Universal Radio Communication Tester CMU 200

Signalling and RF measurements for Bluetooth™

Photo 43 238/16

The new *Bluetooth* ™ ** option shows that the capabilities of the CMU 200 [*] are not restricted to RF tests in line with classic mobile standards such as GSM, IS 95 or IS 136.

Bluetooth functions in the CMU 200

With the *Bluetooth* option, the CMU supports a great variety of applications in R&D, service and production, whether acting as a multimode tester or "simply" as an RF tester for *Bluetooth*.

Signalling

Bluetooth modules are normally tested in a realistic environment with normal signalling, i. e. without particular adaptation of hardware and software. During the RF tests, tester and DUT form a pico network where the CMU functions as the master, signalling the parameters for the individual test steps to the DUT (slave).

Inquiry

In this mode, the CMU searches for DUTs in its environment and stores their addresses in a list (FIG 1).

Paging, connection

The radio communication tester pages the DUT with a specific address entered by the user or obtained through inquiry and sets up a connection in the event of a positive response.

Activating the *Bluetooth* test mode

To perform an RF measurement after a successful call setup, the test mode defined by the *Bluetooth* standard is activated via the air interface. The CMU sets the DUT as required:

- Transmitter test or loop-back mode
- Frequency hopping or discrete frequency
- Packet type: DH 1, DH 3 or DH 5
- Payload lengths: 2 bytes to 339 bytes
- Payload data: PRBS, 1010 pattern, etc
- Data whitening: on / off

Important parameters of the DUT such as version number or service class are exchanged during call setup and displayed as an additional signalling information on the CMU.

Bluetooth transmitter measurements

Nominal power, peak power, leakage power and time alignment measurements can be selected in the power menu of the CMU. The CMU interprets the content of the received signal and sets the appropriate measurement range. The nominal power and the peak power are measured during a burst. The measured leakage power is used to determine the on / off power ramping of the transmitter at the edges of the transmitted packet while the packet alignment measurement determines the transmit time of the DUT with respect to the timing predefined by the master. The last measurement checks whether the slave responds within the tolerances of a specified time window.

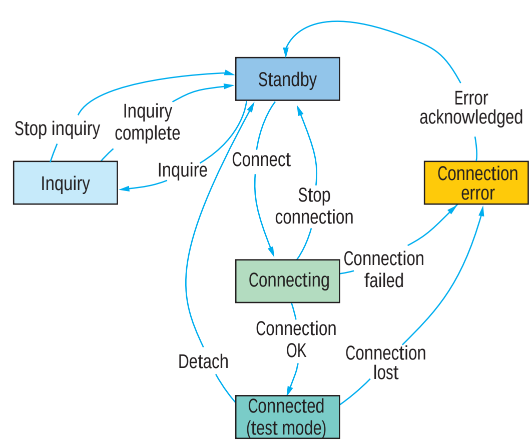

FIG 1 CMU 200 inquiry mode: the tester stores all found DUT addresses in a list

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Key parameters of the Bluetooth RF interface

The most important technical parameters of the *Bluetooth* RF interface are shown in FIG 2. A *Bluetooth* subscriber always operates alternately as transmitter or receiver within a timeslot. The coloured segments in FIG 3 mark the relevant basic elements of a physical packet:

Access code (72 bits)

This area supports the identification and synchronization of *Bluetooth* instruments. A typical 1010 pattern is sent as the 4-bit preamble at the beginning. A measuring instrument must be able to accurately measure the frequency deviation of the DUT within 4 µs.

Header (54 bits)

This area of the packet contains organizational information important for the call: the current address of the called partner in the pico network, packet types used and also flow control and handshake information.

Payload (0 to 2744 bits)

Packet area of variable length where payload data is normally transmitted. The maximum length of the payload is defined so that at least 220 µs are available between the end of the payload and the change of the timeslot for the synthesizer of the *Bluetooth* signal to settle to the next frequency channel.

Parameter	Data	Comment
Frequency band	2.4 GHz to 2.493 GHz	V1.0b: partly national assignment; max. number of channels per system: 79
Channel spacing	1 MHz	
Modulation	Gaussian frequency shift keying (GFSK); B x T = 0.5	Max. frequency deviation 160 kHz
Time multiplex	625 µs/timeslot	Master and slave send alternately
Frequency hopping	1600 hops/s	The frequency is changed in each timeslot (3200 hops/s during call setup, i.e. the frequency is changed in each half timeslot)
Physical packet types	1, 3 and 5 slots	Variable packet length for current packet type. Packet formats with different error correction are used depending on the application.
Power classes	0/+4/+20 dBm	

FIG 2 Key technical parameters of *Bluetooth* RF interface

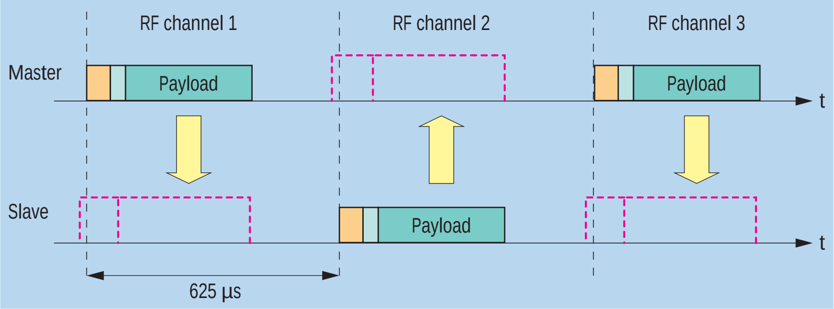


FIG 3 Information transmission to *Bluetooth* standard with frequency hopping and time multiplex

Further information and instruments for *Bluetooth*

- **In this edition:** Test tip – Generating *Bluetooth* RF test signals quickly and easily (pp 50 – 51)
- **Test tip:** Accurately measuring drift on *Bluetooth* transmitter modules. News from Rohde & Schwarz (2000) No. 169, pp 40 – 41
- **Protocol Tester PTW 60** for *Bluetooth* applications – Comprehensive protocol tests to *Bluetooth* qualification program. News from Rohde & Schwarz (2000) No. 169, pp 8 – 10 (search for PTW 60 to find data sheet)
- **Test System TS 8960:** www.rohde-schwarz.com (search for TS 8960)
- ***Bluetooth* flyer** (search for 0757.5489)
- ***Bluetooth* RF Test Specification**, Revision 0.9, 14 March 2000
- ***Bluetooth* Core Specification**, Revision 1.1, 12 June 1999

Or on the Internet:

- **Rohde & Schwarz and *Bluetooth*:** www.rohde-schwarz.com/bluetooth
- **Official *Bluetooth* website:** www.bluetooth.com

Data sheet PTW 60

Bluetooth flyer

	Data pattern 101010	Data pattern 11110000	PRBS and others
Frequency accuracy (measurement along the preamble)	X	X	X
Frequency drift	X	–	–
Maximum drift	X	–	–
Average frequency deviation	X	X	–
Max. frequency deviation	X	X	–
Min. frequency deviation	X	X	–

FIG 4 ***Bluetooth*** **modulation measurements that can be performed with the CMU 200**

Due to its large memory, the CMU is able to graphically display data sections from 1/16 timeslot to a packet of five timeslots in length.

Modulation measurements

As stipulated by the *Bluetooth* RF test specification, the test methods used depend on the data patterns stimulated in the payload. Supported measurements are listed in FIG 4.

The graphics display of the CMU offers flexible means for selecting and extending measurement ranges. For instance, the settling characteristic of the signal can be conveniently analyzed with the pretrigger function (FIG 5). Markers facilitate a detailed analysis of individual ranges.

Not only is it necessary for a DUT to hop quickly between frequencies, the DUT must also maintain a constant carrier frequency during transmission after the hops. Keeping the frequency drift low over the maximum length of the DH5 packet is therefore quite an ambitious task. To be able to execute the required measurement algorithm for all data, the measuring instrument has to store this period at a high resolution.

Test modes of the CMU for transmitter tests

The CMU carries out all power and modulation measurements on DH1, DH3 and DH5 packets, etc by varying several parameters – i.e. TX test or loop back. Special test modes of the CMU are described below:

All channels

In this mode, the CMU evaluates the signal actually received during frequency hopping, independent of the channel number. Thus, measurement results are quickly obtained for all 79 occupied channels. The level spreads which may be caused, for instance, by frequency response are qualitatively recorded either as numeric values or in graphical form via the displayed statistical minimum and maximum values obtained in power measurements.

Single

In this mode, frequency hopping can be performed for signalling. However, the CMU examines only one user-selected channel.

Simultaneous

This mode is optimized so that measurement results for five different frequency channels are rapidly obtained with the reduced hopping function defined in the standard.

Receiver measurements

A condition for receiver measurements is that the DUT decodes the payload bits generated by the tester and returns them to the measuring instrument. The CMU switches the DUT into loop-back mode and compares the data received with the data previously sent.

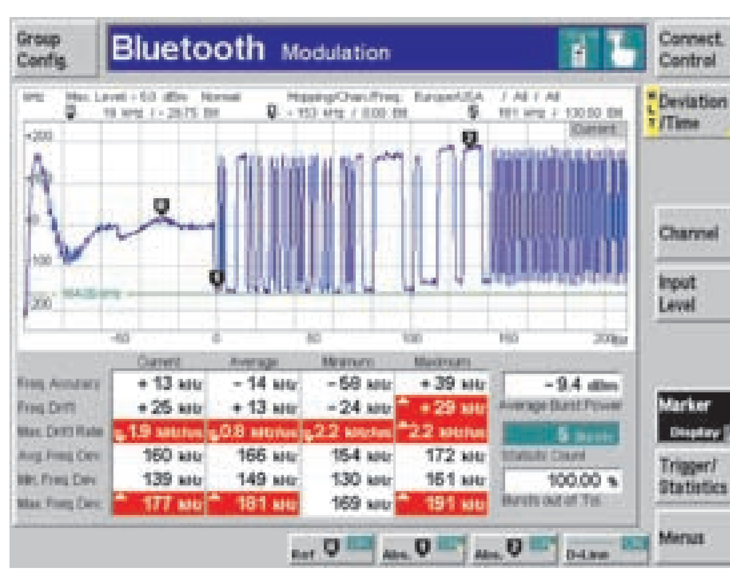


FIG 5 Graphics display: the CMU 200 provides convenient means for signal analysis

Bit error rate (BER)
The BER of the payload data is calculated as follows: errored bits ÷ (total number of bits received by the tester in loop-back mode) x 100 %.

Packet error rate (PER)
If the DUT is not able to understand certain packets, e.g. because the sync word cannot be identified, the CMU marks these packets and they are included in the packet error rate calculation. PER = marked packets ÷ (total of sent packets) x 100 %.

BER search
In this mode, the CMU performs a sequence of BER measurements at a continuously reduced transmission level. The measurement is stopped when a user-defined limit for the BER measurement result is exceeded.

For generating the data pattern used in the loop-back mode, the CMU not only provides a great variety of ready-made data sequences (pseudo random, 1010, 1111000, etc) but also allows the users to define their own data sequences. The desired boundary conditions for receiver measurements can be defined in five test setups.

As with transmitter measurements, flexible receiver measurements can also be carried out in the non-hopping or the realistic hopping mode for different packet types and data lengths.

Parallel operation for high measurement speed

Due to the high measurement speed and large memory capacity of the CMU, transmitter and receiver measurements can be carried out in parallel. When measurements are performed during frequency hopping, a great test depth is rapidly attained. Only a few seconds are required between call setup, transmitter and receiver measurements and call detach.

Many convenient measurement functions

The CMU offers a great number of statistical monitoring and measurement functions. It is possible, for instance, to define individual tolerances for each measured value and to stop a measurement sequence after a certain number of measurements or when a tolerance has been exceeded. Besides the common traces for power and modulation versus time, averaged minimum or maximum traces can also be displayed over a user-defined number of packages.

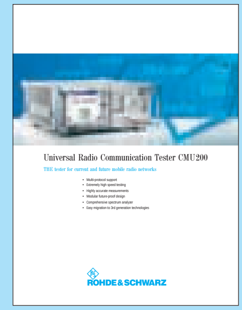
Numerous other applications

A great number of additional *Bluetooth* measurements can be performed with the CMU. For instance, the receiver signal strength indicator (RSSI) test point in the DUT can be stimulated and adjusted by accurate setting of the CMU transmitter level. In the non-signalling mode, the CMU periodically sends a *Bluetooth* packet. In addition to power and frequency, a frequency offset and data pattern can also be selected and used, for instance, for stimulation when a *Bluetooth* FM demodulator is to be measured.

Spectrum analyzer

The RF function group is implemented in the CMU as the basic package along with the *Bluetooth* option. It allows simple RF signals to be generated in a wide level and frequency range. The built-in analyzer evaluates RF input signals in the time or frequency domain.

More information and CMU 200 data sheet at www.rohde-schwarz.com, search for CMU 200 (*Bluetooth* options CMU-B53, -K53, -U53 in the data sheet)



REFERENCES
[*] Universal Radio Communication Tester CMU 200 – On the fast lane into the mobile radio future. News from Rohde & Schwarz (1999) No. 165, pp 4–7

Summary

The CMU supplements the *Bluetooth* test solutions from Rohde & Schwarz: the Protocol Tester PTW 60 and the TS 8960 which is the world's first RF test system for *Bluetooth* components (box on page 10). The CMU has been designed for many subsequent extensions. It may be possible, for instance, to perform *Bluetooth* measurements in addition to measurements in other networks such as GSM; this opens up new prospects for production lines in the future. Customers already using a CMU 200 may order an upgrade kit.

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