
Bringing up the BlueNRG-1, BlueNRG-2 devices

Introduction

The BlueNRG-1 and BlueNRG-2 devices are high performance, ultra-low power wireless systems-on-chip, which support Bluetooth low energy specifications.

In order to achieve the maximum performance, some procedures must be carried out before finalizing the application.

This document summarizes the following fundamental steps:

- Application PCB test points
- Power supply and current consumption tests
- Device configuration
- XTAL and LSOSC centering tests
- Output power test
- Packet exchange test
- Sensitivity test
- Power consumption in advertising mode

Note: The document content is valid both for the BlueNRG-1 and BlueNRG-2 devices. Any reference to the BlueNRG-1 device and platform is also valid for the BlueNRG-2 device and platform. Any specific difference is highlighted whenever it is needed.

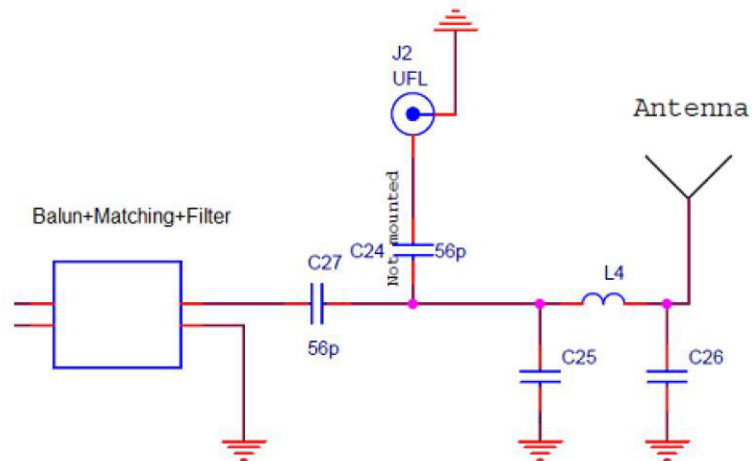
1 Application PCB test points

ST recommends a set of test points to measure the performance of the device on the customer's PCB. According to PCB constraints, it may not always be possible to add all test points, therefore some tests cannot be performed.

Table 1. Test points

Test point	Function	Details of the test point
Current consumption	Should be added to the PCB to measure the BlueNRG-1 current consumption	In series with the VBAT1,2,3 pins
Voltage supply	Should be added to measure the BlueNRG-1 supply voltages	To pins: VDD1V2, SMPSFILT1, SMPSFILT2
RF	If the PCB uses an embedded antenna, like a PCB or a chip antenna, it is recommended to add a UFL connector to allow measurement of the RF performance with a spectrum analyzer	Between the matching network (or balun) and the embedded antenna (see Figure 1. UFL connector).
ANATEST0, ANATEST1	Pins used for the XTAL_startup measure	Pins: ANATEST0, ANATEST1

Figure 1. UFL connector



1.1 DTM test applications

DTM (direct test mode) test application is used as reference software to configure the platform under test. DTM binary file can be built using the DTM test application available on BlueNRG-1_2 DK software package (STSW-BLUENRG1-DK) on BLE_Examples/DTM folder, and it can be directly loaded using the BlueNRG-1, BlueNRG-2 Flasher utility (STSW-BNRGFLASHER). Based on the test requirements, the user can select:

- BlueNRG-1 or BlueNRG-2 DTM project
- UART configuration based on the HS crystal used on the device platform and on the selected BLE stack modular configuration option
- SPI configuration based on the selected BLE stack modular configuration option

The BlueNRG-1, STEVAL-IDB007V1/STEVAL-IDB007V2 (16 MHz HS crystal), DTM UART mode pre-built binary images are available on BlueNRG-1_2 DK software package on folders: Firmware/BLE_Examples/DTM/BlueNRG1 and DTM_basic/BlueNRG1. DTM SPI mode pre-built binary images are also available on the same folders.

The BlueNRG-2, STEVAL-IDB008V1/STEVAL-IDB008V2 (32 MHz HS crystal), DTM UART mode pre-built binary images are available on BlueNRG-1_2 DK software package on folders: \Firmware\BLE_Examples\DTM\BlueNRG-2 and DTM_basic/BlueNRG-2. DTM SPI mode pre-built binary images are also available on the same folders.

2 Power supply test

2.1 Test case specification identifier

SUPPLY_TEST

No specific firmware is needed for this test.

2.2 Test prerequisite

In order to perform this test, you need to add some test points to the platform. Refer to [Section 1 Application PCB test points](#) for test pin description.

2.3 Test description

The aim of this test is to ensure that the BlueNRG-1 is correctly powered.

2.4 Test setup

2.4.1 Hardware

A multimeter is required for this test.

2.4.2 Software

DTM binary file loaded into BlueNRG-1 or BlueNRG-2 device. Please refer to [Section 1.1 DTM test applications](#).

2.5 Test procedure

Power up the BlueNRG-1, BlueNRG-2 platforms.

Measure the voltage in: VBAT1, 2, 3, VDD1V2, SMPSFILT1, SMPSFILT2.

2.6 Expected results

The measured pin voltage and current should be aligned with the following values if the DC-DC converter ON configuration has been chosen.

Table 2. Supply test results

Pin	Expected value
VBAT1,2,3	1.7 – 3.6 V
VDD1V2	1.2 V
SMPSFILT1	Square wave around 1.4 V
SMPSFILT2	1.4 V

If the DC-DC converter OFF configuration has been chosen the SMPSFILT1 pin is left floating and the SMPSFILT2 pin is connected directly to VBAT.

2.7 Note

If some of the measured values are not aligned with the expected values, it is recommended to double-check the integrity of the board connection.

2.8 Other

N/A.

3 Device configuration

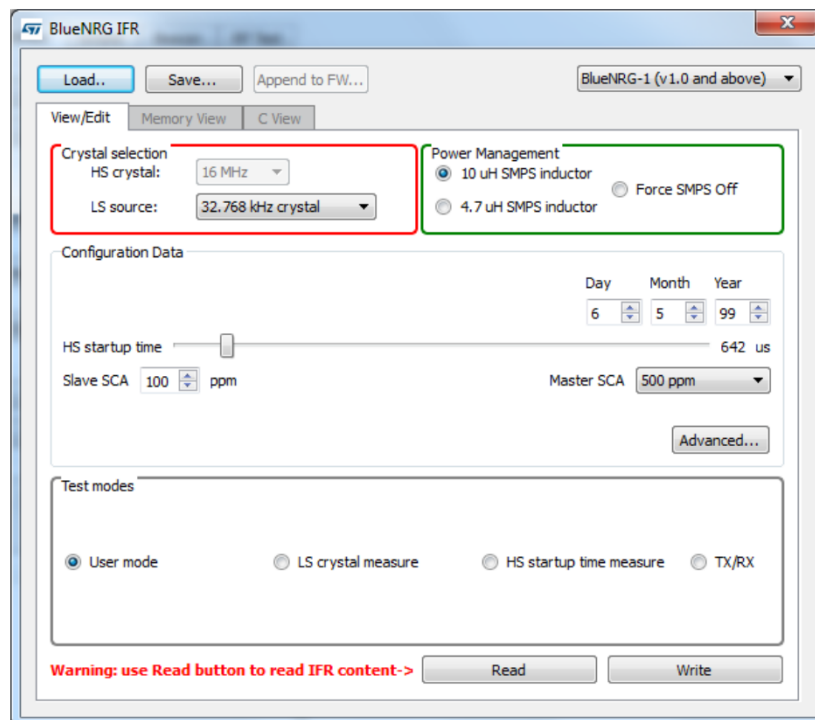
There are some parameters of the BlueNRG-1, BlueNRG-2 devices that must be defined and used during software initialization, before the application board is finalized (see [Section 13 References #4](#)).

These parameters are:

- Low speed oscillator source (32 kHz or the internal ring oscillator)
- Power management options (SMPS inductor or SMPS off configuration)
- Change HS start-up time parameter from 512 μ s to 1953 μ s
- Sleep clock accuracy
- LS crystal period and frequency

The device configuration parameters can also be set using the BlueNRG GUI PC application available on the BlueNRG GUI SW package (STSW-BNRGUI).

Figure 2. BlueNRG GUI IFR tool used for the device configuration



4 HS_Startup_Time

The HS speed clock (16 or 32 MHz) requires the tuning of a specific parameter HS_Startup_Time.

4.1 Test case specification identifier

HS_XTAL_startup_TEST.

4.2 Test prerequisite

The user platform should have the test points for ANATEST0 and ANATEST1 pins (see [Table 1. Test points](#)).

4.3 Test description

The HS_Startup_Time parameter is important because it permits minimization of the current consumption, due to a measurement of the start-up time of the adopted crystal (XTAL_startup). A too short value prevents the BlueNRG-1 from correctly sending/receiving packets.

4.4 Test setup

4.4.1 Hardware

An oscilloscope is required for this test.

4.4.2 Software

The ST BlueNRG GUI and DTM SPI binary file loaded in the BlueNRG-1 and BlueNRG-2 devices. Refer to [Section 1.1 DTM test applications](#).

Note: This test requires the BlueNRG-1 and BlueNRG-2 devices to go to sleep.

4.5 Test procedure

Tick the checkbox present in the BlueNRG IFR tool in the BlueNRG GUI to enable the start-up time test signals. Set the HS start-up time parameter to the maximum value and program this value on the device by selecting the "WRITE" button.

Put two scope probes on test points ANATEST0 and ANATEST1.

Set the BlueNRG-1 and BlueNRG-2 in advertising mode, using these commands with the BlueNRG GUI:
ACI_GATT_INIT

```
ACI_GAP_INIT(Role = Peripheral)
```

```
ACI_GAP_SET_DISCOVERABLE(Advertising_Type=0x00,
```

```
Advertising_Interval_Min=0x0020,
```

```
Advertising_Interval_Max=0x0020,
```

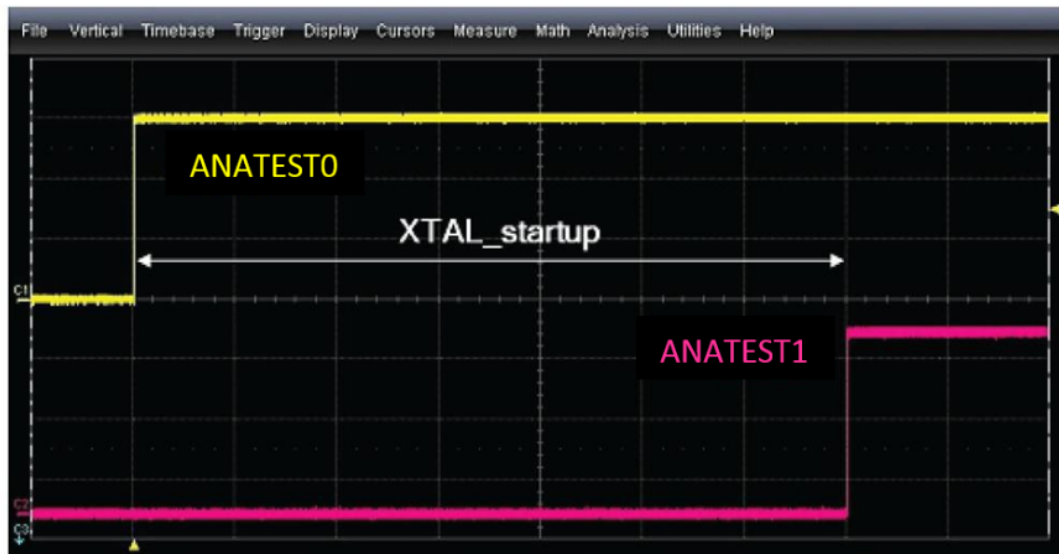
```
Own_Address_Type=0x01,
```

```
Advertising_Filter_Policy=0x03)
```

The time between the rising edge on ANATEST0 and rising edge on ANATEST1 is the time the crystal oscillator takes to start (see [Figure 3. XTAL_start-up measurement](#)).

Since this time can variate a lot in some conditions, especially when the crystal is kept off for around 20 ms, several measurements must be taken using an advertising interval of 20 ms (a good number of measurements is 180000, which corresponds to 1 hour of test). The maximum measured value only must be considered.

Figure 3. XTAL_start-up measurement



Note: This test can be also performed by loading the BlueNRG-1 and BlueNRG-2 devices with an application going to sleep mode and configuring the device in advertising mode with the highlighted advertising parameters (0x20) with the ATB0_ANA_ENG_REG, ATB1_ANA_ENG_REG registers set, respectively, to values 0x04, 0x34 on file system_bluenrg1.c, define COLD_START_CONFIGURATION. Then, the user must put two scope probes on test points ANATEST0 and ANATEST1 and take the time measurements as just described.

4.6 Expected results

The maximum measured value must be compensated in order to consider the variations of the power supply, temperature and the crystal tolerance, by multiplying the value by some specific coefficients:

- 20% : to take in account the effect of power supply variations from 1.7 to 3.6 V
- 10% : to take in account the effect of temperature variations within the related operating range
- 30%: to take in account the effect of crystal motional inductance tolerance. It is strongly recommended to use a crystal with a motional inductance tolerance less than 20%

As a consequence, the compensated value is calculated using this formula:

$$\text{XTAL_startup} = \text{XTAL_startup_measured} * 1.2 * 1.1 * 1.3 = 1.716 * \text{XTAL_startup_measured}$$

The XTAL_startup_measured is the maximum measured value as described in the previous section [Section 4.5 Test procedure](#).

The first coefficient (1.2) can be omitted if the test is performed at the minimum operative voltage.

Finally, to find the HS_STARTUP_TIME value, that must be set in the device configuration parameters, use this formula:

$$\text{HS_STARTUP_TIME} = 110 \mu\text{s} + \text{XTAL_startup}$$

4.7 Note

Examples:

$$\text{XTAL_startup_measured} = 300 \mu\text{s} \rightarrow \text{HS_STARTUP_TIME} = 625 \mu\text{s} \quad \text{XTAL_startup_measured} = 700 \mu\text{s} \rightarrow \text{HS_STARTUP_TIME} = 1311 \mu\text{s}$$

4.8 Other

N/A.

5 XTAL centering test

The BlueNRG-1 and BlueNRG-2 integrate a low-speed frequency oscillator (LSOSC) and a high-speed (16 MHz or 32 MHz) frequency oscillator (HSOSC).

The low frequency clock is used in low power mode and can be supplied either by a 32.7 kHz oscillator that uses an external crystal or by a ring oscillator with maximum ± 500 ppm frequency tolerance, which does not require any external components.

The primary high frequency clock is a 16 MHz or 32 MHz crystal oscillator.

The frequency tolerance of the high-speed crystal oscillator must be below ± 50 ppm.

The BlueNRG-1 and BlueNRG-2 devices, as with all RF systems, are highly dependent on accurate clocks for the correct operation. A deviation in clock frequency directly deviates the radio frequency, and this can degrade RF performance, violate legal requirements or in the worst case lead to a non-functioning system.

For these reasons the crystal frequency must be centered, and the easiest way to find the optimum load capacitor values for a given circuit and layout is through experimentation.

5.1 Test case specification identifier

XTAL_center_TEST.

5.2 Test prerequisite

For this test, the UFL connector (see [Table 1. Test points](#)) is not mandatory.

5.3 Test description

For the reasons previously explained, the crystal frequency must be centered, and the optimum load capacitor values can be found through experimentation. The radio can be set by fixing a constant carrier at a given frequency.

By measuring the output frequency with a spectrum analyzer, the offset can be easily found.

5.4 Test setup

5.4.1 Hardware

A spectrum analyzer is required for this test.

5.4.2 Software

The ST BlueNRG GUI and DTM binary file loaded in the BlueNRG-1 and BlueNRG-2 devices. Refer to [Section 1.1 DTM test applications](#).

5.5 Test procedure

The following procedure is valid for the high-speed oscillator (16 MHz or 32 MHz):

Connect the BlueNRG-1 and BlueNRG-2 board to the spectrum analyzer through an RF cable if it is equipped with UFL connector, otherwise plug a 2.4 GHz antenna into the input port of the instrument.

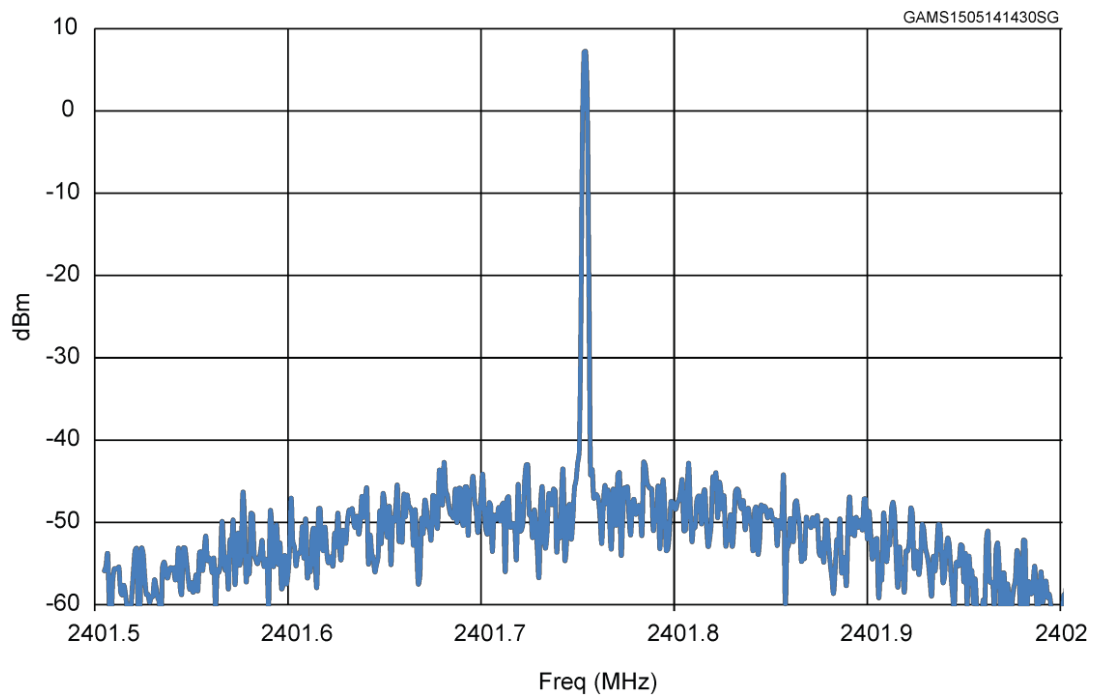
Power up the selected platform.

Set the spectrum analyzer to: res BW = 1 kHz, SPAN = 500 kHz (see [Figure 4. Frequency tone at Ch0 for the XTAL center test](#)).

Generate a carrier wave tone at Ch0 (freq. 2.401750 GHz) using the BlueNRG GUI, RF test window, start tone button and selecting TX frequency as 2402 MHz, channel 0 (a tone can be emitted at $f = 2402 + k * 2 - 0.250$ MHz, with $k = 0$ to 39).

The difference between the desired tone and the measured tone is the frequency offset.

Figure 4. Frequency tone at Ch0 for the XTAL center test



The same results can be achieved by directly using the ACI command: `ACI_HAL_TONE_START()` with offset set to `0x02` (-250 kHz offset).

Note:

Starting from the BlueNRG-1_2 DK software package v3.0.0 (STSW-BLUENRG1-DK), `ACI_HAL_TONE_START()` API has been updated with a further parameter `offset`, which specifies if the tone must be emitted with an offset from the channel center frequency. New API is as follows: `ACI_HAL_TONE_START(RF_Channel, Offset)`. The allowed offset parameter values are:

- `0x00`: 0 kHz offset
- `0x01`: +250 kHz offset
- `0x02`: -250 kHz offset

Please notice that on the previous BlueNRG-1_2 DK software package, the `offset` parameter is not available and the API emits the tone at channel center frequency with the offset fixed at: -250 kHz.

5.6 Expected results

The offset limit is (as reported in point 1 Section 13 References):

$|\text{Offset}| < 50 \text{ kHz}$

If DUT frequency > 2.4018 GHz → increases XTAL caps

If DUT frequency < 2.4017 GHz → decreases XTAL caps

5.7 Note

N/A.

5.8 Other

N/A.

6 LSOSC centering test

The LSOSC is used to have a reference time clock. The advantage of using the external 32.768 kHz clock is that it consumes less power than internal RO and it is more accurate (50 ppm). This test allows its oscillator frequency to be centered, changing the crystal capacitance.

6.1 Test case specification identifier

LSOSC_center_TEST.

6.2 Test prerequisite

For this test, a test point in the pin 14 (ANATEST1) is required.

6.3 Test description

There is a way, using the IFR tool of the BlueNRG GUI, to put the LSOSC signal in the pin 14. By measuring its frequency with an oscilloscope, the frequency offset can easily be measured.

6.4 Test setup

6.4.1 Hardware

An oscilloscope is required for this test.

6.4.2 Software

The ST BlueNRG GUI and DTM binary file loaded in the BlueNRG-1 and BlueNRG-2 devices. Refer to [Section 1.1 DTM test applications](#).

6.5 Test procedure

Connect an oscilloscope probe in the pin 14 (ANATEST1) test point. Power up the BlueNRG-1 platform.

Set the scope to capture a consistent number of 32 kHz waveform periods (for example 64 cycles, so set the time base at 200 μ s). In this way, the influence of the jitter in the measure is minimized.

In the IFR tool of the GUI, perform a "Read" of the current IFR configuration, then tick the check-box "LS crystal measure" and then perform a "Write" operation.

Now a power cycle is required to let the new IFR be operative.

At this point, the 32.768 kHz waveform is visible on the oscilloscope screen.

Perform the measurement of the frequency: the difference between the target value ($f = 32.768$ kHz) and the measured one is the frequency offset Δf .

6.6 Expected results

If DUT frequency > 32.768 kHz \rightarrow increases XTAL caps

If DUT frequency < 32.768 kHz \rightarrow decreases XTAL caps

To find the oscillator ppm, use the following formula:

where:

$$\text{ppm} = \frac{\Delta f}{f} 10^6$$

Δf = offset

$f = 32.768$ kHz

Add to the found ppm value the one declared in the adopted crystal datasheet.

This final value must be used in the slave SCA and master SCA fields when BLE stack is initialized.

6.7 **Note**
N/A.

6.8 **Other**
N/A.

7 Output power test

7.1 Test case specification identifier

OUTPUT_TESTS.

7.2 Test prerequisite

For this test the UFL or SMA connector is mandatory.

7.3 Test description

The aim of this test is verification of the Tx output power level and the step linearity.

7.4 Test setup

7.4.1 Hardware

A spectrum analyzer is required for this test.

7.4.2 Software

The ST BlueNRG GUI and DTM binary file loaded in the BlueNRG-1 and BlueNRG-2 devices. Refer to [Section 1.1 DTM test applications](#).

7.5 Test procedure

Connect the BlueNRG-1 and BlueNRG-2 boards to the spectrum analyzer through an RF cable. Set the spectrum analyzer to: Res BW = 100 kHz, SPAN = 500 kHz.

Power up the BlueNRG-1 platform.

Generate a carrier wave tone at Ch0 (frequency 2.401750 GHz) using the BlueNRG GUI, RF test window:

- Check high power to use BlueNRG-1 and BlueNRG-2 in high power mode
- For the step linearity of the Tx output power, select power level to 0x06
- Click on start transmitter button to generate a carrier wave

The same results can be achieved by using the ACI commands:

- ACI_HAL_SET_TX_POWER_LEVEL (En_High_Power = 0x01, PA_Level: 0x06)
- ACI_HAL_TONE_START (RF_Channel = 0x00, offset = 0x02)

7.6 Expected results

With PA_level=0x07: around 8 dBm

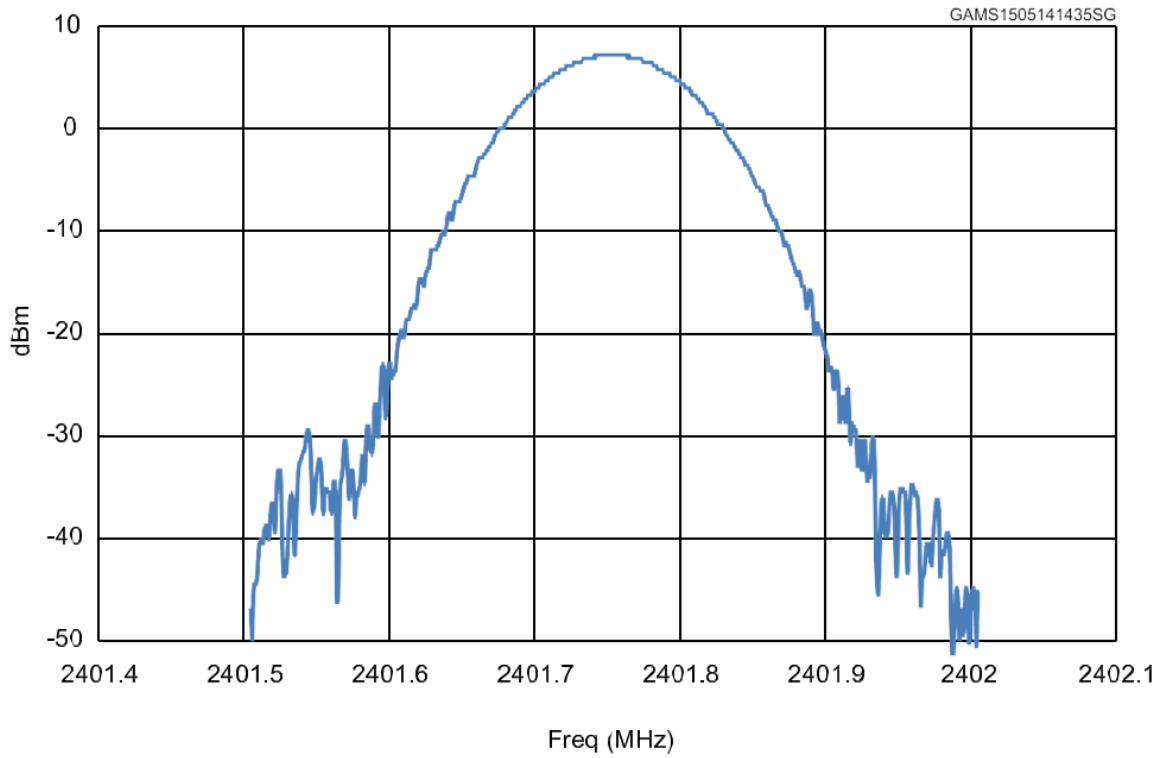
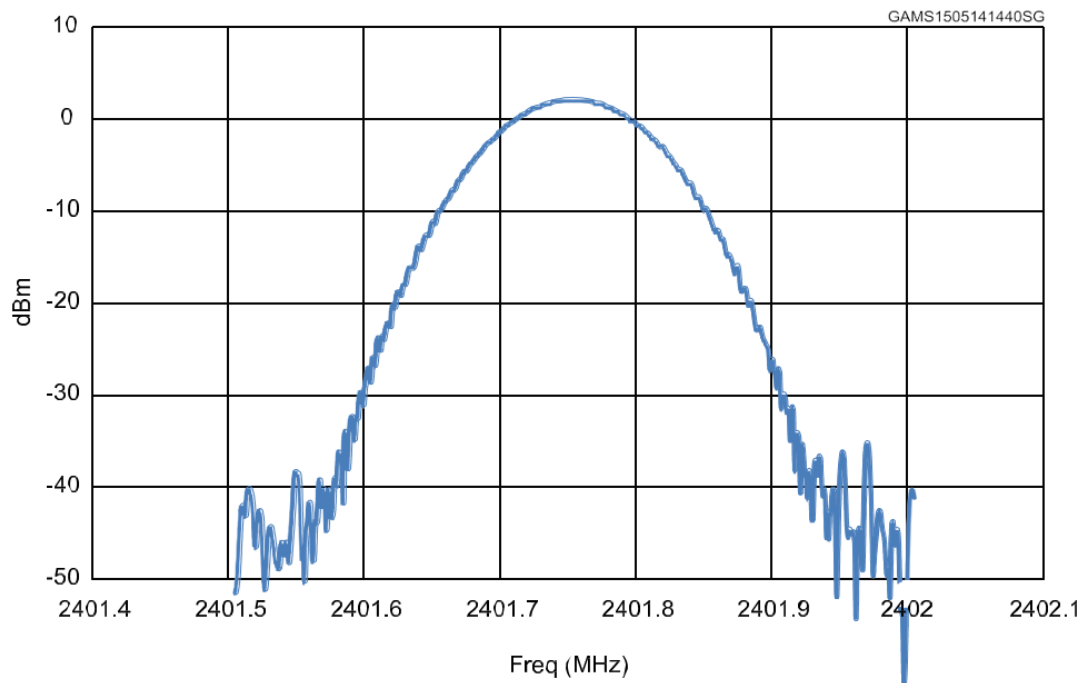
With PA_level = 0x06: around 4 dBm

7.7 Note

The results are significantly influenced by the matching network performance. The user may need to tune it to obtain maximum performance.

7.8 Other

N/A

Figure 6. Output power measurement in high power mode with PA_level 7

Figure 7. Output power measurement in high power mode with PA_level 6


8 Packet exchange test

8.1 Test case specification identifier

PACKET_TEST.

8.2 Test prerequisite

In order to perform these tests, you need a BlueNRG-1 development platform as a master and the DUT board as a slave.

8.3 Test description

The aim of this test is to verify that the DUT board is able to send and receive packets correctly.

8.4 Test setup

8.4.1 Hardware

No instruments required.

8.4.2 Software

The ST BlueNRG GUI and DTM binary file related to the selected BLE stack modular configuration option loaded in the BlueNRG-1 and BlueNRG-2 devices. Refer to [Section 1.1 DTM test applications](#).

8.5 Test procedure

Power up the BlueNRG-1 and BlueNRG-2 platform (Rx) and the DUT board, that acts as Tx and ensures antenna is plugged in.

Follow these steps to start packet exchange test:

In the GUI related to Rx device

- Go to RF test window, RECEIVER section
- Set Rx frequency
- Click on "Start Receiver" button, to start "Receiver Test"

In the GUI related to Tx device

- Go to RF test window, TRANSMITTER section
- Set Tx power
- Set Tx frequency
- Set length of data to 0x25
- Set packet payload format
- Click on "Start Transmitter" button, to start "Transmitter Test"

In the GUI related to Tx device

- Click on "Stop Transmitter" button. The number of transmitted packets are displayed
- On #Packet Transmitted field

In the GUI related to Rx device

- Click on "Stop Receiver" button. The number of received packets are displayed on #Packet Received field
- In the PER section, insert the number of transmitted packet from Tx device in the packet transmitted field (read this value from TRANSMITTER section in the GUI related to Tx device)
- PER (packet error rate) value is showed in the packet error rate field

The same results can be achieved by using the ACI commands:

- Start Rx on DUT: HCI_LE_RECEIVER_TEST

- Make the Tx board send packets: HCI_LE_TRASMITTER_TEST, with the length of test data: 0x25
- Stop test on Tx board: HCI_LE_TEST_END
- Send this command in order to determine the number of packets sent by the Tx:
ACI_HAL_LE_TX_TEST_PACKET_NUMBER
- Stop test on DUT: HCI_LE_TEST_END
- This returns Y as the number of received packets

8.6 Expected results

The number of packets received over-the-air should be equal to the number of packets sent by the Tx board.

8.7 Note

N/A.

8.8 Other

N/A.

9 Sensitivity test

9.1 Test case specification identifier

SENSITIVITY_TEST.

9.2 Test prerequisite

Two different hardware configurations can be adopted for this test:

1. A signal generator (Agilent E4438C, controlled through a GPIB interface) as Tx and the BlueNRG-1 board (DUT) connected as shown in [Figure 1. UFL connector](#).
2. ST BlueNRG-1, BlueNRG-2 demo kit as Tx device and BlueNRG-1, BlueNRG-2 board (DUT).

9.3 Test description

The aim of this test is to verify the sensitivity level of the DUT board.

9.4 Test setup

9.4.1 Hardware

Tx: Agilent E4438C signal generator or ST BlueNRG-1 and BlueNRG-2 demo kit.
Rx: DUT application board to test (see [Figure 1. UFL connector](#)).

9.4.2 Software

ST BlueNRG GUI and DTM binary file related to the selected BLE stack modular configuration option loaded in the BlueNRG-1, BlueNRG-2 device. Refer to [Section 1.1 DTM test applications](#).

9.5 Test procedure

Two procedures can be used.

9.5.1 Signal generator and DUT board

The sensitivity can be evaluated by performing the following steps:

1. Connect the instrument and DUT with an RF cable (with no significant loss)
2. Start Rx on DUT: on RF test window click on "Start Receiver" button
3. Make the generator send X packets (well-formatted as described in "Direct Test Mode", vol. 6, part F, and "Host Controller Interface Functional Specification", vol. 2, part E, in point 3 [Section 13 References](#))
4. Stop test on DUT: on RF test window click on stop receiver button

On packet received tab there is the number of received packets. PER is 1-Y/X.

If PER is below 0.308 (30.8%), go back to step 2 and decrease the power of the transmitter by one step. If PER goes above 0.308, then the level of power emitted by the equipment in the previous test is the sensitivity of the receiver. The algorithm can be more accurate by reducing the power level step when it is close to the sensitivity level.

The same results can be achieved by directly using the ACI commands:

1. Connect the instrument and DUT with an RF cable (with no significant loss)
2. Start Rx on DUT: HCI_LE_RECEIVER_TEST
3. Make the generator send X packets (well-formatted as described in "Direct Test Mode", vol. 6, part F, and "Host Controller Interface Functional Specification", vol. 2, part E, in point 3 [Section 13 References](#))
4. Stop test on DUT: HCI_LE_TEST_END

This returns Y as the number of received packets. PER is 1-Y/X.

If PER is below 0.308 (30.8%), go back to step b and decrease the power of the transmitter by one step. If PER goes above 0.308, then the level of power emitted by the equipment in the previous test is the sensitivity of the receiver.

The algorithm can be more accurate by reducing the power level step when it is close to the sensitivity level.

9.5.2 ST demo kit and DUT board

In this case, the previous procedure changes in the following way:

1. Connect RF input/output of the two boards, DUT and ST BlueNRG-1, BlueNRG-2, by using a variable attenuator
2. In the GUI related to DUT Rx device
 - Go to RF test window, RECEIVER section
 - Set Rx frequency
 - Click on "Start Receiver" button, to start "Receiver Test"
3. In the GUI related to Tx device
 - Go to RF test window, TRANSMITTER section
 - Set Tx power
 - Set Tx frequency
 - Set length of data to 0x25
 - Set packet payload format
 - Click on "Start Transmitter" button, to start "Transmitter Test"
4. In the GUI related to Tx device
 - Click on "Stop Transmitter" button. The number of transmitted packets are displayed on #Packet Transmitted field.
5. In the GUI related to DUT Rx device
 - Click on "Stop Receiver" button. The number of received packets are displayed on #Packet Received field
6. In PER section, insert the number of transmitted packet from Tx device in the packet transmitted field (read this value from TRANSMITTER section in the GUI related to Tx device)
7. PER (packet error rate) value is showed in the packet error rate field

If PER is below 0.308 (30.8%), go back to step 2 and increase the value of attenuation. If PER goes above 0.308, then the level of power received by DUT in the previous test is the sensitivity of the receiver. It is very important to measure correctly or estimate the power received by DUT (for example: by using a tone instead of a modulated signal).

Moreover, in order to reduce the level of the signal received over-the-air by DUT, the ST BlueNRG-1 and BlueNRG-2 demo kit should use the minimum output power. Performing the measurements inside an anechoic chamber also gives more accurate results.

The same results can be achieved by using ACI commands:

1. Connect the RF input/output of the two boards, DUT and STM BlueNRG-1, by using a variable attenuator
2. Start Rx on DUT: HCI_LE_RECEIVER_TEST
3. Make the board send packets: HCI_LE_TRANSMITTER_TEST, with the length of test data: 0x25
4. Stop test on the board: HCI_LE_TEST_END
5. Send a further command to determine the number of packets sent by the board:
ACI_HAL_LE_TX_TEST_PACKET_NUMBER
6. Stop test on DUT: HCI_LE_TEST_END

This returns Y as the number of received packets. PER is 1-Y/X.

If PER is below 0.308 (30.8%), go back to step 2 and increase the value of the attenuation. If PER goes above 0.308, then the level of power received by DUT in the previous test is the sensitivity of the receiver.

9.6 Expected results

The expected value should be a few dB from the value reported in the datasheet. If it is not so, the reason could be related to the matching network.

9.7 Note

Since the sensitivity test is very time-consuming, ST can provide a specific software for both hardware configurations in order to implement an automatic procedure.

9.8 Other

N/A.

10 Power consumption in advertising mode

10.1 Test case specification identifier

CURRENT_TEST.

10.2 Test prerequisite

In order to perform this test the platform must be provided with the test points in series with Vbat1, 2, 3 pins (see [Table 1. Test points](#)).

10.3 Test description

The aim of this test is to verify that BlueNRG-1, BlueNRG-2 current consumption profile during the advertising is aligned with the simulated value (for simulated values use the BlueNRG current consumption estimation tool (STSW-BNRG001) available on www.st.com).

10.4 Test setup

10.4.1 Hardware

Agilent N6705B power analyzer or an oscilloscope.

10.4.2 Software

This test uses an application, which puts the device in advertising mode (i.e. sensor demo example available on the BlueNRG-1_2 DK development kit/STSW-BLUENRG1-DK, on Firmware/BLE_Examples folder).

10.5 Test procedure

The power analyzer has to be connected in series to Vbat pins in BlueNRG-1 and BlueNRG-2. If it is not available, a 10 Ohm resistor has to be used to sense the current, connecting two probes to it.

Power up the BlueNRG-1, BlueNRG-2 platform and load a firmware so that the device is in advertising mode, for example a sensor demo. Capture the current waveform.

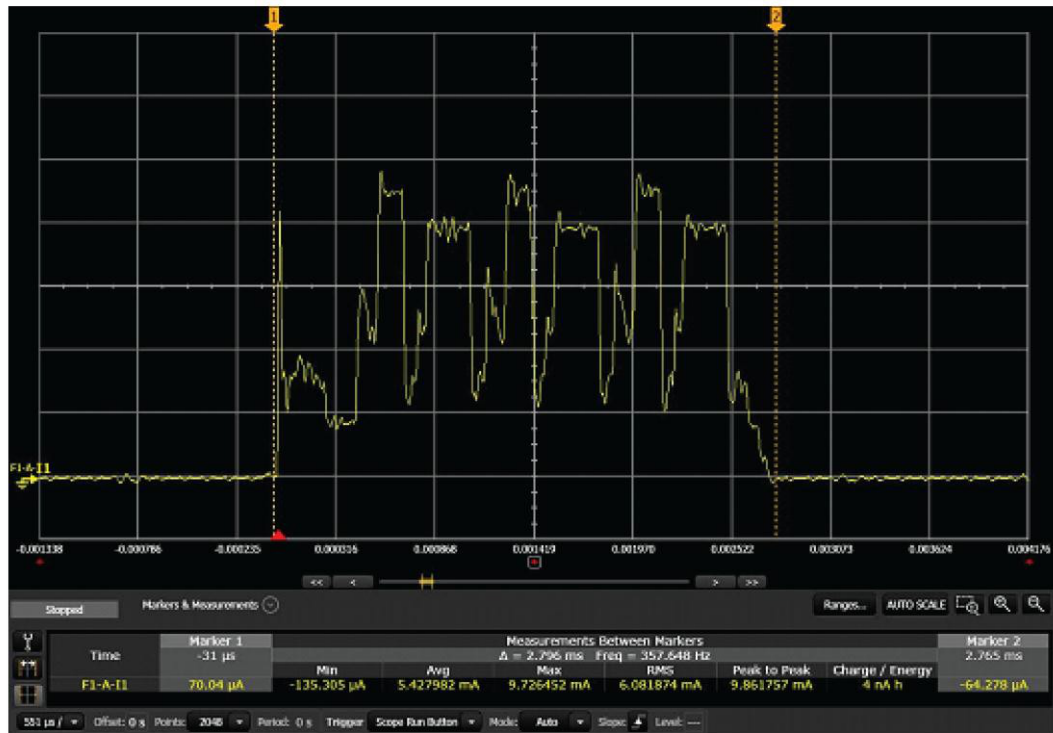
10.6 Expected results

The average current should be reported here (see [Figure 8. Typical current profile during an advertising event](#)):

Average current = approx. 6 mA

Sleep current = approx. 2 μ A (see [Section 13 References #1](#))

These values are significantly influenced by the device configuration parameters, such as: the HS_Startup_Time, the stack mode and the 32 kHz crystal (external or internal ring oscillator)

Figure 8. Typical current profile during an advertising event


10.7 **Note**
N/A.

10.8 **Other**
N/A.

11 RF tests for certification

Tests described in this application note should be used to check the basic functionality of the BlueNRG-1, BlueNRG-2 devices on prototype boards.

Before Bluetooth trademark can be used on BlueNRG-1, BlueNRG-2 devices, the company must complete the Bluetooth compliance program, that means the board must be qualified and listed.

Since BlueNRG-1 is an already qualified product, a board using the BlueNRG-1, BlueNRG-2 device does not have to re-run all Bluetooth tests. However, when using BlueNRG-1, BlueNRG-2 support in a new RF design, the RF-PHY layer must be tested yet.

Below RF tests to be performed (RF-PHY.TS/4.2.0):

- TP/TRM-LE/CA/BV-01-C [output power at NOC]
- TP/TRM-LE/CA/BV-02-C [output power at EOC]
- TP/TRM-LE/CA/BV-03-C [in-band emissions at NOC]
- TP/TRM-LE/CA/BV-04-C [in-band emissions at EOC]
- TP/TRM-LE/CA/BV-05-C [modulation characteristics]
- TP/TRM-LE/CA/BV-06-C [carrier frequency offset and drift at NOC]
- TP/TRM-LE/CA/BV-07-C [carrier frequency offset and drift at EOC]
- TP/RCV-LE/CA/BV-01-C [receiver sensitivity at NOC]
- TP/RCV-LE/CA/BV-02-C [receiver sensitivity at EOC]
- TP/RCV-LE/CA/BV-03-C [C/I and receiver selectivity performance]
- TP/RCV-LE/CA/BV-04-C [blocking performance]
- TP/RCV-LE/CA/BV-05-C [intermodulation performance]
- TP/RCV-LE/CA/BV-06-C [maximum input signal level]
- TP/RCV-LE/CA/BV-07-C [PER report integrity]

Moreover, depending on the country of use, an RF product must be compliant with one or more standards before it can be sold. In particular, Bluetooth low energy products, which operate in the unlicensed ISM band at 2.4 GHz, must be compliant to:

- FCC part 15.205, 15.209, 15.247 in North America
- ETSI EN 300 328 in Europe
- ARIB STD-T66 in Japan

Bluetooth LE tests can be manually performed, but some instruments exist to simplify and automate the testing process.

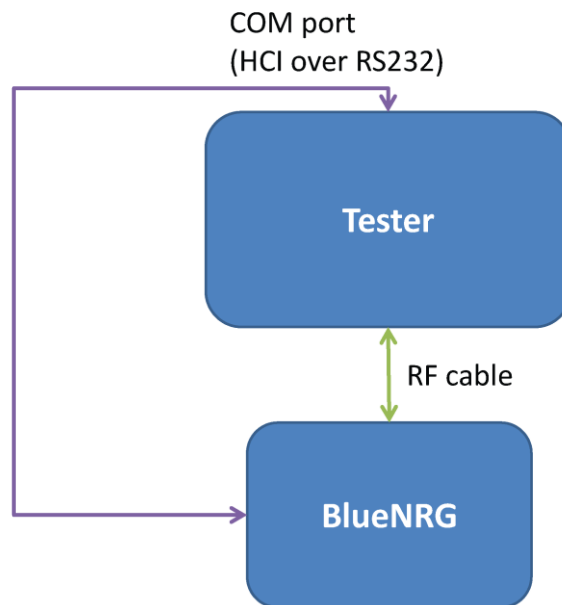
Usually these instruments operate in two modes:

- Signaling mode
- Non-signaling mode

11.1 Signaling mode

In this mode, the instrument can autonomously perform the tests. DUT (device under test) must be connected to the instrument with an RF cable. Moreover, DUT has to be connected to one instrument port so to be controlled by the instrument itself (to start/stop test and receive feedback from DUT). BlueNRG-1 and BlueNRG-2 support the direct test mode over HCI, which allows testing low energy PHY layer (see Bluetooth specifications, core v4.1, vol. 6, part F: direct test mode).

Figure 9. Signaling mode RF tests

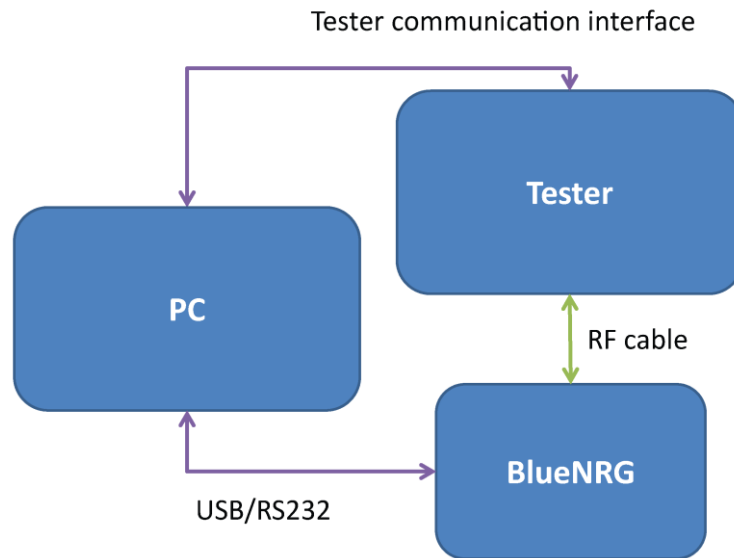


On the test equipment, the serial port for communication with DUT is typically an RS232 interface. BlueNRG-1 and BlueNRG-2 are already provided with UART interface.

11.2 Non-signaling mode

In non-signaling mode a third entity (e.g. a PC) controls both DUT and Test instrument at the same time. Typically, the instrument can be controlled by using proprietary commands. The native communication interface of BlueNRG-1, BlueNRG-2 is UART and this interface can be connected to PC via a serial to USB converter.

Figure 10. Non-signaling mode RF tests



12 RF tests for board manufacturing

Once the final board has been designed and sent to production, the manufacturer may want to run some basic tests to be confident that the device works correctly. The minimal set of suggested tests is:

- Output power (see [Section 7 Output power test](#)) and crystal frequency centering test (see [Section 5 XTAL centering test](#))
- Packet exchange test (see [Section 8 Packet exchange test](#))

Some of these tests can also be performed by dedicated instruments, as described in [Section 11.1 Signaling mode](#). In this case, a set of tests to be performed is:

- Output power
- Carrier frequency offset and drift
- Receiver sensitivity

13 References

1. BlueNRG-1, BlueNRG-2 datasheets
2. Bluetooth specification version BlueNRG-1, BlueNRG-2
3. BlueNRG-1, BlueNRG-2 development kits user manual (UM2071)
4. BlueNRG GUI SW package (STSW-BNRGUI) user manual (UM2058)
5. BlueNRG-1, BlueNRG-2 Flasher utility (STSW-BNRGFLASHER) user manual (UM2406)

Revision history

Date	Version	Changes
29-Jun-2016	1	Initial release.
22-Aug-2016	2	Minor text edits in Test description and Test procedure.
21-Dec-2016	3	"Power supply test", Section 4: "HS_Startup_Time", Section 5: "XTAL centering test", Section 6: "LSOSC centering test" and Section 10: "Power consumption in advertising mode".
10-Jan-2017	4	Updated DTM file version reference and removed note on <i>Section 5.4.2: "Software"</i> , <i>Section 7.4.2: "Software"</i> , <i>Section 8.4.2: "Software"</i> and <i>9.4.2: "Software"</i> .
03-Aug-2017	5	Added the BlueNRG-2 device reference and the related kit platform "STEVAL-IDB008V1". Updated the entire document accordingly.
21-Jun-2018	6	Updated Figure 2. BlueNRG GUI IFR tool used for the device configuration and minor test changes throughout the document.
30-Nov-2018	7	Updated Section 1.1 DTM test applications.
08-Feb-2019	8	Updated Section 5.5 Test procedure and Section 7.5 Test procedure .

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