AN4392
Application note

Using the BlueNRG family transceivers under ARIB STD-T66 in the 2400 – 2483.5 MHz band

Introduction

BlueNRG family devices are very low power Bluetooth low energy (BLE) devices compliant with Bluetooth specifications.

Bluetooth low energy technology operates in the same spectrum range (2400 - 2483.5 MHz, ISM band) as classical Bluetooth technology, but uses a different set of channels. Bluetooth energy technology has 40 channels (37 data channels + 3 advertising channels) in the 2 MHz band. Within the channel, data is transmitted using GFSK (Gaussian Frequency Shift Modulation). The bit rate is 1 Mbit/s, and the maximum transmitting power is 10 mW. Further details are given in volume 6, part A of the Bluetooth Core Specification V4.2.

The BlueNRG family consists of the following:

- BlueNRG single-mode network processor, Bluetooth v4.0 compliant
- BlueNRG-MS single-mode network processor, Bluetooth v4.1 compliant
- BlueNRG-1 single-mode system-on-chip (application processor), Bluetooth v4.2 compliant
- BlueNRG-2 single-mode system-on-chip (application processor), Bluetooth v4.2 compliant

This application note outlines the expected performance when using the BlueNRG under ARIB STD-T66 in the 2400 to 2483.5 MHz band.

For details on the regulatory limits in the 2400 - 2483.5 MHz frequency band, please refer to ARIB STD-T66 V2.1 regulations [2].

These can be downloaded from www.arib.or.jp/english/html/overview/rt_ej.html.

Contents

1 An overview of ARIB regulations

Low power, non-licensed devices operating in the 2400 - 2483.5 MHz band are found everywhere, such as toys, wireless security systems, wireless telemetry, wireless automatic meter reading applications, and so on.

In Japan, the unlicensed use of short range devices in the 2.4 GHz ISM band is regulated by The Association of Radio Industries and Businesses (ARIB) standard STD-T66: “Second generation low power data communication system/Wireless LAN system”.

The communication method is limited to digital signals (including spread spectrum).

2 Technical requirements

2.1 Modulation system

One of the following modulation systems can be used in the 2400 MHz to 2483.5 MHz bandwidth:

- Spread spectrum and orthogonal frequency division multiplexing systems
- Modulation type for information signal
- Modulation techniques for systems other than spread spectrum and OFDM systems.

Although Bluetooth LE uses the frequency hopping method during communication, it is not defined as a system using this method.

Bluetooth LE is classified as a system using "*Digital modulation method other than orthogonal frequency division multiplexing (OFDM) or spread spectrum method*".

2.2 Maximum output power

The maximum allowed output power is 10 mW (10 dBm) measured in a 1 MHz bandwidth for a non-FHSS system.

If FHSS is used, the maximum power is 3 mW measured in a 1 MHz bandwidth if the whole band is used. 10 mW can be used for FHSS systems, but not from 2.427 to 2.47075 GHz, where the limit is 3 mW.

2.3 Frequency tolerance

Frequency tolerance shall be within ± 50 ppm of rated frequency.

2.4 Transmitter spurious emissions

Average power of spurious emissions (outside the specified 2.4 GHz band) shall be as follows:

Table 1. Transmitter spurious emissions

Frequency range	Transmit mask level
< 2387 MHz	- 26 dBm
2387 to 2400 MHz	- 16 dBm
2400 to 2483 MHz	-
2483 to 2496.5 MHz	- 16 dBm
> 2496.5 MHz	- 26 dBm

2.5 Frequency bandwidth

The required frequency bandwidth is limited by:

– 83.5 MHz for FHSS or hybrid FHSS/DSSS systems, 26 MHz in other systems.

– The spreading bandwidth shall be 500 kHz or more in spread spectrum systems.

– The spreading bandwidth is defined as the bandwidth containing 95% of the average radiated power.

2.6 Receiver spurious emission

Secondary emitted radiation is limited to the values given in *Table 2*:

Table 2. Receiver spurious emission

Frequency range	Maximum power
< 1 GHz	- 54 dBm
> 1 GHz	- 47 dBm

3 Application circuit

Figure 1 shows the BlueNRG-MS daughterboard (STEVAL-IDB005V2D) photo. It holds the BlueNRG-MS with the circuits necessary for it to function. The Bluetooth low energy protocol stack (GAP, GATT, SM, L2CAP, LL, RF-PHY) is embedded in the device.

The daughterboard is equipped with a 32 MHz XTAL to provide the correct oscillator to the BlueNRG-MS. A low-speed crystal oscillator, 32.768 kHz, is also mounted on the board and used by the BlueNRG-MS.

An internal SMPS is present on the BlueNRG-MS to drastically reduce power consumption. The SMPS is fed from the battery and provides a programmable voltage to the device (1.4 V typically).

An SMA connector is present to connect the board to an antenna or to an instrument to verify correct functioning and to verify standard compliance.

An integrated balun, STM BALF-NRG-01D3, is used for the differential to single ended conversion and to show the correct impedance at the TX/RX of the BlueNRG-MS device. Also a C-L-C network was introduced for a better matching and to increase the out of band attenuation.

For correct functioning, the daughterboard must be plugged into a

The motherboard includes an STM32L152VBT6 microcontroller to program the transceiver. The microcontroller is programmed with firmware developed for the BlueNRG application. A graphical user interface (GUI) is developed to correctly program the BlueNRG-MS.

Figure 1. BlueNRG-MS application daughterboard

Figure 2. Motherboard

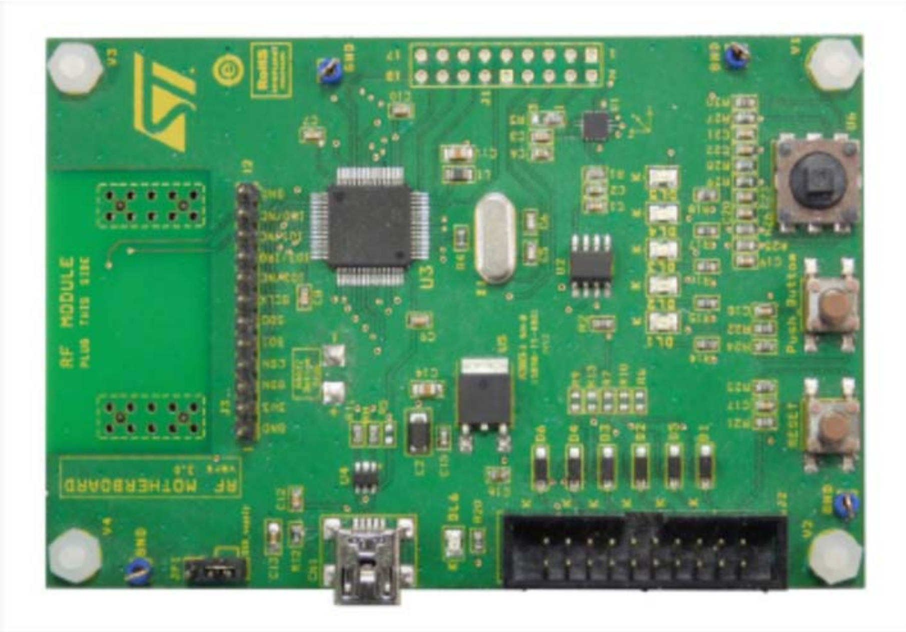


Figure 3 shows the BlueNRG-1 and BlueNRG-2 (STEVAL-IDB007V1 and STEVAL-IDB008V1) evaluation platform.

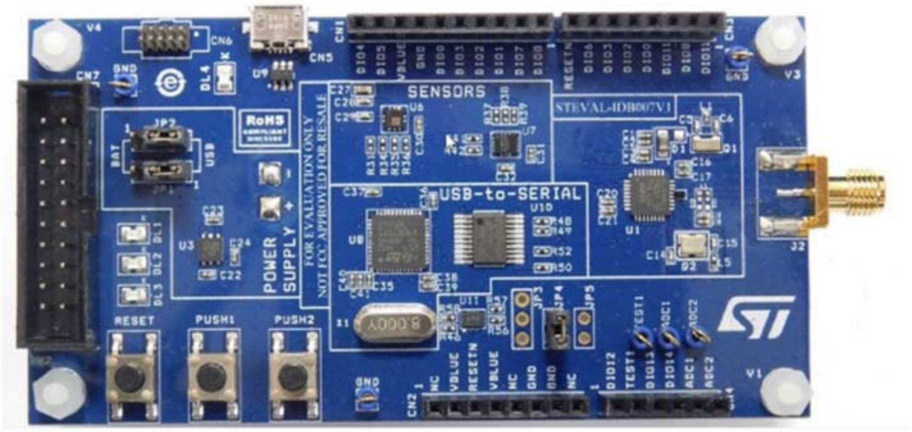
The two platforms also provide a set of hardware resources for implementing a wide range of application scenarios: sensor data (accelerometer, pressure and temperature sensor), remote control (buttons and LEDs) and manage debug messages through USB virtual COM.

Three power options are available (USB only, battery only, external power supply + USB) for high application development and testing flexibility.

An SMA connector is present to connect the board to an antenna or to an instrument to verify correct functioning and to verify standard compliance.

An integrated balun, STM BALF-NRG-01D3, is used for the differential to single ended conversion and to show the correct impedance at the TX/RX of the BlueNRG-1/2 devices. Also a C-L-C network was introduced for a better matching and to increase the out of band attenuation.

Figure 3. BlueNRG-1 and BlueNRG-2 application board



4 Transmitter parameter

All the measurements reported here are measured using the following parameters:

T_c = 25 °C, V_{dd} = 3.3 V, f = 2402 MHz (lower frequency of the useful bandwidth), unless otherwise specified.

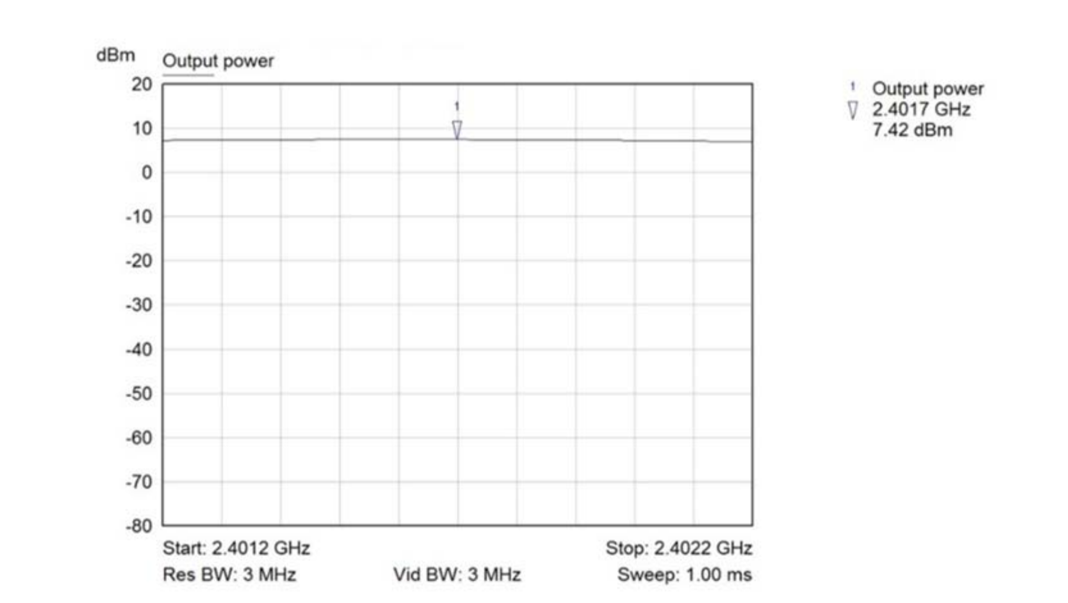
4.1 Maximum output power

No specific spectrum analyzer settings are defined in the standard, so the following settings are used:

- Span = 1 MHz
- RBW ≥ 3 MHz
- VBW ≥ RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

The measurement performed at 2402 MHz (channel 37) shows an output power equal to 7.4 dBm, below the 10 dBm limit of the standard.

Figure 4. Maximum output power



4.2 Frequency tolerance

The BlueNRG meets the ± 50 ppm rated frequency requirements f the crystal used in the application guarantees the same or better performance.

4.3 Transmitter spurious emission

No specific spectrum analyzer settings are defined in the standard, so the following settings are used:

- Span = sufficient to see the required bandwidth
- RBW = 100 kHz below 2.4 GHz, 1 MHz above 2.4835 GHz
- VBW = 3 x RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold
- The device is set to send packet

The BlueNRG meets spurious emission requirements in every range specified, by a large margin.

Figure 5. Spurious emission in the 10 MHz to 2387 MHz bandwidth

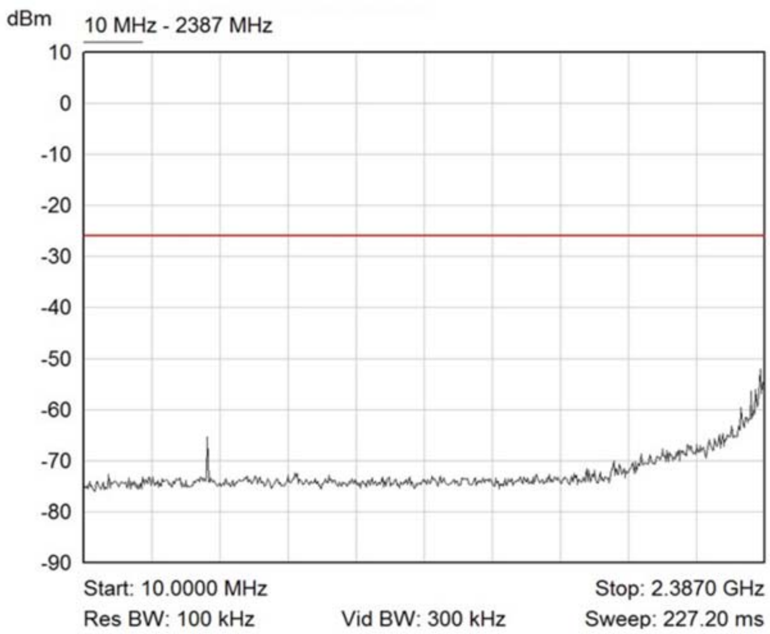


Figure 6. Spurious emission in the 2387 MHz to 2400 MHz bandwidth

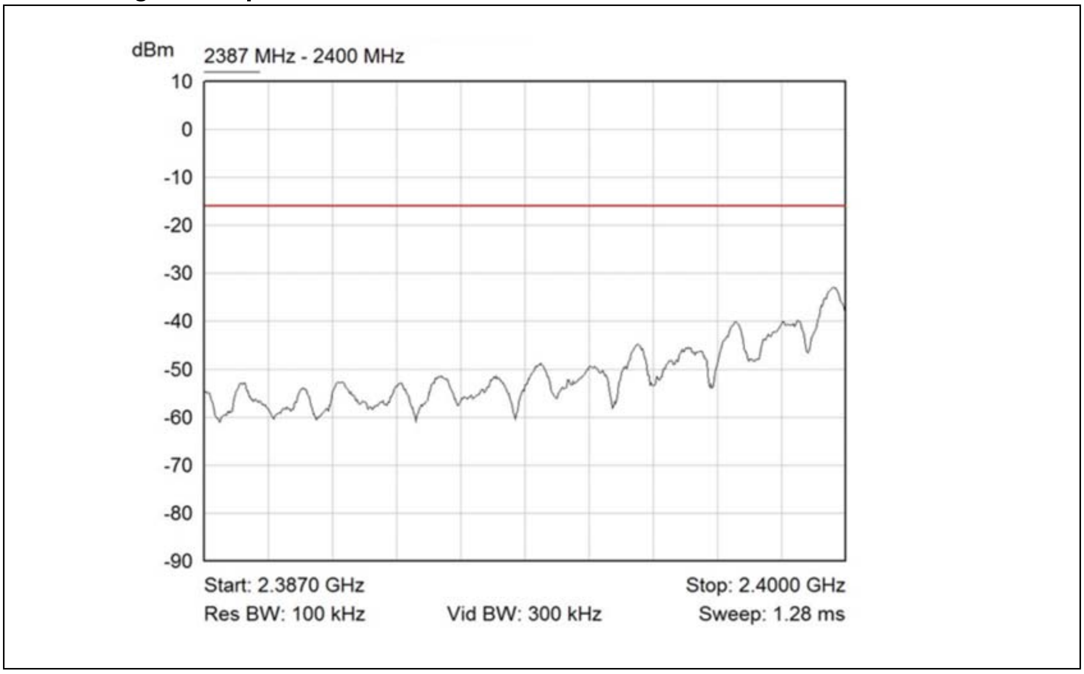


Figure 7. Spurious emission in the 2483.5 MHz to 2496.5 MHz bandwidth

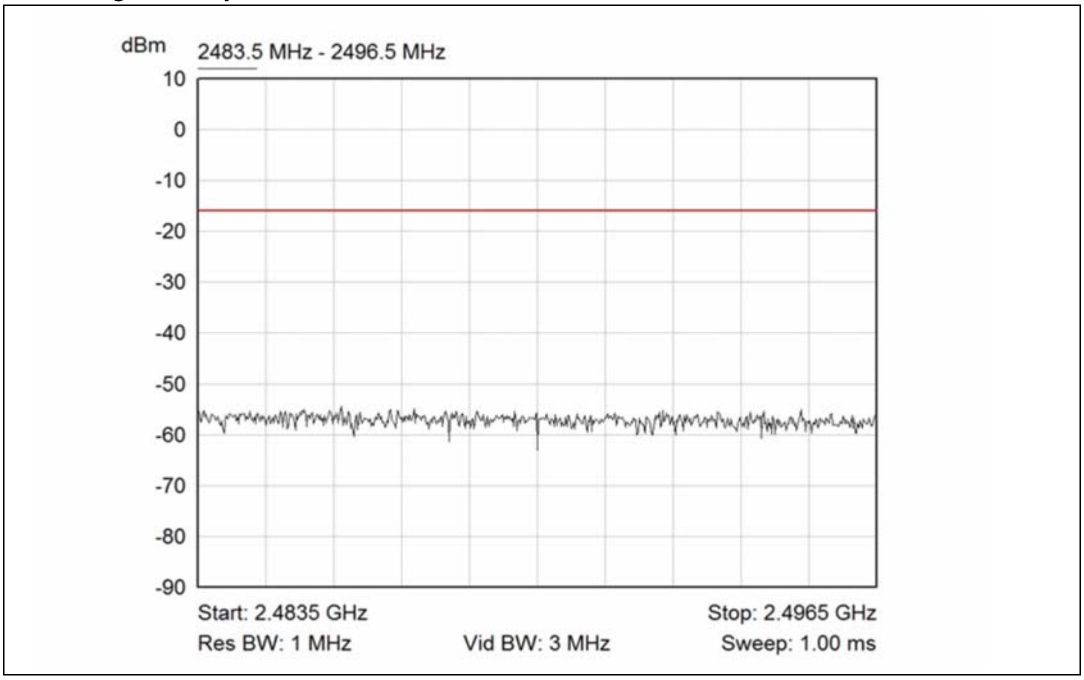
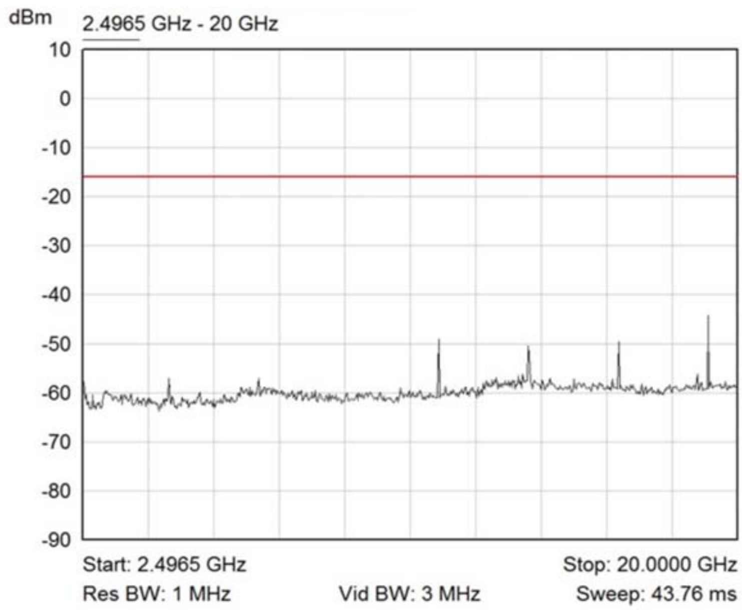


Figure 8. Spurious emission in the 2.4965 GHz to 20 GHz bandwidth



4.4 Maximum frequency bandwidth

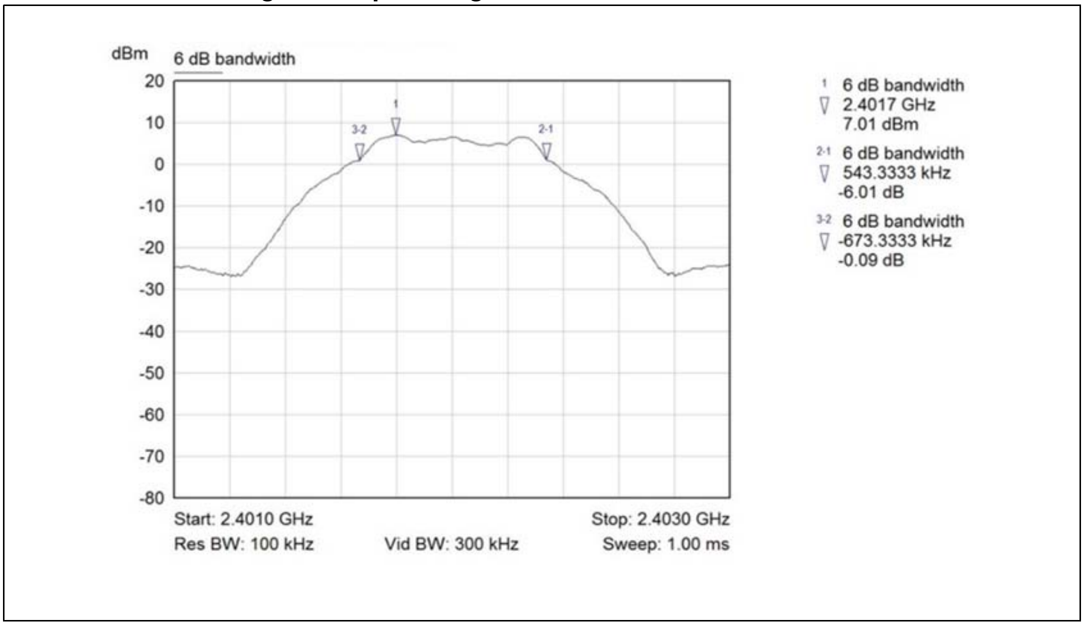
The 6 dB bandwidth is evaluated. The 6 dB channel bandwidth is defined as the difference between the upper and lower frequencies that are -6 dB relative to the peak. The measurement is performed in conducted mode connecting the BlueNRG application board to a spectrum analyzer.

The spectrum analyzer settings are:

- Span = set to approximately 2 to 3 times the 6 dB bandwidth
- RBW ≥ 100 kHz
- VBW ≥ 3 x RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

The measured bandwidth is shown in figure 9. The measured bandwidth is more than 673 kHz, so the ARIB requirement is met with margin.

Figure 9. Spreading bandwidth of CH37: 673 kHz



5 Receiver parameter

No specific spectrum analyzer settings are defined in the standard, so the following settings are used:

- Span = sufficient to see the required bandwidth
- RBW = 100 kHz below 1 GHz, 1 MHz above 1 GHz
- VBW = 3 x RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold
- The device is set in receive mode

BlueNRG performance meets ARIB requirements also as regards receiver spurious emissions.

Figure 10. RX spurious emission in the 10 MHz to 1 GHz bandwidth

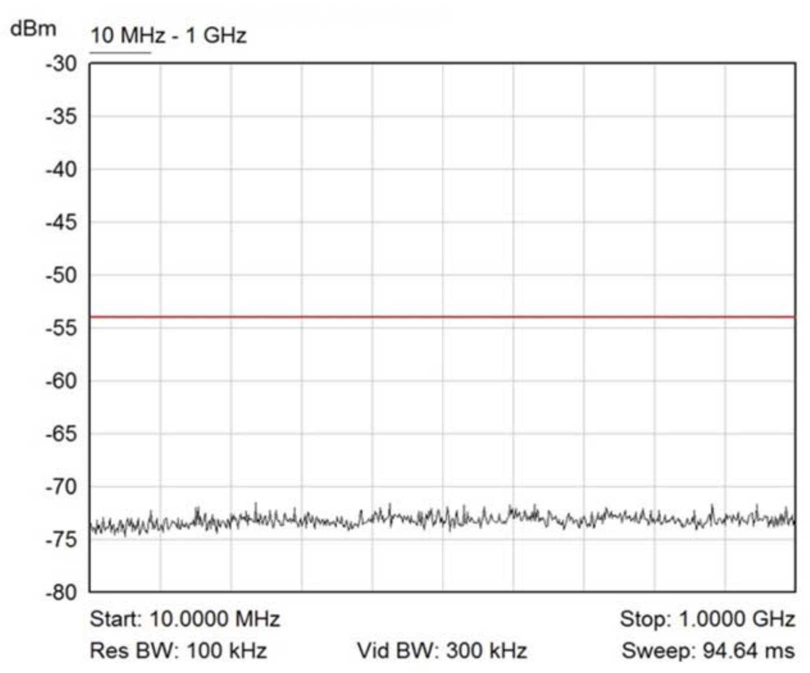
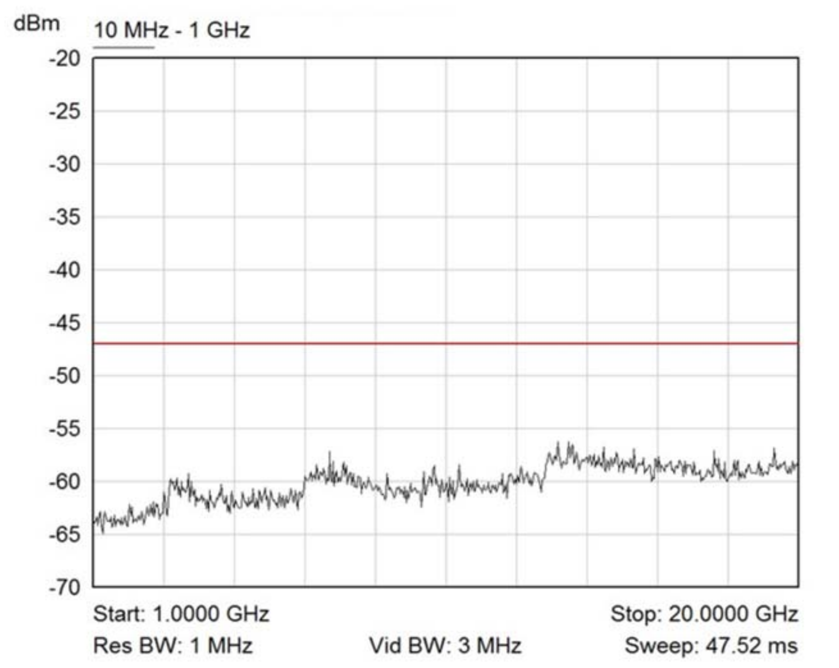


Figure 11. RX spurious emission in the 1 GHz to 20 GHz bandwidth



6 Reference

[1] BlueNRG datasheets

[2] ARIB STD-T66 V3.7

[3] “Bluetooth Low Energy Regulatory Aspects”, from Bluetooth SIG Regulatory Committee

[4] “Radio Equipment Regulations”, Article 4.17.49.20

7 Revision history

Table 3. Document revision history

Date	Revision	Changes
24-Jan-2014	1	Initial release.
07-Apr-2016	2	Updated document title by adding “BlueNRG-MS” *Introduction:* updated text and added a note *Section 3: Application circuit*: updated text and removed 2.0 V to 3.6 V.
26-Apr-2017	3	Title and document modified to add reference to all BlueNRG family devices.