Application note

Using the BlueNRG-LP/LPS transceiver under ARIB STD-T66 in the 2400 – 2483.5 MHz band

Introduction

BlueNRG-LP and BlueNRG-LPS (together referred to as BlueNRG-LP/LPS in this document) 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® Low Energy technology has 40 channels (37 data channels + 3 advertising channels) of 2 MHz band. Within the channel, data are transmitted using GFSK (gaussian frequency shift modulation). The bit rate is 1 Msymb/s, 2 Msymb/s, 500 ksymb/s or 125 ksymb/s the maximum transmit power is 100 mW (20 dBm).

Further details are given in volume 6 part A of the Bluetooth® core specification V5.2.

This application note outlines the expected performance when using the BlueNRG-LP/LPS 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, refer to ARIB STD-T66 V3.7 regulations [2]. These can be downloaded from [5].

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 more.

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

BLE 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) or less 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 is within ± 50 ppm of rated frequency.

2.4 Transmitter spurious emissions

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

Table 1. Transmitter spurious emissions

Frequency range	Transmit mask level
<2387 MHz	- 26 dBm
2387 MHz to 2400 MHz	- 16 dBm
2400 MHz to 2483.5 MHz	-
2483.5 MHz 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 is 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 radiations are limited to the values given in Table 2. Receiver spurious emissions.

Table 2. Receiver spurious emissions

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

3 Application circuit

Figure 1 and Figure 2 show the BlueNRG-LP evaluation platform STEVAL-IDB011V2 and the BlueNRG-LPS evaluation platform STEVAL-IDB012V1.

They provide a set of hardware resources to implement a wide range of application scenarios: sensor data (accelerometer, pressure and temperature sensor), remote control (buttons and LEDs) and manage debug messages though USB virtual COM. Three power options are available (USB only, battery only, external power supply + USB) for high application development and testing flexibility.

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

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

A RF connector (SMA or U.FL) is present to connect the board to an antenna or to an instrument to verify correct functioning and to verify standard compliance.

The evaluation kit includes an STM32F103 microcontroller to program and debug the transceiver.

A graphical user interface (GUI) can be used to control the BlueNRG-LP/LPS.

Figure 1. The BlueNRG-LP evaluation board

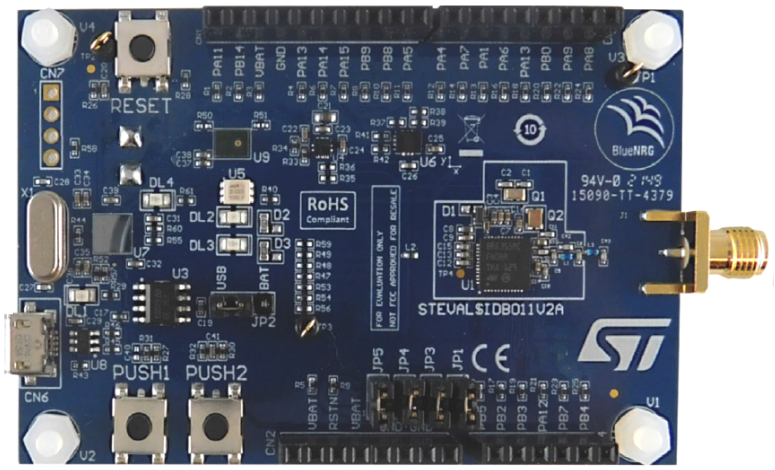

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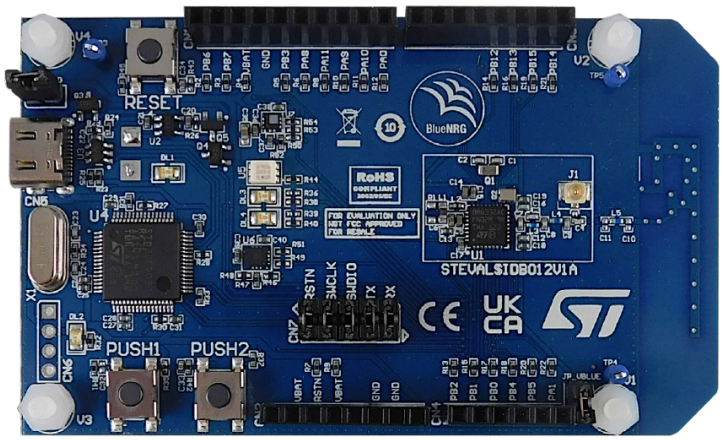
Figure 2. The BlueNRG-LPS application board



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4 Transmitter parameter

All the measurements here reported come from the following parameters: T_C = 25 °C, V_{DD} = 3.3 V, f = 2402 MHz and 2480 MHz (lower and high frequencies 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 results are shown in Table 3. IDB011V2 - Maximum output power.

Table 3. IDB011V2 - Maximum output power

Frequency [MHz]	Output power [dBm]	ARIB spec [dBm]
2402	+7.9	+10
2440	+7.9	+10
2480	+7.9	+10

Table 4. IDB012V1 - Maximum output power

Frequency [MHz]	Output power [dBm]	FCC spec [dBm]
2402	+7.5	+10
2440	+7.3	+10
2480	+7.3	+10

4.2 Frequency tolerance

The BlueNRG-LP/LPS device meets the ±50 ppm rated frequency requirements if the crystal used in the application guarantees the same or a 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-LP/LPS meets spurious emission requirements in every range specified, by a large margin.

Average power of spurious emissions (outside the specified 2.4 GHz band) provided through the antenna feed line should be as follows:

a) 25 mW (-16 dBm) for 2.387 GHz < f < 2.400 GHz and 2.483 GHz < f < 2.4965 GHz.

b) 2.5 mW (-26 dBm) for 2.387 GHz > f and 2.4965 GHz < f.

Figure 3. 'IDB011V2 - Tx (2402 MHz) spurious emission full span

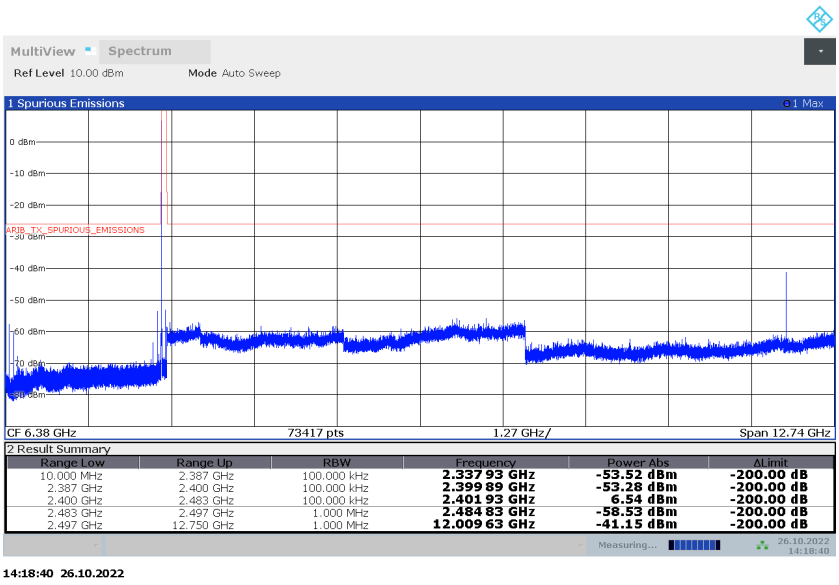

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Figure 4. 'IDB011V2 - Tx (2402 MHz) spurious emission in the 10 MHz to 2387 MHz band

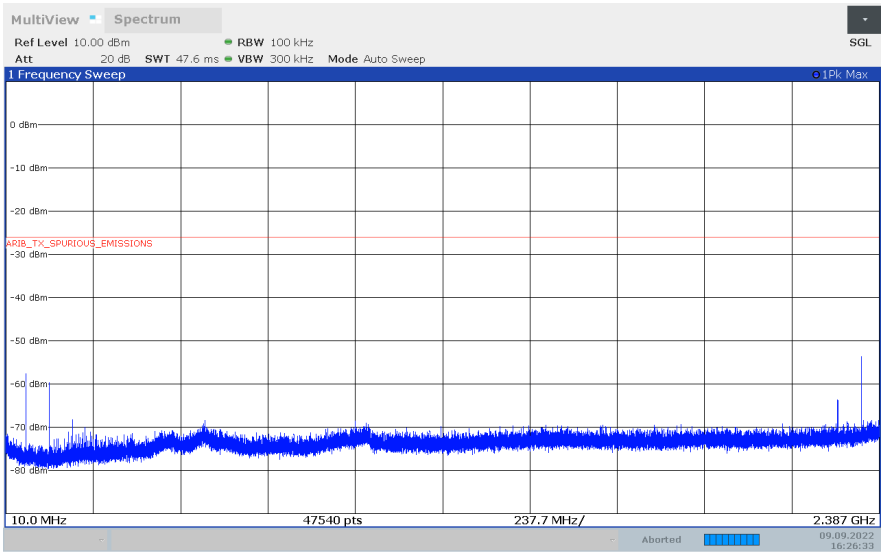

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Figure 5. IDB011V2 - Tx (2402 MHz) spurious emission in the 2387 MHz to 2400 MHz band

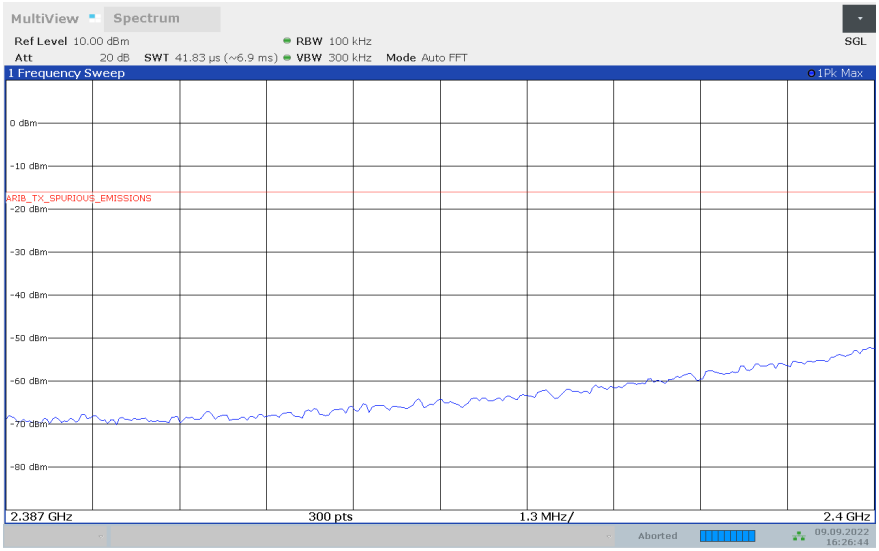

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Figure 6. IDB011V2 - Tx (2402 MHz) spurious emission in the 2483.5 MHz to 2496.5 MHz band

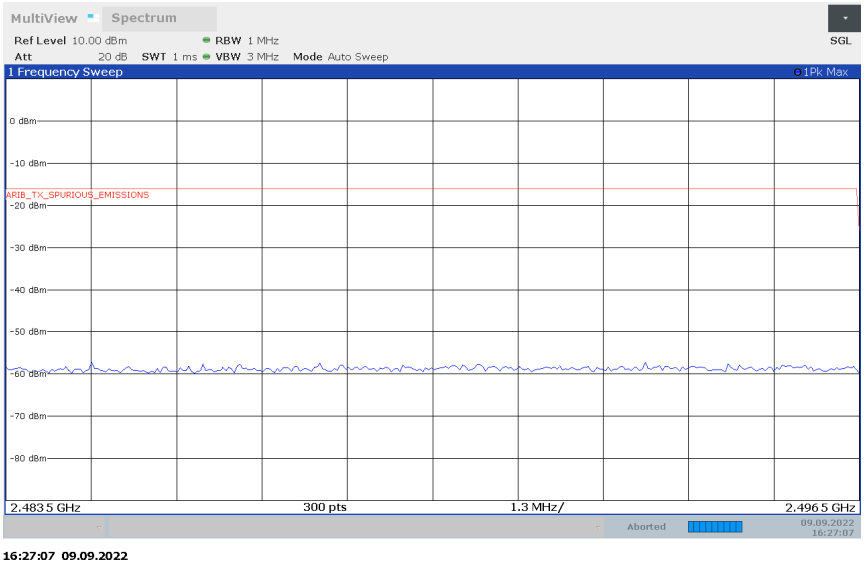

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Figure 7. IDB011V2 - Tx (2402 MHz) spurious emission in the 2496.5 MHz to 13.6 GHz band

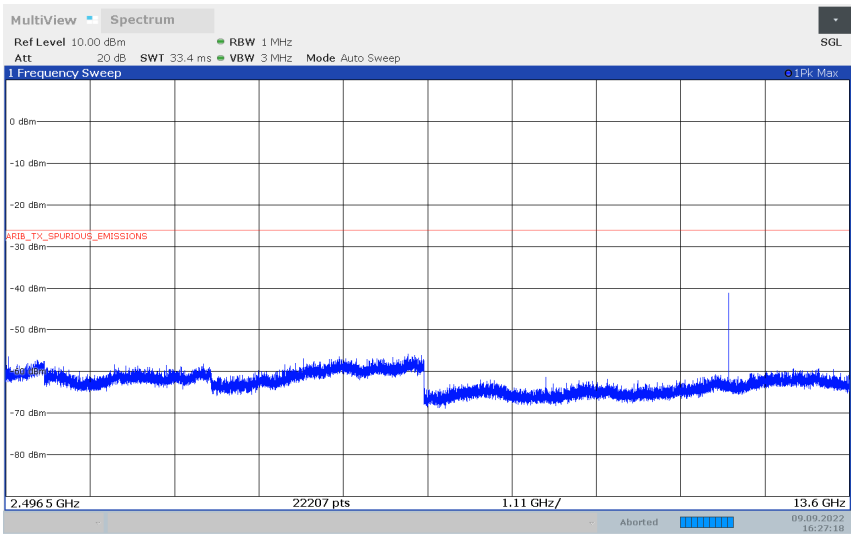

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Figure 8. IDB011V2 - Tx (2480 MHz) spurious emission full span

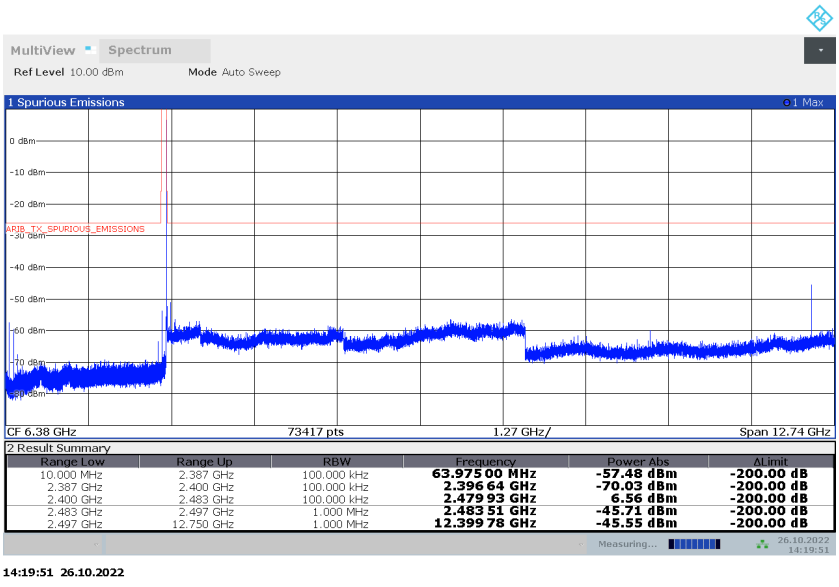

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Figure 9. IDB011V2 - Tx (2480 MHz) spurious emission in the 10 MHz to 2387 MHz band

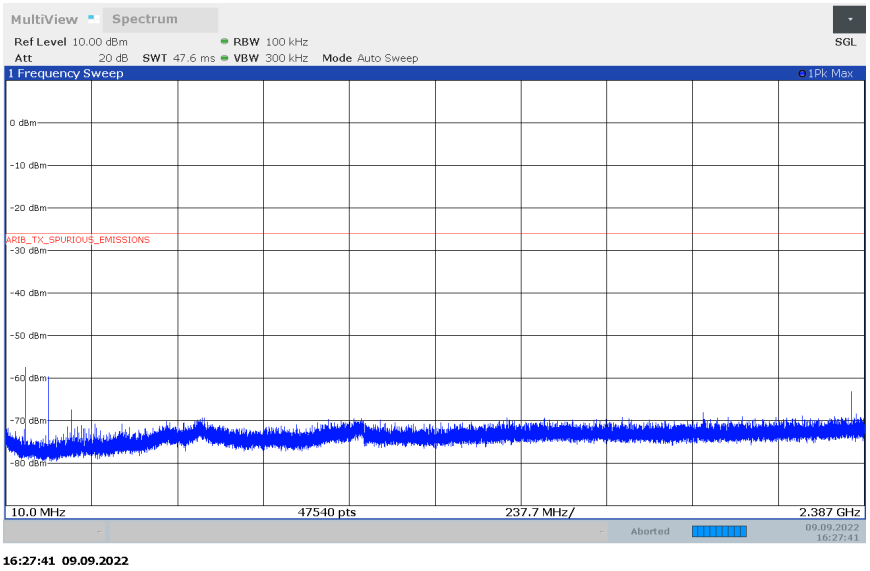

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Figure 10. IDB011V2 - Tx (2480 MHz) spurious emission in the 2387 MHz to 2400 MHz band

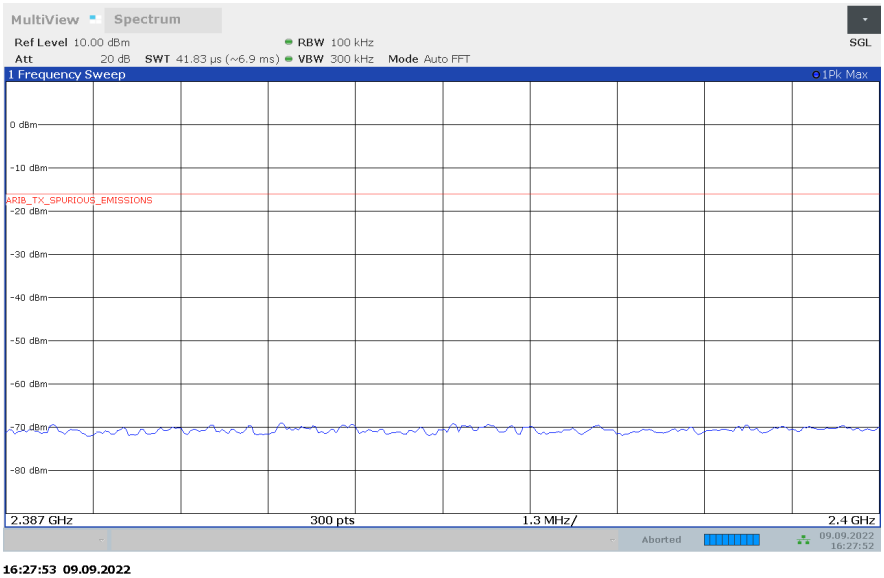

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Figure 11. IDB011V2 - Tx (2480 MHz) spurious emission in the 2483.5 MHz to 2496.5 MHz band

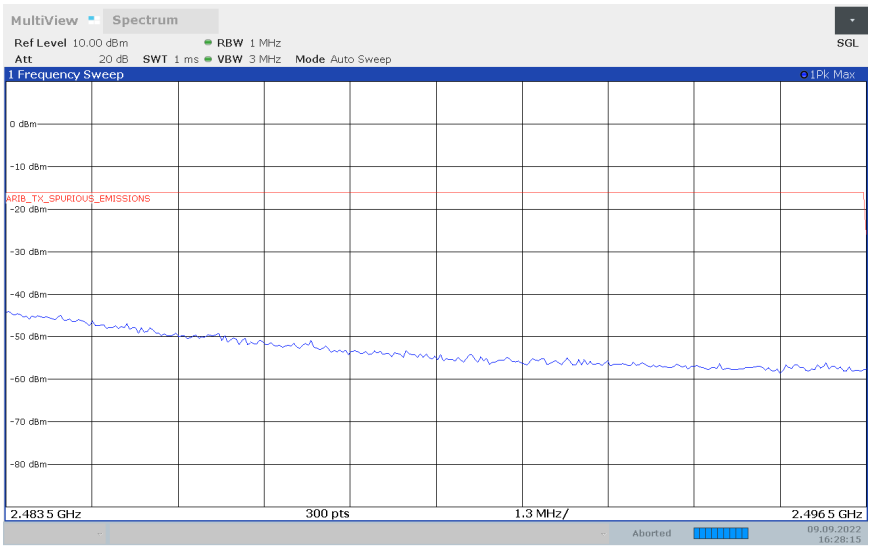

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Figure 12. IDB011V2 - Tx (2480 MHz) spurious emission in the 2496.5 MHz to 13.6 GHz band

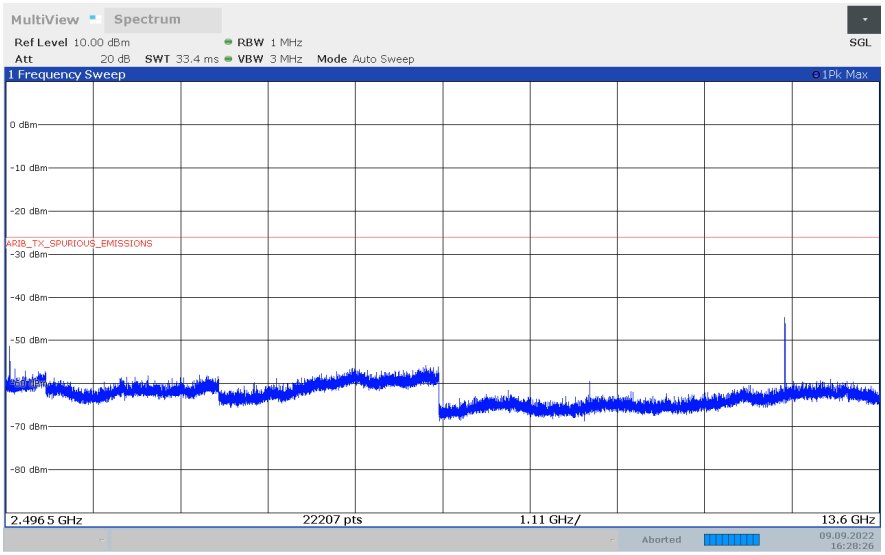

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Figure 13. 'IDB012V1 - Tx (2402 MHz) spurious emission full span

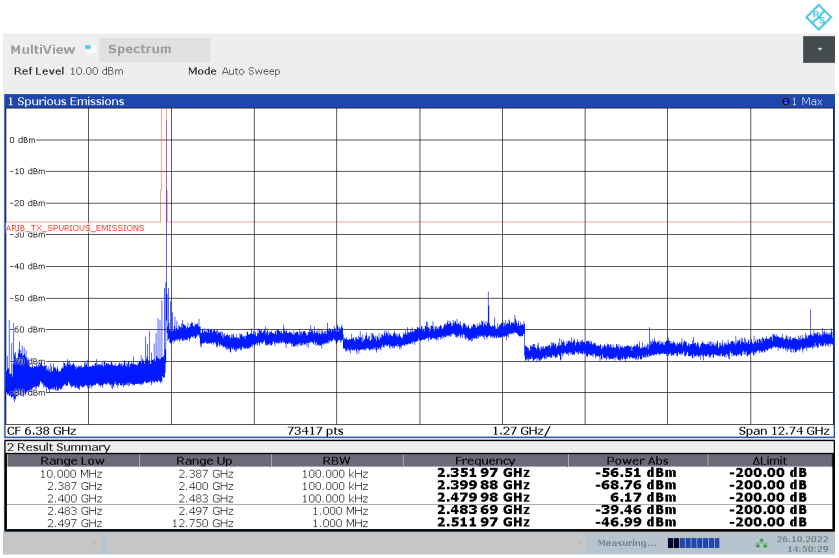

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Figure 14. IDB012V1 - Tx (2402 MHz) spurious emission in the 10 MHz to 2387 MHz band

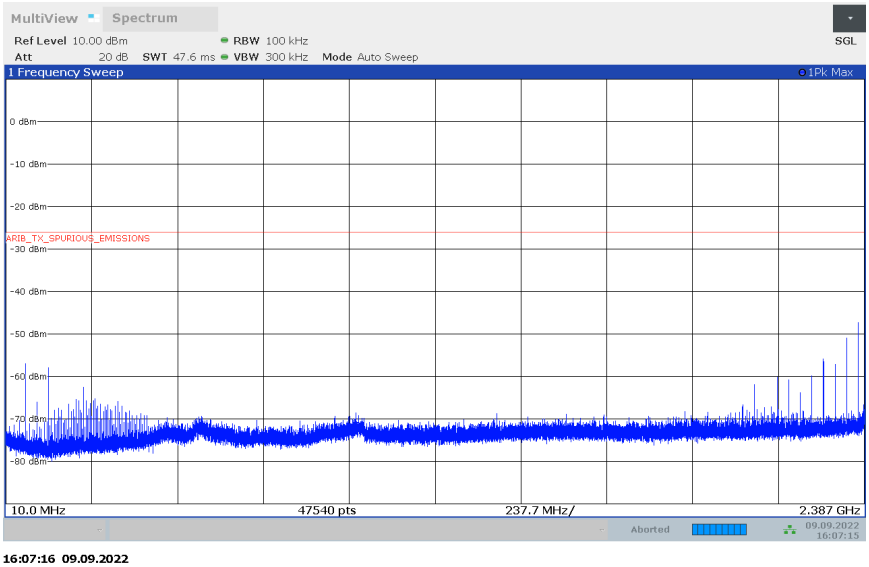

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Figure 15. **IDB012V1 - Tx (2402 MHz) spurious emission in the 2387 MHz to 2400 MHz band**

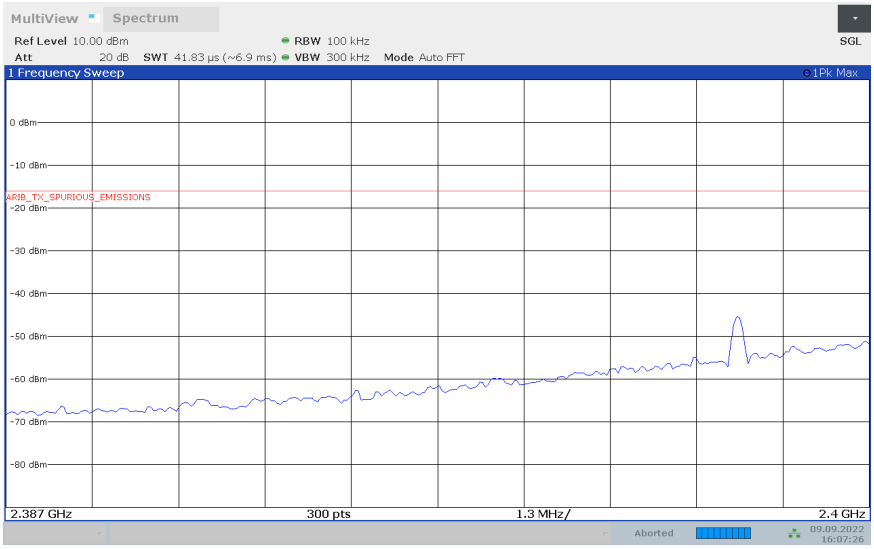

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Figure 16. **IDB012V1 - Tx (2402 MHz) spurious emission in the 2483.5 MHz to 2496.5 MHz band**

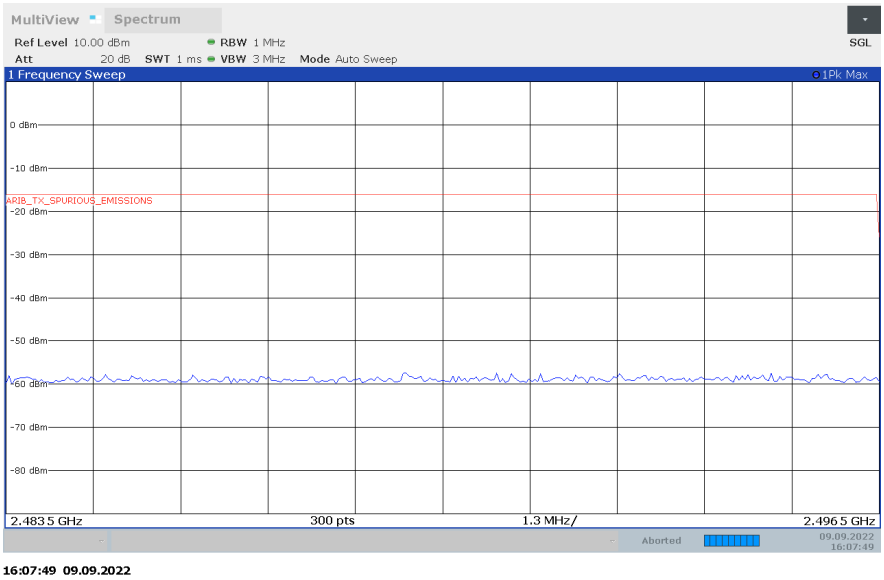

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Figure 17. **IDB012V1 - Tx (2402 MHz) spurious emission in the 2496.5 MHz to 13.6 GHz band**

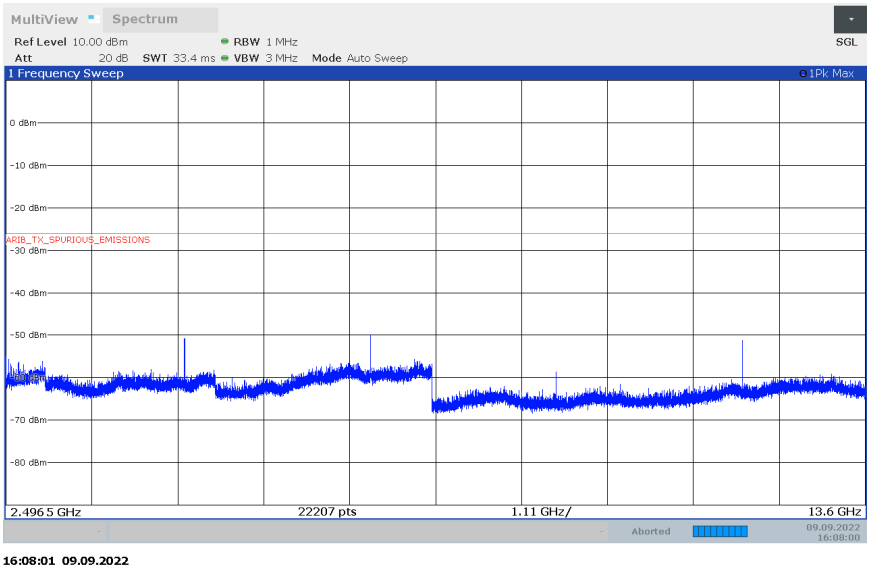

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Figure 18. **IDB012V1 - Tx (2480 MHz) spurious emission full span**

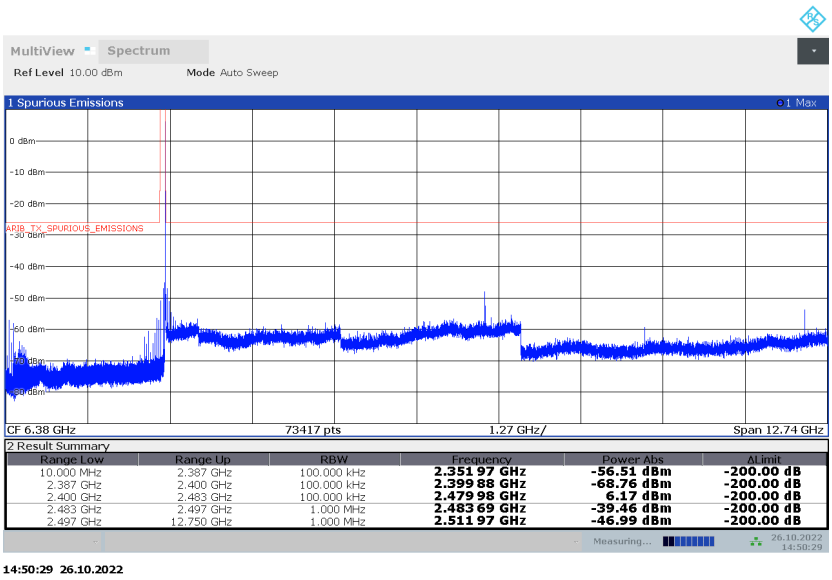

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Figure 19. IDB012V1 - Tx (2480 MHz) spurious emission in the 10 MHz to 2387 MHz band

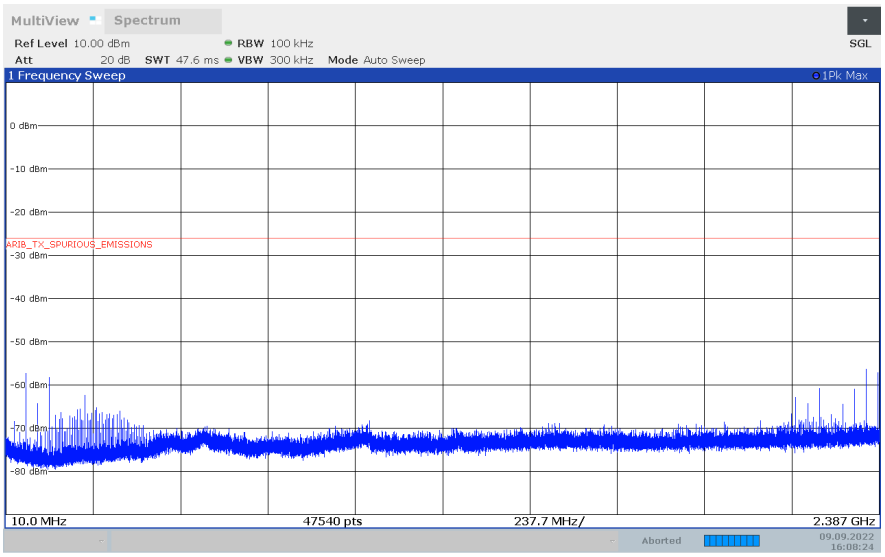

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Figure 20. IDB012V1 - Tx (2480 MHz) spurious emission in the 2387 MHz to 2400 MHz band

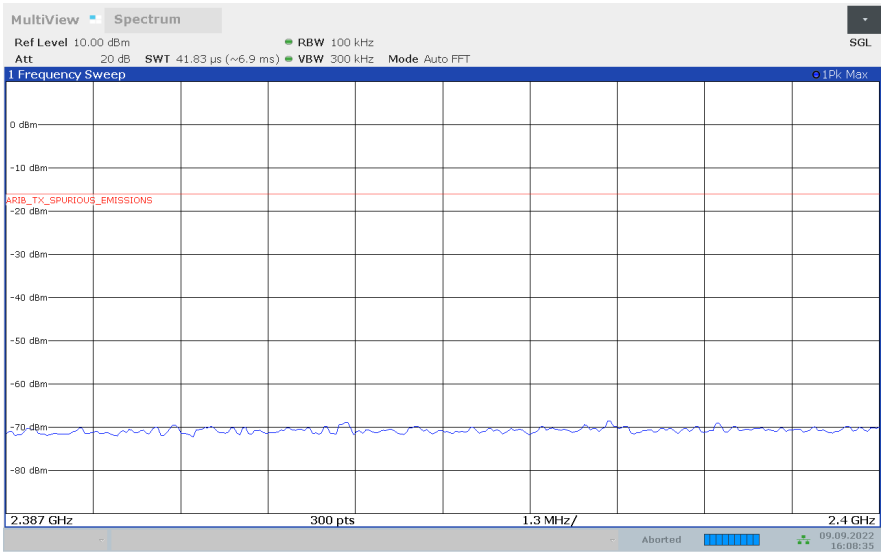

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Figure 21. IDB012V1 - Tx (2480 MHz) spurious emission in the 2483.5 MHz to 2496.5 MHz band

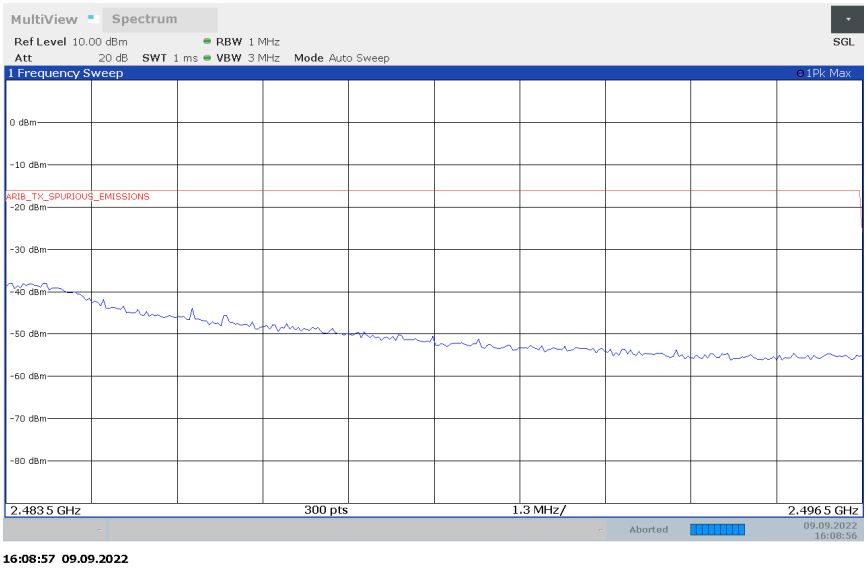

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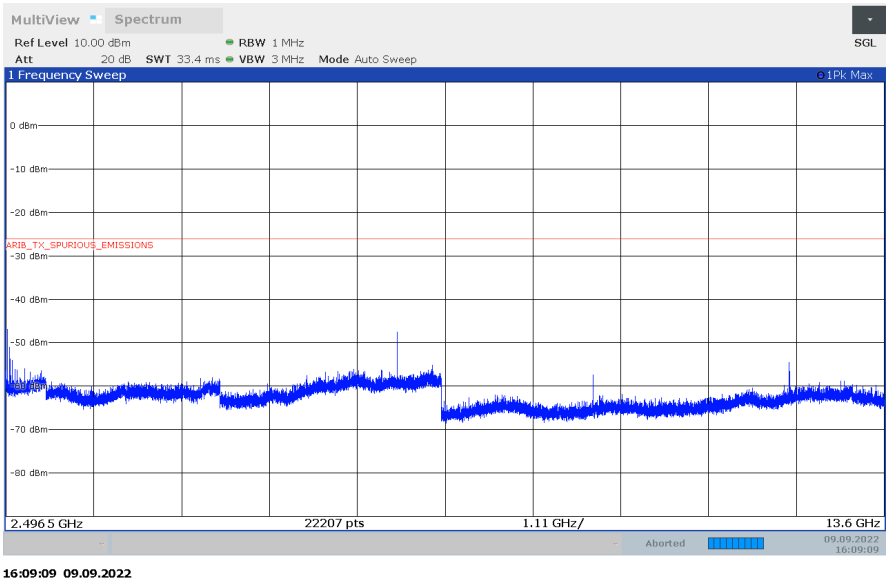
Figure 22. IDB012V1 - Tx (2480 MHz) spurious emission in the 2496.5 MHz to 13.6 GHz band



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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-LP/LPS 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 below. The measured bandwidth is more than 680 kHz, so the ARIB requirement is met with margin.

Figure 23. IDB011V2 - 6 dB bandwidth 2402 MHz

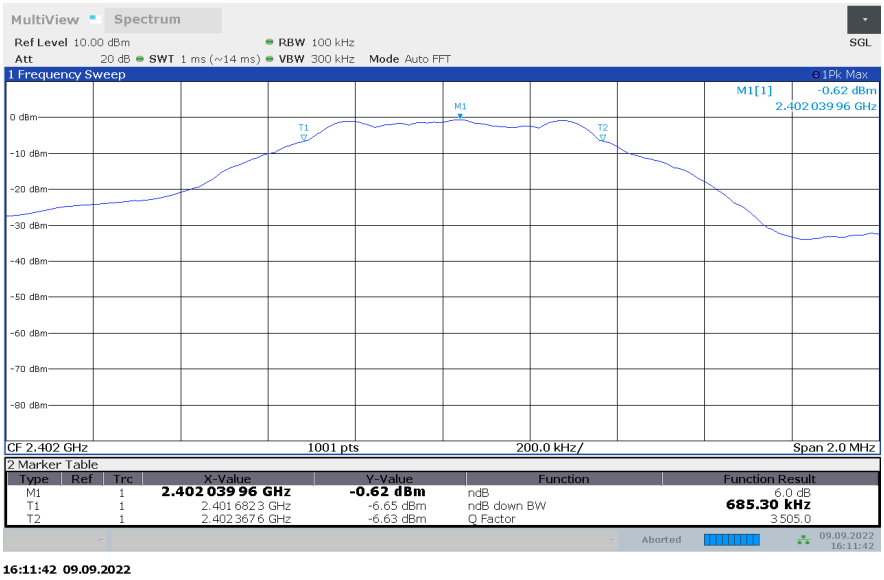

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Figure 24. **IDB011V2 - 6 dB bandwidth 2440 MHz**

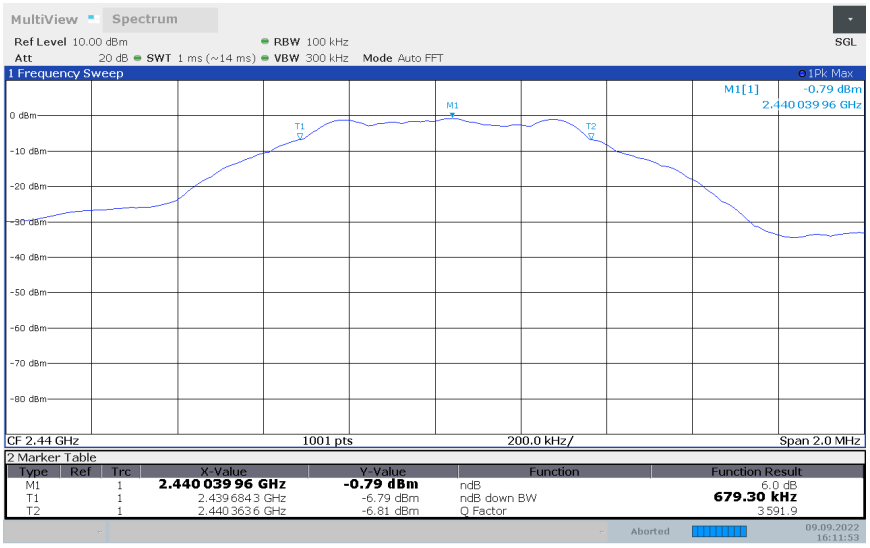

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Figure 25. **IDB011V2 - 6 dB bandwidth 2480 MHz**

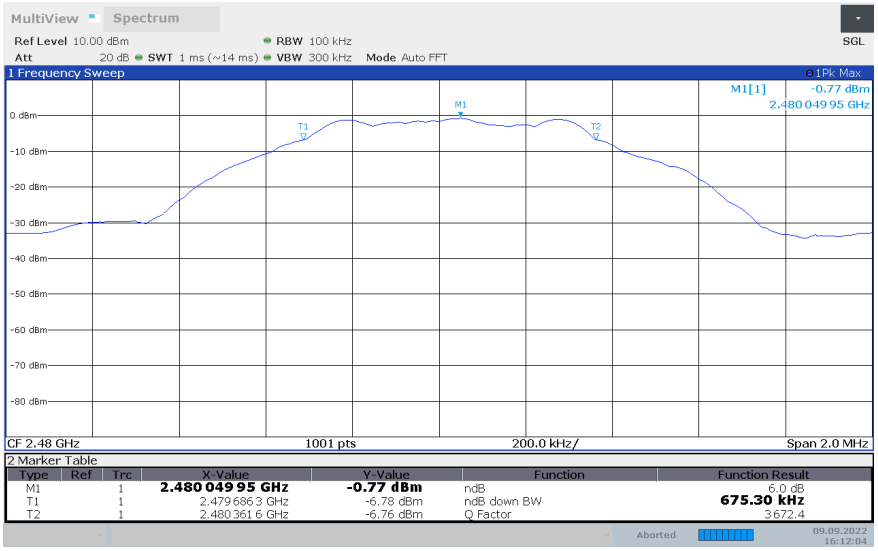

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Figure 26. **IDB012V1 - 6 dB bandwidth 2402 MHz**

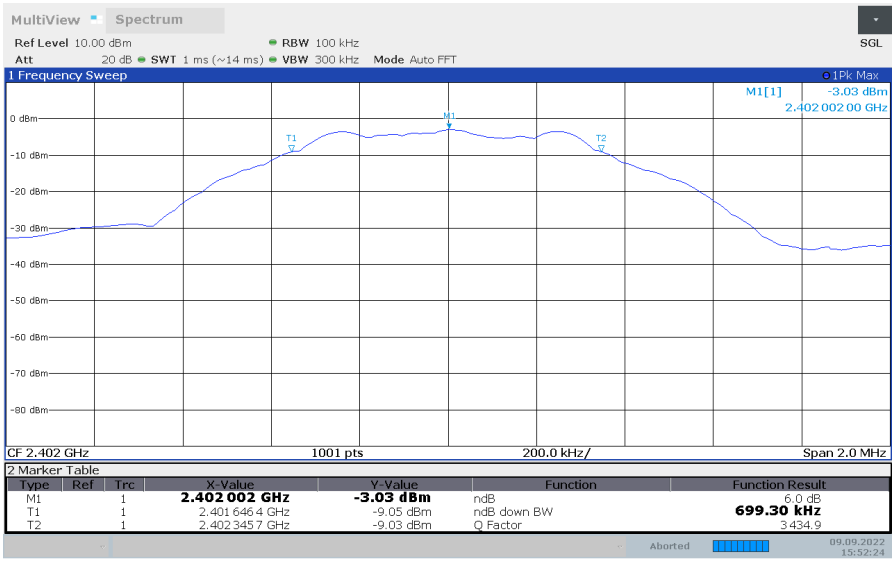

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Figure 27. **IDB012V1 - 6 dB bandwidth 2440 MHz**

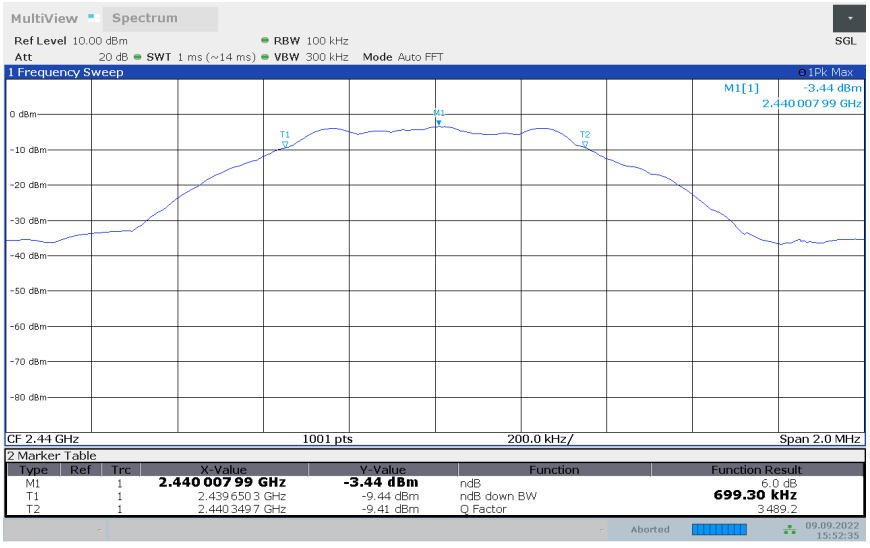

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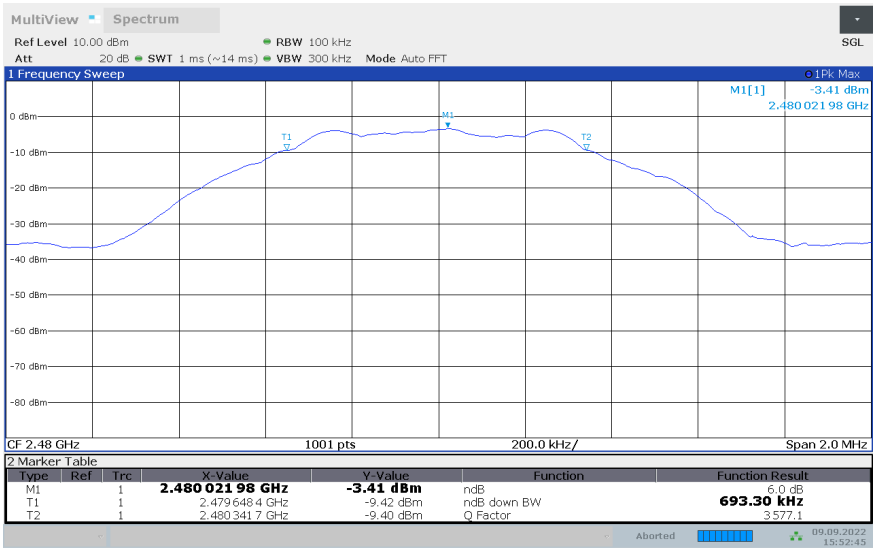
Figure 28. **IDB012V1 - 6 dB bandwidth 2480 MHz**



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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

The BlueNRG-LP/LPS performance meets ARIB requirements also as regards receiver spurious emissions.

Figure 29. IDB011V2 - Rx (2402 MHz) spurious emission full span

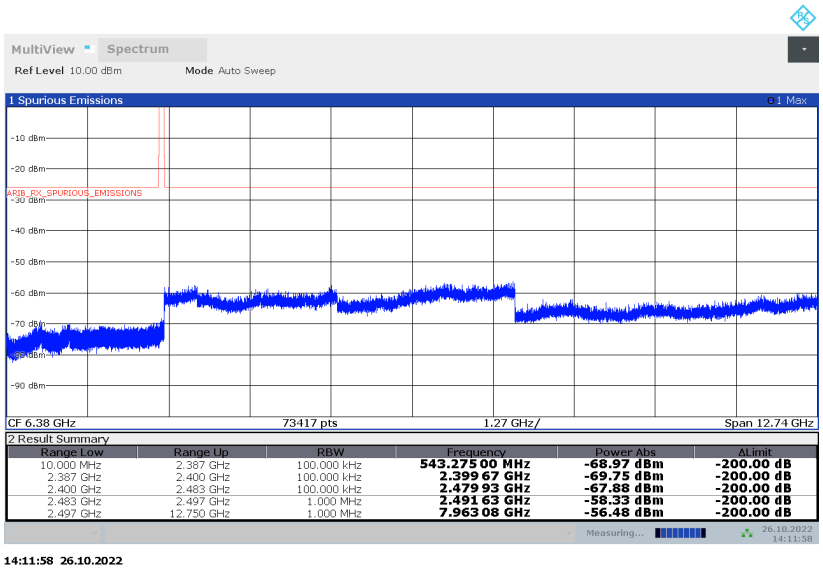

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Figure 30. IDB011V2 - Rx (2402 MHz) spurious emission in the 10 MHz to 2387 MHz band

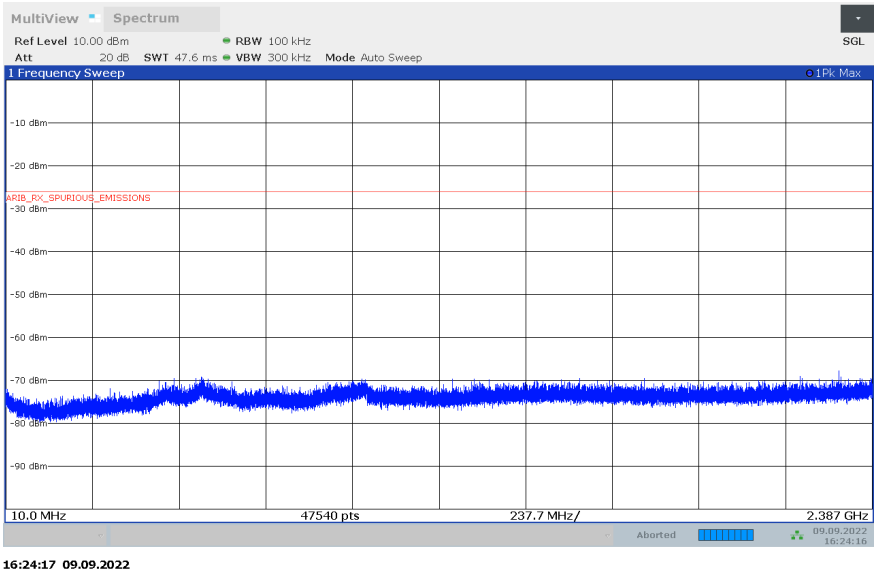

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Figure 31. IDB011V2 - Rx (2402 MHz) spurious emission in the 2387 MHz to 2400 MHz band

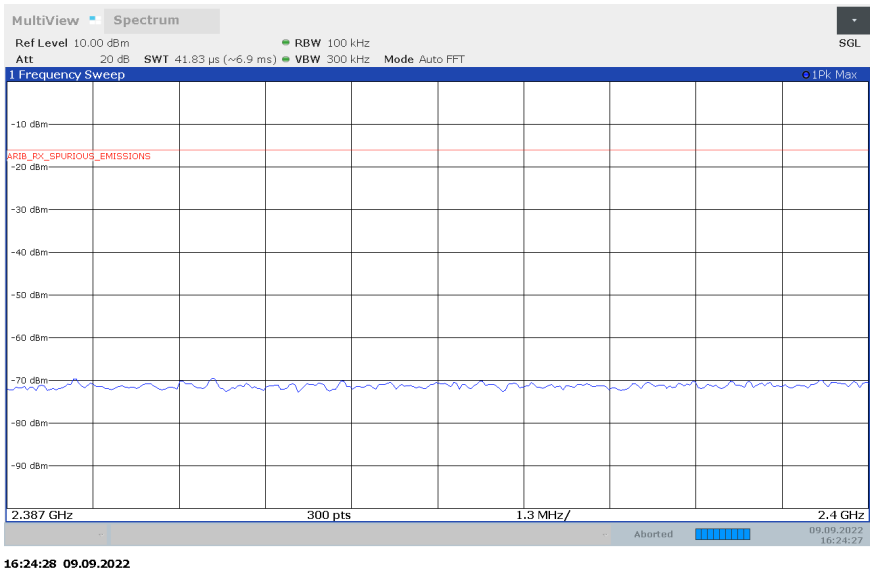

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Figure 32. IDB011V2 - Rx (2402 MHz) spurious emission in the 2483.5 MHz to 2496.5 MHz band

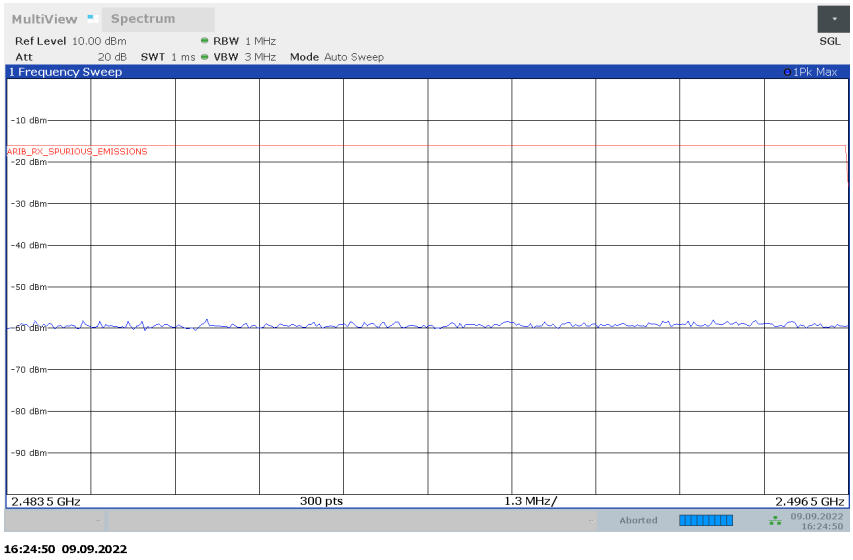

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Figure 33. **IDB011V2 - Rx (2402 MHz) spurious emission in the 2496.5 MHz to 13.6 GHz band**

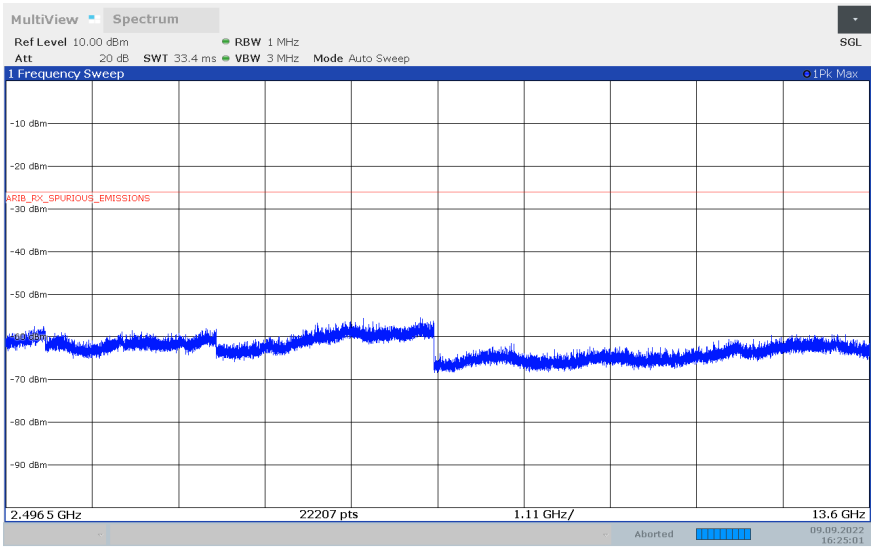

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Figure 34. **'IDB011V2 - Rx (2480 MHz) spurious emission full span**

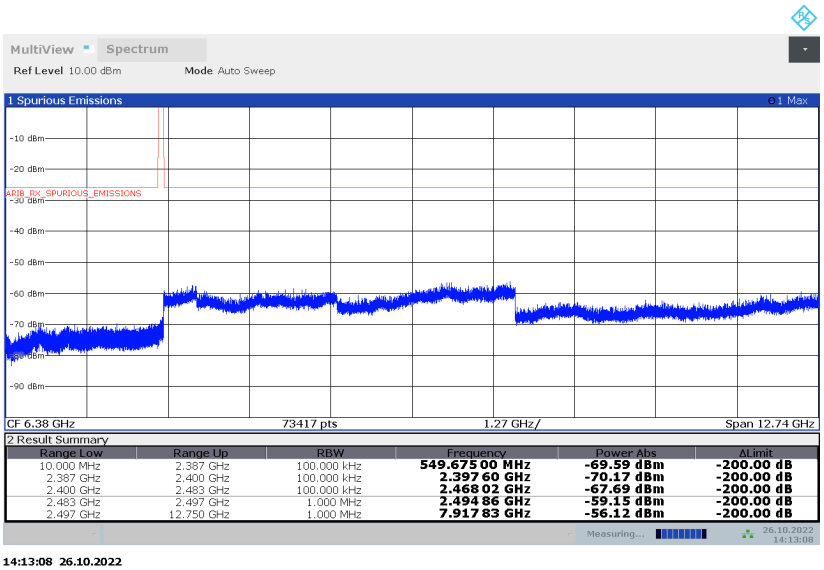

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Figure 35. IDB011V2 - Rx (2480 MHz) spurious emission in the 10 MHz to 2387 MHz band

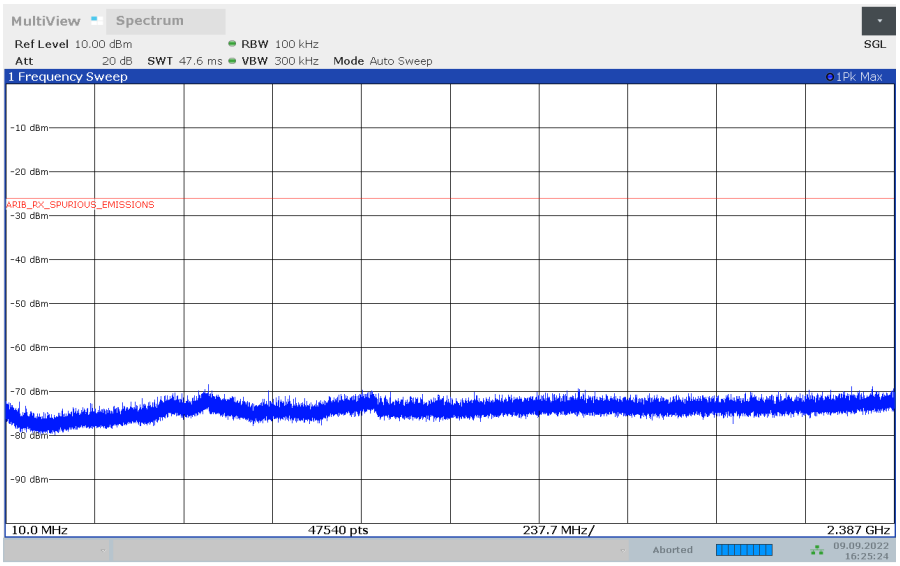

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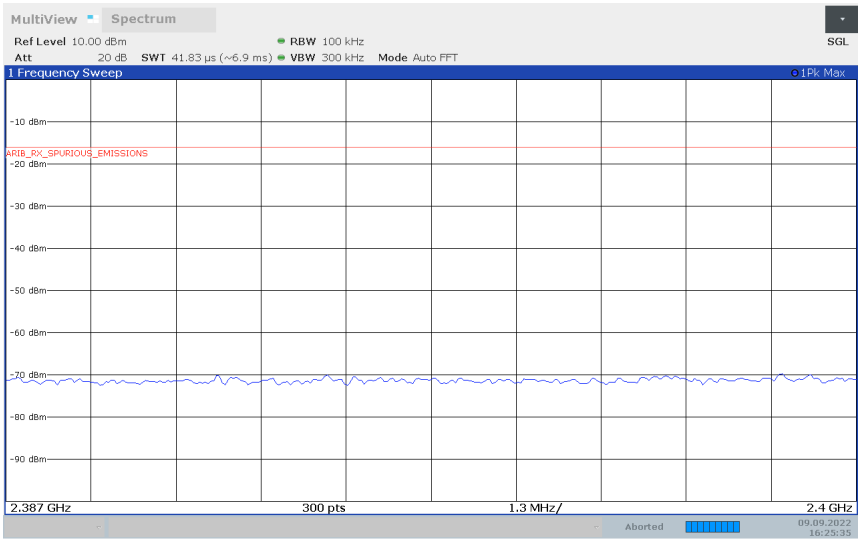
Figure 36. IDB011V2 - Rx (2480 MHz) spurious emission in the 2387 MHz to 2400 MHz band



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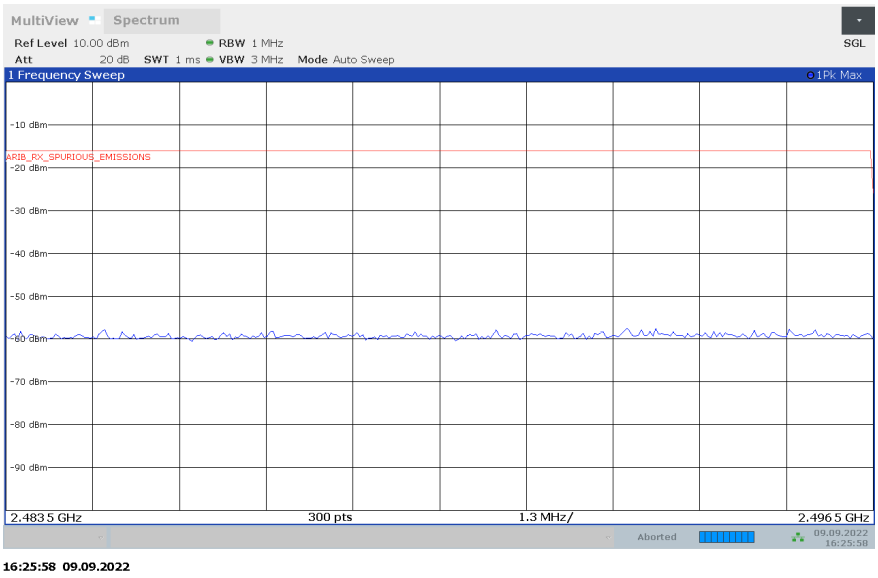
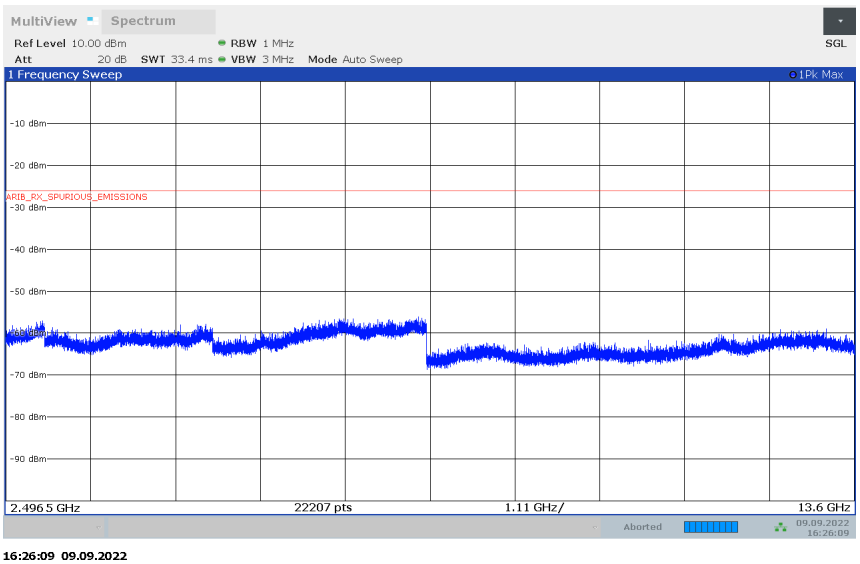
DT57242V1

Figure 37. IDB011V2 - Rx (2480 MHz) spurious emission in the 2483.5 MHz to 2496.5 MHz band



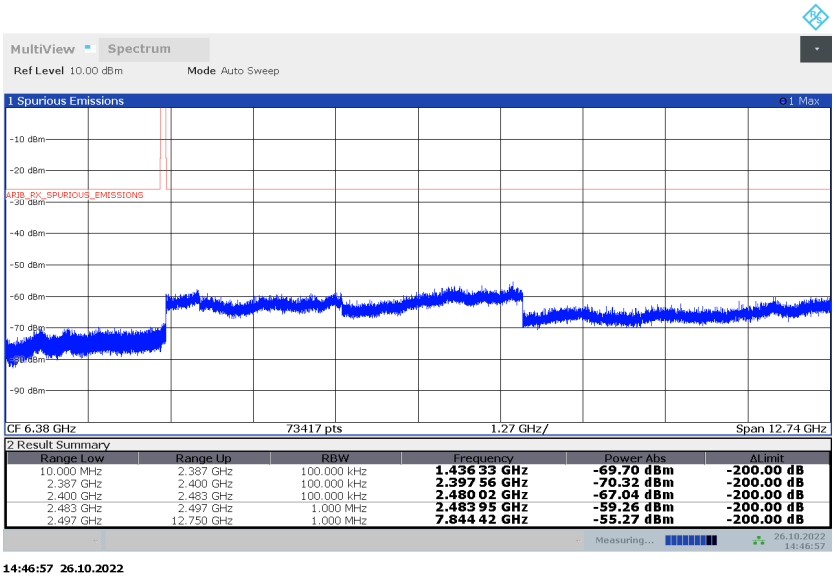
DT57243V1

Figure 38. IDB011V2 - Rx (2480 MHz) spurious emission in the 2496.5 MHz to 13.6 GHz band



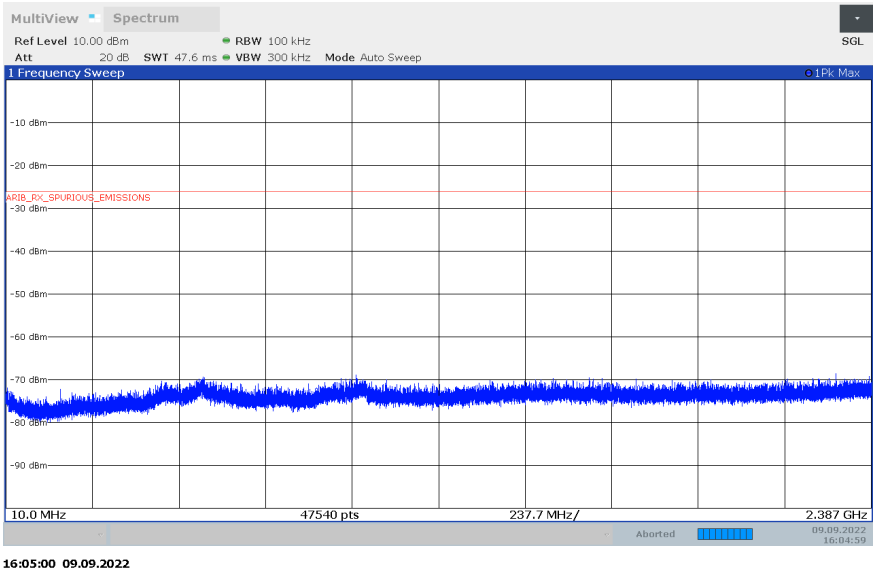
DT57244V1

Figure 39. 'IDB012V1 - Rx (2402 MHz) spurious emission full span



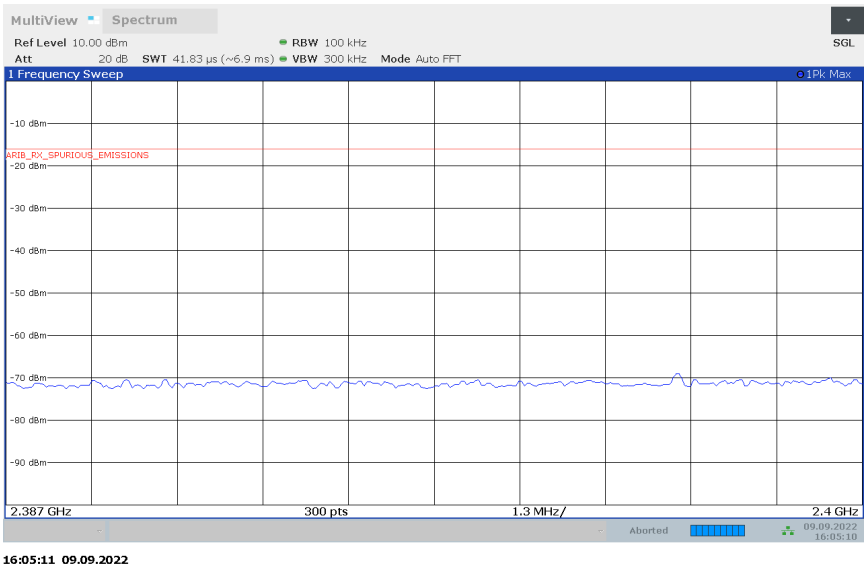
DT57245V1

Figure 40. IDB012V1 - Rx (2402 MHz) spurious emission in the 10 MHz to 2387 MHz band



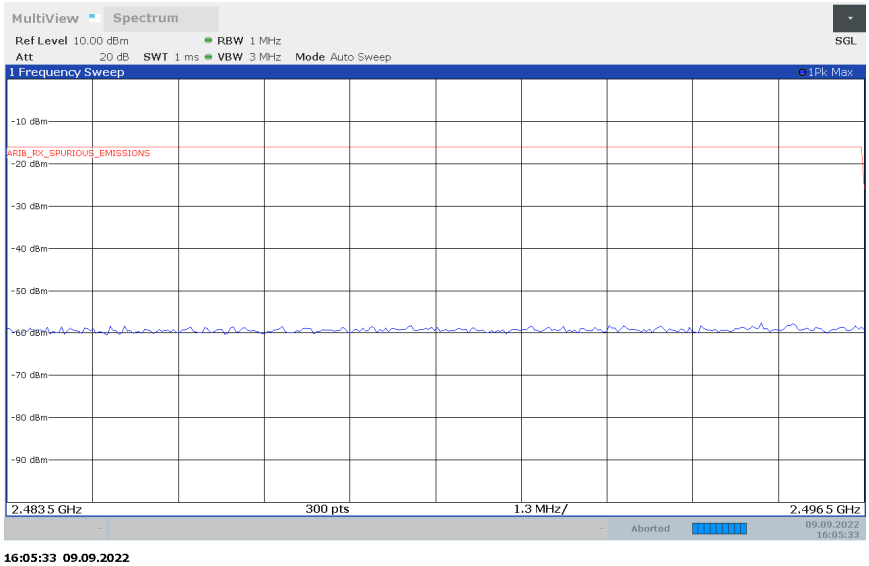
DT57246V1

Figure 41. IDB012V1 - Rx (2402 MHz) spurious emission in the 2387 MHz to 2400 MHz band



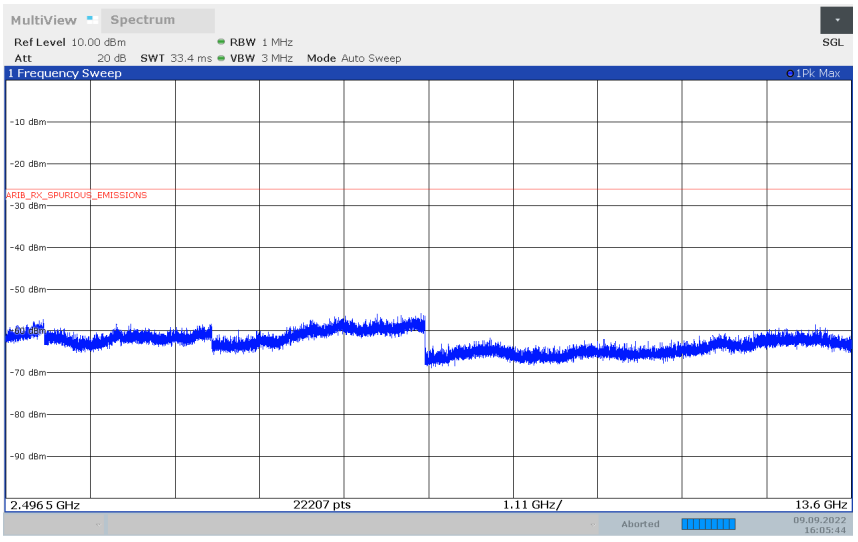
DT57247V1

Figure 42. IDB012V1 - Rx (2402 MHz) spurious emission in the 2483.5 MHz to 2496.5 MHz band



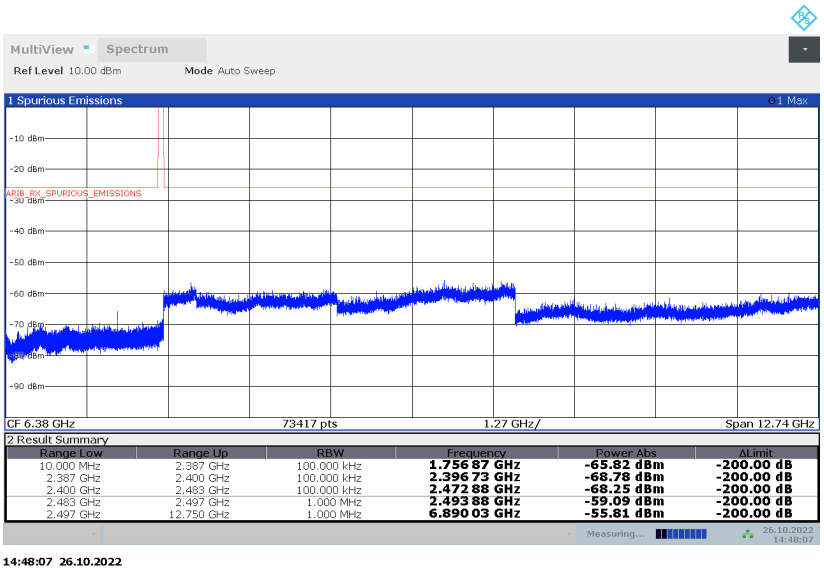
DT57248V1

Figure 43. **IDB012V1 - Rx (2402 MHz) spurious emission in the 2496.5 MHz to 13.6 GHz band**



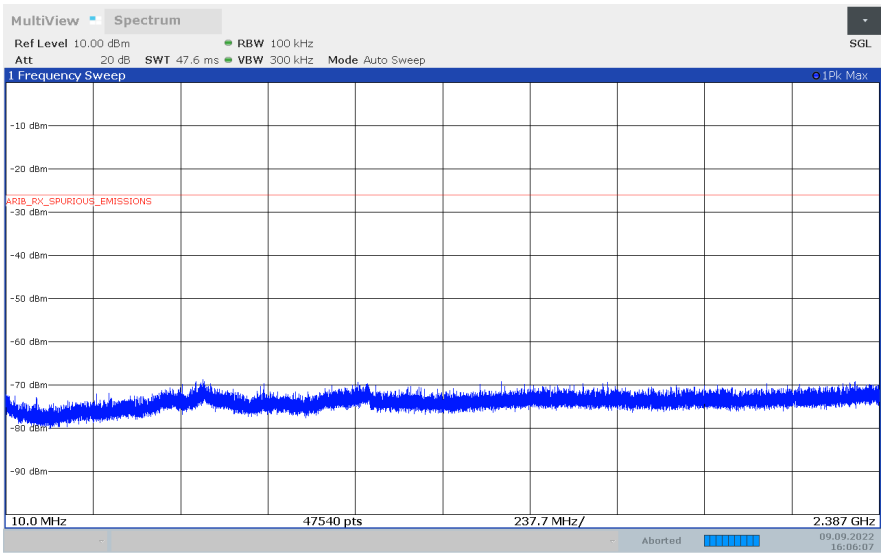
DT57249V1

Figure 44. **IDB012V1 - Rx (2480 MHz) spurious emission full span**



DT57250V1

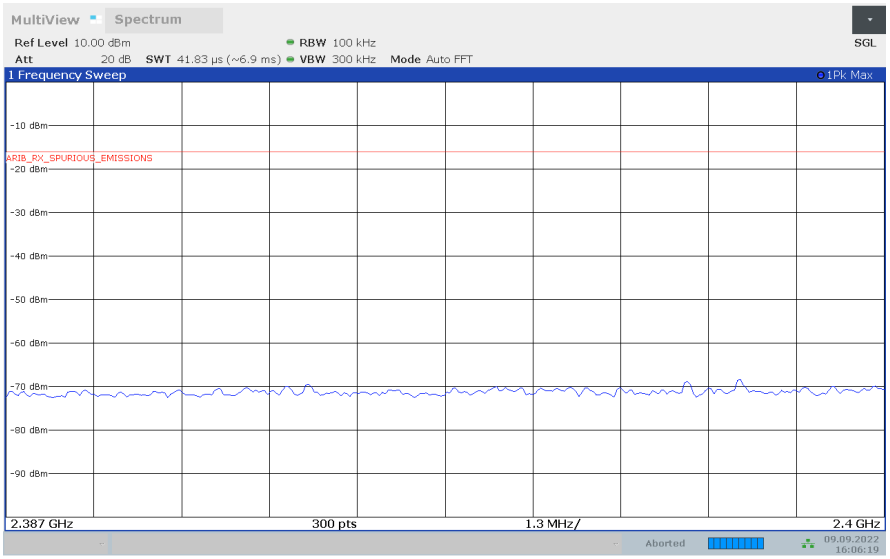
Figure 45. IDB012V1 - Rx (2480 MHz) spurious emission in the 10 MHz to 2387 MHz band



16:06:08 09.09.2022

DT57251V1

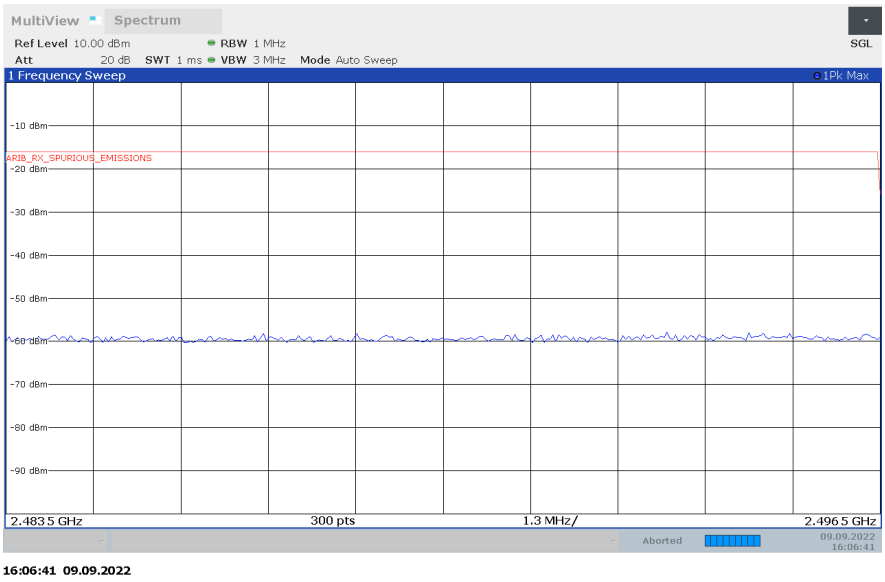
Figure 46. IDB012V1 - Rx (2480 MHz) spurious emission in the 2387 MHz to 2400 MHz band



16:06:19 09.09.2022

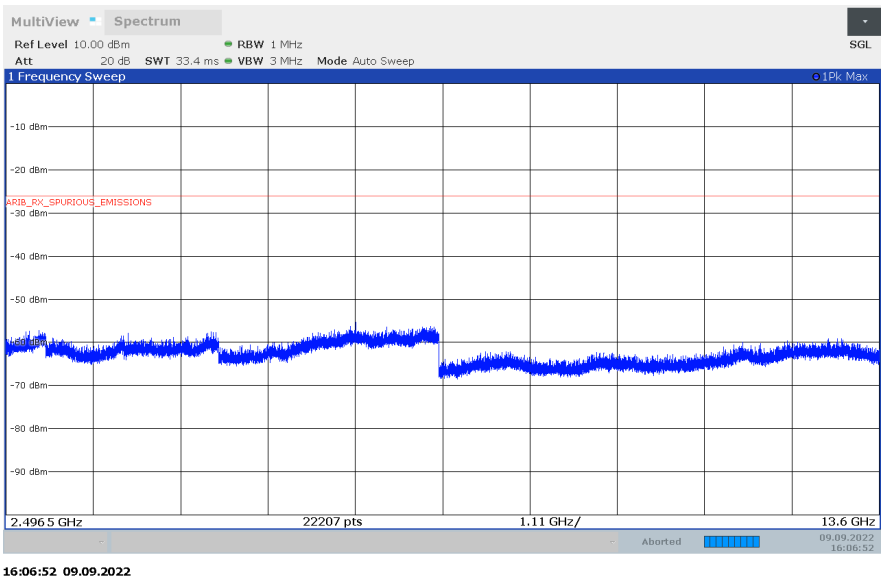
DT57252V1

Figure 47. **IDB012V1 - Rx (2480 MHz) spurious emission in the 2483.5 MHz to 2496.5 MHz band**



DT57253V1

Figure 48. **IDB012V1 - Rx (2480 MHz) spurious emission in the 2496.5 MHz to 13.6 GHz band**



DT57254V1

6 Reference

Table 5. **Document reference**

Reference	Document
[1]	BlueNRG-LP/LPS datasheet
[2]	ARIB STD-T66 V3.7
[3]	Bluetooth® core specification
[4]	“Radio Equipment Regulations”, Article 4.17.49.20
[5]	www.arib.or.jp/english/std_tr/telecommunications/rt_ej.html

Revision history

Table 6. **Document revision history**

Date	Version	Changes
02-Nov-2020	1	Initial release.
08-Dec-2022	2	Added: • BlueNRG-LPS • Table 4. IDB012V1 - Maximum output power Updated: • Section Introduction, Section 3 Application circuit, Section 6 Reference • from Figure 3 to Figure 22, from Figure 23 to Figure 28, from Figure 29 to Figure 48

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