AN4494

Application note

Bringing up the BlueNRG and BlueNRG-MS devices

Introduction

The BlueNRG, BlueNRG-MS devices are high performance, ultra-low power wireless network processors which support Bluetooth specifications.

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

This document summarizes these fundamental steps:

- Application PCB test points
- Power supply and current consumption tests
- SPI interface
- IFR 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 for both BlueNRG and BlueNRG_MS devices. Any reference to BlueNRG device is also valid for the BlueNRG-MS device. Any specific difference is highlighted whenever it is needed.

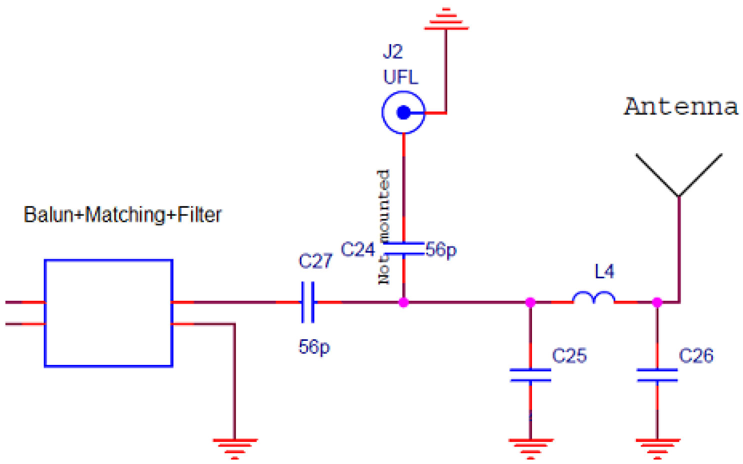
1 Application PCB test points

ST recommends making available a set of test points in order to measure the performance of the device on the customer PCB. Depending on customer PCB constraints, it may not always be possible to add all test points, in which case some tests cannot be performed.

Table 1. **Test points**

Test point	Function	Details of the test point
Current consumption	Should be added in the PCB to measure BlueNRG current consumption.	In series with the VBAT1,2,3 pins.
Voltage supply	Should be added to measure BlueNRG supply voltages.	To pins: VDD1V8, 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).
SPI	Customer PCB should allow exclusion of its own microcontroller and allow connection of the BlueNRG SPI lines to the STEVAL-IDB002V1 motherboard. If the SPI test point is not available, ST can provide the GUI firmware required to port it on the customer microcontroller. This assumes that the customer PCB has a USB or RS232 I/O port available for PC connection.	Between the microcontroller and the BlueNRG.
TEST8, TEST9	Pins used for the XTAL_startup measure	Pins: TEST8, TEST9

Figure 1. UFL connector



2 Power supply and current consumption tests

2.1 Test case specification identifier

SUPPLY_TESTS

No specific firmware is needed for this test.

2.2 Test prerequisite

In order to perform these tests, 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 is correctly powered, and its power consumption does not show anomalies.

2.4 Test setup

2.4.1 Hardware

A multimeter is required for this test.

2.4.2 Software

N/A.

2.5 Test procedure

Power up the BlueNRG platform. The application microcontroller does not have to access the SPI interface while performing this test.

Measure the voltage in: VBAT1,2,3, VDD1V8, VDD1V2, SMPSFILT1, SMPSFILT2.

Measure the current in series with the VBAT1, 2, 3 pins.

2.6 Expected results

The measured pin voltage and current should be aligned with the following values.

Table 2. Supply test results

Pin	Expected value
VBAT1,2,3	2.0 – 3.6 V
VDD1V8	1.8 V
VDD1V2	1.2 V
SMPSFILT1	Square wave around 1.4 V
SMPSFILT2	1.4 V
IBAT (VBAT = 3.0 V)	2 mA

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's connection.

2.8 Other

N/A.

3 SPI interface

3.1 Test case specification identifier

SPI_TEST

3.2 Test prerequisite

The customer's platform should have the SPI test points (see Table 1. Test points and Figure 2. SPI connection).

3.3 Test description

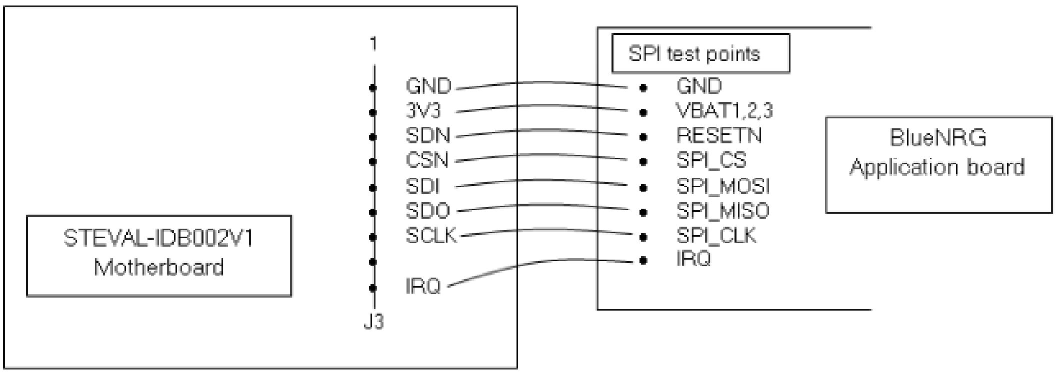
How to verify that SPI access from an external microcontroller is functional.

3.4 Test setup

3.4.1 Hardware

STEVAL-IDB002V1 motherboard, to be connected to the BlueNRG board as showed below:

Figure 2. SPI connection



3.4.2 Software

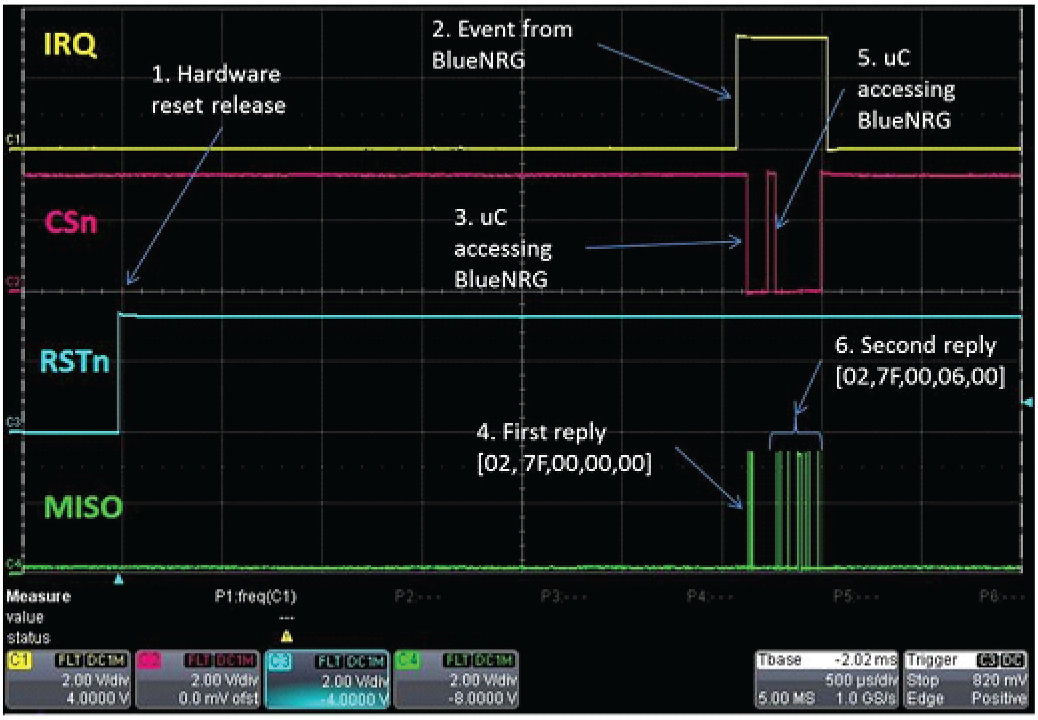
ST BlueNRG GUI, to send SPI commands to the BlueNRG.

3.5 Test procedure

A BlueNRG hardware reset, performed by the microcontroller, generates an ACI event with a sequence described below and shown in Figure 3. BlueNRG SPI transaction on HW reset:

1. Release of hardware reset
2. IRQ goes high to signal an event from BlueNRG (if this signal is not present, it means that the BlueNRG firmware for some reason is not running)
3. The external microcontroller lowers CS to access the BlueNRG and read the event
4. The microcontroller reads 5 bytes from SPI; they should be [02,7F,00,00,00]
5. The external microcontroller, after raising the CS, lowers it again to access the BlueNRG and read the event
6. The microcontroller reads 5 bytes from SPI and [02,7F,00,06,00] is expected, meaning 6 bytes to read
7. The microcontroller reads 6 bytes from SPI and [04, FF, 03, 01, 00, 01] is expected
8. The microcontroller raises the CS again

Figure 3. **BlueNRG SPI transaction on HW reset**



The bytes in step 7 should be interpreted as an HCI vendor specific (VS) event packet (refer to Section 2.3 Test description).

When the BlueNRG firmware is started normally, it gives a Blue_Initialized_Event to the user to indicate the system has started.

The following is a detailed interpretation about this specific HCI VS event packet:

Table 3. **Blue_Initialized_Event**

Bytes	Description
04	It indicates an HCI Event Packet
FF	It is a vendor specific HCI event (Event code 0xFF)
03	HCI VS event parameter total length
01 00	BLUE_INITIALIZED event code
01	Reason code x BLUE_INITIALIZED event: Application started properly

3.6 Expected results

The bytes sent by the BlueNRG are described in Section 3.5 Test procedure.

3.7 Note

If the application board does not have SPI test points, ST can provide the firmware to be ported on the microcontroller used in the customer PCB so that the system can work with the ST GUI.

3.8 Other

If the basic test above is working, we suggest using the ST BlueNRG GUI to run a few commands (for example the HCI_READ_LOCAL_VERSION_INFORMATION, or Get version under the tab Tools) to check that the SPI access with the ST BlueNRG GUI is ok.

4 IFR configuration

There are some parameters of the BlueNRG device that must be set up in a dedicated portion of the BlueNRG Flash, called information register (IFR), before the application board is finalized (see Section 13 Reference section, item 4).

Specifically, they are:

- High speed (HS) crystal (16 or 32 MHz)
- Low speed oscillator source (32 KHz or the internal Ring Oscillator)
- Power Management options (SMPS inductor or SMPS off configuration)
- Stack mode:
  – Mode 1: slave/master, 1 connection only, small GATT database (RAM2 off during sleep)
  – Mode 2: slave/master, 1 connection only, large GATT database (RAM2 on during sleep)
  – Mode 3: only master (BlueNRG), slave/master (BlueNRG-MS), 8 connections, small GATT database (RAM2 on during sleep)
- Change HS startup time parameter. from 512 μs to 1953 μs.
- Sleep clock accuracy.
- LS crystal period and frequency

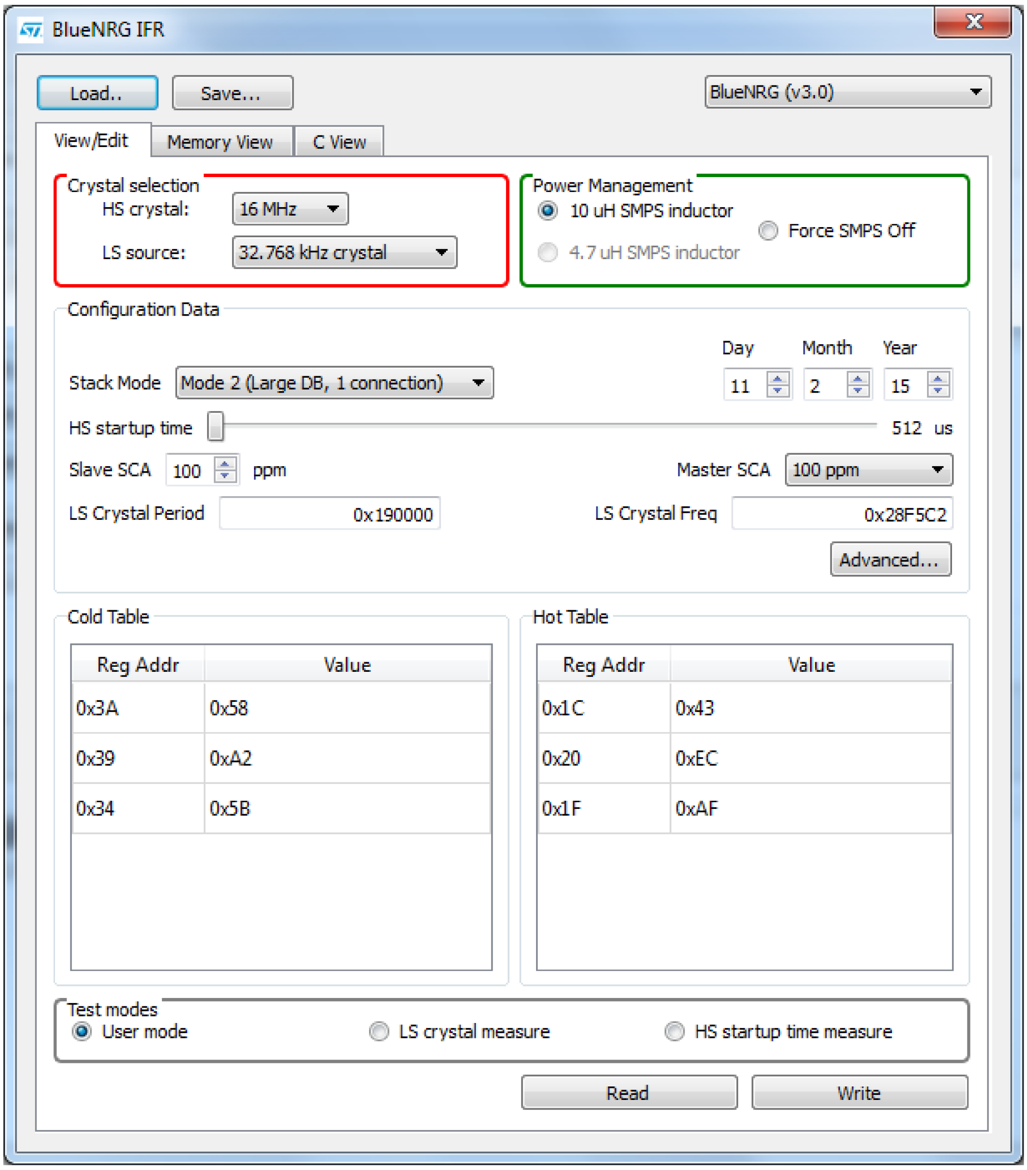
Currently, the crystal configuration implies the possibility to choose a set of preconfigured IFR configuration files (*.dat).

In order to match the user's specific crystal oscillator, the *.dat IFR files can be written in the device through the BlueNRG GUI, under:

Tools / BlueNRG IFR / Load & Write buttons (see Figure 4. BlueNRG GUI IFR tool).

The BlueNRG kit modules are delivered with 16 MHz external high-speed crystal and 32 kHz low-speed crystal, and the related stack image is already tailored to use this configuration (bluenrg_x_x_Mode_2-16MHz-XO32K.img).

Figure 4. BlueNRG GUI IFR tool



4.1 HS_Startup_Time: Test case specification identifier

XTAL_startup_TEST

4.2 Test prerequisite

The user’s platform should have the test points for the pins TEST8 and TEST9 (see Table 1. Test points).

4.3 Test description

The HS_Startup_Time parameter is important because it permits minimization of the current consumption, but to do this a measurement of the startup time of the adopted crystal must be performed (XTAL_startup). A value that is too short prevents the BlueNRG from correctly sending/receiving packets.

4.4 Test setup

4.4.1 Hardware

An oscilloscope is required for this test.

4.4.2 Software

ST BlueNRG GUI, to enable a dedicated test mode.

4.5 Test procedure

Tick the checkbox present in the BlueNRG IFR tool in the BlueNRG GUI to enable the startup time test signals. Set the HS Startup time parameter to the maximum value and program the IFR.

Put two scope probes on test points TEST8 and TEST9.

Set the BlueNRG 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 TEST8 and rising edge on TEST9 is the time the crystal oscillator takes to start (see Figure 5. Frequency tone at Ch0 for the XTAL center test). Since this time may have a great variation 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 correspond to 1 hour of test). Only the maximum measured value must be considered.

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 with some specific coefficients:

- 20%: to take in account the effect of power supply variations from 1.7 to 3.6 Volts
- 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 consequence, the compensated value is calculated using this formula:

XTAL_startup = XTAL_startup_measured*1.2*1.1*1.3 = 1.716*XTAL_startup_measured.

The XTAL_startup_measured is the maximum measured value as described on previous 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 up in the device configuration parameters, use this formula: HS_STARTUP_TIME = MAX(110 μs + XTAL_startup, 370 μs)

4.7 Note

Examples:

XTAL_startup_measured = 300 μs → HS_STARTUP_TIME = 625 μs

XTAL_startup_measured = 700 μs → HS_STARTUP_TIME = 1311 μs

4.8 Other

N/A.

5 XTAL centering test

The BlueNRG integrates 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 device, as with all RF systems, is highly dependent on accurate clocks for correct operation. A deviation in clock frequency is directly reflected as a deviation in 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 easiest way to find the optimum load capacitor values for a given circuit and layout is through experimentation. The radio can be set to put out a constant carrier at a given frequency.

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

5.4 Test setup

5.4.1 Hardware

A spectrum analyzer is required for this test.

5.4.2 Software

ST BlueNRG GUI, to emit a frequency tone.

5.5 Test procedure

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

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

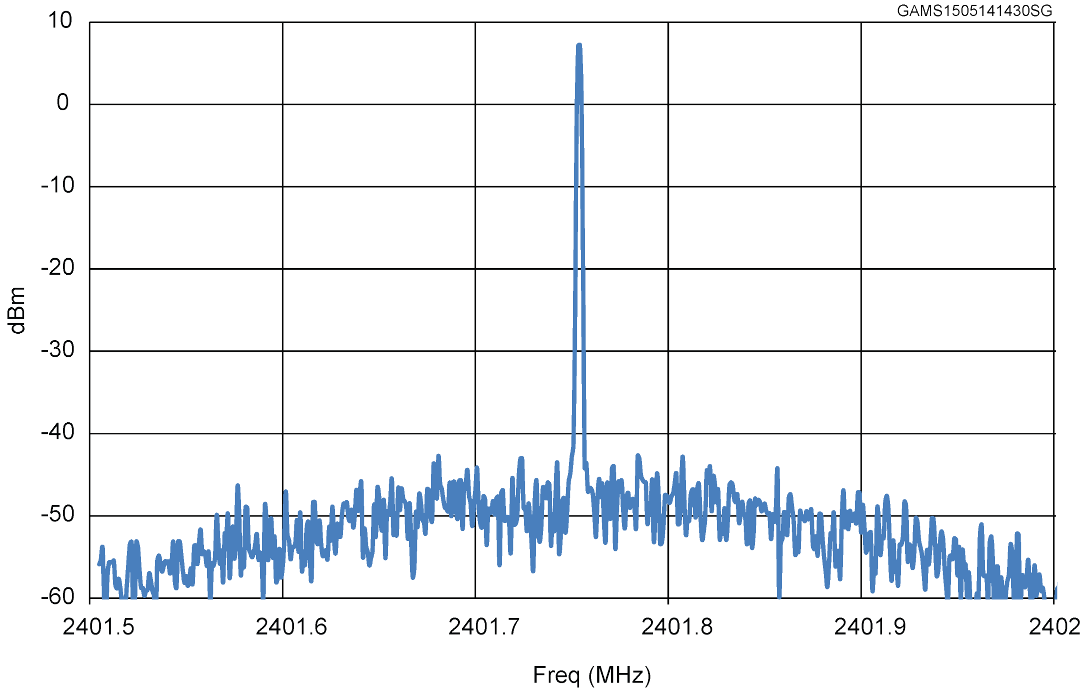
Power up the BlueNRG platform.

Set the spectrum analyzer to: Res BW = 1 KHz, SPAN = 500 KHz (see Figure 5. Frequency tone at Ch0 for the XTAL center test).

Generate a carrier wave tone at Ch0 (freq. 2.401750 GHz) using the ACI command: ACI_HAL_TONE_START (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 5. Frequency tone at Ch0 for the XTAL center test



5.6 Expected results

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

|Offset| < 50 KHz

If DUT freq > 2.4018 GHz → increase XTAL caps

If DUT freq < 2.4017 GHz → decrease 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 permits to center its oscillator frequency, 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 (TEST9) is required.

6.3 Test description

There is a way, using the IFR tool of the BlueNRG GUI, to put out 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

ST BlueNRG GUI.

6.5 Test procedure

Connect an oscilloscope’s probe in the pin 14 (TEST9) test point.

Power up the BlueNRG platform.

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

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

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

At this point, the 32.768 KHz waveform will be 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 freq > 32.768 KHz → increase XTAL caps

If DUT freq < 32.768 KHz → decrease XTAL caps

To find the oscillator ppm use the formula:

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

Where:

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 set in the IFR with the GUI, in the Slave SCA and Master SCA fields.

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

ST BlueNRG GUI, to emit a frequency tone.

7.5 Test procedure

Connect the BlueNRG board to the spectrum analyzer through an RF cable.

Set the spectrum analyzer to: Res BW = 100 KHz, SPAN = 500 KHz.

Power up the BlueNRG platform.

The default configuration of the command ACI_HAL_SET_TX_POWER_LEVEL is with the parameter En_High_Power=0x01 (High power mode) and PA_level=0x07 (+8dBm).

To use the BlueNRG in TX Standard mode, use this command with the parameter En_High_Power=0x00.

Generate a carrier wave tone at Ch0 (freq. 2.401750 GHz) using the ACI command: ACI_HAL_TONE_START (a tone can be emitted at f=2402 + k*2 - 0.250 MHz, with k=0 to 39).

For the step linearity of the Tx output power use the command:

ACI_HAL_SET_TX_POWER_LEVEL (PA_Level: 0x06).

7.6 Expected results

With PA_level=0x07:

High power mode: around 8 dBm

Standard power mode: around 5 dBm

With PA_level = 0x06:

High power mode: around 4 dBm

Standard power mode: around 0 dBm

7.7 Note

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

7.8 Other

N/A

Figure 7. **Output power measurement in High power mode with PA_level 7**

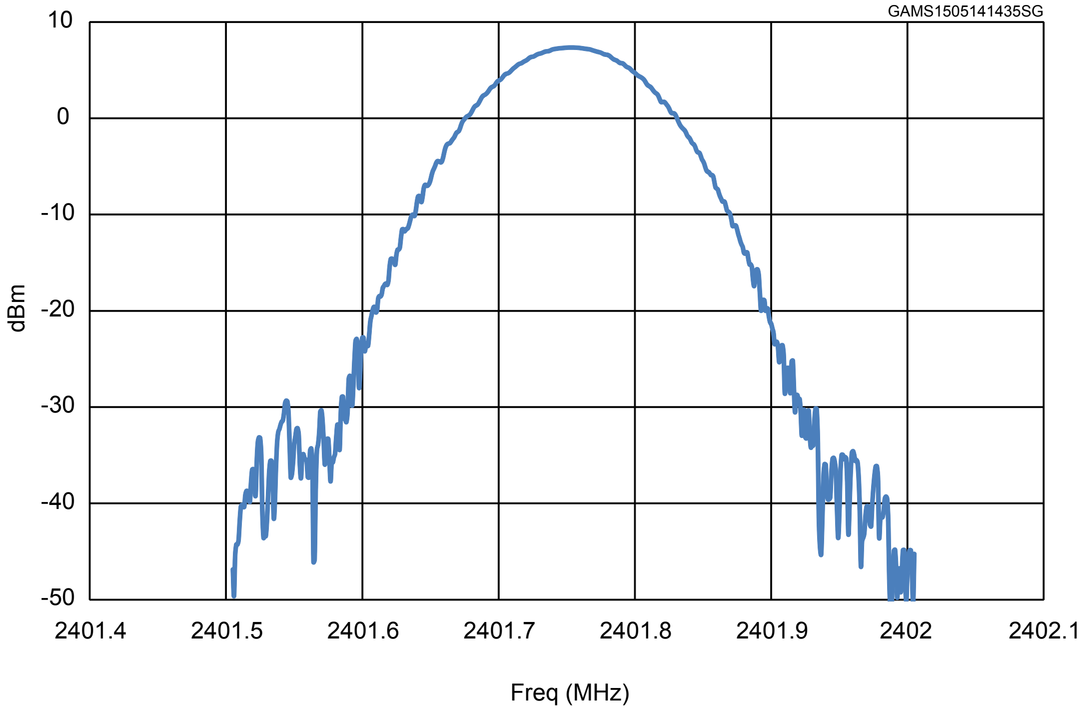
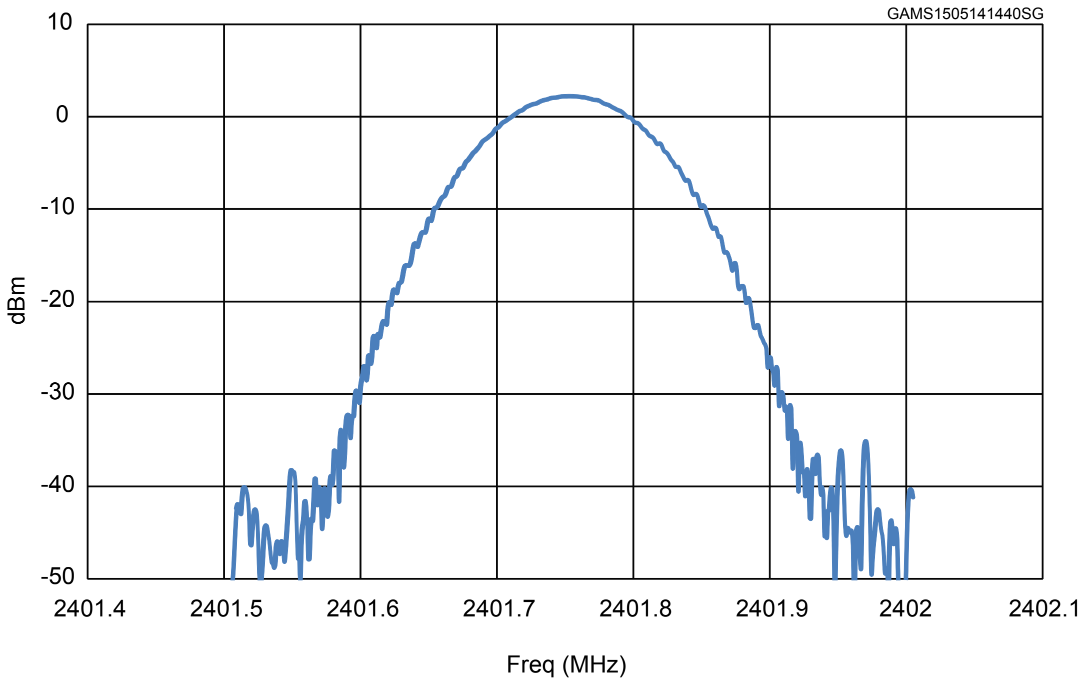


Figure 8. **Output power measurement in High power mode with PA_level 6**



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 development platform (STEVAL-IDB002V1) or a BlueNRG USB dongle (STEVAL-IDB003V1) as a master and the DUT board as a slave.

8.3 Test description

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

8.4 Test setup

8.4.1 Hardware

No instruments required.

8.4.2 Software

BlueNRG software GUI.

8.5 Test procedure

Power up the BlueNRG platform (Rx) and the board that acts as Tx.

Ensure that antennas are plugged in.

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 will return 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

It is possible to adopt two different hardware configurations for this test:

1. A signal generator (ex. the Agilent E4438C, controlled through a GPIB interface) as Tx and the STEVAL-IDB002V1 motherboard connected to the DUT (device under test) as shown in Figure 1. UFL connector.
2. STEVAL-IDB002V1 complete kit as Tx device and STEVAL-IDB002V1 motherboard connected to the BlueNRG DUT

9.3 Test description

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

9.4 Test setup

9.4.1 Hardware

Tx: Agilent E4438C signal generator or STEVAL-IDB002V1 kit

Rx: STEVAL motherboard connected to the BlueNRG DUT board (see Figure 1. UFL connector).

9.4.2 Software

ST BlueNRG GUI.

9.5 Test procedure

Two procedures can be used.

9.5.1 Signal generator & BlueNRG

The sensitivity can be evaluated by performing the following steps:

1. Connect the instrument and the 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 Reference)
4. Stop test on DUT: HCI_LE_TEST_END

This will return 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 made more accurate by reducing the power level step when it is close to the sensitivity level.

9.5.2 Two BlueNRG boards

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

1. Connect the RF input/output of both boards, DUT and tester, by using a variable attenuator.
2. Start Rx on DUT: HCI_LE_RECEIVER_TEST
3. Make the Tx board send packets: HCI_LE_TRANSMITTER_TEST, with the length of test data: 0x25
4. Stop test on Tx board: HCI_LE_TEST_END

5. Send a further command to determine the number of packets sent by the Tx board: ACI_HAL_LE_TX_TEST_PACKET_NUMBER
6. Stop test on DUT: HCI_LE_TEST_END

This will return 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 increase the value of the attenuation. If PER goes above 0.308, then the level of power received by the DUT in the previous test is the sensitivity of the receiver. It is very important to measure correctly or estimate the power received by the DUT (e.g. by the use of a tone instead of a modulated signal). Moreover, in order to reduce the level of the signal received over-the-air by the DUT, the BlueNRG Tester should use the minimum output power. Performing the measurements inside an anechoic chamber will also give more accurate results.

9.6 Expected results

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

9.7 Note

Since the sensitivity test is very time-consuming, ST can provide 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 the Vbat1, 2, 3 pins (see Table 1. Test points).

10.3 Test description

The aim of this test is to verify that the BlueNRG current consumption profile during the advertising is aligned with the simulated value (using the BlueNRG Current Consumption Estimation Tool available on ST BlueNRG website www.st.com/bluenrg).

10.4 Test setup

10.4.1 Hardware

Agilent N6705B power analyzer or an oscilloscope.

10.4.2 Software

ST BlueNRG GUI.

10.5 Test procedure

Connect the power analyzer in series to the Vbat pins in the BlueNRG. If it is not available, use a 10 Ohm resistor to sense the current, connecting two probes to it.

Power up the BlueNRG platform.

Set the BlueNRG in advertising mode, using these commands with the BlueNRG GUI:

ACI_GATT_INIT()

HCI_LE_SET_ADVERTISING_PARAMETERS(interval_min=interval_max=0x0640)

HCI_LE_ADVERTISING_DATA (Data_length 0, Advertising_Data=0x101010…)

HCI_LE_SET_ADVERTISE_ENABLE (Avertising_Enable=0x01)

ACI_HAL_SET_TX_POWER_LEVEL (PA_Level = 5/4)

Capture the current waveform.

10.6 Expected results

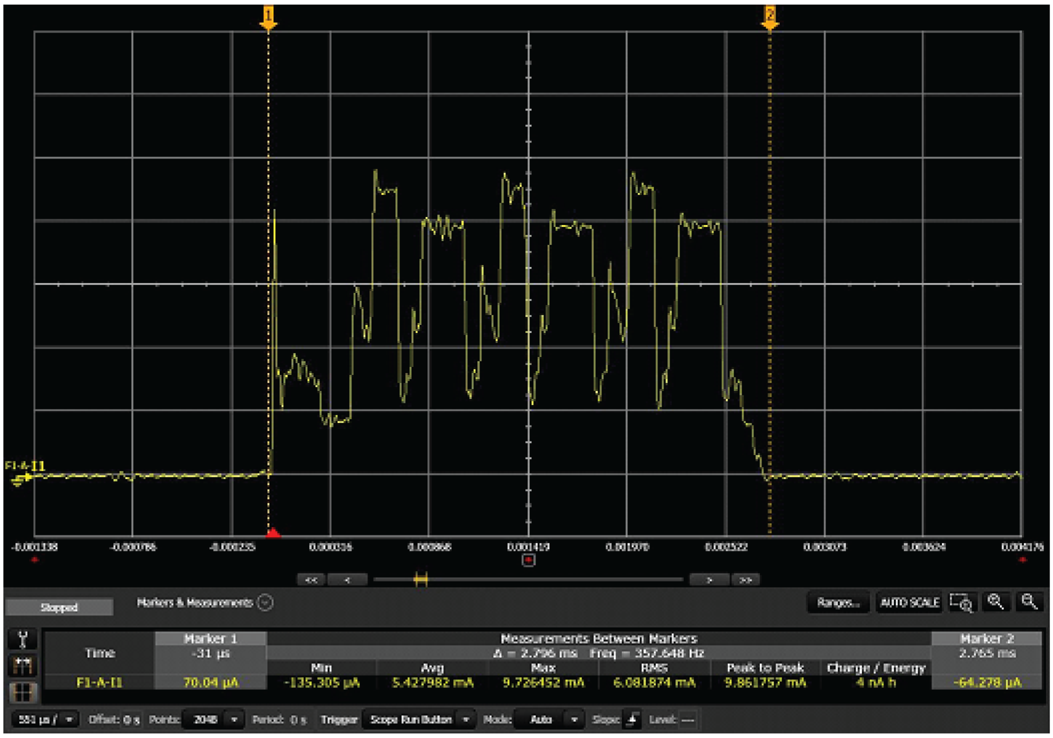
The average current should be as reported here (see Figure 9. Typical current profile during an advertising event):

Avg. current = approx. 6 mA

Sleep current = approx. 2 µA (see Section 13 Reference point 1)

These values are significantly influenced by the IFR parameters, such as the HS_Startup_Time, the Stack Mode and the 32 KHz crystal (external or internal ring oscillator)

Figure 9. **Typical current profile during an advertising event**



10.7 Note

N/A.

10.8 Other

N/A.

11 RF tests for certification

The tests described in this application note should be used to check the basic functionality of the BlueNRG device on prototype boards.

Before Bluetooth trademark can be used on BlueNRG devices, the company must complete the Bluetooth Compliance Program, i.e. the board must be qualified and listed.

Since BlueNRG is an already qualified product, a board that uses BlueNRG device does not have to rerun all the Bluetooth tests. However, when using BlueNRG in a new RF design, the RF-PHY layer still must be tested.

These are the RF tests that have 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]

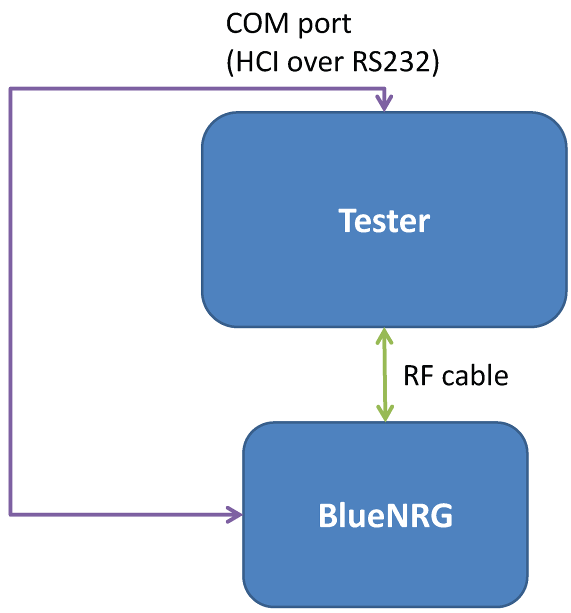
  Moreover, depending on the country of use, an RF product must be compliant with one or more standards before it can be sold. In particular, Bluetooth Low Energy products, which operate in the unlicensed ISM band at 2.4 GHz, must be compliant to:

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

11.1 Signaling mode

In this mode, the instrument can autonomously perform the tests. The DUT (Device Under Test) must be connected to the instrument with an RF cable. Moreover, the DUT has to be connected to one instrument’s port in order to be controlled by the instrument itself (to start/stop test and receive feedback from DUT). BlueNRG supports the Direct Test Mode over HCI, which allows testing Low Energy PHY layer (see Bluetooth specifications, Vol. 6, Part F: Direct Test Mode).

Figure 10. Signaling mode RF tests



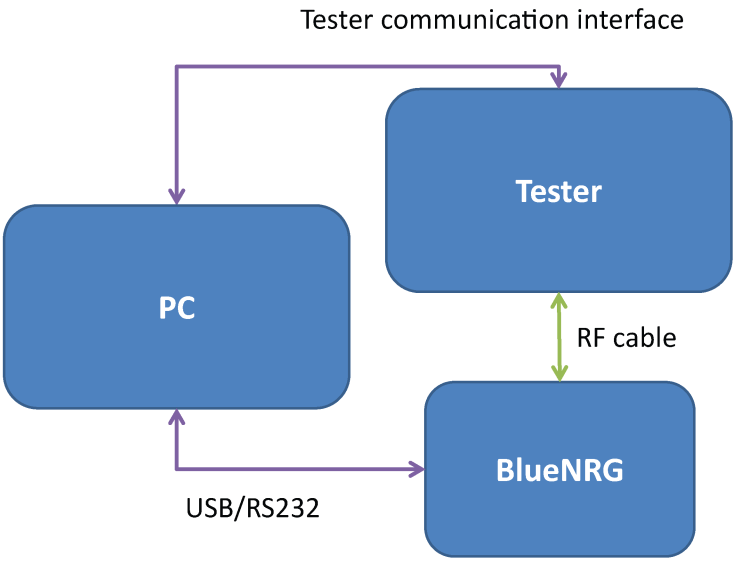
On the test equipment, the serial port for communication with the DUT is typically an RS232 interface. Hence, the DUT must be provided with a compatible interface. The native communication interface of BlueNRG is based on SPI. Therefore, a bridge is needed between BlueNRG's SPI and instrument's interface.

Example: when using STEVAL-IDB002V1 motherboard, there is the possibility to install a firmware into STM32L microcontroller that performs a conversion between UART and BlueNRG SPI. The BlueNRG VCOM project inside SDK already supports UART (select UART configuration in IAR project or define ENABLE_USART preprocessor constant). Since the instrument communication port can have a different operating level than the one used by BlueNRG motherboard (i.e. 3.3 V), a level translator may be needed to adapt RS232 voltage level to the one used by the microcontroller's UART (i.e. RS232-TTL converter). Possibly, this firmware can be ported to other boards defining the preprocessor variable: USER_DEFINED_PLATFORM=USER_EVAL_PLATFORM and defining a USER_Platform_Configuration.h file according to the specific pin configuration.

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. Since the native communication interface of BlueNRG is SPI, a bridge is needed between BlueNRG's SPI and a serial communication port on the PC.

Figure 11. Non-signaling mode RF tests



Example: STEVAL-IDB002V1 has a USB interface for communication with a PC. The VCOM project available in BlueNRG SDK is a firmware that performs a bridge between USB and BlueNRG's SPI (the same firmware is used for BlueNRG GUI). Once the board is plugged into a USB port, the device is recognized as a Virtual COM port. On this port, standard HCI commands can be sent (see Bluetooth specifications, Vol. 2, Part E, chapter 5 for HCI data format). The first byte of sent/received HCI packets is the same used by UART Transport Layer described in Vol. 4, Part A.

12 RF tests for boards 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 is operating correctly.The minimal set of suggested tests is:

- Output power (see Section 7 Output power test) & 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 RF Tests for certification). In this case, a good minimal set of tests to be performed is:

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

13 Reference

1. BlueNRG, BlueNRG-MS datasheets
2. BlueNRG Bluetooth LE stack application command interface (ACI) UM1755
3. Bluetooth specifications
4. BlueNRG, BlueNRG-MS IFR user manual UM1868
5. BlueNRG development kits user manual UM1686
6. BlueNRG-MS Bluetooth LE stack application command interface (ACI) UM1865
7. BlueNRG-MS development kits user manual UM1870

Revision history

Table 4. **Document revision history**

Date	Revision	Changes
30-May-2014	1	Initial release.
18-Sept-2014	2	Added Section 6: "LSOSC centering test" and a few minor text corrections.
11-Mar-2015	3	The document has been adapted to refer to both BlueNRG and BlueNRG-MS devices. Modified section "*IFR configuration*" and "*Two BlueNRG boards*"
27-May-2015	4	Added Section 11 “*RF tests for certification*”and Section 12 “*RF tests for boards manufacturing*”.
06-Sep-2016	5	Updated section related to HS Startup Time.
28-Sep-2016	6	Updated sections related to IFR configuration: Section 4.6: "Expected results" and Section 4.7: "Note".
31-Oct-2018	7	Updated Section Introduction, Section 11.1 Signaling mode and Section 11.2 Non-signaling mode.

Contents

List of figures