Abstract
This document is a guideline for testing the DA1458x SoC device in Bluetooth Direct Test Mode.
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DA1458x Bluetooth Direct Test Mode

1 Terms and definitions
BLE Bluetooth Low Energy (now: Bluetooth Smart)
DTM Direct Test Mode (for Bluetooth Smart devices)
EUT Equipment Under Test
GPIO General Purpose Input Output
GUI Graphical User Interface
PCB Printed Circuit Board
PER Packet Error Rate
SoC System on Chip
UART Universal Asynchronous Receiver/Transmitter

2 References
3 Introduction

DA1458x are Bluetooth® Smart 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.

The DA1458x supports Direct Test Mode (DTM) for RF PHY testing as specified by the Bluetooth SIG. The Device Under Test (DUT) communicates with the Bluetooth tester over a 2-wire HCI UART. See Figure 1 for a description of the test setup.

The DA1458x supports Direct Test Mode when used with the split embedded configuration of the firmware. The prod_test_58x.hex files can be found in the latest SDK and can be downloaded from the Dialog Customer Support site. Please read sections 4.1 to 4.3.4 for setting up DTM for Bluetooth RF testing.

Additionally, using the latest Connection Manager tool and loading the same prod_test_58x.hex file, some production tests can be executed, for example: continuous modulated Tx output, Tx CW output and Rx testing with statistics. This test-mode is started when choosing ‘Boot Test Mode’ in the Connection Manager after downloading the prod_test_58x.hex file. This tool provides a GUI showing the available commands.

Furthermore, a command line interface based executable is available (progtest.exe), offering similar functionality. Please read sections 4.6 and 4.7 for setting up these production test tools.
4 Setting up Direct Test Mode

4.1 Introduction

The measurements on the RF PHY can be performed using for instance the R&S CBT in local mode by controlling the buttons of the CBT equipment, or in remote mode under control of a PC tool running a test script such as CBTgo. The installation guide for the required hardware and software is provided in sections 4.3, 4.3.2, 4.5 and 4.3.3.

![Diagram of Setup for Bluetooth Direct Test Mode](image)

Figure 1: Setup for Bluetooth Direct Test Mode
4.2 UART baud rate considerations

The DA1458x UART baud rate is derived from the internal 1 MHz clock signal. This 1 MHz is the 16 MHz crystal oscillator clock divided by 16. The UART baud rates are defined in Figure 2 below.

![Figure 2: DA1458x actual UART baud rates](image)

The target baud rate of 115.2 kBa actually is 111.1 kBd, having an error of 3.54 %. Since the UART specification allows for a total error of 5 %, this DA1458X baud rate error leaves only 1.46 % for the other side, e.g. the R&S CBT or the Anritsu MT8852B.

When the BLE test equipment is having communication problems with the actual UART baud rate of 111.1 kBd, which is the default value defined in the cust_prod_test.hex file, a lower baud rate must be selected. It is advised to use the target baud rate of 38.4 kBd by applying a divider value of 26, resulting in a very low error of 0.16 %. This lower baud rate will not affect the measurement time.

It was found that the Anritsu MT8852B BT tester definitely requires the lower baud rate of 38.4 kBd, while the R&S CBT normally works fine at a baud rate of 111.1 kBd (divider value 9), but some specific devices might require the lower 38.4 kBd baud rate.

The most flexible method for DTM signalling to the DA1458X is to use a Comm Tunnel tool running on the PC. This tool acts as a baud rate converter and also avoids the use of the level shifter, since the communication runs via the FTDI chip on the motherboard. The PC must have a physical or virtual COM port.

In the example of Figure 3, COM1 is the PC’s COM port to which the serial port of the Bluetooth tester is connected and COM4 is the virtual UART COM port provided by the SDK evaluation mother board. For both endpoints a baud rate of 115.2 kBd is selected, at which the Anritsu MT8852 now also communicates well with the DA1458X. Before downloading the prod_test_58x.hex test software over UART, the Comm Tunnel tool must be stopped by using the ‘Stop’ button.
Figure 3: Example of a Comm Tunnel tool
4.3 Setting up R&S CBT BT/BLE tester

4.3.1 Setting up CBT hardware

4.3.1.1 From the back of the CBT connect the GPIB to the PC and configure the interface. Also see the CBTgo user manual for details.

From the back of the CBT connect an RS232 cable to the PC.

Supply and UART is provided by a USB cable between the PC and the development board. Connect a RF cable between the SMA connector and the CBT.

4.3.2 Installing the software
### 4.3.2.1
Download the CBTgo program from the Rohde&Schwarz website and install:


Current CBTgo version is v3.0.0.

### 4.3.2.2
Set the UART baud rate in the CBT to 115.2 kBd.

### 4.3.2.3
Install and run the latest Connection Manager: ConnectionManager.exe.

"Cortex-M0 identified" should be listed.

Download this tool from the Dialog Semiconductor support website: under the tab “Guide / Software”.

### 4.3.2.4
In the Connection Manager, select the UART COM port.

Locate the provided hex file.

Download the SDK from the Dialog support website.

This is the port having the lowest COM-port number of the relevant COM-port pair.

This is in the latest SDK.

Filename: prod_test_58x.hex.

### 4.3.2.5
Power the DA1458x board and in the Connection Manager choose “Load Firmware”.

Point to the provided file prod_test_58x.hex.
4.3.2.6

The result should look like the output on the right and should show “Verify successful”.

```plaintext
Feature(s): GDB
(Target = 30.000V

Info: Could not measure total IR len. TDI is constant high.
Info: Could not measure total TD len. TDO is constant high.
No devices found on JTAG chain. Trying to find device on SMD.
Info: Found SWD-CP with ID 0x08011147
Info: PRAM: 4 code (SP) slots and 0 literal slots
Info: Found Cortex-M0 v0p0, Little endian.
Core: Core identified.
JTAG speed: 100 kbps
Processing script file...

Reset delay: 6 ms
Reset type NORMAL: Resets core & peripherals via SYSETHRESET & VECTRESET bit.

Writing 0000000000000000
Writing 0000000000000000

Loading binary file... [cust_prod.test.BSP_v0600_original.bin]
Writing bin data into target memory @ 0x00000000.

Loading binary file cust_prod.test.BSP_v0600_original.bin
Reading 21990 bytes data from target memory @ 0x00000000.
Verify successful.

Reset delay: 6 ms
Reset type NORMAL: Resets core & peripherals via SYSETHRESET & VECTRESET bit.

Script processing completed.
```
### 4.3.3 Setting up Bluetooth LE Direct Test Mode

<table>
<thead>
<tr>
<th>4.3.3.1</th>
<th>Set the UART baud rate in the CBT to 115.2 kbps.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td></td>
</tr>
<tr>
<td>4.3.3.2</td>
<td>In Manual mode enable Bluetooth LE.</td>
</tr>
<tr>
<td><img src="image2.png" alt="Image" /></td>
<td></td>
</tr>
<tr>
<td>4.3.3.3</td>
<td>Enable the device in test mode and the device will connect. Tx/Rx test cases can be selected using the software menu.</td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td></td>
</tr>
<tr>
<td>4.3.3.4</td>
<td>Running an Rx test.</td>
</tr>
<tr>
<td><img src="image4.png" alt="Image" /></td>
<td></td>
</tr>
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4.3.4 Setting up Direct Test Mode with CBTgo
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3.4.1</td>
<td>Run the CBTgo v.3.0.0 program from Rohde&amp;Schwarz. For download link and installation, please refer to section 4.3.2.1.</td>
</tr>
<tr>
<td>4.3.4.2</td>
<td>In CBTgo configure for a BT Low Energy device.</td>
</tr>
<tr>
<td>4.3.4.3</td>
<td>In CBTgo configure the tests to be executed. These tests can be saved in a sequence file.</td>
</tr>
<tr>
<td>4.3.4.4</td>
<td>Press the Start button in CBTgo to execute the sequence.</td>
</tr>
<tr>
<td>4.3.4.5</td>
<td>The result file can be saved and exported to other formats.</td>
</tr>
</tbody>
</table>
4.4 Setting up Anritsu MT8852B BT/BLE Tester

Make sure the MT8852B has the latest firmware version: 4.18.000 (August 2014). This firmware version offers communication directly to the DA1458X evaluation kit’s dual FTDI chip via the USB connector. In the tester’s EUT BT address menu, select the following communication method: USB->RS232 (Source), A (Port). Port A is the UART communication port.

Figure 4: Anritsu MT8852B connections

The Anritsu MT8852B appeared not to be able to communicate to the DA1458X device at a baud-rate of 115.2 kBD. The baud rate should be set to 38.4 kBD in order to function correctly. In the MT8852B go to the EUT RS232 setup menu and set the Baud rate to 38400 Bd.
The EUT (DA1458x) must also be set to a baud rate of 38.4 kBd. The file `cust_prod_test.hex` must be prepared for this. In the Keil project `cust_prod_test`, the following must be defined in order to communicate at a baud rate of 38.4 kBd:

Define the divider value for UART_BAUD RATE_38K4 to 26:

```c
#define UART_BAUD RATE_38K4 26
```

In the following code, replace `UART_BAUD RATE_115K2` by `UART_BAUD RATE_38K4`:

```c
void periph_init(void)
{
    // Power up peripherals' power domain
    SetBits16(PMU_CTRL_REG, PERIPH_SLEEP, 0);
    while (!GetWord8(SYS_STAT_REG) & PER_IS_UP)
    SetBits16(CLK_16M_REG, XTAL16_BIAS_SM_DISABLE)
    // Initialize UART component
    #ifdef PROGRAM_ENABLE_UART
    SetBits16(CLK_PER_REG, UART1_ENABLE, 1);    /
    #ifdef UART_MEGABIT
    uart_init(UART_BAUDRATE_11M, 3);
    #endif
    #ifdef UART_BAUDRATE_115K2
    uart_init(UART_BAUDRATE_115K2, 3);
    #endif
    #endif
    //...
```

Compile and build the `cust_prod_test.hex` file. It is best to first rename this file to `cust_prod_test_38k4.hex` to differentiate it from the default version using 115 kBd.

**Procedure:**
1. Load the created hex file in the DA1458X.
2. Connect the USB->RS232 cable
3. Connect the RF-port of the MT8852B to the RF SMA connector on the DA1458x daughterboard.
4. For PC program based testing and test-report generation, connect the PC to the MT8852B by a GPIB cable.
   
   Available PC software: CombiTest v3.2 or BLE Measurement Software v1.15.
4.5 Setting up LitePoint IQ2010/2015 BT/BLE Tester

The Litepoint IQ201x series of universal testers is targeted for fast production line testing.

The setup is simple: the RF1 output of the Litepoint tester is connected to the DA1458X RFIO port, the SMA connector on the BLE device daughterboard. Please use a high quality coaxial cable for this. The PC controls the Litepoint tester and the EUT, the DA1458X device.

The DA1458x BLE device must be running the production test software, the BLE device will be in Direct Test Mode (DTM), also called non-link test mode. For this DTM mode, the following hex file must be loaded into the device: cust_prod_test.hex. It is the same file as used in section 4.3.

The procedure is as follows: for DA1458x Rx testing the IQ201x tester sends out a known number of packets, the Dialog Semiconductor production test software proptest.exe or the Connection Manager.
GUI tool reports the number of packets received by the DA1458X and then a packet error rate (PER) calculation can be executed. Unlike the R&S CBT or the Anritsu MT8852B tester, there is no EUT signalling by the IQ201x tester. The EUT must be controlled by the PC using CLI `prodttest.exe` or `Connection Manager` GUI. See section 4.9, showing the latter option.

### 4.5.1 Vector Signal Generator

The IQ201x tester is controlled by the Litepoint PC control software: `IQsignal`. For RF1 to be used as BLE RF output, as shown in Figure 8, it must be configured as follows in the `Bluetooth Settings` menu of the `IQsignal` program: RF2=>VSA / RF1=>VSG. See Figure 9.

In the Vector Signal Generator (VSG) tab, the required generator file can be selected and loaded. Then the generator can be run continuously or for a certain number of waveforms or packets. Also, the wanted frequency/channel and the RF output level of the tester can be set here. See Figure 10.

In Figure 10 the Dirty packets waveform `BT_LE_DirtyPacket.mod` has been loaded. This waveform contains 40 packets, so when transmitting the waveform 100 times by pressing the `RF On/Off` button, in total 4000 packets will be sent. This is the so-called BLE PER Report Integrity test.

A similar test using packets containing CRC errors can be executed by loading the waveform `BT_LE_CRC_ERROR.mod`. This waveform contains two packets, one good and one having the CRC error. The result at the receiver side could be as follows: 2000 packets received, 1000 packets having a CRC error, PER = 50 %. The resulting PER should be between 50 % and 65.4 %.

![Figure 9: IQsignal Settings menu – using RF1 for VSG](image-url)
Transmitting starts when the RF ON/OFF button is pressed, and when a number is selected, it stops transmitting when this number of waveforms has been sent.

**Procedure:**

1. Give the Start Receiving command to the EUT.
2. Press the RF ON/OFF button in the IQSignal program.
3. After finishing, give the Stop Receiving command to the EUT.

The transmitted number of packets is known. The received number of good packets can be read, either in the prodtest.exe output or in the Connection Manager GUI. In the latter, the test Rx with Readback values must be selected. See sections 4.6 and 4.7.
4.5.2 Vector Signal Analyzer

The Vector Signal Analyzer (VSA) can be used to analyse the Tx output of the EUT. For RF1 to be used as RF input, as shown in Figure 8, it must be configured as follows in the Bluetooth Settings menu of the IQsignal program: RF1=>VSA / RF2=>VSG. See Figure 11.

![Figure 11: IQsignal Settings menu – using RF1 for VSA](image)

The EUT (DA1458x) again is in Direct Test Mode, but now as Tx, transmitting either continuously or a certain number of packets. This can be set in the Connection Manager GUI or the CLI proctest.exe. Use the LE Transmitter Test Command (see section 4.6.2) to set the desired frequency and payload.

The VSA screen displays the Peak Power, Frequency Offset, Delta F1, Delta F2 etc. Via the button Plot Window also a ‘Spectrum Mask’ or a ‘Delta F2 Max versus Time’ can be displayed. For Delta F1 the payload must be set to 11110000, for Delta F2 use a value of 10101010 (Figure 12). The capture length can be set to capture just one packet or multiple packets.

![Figure 12: Vector Signal Analyzer - analysing DA1458X's Tx output](image)

The received packets as shown in the right-hand window can be saved as a waveform.mod file, which again can be used as input waveform for the Vector Signal Generator.
4.6 Setting up test modes with Connection Manager

<table>
<thead>
<tr>
<th>4.6.1</th>
<th>Run Connection Manager tool. Load the file <em>cust_prod_test.hex</em> and select Boot Test Mode.</th>
</tr>
</thead>
</table>

| 4.6.2 | In the left-hand window of the Connection Manager, all available test cases are provided. |

| 4.6.3 | Example: Tx Continuous Test at 2450 MHz will result in a modulated continuous Tx signal at the RFIOp pin. The centre frequency will be 2450 MHz in this example. Using a spectrum analyser, the modulation and the output power can be checked. See picture in next window. |

Example: Tx Continuous Test at 2450 MHz will result in a modulated continuous Tx signal at the RFIOp pin. The centre frequency will be 2450 MHz in this example. Using a spectrum analyser, the modulation and the output power can be checked. See picture in next window.

In case the Unmodulated Tx option is selected, an unmodulated CW signal is available at the RF output. The frequency accuracy could be checked by reading its frequency.
### 4.7 Setting up test modes with Progtest.exe (CLI)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.7.1</strong></td>
<td>Load the file <code>cust_prod_test.hex</code>, either using the Connection Manager (section 4.6.1) or SmartSnippets’ UART Booter. The latter option is shown in the next window.</td>
</tr>
</tbody>
</table>
| **4.7.2** | Progtest.exe -h lists all available options. See output window in section 4.7.6. This CLI tool provides some more options than using the Connection Manager in Boot Test Mode:  
- **Sleep modes**: Deep- and Extended Sleep  
- **16 MHz Xtal trimming possibility**  
Please refer to user manual UM-B-008 ([1](#)) for details on how to use this Progtest.exe tool. |
| **4.7.3** | Example: **Progtest -p 4 unmodulated Tx 2440**  
This command will result in an un-modulated Tx at 2440 MHz. The switch `-p 4` indicates that COM-port 4 is being used for communication. |
| **4.7.4** | Example: **Progtest -p 4 Xtrim en**  
This command enables the 16 MHz Xtal trimming. The 16 MHz oscillator signal will be switched to port P0_5 and can be measured by using e.g. a frequency counter. |
| **4.7.5** | Progtest -p <COM port number> cont_pkt_tx <FREQUENCY> <DATA_LENGTH> <PAYLOAD_TYPE> <NUMBER_OF_PACKETS>  
Progtest -p <COM port number> pkt_tx <FREQUENCY> <DATA_LENGTH> <PAYLOAD_TYPE>  
Progtest -p <COM port number> start_pkt_rx <FREQUENCY>  
Progtest -p <COM port number> stop_pkt_rx  
Progtest -p <COM port number> start_pkt_rx_stats <FREQUENCY>  
Progtest -p <COM port number> stop_pkt_rx_stats  
Progtest -p <COM port number> stoptest  
Progtest -p <COM port number> sleep none <minutes> <seconds>  
Progtest -p <COM port number> sleep extended <minutes> <seconds>  
Progtest -p <COM port number> xtrim rd  
Progtest -p <COM port number> xtrim wr <trim_value>  
Progtest -p <COM port number> xtrim en  
Progtest -p <COM port number> xtrim inc <delta>  
Progtest -p <COM port number> xtrim dec <delta> |

---

**Example:**  
Progtest -p 4 unmodulated Tx 2440  
This command will result in an un-modulated Tx at 2440 MHz. The switch `-p 4` indicates that COM-port 4 is being used for communication.  
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DA1458x Bluetooth Direct Test Mode

Revision history

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>30-May-2013</td>
<td>Initial version.</td>
</tr>
<tr>
<td>0.2</td>
<td>05-Jun-2013</td>
<td>Corrections.</td>
</tr>
<tr>
<td>0.3</td>
<td>07-Nov-2013</td>
<td>Updated for ES3.</td>
</tr>
<tr>
<td>0.4</td>
<td>06-Jan-2014</td>
<td>Updated for ES4.</td>
</tr>
<tr>
<td>0.5</td>
<td>31-Mar-2014</td>
<td>Updated for DA14580_01, adding Anritsu MT8852B BT tester and adding production testing.</td>
</tr>
<tr>
<td>0.6</td>
<td>13-May-2014</td>
<td>Added Litepoint Tester setup.</td>
</tr>
<tr>
<td>0.7</td>
<td>22-Aug-2014</td>
<td>Updated section 4.6 for Anritsu tester.</td>
</tr>
<tr>
<td>1.0</td>
<td>06-May-2015</td>
<td>Added section 4.2 (UART baud rate considerations). Section 4.3 reorganised to include all CBT related information. Section 4.3.1 updated.</td>
</tr>
<tr>
<td>1.1</td>
<td>14-June-2016</td>
<td>Changed pictures and text for DEVKIT pro</td>
</tr>
<tr>
<td>1.2</td>
<td>01-Mar-2017</td>
<td>Generalized for DA1458x</td>
</tr>
</tbody>
</table>
Status definitions

<table>
<thead>
<tr>
<th>Status</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRAFT</td>
<td>The content of this document is under review and subject to formal approval, which may result in modifications or additions.</td>
</tr>
<tr>
<td>APPROVED or unmarked</td>
<td>The content of this document has been approved for publication.</td>
</tr>
</tbody>
</table>

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