# Bluetooth® Testing with the R&S®CMW Wideband Radio Communication Tester


ROHDE&SCHWARZ

Application Brochure | Version 01.00


End call
Telephone
Dial
Settings
Bluetooth
Device management
Bluetooth
visible
Audio player
on
MMI name
Audi MMI 4329
Mailbox
Telekom.de
Settings
ONLINE
13:04
MODE
AUTO
MAX A/C
A/C
Telekom.de LTE 13:06
85 %
Settings
Bluetooth
Bluetooth
Now discoverable as "Utes iPhone".
MY DEVICES
Audi MMI 4329
Connected
BMW 90438
Not Connected
EV3
Not Connected
VMX 100
Not Connected
OTHER DEVICES
To pair an Apple Watch with your iPhone, go to the Watch app.

# Contents

The development and proliferation of Bluetooth® is a unique success story. The number of Bluetooth® wireless technology enabled devices is currently growing by 3.6 billion per year. As Internet of Things (IoT) technology advances, this number will grow significantly over the next years. Bluetooth SIG anticipates that there will be nearly 5.6 billion new Bluetooth® enabled devices in 2022.

To ensure connectivity and trouble-free operation, each Bluetooth® enabled device has to be tested for conformance with Bluetooth SIG standards and regulatory requirements.

**Products from Rohde&Schwarz**

- R&S®CMW wideband radio communication tester
- R&S®CMWrun sequencer software tool

For more information, visit
www.rohde-schwarz.com/cmw

Bluetooth SIG uses the terms “device under test” (DUT), “equipment under test” (EUT) and “implementation under test” (IUT). In this document, the term EUT is always used.

# Rohde&Schwarz expertise in Bluetooth® testing

In 1998, Rohde&Schwarz was the first T&M specialist to become a member of Bluetooth SIG. Rohde&Schwarz played a major role in the development of Bluetooth® right from the start, providing innovative T&M solutions.

## Rohde&Schwarz competence in establishing Bluetooth® technology

In 1998, Rohde&Schwarz became the first T&M specialist to work with the Bluetooth Special Interest Group (SIG) and it has worked closely with Bluetooth SIG ever since. Back then, the technology was called MC-Link because the idea was to realize a wireless connection between a mobile phone (M) and a computer (C). At that time, Bluetooth® was only a project name. It was only later that Bluetooth® became the official designation for the technology.

## Milestones in Bluetooth® testing

In 2000, Rohde&Schwarz introduced the R&S®PTW60 protocol tester, the first Bluetooth® test instrument. It was followed by the R&S®TS8960 Bluetooth® RF qualification test system in 2001. At that time, Bluetooth SIG urgently needed solutions for qualifying the first Bluetooth® chips and components. Since Rohde&Schwarz products met all the requirements, Bluetooth SIG and almost all Bluetooth® test houses worldwide used these two Rohde&Schwarz solutions.

At the same time, Rohde&Schwarz developed the first integrated tester for Bluetooth® RF tests based on the R&S®CMU200 universal radio communication tester. This tester was also launched in 2001.

**Selection of Rohde&Schwarz Bluetooth® testing devices**

**R&S®PTW60**
**Protocol tester for Bluetooth® solutions**
First Bluetooth® protocol tester on the market

**2000**

**R&S®TS8960**
**Bluetooth® qualification test system**
First Bluetooth® qualification test system on the market

**2001**

Another milestone was the R&S®CBT/R&S®CBT32 Bluetooth® tester in 2004. Thanks to its flexibility, high measurement speed and versatile test options, it became a reference for R&D and production and was used by all major Bluetooth® players worldwide. [1)]

## The next level

In 2010, in parallel with the R&S®CBT/R&S®CBT32, Rohde&Schwarz started implementing Bluetooth® test functions in the R&S®CMW wideband radio communication tester. In addition to the current Bluetooth® RF and audio tests, the R&S®CMW platform also supports all mobile communications standards and WLAN. The R&S®CMW platform is continuously enhanced with new functions. Even future Bluetooth® technology developments will be supported. The message to the user is clear: invest once and reap the benefits for many years to come.

1) R&S®PTW60, R&S®TS8960, R&S®CMU200 and R&S®CBT/ R&S®CBT32 have since been discontinued.

## Development of the Bluetooth® technology

### 1 Technology overview

- Short-range wireless communications technology
- Works at 2.4 GHz in the ISM band
- High robustness by using frequency hopping spread spectrum (FHSS)

### 2 Bluetooth® Classic

- Application: mobile phones, headsets, stereo audio, automotive, PCs
- Application throughput: 0.7 Mbps to 2.1 Mbps, voice capable
- Up to seven active slaves, high latency > 100 ms

### 3 Bluetooth® Low Energy (LE)

- Application: mobile phones, automotive, medical, fitness, home sensors, advertisement, PCs
- Application throughput: approx. 305 kbps, not voice capable
- Unlimited number of active slaves, latency < 6 ms

### 4 Bluetooth SIG

- Curator, caretaker and innovator of Bluetooth® technology
- Develops the Bluetooth® specification to ensure interoperability
- Certification body and owner of the brand mark

**R&S®CMU200**
**Universal radio communication tester**
First Bluetooth® signaling RF tester on the market

2001

**R&S®CBT/R&S®CBT32**
**Bluetooth® tester**
Reference for Bluetooth® testing in R&D and production

2004

**R&S®CMW**
**Wideband radio communication tester**
Universal platform for testing Bluetooth® wireless technology and other wireless standards such as WLAN and LTE

since 2010

# 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 networked products in the automotive, healthcare smart home and other IoT segments.

## Rohde&Schwarz – recognized as a reliable partner for Bluetooth® testing solutions

The R&S®CMW wideband radio communication tester platform supports Bluetooth® technology up to version 5. It covers the Bluetooth® Classic signaling function and all Bluetooth® LE transmitter and receiver tests as specified by Bluetooth SIG. The R&S®CMWrun sequencer software tool simplifies conformance testing by automatically executing all Bluetooth SIG test cases. Options for fast and comprehensive production testing of Bluetooth® enabled devices speed up the production process. The R&S®CMW supports Bluetooth® technology as well as other non-cellular standards and all major cellular standards in one box.

## 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 standard 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

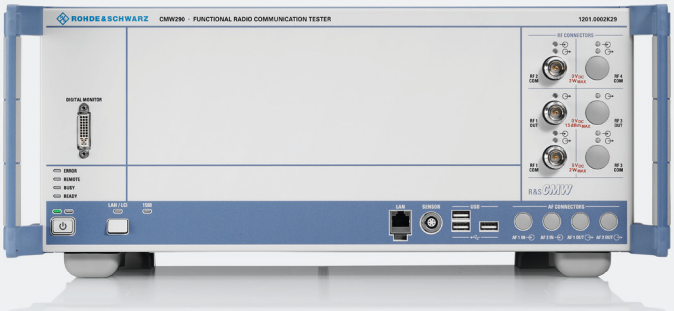
**R&S®CMW500**

**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. It is available as the R&S®CMW500 callbox and the R&S®CMW500 protocol tester. The R&S®CMW500 includes a fully integrated end-to-end (E2E) data solution that permits comprehensive IP throughput and quality measurements. Thanks to the internal fading simulator, it is easy to perform tests under realistic propagation conditions. 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®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.

## Wide variety of hardware and software options

The R&S®CMW platform has a scalable option concept, offering 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.

## One tester for all technologies

### 1 Versatile hardware platform

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

### 2 Multi-RAT signaling

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

### 3 Bluetooth® LE and Bluetooth® Classic

- All Bluetooth SIG RF test cases in remote control mode with detailed test report
- Parametric test concept and very fast spectrum measurements
- Bluetooth® audio measurements (option)
- Bluetooth® 5

### 4 WLAN signaling support

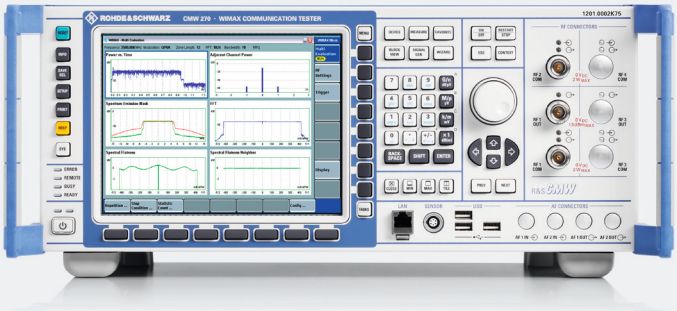
- LTE-WLAN traffic offload
- WLAN E2E and access point testing
- In-device coexistence tests with other technologies

### 5 Outstanding features for production

- Multi-EUT testing for up to 8 devices
- Chipset support for all major suppliers
- Uniform GUI from development to production

### 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.

### 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).

# Bluetooth® technology overview

Bluetooth® technology is a wireless standard for exchanging data over short distances in the ISM band.

## Basic principles

A Bluetooth® device typically consists of a host and a Bluetooth® controller, both of which communicate via the host controller interface (HCI). The Bluetooth® stack and the application run on the host, the Bluetooth® controller provides the baseband operation. Applications use specific profiles to translate a certain functionality of a Bluetooth® device into a service (e.g. temperature measurement).

Since Bluetooth® technology continues to migrate into a wide range of applications, the number of profiles is constantly increasing. Bluetooth® devices that share the same baseband and profiles for interoperability are able to connect with each other.

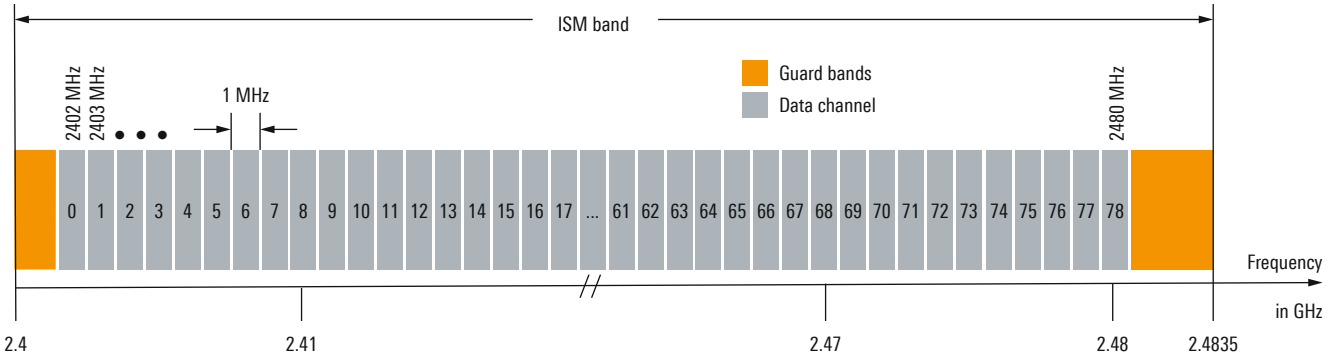
## Bluetooth® Classic

The term Bluetooth® Classic is used for Bluetooth® devices featuring basic rate (BR) and enhanced data rate (EDR) operation as specified in the Bluetooth® core specification, version 1 and higher. The main characteristics of this operating mode are:

- Conventional operation with a low data rate (BR)
- Operation with an improved transmission speed (EDR)

79 RF channels are available for data transfer, each with 1 MHz spacing and located in the 2.4 GHz ISM band. Frequency hopping between the channels is used to prevent interference with ambient radio signals. In adaptive hopping mode, blocked channels are not used. While BR modulation uses Gaussian frequency shift keying (GFSK) with a gross data rate of 1 Mbit/s, EDR further enhances the data rate by using π/4-DQPSK (2 Mbit/s) and 8DPSK (3 Mbit/s) phase shift keying.

### Bluetooth® Classic




| | | |
|---|---|---|
| Transmit power | class 1 | max. 20 dBm, 100 mW |
| | class 2 | max. 4 dBm, 2.5 mW |
| | class 3 | max. 0 dBm, 1 mW |
| Modulation | | |
| GFSK | BT | 0.5 |
| | frequency deviation | 160 kHz |
| | modulation index | 0.28 to 0.35 |
| π/4-DQPSK | DEVM (99 %) | ≤ 0.30 |
| | symbol rate | 1 Msymbol/s |
| 8DQPSK | DEVM (99 %) | ≤ 0.20 |
| | symbol rate | 1 Msymbol/s |
| Packets | ACL link (asynchronous connectionless) | max. 2178 kbit/s |
| | SCO link (synchronous connection-oriented) | max. 864 kbit/s |
| Data rate | gross | 1 Mbit/s to 3 Mbit/s |
| | application | 0.7 Mbit/s to 2.1 Mbit/s |

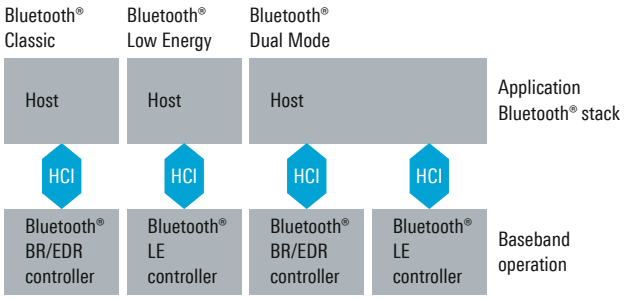
## Bluetooth® Low Energy (LE)

The term Bluetooth® Low Energy (LE) is used for devices that consume less energy than Bluetooth® Classic devices as specified in the Bluetooth® core specification, version 4 and higher. The Bluetooth® 5 specification introduced the following benefits:

- More efficient power management with up to 60 % less energy consumption
- Long-range coverage with up to four times the range
- Double the transmission speed

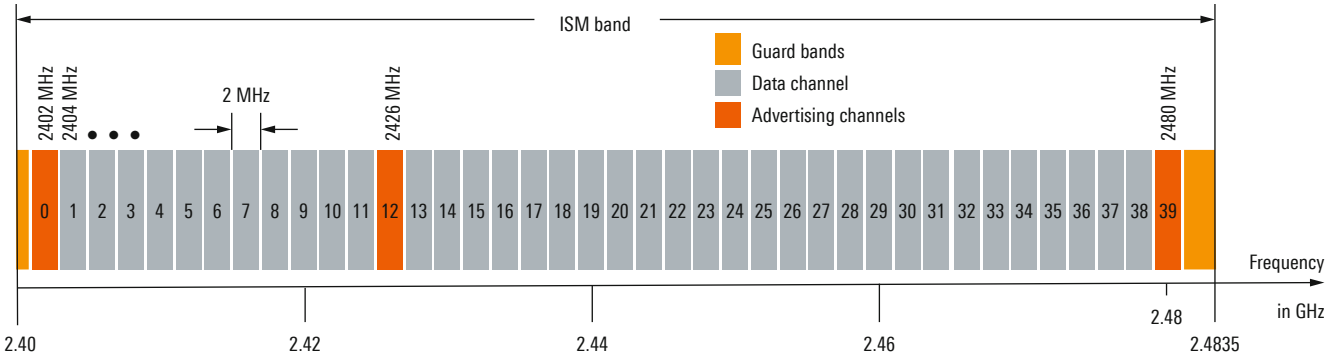
Low energy uses 40 RF channels, each with 2 MHz spacing and located in the 2.4 GHz ISM band. They are separated into three exclusive advertising channels and 37 data and secondary advertising channels. In advertising mode, the channels are used to transmit low data information in a beacon-like fashion. A real data connection at the data channels can be understood as a classic piconet, where adaptive hopping is available. A piconet consists of a master device defining the clock and a maximum of seven slave devices.

## Bluetooth® architecture




GFSK modulation of uncoded data packets yields a gross data rate of up to 2 Mbit/s with a modulation index between 0.45 and 0.55. The corresponding optional stable modulation index lies between 0.495 and 0.505. For long-range operation, coded packet transfer with a gross data rate of up to 500 kbit/s is possible.

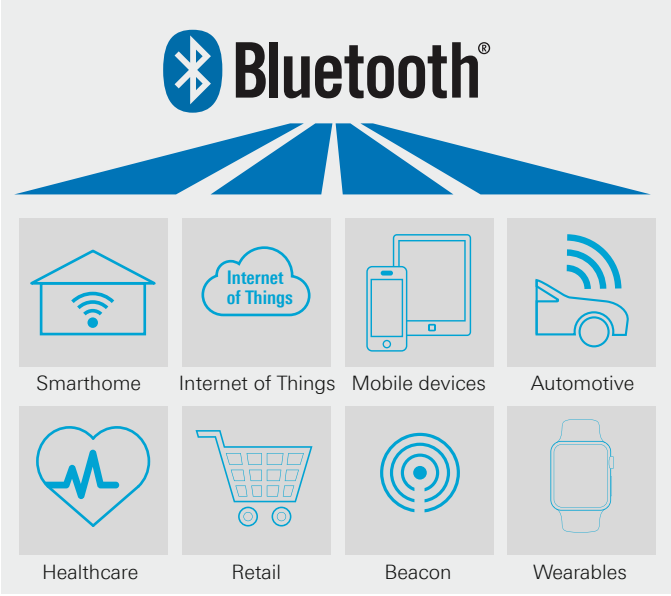
## Bluetooth® Low Energy




| | | |
|---|---|---|
| Transmit power | class 1 | max. 20 dBm, 100 mW |
| | class 1.5 | max. 10 dBm, 10 mW |
| | class 2 | max. 4 dBm, 2.5 mW |
| | class 3 | max. 0 dBm, 1 mW |
| Modulation | | |
| GFSK | BT | 0.5 |
| | frequency deviation | 250 kHz or 500 kHz |
| | modulation index | 0.45 to 0.55 |
| | stable modulation index | 0.495 to 0.505 |
| Packets | LE 1M, uncoded | max. 1 Mbit/s |
| | LE 2M, uncoded | max. 2 Mbit/s |
| | LE, coded, S = 2 : 2 symbols per data bit | max. 500 kbit/s |
| | LE, coded, S = 8 : 8 symbols per data bit | max. 125 kbit/s |
| Data rate | gross | 1 Mbit/s to 2 Mbit/s |
| | application | 0.2 Mbit/s to 0.6 Mbit/s |

# Bluetooth® applications

Today, Bluetooth® technology is everywhere: in cars, smartphones, computers, headsets, fitness tracker bracelets, toys, smart homes, medical technology, industrial applications and more. The range of applications is virtually limitless.




## Automotive

All major car manufacturers offer Bluetooth® enabled hands-free calling systems. Bluetooth® technology goes beyond hands-free calling, bringing infotainment to the car by connecting to the audio system so passengers and drivers can listen to whatever they want while driving or use apps to navigate, check traffic, view weather reports and restaurant information.

The over-the-air (OTA) car key system is a virtual smartphone key for company fleets, car-sharing companies and car rental agencies. The driver books the required car with a smartphone app, and the OTA key system sends the encrypted data to the cell phone to gain access to the car.

New phone apps also use Bluetooth® technology to monitor and diagnose mechanical and electrical components. For example, the tire pressure monitoring and electronic tire information system permanently monitor the tire's inflation pressure and reliably alert the driver in the event of a loss of pressure.

## Health and medical

Bluetooth® technology is the ideal wireless standard for hospital and home applications. Bluetooth® LE enabled blood glucose monitors, pulse oximeters, heart rate monitors, asthma inhalers and other products are becoming more and more common. Consumers like them because they can connect to their own Bluetooth® enabled PCs, tablets and smartphones. Patients and their care providers receive critical information in real time, giving them a more accurate, full picture of the body's response to a prescribed treatment plan. This information can help them track health data over time, showing trends and even providing alerts when necessary.

## Wearables

The fast-growing wearables market encompasses activity monitors, smart glasses, headsets, child and pet monitoring, medical aids, head- and hand-mounted terminals and cameras and even smart clothing. By far, the majority of these products rely on connectivity via Bluetooth® technology. Fitness and wellness wearables are showing up on wrists everywhere to monitor steps, activity, sleep and even emotional levels. Infotainment wearables range from audio headsets to smart watches and smart glasses that use Bluetooth® technology to connect to mobile apps. Industrial wearable applications include hands-free terminals and heads-up displays for more efficient logistics, inventory, production and worker safety.

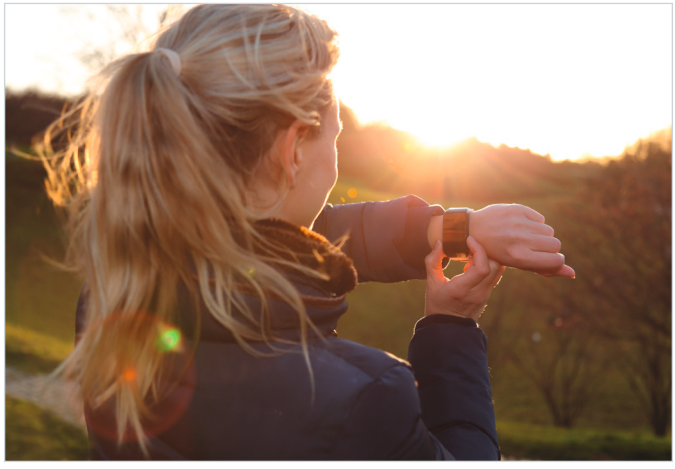
## Consumer electronics and home automation

These days, most consumer electronic devices are connected with the smart, power-efficient wireless Bluetooth® technology. Bluetooth® is practically a standard feature for PC applications. Hundreds of millions of Bluetooth® devices stripped away the wires between music lovers' headsets and speakers and their phone or PC. New products such as gaming VR headsets, toothbrushes, light bulbs, yoga mats, tools and lawn mowers have also been released with a wireless Bluetooth® connection.

With a phone, tablet or laptop in hand, homeowners can control the lights, temperature, household appliances, window and door locks and security systems in their homes. Since most homeowners already have at least one Bluetooth® capable smartphone or tablet, they can use devices they are already familiar with.

## Retail and location based services

The proliferation of Bluetooth® technology is opening up new markets. Beacons – small objects transmitting location information to smartphones and powered by Bluetooth® LE – make mobile wallets and location based services possible. Beacon functionality is already used for marketing in shopping malls, for indoor navigation in large stadiums and for contactless payment, e.g. for parking. Other use cases for beacons include airports, transit stations and large event venues where they are used to easily send out notifications on departures, delays and other passenger information.



# How to get your Bluetooth® product to market

Two main sets of approval requirements must be addressed before products using Bluetooth® technology can legally be placed on the market: Bluetooth SIG and national certification bodies demand official certification.

## Bluetooth® qualification

The aim of the Bluetooth® qualification program defined by the Bluetooth SIG is to protect the value of Bluetooth® technology and the brand. The Bluetooth SIG compliance program is intended to ensure that a product complies with the Bluetooth® specification and will successfully operate with other products claiming to support the same Bluetooth® profile.

First, any company using Bluetooth® wireless technology in their products and services must become a member of Bluetooth SIG. Depending on the developed product, the qualification process requires different test cases such as RF conformance testing, protocol and profile conformance testing and profile interoperability testing. After the product "passes" all required test cases and has been fully declared, suppliers can sell and brand it with Bluetooth® trademarks.

## National approval processes

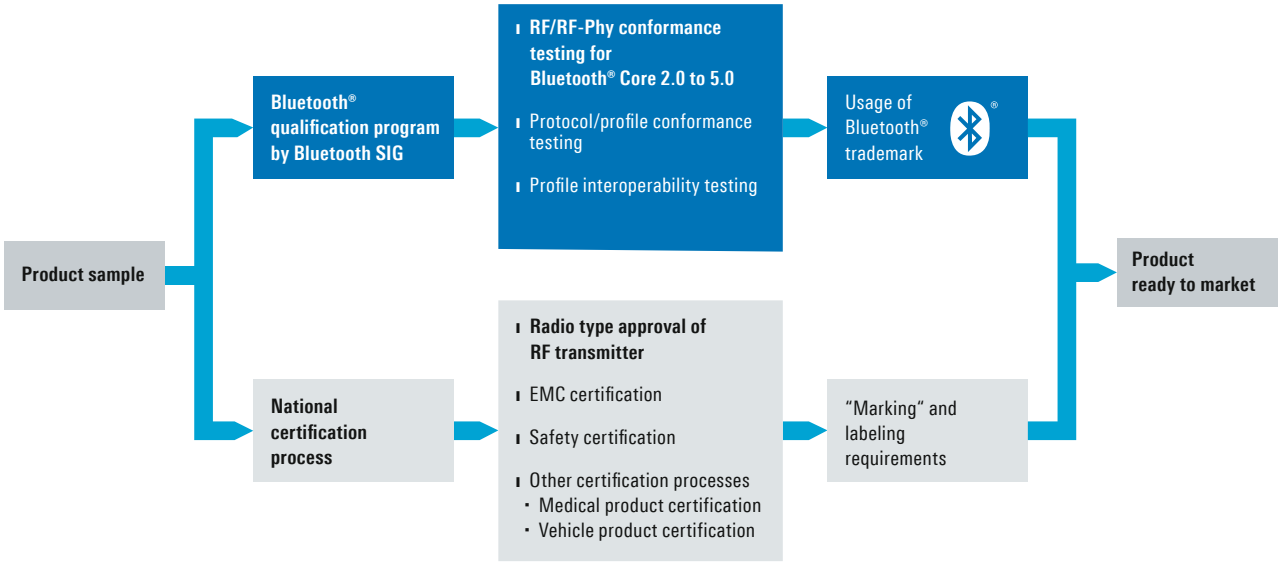
National type approval requirements also apply to Bluetooth® products and are a primary requirement for market entry. Three product certification requirements generally apply to Bluetooth® products:

- Radio type approval of RF transmitter/transceiver unit
- EMC certification of the RF section, usually when installed within the host unit and relative to normal configuration and conditions of usage
- Safety certification, usually dependent upon the operating voltage of the product and any associated power supplies

## Accredited test houses: BQTFs and BRTFs

If RF conformance testing and national radio type approval are needed, testing generally has to be done at a test laboratory accredited by the Bluetooth SIG and the country of interest. The Bluetooth SIG accepts two different types of test houses for qualification conformance tests: Bluetooth® Qualification Test Facility (BQTF) and Bluetooth® Recognized Test Facility (BRTF). Only major test houses can succeed in becoming a BQTF that is recognized by the Bluetooth SIG as competent to perform the qualification conformance tests identified in the test case reference list (TCRL). Very few companies are awarded BRTF status by the Bluetooth SIG. This means, they are authorized to perform testing only on their own behalf and can help customers get their products to market faster.

**Bluetooth® certification**



# Bluetooth® Classic and Low Energy RF test cases

The Bluetooth SIG defines the test cases for Bluetooth® Classic and Bluetooth® Low Energy. The R&S®CMW platform and R&S®CMWrun support all Bluetooth® RF test cases.

| Bluetooth® Classic RF test cases up to Bluetooth® 5 | | | |
|---|---|---|---|
| **Transmitter tests** | **TP/TRM/CA/BV-xx-C** | **Transmitter tests** | **TP/TRM/CA/BV-xx-C** |
| Output power | 01 | Initial carrier frequency tolerance | 08 |
| Power density | 02 | Carrier frequency drift | 09 |
| Power control | 03 | EDR relative transmit power | 10 |
| TX output spectrum – frequency range | 04 | EDR carrier frequency stability and modulation accuracy | 11 |
| TX output spectrum – 20 dB bandwidth | 05 | EDR differential phase encoding | 12 |
| TX output spectrum – adjacent channel power | 06 | EDR in-band spurious emissions | 13 |
| Modulation characteristics | 07 | Enhanced power control | 14 |
| **Receiver tests** | **TP/RCV/CA/BV-xx-C** | **Receiver tests** | **TP/RCV/CA/BV-xx-C** |
| Sensitivity – single-slot packets | 01 | Maximum input level | 06 |
| Sensitivity – multi-slot packets | 02 | EDR sensitivity | 07 |
| C/I performance | 03 | EDR BER floor performance | 08 |
| Blocking performance | 04 | EDR C/I performance | 09 |
| Intermodulation performance | 05 | EDR maximum input level | 10 |

| Bluetooth® Low Energy RF test cases up to Bluetooth® 5 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **LE 1M 1 Msymbol/s** | **LE 2M 2 Msymbol/s** | **LE 1M 1 Msymbol/s SMI** | **LE 2M 2 Msymbol/s SMI** | **Coded 1 Msymbol/s** S = 2 | **Coded 1 Msymbol/s** S = 8 | **Coded 1 Msymbol/s SMI** S = 2 | **Coded 1 Msymbol/s SMI** S = 8 |
| **Transmitter tests** | **TP/TRM-LE/CA/BV-xx-C** | | | | | | | |
| Output power | 01 | | | | | | | |
| In-band emission | 03 | 08 | | | | | | |
| Modulation characteristics | 05 | 10 | 09 | 11 | | 13 | | |
| Carrier frequency offset and drift | 06 | 12 | | | | 14 | | |
| **Receiver tests** | **TP/RCV-LE/CA/BV-xx-C** | | | | | | | |
| Receiver sensitivity | 01 | 08 | 14 | 20 | 26 | 27 | 32 | 33 |
| C/I and receiver sensitivity | 03 | 09 | 15 | 21 | 28 | 29 | 34 | 35 |
| Blocking performance [1)] | 04 | 10 | 16 | 22 | | | | |
| Intermodulation performance [1)] | 05 | 11 | 17 | 23 | | | | |
| Maximum input signal level | 06 | 12 | 18 | 24 | | | | |
| Packet error rate (PER) report integrity | 07 | 13 | 19 | 25 | 30 | 31 | 36 | 37 |

[1)] Requires an additional signal generator.

# One Bluetooth® tester for all product creation phases

The R&S®CMW is a key instrument in nearly all Bluetooth® test houses worldwide. The different R&S®CMW models support the entire product development process, from R&D to prequalification to production.

### Versatile Bluetooth® testing solution

The R&S®CMW platform meets all requirements set by the Bluetooth® qualification scheme by providing complete validated RF test coverage for Bluetooth® 5 and all the legacy specifications for Bluetooth® Classic and Low Energy.

Qualifying a product in line with the Bluetooth SIG is time-consuming and costly. Since most test houses use the R&S®CMW platform in their Bluetooth® test facilities, it makes sense to also use the R&S®CMW for prequalification tests. These prequalification tests can be performed easily and automatically with the R&S®CMWrun solution (see "R&S®CMWrun software for automated testing" on page 34).

The Bluetooth® tester in the R&S®CMW platform can also be used to optimize the design during development. Thanks to the parametric test concept, which allows users to set all parameters independently, various scenarios can be tested – even beyond the requirements in the specification.

The very fast spectrum measurement in the R&S®CMW eliminates the need to perform measurements on an external spectrum analyzer, saving the cost of purchasing such an instrument. The R&S®CMW platform can be used in R&D to design excellent product characteristics and improve market position.

After using the R&S®CMW platform to successfully develop and certify a product, it can be efficiently transferred to production. The cost-effective R&S®CMW100 is code compatible with other R&S®CMW models and is ideal for production tests (see “Production solutions” on page 30).

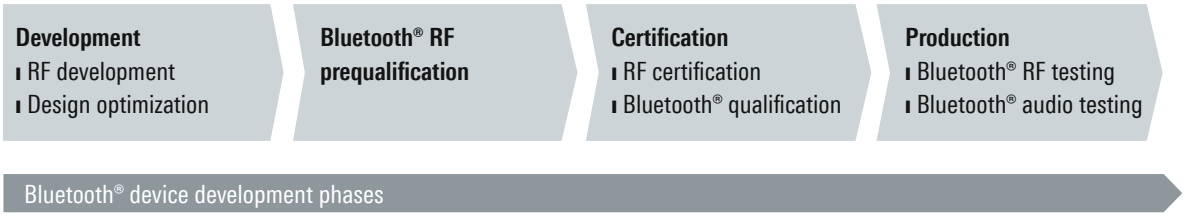
## Setup for RF prequalification testing

The R&S®CMW supports all RF test cases for prequalification of Bluetooth® basic rate (BR), enhanced data rate (EDR) and Bluetooth® low energy (BLE).

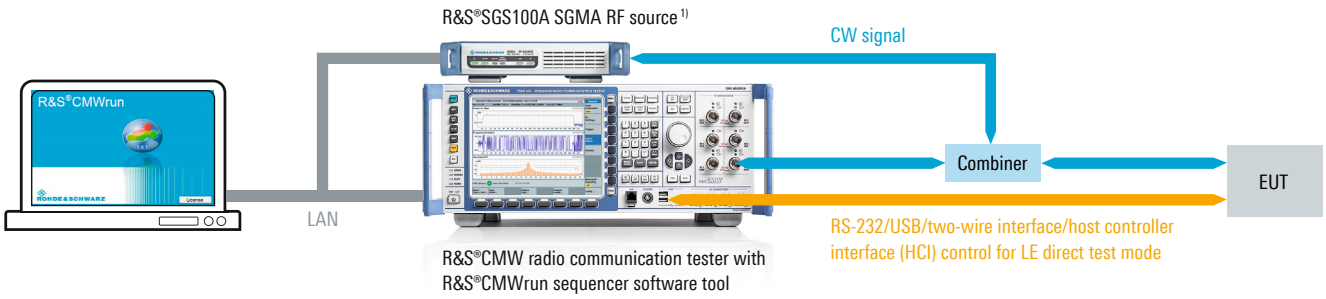
The test setup for RF prequalification testing is easy and straightforward. Using the Bluetooth® LE direct test mode (DTM), the R&S®CMW simply configures the device to transmit or receive test packets. The multi-evaluation mode significantly reduces test time by using an identical sampling data set for parallel transmitter measurements such as power, modulation, spectrum and others. This provides a more detailed overview of the transmitter functions since all measured parameters are correlated. For even more detailed analysis, it is possible to zoom into one of these measurements. The R&S®CMW tester’s very fast spectrum measurements help optimize development time.

The R&S®CMW performs the Bluetooth® RF test cases for prequalification purposes, including the in-band emissions test. The R&S®CMWrun sequencer software tool can be used to fully automate the Bluetooth® LE prequalification tests.

## R&S®CMW Bluetooth® testing covers all product creation phases




## Setup for RF prequalification testing




1) Some test cases require an additional signal generator such as the R&S®SGS100A SGMA RF source.

# RF testing methods for Bluetooth® Classic and LE

The R&S®CMW covers all Bluetooth® RF transmitter and receiver tests. For Bluetooth® Classic, these tests are defined in a signaling test mode. For Bluetooth® LE, the RF tests are specified in a direct test mode (DTM).

## Signaling test mode for Bluetooth® Classic

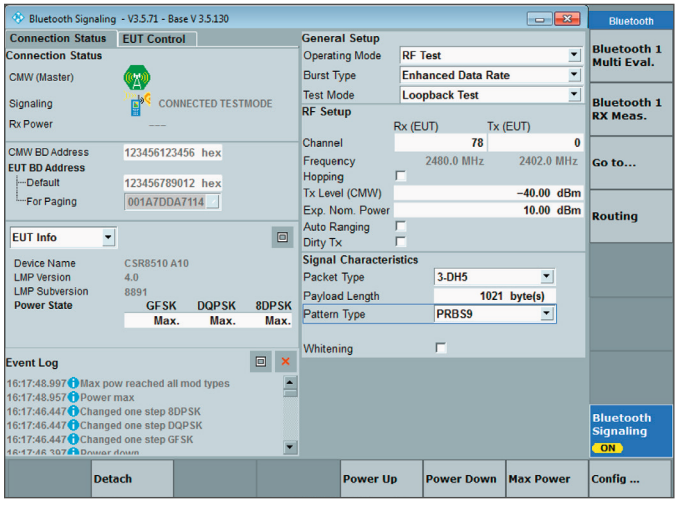
The Bluetooth® core specification defines a test mode for RF tests on Bluetooth® Classic EUTs based on a "real" Bluetooth® connection. The EUT has to be enabled for the test mode via its internal host controller interface (HCI). Acting as the master, the R&S®CMW sets up a Bluetooth® connection to the EUT (slave) by searching for Bluetooth® devices (inquiry) or directly addressing a specific EUT.

Once a Bluetooth® connection is established, the R&S®CMW uses test control commands to control the EUT. The most important operating mode is the loopback test mode. The R&S®CMW sends Bluetooth® packets to the EUT and the EUT loops the packets back to the R&S®CMW. Both TX and RX tests are possible in this mode.

For TX tests, the R&S®CMW transmits at "normal" level, which usually causes no bit errors in the EUT. The EUT returns the packet to the R&S®CMW and the R&S®CMW measures the EUT's TX parameters.

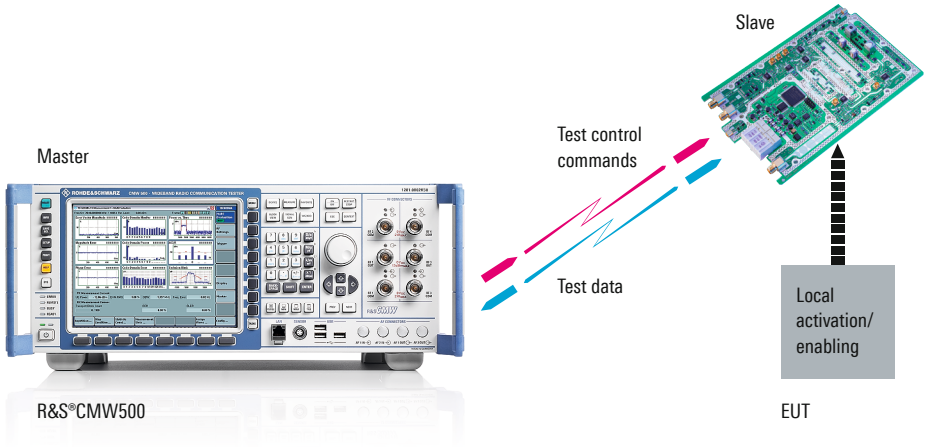
For RX tests, the R&S®CMW transmits at a very low level. Bit errors occur in the EUT when the packet is received. The EUT sends the faulty packet back to the R&S®CMW and the R&S®CMW determines the bit error rate.

The Bluetooth® test mode permits a Bluetooth® connection both in hopping mode and at fixed frequencies.




Test mode settings to establish a Bluetooth® Classic connection.

## The R&S®CMW controls the EUT in the test mode via test control commands

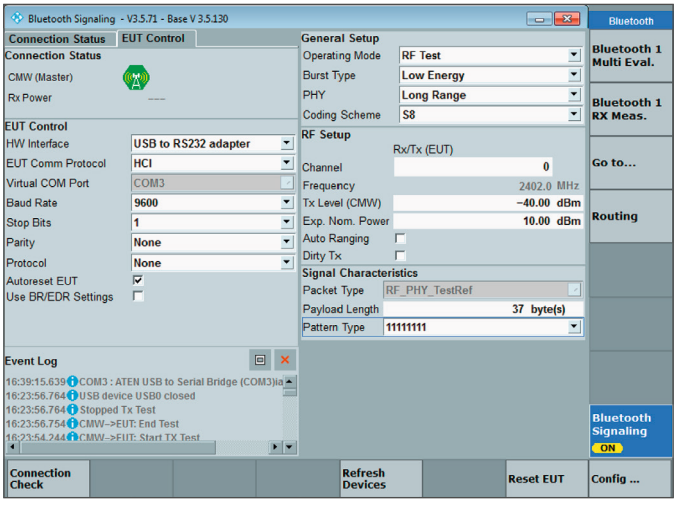


## Direct test mode (DTM) for Bluetooth® Low Energy

The Bluetooth® core specification defines a direct test mode (DTM) for Bluetooth® RF tests on LE EUTs. The DTM is not based on a "real" Bluetooth® connection. Instead, it uses a cable connection between the tester and the EUT. The EUT typically has a UART interface with HCI or two-wire protocol. This interface is used to connect to the R&S®CMW.

For TX tests, the R&S®CMW sends the EUT a DTM command. The EUT responds by sending LE RF test packets to the R&S®CMW. The payload pattern, payload length and Bluetooth® channel settings are configured on the R&S®CMW and transmitted to the EUT via the DTM command.

For RX tests, the R&S®CMW sends the EUT a DTM command that causes the EUT to switch to a specific Bluetooth® channel in receive mode. Then the R&S®CMW sends a defined number of Bluetooth® RF test packets at a suitably low level to the EUT. Depending on the level, the EUT receives some packets correctly while others have bit errors. The EUT counts the number of correctly received packets by calculating a CRC checksum for each received packet and comparing this checksum to the checksum transmitted by the R&S®CMW. At the end of the test, the R&S®CMW transmits a test end command. The EUT transmits to the R&S®CMW the number of packets correctly received via the DTM connection. The R&S®CMW calculates and displays the packet error rate (PER).




Setting the parameters for the DTM connection for Bluetooth® Low Energy.

### Direct test mode for Bluetooth® Low Energy

# Receiver/transmitter RF verification

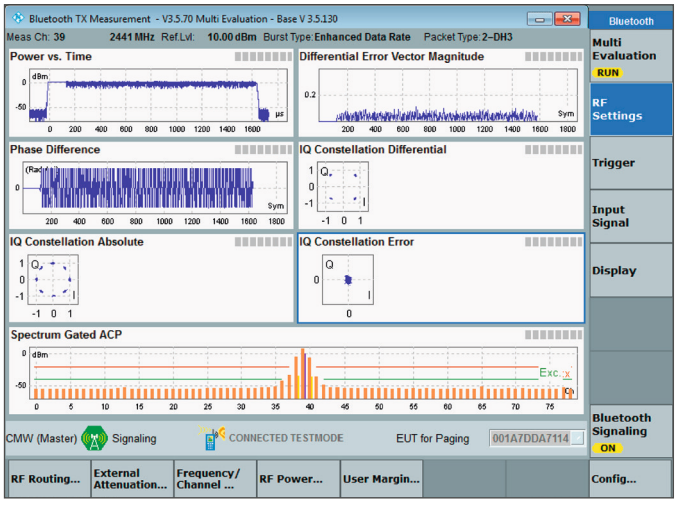
Testing Bluetooth® RF performance and quality is quite easy with the R&S®CMW platform. The R&S®CMW is able to perform all RF test cases specified by Bluetooth SIG up to Bluetooth® 5.

## TX measurements

The R&S®CMW uses the Bluetooth® RF test specification methods to calculate the measurement results. All measurements can be performed on any Bluetooth® channel and with different parameter constellations.

The R&S®CMW performs the different TX measurements simultaneously. The multi-evaluation view provides an overview of all TX measurements. Users can switch from the overview to the individual power, modulation and spectrum measurements to see the results in more detail. All signal parameters such as RF channel(s), packet type, pattern type, packet length and level can be directly and separately modified. The R&S®CMW gives users the flexibility they need for troubleshooting in the lab. An EUT's RF design can be quickly and easily optimized.

For Bluetooth® Classic, the R&S®CMW supports power control for all TX measurements. In addition to controlling the individual power steps, users can examine the influence of the EUT's current power level on the modulation and frequency parameters.




The multi-evaluation view provides an overview of the results for all simultaneously performed measurements. This screenshot shows the Bluetooth® EDR multi-evaluation view. The overview and individual zoom views for the BR, EDR and LE modes are shown on the next few pages.

**R&S®CMW TX measurements at a glance**

| TX measurements | Bluetooth® Classic (BR and EDR) | Bluetooth® Low Energy |
|---|---|---|
| Power | average, peak and leakage power (BR), GFSK and DPDK power (EDR) | average, peak and leakage power |
| Modulation | $\Delta f_1$ and $\Delta f_2$, avg., min. and max. (BR), $\Delta f_2$ 99.9% (BR), DEVM: RMS, peak, 99% (EDR) | $\Delta f_1$ and $\Delta f_2$, avg., min. and max. |
| Frequency | frequency accuracy, frequency drift, drift rate (BR), $\omega_i$, $\omega_{0max}$ (EDR) | frequency accuracy, frequency drift, drift rate (BR) |
| Spectrum | 20 dB bandwidth, frequency range, adjacent channel power (ACP) (BR), EDR in-band spurious emissions (gated ACP) (EDR) | in-band emissions (ACP) |
| Timing | guard period (EDR), packet timing | – |
| Others | constellation diagram, absolute and relative (EDR), phase difference graph (EDR) | – |

## RX measurements

The R&S®CMW covers all Bluetooth® RX measurements in line with Bluetooth® RF test specifications.

### Bit error rate (BER) and packet error rate (PER) tests

Possible RX measurements are BER and PER tests at constant R&S®CMW output power. These tests can be performed as individual measurements using a configurable number of Bluetooth® packets (measurement in line with the specification) or as continuous measurements for error analysis.

### Sensitivity measurements

The R&S®CMW offers an automatic search function for determining the receiver sensitivity level. The R&S®CMW generator level is gradually reduced until the configured limit for BER or PER is reached.

### Dirty transmitter

Bluetooth® RX tests require the use of a dirty transmitter. Depending on the operating mode (basic rate, EDR or LE), Bluetooth® RF test specifications define the dynamic behavior of the tester's RF generator during RX measurements. The R&S®CMW dirty transmitter functionality can be switched on and off.

The table below shows the behavior of the dirty transmitter in "Bluetooth® LE uncoded, 1 Mbps" mode. After every 50 Bluetooth® packets, the generator parameters are changed as shown in this table. Each packet is also superimposed with a defined frequency drift that switches its start phase between 0 and 180 degrees from packet to packet.

In addition to the specification table mode, a single value mode is available for detailed analysis of Bluetooth® receivers. This mode makes it possible to individually change carrier frequency drift, modulation index and symbol timing error, and to activate the superimposed drift when required.

## Adaptive frequency hopping (AFH) tests

The R&S®CMW provides an adaptive frequency hopping function for Bluetooth® Classic. This function permits users to use remote control mode to examine the behavior of Bluetooth® connections that are impaired by external interferers.

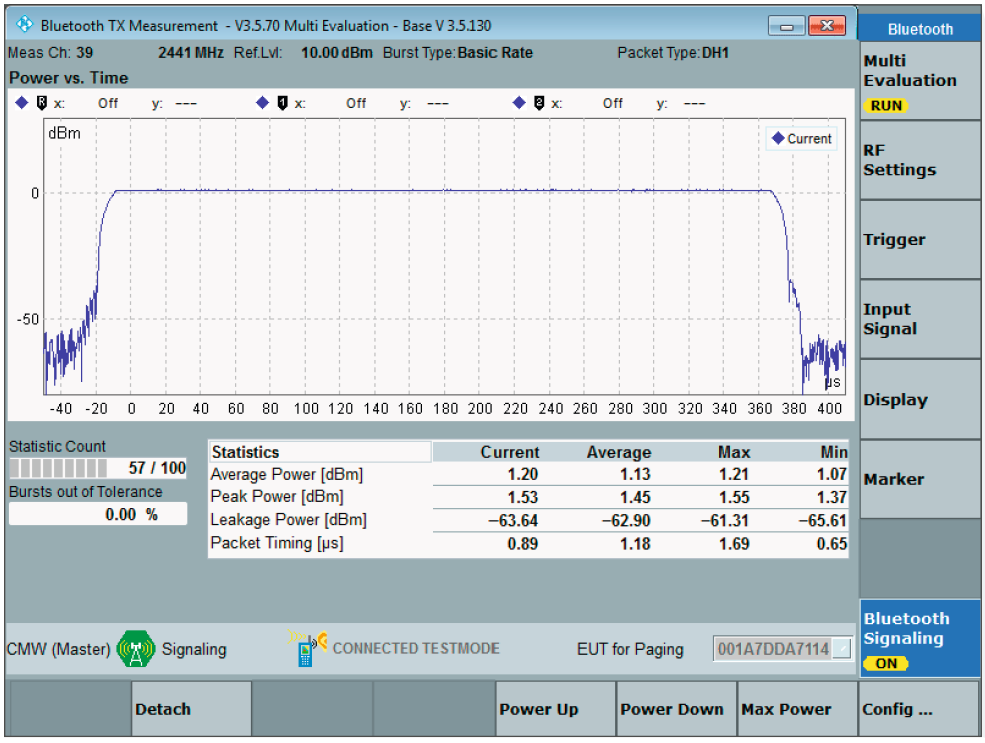
The following (remote) procedures are available on the R&S®CMW500:

- AFH channel map generation: all 79 Bluetooth® channels are queried and listed in a .csv file as blocked (0) or released (1) for AFH
- Bad channel detection based on
  - R&S®CMW and EUT combined detection
  - EUT-only detection
- User-defined AFH channel map: the user can apply individual settings; each of the 79 channels can be blocked or released provided that a minimum number of 20 channels is released

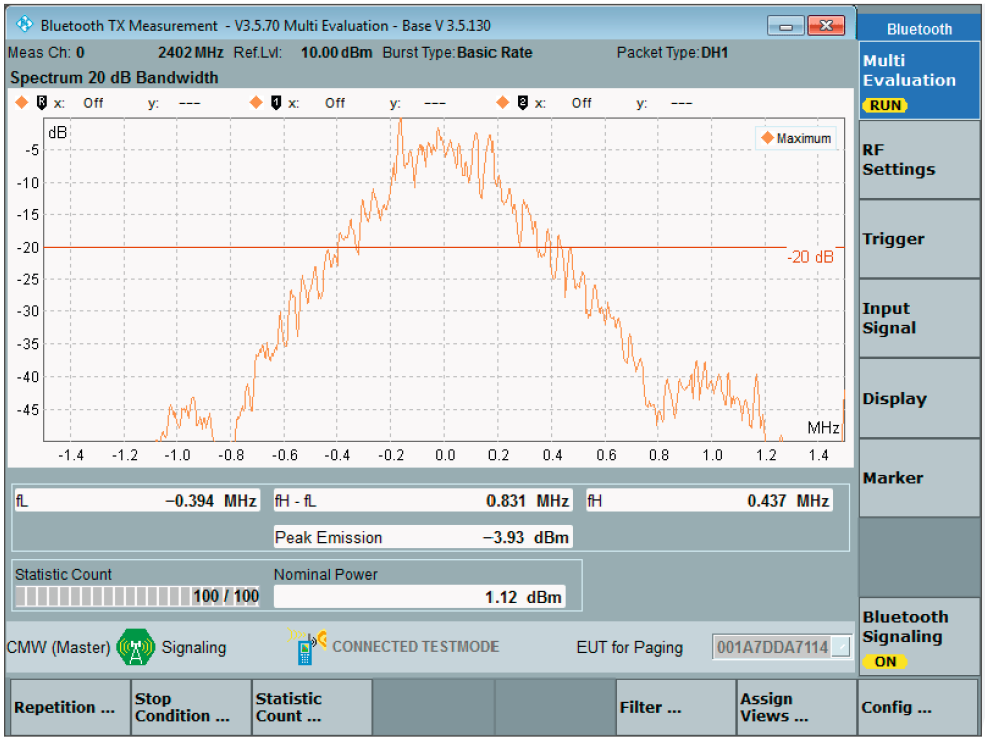
**Behavior of the dirty transmitter in "Bluetooth® LE uncoded, 1 Mbps" mode**

| Test run | Carrier frequency offset | Modulation index | Symbol timing error |
|---|---|---|---|
| 1 | 100 kHz | 0.45 | –50 ppm |
| 2 | 19 kHz | 0.48 | –50 ppm |
| 3 | –3 kHz | 0.46 | +50 ppm |
| 4 | 1 kHz | 0.52 | +50 ppm |
| 5 | 52 kHz | 0.53 | +50 ppm |
| 6 | 0 kHz | 0.54 | –50 ppm |
| 7 | –56 kHz | 0.47 | –50 ppm |
| 8 | 97 kHz | 0.5 | –50 ppm |
| 9 | –25 kHz | 0.45 | –50 ppm |
| 10 | –100 kHz | 0.55 | +50 ppm |

# Basic rate multi-evaluation measurement



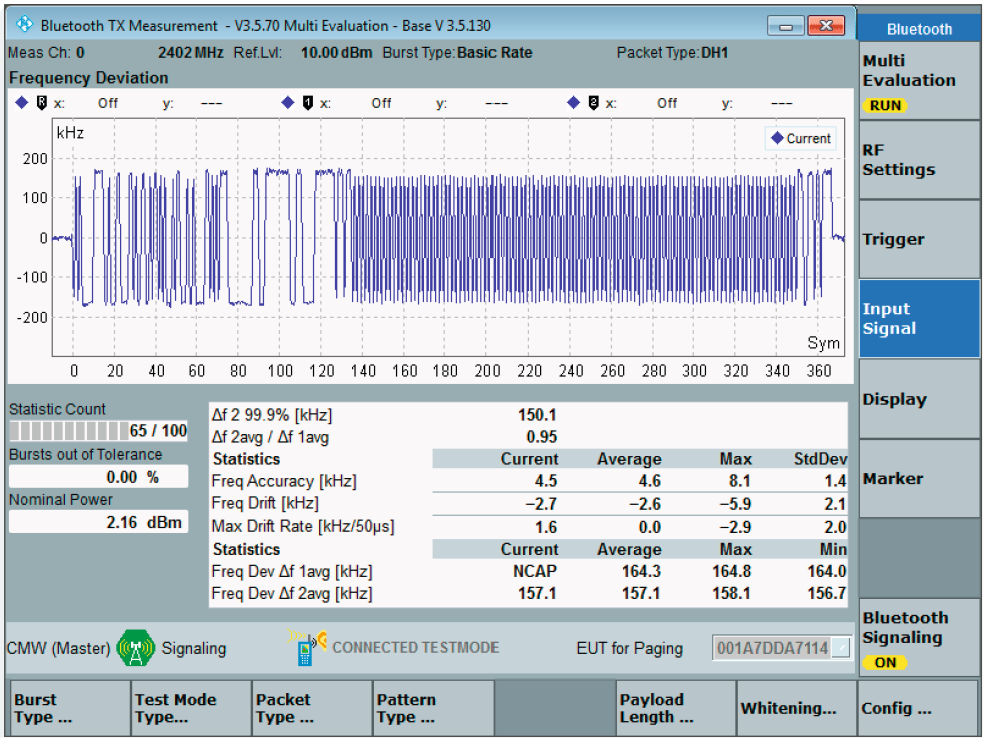

Power and packet timing results. The power control keys are also available in frequency, modulation and spectrum measurement menus. They allow you to investigate the impact of the EUT output power on any measurement result.




The occupied bandwidth measurement allows you to run the “Spectrum – 20 dB bandwidth” test case of the Bluetooth® RF test specification.

The overview shows all measurements in one window. Each measurement can also be displayed individually with additional details.

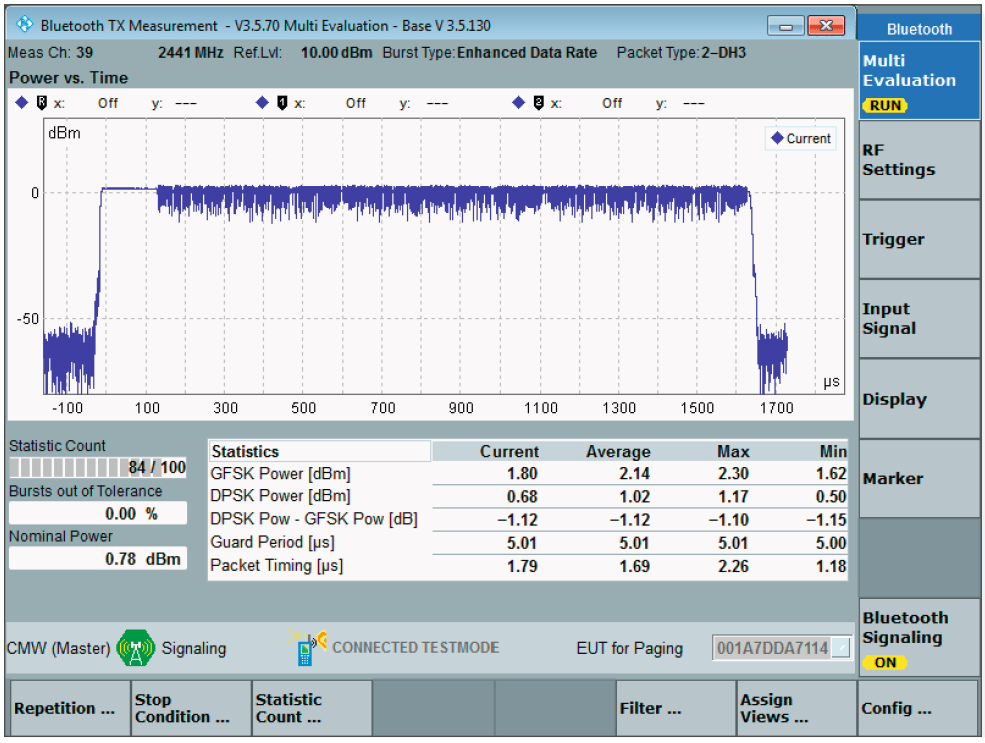
The input signal submenu lets you set up the Bluetooth® test mode signal characteristics.



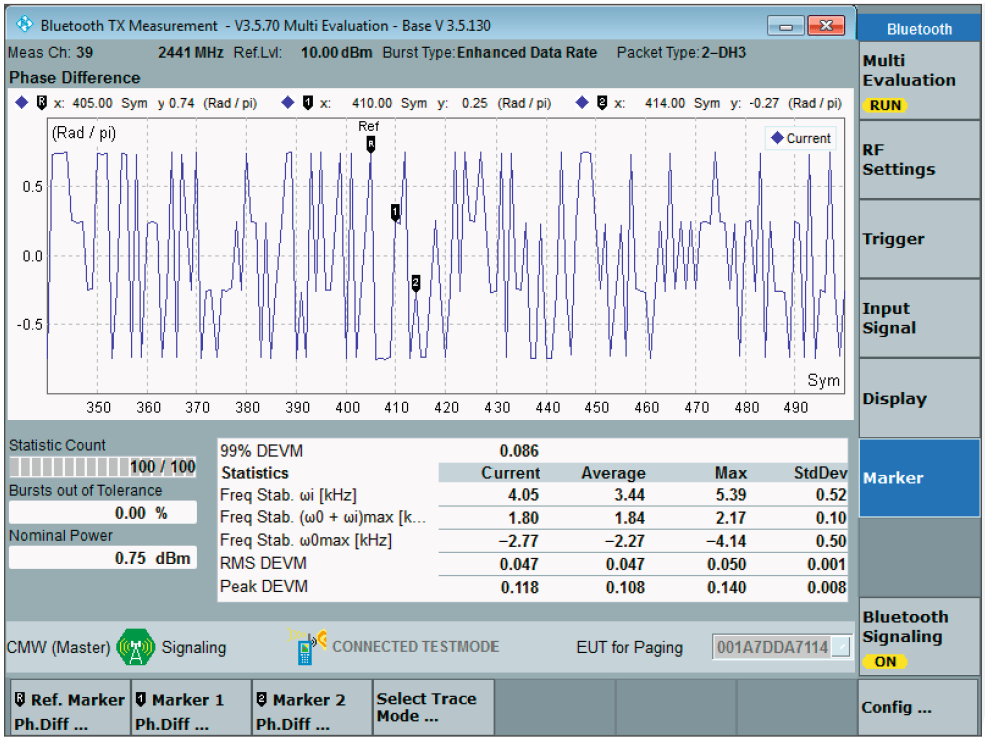

Frequency accuracy, drift, drift rate and frequency deviation results. If the alternating bit pattern is selected, the R&S®CMW displays both $\Delta f_1$ and $\Delta f_2$ results and the ratio $\Delta f_{2\,avg} / \Delta f_{1\,avg}$ as stipulated by the Bluetooth® RF test specification. The R&S®CMW can magnify the graph and up to three cursors can be used to investigate the demodulated signal in detail.


ACP measurement as described in the Bluetooth® RF test specification. The use of markers allows you to read out the detailed results for all channels. Alternatively, you can select a table view of all results.

# EDR multi-evaluation measurement

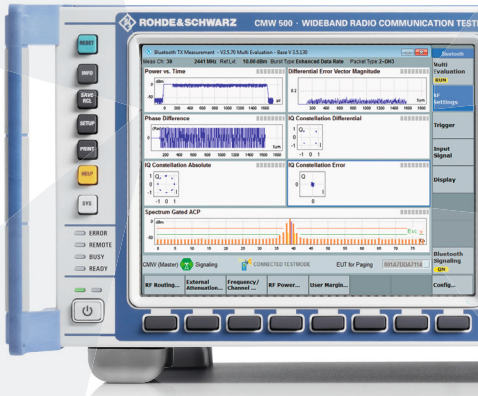



GFSK and DPSK power results. The R&S®CMW also measures the guard period and packet timing.

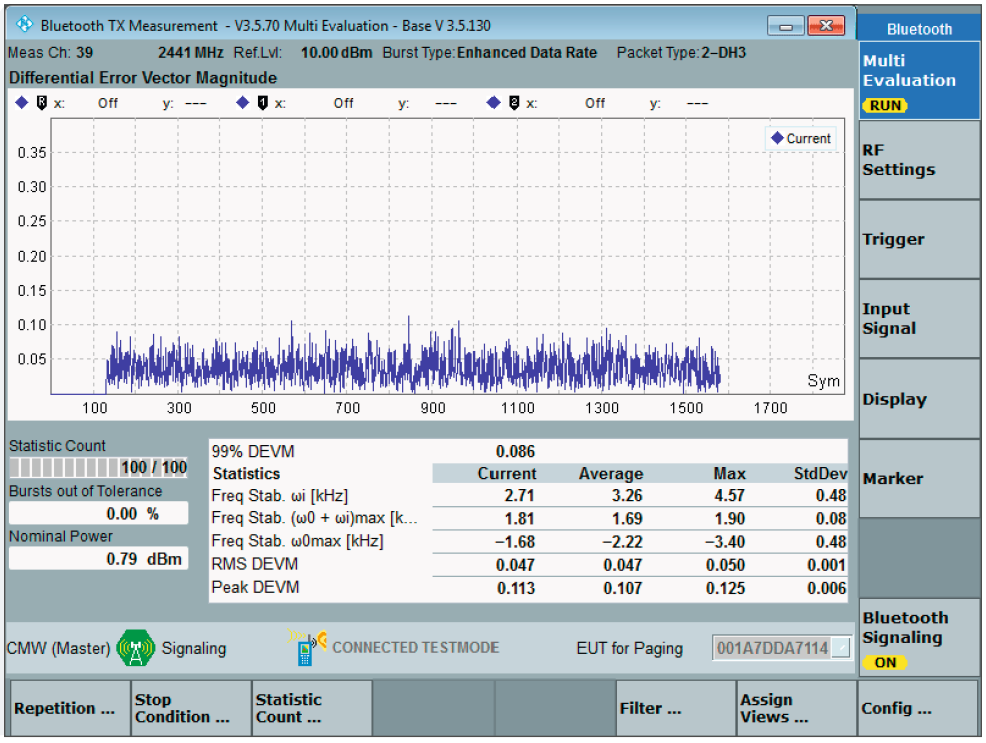



Phase difference graph. The phase difference between two consecutive symbols contains the encoded bit information of the DPSK payload. You can use the markers to verify the phase difference for each symbol.

The overview shows all measurements in one window. Each measurement can also be displayed individually with additional details.



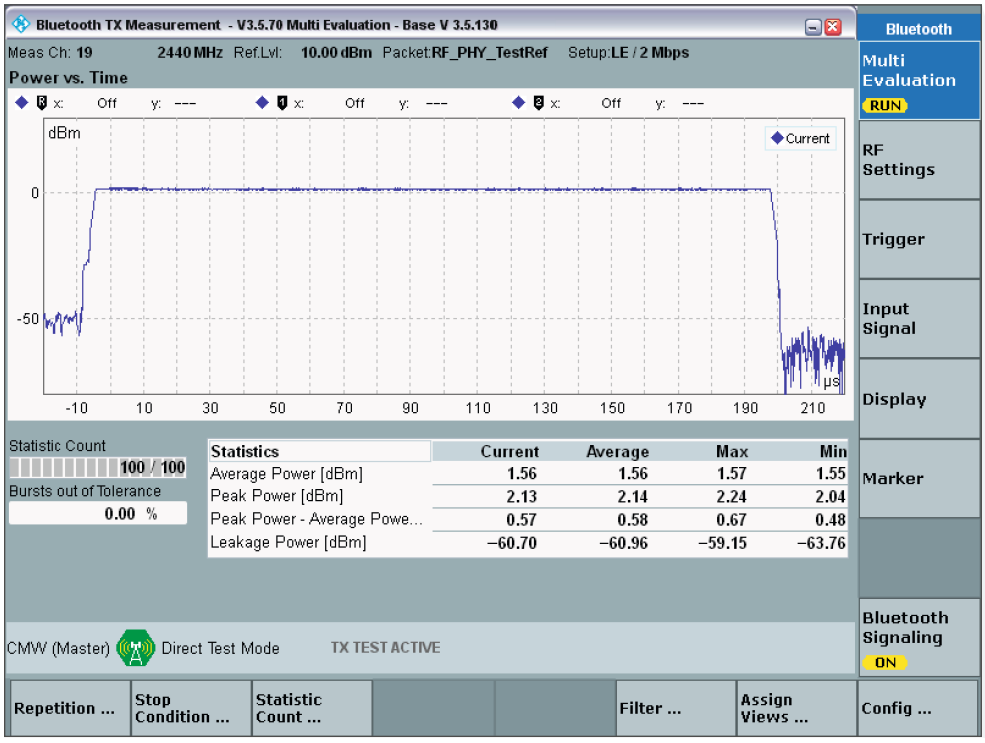
The RF settings submenu lets you set up all RF related parameters, such as RF channels, frequency hopping, external attenuation values and R&S®CMW output power.



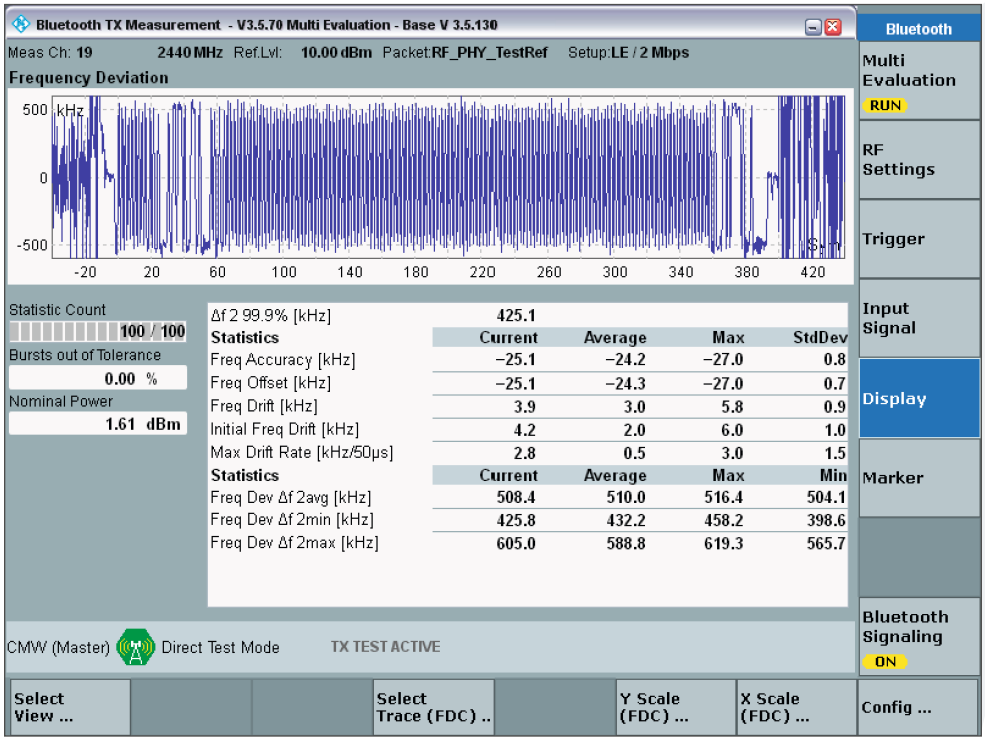

Differential error vector magnitude (DEVM) and frequency stability results. All measurements are performed according to the methods described in the Bluetooth® RF test specification.


EDR in-band spurious emissions test case (gated ACP). The Bluetooth® RF test specification allows the level to exceed –40 dBm (see green limit line) on up to three channels. The R&S®CMW displays the number of these exceptions as one of the measurement results.

# Low Energy multi-evaluation measurement



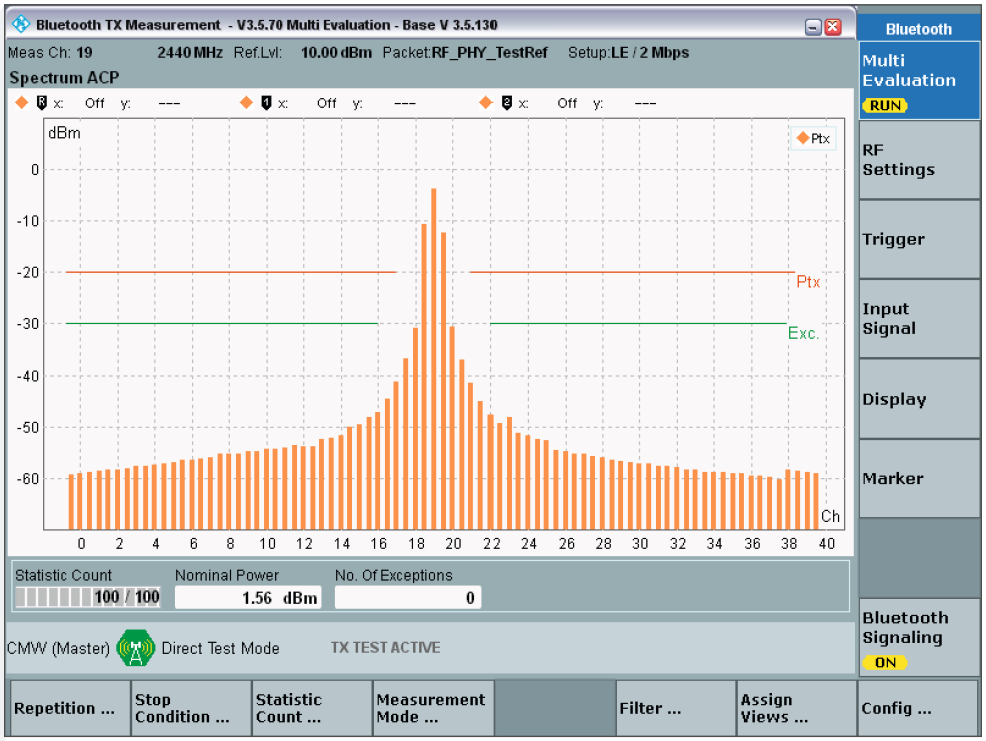

All power results. The R&S®CMW also displays the difference between peak and average power, which has to be checked according to the Bluetooth® RF test specification.



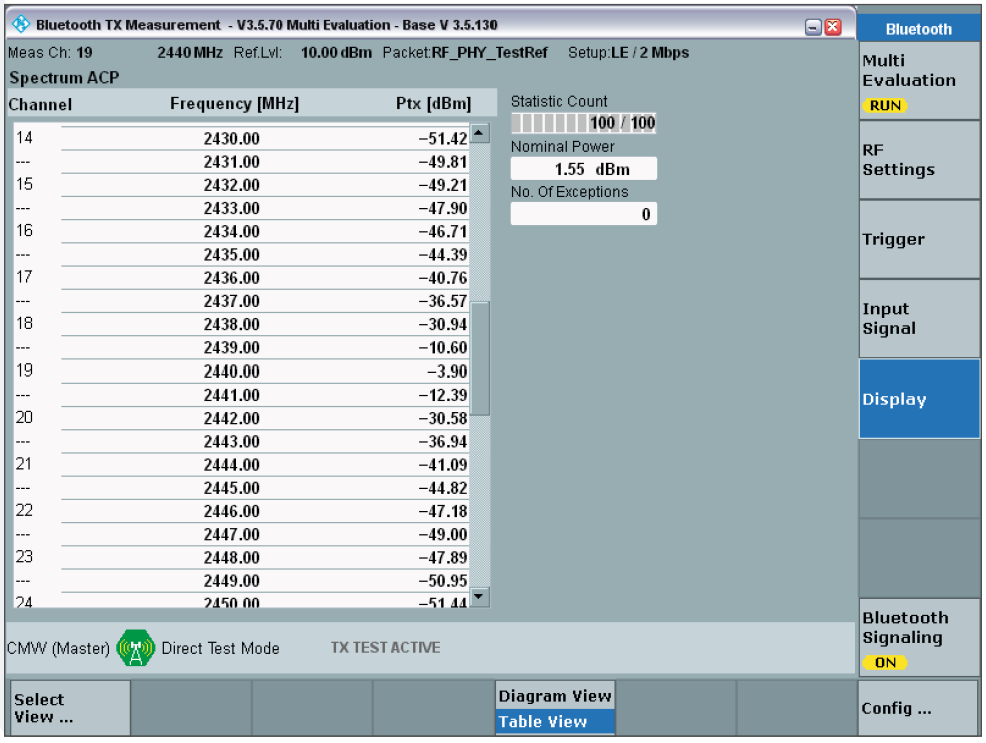

This screen shows all frequency-related results including $\Delta f_2$ results if the bit pattern 10101010 is selected. The $\Delta f_1$ results appear as soon as the bit pattern is changed to 11110000. The graph can be magnified to investigate the value of each single bit.

The overview shows all measurements in one window. Each measurement can also be displayed individually with additional details.

The input signal submenu lets you set up the direct test mode signal characteristics. This also includes a switch to select the PHY for testing devices that support Bluetooth® 5.




LE ACP measurement (in-band emissions). This example shows the spectrum of a 2 Msps signal of a Bluetooth® 5 device. Markers allow you to read out the detailed results for all channels. Alternatively, you can select a table view of all results (see screen below).




The table view shows the ACP results for all measured frequencies in form of a table. A key on the R&S®CMW front panel lets you toggle between the graphical view and the table view.

# Audio quality testing

The R&S®CMW permits testing of common Bluetooth® audio devices such as hands-free kits, multimedia car units, loudspeakers and headsets. It supports a wide range of Bluetooth® profiles and offers various test scenarios for audio measurements.

### Hands-free profile (HFP)

- Application: voice transmission for phone calls
- Testing of audio equipment (e.g. headset)
- Permits measurement of the EUT's analog audio components (microphone, earpiece and loudspeaker signal paths)
- Codecs: CVSD, m-SBC, A-law, µ-law

### Hands-free audio gateway profile (HFP-AG)

- Application: voice transmission for phone calls
- Testing of an audio gateway (e.g. mobile phone)
- Permits verification of the audio design of a Bluetooth® audio gateway
- Codecs: CVSD, m-SBC, A-law, µ-law

### Advanced audio distribution profile (A2DP sink)

- Application: transmission of stereo music
- Testing of audio equipment (e.g. stereo loudspeaker)
- Permits measurement of the EUT's analog audio components (loudspeaker and earpiece paths)
- Codec: SBC


Audio performance testing solution with the R&S®CMW, the R&S®UPV audio analyzer and the R&S®CMWrun software.

## Audio performance testing

For audio tests, the R&S®CMW establishes a Bluetooth® connection to the EUT. The required PIN is set on the R&S®CMW. The R&S®CMW activates the selected audio profile for the audio measurements.

In hands-free operation, the R&S®CMW supports the Bluetooth® volume control functionality, which allows the speaker level and microphone level to be set on the R&S®CMW as required.

The R&S®CMW role can be master or slave for all audio profiles.

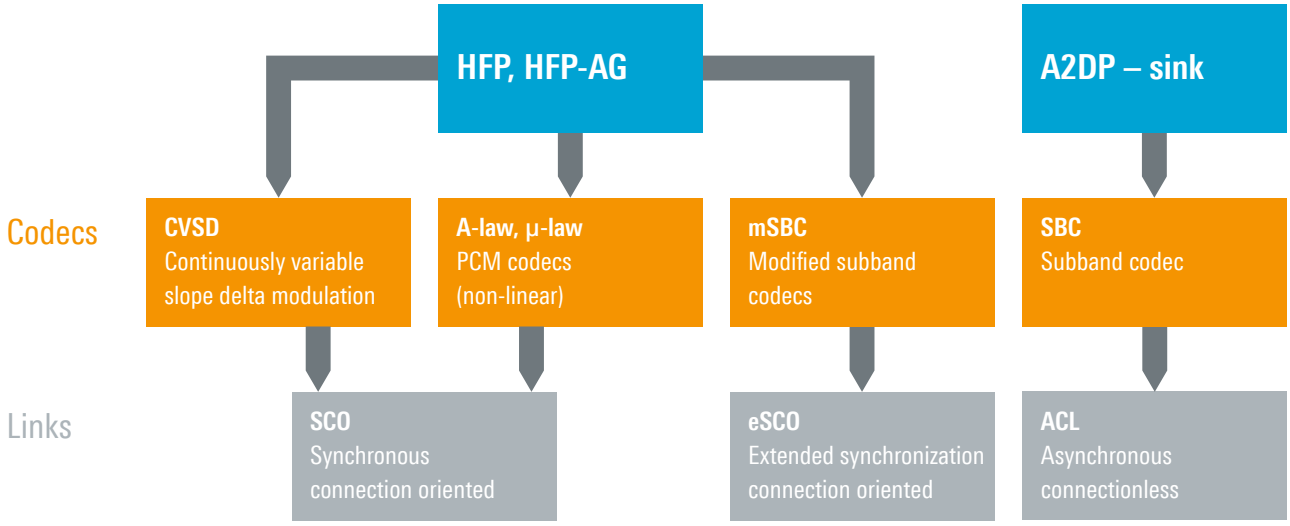
With the R&S®CMW-B400 audio option, the R&S®CMW can perform measurements on two audio channels. An analog and a digital audio generator and an analog and a digital audio analyzer are available for each audio channel. The signal paths of these components can be flexibly assigned to the analog and digital R&S®CMW audio interfaces and the R&S®CMW internal audio codecs. The different test scenarios are shown in the table on page 28.

The audio generators and audio analyzers can be operated in single-tone mode for level and distortion measurements and in multitone or FFT noise mode for fast frequency response measurements. In multitone mode, 20 sounds can be defined by setting the frequency and level.

In single-tone mode, the audio analyzers measure distortion (THD, THD+N, SINAD), signal-to-noise ratio and DC level with different selectable filters. The R&S®CMW can display the FFT spectrum in parallel with these measurements.

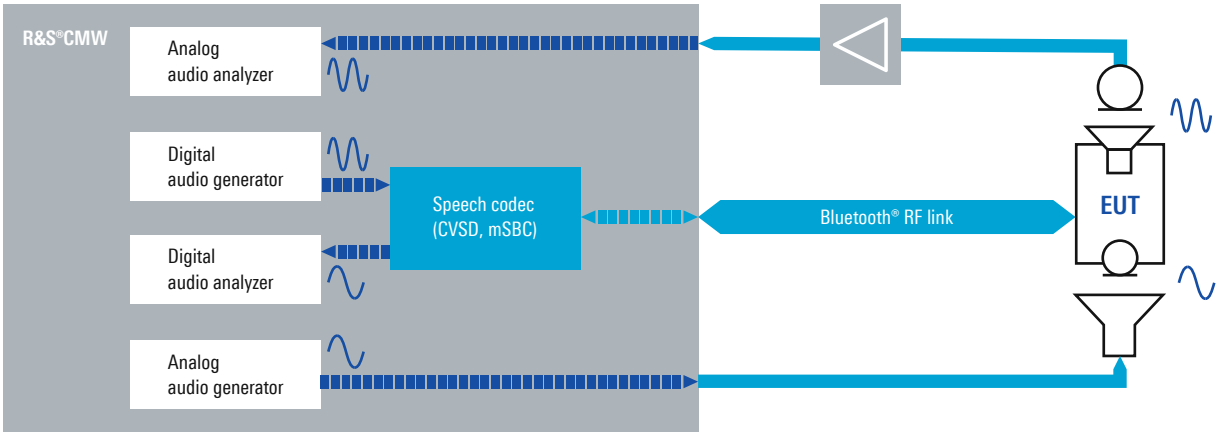
For more advanced audio tests (e.g. PESQ, POLQA), the R&S®CMW can be connected to an external audio analyzer (e.g. R&S®UPV) via analog and digital audio interfaces.

**R&S®CMW Bluetooth® audio: supported profiles, codecs and link types**



## "Microphone and speaker test" scenario using the hands-free profile

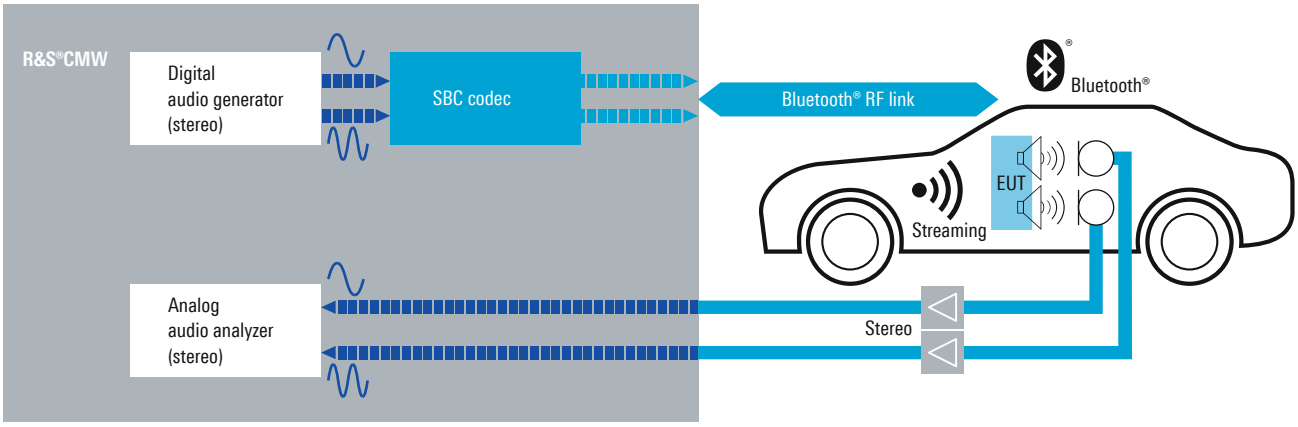
**Measuring the audio characteristics of an EUT in the transmit and receive directions**




## "Stereo speaker test" scenario

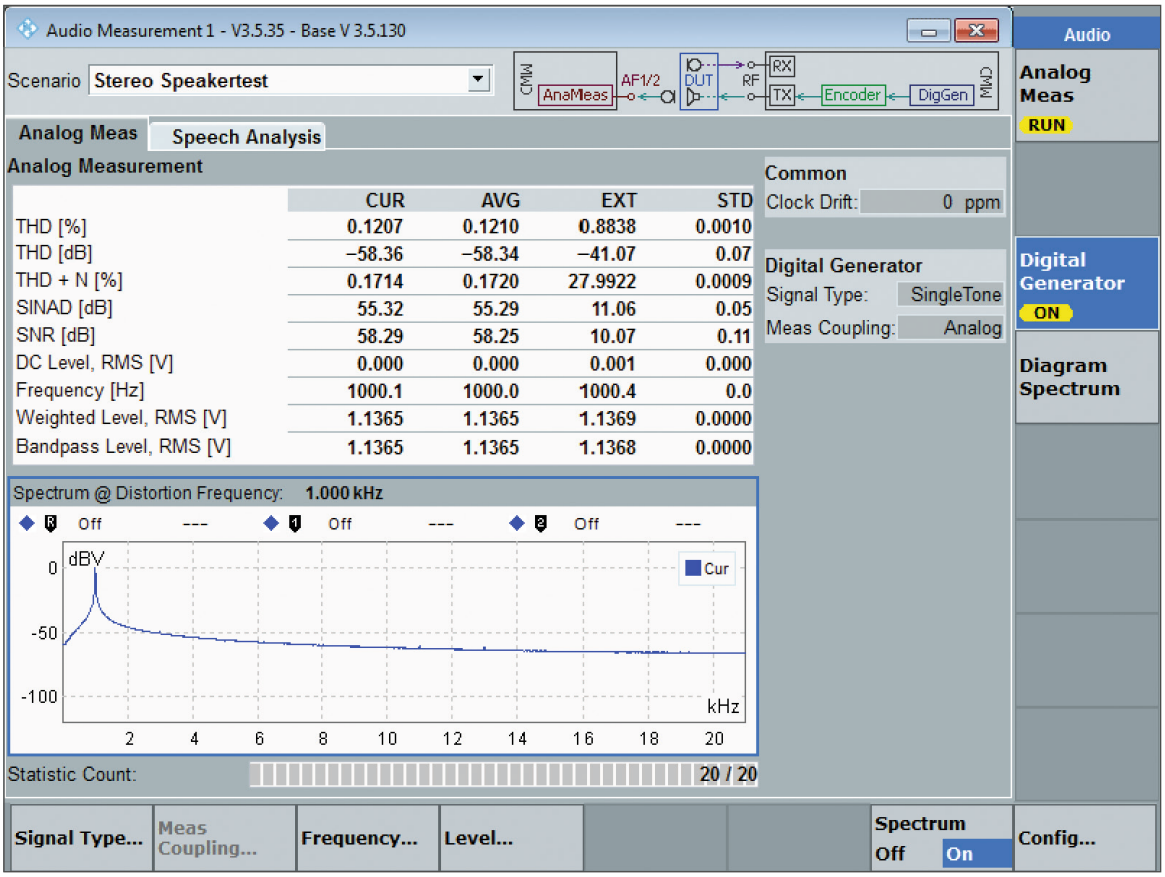
**Measuring the audio characteristics of an EUT for stereo playback**

Single-tone measurement with audio spectrum view

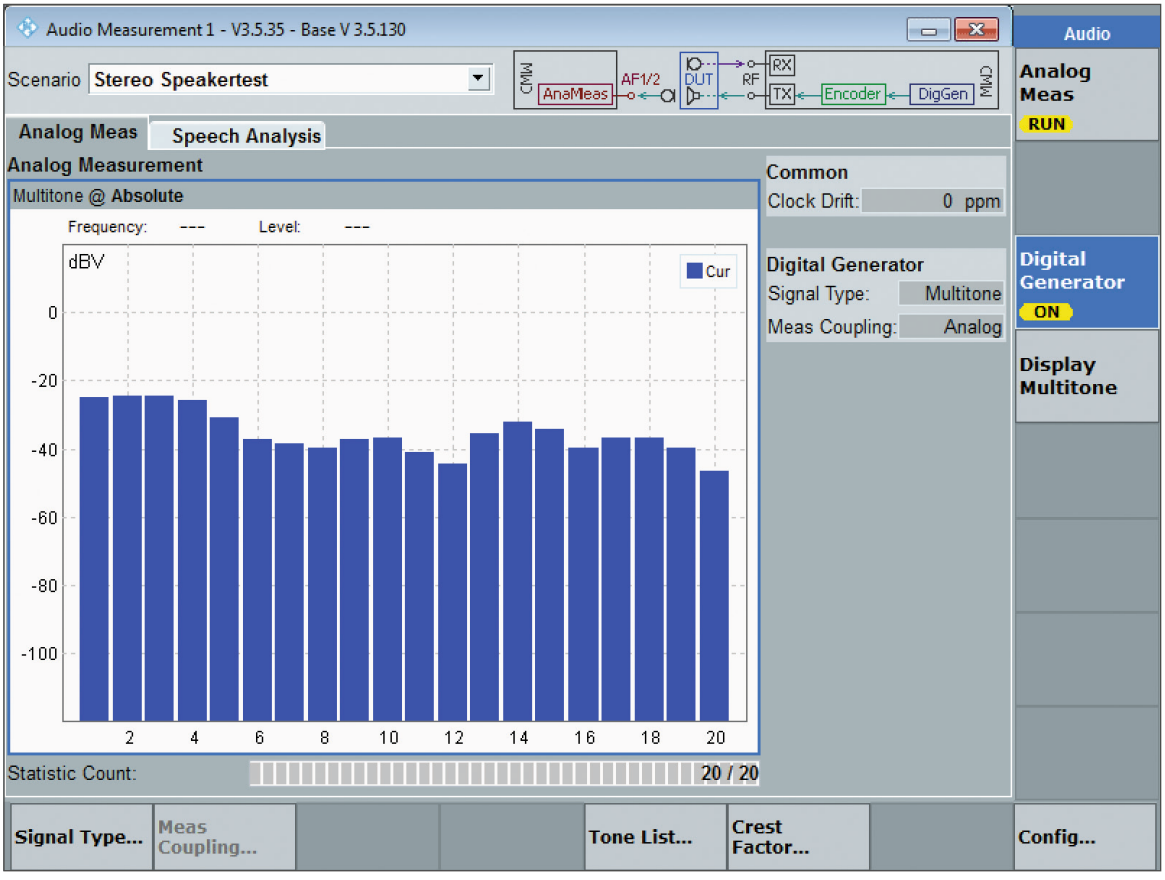



## R&S®CMW Bluetooth® audio test scenarios

| Audio test scenario | Functionality |
|---|---|
| Audio measurement and generator | Standalone operation of audio generators and analyzers |
| External analog speech analysis | Allows the use of external analog audio equipment as sink and/or source for the Bluetooth® speech codec. An external audio analyzer (e.g. R&S®UPV) can be used with this scenario. |
| External digital speech analysis | Same as above, but the interfaces are digital inputs and outputs (SPDIF) |
| Microphone and speaker test | For tests of the microphone and loudspeaker/earpiece characteristics of a device |
| Stereo external analog speech analysis | Allows the use of external analog audio equipment as source for the Bluetooth® SBC codec. An external audio analyzer (e.g. R&S®UPV) can be used with this scenario. |
| Stereo external digital speech analysis | Same as stereo external analog speech analysis, but using the digital input (SPDIF) to connect to an external audio source |
| Stereo speaker test | For testing the loudspeaker/headphone characteristics of a stereo device |




Single-tone measurement with audio spectrum view.




Frequency response measurement in multitone mode.

# Production solutions

The R&S®CMW100 communications manufacturing test set together with the R&S®CMWrun software is ideal for production testing. This solution offers an optimal combination of flexibility, performance and capacity utilization.

## Bluetooth® tests in signaling and non-signaling mode

The signaling mode is ideal for lab applications, such as system development and RF development/certification. During signaling, the EUT is controlled via messages on the protocol layer. Communications between EUT and tester take place via the RF signal. In the R&S®CMW, the signaling mode requires the so-called signaling unit hardware.

The communications overhead caused by signaling and the associated hardware can be eliminated by using non-signaling mode. The EUT is not controlled via the RF signal but by a wired communications channel, e.g. USB. Via this communications channel, test software can send commands to control the EUT. The signal from the tester to the EUT is generated in ARB mode with precalculated waveforms – so only an ARB generator and no signaling unit hardware is required.

Non-signaling mode allows only testing of the PHY layer, which is normally sufficient during production verification. RF tests can be performed faster in non-signaling mode than in signaling mode, but require software to directly control both the tester and the EUT.

## Direct test mode for Bluetooth® LE

Traditionally, Bluetooth® production tests are done in signaling mode. Bluetooth® LE changed this. The mandatory Bluetooth® test mode normally used for Bluetooth® Classic production tests is no longer defined in Bluetooth® LE. Instead, the core specification for Bluetooth® wireless technology defines that all Bluetooth® LE EUTs must support the direct test mode (DTM). In DTM, the EUT is controlled directly via the specified commands using a dedicated communications connection – just like for non-signaling. When testing a device that supports both Bluetooth® LE and Bluetooth® Classic, the required wired communications connection for Bluetooth® LE is often used to perform Bluetooth® Classic tests as well.

The commands to control a Bluetooth® LE EUT have been specified in the RF PHY Bluetooth® test specification and are the same for all EUTs. The commands to control Bluetooth® Classic EUTs via a wired communications channel are vendor-specific and therefore different implementations are required for chipsets from different vendors.


The R&S®CMW100 is ideal for use on fully automated robotic production lines.

## High test efficiency with the R&S®CMW100 innovative smart channel solution

The decreasing unit prices of Bluetooth® devices make it necessary to minimize production test costs yet maintain a defined test depth. Using non-signaling instead of signaling is one way to reduce test costs. Fully utilizing the tester's hardware is another way to minimize test costs.

To facilitate the most efficient use of hardware resources, each R&S®CMW100 has one RF channel (one analyzer/one generator) and eight RF connectors. The signal from one generator can be split so that it is available at all ports at the same time. This allows you to execute RX tests on up to eight EUTs in parallel – and multiply the throughput eight-fold. A precondition to parallel testing (broadcast) is that all EUTs are simultaneously ready for testing at the test station. If this is not the case and the EUTs arrive sequentially, the test steps could be interleaved – while one EUT is measured, another EUT is configured for the next measurement and another EUT is booting up.

Such asynchronous multidevice handling on one shared RF channel normally requires a complex software program. The implementation has to ensure that the tester configuration is not overwritten accidently before one test step has finished and that the results have been obtained before a new test starts.

The R&S®CMW100 offers an innovative solution: the device can be split into virtual subinstruments called smart channels. Each EUT is connected to one smart channel. For the user, each smart channel acts independently. Configuration and result handling of one smart channel can be done without considering other EUTs. One smart channel cannot overwrite the configuration of another smart channel. Each smart channel keeps its measurement results available. While one EUT is measured, the results for another EUT are still available. This further increases the measurement speed since the required tester configuration and result handling for one EUT can be done while another EUT is measured.

Sharing of hardware resources is handled internally in the R&S®CMW100: if a hardware resource is occupied by one smart channel, another smart channel has to wait. But because of the short measurement times, this waiting period is normally only a few milliseconds. The R&S®CMW100 handles the analyzer and generator resources independently. Overall, smart channel functionality makes equipment sharing easy since multi-EUT testing no longer needs a special implementation.

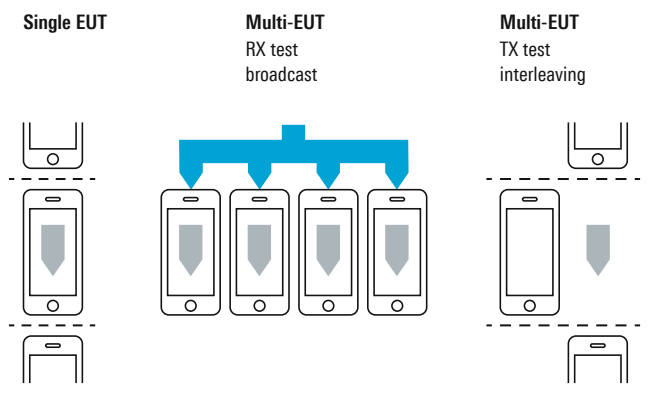
### Key facts for the R&S®CMW100 communications manufacturing test set

- Turnkey R&S®CMWrun based production solution for different chipset suppliers
- Innovative smart channel solution for efficient multi-EUT testing
- Continuous frequency range up to 6 GHz
- Multitechnology solution
- Parallel testing on up to eight RF ports
- High measurement performance
- High measurement accuracy
- Support of a wide range of methods for reducing test time and maximizing capacity utilization
- Minimum space requirements and footprint
- Low weight
- Silent
- High mean time between failures (MTBF)

## Turnkey R&S®CMWrun based production solution for different chipset suppliers

As a turnkey solution, Rohde&Schwarz offers the R&S®CMWrun sequencer software. It remotely controls the R&S®CMW and the EUT using vendor-specific commands for Bluetooth® Classic. Currently, R&S®CMWrun supports Bluetooth® non-signaling for many different chipsets, e.g. from Broadcom, Marvell, Intel, Texas Instruments and Qualcomm. Since all Bluetooth® LE devices use the standardized direct test mode (DTM), all these devices are supported. For multi-EUT testing, multiple instances of R&S®CMWrun can be executed – using the smart channel feature in the background.

### Different test scenarios



A shielded box is recommended for Bluetooth® LE advertiser testing, e.g. the R&S®CMW-Z10 RF shield box.

# Bluetooth® LE advertiser testing

Bluetooth® LE advertiser testing is an over-the-air (OTA) measurement method for easy and fast RF testing of Bluetooth® LE devices. It is ideal for production, but is also used for quick reference measurements in incoming inspection and development. During these tests, the EUT is in a normal operating state, not in a special test mode.

### Bluetooth® LE device testing without control cable connection

The Bluetooth® specifications define the direct test mode (DTM) for RF tests on Bluetooth® LE devices where the EUT is connected to the tester via a control cable. The disadvantage of this method is that the control cable could fundamentally change the RF characteristics of the EUT. When performing RF tests on Bluetooth® LE products in the lab or in production, it is often difficult to connect the control cable to the LE device.

As a solution, the R&S®CMW supplements the direct test mode with the LE advertiser testing mode to perform RF measurements based on advertising packets. Once LE advertising mode has been activated, a Bluetooth® LE device sends advertising packets in regular intervals to set up a connection or to transmit broadcast messages. These packets are sent on three of the in total 40 Bluetooth® LE channels. These three channels are located in the lowest, the highest and in the first third of the Bluetooth® frequency bands (see page 9).

## TX testing

Advertising packets can be used to reliably measure the transmitter characteristics of a Bluetooth® LE device. Since the advertising channels are spread out across the entire Bluetooth® frequency band, the measurement results are representative of all other Bluetooth® LE channels. When determining the RF characteristics of the transmitter, the usual values for power, modulation, frequency and spectrum are measured. Since the TX measurements in DTM are based on specific pattern sequences that do not occur in this form in normal operating mode, the advertiser measurement uses mathematical algorithms to be able to compare the results with the measured DTM values. (In the GUI, these parameters are marked with an asterisk *.)

The R&S®CMW offers transmitter measurements using the advertising packets sent by the EUT. It delivers the following results based on advertising packets:

- Nominal power
- In-band emissions (ACP, ±10 MHz)
- Frequency accuracy
- $\Delta f_1$* (average, min., max.)
- $\Delta f_2$* (average, min., max.)
- Modulation ratio $\Delta f_{2\,avg} / \Delta f_{1\,avg}$*
- $\Delta f_2$ 99.9 %*
- Frequency offset*
- Frequency drift*
- Max. drift rate*

## RX testing

The advertising packets are primarily used to set up a connection to another Bluetooth® device. Like WLAN beacons, the packets contain all the information needed for this process. The connection is set up using a defined handshake procedure with mutual acknowledgment of incoming messages. This acknowledgment process is ideal for performing receiver tests. If, for example, the field strength of a message sent to a Bluetooth® LE device is under the device's receiver sensitivity level, then usually the receiver cannot correctly decode the message, which means it doesn't send an acknowledgment. That is the typical procedure for determining the sensitivity level during receiver testing.

The R&S®CMW offers the following three receiver sensitivity measurement methods based on advertising packets.

### Spot measurement

Spot measurements are the fastest way to verify a receiver. The R&S®CMW simply sends a request message to the EUT asking it to set up a connection and verifies whether the EUT acknowledges this request. This Go/Nogo test is ideal for final testing in production.

### Sensitivity search

To determine the sensitivity level, testing starts with good receive conditions and then the receive level is gradually reduced. The sensitivity level is the level at which no acknowledgement is sent.

### Packet error rate (PER) measurement

During a PER measurement, a predefined number of messages are sent to the EUT at a certain transmit level and the number of acknowledgments are counted. The PER is determined based on the number of acknowledgments that are not received.

### Key facts about Bluetooth® LE Advertiser testing

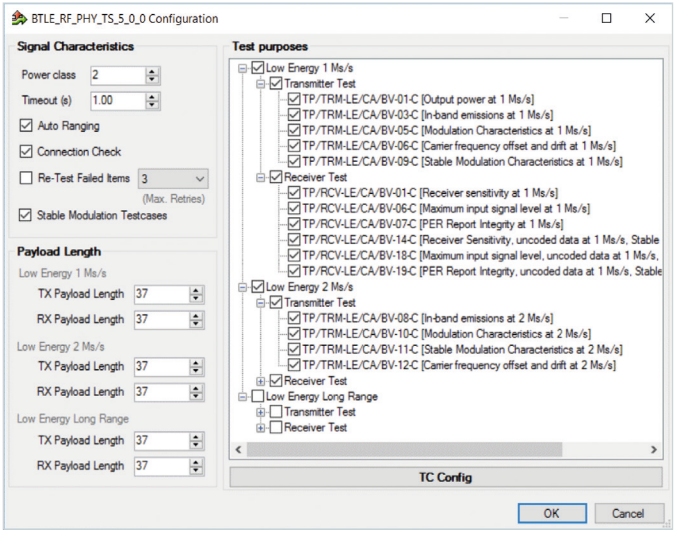
- Very simple, fast and efficient OTA testing method for Bluetooth® LE devices
- Proprietary measurement technique that performs comprehensive RX and TX tests
- Optimized for fast functional tests, for production and development
- The Bluetooth® device is tested under normal operating conditions

### Using Bluetooth® LE advertiser testing offers the following advantages

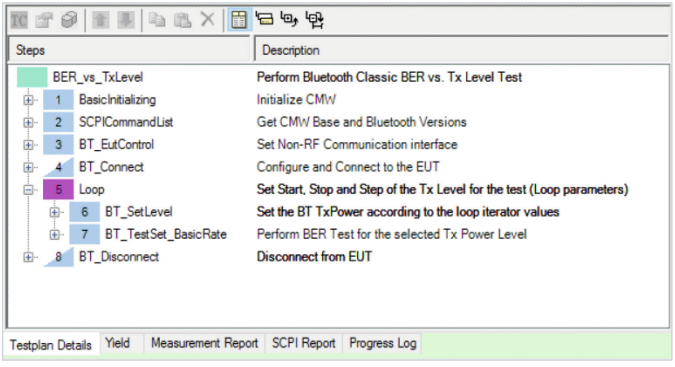
- The EUT is tested under realistic conditions
- The transmit and receive characteristics are reliably measured on frequencies that are representative of the entire frequency band
- Compact Bluetooth® LE devices can be tested without access to an antenna (OTA) or remote control interface

# R&S®CMWrun software for automated testing

The R&S®CMWrun sequencer software tool is a ready-to-use solution for configuring test sequences by remote control. The R&S®CMWrun sequencer software tool can be enhanced with options and used for all standards supported by the R&S®CMW family – for general RF testing, preconformance and superior user experience test scenarios.




Test DLL.




Test sequence.

## Applications and testing scope

The R&S®CMWrun automation software meets all requirements for executing remote control test sequences on the R&S®CMW platform in R&D, quality assurance, production and service. It can handle the requirements of both current and future wireless devices.

The R&S®CMWrun software engine is based on the execution of test dynamic link libraries (DLLs, plug-in assemblies). This architecture allows easy and straightforward configuration of test sequences without specific programming knowledge of how to remotely control the instrument. It also provides full flexibility when configuring parameters and limits for the test items provided in the standard-specific R&S®CMWrun package options.

At the end of the test, an easy-to-read test report containing limits, test results and verdict is generated. The report is available in .csv, .txt, .xml and .pdf format.

The R&S®CMW-KT057 option for R&S®CMWrun offers a large number of Bluetooth® test DLLs for Bluetooth® Classic and Bluetooth® LE.

## Bluetooth® prequalification testing

R&S®CMWrun supports all RF test cases defined in the Bluetooth® RF test specification. Two DLLs contain all "simple" test cases that can be performed using a single-channel R&S®CMW. Two additional DLLs contain "advanced" test cases that require additional generators acting as interferers in the test setup. Either a second RF channel in the R&S®CMW or external generators can be used (see "Bluetooth® Classic and Low Energy RF test cases" on page 13).

## Individual testing and example test plans

A wide variety of other DLLs are available to create individual test sequences using all the capabilities of the R&S®CMW. Some generic DLLs are used to activate and configure the measurements; other DLLs are used to change parameters and the loop design within a test sequence. The R&S®CMWrun Bluetooth® software package contains a number of example sequences that can be used as a basis when designing your own sequences.

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### 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.

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Data without tolerance limits is not binding | Subject to change



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