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## Using the BlueNRG family transceivers under FCC title 47 part 15 in the 2400 – 2483.5 MHz band

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### 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 traditional Bluetooth technology, but uses a different set of channels. Bluetooth low energy technology has 40 channels (37 data channels + 3 advertising channels) of 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 transmit power is 10 mW (10 dBm).

Further details are given in volume 6 part A of the Bluetooth Core Specification V4.0.

The BlueNRG family includes:

- 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 a BlueNRG device under FCC title 47 part 15 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 the FCC title 47 part 15 regulations.

These can be downloaded from [www.scc-ares-races.org/FCCpartstitles.html](http://www.scc-ares-races.org/FCCpartstitles.html).

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# 1 An overview of FCC regulations

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

The FCC is the body responsible in the USA for implementing rules limiting the potential for interference to licensed operations by low power, non-licensed transmitters. These rules are documented in Part 15 of Title 47 of the FCC.

For operation in the 2400 - 2483.5 MHz band, a low power, non-licensed device must meet one of the following sub-parts of the regulation:

- Part 15.247: devices adhering to this part are limited to frequency hopping and digitally modulated scheme.
- Part 15.249: this sub-part does not enforce restrictions on the modulation scheme or the end application.

The FCC classifies Bluetooth BR/EDR as an FHSS system. However, Bluetooth LE does not fulfill these requirements. Instead, the FCC classifies Bluetooth LE as a system using digital modulation techniques.

## 1.1 Part 15.247

To be compliant with the FCC part 15.247 digital modulation scheme, the devices or systems must meet the following requirements:

1. The minimum 6 dB bandwidth of the signal shall be at least 500 kHz.
2. The maximum permitted peak conducted output power is +30 dBm (1 W). However, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.
3. In any 100 kHz bandwidth outside the frequency band of operation, the power shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval the attenuation required under this paragraph shall be 30 dB instead of 20 dB.
4. Attenuation below the general limits specified in 15.209 is not required. In addition, radiated harmonic and spurious emissions which fall within the restricted bands, as defined in FCC part 15.205, must also comply with the radiated emission limits specified in FCC part 15.209.

The FCC document *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Part 15.247* provides guidelines for performing the FCC part 15.24 compliance measurements.

## 1.2 Parts 15.205 and 15.209

Radiated harmonics and spurious emissions of devices that comply with part 15.247, which fall within the restricted bands as defined in FCC part 15.205, must comply with the radiated emission limits specified in FCC part 15.209. For any 100 kHz bandwidth outside the frequency band of operation and outside the restricted bands, the power shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

Part 15.205 shows the bands where only spurious emissions are permitted (see [Table 1: "Restricted bands defined in part 15.205"](#)). The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in part 15.209. The tables that follow show the restricted bands as defined in part 15.205, and the radiated and conducted emission limits are defined in part 15.209. In [Table 2: "Radiated and conducted emission limits defined in part 15.209"](#), the maximum permissible electric field strength at a specific measurement distance is reported along with the equivalent EIRP value. To determine the equivalent EIRP value, the formula described in Chapter 10.2.2.1 of *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Part 15.247* is used.

Table 1: Restricted bands defined in part 15.205

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	399.9 - 410	4.5 – 5.15
0.495 – 0.505	16.69475 – 16.69525	608 - 614	5.35 – 5.46
2.1735 – 2.1905	16.80425 – 16.80475	960 - 1240	7.25 – 7.75
4.125 – 4.128	25.5 – 25.67	1300 - 1427	8.025 – 8.5
4.17725 – 4.17775	37.5 – 38.25	1435 – 1626.5	9.0 – 9.2
4.20725 – 4.20775	73 – 74.6	1645.5 – 1646.5	9.3 – 9.5
6.215 – 6.218	74.8 – 75.2	1660 - 1710	10.6 – 12.7
6.26775 – 6.26825	108 – 121.94	1718.8 – 1722.2	13.25 – 13.4
6.31175 – 6.31225	123 - 138	2200 - 2300	14.47 – 14.5
8.291 – 8.294	149.9 – 150.05	2310 - 2390	15.35 – 16.2
8.362 – 8.366	156.52475 – 156.52525	2483.5 - 2500	17.7 – 21.4
8.37625 – 8.38675	156.7 – 156.9	2690 - 2900	22.01 – 23.12
8.41425 – 8.41475	162.0125 – 167.17	3260 - 3267	23.6 – 24.0
12.29 – 12.293	167.72 – 173.2	3332 - 3339	31.2 – 31.8
12.51975 – 12.52025	240 - 285	3345.8 - 3358	36.43 – 36.5
12.57675 – 12.57725	322 – 335.4	3600 - 4400	Above 38.6
13.36 – 13.41			

Table 2: Radiated and conducted emission limits defined in part 15.209

Frequency (MHz)	Field strength (μV/m)	Measurement distance (m)	Conducted (dBm)
0.009 – 0.490	2400/f [kHz]	300	12.4-20*log(f) <sub>kHz</sub>
0.490 – 1.705	24000/f [kHz]	30	12.4-20*log(f) <sub>kHz</sub>
1.705 – 30.0	30	30	-46
30 - 88	100	3	-56
88 - 216	150	3	-52
216 - 960	200	3	-49
960	500	3	-41

## 1.3 Relaxation factor

FCC regulations outlined in CFR Title 47 part 15 subpart A section 15.35 (b) specify that, unless otherwise noted, emission limits above 1 GHz are expressed employing a measurement instrument's average detector. However, because of an average detector's dependency on the characteristics of pulse train and the specifications of the measuring instrument, repeatability is nearly impossible from instrument to instrument. The FCC regulations provide an allowance for correcting pulsed transmissions when the limits are expressed in terms of an average, and the average measurement may be derived from the peak pulse amplitude corrected for the duty cycle of the pulse modulation. This is the relaxation factor or duty cycle correction, which is in fact a normalized duty cycle correction applied to a peak measurement to increase accuracy and repeatability when representing a pulsed average emission.

The calculation of the duty cycle correction factor is done using a spectrum analyzer with the following settings:

- Span = zero span
- RBW = 1 MHz
- VBW = RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

The transmit pulse widths and period have to be measured.

**If the pulse train is less than 100 ms**, including blanking intervals, the duty cycle is calculated by averaging the sum of the pulse widths over one complete pulse train.

**If the pulse train exceeds 100 ms**, the duty cycle is calculated by averaging the sum of the pulse widths over the 100 ms width with the highest average value.

The duty cycle is the value of the sum of the pulse widths in one period (or 100 ms), divided by the length of the period (or 100 ms). The duty cycle correction factor is then expressed in dB and the peak emissions adjusted accordingly to give an average value of the emission.

Correction factor [dB] =  $20 \times \log_{10}$  (calculated duty cycle)

## 1.4 Considerations regarding unwanted emissions

The DTS rules specify that any emission outside the authorized frequency band has to be attenuated as per the requirement in Part 15.247: *Attenuation below the general limits specified in 15.209 is not required. In addition, radiated harmonic and spurious emissions which fall within the restricted bands, as defined in FCC part 15.205, must also comply with the radiated emission limits specified in FCC part 15.209.*

The described procedure can be used in either an antenna port conducted or radiated test set-up.

Also, the DTS rules specify that emissions which fall into restricted frequency bands shall comply with the general radiated emission limits. Since the emission limits are specified in terms of radiated field strength levels, measurements performed to demonstrate compliance have traditionally relied on a radiated test configuration. Radiated measurements remain the principal method for demonstrating compliance to the specified

limits; however **antenna port conducted measurements are also now acceptable to demonstrate compliance<sup>a</sup>**.

General procedure for conducted measurement in restricted band is:

- Measure the conducted output power, in dBm, using the detector specified.
- Add the maximum transmit antenna gain, in dBi, to the measured output power level to determine the EIRP level.
- Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies  $\leq 30$  MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz and 0 dB for frequencies  $> 1000$  MHz).
- For devices with multiple antenna ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms.
- Convert the applicable limit level to an equivalent dBm level using

$$\text{EIRP} = E + 20\log D - 104.8$$

where:

- E = electric field strength in dBuV/m,
- EIRP = equivalent isotropic radiated power in dBm,
- D = specified measurement distance in meters.
- Compare the resultant applicable limit level in dBm with the measured EIRP.

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<sup>a</sup> Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under § 15.247, 558074 D01 DTS Meas Guidance v03r05, April 8 - 2016



## 2 Application circuit

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

The board 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 and used by the BlueNRG-MS.

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

An SMA connector is present to connect the board to an antenna or to an instrument to verify correct operation 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. A C-L-C network is included for improved matching and to increase the out of band attenuation.

The daughterboard must be plugged onto a motherboard (see *Figure 2: "BlueNRG application motherboard"*) via two 5 x 2 header connectors.

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 available to help program the BlueNRG-MS.

**Figure 1: BlueNRG application daughterboard**

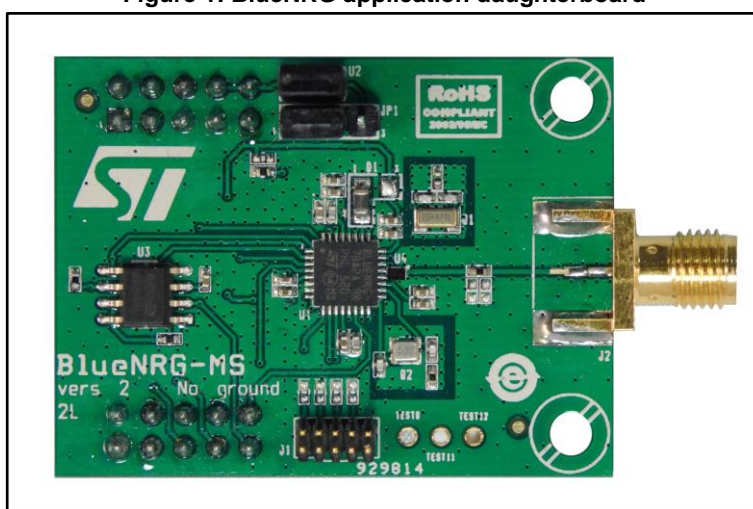


Figure 2: BlueNRG application motherboard

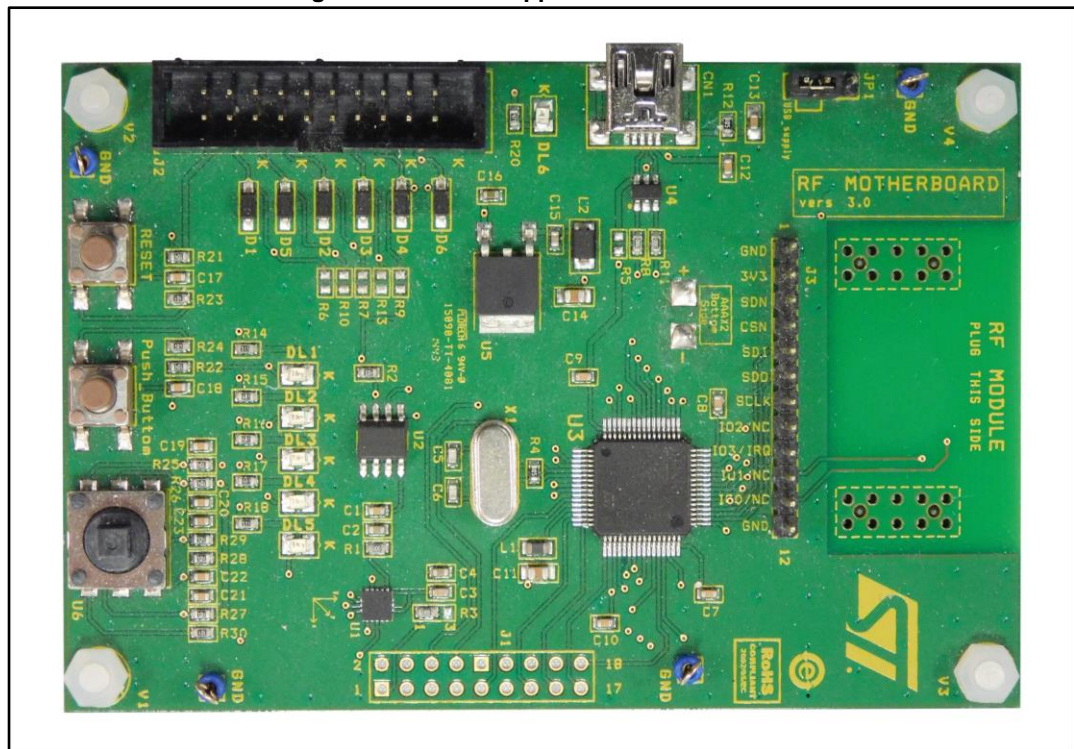


Figure 3: "BlueNRG-1/2 application board" shows the BlueNRG-1/2 (STEVAL-IDB007V1 and STEVAL-IDB008V1) evaluation platform.

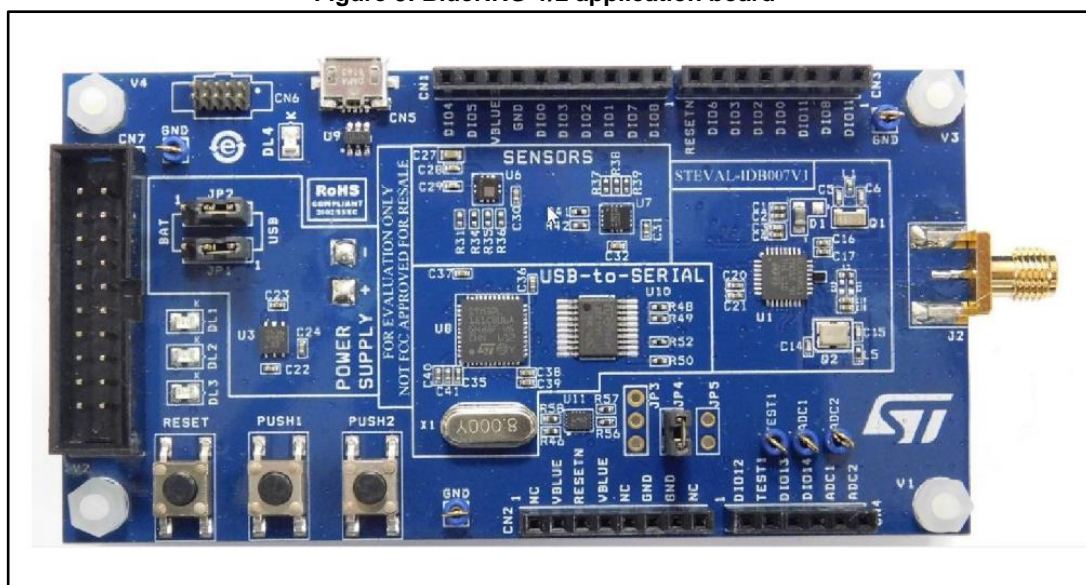
The two platforms also provide a set of hardware resources for implementing a wide range of application scenarios: sensor data (accelerometer, pressure and temperature sensor), remote control (buttons and LEDs) and debug message management via USB virtual COM.

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 operation 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. A C-L-C network is included for better matching and to increase the out of band attenuation.

Figure 3: BlueNRG-1/2 application board



### 3 Transmitter parameter

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

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

#### 3.1 6 dB channel bandwidth

The 6 dB channel bandwidth is defined as the difference between the upper and lower frequencies that are -6 dB relative to the peak.

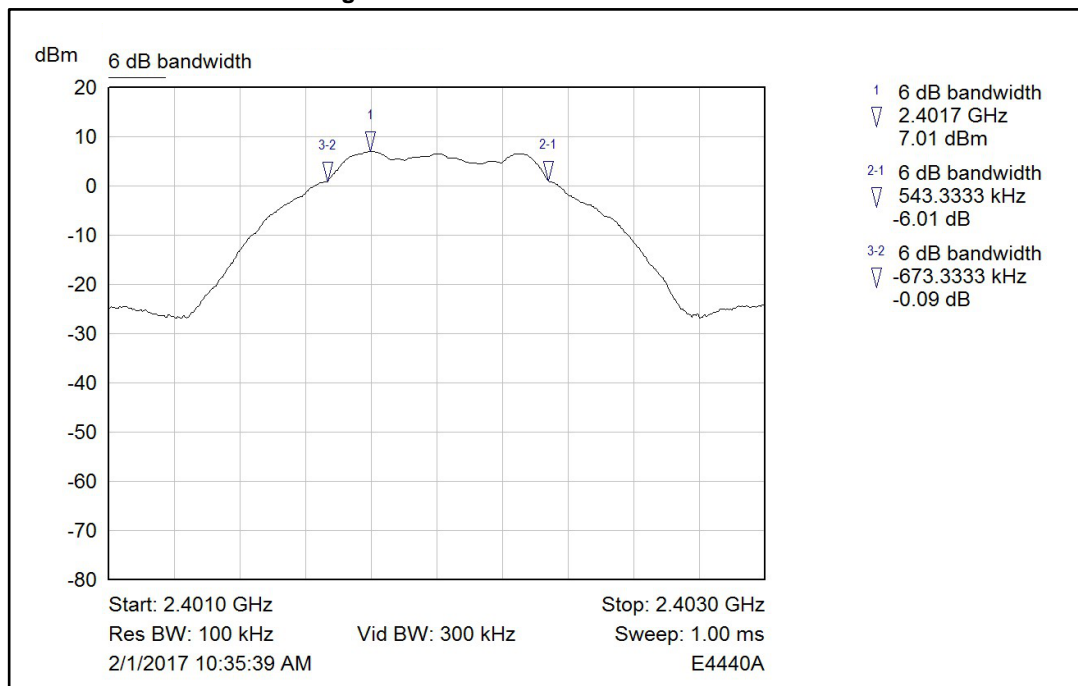
The measurements are performed in conducted mode, connecting the BlueNRG application board to a spectrum analyzer.

The spectrum analyzer settings are<sup>a</sup>:

- Span = no requirement, set to approximately 2 to 3 times the 6 dB bandwidth
- RBW  $\geq 100\text{ kHz}$
- VBW  $\geq 3 \times \text{RBW}$
- Sweep = auto
- Detector function = peak
- Trace = max. hold

The 6 dB bandwidth measurement is shown below. The measured bandwidth is more than 673 kHz, easily satisfying the FCC requirement.

Figure 4: 6 dB bandwidth measurement



<sup>a</sup> as per *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under § 15.247, 558074 D01 DTS Meas Guidance v03r05*, April 8 - 2016

### 3.2 Maximum peak conducted output power

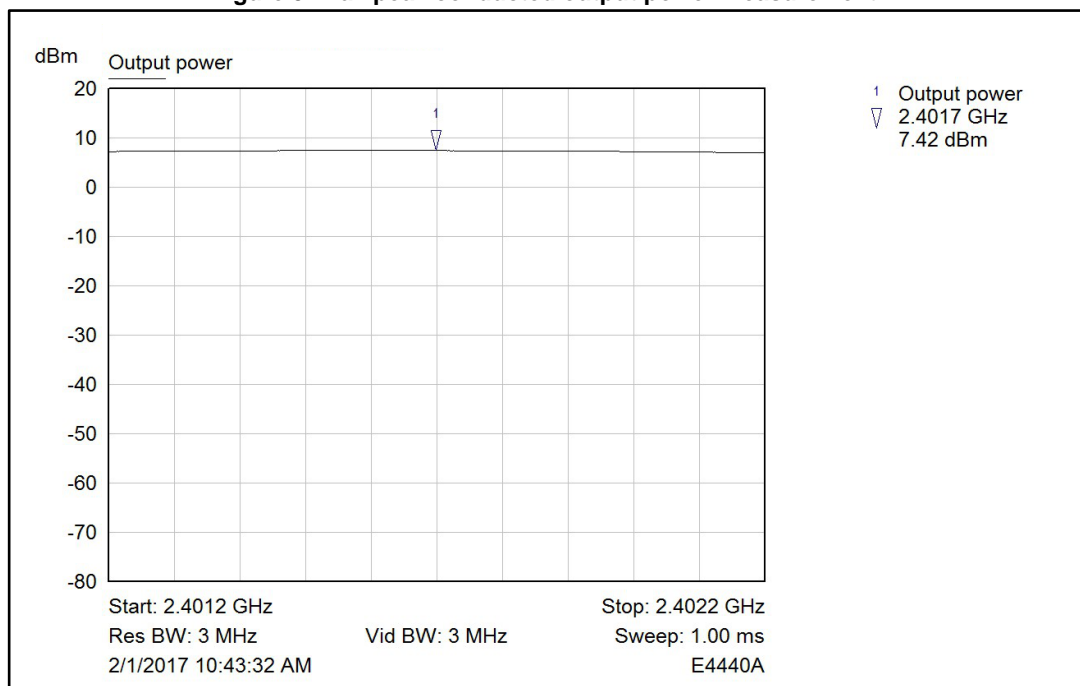
To measure the peak output power, center the spectrum analyzer on the wanted channel and put the BlueNRG-MS in carrier mode.

The spectrum analyzer settings are<sup>a</sup>:

- Span  $\geq 3 \times$  RBW
- RBW  $\geq$  DTS bandwidth (the 6 dB bandwidth)
- VBW  $\geq 3 \times$  RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

The maximum permitted peak conducted output power is 30 dBm (1 W). The measured BlueNRG device output power is below +8dBm. This output power is lower than the maximum permitted output power. The result is shown below.

**Figure 5: Max peak conducted output power measurement**



### 3.3 Maximum power spectral density level in the fundamental emission

The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. The method to measure the power spectral density is similar to that used for the conducted output power.

The spectrum analyzer settings are (method PKPSD - peak PSD)<sup>b</sup>:

<sup>a</sup> as per *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under § 15.247*, 558074 D01 DTS Meas Guidance v03r05, April 8 - 2016

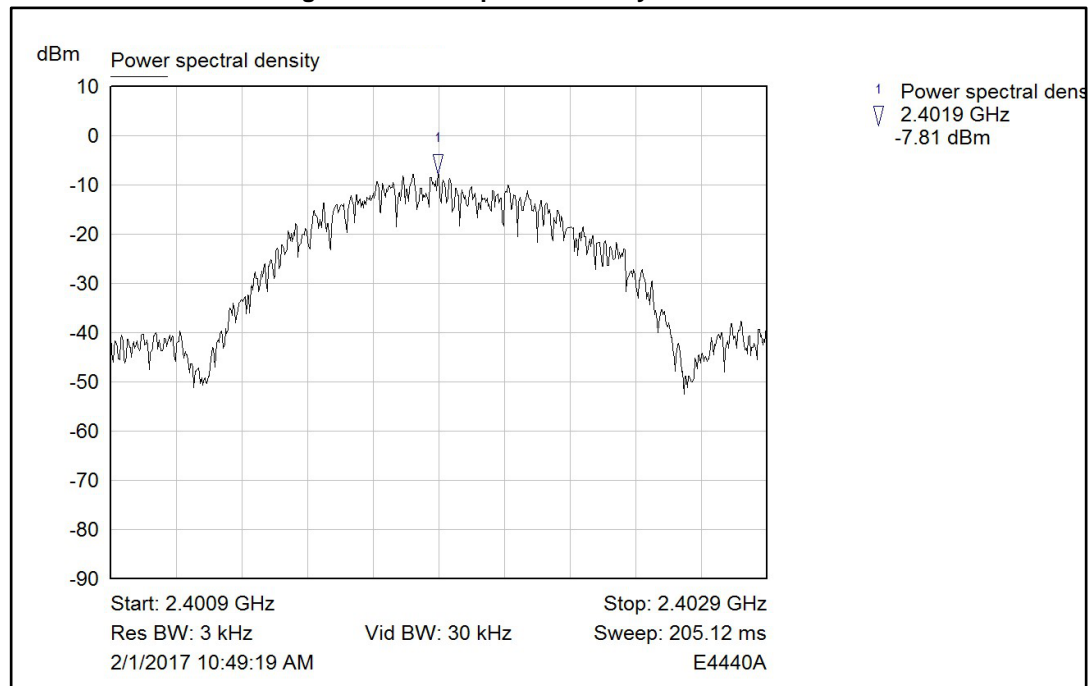
<sup>b</sup> as per *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under § 15.247*, 558074 D01 DTS Meas Guidance v03r05, April 8 - 2016



- Span  $\geq 1.5$  times the DTS bandwidth (the 6 dB bandwidth)
- $3 \text{ kHz} \geq \text{RBW} \geq 100 \text{ kHz}$
- $\text{VBW} \geq 3 \times \text{RBW}$
- Sweep = auto
- Detector function = peak
- Trace = max. hold

The measurement result is about -8 dBm, as shown in the following figure. The BlueNRG devices easily satisfy the power spectral density requirement.

Figure 6: Power spectral density measurement



### 3.4 Unwanted emissions

FCC part 15.247 defines two different cases for the emission outside the 2402 MHz – 2480.5 MHz band:

- Emission that falls in a not-restricted band
- Emission that falls in a restricted band as defined in the 15.205

For the emission in the **not-restricted** band, the DTS<sup>a</sup> rules specify that in any 100 kHz bandwidth, the power shall be attenuated according to the following conditions:

- If the maximum peak conducted output power procedure was used to demonstrate compliance of the fundamental emission output power, then the peak output power measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 20 dBc)
- If maximum conducted (average) output power was used to demonstrate compliance of the fundamental emission output power, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 30 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 30 dBc)

<sup>a</sup> as per *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under § 15.247*, 558074 D01 DTS Meas Guidance v03r05, April 8 - 2016

- In either case, attenuation to levels below the 15.209 general radiated emissions is not required.

The compliance of the fundamental emission output power of the BlueNRG family devices has been demonstrated using the maximum peak conducted output power procedure, so the 20 dBc limit must be considered.

The measurement must be performed using the following settings<sup>a</sup>:

- Set the center frequency and span to encompass frequency range to be measured
- RBW = 100 kHz
- VBW  $\geq 3 \times$  RBW
- Sweep time = auto
- Detector function = peak
- Trace = max hold

Use the peak marker function to determine the maximum amplitude level and ensure that the amplitude of all unwanted emissions are attenuated by at least the minimum requirements.

For the emissions in **restricted** frequency bands, the DTS rules specify that emissions which fall into restricted frequency bands shall comply with the general radiated emission limits. Since the emission limits are specified in terms of radiated field strength levels, measurements performed to demonstrate compliance have traditionally relied on a radiated test configuration. Radiated measurements remain the principal method for demonstrating compliance to the specified limits; however antenna-port conducted measurements are also now acceptable to demonstrate the compliance.

To correctly compare the measured values in conducted mode and the specified limits in radiated mode, the following values are considered in the calculation:

- Antenna gain = 0 dBi
- Ground reflection factor = 0 dB (for frequencies > 1 GHz)

The compliance of the emission in restricted bands of the BlueNRG devices is shown using the conducted measurement. The peak power measurement procedure<sup>b</sup> is used with the following settings:

- RBW = as specified in [Table 3: "RBW as a function of frequency"](#)
- VBW  $\geq 3 \times$  RBW
- Sweep time = auto
- Detector function = peak
- Trace = max hold

**Table 3: RBW as a function of frequency**

Frequency	RBW
9-150 kHz	200–300 Hz
0.15-30 MHz	9–10 kHz
30-1000 MHz	100–120 kHz
>1000 MHz	1 MHz

<sup>a</sup> as per *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under § 15.247, 558074 D01 DTS Meas Guidance v03r05, April 8 - 2016*

<sup>b</sup> paragraph 12.2.4 of *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, 558074 D01 DTS Meas Guidance v02*

If the peak-detected amplitude can be shown to comply with average limit, then it is not necessary to perform a separate average measurement.

Three conditional procedures are provided for performing conducted average power measurements for three cases:

- EUT can be configured to transmit continuously<sup>a</sup>
- EUT cannot be configured to transmit continuously but the duty cycle is constant<sup>b</sup>
- EUT cannot be configured to transmit continuously and the duty cycle is not constant<sup>c</sup>

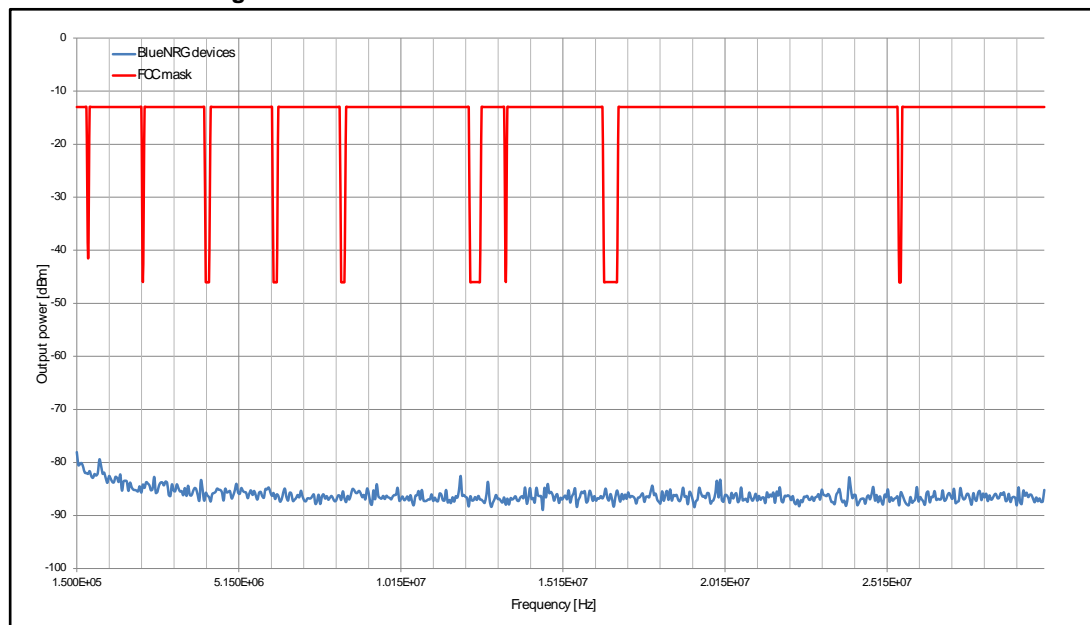
BlueNRG device compliance is already demonstrated by the peak-detected amplitude method, so it is not necessary to perform the average amplitude measurements.

The spurious conducted emissions and the FCC emission masks are shown in [Figure 7: "Unwanted emission in the 150 kHz – 30 MHz band"](#), [Figure 8: "Unwanted emission in the 30 MHz – 1000 MHz band"](#) and [Figure 9: "Unwanted emission in the 1 GHz – 25 GHz band"](#) when the **BlueNRG devices are in TX**.

[Figure 10: "RX unwanted emission in the 150 kHz – 30 MHz band"](#), [Figure 11: "RX unwanted emission in the 30 MHz – 1000 MHz band"](#) and [Figure 12: "RX unwanted emission in the 1 GHz – 25 GHz band"](#) show the unwanted emission when the **BlueNRG devices are in RX**.

Both in TX and RX the FCC unwanted emission requirements are met.

**Figure 7: Unwanted emission in the 150 kHz – 30 MHz band**



<sup>a</sup> paragraph 12.2.5.1 of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, 558074 D01 DTS Meas Guidance v02

<sup>b</sup> paragraph 12.2.5.2 of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, 558074 D01 DTS Meas Guidance v02

<sup>c</sup> paragraph 12.2.5.3 of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, 558074 D01 DTS Meas Guidance v02



Figure 8: Unwanted emission in the 30 MHz – 1000 MHz band

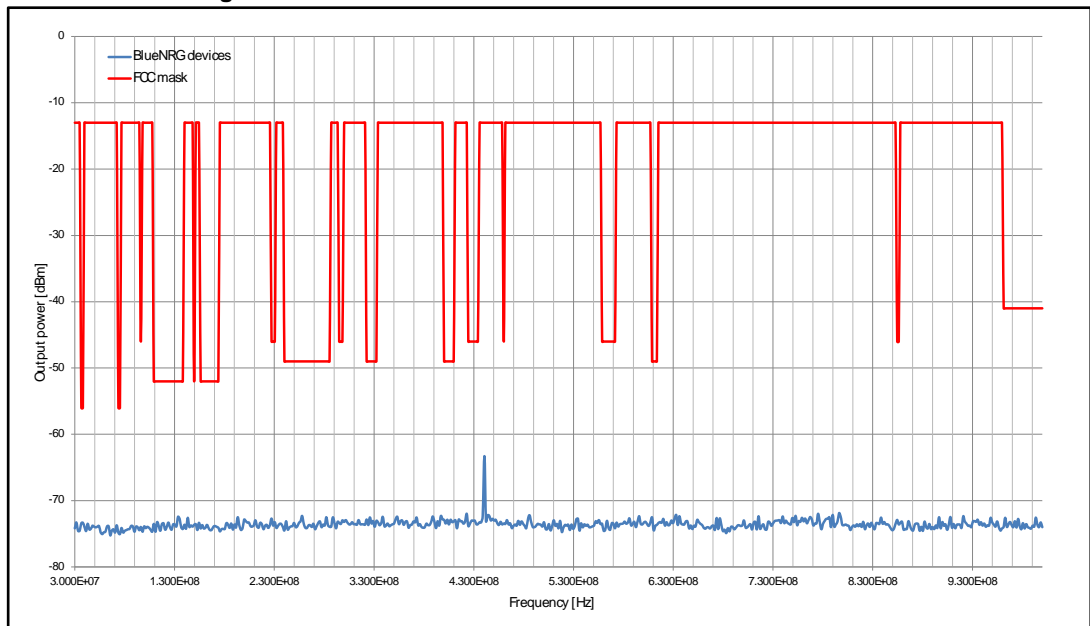


Figure 9: Unwanted emission in the 1 GHz – 25 GHz band

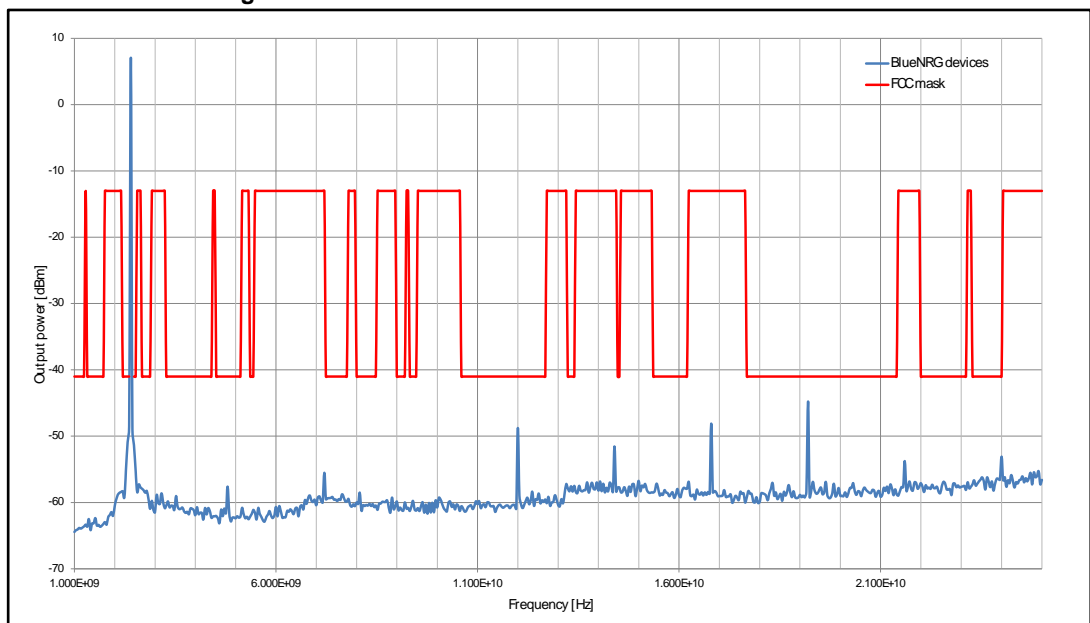


Figure 10: RX unwanted emission in the 150 kHz – 30 MHz band

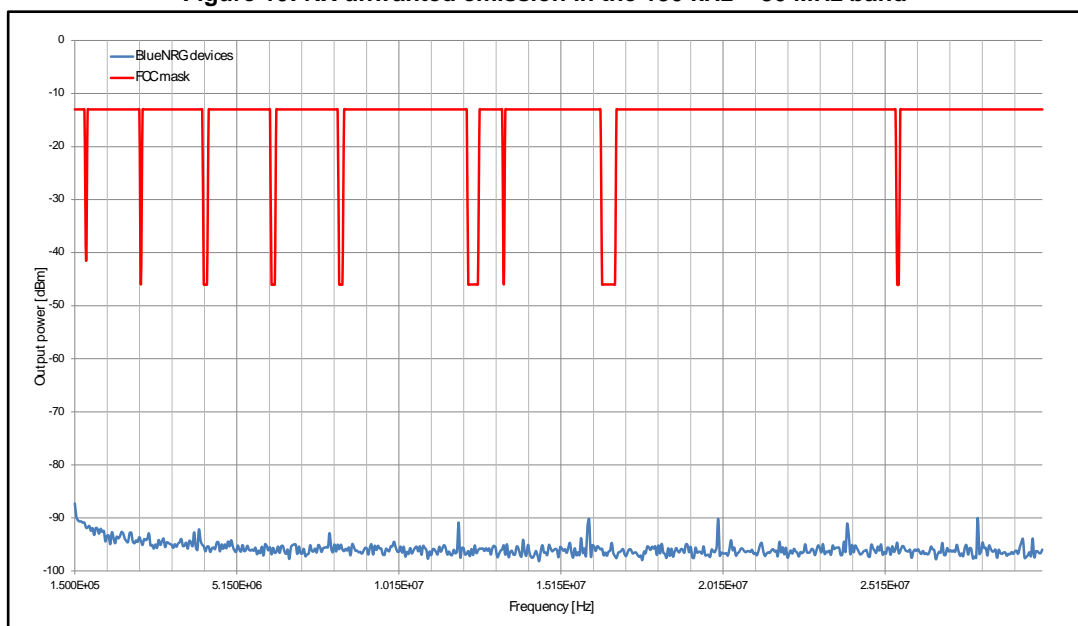


Figure 11: RX unwanted emission in the 30 MHz – 1000 MHz band

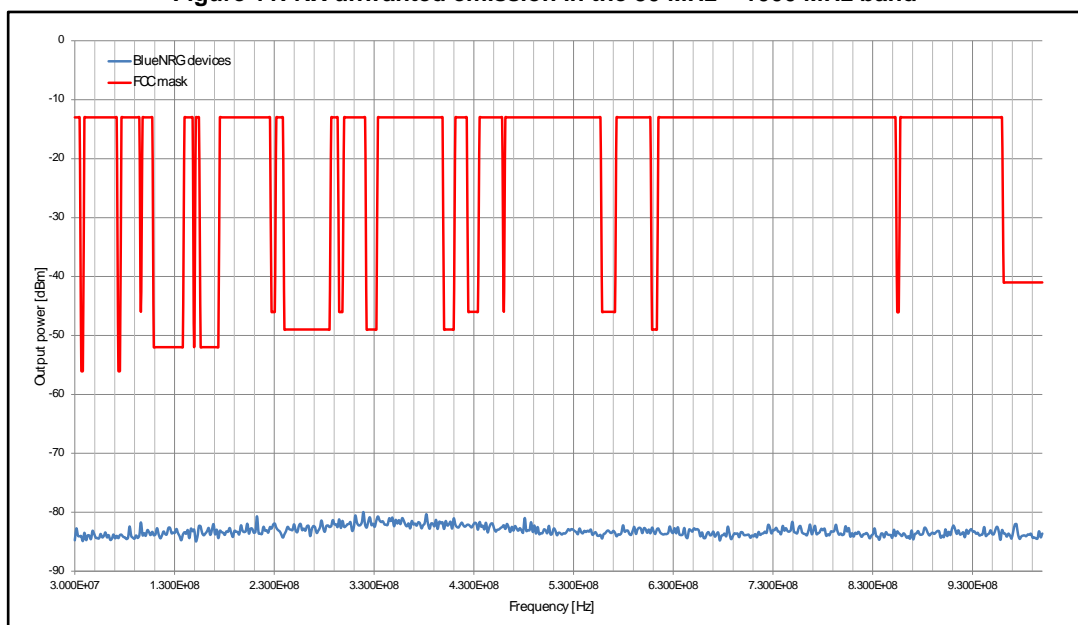
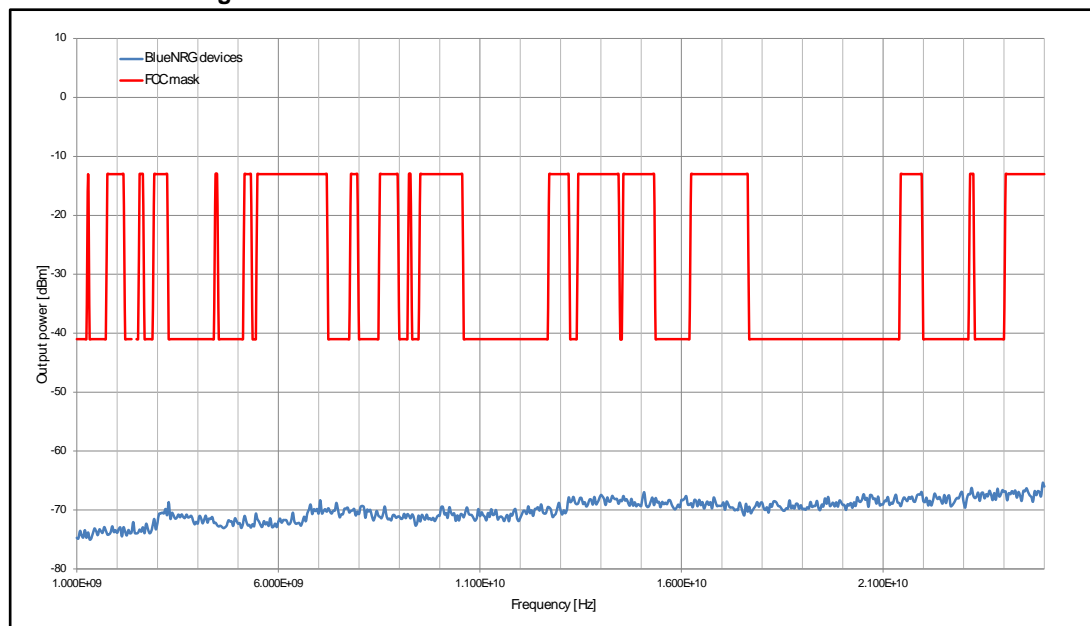


Figure 12: RX unwanted emission in the 1 GHz – 25 GHz band



### 3.5 Band-edge compliance of RF conducted emissions

According to the part 15.247, in any 100 kHz bandwidth outside the frequency bands in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in part 15.205, must also comply with the radiated emission limits specified in part 15.209.

Two different measurement methods are:<sup>a</sup>:

- Marker-delta method
- Integration method with three different cases
  - EUT can be configured to transmit continuously<sup>b</sup>
  - EUT cannot be configured to transmit continuously but the duty cycle is constant<sup>c</sup>
  - EUT cannot be configured to transmit continuously and the duty cycle is not constant<sup>d</sup>

When performing peak or average radiated measurements, emission within 2 MHz of the authorized band edge may be measured using the marker-delta method. The integration method can be used when performing conducted or radiated average measurements.

BlueNRG devices can be programmed to transmit continuously so the marker-delta method is used. The instrument setting is<sup>a</sup>:

<sup>a</sup> Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, 558074 D01 DTS Meas Guidance v02

<sup>b</sup> paragraph 13.3.1 of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, 558074 D01 DTS Meas Guidance v02

<sup>c</sup> paragraph 13.3.2 of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, 558074 D01 DTS Meas Guidance v02

<sup>d</sup> paragraph 13.3.3 of Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, 558074 D01 DTS Meas Guidance v02

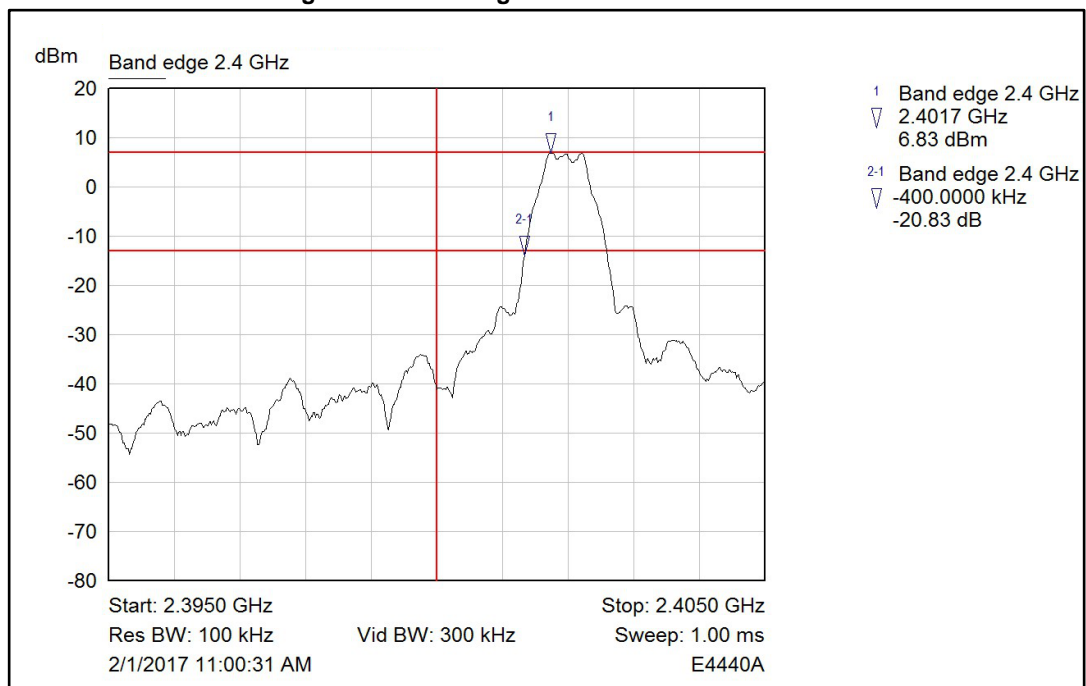
- Set the instrument center frequency to the frequency of the band edge to be measured
- Span = 10 MHz
- RBW = 100 kHz
- VBW  $\geq 3 \times$  RBW
- Sweep time = auto
- Detector function = peak
- Trace = max hold

Record the peak level of the fundamental emission at the relevant band edge emission. Then measure the amplitude delta between the peak of the fundamental and the peak of the band edge emission. This is not a field strength measurement, it is only a relative measurement to determine the amount by which the emission drops at the band edge relative to the highest fundamental emission level.

The conducted emissions in the band edge at 2.4 GHz is fully compliant with the specification, see [Figure 13: "Band edge measurement at 2.4 GHz"](#).

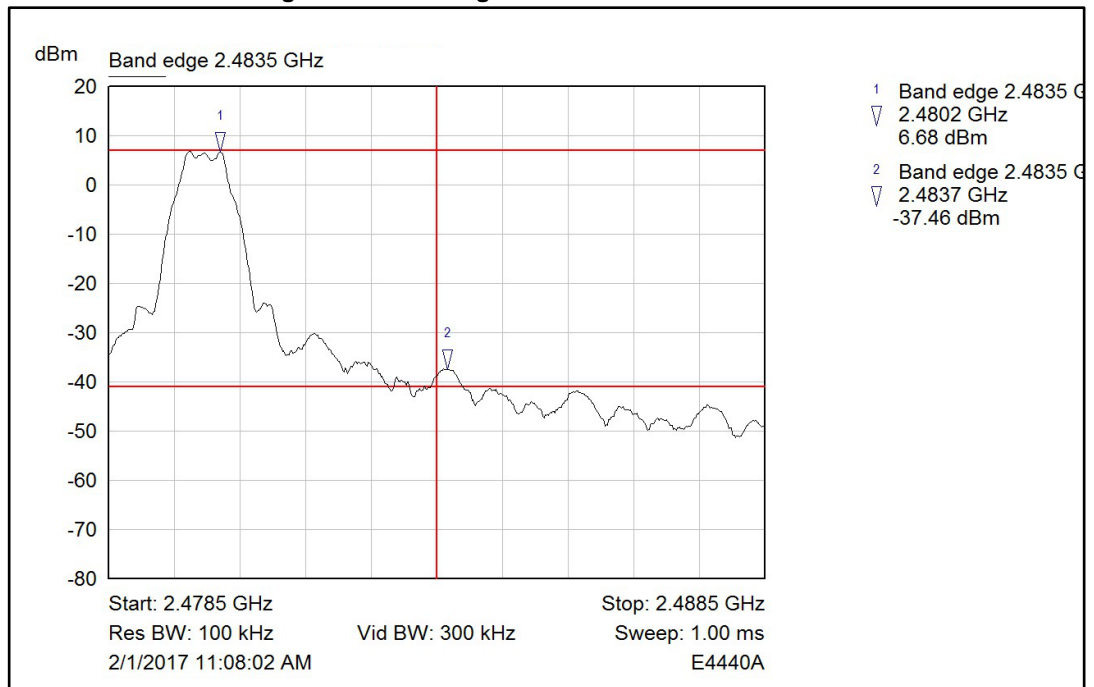
The level of the unwanted emission for frequencies higher than 2.4835 GHz has to be below -41 dBm. It is possible to see in the [Figure 14: "Band edge measurement at 2.4835 GHz"](#) that the specification is not met. In this case, the relaxation factor must be implemented to meet the FCC requirement.

**Figure 13: Band edge measurement at 2.4 GHz**



<sup>a</sup> Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, 558074 D01 DTS Meas Guidance v02

Figure 14: Band edge measurement at 2.4835 GHz



## 4 Receiver parameter

No specific requirements are defined for FCC compliance of the receiver in US FCC Title 47 Part 15<sup>a</sup> in the 2400 to 2483.5 MHz band. The only requirement is regarding the level of unwanted emission when the BlueNRG devices are in RX. This point is covered in [Section 3.4: "Unwanted emissions"](#), so no further measurements are necessary.

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<sup>a</sup> FCC title 47 part 15: *Radio frequency devices*

## 5 References

1. BlueNRG datasheet
2. FCC title 47 part 15: *Radio frequency devices*
3. *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under § 15.247*, 558074 D01 DTS Meas Guidance v03r05, April 8 - 2016
4. FCC KDB 913591

## 6 Revision history

Table 4: Document revision history

Date	Revision	Changes
29-Jan-2014	1	Initial release.
07-Apr-2016	2	Updated document title by adding "BlueNRG-MS" <i>Introduction</i> : updated text and added a note <i>Section 2: Application circuit</i> : updated text and removed 2.0 V to 3.6 V.
11-Apr-2017	3	Throughout document: - widened reference to BlueNRG family to include BlueNRG-1 and BlueNRG-2 - minor text and formatting changes In <a href="#">Section 1.1: "Part 15.247"</a> : - updated list of requirements Added <a href="#">Section 1.3: "Relaxation factor"</a> Added <a href="#">Section 1.4: "Consideration regarding unwanted emissions"</a> In <a href="#">Section 2: "Application circuit"</a> - added BlueNRG-1/2 application board details and board photo - removed <i>Figure 3. Daughterboard schematic</i> In <a href="#">Section 3: "Transmitter parameter"</a> : - updated all measurements and resulting graphs - removed <i>Section 3.4 Maximum unwanted emission levels</i> and subsections - added <a href="#">Section 3.4: "Unwanted emissions"</a> Added <a href="#">Section 3.5: "Band-edge compliance of RF conducted emissions"</a> Updated <a href="#">Section 4: "Receiver parameter"</a>



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