AN14374

FRDM-MCXW71 RF System Evaluation Report for Bluetooth LE and IEEE 802.15.4 Applications

Rev. 1.0 — 16 September 2024 Application note

Document information

Information	Content
Keywords	AN14374, FRDM-MCXW71, RF System Evaluation Report, Bluetooth LE, IEEE 802.15.4 applications
Abstract	This document provides the radio frequency evaluation test results of the FRDM-MCXW71 board for Bluetooth LE (2FSK modulation) and for IEEE 802.15.4 (OQPSK modulation) applications

1 Introduction

This document provides the radio frequency (RF) evaluation test results of the FRDM-MCXW71 board for Bluetooth LE (2FSK modulation) and for IEEE 802.15.4 (OQPSK modulation) applications. It also describes the test setup and the tools that can be used to perform the tests. Figure 1 and Figure 2 show the block diagram and top view of the FRDM-MCXW71 board.

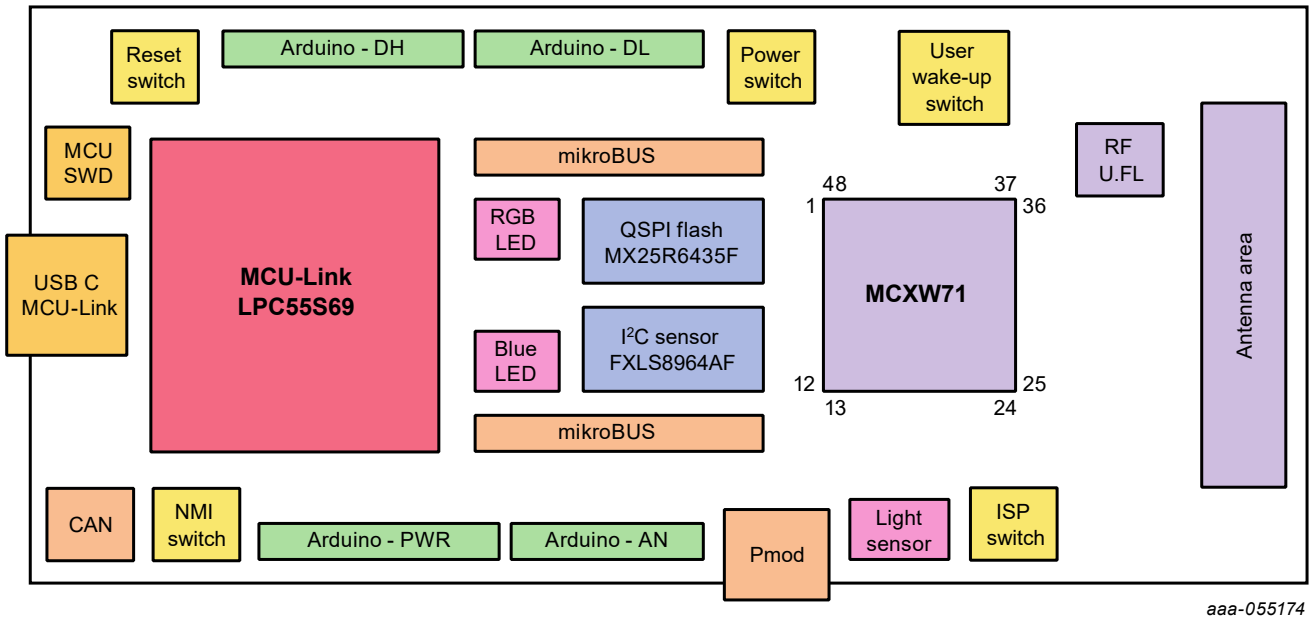

Figure 1. FRDM-MCXW71 block diagram

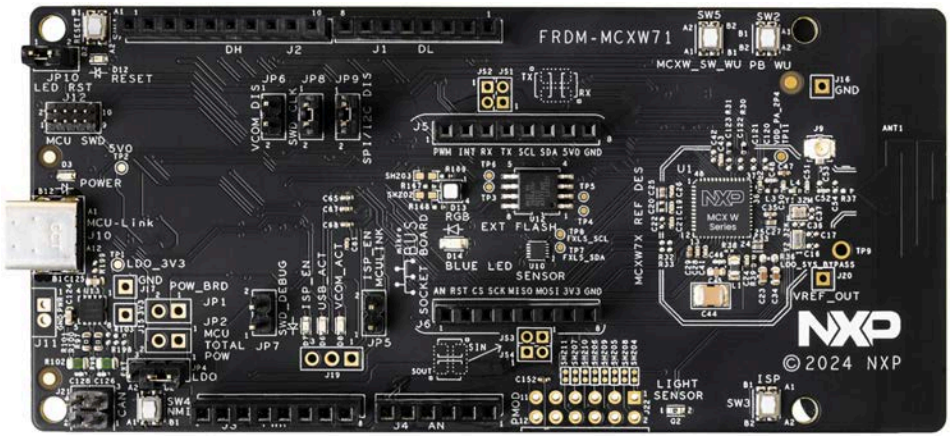

Figure 2. FRDM-MCXW71 board top view

2 Prerequisites

To perform the measurements described in this document, a binary code (Connectivity Software package) must be loaded in the flash memory of the board.

2.1 Software

The document *AN14399, MCXW71 Connectivity Test for 802.15.4 Application* available on the FRDM-MCXW71 webpage describes how to use FRDM-MCXW71 to load the code for the Bluetooth LE or IEEE 802.15.4. The binary code used for the following tests are the following:

- The Connectivity Software package for both Bluetooth LE and IEEE 802.15.4 (refer to the *Connectivity Test Tool User Guide* and *IEEE 802.15.4* document for the explanation of the settings)
- Use the `HCI_blackbox` for Bluetooth LE only. Use the Teraterm terminal emulator to communicate with the MCX W71 MCU.

2.2 List of equipment for Bluetooth Low Energy (BLE) measurements

The below listed equipment products are used to perform the Rx and Tx measurements.

1. Spectrum Analyzer - 25 GHz for harmonic measurements up to H10
2. R&S SFU is used as an interferer source. However, any generator with ARB can be used
3. R&S SMBV100B
4. R&S CMW270 (HCI_blackbox software)
5. Agilent 33250A
6. R&S ZND Vector Network Analyzer – *for S11 measurements*
7. RF Shielded box *(to avoid interferers)*
8. PC equipped with a GPIB interface

List of equipment for IEEE 802.15.4 measurements

1. R&S FSV is used as spectrum analyzer with 802.15.4 PHY test option.
2. Keysight N5182B is used for the test. However, any generator with ARB can be used.
3. Keysight E8267D is used as an interferer source for 802.15.4. However, any generator with ARB can be used.
4. Spectrum Analyzer-25GHz is used for harmonic measurements up to H10.
5. R&S ZND Vector Network Analyzer is used for S11 measurements.
6. Shielded room.

Note: *The FRDM-MCXW71 board LI24180019 was used to perform all Bluetooth RF test measurements.*

Note: *The MCX W71-EVK (former generation) VV21290023 was used to perform all IEEE 802.15.4 RF test measurements.*

3 Bluetooth LE application

3.1 List of tests

Conducted tests

- **TX tests**
  - Frequency accuracy
  - Phase noise
  - TX power Bluetooth LE 1 Msps[1], 2 Msps, 500 Ksps[2] (LR S=2), 125 Ksps (LR S=8)
  - TX power In Band
  - TX spurious (H2 to H10, ETSI and FCC)
  - Lower Band edge (MIIT-China)
  - Upper band edge
  - Maximum TX output power 1 Msps, 2 Msps, 500 Ksps (LR S=2), 125 Ksps (LR S=8)
  - Bluetooth LE TX output spectrum 1 Msps, 2 Msps
  - Modulation characteristics 1 Msps, 2 Msps, 125 Ksps LR (S=8)
  - Carrier frequency offset and drift 1 Msps, 2 Msps, 125 Ksps LR (S=8)
- **RX tests**
  - Sensitivity 1 Msps, 2 Msps, LR (S=2 and S=8)
  - Bathtub 1 Msps, 2 Msps, LR (S=2 and S=8)
  - Receiver maximum input level 1 Msps, 2 Msps, LR (S=2 and S=8)
  - RX spurious (from 30 MHz to 12.5 GHz)
  - Receiver interference rejection performances
    - Adjacent, Alternate and Co-channel rejection – 1 Msps, 2 Msps, 500 Ksps (LR S=2), 125 Ksps (LR S=8)
    - Receiver blocking – 1 Msps – category 1 and category 2
    - Blocking interferers

1 (Mega symbols per second)
2 (Kilo symbols per second)

3.2 Summary of tests

RF PHY Bluetooth Test Specification: RF-PHY.TS.5.0.2 (2017-12-07)

The list of measurements is given in

1. Table 1 for Europe
2. Table 3 for the US
3. Table 4 for China
4. Table 5 for Japan

Table 1. Transmission tests for Europe

Transmission tests	Reference	Limits	Status
TX Maximum Output Power	BLE 5.0, BV-01-C	-20 dBm ≤ PAVG ≤ +10 dBm EIRP	Pass
TX power In Band – 1 Msps	BLE 5.0, BV-03-C	PTX <= -20 dBm for (fTX +/- 2 MHz)	Pass
		PTX <= -30 dBm for (fTX +/- [3 + n] MHz]);	
TX power In Band – 2 Msps	BLE 5.0, BV-08-C	PTX <= -20 dBm for (fTX +/- 4 MHz) and (fTX +/- 5 MHz)	Pass
		PTX <= -30 dBm for (fTX +/- [3 + n] MHz]);	
Modulation characteristics	BLE 5.0, BV-05-C	225 kHz <= delta f1avg <= 275 kHz	Pass
1 Msps	BLE 5.0, BV-13-C		
LE coded (S=8)			
Modulation characteristics 2 Msps	BLE 5.0, BV-10-C	450 kHz <= delta f1avg <= 550 kHz	Pass
Carrier frequency offset and drift	BLE 5.0, BV-06-C	fTX – 150 kHz <= fn <= fTX + 150 kHz	Pass
		where fTX is the nominal transmit frequency and n=0,1,2,3…k	
1 Msps		|f0 – fn| <= 50 kHz, where n=2,3,4…k	
2 Msps	BLE 5.0, BV-12-C	|f0 – f3| <= 19.2 kHz	
		|f0 – f(n-3)| <= 19.2 kHz, where n=7,8,9,…k	
Carrier frequency offset and drift LE coded (S=8)	BLE 5.0, BV-14-C	fTX – 150 kHz <= fn <= fTX + 150 kHz	Pass
		where fTX is the nominal transmit frequency and n=0,1,2,3…k	
		|f0 – fn| <= 50 kHz	
		where n=2,3,4…k	
Spurious 30 MHz - 1 GHz	ETSI EN 300 328 v2.2.2	-36 dBm or -54 dBm (depends on frequency)	Pass
		(100 KHz BW)	
Spurious 1 GHz - 25 GHz	ETSI EN 300 328	-30 dBm (1 MHz BW)	Pass
	v2.2.2		
Eirp Tx spectral density	ETSI EN 300 328	10 dBm/MHz	Pass
	v2.2.2		
Phase noise (unspread)	NA	NA	For information

Table 2. Reception Tests for Europe

Reception Tests	Reference	Limits	Result
RX Sensitivity - 1 Msps	BLE 5.0, BV-01-C	PER 30.8% with a minimum of 1500 packets	Pass
RX Sensitivity - 2Msps	BLE 5.0, BV-08-C	PER 30.8% with a minimum of 1500 packets	Pass
RX Sensitivity - LE coded (S=2)	BLE 5.0, BV-26-C	PER 30.8% with a minimum of 1500 packets	Pass
RX Sensitivity - LE coded (S=8)	BLE 5.0, BV-27-C	PER 30.8% with a minimum of 1500 packets	Pass
Co-channel - 1Msps	BLE 5.0, BV-03-C	> 21 dB	Pass
Adjacent channel interference rejection (N+/-1, 2, 3+ MHz) 1 Msps	BLE 5.0, BV-03-C	> 15 dB, -17 dB, -27 dB	Pass
Co-channel - 2 Msps	BLE 5.0, BV-09-C	> 21 dB	Pass
Adjacent channel interference rejection (N+/-2, 4, 6+ MHz) - 2 Msps	BLE 5.0, BV-09-C	> 15 dB, -17 dB, -27 dB	Pass
Co-channel - LE coded (S=2)	BLE 5.0, BV-28-C	> 17 dB	Pass
Adjacent channel interference rejection (N+/-2, 4, 6+ MHz) LE coded (S=2)	BLE 5.0, BV-09-C	> 11 dB, -21 dB, -31 dB	Pass
Co-channel - LE coded (S=8)	BLE 5.0, BV-28-C	> 12 dB	Pass
Adjacent channel interference rejection (N+/-2, 4, 6+ MHz) LE coded (S=8)	BLE 5.0, BV-09-C	> 6 dB, -26 dB, -36 dB	Pass
Blocking Interferers	BLE 5.0, BV-04-C	-30 dBm (30 MHz-2 GHz and 3-12.5 GHz)	Pass
Receiver Blocking 2 Msps	ETSI v2.2.2	-43 dBm / - 53 dBm	
Receiver Blocking 1 Msps	ETSI v2.2.2	-43 dBm / - 53 dBm	
Receiver Blocking 500 Ksps	ETSI v2.2.2	-43 dBm / - 53 dBm	
Receiver Blocking 125 Ksps	ETSI v2.2.2	-43 dBm / - 53 dBm	
1 Msps	BLE 5.0, BV-010-C	-35 dBm (2003-2399 MHz and 2484-2997 MHz)	
2 Msps			
Rx Maximum input level	BLE 5.0, BV-06-C	PER 30.8% with a minimum of 1500 packets	Pass
1 Msps	BLE 5.0, BV-12-C		
2 Msps			
RX emissions 30 MHz - 1 GHz	ETSI EN 300 328	-57 dBm (100 KHz)	Pass
	v2.2.2		
RX emissions 1 GHz - 12.5 GHz	ETSI EN 300 328	-47 dBm (1MHz)	Pass

Miscellaneous tests

Return loss (S11)	Return loss in Tx mode	For information
	Return loss in Rx mode	For information

Test list for US

Table 3. Transmission test for US

Transmission test type	*Reference*	*Limit*	*Status*
TX maximum power	FCC part15.247	PAVG ≤ 100 mW +20 dBm EIRP	Pass
Spurious 1 GHz - 25 GHz	FCC part15.249	field strength < 50 mV/m @3m -41.12 dBm (1 MHz BW)	Pass

Test list for China

Table 4. Transmission test for China

Transmission test type	Reference	Limit	Status
Tx Lower Band Edge	MIIT Standard Specification	• -40 dBm for 2300 - 2390 MHz • -30 dBm for 2390-2400 MHz	Pass
Tx Upper Band Edge	MIIT Standard Specification	-40 dBm for 2483.5 - 2500 MHz	Pass

Test list for Japan

Table 5. Transmission test for Japan

Transmission test type	Reference	Limit	Status
Tx Out Of Band	ARIB STD T-66	-16 dBm under 2400 MHz and above 2483.5 MHz	Pass

3.3 Conducted tests

This section describes the results for the tests conducted for Bluetooth Low Energy. These include transmission tests, receiver tests, and their sub-cateogries.

3.3.1 Transmitter (Tx) tests

3.3.1.1 Test setup

Figure 3. Test setup for Tx tests

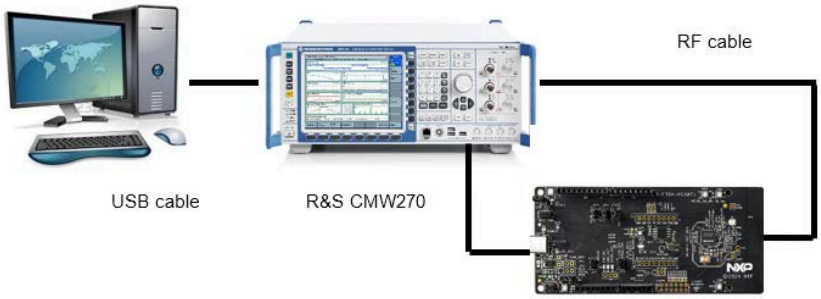

Figure 4. Specific Conducted Tx test Setup

3.3.1.2 Frequency accuracy

3.3.1.2.1 Test method

Use the following steps:

1. Set the radio to:
   - TX mode, Continuous Wave (CW), continuous mode, frequency: channel 19
2. Set the analyzer to:
   - Center frequency = 2.44 GHz, span = 1 MHz, Ref amp = 20 dBm, RBW = 10 kHz, VBW = 100 kHz
3. Measure the CW frequency with the marker of the spectrum analyzer

3.3.1.2.2 Result

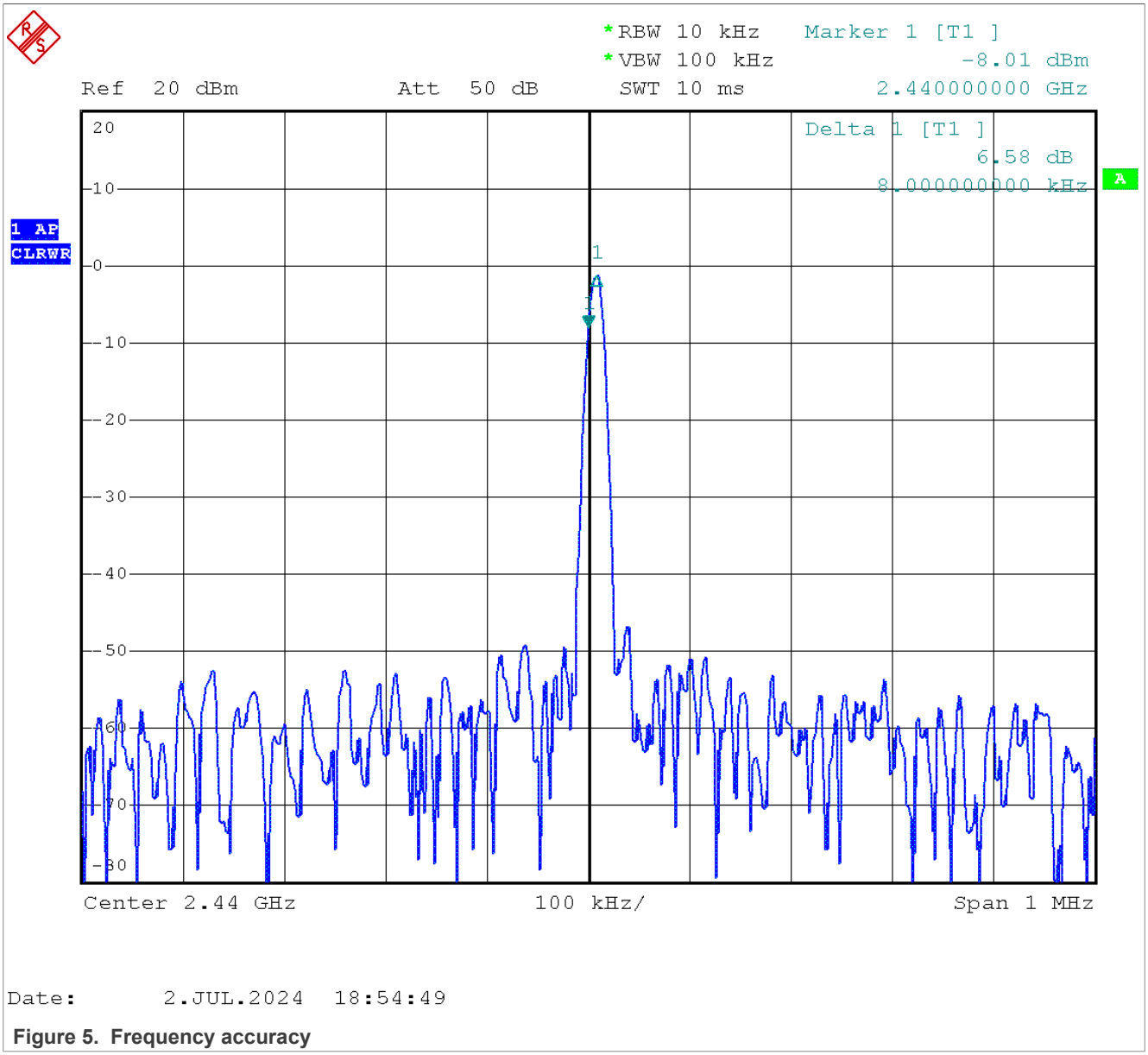

Figure 5. Frequency accuracy

- Measured frequency: 2.440008 GHz

- ppm value = (2.440008-2.44) / 2.44 = 3.3 ppm

Table 6. Frequency accuracy result

Frequency accuracy	
Result	**Target**
3.3 ppm	+/-25 ppm

The frequency accuracy depends on the XTAL model. The model used on board is NX1612SA 32MHZ EXS00A CS14160.

Conclusion:

- The frequency accuracy complies to the datasheet..

3.3.1.3 Phase noise

3.3.1.3.1 Test method

1. Set the radio to:
   - TX mode, CW, continuous mode, frequency: BLE Channel 17 (2.440 GHz)
2. Set the analyzer to:
   - Center frequency = 2.44 GHz, span = 1 MHz, Ref amp = 20 dBm, RBW = 10 kHz, VBW = 100 kHz
3. Measure the phase noise at the 100-kHz offset frequency
4. RBW (spectrum analyzer) = 10 KHz (20log(10KHz) = 40 dBc)

3.3.1.3.2 Result

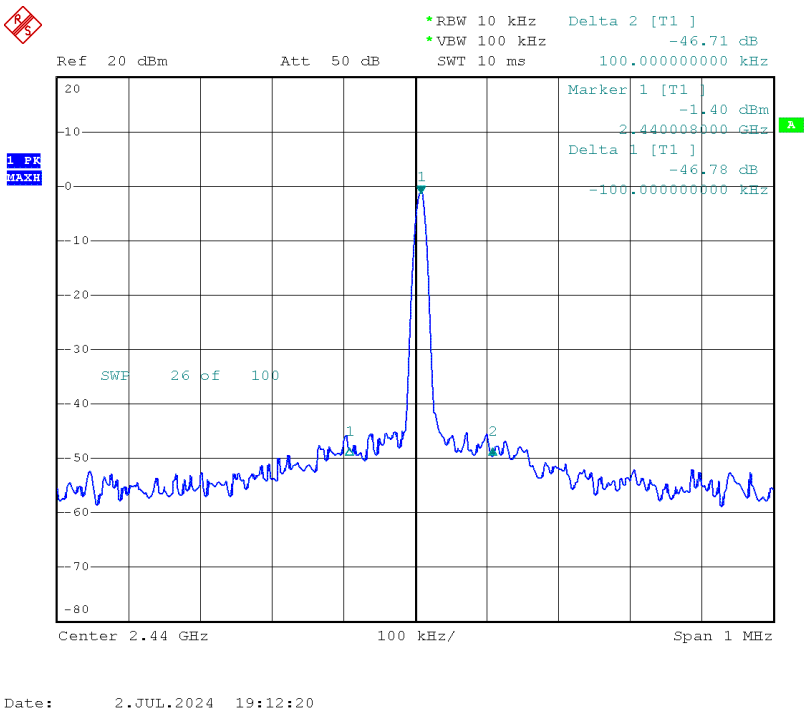

Figure 6. Conducted phase noise

- Marker value (delta) = -46.78 dBm / 100 kHz = -96.78 dBc/Hz

The phase noise is just for informational purposes. No specific issue on this parameter.

3.3.1.4 Tx power (fundamental)

3.3.1.4.1 Test method

Follow the steps listed below:

1. Set the radio to:
   - TX mode, modulated, continuous mode, data rate (1 Msps, 2 Msps, 500 Ksps, 125 Ksps for Bluetooth LE)
2. Set the analyzer to:
   - Start frequency = 2.392 GHz, Stop frequency = 2.49 GHz, Ref amp = 10 dBm, sweep time = 100 ms, RBW = 3 MHz, VBW = 3 MHz

- Max Hold mode
- Detector = RMS
- Sweep all the 40 BLE channels starting from Channel 37 (2.402 GHz) to Channel 39 (2.480 GHz).
  - The Connectivity Test Software tool allows sweep from GenFSK Channel 0 (2.36 0 GHz) to GenFSK Channel 127 (2.488 GHz).

3.3.1.4.2 Result

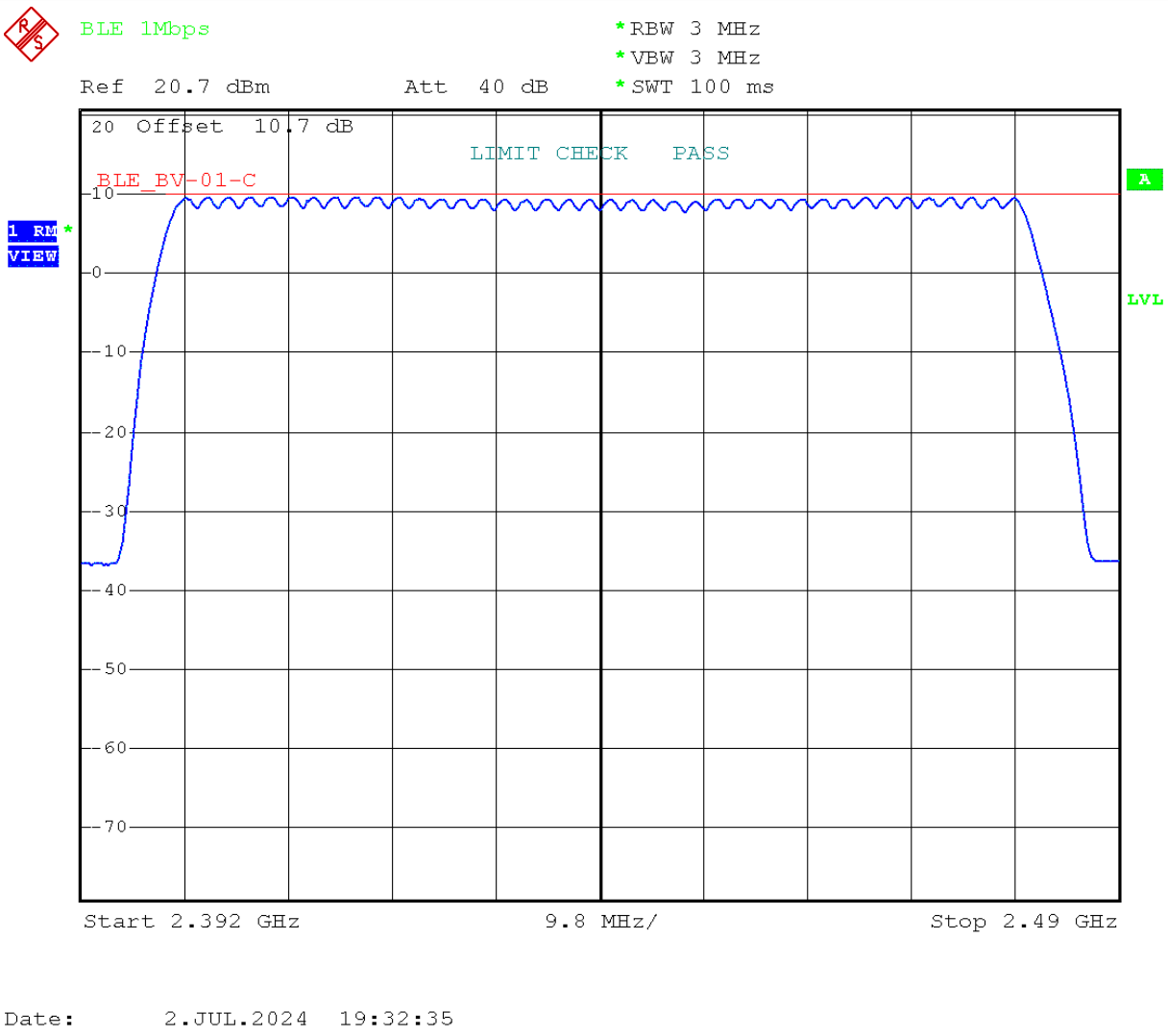

Figure 7. TX power

- Maximum power is on channel 22: 9.12 dBm
- Minimum power is on channel 4: 9.65 dBm
- Tilt over frequencies is: 0.53 dB

Conclusion:

- The default TX power is in line with the expected results.
- TX Power is flat over frequencies.

3.3.1.5 Tx power in Band

Follow the below test method:

1. Set the radio to:
   - TX mode, modulated, continuous mode, data rate (1 Msps, 2 Msps, 500 Ksps, 125 Ksps)
2. Set the analyzer to:
   - Start frequency= 2.35 GHz, Stop frequency= 2.5 GHz, Ref amp = 10 dBm, sweep time = 100 ms,
   - RBW = 100 KHz, Video BW = 300 KHz
   - Max Hold mode
   - Detector = RMS
   - Number of Sweeps = 10
3. Sweep on BLE Channel 37, Channel 19, and Channel 39

3.3.1.5.1 Result

This section provides the result for TX Power In Band – Channel 37 (2.402 GHz), BLE Channel 17 (2.440 GHz), and BLE Channel 39 (2.480 GHz).

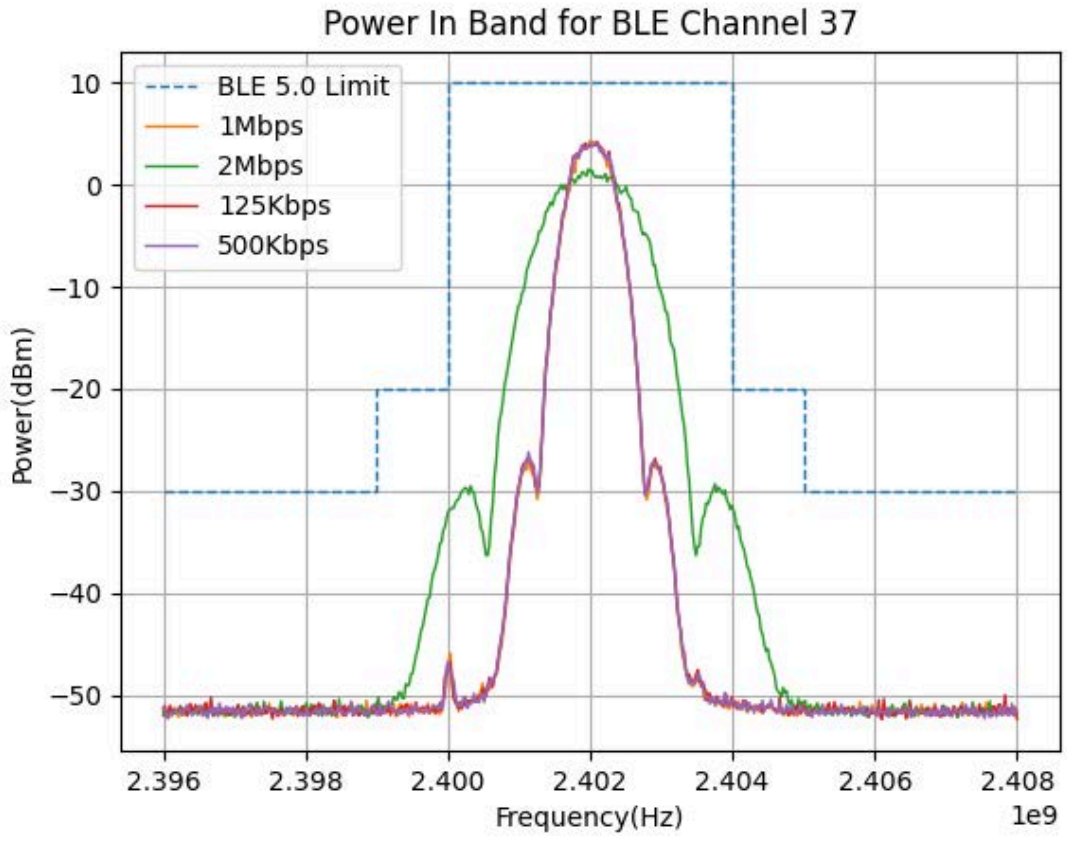

Figure 8. TX Power In Band – BLE Channel 37 (2.402 GHz)

3.3.1.5.1.1 TX Power In Band – BLE Channel 37 (2.402 GHz)

Table 7. Results Power in Band 1 Msps for BLE Channel 37 (2.402 GHz)

Parameter	Parameter Value	Unit		Condition	Unit
Max peak level <=-2 MHz	-49.63	dBm	@	2.400	GHz
Max peak level >=+2 MHz	-48.99	dBm	@	2.404	GHz
Max peak level <=-3 MHz	-48.81	dBm	@	2.399	GHz
Max peak level >=+3 MHz	-49.63	dBm	@	2.405	GHz

Table 8. Results Power in Band 2 Msps for BLE Channel 37 (2.402 GHz)

Parameter	Parameter Value	Unit		Condition	Unit
Max peak level <=-2 MHz	-33.04	dBm	@	2.400	GHz
Max peak level >=+2 MHz	-33.51	dBm	@	2.404	GHz
Max peak level <=-3 MHz	-49.13	dBm	@	2.399	GHz
Max peak level >=+3 MHz	-49.55	dBm	@	2.405	GHz

Table 9. Results Power in Band 500 Ksps for BLE Channel 37 (2.402 GHz)

Parameter	Parameter Value	Unit		Condition	Unit
Max peak level <=-2 MHz	-49.54	dBm	@	2.404	GHz
Max peak level >=+2 MHz	-49.18	dBm	@	2.408	GHz
Max peak level <=-3 MHz	-49.39	dBm	@	2.403	GHz
Max peak level >=+3 MHz	-49.6	dBm	@	2.411	GHz

Table 10. Results Power in Band 125 Ksps for BLE Channel 17 (2.440 GHz)

Parameter	Parameter Value	Unit		Condition	Unit
Max peak level <=-2 MHz	-49.69	dBm	@	2.400	GHz
Max peak level >=+2 MHz	-48.65	dBm	@	2.404	GHz
Max peak level <=-3 MHz	-48.36	dBm	@	2.399	GHz
Max peak level >=+3 MHz	-49.43	dBm	@	2.405	GHz

3.3.1.5.1.2 Results Power in Band BLE Channel 17

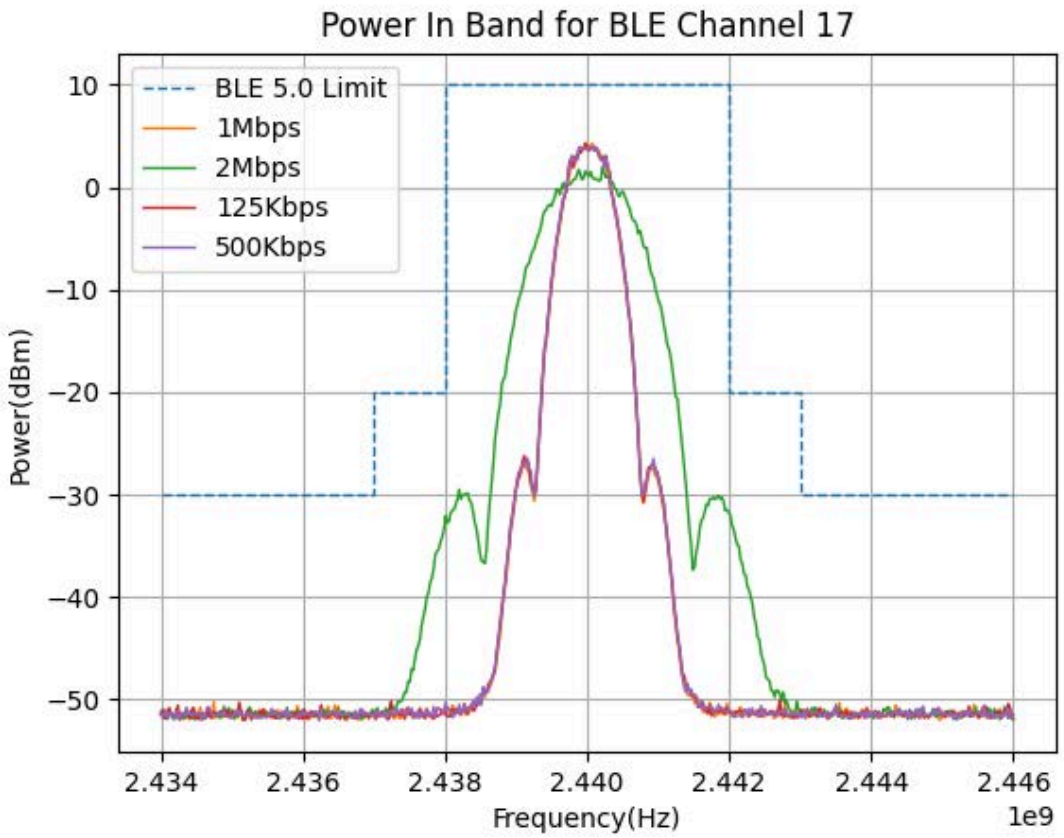

Figure 9. TX power In Band – BLE Channel 17 (2.440 GHz)

Results for Power in Band BLE Channel 17 (2.440 GHz)

Table 11. Results Power in Band 1 Msps for BLE Channel 17 (2.440 GHz)

Parameter	Parameter Value	Unit		Condition	Unit
Max peak level >=+2 MHz	-49.2	dBm	@	2.438	GHz
Max peak level >=+2 MHz	-49.28	dBm	@	2.442	GHz
Max peak level <=-3 MHz	-49.19	dBm	@	2.437	GHz
Max peak level >=+3 MHz	-48.86	dBm	@	2.443	GHz

Results Power in Band 1 Msps for BLE Channel 17 (2.440 GHz)

Table 12. Results Power in Band 2 Msps for BLE Channel 17 (2.440 GHz)

Parameter	Parameter Value	Unit	Condition		
				Value	Unit
Max peak level <=-2 MHz	-34.6	dBm	@	2.438	GHz
Max peak level >=+2 MHz	-33.43	dBm	@	2.442	GHz
Max peak level <=-3 MHz	-48.85	dBm	@	2.437	GHz
Max peak level >=+3 MHz	-49.53	dBm	@	2.443	GHz

Table 13. Results Power in Band 500 Ksps for BLE Channel 17 (2.440 GHz)

Parameter Value	Parameter Value	Unit		Condition	Unit
Max peak level <=-2 MHz	-48.98	dBm	@	2.438	GHz
Max peak level >=+2 MHz	-48.98	dBm	@	2.442	GHz
Max peak level <=-3 MHz	-49.19	dBm	@	2.437	GHz
Max peak level >=+3 MHz	-49.33	dBm	@	2.443	GHz

Table 14. Results Power in Band 125 Ksps for BLE Channel 17 (2.440 GHz)

Parameter Value	Parameter Value	Unit		Condition	Unit
Max peak level <=-2 MHz	-49.16	dBm	@	2.438	GHz
Max peak level >=+2 MHz	-49.5	dBm	@	2.442	GHz
Max peak level <=-3 MHz	-49.16	dBm	@	2.437	GHz
Max peak level >=+3 MHz	-49.43	dBm	@	2.443	GHz

3.3.1.5.1.3 Results Power in Band Channel 39

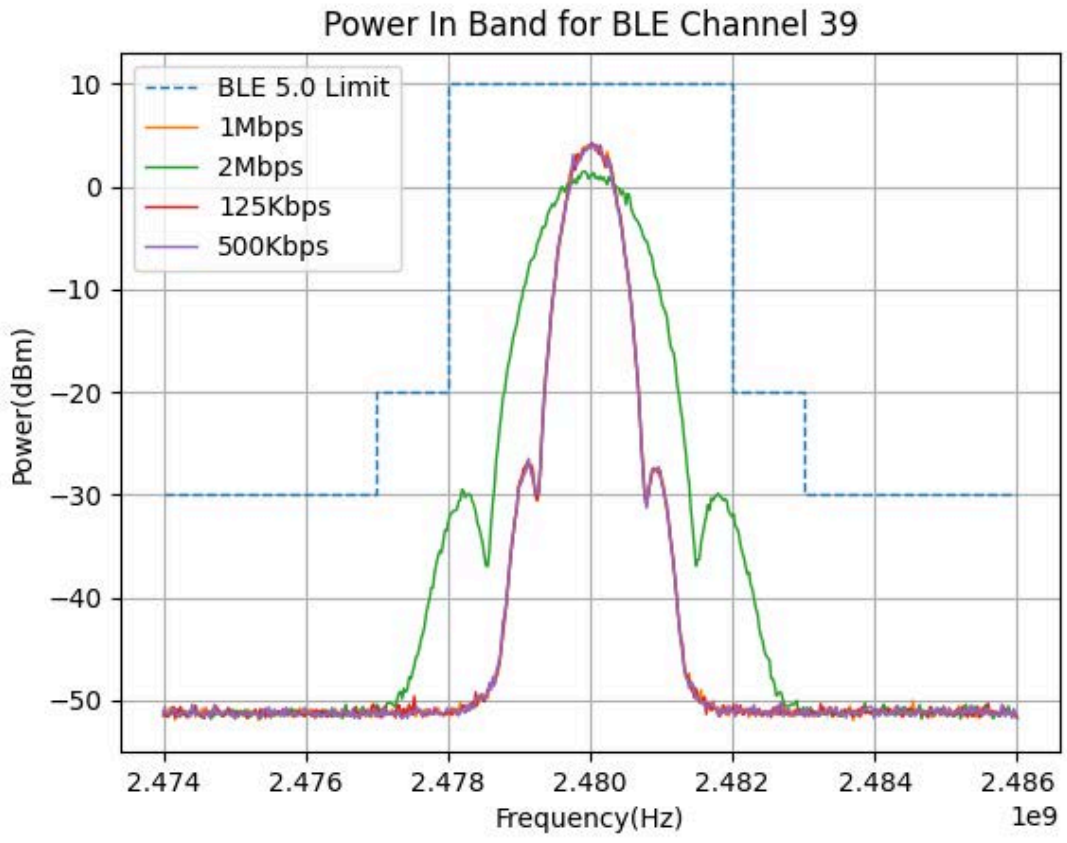

Figure 10. TX power In Band – BLE Channel 39 (2.480 GHz)

Table 15. Results Power in Band 1 Msps for BLE Channel 39 (2.480 GHz)

Parameter Value	Parameter Value	Unit		Condition	Unit
Max peak level <=-2 MHz	-48.9	dBm	@	2.478	GHz
Max peak level >=+2 MHz	-49.04	dBm	@	2.482	GHz
Max peak level <=-3 MHz	-49.19	dBm	@	2.477	GHz
Max peak level >=+3 MHz	-48.86	dBm	@	2.483	GHz

Table 16. Results Power in Band 2 Msps for BLE Channel 39 (2.480 GHz)

Parameter Value	Parameter Value	Unit		Condition	Unit
Max peak level <=-2 MHz	-32.23	dBm	@	2.478	GHz
Max peak level >=+2 MHz	-33.51	dBm	@	2.482	GHz
Max peak level <=-3 MHz	-49.22	dBm	@	2.477	GHz
Max peak level >=+3 MHz	-49.07	dBm	@	2.483	GHz

Table 17. Results Power in Band 500 Ksps for BLE Channel 39 (2.480 GHz)

Parameter Value	Parameter Value	Unit		Condition	Unit
Max peak level <=-2 MHz	-49.09	dBm	@	2.478	GHz
Max peak level >=+2 MHz	-49.24	dBm	@	2.482	GHz
Max peak level <=-3 MHz	-49.28	dBm	@	2.477	GHz
Max peak level >=+3 MHz	-48.76	dBm	@	2.483	GHz

Table 18. Results Power in Band 125 Ksps for BLE Channel 39 (2.480 GHz)

Parameter Value	Parameter Value			Condition	Unit
Max peak level <=-2 MHz	-49.33	dBm	@	2.478	GHz
Max peak level >=+2 MHz	-48.87	dBm	@	2.482	GHz
Max peak level <=-3 MHz	-49.00	dBm	@	2.477	GHz
Max peak level >=+3 MHz	-48.87	dBm	@	2.483	GHz

Conclusion:

- The FRDM-MCXW71 board passes the BLE 5.0 certification the Power In Band test.

3.3.1.6 Tx spurious

The following sections describe the Tx spurious results in the 1 GHz to 30 GHz range for H2 to H10 in ETSI and FCC test conditions.

3.3.1.6.1 1 GHz to 30 GHz

Spurious overview of the full band from 1 GHz to 30 GHz when the device is in the transmission mode.

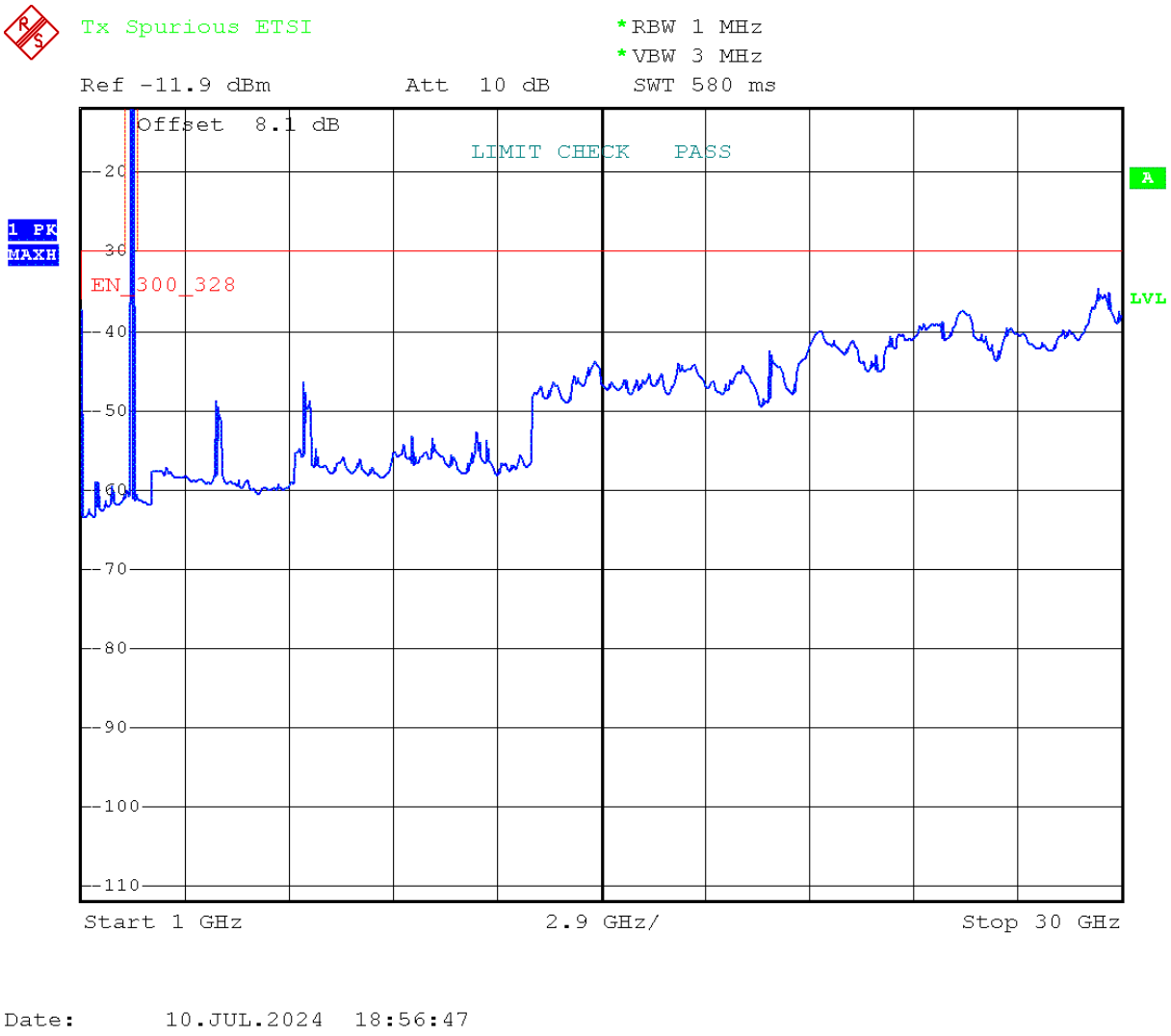

Figure 11. Bluetooth LE - Conducted Tx spurious (1 GHz to 30 GHz)

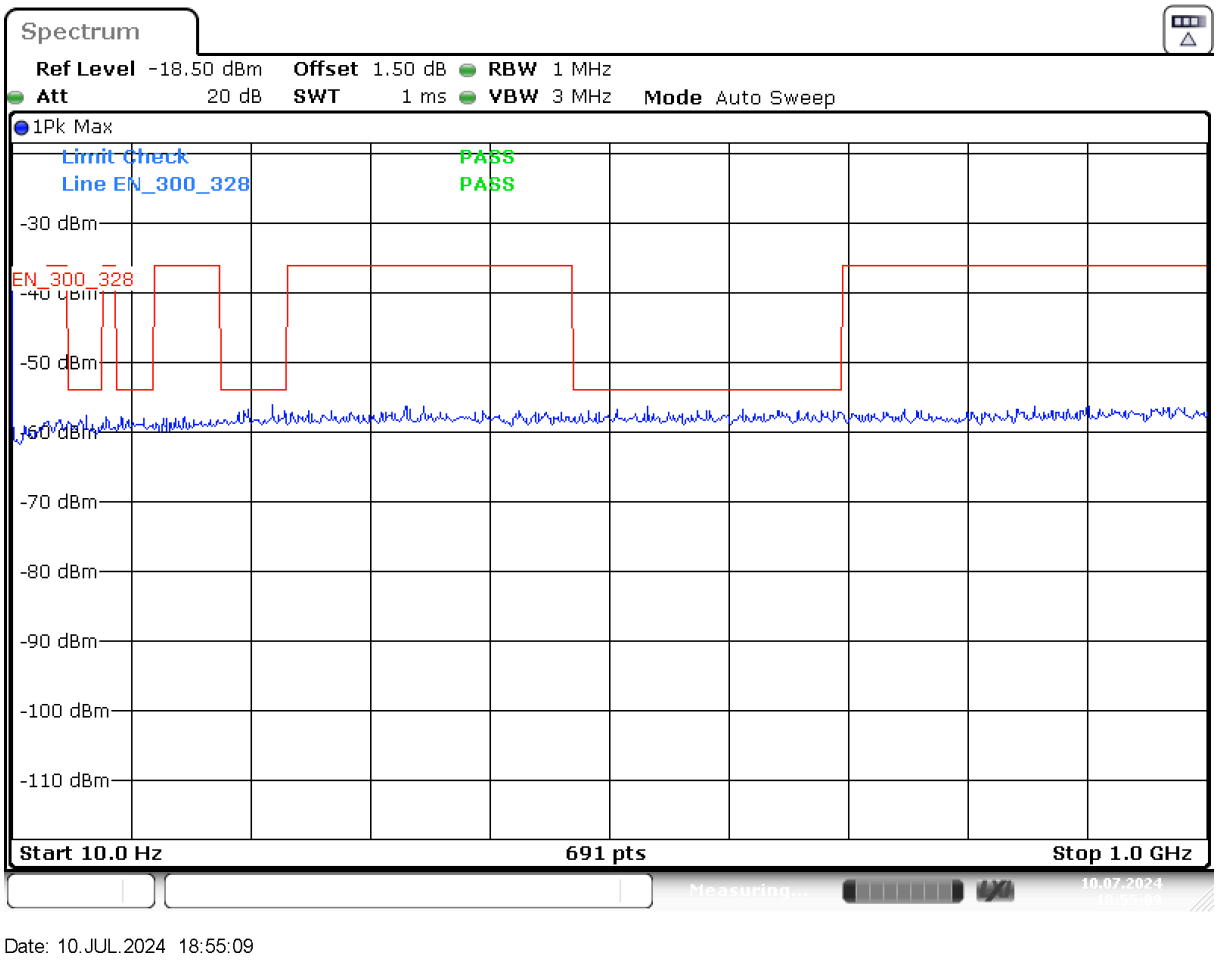

Figure 12. Bluetooth LE - Zoom In - Conducted Tx spurious (1 GHz to 30 GHz)

Conclusion:

- The FRDM-MCXW71 passes the ETSI Tx Spurious Certification with a margin of 4.5 dB.
- Harmonics are measured in the following paragraphs.

3.3.1.6.2 H2 (ETSI test conditions, peak measurement)

Test method:

- Set the radio to:
  - Tx mode, modulated, continuous mode
- Set the analyzer to:
  - Start frequency = 4.7 GHz, Stop frequency = 5 GHz,
  - Ref amp = -20 dBm, sweep time = 100 ms, RBW = 1 MHz, VBW = 3 MHz
- Max Hold mode
- Detector: Peak
- Sweep all the 40 BLE channels starting from Channel 37 (2.402 GHz) to Channel 39 (2.480 GHz)

3.3.1.6.2.1 Bluetooth LE results

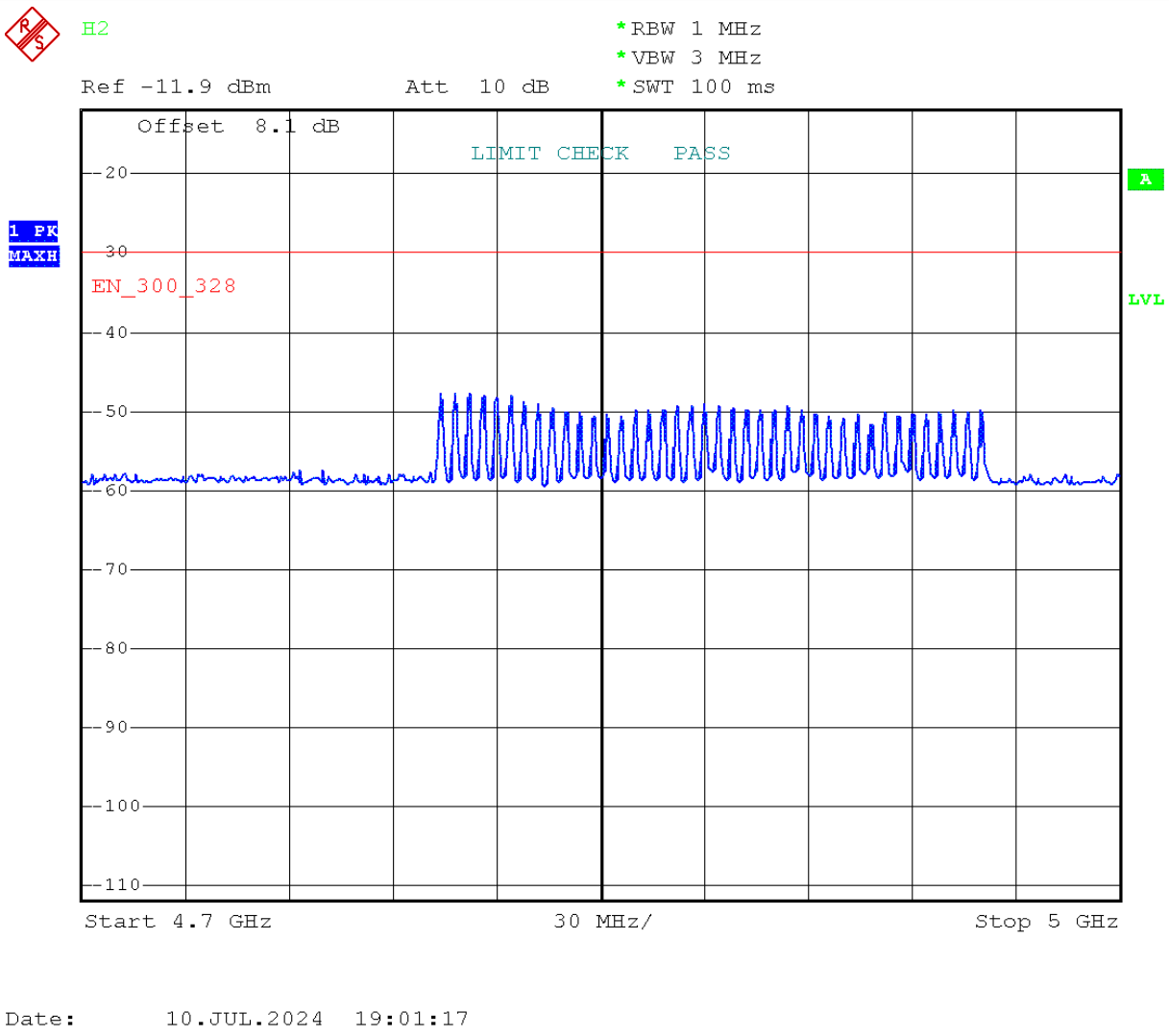

Figure 13. Bluetooth LE - Conducted H2 spurious

- Maximum power is at frequency 4.81 GHz: -47.62 dBm

Conclusion:

- There is more than 17.6 dB margin for Bluetooth LE to the ETSI limit

3.3.1.6.3 H3 (ETSI test conditions, peak measurement)

The same method as for H2, except that the spectrum analyzer frequency start/stop is set to 7.0 and 7.5 GHz.

3.3.1.6.3.1 Bluetooth LE results

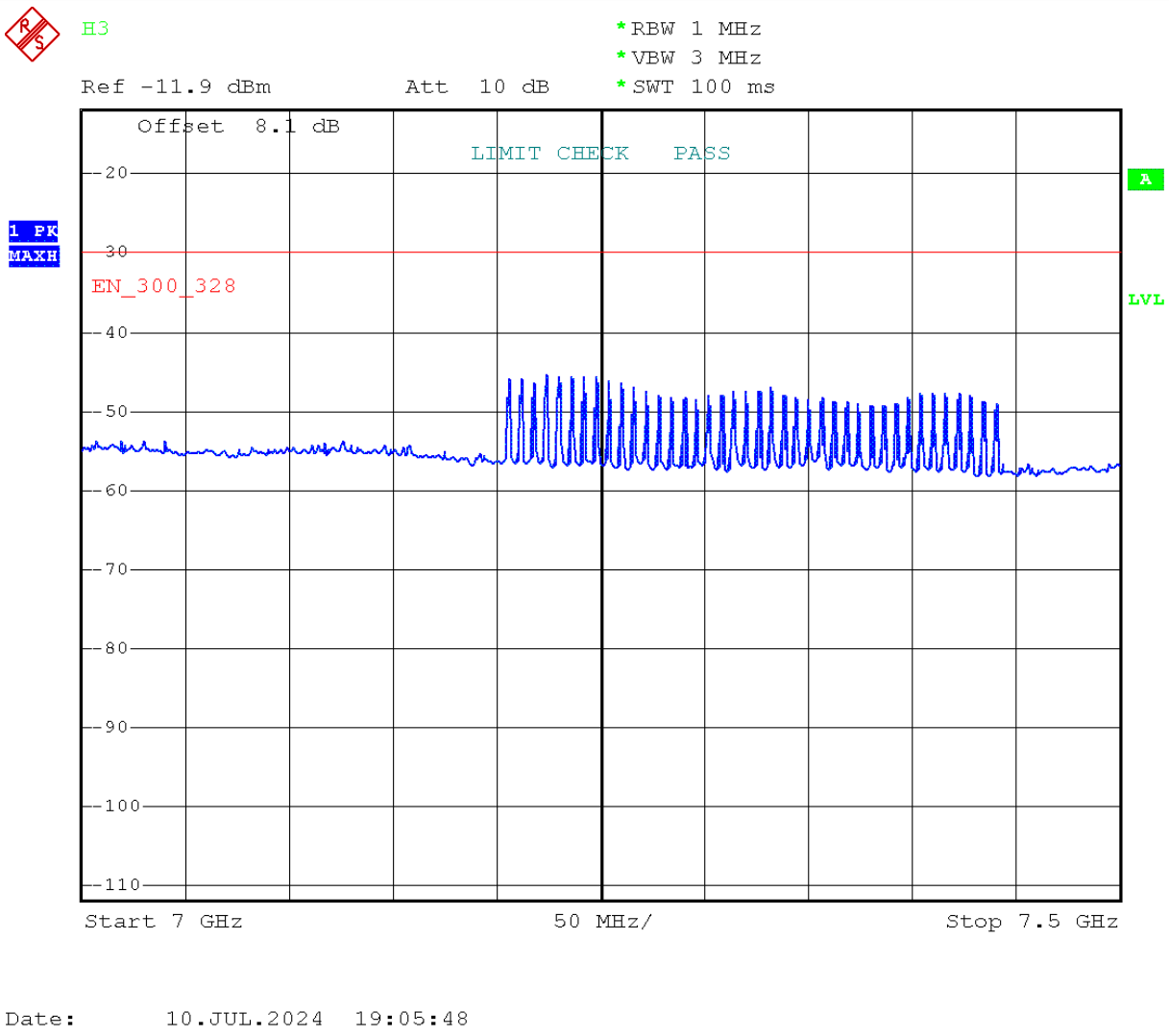

Figure 14. Bluetooth LE - Conducted H3 spurious

- Maximum power is at frequency 7.23 GHz : -45.7 dBm

Conclusion:

- There is more than 15.7 dB margin for Bluetooth LE to the ETSI limit

.

3.3.1.6.4 H4 (ETSI test conditions, peak measurement)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 9.4 to 10.0 GHz.

3.3.1.6.4.1 Bluetooth LE results

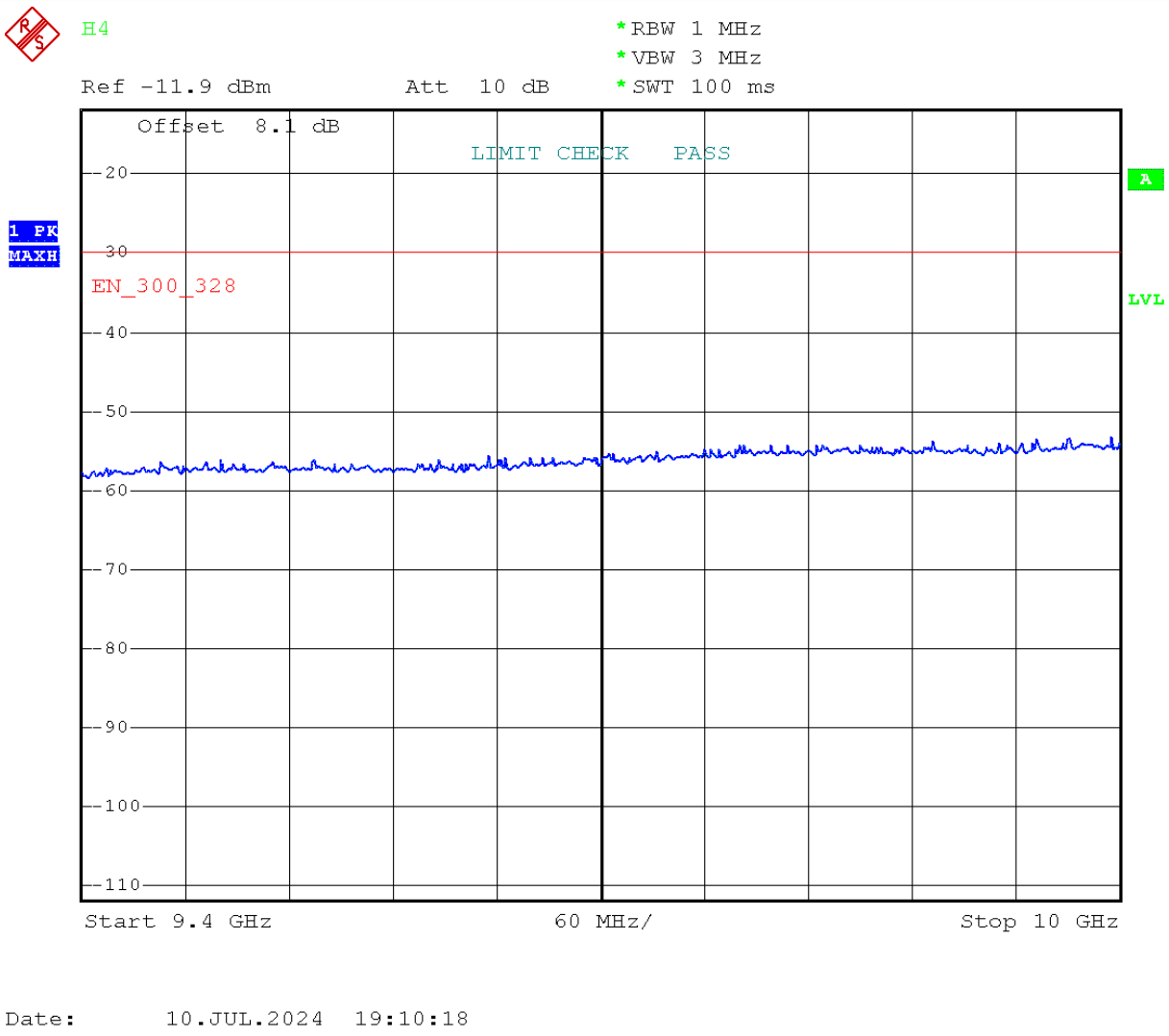

Figure 15. Bluetooth LE - Conducted H4 spurious

- Maximum power is at frequency 10.0 GHz: -53.18 dBm

Conclusion:

- There is more than 23.2 dB margin for Bluetooth LE to the ETSI limit

3.3.1.6.5 H5 (ETSI test conditions, peak measurement)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 11.7 GHz to 12.5 GHz.

3.3.1.6.5.1 Bluetooth LE results

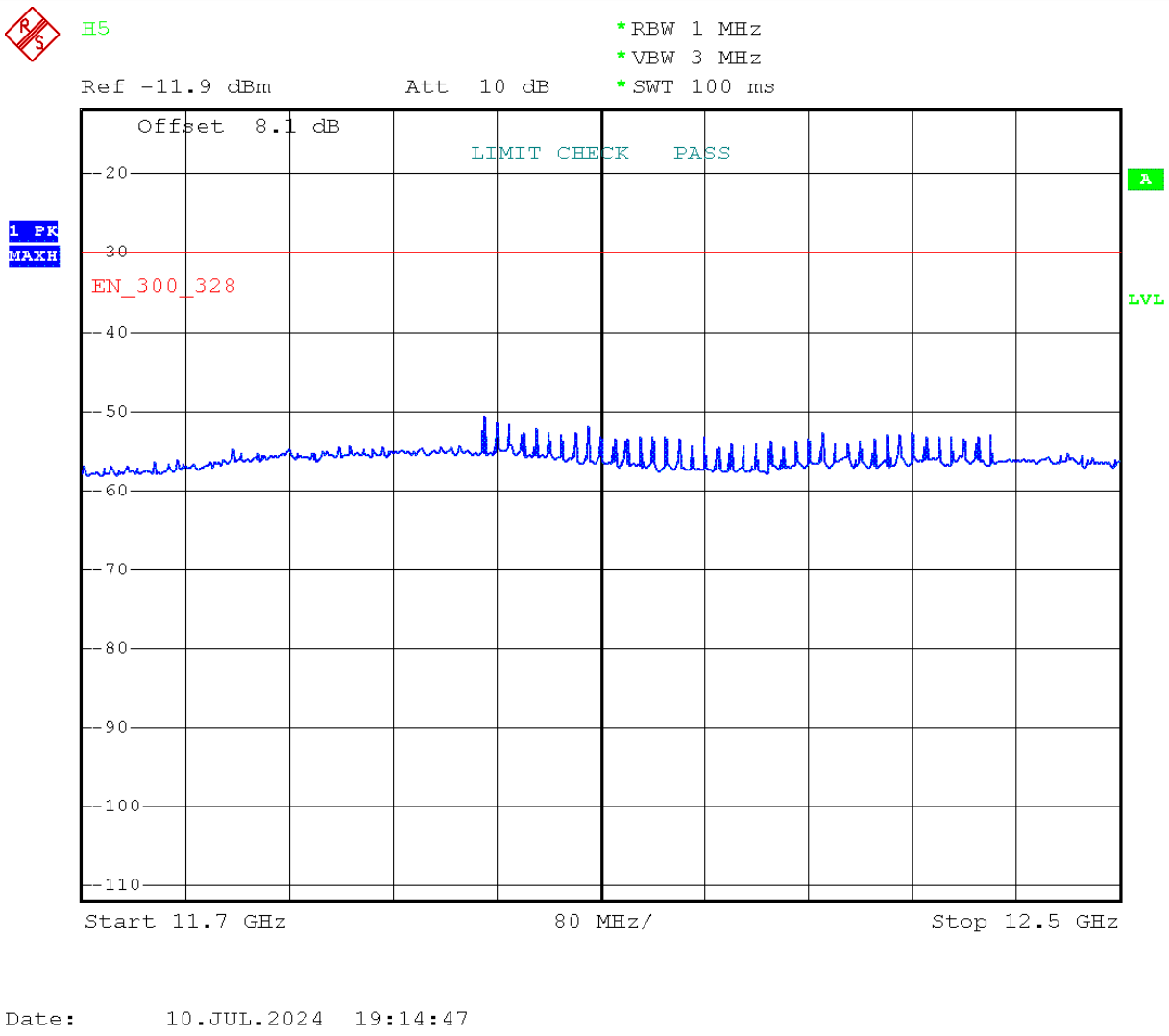

Figure 16. Bluetooth LE - Conducted H5 spurious

- Maximum power is at frequency 12.02 GHz: -51.28 dBm

Conclusion:

- There is more than 21.3 dB margin for Bluetooth LE to the ETSI limit

3.3.1.6.6 H6 (ETSI test conditions, peak measurement)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 14.1 GHz to 15 GHz.

Result:

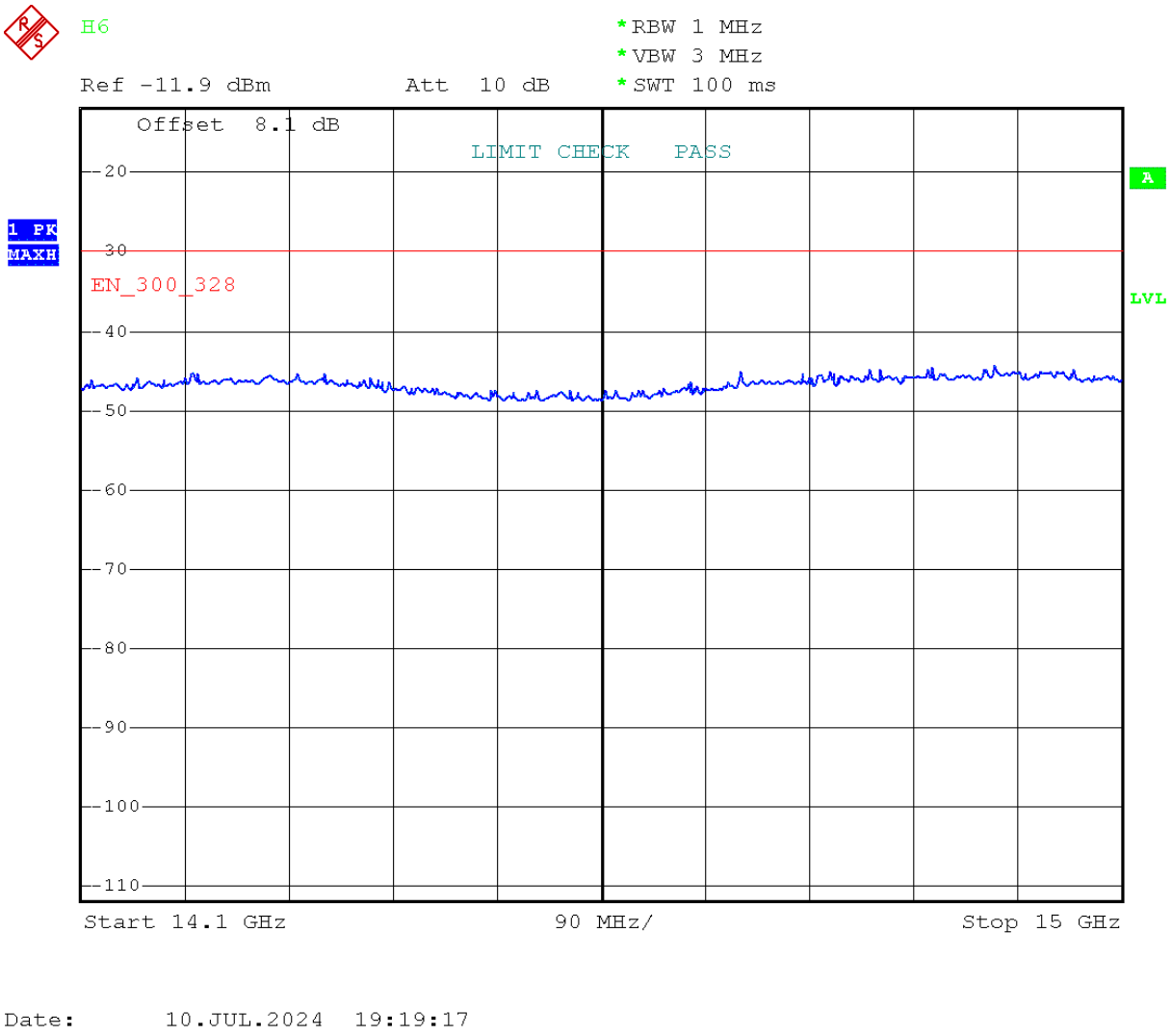

Figure 17. Bluetooth LE - Conducted H6 spurious

- Maximum power is at frequency 14.89 GHz-44.3 dBm

Conclusion:

- There is more than 14.3 dB margin for Bluetooth LE to the ETSI limit

3.3.1.6.7 H7 (ETSI test conditions, peak measurement)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 16.45 GHz to 17.5 GHz.

Result:

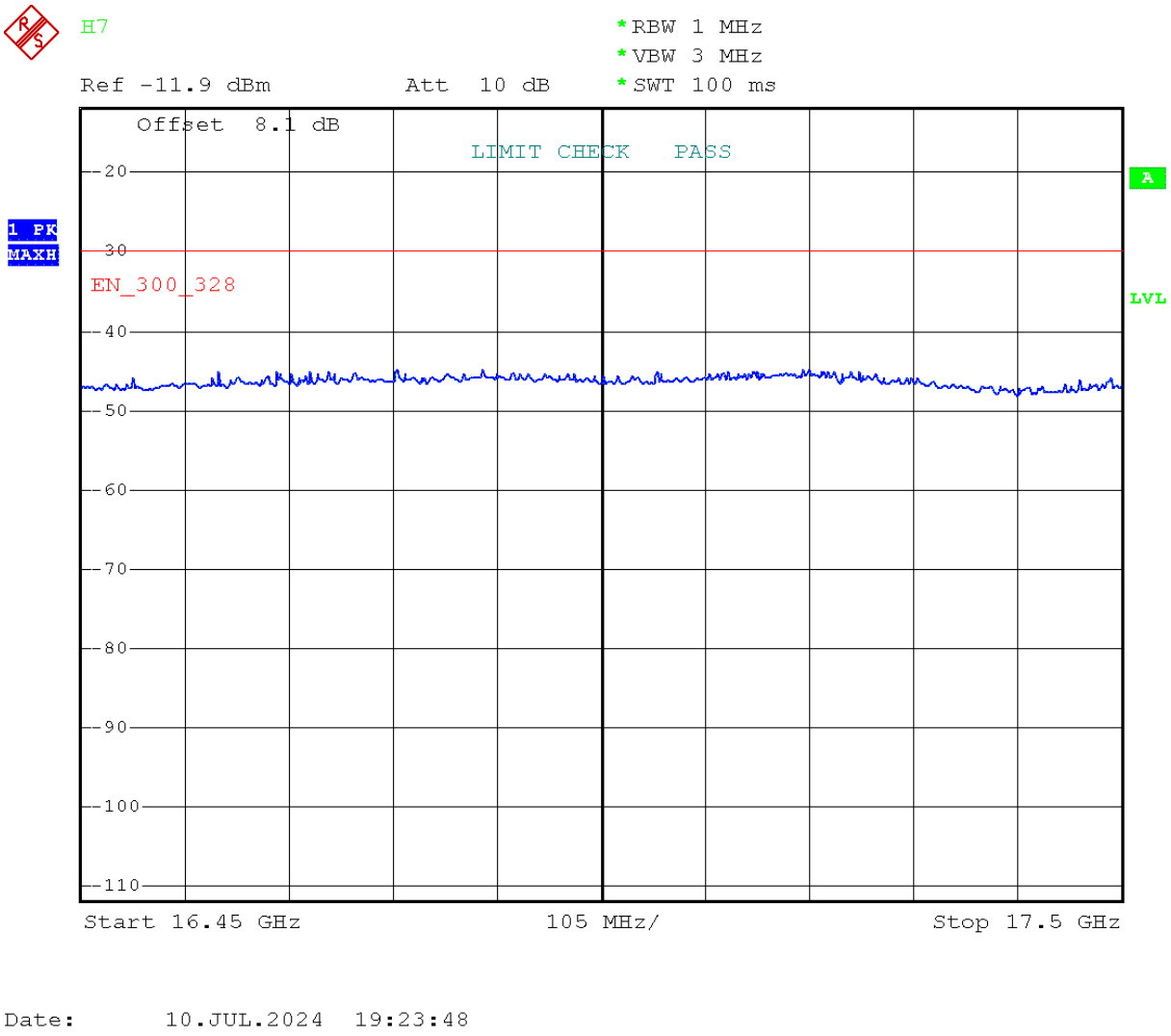

Figure 18. Bluetooth LE - Conducted H7 spurious

- Maximum power is at frequency 16.86 GHz: -44.73 dBm

Conclusion:

- There is more than 14.7 dB margin for Bluetooth LE to the ETSI limit

.

3.3.1.6.8 H8 (ETSI test conditions, peak measurement)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 16.45 GHz to 17.5 GHz.

Result:

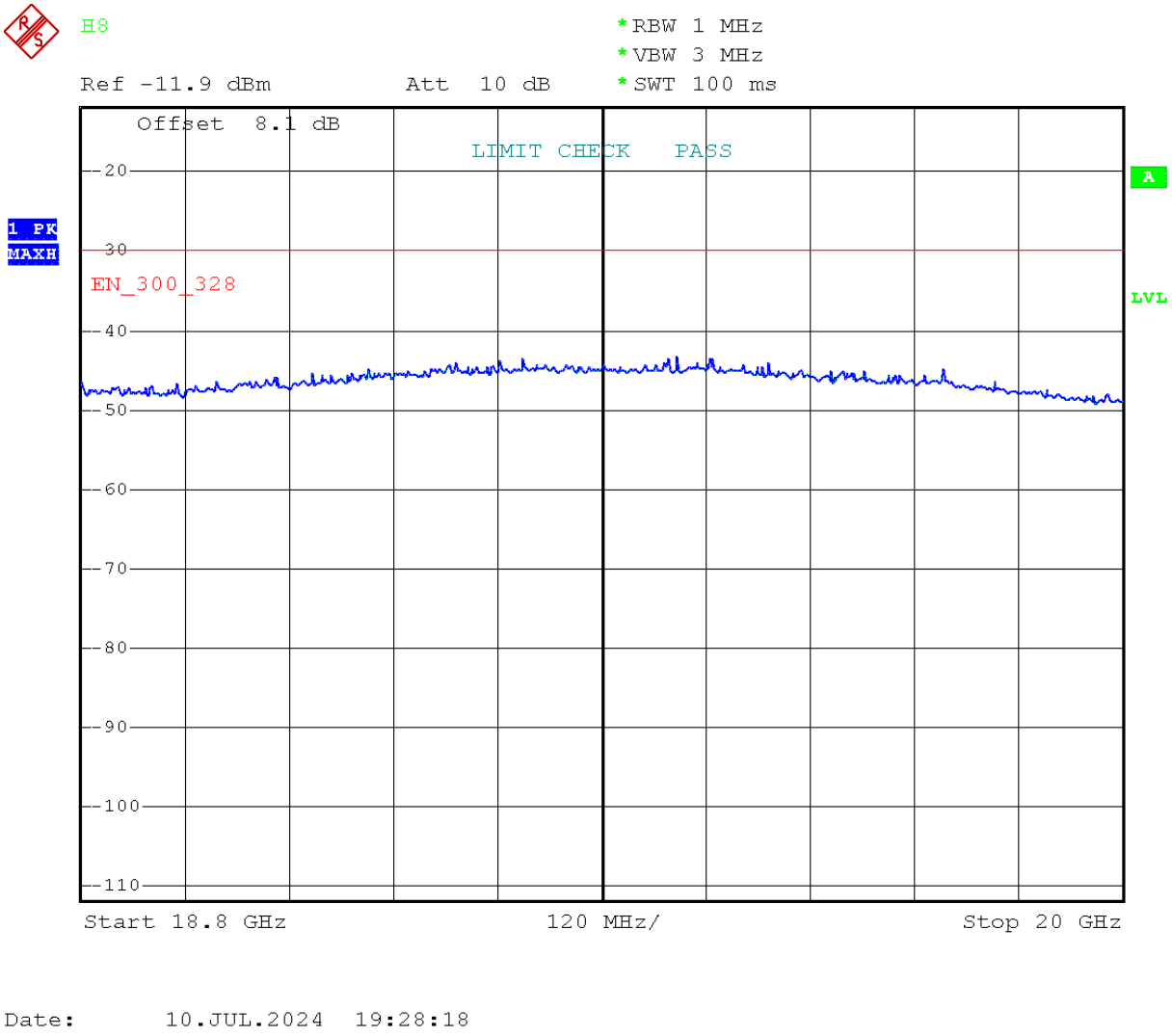

Figure 19. Bluetooth LE - Conducted H8 spurious

- Maximum power is at frequency 19.49 GHz -43.34 dBm

Conclusion:

- There is more than 13.3 dB margin for Bluetooth LE to the ETSI limit.

3.3.1.6.9 H9 (ETSI test conditions, peak measurement)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 21.15 GHz to 22.5 GHz.

Result:

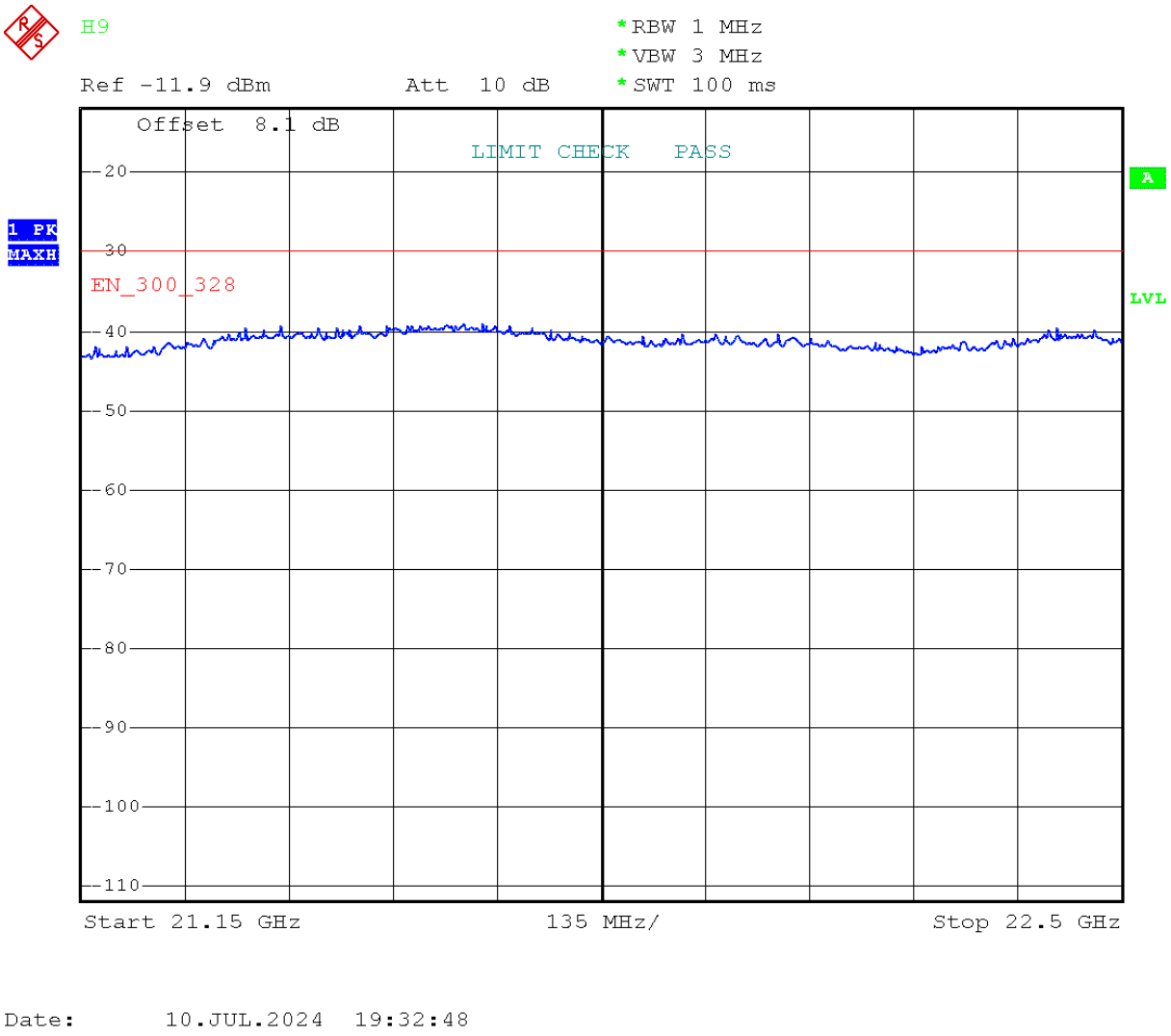

Figure 20. Bluetooth LE - Conducted H9 spurious

- Maximum power is at frequency 21.67 GHz: -39.15 dBm

Conclusion:

- There is more than 9.1 dB margin for Bluetooth LE to the ETSI limit.

3.3.1.6.10 H10 (ETSI test conditions, peak measurement)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 23.35 GHz to 25 GHz.

Result:

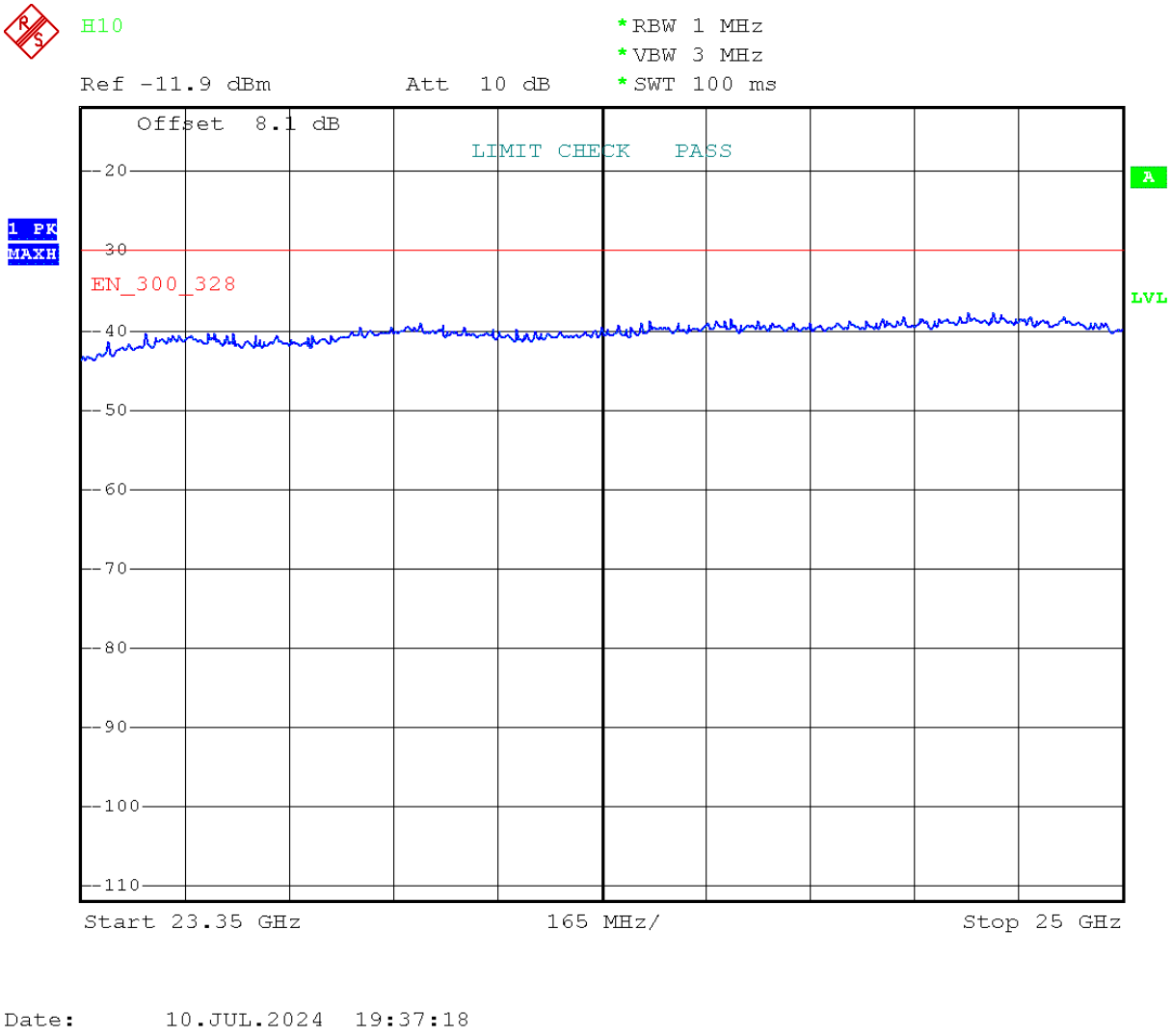

Figure 21. Bluetooth LE - Conducted H10 spurious

- Maximum power is at frequency 24.8 GHz: -37.85 dBm

Conclusion:

- There is more than 7.9 dB margin for Bluetooth LE to the ETSI limit.

3.3.1.6.11 H2 (FCC test conditions, average measurements)

Test method:

- Set the radio to:
  - Tx mode, modulated, continuous mode
- Set the analyzer to:
  - Start frequency = 4.7 GHz, Stop frequency = 5 GHz,
  - Ref amp = -20 dBm, sweep time = 100 ms, RBW = 1 MHz, VBW = 3 MHz
- Trace: Max Hold mode
- Detector: RMS
- Sweep all the 40 BLE channels starting from Channel 37 (2.402 GHz) to Channel 39 (2.480 GHz)

3.3.1.6.11.1 Bluetooth LE results

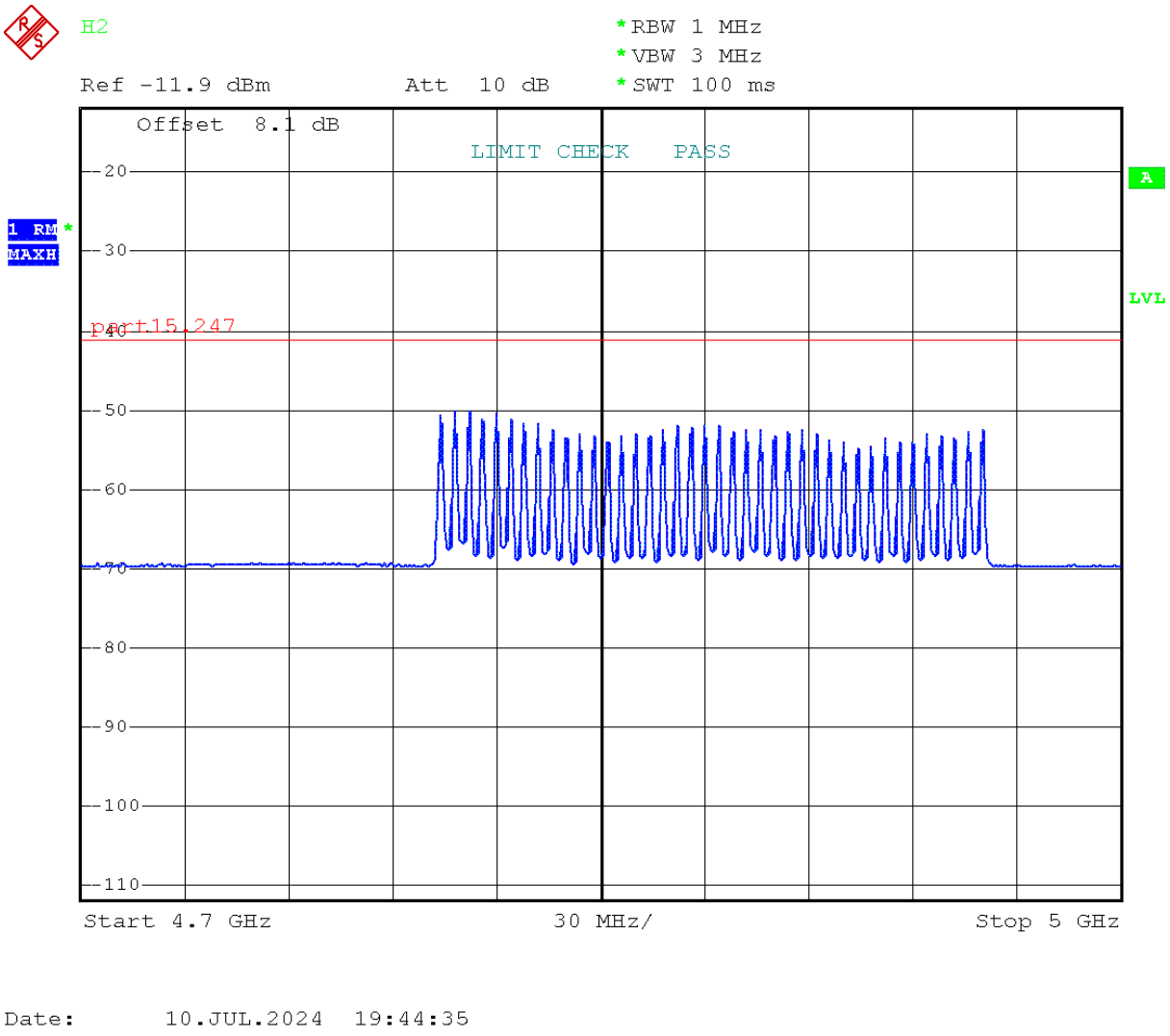

Figure 22. Bluetooth LE - Conducted H2 FCC spurious

- Maximum power is at frequency 4.81 GHz -50.18 dBm

Conclusion:

- There is more than 9.1 dB margin for Bluetooth LE to the FCC limit

3.3.1.6.12 H3 (FCC test conditions, average measurements)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 7.0 GHz to 7.5 GHz.

3.3.1.6.12.1 Bluetooth LE results

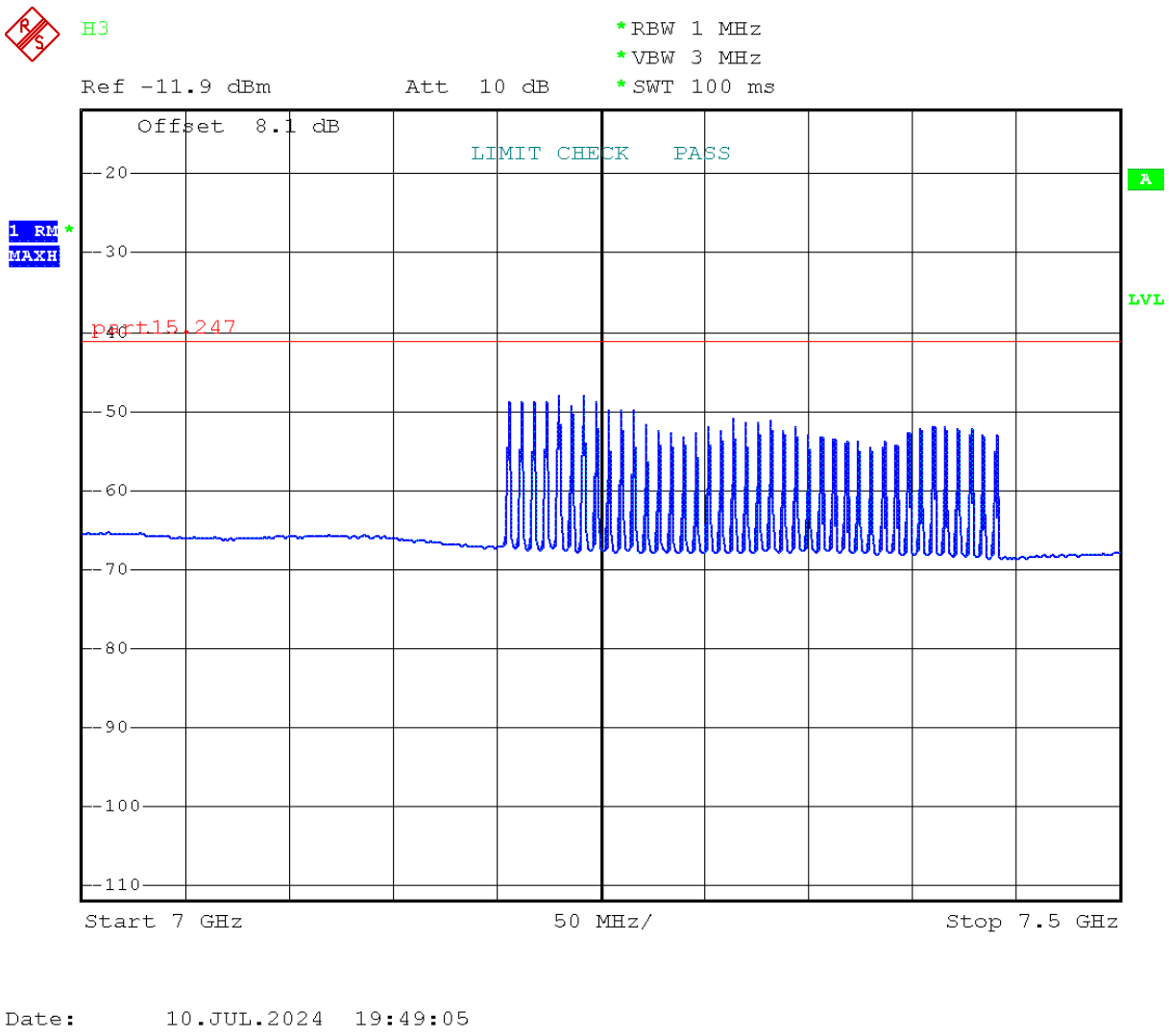

Figure 23. Bluetooth LE - Conducted H3 FCC spurious

- Maximum power is at frequency 7.23 GHz: -48.13 dBm

Conclusion:

- There is more than 7.0 dB margin for Bluetooth LE to the FCC limit

3.3.1.6.13 H4 (FCC test conditions, average measurements)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 9.4 GHz to 10 GHz.

3.3.1.6.13.1 Bluetooth LE results

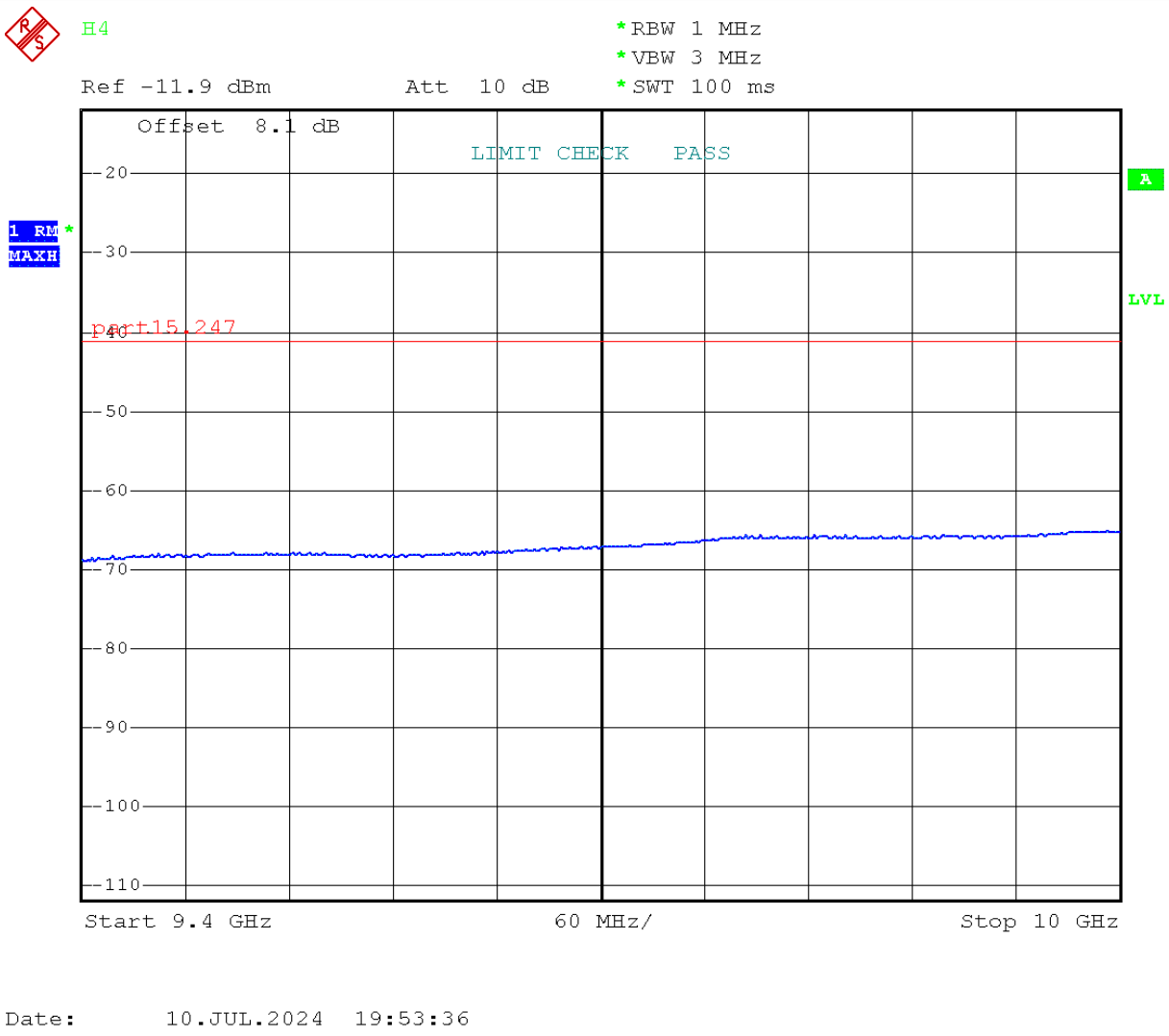

Figure 24. Bluetooth LE - Conducted H4 FCC spurious

- Maximum power is at frequency 9.99 GHz: -65.1 dBm

Conclusion:

- There is more than 24.0 dB margin for Bluetooth LE to the FCC limit

3.3.1.6.14 H5 (FCC test conditions, average measurements)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 11.7 GHz to 12.5 GHz.

3.3.1.6.14.1 Bluetooth LE result

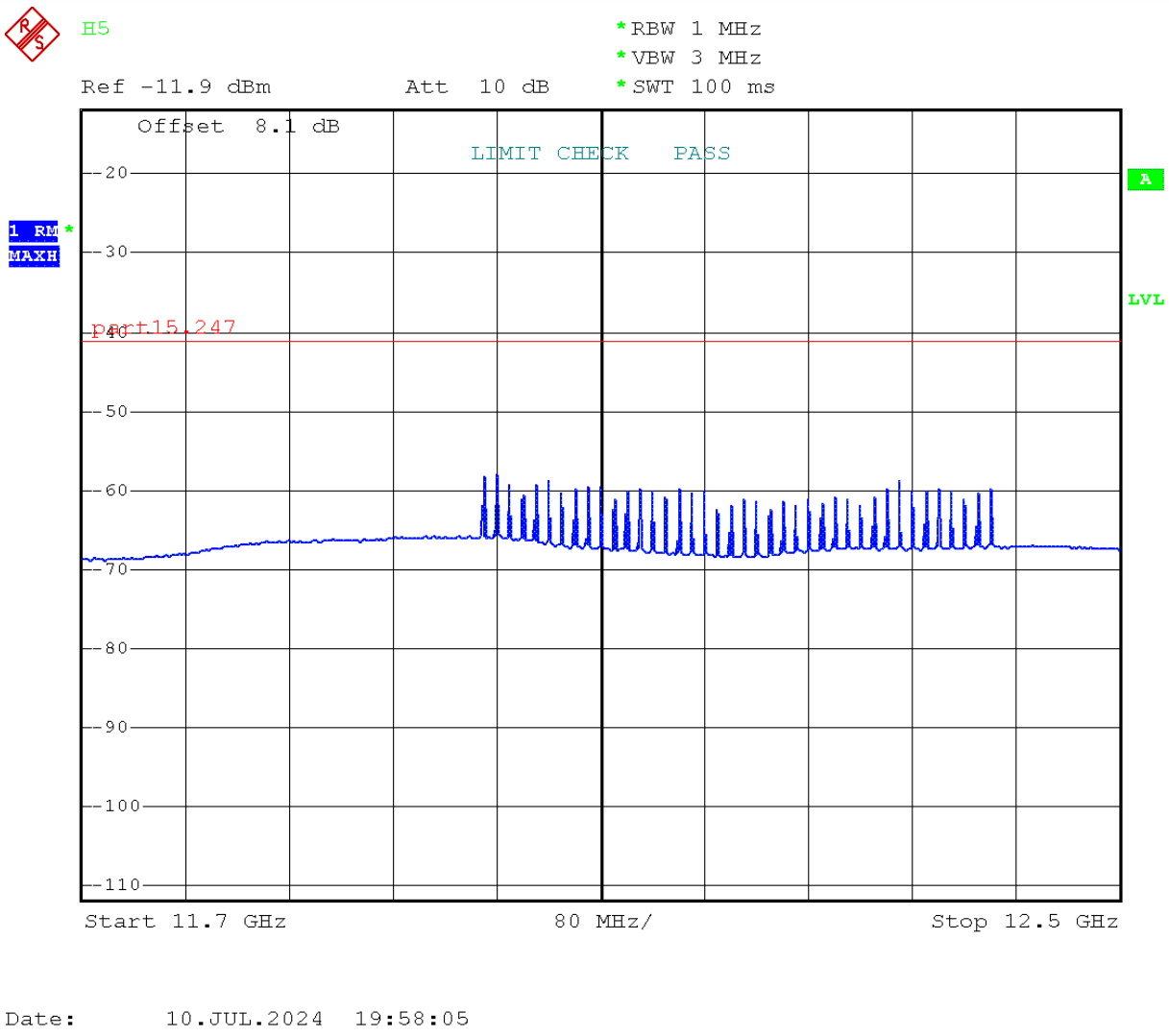

Figure 25. Bluetooth LE - Conducted H5 FCC spurious

- Maximum power is at frequency 12.02 GHz: -58.26 dBm

Conclusion:

- There is more than 17.1 dB margin for Bluetooth LE to the FCC limit

3.3.1.6.15 H6 (FCC test conditions, average measurements)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 14.1 GHz to 15 GHz.

Result:

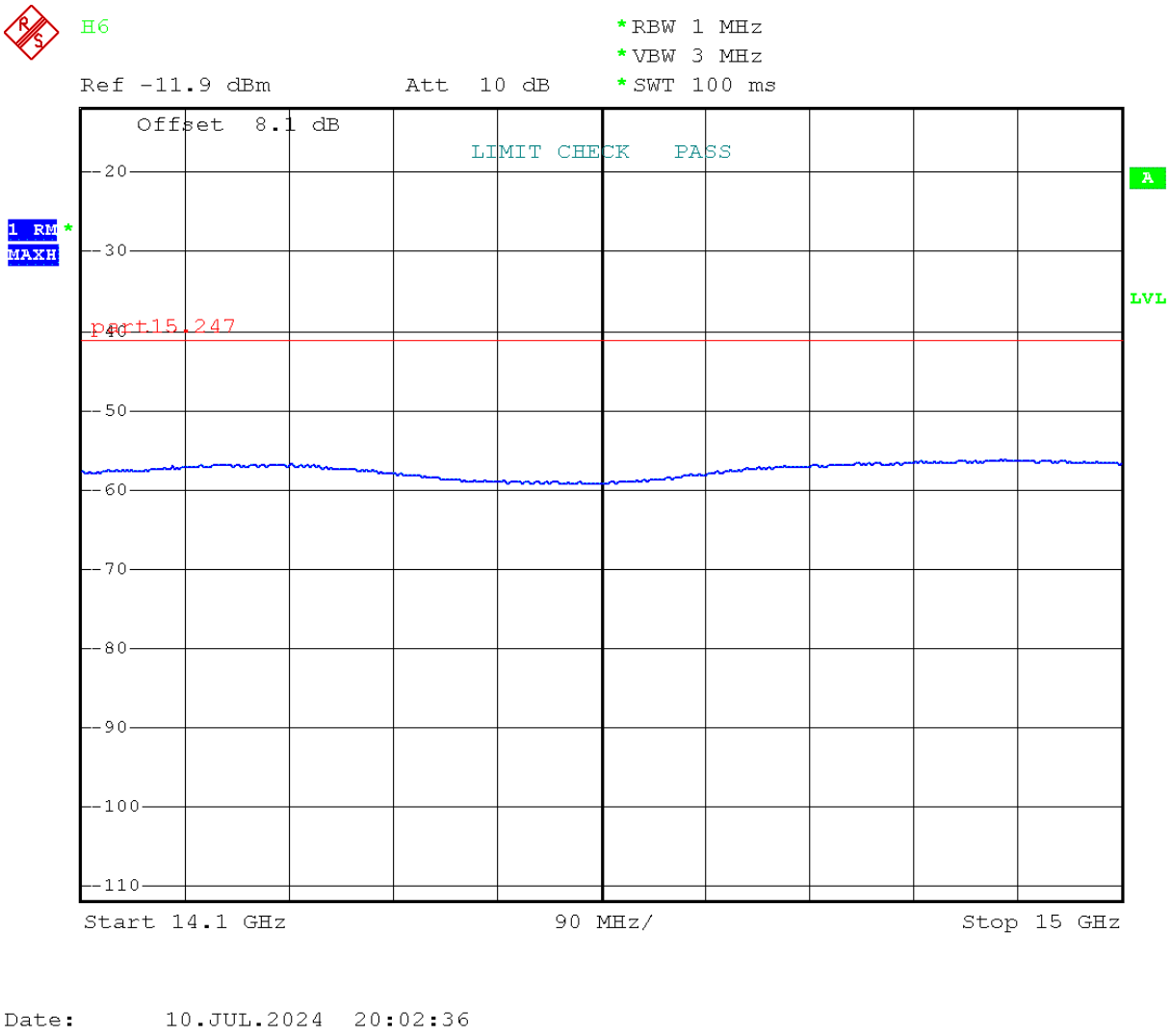

Figure 26. Bluetooth LE - Conducted H6 FCC spurious

- Maximum power is at frequency 14.9 GHz: -56.23 dBm

Conclusion:

- There is more than 15.1 dB margin for Bluetooth LE to the FCC limit

3.3.1.6.16 H7 (FCC test conditions, average measurements)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 16.45 GHz to 17.5 GHz.

Result:

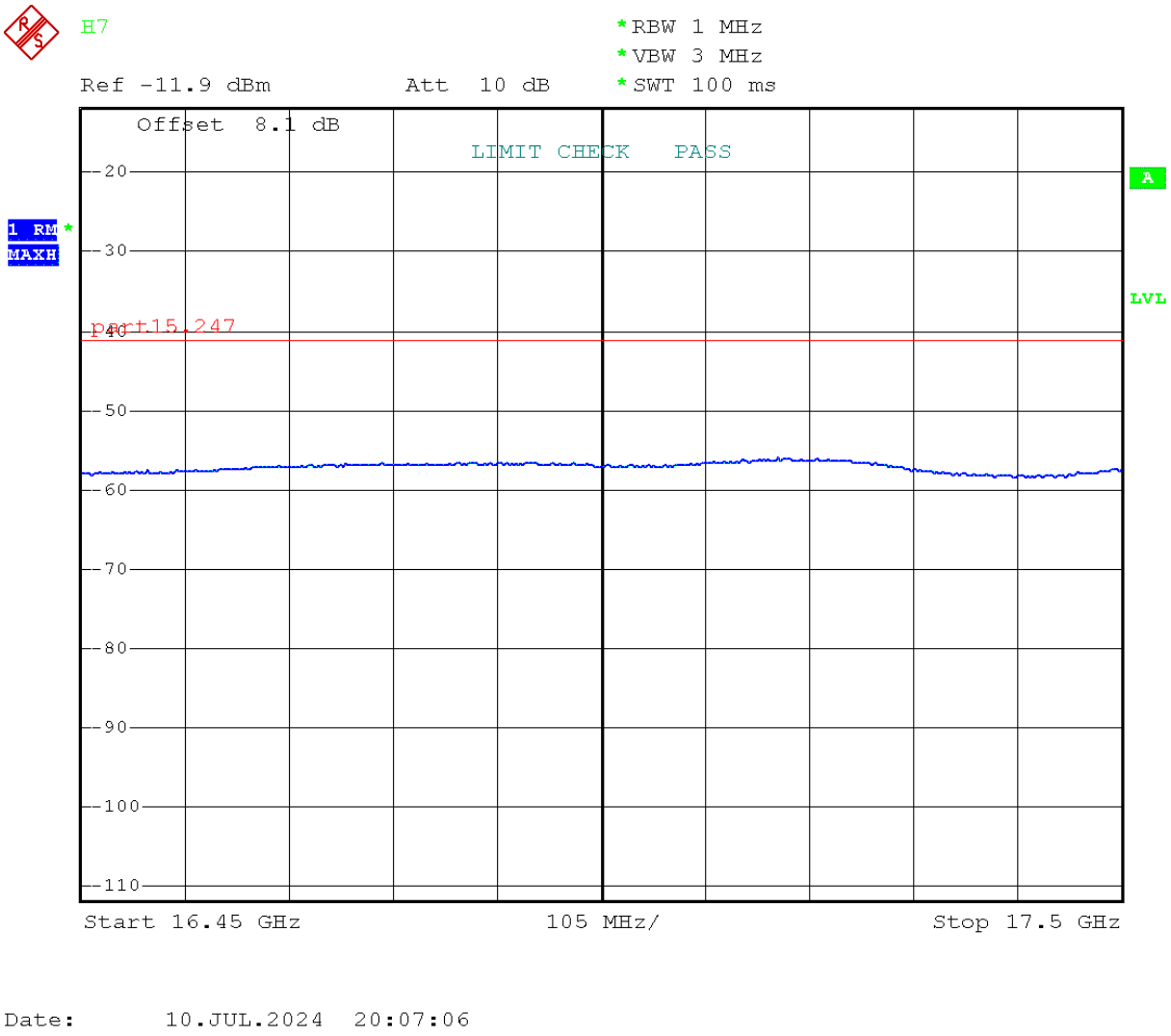

Figure 27. Bluetooth LE - Conducted H7 FCC spurious

- Maximum power is at frequency 17.15 GHz: -55.95 dBm

Conclusion:

- There is more than 14.8 dB margin for Bluetooth LE to the FCC limit

3.3.1.6.17 H8 (FCC test conditions, average measurements)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 16.45 GHz to 17.5 GHz.

Result:

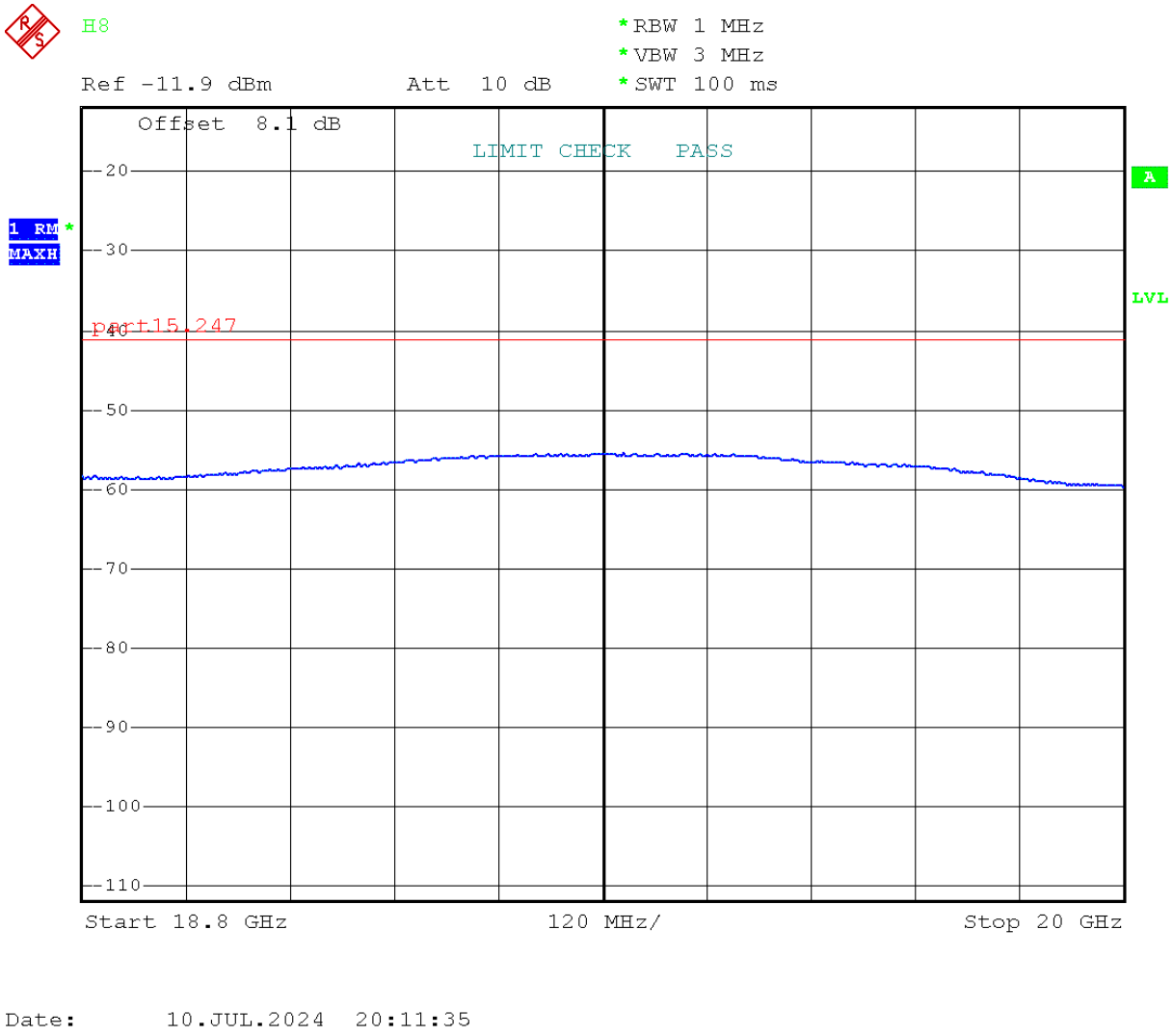

Figure 28. Bluetooth LE - Conducted H8 FCC spurious

- Maximum power is at frequency 19.42 GHz: -55.27 dBm

Conclusion:

- There is more than 14.2 dB margin for Bluetooth LE to the FCC limit

.

3.3.1.6.18 H9 (FCC test conditions, average measurements)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 21.15 GHz to 22.5 GHz.

Result:

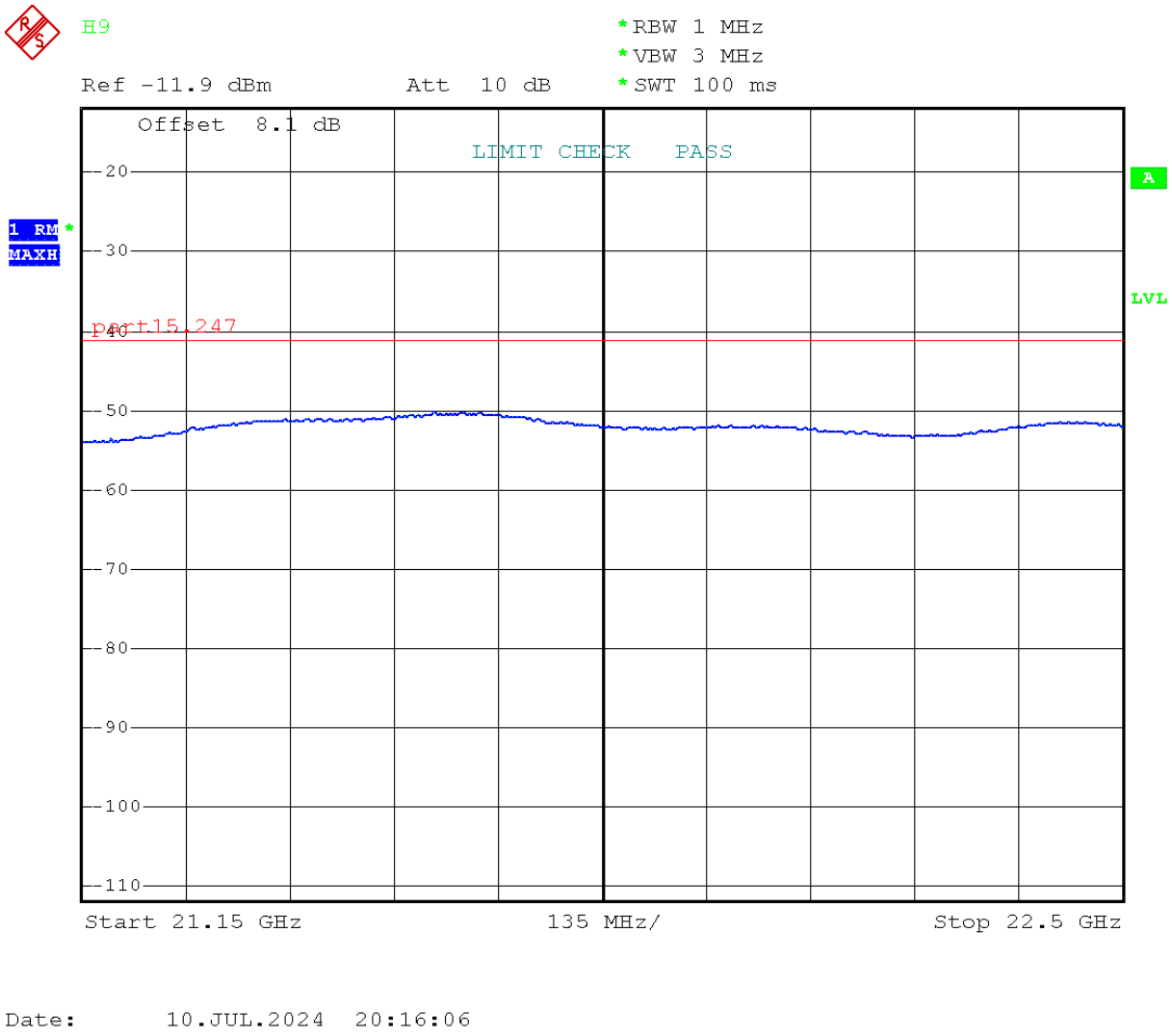

Figure 29. Bluetooth LE - Conducted H9 FCC spurious

- Maximum power is at frequency 21.63 GHz: -50.25 dBm

Conclusion:

- There is more than 9.1 dB margin for Bluetooth LE to the FCC limit.

3.3.1.6.19 H10 (FCC test conditions, average measurements)

Use the same method as H2, except that the spectrum analyzer frequency span must be set from 23.35 GHz to 25 GHz.

Result:

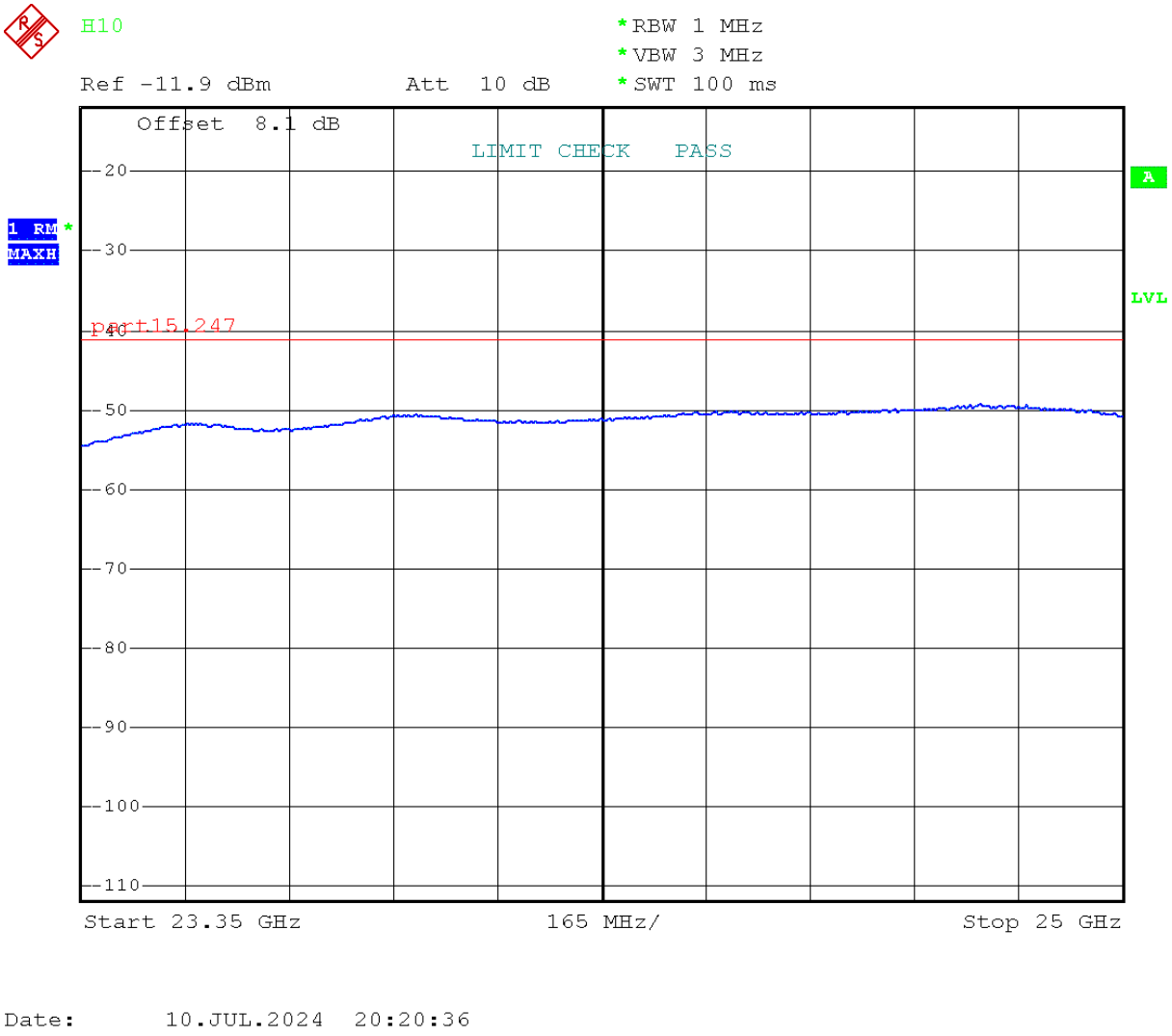

Figure 30. Bluetooth LE - Conducted H10 FCC spurious

- Maximum power is at frequency 24.76 GHz: -49.38 dBm

Conclusion:

- There is more than 8.3 dB margin for Bluetooth LE to the FCC limit

3.3.1.7 Lower Band Edge – MIIT China

3.3.1.7.1 Test method

- Set the radio to:
  - TX mode, modulated, burst mode, TX Power level @ 10 dBm
- Set the BLE Channel 37 (2.402 GHz)
- Set the analyzer to:
  - Start frequency = 2.375 GHz, Stop frequency=2.405 GHz,
  - Ref amp=-20 dBm, sweep time=100 ms, sweep point: 8001 pts
  - RBW = 1 MHz,

– Video BW = 3 MHz
– Detector = RMS MaxHold

3.3.1.7.2 Bluetooth LE results

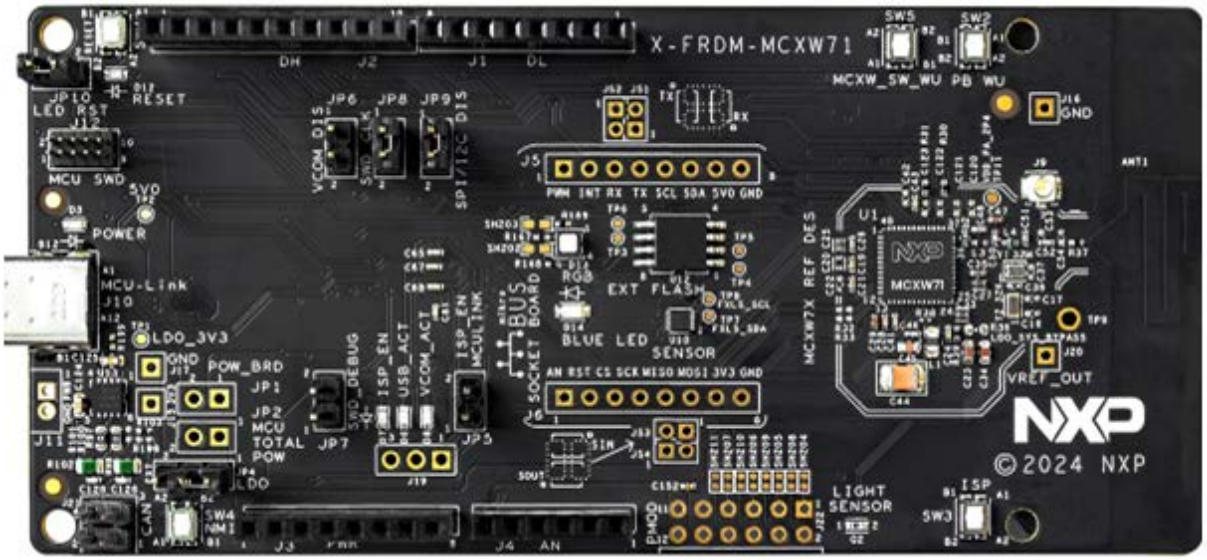

Figure 31. Lower Band Edge – Channel 0

Conclusion:

- The Lower Band Edge test passes the Lower Band Edge test certification.
- There is a good margin of 5.52 dB.

3.3.1.8 Upper Band Edge – MIIT China

3.3.1.8.1 Test method

- Set the radio to:
  - TX mode, modulated, burst mode
- Set the channel 39 (2.48 GHz)
- Set the analyzer to:
  - Start frequency = 2.477 GHz, Stop frequency=2.507 GHz, Ref amp=-20 dBm, sweep time=40 ms, sweep point: 8001 pts
  - RBW = 1 MHz, Video BW = 3 MHz Detector = RMS MaxHold

3.3.1.8.2 Results

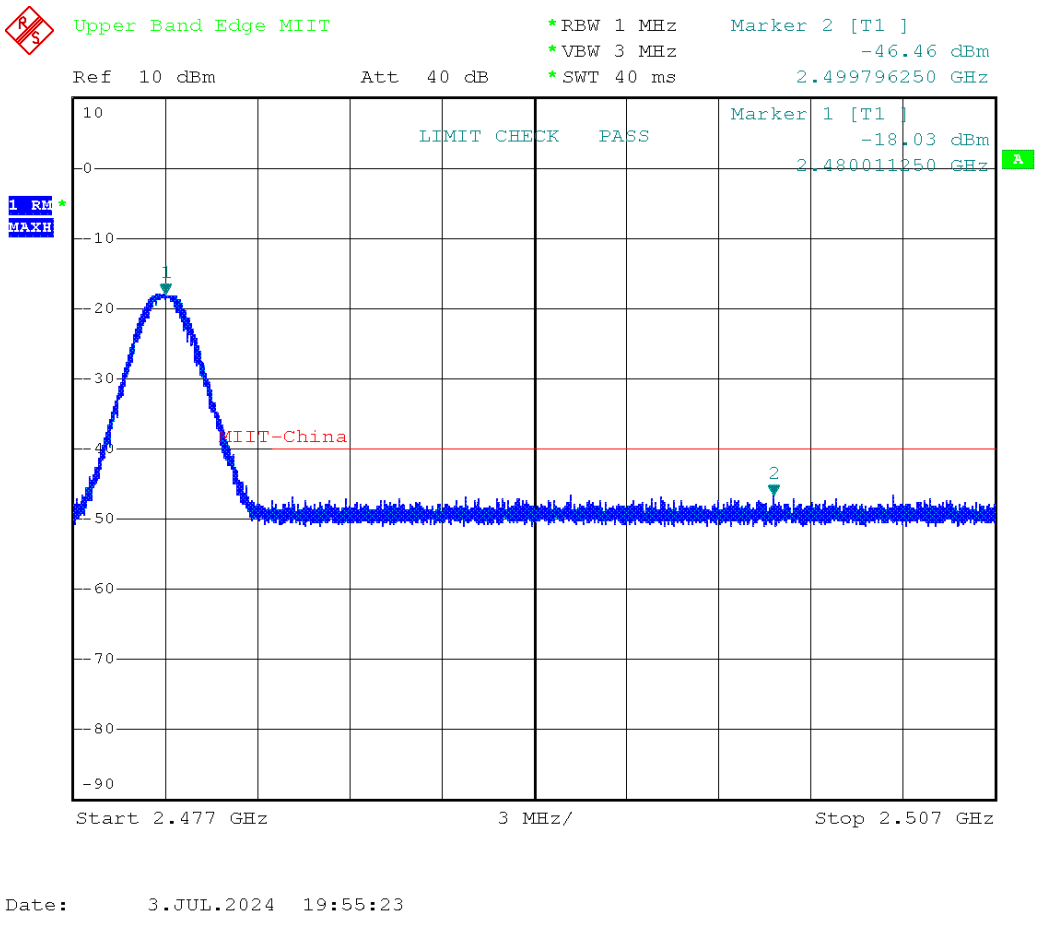

Figure 32. Upper Band Edge test from MIIT-China – Channel 39

Conclusion:

- The board passes the Upper Band Edge MIIT certification.
- There is a good margin of 5.54 dB.

3.3.1.9 Upper Band Edge (FCC ANSI C63.10, 558074 D01 DTS)

3.3.1.9.1 Test method

- Set the radio to:
  - TX mode, modulated (1 Msps, 2 Msps, 500 Ksps, 125 Ksps), continuous mode, Maximum RF output power +10 dBm
- Set the analyzer to:
  - Start frequency = 2.475 GHz, Stop frequency=2.485 GHz, Ref amp=-20 dBm, sweep time=AUTO,
  - RBW = 100 kHz, Video BW = 300 kHz Detector = Average
  - Average mode: power
  - Number of Sweeps = 100
- Set the BLE Channel 39 (2.48GHz) Trace mode: Max hold

3.3.1.9.2 Bluetooth LE results

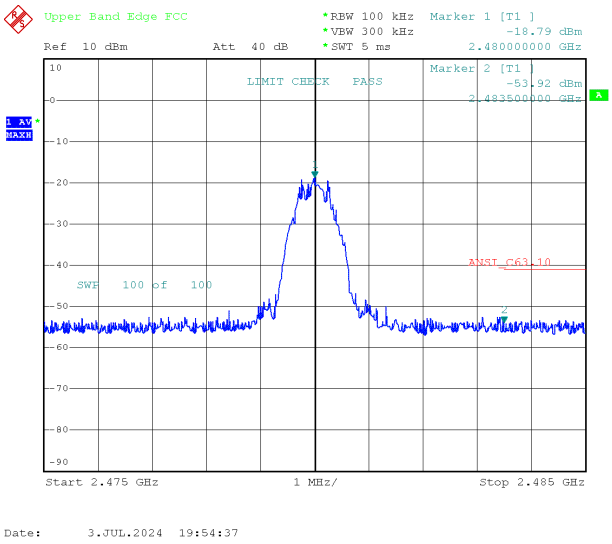

Figure 33. Upper Band Edge (FCC ANSI) (1 Msps)

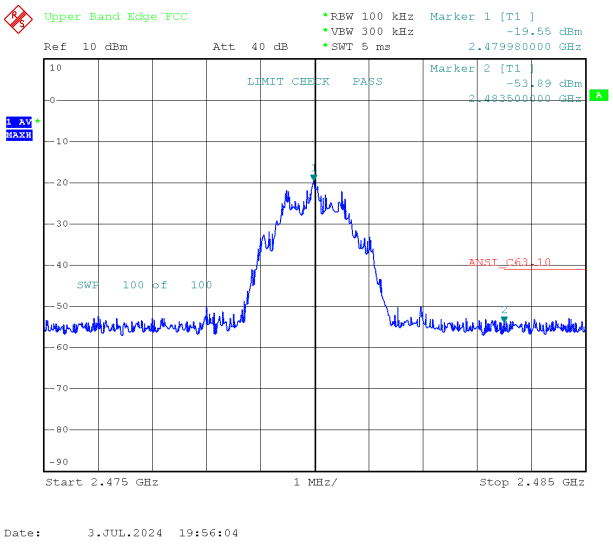

Figure 34. Upper Band Edge (FCC ANSI) (2 Msps)

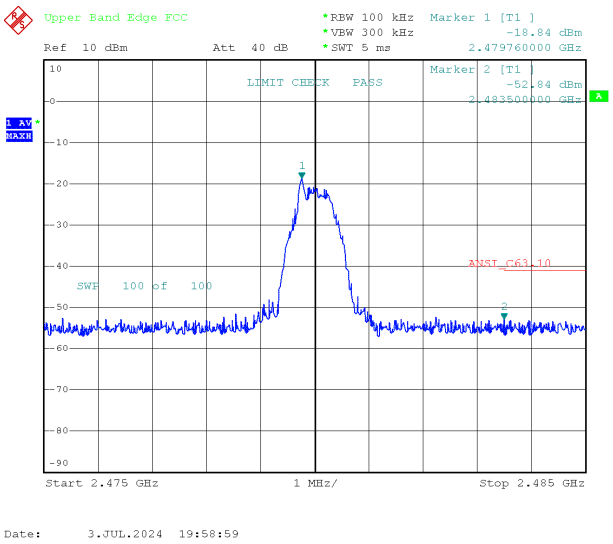

Figure 35. Upper Band Edge (FCC ANSI) (500 Ksps)

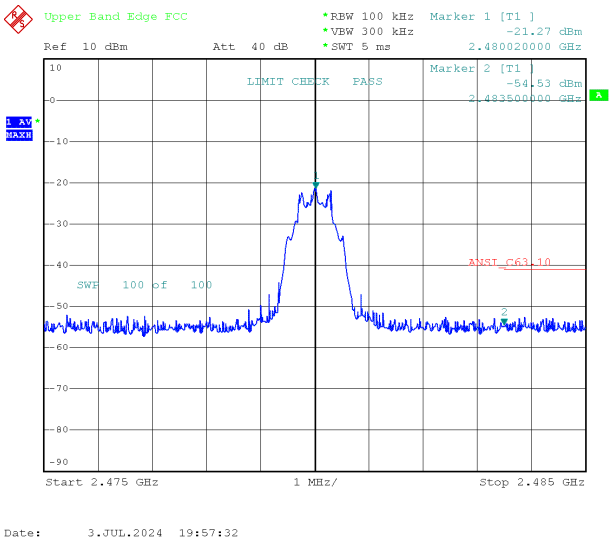

Figure 36. Upper Band Edge (FCC ANSI) (125 Ksps)

Results

Table 19. Upper Band Edge (FCC ANSI) – Channel 39

Modulation	1 Msps	2 Msps	500 Ksps	125 Ksps
Level @2.4835GHz	-53.92 dBm	-53.89 dBm	-52.84 dBm	-54.53 dBm

FCC limit: <-41.15 dBm

Conclusion:

- The board passes the Upper Band Edge FCC Certification.
- There is a minimum of 11.69 dB margin.

3.3.1.10 Out Of Band (ETSI 300, 328 Chapter 5.4.8.2.1)

Test method:

- Set the radio to:
  - TX mode, modulated, continuous mode, TX output power = +10 dBm
- Set the analyzer to:
  - Start frequency = 2.475 GHz, Stop frequency=2.485 GHz, Ref amp=-20 dBm, sweep time=100 ms,
  - RBW = 1 MHz, Video BW = 3 MHz Detector = RMS
  - Average mode: power
  - Number of Sweeps = 100
- Set the channel 39 (2.48 GHz)
- Trace mode: Max hold

Results:

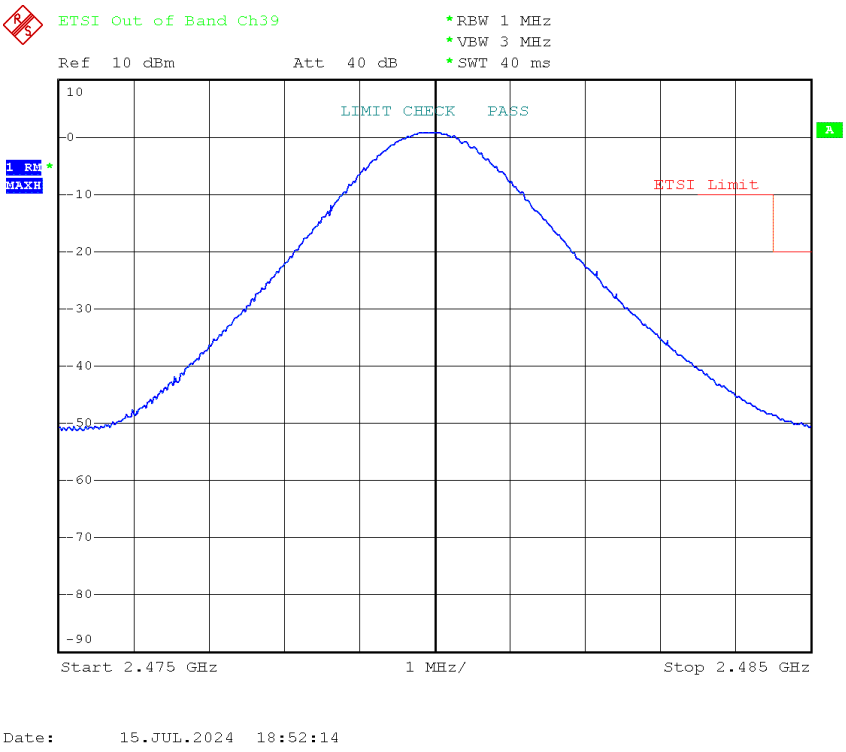

Figure 37. Out Of Band (ETSI 300) test – Channel 39 (1 Msps)

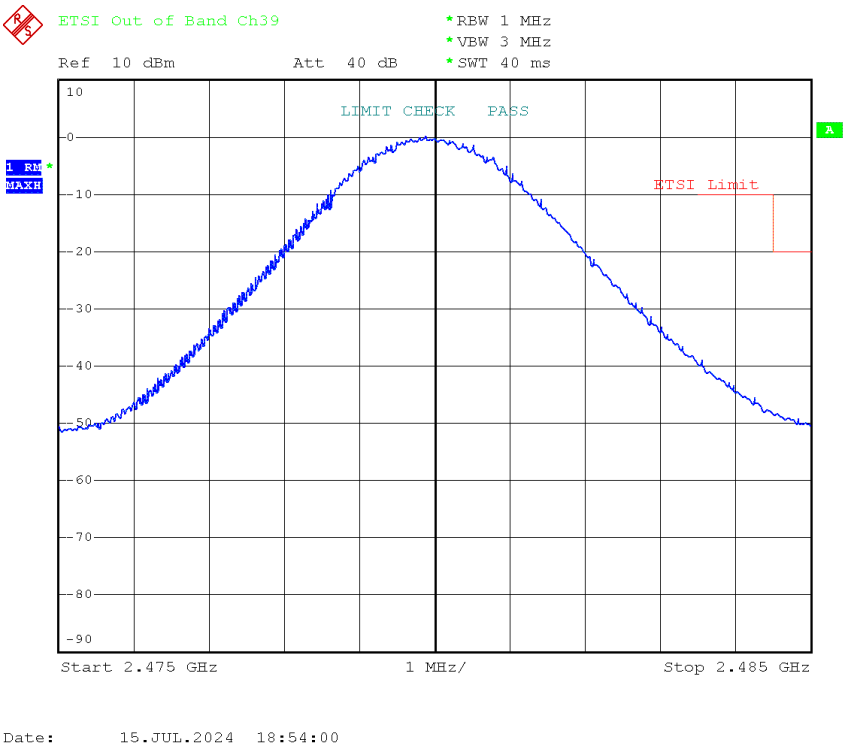

Figure 38. Out Of Band (ETSI 300) test – Channel 39 (2 Msps)

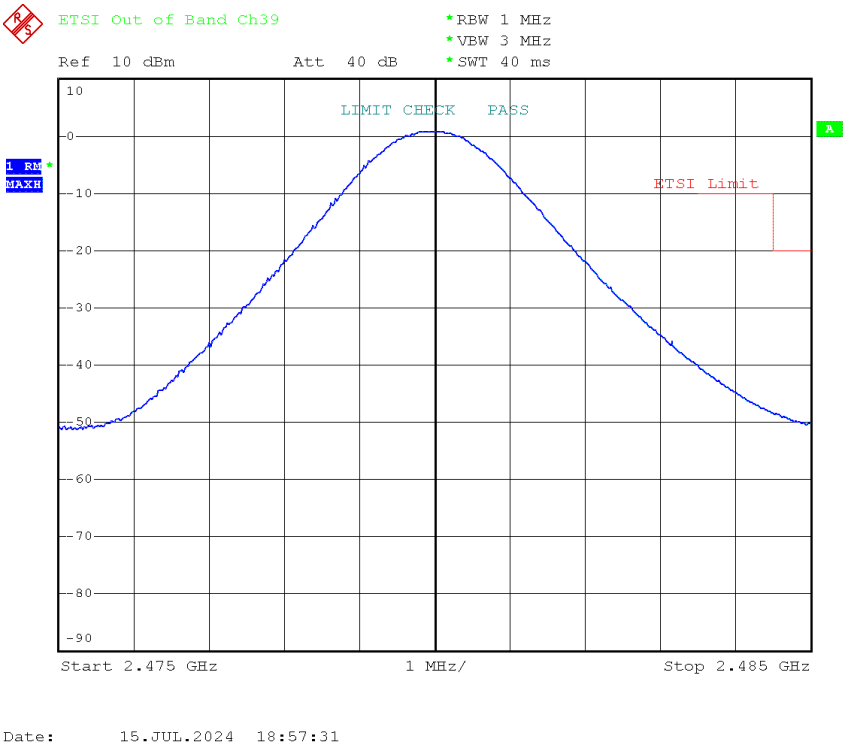

Figure 39. Out Of Band (ETSI 300) test – Channel 39 (500 Ksps)

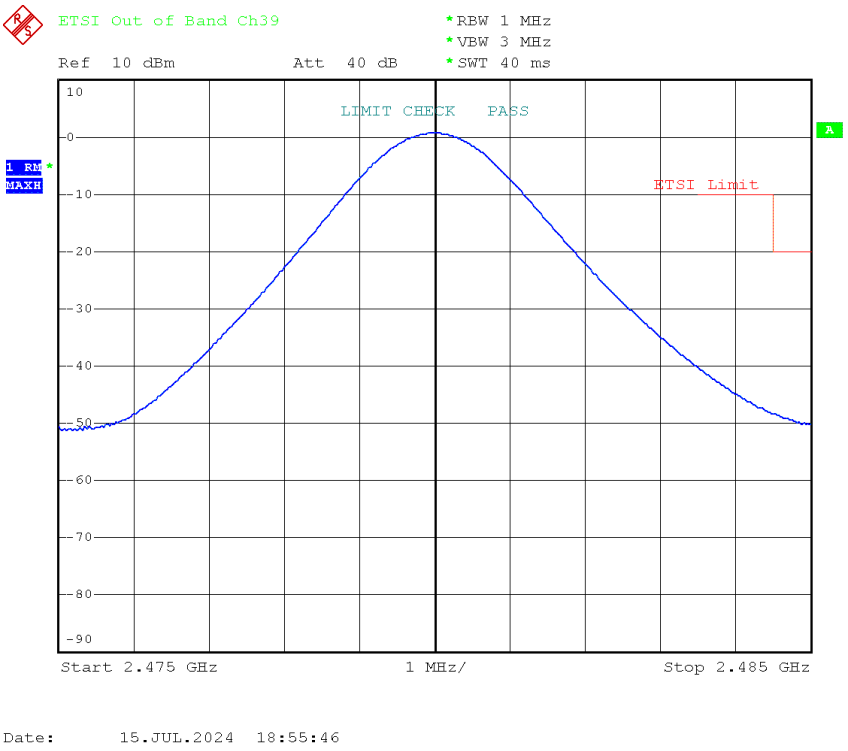

Figure 40. Out Of Band (ETSI 300) test – Channel 39 (125 Ksps)

Conclusion

- The FRDM-MCXW71 passes the ETSI limit.
- There is a 28.5 dB margin below the limit.

3.3.1.11 Out Of Band (ARIB STD T-66)

Test method:

Set the radio to:

- TX mode, modulated, continuous mode, TX output power = +10 dBm
- Set the analyzer to:
  - Start frequency = 2.475 GHz, Stop frequency=2.485 GHz, Ref amp=-20 dBm, sweep time=100 ms,
  - RBW = 1 MHz, Video BW = 1 MHz Detector = Peak
  - Average mode: power Number of Sweeps = 100
- Set the channel 37 (2.402 GHz) and 39 (2.48 GHz) Trace mode: Max hold

Detailed results of Channel 37:

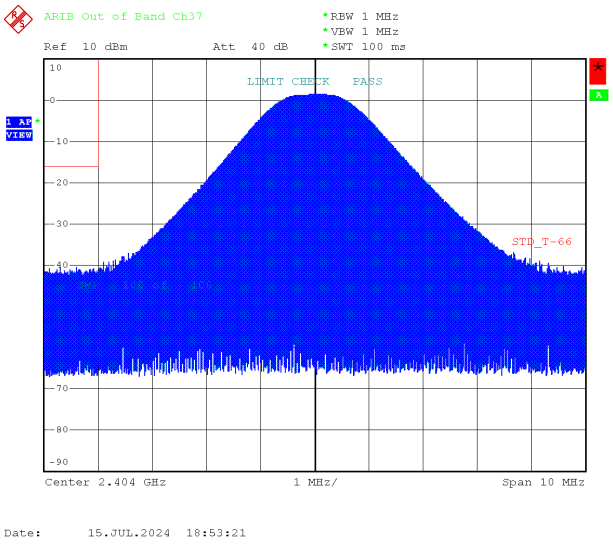

Figure 41. Out of Band 1 Msps Channel 37 ARIB

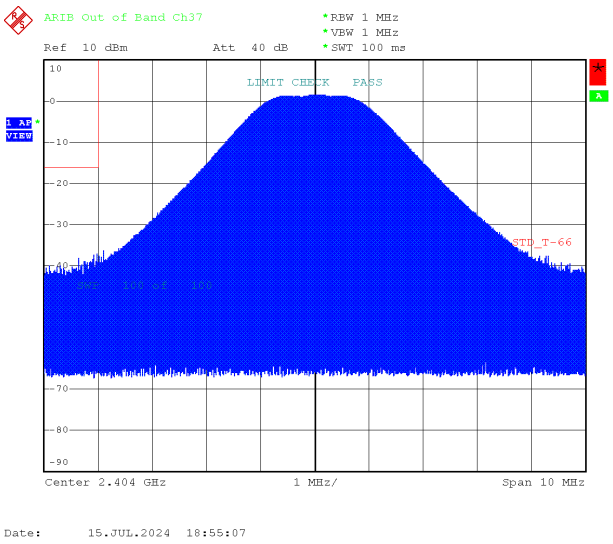

Figure 42. Out of Band 2 Msps Channel 37 ARIB

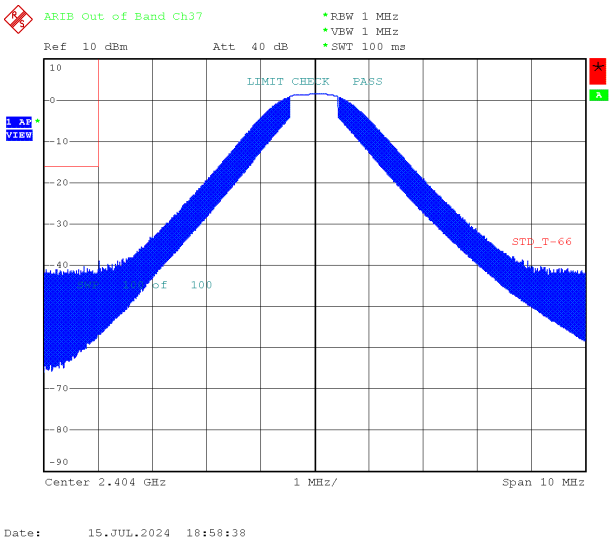

Figure 43. Out of Band 500 Ksps Channel 37 ARIB

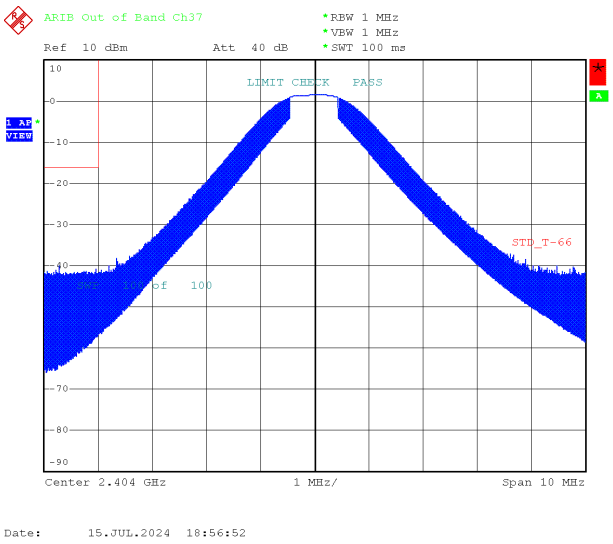

Figure 44. Out of Band 125 Ksps Channel 37 ARIB

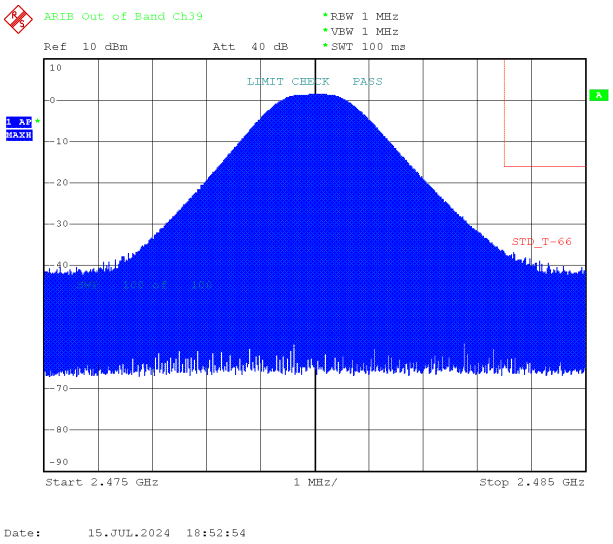

Figure 45. Out of Band 1 Msps Channel 39 ARIB

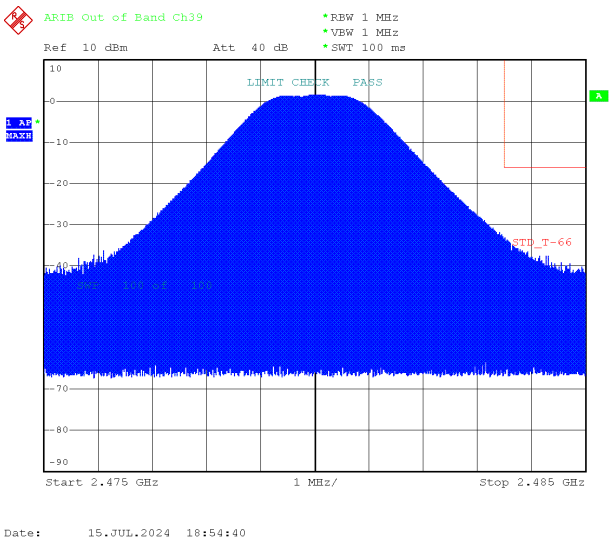

Figure 46. Out of Band 2 Msps Channel 39 ARIB

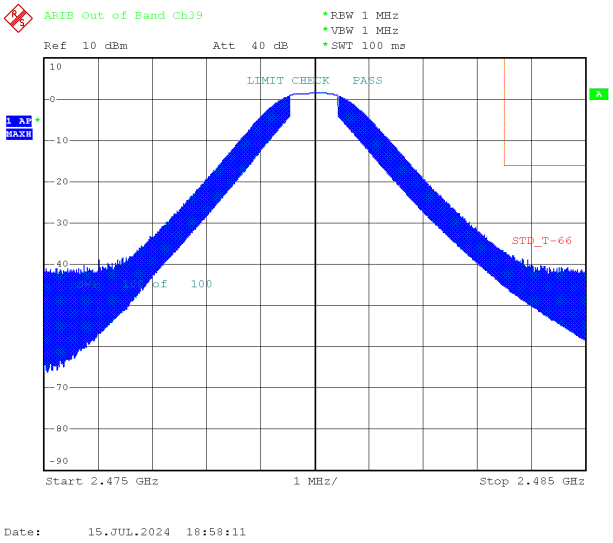

Figure 47. Out of Band 500 Ksps Channel 39 ARIB

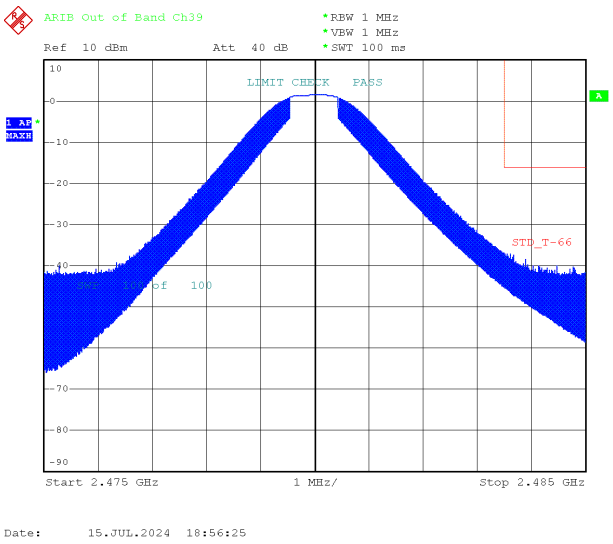

Figure 48. Out of Band 125 Ksps Channel 39 ARIB

Conclusion:

- The FRDM-MCXW71 passes the ARIB limit.
- There is a 21.04 dB margin below the limit.

3.3.1.12 Maximum Tx output power

A CMW equipment is used to measure the PER at the maximum Tx output power.

Flashed SW: A specific binary is flashed: `hci_bb.bin` (available in the Bluetooth application examples)

Test method:

- Generator for the desired signal: CMW R&S
- Criterion: PER < 30.8 % with 1500 packets
- BLE Channels under test: 37 (2.402 GHz), 17 (2.440 GHz) and 39 (2.480 GHz),

Result:

Table 20. Maximum Tx output power Bluetooth LE 1 Msps

BLE Channel	Power Type	Measured (dBm)	Lower Limit (dBm)	Upper Limit (dBm)	Status
37	Average	**8.61**	*-20.0*	*20.0*	PASS
	Peak	**8.97**	*None*	*13.72*	PASS
17	Average	**8.48**	*-20.0*	*20.0*	PASS
	Peak	**8.9**	*None*	*13.58*	PASS
39	Average	**8.46**	*-20.0*	*20.0*	PASS
	Peak	**8.88**	*None*	*13.35*	PASS

Conclusion: The FRDM-MCXW71 board passes the BLE BV-01-C test.

3.3.1.13 Bluetooth LE Tx Output Spectrum

A CMW equipment is used to measure the adjacent channel power.

Flashed SW: A specific binary is flashed: hci_bb.bin (available in the Bluetooth application examples)

Test method:

- Generator for the desired signal: CMW R&S
- Criterion: PER < 30.8 % with 1500 packets
- BLE Channels under test: 2 (2.408 GHz), 17 (2.440 GHz) and 35 (2.476 GHz)

Result:

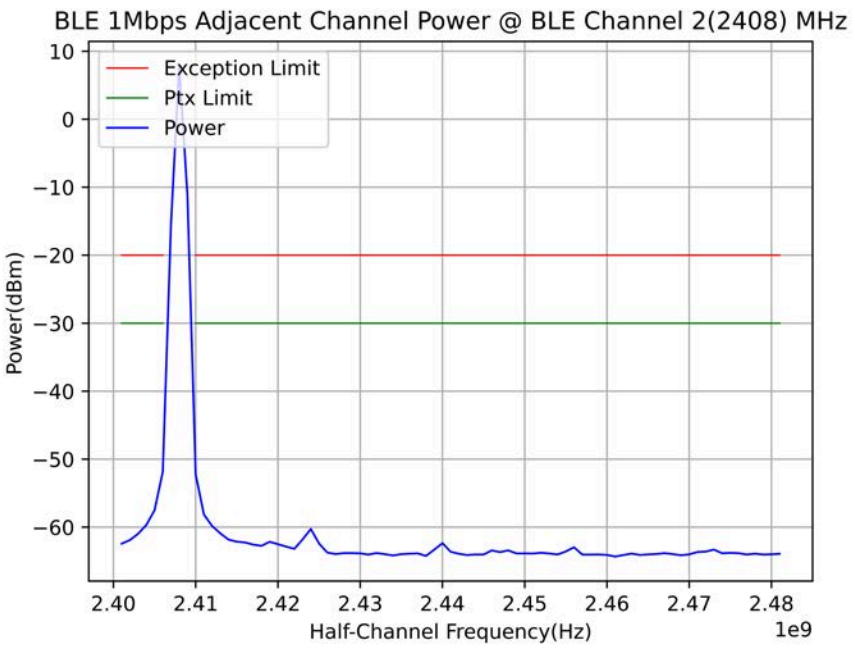

Figure 49. Bluetooth LE Tx output spectrum, Channel 2

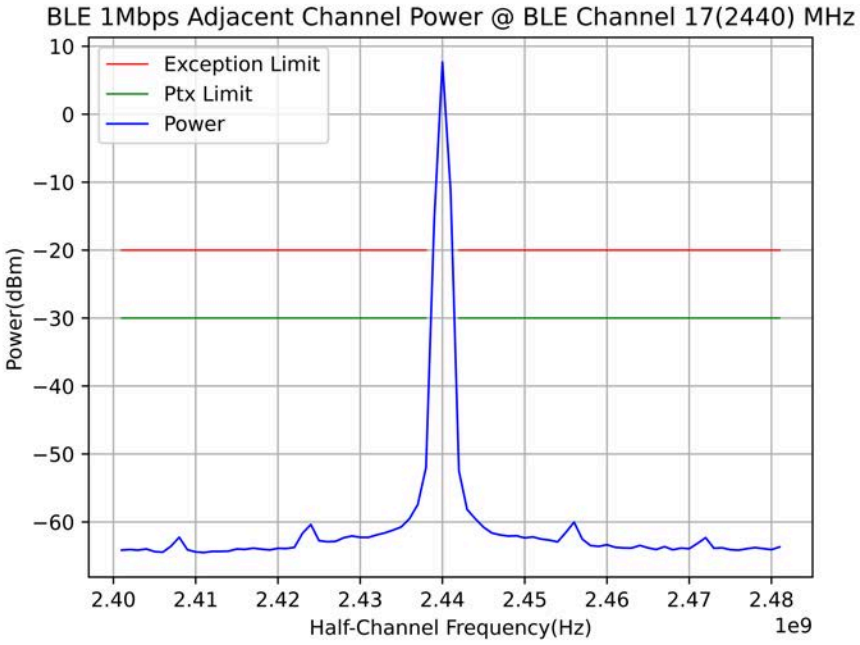

Figure 50. Bluetooth LE Tx output spectrum, Channel 17, 1 Msps

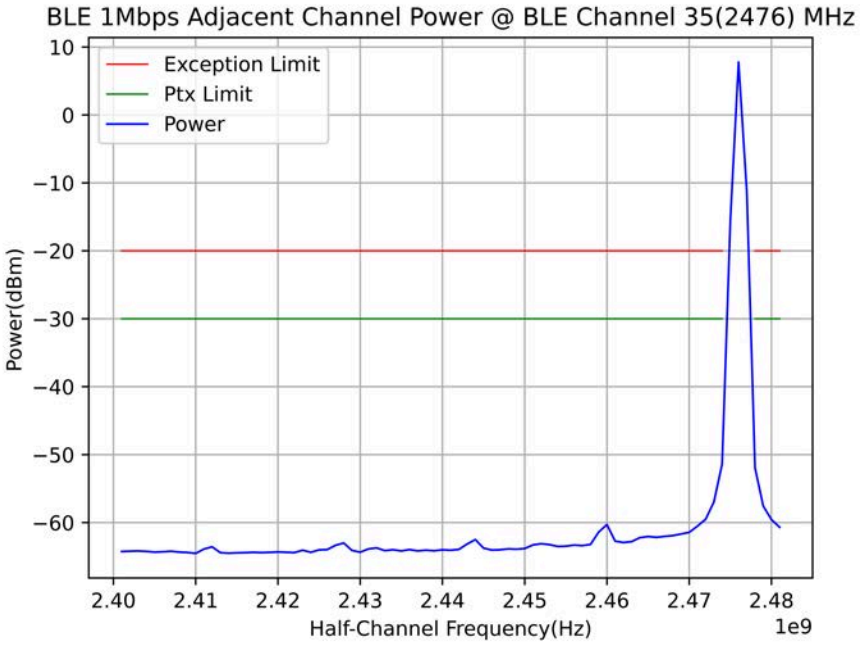

Figure 51. Bluetooth LE Tx output spectrum, Channel 35

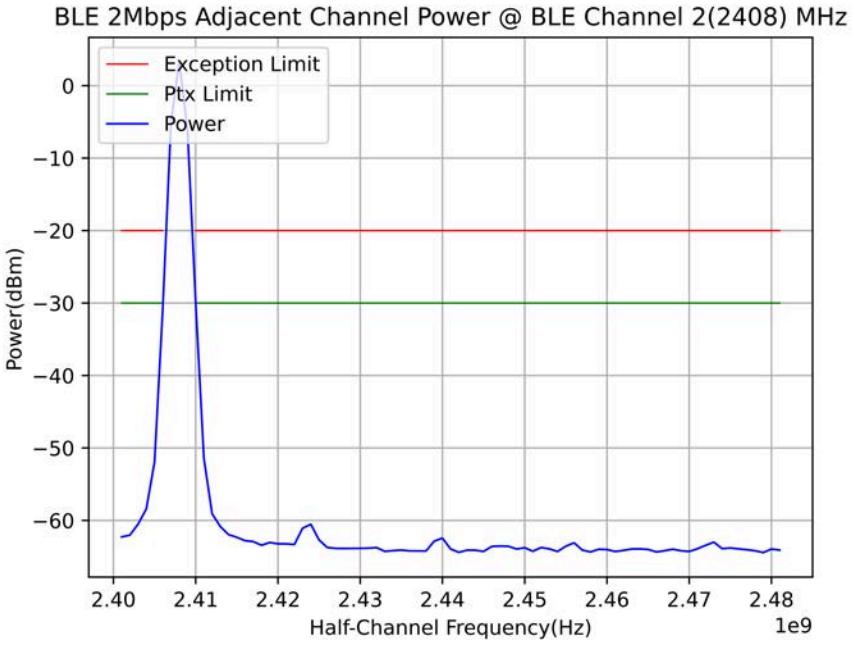

Figure 52. Channel 2, 2 Msps

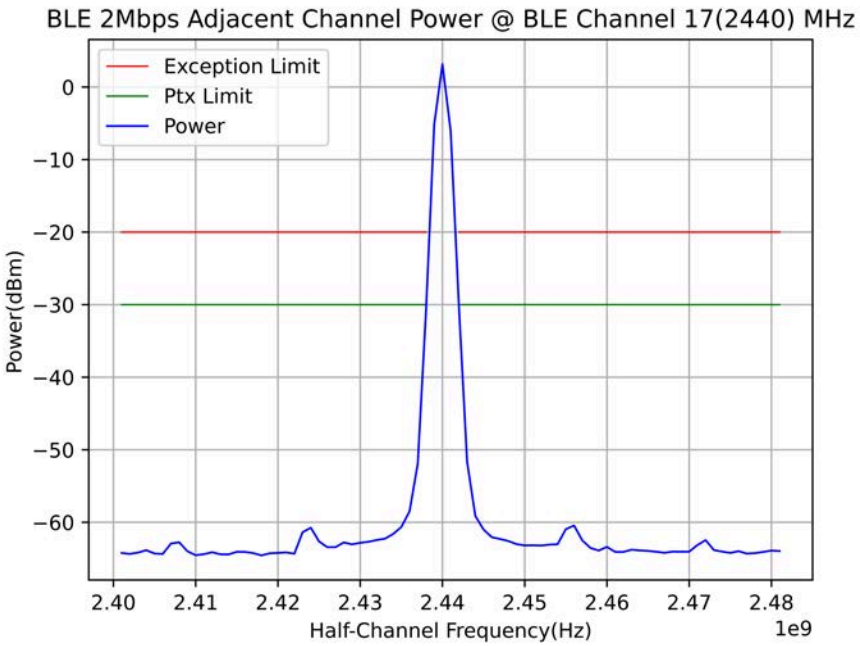

Figure 53. Channel 17, 2 Msps

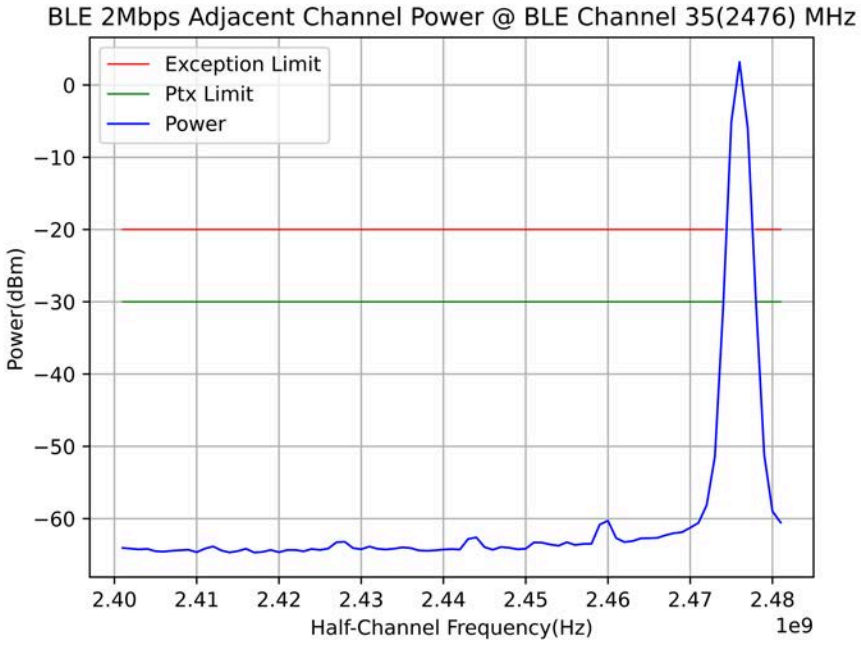

Figure 54. Channel 35, 2 Msps

3.3.1.14 Modulation characteristics

A CMW equipment is used to measure the frequency deviation df1 and df2.

Flashed SW: A specific binary is flashed: `hci_bb.bin` (available in the Bluetooth application examples)

Test method:

- Generator for the desired signal: CMW R&S
- Criterion: PER < 30.8 % with 1500 packets
- BLE Channels under test: 37 (2402 MHz), 17 (2440 MHz) and 39 (2480 MHz),

Result:

Table 21. Modulation characteristics result at 1 Msps

BLE Channel	Frequency Deviation Type	Measured	Lower Limit	Upper Limit	Status
37	df1 Average (Hz)	**252886.8**	*225000.0*	*275000.0*	PASS
	df2 99.9% (Hz)	**208939.6**	*185000.0*	*None*	PASS
	df2 Average / df1 Average	**0.825**	*0.8*	*None*	PASS
17	df1 Average (Hz)	**252737.3**	*225000.0*	*275000.0*	PASS
	df2 99.9% (Hz)	**210138.3**	*185000.0*	*None*	PASS
	df2 Average / df1 Average	**0.826**	*0.8*	*None*	PASS
39	df1 Average (Hz)	**257038.1**	*225000.0*	*275000.0*	PASS
	df2 99.9% (Hz)	**208040.5**	*185000.0*	*None*	PASS

Table 21. Modulation characteristics result at 1 Msps...*continued*

BLE Channel	Frequency Deviation Type	Measured	Lower Limit	Upper Limit	Status
	df2 Average / df1 Average	**0.809**	*0.8*	*None*	PASS

Table 22. Modulation characteristics at 2 Msps

BLE Channel	Frequency Deviation Type	Measured	Lower Limit	Upper Limit	Status
37	df1 Average (Hz)	**511918.1**	*450000.0*	*550000.0*	PASS
	df2 99.9% (Hz)	**414083.0**	*370000.0*	*None*	PASS
	df2 Average / df1 Average	**0.808**	*0.8*	*None*	PASS
17	df1 Average (Hz)	**499804.0**	*450000.0*	*550000.0*	PASS
	df2 99.9% (Hz)	**410486.7**	*370000.0*	*None*	PASS
	df2 Average / df1 Average	**0.82**	*0.8*	*None*	PASS
39	df1 Average (Hz)	**500343.8**	*450000.0*	*550000.0*	PASS
	df2 99.9% (Hz)	**411485.7**	*370000.0*	*None*	PASS
	df2 Average / df1 Average	**0.821**	*0.8*	*None*	PASS

Table 23. Modulation characteristics at LE coded (S8)

BLE Channel	Frequency Deviation Type	Measured	Lower Limit	Upper Limit	Status
37	df1 Average (Hz)	**252759.5**	*225000.0*	*275000.0*	PASS
	df1 99.9% (Hz)	**244015.7**	*185000.0*	*None*	PASS
17	df1 Average (Hz)	**252790.2**	*225000.0*	*275000.0*	PASS
	df1 99.9% (Hz)	**244415.8**	*185000.0*	*None*	PASS
39	df1 Average (Hz)	**255425.9**	*225000.0*	*275000.0*	PASS
	df1 99.9% (Hz)	**236214.4**	*185000.0*	*None*	PASS

Conclusion: The FRDM-MCXW71 passes the Modulation Characteristics test.

3.3.1.15 Carrier frequency offset and drift

A CMW equipment is used to measure the frequency deviation df1 and df2.

Flashed SW: A specific binary is flashed: hci_bb.bin (available in the Bluetooth application examples)

Test method:

- Generator for the desired signal: CMW270 R&S
- Criterion: PER < 30.8 % with 1500 packets

BLE Channels under test: 37, 17, and 39

Result: for BLE Channels under test: 37, 17, and 39

Table 24. Carrier frequency offset and drift at 1 Msps

BLE Channel	Measure Type	Measured	Lower Limit	Upper Limit	Status
37	Frequency Accuracy (Hz)	**23815.39**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**2293.35**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**1105.07**	*-20000*	*20000*	PASS
	Frequency Offset (Hz)	**24893.05**	*-150000*	*150000*	PASS
	Initial Frequency Drift (Hz)	**1571.18**	*-20000*	*20000*	PASS
17	Frequency Accuracy (Hz)	**23594.38**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**2175.57**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**-1162.29**	*-20000*	*20000*	PASS
	Frequency Offset (Hz)	**25222.78**	*-150000*	*150000*	PASS
	Initial Frequency Drift (Hz)	**1461.27**	*-20000*	*20000*	PASS
39	Frequency Accuracy (Hz)	**27233.12**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**-3113.03**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**-1470.57**	*-20000*	*20000*	PASS
	Frequency Offset (Hz)	**27233.12**	*-150000*	*150000*	PASS
	Initial Frequency Drift (Hz)	**-1122.24**	*-20000*	*20000*	PASS

Table 25. Result: for Carrier frequency offset and drift at 2 Msps

BLE Channel	Measure Type	Measured	Lower Limit	Upper Limit	Status
37	Frequency Accuracy (Hz)	**22698.4**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**3498.55**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**1626.02**	*-20000*	*20000*	PASS
	Frequency Offset (Hz)	**25129.8**	*-150000*	*150000*	PASS
	Initial Frequency Drift (Hz)	**2335.07**	*-20000*	*20000*	PASS
17	Frequency Accuracy (Hz)	**23648.26**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**2675.06**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50µs)	**1230.72**	*-20000*	*20000*	PASS
	Frequency Offset (Hz)	**25401.12**	*-150000*	*150000*	PASS
	Initial Frequency Drift (Hz)	**1563.07**	*-20000*	*20000*	PASS
39	Frequency Accuracy (Hz)	**26306.15**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**4117.49**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**3422.74**	*-20000*	*20000*	PASS
	Frequency Offset (Hz)	**26550.29**	*-150000*	*150000*	PASS
	Initial Frequency Drift (Hz)	**-3395.08**	*-20000*	*20000*	PASS

Table 26. Carrier frequency offset and drift at 500 ksps, LR (S=2)

500 ksps BLE Channel	Measure Type	Measured	Lower Limit	Upper Limit	Status
37	Frequency Accuracy (Hz)	**24045.94**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**1049.04**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**1013.99**	*-19200*	*19200*	PASS
	Frequency Offset (Hz)	**24297.24**	*-150000*	*150000*	PASS

Table 26. Carrier frequency offset and drift at 500 ksps, LR (S=2)*...continued*

500 ksps BLE Channel	Measure Type	Measured	Lower Limit	Upper Limit	Status
17	Frequency Accuracy (Hz)	**24413.82**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**971.32**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**810.15**	*-19200*	*19200*	PASS
	Frequency Offset (Hz)	**24867.77**	*-150000*	*150000*	PASS
39	Frequency Accuracy (Hz)	**24840.83**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**1057.86**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50µs)	**987.05**	*-19200*	*19200*	PASS
	Frequency Offset (Hz)	**25223.02**	*-150000*	*150000*	PASS

Table 27. Carrier frequency offset and drift at 125 ksps, LR (S=8)

125 ksps BLE Channel	Measure Type	Measured	Lower Limit	Upper Limit	Status
37	Frequency Accuracy (Hz)	**24000.17**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**1536.13**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**-944.85**	*-19200*	*19200*	PASS
	Frequency Offset (Hz)	**24857.04**	*-150000*	*150000*	PASS
17	Frequency Accuracy (Hz)	**24375.92**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**1505.61**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**1053.81**	*-19200*	*19200*	PASS
	Frequency Offset (Hz)	**25174.62**	*-150000*	*150000*	PASS
39	Frequency Accuracy (Hz)	**24771.69**	*-150000*	*150000*	PASS
	Frequency Drift (Hz)	**1550.67**	*-50000*	*50000*	PASS
	Max Drift Rate (Hz/50 µs)	**1126.53**	*-19200*	*19200*	PASS

Table 27. Carrier frequency offset and drift at 125 ksps, LR (S=8)*...continued*

125 ksps BLE Channel	Measure Type	Measured	Lower Limit	Upper Limit	Status
	Frequency Offset (Hz)	**25676.97**	*-150000*	*150000*	PASS

Conclusion: The FRDM-MCXW71 passes the Carrier Frequency Offset and Drift test.

3.3.2 Receiver (Rx) tests

3.3.2.1 Test setup

This section describes Rx tests for BLE.

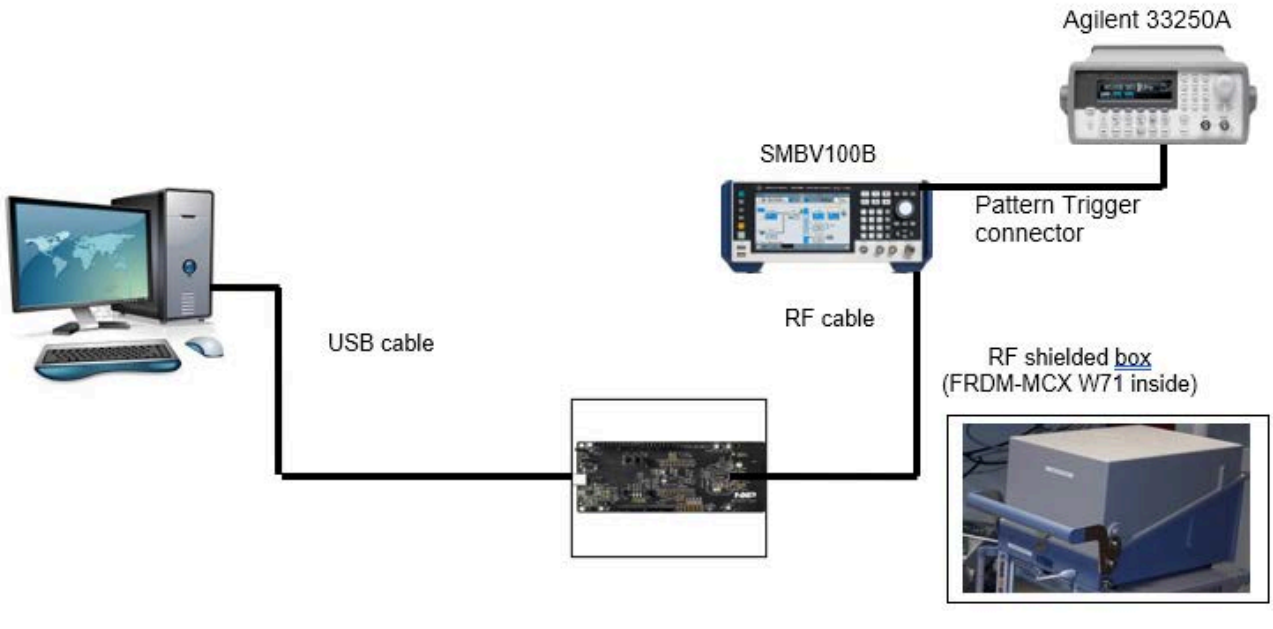

Figure 55. RX test setup for BLE

Conducted Rx test setup for sensitivity with RF generator and Faraday box

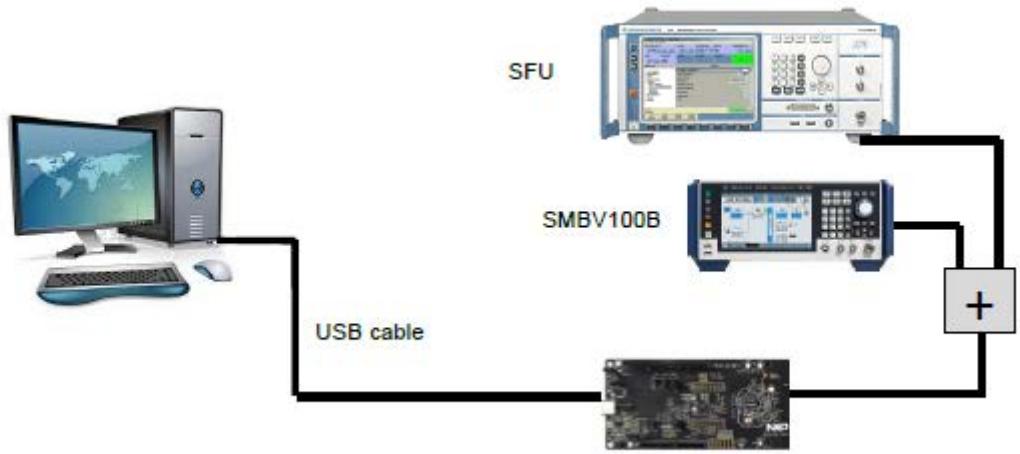

Figure 56. Conducted Rx test setup for interference rejection

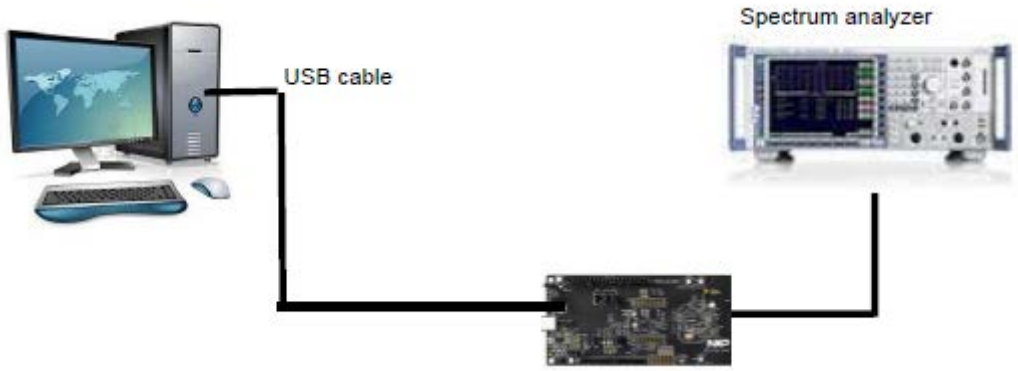

Figure 57. Conducted Rx test setup for spurious

3.3.2.2 Application Test setup RX

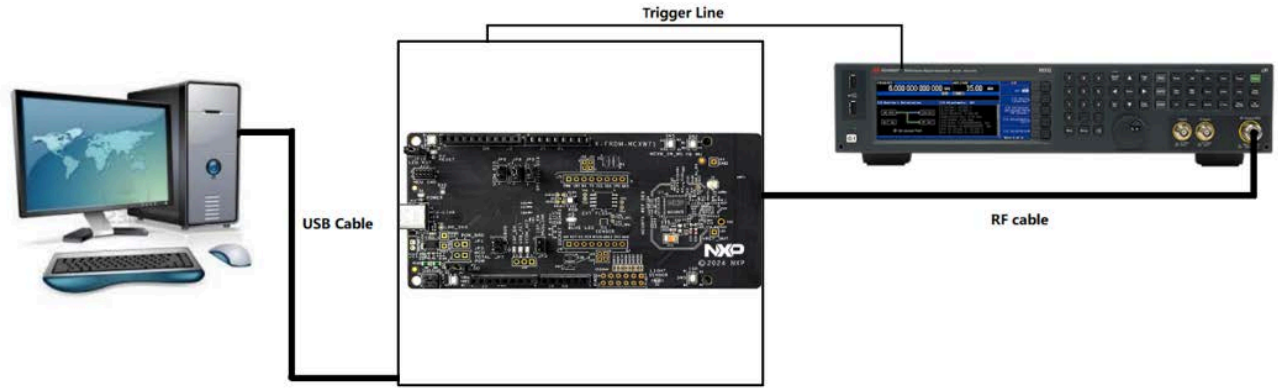

Figure 58. Conducted Rx test setup for sensitivity with RF generator and faraday box

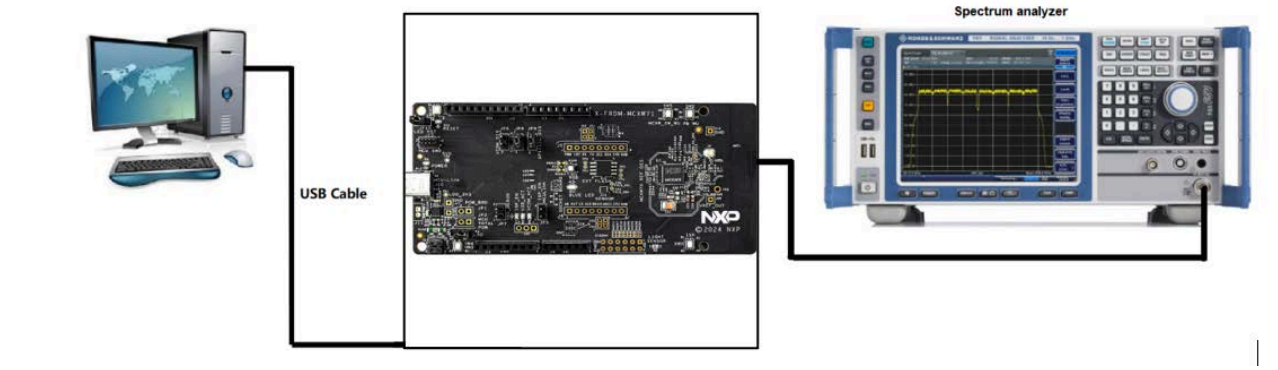

Figure 59. Conducted Rx test setup for spurious

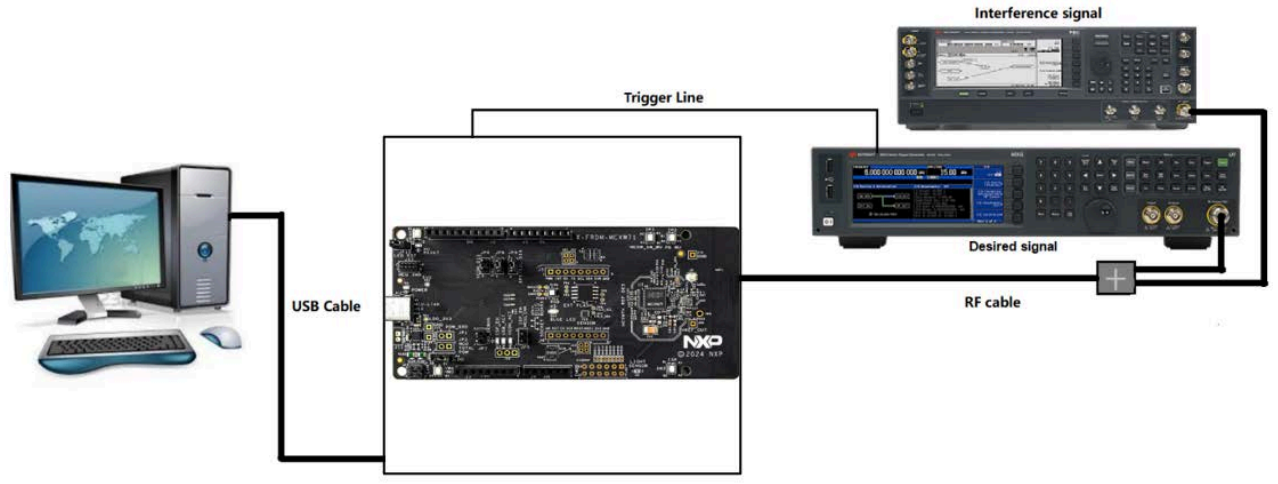

Figure 60. Conducted Rx test setup for interference rejection

3.3.2.3 Sensitivity

3.3.2.3.1 With the ARB generator

Flashed SW: Connectivity test

Test method:

- To remain immune to external parasitic signals, FRDM-MCXW71 is put into an RF shielded box.

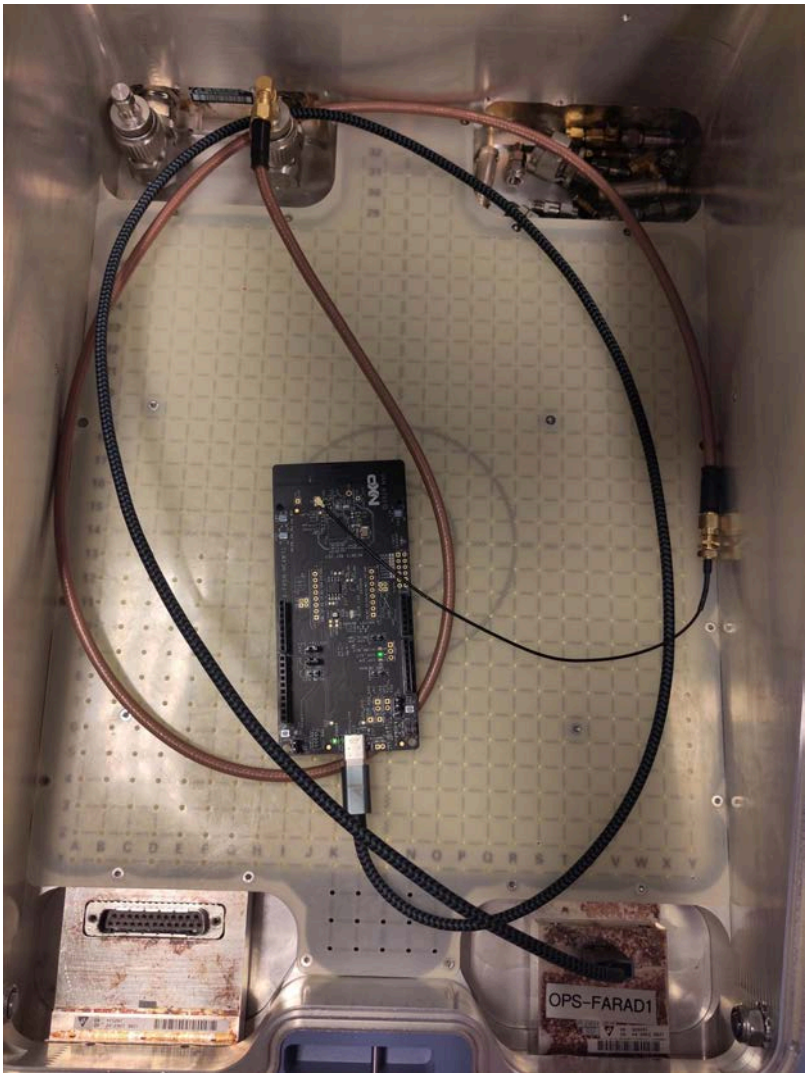

Figure 61. Sensitivity test using the ARB generator

3.3.2.3.1.1 Bluetooth LE

The generator (Agilent NX5181 MXG) is used in the ARB mode to generate a pattern of 1500 packets. The Teraterm window is used to control the module.

- 4 modes are checked: 1 Msps, 2 Msps, LR (S=2) & LR (S=8)
- Set the Channel 0.
- The connection is automatically established and the PER (Packet Error Rate) is measured.

- Decrease the level of the SFU at the RF input of the module until PER = 30.8 %.
- Repeat it up to Channel 39.

3.3.2.3.1.2 Bluetooth LE results (@SMA connector)

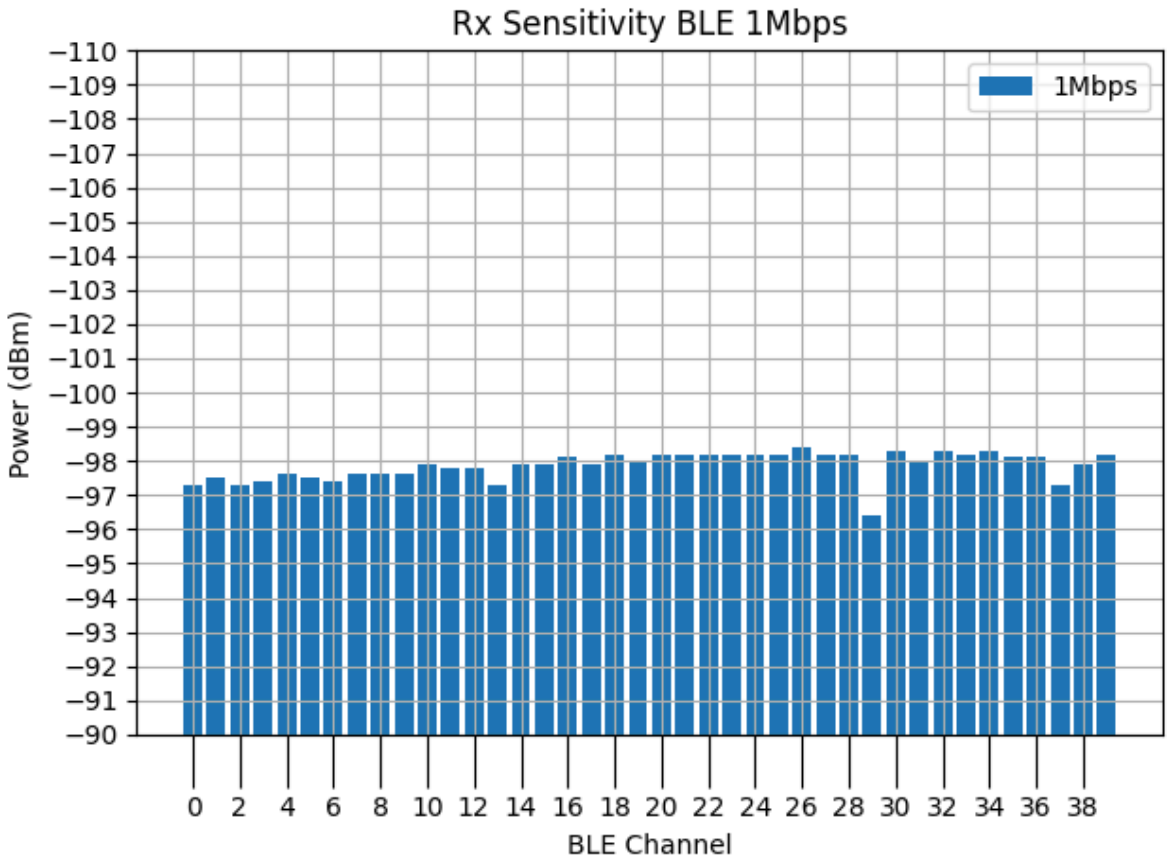

Figure 62. Rx Sensitivity result – 1 Mbps

- The best sensitivity is on channel 16: -98.0 dBm
- The lowest sensitivity is on channel 29: -96.1 dBm
- Delta over channels: 1.9 dB

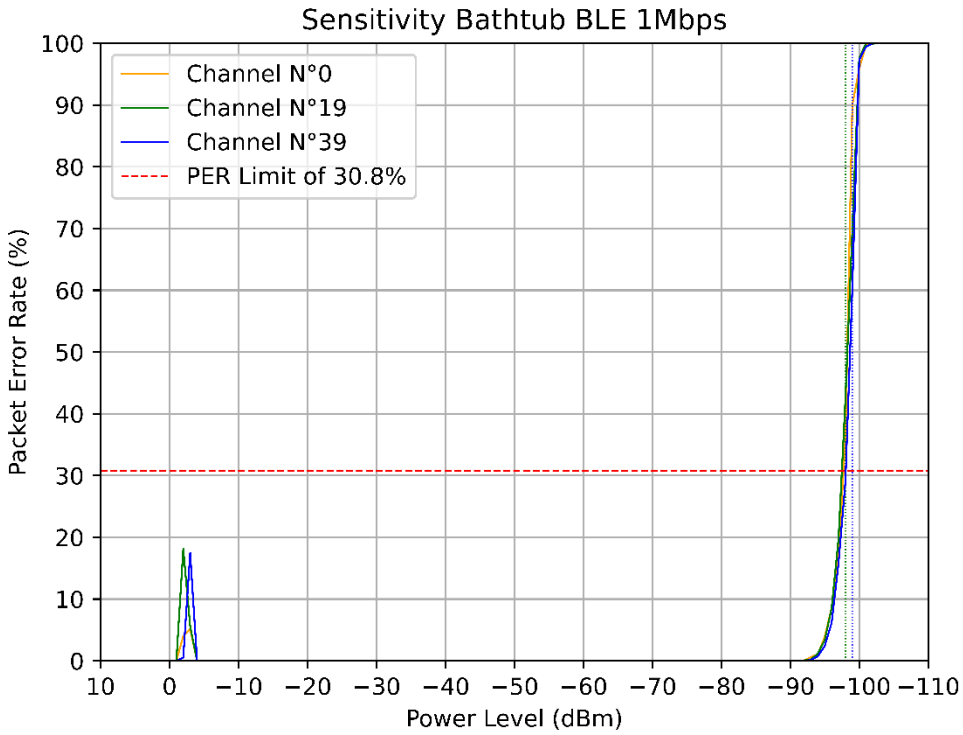

Figure 63. Sensitivity bathtub result – 1 Msps

FRDM-MCXW71 shows an average value of -97.7225 dBm (1 Mbps) at SMA connector.

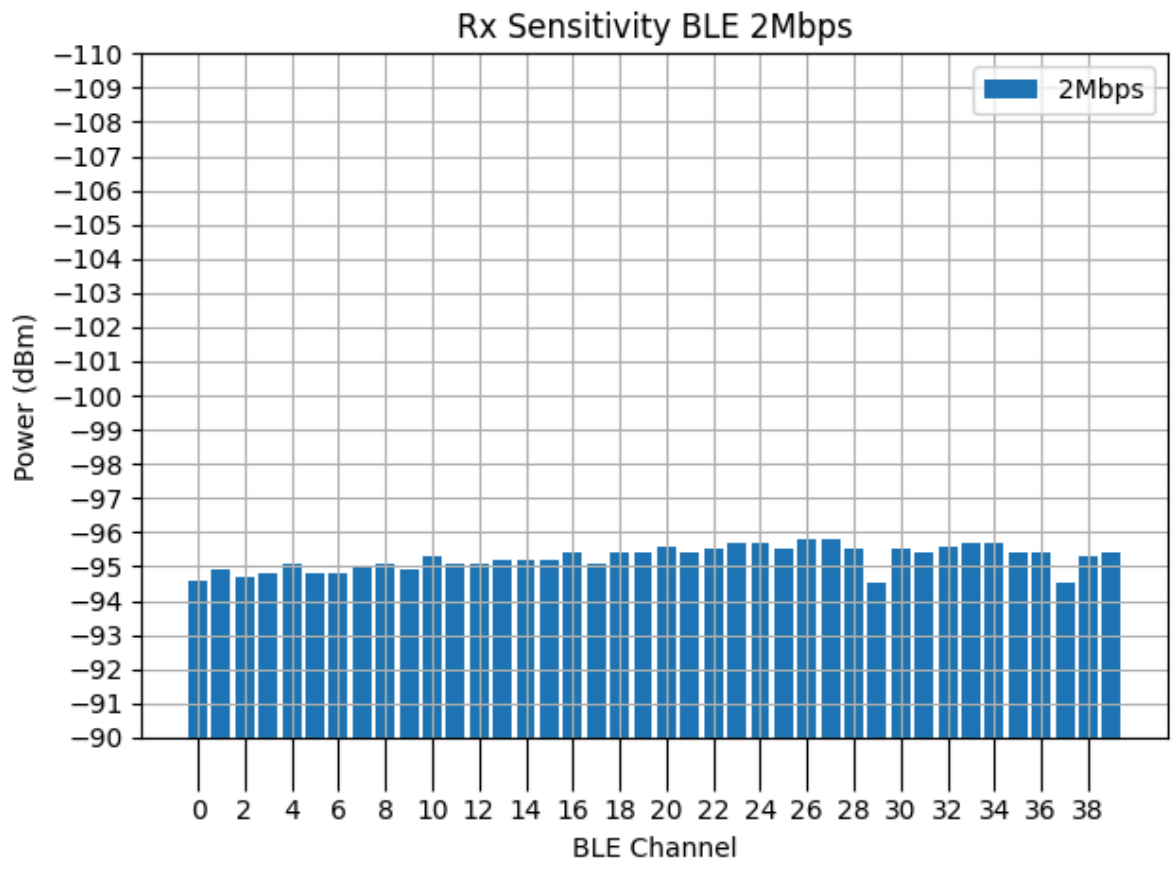

Figure 64. Sensitivity result – 2 Msps

- The best sensitivity is on channel 21: -95.4dBm
- The lowest sensitivity is on channel 29: -94.2 dBm
- Delta over channels: 1.2 dB

FRDM-MCXW71 shows an average value of -95.1 dBm (2 Msps) at SMA connector

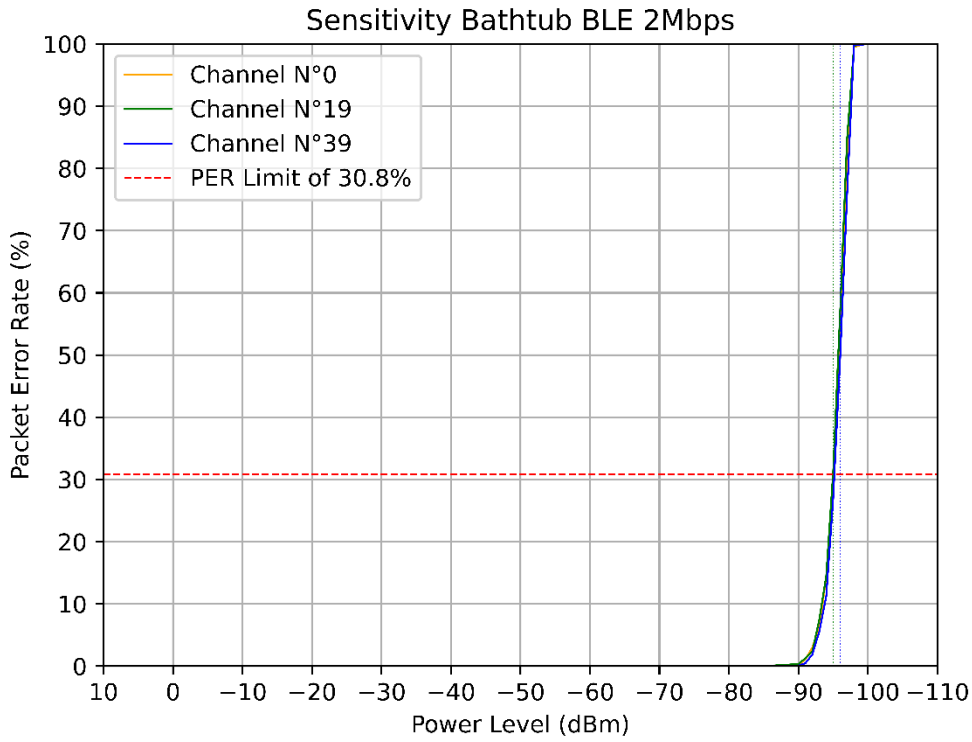

Figure 65. Sensitivity bathtub result – 2 Mbps

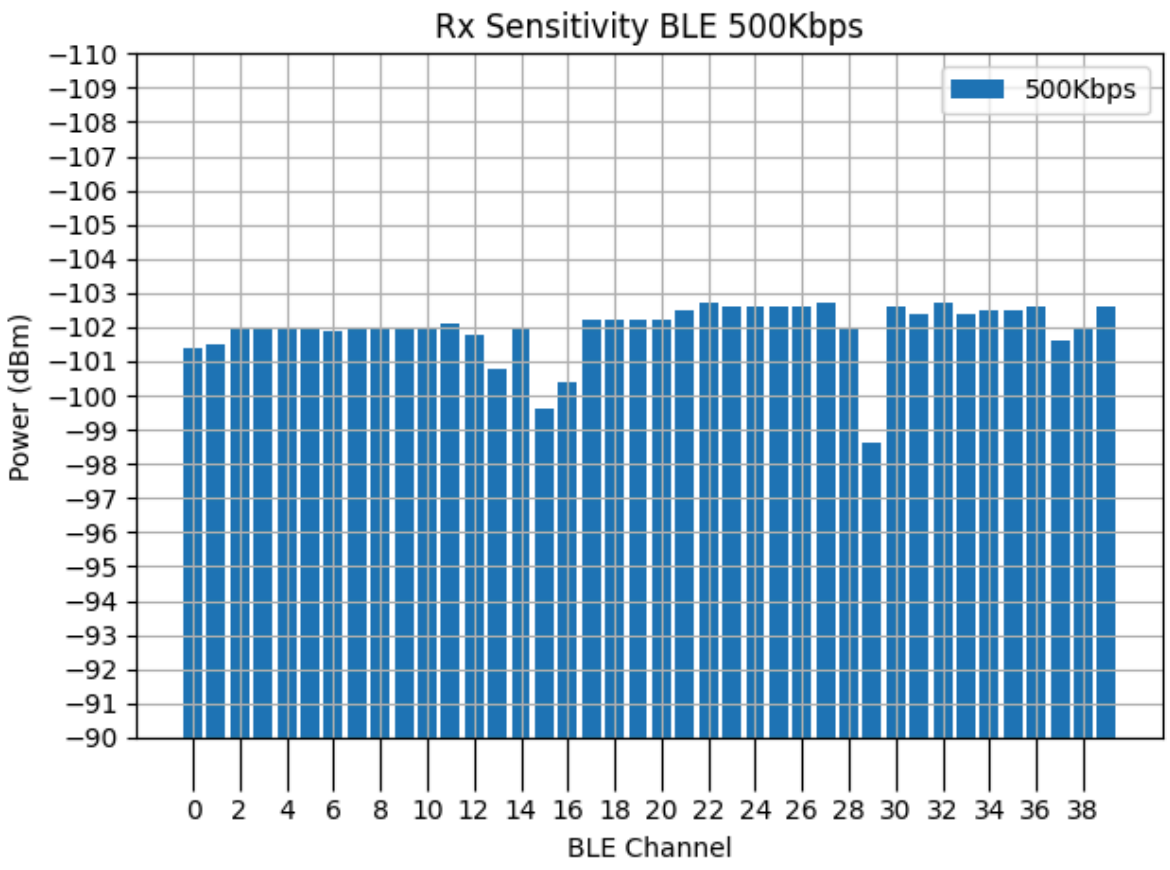

Figure 66. Sensitivity result – LR (S=2)

- The best sensitivity is on channel 23: -102.6 dBm
- The lowest sensitivity is on channel 29: -98.6 dBm
- Delta over channels: 102.6 dB

FRDM-MCXW71 shows an average value of -99.41 dBm (500 Kbps) at SMA connector

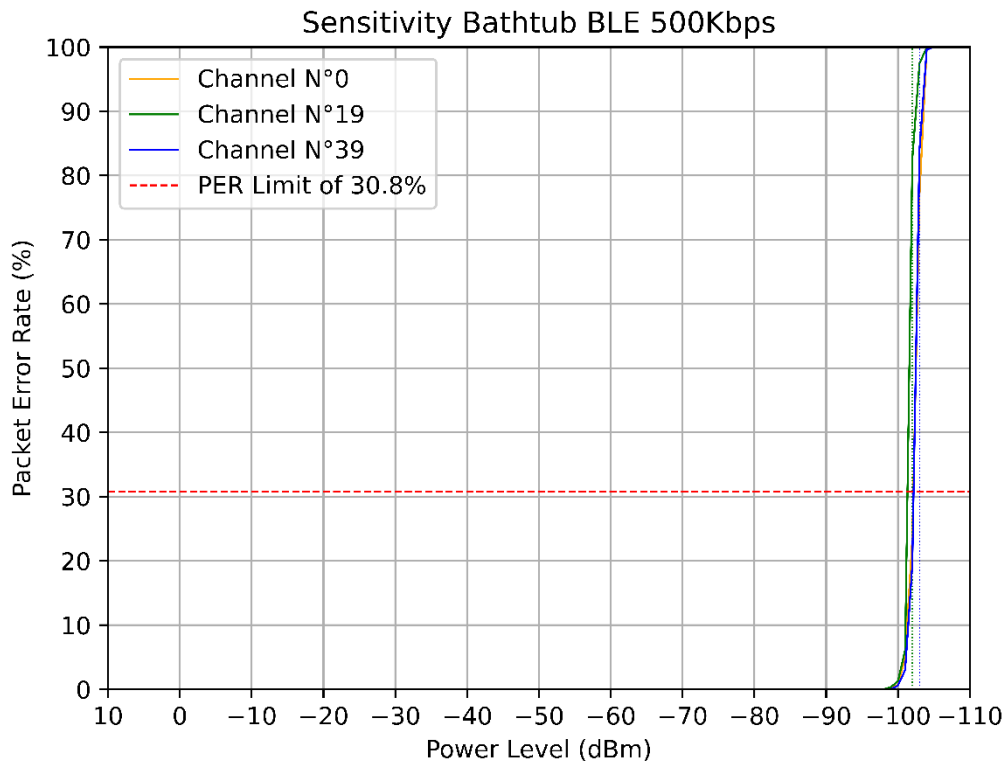

Figure 67. Sensitivity bathtub result – 500 ksps

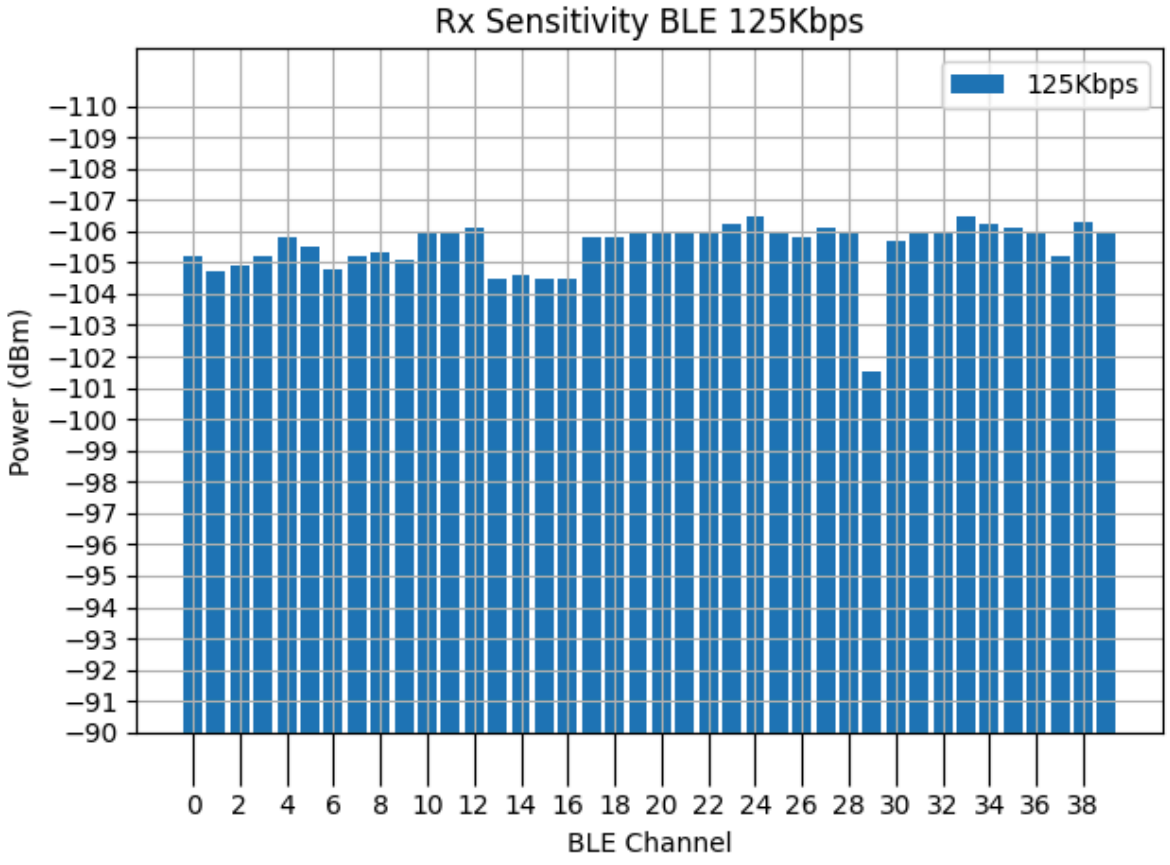

Figure 68. Sensitivity result – LR (S=8)

- The best sensitivity is on channel 16: -106.0 dBm.
- The lowest sensitivity is on channel 29: -100.8 dBm.
- Delta over channels: 5.2 dB

FRDM-MCXW71 shows an average value of -105.6 dBm (125 Ksps) at SMA connector.

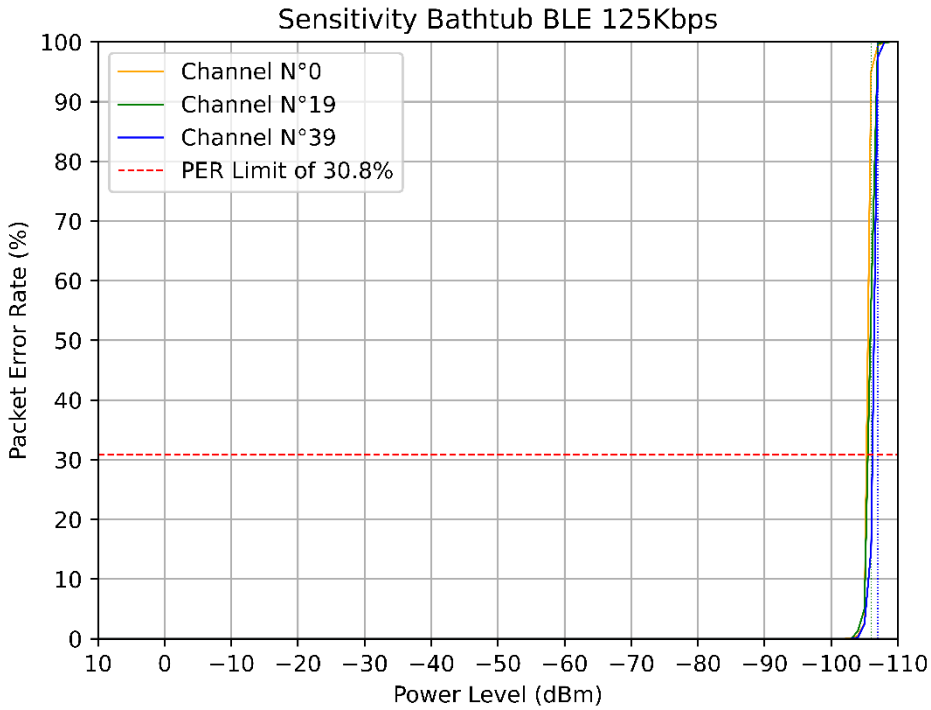

Figure 69. Sensitivity bathtub result – 125 kbps

Conclusion:

FRDM-MCXW71 withstand an average sensitivity level of:

- -97.7225 dBm @1Msps
- -95.1 dBm @2Msps
- -99.41 dBm @LRS2
- -105.495 dBm @LRS8

3.3.2.4 Receiver maximum input level

3.3.2.4.1 Bluetooth LE

Flashed SW: HCI_BB

Test method:

- The same test setup as with the sensitivity test is used but with a CMW270 instrument replacing the combination of RF Generator + ARB Generator.
- The signal level is increased up to the PER = 30.8 % with 1500 packets.

Results:

Table 28. Maximum input power – 1 Msps

BLE Channel	RF Level (dBm)	Packet Error Rate (%)	Lower Limit (%)	Upper Limit(%)	Status
37	0.0	0.0	*None*	*30.8*	Pass
17	0.0	0.0	*None*	*30.8*	Pass
39	0.0	0.0	*None*	*30.8*	Pass

Table 29. Maximum input power – 2 Msps

BLE Channel	RF Level (dBm)	Packet Error Rate (%)	Lower Limit (%)	Upper Limit (%)	Status
37	**0.0**	0.0	*None*	*30.8*	PASS
17	**0.0**	0.0	*None*	*30.8*	PASS
39	**0.0**	0.0	*None*	*30.8*	PASS

Conclusion:

- The maximum input level is superior to 0.0 dBm. The results are limited by the maximum output power of the equipment.

3.3.2.5 RX spurious (BLE)

Flashed SW: Connectivity test

Test method:

- Set the radio to:
  - Receiver mode, frequency: channel 18
- Set the analyzer to:
  - Ref amp = - 20 dBm, Trace = max hold, detector = max peak
  - Start/stop frequency: 30 MHz / 1 GHz
  - RBW = 100 kHz, VBW = 300 kHz
- Then, set the start/stop frequency:
  - 1 GHz / 30 GHz
  - RBW = 1 MHz, VBW = 3 MHz

3.3.2.5.1 Bluetooth LE results

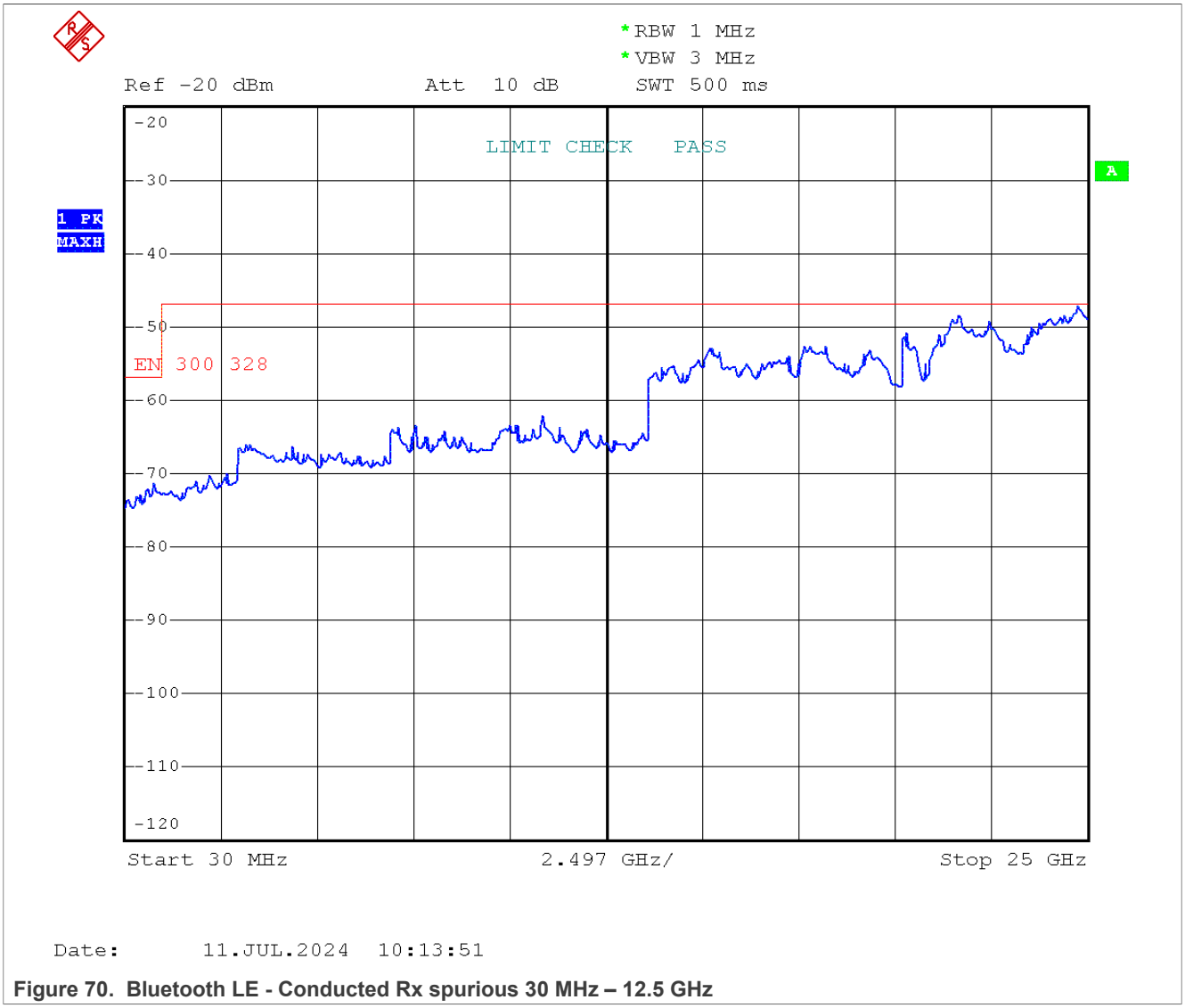

Figure 70. Bluetooth LE - Conducted Rx spurious 30 MHz – 12.5 GHz

Conclusion:

- The FRDM-MCXW71 passes the ETSI limit..

3.3.2.6 Interferer results in Bluetooth

3.3.2.6.1 Receiver interference rejection performances

This section provides the Receiver interference rejection performances for adjacent, alternate, and co-channel rejection results. The tests are conducted for Bluetooth LE at the conditions 1 Msps, 2 Msps, 500 Ksps (LR S=2), and 125 Ksps (LR S=8).

The interferers are located at the adjacent channel (+/-1 MHz, +/-2 MHz, +/-3 MHz) or co-channel. The test is performed with only one interfering unmodulated signal at a time.

Test method:

- Generator for the desired signal: Rhode & Schwarz SMBV100B
- Generator for interferers: R&S SFU
- Criterion: PER < 30.8 % with 1500 packets
- The wanted signal is set to -67dBm, which corresponds to 3 dB over the reference sensitivity level; the interferer is increased until the PER threshold is reached
- BLE Channels under test: 1 (2.406 GHz), 17 (2.440 GHz) and 35 (2.476 GHz).

3.3.2.6.1.1 Test results

Results @ 1 Mbit/s

Table 30. Channel 1 result for Adjacent, alternate, and co-channel rejection 1 Msps

Desired	Channel 1						
frequency (MHz):	*2406*						
Interferer:	N-3MHz (Adjacent)	N-2MHz (Adjacent)	N-1MHz (Adjacent)	N (Co-channel)	N+1 MHz (Adjacent)	N+2MHz (Adjacent)	N+3MHz (Adjacent)
Interferer frequency (MHz)	*2403*	*2404*	*2405*	*2406*	*2407*	*2408*	*2409*
Maximum Interferer level (dBm)	4.0	-20.5	-9.0	-53.0	-12.9	3.1	6.0
Maximum Interferer level (C/I dB)	-71.0	-46.5	-58.0	-14.0	-54.1	-70.1	-73.0
BLE 5.x limit (C/I limit)	-27	-17	15	21	15	-17	-27
Margin (dB)	44.0	29.5	73.0	35.0	69.1	53.1	46.0

Table 31. Channel 17 result for Adjacent, alternate, and co-channel rejection 1 Msps

Wanted	Channel 17						
Wanted frequency (MHz)	*2440*						
Interferer	N-3 MHz (Adjacent)	N-2 MHz (Adjacent)	N-1 MHz (Adjacent)	N (Co-channel)	N+1 MHz (Adjacent)	N+2 MHz (Adjacent)	N+3 MHz (Adjacent)
Interferer frequency (MHz)	*2437*	*2438*	*2439*	*2440*	*2441*	*2442*	*2443*
Maximum Interferer level (dBm)	4.7	-21.7	-10.4	-53.9	-13.1	1.0	5.1
Maximum Interferer	-71.7	-45.3	-56.6	-13.1	-53.9	-68.0	-72.1

Table 31. Channel 17 result for Adjacent, alternate, and co-channel rejection 1 Msps*...continued*

Wanted	Channel 17						
Wanted frequency (MHz)	*2440*						
Interferer	N-3 MHz (Adjacent)	N-2 MHz (Adjacent)	N-1 MHz (Adjacent)	N (Co-channel)	N+1 MHz (Adjacent)	N+2 MHz (Adjacent)	N+3 MHz (Adjacent)
level (C/I dB)							
BLE 5.x limit (C/I limit):	-27	-17	15	21	15	-17	-27
Margin (dB)	44.7	28.3	71.6	34.1	68.9	51.0	45.1

Table 32. Channel 35 result for Adjacent, alternate, and co-channel rejection 1 Msps

Wanted	Channel 35						
Wanted frequency (MHz)	*2476*						
Interferer	N-3 MHz (Adjacent)	N-2 MHz (Adjacent)	N-1 MHz (Adjacent)	N (Co-channel)	N+1 MHz (Adjacent)	N+2 MHz (Adjacent)	N+3 MHz (Adjacent)
Interferer frequency (MHz)	*2473*	*2474*	*2475*	*2476*	*2477*	*2478*	*2479*
Maximum Interferer level (dBm)	4.1	-20.2	-8.8	-52.8	-12.5	1.4	4.0
Maximum Interferer level (C/I dB)	-71.1	-46.8	-58.2	-14.2	-54.5	-68.4	-71.0
BLE 5.x limit (C/I limit)	-27	-17	15	21	15	-17	-27
Margin (dB)	44.1	29.8	73.2	35.2	69.5	51.4	44.0

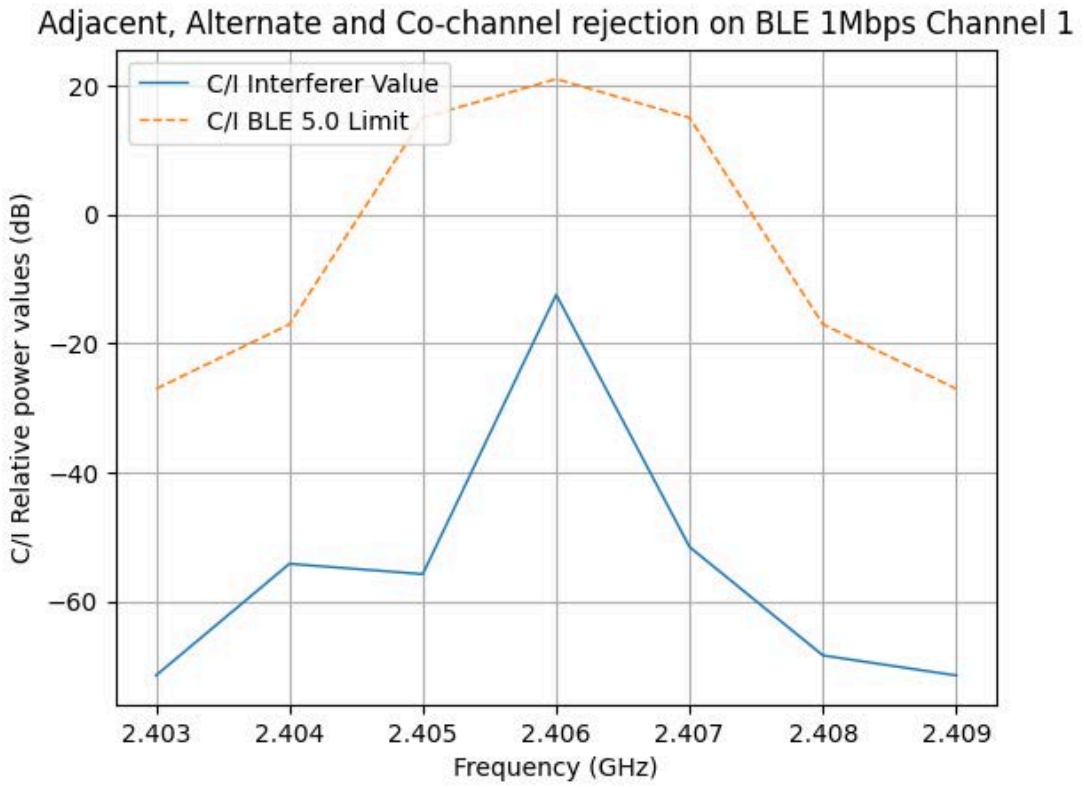

Figure 71. Adjacent, alternate, and co-channel rejection @Channel 1

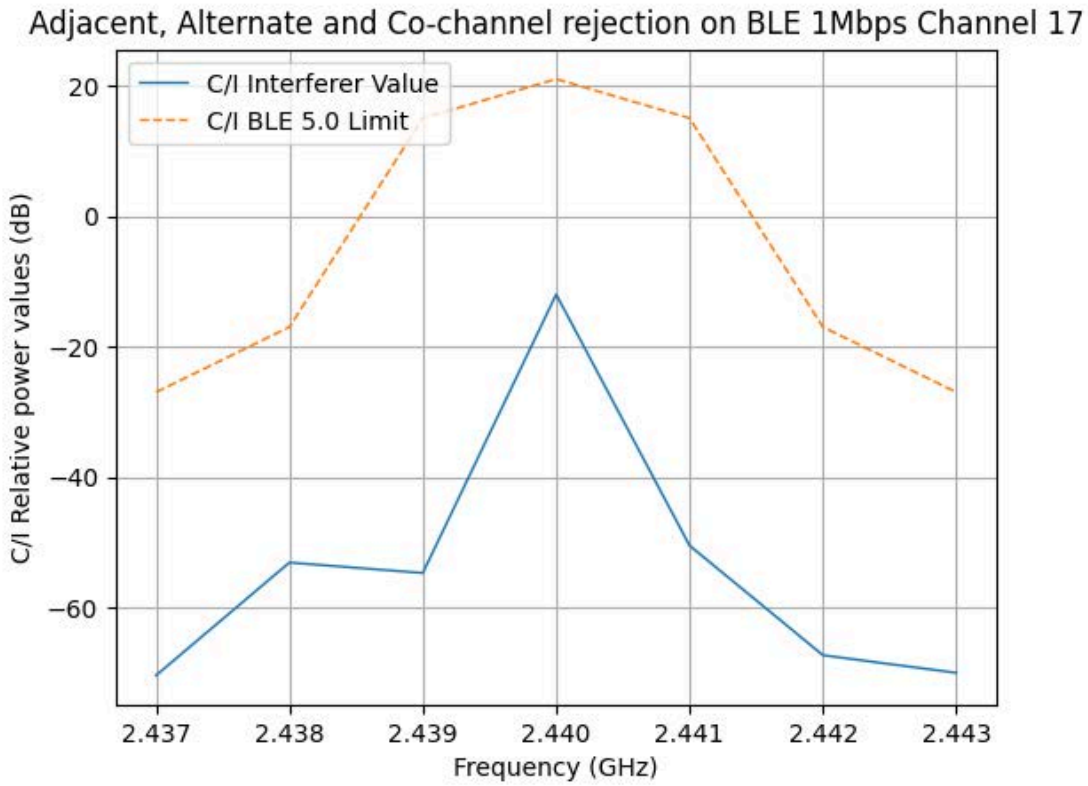

Figure 72. Adjacent, alternate, and co-channel rejection @Channel 17

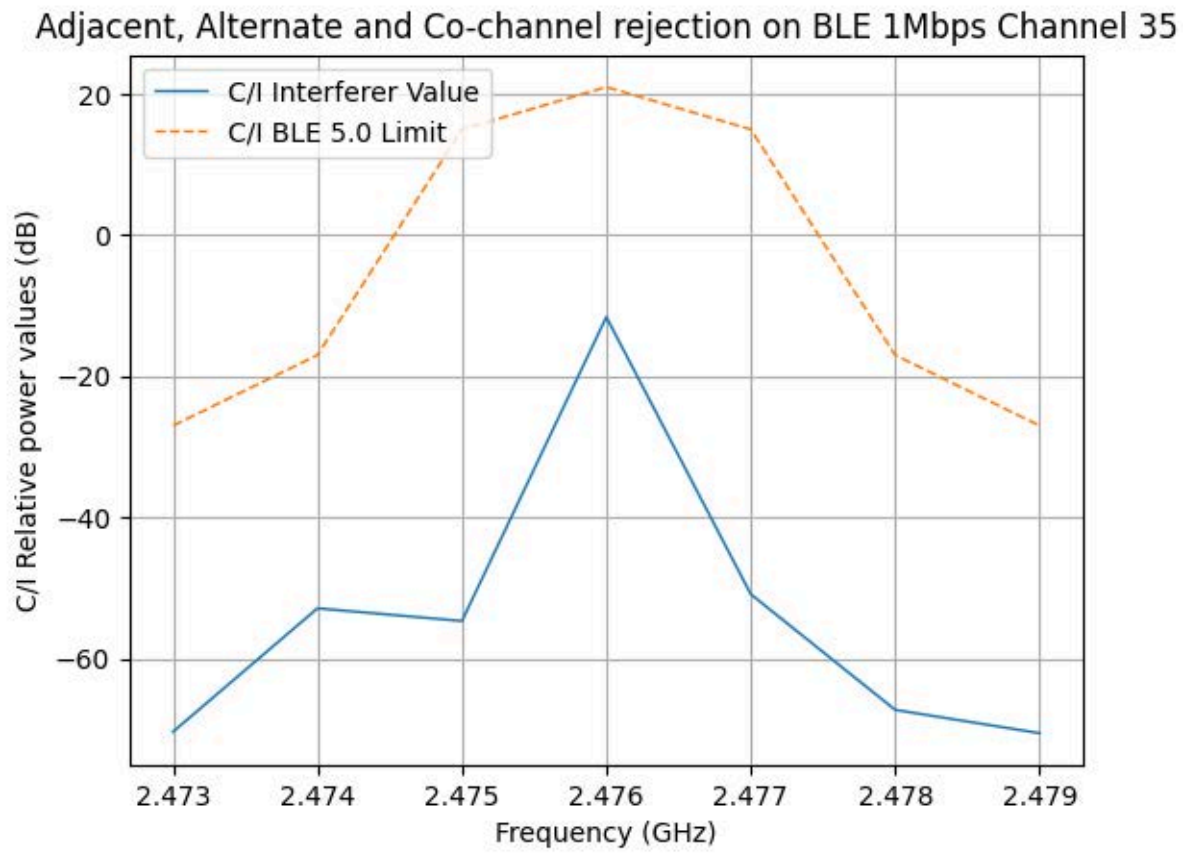

Figure 73. Adjacent, alternate, and co-channel rejection @Channel 35

Conclusion: The FRDM-MCXW71 board passes the BLE certification for this test with a worst margin of 28.3.

Results: Bluetooth LE @2Msps

Table 33. Bluetooth LE @2Msps Channel 1

Wanted:	Channel 1						
Wanted frequency (MHz):	*2406*						
Interferer:	N-6 MHz (Adjacent)	N-4 MHz (Adjacent)	N-2 MHz (Adjacent)	N (Co-channel)	N+2 MHz (Adjacent)	N+4 MHz (Adjacent)	N+6 MHz (Adjacent)
Interferer frequency (MHz):	*2400*	*2402*	*2404*	*2406*	*2408*	*2410*	*2412*
Maximum Interferer level (dBm):	4.0	-24.3	-24.7	-53.6	-4.9	3.4	3.3
Maximum Interferer level (C/I dB):	-71.0	-42.7	-42.3	-13.4	-62.1	-70.4	-70.3

Table 33. Bluetooth LE @2Msps Channel 1*...continued*

Wanted:	Channel 1						
Wanted frequency (MHz):	*2406*						
Interferer:	N-6 MHz (Adjacent)	N-4 MHz (Adjacent)	N-2 MHz (Adjacent)	N (Co-channel)	N+2 MHz (Adjacent)	N+4 MHz (Adjacent)	N+6 MHz (Adjacent)
BLE 5.x limit (C/I limit):	-27	-17	15	21	15	-17	-27
Margin (dB):	44.0	25.7	57.3	34.4	77.1	53.4	43.3

Table 34. Bluetooth LE @2Msps Channel 17

Wanted:	Channel 17						
Wanted frequency (MHz):	*2440*						
Interferer:	N-6 MHz (Adjacent)	N-4 MHz (Adjacent)	N-2 MHz (Adjacent)	N (Co-channel)	N+2 MHz (Adjacent)	N+4 MHz (Adjacent)	N+6 MHz (Adjacent)
Interferer frequency (MHz):	*2434*	*2436*	*2438*	*2440*	*2442*	*2444*	*2446*
Maximum Interferer level (dBm):	2.1	-25.7	-26.0	-54.6	-6.1	2.4	2.5
Maximum Interferer level (C/I dB):	-69.1	-41.3	-41.0	-12.4	-60.9	-69.4	-69.5
BLE 5.x limit (C/I limit):	-27	-17	15	21	15	-17	-27
Margin (dB):	42.1	24.3	56.0	33.4	75.9	52.4	42.5

Table 35. Bluetooth LE @2Msps Channel 35

Wanted	Channel 35						
Wanted frequency (MHz)	*2476*						
Interferer	N-6 MHz (Adjacent)	N-4 MHz (Adjacent)	N-2 MHz (Adjacent)	N (Co-channel)	N+2 MHz (Adjacent)	N+4 MHz (Adjacent)	N+6 MHz (Adjacent)
Interferer frequency (MHz):	*2470*	*2472*	*2474*	*2476*	*2478*	*2480*	*2482*
Maximum Interferer level (dBm):	4.1	-24.0	-24.8	-53.5	-4.6	3.2	3.7
Maximum Interferer level (C/I dB):	-71.1	-43.0	-42.2	-13.5	-62.4	-70.2	-70.7
BLE 5.x limit (C/I limit):	-27	-17	15	21	15	-17	-27
Margin (dB):	44.1	26.0	57.2	34.5	77.4	53.2	43.7

Results Channel 1 @2 Msps

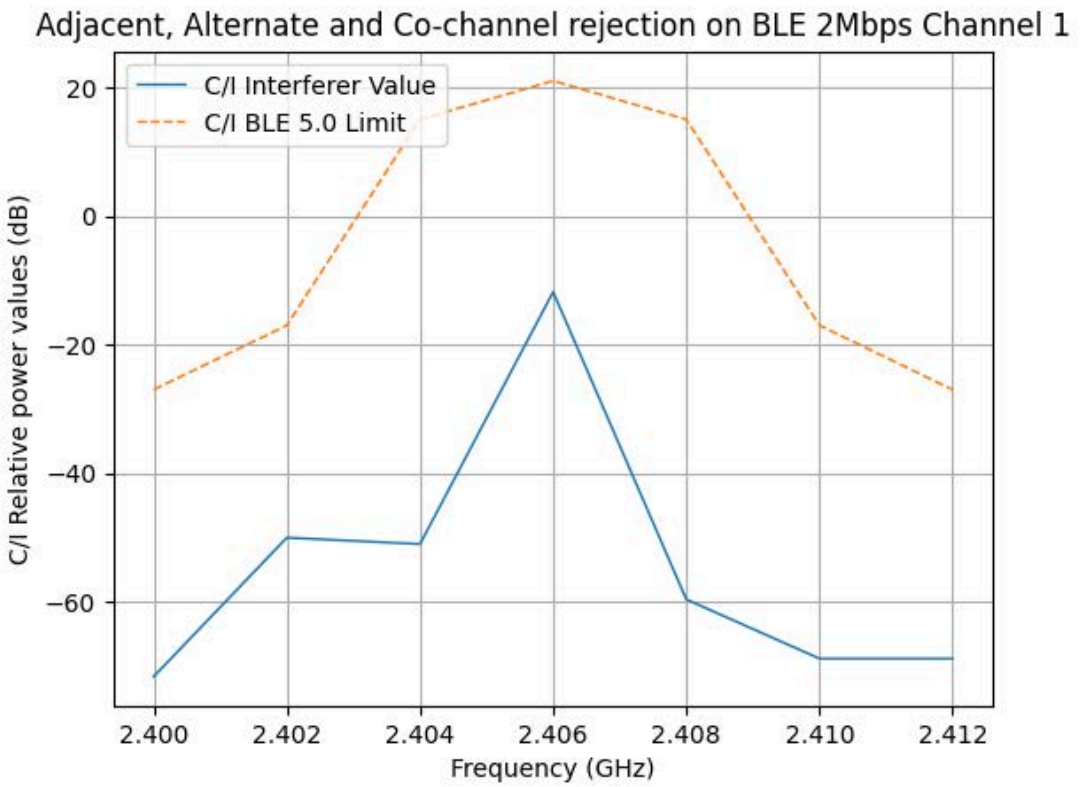

Figure 74. Adjacent, alternate, and co-channel rejection Bluetooth LE @2 Msps Channel 1

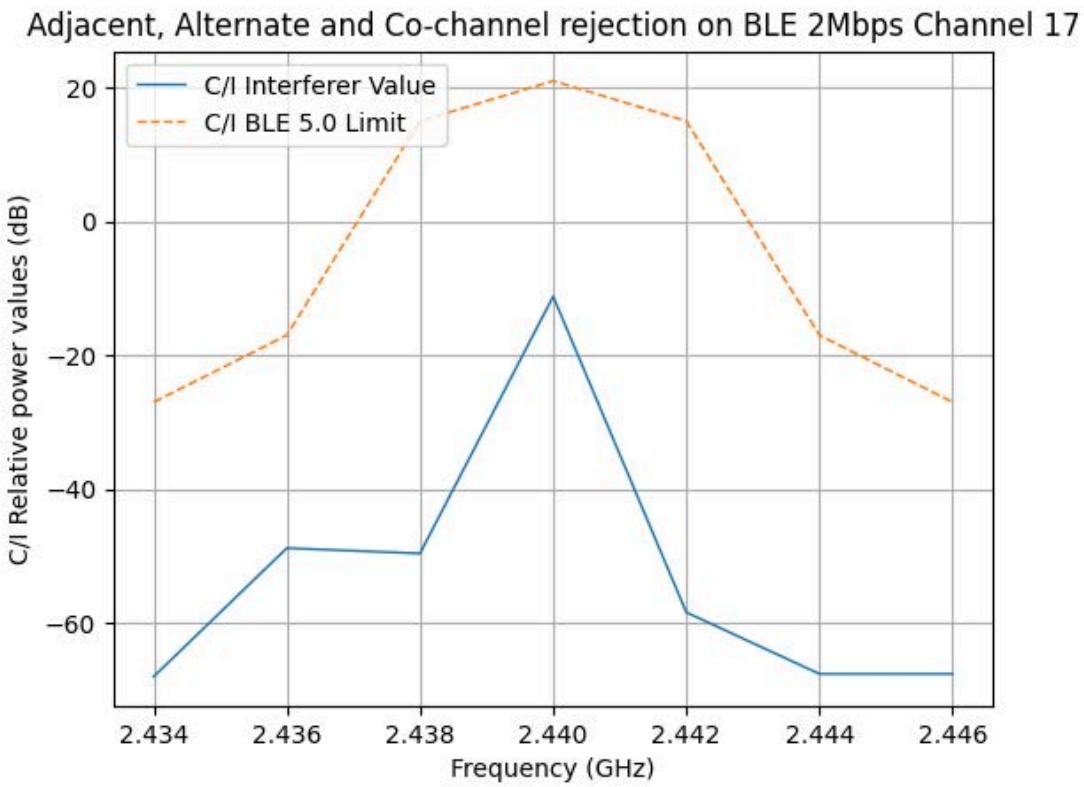

Figure 75. Adjacent, alternate, and co-channel rejection Bluetooth LE @2 Msps Channel 17

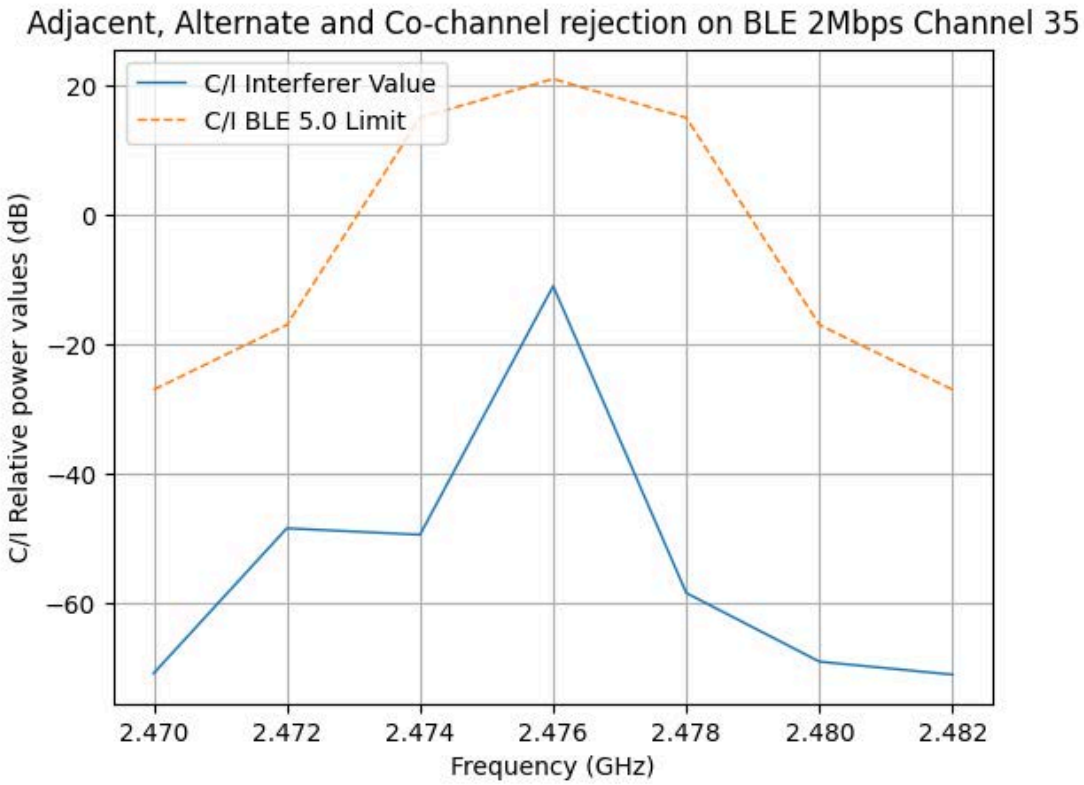

Figure 76. Adjacent, alternate, and co-channel rejection Bluetooth LE @2 Msps Channel 35

Conclusion : The FRDM-MCXW71 board passes the BLE certification for this test with a worst margin of 28.3

Results @500 Ksps (LR S=2)

Table 36. Bluetooth LE @500 Ksps (LR S=2) Channel 1

Wanted:	Channel 1						
Wanted frequency (MHz):	*2406*						
Interferer:	N-3MHz (Adjacent)	N-2MHz (Adjacent)	N-1MHz (Adjacent)	N (Co-channel)	N+1MHz (Adjacent)	N+2MHz (Adjacent)	N+3MHz (Adjacent)
Interferer frequency (MHz):	*2403*	*2404*	*2405*	*2406*	*2407*	*2408*	*2409*
Maximum Interferer level (dBm):	4.0	-19.0	-3.0	-52.0	-8.8	7.2	9.4
Maximum Interferer level (C/I dB):	-71.0	-48.0	-64.0	-15.0	-58.2	-74.2	-76.4
BLE 5.x limit (C/I limit):	-27	-17	15	21	15	-17	-27
Margin (dB):	44.0	31.0	79.0	36.0	73.2	57.2	49.4

Table 37. Bluetooth LE @500 Ksps (LR S=2) Channel 17

Wanted:	Channel 17						
Wanted frequency (MHz):	*2440*						
Interferer:	N-3 MHz (Adjacent)	N-2 MHz (Adjacent)	N-1 MHz (Adjacent)	N (Co-channel)	N+1 MHz (Adjacent)	N+2 MHz (Adjacent)	N+3 MHz (Adjacent)
Interferer frequency (MHz):	*2437*	*2438*	*2439*	*2440*	*2441*	*2442*	*2443*
Maximum Interferer level (dBm):	1.1	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0
Maximum Interferer level (C/I dB):	-68.1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
BLE 5.x limit (C/I limit):	-27	-17	15	21	15	-17	-27
Margin (dB):	41.1	-16.0	16.0	22.0	16.0	-16.0	-26.0

Table 38. Bluetooth LE @500 Ksps (LR S=2) Channel 35

Wanted:	**Channel 35**						
Wanted frequency (MHz):	***2476***						
Interferer:	**N-3MHz (Adjacent)**	**N-2MHz (Adjacent)**	**N-1MHz (Adjacent)**	**N (Co-channel)**	**N+1MHz (Adjacent)**	**N+2MHz (Adjacent)**	**N+3MHz (Adjacent)**
Interferer frequency (MHz):	*2473*	*2474*	*2475*	*2476*	*2477*	*2478*	*2479*
Maximum Interferer level (dBm):	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0
Maximum Interferer level (C/I dB):	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
BLE 5.x limit (C/I limit):	-27	-17	15	21	15	-17	-27
Margin (dB):	-26.0	-16.0	16.0	22.0	16.0	-16.0	-26.0

Adjacent, alternate, and co-channel rejection Bluetooth LE @500 Ksps (LR S=2)

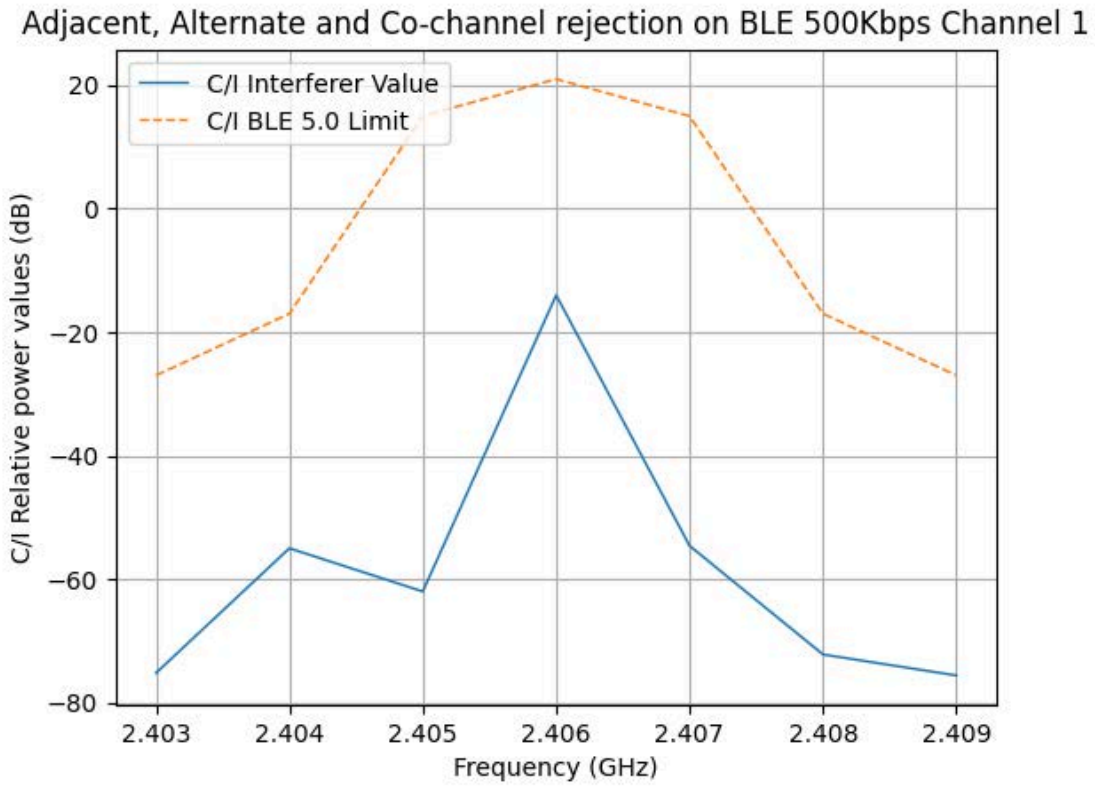

Figure 77. Adjacent, alternate, and co-channel rejection Bluetooth LE @500 Ksps (LR S=2) Channel 1

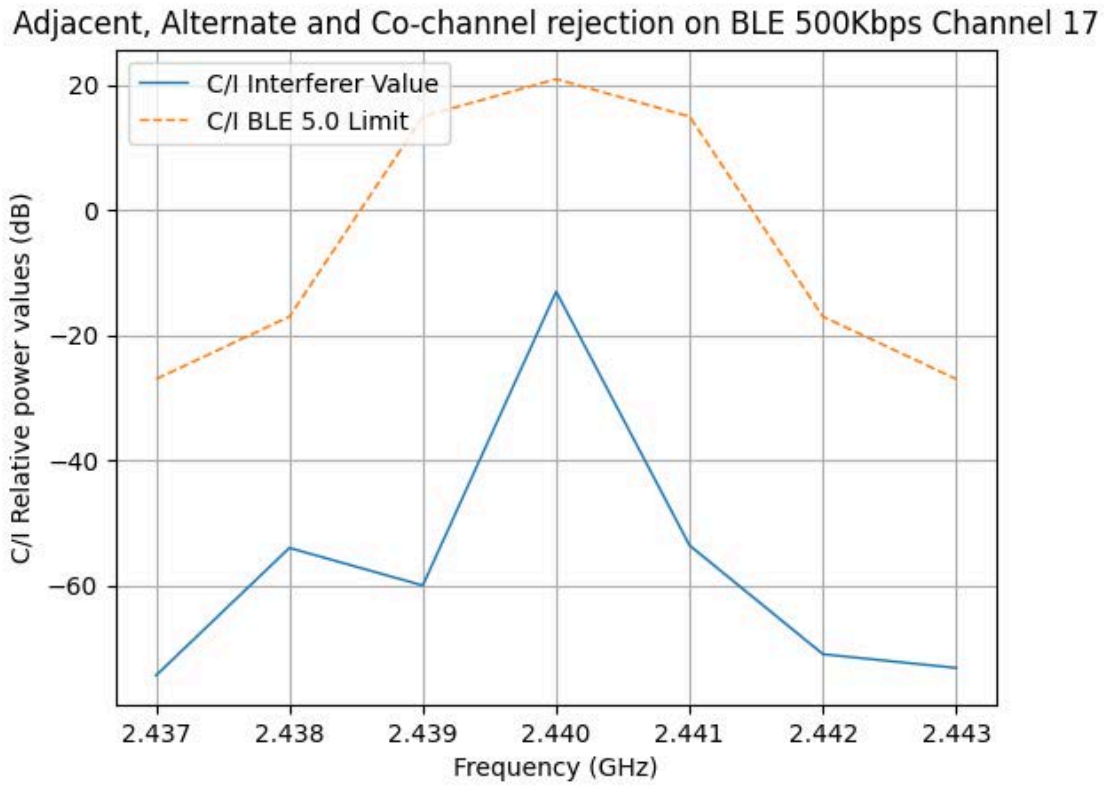

Figure 78. Adjacent, alternate, and co-channel rejection Bluetooth LE @500 Ksps (LR S=2) channel17

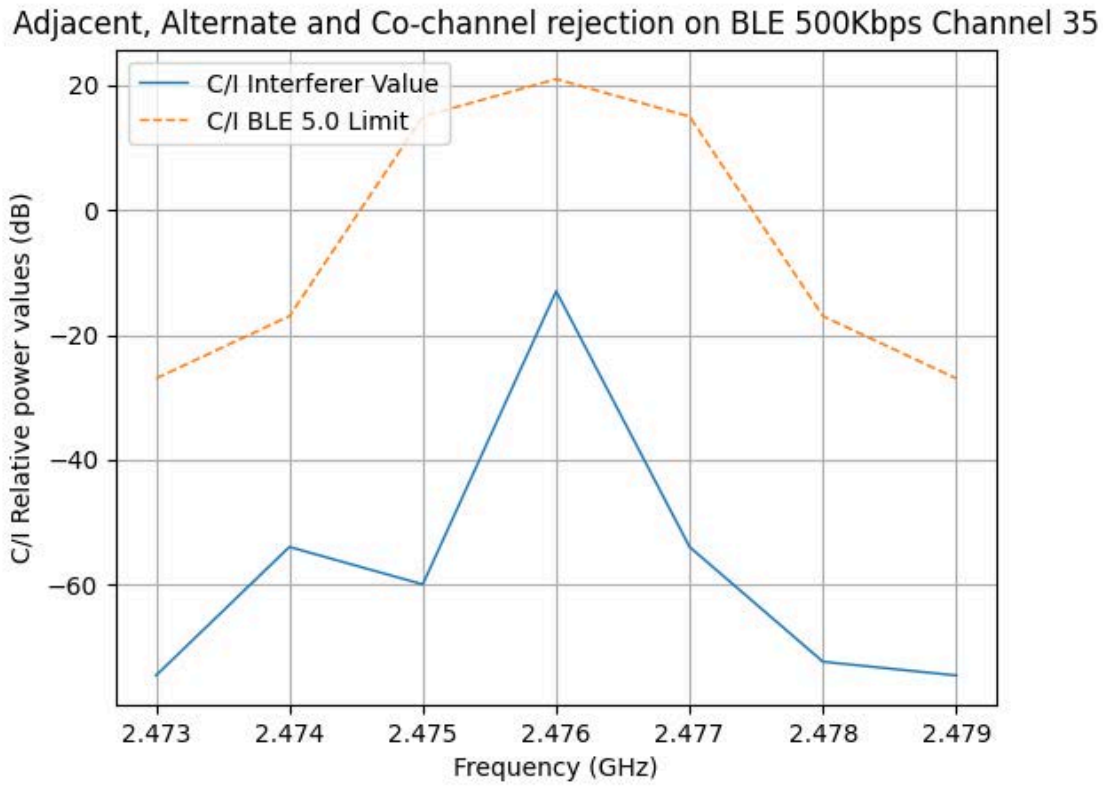

Figure 79. Adjacent, alternate, and co-channel rejection Bluetooth LE @500 Ksps (LR S=2) channel 35

Conclusion : The FRDM-MCXW71 board passes the BLE certification for this test with a worst margin of 28.3

Results @125 Ksps (LR S=8)

Table 39. Bluetooth LE @125 Ksps (LR S=8) results, Channel 1

Wanted:	**Channel 1**						
Wanted frequency (MHz):	***2406***						
Interferer:	**N-3 MHz (Adjacent)**	**N-2 MHz (Adjacent)**	**N-1 MHz (Adjacent)**	**N (Co-channel)**	**N+1 MHz (Adjacent)**	**N+2 MHz (Adjacent)**	**N+3 MHz (Adjacent)**
Interferer frequency (MHz):	*2403*	*2404*	*2405*	*2406*	*2407*	*2408*	*2409*
Maximum Interferer level (dBm):	13.8	-18.0	-2.7	-51.0	-8.9	9.0	13.0
Maximum Interferer level (C/I dB):	-80.8	-49.0	-64.3	-16.0	-58.1	-76.0	-80.0

Table 39. Bluetooth LE @125 Ksps (LR S=8) results, Channel 1*...continued*

Wanted:	Channel 1						
Wanted frequency (MHz):	*2406*						
Interferer:	N-3 MHz (Adjacent)	N-2 MHz (Adjacent)	N-1 MHz (Adjacent)	N (Co-channel)	N+1 MHz (Adjacent)	N+2 MHz (Adjacent)	N+3 MHz (Adjacent)
BLE 5.x limit (C/I limit):	-27	-27	-27	-27	15	-17	-27
Margin (dB):	53.8	32.0	79.3	37.0	73.1	59.0	53.0

Table 40. Bluetooth LE @125 Ksps (LR S=8) results, Channel 17

Wanted:	Channel 17						
Wanted frequency (MHz):	*2440*						
Interferer:	N-3MHz (Adjacent)	N-2MHz (Adjacent)	N-1MHz (Adjacent)	N (Co-channel)	N+1MHz (Adjacent)	N+2MHz (Adjacent)	N+3MHz (Adjacent)
Interferer frequency (MHz):	*2437*	*2438*	*2439*	*2440*	*2441*	*2442*	*2443*
Maximum Interferer level (dBm):	12.3	-19.0	-4.0	-52.0	-9.0	8.0	12.4
Maximum Interferer level (C/I dB):	-79.3	-48.0	-63.0	-15.0	-58.0	-75.0	-79.4
BLE 5.x limit (C/I limit):	-27	-27	-27	-27	15	-17	-27
Margin (dB):	52.3	31.0	78.0	36.0	73.0	58.0	52.4

Table 41. Bluetooth LE @125 Ksps (LR S=8) results, Channel 35

Wanted:	**Channel 35**						
Wanted frequency (MHz)	***2476***						
Interferer	**N-3 MHz (Adjacent)**	**N-2 MHz (Adjacent)**	**N-1 MHz (Adjacent)**	**N (Co-channel)**	**N+1 MHz (Adjacent)**	**N+2 MHz (Adjacent)**	**N+3 MHz (Adjacent)**
Interferer frequency (MHz):	*2473*	*2474*	*2475*	*2476*	*2477*	*2478*	*2479*
Maximum Interferer level (dBm):	4.0	-18.0	-2.6	-51.0	-8.5	9.2	14.0
Maximum Interferer level (C/I dB):	-71.0	-49.0	-64.4	-16.0	-58.5	-76.2	-81.0
BLE 5.x limit (C/I limit):	-27	-27	-27	-27	15	-17	-27
Margin (dB):	44.0	32.0	79.4	37.0	73.5	59.2	54.0

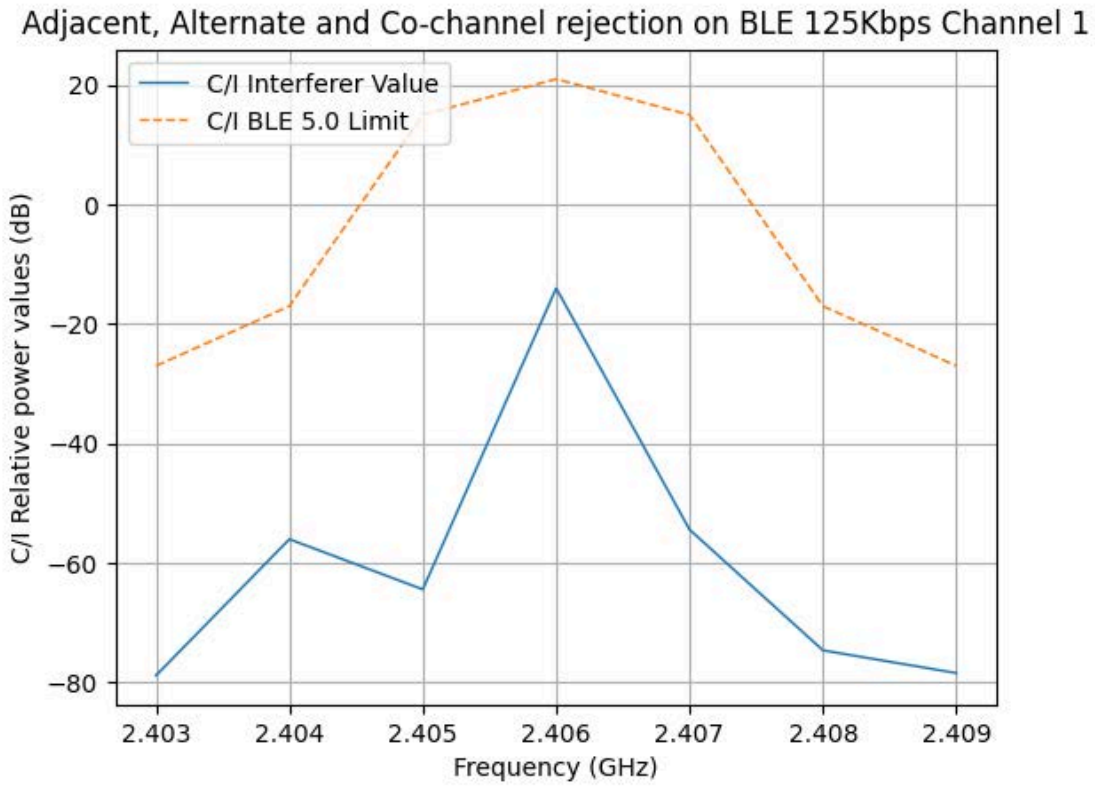

Figure 80. Adjacent, alternate, and co-channel rejection Bluetooth LE @125 Ksps (LR S=8) @ Channel 1

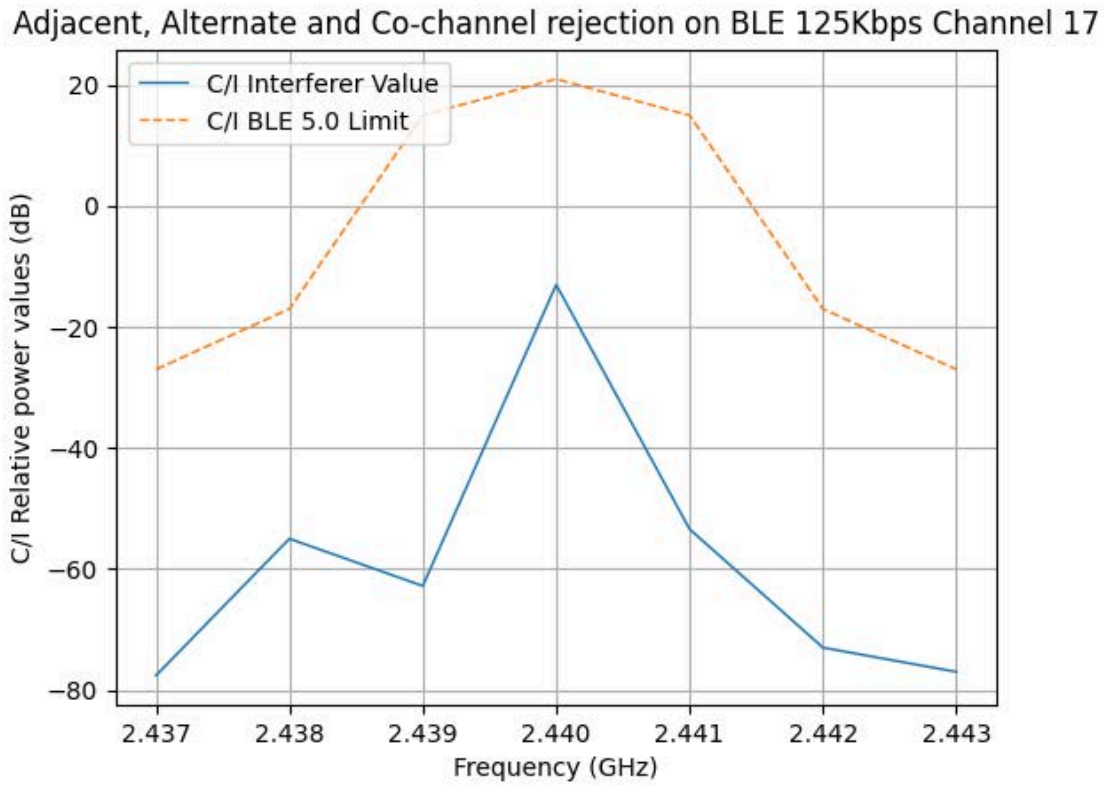

Figure 81. Adjacent, alternate, and co-channel rejection Bluetooth LE @125 Ksps (LR S=8) @ Channel 17

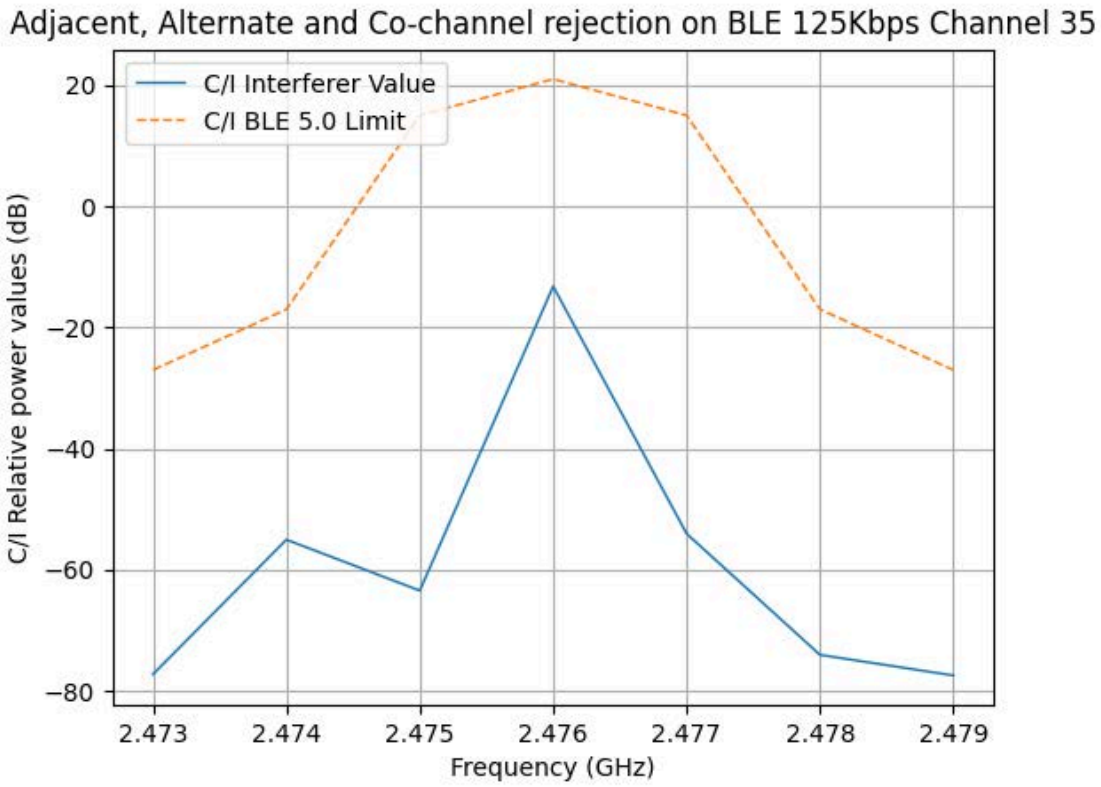

Figure 82. Adjacent, alternate, and co-channel rejection Bluetooth LE @125 Ksps (LR S=8) @ Channel 35

Conclusion: The FRDM-MCXW71 board passes the BLE certification for this test with a worst margin of 28.3

3.3.2.6.2 Receiver Blocking

The blocking interferers are located at the out of band channels depending on the receiver category.

3.3.2.6.2.1 Receiver category 1 - Bluetooth LE-1 Msps

This section describes the results for Receiver category 1 - Bluetooth LE-1 Msps (Refer to ETSI 300.328 2.2.2 chapter 4.3.1.12.4.2)

The test is performed with only one interfering signal at a time.

Flashed Software: Connectivity test

Test method:

- Generator for the desired signal (**BLE-1 Msps**): Rhode & Schwarz SMBV100B
- Generator for interferers: Rhode & Schwarz SFU
- Criterion: PER < 10 %
  - For an interferer set at 2.380 GHz and 2.504 GHz, the wanted signal is set to the lowest value between 10log(OCBW)-133 dBm and -68 dBm.
  - For an interferer set at 2.300 GHz, 2.330 GHz, 2.360 GHz, 2.524 GH, 2.584GHz and 2.674 GHz, the wanted signal is set to the lowest value between 10log(OCBW)-139 dBm and -74 dBm.
    In both cases, the interferer power level is increased until the PER threshold is reached
- BLE Channels under test: 37 (2.402 GHz), and 39 (2.480 GHz)

Result:

Table 42. Receiver Blocking (Out Of Band) rejection - BLE-1 Msps - Category 1, Channel 37

Channel:	**37**							
Frequency (MHz):	**2402**							
Interferer Type:	**Low**	**Low**	**Low**	**Low**	**High**	**High**	**High**	**High**
Interferer Frequency (MHz):	2300	2330	2360	2380	2504	2524	2584	2674
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-47	-47	-53	-53	-47	-47	-47
Margin(dB)	57.0	57.0	57.0	63.0	63.0	57.0	57.0	57.0

Table 43. Receiver Blocking (Out Of Band) rejection - BLE-1 Msps - Category 1, Channel 39

Channel:	**39**							
Frequency (MHz):	**2480**							
Interferer Type:	**Low**	**Low**	**Low**	**Low**	**High**	**High**	**High**	**High**

Table 43. Receiver Blocking (Out Of Band) rejection - BLE-1 Msps - Category 1, Channel 39*...continued*

Channel:	**39**							
Frequency (MHz):	**2480**							
Interferer Frequency (MHz):	2300	2330	2360	2380	2504	2524	2584	2674
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-47	-47	-53	-53	-47	-47	-47
Margin(dB)	57.0	57.0	57.0	63.0	63.0	57.0	57.0	57.0

Conclusion: The FRDM-MCXW71 passes the Receiver Blocking Category 1 test, there is a margin of 57.0 dB until the limit.

3.3.2.6.2.2 Receiver category 2- Bluetooth LE-1 Msps

This section describes the results for Receiver category 2- Bluetooth LE-1Msps. (Refer to *ETSI 300.328 2.2.2 Chapter 4.3.1.12.4.3*)

The test is performed with only one interfering signal at a time.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**BLE-1Msps**): Rhode & Schwarz SMBV100B
- Generator for interferers: Rhode & Schwarz SFU
- Criterion: PER < 10 %
- The wanted signal is set to the lowest value between-64dBm and 10log(OCBW)-129 dBm; the CW interferer is increased until the PER threshold is reached
- Channels under test: BLE Channel 37 (2.402 GHz), and BLE Channel 39 (2.480 GHz)

Result:

Table 44. Receiver Blocking (Out Of Band) rejection - BLE-1Msps - Category 2 Channel 37

Channel	**Channel 37**			
Frequency (MHz)	**2402**			
Interferer Type:	**Low**	**Low**	**High**	**High**
Interferer Frequency (MHz):	2300	2380	2504	2584
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-57	-57	-47
Margin(dB)	57.0	67.0	67.0	57.0

Table 45. Receiver Blocking (Out Of Band) rejection - BLE-1Msps - Category 2 Channel 39

Channel	**Channel 39**			
Frequency (MHz)	**2480**			
Interferer Type:	**Low**	**Low**	**High**	**High**
Interferer Frequency (MHz)	2300	2380	2504	2584
Maximum Interferer Level (dBm)	**>10**	**>10**	**10.6**	**>10**
300.328 Lower limit (dBm)	-47	-57	-57	-47
Margin(dB)	57.0	67.0	67.6	57.0

Conclusion: The FRDM-MCXW71 passes the Receiver Blocking Category 2 test, there is a margin of 67.6 dB until the limit.

3.3.2.6.2.3 Receiver category 1 - Bluetooth LE- 2 Msps

This section describes the results for Receiver category 1 - Bluetooth LE- 2 Msps (Refer to *ETSI 300.328 2.2.2 chapter 4.3.1.12.4.2*)

The test is performed with only one interfering signal at a time.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**BLE- 2 Msps**): Rhode & Schwarz SMBV100B
- Generator for interferers: Rhode & Schwarz SFU
- Criterion: PER < 10 %
- For an interferer set at 2.380 GHz and 2.504 GHz, the wanted signal is set to the lowest value between 10log(OCBW)-133 dBm and -68 dBm.
  For an interferer set at 2.300 GHz, 2.330 GHz, 2.360 GHz, 2.524 GH, 2.584GHz and 2.674 GHz, the wanted signal is set to the lowest value between 10log(OCBW)-139 dBm and -74 dBm.
  In both cases, the interferer power level is increased until the PER threshold is reached.
- BLE Channels under test: 37 (2.402 GHz), and 39 (2.480 GHz)

Result:

Table 46. Receiver Blocking (Out Of Band) rejection: BLE-2Msps (Category 1)

Channel:	**37**						
Frequency (MHz):	**2402**						
Interferer Type:	**Low**	**Low**	**Low**	**Low**	**High**	**High**	**High**	**High**
Interferer Frequency (MHz):	2300	2330	2360	2380	2504	2524	2584	2674
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-47	-47	-53	-53	-47	-47	-47
Margin(dB)	57.0	57.0	57.0	63.0	63.0	57.0	57.0	57.0

Table 47. Receiver Blocking (Out Of Band) rejection - BLE-2Msps - Category 1

Channel:	**39**						
Frequency (MHz):	**2480**						
Interferer Type:	**Low**	**Low**	**Low**	**Low**	**High**	**High**	**High**	**High**
Interferer Frequency (MHz):	2300	2330	2360	2380	2504	2524	2584	2674
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-47	--47	-53	-53	-47	-47	-47
Margin(dB)	57.0	57.0	57.0	63.0	63.0	57.0	57.0	57.0

Receiver Blocking (Out Of Band) rejection - BLE-2Msps - Category 1

Conclusion: The FRDM-MCXW71 passes the Receiver Blocking Category 1 test, there is a margin of 57.0 dB until the limit.

3.3.2.6.2.4 Receiver category 2- Bluetooth LE - 2 Msps

This section describes the results for Receiver category 2- Bluetooth LE-2 Msps (Refer to the *300.328 2.2.2 chapter 4.3.1.12.4.3*.)

This test is performed with only one interfering signal at a time.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**BLE-2Msps**): Rhode & Schwarz SMBV100B
- Generator for interferers: Rhode & Schwarz SFU
- Criterion: PER < 10 %
- The wanted signal is set to the lowest value between-64dBm and 10log(OCBW)-129 dBm; the CW interferer is increased until the PER threshold is reached
- BLE Channels under test: 37 (2.402 GHz), and 39 (2.480 GHz)

Result:

Table 48. Receiver Blocking (Out Of Band) rejection - Bluetooth LE-2 Msps Receiver category 2- Channel 37

Channel	Channel 37			
Frequency (MHz):	2402			
Interferer Type:	**Low**	**Low**	**High**	**High**
Interferer Frequency (MHz):	2300	2380	2504	2584
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-57	-57	-47
Margin (dB)	57.0	67.0	67.0	57.0

Table 49. Receiver Blocking (Out Of Band) rejection - Bluetooth LE-2 Msps Receiver category 2- Channel 39

Channel	Channel 39			
Frequency (MHz)	**2480**			
Interferer Type:	**Low**	**Low**	**High**	**High**
Interferer Frequency (MHz):	2300	2380	2504	2584

Table 49. Receiver Blocking (Out Of Band) rejection - Bluetooth LE-2 Msps Receiver category 2- Channel 39*...continued*

Channel	Channel 39			
Frequency (MHz)	**2480**			
Maximum Interferer Level (dBm)	**>10**	**7.0**	**-9.5**	**>10**
300.328 Lower limit (dBm)	-47	-57	-57	-47
Margin (dB)	57.0	64.0	-47.5	57.0

Conclusion: The FRDM-MCXW71 passes the Receiver Blocking Category 2 test, there is a margin of 67.0 dB until the limit.

3.3.2.6.2.5 Receiver category 1 - Bluetooth LE- 500 Ksps (LR S=2)

This section describes the results for Receiver category 1 - Bluetooth LE-500 Ksps (LR S=2). (Refer to the *300.328 2.2.2 Chapter 4.3.1.12.4.2*)

The test is performed with only one interfering signal at a time.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**Bluetooth LE - 500 Ksps [LR S=2]**): Rhode and Schwarz SMBV100B
- Generator for interferers: Rhode & Schwarz SFU
- Criterion: PER < 10 %
- For an interferer set at 2.380 GHz and 2.504 GHz, the wanted signal is set to the lowest value between 10log(OCBW)-133 dBm and -68 dBm.
  For an interferer set at 2.300 GHz, 2.330 GHz, 2.360 GHz, 2.524 GH, 2.584GHz, and 2.674 GHz, the wanted signal is set to the lowest value between 10log(OCBW)-139 dBm and -74 dBm.
  In both cases, the interferer power level is increased until the PER threshold is reached.
- Channels under test: 37 (2.402 GHz), and 39 (2.480 GHz)

Result:

Table 50. Receiver Blocking (Out Of Band) rejection - BLE-500 Ksps (LR S=2) Category 1

Channel:	**37**							
Frequency (MHz):	**2402**							
Interferer Type:	**Low**	**Low**	**Low**	**Low**	**High**	**High**	**High**	**High**
Interferer Frequency (MHz):	2300	2330	2360	2380	2504	2524	2584	2674
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**

Table 50. Receiver Blocking (Out Of Band) rejection - BLE-500 Ksps (LR S=2) Category 1*...continued*

Channel:	**37**							
Frequency (MHz):	**2402**							
300.328 Lower limit (dBm)	-47	-47	-47	-53	-53	-47	-47	-47
Margin(dB)	57.0	57.0	57.0	63.0	63.0	57.0	57.0	57.0

Table 51. Receiver Blocking (Out Of Band) rejection - BLE-500 Ksps (LR S=2) - Category 1

Channel:	**39**							
Frequency (MHz):	**2480**							
Interferer Type:	**Low**	**Low**	**Low**	**Low**	**High**	**High**	**High**	**High**
Interferer Frequency (MHz):	2300	2330	2360	2380	2504	2524	2584	2674
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-47	-47	-53	-53	-47	-47	-47
Margin(dB)	57.0	57.0	57.0	63.0	63.0	57.0	57.0	57.0

Receiver Blocking (Out Of Band) rejection - BLE-500 Ksps (LR S=2) - Category 1

Conclusion: The FRDM-MCXW71 passes the Receiver Blocking Category 2 test, there is a margin of 67.0 dB until the limit.

3.3.2.6.2.6 Receiver category 2 - Bluetooth LE- 500 Ksps (LR S=2)

This section describes the results for Receiver category 2- Bluetooth LE-500 Ksps (LR S=2) (Refer to the *300.328 2.2.2 chapter 4.3.1.12.4.3*)

The test is performed with only one interfering signal at a time.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**BLE-500Ksps [LR S=2]**): Rhode & Schwarz SMBV100B
- Generator for interferers: Rhode & Schwarz SFU
- Criterion: PER < 10 %
- The wanted signal is set to the lowest value between-64dBm and 10log(OCBW)-129 dBm; the CW interferer is increased until the PER threshold is reached.
- BLE Channels under test: 37 (2.402 GHz), and 39 (2.480 GHz)

Result:

Table 52. Receiver Blocking (Out Of Band) rejection - BLE-500Ksps (LR S=2) - Category 2

Channel:	**Channel 37**			
Frequency (MHz):	**2402**			
Interferer Type:	**Low**	**Low**	**High**	**High**
Interferer Frequency (MHz):	2300	2380	2504	2584
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-57	-57	-47
Margin(dB)	57.0	67.0	67.0	57.0

Table 53. Receiver Blocking (Out Of Band) rejection - Bluetooth LE- 500 Ksps (LR S=2) Category 2

Channel:	**Channel 39**			
Frequency (MHz):	**2480**			
Interferer Type:	**Low**	**Low**	**High**	**High**
Interferer Frequency (MHz):	2300	2380	2504	2584
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-57	-57	-47
Margin(dB)	57.0	67.0	67.0	57.0

Conclusion: The FRDM-MCXW71 passes the Receiver Blocking Category 2 test, there is a margin of 67.0 dB until the limit.

3.3.2.6.2.7 Receiver category 1 - Bluetooth LE-125 Ksps (LR S=8)

This section describes the results for Receiver category 1 - Bluetooth LE-125 Kbps (LR S=8). (Refer to the *300.328 2.2.2 Chapter 4.3.1.12.4.2*)

The test is performed with only one interfering signal at a time.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**Bluetooth LE-125 Ksps [LR S=8]**): Rhode and Schwarz SMBV100B
- Generator for interferers: R&S SFU
- Criterion: PER < 10 %
- The wanted signal is set to Pmin+6 dB (-82 dBm); the interferer is increased until the PER threshold is reached
- Channels under test: 37 (2.402 GHz) and 39 (2.480 GHz)

Results:

Receiver Blocking (Out Of Band) rejection - BLE-125Ksps (LR S=8)

Table 54. Receiver Blocking (Out Of Band) rejection - BLE-125Ksps (LR S=8) - Category 1

Channel:	**37**							
Frequency (MHz):	**2402**							
Interferer Type:	**Low**	**Low**	**Low**	**Low**	**High**	**High**	**High**	**High**
Interferer Frequency (MHz):	2300	2330	2360	2380	2504	2524	2584	2674
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-47	-47	-53	-53	-47	-47	-47
Margin(dB)	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0

Table 55. Receiver Blocking (Out Of Band) rejection - BLE-125Ksps (LR S=8) - Category 1

Channel:	**39**							
Frequency (MHz):	**2480**							
Interferer Type:	**Low**	**Low**	**Low**	**Low**	**High**	**High**	**High**	**High**
Interferer Frequency (MHz):	2300	2330	2360	2380	2504	2524	2584	2674
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-47	-47	-53	-53	-47	-47	-47
Margin(dB)	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0

Conclusion: The FRDM-MCXW71 passes the Receiver Blocking Category 1 test, there is a margin of 57.0 dB until the limit.

3.3.2.6.2.8 Receiver category 2- Bluetooth LE-125 Ksps (LR S=8)

This section describes the tests for Receiver category 2- Bluetooth LE-125 Ksps (LR S=8) (Refer to the *300.328 2.2.2 chapter 4.3.1.12.4.3*)

The test is performed with only one interfering signal at a time.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**Bluetooth LE-125 Ksps [LR S=8]**): Rhode and Schwarz SMBV100B

- Generator for interferers: R&S SFU
- Criterion: PER < 10 %
- The wanted signal is set to Pmin+6 dB (-82 dBm); the interferer is increased until the PER threshold is reached.
- Channels under test: 37 (2.402 GHz) and 39 (2.480 GHz)

Result:

Receiver Blocking (Out Of Band) rejection - BLE-125Ksps (LR S=8)

Table 56. Receiver Blocking (Out Of Band rejection - BLE-125Ksps (LR S=8) - Category 2

Channel:	**Channel 37**			
Frequency (MHz):	**2402**			
Interferer Type:	**Low**	**Low**	**High**	**High**
Interferer Frequency (MHz):	2300	2380	2504	2584
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-57	-57	-47
Margin(dB)	57.0	67.0	67.0	57.0

Table 57. Receiver Blocking (Out Of Band) rejection - BLE-125Ksps (LR S=8) - Category 2

Channel:	**Channel 39**			
Frequency (MHz):	**2480**			
Interferer Type:	**Low**	**Low**	**High**	**High**
Interferer Frequency (MHz):	2300	2380	2504	2584
Maximum Interferer Level (dBm)	**>10**	**>10**	**>10**	**>10**
300.328 Lower limit (dBm)	-47	-57	-57	-47
Margin(dB)	57.0	67.0	67.0	57.0

Conclusion: The FRDM-MCXW71 passes the Receiver Blocking Category 2 test, there is a margin of 67.0 dB until the limit.

3.3.2.6.3 Blocking interferers

3.3.2.6.3.1 Bluetooth LE 1 Msps

A CW is used as the interferer source to verify that the receiver performs satisfactorily in frequency range outside the 2400 MHz to 2483.5 MHz band.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**Bluetooth LE-1 Msps**): Rhode and Schwarz SMBV100B
- Generator for the blocker: R&S SFU
- Criterion: PER < 30.8 % with 1500 packets
- The wanted signal is set to -67 dBm; the interferer level is increased until the PER threshold is reached.
- Channel under test: 12 (2426 MHz)

Table 58. BLE Rx Blocking Interferers – 1 Msps

Wanted signal 2426 MHz @-67 dBm	ch12	ch12	ch12	ch12	
	2426 MHz	2426 MHz	2426 MHz	2426 MHz	
Interferer (MHz)	30-2000 (step 10MHz)	2003 – 2399 (step 3MHz)	2484 – 2997 (step 3MHz)	3 GHz-12.75 GHz (step 25MHz)	
Unwanted level (dBm)	-30	-35	-35	-30	
Status (unwanted level)	PASS	PASS	PASS	PASS	
Number of blocking fail	0	0	0	0	Fail blockers must not exceed 10
Status (UnW level -50dBm)	PASS	PASS	PASS	PASS	
Number of blocking fail	0	0	0	0	Fail blockers must not exceed 3

Conclusion:

- The FRDM-MCXW71 passes the 1Msps Blocking Interferers test.

3.3.2.6.3.2 Bluetooth LE 2 Msps

A CW is used as the interferer source to verify that the receiver performs satisfactorily outside the frequency range of 2400MHz-2483.5MHz.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**Bluetooth LE-2 Msps**): Rhode and Schwarz SMBV100B
- Generator for the blocker: R&S SFU
- Criterion: PER < 30.8 % with 1500 packets
- The wanted signal is set to -67 dBm; the interferer level is increased until the PER threshold is reached.
- Channel under test: 12 (2426 MHz)

Table 59. BLE Rx Blocking interferers test (2 Msps)

Wanted signal 2426 MHz @-67dBm	Channel 12	Channel 12	Channel 12	Channel 12	Note
	2426 MHz	2426 MHz	2426 MHz	2426 MHz	
Interferer (MHz)	30-2000 (step 10 MHz)	2003 – 2399 (step 3 MHz)	2484 – 2997 (step 3 MHz)	3 GHz-12.75 GHz (step 25 MHz)	
Unwanted level (dBm)	-30	-35	-35	-30	
Status (unwanted level)	PASS	PASS	PASS	PASS	
Number of blocking fail	0	0	0	0	Fail blockers must not exceed 10
Status (UnW level -50dBm)	PASS	PASS	PASS	PASS	
Number of blocking fail	0	0	0	0	Fail blockers must not exceed 3

Conclusion:

- The FRDM-MCXW71 passes the 2 Msps Blocking Interferers test.

3.3.2.6.3.3 Bluetooth LE 500 Ksps (LR S=2)

A CW is used as the interferer source to verify that the receiver performs satisfactorily outside the frequency range of 2400 MHz to 2483.5 MHz.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**Bluetooth LE-500 ksps [LR S=2]**): Rhode and Schwarz SMBV100B
- Generator for the blocker: R&S SFU
- Criterion: PER < 30.8 % with 1500 packets
- The wanted signal is set to -67 dBm; the interferer level is increased until the PER threshold is reached.
- Channel under test: 12 (2426 MHz)

Table 60. BLE Rx Blocking interferers test (500 ksps)

Wanted signal 2426MHz @-67dBm	ch12	ch12	ch12	ch12	Note
	2426 MHz	2426 MHz	2426 MHz	2426 MHz	
Interferer (MHz)	30-2000 (step 10MHz)	2003 – 2399 (step 3MHz)	2484 – 2997 (step 3MHz)	3 GHz-12.75 GHz (step 25MHz)	
Unwanted level (dBm)	-30	-35	-35	-30	
Status (unwanted level)	PASS	PASS	PASS	PASS	
Number of blocking fail	0	0	0	0	Fail blockers must not exceed 10
Status (UnW level -50dBm)	PASS	PASS	PASS	PASS	
Number of blocking fail	0	0	0	0	Fail blockers must not exceed 3

Conclusion:

- The FRDM-MCXW71 passes the 500 ksps Blocking Interferers test.

3.3.2.6.3.4 Bluetooth LE 125 Ksps (LR S=8)

A CW is used as the interferer source to verify that the receiver performs satisfactorily in frequency outside the 2400 MHz to 2483.5 MHz range.

Flashed SW: Connectivity test

Test method:

- Generator for the desired signal (**Bluetooth LE-125kbps [LR S=8]**): Rhode and Schwarz SMBV100B
- Generator for the blocker: R&S SFU
- Criterion: PER < 30.8 % with 1500 packets
- The wanted signal is set to -67 dBm; the interferer level is increased until the PER threshold is reached.
- Channel under test: 12 (2426 MHz)

Table 61. BLE Rx Blocking Interferers – 125 ksps

Wanted signal 2426MHz @-67dBm	ch12	ch12	ch12	ch12	Note
	2426 MHz	2426 MHz	2426 MHz	2426 MHz	
Interferer (MHz)	30-2000 (step 10MHz)	2003 – 2399 (step 3MHz)	2484 – 2997 (step 3MHz)	3 GHz-12.75 GHz (step 25MHz)	
Unwanted level (dBm)	-30	-35	-35	-30	
Status (unwanted level)	PASS	PASS	PASS	PASS	
Number of blocking fail	0	0	0	0	Fail blockers must not exceed 10
Status (UnW level -50dBm)	PASS	PASS	PASS	PASS	
Number of blocking fail	0	0	0	0	Fail blockers must not exceed 3

Conclusion:

- The FRDM-MCXW71 passes the 125kbps Blocking Interferers test.

4 IEEE 802.15.4 applications

This section describes the RF tests conducted for IEEE 802.15.4 applications along with the test setup and a summary of the tests performed.

4.1 List of tests

CAUTION: *The following tests concerning IEEE 802.15.4 application have been performed using the former generation of MCXW71 devices. This could lead to differences with the results of the new generation used in the BLE application.*

1. Conducted tests
   a. Tx tests
      i. Frequency accuracy
      ii. Phase noise
      iii. Tx power
      iv. Tx spurious
      v. Harmonics
      vi. EVM & offset EVM
      vii. Upper band edge
   b. Rx tests
      i. Sensitivity
      ii. Sensitivity bathtub
      iii. Maximum Input Level
      iv. Rx spurious
      v. LO leakage
      vi. Interferers (as per 802.15.4 requirements)
      vii. Co-channel
      viii. Receiver Blocking (as per ETSI 300 328 requirements)

4.2 Test summary

This section summarizes the main tests performed on the MCXW71 (former generation) modules. Most of the test results details and setup are described in this document (See Table 62, Table 63, and Table 64). For further information, contact your NXP local contact.

Table 62. Transmission tests (Europe)

Test parameter	Reference	Limit	Status
Tx maximum power	ETSI EN 300 328	20 dBm, 100 mW (radiated)	Pass
Eirp Tx spectral density	ETSI EN 300 328	10 dBm/MHz	Pass
Tx spectral density	802.15.4_2011	-20 dBc or -30 dBm (100 kHZ ,	Pass
		f-fc > 3.5 MHz)	
Spurious 30 MHz – 1 GHz	ETSI EN 300 328	-36 dBm or	Pass
		-54 dBm (depends on frequency)	
		(100 kHz BW)	
Spurious 1 GHz - 12.5 GHz	ETSI EN 300 328	-30 dBm	Pass
		(1 MHz BW)	

Table 62. Transmission tests (Europe)*...continued*

Test parameter	Reference	Limit	Status
EVM	802.15.4_2011	35%	Pass
Tx frequency tolerance	802.15.4_2011	+/- 40 ppm	Pass
Reachable low limit of maximum power	802.15.4_2011	-3 dBm	Pass
Phase noise (unspread)	802.15.4_2003	NA	For information

Table 63. Reception tests (Europe)

Test parameter	Reference	Limit	Status
Rx emissions 30 MHz – 1 GHz	ETSI EN 300 328	-57 dBm (100 kHz)	Pass
Rx emissions 1 GHz - 12.5 GHz	ETSI EN 300 328	-47 dBm (1 MHz)	Pass
Rx sensitivity	802.15.4	-85 dBm	Pass
Adjacent channel interference rejection N+/-1	802.15.4_2011	0 dB	Pass
Alternate channel interference rejection N+/-2	802.15.4_2011	30 dB	Pass
Receiver blocking	ETSI EN 300 328	-57 dBm/-47 dBm	Pass
Rx maximum input level	802.15.4_2011	-20 dBm	Pass
Return loss (S11)	Return loss in Tx mode	For information	
	Return loss in Rx mode	For information	

Table 64. Transmission tests (US)

Test parameter	Reference	Limit	Status
Spurious 1 GHz - 12.5 GHz	FCC part15	-41 dBm (1 MHz BW)	Pass

4.3 Conducted tests

This section describes the results for the tests conducted for IEEE 802.15.4. These include transmission tests, receiver tests and their subcategories.

4.3.1 Tx tests

4.3.1.1 Test setup

The Tx power of the MCXW71 (Former Generation) is set to **+10 dBm**. Connect the RF port of the module to the spectrum analyzer via RF cable.

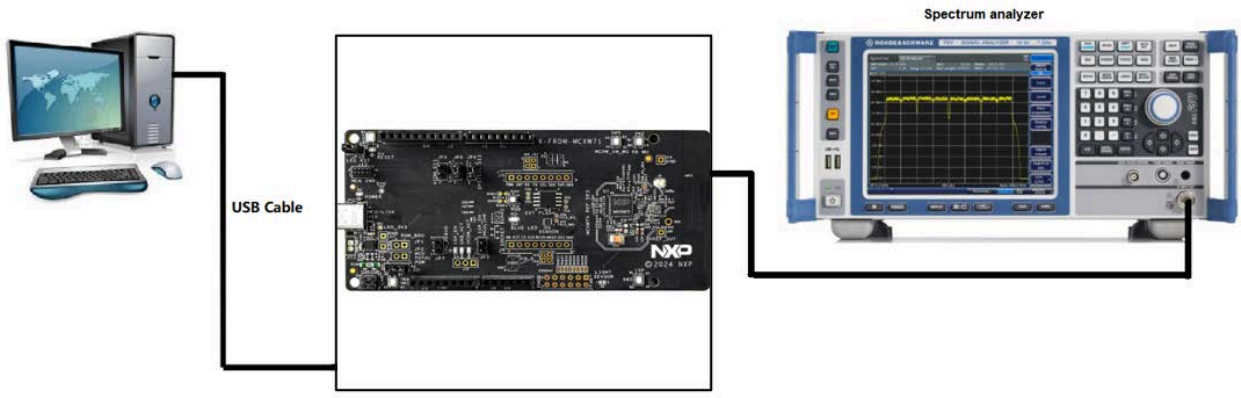

Figure 83. Conducted Tx test setup using FRDM-MCXW71 board

4.3.1.2 Frequency accuracy

Test method:

- Set the radio in:
  - Tx mode, CW, continuous mode, frequency: channel 18
- Set the analyzer to:
  - Center frequency = 2.44 GHz, span = 1 MHz, Ref amp = 20 dBm, RBW = 10 kHz
- Measure the CW frequency with the marker of the spectrum analyzer

Result:

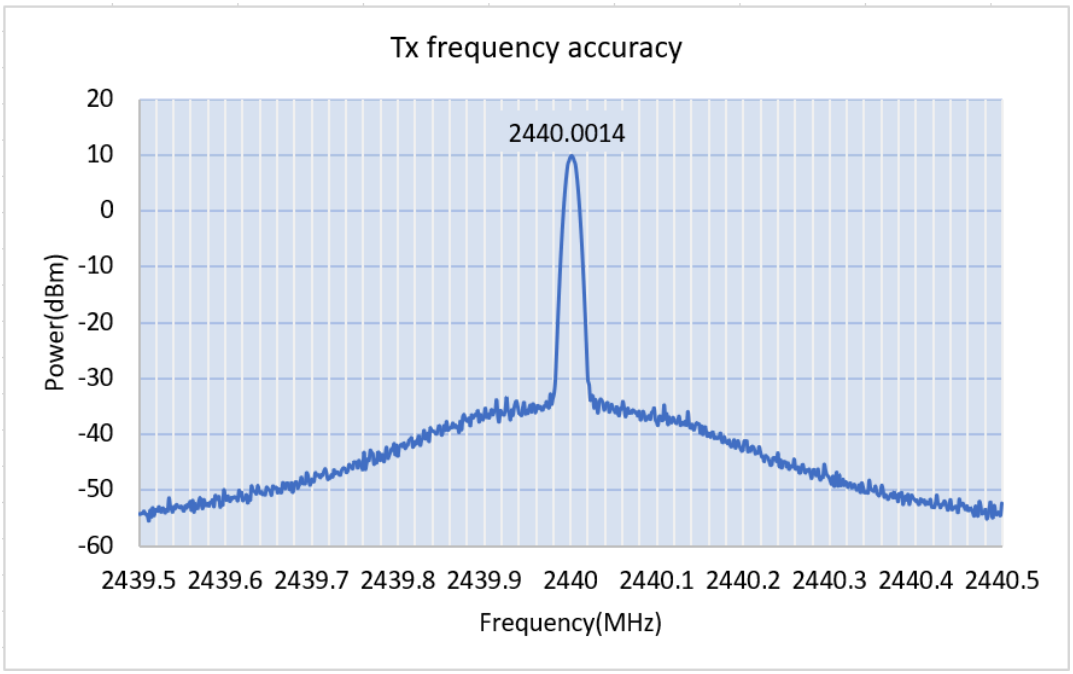

Figure 84. Tx Frequency accuracy (IEEE)

Frequency accuracy

- Measured frequency: 2440.0014 MHz
- ppm value = 0.57 ppm

Table 65. Tx Frequency accuracy (IEEE)

Result	Target	802.15.4 limit
0.57 ppm	+/- 25 ppm	+/- 40 ppm

Note: *The frequency accuracy depends on the XTAL model. The model used on the MCX W71 (Former Generation) is NX2016SA EXS00A-CS11775 from NDK and set the XtalTrim to "15".*

Conclusion: The channel frequency is correctly centered and therefore, fully compliant with the IEEE 802.15.4 specifications.

4.3.1.3 Phase noise @ 100 kHz offset

Test method:

- Set the radio in:
  - Tx mode, CW continuous mode, frequency: channel 18
- Set analyzer to:
  - Center frequency = 2.44 GHz, span = 1 MHz, Ref amp = 20 dBm
- Measure the phase noise at 100 kHz offset frequency
  - RBW = 10 kHz (40 dBc)

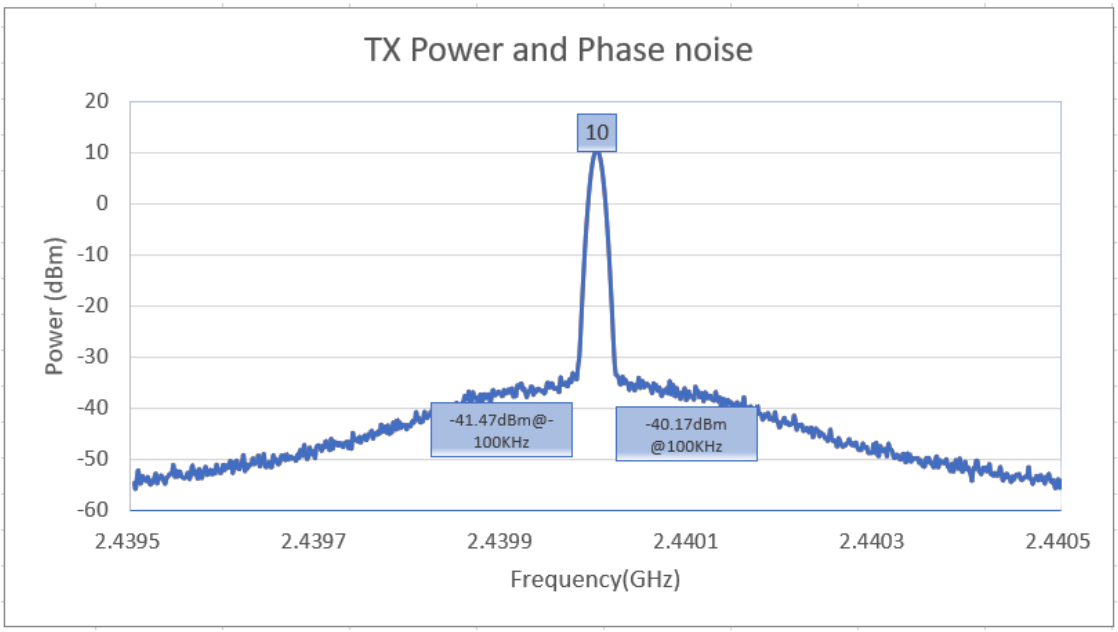

Figure 85. Phase noise at 100 kHz offset frequency

Phase noise

Results:

- Marker value = - 41.1 dBm within 10 kHz RBW ➔
  - Marker delta = 10.0 - (-41.1) = 51.1 dB
  - Phase noise at 100 kHz offset = - 51.1-10 Log (10 kHz) = **- 91.1 dBc/Hz**

Note:

- Phase noise is for information only.

4.3.1.4 Tx Power (fundamental)

Test method:

- Set the radio in:
  - Txmode, modulated, continuous mode
- Set the analyzer to:
  - Start frequency = 2.4 GHz, Stop frequency = 2.5 GHz,
  - Ref amp = 20 dBm, sweep time = 100 ms, RBW = 3 MHz
  - Max Hold mode
  - Detector: Peak
- Sweep all the channels from ch11 to ch26

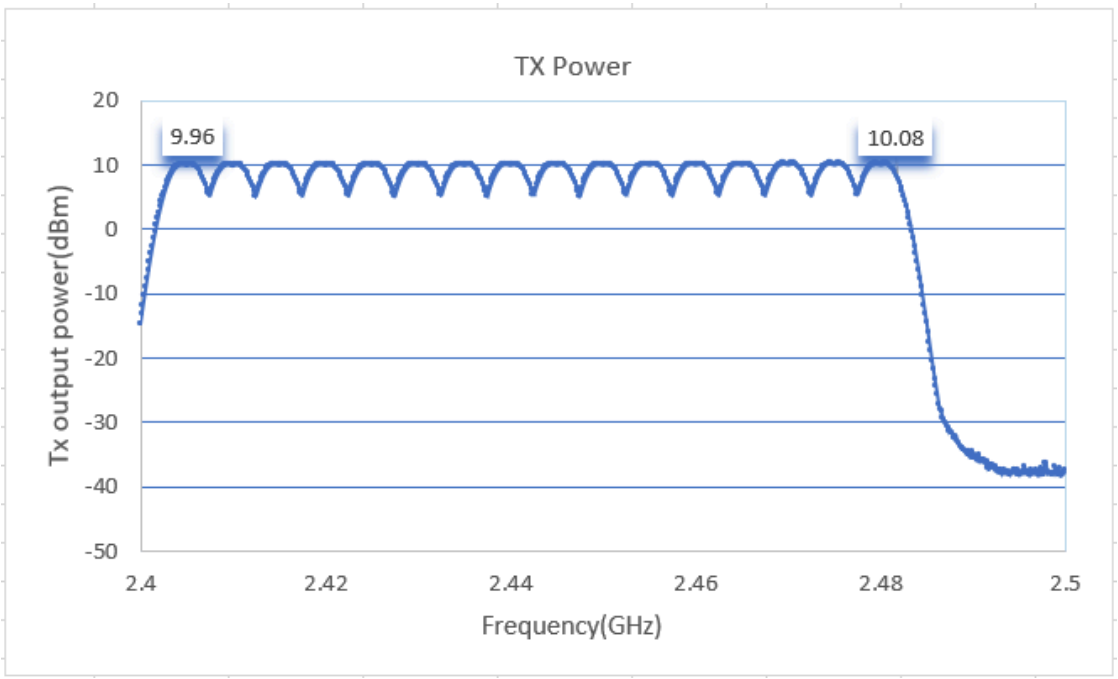

Figure 86. Tx Power (fundamental) (IEEE results)

Tx maximum power

Result:

Maximum power is on channel 26: +**10.08 dBm**

Minimum power is on channel 11: **+9.96 dBm**

Tilt over frequencies is **0.1 dB**

Conclusion:

- The power is flat over frequency.

4.3.1.5 Tx power In Band

Test method:

- Set the radio to:
  - TX mode, modulated, continuous mode, data rate (1 Msps, 2 Msps, 500 Ksps, 125 Ksps)
- Set the analyzer to:
  - Start frequency = 2.35 GHz, Stop frequency = 2.5 GHz, Ref amp = 10 dBm, sweep time = 100 ms
  - RBW = 100 KHz, Video BW = 300 KHz
  - Max Hold mode
  - Detector = RMS
  - Number of Sweeps = 10
- Sweep on 15.4 channel 11, channel 18, and channel 26

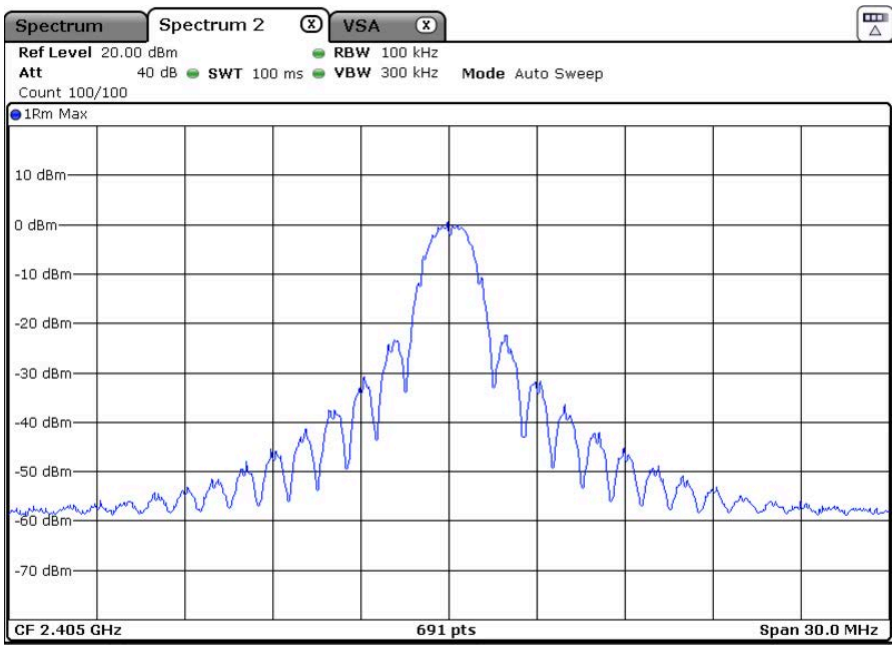

Figure 87. TX power In Band – Channel 11

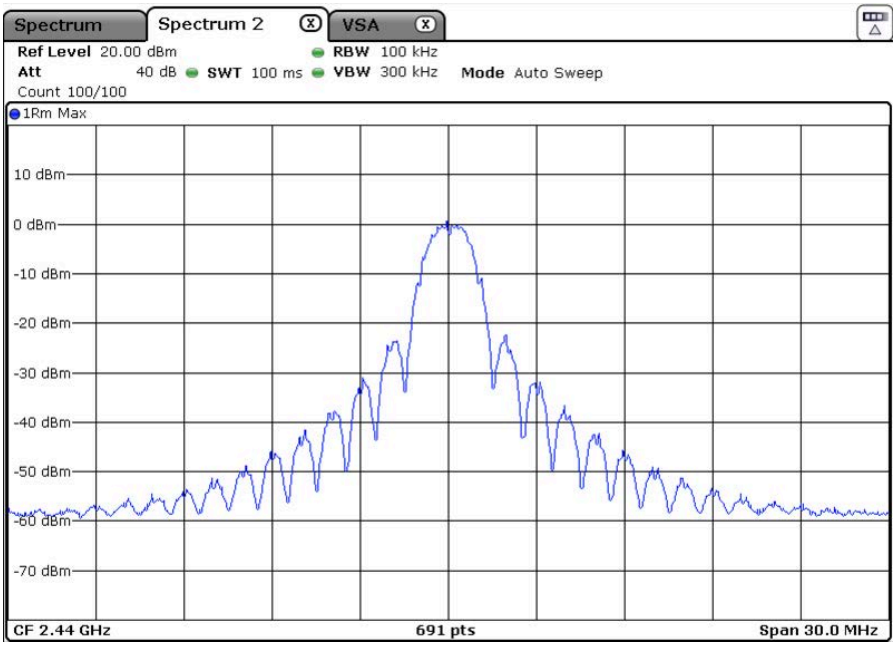

Figure 88. TX power In Band – Channel 18

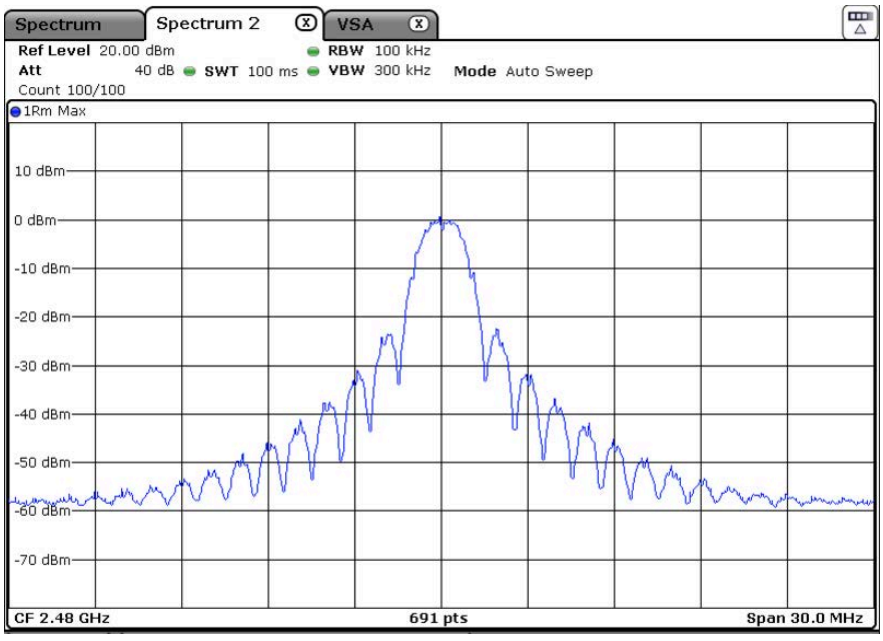

Figure 89. TX power In Band – Channel 26

Conclusion:

- These results are compliant to 802.15.4

4.3.1.6 Tx spurious

This section describes IEEE 802.15.4 test results for Tx spurious transmission for both ETSI and FCC test conditions.

4.3.1.6.1 Global view from 0.3 GHz to 12.5 GHz (wanted = channel 18)

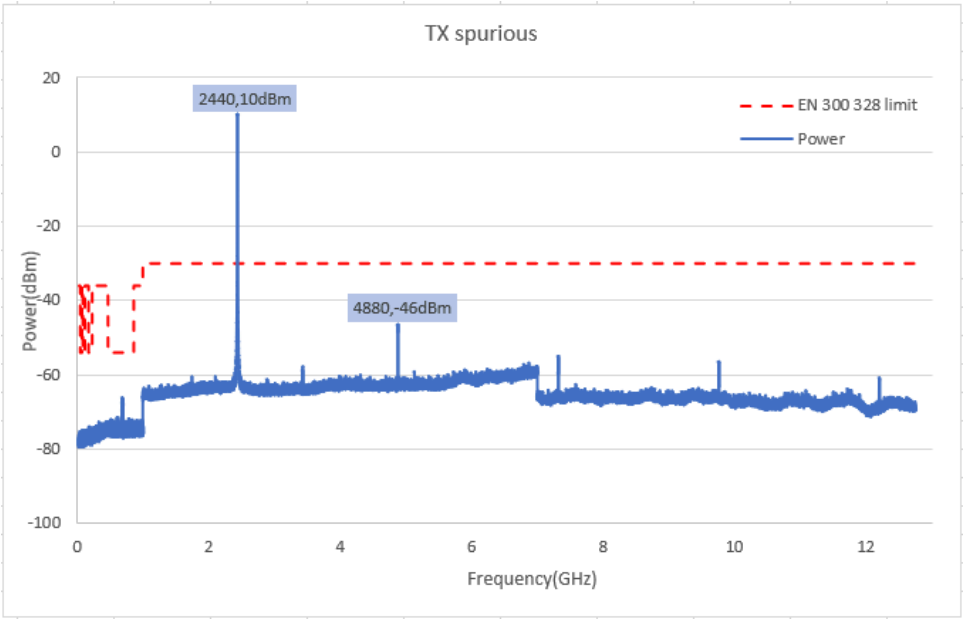

Figure 90. Tx spurious global view

Conducted Tx spurious

Conclusion:

- There are no Tx spurs above the EN 300 328 limit, about 16 dB of margin is observed.
- Harmonics are specifically measured in the following paragraphs.

4.3.1.6.2 H2 (ETSI test conditions)

Test method:

- Set the radio in:
  - Tx mode, modulated, continuous mode
- Set analyzer to:
  - Start frequency = 4.8 GHz, Stop frequency = 5 GHz,
  - Ref amp = -20 dBm, sweep time = 100 ms, RBW = 1 MHz
- Max Hold mode
- Detector peak
- Sweep all the channels from Channel 11 to Channel 26

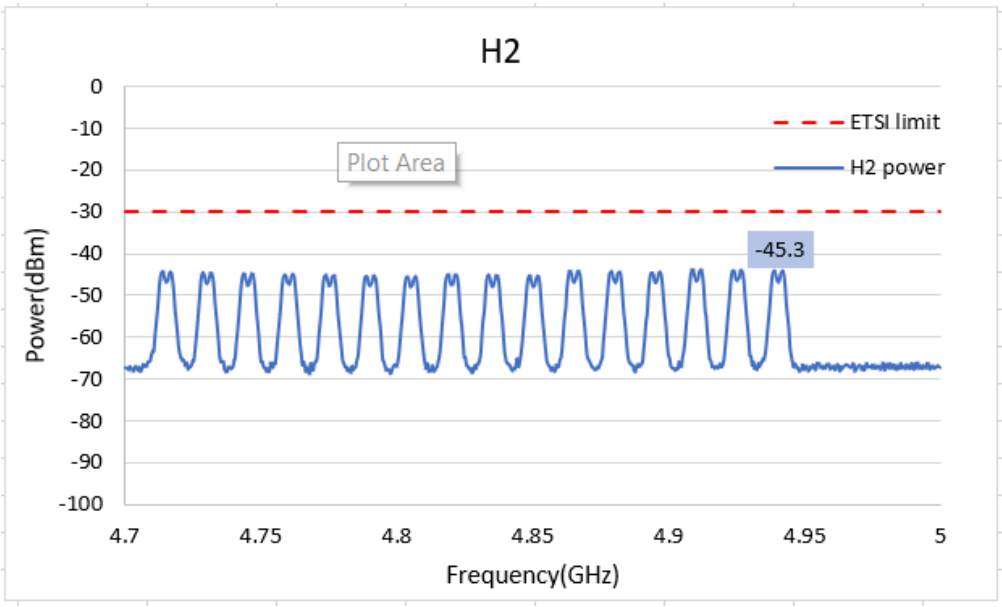

Figure 91. Tx spurious (H2, ETSI test conditions)

Conducted H2 spurious

Results:

Maximum power is on Channel 11: **-45.3 dBm**

Conclusion:

- There is **15.3 dB** margin to ETSI limit

4.3.1.6.3 H3 (ETSI test conditions)

The test method is similar as for the H2, except the spectrum analyzer frequency start/stop are set to 7.2 GHz and 7.5 GHz.

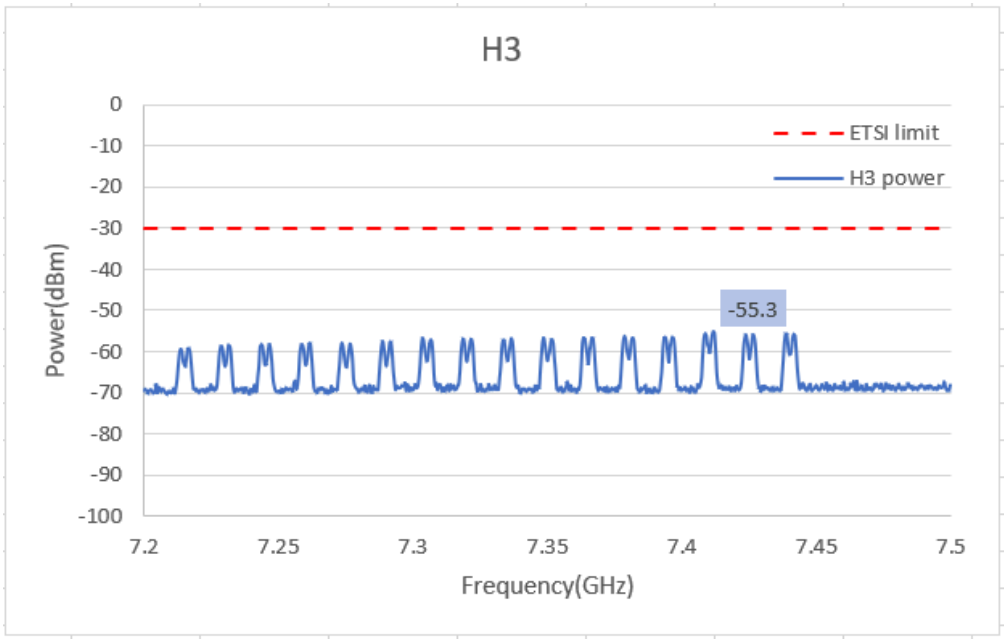

Figure 92. Tx spurious (H3, ETSI test conditions)

Conducted H3 spurious

Results:

Maximum power is on Channel 19: **-55.3 dBm**

Conclusion:

- There is **25.3** dB margin to the ETSI limit.

4.3.1.6.4 H4 (ETSI test conditions)

The test method is similar as for the H2, except the spectrum analyzer frequency span is set from 9.6 GHz to 10.0 GHz.

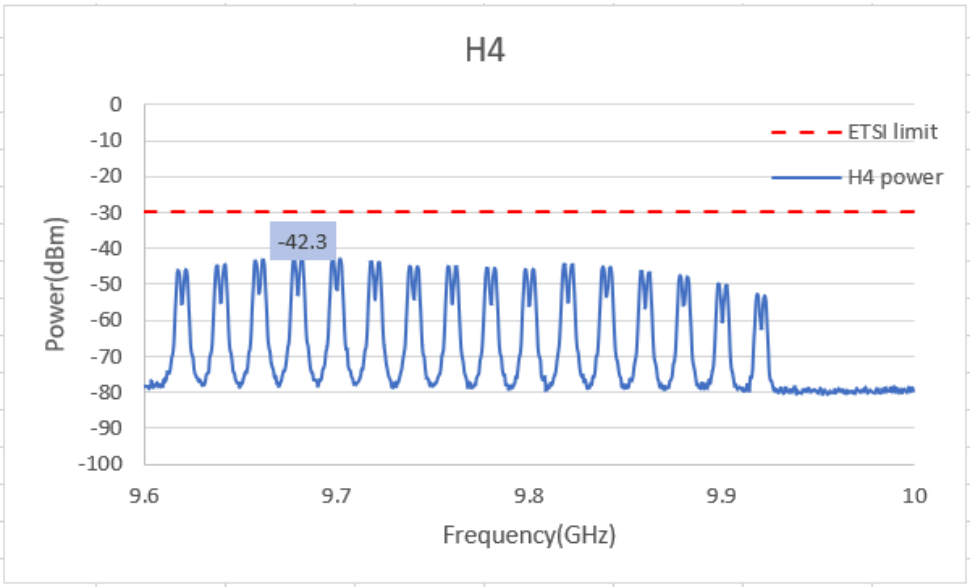

Figure 93. Tx spurious (H4, ETSI test conditions)

Conducted H4 spurious

Results:

Maximum power is on Channel 16: **-42.3 dBm**

Conclusion:

- There is **12.3** dB margin to the ETSI limit.

4.3.1.6.5 H5 (ETSI test conditions)

The test method is similar as for the H2, except the spectrum analyzer frequency span is set from 12.0 GHz to 12.5 GHz.

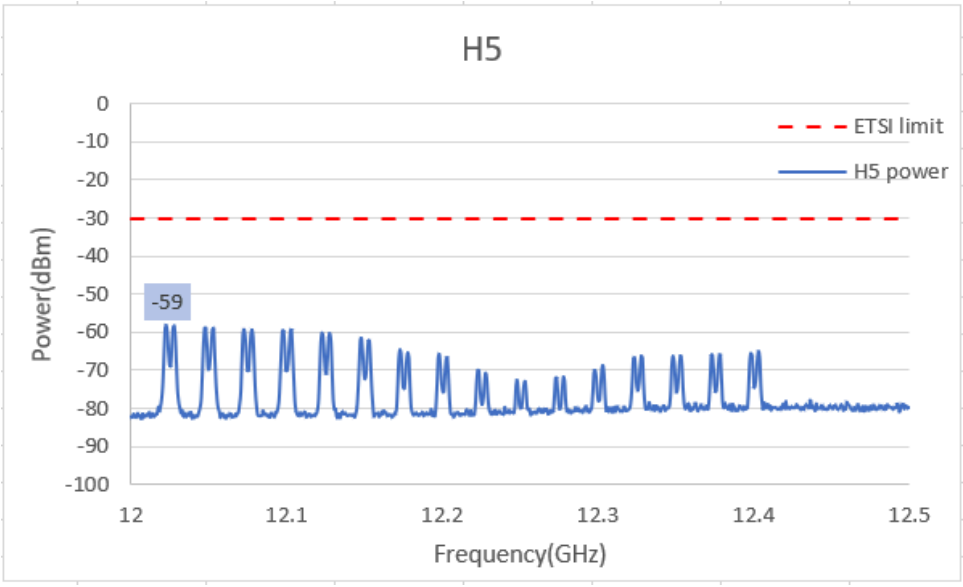

Figure 94. Tx spurious (H5, ETSI test conditions)

Conducted H5 spurious

Results:

Maximum power is on Channel 16: **-59 dBm**

Conclusion:

- There is **29** dB margin to the ETSI limit.

4.3.1.6.6 H6 to H10 (ETSI test conditions)

The test method is similar as for the H2, except the spectrum analyzer frequency span is set to corresponding frequency range.

Table 66. Conducted H6 to H10 spurious

-	H6	H7	H8	H9	H10
EN limit	-30	-30	-30	-30	-30
Spurious Power	-48.6	-55.6	-55.2	-48.3	-47.3
Margin	18.6	25.6	25.2	18.3	17.3

Conducted H6 to H10 spurious

Conclusion:

- There is **good** margin to the ETSI limit.

4.3.1.6.7 Test result details

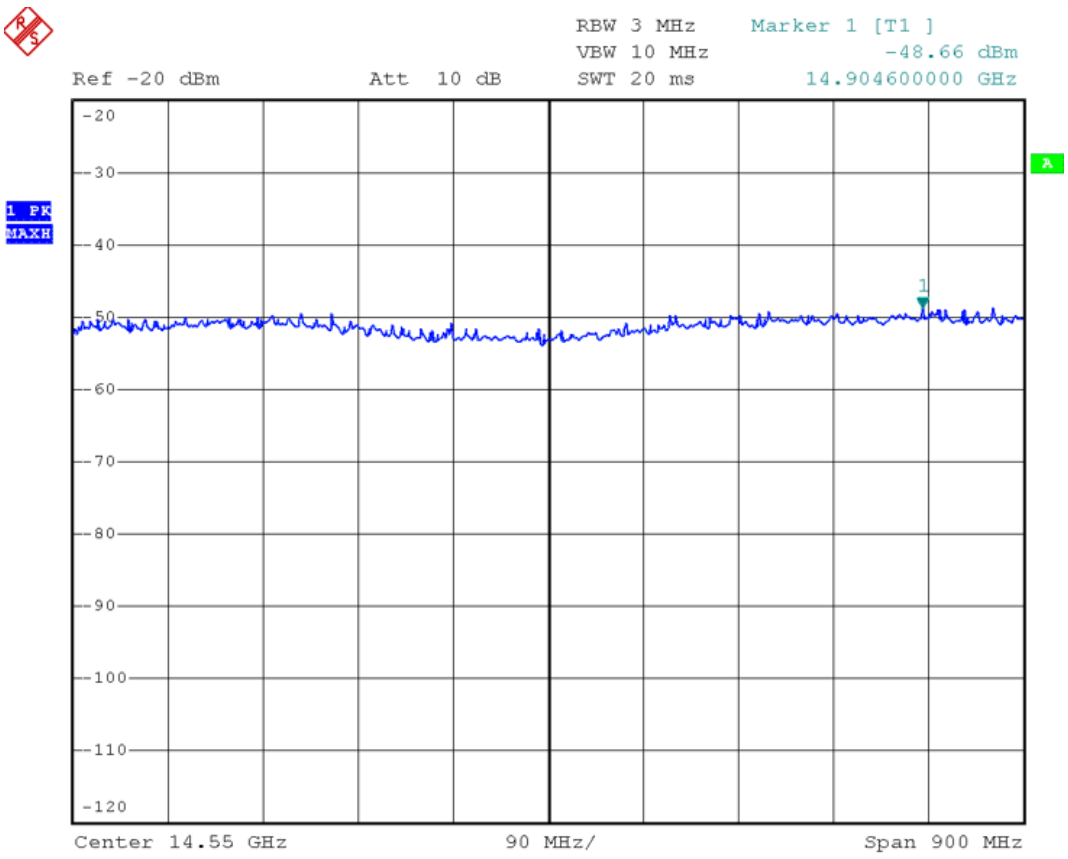

Figure 95. Conducted H6 spurious

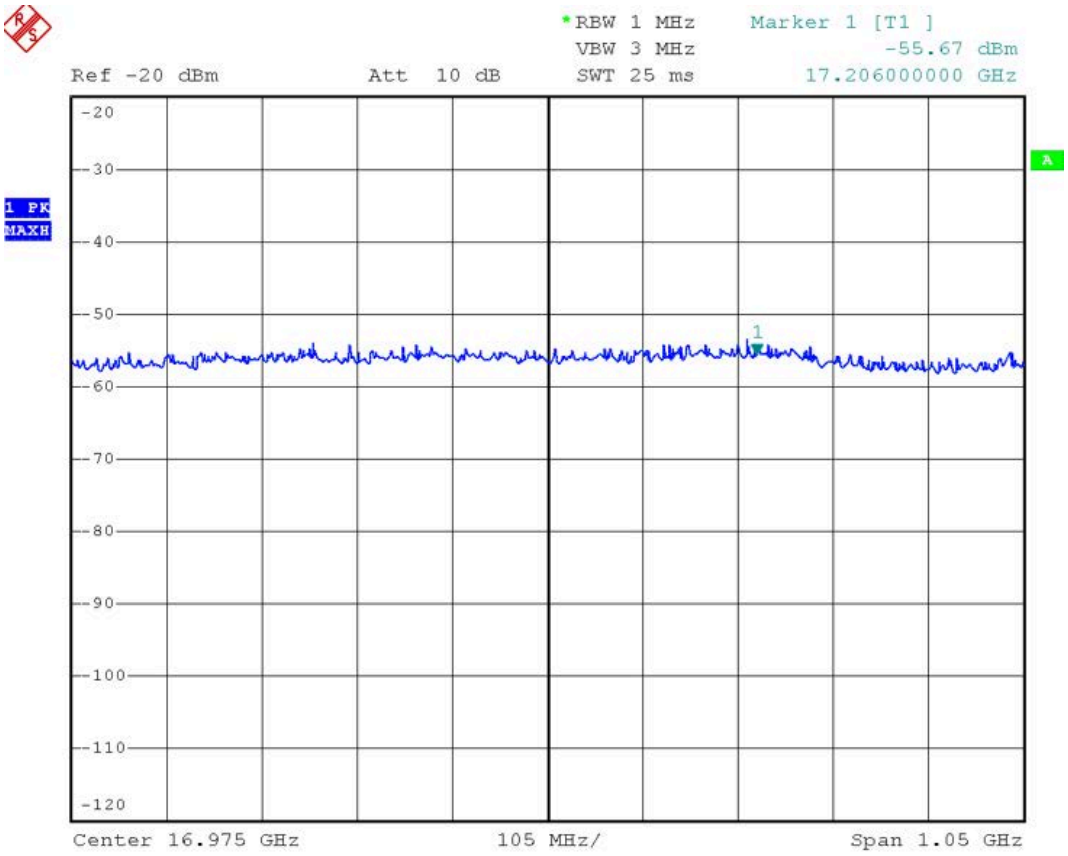

Figure 96. Conducted H7 spurious

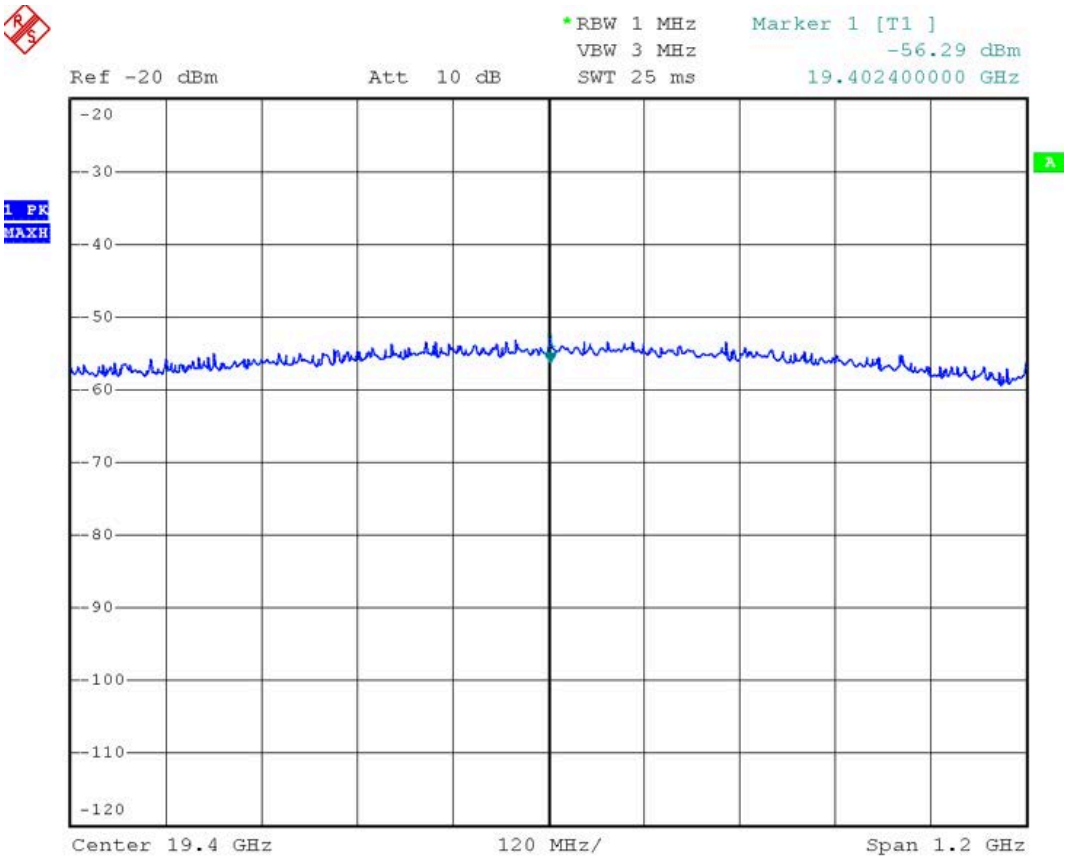

Figure 97. Conducted H8 spurious

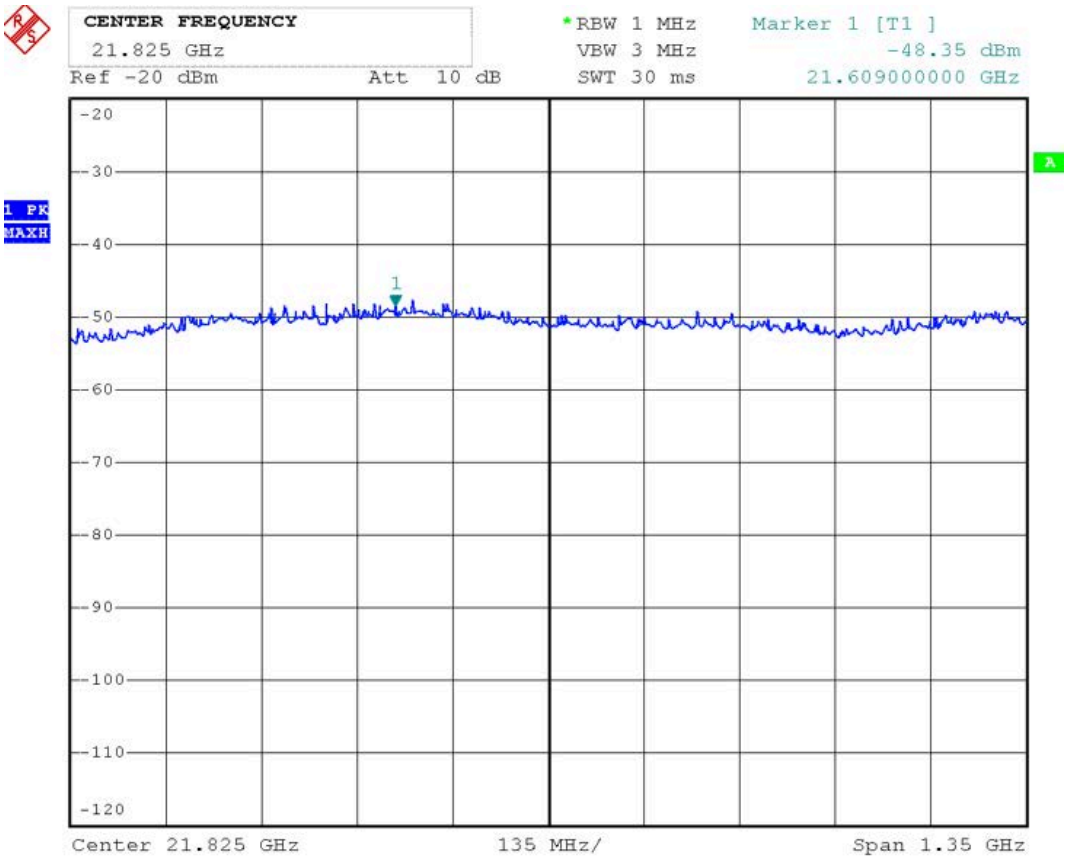

Figure 98. Conducted H9 spurious

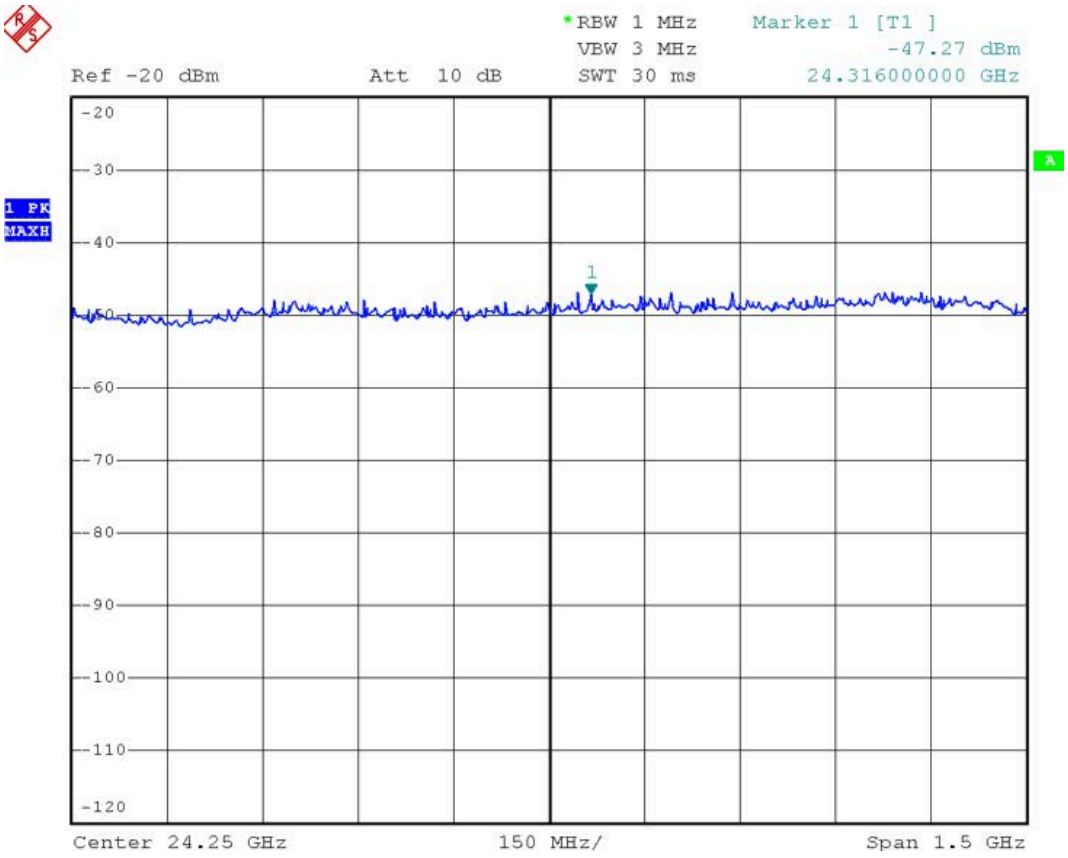

Figure 99. Conducted H10 spurious

4.3.1.6.8 H2 (FCC test conditions)

Test method:

- Set the radio in:
  - Tx mode, modulated, continuous mode
- Set analyzer to:
  - Start frequency= 4.8 GHz, Stop frequency = 5 GHz,
  - Ref amp = -20 dBm, RF attenuation = sweep time = 100 ms, RBW = 1 MHz
- Trace mode: Average
- Detector RMS
- Sweep all the channels from Channel 11 to Channel 26

Results:

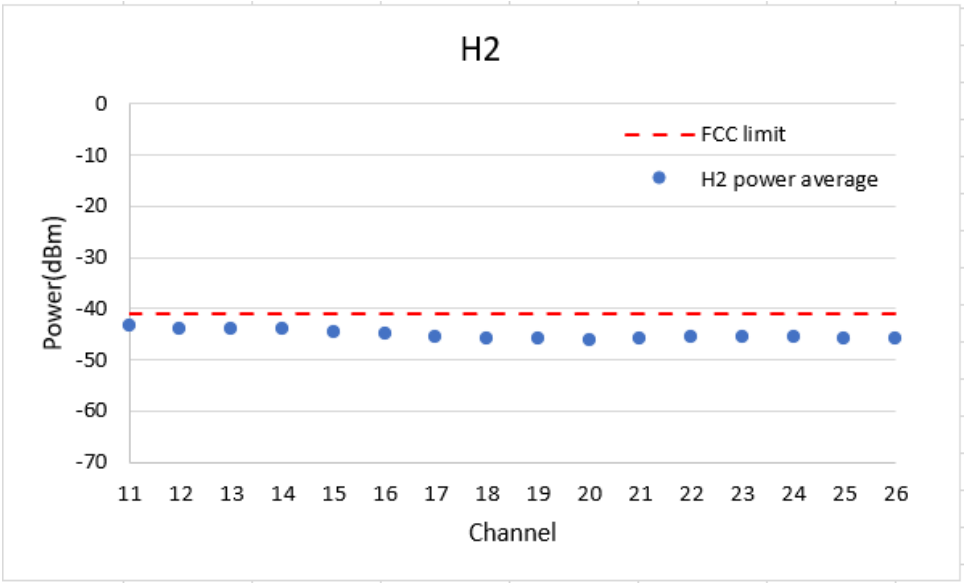

Figure 100. Tx spurious (H2, FCC test conditions)

Conducted H2 spurious

Maximum power is: **-43.5 dBm** on Channel 11.

Conclusion:

- There is **2.5 dB** margin to the FCC limit

4.3.1.6.9 H3 (FCC test conditions)

The test method is similar as for the H2, except the spectrum analyzer frequency start/stop are set to 7.2 GHz and 7.5 GHz.

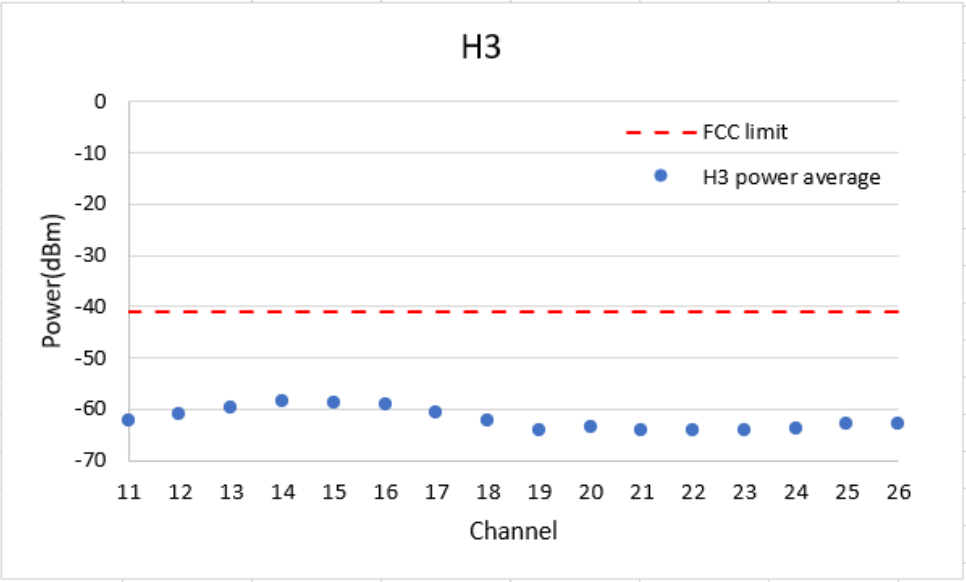

Figure 101. Tx spurious (H3, FCC test conditions)

Conducted H3 spurious

Results:

Maximum power is on channels 18 to 26: **-58 dBm**

Conclusion:

- There is **17** dB margin to the FCC limit.

4.3.1.6.10 H4 (FCC test conditions)

The test method is similar as for the H2, except the spectrum analyzer frequency span is set from 9.6 GHz to 10.0 GHz.

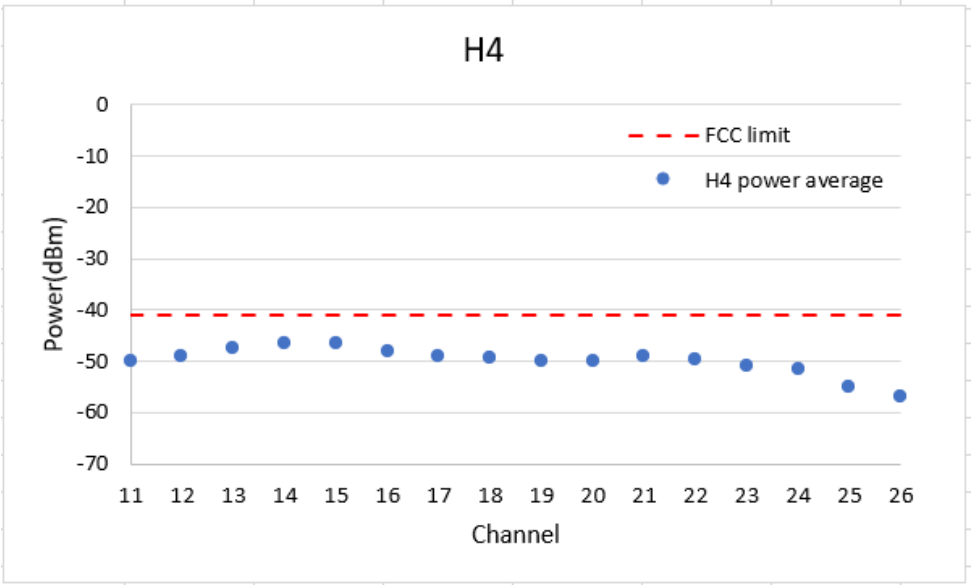

Figure 102. Tx spurious (H4, FCC test conditions)

.

Conducted H4 spurious

Results: Maximum power is on channel 17: **-46 dBm**

Conclusion:

- There is **5** dB margin to the FCC limit.

4.3.1.6.11 H5 (FCC test conditions)

The test method is similar as for the H2, except the spectrum analyzer frequency span is set from 12 GHz to 12.5 GHz.

Result:

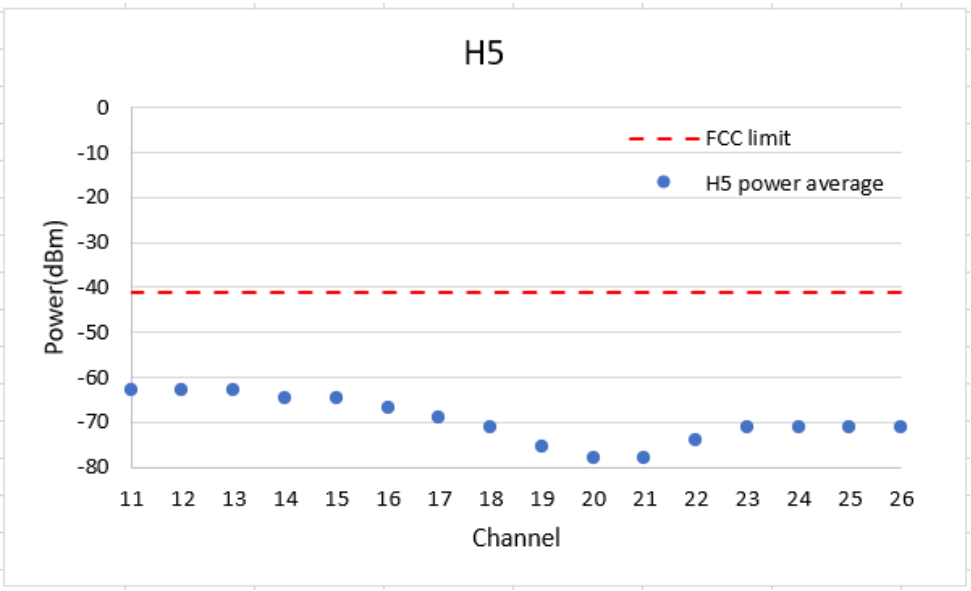

Figure 103. Tx spurious (H5, FCC test conditions)

Conducted H5 spurious

Maximum power is on channel 17: **-63 dBm**

Conclusion:

- There is **22** dB margin to the FCC limit.

4.3.1.6.12 H6 to H10 (FCC test conditions)

The test method is similar as for the H2, except the spectrum analyzer frequency span is set to corresponding frequency range.

Result:

Table 67. Conducted H6 to H10 spurious

-	H6	H7	H8	H9	H10
FCC limit	-41.5	-41.5	-41.5	-41.5	-41.5
Spurious Power	-59.5	-63.2	-62.9	-57.4	-58.3
Margin	18	21.7	21.4	15.9	16.8

Conducted H6 to H10 spurious

Conclusion:

- There is **good** margin to the FCC limit on H6, H7, H8, H9, and H10 range.

4.3.1.6.13 Test result details

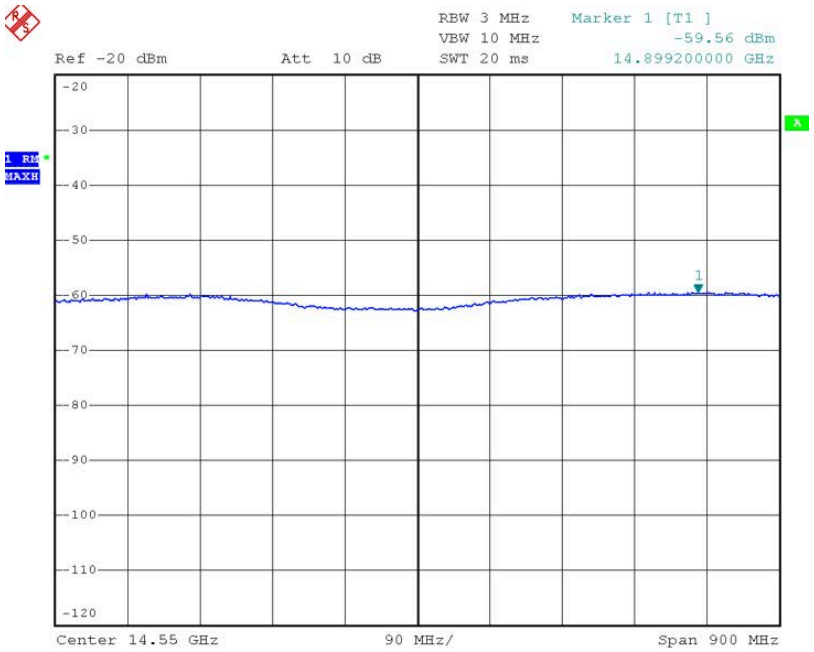

Figure 104. Conducted H6 spurious

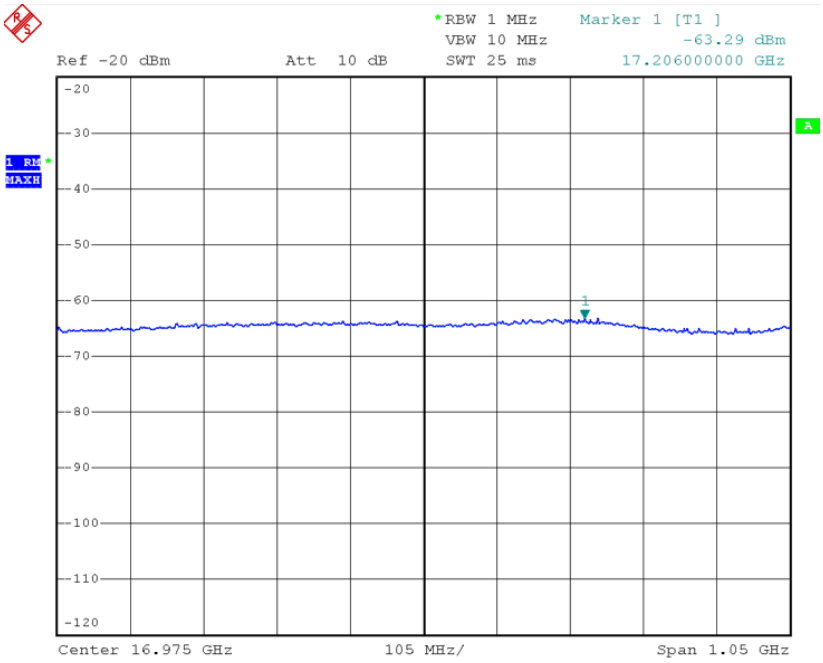

Figure 105. Conducted H7 spurious

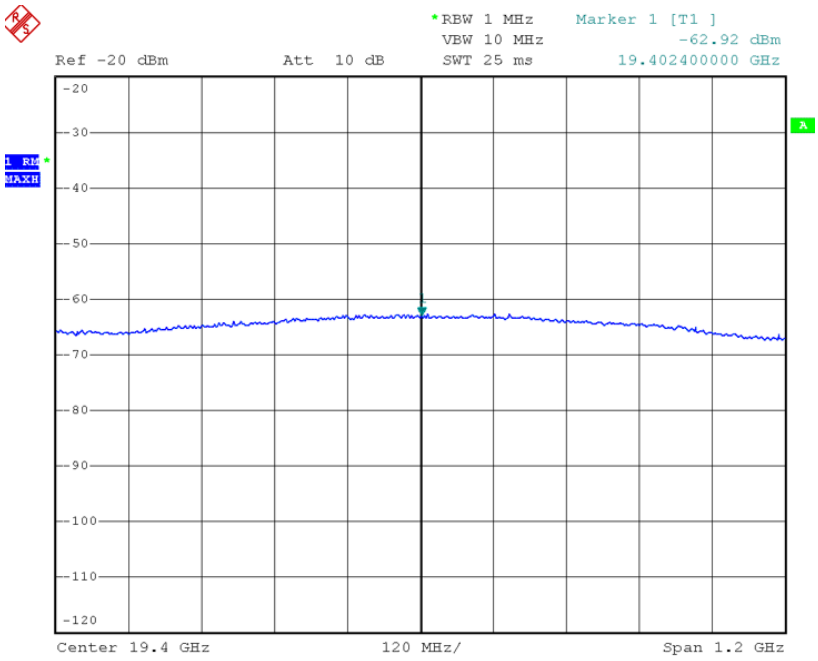

Figure 106. Conducted H8 spurious

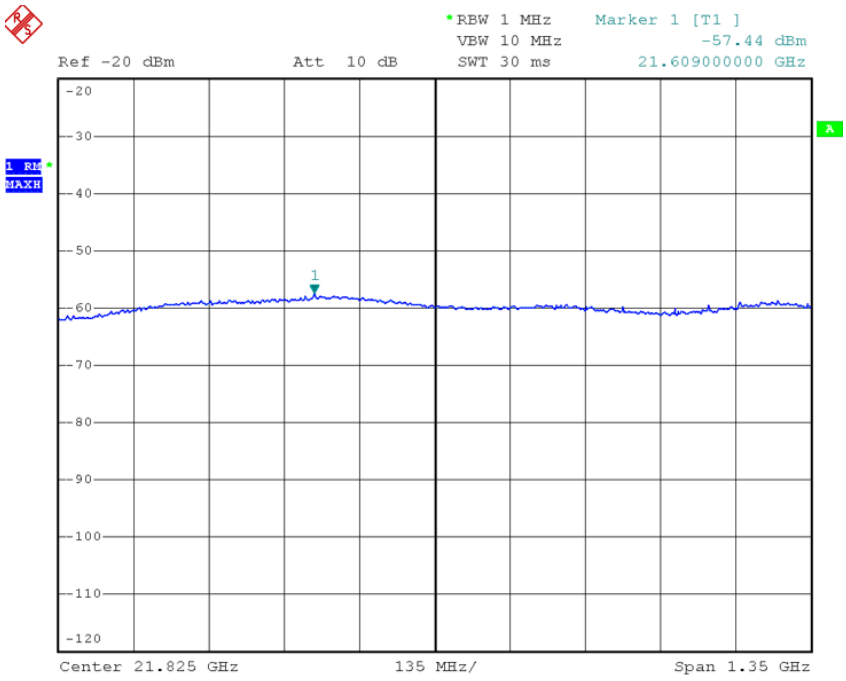

Figure 107. Conducted H9 spurious

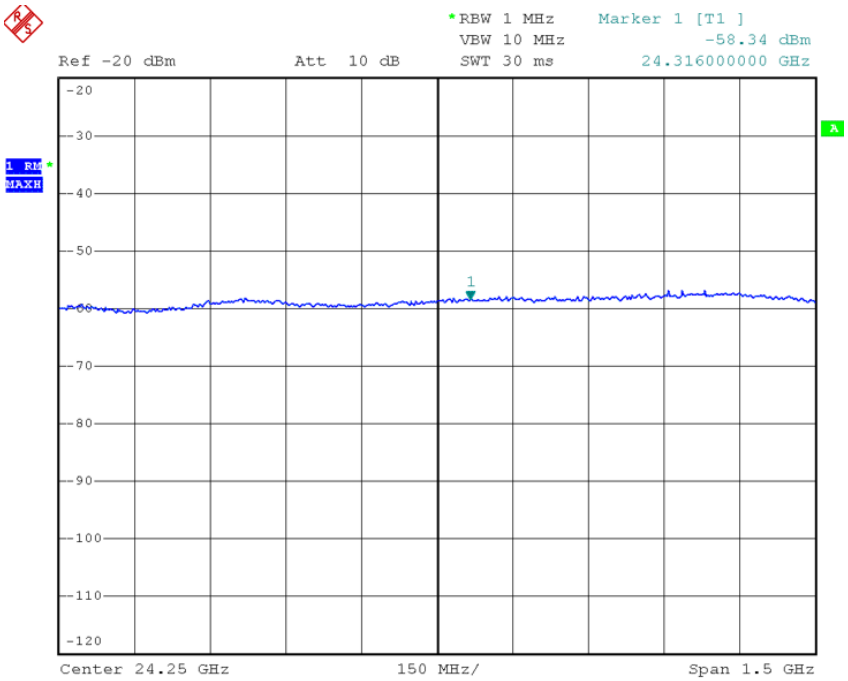

Figure 108. Conducted H10 spurious

4.3.1.7 Tx modulation

4.3.1.7.1 EVM

Test method

- Connect the RF port of the module to the R&S FSV spectrum analyzer. Use the specific menu of the SA to perform EVM measurement.
- Set the board in continuous modulated mode.
- Set the Tx frequency to channel 11.
- Measure the offset EVM value.
- Repeat the test for each channel.

The graphs in the following sections show the EVM test result.

EVM in regular mode

Result:

maximum value on channel 23 = **7.0 %**

Conclusion:

- Very good margin versus the 802.15.4 limit.

4.3.1.7.2 Offset EVM

Test method:

- Similar method as for the EVM measurement

Offset EVM in regular mode

Result:

Max value on channel 24 = **0.38 %**

Conclusion:

- Very good margin

4.3.1.8 Lower Band Edge – China MIIT

4.3.1.8.1 Test method

- Set the radio to:
  - TX mode, modulated, burst mode
- Set the channel 11 (2.405GHz)
- Set the analyzer to:
  - Start frequency = 2.385 GHz, Stop frequency=2.415 GHz, Ref amp=-20 dBm, sweep time=100 ms, sweep point: 8001pts
  - RBW = 1 MHz, Video BW = 3 MHz Detector = RMS MaxHold

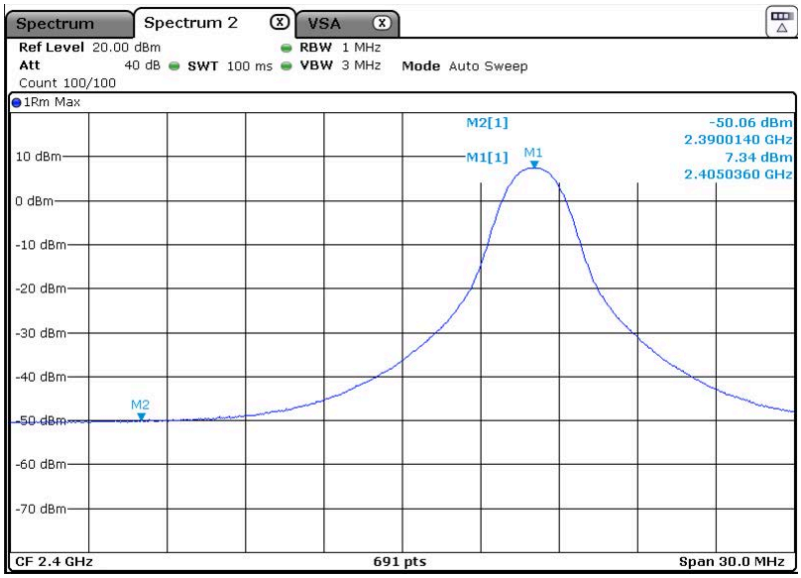

Figure 109. Lower Band Edge – Channel 11

Conclusion:

- The Lower Band Edge test pass the Lower Band Edge test certification.
- There is good margin to MIIT-China limit (-50 dBm below 2.39 GHz).

4.3.1.9 Upper Band Edge – MIIT China

4.3.1.9.1 Test method

- Set the radio to:
  - TX mode, modulated, continuous mode, Maximum RF output power +10 dBm（Does not pass the FCC requirement）
- Set the channel 26 (2.48 GHz)
- Set the power to -5 dBm for 802.15.4
- Set the analyzer to:
  - Start frequency = 2.477 GHz, Stop frequency=2.507 GHz,
  - Ref amp=-20 dBm, sweep time=40 ms, sweep point: 8001pts
  - RBW = 1 MHz, Video BW = 3 MHz Detector = RMS MaxHold

4.3.1.9.2 Results for Upper Band Edge – MIIT China

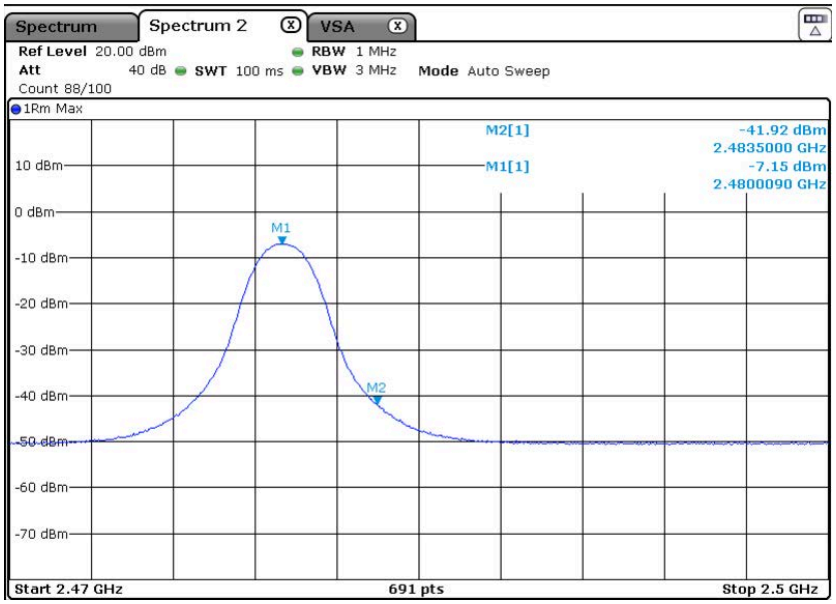

Figure 110. 802.15.4 - Upper Band Edge – Channel 26

Conclusion:

- The Upper Band Edge test passes the Upper Band Edge test from MIIT-China certification.
- The TX power must be set down to -5 dBm from +10 dBm on channel 26 to be sure to pass the test.

4.3.1.10 Upper Band Edge (FCC ANSI C63.10, 558074 D01 DTS)

4.3.1.10.1 Test method

- Set the radio to:
  - TX mode, modulated, continuous mode, Maximum RF output power +10dBm（is not pass the FCC requirement）
- Set the RF output power +5dBm
- Set the analyzer to:
  - Start frequency = 2.475 GHz, Stop frequency=2.485 GHz, Ref amp=-20 dBm, sweep time=100 ms,
  - RBW = 100kHz, Video BW = 300kHz
  - Detector = Average
  - Average mode

  : power Number of Sweeps = 100
- Set the channel 26 (2.48GHz) Trace mode: Max hold

4.3.1.10.2 Results

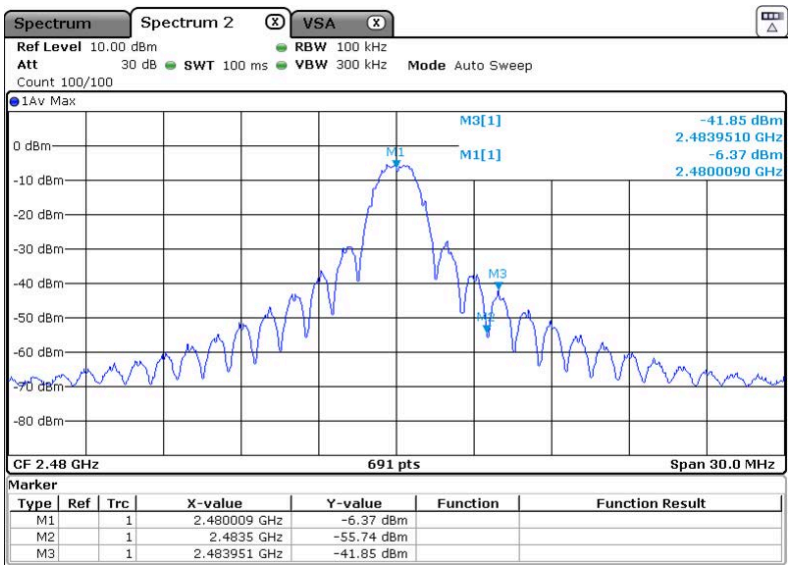

Figure 111. Upper Band Edge – Channel 39

Results:

Table 68. Results: *FCC limit: < -41.15 dBm*

Modulation	Tx power + 5 dBm
Level @2.4835GHz	-42 dBm

Conclusion:

- The Upper Band Edge test pass the FCC certification (< 41.15 dBm@2.4835GHz) in Tx power have to set down to +5 dBm from +10 dBm on Channel 26.

4.3.1.11 Out Of Band (ETSI 300 328)

This section describes the test method and results for Out Of Band (*ETSI 300 328*. Refer to *Chapter 5.4.8.2.1*)

Test method:

- Set the radio to:
  - TX mode, modulated, continuous mode
- Set the channel 0 (2.402 GHz) and 39 (2.48 GHz)
- Set the analyzer to:
  - Start frequency = 2.375 GHz, Stop frequency=2.510 GHz, Ref amp=-20 dBm, sweep time=100 ms,
  - RBW = 1 MHz, Video BW = 3 MHz Detector = RMS
  - Average mode: power Number of Sweeps = 100
- Set the channel 0 (2.402 GHz) and 39 (2.48 GHz) Trace mode: Max hold

Results:

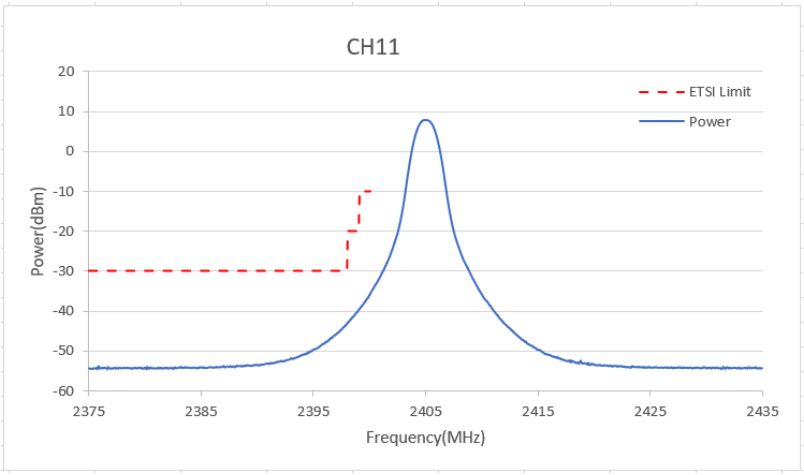

Figure 112. Out Of Band – Channel 11

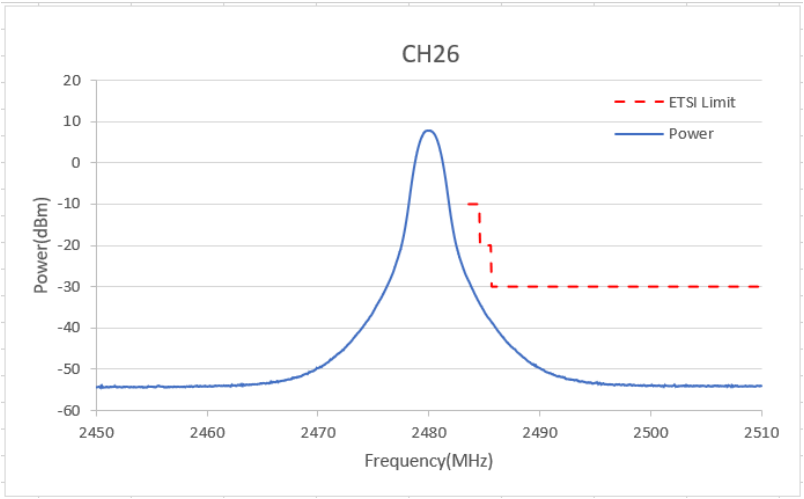

Figure 113. Out Of Band – Channel 26

Conclusion:

- The Out Of Band test passes the ETSI certification.

4.3.1.12 Out Of Band (ARIB STD T-66)

Test method:

- Set the radio to: TX mode, modulated, continuous mode
- Set the analyzer to:
  - Start frequency = 2.475 GHz, Stop frequency=2.485 GHz, Ref amp=-20 dBm, sweep time=100 ms,
  - RBW = 1MHz, Video BW = 1MHz Detector = Peak
  - Average mode: power Number of Sweeps = 100
- Set the channel 0 (2.402GHz) and 39 (2.48GHz) Trace mode: Max hold

Detailed results:

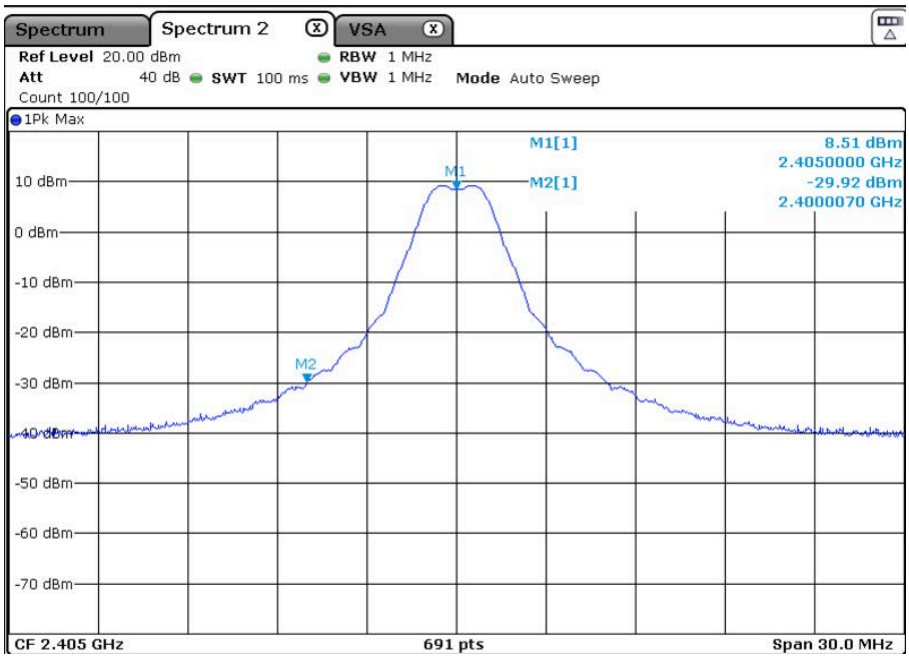

Figure 114. Out of Band – Channel 0 - ARIB

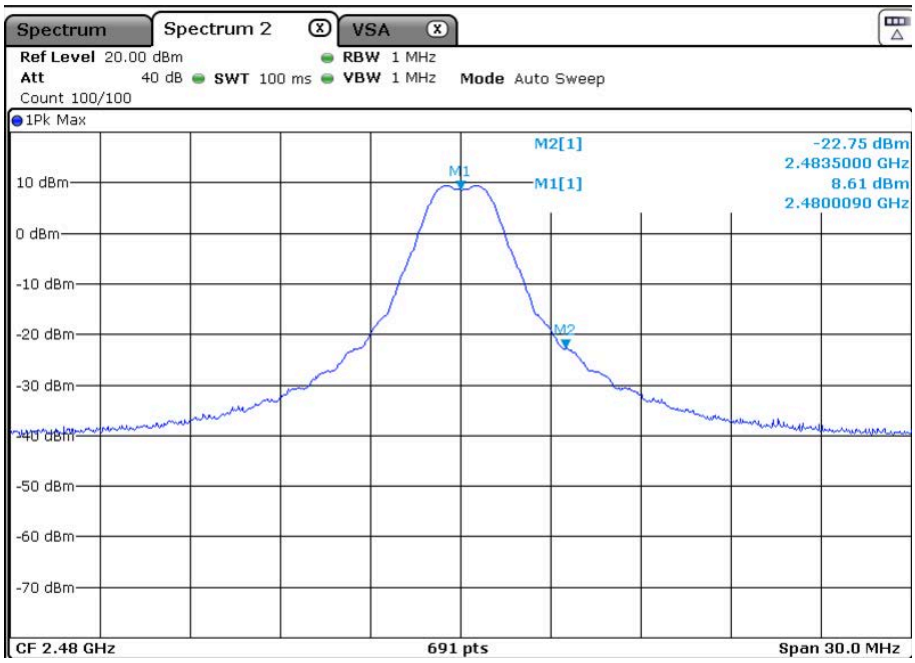

Figure 115. Out of Band – Channel 39 - ARIB

Conclusion:

- The Out of Band test pass the ARIB STD T-66 certification.

4.3.2 Rx tests

4.3.2.1 Application Test setup RX

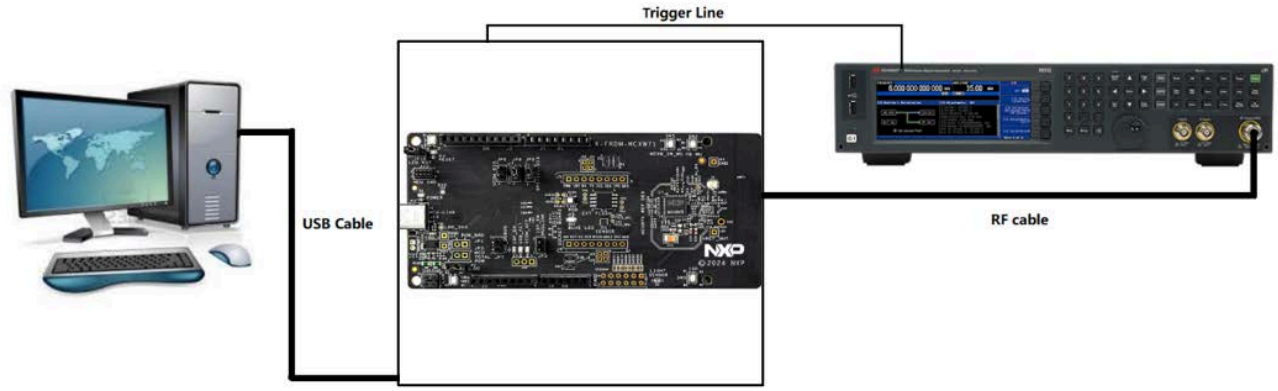

Figure 116. Conducted Rx test setup for sensitivity with RF generator and faraday box

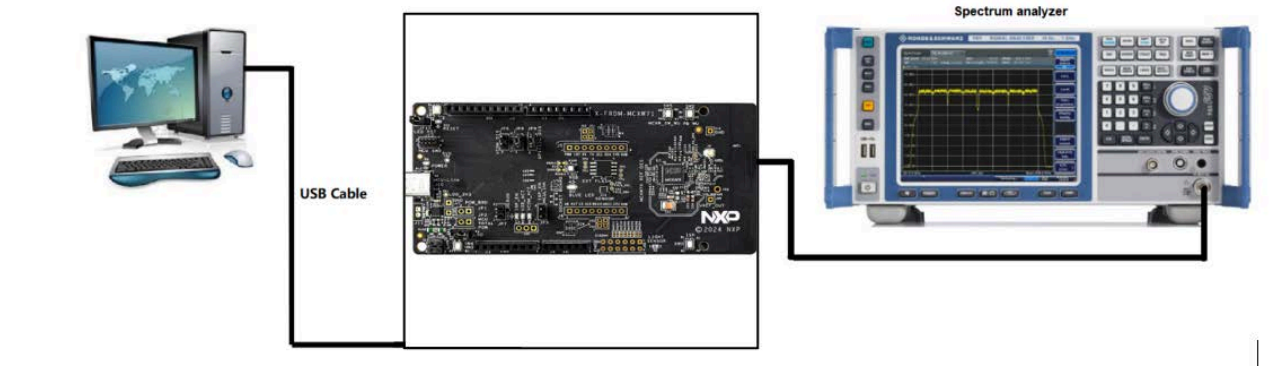

Figure 117. Conducted Rx test setup for spurious

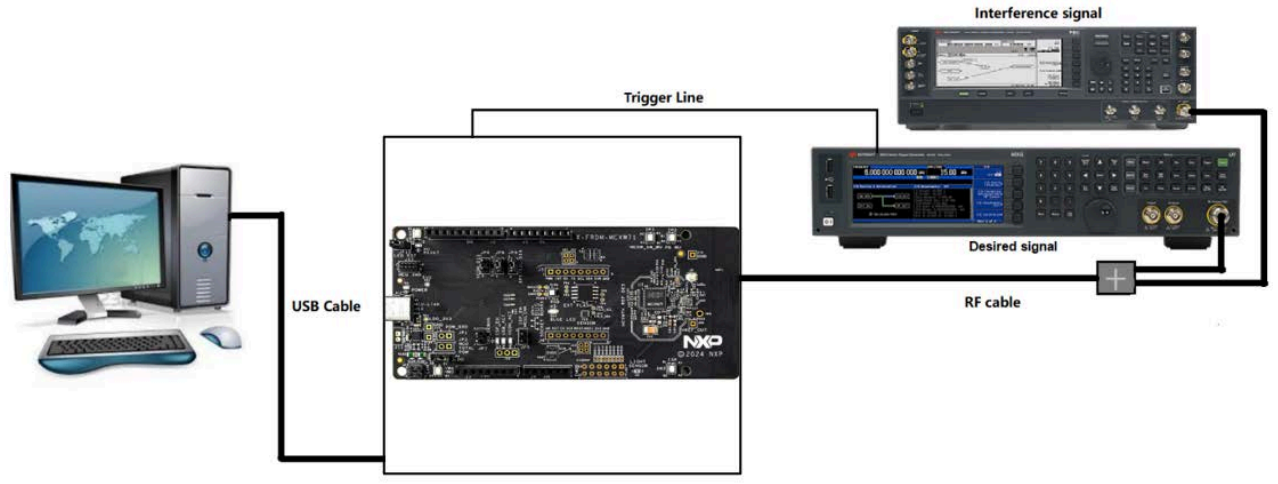

Figure 118. Conducted Rx test setup for interference rejection

4.3.2.2 Rx sensitivity (IEEE)

Test method:

The carrier board and MCX W71-EVK (former generation) module are placed in a RF shield room to avoid any interference.

Generator: Keysight N5182B

The generator is used in ARB mode. It generates a pattern of 1000 packets of 20 octets. The DIO19 of the MCXW71(Former Generation) is connected to the trigger input of the generator.

A Teraterm window is used to control the module.

- Set the receive frequency to channel 11
- Set the module in Trigger packet test
- The connection is automatically established and the Packet Error Rate (PER) is measured.
- Decrease the level of the generator at the RF input of the module until PER = 1%.
- Do the same for other channels.

Result:

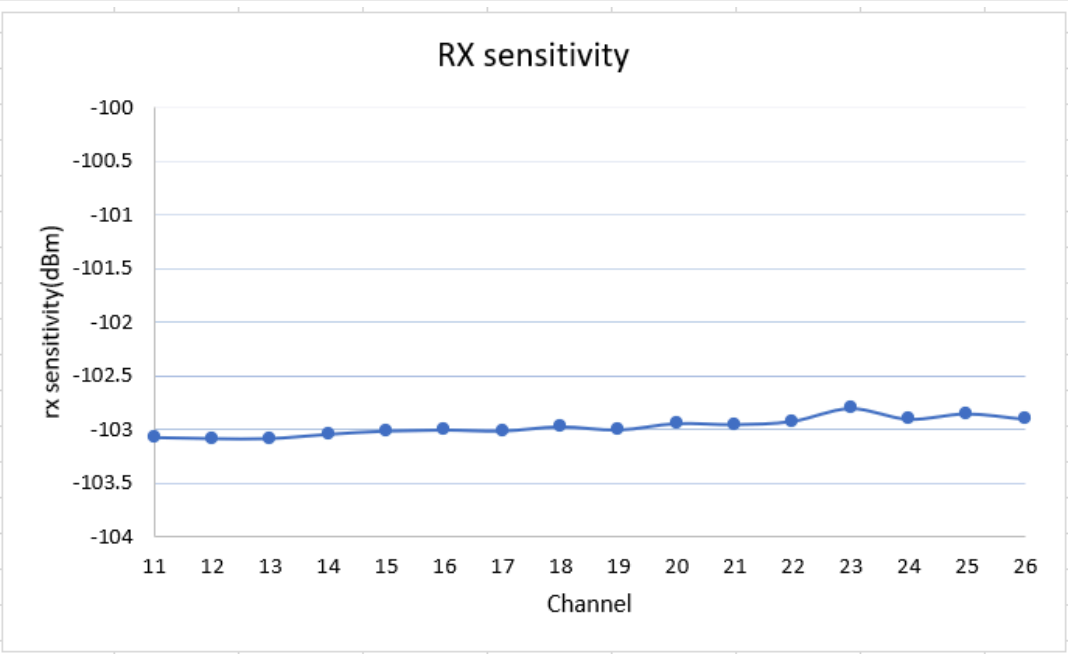

Figure 119. Rx sensitivity

RX Sensitivity

Conclusion:

Minimum value: **- 103.1 dBm on channel 12**

Maximum value: **-102.8 dBm on channels 23**

All frames are 20 bytes = 40 bytes + 12 symbols for PHY header = 52 symbols

Time delta between two 20 bytes frames is 832 µs = 52 symbols.

time delta = **SFD2 - SFD1**

= [4 bytes preamble, 1 byte SFD] of frame2 + [IFS] + [length + PHY payload] of frame 1 = 10 symbols +IFS + 42 symbols =

= 52 symbols + IFS => IFS = 0

4.3.2.3 Rx sensitivity bathtub

Test method:

The carrier board and MCXW71 (Former Generation) module are placed in a RF shield room to avoid any interference.

Generator: Keysight N5182B

The generator is used in ARB mode. It generates a pattern of 1000 packets of 20 octets. The DIO19 of the MCXW71(Former Generation) is connected to the trigger input of the generator.

A Teraterm window is used to control the module.

- Set the receive frequency to Channel 11.
- Set the module in Trigger packet test.
- The connection is automatically established and the Packet Error Rate (PER) is measured.
- Decrease the level of the generator at the RF input of the module until PER = 1%.

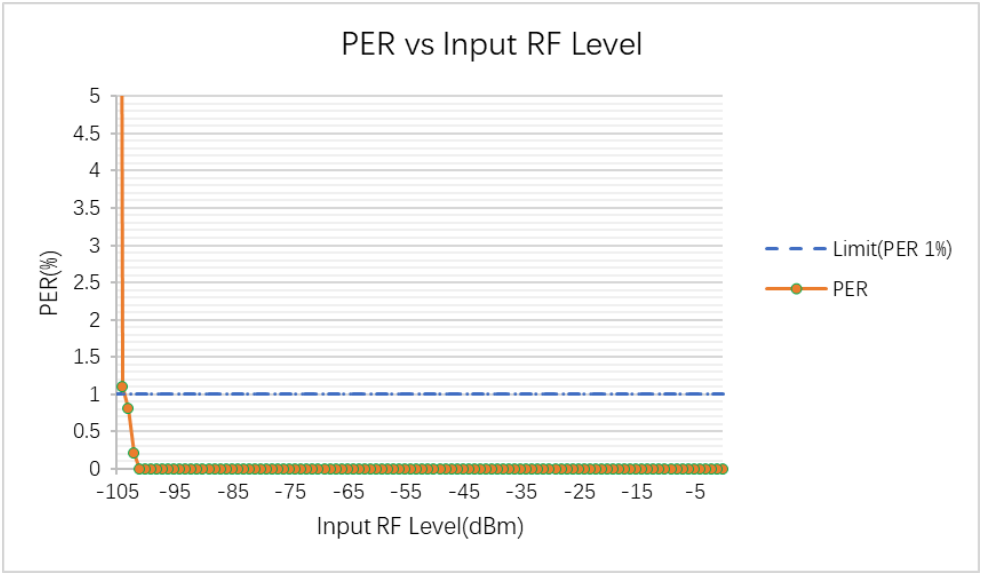

Figure 120. Rx sensitivity bathtub

Result:

Sensitivity bathtub

4.3.2.4 Receiver maximum input level (IEEE)

Test method

Generator: Keysight N5182B

The generator is used in ARB mode. It generates a pattern of 1000 packets of 20 octets. The DIO19 of the MCX W71-EVK (former generation) is connected to the trigger input of the generator.

A Teraterm window is used to control the module.

- Set the receive frequency to channel 11
- Set the module in Trigger packet test
- The connection is automatically established and the PER is measured.
- Increase the level of the generator at the RF input of the module until PER = 1%.
- Do the same for other channels.

Maximum input power

Conclusion

The actual maximum input level cannot be measured with the test environment. The maximum level that can be delivered to the MCXW71(Former Generation) is limited by the maximum output power of the generator.

The maximum input level of MCXW71(Former Generation) is higher than **20 dBm** on all channels.

4.3.2.5 Rx spurious (IEEE)

Test method:

- Set the radio in: Receiver mode, frequency: channel 18
- Set the analyzer to:
  - Ref amp = - 20 dBm, Trace = max hold, detector = max peak
  - Start/stop frequency: 30 MHz/1 GHz, RBW = 100 kHz,
  - Then start/stop frequency: 1 GHz/12.75 GHz, RBW = 1 MHz

Results:

Conducted Rx spurious

Note: *No spurious has been detected.*

4.3.2.6 Receiver interference rejection

4.3.2.6.1 Adjacent and alternate channels with standard interferers

Interferers are located in the adjacent channel (n-1 and n+1) or alternate channels (n-2 and n+2). See Table 69.

The test is performed with only one interfering signal at a time.

Test method:

Generator for desired signal: Keysight N5182B generator (modulated)

Generator for interferers: Keysight E8267D (modulated)

Criterion: PER < 1 %

The expected signal is set to - 82 dBm. The interferer is increased until the PER threshold has been reached.

Channels under test: 11, 18, and 26 (although n-1, n-2 are not system relevant for channel 11 and n+, n+2 are not system relevant for channel 26).

Results:

Table 69. Adjacent and alternate rejection

-	2405				2440				2480			
-	n-2	n-1	n+1	n+2	n-2	n-1	n+1	n+2	n-2	n-1	n+1	n+2
-	2395	2400	2410	2415	2430	2435	2445	2450	2470	2475	2485	2490

Table 69. Adjacent and alternate rejection...*continued*

-	2405				2440				2480			
interfere (dBm)	-35	-45	-45	-36	-36	-45	-45	-35	-36	-45	-45	-36
Interfere (dBc)	47	37	37	46	46	37	37	47	46	37	37	46
802.15.4 limit	30	0	0	30	30	0	0	30	30	0	0	30
Margin	**17**	**37**	**37**	**16**	**16**	**37**	**37**	**17**	**16**	**37**	**37**	**16**

Conclusion: Good margin, in line with the expected results.

4.3.2.6.2 N-3 and n+3 channels with standard interferers

Test method:

Similar as for the adjacent and alternate channels but the interferer is set at +/- 15 MHz offset from the desired channel.

Results:

Table 70. N-/+3 band rejection

-	2405		2440		2480	
-	n-3	n+3	n-3	n+3	n-3	n+3
-	2390	2420	2425	2455	2465	2495
Interferer (dBm)	-31	-31	-31	-31	-31	-31
Interferer (dBc)	51	51	51	51	51	51

Conclusion:

The result is In line with expected values.

4.3.2.6.3 Co-channel

Results: Table 71 and Table 72 display the results for Receiver interference rejection (co-channel case).

Table 71. Co-channel

Parameter Name	2405	2440	2480
Expected	-82	-82	-82I
Interferer (dBm)	-85	-86	-85
Interferer (dBc	-3	-4	-3

Table 72. Co-channel with worst case

	2405	2440	2480
Expected (sensi + 3 dB)	-100	-100	-100
Interferer (dBm)	-104	-104	-103
Interferer (dBc)	-4	-4	-3

Conclusion:

Results are in line with the expected values.

4.3.2.7 Receiver blocking

The MCX W71-EVK (former generation) is an equipment of category 1 as defined by the ETSI 300 328 (Tx signal higher than 10 dBm). Tests and limits are used according to category 1. Interferer is a CW signal.

4.3.2.7.1 Test 1

Table 73 displays the results for IEEE 802.15.4 Receiver blocking test 1.

Table 73. Receiver blocking test 1

Channel	11	11	26	26
Wanted Frequency (MHz)	2405	2405	2480	2480
Interferer Type	Low	High	Low	High
Interferer Frequency (MHz)	2380	2504	2380	2504
Interferer Level (dBm)	3.7	5.8	5.5	3.3
Interferer Level (dBc)	72.9	75	74.7	72.5
802.15.4 Limit (dBm)	-34	-34	-34	-34
Margin (dB)	**37.7**	**39.8**	**39.5**	**37.3**

Conclusion: Very good margin

4.3.2.7.2 Test 2

Table 74 displays the results for IEEE 802.15.4 Receiver blocking test 2.

Table 74. Receiver blocking test 2

Channel	11	11	11	26	26	26
Wanted Frequency (MHz)	2405	2405	2405	2480	2480	2480
Interferer Type	Low	Low	Low	Low	Low	Low
Interferer Frequency (MHz)	2300	2330	2360	2300	2330	2360
Interferer Level (dBm)	0.2	-0.5	0.5	0	0	-0.2
Interferer Level (dBc)	79	78	77	79	77	78
802.15.4 Limit (dBm)	-34	-34	-34	-34	-34	-34
Margin (dB)	**34.2**	**33.5**	**34.5**	**34**	**34**	**33.8**

Conclusion: Very good margin

4.3.2.7.3 Test 3

Table 75 displays the results for IEEE 802.15.4 Receiver blocking test 3.

Table 75. Receiver blocking test 3

Channel	11	11	11	11	11	11	26	26	26	26	26	26
Wanted Frequency (MHz)	2405	2405	2405	2405	2405	2405	2480	2480	2480	2480	2480	2480
Interferer Type	High	High	High	High	High	High	High	High	High	High	High	High
Interferer Frequency (MHz)	2524	2554	2584	2614	2644	2674	2524	2554	2584	2614	2644	2674
Interferer Level (dBm)	0.3	0.3	0.7	1	0.8	1	-0.7	0	0.1	0.5	0.6	0.6
Interferer Level (dBc)	77	77	78	78	78	78	76	77	77	77	77	77
802.15.4 Limit (dBm)	-34	-34	-34	-34	-34	-34	-34	-34	-34	-34	-34	-34
Margin (dB)	**34.3**	**34.3**	**34.7**	**35**	**34.8**	**35**	**33.3**	**34**	**34.1**	**34.5**	**34.5**	**34.6**

Conclusion: Very good margin

5 Return loss

This section describes the return loss in RX and TX modes and the RF line insertion loss.

5.1 RX

In the Rx mode, the return loss measurement is performed by setting the LNA gain of MCXW71 (Former Generation) to the maximum.

Hardware used: MCX W71-EVK (former generation)

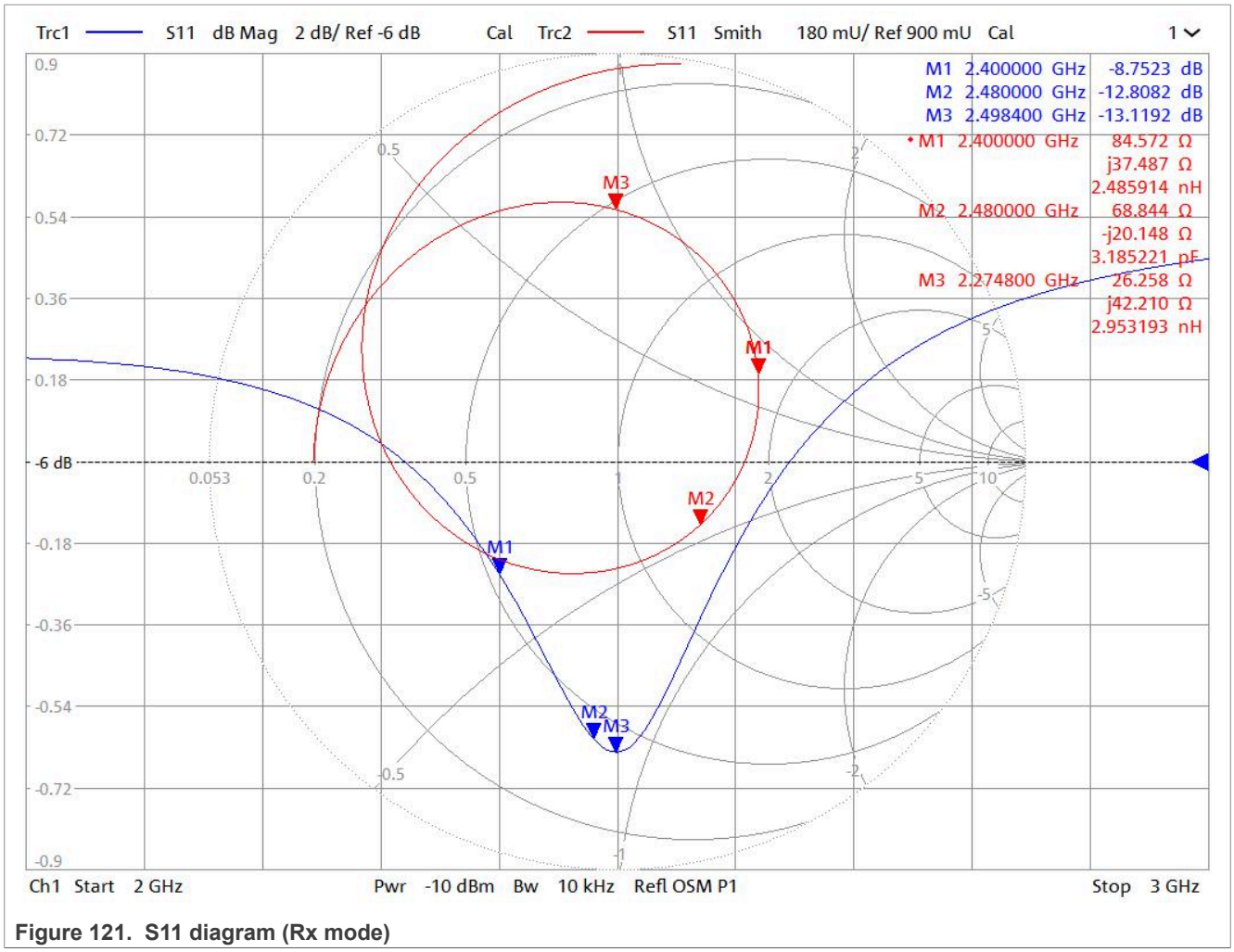

Figure 121. S11 diagram (Rx mode)

Results:

- Return loss: -12.8 dB (2.48 GHz) < S11 < -8.7 dB (2.4 GHz)

There is no specification for the return loss.

Conclusion:

- The return loss (S11) is lower than -8 dB

5.2 TX

In the Tx mode, the return loss measurement is performed by setting the MCXW71 (Former Generation) RF output power to the minimum.

Hardware used: MCX W71-EVK (former generation)

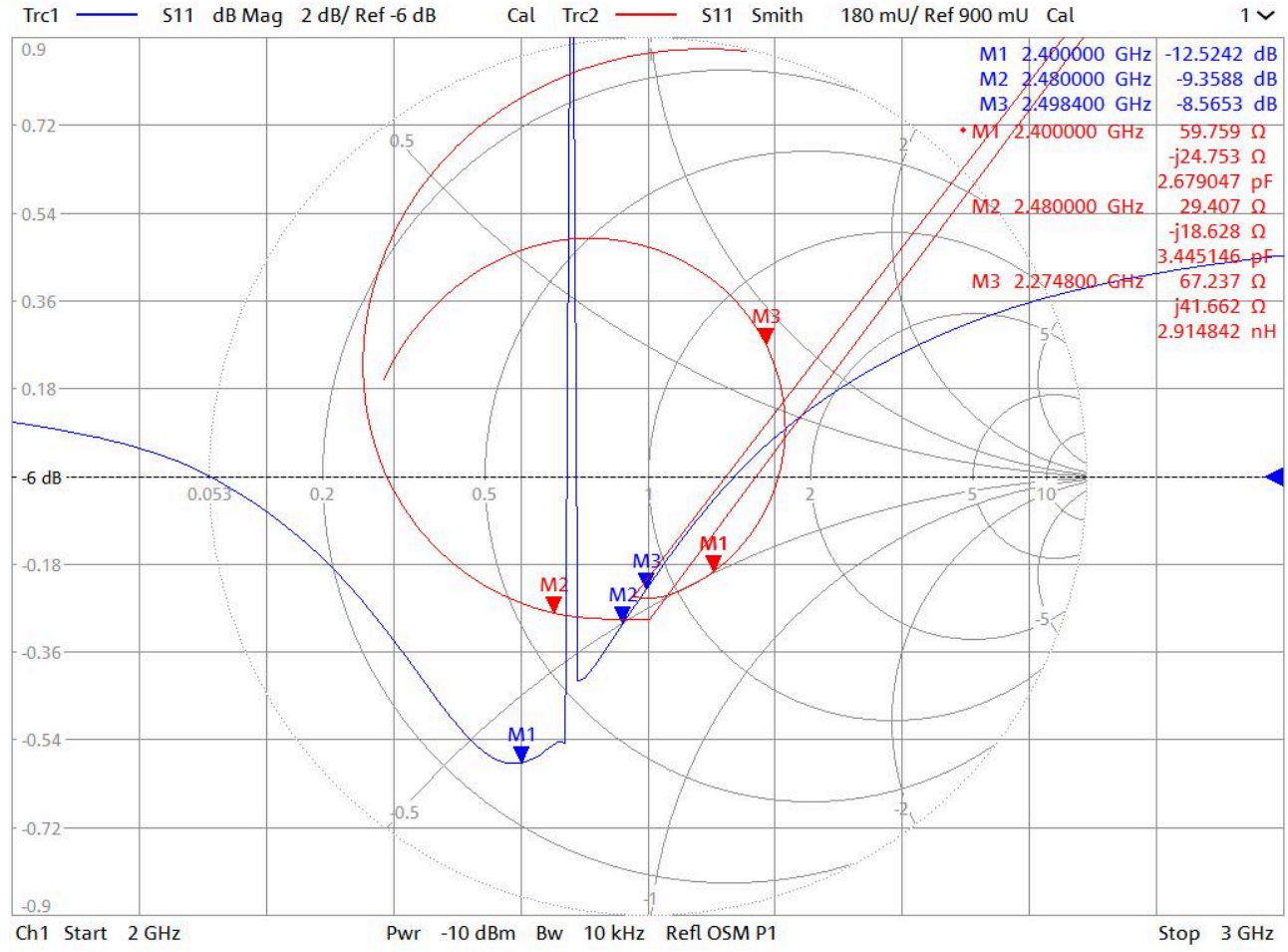

Figure 122. S11 diagram (Tx mode)

Results:

- Return loss: -12.5 dBm (2.4 GHz) < S11 < -9.3dB (2.48 GHz)

There is no specification for the return loss.

Conclusion:

- The return loss (S11) is lower than -9 dB.

5.3 RF line insertion loss

To extract RF line insertion loss, cut the board and solder SMA on Pin ANT_2P4GHZ to isolate the RF line. Remove default component matching and replace by 0 Ω resistor.

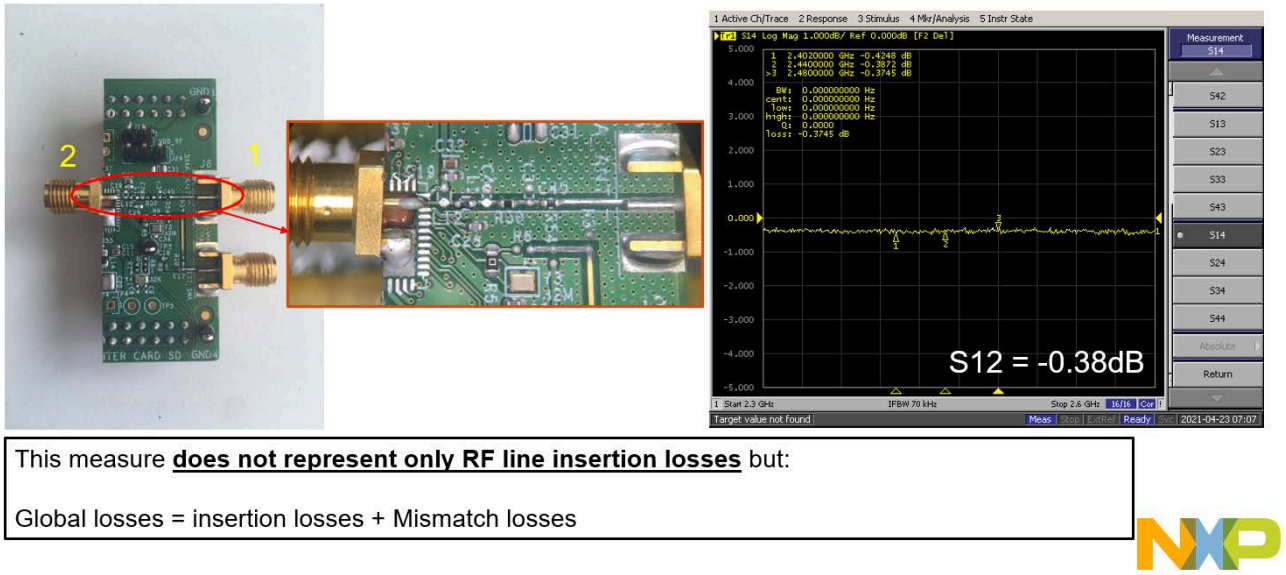

Figure 123. RF line insertion loss measurement

Insertion losses = $\frac{1}{1-|S11|^2} \times |S12|^2$

Use this equation to quantify insertion losses and mismatch losses.

Mismatch losses = -10 x log (1 - Γ^2)

$\Gamma = 10^{-15.3/20} = 0.171791$

Mismatch losses = -10 log (1- 0.171791^2) = -0.13 dB

Insertion losses = Global losses – Mismatch losses

Insertion losses = -0.38 – (-0.13)

Insertion losses = -0.25 dB

In additional to insertion line losses, we must add SMD insertion losses estimated at 0.1 dB

6 Conclusion

Beyond the RED, FCC, Bluetooth LE 5.0 and 802.15.4 compliances, the radio tests described in this document prove a good performance of the MCXW71 wireless MCUs.

7 Appendix A

This section describes the Connectivity Test tools settings that must be used for performing the tests described in this application note.

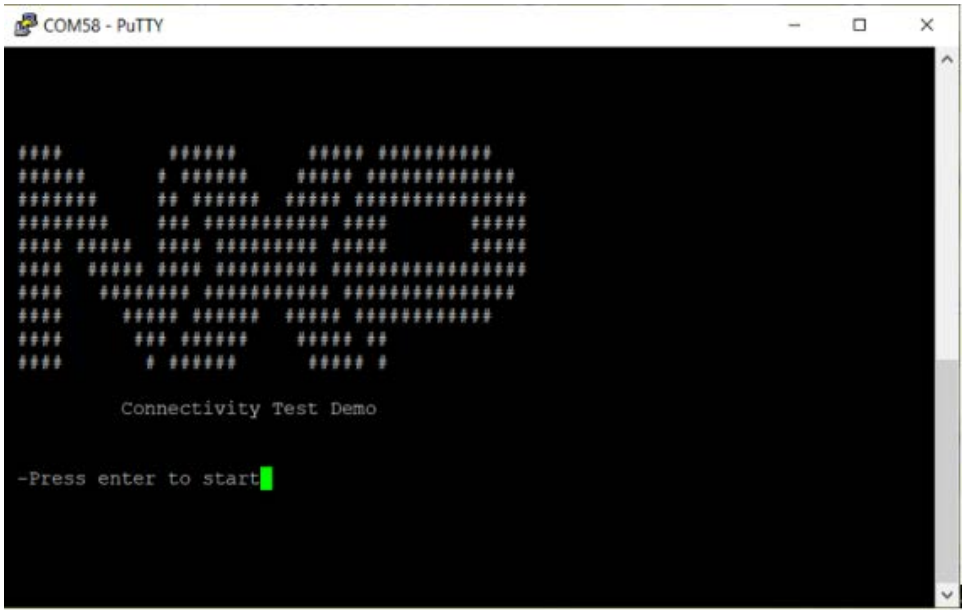

Figure 124. Connectivity test demo Application tools settings

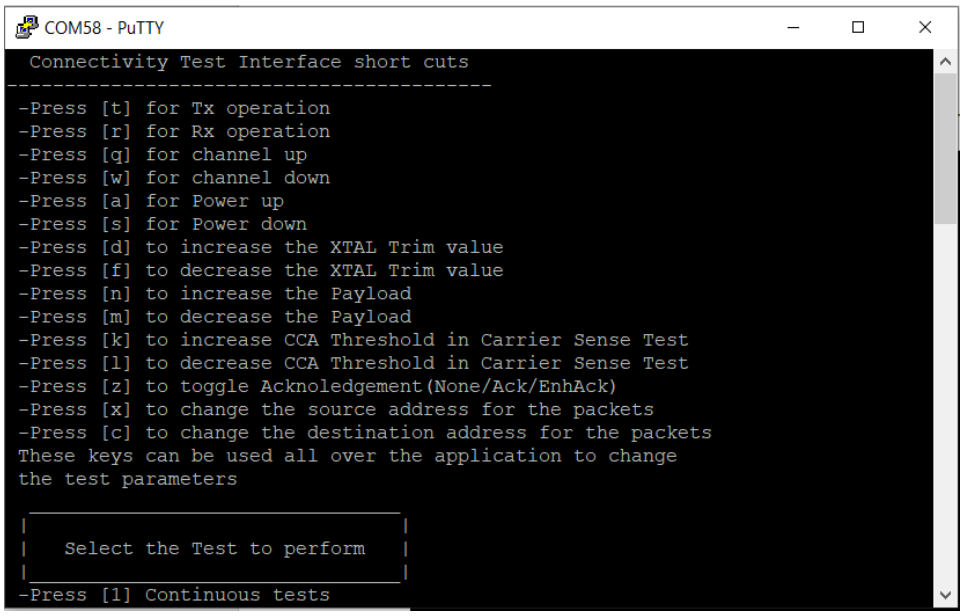

Figure 125. Connectivity Test Interface shortcut keys

Table 76 lists the key selection for the menus available in the Connectivity test tools application for performing the tests described in the left column.

Table 76. For Test in Transmit modes

Link to Chapter §	CMET selection key in Connectivity tools Application
Frequency Accuracy	1) 4)
Section 4.3.1.3	1) 4)
TX Power (fundamental)	1) 3) 2)+/-
TX spurious	1) 3) 2)
TX Modulation	1) 3) 2)
EVM	1) 3) 2)
Offset EVM	1) 4)
Upper band edge	1) 3) ch26
TX return loss	1) 3) 2）

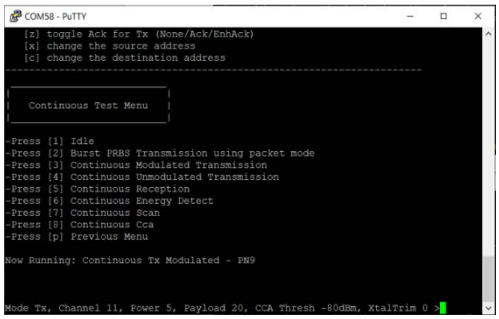

Figure 126. Continuous Test Menu

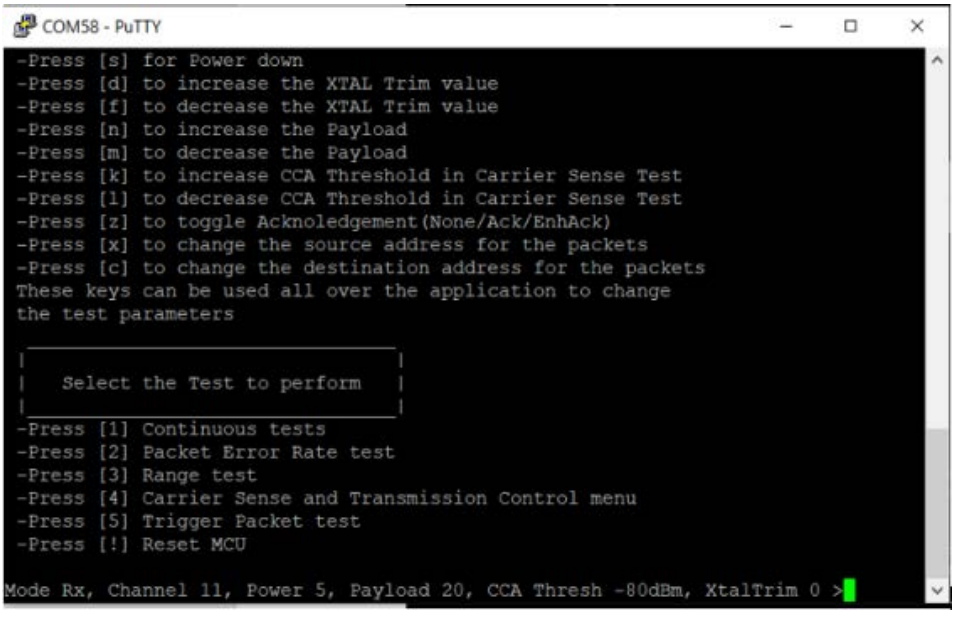

Figure 127. Test Selection

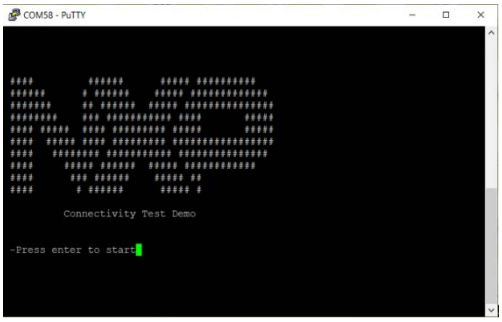

Figure 128. Starting the Application

For PER test:

Table 77. For PER test

Chapter ¤§	CMET selection
Sensitivity	5)bar)+/-
Sensitivity PER bathtub	5)bar)
Receiver Maximum Input Level	5)bar)+/-
RX Spurious	5)bar)
Receiver interference rejection	5)bar)+/-
Receiver Blocking	5)bar)+/-
RX Return loss	

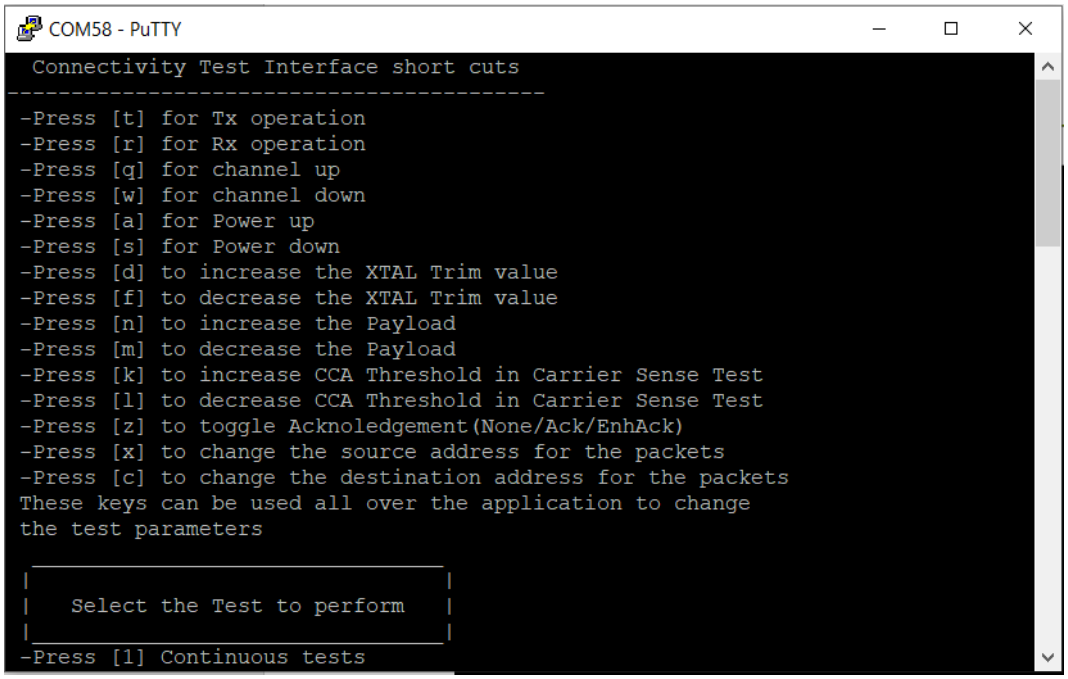

Figure 129. Connectivity Test interface shortcuts

A signal generator sends packets to the MCXW71 (Former Generation) device. Then, the packet is received by MCXW71 (Former Generation) are counted for about 6 seconds and “packets received” to “sent packets” is calculated and displayed.

Test done

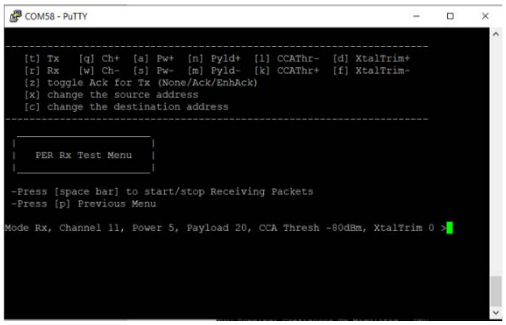

Figure 130. PER RX Test menu

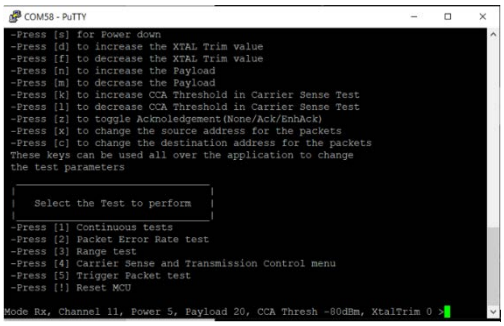

Figure 131. PER RX Test selection

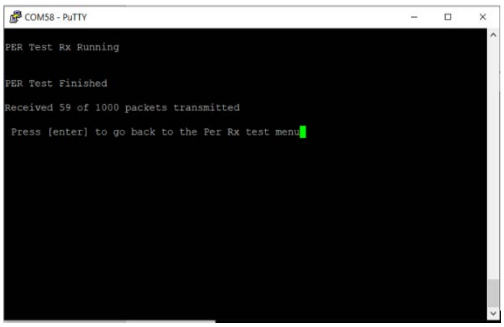

Figure 132. PER RX Test running

8 References

References available on the NXP website

- For more information about the Bluetooth LE and 802.15.4 radio parameters, refer to the FRDM-MCXW71 datasheets.
- For more information about the FRDM-MCXW71 board, refer to the '*UM12063, FRDM-MCXW71 Board User Manual*'. See the FRDM-MCXW71 webpage.
- The schematic and design files can be downloaded from the URL below: https://www.nxp.com/design/design-center/development-boards-and-designs/general-purpose-mcus/frdm-development-board-for-mcx-w71x-wireless-mcus:FRDM-MCXW71

Other references

1. **FCC**: 47 CFR Part 15C
2. **RED:** European Radio Equipment Directive applied from June 2016
3. **R&TTE:** Radio & Telecommunications Terminal Equipment Directive (R&TTED) (1999/5/EC) was stopped on June 2016
4. **ETSI EN 300 328 v2.2.2**: European Telecommunication Standard - Radio Equipment and Systems (RES) Wideband data transmission systems, Technical characteristics and test conditions for data transmission equipment operating in the 2.4 GHz ISM band and using spread spectrum modulation techniques
5. **IEEE 802.15.4:** IEEE standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personnel Area Networks (LR-WPANs)
6. **RF-PHY TS 4.2.0/5.0**: Bluetooth Test Specification. This document defines test structures and procedures for qualification testing of Bluetooth implementations of the Bluetooth Low Energy RF PHY.
7. **FCC Part 15**: Operation to FCC Part 15 is subject to two conditions. Firstly, the device may not cause harmful interference. Secondly, the device must accept any interference received, including interference that may cause undesired operation. Hence, there is no guaranteed quality of service when operating a Part 15 device.

9 Revision history

Table 78 summarizes the revisions to this document.

Table 78. Document revision history

Document ID	Release date	Description
AN14374 v.1.0	16 September 2024	Initial public release

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Tables

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