DA1459x Bluetooth® Direct Test Mode for RF Testing

This document explains how to set up RF testing for the DA1459x Bluetooth® Low Energy SoC using a Bluetooth tester. Four setups for four different Bluetooth testers are discussed.

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1. Terms and Definitions

Bluetooth LE	Bluetooth® Low Energy
C/I	Carrier-to-Interference
DTM	Direct Test Mode
DUT	Device Under Test
EUT	Equipment Under Test
GPIB	General Purpose Interface Bus
GPIO	General Purpose Input Output
HCI	Host Controller Interface
LSB	Least Significant Bit
MSB	Most Significant Bit
OGF	Opcode Group Field
PLT	Production Line Testing
Pro Devkit	Professional Development Kit
RF	Radio Frequency
SoC	System on Chip
SWD	Serial Wire Debug
UART	Universal Asynchronous Receiver Transmitter

2. References

[1] DA1459x-00, Datasheet, Renesas Electronics.

[2] Bluetooth Core specification v 5.2, Bluetooth SIG.

[3] AN-B-043, DA1468x Bluetooth Direct Test Mode, Application Note, Renesas Electronics.

[4] AN-B-070, DA1469x Bluetooth Direct Test Mode, Application Note, Renesas Electronics.

[5] UM-B-167, DA1459x Pro Development Kit, User Manual, Renesas Electronics.

Note 1 References are for the latest published version, unless otherwise indicated.

3. Introduction

The DA14592 and DA14594 (DA1459x) are Bluetooth® Low Energy (Bluetooth LE) SoC devices working with extremely low power while providing world class RF performance, a small footprint and flexible peripheral configurations for a wide range of applications like wearables.

This document describes how to measure the RF performance of the DA1459x family of products using a Bluetooth tester like the R&S® CMW270 and the Anritsu MT8852B using the Bluetooth LE Direct Test Mode (DTM). See Ref. [2] for the detailed description of DTM.

The Bluetooth LE RF PHY test specification uses DTM for all TX and RX test cases. Frequency hopping and whitening are disabled.
DTM uses a direct communication channel between the Bluetooth LE Device Under Test (DUT) and the Bluetooth tester to control the DUT. The DA1459x SoC supports DTM for the RF PHY as specified by the Bluetooth SIG. The DUT, the DA1459x SoC, supports 1M and 2M PHY and communicates with the Bluetooth tester over a 2-wire UART. See Sections 4.1 and 4.2 for software and hardware setup.

4. Direct Test Mode Setup

4.1 Software Setup

For standard Bluetooth LE DTM testing (Bluetooth LE core commands), Renesas recommends using the SDK ST_FW project (C:\SDK_10.1.2.86\projects\dk_apps\reference_designs\st_fw).

Build the project for RAM usage and load the binary in RAM using the SmartSnippets Toolbox RF Master (RF Master). Or build it for eFlash and program the firmware in eFlash using Renesas Flash Programmer or Renesas e^{2}Studio.

For example, to download the ST_FW firmware into RAM, the RF Master is used. Download the readily built st_fw binary using UART or JTAG when set in the RF Master and click the **Download** button. See Figure 1.

Figure 1. Firmware download in RF Master

Following should be displayed in the bottom part of the log window after downloading, indicating the download to RAM was successful:

```
[INFO    General      BTLE device selected.
[INFO    General      Succesfully connected to JLinkGDBServer on localhost: 2331
[INFO    General      Firmware file \st_fw.bin has been successfully
                      uploaded to the device.
[INFO    RF Master    Successfully downloaded firmware file to the board.
```

After downloading the firmware using the RF Master, the RF Master tool also can be used to set the DA1459x chip in receive or transmit mode, for example, LE Transmitter Continuous Packet TX. For this, the UART COM port must be selected and set in the RF Master, in this example COM5. See Figure 2. When the Power Profiler is running at the same time, the waveform shows the TX current. Alternatively, a serial terminal program as shown in Section 4.4 can be used.

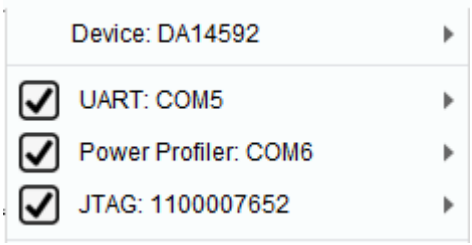

Figure 2. COM port and JTAG selection

The supported RF test modes in the ST_FW project are:

- Pkt_tx
- Cont_pkt_tx
- Start_pkt_rx
- Stop_test
- Rx_test_stats (get packet statistics like number of received packets)
- Unmodulated TX

By default, the UART baud rate is set to 115200 bit/sec and the UART GPIOs used for control and signaling between the Bluetooth tester and the DUT are shown in Table 1.

Table 1. UART GPIOs

UART RX	UART TX	UART CTS	UART RTS
P0_15	P0_13		

Summarizing the UART:

- UART baud rate: 115200 bit/sec
- Byte size: 8
- Stop bits: 1
- Parity: None

The switches 1 to 4 of the DIP switch S1 on the DA1459x Pro Devkit motherboard are the UART switches and must be set to **ON**, to the upper position as shown in Figure 3. Switches 5 and 6 are for JTAG/SWD.

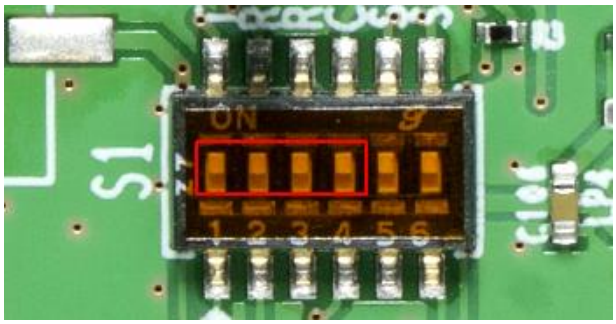

Figure 3. UART switch positions

When using an external J-Link connection for firmware downloading, the J-Link signals should be connected to the M33 SWD pins of the Pro Devkit board. These pins are assigned as shown in Table 2.

Table 2. SWD pins

M33 SWDIO	M33 SWCLK
P0_06	P0_07

These SWD GPIOs are located on the connector J3, which can be found on the left-hand side of the DA1459x Pro Devkit motherboard. See Figure 18.

When using the external J-Link connection, set the SWD switches 5 and 6 of S1 (see Figure 3) to **OFF**, to the lower position. Other relevant jumper settings can be found in Appendix A. See Figure 18 to check whether the board for DTM RF testing is properly configured. The USB connector on the DA1459x Pro Devkit motherboard provides the supply and the 2-wire serial communication to the DA1459x daughterboard.

4.1.1 Temperature Triggered RF Recalibrations

This section describes the temperature triggered RF recalibrations used in the SDK.

In the SDK projects, temperature triggered RF recalibrations are provided to make sure the radio is in optimal condition at any temperature. This is realized by shortly waking up the chip at regular intervals at which the chip's temperature is measured. When the temperature has decreased or increased 10 degrees centigrade or more, an RF recalibration is triggered and executed.

In the DTM mode only, these temperature triggered RF recalibrations are not active. This is intended to make sure the RF recalibration is not interfering with a running RF test, leading to a failing test.

When RF testing at low and high temperatures is desired, you need to perform a hardware reset on the chip, which makes the chip reboot and RF recalibration executed at the current temperature before the RF test starts. This makes sure the radio is in optimal condition.

In this situation, it is convenient to have the firmware programmed in Flash because it is reloaded from Flash automatically after a reset.

Normally, RF recalibration is not required in the temperature range from -20°C to +80°C, but Renesas recommends triggering a RF recalibration after a 20 °C temperature change.

The receiver sensitivity is affected first, degrading a bit at low and high temperatures. However, the transmitter performance is not very much over temperature.

In Bluetooth LE mode - advertising or connected, the temperature triggered RF recalibrations are in place. The radio is in optimal condition at any temperature.

4.2 Hardware Setup

This section describes four RF test setups.

- The R&S CMW270 Bluetooth 5 tester. The DA1459x Pro Devkit is connected and supplied by a (front) USB port of the CMW270. Bluetooth LE signaling is executed over the same USB port. See Section 4.2.1.
- The Anritsu MT8852B Bluetooth 5 tester. A computer supplies the Pro Devkit board and connects the Bluetooth tester and the DUT through a Comm Tunnel tool running on your computer. See Section 4.2.2.
- The R&S CBT Bluetooth tester. Use the Comm Tunnel tool for RF test. Otherwise, a serial interface with level-shifter is required. See Ref. [3]. The CBT tester does not support Bluetooth LE 2 Mbps. The computer supplies the Pro Devkit board through its USB connector. See Section 4.2.3.
- The Teledyne LeCroy TLF3000 Bluetooth tester. See Section 4.2.4.

A LitePoint IQxel-M Bluetooth tester connection example can be found in Ref. [3]

The RF connection between the Pro Devkit board and the Bluetooth tester can be established using the onboard Murata miniature RF-switch/connector, type MM8130-2600: J7 (see Figure 5 and Figure 19). The following Murata SMA RF-cable type should be used for connecting the DA1459x board to the RF port of the Bluetooth tester: MXHS83QH3000 as shown in Figure 4.

NOTE
The insertion loss of this RF cable assembly is 1.15 dB typical.

Figure 4. RF cable MXHS83QH3000

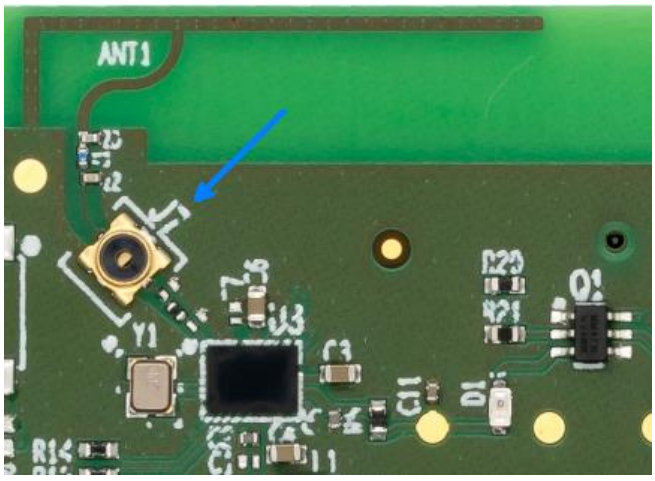

Figure 5. Pro Devkit board, RF connector J7

4.2.1 R&S CMW270 Bluetooth Tester Setup

The FTDI USB to Serial driver for the FTDI chip on the Pro Devkit must be installed on the R&S CMW270. When the Pro Devkit board is connected, two virtual COM ports are created such as COM5 and COM6. The first port, COM5 in this example, provides the UART 2-wire connection and this one should be selected in the CMW270's connection setup. See Bluetooth Connection Setup for LE from the official website.

For detailed instructions on how to set up, go to the official website (https://www.rohde-schwarz.com) and search for the Configuration of the R&S CMW for Bluetooth Low Energy Direct Test Mode application note.

Overview of the required CMW270 connection settings:

- USB to RS232 adapter as hardware interface
- HCI in EUT communication protocol
- RS232 COM port: the used virtual COM port (COM5)
- Baud rate: 115200
- Flow control protocol: set to None
- Parity: None
- Stop bits: 1

The FTDI driver for the FT2232 FTDI chip used on the Pro Devkit motherboard can be found in the official website (https://www.ftdichip.com/Drivers/D2XX.htm).

When using front-panel operation, connecting the Pro Devkit debug USB port to a front USB port of the CMW270 and an RF cable from the CMW270 RF port (for example, RF1 COM) to the Pro Devkit RF connector is all what is needed to run some basic Bluetooth LE TX and RX tests. Therefore, the GPIB connection is not needed. For script testing, using the R&S CMWRUN scripting tool, a GPIB connection between the PC and CMW270 must be established. See Figure 6.

In this setup, programming the firmware in the Flash memory at forehand is more convenient, even more when planning to execute multiple RF tests. When deciding to download the firmware into RAM, an external J-Link connection must be used. See Section 4.1 for details on downloading the firmware using SWD.

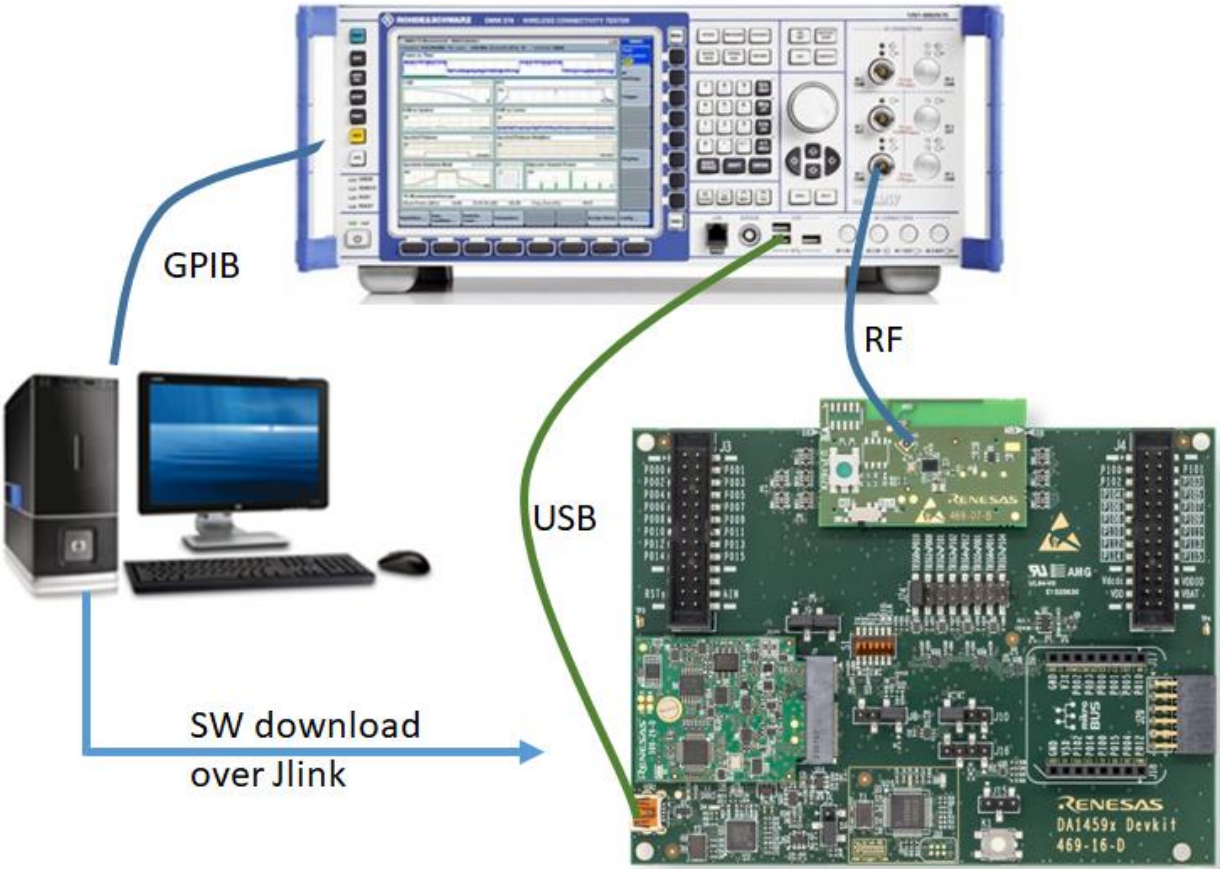

Figure 6. R&S CMW270 connections

4.2.2 Anritsu MT8852B Bluetooth Tester Setup

The MT8852B's EUT control port cable (supplied with the tester) should be connected to a physical serial port of the personal computer or to an USB port when using a Serial to USB converter, for example, UC232R-10 or Chipi-X10: https://www.ftdichip.com/Products/Cables/USBRS232.htm. See Figure 7.

The Comm Tunnel tool running on the personal computer connects the computer's serial port (COM1) at which the MT8852B EUT port is connected, to the Pro Devkit's virtual COM port (COM5).

The Pro Devkit board creates two virtual COM ports on the computer, for example, COM5 and COM6. The COM port having the lowest number (COM5 in this example) must be selected for UART. The second virtual COM port is the SPI channel, used for transmitting the PowerProfiler data from the motherboard to the SmartSnippets Power Profiler tool running on your computer. See Figure 9 and Figure 10 for the Comm Tunnel tool.

NOTE
The version that was used for this document, visit http://www.serialporttool.com/CommTunnel.htm.

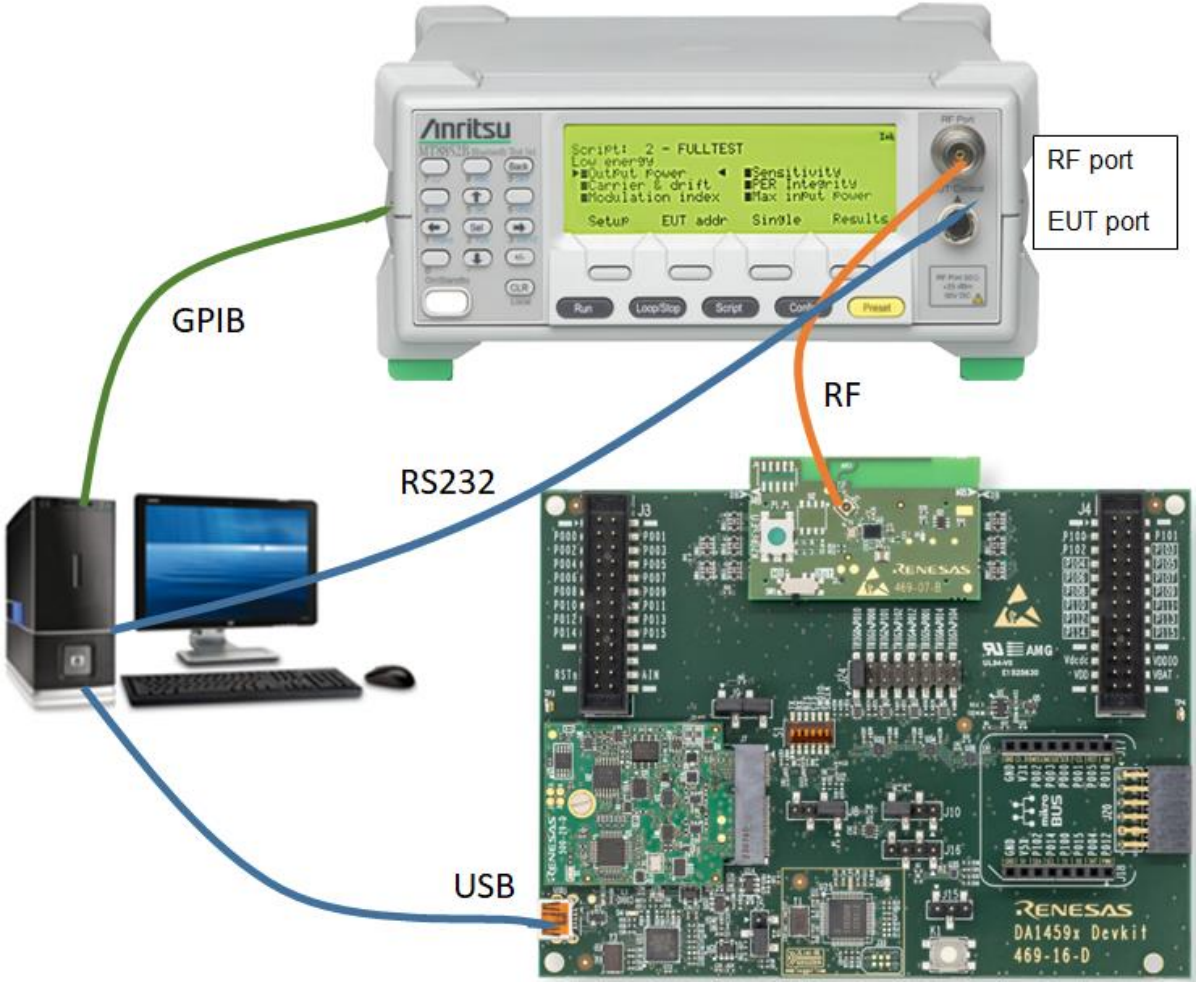

Figure 7. Anritsu MT8852B connections

Figure 7 shows the connections between the MT8852B tester, the DUT, and the personal computer. A Comm Tunnel tool is running on the computer, connecting the MT8852B's EUT control port to the virtual UART COM port of the Pro Devkit board.

Before starting the Comm Tunnel program, the RF test firmware can be downloaded in RAM using the same computer USB port and the Pro Devkit virtual COM port. See Section 4.1.

After the firmware download, the Comm Tunnel can be started, and RF testing can begin. Front-panel operation is available for basic TX and RX tests. For this, the Comm Tunnel should be started, but the GPIB connection is not needed.

When running Anritsu's Bluetooth LE measurement software, TX-modulation can be displayed, script testing can be executed, and a test-report could be created. See Ref. [3]. The GPIB connection between the tester and the computer is required for this test case.

The MT8852B connection settings in the Anritsu Bluetooth® LE measurement software. Generally, RS232 handshaking is not used and so set it to **None**, but if handshaking is used, it sets to **RTS/CTS**. See Figure 8.

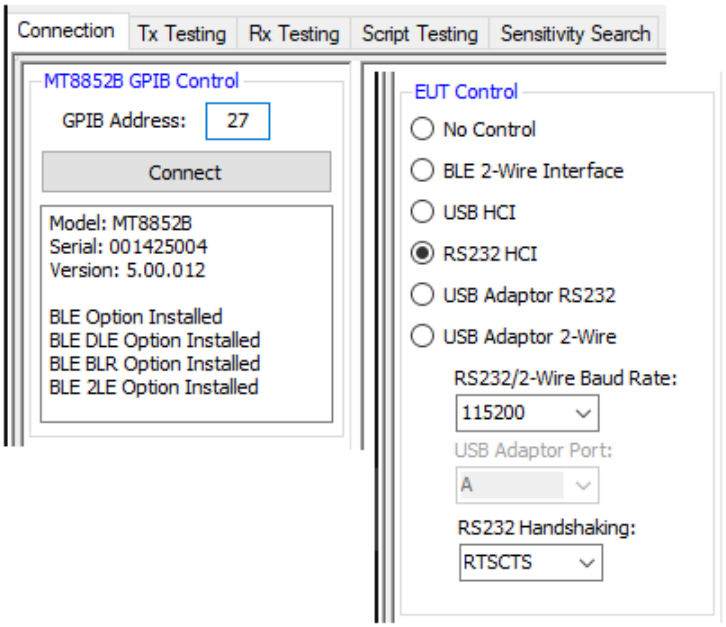

Figure 8. MT8852B connection settings

Comm Tunnel settings (Setting) appears when selecting **Setting** in **Endpoint 1** (Tester) or **Endpoint 2-1** (DUT). See Figure 9 and Figure 10. After entering the correct values, click the **Start** button. **Endpoint 2-1** (DUT UART) is connected to **Endpoint 1** (Tester serial port).

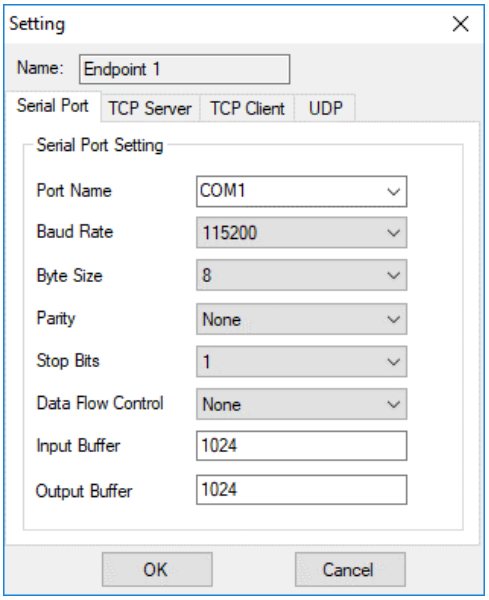

Figure 9. Comm Tunnel setup

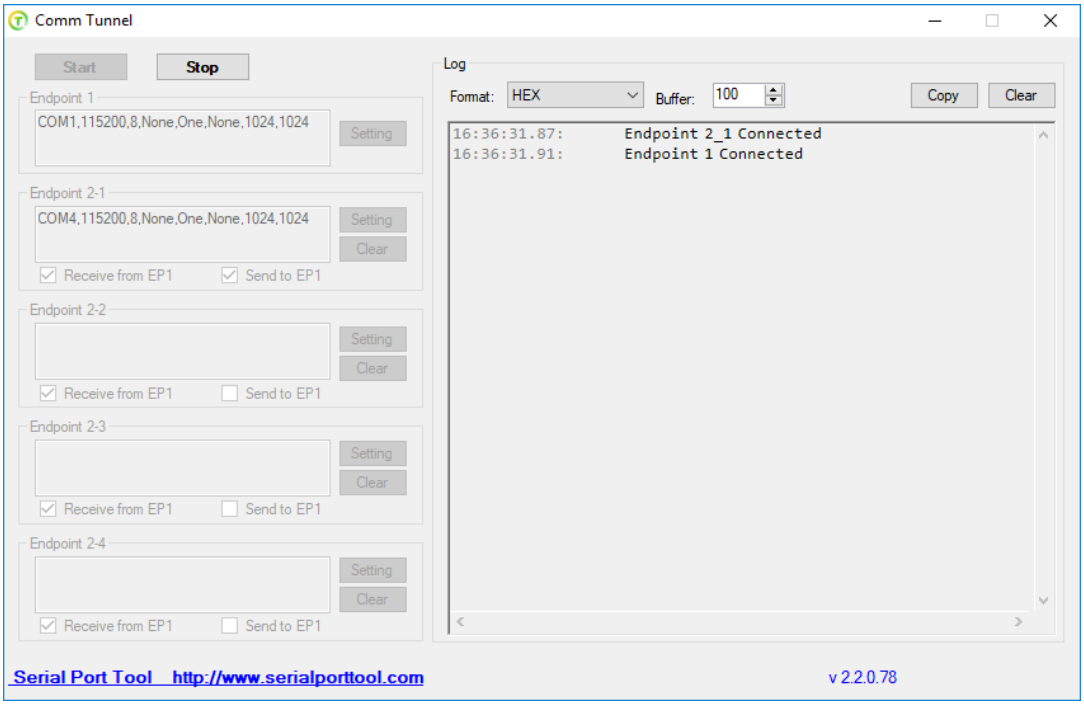

Figure 10. Comm Tunnel tool

4.2.3 R&S CBT Bluetooth Tester Setup

The R&S CBT setup basically is similar to the MT8852B setup in 4.2.2. The CBT's COM port at the back is connected to a serial port on the computer, and the Comm Tunnel program connects the CBT COM port to the UART/HCI port of the DA1459x DUT through the virtual COM port created by the DA1459x Pro Devkit board. See Figure 11 for the connections.

When the computer does not have a physical serial port, a Serial to USB converter can be applied. For details on this and the Comm Tunnel usage, see Section 4.2.2. The computer can be used to download the RF test firmware to the DA1459x chip into RAM. After starting the Comm Tunnel tool, the same USB port is used for Bluetooth signaling.

Basic testing like LE TX modulation performance can be executed from the front panel and viewed in the CBT's display. GPIB interfaces and a GPIB cable are not needed.

Extended script testing can be done using the R&S CBTgo tool, which runs on the computer. The CBTgo tool can also generate an extensive test report. A GPIB cable must be connected between the computer and the CBT for using CBTgo.

The CBT communication settings, to be set in the CBT or in the CBTgo control program:

- EUT protocol: HCI
- Baud rate: 115200
- Number of bits: 8
- Stop bits: 1
- Parity: None
- Flow control: None

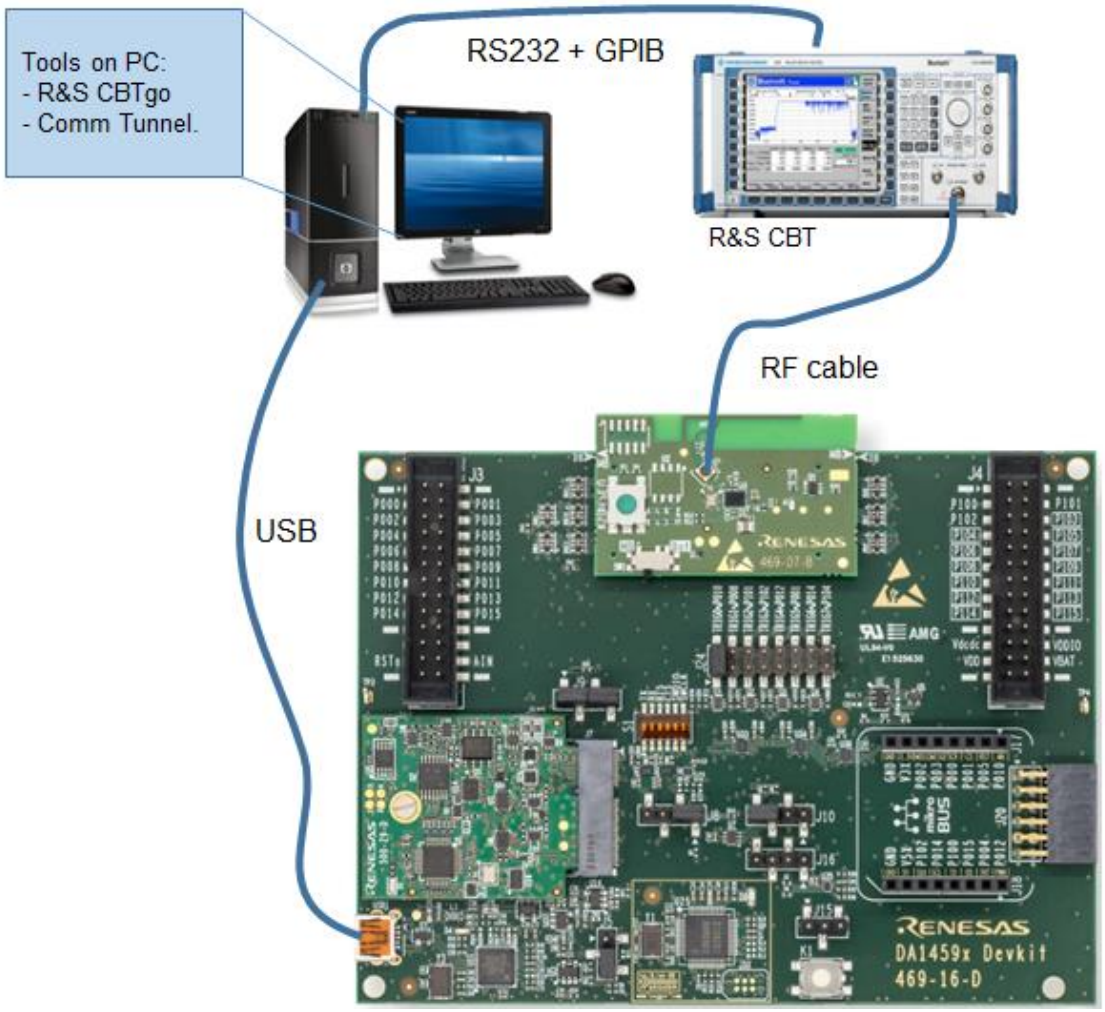

Figure 11. R&S CBT connections

4.2.4 Teledyne LeCroy TLF3000 Bluetooth Tester Setup

The TLF3000 is a fast and flexible Bluetooth tester for the standard transmitter and receiver tests and featuring integrated Carrier-to-Interference (C/I) and blocking measurements up to 6 GHz. The application GUI is installed on the computer. Connection from the TLF3000 tester to the USB port on the computer is through the USB socket on the backside of the TLF3000. The application GUI on your computer can control the TLF3000. The DA1459x Pro DK board also should be connected to your computer, and two virtual COM ports are established. Now it is possible to select the first listed COM port in the TLF3000 GUI and run the UART communication between the GUI and the DUT. Figure 13 shows the GUI interface. No additional interfacing hardware or a Comm Tunnel tool is needed.

Connect the RF cable for conducted RF tests between the DUT antenna and the TX/RX connection (SMA) on the front of the TLF3000 tester. See Figure 12.

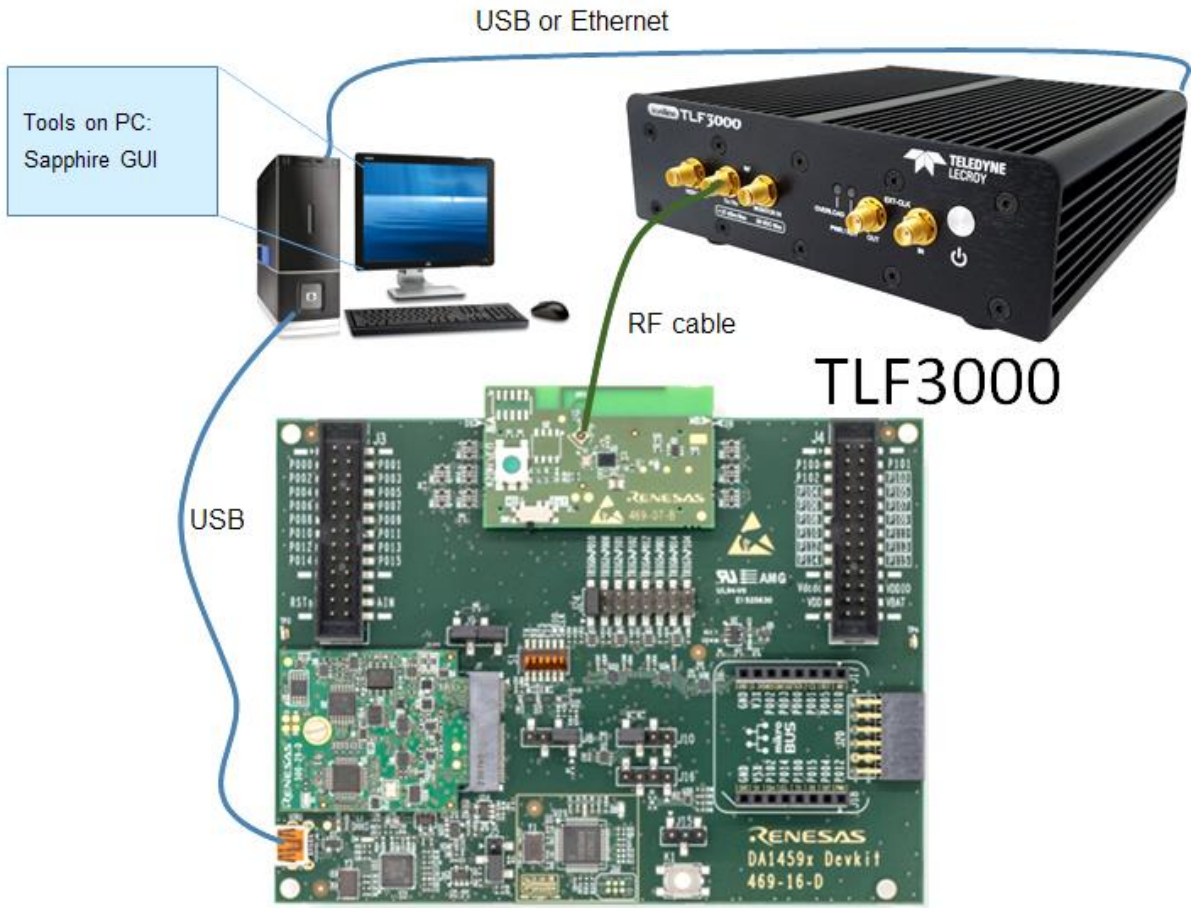

Figure 12. TLF3000 connections

Figure 14 shows the Phy Tester mode that displays communication between the TLF3000 application and the DUT setup. You can see the proof of communication between the TLF3000 application GUI and the DUT by clicking the **Query DUT** button on the **DUT Features** window. As shown in Figure 14, Query DUT is a feature of the DTM functionality and the DA1459x chip supports the Query DUT functionality.

For more information on the Teledyne LeCroy TLF3000, visit the official website (http://fte.com/products/tlf3000.aspx).

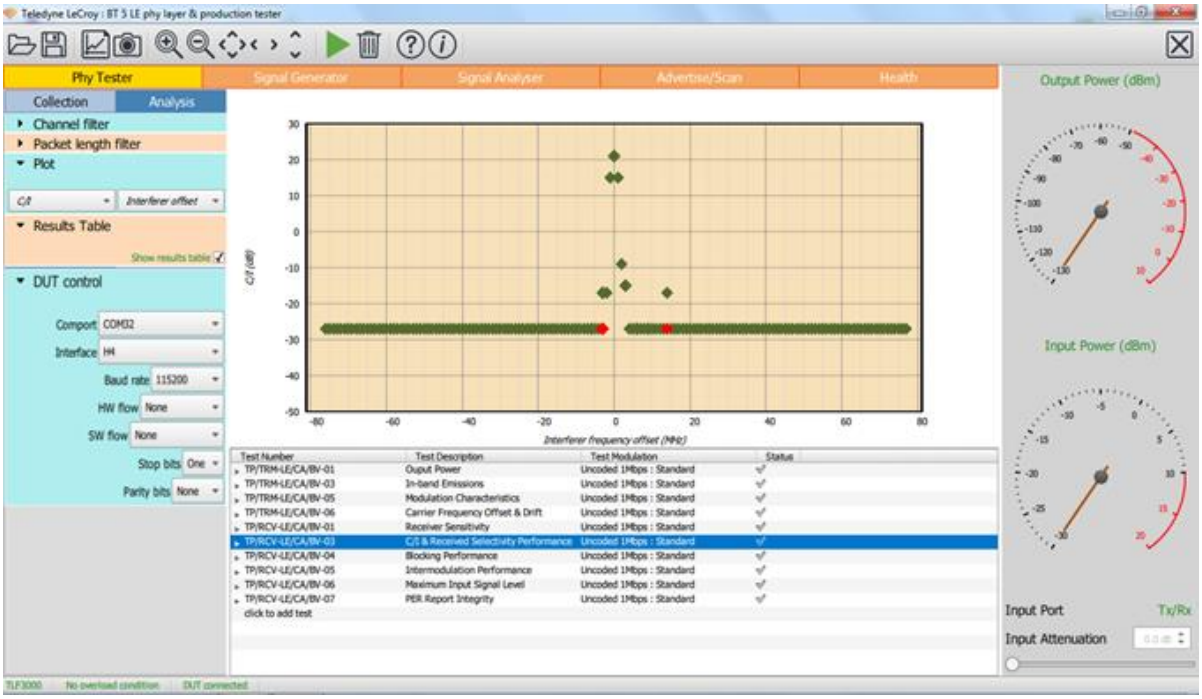

Figure 13. TLF3000 GUI

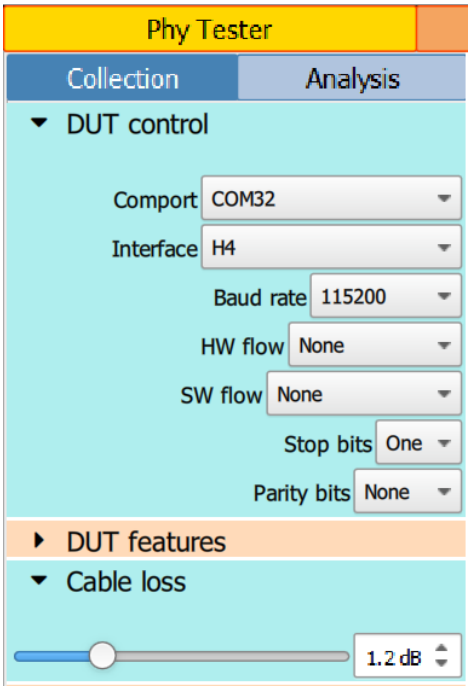

Figure 14. DUT control settings for the DA1459x

4.3 Bluetooth Low Energy 2 Mbps Testing

The R&S CBT Bluetooth tester supports only 1 Mbps PHY, not Bluetooth Low Energy 2 Mbps testing. For Bluetooth Low Energy 2 Mbps testing, either the R&S CMW270 tester with the proper licenses, the Anritsu MT8852B tester having firmware 5.00.xxx, the Teledyne LeCroy TLF3000 tester or any other Bluetooth 5 capable tester should be used.

4.4 Terminal Control

This section provides an example using the RealTerm terminal program and explains how to set the DA1459x chip in TX Unmodulated mode. This mode can be used to check the TX frequency accuracy or used to measure the TX harmonic levels. Also, other parameters of this HCI command are discussed showing to put it in finite packetized TX mode, to send a certain limited number of packets.

The ST_FW project must have been loaded into RAM or programmed into the flash. See Section 4.1.

4.4.1 TX Unmodulated and More

The required HCI test command using the vendor specific opcode `0xFC14` for starting continuous unmodulated TX at Ch.0 (2402 MHz) is as follows:

- `0x14 0xFC 0x0B 0x00(Ch) 0x25 0x00 0x01 0x04(unmod) 0xF4 0x01 0x71 0x02 0x00 0x00`
- `0x00(Ch)` indicates the Bluetooth LE RF channel number: channel 0 (2402 MHz).
- `0x04(unmod)` indicates the TX output signal is unmodulated.
- Expected reply from the chip: `0x0E 0x04 0x05 0x14 0xFC 0x00`
- StopTest command: `0x1F 0x20 0x00`
- Reply from the chip: `0x0E 0x06 0x05 0x1F 0x20 0x00(succeeded) 0xF4 0x01`

The same opcode (`0xFC14`) with other modulation parameter values may also be used to set the DA1459x chip into Finite, Continuous Modulated Packetized, or Continuous Non-packetized TX mode.

The HCI command for starting Finite Modulated Packetized TX at Ch.00 (2402 MHz):

- `0x14 0xFC 0x0B 0x00(Ch) 0x25 0x00 0x01 0x03(finite) 0xF4 0x01 0x71 0x02 0x00 0x00`
- The above command results in sending `0x01F4` (500) packets and then stops transmitting packets.
- StopTest reply: `0x0E 0x06 0x05 0x1F 0x20 0x00(succeeded) 0xF4 0x01(500 pkts sent)`
- The HCI command for starting Continuous Modulated Non-Packetized TX at Ch.19 (2440 MHz):
- `0x14 0xFC 0x0B 0x13(Ch) 0x25 0x00 0x01 0x02(nonpkt) 0xF4 0x01 0x71 0x02 0x00 0x00`
- The HCI command for starting Continuous Modulated Packetized TX at Ch.39 (2480 MHz):
- `0x14 0xFC 0x0B 0x27(Ch) 0x25 0x00 0x01 0x01(contpkt) 0xF4 0x01 0x71 0x02 0x00 0x00`

Table 3 shows the structure of the HCI TX enhanced command having opcode `0xFC14`.

Table 3. Opcode 0xFC14 parameters

Parameter	Value	Description
Command length	0x0B	# Bytes that follow
TX channel number	0x13	Channel 0x13 (19: 2440 MHz)
Data length	0x25	37 Bytes (up to 0xFF/255)
Payload type	0x00 (PRBS9)	`0x01` for **11110000**, `0x02` for **10101010**
PHY	0x01	`0x01` for 1 Mbps, `0x02` for 2 Mbps
Test type	0x04 (unmodulated)	1: cont.pkt, 2: non-pkt, 3: # pkts, 4: un-mod
# of TX packets	0x01F4 (500 pkts)	LSB comes first
Packet interval time:	0x0271 (625 µs)	LSB comes first

4.4.2 HCI LE Controller Commands

The LE Controller HCI commands (OGF = 0x08) for the LE (v1) or LE Enhanced (v2) Transmitter Test and Receiver Test used in DTM RF testing as for instance sent by a Bluetooth tester are as follows:

TX: the HCI commands for LE Cont_Pkt_TX, 1 Mbps or 2 Mbps, Ch.0 (0x00), Payload 37 bytes (0x25) and using PRBS9 (0x00) are:

- 1 Mbps: 0x1E 0x20 0x03 0x00(Ch) 0x25 0x00
- 2 Mbps: 0x34 0x20 0x04 0x00(Ch) 0x25 0x00 0x02(PHY) (LE v2 command)
- StopTest command: 0x1F 0x20 0x00
- Expected reply: 0x0E 0x06 0x05 0x1F 0x20 0x00 0xnn 0xnn (nn: number of sent packets).

RX: the required HCI commands for LE Pkt_RX, 1 Mbps or 2 Mbps, Ch.39 (0x27) are:

- 1 Mbps: 0x1D 0x20 0x01 0x27(Ch)
- 2 Mbps: 0x33 0x20 0x03 0x27(Ch) 0x02(PHY) 0x00 (LE v2 command)
- StopTest command: 0x1F 0x20 0x00
- Reply example from the StopTest: 0x0E 0x06 0x00 0x1F 0x20 0x07 0x0C 0xDC

The last two words of HCI commands represent the number of received packets, least significant bit (LSB) and most significant bit (MSB) respectively.

For example, if the reply is 0x05DC, it means that you received 1500 packets (the number of received packets can be any other value).

The following vendor specific HCI commands can be used to get statistics for the received packets: packets having CRC errors, having Sync errors and the RSSI value of the received packets. This command uses opcode 0xFC16 and must be executed after a regular RX test.

- Get RX Test Stats HCI command: 0x01 0x16 0xFC 0x00
- Reply example: 0x0E 0x0E 0x00 0x16 0xFC 0x07 0xE8 0x03 0x00 0x00 0x00 0x00 0x00 0x00 0x8A 0x00

The data you need to pay attention are follows after 0xFC 0x07, in pairs, LSB first.

Table 4 shows the descriptions of the example values.

Table 4. Received packet statistics

Parameter	Value	Description
Total number of received packets	0x03E8	1000 packets received
Number of packets having SYNC error	0x0000	0 packets having SYNC error
Number of packets having Length error	0x0000	0 packets having Length error
Number of packets having CRC error	0x0000	0 packets having CRC error
RSSI value of the received packets (Note 1)	0x008A	138, corresponds to -51 dBm

Note 1 The equation for calculation of the RSSI value into dBm is: RSSI [dBm] = RSSI_Value/2 - 120.
The equation is valid for the monotonous RF input power range: 50 < RSSI < 175 (-87 ~ -25 dBm).

The above listed HCI commands can be copied and pasted into the **Send** fields of the terminal program. See Figure 15.

NOTE

- When copying/pasting the HCI commands, delete the inserted descriptive texts: (Ch), (pkt), (unmod), or (PHY). Else it causes errors. And 0x01 must be added at the start of the used HCI commands.
- The applied TX packet data length in all examples is 0x25 (37 bytes). It is given in the field after the channel number (0x13). The data length can be as long as 0xFF (255 bytes). For a data length = 255 bytes, enter the value 0xFF instead of 0x25.

Figure 15 shows the terminal's interface. The commands for starting TX unmodulated using opcode 0xFC14 (in the upper field) at Ch.19 (0x13) and stopping the test (in the lower field) are shown in the **Send** tab.

After pasting or entering the HCI commands, clicking the **Send Numbers** button to send the command to the chip (in green color). The chip should reply (in yellow color).

The terminal's **Display** settings are best set to Hex [space] and Half Duplex.

The terminal's **Port** settings are as follows:

- Baud-rate: 115200
- Parity: None
- Data-bit: 8
- Stop-bit: 1

When enabling the Hardware Flow Control in the software, RTS/CTS should be set.

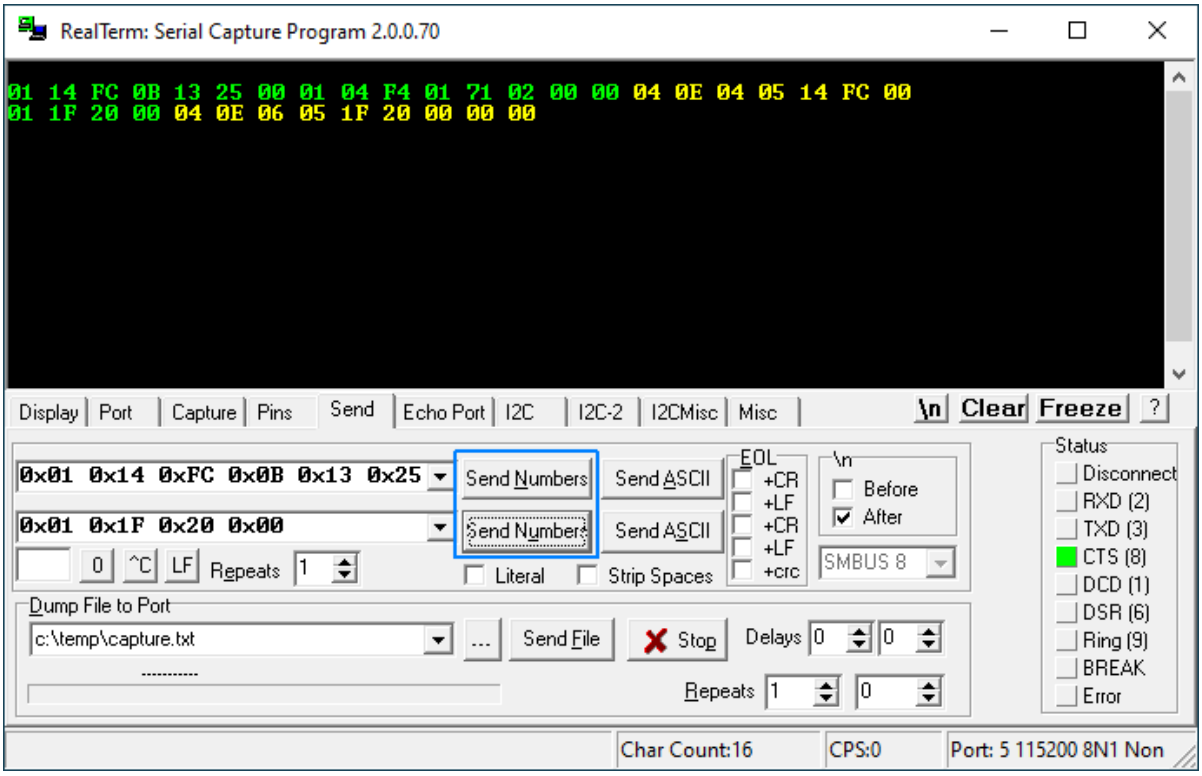

Figure 15. RealTerm send window

All the Bluetooth LE Controller and the Vendor Specific commands can also be generated by the RF Master in the SmartSnippets Toolbox. See Figure 16 for continuous TX or RX.

The buttons for TX modulation tests from left to right:

- Modulated Continuous Packet test
- Modulated Continuous Non-Packet test
- Modulated Finite Packet test (# of packets to send)
- Unmodulated Continuous Non-Packet test

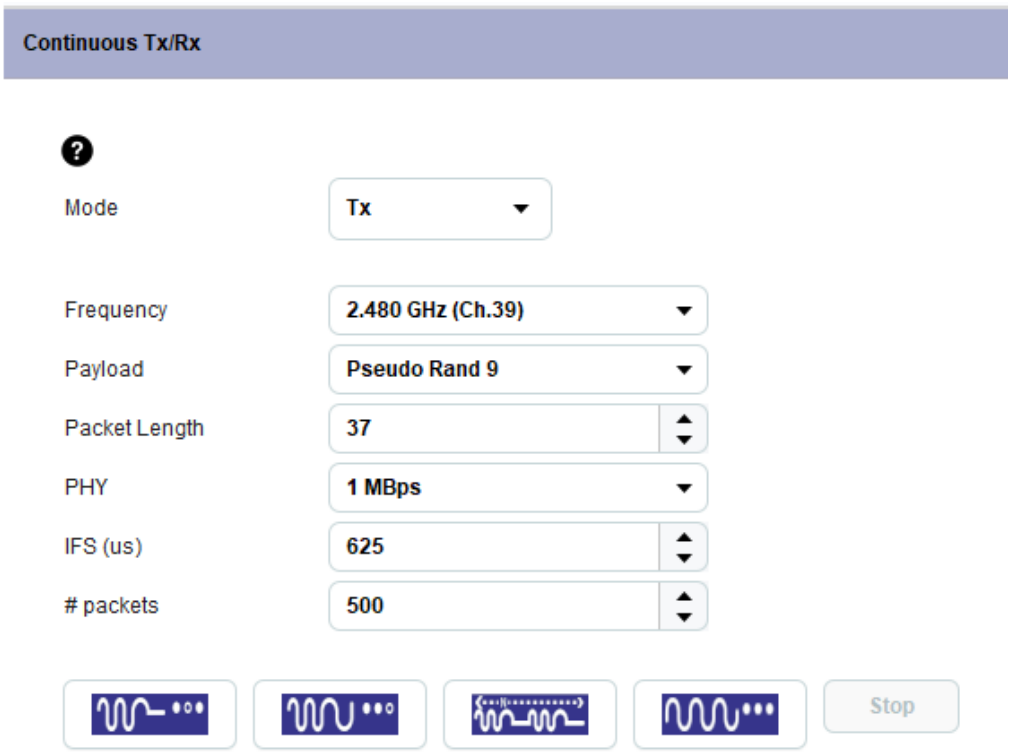

Figure 16. RF Master continuous TX or RX

Bluetooth Core v5.2 LE Controller specifications:

- LE Receiver/Transmitter Test (v1) as defined in Bluetooth Core v5.2/Vol.4/Part E/7.8.28 and 7.8.29.
- LE Enhanced Tests (v2, v3) as defined in Bluetooth Core v5.2/Vol.4/Part E/7.8.28 and 7.8.29.
- LE Test_End (StopTest) as defined in Bluetooth Core v5.2/Vol.4/Part E/7.8.30.

The v1 set of commands supports the 1 Mbps Phy only and the LE Enhanced v2 and v3 command sets also support the 2 Mbps Phy. See Ref. [2].

5. Bluetooth PHY Qualification

To release a Bluetooth application to the market, the application needs to be Qualified. The Renesas Electronics Bluetooth® Low Energy Socs have Qualified Design Listings (https://qualification.bluetooth.com/MyProjects/ListingsSearch) with corresponding Qualified Design Identification (QDID) for all Host Subsystems and Controller Subsystems. Enter Renesas Electronics Corporation in the **Product Search** field for finding all former Dialog Semiconductor and Renesas Electronics listings as shown in Figure 17.

By referring to the Renesas Electronics QDIDs, the amount of testing required to list a Bluetooth LE application is greatly reduced. Generally, Bluetooth PHY testing must be done for new hardware, meaning that Bluetooth PHY testing done by Renesas Electronics on the evaluation kits cannot be reused. This PHY testing must be done by an authorized test house.

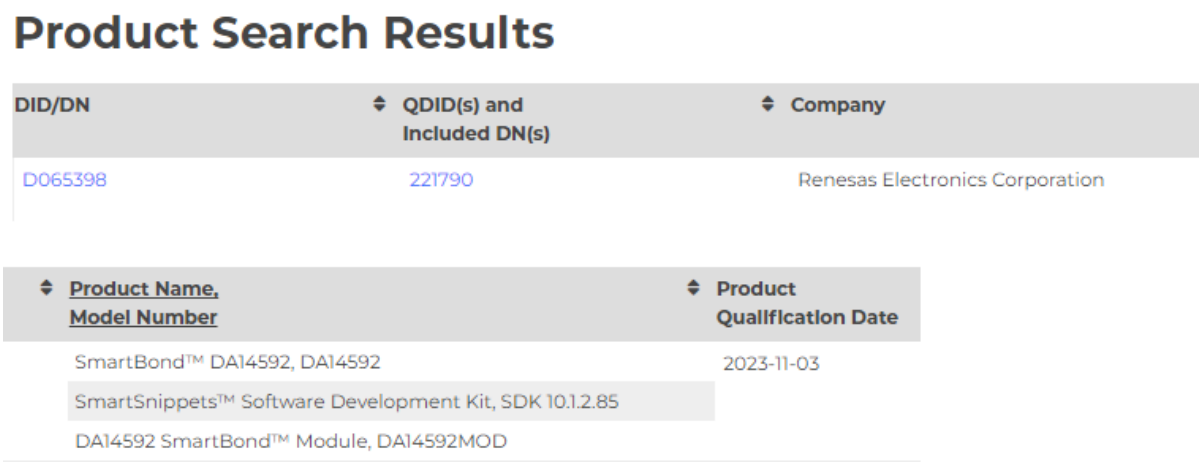

Figure 17. Product search results for DA14592

Table 5 and Table 6 display the Protocol Implementation Extra Information for Test (PIXIT) entries that the test house needs for PHY qualification.

Table 5. PIXIT entries for Bluetooth LE 1 Mbps

PIXIT reference	Identifier	Sub-identifier (Optional)	Value	Units
RF-PHY:P1:1	Inband image frequency	Low frequency	2	MHz
RF-PHY:P1:2		Middle frequency	2	MHz
RF-PHY:P1:3		High frequency	2	MHz
RF-PHY:P2:1	Value n for intermodulation test	Low frequency	3	Integer
RF-PHY:P2:2		Middle frequency	3	Integer
RF-PHY:P2:3		High frequency	3	Integer
RF-PHY:P3	Type of power source			
RF-PHY:P4:1	Power source voltage	Nominal (NOC)	End product spec	V
RF-PHY:P4:2		Maximum (NOC)	End product spec	V
RF-PHY:P4:3		Minimum (NOC)	End product spec	V
RF-PHY:P5:1	Operation temperature	Nominal (EOC)	End product spec	°C
RF-PHY:P5:2		Maximum (EOC)	End product spec	°C
RF-PHY:P5:3		Minimum (EOC)	End product spec	°C
RF-PHY:P6:1	Air humidity range (relative)	Maximum (EOC)	End product spec	%
RF-PHY:P6:2		Minimum (EOC)	End product spec	%
RF-PHY:P6:3		Air humidity level for NOC/EOC tests	End product spec	%
RF-PHY:P7:1	Test interface implementation	HCI or 2-wire UART	HCI	
RF-PHY:P7:2		Datarate	115000	bps
RF-PHY:P8	Antenna gain	Low	End product spec	dBi
		Middle	End product spec	dBi
		High	End product spec	dBi

Table 6. PIXIT entries for Bluetooth LE 2 Mbps

PIXIT reference	Identifier	Sub-identifier (Optional)	Value	Units
RF-PHY:P1:1	Inband image frequency	Low frequency	4	MHz
RF-PHY:P1:2		Middle frequency	4	MHz
RF-PHY:P1:3		High frequency	4	MHz
RF-PHY:P2:1	Value n for intermodulation test	Low frequency	3	Integer
RF-PHY:P2:2		Middle frequency	3	Integer
RF-PHY:P2:3		High frequency	3	Integer
RF-PHY:P3	Type of power source			
RF-PHY:P4:1	Power source voltage	Nominal (NOC)	End product spec	V
RF-PHY:P4:2		Maximum (NOC)	End product spec	V
RF-PHY:P4:3		Minimum (NOC)	End product spec	V
RF-PHY:P5:1	Operation temperature	Nominal (EOC)	End product spec	°C
RF-PHY:P5:2		Maximum (EOC)	End product spec	°C
RF-PHY:P5:3		Minimum (EOC)	End product spec	°C
RF-PHY:P6:1	Air humidity range (relative)	Maximum (EOC)	End product spec	%
RF-PHY:P6:2		Minimum (EOC)	End product spec	%
RF-PHY:P6:3		Air humidity level for NOC/EOC tests	End product spec	%
RF-PHY:P7:1	Test interface implementation	HCI or 2-wire UART	HCI	
RF-PHY:P7:2		Datarate	115000	bps
RF-PHY:P8	Antenna gain	Low	End product spec	dBi
		Middle	End product spec	dBi
		High	End product spec	dBi

Appendix A DA1459x Motherboard

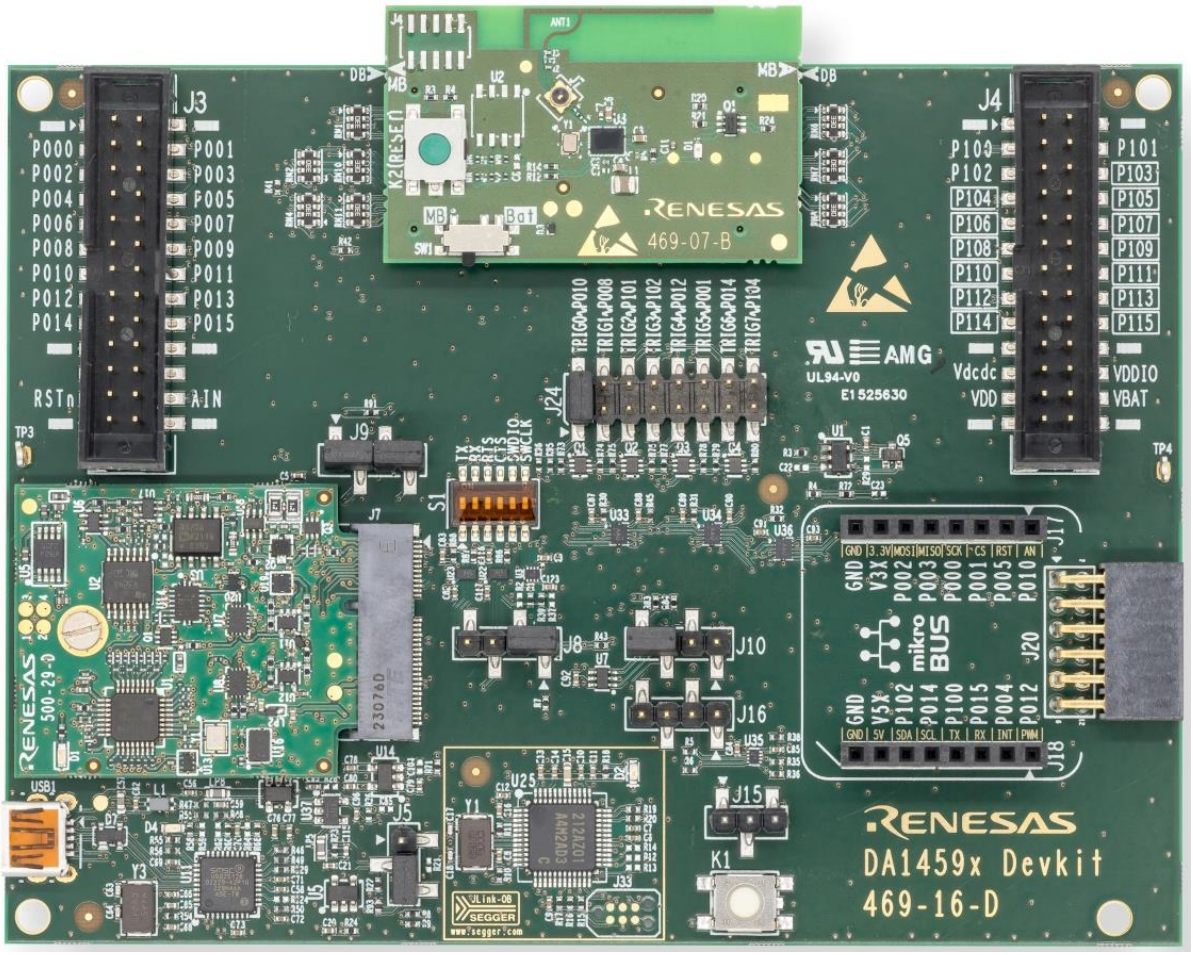

Figure 18. DA1459x Pro Devkit motherboard

Appendix B DA1459x Daughterboard

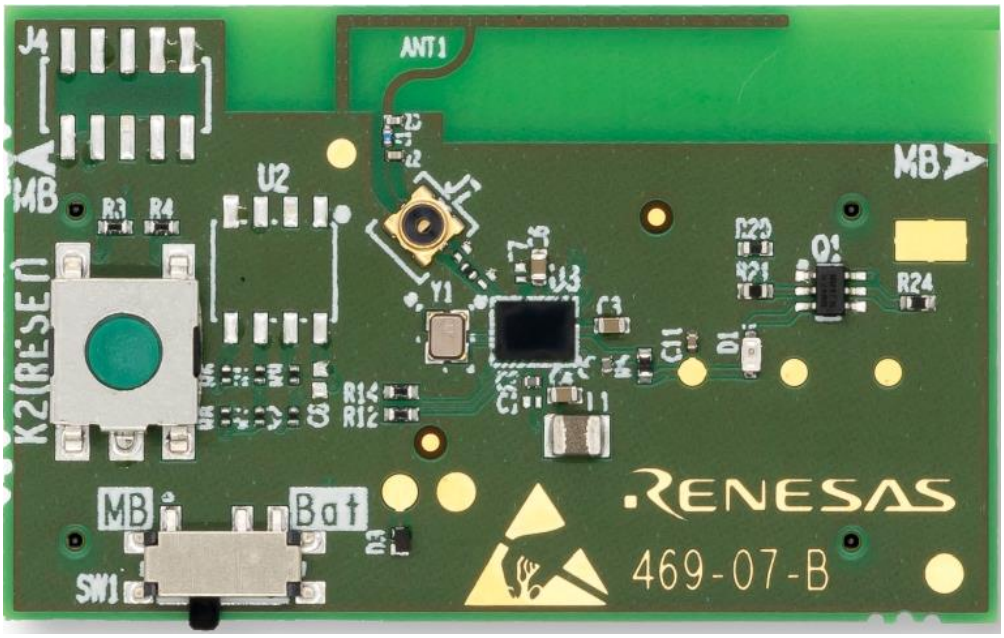

Figure 19. DA14592 wlcsp39 Pro Devkit daughterboard

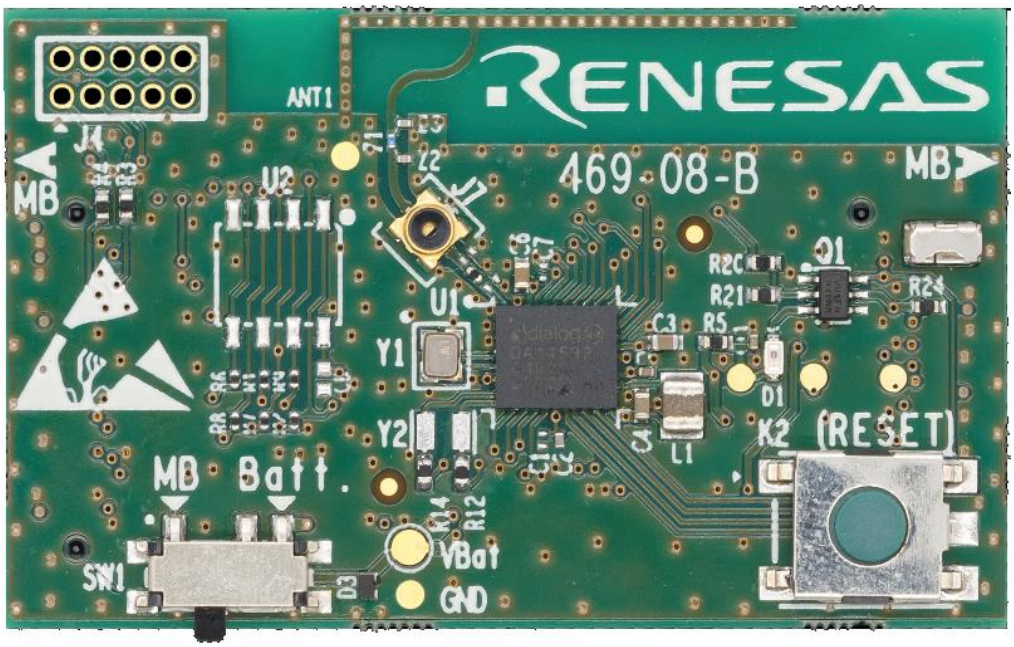

Figure 20. DA14592 fcqfn52 Pro Devkit daughterboard

6. Revision History

Revision	Date	Description
01.00	Nov 28, 2024	Initial release

STATUS DEFINITIONS

Status	Definition
DRAFT	The content of this document is under review and subject to formal approval, which may result in modifications or additions.
APPROVED or unmarked	The content of this document has been approved for publication.

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