IEEE 802.11 Wireless LAN Testing with the R&S®CMW Wideband Radio Communication Tester

WLAN

ROHDE&SCHWARZ

Application Brochure | Version 02.01

Wireless local area network (WLAN), as the IEEE 802.11 wireless standard is commonly known, is indispensable in the modern world of communications. Not only mobile phones, laptops and printers use this standard. Even refrigerators, cameras and cars are now equipped with it.

To ensure trouble-free operation, WLAN-capable devices have to undergo a wide range of tests – from development to production. The scope of these tests increases depending on the quality requirements and whether WLAN is operated in parallel with other wireless standards such as Bluetooth® or LTE.

Contents

For more information, visit
www.rohde-schwarz.com/product/cmw_wt
www.rohde-schwarz.com/wlan

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R&S®CMW platform overview

The R&S®CMW wideband radio communication tester platform offers all major radio access technologies in a single compact tester, making it ideal for testing mobile devices such as smartphones and tablets as well as base stations and access points. It is also an excellent platform for testing the diverse requirements of connected products in the automotive, healthcare, smart home and other IoT segments.

Rohde&Schwarz – recognized as a reliable partner for WLAN testing solutions

As a leading supplier of T&M solutions for the wireless communications market, Rohde&Schwarz offers the R&S®CMW wideband radio communication tester, a universal, flexible platform for all major cellular and non-cellular standards. The R&S®CMW measures the RF characteristics of transmitters and receivers on the air interface of wireless devices. It evaluates the applications and performance, and analyzes the protocol stack.

Numerous advantages of the future-ready R&S®CMW all-in-one platform

With its extremely stringent speed and reliability requirements, the user-friendly R&S®CMW platform efficiently performs all measurement tasks – from complex lab tests to production line testing.

While the high-end R&S®CMW500 covers the entire spectrum, the R&S®CMW270 has been specialized for non-cellular connectivity applications. The R&S®CMW290 is a cost-effective, compact version for basic measurements and functional tests. The R&S®CMW100 tester is optimized for production.

Since all R&S®CMW models are code compatible, it is easy to reuse code on other models, e.g. for remote control.

Platform overview – preconfigured models

R&S®CMW500

The all-in-one test platform

The R&S®CMW500 wideband radio communication tester is the universal test platform for RF integration and protocol development. The R&S®CMW500 includes a fully integrated end-to-end data solution that permits comprehensive IP throughput and quality measurements. The R&S®CMW500 can be used in all phases – from product development to production to service. It is the solution with the widest range of supported technologies.

R&S®CMW270

The expert for all non-cellular technologies

The R&S®CMW270 wireless connectivity tester is a cost-effective alternative for development, production and service. The non-cellular specialist offers features comparable to those of the R&S®CMW500. It supports Bluetooth®, WLAN and broadcast technologies.

Wide variety of hardware and software options

The R&S®CMW platform has a scalable option concept and offers a variety of software and hardware options. As a result, the R&S®CMW can be individually configured to meet the given T&M requirements.

The R&S®CMW keeps pace with continuous technological developments by providing software updates and new software options. Hardware components can be upgraded as well.

Unique software tools that extend the range of functions are also available. The R&S®CMW platform covers the entire T&M spectrum with a single instrument.

From pre-sale to service. At your doorstep.

The Rohde&Schwarz network in over 70 countries ensures optimum on-site support by highly qualified experts who help you determine the best solution for your requirement. The company stands for high quality, preventative service and compliance with delivery schedules – covering every requirement from calibration to application support.

All-in-one test platform for wireless devices

1 Versatile hardware platform

- 6 GHz support
- Up to 4 RF channels
- Internal server for E2E testing

2 Multi-RAT signaling

- LTE, WCDMA/HSPA+, GSM/GPRS/EGPRS
- CDMA2000® 1xRTT/EV-DO
- WLAN, Bluetooth®

3 LTE-Advanced

- 8 DL CC up to 4x4/8x2 MIMO fading, 2 UL CA
- FDD/TDD joint operation, 1024QAM DL
- LTE-U/LTE-LAA, LTE-D, LTE-D2D, eMTC, C-V2X

4 WLAN signaling support

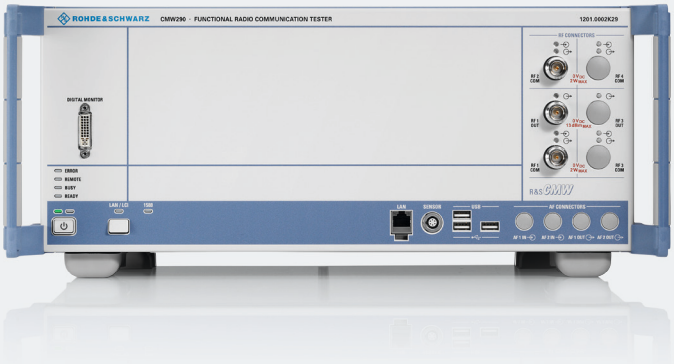
- LTE-WLAN traffic offload
- WLAN E2E and access point testing
- In-device coexistence tests with other technologies

5 Outstanding features for manufacturing

- Multi-DUT testing for up to 8 devices
- Chipset support for all major suppliers
- Support of cellular, Bluetooth®, WLAN and IEEE 802.15.4 (ZigBee) technologies

R&S®CMW290

The compact RF tester for basic functional tests



The R&S®CMW290 functional radio communication tester is the cost-effective compact version of the R&S®CMW500. The tester is the right instrument for users who need to measure fundamental RF characteristics or verify the functionality of wireless devices. The R&S®CMW290 provides service companies with a high-quality, customized, automated test environment for functional input and output tests. Powerful network emulation allows IoT/M2M system integrators to functionally test module integration and custom IP applications.

R&S®CMW100

The compact RF tester for production

The R&S®CMW100 communications manufacturing test set is based on the R&S®CMW platform. The flexible RF interface permits simultaneous testing of up to eight RF ports. The R&S®CMW100 remote control and measurement concepts are compatible with the R&S®CMW500. Both testers use the same methods for optimizing test time and capacity utilization. The R&S®CMW100 can be used to cost-effectively calibrate and verify wireless devices in non-signaling mode (analyzer/generator).

Transmitter and receiver tests

A fundamental requirement for wireless communications is that the receiver and transmitter function properly and are standard-compliant. Regulatory provisions further tighten these requirements.

One tester for the entire product lifecycle

A wide range of tests are performed early on during the development and design phase, preferably under realistic operation conditions, in so-called signaling mode. The focus is on determining receiver sensitivity and the spectral purity of the transmitter.

In production, test times need to be as short as possible, but the tests still have to fulfill high quality requirements. This is only possible in non-signaling mode. In non-signaling mode, the device under test (DUT) is remote controlled via an electrical cable. This special operating mode supports time-optimized calibration and testing of the transmitter and receiver. These tests require a suitable T&M instrument equipped with a signal generator and analyzer. When using this time-optimized test and measurement method, it is understood that a custom remote control program is required for each chipset to be tested and a wired remote control interface must be available.

The modular R&S®CMW platform covers all these test requirements in all phases of the product lifecycle – from development to production to service.

Multi-evaluation of transmitter characteristics

It is essential to verify the transmitter characteristics in order to:

- Verify compliance with legal requirements, for example with regard to the maximum permissible transmit power
- Minimize interference with other radio transmissions
- Ensure high user satisfaction through reliable radiocommunications

To verify transmitter characteristics, the R&S®CMW offers a full range of power, modulation and spectrum RF measurements for the IEEE 802.11a/b/g/n/p/ac/ax WLAN standards with bandwidths up to 160 MHz. Thanks to the system architecture of the R&S®CMW platform, these different measurements can be performed simultaneously and quickly.

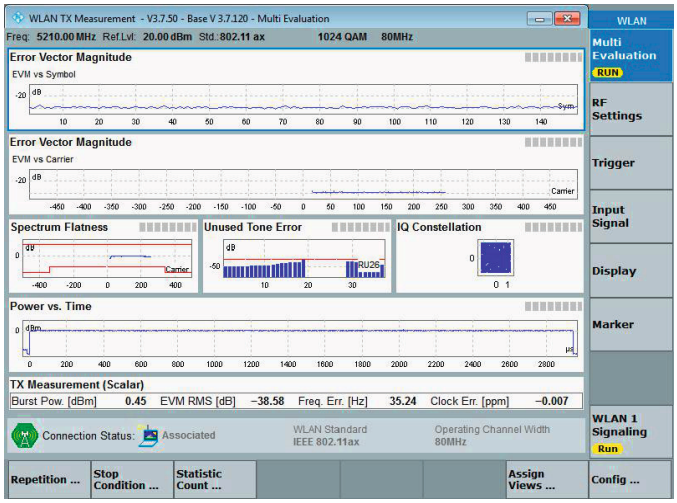
Output power

Every commercial WLAN device has to be compliant with various regulations. One of these is the maximum allowable transmit power for the regulatory domain. Specified spectral power limitations result in maximum output power limits, which have to be determined bandwidth dependent for each device. Measurement of maximum conducted output power requires integrating the spectrum across a particular frequency span.

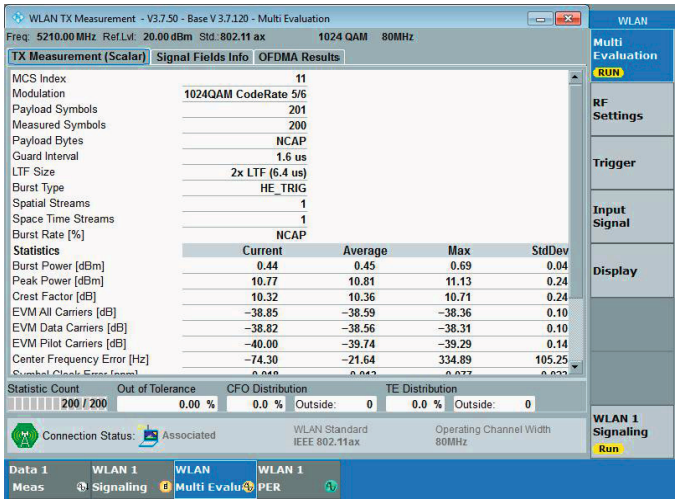
Transmit spectrum mask

It is essential to ensure that a transmission stays within its channel and that multiple WLAN devices do not unduly interfere with each other. The energy that spills outside the designated radio channel increases the interference with adjacent channels and decreases the system capacity. The amount of excessive radiation at frequencies beyond the necessary bandwidth is assessed by a transmit spectrum measurement.

The multi-evaluation view provides an overview of the results of all simultaneously performed measurements.



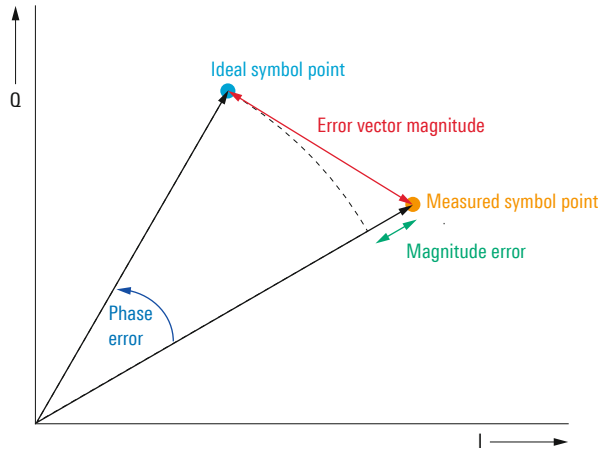
Scalar results for IEEE 802.11ax in multi-user operation (OFDMA).



Modulation accuracy

Transmit modulation accuracy covers transmitter center frequency leakage and transmitter relative constellation error. It quantifies the performance of a transmitter. The test is performed after converting the transmitted signals into a stream of complex samples. All constellation points should be precisely at the ideal locations. But various imperfections in the implementation cause the actual constellation points to deviate from the ideal locations. Error vector magnitude (EVM) is a measure of how far the points are from the ideal locations and provides a comprehensive measure of the quality of a radio transmitter.

Error vector magnitude (EVM)



The error vector magnitude (EVM) is the critical quantity to assess the modulation accuracy of a transmitter.

Receiver quality analysis

To check receiver sensitivity, several data packets with specific length, content, modulation and transmission levels are transmitted to the DUT to determine the packet error ratio (PER).

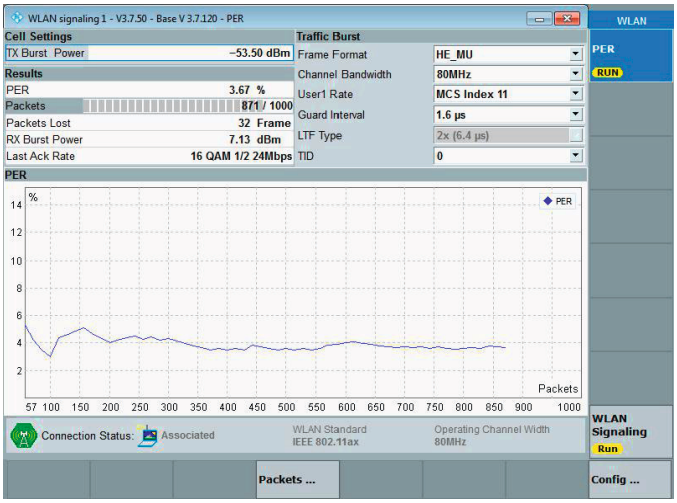
After decoding the transmitted data, the receiver calculates a checksum and compares it with the checksum sent by the transmitter. If they are the same, this is evaluated as error-free reception and an acknowledgement (ACK) is sent to the transmitter. If they are not the same, no acknowledgement is required. Based on the ACKs generated or not generated by the receiver, a statement is made about the quality of the receiver sensitivity.

When analyzing the quality of transmitters and receivers, limits and how they are to be measured are precisely specified. The measurements on the R&S®CMW platform are implemented in line with relevant specifications.

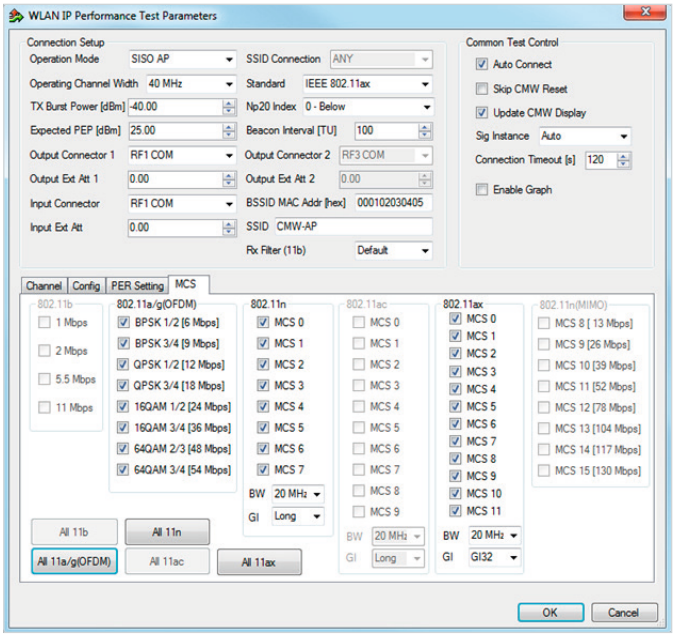
Test automation with R&S®CMWrun

All these tests can be performed manually or automatically. The R&S®CMWrun sequencer software tool offers a series of easily configurable test sequences that can be used to efficiently execute time-consuming measurement sequences.

Packet error ratio (PER) tests are used to measure the performance of WLAN receivers. The PER measurement transmits user data to the DUT and calculates the PER as the ratio of unacknowledged packets to transmitted packets.



Automated RX performance test procedures with R&S®CMWrun.



Network emulation

Frequently, the RF characteristics of WLAN radio modules are tested only in non-signaling mode under non-realistic operating conditions. However, there is a risk that the device could behave differently in subsequent normal operation. This risk can be minimized by testing in signaling mode during development and quality assurance.

In signaling mode the T&M instrument emulates either an access point (AP) or a WLAN station (STA), and the DUT connects to the emulated AP or STA like it would under normal operating conditions. Using standard-compliant signaling, the DUT can be placed in any desired operating state required for the measurements. Typical examples include:

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

DUT testing in signaling mode

In addition to determining RF characteristics, R&S®CMW users can define an entire series of connection settings such as MAC addresses, SSID, country code, authentication protocol and encryption. The R&S®CMW emulates different types of WLAN devices in the 2.4 GHz and 5 GHz frequency bands in line with IEEE 802.11a/b/g/n/ac/ax standards. The tests can be reproduced at any time under lab conditions.

Additional test requirements with IEEE 802.11ax

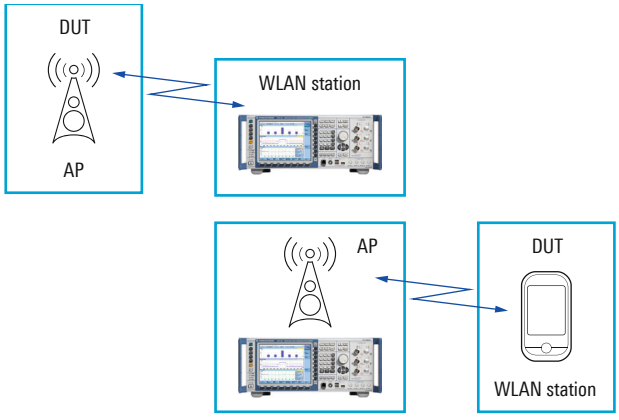
The orthogonal frequency division multiplexing access (OFDMA) method, which with IEEE 802.11ax can also be used for WLAN, provides a significant improvement of the efficiency of the available radio channel. The available bandwidth is divided into resource units (RU) that the access point dynamically assigns to its allocated stations on demand. This allows multiple users to transmit at the same time. This is a significant improvement over previous standards where only one user at a time could use the entire bandwidth exclusively.

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

Uplink OFDMA synchronization

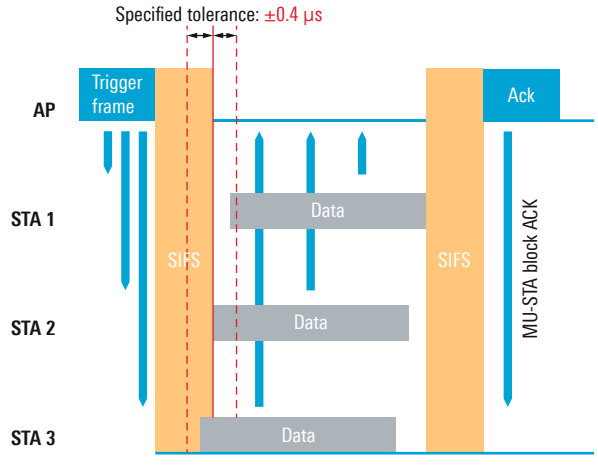
One of the prerequisites for efficient parallel operation of multiple WLAN ax stations is proper synchronization. Triggered by the AP, all stations must start transmitting within ±0.4 µs (see figure on next page). The R&S®CMW can reliably measure compliance with this tolerance in signaling mode.

Network emulation



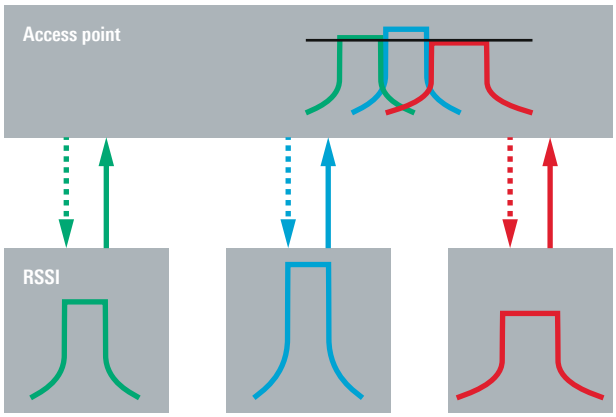
The R&S®CMW270/R&S®CMW500 can emulate AP and STA to establish a standardized IEEE 802.11 network connection to DUT.

Uplink OFDMA synchronization



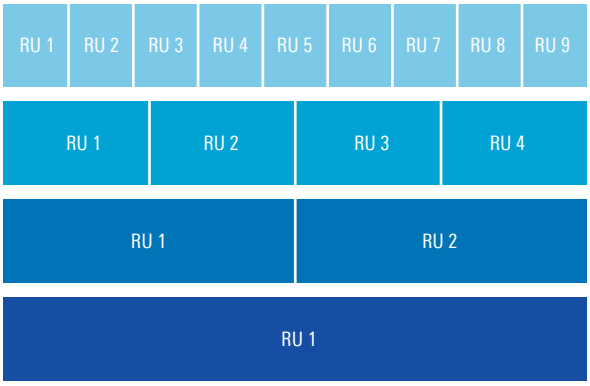
Starting with the AP's trigger signal, all STAs must synchronously transmit their data packets to the AP within a time of departure accuracy of 0.4 µs.

Dynamic power control



During uplink multi user transmission each station have to adjust its transmit power.

Multi-user channel distribution



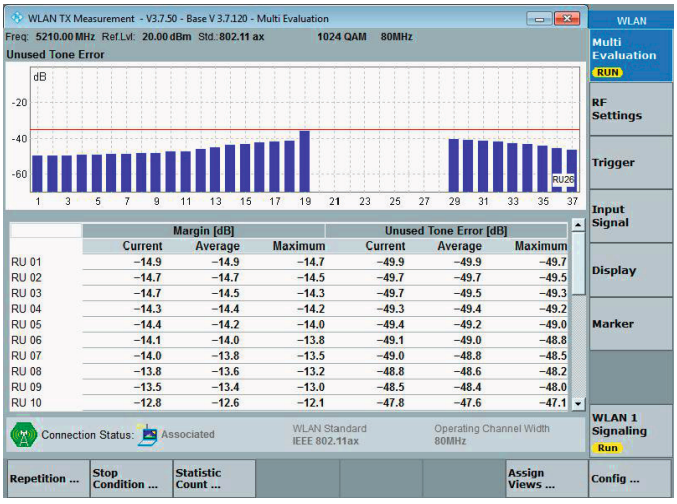
With IEEE 802.11ax in multi-user mode, a 20 MHz channel (for example) is divided into resource units (RU) that can be combined in different sizes.

Dynamic power control

Excessive field strength differences between the different STAs at the AP receiving antenna would hinder proper OFDMA operation. This problem can be prevented if the STAs adjust their transmitted power so that all signals arrive at the AP with approximately the same field strength. The accuracy with which an STA performs dynamic power control is a new and important quality criterion that is ideally tested in signaling mode under realistic conditions.

Unused tone error

In the uplink, each station transmits only on the resource unit assigned to it by the AP. Spurious emissions into adjacent spectrums, which are of course used by other stations, must be minimized. IEEE 802.11ax introduces the unused tone error for this purpose. The power for the subcarriers that remain unused by a station is calculated and set proportionate to the power of the active RU, similar to an adjacent channel leakage ratio (ACLR) measurement.



The power limits of unused tones are defined relative to the EVM limits of the active RU.

Multiple network emulation

The R&S®CMW270/290/500 can simultaneously emulate up to four same or different radio networks to implement complex test scenarios.

Comprehensive complex RF signaling tests based on Bluetooth® and WLAN

The R&S®CMW is the only platform to provide WLAN signaling and all defined Bluetooth® SIG RF signaling tests in combination with other cellular technologies such as LTE-A, WCDMA, GSM, CDMA2000®. The R&S®CMWrun automation tool offers solutions for Bluetooth® prequalification tests. The R&S®CMW500 can emulate networks or base stations for the following radio access technologies (RAT): GSM, WCDMA, LTE, CDMA2000® 1xEV-DO, WLAN, Bluetooth®.

MIMO TX/RX measurements

Multiple input multiple output (MIMO) is a multiple antenna system to increase the data rate or to improve signal quality and robustness in wireless communications. MIMO transmitters simultaneously send different signals (streams) on the same frequency via separate antennas.

TX diversity

When there are more TX than RX antennas, this is called TX diversity. The simplest scenario uses two TX and one RX antenna (2x1 MIMO). It´s intended to improve the signal-to-noise ratio. With a more robust transmission method, the coverage area expands and the use of higher modulation becomes more probable.

Spatial multiplexing

The goal of spatial multiplexing is to increase the data rate. To do this, the data stream is divided into separate streams that are transmitted independently via separate antennas. On the receiver end, each antenna receives a signal that is the sum of all the different transmitted signals. Successful decoding of a MIMO data transfer requires solving a linear system of multiple equations. These equations can be solved as long as all equations are independent.

Physically, this means that multipath propagation on relatively spatially independent, uncorrelated transmission paths is required. In order for the complex mathematical algorithms to be able to reconstruct the signal, certain minimum requirements must be satisfied with regard to the spectral purity of the transmitters and the sensitivity of the receivers. Both must be tested in development and also to some extent in production.

Receiver testing

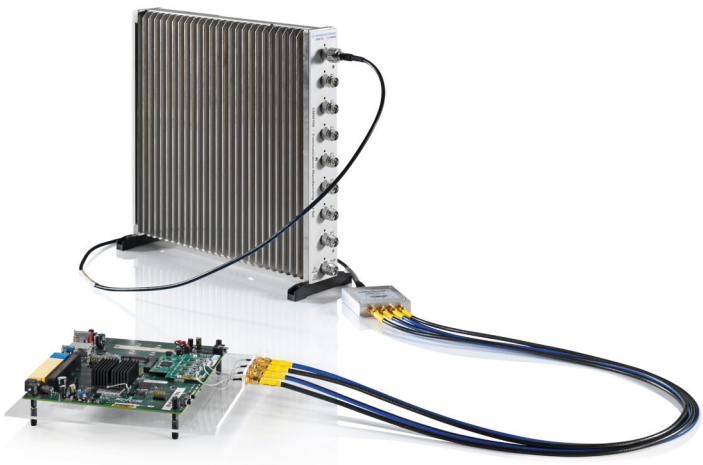
The MIMO receiver test is performed simultaneously on all receiving antennas. Each antenna is connected to a separate signal generator. Once all of the generators have been synchronously started, a packet error rate measurement is performed.

Transmitter testing

For transmitter testing, there are several methods that differ in terms of test depth and equipment complexity.

Composite MIMO TX measurement

With this method, all MIMO signals transmitted in parallel (up to eight) are combined in a power combiner and the sum signal is transmitted to an R&S®CMW for analysis. Although the MIMO antennas transmit different bit sequences, the analyzer is able to determine the transmitted power of each antenna and provide a quality assessment for the sum signal in the form of the error vector magnitude (EVM) value. The composite MIMO TX measurement is the method of choice for production because it quickly verifies MIMO performance without a lot of test equipment and finds faulty antenna connections.



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

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

Switched MIMO TX measurement

For the switched MIMO TX measurement, each transmitting antenna is connected to a port on one R&S®CMW100. All antennas are switched in rapid succession and the RF properties on all transmit paths are analyzed individually. Even an 8x8 MIMO TX system can be analyzed with just one instrument.

True MIMO TX measurement

In contrast to the sequential switched measurement, the true MIMO TX measurement is performed simultaneously on all channels. The speed advantage comes at a high hardware investment since a separate R&S®CMW100 is required for each transmitting antenna.

Multi-user MIMO and beamforming

Instead of simultaneously sending multiple MIMO data streams to a single user to boost the data throughput, the data streams can be distributed among multiple users. To implement multi-user MIMO (MU-MIMO), in principle the receiver requires as many receiving antennas as in the single-user case. One way to reduce the number of receiving antennas is to use beamforming, which augments or suppresses the propagation of individual signals in certain directions by exploiting the radiation patterns of multi-antenna systems. Each user then receives only their intended data stream with high field strength. Based on this technique, even a user with only one receiving antenna can successfully decode their intended data stream in an 8x8 MU-MIMO scenario. All of these methods are supported by the R&S®CMW100 communications manufacturing test set (model K06) in non-signaling mode.

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

2x2 MIMO signaling test

The basic concept of MIMO is to exploit multipath propagation. This requires a minimum separation distance between the transmit and receive antennas, but the compact design of mobile devices such as smartphones is a limiting factor. These devices can hold at most two transmit and two receive antennas, which limits transmission to 2x2 MIMO. Using 2x2 MIMO, and under perfect conditions, you can still achieve double the data rate of single antenna systems.

R&S®CMW270, R&S®CMW290 and R&S®CMW500 are able to emulate an 2x2 MIMO AP and support the following tests and measurements with a 2x2 MIMO STA as the DUT under realistic, normal operating conditions:

- Receiver quality analysis
- True MIMO TX measurements
- Application and performance tests

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

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

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

Measurement results for an 8x8 MU-MIMO scenario with four WLAN stations: User 1 is supplied with four data streams, User 2 with two data streams and Users 3 and 4 with one data stream each.

End-to-end testing and performance testing

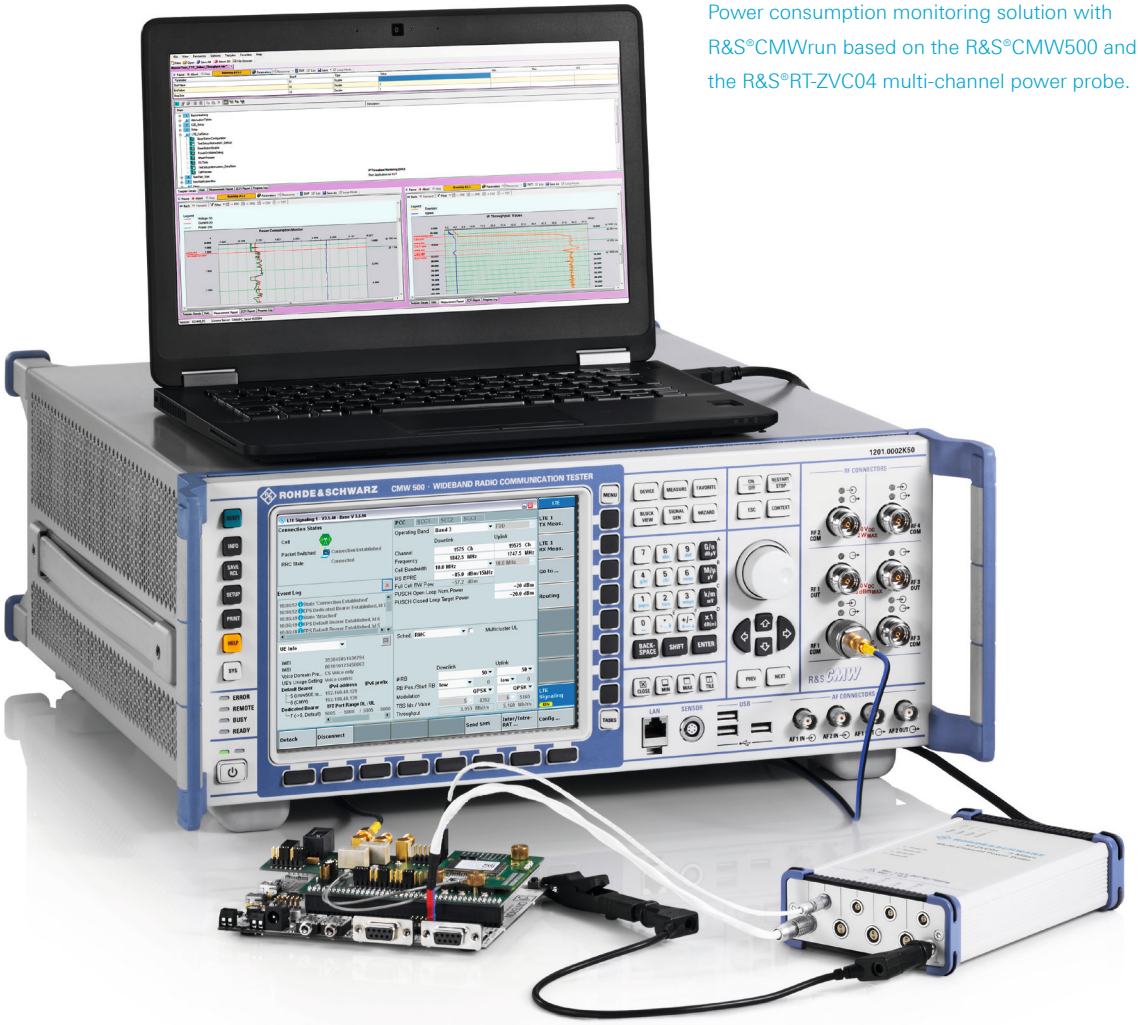
A state-of-the-art communications device will only succeed on the market when its applications function correctly. How good is the voice quality? How high is the data throughput? How long does a battery charge last? These and other questions need to be answered.

The R&S®CMW test platform can be used to perform, document and evaluate complex user experience tests under simulated, yet realistic conditions. An R&S®CMW tester combined with the R&S®CMWrun automation tool provides an enormous test bandwidth that is unmatched on the market.

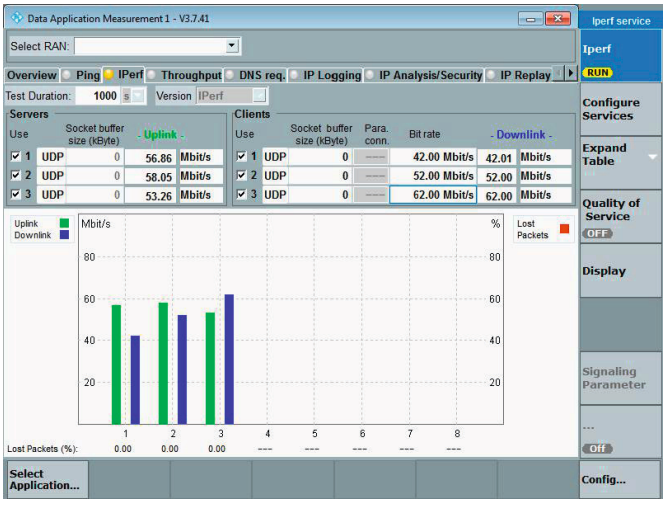
IP application testing under fully controlled network conditions

One of the strengths of the R&S®CMW platform is the ability to test wireless applications, such as browsers and video telephony, on a smartphone under lab conditions. In contrast to real networks, users can define the test conditions in the R&S®CMW. They can adjust quality-of-service parameters (e.g. delay and jitter), data throughput and other qualitative parameters to determine when they affect the application quality. In addition to these wireless parameters, the user can also adjust the wireline parameters. The R&S®CMW allows users to subjectively assess the results. It also provides an objective, quantitative assessment.

Most communications applications are IP-based and require a corresponding server. The R&S®CMW270/290/500 has an integrated data application unit (DAU) with a number of key servers. One of these is the IP multimedia subsystem (IMS), the basis of many audio and video applications.



Power consumption monitoring solution with R&S®CMWrun based on the R&S®CMW500 and the R&S®RT-ZVC04 multi-channel power probe.



Unidirectional and bidirectional data throughput measurements based on the iPerf network testing tool.

Determination of data throughput

The main motivation for the continued development of the various wireless standards has been to increase the achievable data throughput. Being able to determine the throughput under reproducible lab conditions is a prerequisite for the success of development, quality assurance and every benchmark.

Once the quality criteria has been defined for the wireless connection and the subsequent wireline transmission, the free iPerf software tool that is integrated into the R&S®CMW user interface can be used to determine the maximum possible data throughput in the transmit and receive direction, both separately and simultaneously.

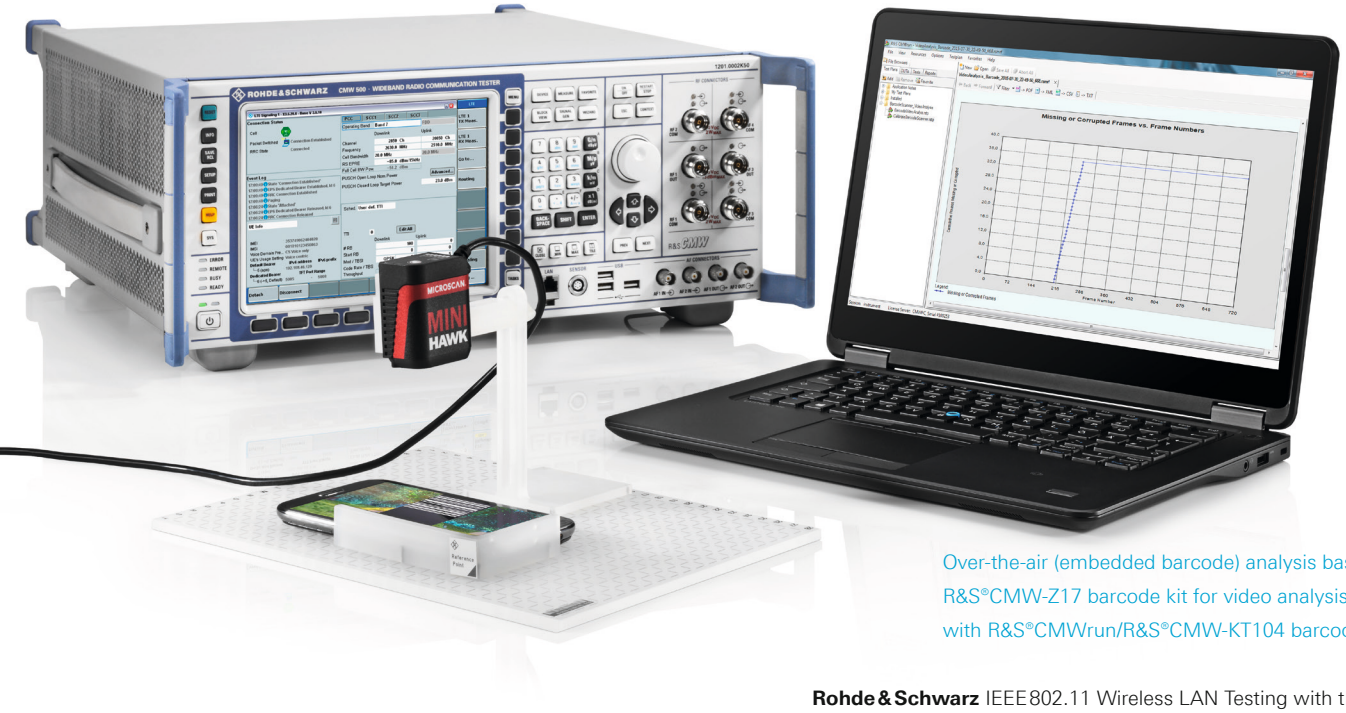
Battery life and current drain measurements

A key quality criterion for modern smartphones is their battery life. Even when many different power-saving mechanisms are used to manage device resources, it is necessary to thoroughly examine the device's internal actions and the resulting power consumption in order to effectively minimize power consumption. This applies to every device function and every app. An intelligent power supply is needed to take over the function of the built-in rechargeable battery. The R&S®RT-ZVC02/R&S®RT-ZVC04 multichannel power probe is a good choice for this task. For battery life and current drain measurements, Rohde&Schwarz offers a complete, all-in-one solution.

Configuring test sequences by remote control with R&S®CMWrun

Test setups for end-to-end and performance testing need to control various devices, which can be a complex undertaking. They also have to precisely synchronize the measurements, analytics and trigger events.

With that in mind, and to simplify test sequences, Rohde&Schwarz offers the R&S®CMWrun automation software for executing different test scenarios and processing the results. The software offers automated test scenarios ranging from audio/video performance testing to battery life testing to standardized transmitter/receiver measurements.



Over-the-air (embedded barcode) analysis based on the R&S®CMW-Z17 barcode kit for video analysis in combination with R&S®CMWrun/R&S®CMW-KT104 barcode video analysis.

Voice over WLAN

Network operators worldwide have discovered the expediency of WLAN calling solutions. Even though government authorities and standardization committees do not specify quality standards, users still expect good voice quality, and the reference is always cellular technologies. Voice quality will determine market success.

Voice over IP

With WLAN, all applications, including voice service, are based on the internet protocol. Voice signals are converted into IP packets and, as far as possible, transmitted without packet loss, jitter and delays. A key technology for integrating voice services is the IP multimedia subsystem (IMS), an architectural framework for delivering IP multimedia services.

Audio analysis

In voice over WLAN (VoWLAN), the voice packets are tunneled through the internet to a gateway provided by the network operator. This evolved packet data gateway (ePDG) creates a link between the mobile network and the WLAN connection. The R&S®CMW270/290/500 also has a number of integrated servers, such as ePDG and IMS. This allows users to test VoWLAN on a smartphone under realistic conditions without additional equipment.

At the receiving end, buffers are used to try to minimize the impact of packet loss, jitter and delays. The effectiveness of these measures can be specifically tested by selecting IP impairments, i.e. user-definable error rates at the IP level.

On the R&S®CMW270/290/500, users can specify all signaling and wireless parameters that affect audio quality and how it is subjectively perceived. They can reproduce tests as often as needed under lab conditions. The tester can be used in combination with the R&S®UPV audio analyzer to quantitatively measure VoWLAN voice quality. The audio analyzer uses the ITU-T test algorithms PESQ and POLQA to compare the test signal to a reference signal and assess the difference in perception.

Audio analysis using the R&S®CMW500 in combination with the R&S®UPV audio analyzer.

In-device coexistence interference testing

Modern communications devices support a large number of standards in a very small space, which can lead to interference due to occupying the same or adjacent frequency bands or due to harmonics. Ensuring standard-compliant operation and minimal mutual interference is crucial.

Multiple standards in one instrument

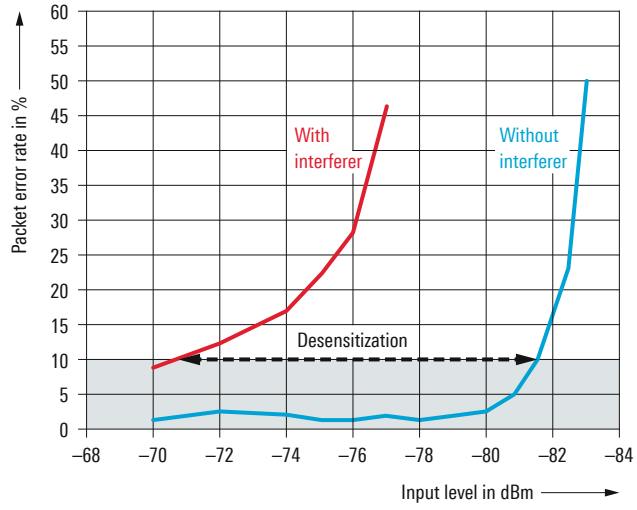
Modern communications devices can contain multiple RF systems, e.g. cellular multiband antennas for LTE-A, 3G, CDMA2000®, 2G and non-cellular technologies such as WLAN, Bluetooth® and various GNSS systems. Measurements of in-device coexistence determine the desensitization, i.e. reduction of the RX sensitivity with and without a strong internal interferer signal. For standard sensitivity tests, measuring the receiver error rate has been adopted as the evaluation criterion. The packet error rate (PER) is measured for WLAN, for example.

Coexistence measurements with the R&S®CMW500

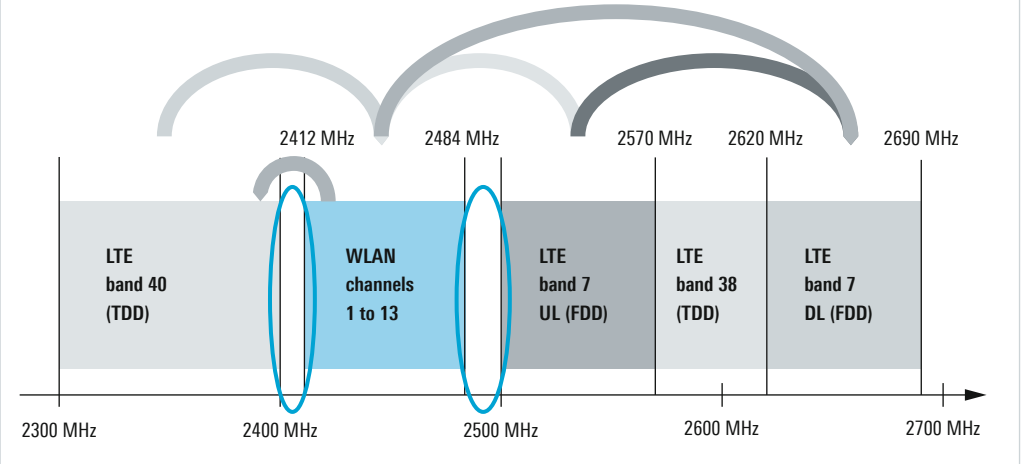
The R&S®CMW500 is ideal for coexistence measurements. It provides signaling for both cellular and non-cellular technologies. It can operate two different wireless systems in parallel and can define the relative RX sensitivity measurements. In combination with a shielded chamber (e.g. R&S®TS7124 RF shielded box, R&S®CMW-Z10 RF shield box or R&S®DST200 RF diagnostic chamber), measurements can be performed in the lab with a high degree of reproducibility. The R&S®CMWrun sequencer software tool can be used to automate measurements and test reports.

The test results can be used to determine specific, effective measures for optimizing development and integration. Specific examples include improving the decoupling of the antenna system, effectively reducing the signal-to-noise ratio of the interferer and optimizing the operating mode.

RX sensitivity measurement



Possible interference between WLAN and LTE



LTE-WLAN traffic offload

Single-box test solution: the R&S®CMW500 with its multitechnology concept can simultaneously emulate an LTE base station and WLAN access point. As a result, the R&S®CMW500 offers a high degree of reproducibility for various tests and solutions in a single instrument – from protocol development to functional testing.

Compact system solution in a single instrument

Cellular networks ensure comprehensive mobile service coverage, but broadband WLANs can reduce the load on cellular networks. The underlying technology is referred to as WLAN traffic offload. An important precondition for the acceptance of LTE-WLAN traffic offload is uninterrupted rerouting between the cellular standards and WLANs. Tests focus mainly on the mobile device, which must connect to both technologies.

The test setup for LTE-WLAN traffic offload includes the following core components:

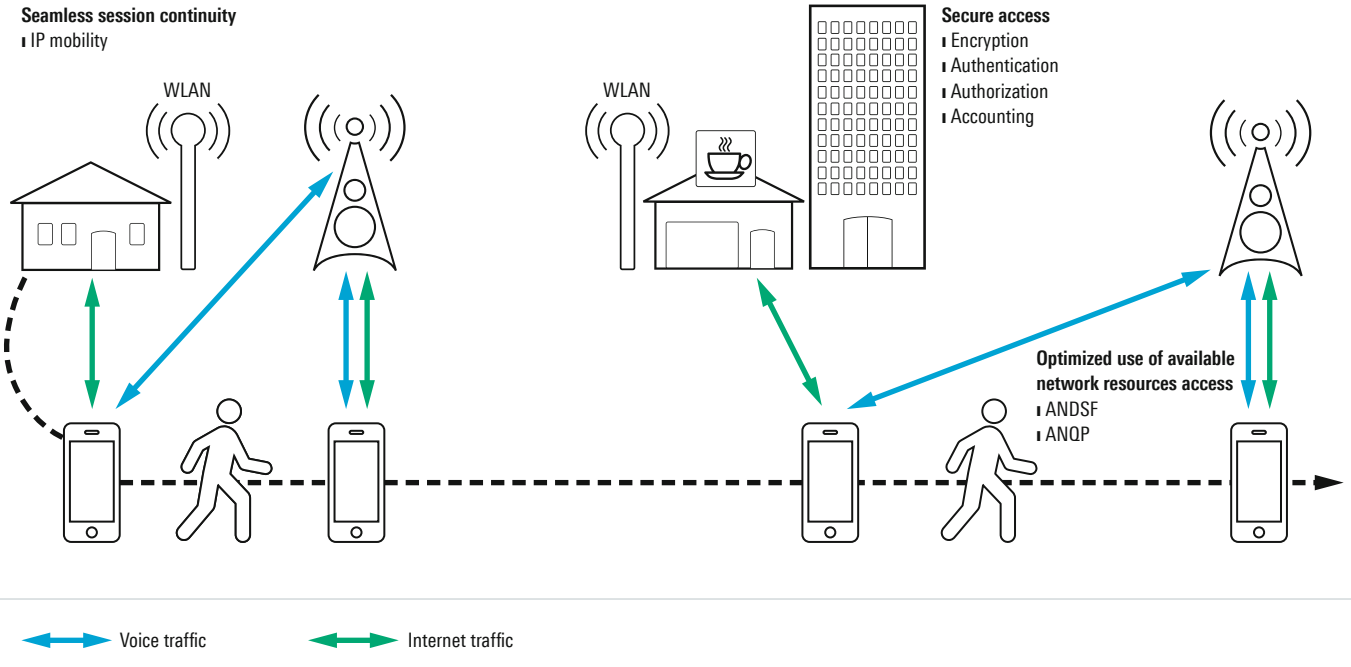
- Emulated LTE base station, including the LTE core network
- Emulated WLAN access point
- Gateway/firewall (ePDG) during the offload from WLAN to the LTE core network
- IMS server for implementing real-world applications such as video and voice telephony
- Message analyzer for recording all protocol messages between the DUT and the WLAN access point or LTE base station

The R&S®CMW500 integrates all of these components into one box to provide efficient test capabilities. Another advantage is the easy detection of discrepancies based on the synchronously running protocol stacks for both technologies.

Customized solutions for protocol stack development and complex functional tests

To integrate LTE and WLAN protocol stacks, the lower protocol layers need to be tested in an early development phase. With the R&S®CMW500 and the R&S®CMWcards GUI, signaling tests can be performed without any special programming knowledge. The MLAPI test scenarios can be used to program more complex tests. The R&S®CMW500 callbox is ideal for reproducible testing – from verifying the DUT's RF characteristics to functional testing. It can also efficiently perform complex tests by analyzing the LTE and WLAN protocol messages.

Traffic offload principle



R&S®CMWmars multifunctional logfile analyzer

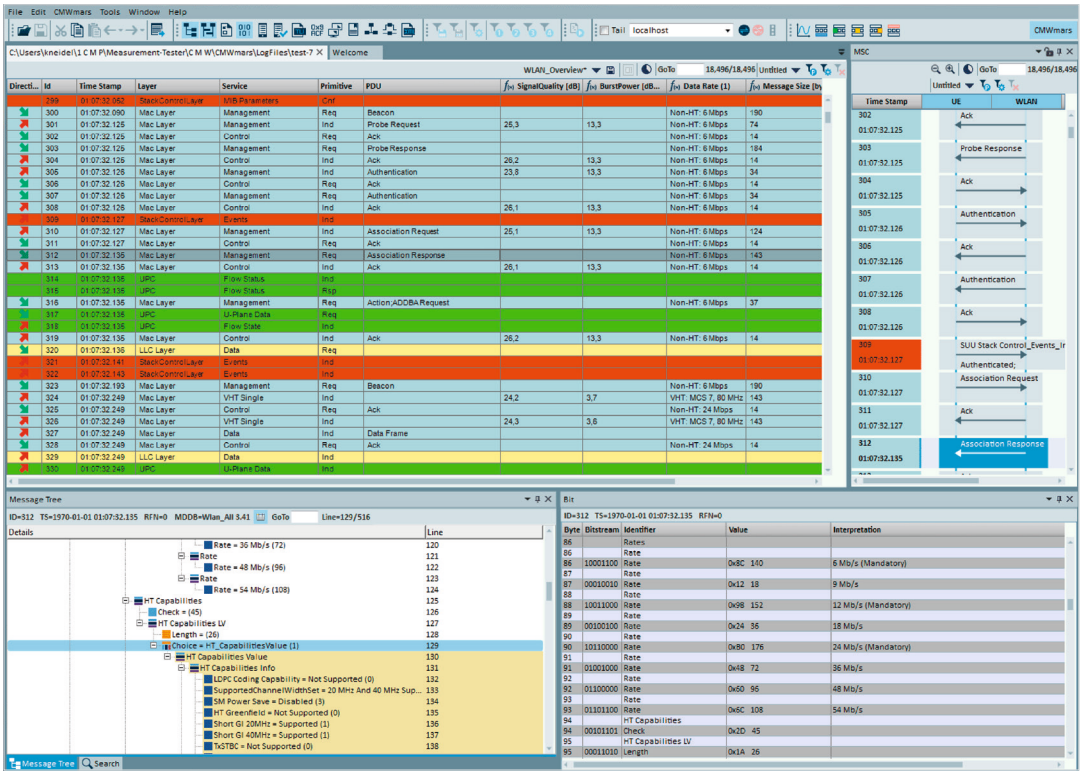
Powerful message analyzer for all R&S®CMW signaling applications and use cases

R&S®CMWmars is the message analyzer for all R&S®CMW signaling applications. Users can efficiently analyze recorded message logfiles or trace information on the fly in realtime while a test is running. The convenient, intuitive R&S®CMWmars user interface combined with various tools and views helps users quickly narrow down the root cause of signaling protocol and lower layer problems. The multifunctional logfile analyzer provides access to all information elements of all protocol layers for LTE, WCDMA, GSM, CDMA2000® and WLAN, including the MAC and IP layers. It is well-established as the standard analysis tool for chipset manufacturers, handset manufacturers and network operators as well as for device certification in test houses.

Key facts

- Access to all protocol stack layers of all wireless technologies, from the MAC layer up to the IP data layer
- Easiest filtering thanks to optimized GUI usability
- Inline message and message content comparison
- Pass/fail view at a glance
- Smart UE capability view for DUT features at a glance
- Unique graphical timeline view for chronological analysis
- Easy navigation in logfiles with powerful full-text search features and bookmarks
- Realtime display of message flow (online tracing) during test case execution
- Effective graphical protocol measurement charts for throughput and block error rate/packet error rate (BLER/PER) measurements on all layers
- Postprocessing (offline analysis) of recorded message logs
- Powerful scripting interface for automatic logfile analysis using predefined macros

R&S®CMW-KT021 CMWmars presents the logfile in various synchronized views that visualize the data from different perspectives, helping users to post-process complex message logs in a very intuitive and easy way.



Various views from different perspectives of all protocol stack layers of a recorded message logfile.

Production solutions

The primary goal of high-volume production testing is to minimize test costs. This is achieved by minimizing the test time per DUT while maintaining a defined minimum test depth and optimally utilizing the measuring instrument. Since the complexity of DUTs and the number of technologies and frequency bands continues to increase, this is no easy task.

High efficiency through parallel testing, high measurement accuracy and optimized test times

Production test solutions based on the R&S®CMW platform offer extremely short measuring times, great test coverage, high accuracy, optimized process sequences and the ability to simultaneously control multiple DUTs. Simultaneously determining various transmitter measurements significantly shortens test time. The R&S®CMW platform simultaneously determines and displays the following parameters: peak and average power, error vector magnitude (EVM), spectrum mask and spectral flatness.

To minimize throughput times when calibrating and verifying transmitters and receivers, measurements are generally performed in non-signaling mode. However, this requires a dedicated remote control for the DUT and the measuring instrument.

The R&S®CMW100 is specifically designed to cover the requirements of fully automated production test sequences. It is rugged and compact and does not have ventilation slots in the housing. The R&S®CMW100 is ideal for challenging and harsh test environments.

The parallel processing architecture of the R&S®CMW100 simultaneously controls up to eight bidirectional RF ports. As a result, a single smartphone with all its different technologies and associated antennas can be connected to the R&S®CMW100 and thoroughly tested. Or the antennas of several DUTs can be tested in parallel. In broadcast mode, up to eight receivers can be tested simultaneously.

The R&S®CMW100 together with the R&S®TS7124 RF shielded box for device testing.

Independent, simultaneous receiver and transmitter tests

The R&S®CMW offers maximum flexibility when designing test strategies because the generator and analyzer can be used simultaneously and independently of each other. Simultaneous transmitter and receiver tests on single and multiple DUTs can be economically set up.

Various test strategies can be implemented to cover different production workflows. DUTs can be tested sequentially, virtually in parallel in interleave mode, or simultaneously.

Reduce test time by controlling the test sequence with list mode

In non-signaling mode, the production test sequence is controlled by numerous individual steps that synchronize the commands to the DUT and T&M instrument. Each individual step corresponds to a remote control command whose execution takes a certain amount of time. The overall test time can be considerably shortened by storing entire sequences in the DUT and instrument chipsets, synchronously starting them and running them independently in list mode without further interaction from the control software.

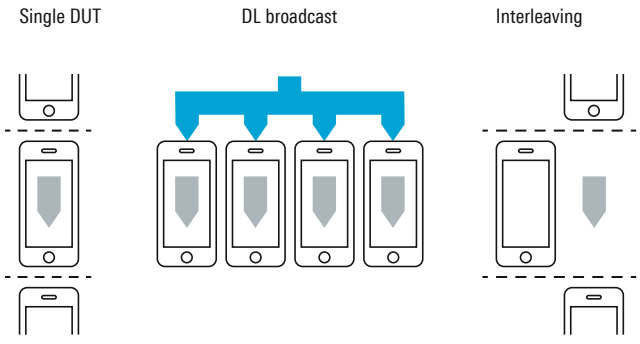
The R&S®CMW supports all common cellular and non-cellular technologies required during the production of state-of-the-art communications devices, including the GPS receiver and other broadcast technologies.

As a result, only one measuring instrument is needed to calibrate and verify the wireless components in advanced communications devices.

Complete turnkey solution with test sequence control

In addition to T&M instruments, Rohde&Schwarz offers a complete turnkey solution: the R&S®CMWrun test sequencer software that controls both the T&M instrument and the DUT. Control of the DUT depends on the chipset it uses. R&S®CMWrun contains an extensive library of supported chipsets. This library is continuously expanded. Alternatively, test sequence control can be integrated into user-specific process and control software.

Different test modes



Service that adds value

- Worldwide
- Local and personalized
- Customized and flexible
- Uncompromising quality
- Long-term dependability

About Rohde&Schwarz

The Rohde&Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, has an extensive sales and service network with locations in more than 70 countries.

Sustainable product design

- Environmental compatibility and eco-footprint
- Energy efficiency and low emissions
- Longevity and optimized total cost of ownership

Certified Quality Management
ISO 9001

Certified Environmental Management
ISO 14001

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