Setting up production test using DTM

nAN-034

Application Note v1.0

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1 Introduction

The main function of a production test is to verify that all the components are mounted correctly and have correct values after assembling a device.

To perform a production test on a *Bluetooth*® low energy application, it is preferable to use a built-in function called Direct Test Mode (DTM). The DTM enables testing of the RF parameters and is also used for end-product qualification testing of the RF physical layer (RF PHY). All *Bluetooth* low energy products include a UART interface that gives access to the Direct Test Mode (DTM).

The DTM has two main modes of operation; the transmit test mode and the receive test mode. In transmit test mode, the Device Under Test (DUT) generates a predefined set of test packets. In receive test mode, the DUT counts the number of test packets received.

This application note describes two alternatives for setting up a production test with DTM:

- By using Anritsu MT8852B *Bluetooth* Test Set
  - Qualified by *Bluetooth* SIG
  - Wide range of DTM test
- By using the nRF8001 Development Kit or the nRF51822 Development Kit together with a computer as the tester
  - Simple range of DTM tests
  - Low cost

1.1 Prerequisites to the Application note

1.1.1 Hardware requirements

- nRF8001 Development Kit (nRF8001-DK) or nRF51822 Development Kit (nRF51822-DK)
- nRFgo Starter Kit (nRF6700)

1.1.2 Software requirements

- nRF8001 SDK or nRF51 SDK
- nRFgo Studio

2 Production test level

The level on the production test should be based on the fact that the RF circuitry on every chip from Nordic Semiconductor is already tested, including both transmit and receive functionality. During your prototype testing of a device, all the main parameters such as output power, range, and functionality are verified.

This means that the production test needed on every assembled device can be simplified compared to the prototype testing.

Passing a production test using DTM will verify:

- The transceivers output power is sufficient, indicating that the matching network and related circuitry are mounted correctly and have correct component values.
- The functionality of the device.

After the production test is passed, the device is ready to use.

3 Setting up your production test

3.1 Using Anritsu MT8852B as Tester

The Anritsu MT8852B supports *Bluetooth* low energy (BLE) DTM testing on a device by controlling the device through a HCI or two-wire (UART) interface while measuring the RF performance. The UART interface is available on all Nordic Semiconductor BLE devices. The Anritsu MT8852B can run BLE tests directly, or the testing can be controlled from a computer.

The DUT is controlled by sending DTM commands over the UART interface. There are ready made BLE full-tests and quick-tests available from Anritsu, along with the possibility to create manual test scripts.

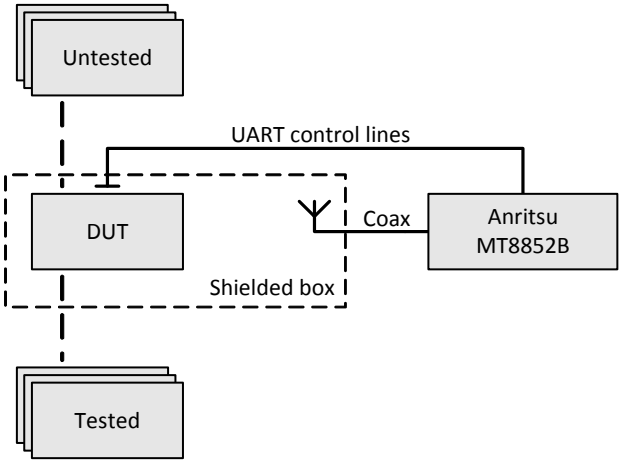

Figure 1 *Using Anritsu MT8852B as Tester*

To access the documentation, software, operation manuals, and supported test modes for the Anritsu MT8822B, please visit www.anritsu.com.

3.2 Using a Nordic Semiconductor Development Kit as Tester

To be able to use a Nordic Semiconductor Development Kit as a tester, an attenuator is needed between the DUT and the tester, see ***Figure 2***.

The attenuator must be adjusted so the RF output power is just above a threshold set on the Tester. If the output power from the DUT is lower than expected, it will end up under the threshold and identified by the Tester as a faulty device.

The difference between a functional and a faulty matching network is at least 10 dB, so it is possible to use a Tester with an attenuator to differentiate between a good and a bad DUT.

Figure 2 shows a typical setup with a PCB module with SMA connector from nRF8001-DK or nRF51822-DK, together with a computer acting as a Tester in a production test setup. The PCB module with SMA connector from the Development Kit will work as the Lower Tester (RF PHY) and the computer will work as the Upper Tester (UART control lines).

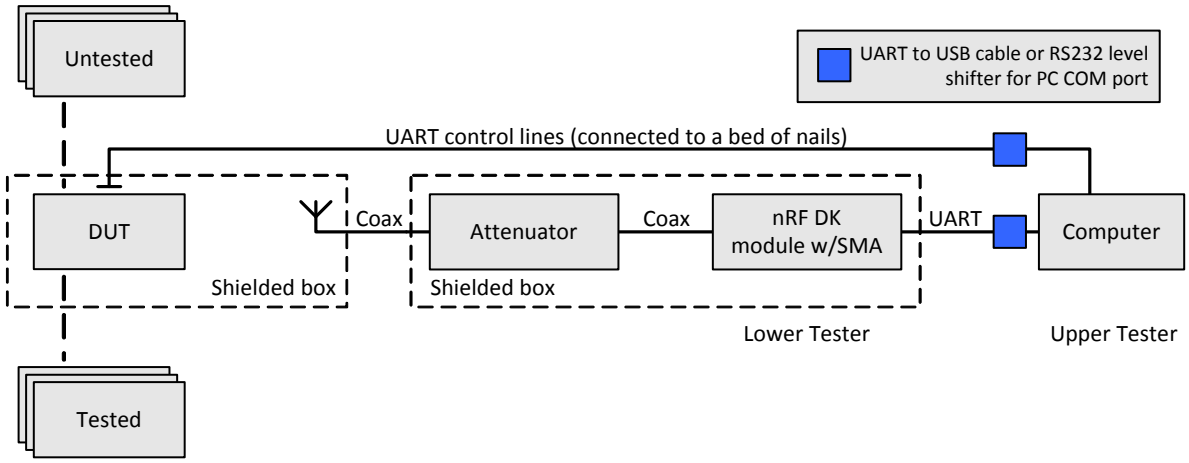

Figure 2 *Setup with PCB module with SMA connector as Lower Tester*

Figure 3 shows a simplified setup of ***Figure 2*** on page 6. This setup will use the DTM_ENABLE pin to setup transmit mode directly on the DUT, without use of UART control lines (See ***Section 3.3 "Enable DTM on DUT"*** on page 9. for details). The computer should now run the DTM receive test only. This setup is sufficient to verify production test levels as described in ***Chapter 2*** on page 4.

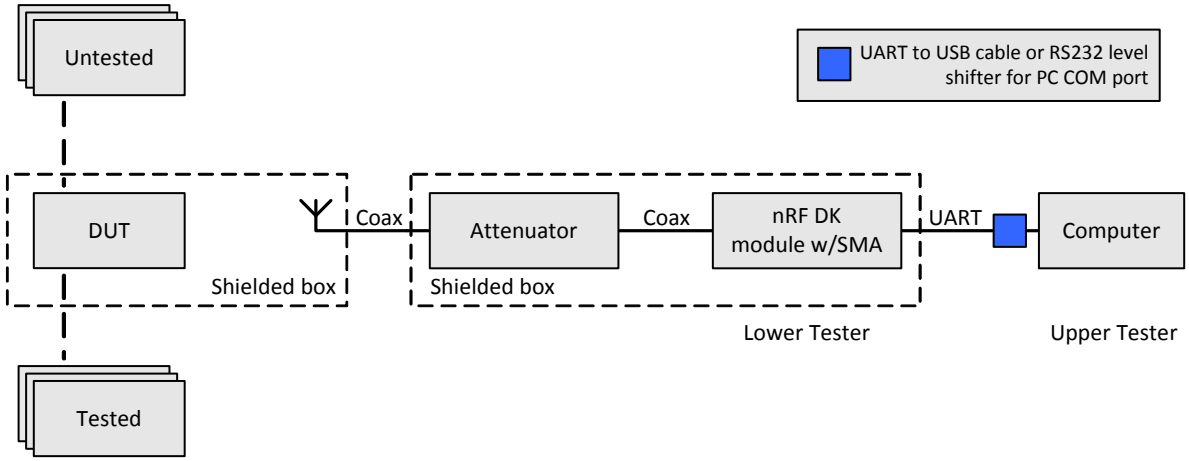

Figure 3 *Simple setup with PCB module with SMA connector as Tester*

3.2.1 Hardware requirements

To use the Nordic Semiconductor Development Kit as the tester, requires two COM ports on the computer, one to control the PCB with SMA connector and one to control the DUT. It is possible to use FTDI based USB to Serial (TTL 3.3 V) adapters on the computer to connect to the UART control lines, or alternatively use RS232 with level shifters.

An Nordic Semiconductor Development Kit consists of several PCB modules; however only the PCB module with SMA connector can be used as Lower Tester in the production test. Set up the hardware for testing with DTM as described in the respective Development Kit User Guides.

The PCB module with SMA connector and the attenuator should be placed within a shielded box, especially if it is used in an environment with multiple DTM test stations in close proximity.

The DTM UART settings for the Development Kit modules:

- UART interface: TXD and RXD
  - Baud rate: 19200
  - Data bits: 8
  - Stop bit: 1
  - No parity
  - No flow control (no RTS or CTS)

3.2.2 Computer Software

The computer (Upper Tester) software is written in the Python programming language and consists of a DTM library, an example script, and a readme file. The software is enclosed in the zip-file together with this application note. The software has been run and tested on a Windows 7 computer. The software can be ported to other platforms that support Python.

The DTM library can set up different DTM modes through UART commands as described in the *Bluetooth* specifications Ver 4.0, Vol 6, part F. The example script uses the DTM library to control both Tester and DUT over their respective COM ports on the computer.

The DTM library supports both receive and transmit test modes, and will output Packet Error Rate (PER) for both modes. Typically a PER of > 30% in either mode can be used to detect a failing DUT.

Refer to the readme file included in the attached software for documentation on the requirements and usage of the software.

3.2.3 Setting attenuation level

The attenuator level should be set by using a golden sample as DUT. This golden sample is a tested prototype device that meets the requirements in terms of output power and range for your product. Place the golden sample in the shielded box as DUT, and carefully adjust the attenuator to the highest attenuator setting which still allows the golden sample to pass the DTM test. Decrease the attenuation level by 4 to 6 dB to allow for some production variation, this is the setting you should use for the test station. Repeat this procedure to set attenuation level for every test station.

3.3 Enable DTM on DUT

The Tester must have access to 5 test points on the DUT to run the DTM test.

Test points	Description	Comment
1	VSS (Ground)	Power supply
2	VCC	Power supply
3	DTM_ENABLE	Enable DTM test (optional)
4	TXD	UART control line
5	RXD	UART control lines

Table 1 *Required pin connection for the DUT*

The DTM_ENABLE pin is an optional pin that can be used by the application controller to enable the UART control lines for DTM tests. For example, the DTM_ENABLE test pin can be an input pin with a pull up resistor, and if this pin is pulled low externally, the application should enable the UART control lines for DTM tests. The DTM_ENABLE pin can also be used to setup transmit mode directly, without the use of the UART control lines.

The actual baud rate used by the DUT depends on the BLE chip used in the product. For some BLE chips the baud rate is fixed, while for others the baud rate can be modified. Refer to the specific product specification or source code for details.

4 Exceptions when Production test on nRF8002 based products

Note: The nRF8002 Direct Test Mode (DTM) is not available after the configuration of the nRF8002 is placed in OTP.

Typically the DUT should be a preprogrammed module with application firmware or configuration; however, for the nRF8002 the DTM test is only available before the configuration is locked in OTP. The nRF8002 can receive DTM commands over the UART after power is applied and before any configuration is locked to OTP.

This means that for products based on the nRF8002 the configuration should be written after the DTM test is passed. This will still verify that the hardware is fully operational and meet the requirements of the final product.

5 Glossary

Term	Description
RF PHY	Radio Frequency Physical layer - including crystal, matching network and antenna
OTP	One Time Programmable Memory
DK	Development Kit
DTM	Direct Test Mode
DUT	Device Under Test
Tester	The actual hardware executing the DTM test, can be split in a Lower and Upper Tester
BLE	*Bluetooth* low energy
PER	Packet Error Rate
UART	Universal asynchronous receiver/transmitter

6 References

How to enable the DTM mode on the chip in use:

- **nRF8001** - Use the ACI Test command with the enable DTM over ACI option or DTM over UART as defined in the nRF8001 Product Specification. The nRF8001 Product Specification can be found on www.nordicsemi.com. Read the Development Kit User Guide for the nRF8001 for more information on DTM.
- **nRF518xx and other nRF devices** - Read the Development Kit User Guide for the respective chip on how to configure and enable DTM. The Development Kit User Guide for the respective chip can be found on www.nordicsemi.com.

See *Bluetooth* specification Ver 4.0, Vol 6, part F for DTM command word format and options. The *Bluetooth* specification can be found on www.bluetooth.org.

See RF Performance Test Guidelines, White Paper nWP-006, that describes how to run various RF front end tests. The White Paper can be found on www.nordicsemi.com/eng/Support/Whitepapers.

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Revision History

Date	Version	Description
April 2013	1.0	First release