Bluetooth® Low Energy Measurements Using R&S®CBTgo

Additional Tests

Application Note

Products:

- R&S®CBT
- R&S®CBT32
- R&S®CBT-K57
- R&S®CBTgo
- R&S®SMF
- R&S®SMW200A
- R&S®SMU200A
- R&S®SMJ100A
- R&S®SMBV100A
- R&S®SMB
- R&S®SMR

Nearly all tests in accordance with the Bluetooth® low energy test specification V4.0 [1] can be performed using the R&S®CBT alone. Some tests additionally call for signal generators to provide interference signals.

This application note describes the tests performed with additional equipment and presents straightforward solutions based on the R&S®CBTgo software.

Please note that Basic Rate and EDR Measurements are covered in the application note 1MA106.

Application Note

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July 2013 - 1MA200_3e

ROHDE&SCHWARZ

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The following abbreviations are used in this application note for Rohde & Schwarz test equipment:

- The R&S®CBT/CBT32 Bluetooth®1) tester is referred to as the CBT.
- The R&S®CBTgo software is referred to as CBTgo.
- The R&S®SMF microwave signal generator is referred to as the SMF.
- The R&S®SMB100A microwave signal generator is referred to as the SMB.
- The R&S®SMW200A vector signal generator is referred to as the SMW.
- The R&S®SMJ100A vector signal generator is referred to as the SMJ.
- The R&S®SMATE200A vector signal generator is referred to as the SMATE.
- The R&S®SMU200A vector signal generator is referred to as the SMU.
- The R&S®SMBV100A vector signal generator is referred to as the SMBV.
- The R&S®SMR microwave signal generator is referred to as the SMR.

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1 Introduction

In version 4.0 of the Bluetooth specification [1], the low energy (LE) function was introduced. This function addresses devices that, although they have to transmit only small data volumes, must feature very low energy consumption but very long battery runtimes. They are known as button-cell devices such as wristwatches, sensors for sport and personal health monitoring, as well as remote control devices.

The air interface they use (low energy RF – LE RF) is similar to the air interface of the Bluetooth basic rate (V1.1). However, some parameters, such as channel spacing, modulation index and packet structure, are different. In addition, pure transmitter or pure receiver devices are also possible.

Rohde & Schwarz offers the established CBT Bluetooth tester family for RF tests. The tester is available in two versions (CBT, CBT32) and performs qualified RF measurements in line with Bluetooth SIG at an extremely high speed. Equipped with the CBT-K57 software option, it also supports the low energy tests.

In addition, Rohde & Schwarz provides the free-of-charge CBTgo PC software for controlling the CBT. Using CBTgo, you can conveniently create any desired test sequences by configuring and combining selectable test modules. CBTgo offers a number of sample sequences, e.g. for automatically performing the various Bluetooth RF test cases.

Some tests require, besides the CBT, additional instruments such as signal generators. This application note describes how to perform these tests using CBTgo.

2 General

2.1 Bluetooth Low Energy (BLE) Parameter

On the air interface BLE is similar to the basic rate and therefore offers data rates of 1 Msymbol/s using GFSK modulation. Unlike the basic rate, it uses a modulation index of 0.5, which results in a frequency deviation of 250 kHz. In addition, in the ISM band only 40 channels with a spacing of 2 MHz are defined. The level range is the same as that of the normal Bluetooth; to save energy, the usual transmit levels are at 0 dBm.

A special test packet has been defined for the RF tests. The length of the payload (and therefore the length of the test packet) may vary, depending on the test. With the maximum payload length of 37 byte, the complete packet has a length of 376 bit and thus a duration of 376 µs.

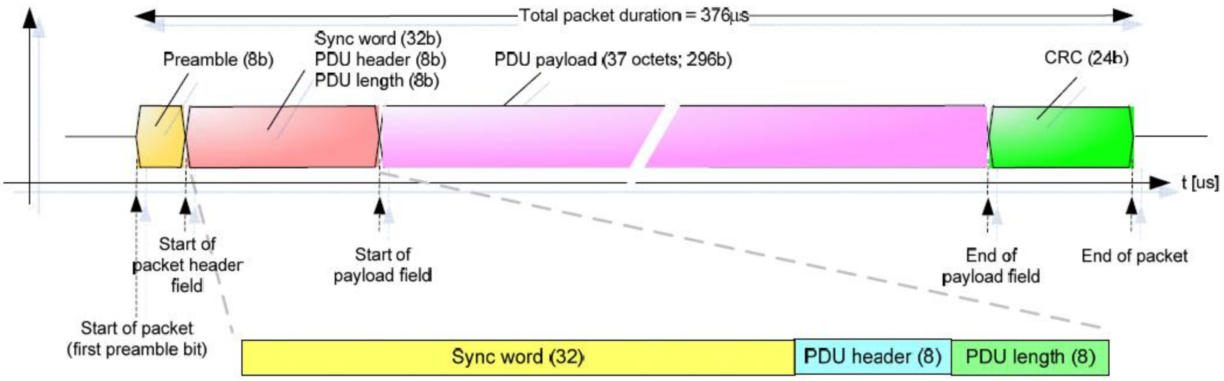

Fig. 1: Overview of the LE test packet [1]. The length of the PDU payload may vary depending on the test.

The individual tests are defined in accordance with [1] (Table 1 and Table 2). All tests can be performed using the CBT and CBTgo. This application note discusses the receiver tests marked in green. NOC stands for normal operating conditions and EOC for extreme operating conditions.

Transmitter tests (TRM-LE)		
Test	**Designation**	**Section**
Output power at NOC	TRM/CA-01-C	6.2.1
Output power at EOC	TRM/CA-02-C	6.2.2
In-band emissions at NOC	TRM/CA-03-C	6.2.3
In-band emissions at EOC	TRM/CA-04-C	6.2.4
Modulation characteristics	TRM/CA-05-C	6.2.5
Carrier frequency offset and drift at NOC	TRM/CA-06-C	6.2.6
Carrier frequency offset and drift at EOC	TRM/CA-07-C	6.2.7

Table 1: Overview of LE transmitter tests.

Receiver tests (RCV-LE)		
Test	**Designation**	**Section**
Receiver sensitivity at NOC	RCV/CA-01-C	6.3.1
Receiver sensitivity at EOC	RCV/CA-02-C	6.3.2
C/I and receiver selectivity performance	RCV/CA-03-C	6.3.3
Blocking performance	RCV/CA-04-C	6.3.4
Intermodulation performance	RCV/CA-05-C	6.3.5
Maximum input signal level	RCV/CA-06-C	6.3.6
PER report integrity	RCV/CA-07-C	6.3.7

Table 2: Overview of LE receiver tests.

Direct test mode
Low energy tests are performed in a direct test mode; an RF connection is not made. In the test, the DUT is put into the direct test mode via a local serial interface. Test commands such as the frequency to be tested or reading out the properly received packets during RX tests run via an external interface. The CBT can send these commands via RS-232-C (COM port).

2.2 CBTgo

CBTgo is a PC software application for remote control of the CBT. The software can be downloaded free-of-charge from the Rohde & Schwarz website. Using CBTgo, you can conveniently create any desired test sequences by configuring and combining selectable test modules. This requires no knowledge of remote programming. The software generates measurement reports at the press of a button. Reports can be stored in various formats.

CBTgo offers a number of sample sequences, e.g. for automatically performing the various Bluetooth RF test cases. Reports of remote commands can also be output, stating the times of the individual steps, and such reports can be copied to the Windows clipboard for further use. The software allows a large number of graphical elements to be integrated into the measurement report and is thus a valuable tool in R&D and product verification.

2.2.1 PC Hardware and Software Requirements

Hardware requirements
- CPU: at least 300 MHz
- RAM: at least 64 Mbyte
- Monitor: SVGA with 800 x 600 pixels or higher
- Hard disk: 50 Mbyte available space
- Peripherals: National Instruments GPIB-bus or RS-232-C interface, mouse

Software requirements
- Windows 98/ME/2000/XP/7
- CBTgo V2.2.0 with V2.2.0 Bluetooth modules or later

2.2.2 Operation of CBTgo

Please refer to the CBTgo manual [2] for information on how to connect the computer with the CBT, as well as how to install, start and operate CBTgo.

2.2.2.1 Preparing for Operation

Setting the GPIB parameters in CBTgo

The GPIB parameters of the CBT can be set via CONFIGURATION|REMOTE PORT. CBTgo uses auxiliary channels in order to communicate with additional devices.
To configure an additional device, open the **Configuration** menu (Fig. 2) and select an *Auxiliary GPIB Port*. A window with further parameters will open (Fig. 3).

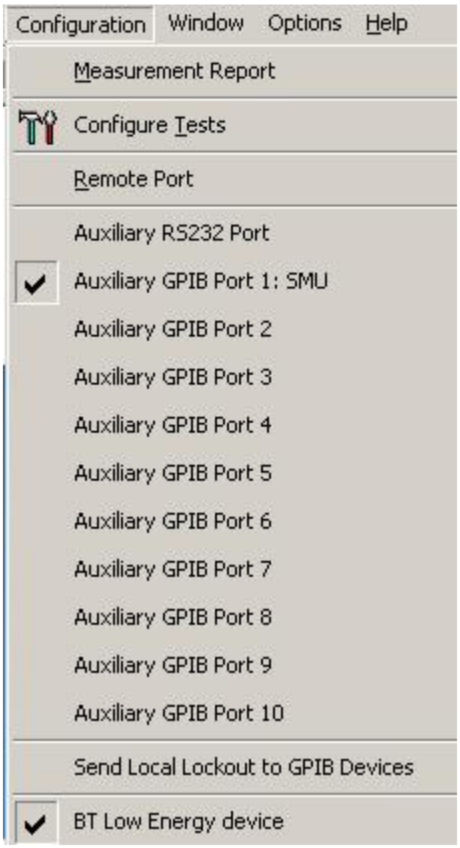

Fig. 2: Configuration menu of CBTgo. Set the auxiliary port and the BT Low Energy device mode.

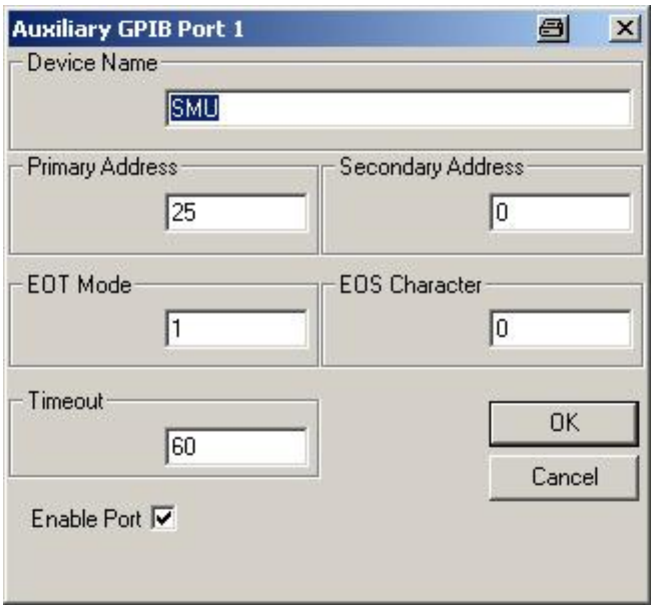

Fig. 3: Auxiliary GPIB Port x.

The device name entered under *Auxiliary GPIB Port x* must be identical to the name entered in the Bluetooth modules for the individual tests. The usual GPIB parameters can be set. Note that *Enable Port* must be enabled.

Setting the reference frequency in CBTgo

Via the *Basic Initializing* module, the CBT can be synchronized with other equipment using a 10 MHz clock signal. For this purpose, enable *External 10 MHz Reference* (Fig. 6), and connect a BNC cable between the REF OUT output of a generator/analyzer and the REF IN socket of the CBT.

Setting the LE device mode in CBTgo

In low energy mode, the individual Bluetooth products are not controlled via signaling but rather must be controlled directly via an interface. To make the settings for this, select *BT Low Energy Device* in the CBTgo *Configuration* menu (see Fig. 4 and Fig. 5).

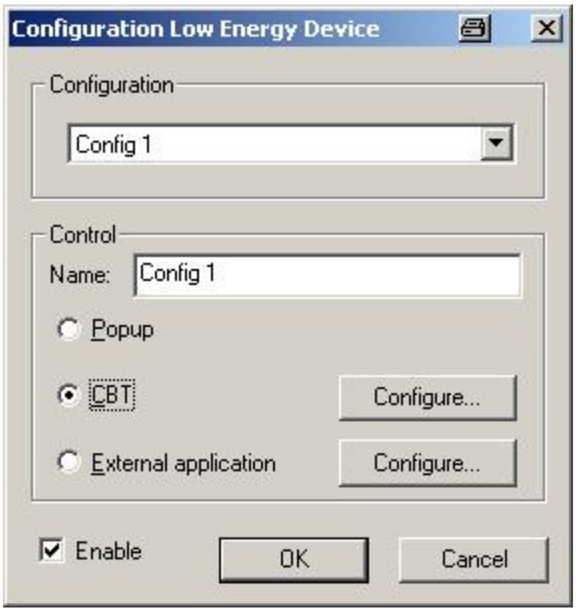

Fig. 4: Setting the LE device mode.

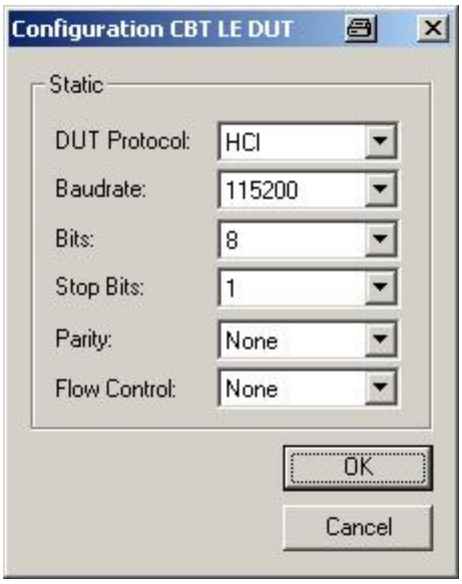

Fig. 5: Configuration CBT LE DUT interface.

Measuring the attenuation values

To obtain correct results, the attenuation between the CBT and the DUT must be measured and entered into the *BT Call Setup* module. Likewise, the attenuation between the DUT and the signal generator(s) and/or the spectrum analyzer must be measured and entered into the appropriate module(s).

Rohde & Schwarz also offers the free-of-charge **FreRes** software which allows you to record the frequency response. It is available under http://www.rohde-schwarz.com/appnote/1MA09

2.2.2.2 Required Standard CBTgo Modules

For proper operation, all new modules presented here require other CBTgo modules. For these basic modules, detailed descriptions already exist (see [3]); therefore, only the main settings will be described in this document.

Each test sequence requires the **Basic Initializing** and the **BT Low Energy Connection Setup** modules.

Basic Initializing must be the first module of every sequence. Please enable the *Bluetooth Low Energy* function group here.

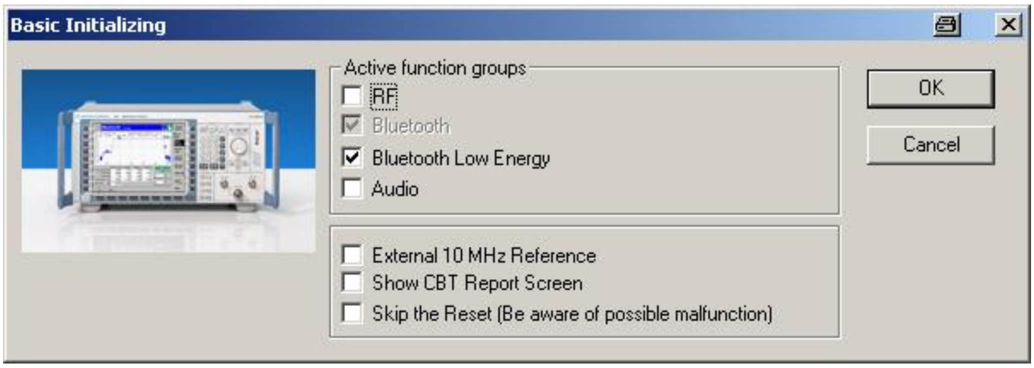

Fig. 6: Basic Initializing module.

The *Bluetooth LE Connection Setup* module is required at the start of each Bluetooth low energy test sequence (after *Basic Initializing*). The main parameters for setting up a connection to a Bluetooth low energy device are set in this module.

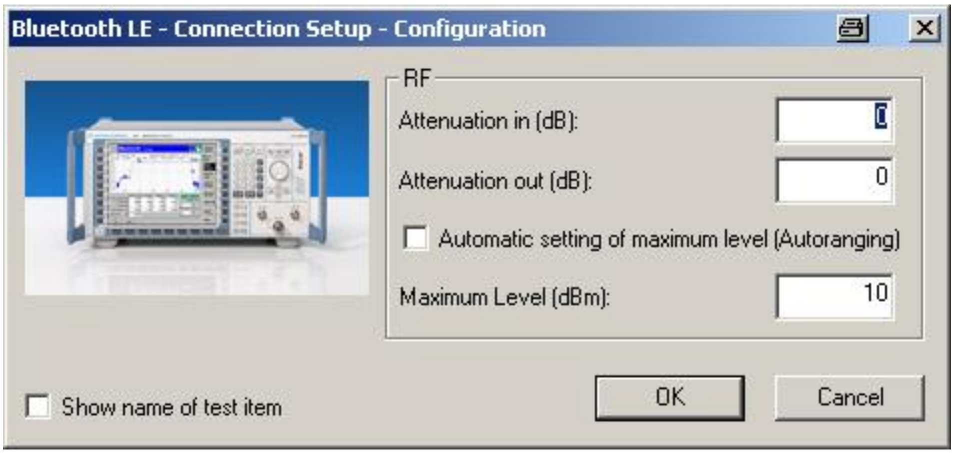

Fig. 7: Bluetooth low energy connection setup.

Besides the attenuation parameters, you can either set the *Autoranging* mode or enter a maximum level manually.

3 Stipulated Measurements

3.1 C/I and Receiver Selectivity Performance (RCV-LE/CA/03/C)

This test verifies the receiver performance of the DUT in presence of a Bluetooth co-/adjacent channel interferer within the Bluetooth band. The result is obtained by means of a packet error rate (PER) measurement.

The wanted signal is transmitted on a single channel in non-hopping mode. A Bluetooth interferer is likewise generated on a single channel, coupled in, and the PER is determined. In the next step, the Bluetooth interferer is generated on all channels one after the other, and the PER is measured for each interferer channel. The complete test sequence is repeated twice, i.e. the PER measurement is performed with the wanted signal on three channels in total (Fig. 8).

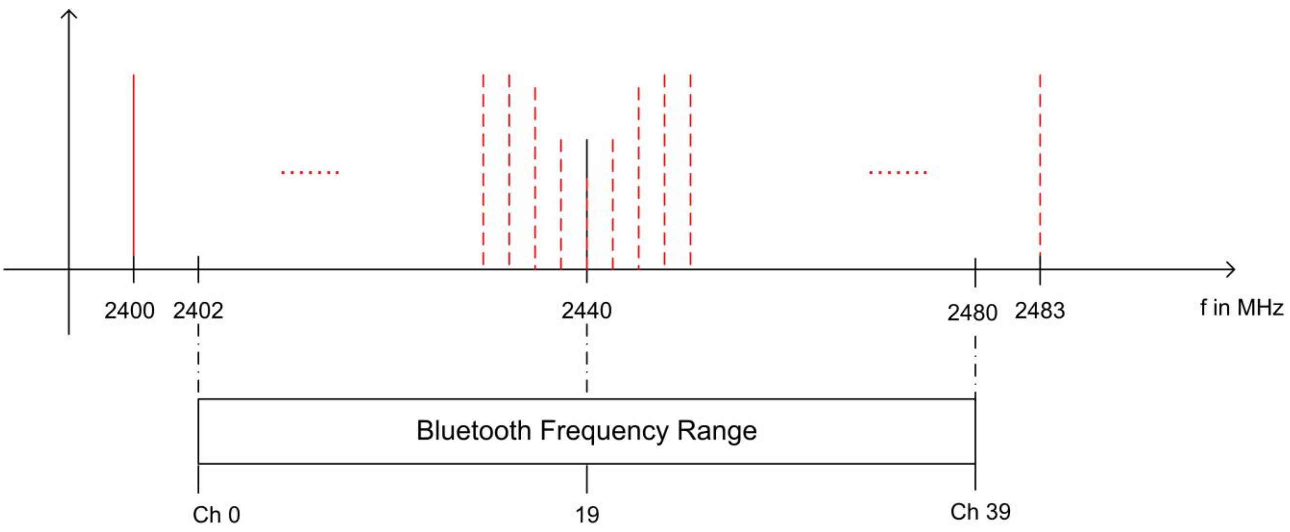

Fig. 8: C/I performance: For the three individual channels, the packet error rate in the presence of a Bluetooth interferer inside the Bluetooth band is measured. The measurement is repeated after shifting the interferer by 1 MHz.

The Bluetooth test specification defines the following settings:

- DUT in direct RX mode
- Hopping off (RX on single channel)
- Three channels (0, 19, 39)
- Test packets with 37 octet PRBS9 payload
- Interferer: GFSK (modulation index 0.5) with PRBS15 on all Bluetooth channels in consecutive order
- 1500 packets
- Wanted input level at EUT: –67 dBm

For levels see Table 3.

C/I level settings			
Interference signal frequency	**Interferer level (abs)**	**C/I level**	**Wanted signal (abs)**
Co-channel $(f_{RX} = f_{Interference})$	–88 dBm	21 dB	–67 dBm
Adjacent channel $(f_{Interference} = f_{RX} \pm 1\text{ MHz})$	–82 dBm	15 dB	–67 dBm
Adjacent channel $(f_{Interference} = f_{RX} \pm 2\text{ MHz})$	–50 dBm	–17 dB	–67 dBm
Adjacent channel $(f_{Interference} = f_{RX} \pm (3 + n)\text{ MHz})$	–40 dBm	–27 dB	–67 dBm
Image frequency $(f_{Interference} = f_{Image})$	–58 dBm	–9 dB	–67 dBm
Adjacent channel to image frequency $(f_{Interference} = f_{Image} \pm 1\text{ MHz})$	–52 dBm	–15 dB	–67 dBm

Table 3: C/I and receiver selectivity test parameter settings [1].

Results:

- For all measurements, the PER must be better than 30.8 % for a minimum of 1500 packets
- For each of the three wanted channels, the PER may exceed 30.8 % for five interferer frequencies spaced ≥ 2 MHz from the carrier and spaced ≥ 1 MHz from the image frequency
- For the interferer frequencies (max. five) at which the PER limit is exceeded, the PER is measured in a second test run with a relaxed C/I of –17 dB. The PER limit is again 30.8 %

Test setup

Fig. 9 shows a typical test setup. The CBT and the DUT are connected to each other by a combiner via which the interference signal from a Bluetooth generator is coupled in. If the DUT transmits at high power levels, an attenuator may be inserted to protect the generator.

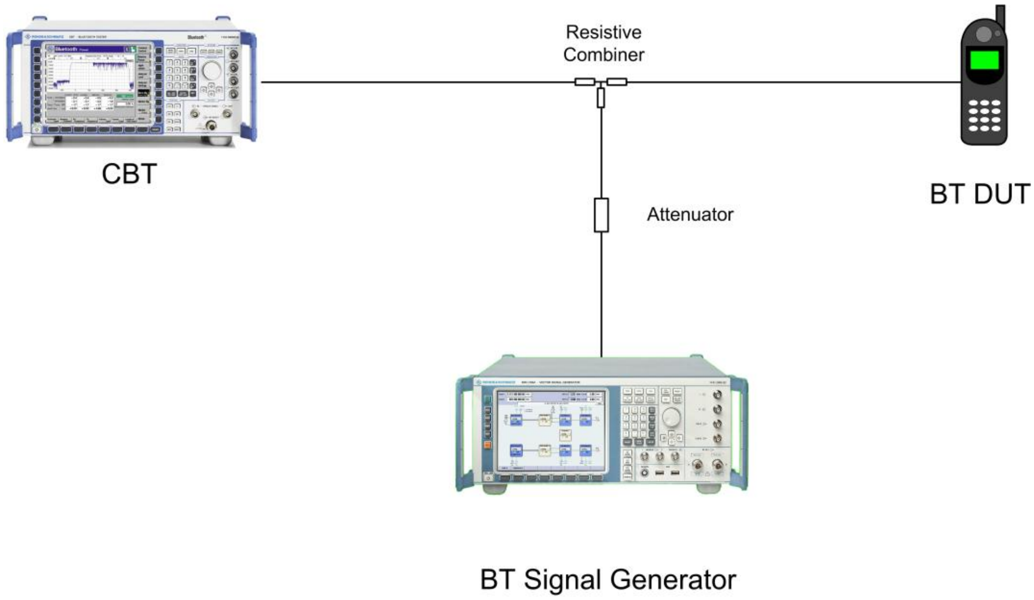

Fig. 9: Test setup for C/I performance measurement.

Measuring equipment and accessories

- CBT tester, SMx (SMU, SMJ, SMATE, SMBV) signal generator
- Resistive combiner: up to 2.5 GHz (e.g. Weinschel 1515 1)
- Attenuator: up to 2.5 GHz (e.g. Suhner)

The measurement is performed using the BT LE C/I Performance module in CBTgo (Fig. 10).

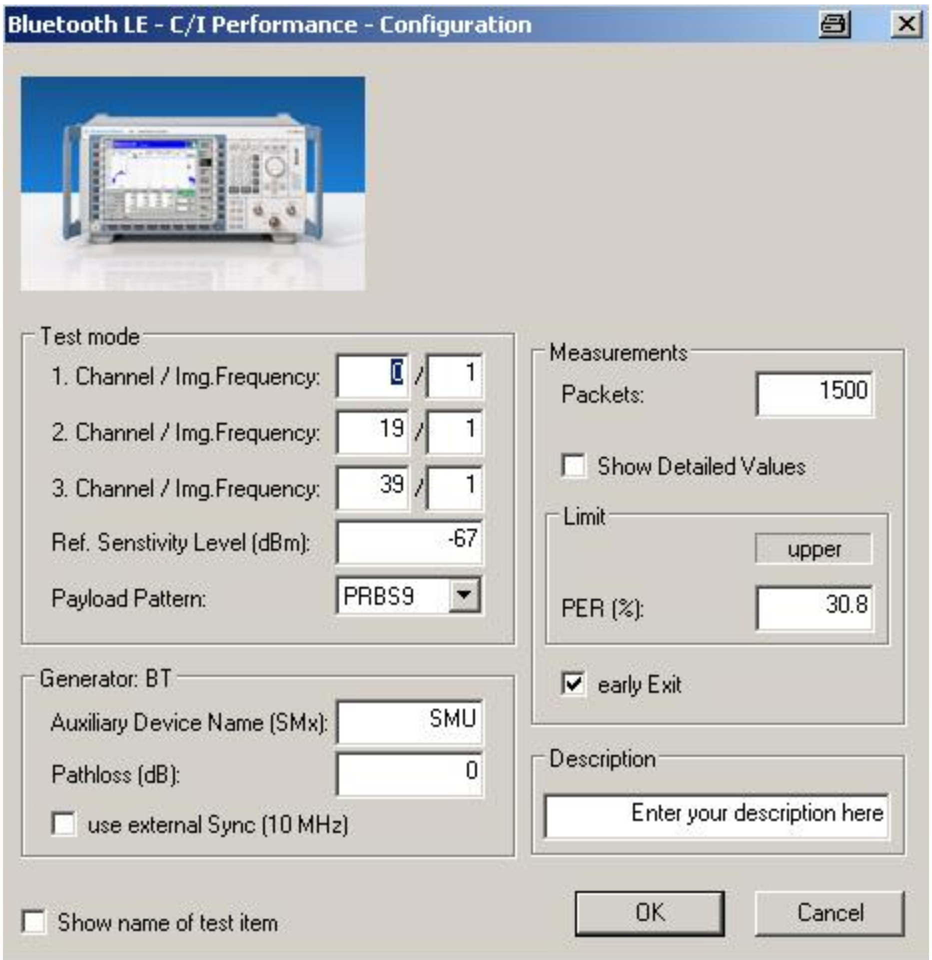

Fig. 10: BT Low Energy C/I Performance module in CBTgo.

Under **Test mode**, you can select the test packet payload type and the three RX channels with different manufacturer-specific Image frequencies in Megahertz. The reference sensitivity is according to the specification –67 dBm (see Table 3).

Under **Generator BT**, the auxiliary device name is to be entered. The name must be identical to that entered for *Auxiliary GPIB Port x* in the **Configuration** menu. Moreover, the path loss between the generator and the DUT can be entered.

Under **Measurements**, you can enter the PER limit and the number of packets. If *Early Exit* is enabled, the measurement is exited if more then five spurious frequencies are detected. You can show all measurement values with enabling *Show detailed Values*.

The different levels are set automatically for measurements on the image-frequency channel (see Table 3). The default settings comply with the test specification. CBTgo automatically performs the test on the three channels with the selected generator settings.

In the first test run, all frequencies with a PER above the set limit are determined and displayed. In the second test run, which is also performed automatically, the DUT's performance at these frequencies is retested with a C/I of –17 dB. This only takes place for a maximum of five interference frequencies that are not:

- Co-channel
- Adjacent channel ± 1 MHz
- Image frequency
- Adjacent channel to image frequency

With the settings in compliance with the test specification, the measurement time is at least four minutes (approx. 1 second per PER measurement × 79 interferer channels × three wanted channels).

Fig. 11 shows a typical C/I performance test report.

Reference Sensitivity Level: -67.0 dBm, Packets: 1500, Payload: PRBS 9, Length: 37 Bytes, allowed Exceptions: 5/Ch.

Generator (BT): SMU, Pathloss: 0.00 dB, Interferer: GFSK, PRBS15

Channel: 00, Image frequency: 01 MHz

PER *Interferer Freq: 2450 MHz, C/I: -27 dB*		30.80 %	55.80 %	–
PER *Interferer Freq: 2451 MHz, C/I: -27 dB*		30.80 %	41.29 %	–
PER *Interferer Freq: 2452 MHz, C/I: -27 dB*		30.80 %	46.38 %	–
03 spurious frequencies detected! *(refer to 2nd run)*			passed	✔

Channel: 19, Image frequency: 01 MHz

No spurious frequencies detected!			passed	✔

Channel: 39, Image frequency: 01 MHz

PER *Interferer Freq: 2456 MHz, C/I: -27 dB*		30.80 %	41.12 %	–
PER *Interferer Freq: 2457 MHz, C/I: -27 dB*		30.80 %	70.66 %	–
PER *Interferer Freq: 2458 MHz, C/I: -27 dB*		30.80 %	90.85 %	–
PER *Interferer Freq: 2459 MHz, C/I: -27 dB*		30.80 %	93.88 %	–
04 spurious frequencies detected! *(refer to 2nd run)*			passed	✔

2nd run: Channel: 00 with 03 freq.

PER *Interferer Freq: 2450 MHz, C/I: -17 dB*		30.80 %	18.93 %	✔
PER *Interferer Freq: 2451 MHz, C/I: -17 dB*		30.80 %	22.41 %	✔
PER *Interferer Freq: 2452 MHz, C/I: -17 dB*		30.80 %	1.33 %	✔
No spurious frequencies detected!			passed	✔

2nd run: Channel: 39 with 04 freq.

PER *Interferer Freq: 2456 MHz, C/I: -17 dB*		30.80 %	20.57 %	✔
PER *Interferer Freq: 2457 MHz, C/I: -17 dB*		30.80 %	30.08 %	✔
PER *Interferer Freq: 2458 MHz, C/I: -17 dB*		30.80 %	9.70 %	✔
PER *Interferer Freq: 2459 MHz, C/I: -17 dB*		30.80 %	17.53 %	✔
No spurious frequencies detected!			passed	✔

Fig. 11: C/I performance test reports. CBTgo shows the measurement results at the detected spurious frequencies and a summary. The repeated measurements with relaxed conditions is also shown.

3.2 Blocking Performance (RCV-LE/CA/04/C)

This measurement determines the receiver quality of the DUT if a continuous-wave (CW) interferer is present outside the Bluetooth band. The result is obtained by means of a packet error rate (PER) measurement.
The wanted signal is transmitted on a single channel in non-hopping mode. A CW interferer is likewise generated on a single channel, coupled in, and the BER is determined. In the next step, the CW interferer is generated at intervals in consecutive order over a specific frequency range, and the PER is determined for each interferer frequency (Fig. 12).

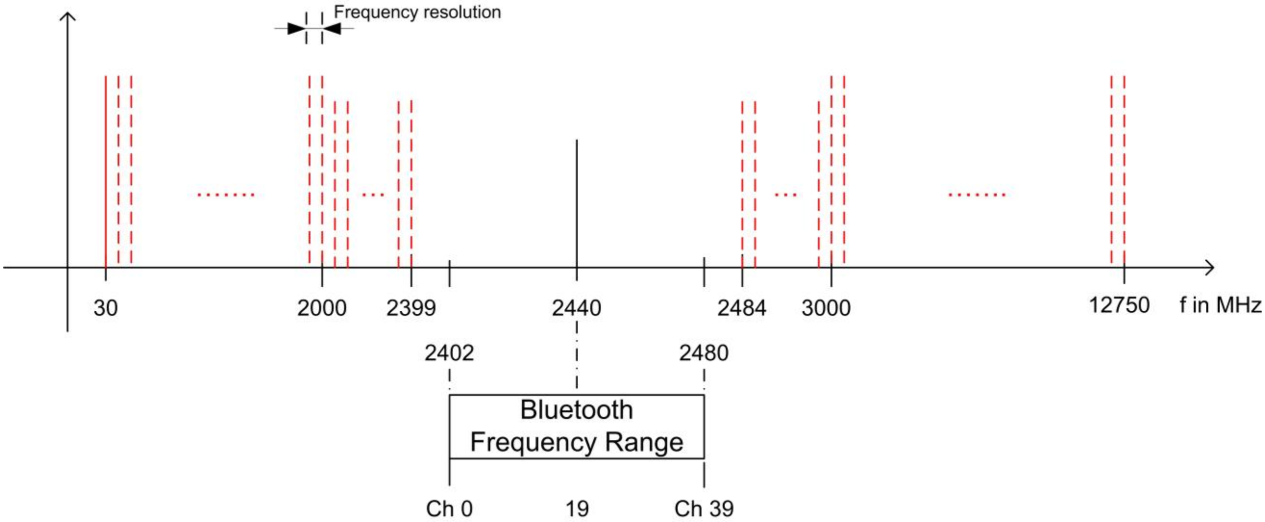

Fig. 12: Blocking performance: For one channel, the packet error rate in the presence of a CW interferer outside the Bluetooth band is measured. The measurement is repeated after shifting the interferer by the frequency resolution.

The Bluetooth test specification defines the following settings:

- DUT in direct RX mode
- Hopping off (RX on single channel)
- One channel (19)
- Test packets with 37 octet PRBS9 payload
- Interferer: CW signal; for levels and frequency ranges, see Table 4
- 1500 packets
- Wanted input level at EUT: –67 dBm

Blocking level settings			
Interference signal frequency	**Wanted signal level**	**Blocking signal level**	**Frequency resolution**
30 MHz to 2000 MHz	–67 dBm	–30 dBm	10 MHz
2003 MHz to 2399 MHz	–67 dBm	–35 dBm	3 MHz
2484 MHz to 2997 MHz	–67 dBm	–35 dBm	3 MHz
3000 MHz to 12.75 GHz	–67 dBm	–30 dBm	25 MHz

Table 4: Blocking performance parameters, first test run.

Results:

- 1st test run: At each interferer frequency, 1500 packets are measured. The frequencies at which a PER > 30.8 % is obtained are recorded**.** The number of frequencies recorded here must not exceed ten
- 2nd test run: At each frequency recorded during the 1st test run, 1500 packets are measured at reduced interferer levels of –50 dBm. The frequencies at which a PER > 30.8 % is obtained are again recorded. The PER limit may be exceeded for a maximum of three frequencies

Test setup

Fig. 13 shows a typical test setup. The CBT and the DUT are connected to each other by a combiner via which the interference signal from a CW generator is coupled in. If the DUT transmits at high power levels, an attenuator may be inserted to protect the generator.

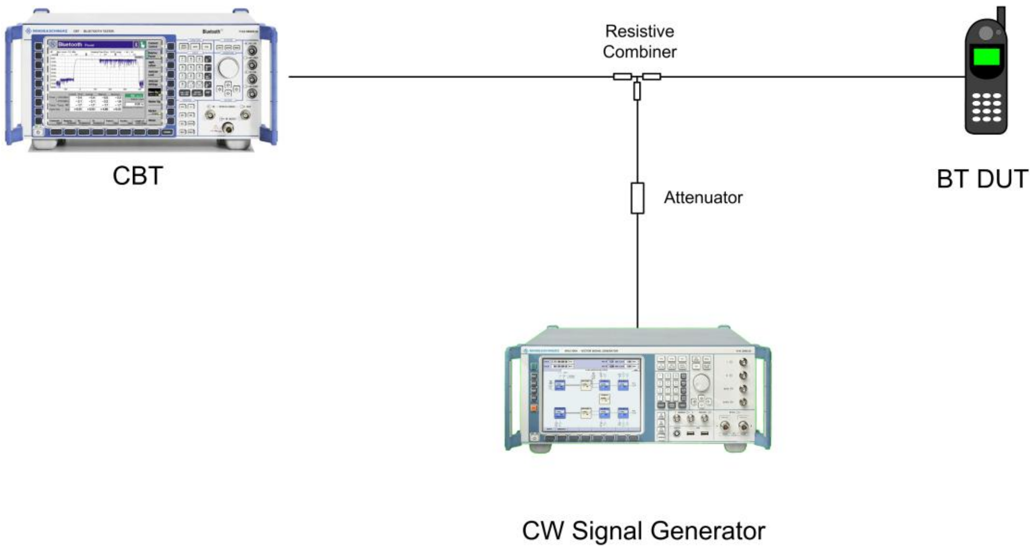

Fig. 13: Test setup for blocking performance measurement.

Measuring equipment and accessories

- CBT tester, SMx (SMF, SMB, SMR) generator up to 12.75 GHz
- Resistive combiner: up to 12.75 GHz (e.g. Weinschel 1515 1)
- Attenuator: up to 12.75 GHz (e.g. Suhner)

The measurement is performed using the *BT Low Energy Blocking Performance* module in CBTgo (Fig. 14).

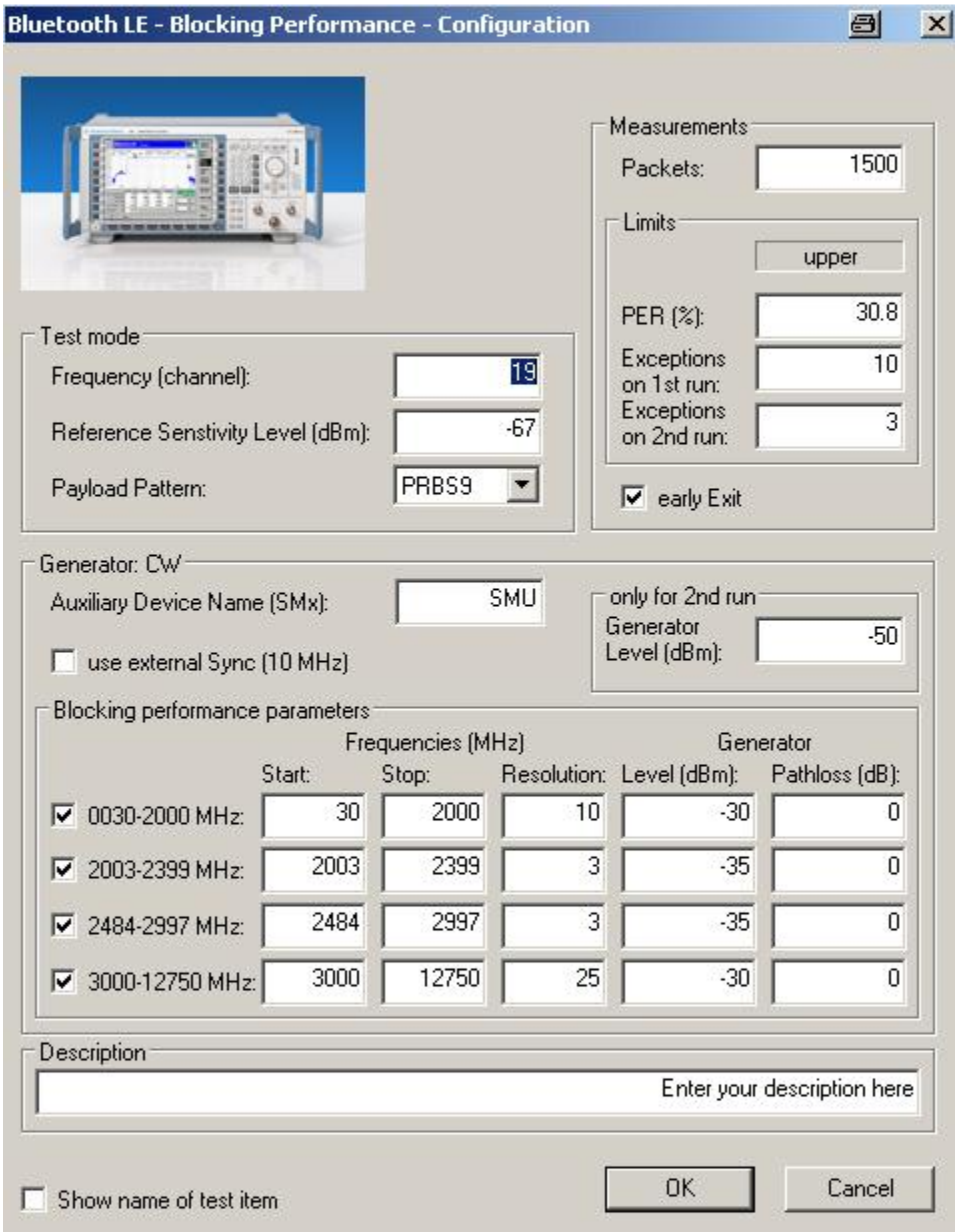

Fig. 14: CBTgo BT Low Energy Blocking Performance module.

Under **Test mode**, you can select the test packet payload type. The RX frequency of the measurement channel can be set. The reference sensitivity level can be modified as required. According to the specification, this must be –67 dBm.

Under **Generator CW**, the auxiliary device name is to be entered. The name must be identical to that entered for Auxiliary GPIB Port x in the Configuration menu. Moreover, the path loss between the generator and the DUT can be set. Under Blocking performance parameters the generator level as well as a start and a stop frequency can be entered in four columns. In addition, you can enter the measurement frequency resolution. The default settings are the four ranges according to the specification (see Table 4).

Under **Measurements**, you can enter the PER limit, the number of packets and the allowed exceptions for the two runs separately. If *Early Exit* is enabled, the measurement is exited if more then ten spurious frequencies are detected. CBTgo automatically performs the test using the selected generator settings.

With the settings in compliance with the test specification, the measurement time is at least 15 minutes (1 s per PER measurement × approx. 890 interferer channels in the 1st test run).

Fig. 15 shows a typical entry in the test report.

TX Level: -67.0 dBm, Packets: 1500, Payload: PRBS 9, Length: 37 Bytes, RX Channel: 19

Generator (CW): SMU, Pathloss: 0.00 dB, allowed Exceptions: 10

Start Frequency: 30 MHz, Stop Frequency: 2000 MHz, Generator Level: -30.0 dBm, Frequency resolution: 10 MHz

Correct Packets			101.75	
PER *Interferer Frequency: 1140 MHz*		30.80 %	93.22 %	–
Correct Packets			370.63	
PER *Interferer Frequency: 1623 MHz*		30.80 %	75.29 %	–
02 spurious frequencies detected!			passed	✔

Start Frequency: 2003 MHz, Stop Frequency: 2399 MHz, Generator Level: -35.0 dBm, Frequency resolution: 3 MHz

Correct Packets			919.01	
PER *Interferer Frequency: 2193 MHz*		30.80 %	38.73 %	–
01 spurious frequency detected!			passed	✔

Start Frequency: 2484 MHz, Stop Frequency: 2997 MHz, Generator Level: -35.0 dBm, Frequency resolution: 3 MHz

Correct Packets			590.41	
PER *Interferer Frequency: 2943 MHz*		30.80 %	60.64 %	–
Correct Packets			1251.98	
PER *Interferer Frequency: 2867 MHz*		30.80 %	16.53 %	–
Correct Packets			343.75	
PER *Interferer Frequency: 2924 MHz*		30.80 %	77.08 %	–
Correct Packets			1094.70	
PER *Interferer Frequency: 2747 MHz*		30.80 %	27.02 %	–
04 spurious frequencies detected!			passed	✔

Start Frequency: 3000 MHz, Stop Frequency: 12750 MHz, Generator Level: -30.0 dBm, Frequency resolution: 25 MHz

No spurious frequencies detected!			passed	✔

2nd run with 07 frequencies: Generator Level: -50.0 dBm, Pathloss: 0.00 dB, allowed Exceptions: 3

Correct Packets			1307.35	
PER *Interferer Frequency: 1140 MHz*		30.80 %	12.84 %	✔
Correct Packets			1419.20	
PER *Interferer Frequency: 1623 MHz*		30.80 %	5.39 %	✔
Correct Packets			1389.63	
PER *Interferer Frequency: 2193 MHz*		30.80 %	7.36 %	✔
Correct Packets			1283.96	
PER *Interferer Frequency: 2943 MHz*		30.80 %	14.40 %	✔
Correct Packets			1367.99	
PER *Interferer Frequency: 2867 MHz*		30.80 %	8.80 %	✔
Correct Packets			1360.80	
PER *Interferer Frequency: 2924 MHz*		30.80 %	9.28 %	✔
Correct Packets			1042.44	
PER *Interferer Frequency: 2747 MHz*		30.80 %	30.50 %	✔

Fig. 15: Blocking performance test report. CBTgo shows the measurement results at the detected spurious frequencies and a summary for the different sections. The repeated measurements with relaxed conditions are also shown.

3.3 Intermodulation Performance (RCV-LE/CA/05/C)

This measurement verifies the intermodulation performance of the DUT's receiver. A PER measurement is performed using two interferers that cause intermodulation at the DUT's receive frequency.

The wanted signal is transmitted on a single channel in non-hopping mode. A CW interferer spaced +n MHz and a Bluetooth interferer spaced +2n MHz from the wanted signal are generated, coupled in, and the PER is determined. The measurement is then performed with the interferers at –n MHz and –2n MHz. The two measurements are repeated on two more wanted channels (Fig. 16).

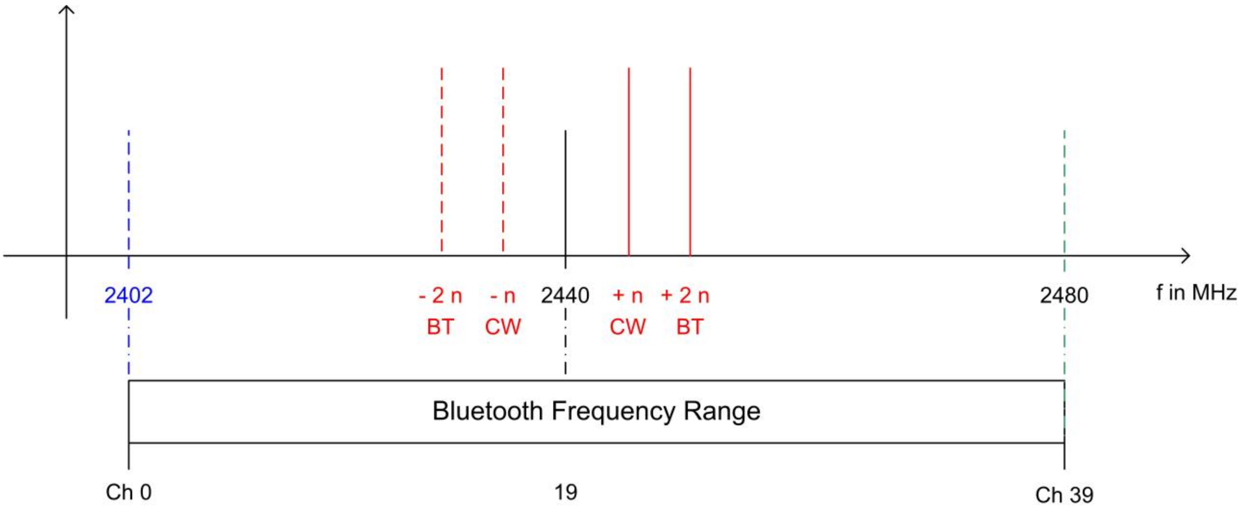

Fig. 16: Intermodulation performance: For each of three channels, the packet error rate in the presence of a CW interferer in a distance n and in the presence of a Bluetooth interferer in a distance 2n is measured.

The Bluetooth test specification defines the following settings:

- Hopping off (RX on single channel)
- Three channels (0, 19, 39)
- PRBS9
- Wanted signal level at –64 dBm
- n = 3, 4 or 5 (defined by manufacturer)
- Bluetooth interferer: low energy GFSK with PRBS15 spaced ±2n MHz from wanted signal, level –50 dBm
- CW interferer: spaced ±n MHz from wanted signal, level –50 dBm
- 1500 packets

Result:

- A PER of 30.8 % must be obtained for each of the three channels

Test setup

The two interferer signals required in this measurement are supplied via two generator paths that are combined via a hybrid combiner. The resulting signal is coupled into the line connecting the CBT and the DUT via a second hybrid combiner. If a dual-channel SMU is used, one generator is sufficient (Fig. 17), otherwise two generators are required (Fig. 18).

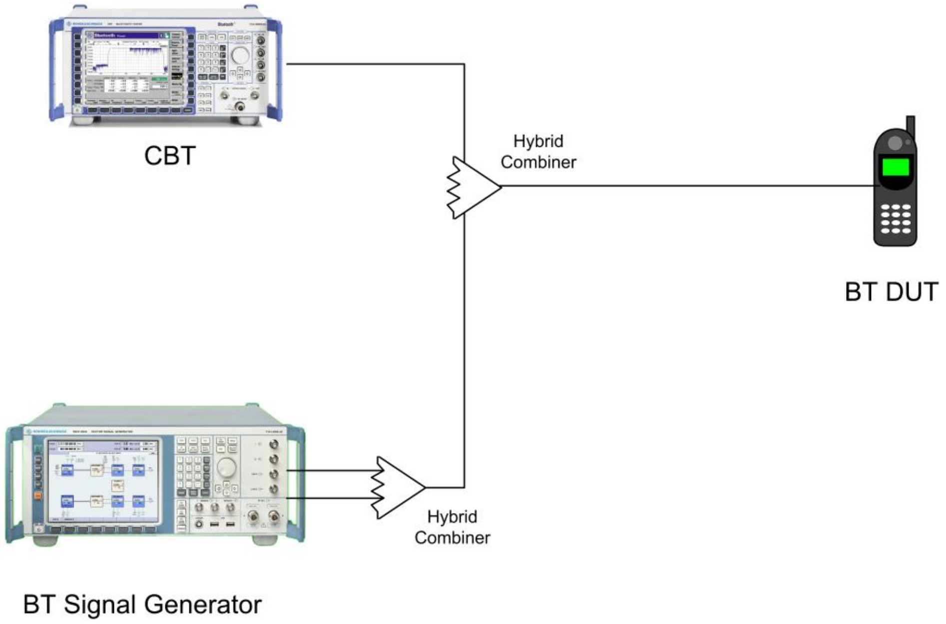

Fig. 17: Test setup 1 for intermodulation performance measurement using one generator.

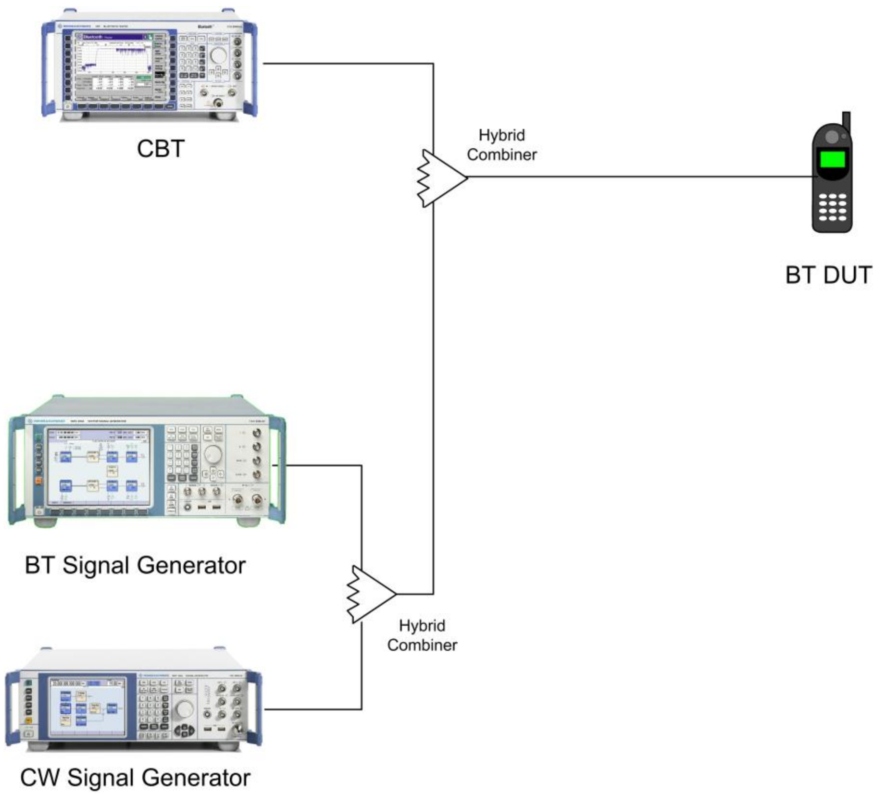

Fig. 18: Test setup 2 for intermodulation performance using two generators.

Measuring equipment and accessories

- CBT tester, SMU or SMJ + SMF or SMB or SMR signal generators
- Two hybrid combiners (e.g. Minicircuits ZFSC 2 2500)

The measurement is performed using the *BT Low Energy Intermodulation Performance* module in CBTgo (Fig. 19).

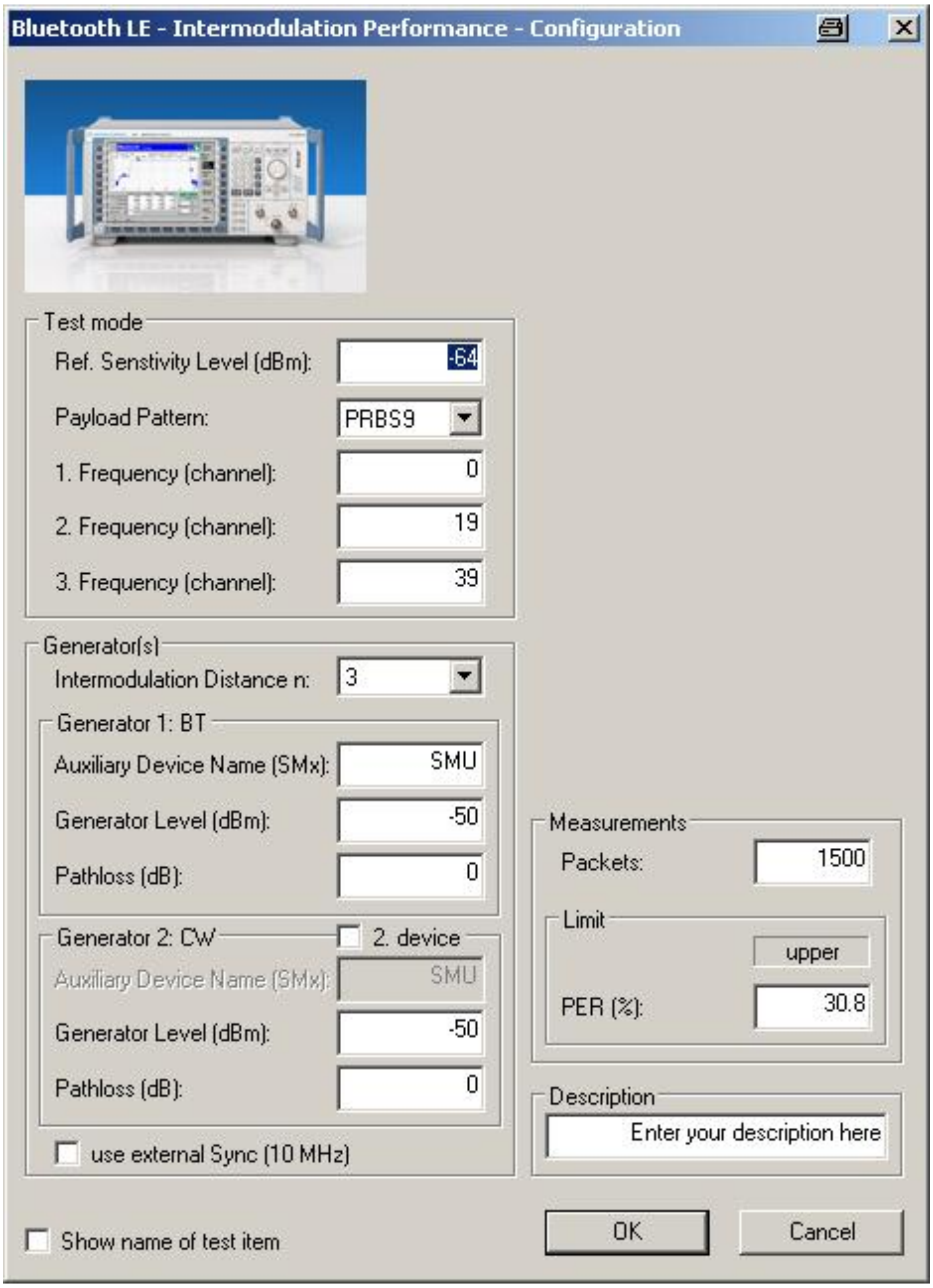

Fig. 19: CBTgo BT Low Energy Intermodulation Performance module.

Under **Test Mode**, you can select the test packet payload type. The RX frequencies of the three channels can be set. The reference sensitivity level can be modified as required. According to the specification, this must be – 64 dBm.

Under **Generator 1** and **Generator 2**, the auxiliary device name is to be entered. The name must be identical to that entered for Auxiliary GPIB Port x in the Configuration menu. The intermodulation distance **n** (spacing from wanted signal) must be selected. Moreover, the path loss between the generator and the DUT as well as the interference level can be entered for each generator. A second generator can be included in the test setup if the first generator does not offer dual-channel capability.

Under **Measurements**, you can enter the PER limit and the number of packets. The default settings comply with the test specification.

CBTgo automatically performs the test on the three channels using the selected generator settings.

Fig. 20 shows a typical entry in the test report.

TX Level: -64 dBm, Bursts: 1500; Payload: PRBS 9, Length: 37 Bytes

Generator: SMU, Level: -50.00, Pathloss: 0.00 dB, Interferer: GFSK, PRBS15, Distance n= 3

Generator: SMU, Level: -50.00, Pathloss: 0.00 dB, Interferer: CW

Channel: 0, 2402 MHz			
Correct Packets		1424.00	
PER *Interferer BT / CW (MHz): 2396 , 2399*	30.80 %	5.07 %	✔
Correct Packets		1421.00	
PER *Interferer BT / CW (MHz): 2408 , 2405*	30.80 %	5.27 %	✔
Channel: 19, 2440 MHz			
Correct Packets		1424.00	
PER *Interferer BT / CW (MHz): 2434 , 2437*	30.80 %	5.07 %	✔
Correct Packets		1422.00	
PER *Interferer BT / CW (MHz): 2446 , 2443*	30.80 %	5.20 %	✔
Channel: 39, 2480 MHz			
Correct Packets		1424.00	
PER *Interferer BT / CW (MHz): 2474 , 2477*	30.80 %	5.07 %	✔
Correct Packets		1422.00	
PER *Interferer BT / CW (MHz): 2486 , 2483*	30.80 %	5.20 %	✔

Fig. 20: Low energy intermodulation performance test report.

4 Appendix

4.1 References

[1] Bluetooth Test & Interoperability Working Group: **Bluetooth Low Energy RF PHY Test Specification**, RF-PHY.TS/4.0.2, 12/2012, Bluetooth SIG, Inc.

[2] Rohde & Schwarz: **Manual for Windows Application** CBTgo (V1.70),

[3] Rohde & Schwarz: **Measurements on Bluetooth Products using R&S CMU200/CBT and CMUgo/CBTgo**, Application Note 1CM50, 10/2006

[4] Rohde & Schwarz: **Bluetooth Measurements Using CBTgo; Additional Tests**, Application Note 1MA106, 02/2013

4.2 Additional Information

Please send your comments and suggestions regarding this application note to

TM-Applications@rohde-schwarz.com

Visit the CBTgo website at

http://www2.rohde-schwarz.com/en/products/test_and_measurement/mobile_radio/CBT_CBT32-|-Tools-|-67-|-1459.html

or, as a registered user in GLORIS, the CMU Customer Web at

https://extranet.rohde-schwarz.com/

4.3 Ordering Information

Ordering information		
Bluetooth tester		
CBT	Bluetooth tester with display	1153.9000.35
CBT32	Bluetooth tester without display	1153.9000.32
CBT-K57	Bluetooth Low Energy	1170.4102.02
Vector signal generator		
SMU200A	Vector Signal Generator	**1141.2005.02**
SMU-B9	Baseband Generator, 128 Msample	1161.0766.02
SMU-B10	Baseband Generator, 64 Msample	1141.7007.02
SMU-B11	Baseband Generator, 16 Msample	1159.8411.02
SMU-B13	Baseband Main Module	1141.8003.04
SMU-B10x	RF Path A	
SMU-B20x	RF Path B	
SMW200A	Vector Signal Generator	**1412.0000.02**
SMW-B10	Baseband Generator with ARB (64 Msample) and Digital Modulation (realtime), 120 MHz RF bandwidth	1413.1200.02
SMW-B13	Baseband Main Module, one I/Q path to RF	1413.2807.02
SMW-B10x	RF Path A	
SMW-B20x	RF Path B	
SMBV100A	Vector Signal Generator	**1407.6004.02**
Signal generator		
SMF100A	Microwave Signal Generator, up to 43.5 GHz	**1167.0000.02**
SMB100A	RF and Microwave Signal Generator, up to 12.75 GHz	**1406.6000.02**

xx stands for the different frequency ranges (e.g. 1155.5001.26 MHz to 26 GHz

Note: Available options are not listed in detail.

Please contact your local Rohde & Schwarz sales office for further assistance.

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ISO 9001

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