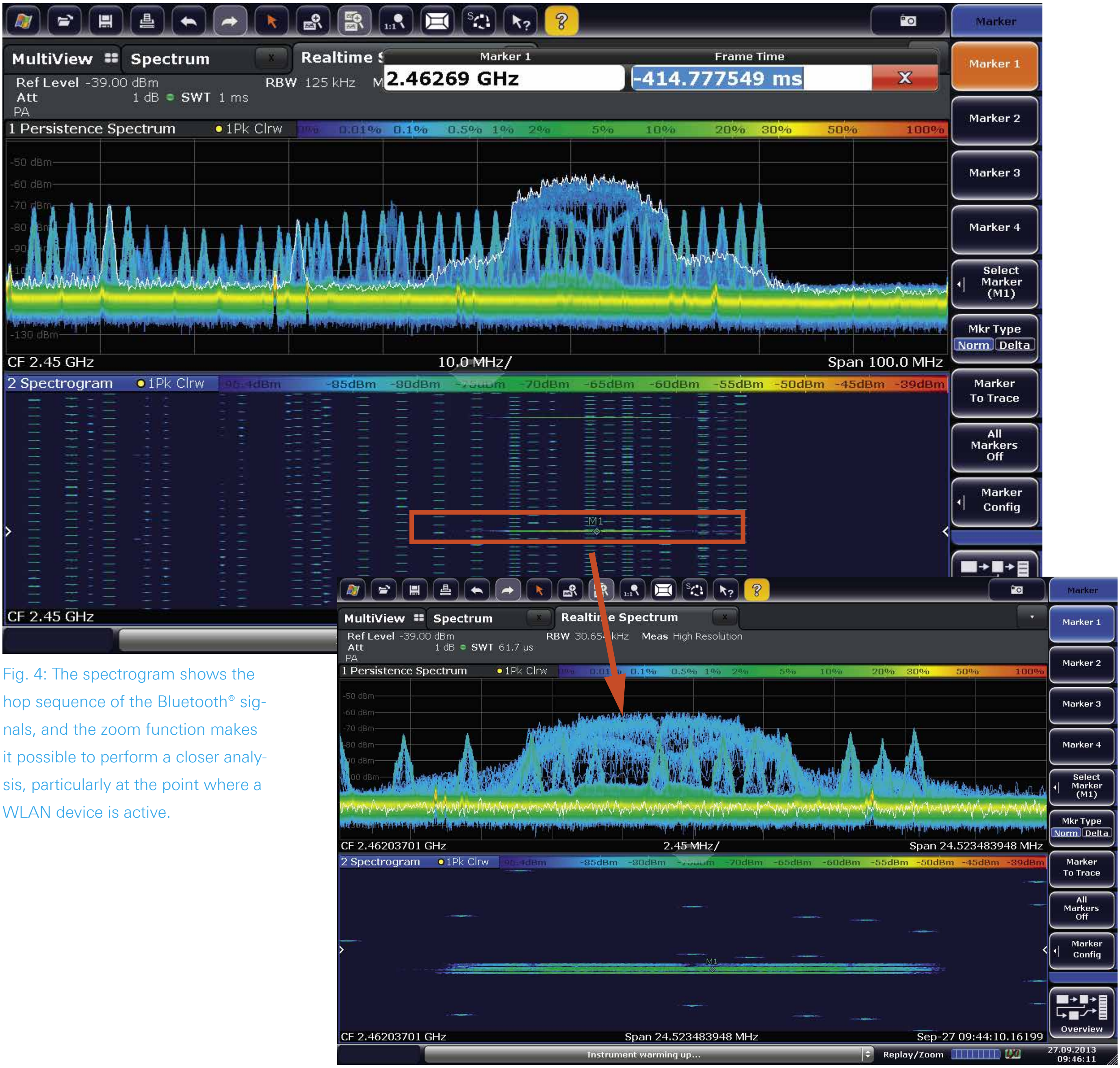


Fig. 4: The spectrogram shows the hop sequence of the Bluetooth® signals, and the zoom function makes it possible to perform a closer analysis, particularly at the point where a WLAN device is active.

recognize even extremely short signals and see their amplitude and frequency. The persistence spectrum (Fig. 3) therefore provides a good overview of the dynamics of frequency agile systems. Frequency hops occur, for example, in the industrial, scientific and medical (ISM) bands, where data rates are reduced by collisions between Bluetooth® signals and WLAN signals, for example. However, this display is not only an essential tool for analyzing wireless communications. It is also indispensable for measuring modern radar applications, because these applications also use frequency hopping to minimize interference caused by atmospheric noise, other systems and hostile signals.

The persistence spectrum also displays signals that are hidden beneath a stronger signal and cannot be detected with a conventional spectrum analyzer, as shown in the example in Fig. 3 with a Bluetooth® and a WLAN signal. These interferers are capable of reducing data transmission rates. In all of these applications, transients that occur during frequency hopping or due to digital signal processing can be transmitted, significantly disrupting other systems as well as the user's own application. The ability to make transients visible in persistence mode is extremely useful for troubleshooting. A current example of this is the interaction between LTE signals in the 800 MHz band and short range devices.

Spectrogram function seamlessly records signals

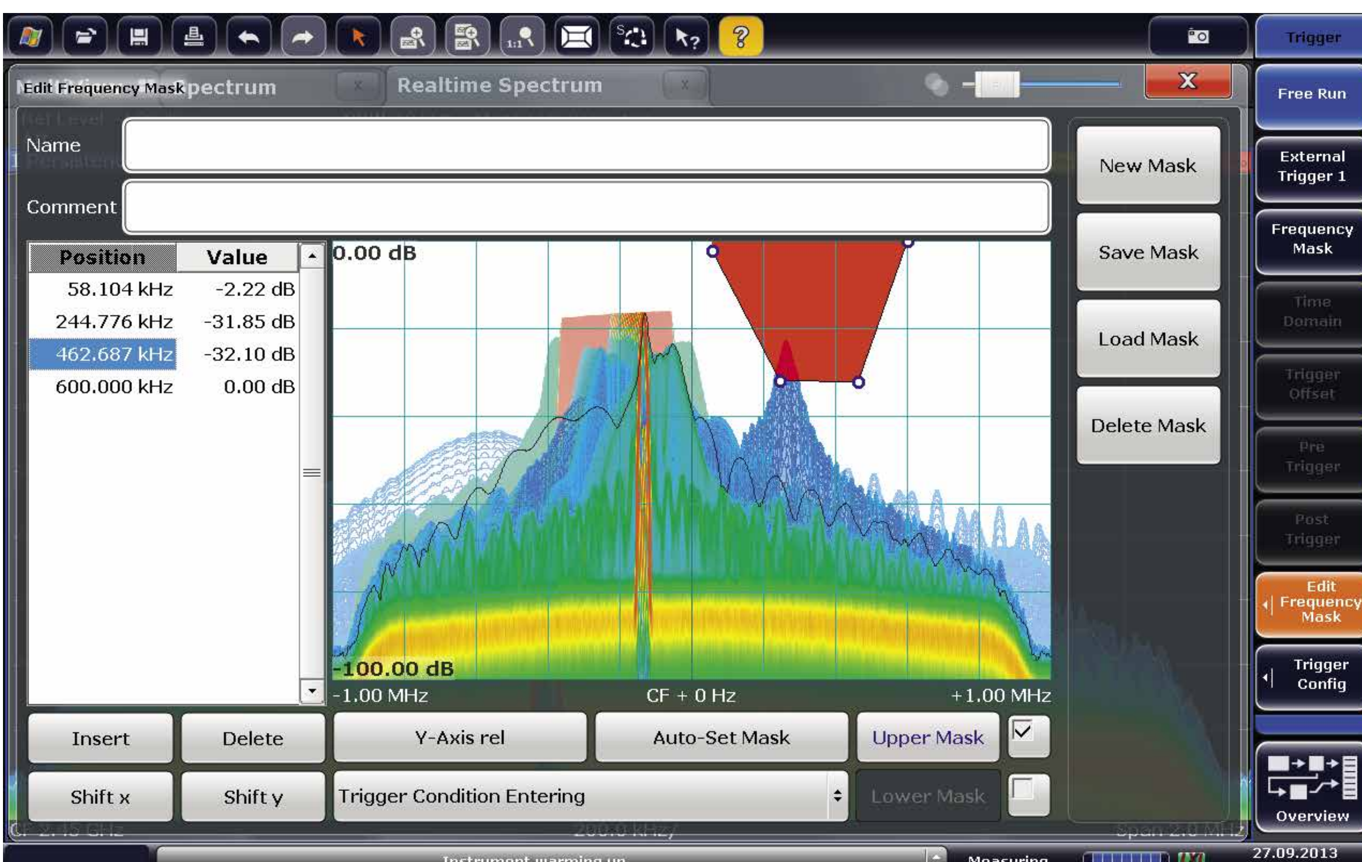
The persistence spectrum helps users with new ways of analyzing errors by displaying the dynamic behavior in the frequency domain. The spectrogram, however, shows errors in detail in the time domain. Each pixel of the spectrum is assigned a color that corresponds to the amplitude. This makes it possible to display each spectrum as a horizontal line. All spectral lines are continuously sequenced, seamlessly representing the time development in the frequency domain. In this mode, the R&S®FSW sequences up to 20000 spectra per second and stores up to 100000 spectra in a ring buffer. This lets users record the frequency domain seamlessly for up to five hours, depending on the update rate setting, and see at a glance when signals were transmitted, at which frequencies and with what power.

A closer analysis can be performed using markers, which the user can move over the frequency and time axes to measure the time and frequency difference between events. The spectrum of each individual line can be displayed in a separate window. Since the R&S®FSW stores the I/Q data in a 400 Msample ring buffer in realtime mode, at a bandwidth of 160 MHz the most recently recorded data with a duration of approximately one second is available for a more accurate or repeated calculation. This makes it possible to zoom into scenarios of interest with a minimum time resolution of 30 ns. Collisions between different signals or extremely brief interferers can be analyzed in detail in this way, as shown in Fig. 4. Zooming into the area where two signals are simultaneously active helps to analyze collisions and improve frequency agile systems.

Frequency mask trigger uncovers events of interest

The information from the spectrogram or the persistence spectrum can be used to define a trigger in the frequency domain. The FMT responds to signals that violate a defined frequency mask in the spectrum. Fig. 5 shows how the mask is defined. When the trigger is active, the R&S®FSW

Fig. 5: If the frequency mask (red area) is violated, the trigger is activated. The mask can be entered numerically via a table or easily defined on the touchscreen.



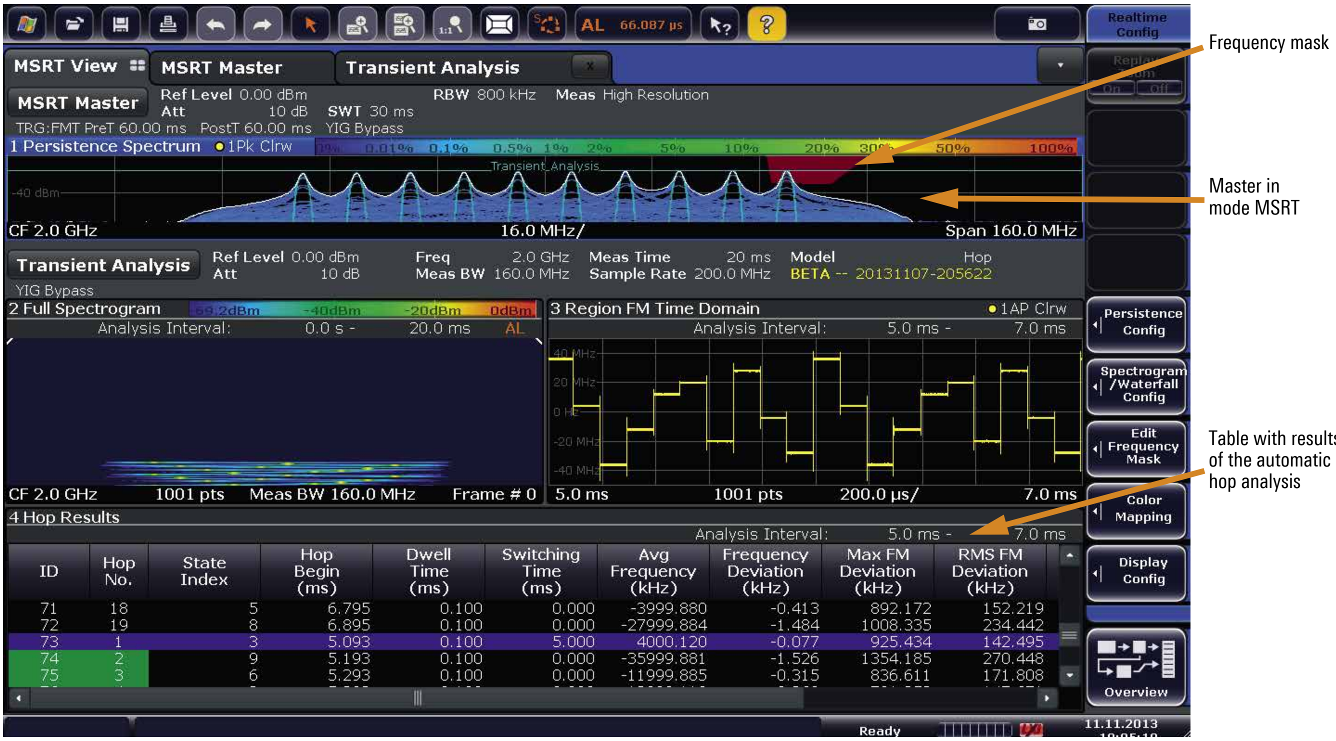
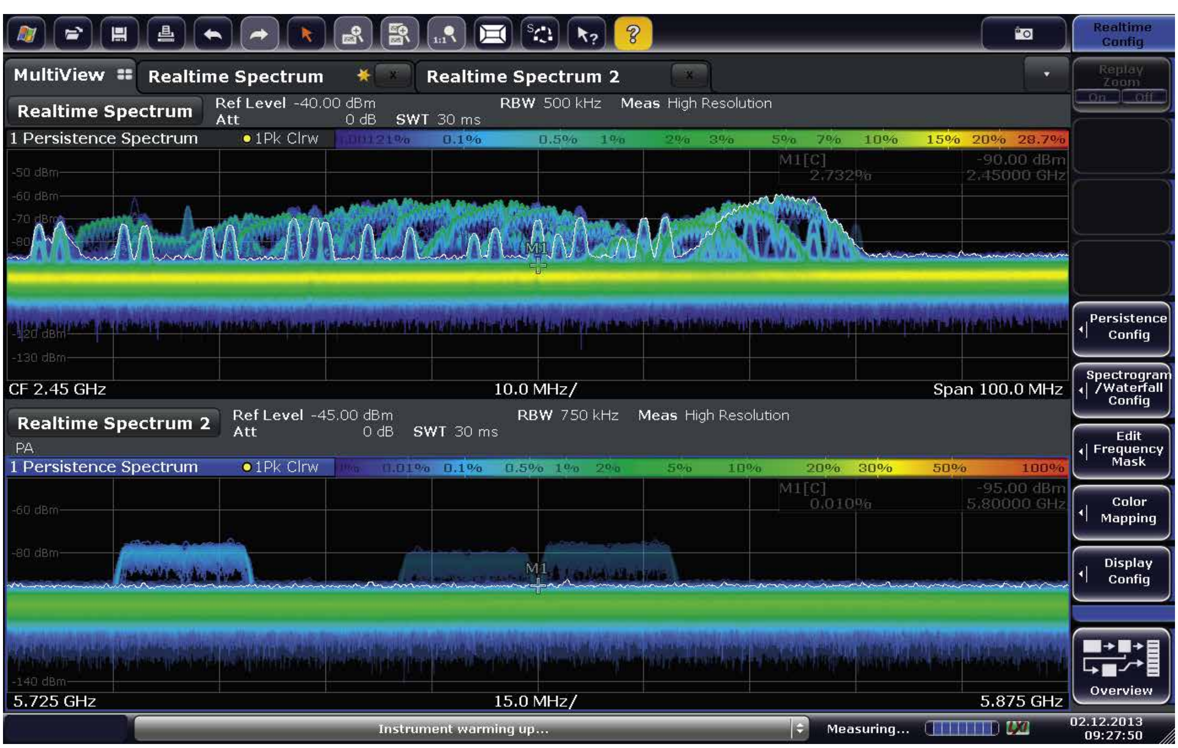


Fig. 6: The frequency mask trigger is defined in the realtime spectrum analyzer (top). Automatic analysis of the hop sequence (bottom) takes place in the R&S®FSW-K60 transient analysis option.

Fig. 7: Two ISM bands in one display. Top: The 5.6 GHz ISM band, where only devices that are compliant with WLAN standard 802.11n are active. Below: The 2.4 GHz ISM band is at the bottom of the display, in which both Bluetooth® and WLAN signals can be seen.



compares each individual spectrum – 600 000 per second – with this frequency mask. If the mask is violated, it stores the data for further analysis. The user can define which time range before and after the event is to be recorded, and whether recording stops or analysis restarts when the trigger event occurs. This function makes it possible to detect brief interferers or only analyze signals of a certain frequency and amplitude. The user can concentrate on the signals of interest and does not have to evaluate large quantities of seamlessly recorded data. The stored signals can, for example, be analyzed in detail in the spectrogram, processed on an external computer or examined on the R&S®FSW using other measurement applications.

MSRT combines realtime analysis with other applications

The multistandard realtime (MSRT) operating mode makes it possible to use the frequency mask trigger also in other measurement applications. In such cases, the realtime analyzer acts as master. The user sets the frequency mask and determines the analysis bandwidth and the record length. When an event has activated the trigger, the data that has been acquired is made available to the other measurement applications and analyzed by them. This is extremely useful if the signal that is being analyzed only occurs rarely and is therefore difficult to record. Fig. 6 shows a typical application. In order to measure the hop sequence of a transmitter that is only occasionally active, it is advisable to use the frequency mask trigger in realtime mode in order to trigger at a certain frequency. Subsequently the data is examined in the transient analysis (R&S®FSW-K60 option) and the hop sequence is automatically evaluated. This used to be a complicated task, since users were forced to record extremely long data sequences in the hope of capturing the transmitter's active phase by chance. Now, however, this succeeds with the very first measurement.

Parallel display of different modes makes evaluation easier

The R&S®FSW-K160R measurement application is merely a software option for the R&S®FSW signal and spectrum analyzer; only the R&S®FSW-B160 bandwidth extension is additionally required. The R&S®FSW can still be operated as a conventional spectrum analyzer, and the different modes can be displayed simultaneously, as shown in Fig. 3. Users can simply switch between these channels or display them in parallel. Applications such as the realtime measurement application can also be started multiple times. Seamless spectrum analysis is only possible in one window, but users can easily compare the frequency utilization of different bands in this way, as shown in the example in Fig. 7 with the ISM band at 2.4 GHz and 5.6 GHz.

Summary

The R&S®FSW signal and spectrum analyzer [2], equipped with the R&S®FSW-K160R option, is the third realtime spectrum analyzer from Rohde & Schwarz following the R&S®FSVR realtime analyzer [3] and the R&S®ESR EMI test receiver [4]. With almost 600 000 spectra per second, it is twice as fast as competitor products. With a probability of intercept of 100 %, it detects signals accurately up to a minimum duration of 1.87 µs and comes out on top in any comparison. Together with its outstanding RF characteristics and new modes such as MSRT (all controlled via its convenient user interface), it is a unique measuring instrument on the market.

Dr. Wolfgang Wendler

The app version of this article contains a video about R&S®FSW-K160R.

References
[1] Dr. Florian Ramian: Implementation of Real-Time Spectrum Analysis. White Paper from Rohde & Schwarz (2013). Search term: 1EF77.
[2] The new benchmark: R&S®FSW. NEWS (2011), No. 204 (extra section in middle of magazine).
[3] It detects everything: the R&S®FSVR real-time spectrum analyzer. NEWS (2010) No. 202, pp. 14–17.
[4] The world's fastest EMI test receiver drastically reduces testing times. NEWS (2012) No. 207, pp. 22–27.

R&S®FSW 67: signal analysis up to 67 GHz and with bandwidths up to 500 MHz

The new R&S®FSW 67 signal and spectrum analyzer expands the frequency range of the R&S®FSW family up to 67 GHz. For the first time, broadband signal and modulation analysis with up to 500 MHz bandwidth can be performed in the frequency range above 50 GHz.

A first in the world of signal and spectrum analyzers

The frequency range between 50 GHz and 70 GHz (including the ISM* band at 60 GHz) is becoming ever more important for commercial applications owing to its large available bandwidths and associated high transmission rates. However, large signal bandwidths are what makes it very difficult or even impossible to carry out ** spectral measurements with external harmonic mixers as is customary above 50 GHz. This includes the tasks of measuring spectrum masks and verifying spurious emission limit compliance.

* Industrial, scientific and medical

** R&S®FSW signal and spectrum analyzer: best in class now up to 50 GHz. NEWS (2013) No. 208, pages 38 to 42.

This is one of the key fields of application of the new R&S®FSW 67 signal and spectrum analyzer (Fig. 1). With a continuous frequency range up to 67 GHz (adjustable to 70 GHz), it always delivers conclusive measurement results. When combined with an optional preamplifier up to 67 GHz, its displayed average noise level (DANL) is 60 GHz at only –160 dBm (1 Hz), and it detects even the weakest signals reliably and quickly. The R&S®FSW 67 is an ideal noise factor meter for developing 60 GHz band receiver systems.

Like the other R&S®FSW models, the R&S®FSW 67 has low phase noise; –112 dBc (1 Hz) with 10 kHz offset from carrier and a 60 GHz carrier frequency provide a solid foundation for oscillator development. Equipped with the R&S®FSW-K40 phase noise measurement option, the analyzer becomes an easy-to-use phase noise tester. This option reliably measures heavily drifting, free-running oscillators up to small carrier offset values – a particularly important feature for microwave oscillator development.

Fig. 1: The R&S®FSW 67 is the first signal and spectrum analyzer capable of analyzing signals with a bandwidth of up to 500 MHz in the 60 GHz band.

Fig. 2: Example of an EVM measurement on a QPSK signal with a 256 MHz symbol rate at 67 GHz.

The R&S®FSW67 is the first signal and spectrum analyzer capable of analyzing signals with a bandwidth of up to 500 MHz in the 60 GHz band (Fig. 2). When equipped with the R&S®FSW-K70 signal analysis option, any of the models in the R&S®FSW family can be used to analyze QAM, MSK, PSK, APSK or FSK-modulated single carriers. The user-configurable R&S®FS-K96 OFDM analysis software measures OFDM signals.

The new R&S®FSW-B500 bandwidth option increases the analysis bandwidth of all models in the R&S®FSW family from 320 MHz to 500 MHz. The option can be integrated into the analyzer to avoid the complicated and cumbersome alignment routines required for combinations with an oscilloscope serving as a digital converter for the wideband IF output of an analyzer. With up to 500 MHz analysis bandwidth, it enables radar system developers to verify shorter pulses and rise times and track greater frequency hop sizes. For amplifier characterization and linearization, it is essential to not only determine the distortion products in the wanted signal but also those in the adjacent channels. Now, for the first time, it is possible to fully measure both adjacent channels and the signal carrier in 160 MHz 802.11ac systems.

Herbert Schmitt

Condensed data of the R&S®FSW67

Frequency range (adjustable to 70 GHz)	2 Hz to 67 GHz, (DC coupling); 10 MHz to 67 GHz (AC coupling)
DANL at 62 GHz	
Without preamplifier	typ. –129 dBm (1 Hz)
With preamplifier	typ. –152 dBm (1 Hz)
DANL with noise cancellation	max. 13 dB
Phase noise at 60 GHz	
10 kHz offset from carrier	typ. –112 dBc (1 Hz)
Third-order intercept at f > 40 GHz	+12 dBm nominal

R&S®ESR 26 EMI test receiver – 26.5 GHz for certification by any standard

A great leap forward – the new R&S®ESR 26 pushes the upper frequency limit of the test receiver family to 26.5 GHz. More universal than previous models, the R&S®ESR 26 is ideal for relevant certification measurements in line with CISPR, EN, MIL and FCC standards.

Many new applications

The first R&S®ESR EMI test receiver models (Fig. 1) were introduced in 2012 under the slogan "more speed, more insight, more intelligence". With the addition of the R&S®ESR 26, the family now covers the frequency range from 10 Hz to 26.5 GHz (Fig. 2). The main focus is on product certification measurements in line with relevant commercial EMC standards. With their integrated preselection, a 20 dB preamplifier and a highly linear frontend, the instruments meet the requirements of the CISPR 16-1-1 basic standard and are ideal for all commercial standard measurements. What makes these instruments truly outstanding is their time domain scan and FFT-based receiver technology that measures electromagnetic disturbances at a speed so far unattained.* EMC measurements which took hours in the past can now be completed in just seconds. The

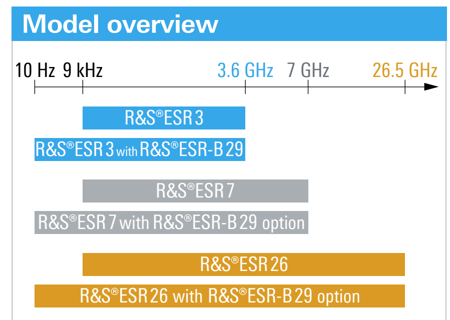


Fig. 2: Models and frequency ranges of the R&S®ESR EMI test receiver family.

* The world's fastest EMI test receiver drastically reduces testing times. NEWS (2012) No. 207, pp. 22–27.

Fig. 1: The R&S®ESR 26 EMI test receiver covers the entire CISPR frequency range as well as key military standards.

optional realtime spectrum analysis with a wide range of diagnostic tools provides new insight into disturbance signals and their history. Besides offering EMC testing functionality, the R&S®ESR is a full-featured, powerful signal and spectrum analyzer for lab applications. It comes with a clearly structured, intuitive touchscreen interface that makes it very easy to operate in any mode.

The right receiver for every standard

Receiver model selection is driven by the EMC standard governing the T&M task at hand. CISPR standards play an important role in the commercial sector, and in Europe, they are part of the European standards (EN). For instance, the CISPR 22 standard for information technology equipment (ITE) is reflected in EN 55022. Many other countries such as China, Russia, Japan and Korea also adhere to CISPR or EN standards. Those seeking to introduce electronic products in these countries must ensure compliance with the EMI limits specified in the CISPR standards.

CISPR 22 (to be replaced by CISPR 32) for information technology equipment, for example, establishes limits up to 6 GHz (Fig. 3) – a range covered by the R&S®ESR7 EMI test receiver. Household microwave devices (CISPR 11) and satellite receiver systems (CISPR 13, to be replaced by CISPR 32) must be tested up to 18 GHz. The R&S®ESR26 is the right T&M instrument for this task.

In North America, Federal Communications Commission (FCC) specifications are the legal standard for telecommunications devices. Section 15 of the Code of Federal Regulations (CFR) 47 differentiates between intentional and unintentional radiators.

Section 15.33 Frequency range of radiated measurements.

(a) Unless otherwise noted in the specific rule section under which the equipment operates for an intentional radiator the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:

(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

The CFR requires that intentional radiator signals be measured to the tenth harmonic. In the crucial ISM band (2.4 GHz to 2.5 GHz) where Bluetooth® and WLAN devices, cordless telephones, baby phones and many others operate, this means testing up to 25 GHz.

Computer processors, in contrast, are unintentional radiators and typically have a clock frequency in the range up to 4 GHz. The FCC requires that such devices be tested to the fifth harmonic, i.e. up to 20 GHz. The R&S®ESR26 meets both requirements.

The R&S®ESR-B29 option featuring a frequency extension down to 10 Hz and 6 dB bandwidths in decade steps from 10 Hz to 1 MHz makes the R&S®ESR26 ideal for measurements in line with MIL standards and manufacturer-specific standards in the automotive sector.

New spectrogram display

The release of the R&S®ESR26 was accompanied by new measurement functions for every model of the receiver family. A software update is available free of charge for instruments that have already been delivered. The new functions include a spectrogram display for scan and measurement results – a feature that shows how measured signals change over time. The R&S®ESR also displays all measured spectra as linear overlays with color-coding to indicate their levels (Fig. 4).

Device classes	Product standard	Frequency range
Industrial, scientific and medical (ISM) equipment	11	9 kHz to 18 GHz
Vehicles, protection of broadcast receivers	12	30 MHz to 1 GHz
Sound and television broadcast receivers and associated consumer electronics equipment	13	150 kHz to 18 GHz
Household appliances and electric tools	14-1	9 kHz to 1 GHz
Electrical lighting equipment	15	9 kHz to 300 MHz
Information technology equipment (ITE)	22	150 kHz to 6 GHz
Protection of receivers installed in vehicles, boats and devices	25	150 kHz to 2,5 GHz
Multimedia equipment	32 (will replace CISPR 13 and CISPR 22 on March 5, 2017)	150 kHz to 6 GHz (18 GHz*)

Fig. 3: Device classes covered by CISPR 11 to 32 with frequency ranges.
*Household satellite receiver systems will be covered by CISPR 32.

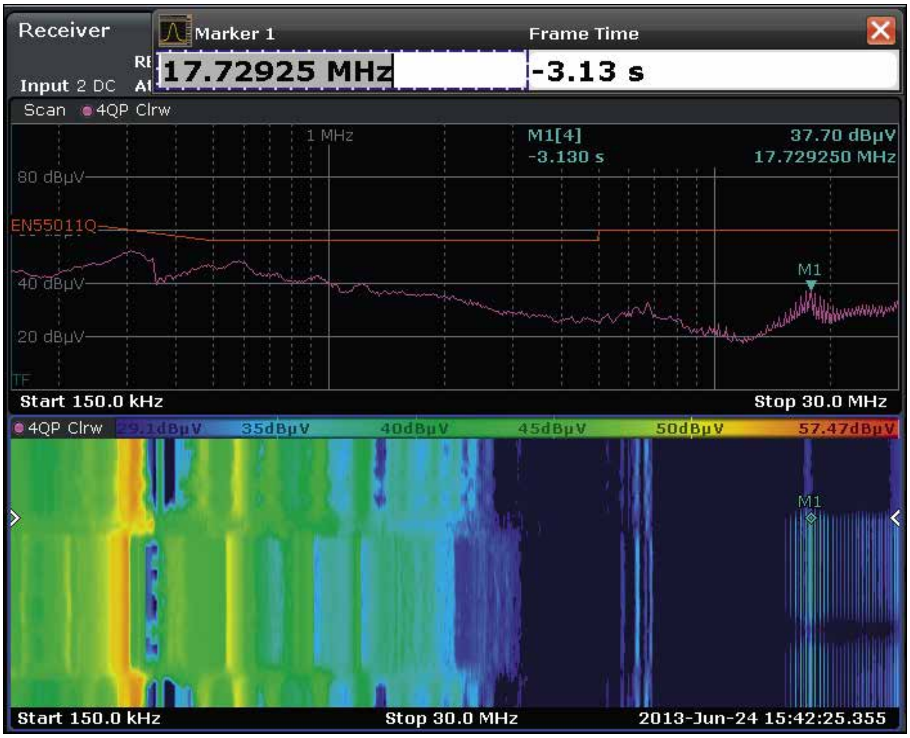
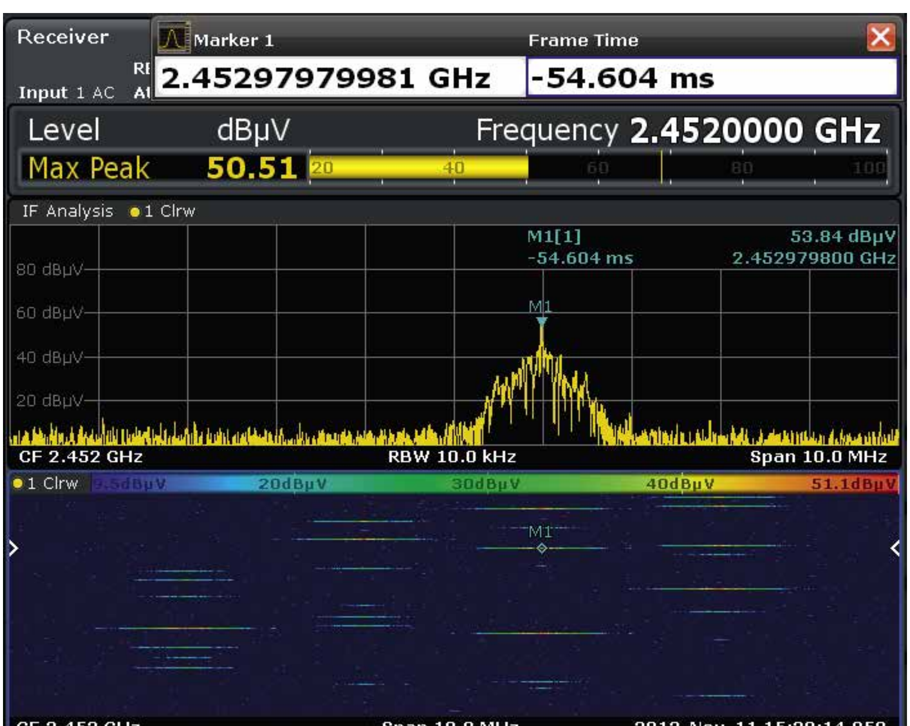


Fig. 4: Seamless spectrogram measured using the quasi-peak detector. The DUT is a computer power supply; the spectrum changes over time due to varying load states.

Fig. 5: IF analysis spectrogram of a Bluetooth® signal – the time domain behavior of the spectrum is visible around the receive frequency.



In this example, the receiver's FFT-based time domain scan is measuring the entire CISPR band B from 150 kHz to 30 MHz at once. In continuous scan mode, this spectrogram delivers a seamless image of signal characteristics over time. Users can stop the scan when unexpected or especially interesting events occur and move the marker backward across the spectrogram chronologically to examine frequency spectra saved by the receiver. Seamless, standard-compliant measurements ensure that no event goes undetected, and various operating modes can be quickly accessed and recorded to provide more reliable measurement results.

Just as with the scan display function, users can also assign a spectrogram to the IF analysis (Fig. 5). The purpose of the optional R&S®ESR IF analysis function is to provide a spectral display of the RF input signal around the receive frequency. It provides a detailed overview of the spectrum occupancy around the measurement channel as well as information about the spectral distribution of a modulated signal. Any signals received can be quickly classified as either disturbance signals or wanted signals. The spectrogram display also shows spectrum changes over time. When used with the digital audio demodulators, this feature allows users to visually and acoustically analyze disturbance signals.

Measuring conducted disturbances in one go

A binding compliance test using a quasi-peak detector requires a minimum measurement time of one second for every frequency point. For the conventional stepped scan, this means a scan time of almost two hours when sampling the frequency range up to 30 MHz at half the measurement bandwidth of 4.5 kHz. This is why at some point in the past, it became common to split the process into preview measurement and final measurement. The peak detector and average detector

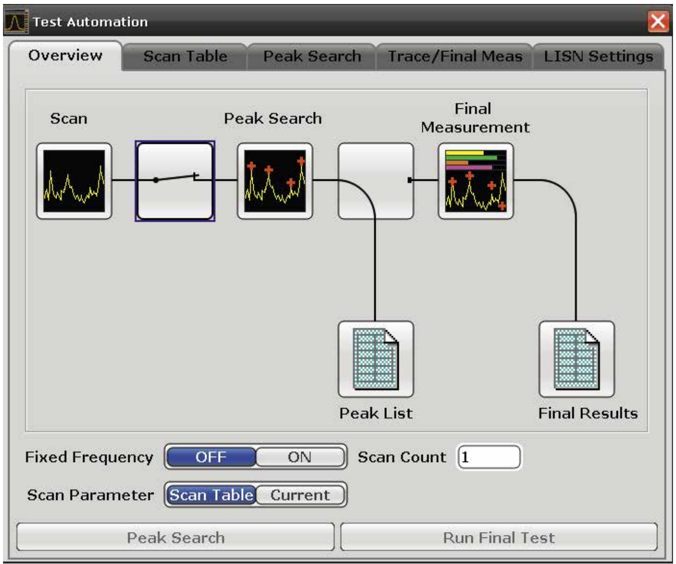


Fig. 6: Test automation dialog box: Thanks to the fast time domain scan, users do not need to split the process into preview and final measurements. Final measurement results are available in the peak list.

Fig. 7: Users can select multiple phases for a scan sequence, which the receiver carries out automatically. A final measurement is not needed.

are used for the preview measurement. The measurement time per frequency point is 20 ms, for example, and a spectrum is available after two to three minutes. During the final measurement, the receiver uses the standard-compliant quasi-peak and CISPR-average detectors to measure only the 25 frequencies closest to the limit line. The receiver requires two seconds for each measurement. After every frequency change, the instrument requires one second settling time for the detector so that it can measure pulses correctly, and one second measurement time. For two detectors and 25 values each, this is:
2 seconds × 2 detectors × 25 values = 100 seconds.

The final measurement lasts 100 seconds when using the conventional method. The measurement is typically performed with a line impedance stabilization network (LISN) and takes a full 200 seconds for single-phase DUTs (phase and neutral conductor) and 400 seconds for three-phase DUTs.

The R&S®ESR FFT-based time domain scan opens up new possibilities (Figs. 6 and 7). For example, at an FFT bandwidth of 30 MHz, the R&S®ESR delivers standard-compliant measurement results for the entire CISPR band B after two seconds, and that includes the required settling time of one second. Now the calculation is much more palatable:
2 seconds × 2 detectors = 4 seconds for the complete, standard-compliant measurement of one line. It takes a total of 8 seconds to measure single-phase DUTs and 16 seconds for three-phase DUTs. In addition, the test engineer can already determine during the development phase whether the disturbance signals will fluctuate versus time or whether intermittent disturbance signals with low repetition rates are present. It is now easy to extend the observation period to 5 seconds in order to better capture fluctuating disturbances. Including the required one second settling time, the total is
6 seconds × 2 detectors = 12 seconds measurement time per line. A small investment in measurement time produces reliable results even for difficult-to-capture signals.

Summary

Thanks to the frequency range extension to 26 GHz, the R&S®ESR26 opens up new applications. It covers the entire frequency range of the CISPR standards and of key military standards and can also be used for FCC-compliant measurements.

Rohde&Schwarz is continuously expanding the functional range of its test receivers. Scan and IF analysis spectrograms and greatly improved conducted disturbance measurements represent significant value added for users. They provide deeper insight into the EMC characteristics of DUTs and produce faster and more reliable results.

Matthias Keller

Focus on costs and the environment: leading the way with efficient transmitters

Energy and infrastructure costs are the top concern for broadcast network operators worldwide. Rohde & Schwarz has the right solution in the form of the R&S®Tx9 generation of transmitters. This product line has now been extended to include DAB high-power and medium-power transmitters and FM high-power transmitters. All of these transmitters exhibit outstanding energy efficiency combined with a space-saving design.

Examples of transmitters from the R&S®Tx9 line. Left: the new R&S®THR9 liquid-cooled FM transmitter (see page 42); center: the R&S®THU9/R&S®THV9 liquid-cooled high-power transmitter with Doherty technology; right: one of the new R&S®TMU9/R&S®TMV9 air-cooled medium-power transmitters (see page 46).


ROHDE&SCHWARZ
ROHDE&SCHWARZ
ROHDE&SCHWARZ

Latest generation of FM transmitters: world champions in compact design and energy efficiency

Despite the Internet and today's omnipresent mobile media devices, FM sound broadcasting remains popular around the globe. The new R&S®THR9 liquid-cooled FM high-power transmitters are the perfect choice for satisfying the requirements of network operators.

The new R&S®THR9 FM transmitters proudly display this logo reflecting their fivefold advance in efficiency:

- Energy consumption
- Required space
- Operation
- Configuration
- Total lifecycle

The R&S®THR9 FM transmitter family: top efficiency in the smallest possible space

The R&S®THR9 liquid-cooled FM transmitters (see photo on page 41) are available in power classes from 5 kW to 40 kW for VHF band II (87.5 MHz to 108 MHz). They use various innovative technologies that have already proven their worth in Rohde & Schwarz TV transmitters and are now finding their way into sound broadcasting systems for the first time.

For example, there is the MultiTX system concept to integrate multiple transmitters into a single rack. Like the liquid cooling system, this helps reduce the amount of space required (Fig. 1). In the case of the R&S®THR9, as many as four 10 kW transmitters can be housed in a single rack. Central components such as the transmitter control unit and the liquid cooling system are shared by all transmitters in the rack.

Liquid cooling

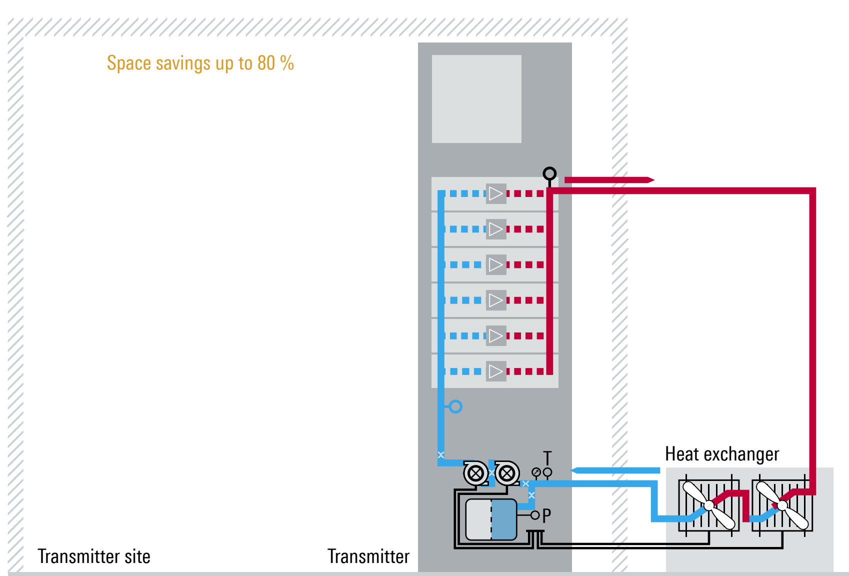


Fig. 1: Liquid-cooled transmitters use up to 80 % less space at transmitter sites. The large air ducting systems required for air-cooled transmitters are eliminated. The heat exchanger also requires minimal space and is installed outside the transmitter site. The pumps are integrated into the transmitter rack.

From pioneer to modern trendsetter

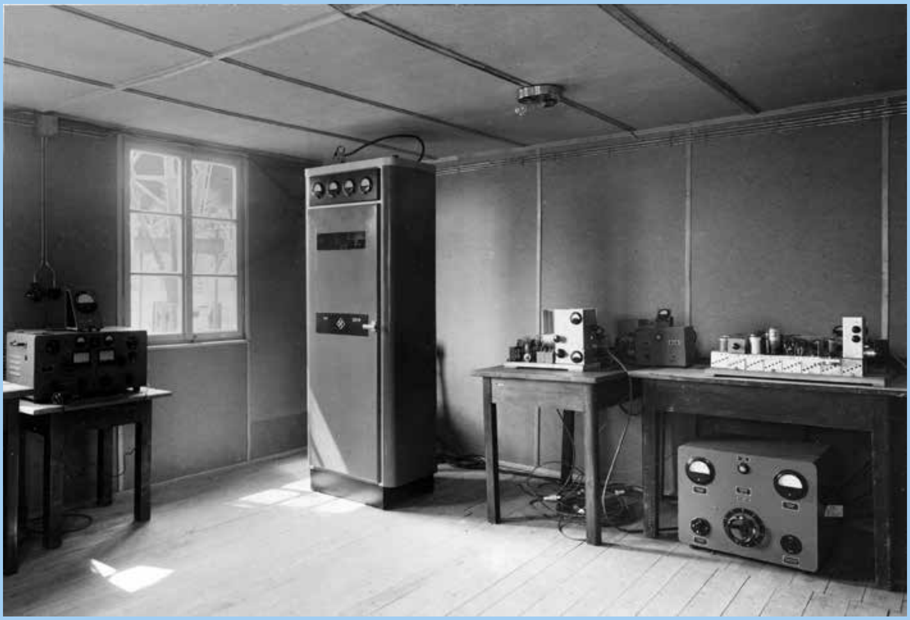
The basic concept of frequency modulation (FM) was developed in the 1920s, but the earliest efforts to use this technology were not very successful. Following extensive development work and testing, the first patent applications for FM technology were filed in the 1930s and the first FM station licenses were issued in the US at the end of the same decade.

In Europe, Rohde & Schwarz played an active role in the spread of FM technology. The company's involvement began shortly after the drafting of the 1948 Copenhagen Frequency Plan when the Bavarian Broadcasting Corporation ordered an FM transmitter from Rohde & Schwarz. It took only six weeks for the company to fill this order, allowing Europe's first VHF FM transmitter to go into operation on February 28, 1949 (see picture on right).

The audio quality of FM radio met with great approval and the transmitter network expanded rapidly. Due to FM radio's good interference immunity, combined with ongoing innovations in hi-fi quality, it became popular across Europe in the VHF band and ultimately worldwide. Of course, the transistor radio boom in the 1950s and 1960s played a significant role.

Further technical advances were triggered by this popularity. By the start of the 1960s, stereo reception was possible. In the 1980s, Rohde & Schwarz played a major role in the development of the radio data system (RDS). RDS was officially launched in 1987 and is still used today primarily in car radios to help provide alternative frequencies.

Despite the popularity of the Internet and widespread use of portable media devices, FM radio remains an important mass medium worldwide. For 65 years now, Rohde & Schwarz has been a part of this development, delivering reliable FM sound broadcasting systems everywhere around the globe. The latest generation represented by the R&S®Tx9 transmitter family introduces a new level of energy efficiency together with a space-saving design.



Europe's first commercial VHF FM transmitter went into operation on February 28, 1949. The supplier was Rohde & Schwarz. This photo was taken in the 16 m^2 wooden structure operated by the Bavarian Broadcasting Corporation at the foot of the antenna tower in Munich-Freimann.

VHF transmitter from the year 1963 (5 kW in 1 + 1 standby).

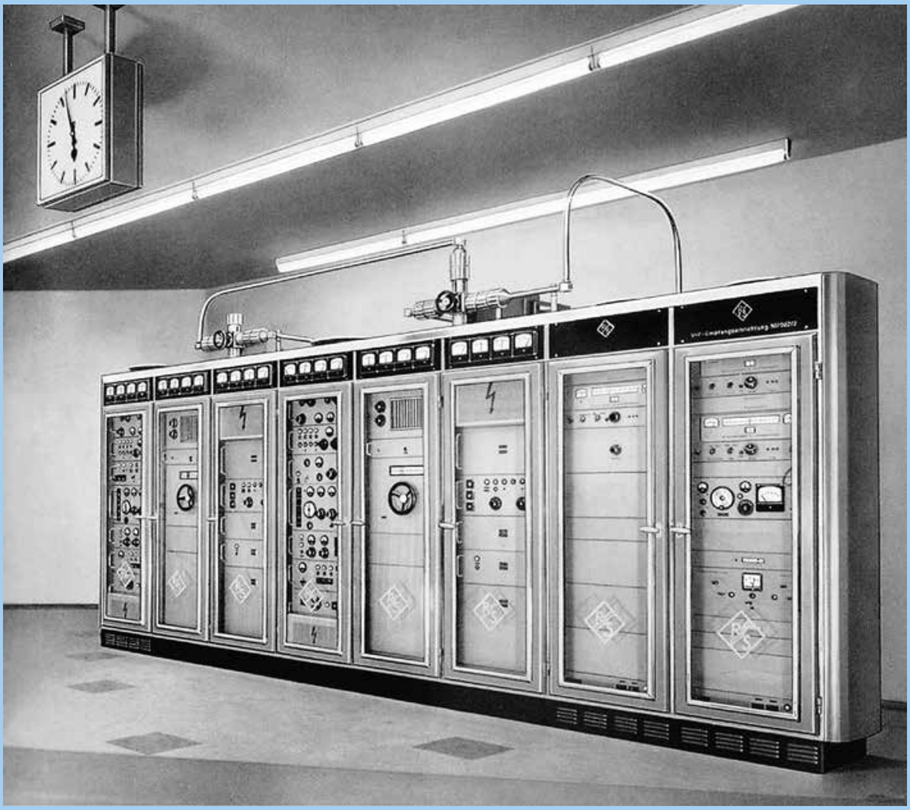


Fig. 2: Redundant, integrated pump modules for cooling single transmitters up to 20 kW.

A central system control unit monitors the transmitters in a MultiTX system and provides a graphical user interface. This concept ensures flexibility and scalability at an affordable cost while meeting the stringent availability requirements that apply to transmitter systems. Moreover, there is enough space left in the R&S®THR9 rack to allow integration of third-party components.

First time ever: liquid cooling for band II transmitters

Liquid cooling has been used in terrestrial TV transmitter systems for several years. Now for the first time, Rohde&Schwarz has implemented this cooling concept in high-power transmitters for band II. At high power levels, liquid cooling has multiple advantages over air-cooled systems, which in some cases require considerable adaptation of buildings and infrastructure.

The amplifiers are integrated into a closed cooling circuit along with the redundant pumps (Fig. 2) and heat exchanger. Compared with air cooling, the main benefit of liquid cooling is that less space is required, since the waste heat is transferred directly from the transmitter room using a heat exchanger installed outside the building – without using any additional infrastructure. Only cooling hoses have to be installed. No costly, high-maintenance systems are needed to remove the hot air. Moreover, the pumps can be integrated into the transmitter rack. Another important aspect is the significant noise reduction at the transmitter site compared with air-cooled systems. The pumps and heat exchanger are easy to service and can be configured to meet practically any requirement. Intelligent algorithms have been implemented to ensure optimized coolant flow.

Leading in energy efficiency and power density

Whereas typical air-cooled transmitter systems achieve energy efficiency between 60 % and 65 %, the R&S®THR9 transmitter stands out with efficiency values of up to 75 %. The transmitters attain such high efficiency due to their state-of-the-art LDMOS transistors, power combiners with minimal loss and well-designed liquid cooling system. This is what makes them the market leaders among transistor-based FM transmitters, enabling a significant reduction in energy costs for the transmitters and the cooling system.

Each amplifier can deliver an output power of up to 5 kW. Since up to eight amplifiers fit into a rack, single transmitters can be set up with up to 40 kW output. Despite the high power levels produced by a single R&S®THR9 rack, there is room for additional equipment that had to be housed elsewhere in the past.

Measurements on FM Transmitters for Acceptance, Commissioning and Maintenance

Application Note

Product:

R&S®ETL

Despite the advent of advanced digital transmission methods, analog broadcasting remains highly important. Until now, measurements on FM transmitters in connection with acceptance testing, commissioning and maintenance required using a variety of T&M instruments.

The R&S®ETL TV analyzer combines these instruments' capabilities in a single unit and can completely replace them. Now, for the first time, acceptance test measurements can be conducted on FM transmitters quickly and easily using just one compact test instrument. The R&S®ETL provides the functionalities of a power meter, spectrum analyzer, audio generator, FM measurement demodulator, stereo decoder, audio analyzer and more in just one box.

ROHDE&SCHWARZ

This 89-page application note discusses how to use the R&S®ETL TV analyzer to perform all of the measurements required for acceptance, commissioning and maintenance of FM transmitters (search term: 7BM105).

Redundancy at multiple levels

Proven transmitter system redundancy concepts such as exciter standby and n + 1 standby (one standby transmitter for n program transmitters) can be implemented in a wide range of configurations and also combined with the MultiTX system concept. The cooling system has a redundant design with two pumps. Thanks to the clever dimensioning of the amplifier power supplies, transmitter operation can continue without a major loss of output power even if a power supply fails.

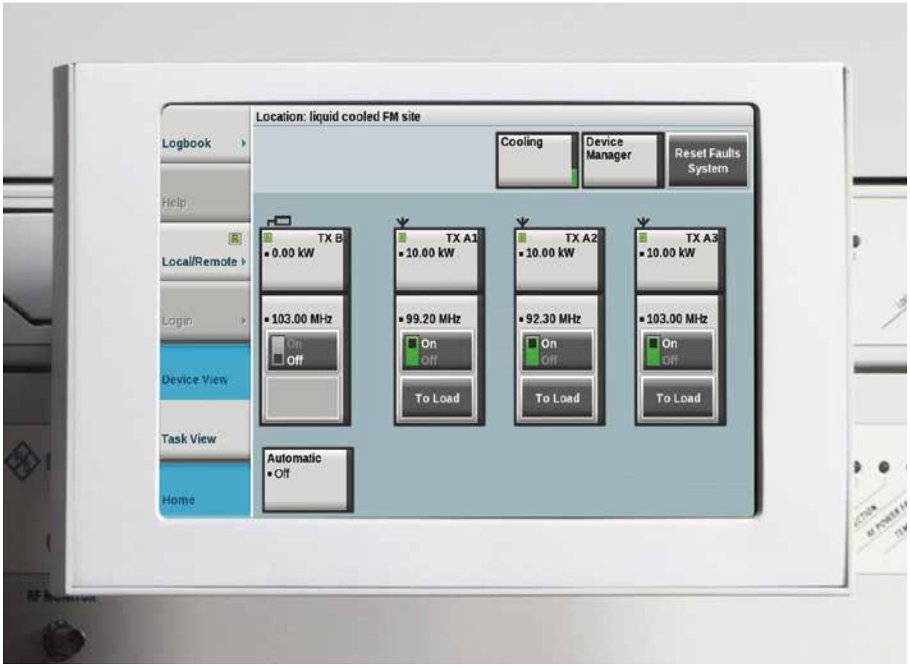


Fig. 3: R&S®TDU900 transmitter display unit showing a 3 + 1 system with 10 kW output power per transmitter.

Fig. 4: The R&S®TCE900 exciter is configured with plug-ins and can be upgraded for HD Radio™.

Modular design of the exciter and transmitter control unit

The R&S®TCE900 transmitter control exciter is used in all members of the R&S®Tx9 transmitter family (Fig. 4). Using appropriate plug-ins, it can be configured either as an exciter or transmitter control unit, or these two functions can be combined in a single device.

Using an add-on board, the exciter can be upgraded to the latest generation of the HD Radio™ digital standard that is popular in the US. The transmitters are well-prepared for additional digital standards in band II as well as for the future growth of audio over IP.

Easy operation in every configuration

The R&S®TSP900 transmitter status panel allows convenient operation of single transmitters, and a web browser can also be used via the Ethernet interface. A recommended alternative especially for systems with multiple transmitters is the R&S®TDU900 transmitter display unit with a touchscreen (Fig. 3). It can be swiveled into various positions or retracted back into the transmitter rack. Of course, the R&S®THR9 can also be easily integrated into operators' network management systems via remote control using the simple network management protocol (SNMP).

Summary

The R&S®THR9 are the world's most efficient FM high-power transmitters, delivering top efficiency in minimal space. These transmitters allow audio broadcast network operators to cut energy costs as well as to reduce maintenance and rental costs over the entire transmitter lifecycle.

Outstanding power density is achieved using the MultiTX system concept with multiple amplifiers in a single rack combined with liquid cooling. Key aspects include energy efficiency values up to 75 % at the transmitter end as well as diverse concepts for liquid cooling. Finally, the transmitter family is ideally positioned to handle future developments.

Stefan Dzieminski

Latest transmitter technology for VHF band III

Radio and television are celebrating a comeback in VHF band III as the UHF band is increasingly dedicated to other applications such as wireless communications. With the R&S®TMV9 medium-power transmitters and the R&S®THV9 high-power transmitters, network operators are now able to use the latest technology in this frequency band, too.

Broadcasting in VHF band III is gaining new momentum

Terrestrial broadcasting transmitters for UHF bands IV/V have somewhat overshadowed transmitters for VHF band III over the past few years. That's changing with the digital dividend, which has brought increased significance to band III for analog and digital TV as well as for digital audio broadcasting. This is because regulatory authorities in many countries have instructed broadcast network operators to release frequencies in the UHF band so that they can be available for other applications such as wireless communications. Free channels in VHF band III can be used for analog and digital TV. In addition, digital audio broadcasting in line with the DAB(+) standard will be implemented in this band. DAB(+) networks are being expanded in some regions, while new, nationwide networks are being built in others. Broadcasting in VHF band III is gaining momentum.

Fig. 1: Liquid-cooled R&S®THV9 high-power VHF transmitter featuring 5.2 kW output power from four amplifiers.

To accommodate this transition, Rohde & Schwarz has announced two new compact transmitter families that provide network operators with peak values in energy efficiency, power density and flexibility.

R&S®TMV9 and R&S®THV9 – from 350 W to 30 kW

The new air-cooled R&S®TMV9 medium-power VHF transmitter provides power levels from 350 W to 4.3 kW. The liquid-cooled R&S®THV9 is a high-power transmitter, offering power levels from 1.3 kW up to 15 kW in one rack (Fig. 1). Up to 30 kW is available by combining two racks. Both transmitters are suitable for the DAB, DAB+ and T-DMB standards in the VHF range, and they also support the DVB-T/DVB-H, DVB-T2, ISDB-T/ISDB-T_B, DTMB and ATSC digital TV standards as well as analog TV standards.

The new generation is based on the R&S®Tx9 transmitter platform, whose UHF models for analog and digital TV standards are successfully positioned on the market (see box at right for an example). The VHF transmitters now share their industry-unique characteristics:

- Exceptional efficiency through intelligent multiband Doherty technology
- MultiTX concept with multiple transmitters in a single rack
- Maximum power density in a single rack
- Versatile configuration options

Saving energy costs – efficiency up to 50 %

The liquid-cooled R&S®THV9 transmitter's efficiency has the greatest impact on operating costs. The increased energy efficiency saves operators a significant percentage of their operating costs. With an efficiency of up to 46 % including cooling

Rohde & Schwarz transmitters successful in many countries – one example:

Rohde & Schwarz transmitters in Spain: profitable, especially in times of crisis

Due to a resolution by the European Commission, EU member countries must release TV channels 60 to 69 in the UHF band by January 1, 2015. The intention is to use this frequency spectrum as a digital dividend for other purposes, e.g. for wireless communications.

In Spain, the government wanted to partially reimburse operators for the costs they incur as a result of the transition and during dual operation in transitional periods. However, one year later in 2011, a new government was elected that was forced by the economic crisis to cancel this planned financial support. In addition, the number of channels and multiplexers was to be reduced – decisions that, taken together, result in significant losses for large TV network operators. The Spanish operator Abertis, which has been using Rohde & Schwarz transmitters for years, then decided to put all planned investments on ice for the time being.

Despite this decision and the risks that could result from the loss of channels, Abertis resolved to replace transmitters that were more than ten years old, since the company knew about the improved efficiency of the new Rohde & Schwarz transmitters, due to the work of the local Rohde & Schwarz office. The local office had good arguments: At IBC in September 2011, Rohde & Schwarz had introduced the new 9000 TV transmitter family, whose energy-saving Doherty technology and small footprint significantly reduce operating costs. The transmitters convinced the Spanish network operator. Crucial factors for the new investments included the old transmitters' extremely high energy costs, which would continue to rise, and the increasing maintenance effort to be expected in the future due to the age of the existing transmitter systems.

Altogether 37 R&S®TMU9 MultiTX transmitters were installed at 14 sites. At the time of delivery the allocation of frequencies was still not finalized, so the transmitters must be switched to new channels later. Thanks to their broadband architecture (470 MHz to 862 MHz) and the patented Doherty Tunit frequency option, the transmitters can be used in the entire frequency range without exchanging amplifiers. Integrating the new transmitters into the existing n + 1 system was a particularly challenging task. But due to their flexible mechanical design and the new software platform, this integration required no great additional effort.

The transmitters delivered to Abertis were the first of the new family. They are operating to the customer's utmost satisfaction.

Reinhard Scheide; Juan Castellanos

The Montserrat site has also been equipped with latest-generation transmitters.

Photo: Abertis

for COFDM standards, the energy costs are less than one-half those of conventional transmitters. With ATSC, the efficiency is even up to 50 %.

This high degree of efficiency is made possible by implementing the Doherty technology* in the R&S®PMV901 and R&S®PHV902 VHF power amplifiers. The amplifiers can easily be configured for various frequency ranges in Doherty mode. If no time is available for this optimization, the amplifiers will automatically switch to a broadband mode as needed. The maximum output power for the air-cooled R&S®PMV901 VHF amplifier (Fig. 2) is 750 W for COFDM standards, while the liquid-cooled R&S®PHV902 (Fig. 3) achieves up to 1.35 kW.

*** Doherty**
The basic principle behind Doherty technology is to split signal amplification into two paths. The main amplifier amplifies only the average signal and no power reserves for peak signals are required in this path. The peak amplifier is active only when peaks occur in the signal.

See NEWS (2013) No. 209, pp. 44–47 ("Optimizing efficiency of high-power TV transmitters") for a detailed description of the Doherty concept.

MultiTX maximizes power density

A compact design and high power density save rack space. The maximum output power available from a single rack is up to 4.3 kW for the air-cooled R&S®TMV9 and up to 15 kW for the liquid-cooled R&S®THV9. The MultiTX concept makes it possible to fit multiple transmitters in a single rack, with plenty of space for other components such as the pump unit for liquid cooling. Complete n + 1 systems can be implemented in a single rack, providing a flexibility that meets almost any requirement. A variety of options is available for expanding the transmitters, including bandpass filters, directional couplers, dual drive and power supply redundancy, for example.

Fig. 2: The air-cooled R&S®PMV901 VHF amplifier supplies up to 750 W in the COFDM standard.

Synergies simplify spare parts inventory management

The use of the flexible R&S®TCE900 transmitter control exciter for all R&S®Tx9 transmitter families simplifies and improves spare parts inventory management. By inserting supplementary specific plug-in boards, the base unit can be configured as a transmitter control unit or as an exciter for various standards, resulting in unprecedented flexibility for network operators. To reconfigure the R&S®TCE900 on site for another application, the user simply needs to exchange the modules. The platform also offers free option slots for expanding its functionality, e.g. for integrating a satellite receiver. And a further advantage: By using the common transmitter control exciter, all R&S®Tx9 high-power and medium-power UHF and VHF transmitter families are based on a single software platform, which means expanded functionality.

Fig. 3: The liquid-cooled R&S®PHV902 amplifier achieves a maximum output power of 1.35 kW in the COFDM standard.

Summary

The new R&S®TMV9 and R&S®THV9 VHF transmitters are gaining attention on the market. Network operators appreciate their potential for saving energy, their small footprint and their high degree of flexibility. As such, it was no surprise that several orders had already been placed before the transmitters were officially presented at IBC in Amsterdam in September 2013. Deliveries on those first orders started in October 2013. For example, the Bayern Digital Radio GmbH (BDR), headquartered in Munich, Germany, was the first company globally to use the R&S®THV9 in a transmitter network for DAB / DAB+.

Johannes Sinnhuber

More efficient TV studio production with VENICE

Systems from Rohde & Schwarz DVS GmbH are in use in many TV studios around the world. This article introduces VENICE, which helps studios to streamline production processes, from ingest and studio playout to content distribution.

Dramatic changes in TV production

TV studios today face a variety of challenges, one of which is production speed. For example, content for news and sports reports must be produced very quickly with a high degree of quality and relevance. This makes it imperative that production be converted to file-based workflows, allowing picture content to be distributed to processing stations quickly in parallel as files instead of serially on video tape.

But the migration from tape-based to file-based workflows is not the only task requiring an enormous amount of effort. Many TV studios find themselves in the middle of a conversion from SD to HD and are therefore forced to combine different formats and resolutions in their workflows. The advent of file-based workflows as well as the need to handle different resolutions regularly bring new, more efficient video codecs to the production environment. Then there are the new distribution paths, such as

Fig. 1: In recognition of its innovative approach, the VENICE media production hub was awarded the Broadcast Engineering Pick Hit Award at NAB and the Trophée SATIS at SATIS, both in 2013.

video-on-demand (VoD) platforms or over-the-top (OTT) services that require parallel file-based processing and distribution of short-lived content.

And as if these circumstances were not already enough of a challenge, TV studios also find themselves under enormous cost pressure. Their only logical choice is to increase their profitability, for example by centralizing the individual tasks within their workflows as much as possible. However, studios often operate in a heterogeneous infrastructure built up over many years, with a variety of production islands that reflect changing preferences over time. Every editorial office – news, sports or lifestyle – has its own production island with its own set of production and editing systems that match the editors' specific requirements and preferences, but that cannot reasonably be linked to or networked with the systems of other editorial offices. This heterogeneous infrastructure must continually be adapted to meet changing requirements, such as updated or completely new production formats.

It is therefore not uncommon for studios to experience loss of time and productivity using conventional production methods. For example, media exchanges often require time-consuming transcodings and transfers. If the material is being exchanged via video tape, there is often no comprehensive overview of the tape contents because associated data or metadata is not managed fully in a central database.

Because each of these production islands requires its own ingest and outgest for technical reasons, a variety of systems and channels are needed. Any integration of additional systems into the infrastructure requires an enormous amount of effort. Many production islands are not even used continuously because some TV formats are produced only at certain times. For example, sports productions take place mostly on the weekend, and so the production unit is not fully utilized during the work week. A fast and flexible allocation of existing resources is not possible when the individual channels of the various systems are reserved for ingest or playout, i.e. each system is assigned a specific task.

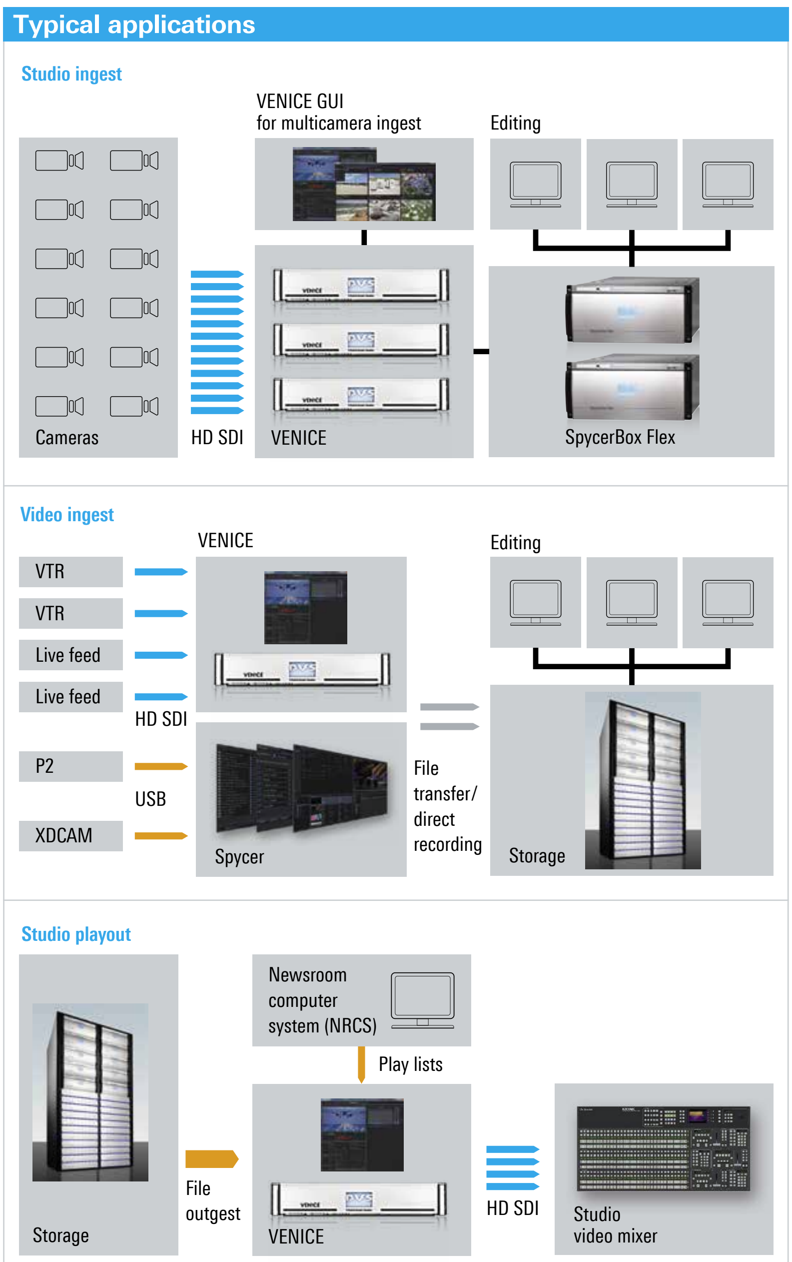


Fig. 2: With its variety of supported file formats, codecs and interfaces, its wide scope of functions and its modern, open system architecture, VENICE is a versatile tool for TV studios.

VENICE – the bridge between production environments

TV broadcasters are facing these challenges by improving flexibility and resource utilization through the centralization of individual tasks within a workflow and the allocation of newly available capacities to other tasks. Unifying as many functions as possible into fewer systems reduces costs and leads to more efficient workflows. It is essential that the studio environment be interconnected to allow the quickest and most efficient parallel distribution of content possible. For example, this means bridges between the tape-based and the file-based world, between the various resolutions and formats, and between the various production islands.

The VENICE media production hub from Rohde&Schwarz DVS is the best solution for these highly complex challenges (Fig. 1). It supports broadcasters in migrating SDI workflows to file-based workflows. Its multiformat capabilities allow studios to design their file-based production to meet their needs for all resolutions up to and including the future 4K. In recognition of this innovative approach, VENICE was awarded the Broadcast Engineering Pick Hit Award at NAB and the Trophée SATIS at SATIS, both in 2013.

VENICE builds bridges between diverse production environments, giving studios access to a wide variety of communications channels. Its bridge-building capabilities gave the media production hub its name, and they also form the basis for its ability to seamlessly integrate into any infrastructure. Using VENICE, the workflow architect can simply adapt the workflows to a TV broadcaster's actual requirements, without being tied to a specific manufacturer. Even new TV formats can be included.

Its versatility permits VENICE to bridge diverse production environments for use in a wide range of applications (Fig. 2), including:

- **Ingest during studio productions:** Covers the recording of SDI signals from cameras and video mixers during show or news productions.
- **Ingest of picture material:** Loading raw data from tapes and satellite feeds for subsequent editing or from data carriers such as XDCAM or P2 cards.
- **Studio playout:** Edited segments are returned to the studio in the shortest possible time. One example is during news productions, where speed is critical.
- Further **distribution** of segments, e.g. via VoD or OTT platforms. An integrated transcoder is available for this purpose.

Every application benefits from the media production hub's ability to access nearly every storage system available on the market. VENICE extends the conventional video server functions to include essential features that permit file-based workflows in a future-oriented TV production environment.

Open standards for autonomy and flexibility

VENICE can be integrated into every production environment through the use of open communications standards and its web-service-based architecture, and it supports all conventional broadcast file formats and codecs. Rohde&Schwarz DVS was among the first worldwide to integrate the open, web-service-controlled framework for interoperable media services (FIMS) communications standard into VENICE. This standard was approved by the Advanced Media Workflow Association (AMWA) in the US as well as by the European Broadcast Union (EBU). The goal of FIMS is to create a state-of-the-art communications standard that minimizes the effort for integrating additional systems as much as possible.

VENICE is designed for use in a wide variety of applications and is available in different versions. The versions differ in scope of functions, housing dimensions, the number of channels, and the availability of an internal storage device. For example, the light version in a 2 HU housing fits in the smallest of spaces and is ideal for mobile use.

Summary

With its variety of supported file formats, codecs and interfaces, its wide scope of functions and its modern, open system architecture, VENICE is a versatile tool for TV studios for applications ranging from ingest to studio playout to content distribution. This flexibility facilitates the simple setup and modification of workflows and scenarios and permits studios to respond quickly to new technologies and market changes.

VENICE smooths the path from tape-based to file-based workflows for TV studios and builds bridges between the various production environments. Even the conversion from SD to HD and onward to 4K is easy and cost-efficient with VENICE.

Broadcasters can organize their production based on their own needs, without restrictions imposed by proprietary solutions. VENICE has already proven its performance in many applications. It is being used in studios for the production of entertainment formats, for news production and for sporting events. For example, the DVS technology played an important role in the broadcast of the UEFA EURO 2012, the Olympic Games in London and Sochi and the Tour de France.

Katrin Brussa; Niklas Fabian

Trio of TV analyzers for all DVB-T2 network measurements

The R&S®ETL, R&S®ETC and R&S®EFL340 TV analyzers cover the entire spectrum of tests and measurements required for DVB-T2 network operators – from planning and setup to network optimization and maintenance. But which instrument is the best for which measurements?

Various T&M requirements in all phases of network setup and operation

A large number of different measurements are already needed during the setup of DVB-T2 transmitter networks. For example, the main transmitters must be tested to ensure that they are performing as specified in the planning. Gap-free coverage can only be ensured if the main transmitters transmit signals at a sufficient strength and quality – in combination with the necessary repeaters or gap fillers.

After a transmitter network has been set up, the next important step is to assess the network coverage using test vehicles and to compare the measured field strengths against the planning. When optimizing the network coverage by adding repeaters or gap fillers, the results help to ensure that there are no coverage gaps even in remote areas. All of the measurements and acceptance tests mentioned above require a high-end TV analyzer in terms of both performance and functional range.

The situation is different with maintenance and repair as well as regular assessment of the quality of service – in other words, measurements performed over the life of a network. Instead of high-end equipment, these tasks require portable, cost-effective instruments that offer an appropriate set of functions and are easy to use.

TV analyzers from Rohde & Schwarz – suitable for all applications

Rohde & Schwarz has tailored its portfolio of TV analyzers to meet the diverse requirements with respect to performance, functional range and applications (Fig. 1). Figs. 2 and 3 show typical applications and the most suitable analyzers.

For tests during transmitter production or commissioning, a high-end instrument such as the R&S®ETL TV analyzer with its excellent RF characteristics is the best choice. It can be used for reproducible, high-quality analysis of TV and sound broadcasting signals as needed at the transmitter site or for quality assurance in transmitter test bays. As an all-in-one platform, it combines the functionality of a video and MPEG-2 transport stream analyzer, an FM sound broadcasting signal analyzer and a generator for analog video and sound broadcasting signals and for MPEG-2 transport streams. Its wide range of functions and flexible configuration make the R&S®ETL the universal reference for the analysis of TV signals.

Maintenance tasks and applications where the performance of medium-power or low-power transmitters has to be characterized (such as repeaters or gap fillers) require a mid-range analyzer with good RF quality. The R&S®ETC compact TV analyzer is the right instrument in this class. It features a

Fig. 1: This trio covers all measurements in DVB-T2 networks (from left to right): R&S®ETL TV analyzer, R&S®ETC compact TV analyzer and R&S®EFL340 portable TV test receiver.

Applications

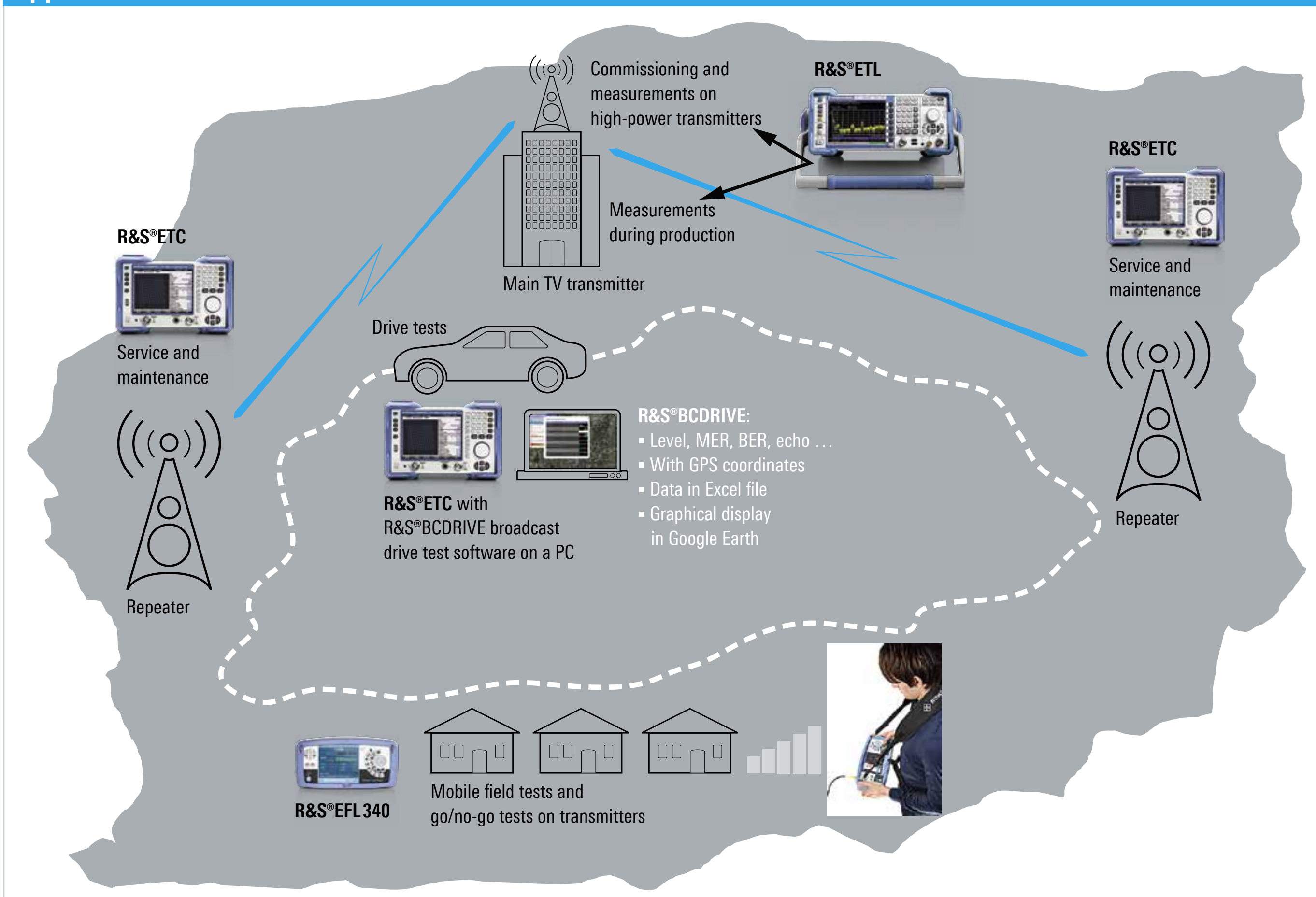


Fig. 2: The DVB-T2 TV analyzers from Rohde & Schwarz and the tasks they are best suited for.

comprehensive set of RF analysis functions and is positioned in the medium price segment. Its compact, lightweight design makes it perfect for portable use at transmitter sites located in remote areas or in confined spaces. It is also ideal for use in vehicles. When combined with the R&S®BCDRIVE broadcast drive test software running on a PC, the R&S®ETC can compare the current network coverage against the planning.

The handy, lightweight R&S®EFL340 portable TV test receiver is the best choice for mobile outdoor tests. It offers a variety of measurement functions coupled with a battery life of more than four hours. Its 5.7" display provides an overview of spectrum analysis results, RF parameters and TV program content. Shortcut keys allow the user to quickly access important functions.

The trio of analyzers covers all measurement tasks in DVB-T2 networks. The analyzers are perfectly adapted to the different T&M tasks, which means that customers only have to pay for the functions they need.

Vandy Eng

Applications	R&S®ETL	R&S®ETC	R&S®EFL340
Transmitter acceptance tests / installation	■	○	–
Transmitter maintenance	■	■	–
Transmitter go/no-go tests	–	–	■
Servicing	■	○	–
SFN optimization	■	○	○
Network coverage measurements in vehicles	■	■	–
Field measurements	■	○	■

Fig. 3: Comparison of the areas of application for the TV analyzers:
■ Complete solution, ideal choice;
○ Suitable (additional instruments may be needed).

Streaming numerous MPEG-2 transport streams over an IP interface

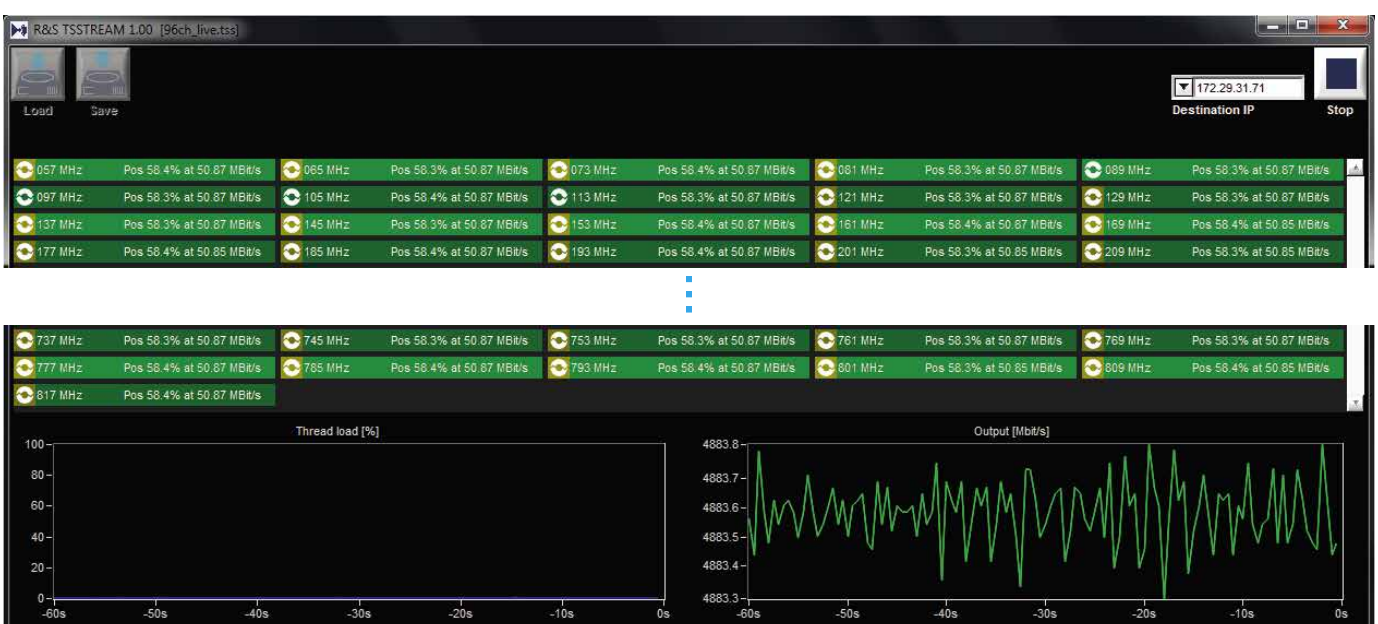
The R&S®TSStream multi-TS streaming software is used to play numerous MPEG-2 transport streams (TS) simultaneously over a single IP interface. It outputs all transport streams as seamless loops regardless of differences in individual stream play times. R&S®TSStream is well-suited for feeding data into the R&S®CLG cable load generator and the R&S®SLG satellite load generator and also for IPTV system testing.

Simulating real-world satellite and cable network configurations in the lab

The R&S®CLG and R&S®SLG [1, 2] multichannel TV signal generators simultaneously modulate numerous TV channels in realtime. They use pseudo random bit sequence (PRBS) data as digital channel content, and, for real program content feed, feature a broadband network interface capable of receiving MPEG-2 transport streams over IP for individual digital channels at separate UDP ports.

The new R&S®TSStream software performs well enough to operate this high data rate network interface (Fig. 1) even on a standard PC. This makes it possible to simultaneously broadcast any TS content on all digital R&S®CLG and R&S®SLG channels. As a result, cable TV network configurations and satellite transponder assignments can now be reproducibly simulated in the lab with real-world continuous audio and video content – a capability that greatly simplifies signal generation for a multitude of T&M tasks. This generally includes all receiver tests at the A/V service level since they require a continuous transport stream. A special application is found in developing and testing channel scan algorithms in set-top boxes and TVs which achieve faster search times by evaluating factors such as the network information table (NIT) of transport streams. Moreover, R&S®TSStream is commonly used as a signal source for IPTV equipment testing owing to its high data rates. The software provides various kinds of content on each channel, which is a prerequisite for visual switching tests.

Fig. 1: The R&S®TSStream streaming view displays the status of all generated IP streams, computer workload and total generated data rates at a glance.



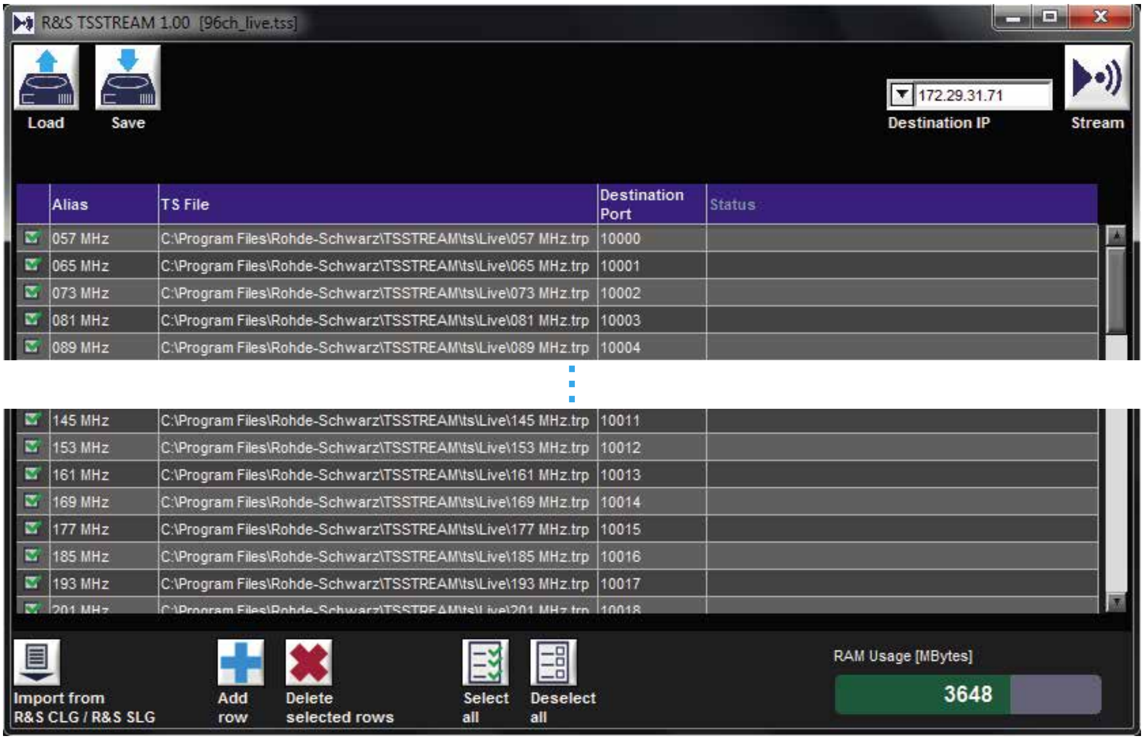


Fig. 2: Each table row of the clearly organized R&S®TSStream configuration view represents an IP stream to be generated. Drag & drop support and import functions for R&S®CLG and R&S®SLG configuration files allow for fast configuration of even large numbers of IP streams.

Sufficiently high data rates (> 5 Gbit/s) even on standard PCs

The large number of parallel modulators in the R&S®CLG and R&S®SLG require a high data rate signal feed. For example, a typical R&S®CLG configuration contains 96 individual 8 MHz digital cable channels with a net data rate of approx. 50 Mbit/s each. That adds up to a total data rate of over 5 Gbits/s. To make the streams available on standard PCs, R&S®TSStream first loads the TS files into RAM instead of playing them directly from the hard disk. As a result, the maximum number and length of the transport streams is limited only by the computer's RAM. If transport streams are assigned to multiple IP streams, they only have to be loaded once.

TV receivers require a continuous signal for interruption-free operation, and this is why R&S®TSStream plays all TS files in a seamless loop at the MPEG level. The PCR, PTS, DTS and continuity counter parameters are continuously restamped. The receiver can even deliver an interruption-free video and audio signal if the TS file contains a seamless elementary stream. Fig. 3 provides run time examples.

IP streams	Data rate / IP stream	Transport stream (TS)	RAM	Loop time
100	50 Mbit/s	Different TS for each IP stream	32 Gbyte	> 50 s
100	50 Mbit/s	Same TS for all IP streams	4 Gbyte	> 9 min

Fig. 3: Run time examples.

Easy operation – fast configuration

R&S®TSStream features an easy-to-understand graphical user interface (Figs. 1 and 2). Status, memory occupancy and processor load are displayed continuously. Drag & drop operation makes it easier to work with large numbers of transport streams. A function for importing configuration files from the R&S®CLG and R&S®SLG is a special feature that quickly and easily applies the settings of these generators in R&S®TSStream.

Marius Schipper

Request your 30-day test license free of charge by sending a request to tsstream@rohde-schwarz.com.

References
[1] R&S®CLG: NEWS (2012) No. 207, p. 34.
[2] R&S®CLS: NEWS (2013) No. 209, pp. 38–39.

The need for speed: Spectral shape detector accelerates signal search

The challenges of radiomonitoring are on the rise as radio networking sweeps the globe, but the spectral shape detector offers a way forward. It represents a new class of innovative signal monitoring and recognition solutions that instantaneously detect definable spectral shapes in densely populated frequency bands.

Challenge accepted – and mastered

Intercept operators typically deal with one or more of the following tasks:

- Identifying and extracting signals of interest
- Identifying and excluding unwanted signals
- Expanding lists of identifiable signal types

The explosive growth in number and diversity of radio technologies in recent years has created challenges that call for high-performance technical solutions. The spectral shape detector software package from Rohde & Schwarz sustainably accelerates the signal recognition and analysis process. It analyses over 1000 signals per second to ensure effective monitoring of radio bands of interest and reliable detection of signals even under harsh radio conditions (see box on right). When combined with Rohde & Schwarz high-speed scalable signal search solutions (examples in Fig. 1), it drastically improves signal detection and signal processing workflows.

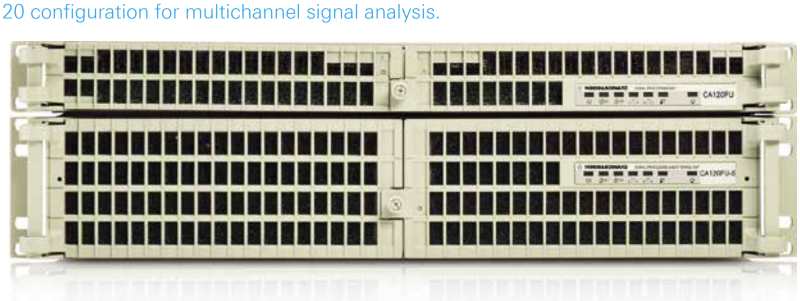
The spectral shape detector features a filter function (based on a spectral reference library) that accelerates automatic recognition, search and classification processes. It performs advanced spectral pattern matching based on user-defined signal categories to select signals for further processing.

Unique features

The spectral shape detector combines high speed, predefined spectral shapes and a new search algorithm to offer the following:

- **High-speed spectral search function**
  The spectral shape detector analyzes more than 1000 signals per second – a task that would take over ten minutes with a baseband classifier.
- **Outstanding robustness and reliability**
  The software excels in dealing with varying signal scenarios, by considering the noise, fading or sampling rate variations. The shape descriptions used for signal recognition are based on numerous samples of actual signals and produce reliable analysis results even in complex scenarios.
- **High productivity from the start**
  The spectral shape detector is delivered with predefined distinct spectral shapes (e. g. CW, AM DSB, multichannel and FSK signals) to ensure immediate productive operation upon installation. Users can also expand the spectral reference library quickly and easily.
- **Flexible configuration**
  The spectral shape detector offers users diverse options for defining and configuring spectral shapes according to their requirements.

Fig. 1: The spectral shape detector is a software extension for Rohde & Schwarz signal analysis solutions. Left: The R&S®CA100 PC-based signal processing and signal analysis software. Right: Example of R&S®CA120 configuration for multichannel signal analysis.



The spectral shape detector at a glance

In radiocommunications today, frequency bands are occupied with thousands of signals. This creates an immense challenge for radiomonitoring system operators searching for signals of interest in large, densely populated frequency ranges. To simplify this task, Rohde & Schwarz has developed the spectral shape detector for high-speed detection of signals in the spectrum (Fig. 2). Its unique detection mechanism analyzes over 1000 spectral shapes per second to ensure effective monitoring and interception of activities in today's signal scenarios. The detector can be configured as an intelligent search filter to let through signals of interest or filter out unwanted signals prior to further processing. The decisions of the spectral shape detector matching algorithm are based on criteria stored in a comprehensive decision matrix that reliably evaluates the similarities between input signals and the saved shape description set.

High-speed signal search with the spectral shape detector

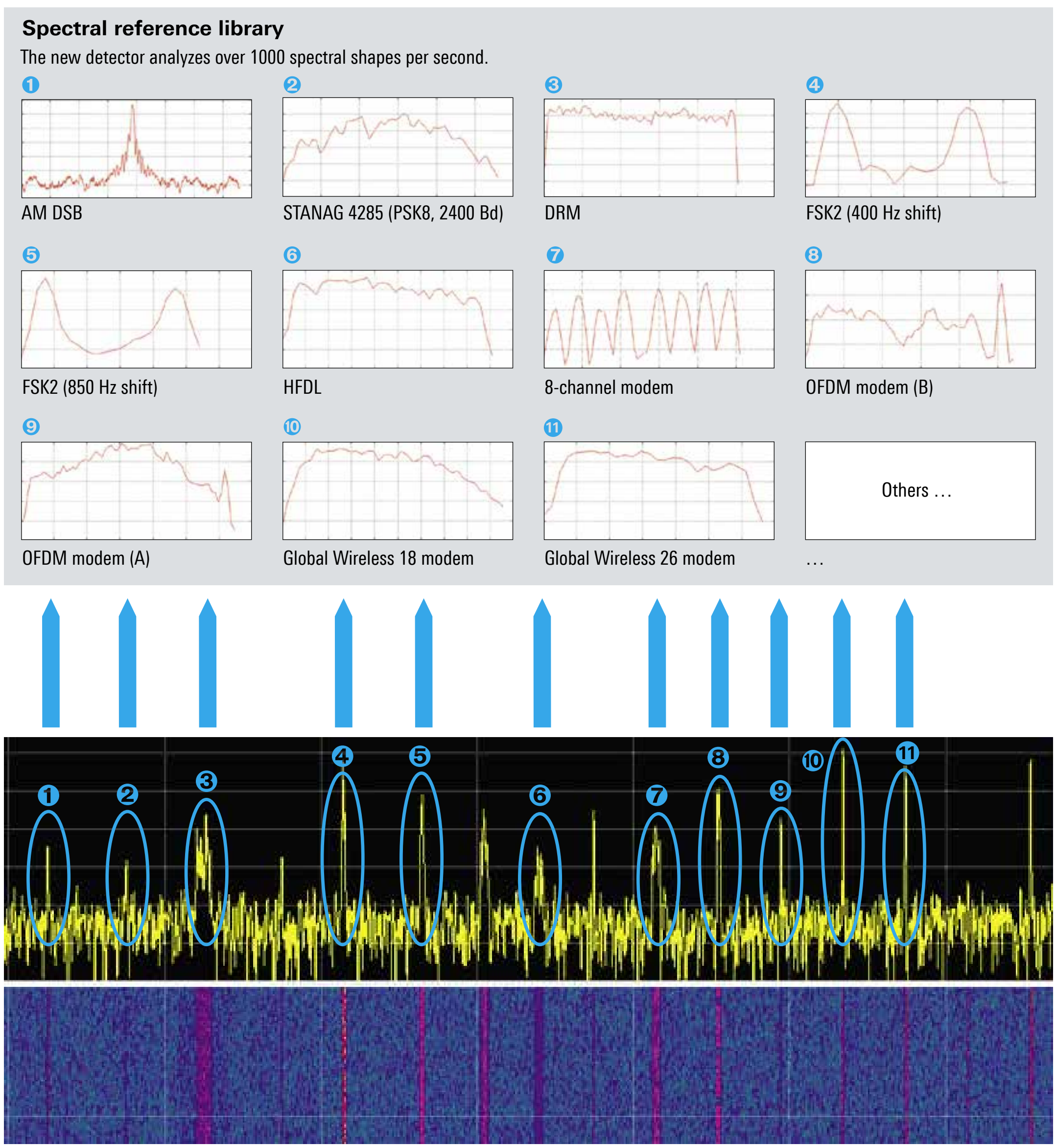


Fig. 2: High-speed search for spectral shapes by comparing the live spectrum with user-defined or predefined generic spectral shapes stored in the spectral reference library.

Core concept of signal detection

The spectral shape detector is compatible with Rohde&Schwarz signal analysis solutions such as the R&S®CA100 and R&S®CA120. It matches incoming signals with shapes defined in a spectral reference library. These shapes contain user-defined signal categories and predefined categories (e.g. CW, AM DSB, multichannel and FSK signals). The detector recognizes certain generic signal types without requiring spectral shapes to be created for them.

The operational workflow is as follows: The spectral shape detector consists of a training application and a detection application (Fig. 4). The training application has two parts (the spectral collector and the spectral detector trainer) and is used for acquiring new shapes and expanding the spectral reference library. The spectral collector automatically gathers and processes various instances of the same signal type (Fig. 3). The spectral detector trainer recognizes these instances as a learning resource, from which it extracts the spectral characteristics of a given signal type and feeds them into the spectral reference library.

After the training phase has been completed, the spectral shape detector can detect signals with similar spectral characteristics and process live spectra (receiver can be in fixed frequency or scanning mode). The detector employs a decision algorithm to determine how closely the features of an acquired signal correlate with shapes stored in the spectral reference library. A decision is made based on many criteria and comprehensive evaluation functions.

Benefits of collaboration with baseband classification

The advantages of the spectral shape detector become particularly clear when it is combined with a baseband classifier – a well-established and reliable solution for the technical analysis of a wide variety of signals. Unlike the spectral shape detector, baseband classifiers operate in the time domain. They determine the modulation type and transmission system or code of a given signal and measure all of its parameters, including time behavior and symbol rate. However, as already mentioned, this type of analysis is relatively time-consuming. The

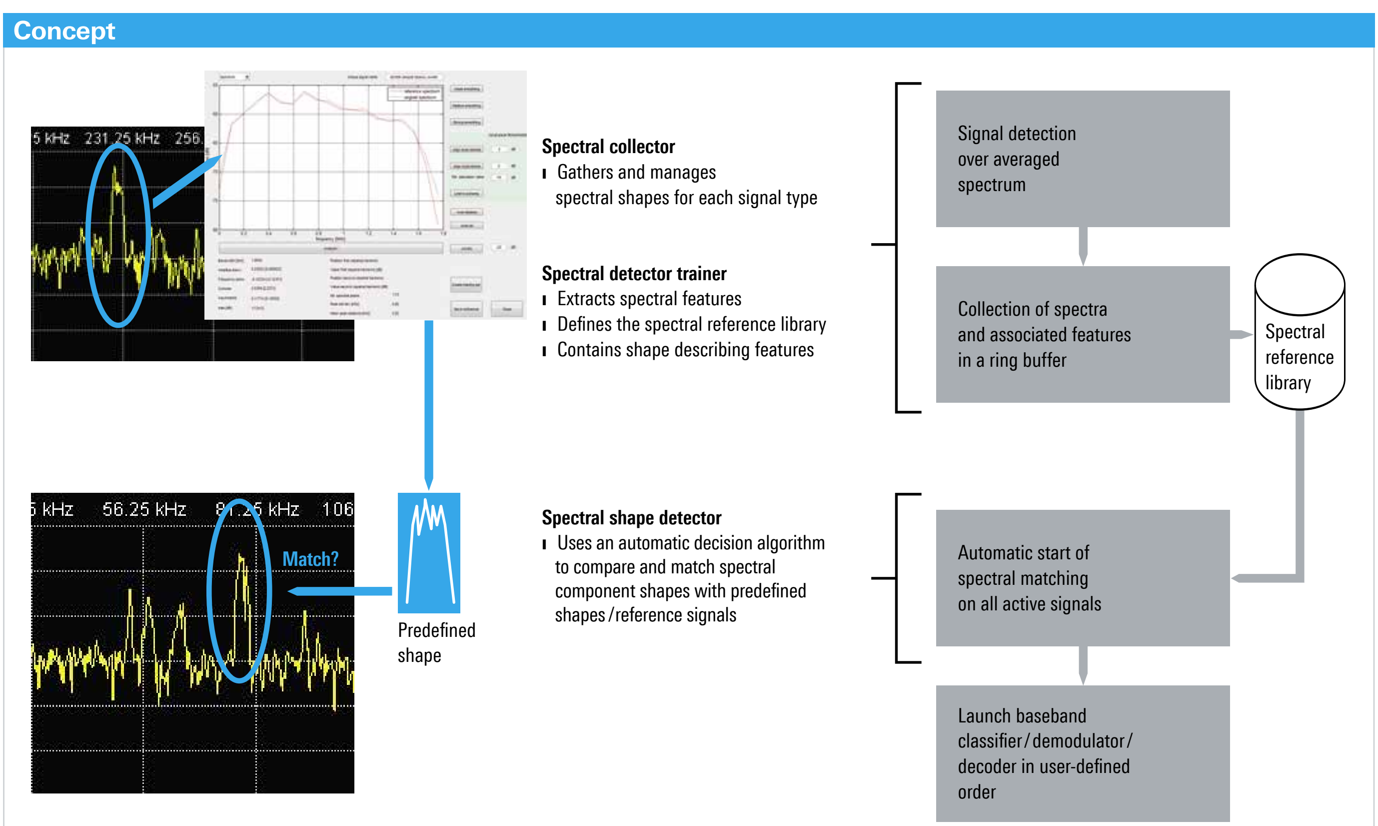
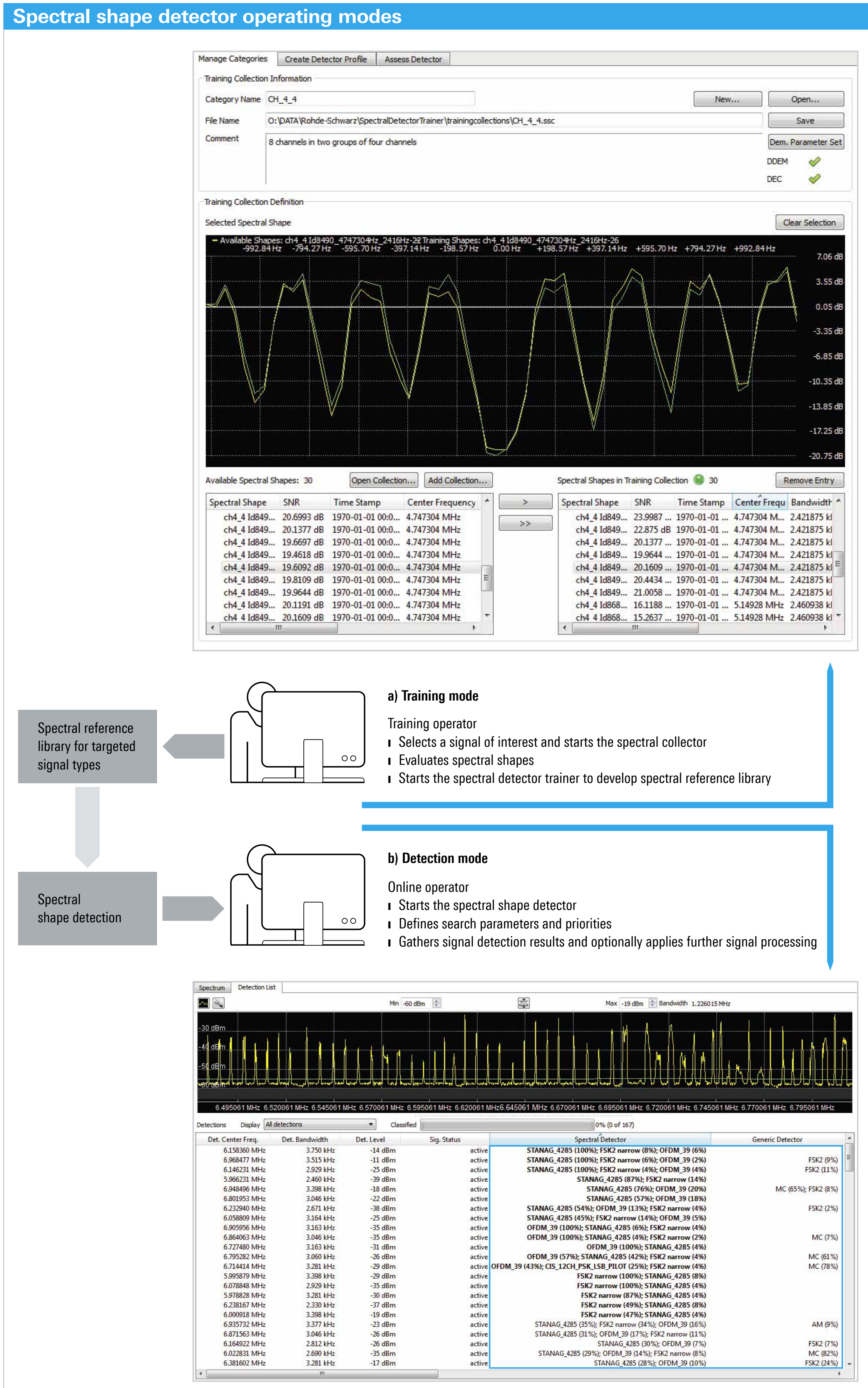


Fig. 3: Spectral shape detection process with the spectral collector, spectral detector trainer and spectral shape detector.

Fig. 4: Training (upper section) and detection modes of the spectral shape detector. The spectral shape collector gathers shapes that are similar to a specified signal and then the spectral detector trainer extracts the features of this signal type from all of these samples and stores them in the spectral reference library. The lower section of Fig. 4 shows productive operation with detection results.



baseband classifier should therefore only deal with wanted signals, which the spectral shape detector can reliably supply. As an upstream filter, the spectral shape detector only forwards signals of interest to the baseband classifier for optimum utilization of analysis resources. The high speed of the spectral shape detector combined with the in-depth analysis of the baseband classifier provides a very effective total solution.

System solution with R&S®RAMON

An integrated system solution based on the R&S®RAMON system software is currently under development (Figs. 5 and 6) and will provide users with a number of additional functions. Depending on the setup of the radiomonitoring system on which the R&S®CA120 analysis system is installed, the signals delivered by the spectral shape detector will be linked with signals from other sensors such as direction finders and saved in the R&S®RAMON signal and reference database. This allows extensive automatic analysis of acquired transmissions as well as fully automatic recognition of selected radio networks.

Example: R&S®RAMON radiomonitoring system with three workstations

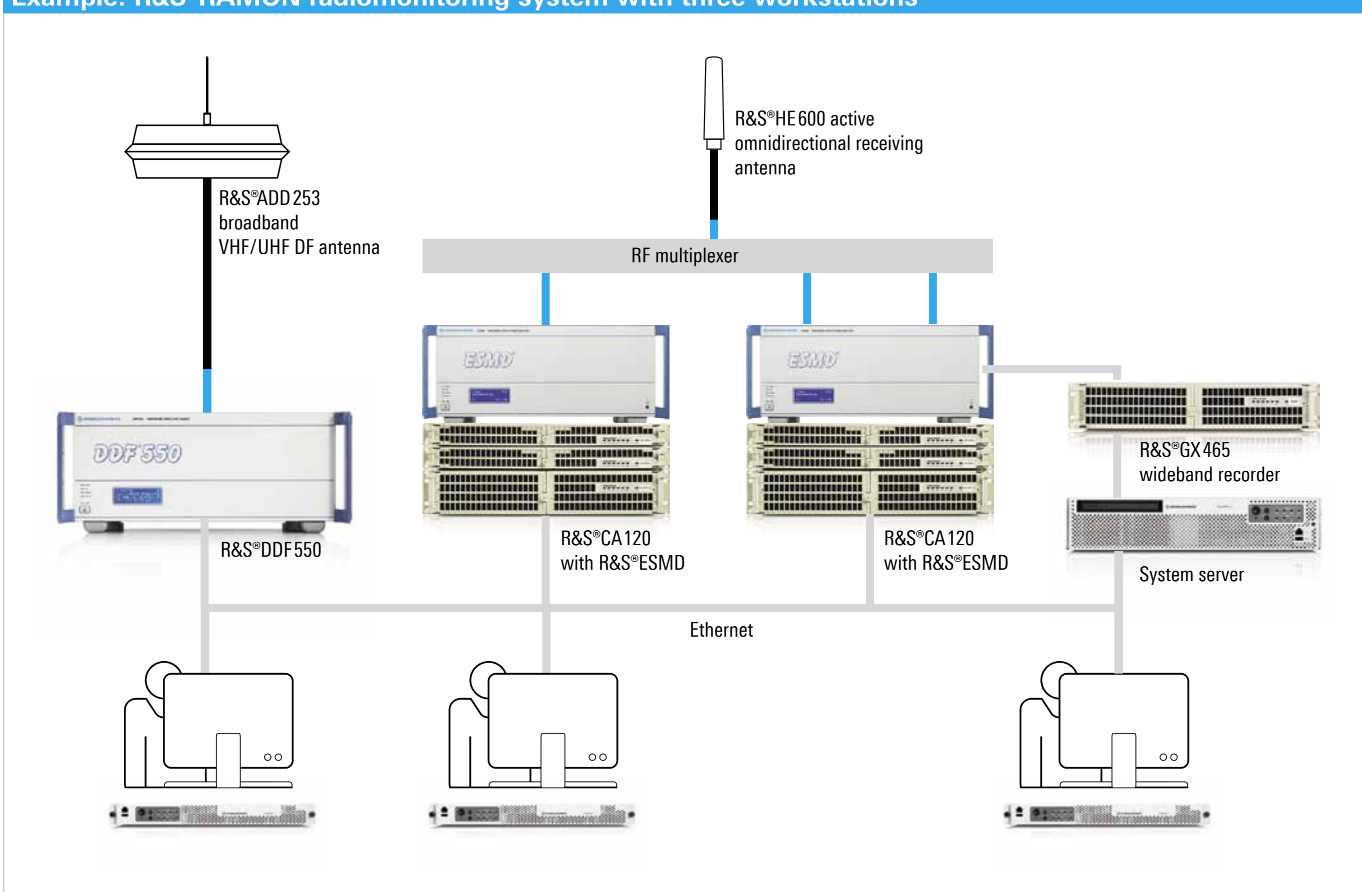


Fig. 5: The R&S®RAMON system with two R&S®ESMD wideband receivers, an R&S®DDF550 direction finder, an R&S®GX465 wideband recorder and three workstations. Each R&S®CA120 signal analysis solution automatically processes the wideband signal scenario from the R&S®ESMD on up to 32 channels simultaneously. The spectral shape detector can be combined with the R&S®RAMON software for very high-speed search applications.

Fig. 6: Detection results of the R&S®RAMON system software with the spectral shape detector.

Summary

With its quick, robust, reliable and configurable spectral shape recognition function, the spectral shape detector from Rohde & Schwarz makes it possible to conduct high-speed signal searches within a wide frequency band and in densely populated signal scenarios. The spectral shape detector enhances the R&S®CA100 and R&S®CA120 with high-speed signal search applications by improving their signal recognition and processing workflows.

In addition to the features and applications of the spectral shape detector described above, a scripting interface is made available to fully automate the processing application. The benefit for users is the combination of the spectral shape detector and fully automatic signal processing (demodulation, decoding and recording). JavaScript can be used to trigger actions to control recording and further processing. Scripts are used to define conditions and criteria based on all relevant parameters.

YingSin Phuan

Professor Rohde receives honorary membership

Professor Dr. Ulrich L. Rohde.

In recognition of his outstanding scientific achievements, Prof. Dr.-Ing. habil. Dr. h. c. mult. Ulrich L. Rohde was selected as an honorary member of the Bavarian Academy of Sciences and Humanities by its plenary assembly in late 2013. Besides Duke Franz of Bavaria, Ulrich L. Rohde is now the second honorary member of the Academy. He has supported the Academy for many years in its efforts to foster promotion of young researchers and has championed the Academy's Young Scholars Program ("Junges Kolleg") created in 2010 to open new career doors for the next generation of scientists. Founded in 1759, the Academy is not only one of the largest and oldest organizations of its type in Germany. It also has an international reputation for its fundamental research in natural sciences and humanities. The Academy's most renowned members include Johann Wolfgang von Goethe, Alexander von Humboldt and Albert Einstein.

Rohde & Schwarz supports 5G research center

In late 2013, Rohde & Schwarz co-founded a research consortium with the University of Surrey (UK) and other leading companies in the mobile radio sector including Fujitsu, Huawei, Samsung, Vodafone AIRCOM, BBC, British Telecom, EE and Telefónica. The objective of the consortium is to develop pioneering 5G mobile radio technologies. Its members and the British government are investing a total of over EUR 37 million in the construction of a 5G research center at the university's campus in Guildford and providing expert support for the endeavor. Starting in January 2015, 150 researchers and approx. 100 PhD candidates will begin working on the structures and components of the fifth generation of mobile radio (5G). The project is expected to include the setup of a fully functional mobile radio network to test new technologies in a realistic environment.

Photo: University of Surrey

Gerhard Sonnde, Director of the T&M Central Marketing Subdivision (row 2, third from right), represented Rohde & Schwarz at the agreement signing ceremony.

BTR diamonds for Rohde & Schwarz cable TV test equipment

The R&S®EFL210 cable TV analyzer and leakage detector and the R&S®CLG cable load generator received top scores in the Broadband Technology Report (BTR) online magazine. The news platform's independent judges gave the instruments a score of 4.5 out of a possible five "diamonds." The R&S®EFL210 is a handy portable instrument for detecting and localizing radiated emissions from cable TV networks. The R&S®CLG is a multichannel signal generator for cable TV signals. It is the world's first instrument to simulate cable TV networks with full channel loading. The judges were thrilled with the sophisticated technology of the two instruments. With its annual Diamond Technology Reviews, the judges honor outstanding products in the broadband cable industry.

Two BTR diamonds for Rohde & Schwarz broadcasting T&M equipment.

Rohde & Schwarz hosts ITU Academy in Munich

In November 2013, the International Telecommunication Union (ITU) held a workshop on implementing radiomonitoring systems in line with ITU-R recommendations at the Rohde & Schwarz headquarters' training center in Munich. The partnership between the company and ITU serves to provide instruction and training to the employees of regulatory authorities. The five-day workshop was attended by twelve representatives of such authorities from various countries in Africa, Asia and the Persian Gulf region. Rohde & Schwarz experts gave presentations and provided practical demonstrations on spectrum monitoring.

Participants, ITU representatives and Rohde & Schwarz experts at the Munich workshop.

IP-based voice communications system for Ireland and Iceland

Rohde & Schwarz will provide the aviation authorities of Iceland and Ireland with HF radios and a new voice communications system for their air traffic control services. The Icelandic Civil Aviation Administration (ISAVIA) and the Irish Aviation Authority (IAA) want to link their locations in Gufunes and Ballygirreen with a state-of-the-art virtual control center. The ISAVIA and IAA contract includes receivers of the R&S®M3SR Series 4100 HF radio family and two R&S®VCS-4G IP-based voice communications systems in line with EUROCAE ED-137. The concept of the virtual control center enables the voice communications systems to function in a joint operating mode. Air traffic controllers now have full access to all of the resources and functions of the two systems. Resources and required infrastructure can be reassigned during emergencies to maintain operations and alleviate the situation. The systems will cover communications in the North-Atlantic Reykjavik Oceanic and Shanwick Oceanic airspaces known as the North Atlantic flight corridor.

Service center in Hungary to become calibration laboratory

The Hungarian National Accreditation Board (NAT) approved the Rohde & Schwarz service center in Budapest as a calibration laboratory in late 2013. ISO/IEC 17025:2005-compliant certification means the service center is now authorized to calibrate Rohde & Schwarz products as well as instruments and components from other manufacturers anywhere in Europe. The NAT is a member of the International Laboratory Accreditation Cooperation (ILAC).

The service team in Hungary is responsible for Central and Eastern Europe.