Products: CMU200

Transmitter and Receiver Measurements on Bluetooth™ Modules with CMU200

Application Note

The Rohde & Schwarz CMU200 test set can be configured as a standalone Bluetooth test solution for production, R&D, service and QA use, and is the fastest signalling tester for Bluetooth test modes available.

This document is intended as a guide to configuring the available measurements to achieve test scenarios very close to the relevant Bluetooth test specifications.

ROHDE & SCHWARZ

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1   Overview

The widely supported *Bluetooth* wireless technology standard (more than 2500 adopters at the beginning of 2001) promises radio link short range connectivity for devices such as PCs, printers, PDAs or mobile phones.

Rohde & Schwarz already offers a complete range of products aimed specifically at RF, Protocol, Pre-Compliance and Conformance Testing of devices designed to support *Bluetooth* wireless technology. As the latest member to this comprehensive range of test solutions, Rohde & Schwarz offers the market's first *Bluetooth* production test set. It is based on the overwhelmingly successful *CMU200* radio tester.

The Rohde & Schwarz *CMU200* test set can be configured as a standalone *Bluetooth* test solution for production, R&D, service and QA use, and is the fastest signalling tester for *Bluetooth* test modes available. The *CMU200* can also be configured with options for testing major cellular radio standards, if desired. Since many applications in PCs, PDAs and mobile phones mean that some kind of cellular standard is likely to co-exist with *Bluetooth* wireless technology in the same piece of equipment, a *CMU200*-based test solution can test both *Bluetooth* (short range) and cellular standard (longer range) RF functions at the same time using just a single test set.

For users who already own a *CMU200* radio test set, the *CMU-U53* upgrade kit is available to add *Bluetooth* testing functionality. This option is a particularly cost-effective upgrade path offering maximum-throughput testing for the existing very large base of *CMU200* users.

2 Introduction

The signalling and tests on *Bluetooth* wireless technology provided by the *CMU200* largely follow the officially released documents for protocol and radio acceptance testing for *Bluetooth* devices. The RF specification version 0.9 (ref. [1]) and the core specification versions 1.0, 1.0b and 1.1 (ref. [2], [3]) were taken as guides to programming the features *CMU200* supports. For extra ease of use, the *Bluetooth* core specification version implemented on the Equipment Under Test (EUT) is detected by the *CMU200* automatically.

CMU200 is not a conformance test system, but a standalone RF test set. Full compliance with the *Bluetooth* test specifications is not possible for a number of reasons, one of them being that [1] unconditionally prescribes the use of a spectrum analyzer for the measurements.

This document is mainly intended as a guide to configuring the available measurements to achieve test scenarios very close to the relevant *Bluetooth* test specifications. Note that the configurations described are optimized to achieve near-specification testing, which is not necessarily compatible with achieving the maximum test throughput possible.

CMU200 supports *Bluetooth* measurements for:

- Hopping
- Reduced hopping
- Single channel operation

Furthermore, it is possible to operate the EUT in hopping mode while measuring on a single channel.

Tests can be carried out with EUT in *Transmitter Test* or *Loopback* mode. In *Transmitter Test* mode, the *CMU200* commands the EUT to generate and transmit one of the test patterns defined in the *Bluetooth* test specification. In *Loopback* mode, the *CMU200* commands the EUT to close the loop; the test patterns have to be generated by *CMU200*. Data content can be freely chosen from a range of alternatives, including "00001111", "1010", "All-1", "All-0" and PRBS data sequences for the payload part of the chosen packet type. The payload length is configurable between zero and the maximum allowed payload length for the packet type.

The *Loopback* test mode is of the Asynchronous Connection Oriented (ACL) type; it is implemented with and without data whitening.

Supported data packet types are:

- DH1
- DH3
- DH5

Each packet type can be used with any of the provided measurements.

To configure most of the tests, it is necessary to know the *Bluetooth* features an EUT supports, as they influence the test scenario applicable [1]. During the connecting procedure, CMU200 receives information about the EUT and stores a list of the supported features. This list can be displayed and also be read via the remote interface.

For *Bluetooth* the *CMU200* test set measures:

- Transmitter Output Power

- Transmitter Modulation

    Frequency Accuracy / Initial Carrier Frequency

    Frequency Drift, Maximum Drift Rate

    Frequency Deviation

- Receiver Quality

    Reference Sensitivity

    Receiver Maximum Input Level

CMU200 supports the standard inquiry procedure. Alternatively, an EUT's *Bluetooth* Address can be supplied to the *CMU200* before establishing the radio link. *CMU200* does not support the transmitter power density measurement described in [1] 5.1.4. The RF spurious emission and RF transmitter output spectrum measurements defined in the relevant BT test documents cannot be supported, in part due to the frequency range of the *CMU200*. However, the *CMU200* and a suitable spectrum analyzer (such as Rohde & Schwarz FSIQ, FSE or FSP series) ranging up to at least 12.5 GHz can be used in a test setup including a *CMU200*, the EUT, and a suitable directional coupler. With a second RF source, C/I and RF blocking measurements can also be tested.

Although whitening is never used for transmitter tests according to [3] 2.1.1, the *CMU200* supports the use of whitening for R&D on transmitter tests in *Loopback* mode.

3 Transmitter Output Power

CMU200 measures the output power of the Equipment Under Test and shows the result in graphical and numeric form. In addition to the currently measured power values, the average, minimum, and maximum values within a measurement cycle are provided. This cycle can be defined by presetting a counter from 1 to 1000 bursts (packets).

An extension to the comprehensive burst profile measurement suite is the RF leakage power measurement. Moreover, the packet alignment (timing) is displayed numerically. These essential measurements are not described specifically in [1].

Tolerance limits can be specified for the numeric measurement results including the packet alignment. If a measured value exceeds a specified limit, this can be used to halt the running measurement.
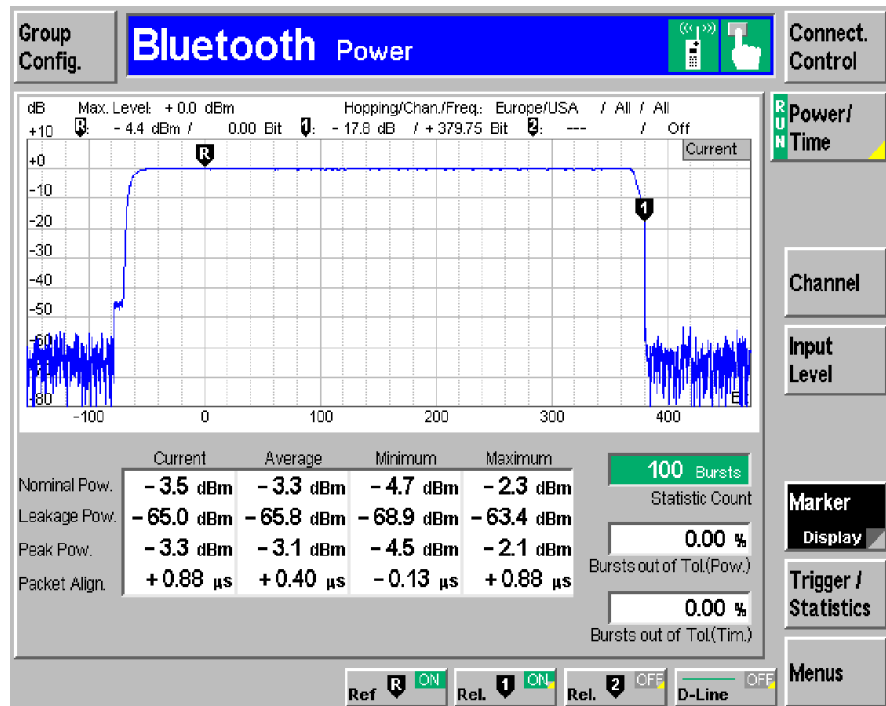

Fig. 1   Bluetooth Power Display

To meet [1] 5.1.3, the EUT has to be in *Loopback* mode, and CMU200 has to transmit a PRBS sequence using the frequency hopping measurement mode. CMU200 also provides the *Transmitter Test* mode, and the measurement modes reduced frequency hopping and hopping off (single frequency).

4 Transmitter Modulation

CMU200 measures and displays the transmitter frequency accuracy, drift, and deviation, and shows the demodulated signal of the EUT versus time. In addition to the currently measured value, the average, minimum, and maximum values within the measurement cycle are provided. This cycle can be set from 1 to 1000 bursts (packets). Upper and lower limits can be defined for all numeric measurement results. If a measured value exceeds a specified limit, this can be used to halt the running measurement.
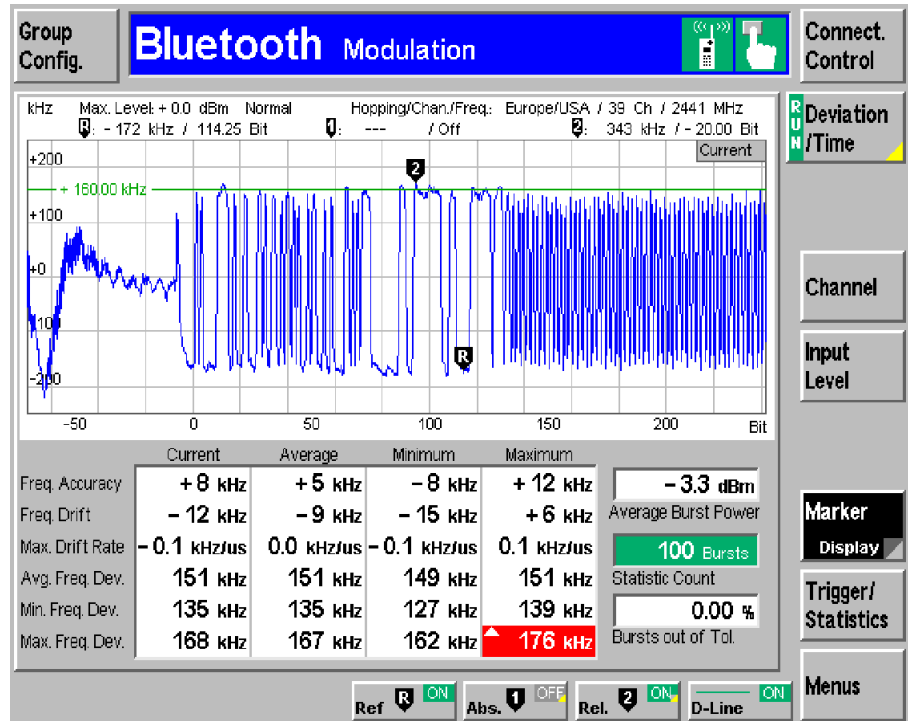

Fig. 2   Bluetooth Modulation Display

Frequency Accuracy / Initial Carrier Frequency

The frequency accuracy stands for the measured initial carrier frequency at the beginning of the packet minus the nominal *Bluetooth* channel frequency, [2] 3.3. To meet [1] 5.1.10, the EUT must be in *Loopback* test mode. CMU200 has to use DH1 packets carrying a PRBS sequence. Both hopping and single frequency operation must be tested.

CMU200 also supports the *Transmitter Test* mode with payload patterns such as 1010 or 11110000 (and DH3 and DH5 packets).

Frequency Drift, Maximum Drift Rate

The frequency drift is defined as the difference between the measured initial carrier frequency at the start of the packet and the average frequency of 10-bit sections in the payload. The maximum drift rate is the maximum frequency difference of two 10-bit sections 50 µs apart from each other ([2] 3.3.).

Select the longest data packet type supported by the EUT. Set the *CMU200* to transmit a "1010" payload pattern. Both non-hopping and single frequency operation must be tested.

Frequency Deviation

CMU200 measures and displays transmitter frequency deviation. If necessary, the GFSK/2FSK modulation index ([2] 3.1) can be calculated from the frequency deviation by the formula:

$$m = 2 * (\text{frequency deviation} / 1 \text{ MHz})$$

To meet [1] 5.1.9, the EUT has to be in *Loopback* mode and frequency hopping must be switched off. This test consists of two parts, each with different payload pattern. Select the "11110000" pattern and the "1010" pattern as payload sequences. Use the highest output power, the longest packet type and the longest data sequence supported by the EUT.

CMU200 also supports hopping mode for this test.

5 Receiver Quality

Receiver Reference Sensitivity

CMU200 measures and displays RF sensitivity for single and multislot packets, [2] 4.1. The value is expressed as a Bit Error Rate (BER).

Up to five programmable test setups with different parameters can be used. An upper limit can be defined for the measurement result. The measurement cycle can be set from 1 to 10000 bursts (packets).

For single slot packets: To meet [1] 5.1.13 but excluding 5.1.13.3c (see 5.1.13.6), the EUT has to be in *Loopback* mode, CMU200 has to transmit DH1 packets containing a PRBS sequence at –70 dBm.

For multislot packets: To meet [1] 5.1.14 but excluding 5.1.14.3c (see 5.1.14.6), the EUT has to be in *Loopback* mode, CMU200 has to transmit DH5 packets (or DH3 packets, if DH5 are not supported by the EUT) containing a PRBS sequence at –70 dBm.

Switch hopping off. Select the highest output power supported by the EUT and averaging in such a way that 1.6 million bits are returned. The test must be carried out at the lowest, a middle, and the highest operating frequency.
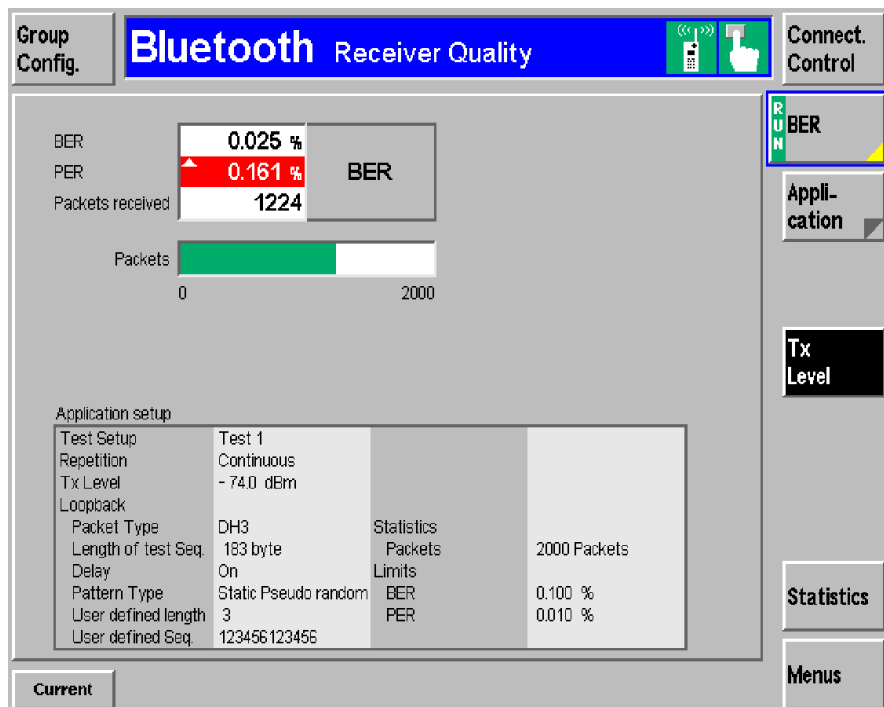

Fig. 3   Bluetooth Receiver Quality Display

As an add-on, *CMU200* measures a continuous BER, displays lost packets (PER) and can fulfil the optional clause [1] 5.1.13.7 / 5.1.14.7 by switching the EUT to hopping mode. A search routine provides an easy way to output the result for *Actual Sensitivity Level,* as defined in [2] 4.1. For production use, throughput can be maximized by also switching *CMU200* to hopping mode.

Receiver Maximum Input Level

CMU200 measures and displays the Bit Error Rate (BER) at –20 dBm power at the receiver input of the EUT [2] 4.5.

To meet [1] 5.1.18, the EUT must be in *Loopback* test mode. CMU200 has to use DH1 packets carrying a PRBS sequence at –20 dBm.

Switch hopping off. Select the highest output power supported by the EUT and averaging in such a way that 1.600.000 bits are returned. The test must be carried out at the lowest, a middle, and the highest operating frequency.

As an add-on, *CMU200* can measure a continuous BER and display lost packets (PER). Also, the high output level of the tester allows increased stress and/or provides a useful reserve to accomplish full compensation from RF path loss, for example RF attenuation due to an air link connection.

6   Additional Notes

BER measurements require at least 1.6 million samples (bits of payload data). For minimum test time, set the length of the test sequence to its maximum value and limit the measurement cycle *(Statistic Count)* to the *Min. No. of Packets* listed in the table below.

Packet Type	Max. Length	Min. No. of Packets
DH1	27 bytes	7408
DH3	183 bytes	1093
DH5	339 bytes	590

All measurements can be made using a wired RF connection or a true air radio link. For an air link between EUT and CMU200, use the sensitive input RF4 IN and the high-power output RF3 OUT instead of the duplex port RF2.

If a measured value exceeds a specified limit, this can be used to halt a running measurement. The limit violation is displayed and can be queried by remote control.

Future releases of the CMU will support modifying the parameters of the signal generated by the CMU, such as the modulation index. This feature is required for measurements relying on a dirty transmitter signal.

7   Summary

CMU200 provides an unsurpassed choice in measurement parameterization for flexibility in Research and Development use, as well as for optimizing test throughput for production. Properly optimized, the *CMU200* can reliably test an EUT in less than five seconds.

For comments and further suggestions, please contact **TM-Applications@rsd.rohde-schwarz.com**.

8 References

[1] *Bluetooth* Test Specification RF, Version 0.9, May 2nd, 2000

[2] *Bluetooth* Specification, Version 1.1, February 22nd, 2001
Part A – Radio Specification

[3] *Bluetooth* Specification, Version 1.1, February 22nd, 2001
Part I:1 – *Bluetooth* Test Mode

9 Ordering information

CMU	Universal Radio Communication Tester	1100.0008.02
CMU-B21	Signalling for CMU	1100.5200.02
CMU-B53	Bluetooth Extension	1100.5700.02
CMU-K53	Software Bluetooth	1115.5000.02
CMU-U53	Bluetooth Upgrade Kit for CMU	1100.7302.02

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