ETSI EN 300 328 V2.2.2 (DTS)

TEST REPORT

For

Bluetooth Module

Model No.: HM-BT2102
Series Model: HM-BT2101, HM-BT2103, HM-BT2104

REPORT NUMBER: E01A23050809R00201

ISSUE DATE: June 30, 2023

Prepared for

Shenzhen Hope Microelectronics Co., Ltd

30th floor of 8th Building, C Zone, Vanke Cloud City, Xili Sub-district, Nanshan, Shenzhen, GD, P.R. China

Prepared by

Dong Guan Anci Electronic Technology Co., Ltd.

1-2 Floor, Building A, No.11, Headquarters 2 Road, Songshan, Lake Hi-tech Industrial Development Zone, Dongguan City, Guangdong Pr., China.

Revision History

Rev.	Issue Date	Revisions	Revised By
V0	June 30, 2023	Initial Issue	Duke

Summary of Test Results

Summary of Test Results			
Test Item	**Clause**	**Limit/Requirement**	**Result**
NORMAL AND EXTREME CONDITIONS	N/A	Clause 5.1.2	Pass
RF output power	Clause 5.4.2.2.1.2	Clause 4.3.2.2	Pass
Power Spectral Density	Clause 5.4.3.2.1	Clause 4.3.2.3	Pass
Duty Cycle, Tx-sequence, Tx-gap	Clause 5.4.2.2.1.3	Clause 4.3.2.4	N/A
Medium Utilization (MU) factor	Clause 5.4.2.2.1.4	Clause 4.3.2.5	N/A
Adaptivity (non-FHSS)	Clause 5.4.6.2.1	Clause 4.3.2.6	Pass
Occupied Channel Bandwidth	Clause 5.4.7.2.1	Clause 4.3.2.7	Pass
Transmitter unwanted emissions in the out-of-band domain	Clause 5.4.8.2.1	Clause 4.3.2.8	Pass
Transmitter unwanted emissions in the spurious domain	Clause 5.4.9.2.1& Clause 5.4.9.2.2	Clause 4.3.2.9	Pass
Receiver spurious emissions	Clause 5.4.10.2.1& Clause 5.4.10.2.2	Clause 4.3.2.10	Pass
Receiver Blocking	Clause 5.4.11.2.1	Clause 4.3.2.11	Pass
Geo-location capability	N/A	Clause 4.3.2.12	N/A

Note:
1. N/A: In this whole report not applicable.

*This test report is only published to and used by the applicant, and it is not for evidence purpose in China.
*The measurement result for the sample received is <Pass> according to <ETSI EN 300 328 V2.2.2 (DTS)> when <Accuracy Method> decision rule is applied.

CONTENTS

1. ATTESTATION OF TEST RESULTS....5

2. TEST METHODOLOGY....6

3. FACILITIES AND ACCREDITATION....6

4. CALIBRATION AND UNCERTAINTY....7

4.1. MEASURING INSTRUMENT CALIBRATION....7

4.2. MEASUREMENT UNCERTAINTY....7

5. EQUIPMENT UNDER TEST....8

5.1. DESCRIPTION OF EUT....8

5.2. RECEIVER CATEGORY....8

5.3. CHANNEL LIST....9

5.4. MAXIMUM AVERAGE EIRP....9

5.5. TEST CHANNEL CONFIGURATION....9

5.6. THE WORSE CASE POWER SETTING PARAMETER....9

5.7. DESCRIPTION OF AVAILABLE ANTENNAS....10

5.8. ENVIROMENTAL CONDITIONS FOR TESTING....10

5.9. SUPPORT UNITS FOR SYSTEM TEST....10

5.10. SETUP DIAGRAM....10

5.11. TEST SYSTEM CONFIGURATION....11

5.12. DESCRIPTION OF THE EQUIPMENT UNDER TESTED....11

6. MEASURING EQUIPMENT AND SOFTWARE USED....14

7. TEST PROCEDURES AND RESULTS....15

7.1. RF output power....15

7.2. Power Spectral Density....15

7.3. Occupied Channel Bandwidth....16

7.4. Transmitter unwanted emissions in the out-of-band domain....17

7.5. Transmitter unwanted emissions in the spurious domain....18

7.6. Receiver spurious emissions....20

7.7. Receiver Blocking....28

8. TEST DATA....32

APPENDIX: PHOTOGRAPHS OF THE EUT....57

1. ATTESTATION OF TEST RESULTS

Applicant Information

Company Name: Shenzhen Hope Microelectronics Co., Ltd
Address: 30th floor of 8th Building, C Zone, Vanke Cloud City, Xili Sub-district, Nanshan, Shenzhen, GD, P.R. China

Manufacturer Information

Company Name: Shenzhen Hope Microelectronics Co., Ltd
Address: 30th floor of 8th Building, C Zone, Vanke Cloud City, Xili Sub-district, Nanshan, Shenzhen, GD, P.R. China

EUT Information

EUT Name: Bluetooth Module
Model No.: HM-BT2102
Serial model: HM-BT2101, HM-BT2103, HM-BT2104
Difference Description : All the same except for the model name.
Brand: HOPERF
Sample Received Date: June 10, 2023
Sample Status: Normal
Sample ID: A23050809 002
Date of Tested: June 10, 2023 to June 20, 2023

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
ETSI EN 300 328 V2.2.2 (DTS)	**Pass**

Prepared By:

Duke Liu

Duke Liu
Project Engineer

Checked By:

Dyson

Dyson Dai
Project Engineer

Dongguan Anci Electronic Technology Co., Ltd.
GTG
★ CERTIFICATE ★

Approved By:

Tiger Xu

Tiger
Laboratory Supervisor

2. TEST METHODOLOGY

All tests were performed in accordance with the standard ETSI EN 300 328 V2.2.2 (DTS)

3. FACILITIES AND ACCREDITATION

Site Description

Name of Firm	:	Dong Guan Anci Electronic Technology Co., Ltd.
Site Location	:	1-2 Floor, Building A, No.11, Headquarters 2 Road, Songshan, Lake Hi-tech Industrial Development Zone, Dongguan City,evelopment Zone, Dongguan City, Guangdong Pr., China.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations and is traceable to recognized national standards.

4.2. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Test Case	Description	Limit	Uncertainties
5.3.2.2.1.1	RF Output Power	±1.5 dB	1.15
5.3.2.2.1.2	Duty Cycle	±5 %	0.03
	Tx Sequence	±5 %	0.03
	Tx Gap	±5 %	0.03
5.3.2.2.1.3	Medium Utilisation	±5 %	0.10
5.3.3.2.1	Power Spectral Density	±3 dB	1.21
5.3.4.2.1	Accumulated Dwell Time	±5 %	0.05
	Minimum Frequency Occupation Time	±5 %	0.15
5.3.5.2.1	Hopping Frequency Separation	-	0.24
5.3.8.2.1	Occupied Channel Bandwidth	±5 %	1.71
5.3.9..2.1	Out-of-band emissions	±3 dB	1.39
5.3.10.2.1	Transmitter unwanted emissions in the spurious domain		
	30 MHz to 1 GHz	±3 dB	0.64
	1 GHz to 12.75GHz	±3 dB	1.68
5.3.11.2.1	Receiver Spurious emission		
	30 MHz to 1 GHz	±3 dB	0.64
	1 GHz to 12.75GHz	±3 dB	1.68

Test Item	Uncertainty
Uncertainty for Radiation Emission test	4.62 dB (30 MHz-1 GHz)
	3.50 dB (1 GHz-18 GHz)
Note: This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level using a coverage factor of k=2.	

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

EUT Name	Bluetooth Module
Model No.:	HM-BT2102
Series Model:	HM-BT2101, HM-BT2103, HM-BT2104
EUT Classification	Class B
Internal Frequency	2500MHz
Hardware Version	V1.0
Ratings	DC 1.71V-3.8V
PC DC	3.3V

Frequency Band:	2400 MHz to 2483.5 MHz
Frequency Range:	2402 MHz to 2480 MHz
Bluetooth Version:	Bluetooth Ver.5.1 BLE
Bluetooth Mode:	Bluetooth LE
Geo-location Capability:	Not Support
Type of Modulation:	GFSK
Number of Channels:	40
Channel Separation:	2 MHz
Maximum EIRP:	19.87dBm
Antenna Type:	Internal PCB antenna
Antenna Gain:	0.5 dBi
Normal Test Voltage:	3.3 Vdc
Extreme Test Temperature:	Portable: -10 °C to +50 °C

5.2. RECEIVER CATEGORY

EUT belong to	Receiver category	Relevant receiver clauses
☒	1	Adaptive equipment with a maximum RF output power greater than 10 dBm e.i.r.p.
☐	2	Non-adaptive equipment with a Medium Utilization (MU) factor greater than 1 % and less than or equal to 10 % or adaptive equipment with a maximum RF output power of 10 dBm e.i.r.p.
☐	3	Non-adaptive equipment with a maximum Medium Utilization (MU) factor of 1 % or adaptive equipment with a maximum RF output power of 0 dBm e.i.r.p.

5.3. CHANNEL LIST

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	**2402**	11	2424	22	2446	33	2468
1	2404	12	2426	23	2448	34	2470
2	2406	13	2428	24	2450	35	2472
3	2408	14	2430	25	2452	36	2474
4	2410	15	2432	26	2454	37	2476
5	2412	16	2434	27	2456	38	2478
6	2414	17	2436	28	2458	39	**2480**
7	2416	18	2438	29	2460	/	/
8	2418	19	**2440**	30	2462	/	/
9	2420	20	2442	31	2464	/	/
10	2422	21	2444	32	2468	/	/

5.4. MAXIMUM AVERAGE EIRP

Test Mode	Frequency (MHz)	Channel Number	Max AVG EIRP (dBm)
GFSK(1Mbps), π/4-DQPSK(2Mbps)	2402 ~ 2480	0-39[40]	19.87

5.5. TEST CHANNEL CONFIGURATION

Test Mode	Test Channel	Frequency
LE 1M, LE 2M	CH 0(Low Channel), CH 19(MID Channel), CH 39(High Channel)	2402 MHz, 2440 MHz, 2480 MHz

5.6. THE WORSE CASE POWER SETTING PARAMETER

The Worse Case Power Setting Parameter under 2400 ~ 2483.5MHz Band				
Test Software Version		nrfconnect-setup-4.0.1-ia32.exe		
Modulation Type	Transmit Antenna Number	Test Software setting value		
		CH 0	CH 19	CH 39
GFSK(1Mbps), π/4-DQPSK (2Mbps)	1	Max	Max	Max

5.7. DESCRIPTION OF AVAILABLE ANTENNAS

Antenna	Frequency (MHz)	Antenna Type	MAX Antenna Gain (dBi)
1	2402-2480	External Antenna	0.5

Test Mode	Transmit and Receive Mode	Description
GFSK(1Mbps), π/4-DQPSK (2Mbps)	1TX, 1RX	Chain 1 can be used as transmitting/receiving antenna.

Note: The value of the antenna gain was declared by customer.

5.8. ENVIROMENTAL CONDITIONS FOR TESTING

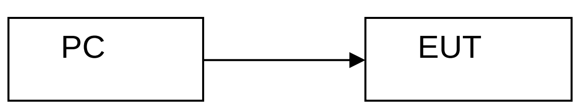
Environment Parameter	Selected Values During Tests		
Test Condition	Ambient		
	Temperature (°C)	Voltage	Relative Humidity (%)
TN/VN	+15 to +35	3.3 V	20 to 75 (Except Electrostatic Discharge is 30% to 60%)
TH/VN	40	3.3 V	20 to 75
TL/VN	-10	3.3 V	20 to 75
Remark: 1) NV: Normal Voltage; NT: Normal Temperature			

5.9. SUPPORT UNITS FOR SYSTEM TEST

The EUT has been tested as an independent unit

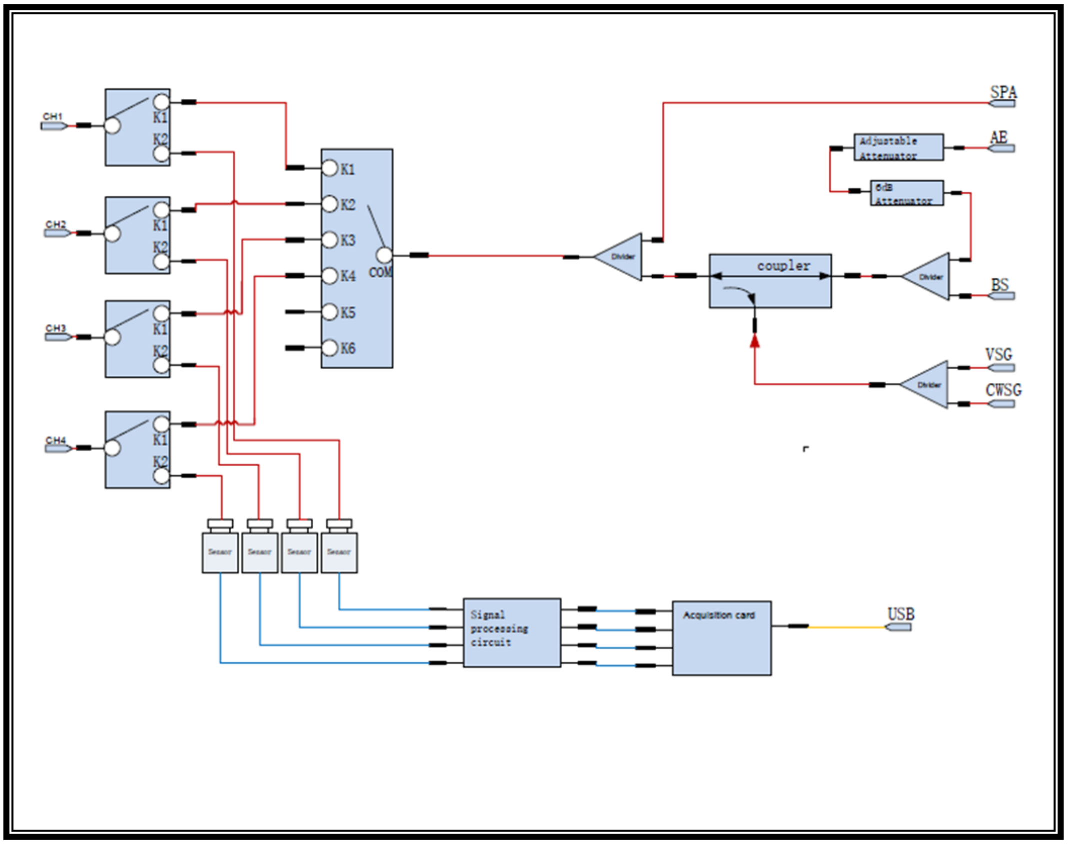
Equipment	**Manufacturer**	**Model No.**
PC	Lenovo	T430

5.10. SETUP DIAGRAM



5.11. TEST SYSTEM CONFIGURATION

Tonsend SRD Test System



5.12. DESCRIPTION OF THE EQUIPMENT UNDER TESTED

(INFORMATION AS REQUIRED BY EN 300 328 V2.2.2, CLAUSE 5.4.1)

a)	Modulation Type		
	☐ FHSS		
	☒ non-FHSS		
b)	FHSS Equipment Description		
	The Number of Hopping Frequencies	The Maximum	/
		The Minimum	/
	The (average) dwell time	/	
c)	**Adaptive / Non-adaptive Equipment**		
	☐ Non-adaptive Equipment		
	☒ Adaptive Equipment Without the Possibility to Switch to A Non-adaptive Mode		
	☐ Adaptive Equipment Which can also operate in A Non-adaptive Mode		
d)	**Adaptive Equipment Description**		
	The maximum Channel Occupancy Time implemented by the equipment	/	
	☒ The equipment has implemented an LBT mechanism		
	☐ The equipment has implemented a DAA mechanism		
	☐ The equipment can operate in more than one adaptive mode		
e)	**The different transmit operating modes**		
		☒ Equipment with only one antenna	

<table>
<tr><td rowspan="8"></td><td rowspan="2">☒ Operating mode 1 (single antenna)</td><td>☐ Equipment with two diversity antennas but only one antenna active at any moment in time</td></tr>
<tr><td>☐ Smart Antenna Systems with two or more antennas, but operating in a (legacy) mode where only one antenna is used (e.g. IEEE 802.11™ legacy mode in smart antenna systems)</td></tr>
<tr><td rowspan="3">☐ Operating mode 2: Smart Antenna Systems - Multiple Antennas without beam forming</td><td>☐ Single spatial stream/Standard throughput/(e.g. IEEE 802.11™ legacy mode)</td></tr>
<tr><td>☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1</td></tr>
<tr><td>☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2</td></tr>
<tr><td rowspan="3">☐ Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming</td><td>☐ Single spatial stream/Standard throughput (e.g. IEEE 802.11™ legacy mode)</td></tr>
<tr><td>☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1</td></tr>
<tr><td>☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2</td></tr>
</table>

f)	**In case of Smart Antenna Systems**	
	The number of Receive chains	1
	The number of Transmit chains	1
	In case of beam forming, the maximum (additional) beam forming gain:	/
g)	**Operating Frequency Range(s) of the equipment**	
	Operating Frequency Range	2402 MHz to 2480 MHz
h)	**Nominal Channel Bandwidth(s)**	
	Occupied Channel Bandwidth	1.037MHz

<table>
<tr><td>i)</td><td colspan="6">Type of Equipment</td></tr>
<tr><td></td><td colspan="6">☒Stand-Alone</td></tr>
<tr><td></td><td colspan="6">☐ Plug-in radio Equipment</td></tr>
<tr><td></td><td colspan="6">☐ Combined Equipment</td></tr>
<tr><td>j)</td><td colspan="6">The extreme operating conditions that apply to the equipment</td></tr>
<tr><td></td><td colspan="2">Operating temperature range</td><td colspan="4">-10°C to 50 °C</td></tr>
<tr><td>k)</td><td colspan="6">The intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p levels</td></tr>
<tr><td></td><td>Antenna Type</td><td>☐ Integral Antenna</td><td>Antenna Gain</td><td colspan="3"></td></tr>
<tr><td rowspan="6"></td><td rowspan="6"></td><td rowspan="6">☒ Dedicated Antennas (equipment with antenna connector)</td><td rowspan="3">☒Single power level with corresponding antenna(s)</td><td rowspan="3">Gain</td><td>ANT1</td><td>0.5 dBi</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td rowspan="3">☐Multiple power settings and corresponding antenna(s)</td><td colspan="2">Power Level 1</td><td></td></tr>
<tr><td colspan="2">Power Level 2</td><td></td></tr>
<tr><td colspan="2">Power Level 3</td><td></td></tr>
</table>

<table>
<tr><td>l)</td><td colspan="3">The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices:</td></tr>
<tr><td></td><td rowspan="3">Details provided are for the</td><td colspan="2">☒ Testing of stand-alone equipment</td></tr>
<tr><td></td><td colspan="2">☐ Combined equipment</td></tr>
<tr><td></td><td colspan="2">☐ Test jig</td></tr>
<tr><td></td><td>Supply Voltage</td><td>☐ AC mains</td><td>State AC voltage</td></tr>
</table>

		☒ DC	State DC voltage	☐ Internal Power Supply	
				☐ External Power Supply or AC/DC adapter	
				☒ PC	3.3 V
				☐Other	
m)	**The equipment type**				
	☒ Bluetooth®				
	☐ IEEE 802.11™ [i.3]				
	☐ Proprietary				
n)	**Geo-location capability supported by the equipment**		☐ Yes ☐ The geographical location determined by the equipment as defined in clause 4.3.1.13.2 or clause 4.3.2.12.2 is not accessible to the user.		
			☒ No		

6. MEASURING EQUIPMENT AND SOFTWARE USED

or Spurious Emissions Test

Equipment Type	Manufacturer	Model No.	Serial Number	Calibrated until
EMI Test Receiver	Rohde & Schwarz	ESPI	100502	2023-10-07
EMI Test Receiver	Rohde & Schwarz	FSV40	102257	2023-10-07
Pre-Amplifier	HP	8447D	2727A06172	2024-05-09
Pre-Amplifier	A-INFO	LA1018N4009	J1013130524001	2024-05-09
Bilog Antenna	Schwarzbeck	VULB9163	VULB9163-588	2024-05-09
Horn Antenna	A-INFO	LB-10180-SF	J2031090612123	2024-05-09
Cable	N/A	N/A	6#	2024-05-09
Cable	N/A	N/A	1-1#	2024-05-09
Cable	N/A	N/A	1-2#	2024-05-09
Cable	N/A	N/A	7#	2024-05-09
3m Semi-anechoic Chamber	chengyu	9m*6m*6m	N/A	2024-05-09
Test Software	Farad	EZ-EMC Ver:ANCI-3A1	N/A	N/A

For Other Test Items:

Equipment Type	Manufacturer	Model No.	Serial Number	Calibrated until
Spectrum Analyzer	Rohde & Schwarz	FSV40	102257	2023-10-07
WIDEBAND RADIO COMMUNICATION	Rohde & Schwarz	CMW500	157423	2023-10-07
Vector Signal Generator	Agilent	5182A	MY50140563	2023-10-07
ESG SERIES SIGNAL GENERATOR	Agilent	E4421B	40050971	2023-10-07
USB RF Power sensor	RadiPower	RPR3006W	17I00015SNO88	2023-10-07
RF Test Software	MAIWEI	MTS 8310	N/A	N/A
Humidity Chamber	GAOXIN	GX-3000-150LHT	1801027	2024-05-09
Dc source	RUIYUAN	WYK-6030K	180828026030	2024-05-09

7. TEST PROCEDURES AND RESULTS

7.1. RF OUTPUT POWER

LIMITS

RF OUTPUT POWER	
Condition	Limit
☐ Non-adaptive non-FHSS Equipment	For non-adaptive non-FHSS equipment, where the manufacturer has declared an RF output power of less than 20 dBm e.i.r.p., the RF output power shall be equal to or less than that declared value.
☒ Adaptive non-FHSS Equipment	non-FHSS equipment shall be equal to or less than 20 dBm.

TEST PROCEDURE

Refer to ETSI EN 300 328 V2.2.2 (2019-07) Clause 5.4.2

The power sensor was used for power measurement, and it use a fast power sensor with a minimum sensitivity of -40 dBm and capable of minimum 1 MS/s.

The test software was used to control the power detector and the sampling unit.

For adaptive equipment, the measurement duration shall be long enough to ensure a minimum number of bursts (at least 10) are captured.

Measurement	
☒Conducted measurement	☐Radiated measurement

CALCULATIONS

Add the (stated) antenna assembly gain G in dBi of the individual antenna.
• In case of smart antenna systems operating in mode with beamforming (see clause 5.3.2.2.4), add the additional beamforming gain Y in dB.
• If more than one antenna assembly is intended for this power setting, the maximum overall antenna gain (G or G + Y) shall be used.
• The RF Output Power (Pout) shall be calculated using the formula below:

$$P_{out} = A + G + Y$$

TEST ENVIRONMENT

Temperature	24℃	Relative Humidity	50%
Atmosphere Pressure	101kPa		

TEST RESULTS

Please refer to section "Test Data" - Appendix A**POWER SPECTRAL DENSITY**

LIMITS

Power Spectral Density

Condition	Limit
All types of non-FHSS equipment	10 dBm/MHz

TEST PROCEDURE

Refer to ETSI EN 300 328 V2.2.2 (2019-07) Clause 5.4.3

R&S EMC32 software is used to control the spectrum analyzer to use the following settings:

Start Frequency	2400MHz
Stop Frequency	2483.5MHz
Detector	RMS
Sweep Point	> 8 350; for spectrum analysers not supporting this number of sweep points, the frequency band may be segmented
RBW	10KHz
VBW	30KHz
Trace Mode	Max Hold
Sweep Time	For non-continuous transmissions: 2 × Channel Occupancy Time × number of sweep points For non-adaptive equipment use the maximum TX-sequence time in the formula above instead of the Channel Occupancy Time For continuous transmissions: 10 s; the sweep time may be increased further until a value where the sweep time has no further impact anymore on the RMS value of the signal

The test software acquires the trace data and calculate the Spectral Density in 1MHz.

TEST ENVIRONMENT

Temperature	24℃	Relative Humidity	50%
Atmosphere Pressure	101kPa		

TEST RESULTS

Please refer to section "Test Data" - Appendix **OCCUPIED CHANNEL BANDWIDTH**

LIMITS

OCCUPIED CHANNEL BANDWIDTH		
Condition		Limit
All types of equipment		Each hopping frequency shall be within the 2400 to 2483.5 MHz band
Additional requirement	For non-adaptive non-FHSS equipment with e.i.r.p. greater than 10 dBm	Each hopping frequency shall be equal to or less than 20 MHz

TEST PROCEDURE

Refer to ETSI EN 300 328 V2.2.2 (2019-07) clause 5.4.7

Measurement	
☒Conducted measurement	☐Radiated measurement

Connect the UUT to the spectrum analyser and use the following settings:

Center Frequency	The center frequency of the channel under test
Frequency Span	2 × Nominal Channel Bandwidth
Detector	RMS
RBW	~ 1 % of the span without going below 1 %
VBW	3 × RBW
Trace	Max hold
Sweep Time	1s

TEST ENVIRONMENT

Temperature	24℃	Relative Humidity	50%
Atmosphere Pressure	101kPa		

TEST RESULTS

Please refer to section "Test Data" - Appendix **TRANSMITTER UNWANTED EMISSIONS IN THE OUT-OF-BAND DOMAIN**

LIMITS

Transmitter Unwanted Emissions in The Out-Of-Band Domain	
Condition	Limit
Under Normal Test Condition	The transmitter unwanted emissions in the out-of-band domain shall not exceed the values provided by the mask in figure 3.

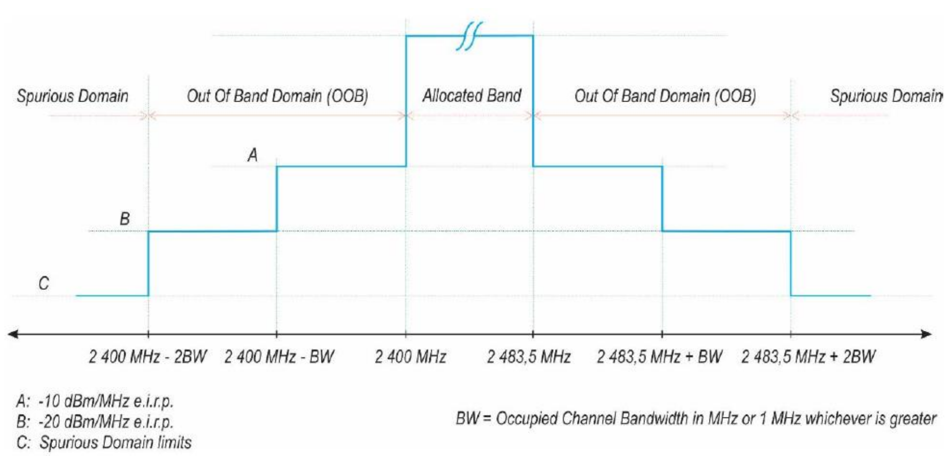


Figure 3: Transmit mask

TEST PROCEDURE

Refer to ETSI EN 300 328 V2.2.2 (2019-07) clause 5.4.8

Measurement	
☒Conducted measurement	☐Radiated measurement

Connect the UUT to the spectrum analyser and use the following settings:

Span	Zero Span
Filter Mode	Channel Filter
Trace Mode	Max Hold
Trigger Mode	Video
Detector	RMS
Sweep Points	Sweep time [μs] / (1 μs) with a maximum of 30 000
RBW / VBW	1MHz / 3MHz
Measurement Mode	Time Domain Power
Sweep Time	> 120 % of the duration of the longest burst detected during the measurement of the RF Output Power

TEST ENVIRONMENT

Temperature	24℃	Relative Humidity	50%
Atmosphere Pressure	101kPa		

TEST RESULTS

Please refer to section "Test Data" - Appendix **TRANSMITTER UNWANTED EMISSIONS IN THE SPURIOUS DOMAIN**

LIMITS

The transmitter unwanted emissions in the spurious domain shall not exceed the values given in table 12.
In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and as e.i.r.p. for emissions above 1 GHz.

Table 12: Transmitter limits for spurious emissions

Frequency range	Maximum power	Bandwidth
30 MHz to 47 MHz	-36 dBm	100 kHz
47 MHz to 74 MHz	-54 dBm	100 kHz
74 MHz to 87,5 MHz	-36 dBm	100 kHz
87,5 MHz to 118 MHz	-54 dBm	100 kHz
118 MHz to 174 MHz	-36 dBm	100 kHz
174 MHz to 230 MHz	-54 dBm	100 kHz
230 MHz to 470 MHz	-36 dBm	100 kHz
470 MHz to 694 MHz	-54 dBm	100 kHz
694 MHz to 1 GHz	-36 dBm	100 kHz
1 GHz to 12,75 GHz	-30 dBm	1 MHz

TEST PROCEDURE

Refer to Refer to ETSI EN 300 328 V2.2.2 (2019-07) clause 5.4.9

Measurement	
☒Conducted measurement	☐Radiated measurement

Spectrum analyser settings for pre-scan:

RBW	100 kHz (< 1 GHz) / 1 MHz (> 1 GHz)
VBW	300 kHz (< 1 GHz) / 3 MHz (> 1 GHz)
Detector Mode	Peak
Filter type	3 dB (Gaussian)
Trace Mode	Max hold
Sweep Points	⩾ 19 400 (< 1 GHz); ⩾ 23 500 (> 1 GHz); for spectrum analysers not supporting this high number of sweep points, the frequency band may be segmented.
Sweep Time	For non continuous transmissions (duty cycle less than 100 %), the sweep time shall be sufficiently long, such that for each 100 kHz frequency step, the measurement time is greater than two transmissions of the UUT, on any channel. For FHSS equipment operating in a normal operating (hopping not disabled) mode, the sweep time shall be further increased to capture multiple transmissions on any of the hopping frequencies. The above sweep time setting may result in long measuring times in case of FHSS equipment. To avoid such long measuring times, an FFT analyser may be used.

Spectrum analyser settings for the emissions identified during the pre-scan:

Measurement Mode	Time Domain Power
Centre Frequency	Frequency of the emission identified during the pre-scan
RBW	100 kHz (< 1 GHz) / 1 MHz (> 1 GHz)

VBW	300 kHz (< 1 GHz) / 3 MHz (> 1 GHz)
Frequency Span	Zero Span
Sweep Mode	Single Sweep
Detector Mode	RMS
Trace Mode	Max hold
Trigger Mode	Video (burst signals) or Manual (continuous signals)
Sweep Points	Sweep time [μs] / (1 μs) with a maximum of 30 000
Sweep Time	> 120 % of the duration of the longest burst detected during the measurement of the RF Output Power

TEST ENVIRONMENT

Temperature	24℃	Relative Humidity	50%
Atmosphere Pressure	101kPa		

TEST RESULTS

Please refer to section "Test Data" - Appendix **RECEIVER SPURIOUS EMISSIONS**

LIMITS

The spurious emissions of the receiver shall not exceed the values given in table 13.
In case of non-FHSS equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or for emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 13: Spurious emission limits for receivers

Frequency range	Maximum power	Bandwidth
30 MHz to 1 GHz	-57 dBm	100 kHz
1 GHz to 12,75 GHz	-47 dBm	1 MHz

TEST PROCEDURE

Please refer to ETSI EN 300 328 V2.2.2 (2019-07) Clause 5.4.10

Measurement	
☒Conducted measurement	☐Radiated measurement

Please refer to ETSI EN 300 328 V2.2.2 (2019-07) Clause 5.4.10

Spectrum analyser settings for pre-scan:

RBW	100 kHz (< 1 GHz) / 1 MHz (> 1 GHz)

VBW	300 kHz (< 1 GHz) / 3 MHz (> 1 GHz)
Detector Mode	Peak
Filter type	3 dB (Gaussian)
Trace Mode	Max hold
Sweep Points	⩾ 19 400 (< 1 GHz); ⩾ 23 500 (> 1 GHz); for spectrum analysers not supporting this high number of sweep points, the frequency band may be segmented.
Sweep Time	Auto

Spectrum analyser settings for the emissions identified during the pre-scan:

Measurement Mode	Time Domain Power
Centre Frequency	Frequency of the emission identified during the pre-scan
RBW	100 kHz (< 1 GHz) / 1 MHz (> 1 GHz)
VBW	300 kHz (< 1 GHz) / 3 MHz (> 1 GHz)
Frequency Span	Zero Span
Sweep Mode	Single Sweep
Detector Mode	RMS
Trace Mode	Max hold
Trigger Mode	Video (burst signals) or Manual (continuous signals)
Sweep Points	⩾ 30 000
Sweep Time	30 ms

TEST ENVIRONMENT

Temperature	24℃	Relative Humidity	50%
Atmosphere Pressure	101kPa		

TEST RESULTS

Please refer to section "Test Data" - Appendix

7.7. ADAPTIVITY

Applicable standard

ETSI EN 300 328 clause 4.3.2.6

Conformance Limit

Only for adaptive equipment and RF output power >=10dBm(EIRP)

■ Adaptive Frequency Hopping equipment using LBT based DAA shall comply with the following minimum set of requirements:

1) At the start of every dwell time, before transmission on a hopping frequency, the equipment shall perform a Clear Channel Assessment (CCA) check using energy detect. The CCA observation time shall be not less than 0,2 % of the Channel Occupancy Time with a minimum of 18 μs. If the equipment finds the hopping frequency to be clear, it may transmit immediately.
2) If it is determined that a signal is present with a level above the detection threshold defined in step 5 the hopping frequency shall be marked as 'unavailable'. Then the equipment may jump to the next frequency in the hopping scheme even before the end of the dwell time, but in that case the 'unavailable' channel cannot be considered as being 'occupied' and shall be disregarded with respect to the requirement of the minimum number of hopping frequencies as defined in clause 4.3.1.4.3.2. Alternatively, the equipment can remain on the frequency during the remainder of the dwell time. However, if the equipment remains on the frequency with the intention to transmit, it shall perform an Extended CCA check in which the (unavailable) channel is observed for a random duration between the value defined for the CCA observation time in step 1 and 5 % of the Channel Occupancy Time defined in step 3. If the Extended CCA check has determined the frequency to be no longer occupied, the hopping frequency becomes available again. If the Extended CCA time has determined the channel still to be occupied, it shall perform new Extended CCA checks until the channel is no longer occupied.
3) The total time during which an equipment has transmissions on a given hopping frequency without re-evaluating the availability of that frequency is defined as the Channel Occupancy Time.
   The Channel Occupancy Time for a given hopping frequency, which starts immediately after a successful CCA, shall be less than 60 ms followed by an Idle Period of minimum 5 % of the Channel Occupancy Time with a minimum of 100 μs.
   After the Idle Period has expired, the procedure as in step 1 shall be repeated before having new transmissions on this hopping frequency during the same dwell time.
   EXAMPLE: An equipment with a dwell time of 400 ms can have 6 transmission sequences of 60 ms each, separated with an Idle Period of 3 ms. Each transmission sequence was preceded with a successful CCA check of 120 μs.
   For LBT based adaptive frequency hopping equipment with a dwell time < 60 ms, the maximum Channel Occupancy Time is limited by the dwell time.
4) 'Unavailable' channels may be removed from or may remain in the hopping sequence, but in any case:
   - apart from Short Control Signalling Transmissions referred to in clause 4.3.1.7.4, there shall be no transmissions on 'unavailable' channels;
   - a minimum of N hopping frequencies as defined in clause 4.3.1.4.3.2 shall always be maintained.
5) The detection threshold shall be proportional to the transmit power of the transmitter: for a 20 dBm e.i.r.p. transmitter the detection threshold level (TL) shall be equal to or less than -70 dBm/MHz at the input to the receiver assuming a 0 dBi (receive) antenna assembly. This threshold level (TL) may be corrected for the (receive) antenna assembly gain (G); however, beamforming gain (Y) shall not be taken into account. For power levels less than 20 dBm e.i.r.p., the detection threshold level may be relaxed to:
   TL = -70 dBm/MHz + 10 × log10 (100 mW / Pout) (Pout in mW e.i.r.p.)
6) The equipment shall comply with the requirements defined in step 1 to step 4 of the present clause in the presence of an unwanted CW signal as defined in table 2.

Unwanted Signal parameters

Wanted signal mean power from companion device	Unwanted signal frequency (MHz)	Unwanted CW signal power (dBm)
sufficient to maintain the link (see note 2)	2 395 or 2 488,5 (see note 1)	-35 (see note 3)
NOTE 1: The highest frequency shall be used for testing operating channels within the range 2 400 MHz to 2 442 MHz, while the lowest frequency shall be used for testing operating channels within the range 2 442 MHz to 2 483,5 MHz. See clause 5.4.6.1. NOTE 2: A typical value which can be used in most cases is -50 dBm/MHz. NOTE 3: The level specified is the level in front of the UUT antenna. In case of conducted measurements, this level has to be corrected by the actual antenna assembly gain.		

● Short control signaling transmissions

If implemented, Short Control Signalling Transmissions shall have a maximum TxOn / (TxOn + TxOff) ratio of 10 % within any observation period of 50 ms or within an observation period equal to the dwell time, whichever is less.

■ For LBT based Detect and avoid equipment shall comply with the following requirement

Load Based Equipment may implement an LBT based spectrum sharing mechanism based on the Clear Channel

Assessment (CCA) mode using energy detect as described in IEEE 802.11™-2012 [i.3], clause 9, clause 10, clause 16, clause 17, clause 19 and clause 20, or in IEEE 802.15.4™-2011 [i.4], clause 4, clause 5 and clause 8 providing the equipment complies with the conformance requirements referred to in clause 4.3.2.6.3.4. Load Based Equipment not using any of the mechanisms referenced above shall comply with the following minimum set of requirements:

1) Before a transmission or a burst of transmissions, the equipment shall perform a Clear Channel Assessment (CCA) check using energy detect. The equipment shall observe the operating channel for the duration of the CCA observation time which shall be not less than 18 µs. The channel shall be considered occupied if the energy level in the channel exceeds the threshold given in step 5 below. If the equipment finds the channel to be clear, it may transmit immediately.

2) If the equipment finds the channel occupied, it shall not transmit on this channel (see also the next paragraph). The equipment shall perform an Extended CCA check in which the channel is observed for a random duration in the range between 18 µs and at least 160 µs. If the extended CCA check has determined the channel to be no longer occupied, the equipment may resume transmissions on this channel. If the Extended CCA time has determined the channel still to be occupied, it shall perform new Extended CCA checks until the channel is no longer occupied.

NOTE: The Idle Period in between transmissions is considered to be the CCA or the Extended CCA check as there are no transmissions during this period. The equipment is allowed to switch to a non-adaptive mode and to continue transmissions on this channel providing it complies with the requirements applicable to non-adaptive equipment. Alternatively, the equipment is also allowed to continue Short Control Signalling Transmissions on this channel providing it complies with the requirements given in clause 4.3.2.6.4.

3) The total time that an equipment makes use of a RF channel is defined as the Channel Occupancy Time. This Channel Occupancy Time shall be less than 13 ms, after which the device shall perform a new CCA as described in step 1 above.

4) The equipment, upon correct reception of a packet which was intended for this equipment can skip CCA and immediately (see also next paragraph) proceed with the transmission of management and control frames (e.g. ACK and Block ACK frames are allowed but data frames are not allowed). A consecutive sequence of transmissions by the equipment without a new CCA shall not exceed the maximum channel occupancy time as defined in step 3 above.

For the purpose of multi-cast, the ACK transmissions (associated with the same data packet) of the individual devices are allowed to take place in a sequence.

5) The energy detection threshold for the CCA shall be proportional to the transmit power of the transmitter: for a 20 dBm e.i.r.p. transmitter the CCA threshold level (TL) shall be equal to or less than -70 dBm/MHz at the input to the receiver assuming a 0 dBi (receive) antenna assembly. This threshold level (TL) may be corrected for the (receive) antenna assembly gain (G); however, beamforming gain (Y) shall not be taken into account. For power levels less than 20 dBm e.i.r.p., the CCA threshold level may be relaxed to:

TL = -70 dBm/MHz + 10 × log10 (100 mW / Pout) (Pout in mW e.i.r.p.)

6) The equipment shall comply with the requirements defined in step 1 to step 4 of the present clause in the presence of an unwanted CW signal as defined in below.

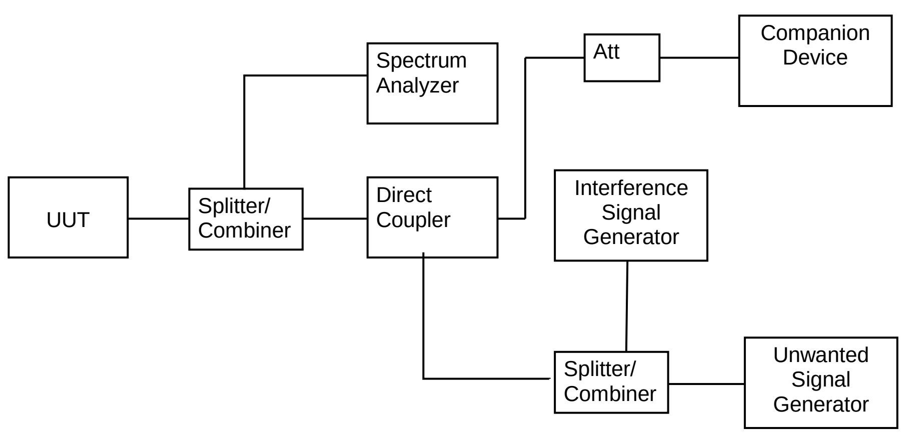
Unwanted Signal parameters

Wanted signal mean power from companion device	Unwanted signal frequency (MHz)	Unwanted signal power (dBm)
sufficient to maintain the link (see note 2)	2 395 or 2 488,5 (see note 1)	-35 (see note 3)
NOTE 1: The highest frequency shall be used for testing operating channels within the range 2 400 MHz to 2 442 MHz, while the lowest frequency shall be used for testing operating channels within the range 2 442 MHz to 2 483,5 MHz. See clause 5.4.6.1. NOTE 2: A typical value which can be used in most cases is -50 dBm/MHz. NOTE 3: The level specified is the level in front of the UUT antenna. In case of conducted measurements, this level has to be corrected by the actual antenna assembly gain.		

■ Short control signaling transmissions

If implemented, Short Control Signalling Transmissions of adaptive equipment using wide band modulations other than FHSS shall have a maximum TxOn / (TxOn + TxOff) ratio of 10 % within any observation period of 50 ms.

Test Configuration



Test Procedure

1. Please refer to ETSI EN 300 328 (V2.2.2) clause 5.4.6.1 for the test conditions.
2. Please refer to ETSI EN 300 328 (V2.2.2) clause 5.4.6.2 for the measurement method.

■ Conducted measurement

Adaptive Frequency Hopping equipment using DAA

● Step 1 to step 7 below define the procedure to verify the efficiency of the DAA based adaptive mechanisms for frequency hopping equipment. These mechanisms are described in clause 4.3.1.7. For systems using multiple receive chains only one chain (antenna port) need to be tested. All other receiver inputs shall be terminated.

Step 1:

- The UUT shall connect to a companion device during the test. The interference signal generator, the unwanted signal generator, the spectrum analyser, the UUT and the companion device are connected using a set-up equivalent to the example given by figure 5, although the interference and unwanted signal generators do not generate any signals at this point in time. The spectrum analyser is used to monitor the transmissions of both the UUT and the companion device and it should be possible to distinguish between either transmission. In addition, the spectrum analyser is used to monitor the transmissions of the UUT in response to the interfering and the unwanted signals.
- For the hopping frequency to be tested, adjust the received signal level (wanted signal from the companion device) at the UUT to the value defined in table 2 and table 3 (clause 4).
  Testing of Unidirectional equipment does not require a link to be established with a companion device.

• The analyser shall be set as follows:
- RBW: use next available RBW setting below the measured Occupied Channel Bandwidth
- Filter type: Channel Filter
- VBW: ⩾ RBW
- Detector Mode: RMS
- Centre Frequency: Equal to the hopping frequency to be tested
- Span: 0 Hz
- Sweep time: > Channel Occupancy Time of the UUT. If the Channel Occupancy Time is non-contiguous (non-LBT based equipment), the sweep time shall be sufficient to cover the period over which the Channel Occupancy Time is spread out
- Trace Mode: Clear/Write
- Trigger Mode: Video

Step 2:

• Configure the UUT for normal transmissions with a sufficiently high payload resulting in a minimum transmitter activity ratio (TxOn / (TxOn + TxOff)) of 0,3. Where this is not possible, the UUT shall be configured to the maximum payload possible.

• Using the procedure defined in clause 5.4.6.2.1.5, it shall be verified that, for equipment with a dwell time greater than the maximum allowable Channel Occupancy Time, the UUT complies with the maximum Channel Occupancy Time and minimum Idle Period defined in clause 4.3.1.7.2.2 or clause 4.3.1.7.3.2. When measuring the Idle Period of the UUT, it shall not include the transmission time of the companion device.

Step 3: Adding the interference signal

• An interference signal as defined in clause B.7 is injected centred on the hopping frequency being tested. The power spectral density level (at the input of the UUT) of this interference signal shall be equal to the detection threshold defined in clause 4.3.1.7.2.2 or clause 4.3.1.7.3.2.

Step 4: Verification of reaction to the interference signal

• The spectrum analyser shall be used to monitor the transmissions of the UUT on the selected hopping frequency with the interfering signal injected. This may require the spectrum analyser sweep to be triggered by the start of the interfering signal.

• Using the procedure defined in clause 5.4.6.2.1.5, it shall be verified that:

i) The UUT shall stop transmissions on the hopping frequency being tested.
The UUT is assumed to stop transmissions on this hopping frequency within a period equal to the maximum Channel Occupancy Time defined in clause 4.3.1.7.2.2 or clause 4.3.1.7.3.2. As stated in clause 4.3.1.7.3.2, step 3, the Channel Occupancy Time for non-LBT based frequency hopping equipment may be non-contiguous.

ii) For LBT based frequency hopping equipment, apart from Short Control Signalling Transmissions (see iii) below), there shall be no subsequent transmissions on this hopping frequency, as long as the interference signal remains present.
For non-LBT based frequency hopping equipment, apart from Short Control Signalling Transmissions (see iii) below), there shall be no subsequent transmissions on this hopping frequency for a (silent) period defined in clause 4.3.1.7.3.2, step 2. After that, the UUT may have normal transmissions again for the duration of a single Channel Occupancy Time period (which may be non-contiguous). Because the interference signal is still present, another silent period as defined in clause 4.3.1.7.3.2, step 2 needs to be included. This sequence is repeated as long as the interfering signal is present.
In case of overlapping channels, transmissions in adjacent channels may generate transmission bursts on the channel being investigated; however, they have a lower amplitude as on-channel transmissions. Care should be taken to only evaluate the on-channel transmissions. The Time Domain Power Option of the analyser may be used to measure the RMS power of the individual bursts to distinguish on-channel transmissions from transmissions on adjacent channels. In some cases, the RBW may need to be reduced.
To verify that the UUT is not resuming normal transmissions as long as the interference signal is present, the monitoring time may need to be 60 s or more. If transmissions are detected during this period, the settings of the analyser may need to be adjusted to allow an accurate assessment to verify the transmissions comply with the limits for Short Control Signalling Transmissions.

iii) The UUT may continue to have Short Control Signalling Transmissions on the hopping frequency being tested while the interference signal is present. These transmissions shall comply with the limits defined in clause 4.3.1.7.4.2. The verification of the Short Control Signalling transmissions may require the analyser settings to be changed (e.g. sweep time).

iv) Alternatively, the equipment may switch to a non-adaptive mode.

Step 5: Adding the unwanted signal

• With the interfering signal present, a 100 % duty cycle CW signal is inserted as the unwanted signal. The frequency and the level are provided in table 2 of clause 4.3.1.7.2.2, step 6 or table 3 of clause 4.3.1.7.3.2,
step 6.
• The spectrum analyser shall be used to monitor the transmissions of the UUT on the selected hopping frequency. This may require the spectrum analyser sweep to be triggered by the start of the unwanted signal.
• Using the procedure defined in clause 5.4.6.2.1.5, it shall be verified that:
i) The UUT shall not resume normal transmissions on the hopping frequency being tested as long as both the interference and unwanted signals remain present.
To verify that the UUT is not resuming normal transmissions as long as the interference and unwanted signals are present, the monitoring time may need to be 60 s or more. If transmissions are detected during this period, the settings of the analyser may need to be adjusted to allow an accurate assessment to verify the transmissions comply with the limits for Short Control Signalling Transmissions.
ii) The UUT may continue to have Short Control Signalling Transmissions on the hopping frequency being tested while the interference and unwanted signals are present. These transmissions shall comply with the limits defined in clause 4.3.1.7.4.2.
The verification of the Short Control Signalling transmissions may require the analyser settings to be changed (e.g. sweep time).
Step 6: Removing the interference and unwanted signal
• On removal of the interference and unwanted signal, the UUT is allowed to re-include any channel previously marked as unavailable; however, for non-LBT based equipment, it shall be verified that this shall only be done after the period defined in clause 4.3.1.7.3.2, step 2.
Step 7:
• Step 2 to step 6 shall be repeated for each of the hopping frequencies to be tested.

LBT based adaptive equipment using modulations other than FHSS
Step 1 to step 7 below define the procedure to verify the efficiency of the LBT based adaptive mechanism of equipment using wide band modulations other than FHSS. This method can be applied on Load Based Equipment and Frame Based Equipment.
Step 1:
• The UUT shall connect to a companion device during the test. The interference signal generator, the unwanted signal generator, the spectrum analyser, the UUT and the companion device are connected using a set-up equivalent to the example given by figure 5 although the interference and unwanted signal generator do not generate any signals at this point in time. The spectrum analyser is used to monitor the transmissions of both the UUT and the companion device and it should be possible to distinguish between either transmission. In addition, the spectrum analyser is used to monitor the transmissions of the UUT in response to the interfering and the unwanted signals.
• Adjust the received signal level (wanted signal from the companion device) at the UUT to the value defined in table 10 (clause 4.3.2.6.3.2.2) for Frame Based Equipment or in table 11 (clause 4.3.2.6.3.2.3) for Load Based Equipment.
Testing of Unidirectional equipment does not require a link to be established with a companion device.
• The analyser shall be set as follows:
- RBW: ≥ Occupied Channel Bandwidth (if the analyser does not support this setting, the highest available setting shall be used)
- VBW: 3 × RBW (if the analyser does not support this setting, the highest available setting shall be used)
- Detector Mode: RMS
- Centre Frequency: Equal to the centre frequency of the operating channel
- Span: 0 Hz
- Sweep time: > maximum Channel Occupancy Time
- Trace Mode: Clear Write
- Trigger Mode: Video
Step 2:
• Configure the UUT for normal transmissions with a sufficiently high payload resulting in a minimum transmitter activity ratio (TxOn / (TxOn + TxOff)) of 0,3. Where this is not possible, the UUT shall be configured to the maximum payload possible.
• For Frame Based Equipment, using the procedure defined in clause 5.4.6.2.1.5, it shall be verified that the UUT complies with the maximum Channel Occupancy Time and minimum Idle Period defined in

clause 4.3.2.6.3.2.2, step 3. When measuring the Idle Period of the UUT, it shall not include the transmission time of the companion device.

- For Load Based equipment, using the procedure defined in clause 5.4.6.2.1.5, it shall be verified that the UUT complies with the maximum Channel Occupancy Time and minimum Idle Period defined in clause 4.3.2.6.3.2.3, step 2 and step 3. When measuring the Idle Period of the UUT, it shall not include the transmission time of the companion device.
  For the purpose of testing Load Based Equipment referred to in the first paragraph of clause 4.3.2.6.3.2.3 (IEEE 802.11™ [i.3] or IEEE 802.15.4™ [i.4] equipment), the limits to be applied for the minimum Idle Period and the maximum Channel Occupancy Time are the same as defined for other types of Load Based Equipment (see clause 4.3.2.6.3.2.3, step 2 and step 3). The Idle Period is considered to be equal to the CCA or Extended CCA time defined in clause 4.3.2.6.3.2.3, step 1 and step 2.

Step 3: Adding the interference signal

- An interference signal as defined in clause B.7 is injected on the current operating channel of the UUT. The power spectral density level (at the input of the UUT) of this interference signal shall be equal to the detection threshold defined in clause 4.3.2.6.3.2.2, step 5 (frame based equipment) or clause 4.3.2.6.3.2.3, step 5 (load based equipment).

Step 4: Verification of reaction to the interference signal

- The spectrum analyser shall be used to monitor the transmissions of the UUT on the selected operating channel with the interfering signal injected. This may require the spectrum analyser sweep to be triggered by the start of the interfering signal.
- Using the procedure defined in clause 5.4.6.2.1.5, it shall be verified that:
  i) The UUT shall stop transmissions on the current operating channel.
  The UUT is assumed to stop transmissions within a period equal to the maximum Channel Occupancy Time defined in clause 4.3.2.6.3.2.2 (frame based equipment) or clause 4.3.2.6.3.2.3 (load based equipment).
  ii) Apart from Short Control Signalling Transmissions, there shall be no subsequent transmissions while the interfering signal is present.
  To verify that the UUT is not resuming normal transmissions as long as the interference signal is present, the monitoring time may need to be 60 s or more.
  iii) The UUT may continue to have Short Control Signalling Transmissions on the operating channel while the interfering signal is present. These transmissions shall comply with the limits defined in clause 4.3.2.6.4.2.
  The verification of the Short Control Signalling transmissions may require the analyser settings to be changed (e.g. sweep time).
  iv) Alternatively, the equipment may switch to a non-adaptive mode.

Step 5: Adding the unwanted signal

- With the interfering signal present, a 100 % duty cycle CW signal is inserted as the unwanted signal. The frequency and the level are provided in table 10 (clause 4.3.2.6.3.2.2) for Frame Based Equipment or in table 11 (clause 4.3.2.6.3.2.3) for Load Based Equipment.
- The spectrum analyser shall be used to monitor the transmissions of the UUT on the selected operating channel. This may require the spectrum analyser sweep to be triggered by the start of the unwanted signal.
- Using the procedure defined in clause 5.4.6.2.1.5, it shall be verified that:
  i) The UUT shall not resume normal transmissions on the current operating channel as long as both the interference and unwanted signals remain present.
  To verify that the UUT is not resuming normal transmissions as long as the interference and unwanted signals are present, the monitoring time may need to be 60 s or more.
  ii) The UUT may continue to have Short Control Signalling Transmissions on the operating channel while the interfering and unwanted signals are present. These transmissions shall comply with the limits defined in clause 4.3.2.6.4.2.
  The verification of the Short Control Signalling transmissions may require the analyser settings to be changed (e.g. sweep time).

Step 6: Removing the interference and unwanted signal

- On removal of the interference and unwanted signals the UUT is allowed to start transmissions again on this channel; however, this is not a requirement and, therefore, does not require testing.

Step 7:

- Step 2 to step 6 shall be repeated for each of the frequencies to be tested.

■Radiated measurements

When performing radiated measurements on equipment with dedicated antennas, measurements shall be repeated for each alternative dedicated antenna.

A test site as described in annex B and applicable measurement procedures as described in annex C shall be used. The test procedure is further as described under clause 5.4.6.2.1.

TEST RESULTS

Please refer to section "Test Data" - Appendix

7.8. RECEIVER BLOCKING

LIMITS

Performance Criteria

For equipment that supports a PER or FER test to be performed, the minimum performance criterion shall be a PER or FER less than or equal to 10 %.
For equipment that does not support a PER or a FER test to be performed, the minimum performance criterion shall be no loss of the wireless transmission function needed for the intended use of the equipment.

While maintaining the minimum performance criteria as defined in clause 4.3.2.11.3, the blocking levels at specified frequency offsets shall be equal to or greater than the limits defined for the applicable receiver category provided in table 14, table 15 or table 16.

☒ Receiver Category 1

Table 14: Receiver Blocking parameters for Receiver Category 1 equipment

Wanted signal mean power from companion device (dBm) (see notes 1 and 4)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 4)	Type of blocking signal
(-133 dBm + 10 × $\log_{10}$(OCBW)) or -68 dBm whichever is less (see note 2)	2 380 2 504	-34	CW
(-139 dBm + 10 × $\log_{10}$(OCBW)) or -74 dBm whichever is less (see note 3)	2 300 2 330 2 360 2 524 2 584 2 674		

NOTE 1: OCBW is in Hz.

NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 26 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.

NOTE 3: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 20 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.

NOTE 4: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.

☐ Receiver Category 2

Table 15: Receiver Blocking parameters receiver Category 2 equipment

Wanted signal mean power from companion device (dBm) (see notes 1 and 3)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 3)	Type of blocking signal
(-139 dBm + 10 × $\log_{10}$(OCBW) + 10 dB) or (-74 dBm + 10 dB) whichever is less (see note 2)	2 380 2 504 2 300 2 584	-34	CW

NOTE 1: OCBW is in Hz.
NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 26 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.
NOTE 3: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.

☐ Receiver Category 3

Table 16: Receiver Blocking parameters receiver Category 3 equipment

Wanted signal mean power from companion device (dBm) (see notes 1 and 3)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 3)	Type of blocking signal
(-139 dBm + 10 × $\log_{10}$(OCBW) + 20 dB) or (-74 dBm + 20 dB) whichever is less (see note 2)	2 380 2 504 2 300 2 584	-34	CW

NOTE 1: OCBW is in Hz.
NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 30 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.
NOTE 3: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.

TEST PROCEDURE

Please refer to ETSI EN 300 328 V2.2.2 (2019-07) Clause 5.4.11

Measurement	
☒Conducted measurement	☐Radiated measurement

Step 1:
• For non-FHSS equipment, the UUT shall be set to the lowest operating channel on which the blocking test has to be performed (see clause 5.4.11.1).
Step 2:
• The blocking signal generator is set to the first frequency as defined in the appropriate table corresponding to the receiver category and type of equipment.
Step 3:
• With the blocking signal generator switched off, a communication link is established between the UUT and the associated companion device using the test setup shown in figure 6.
• Unless the option provided in note 2 of the applicable table referred to in clause 5.4.11.2.1 is used, the level of the wanted signal shall be set to the value provided in the table corresponding to the receiver category and type of equipment. The test procedure defined in clause 5.4.2, and more in particular clause 5.4.2.2.1.2, can be used to measure the (conducted) level of the wanted signal however no correction shall be made for antenna gain of the companion device (step 6 in clause 5.4.2.2.1.2 shall be ignored). This level may be measured directly at the output of the companion device and a correction is made for the coupling loss into the UUT. The actual level for the wanted signal shall be recorded in the test report.
• When the option provided in note 2 of the applicable table referred to in clause 5.4.11.2.1 is used, the attenuation of the variable attenuator shall be increased in 1 dB steps to a value at which the minimum performance criteria as specified in clause 4.3.1.12.3 or clause 4.3.2.11.3 is still met. The resulting level for the wanted signal at the input of the UUT is Pmin. This signal level (Pmin) is increased by the value provided in note 2 of the applicable table corresponding to the receiver category and type of equipment.
Step 4:
• The blocking signal at the UUT is set to the level provided in the table corresponding to the receiver category and type of equipment.
• If the performance criteria as specified in clause 4.3.1.12.3 or clause 4.3.2.11.3 are met then proceed to step 6.
Step 5:
• If the performance criteria as specified in clause 4.3.1.12.3 or clause 4.3.2.11.3 is not met, step 3 and step 4 shall be repeated after that the frequency of the blocking signal set in step 2 has been increased with a value equal to the Occupied Channel Bandwidth except:
- For the blocking frequency 2 380 MHz, where this frequency offset shall be less than or equal to 10 MHz. If this frequency offset is more than 7 MHz, the level of the wanted signal shall be increased by 3 dB.
- For the blocking frequency 2 503,5 MHz, where this frequency offset shall be less than or equal to 10 MHz. If this frequency offset is more than 7 MHz, the level of the wanted signal shall be decreased by 3 dB.
• If the performance criteria as specified in clause 4.3.1.12.3 or clause 4.3.2.11.3 is still not met, step 3 and step 4 shall be repeated after that the frequency of the blocking signal set in step 2 has been decreased with a value equal to the Occupied Channel Bandwidth except:
- For the blocking frequency 2 380 MHz, where this frequency offset shall be less than or equal to 10 MHz. If this frequency offset is more than 7 MHz, the level of the wanted signal shall be decreased by 3 dB.
- For the blocking frequency 2 503,5 MHz, where this frequency offset shall be less than or equal to 10 MHz. If this frequency offset is more than 7 MHz, the level of the wanted signal shall be increased by 3 dB.
• If the performance criteria as specified in clause 4.3.1.12.3 or clause 4.3.2.11.3 is still not met, the UUT fails to comply with the Receiver Blocking requirement and step 6 and step 7 are no longer required.

• It shall be recorded in the test report whether the shift of blocking frequencies as described in the present step was used.
Step 6:
• Repeat step 4 and step 5 for each remaining combination of frequency and level for the blocking signal as provided in the table corresponding to the receiver category and type of equipment.
Step 7:
• For non-FHSS equipment, repeat step 2 to step 6 with the UUT operating at the highest operating channel on which the blocking test has to be performed (see clause 5.4.11.1).
Step 8:
• It shall be assessed and recorded in the test report whether the UUT complies with the Receiver Blocking requirement.

TEST ENVIRONMENT

Temperature	24℃	Relative Humidity	50%
Atmosphere Pressure	101kPa		

TEST RESULTS

Please refer to section "Test Data" - Appendix **TEST DATA**

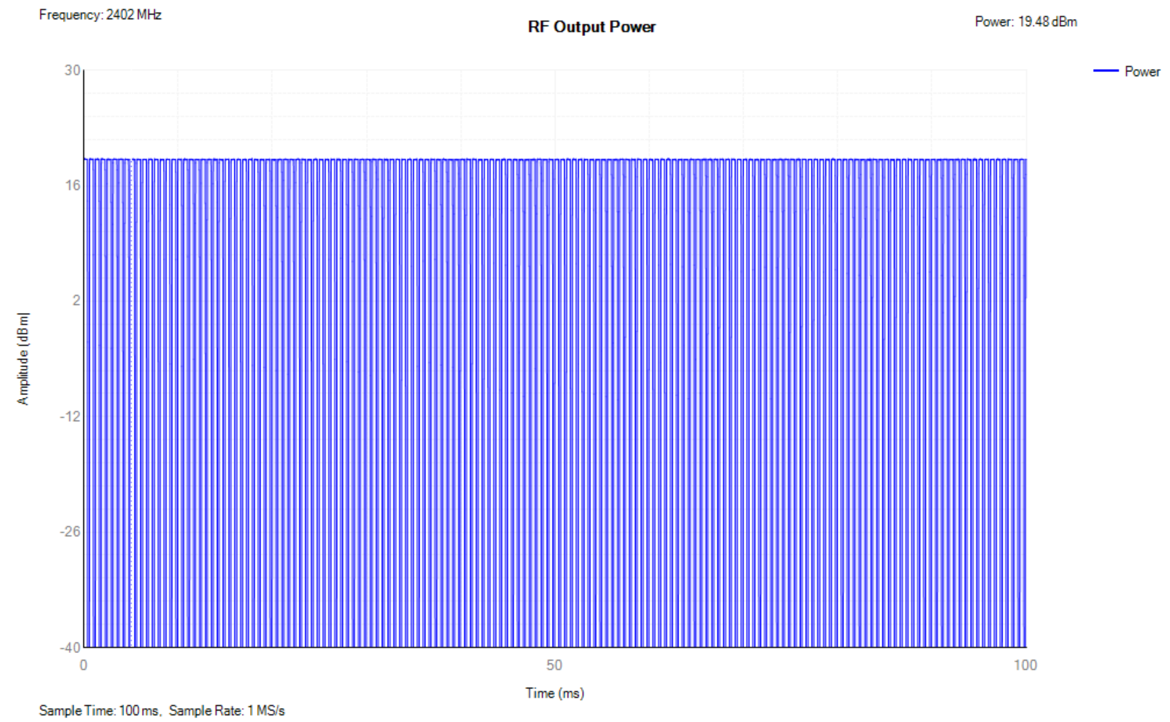
Duty Cycle, Tx Sequence, Tx Gap, Medium Utilisation

Condition	Mode	Frequency (MHz)	Antenna	Duty Cycle (%)	Tx-sequence (ms)	Tx Gap (ms)	MU (%)
NVNT	BLE 1M	2402	Ant1	68.88	0.43	0.2	54.46
NVNT	BLE 1M	2440	Ant1	68.91	0.43	0.2	57.85
NVNT	BLE 1M	2480	Ant1	68.92	0.43	0.2	59.61
NVLT	BLE 1M	2402	Ant1	68.88	0.43	0.2	54.34
NVLT	BLE 1M	2440	Ant1	68.9	0.43	0.2	57.31
NVLT	BLE 1M	2480	Ant1	68.92	0.43	0.2	59.34
NVHT	BLE 1M	2402	Ant1	68.88	0.43	0.2	54.34
NVHT	BLE 1M	2440	Ant1	68.9	0.43	0.2	57.31
NVHT	BLE 1M	2480	Ant1	68.92	0.43	0.2	59.2

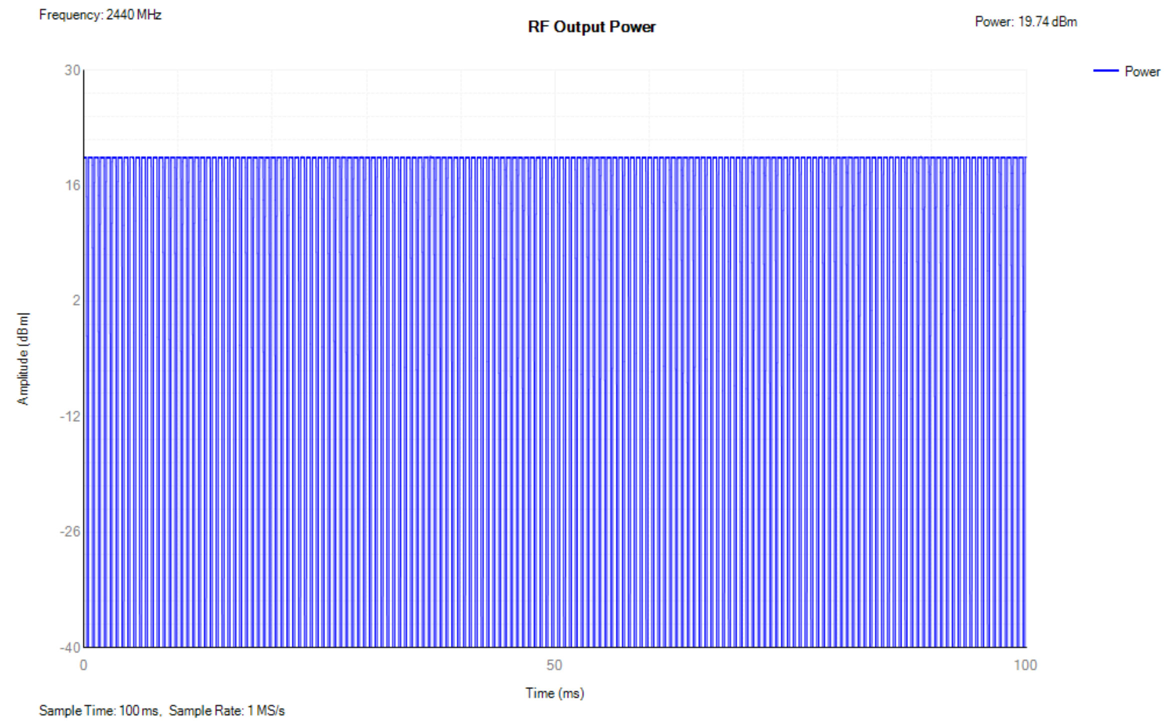
RF Output Power

Condition	Mode	Frequency (MHz)	Antenna	Max Burst RMS Power (dBm)	Burst Number	Gain (dB)	Max EIRP (dBm)	Limit (dBm)	Verdict
NVNT	BLE 1M	2402	Ant1	18.98	161	0.5	19.48	20	Pass
NVNT	BLE 1M	2440	Ant1	19.24	161	0.5	19.74	20	Pass
NVNT	BLE 1M	2480	Ant1	19.37	161	0.5	19.87	20	Pass
NVLT	BLE 1M	2402	Ant1	18.97	161	0.5	19.47	20	Pass
NVLT	BLE 1M	2440	Ant1	19.2	160	0.5	19.7	20	Pass
NVLT	BLE 1M	2480	Ant1	19.35	161	0.5	19.85	20	Pass
NVHT	BLE 1M	2402	Ant1	18.97	161	0.5	19.47	20	Pass
NVHT	BLE 1M	2440	Ant1	19.2	160	0.5	19.7	20	Pass
NVHT	BLE 1M	2480	Ant1	19.34	160	0.5	19.84	20	Pass

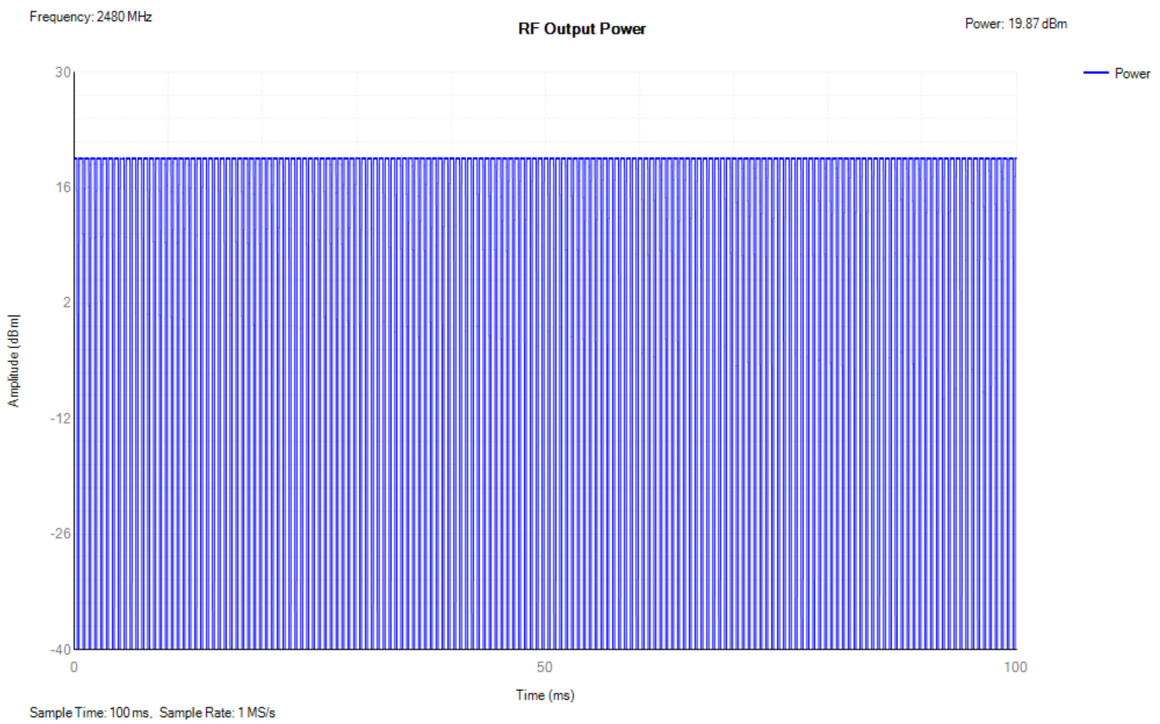
Test Graphs
Power NVNT BLE 1M 2402MHz Ant1



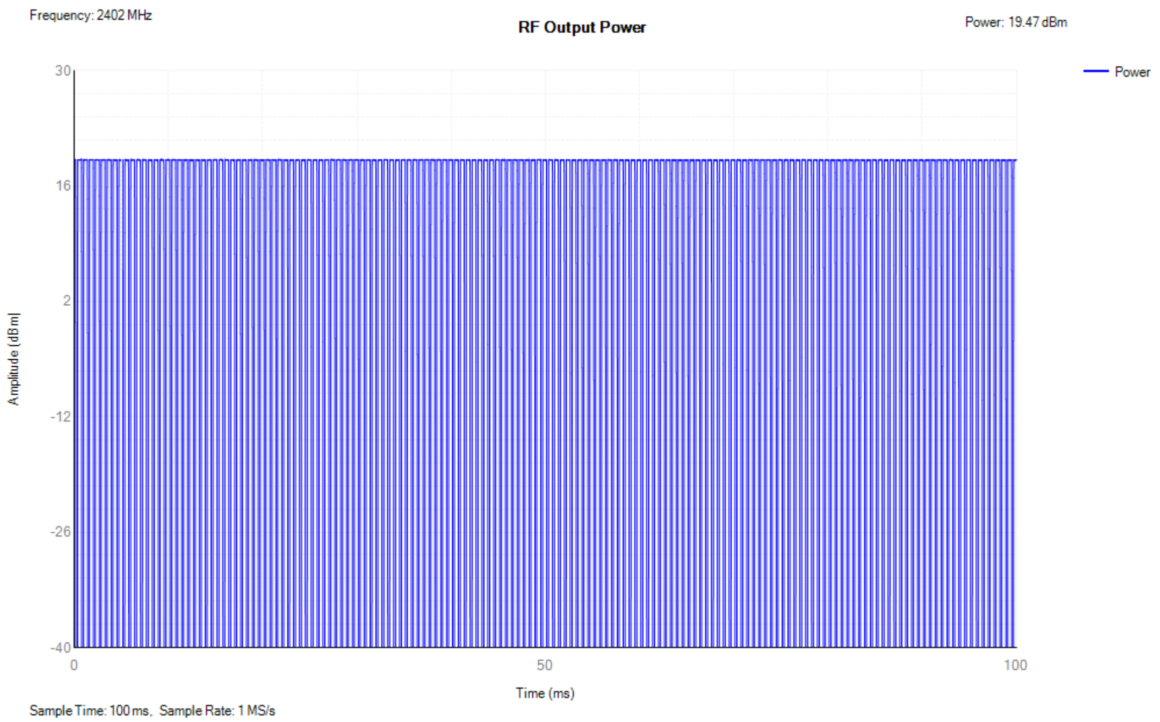
Power NVNT BLE 1M 2440MHz Ant1



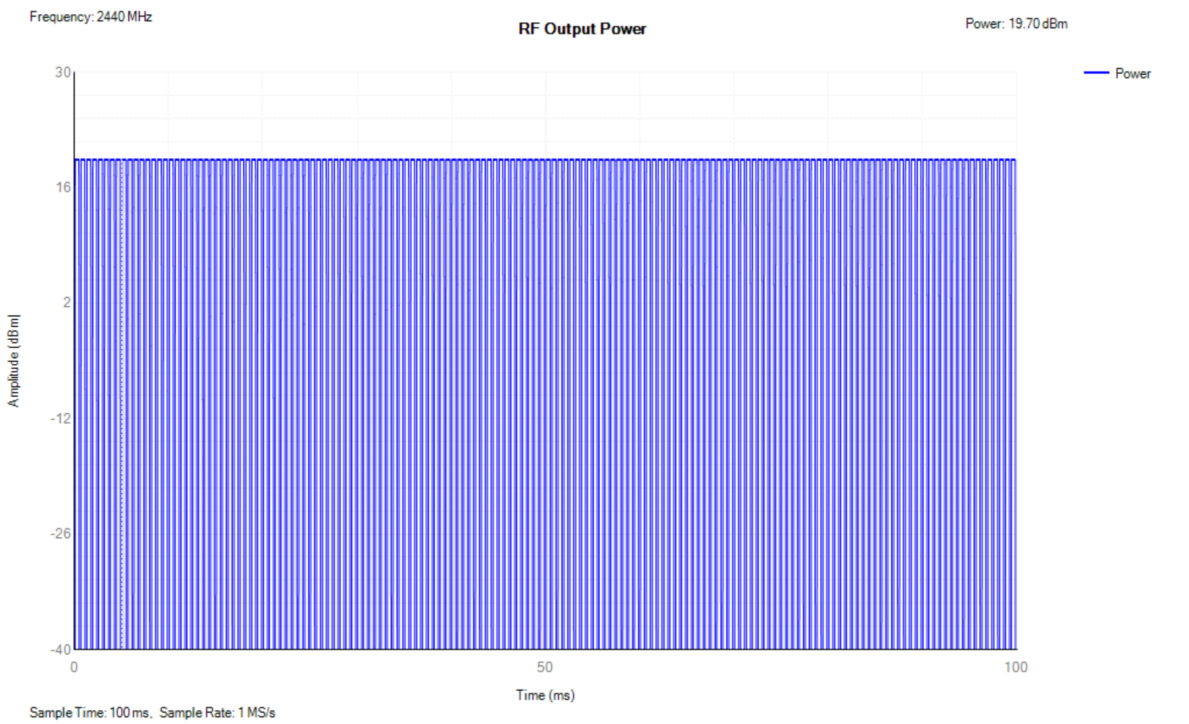
Power NVNT BLE 1M 2480MHz Ant1



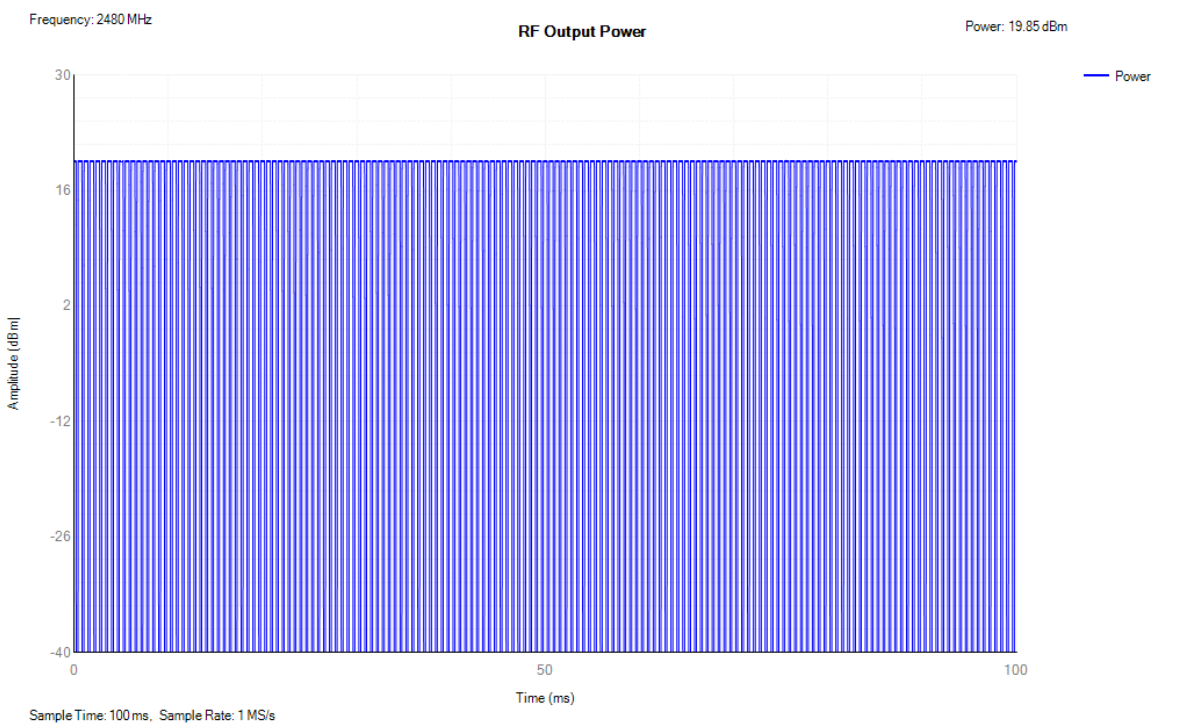
Power NVLT BLE 1M 2402MHz Ant1



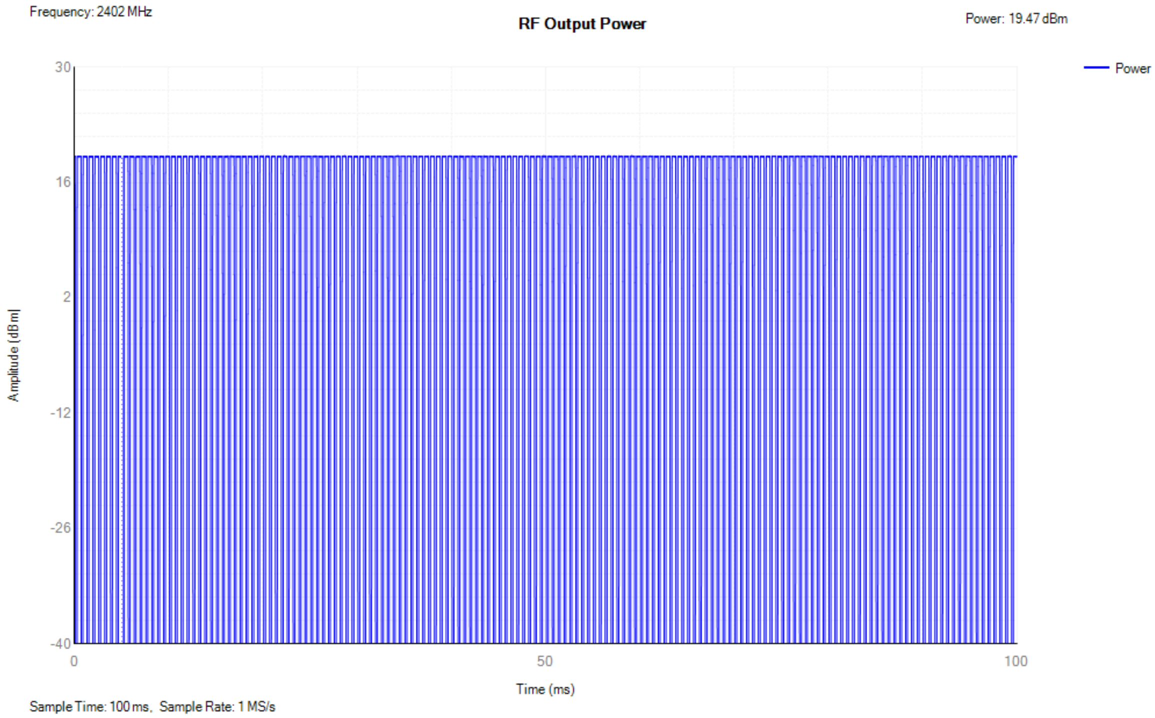
Power NVLT BLE 1M 2440MHz Ant1



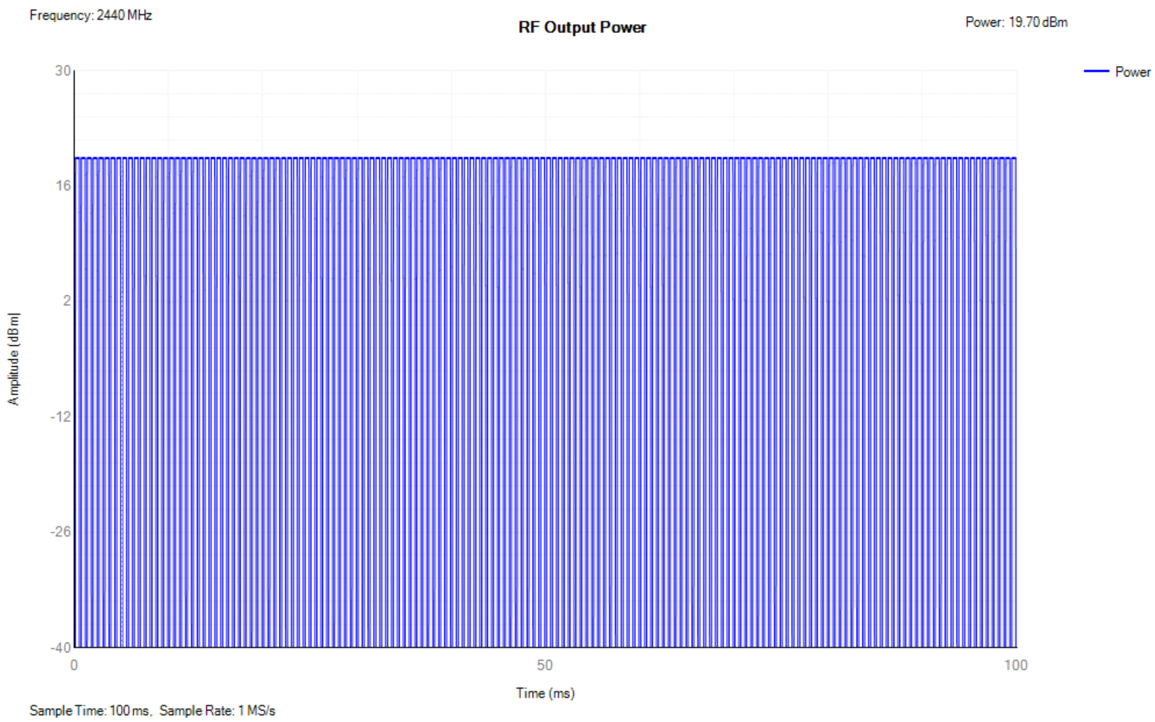
Power NVLT BLE 1M 2480MHz Ant1



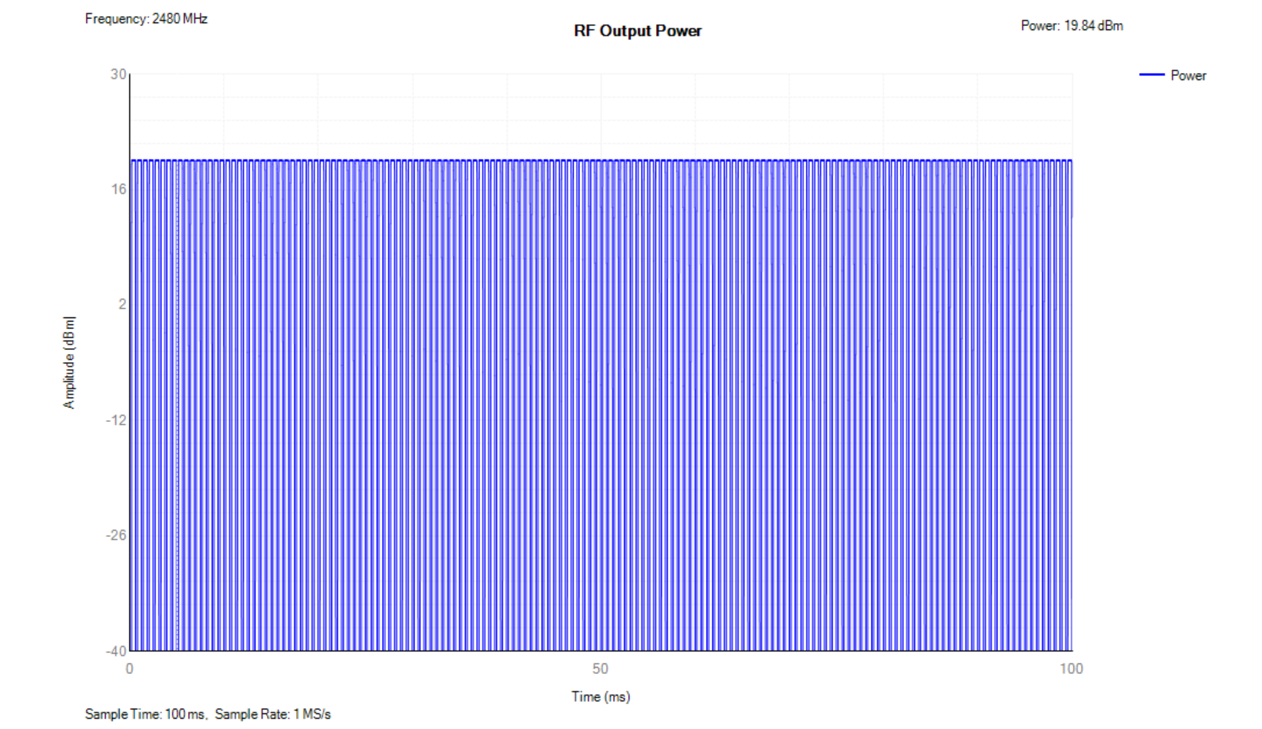
Power NVHT BLE 1M 2402MHz Ant1



Power NVHT BLE 1M 2440MHz Ant1

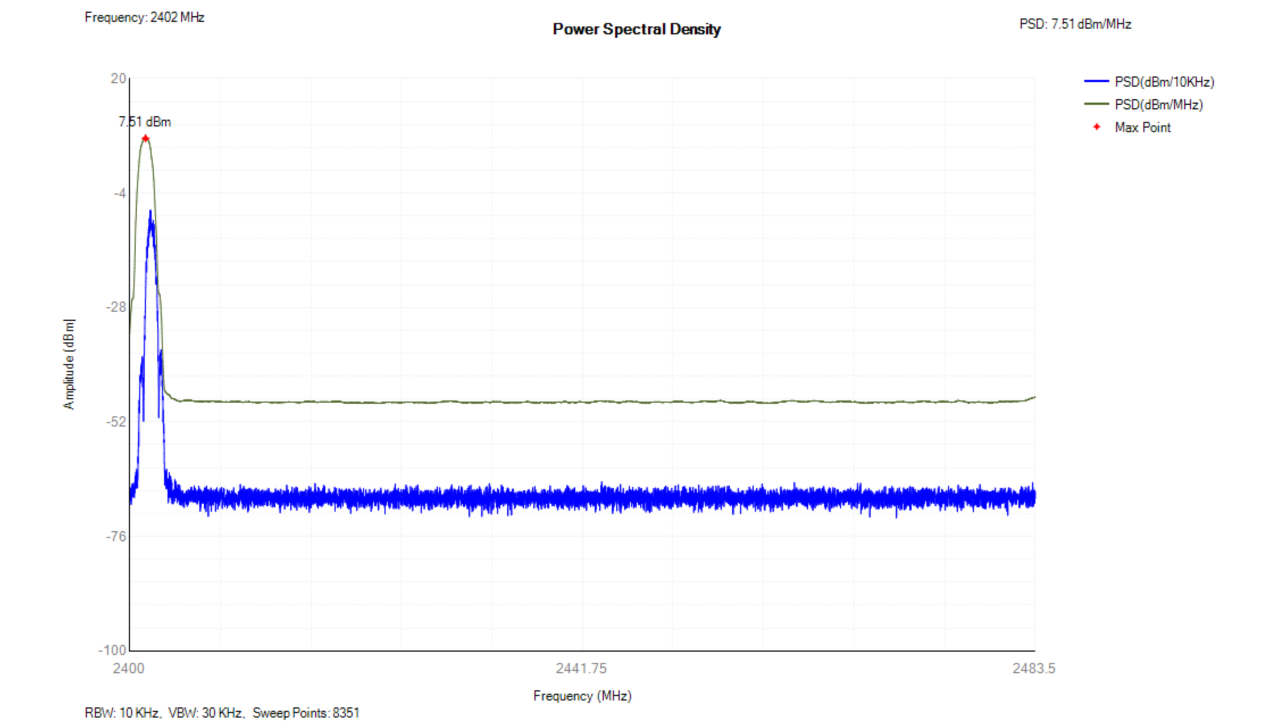
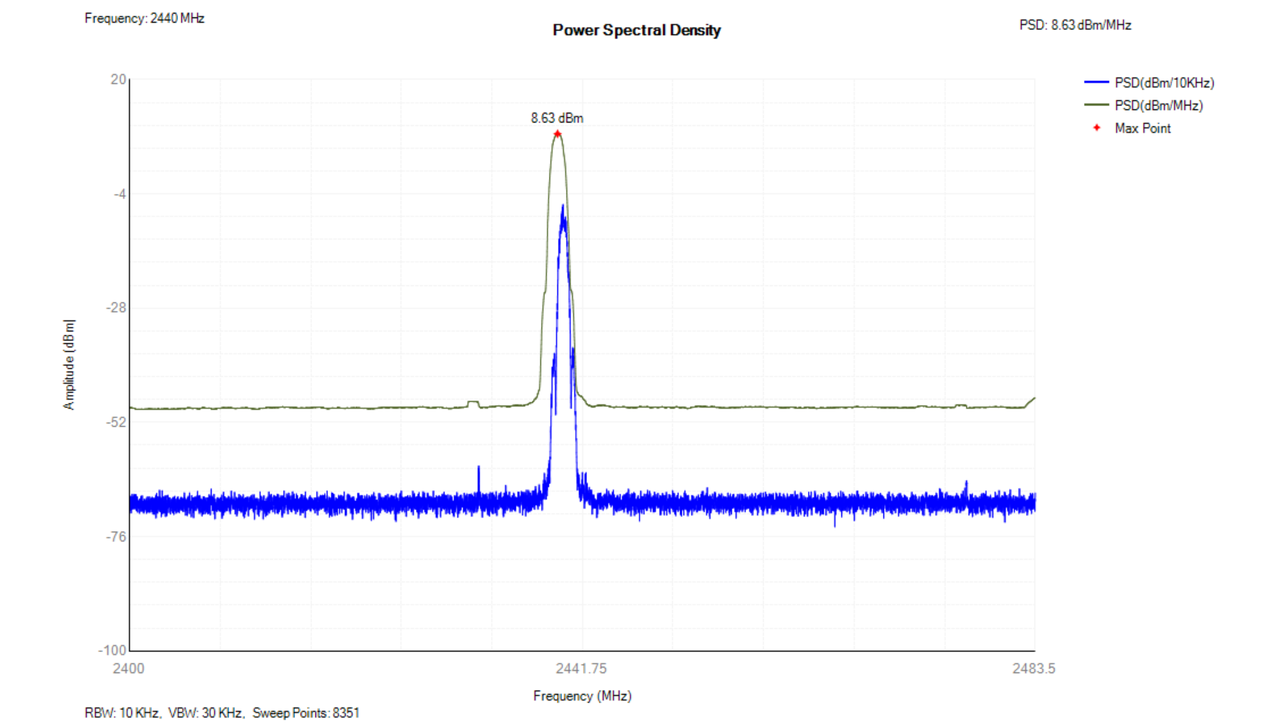


Power NVHT BLE 1M 2480MHz Ant1

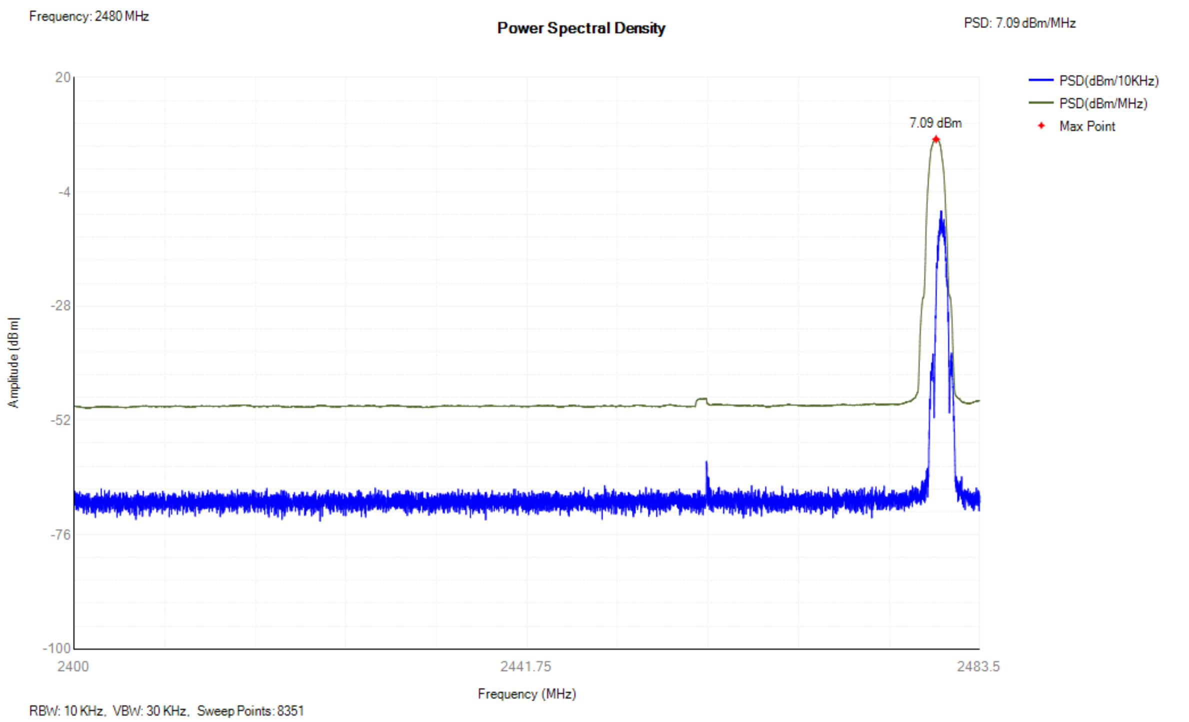


Power Spectral Density

Condition	Mode	Frequency (MHz)	Antenna	Max PSD (dBm/MHz)	Limit (dBm/MHz)	Verdict
NVNT	BLE 1M	2402	Ant1	7.51	10	Pass
NVNT	BLE 1M	2440	Ant1	8.63	10	Pass
NVNT	BLE 1M	2480	Ant1	7.09	10	Pass

Test Graphs
PSD NVNT BLE 1M 2402MHz Ant1

PSD NVNT BLE 1M 2440MHz Ant1


PSD NVNT BLE 1M 2480MHz Ant1

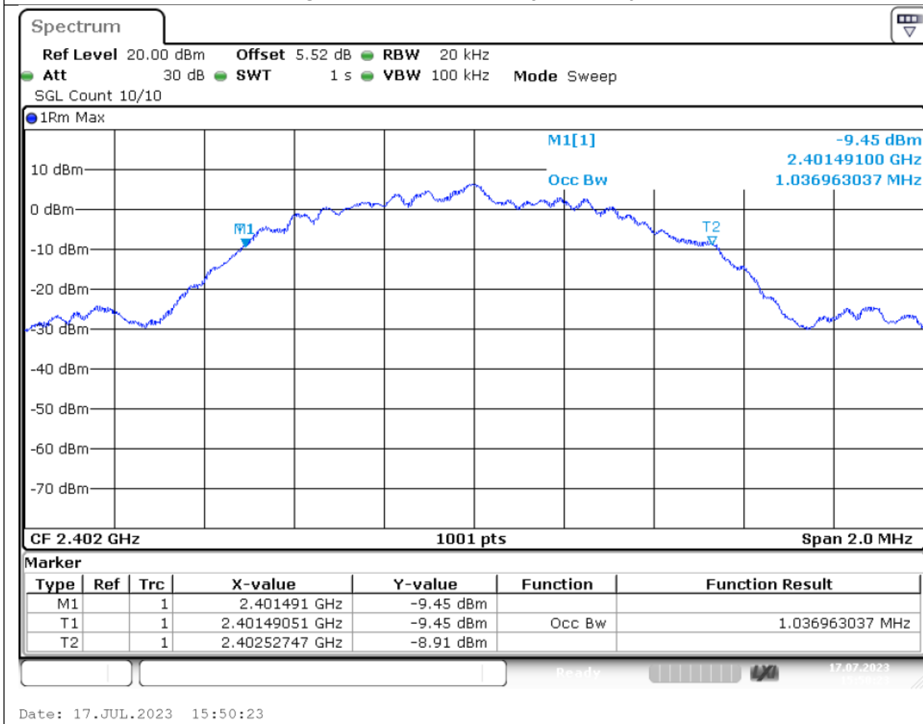


Occupied Channel Bandwidth

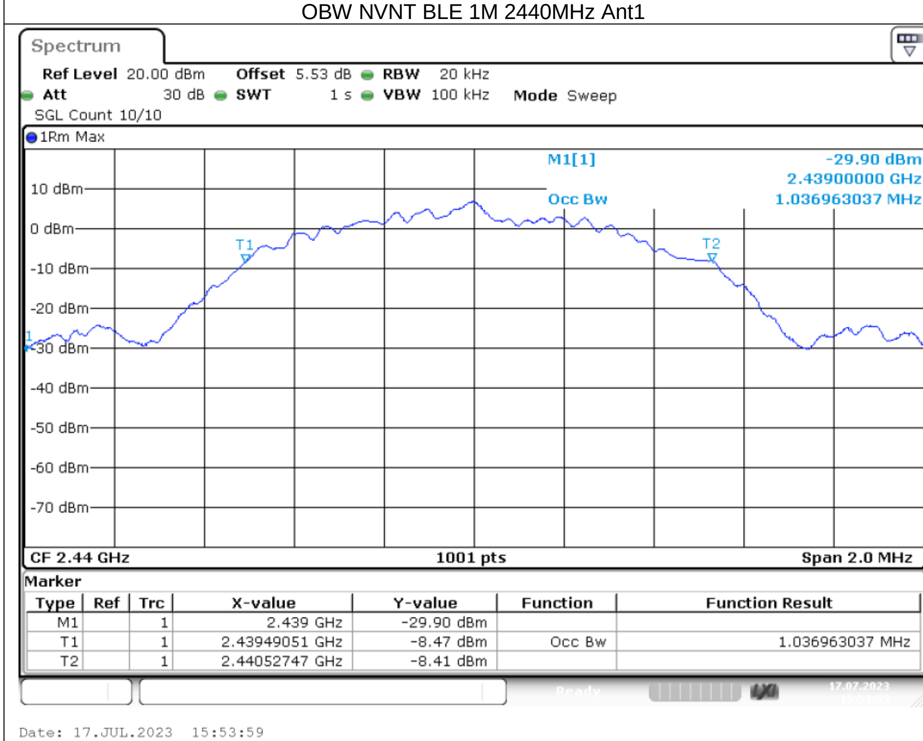
Condition	Mode	Frequency (MHz)	Antenna	Center Frequency (MHz)	OBW (MHz)	Lower Edge (MHz)	Upper Edge (MHz)	Limit OBW (MHz)	Verdict
NVNT	BLE 1M	2402	Ant1	2402.009	1.037	2401.491	2402.527	2400 - 2483.5MHz	Pass
NVNT	BLE 1M	2440	Ant1	2440.009	1.037	2439.491	2440.527	2400 - 2483.5MHz	Pass
NVNT	BLE 1M	2480	Ant1	2480.009	1.037	2479.491	2480.527	2400 - 2483.5MHz	Pass

Test Graphs

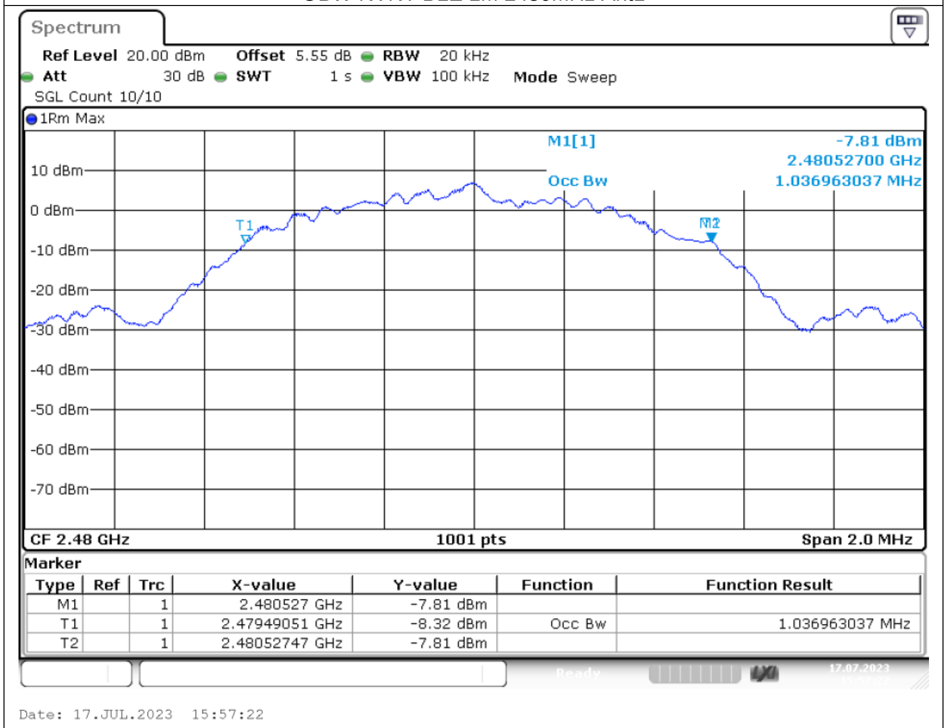
OBW NVNT BLE 1M 2402MHz Ant1



OBW NVNT BLE 1M 2440MHz Ant1

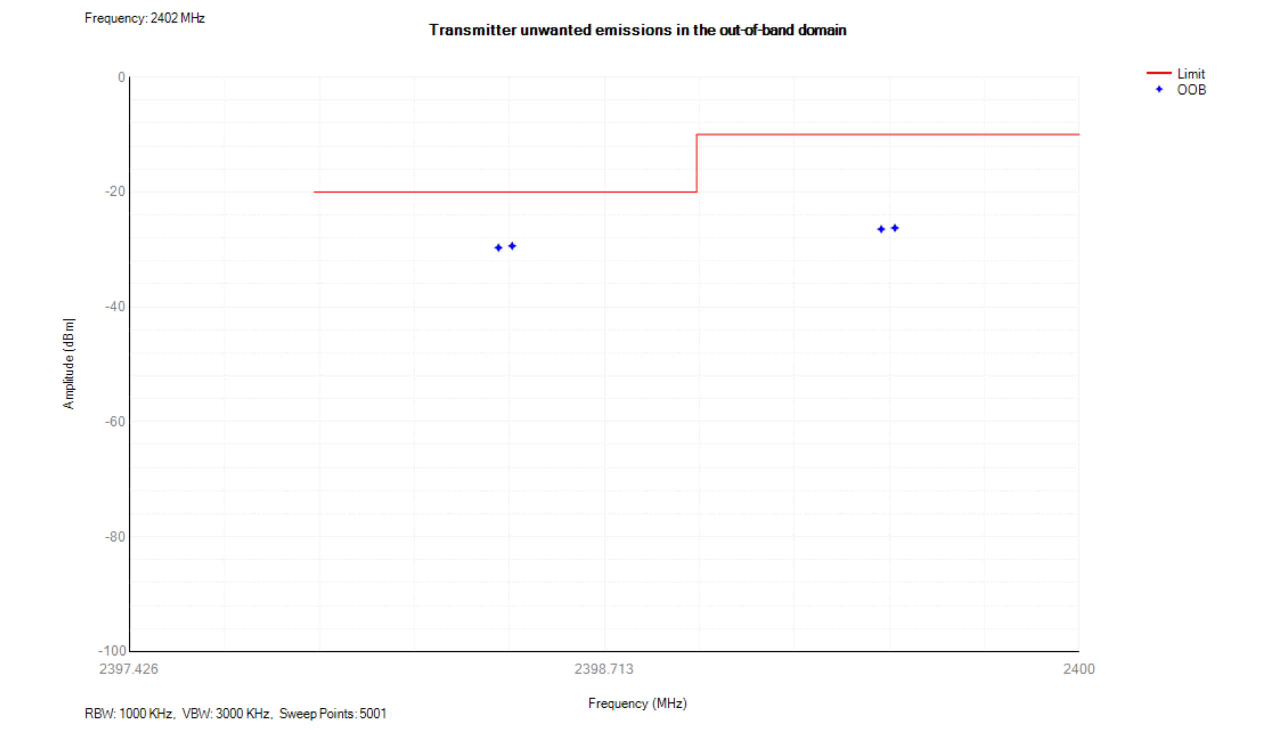
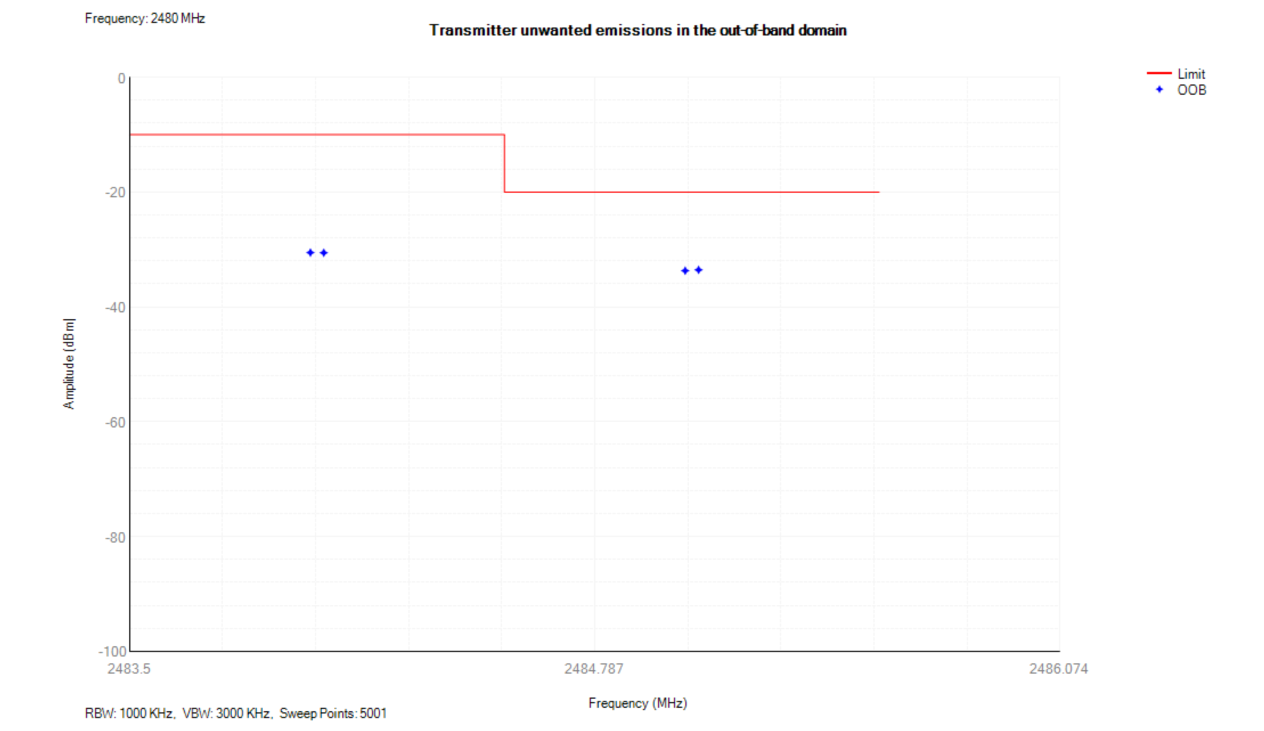


OBW NVNT BLE 1M 2480MHz Ant1



Transmitter unwanted emissions in the out-of-band domain

Condition	Mode	Frequency (MHz)	Antenna	OOB Frequency (MHz)	Level (dBm/MHz)	Limit (dBm/MHz)	Verdict
NVNT	BLE 1M	2402	Ant1	2399.5	-26.25	-10	Pass
NVNT	BLE 1M	2402	Ant1	2399.463	-26.46	-10	Pass
NVNT	BLE 1M	2402	Ant1	2398.463	-29.38	-20	Pass
NVNT	BLE 1M	2402	Ant1	2398.426	-29.69	-20	Pass
NVNT	BLE 1M	2480	Ant1	2484	-30.53	-10	Pass
NVNT	BLE 1M	2480	Ant1	2484.037	-30.56	-10	Pass
NVNT	BLE 1M	2480	Ant1	2485.037	-33.69	-20	Pass
NVNT	BLE 1M	2480	Ant1	2485.074	-33.54	-20	Pass

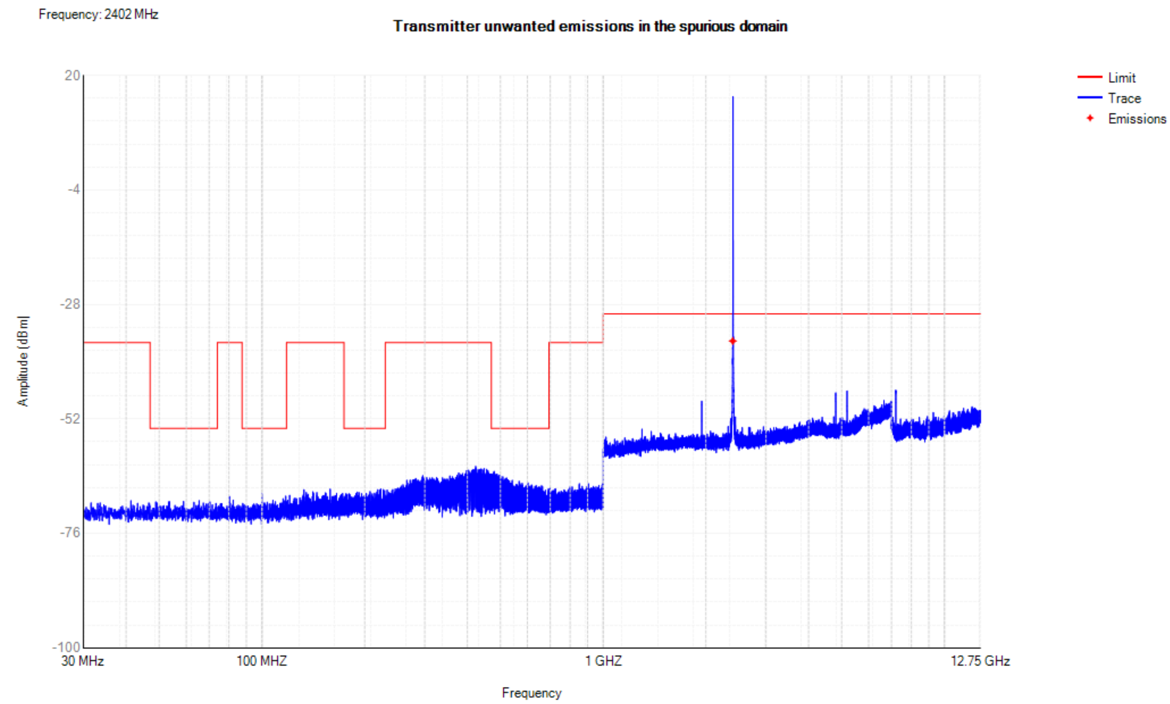
Test Graphs
Tx. Emissions OOB NVNT BLE 1M 2402MHz Ant1

Tx. Emissions OOB NVNT BLE 1M 2480MHz Ant1


Transmitter unwanted emissions in the spurious domain

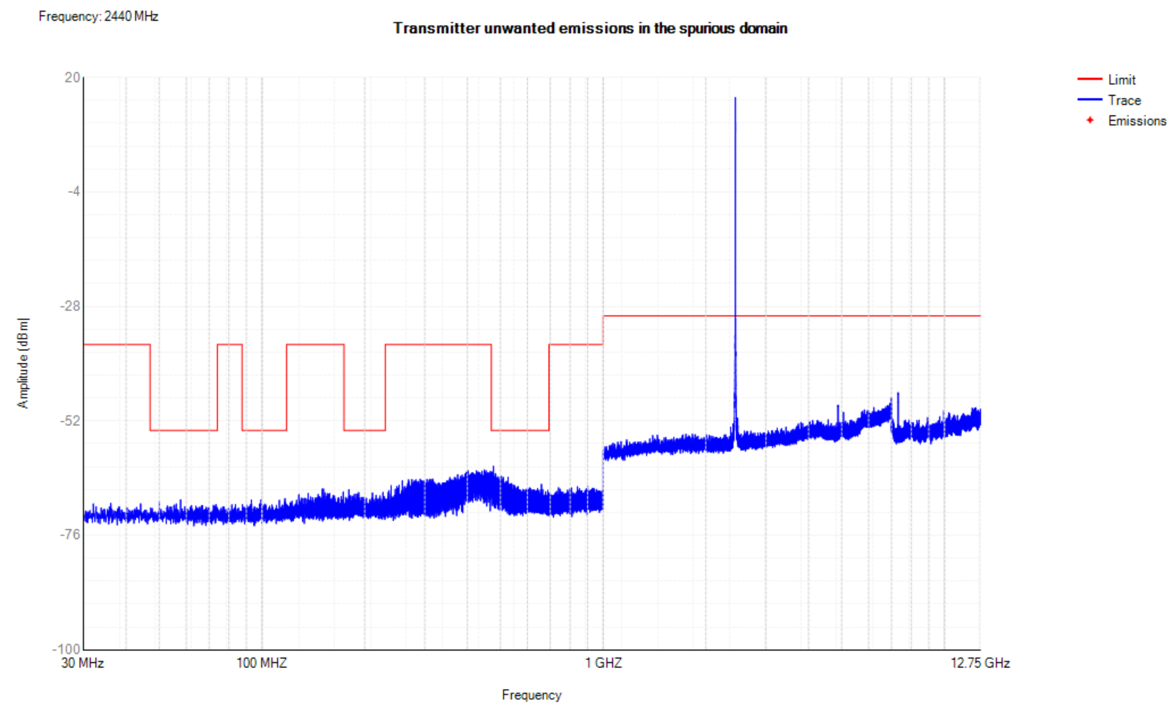
Condition	Mode	Frequency (MHz)	Antenna	Range (MHz)	Spur Freq (MHz)	Peak (dBm)	RMS (dBm)	Limit (dBm)	Verdict
NVNT	BLE 1M	2402	Ant1	30 -47	41.30	-69.15	NA	-36	Pass
NVNT	BLE 1M	2402	Ant1	47 -74	65.45	-69.14	NA	-54	Pass
NVNT	BLE 1M	2402	Ant1	74 -87.5	80.35	-68.27	NA	-36	Pass
NVNT	BLE 1M	2402	Ant1	87.5 -118	100.00	-67.73	NA	-54	Pass
NVNT	BLE 1M	2402	Ant1	118 -174	158.45	-66.73	NA	-36	Pass
NVNT	BLE 1M	2402	Ant1	174 -230	222.90	-66.67	NA	-54	Pass
NVNT	BLE 1M	2402	Ant1	230 -470	423.10	-61.97	NA	-36	Pass
NVNT	BLE 1M	2402	Ant1	470 -694	479.30	-63.01	NA	-54	Pass
NVNT	BLE 1M	2402	Ant1	694 -1000	851.50	-65.59	NA	-36	Pass
NVNT	BLE 1M	2402	Ant1	1000 -2398	2397.50	-34.27	-35.68	-30	Pass
NVNT	BLE 1M	2402	Ant1	2485.5 - 12750	7207.00	-46.03	NA	-30	Pass
NVNT	BLE 1M	2440	Ant1	30 -47	36.05	-69.25	NA	-36	Pass
NVNT	BLE 1M	2440	Ant1	47 -74	57.75	-68.53	NA	-54	Pass
NVNT	BLE 1M	2440	Ant1	74 -87.5	83.65	-69.58	NA	-36	Pass
NVNT	BLE 1M	2440	Ant1	87.5 -118	116.75	-68.27	NA	-54	Pass
NVNT	BLE 1M	2440	Ant1	118 -174	151.40	-66.25	NA	-36	Pass
NVNT	BLE 1M	2440	Ant1	174 -230	179.80	-66.40	NA	-54	Pass
NVNT	BLE 1M	2440	Ant1	230 -470	448.20	-62.27	NA	-36	Pass
NVNT	BLE 1M	2440	Ant1	470 -694	477.05	-61.50	NA	-54	Pass
NVNT	BLE 1M	2440	Ant1	694 -1000	900.75	-65.79	NA	-36	Pass
NVNT	BLE 1M	2440	Ant1	1000 -2398	2363.00	-53.30	NA	-30	Pass
NVNT	BLE 1M	2440	Ant1	2485.5 - 12750	7320.00	-46.08	NA	-30	Pass
NVNT	BLE 1M	2480	Ant1	30 -47	45.00	-69.49	NA	-36	Pass
NVNT	BLE 1M	2480	Ant1	47 -74	65.75	-69.12	NA	-54	Pass
NVNT	BLE 1M	2480	Ant1	74 -87.5	80.35	-69.05	NA	-36	Pass
NVNT	BLE 1M	2480	Ant1	87.5 -118	103.10	-68.07	NA	-54	Pass
NVNT	BLE 1M	2480	Ant1	118 -174	165.75	-66.90	NA	-36	Pass
NVNT	BLE 1M	2480	Ant1	174 -230	229.25	-66.39	NA	-54	Pass
NVNT	BLE 1M	2480	Ant1	230 -470	434.15	-62.14	NA	-36	Pass
NVNT	BLE 1M	2480	Ant1	470 -694	490.40	-63.05	NA	-54	Pass
NVNT	BLE 1M	2480	Ant1	694 -1000	883.95	-65.38	NA	-36	Pass
NVNT	BLE 1M	2480	Ant1	1000 -2398	2375.50	-53.93	NA	-30	Pass
NVNT	BLE 1M	2480	Ant1	2485.5 - 12750	2486.50	-38.52	NA	-30	Pass

Test Graphs

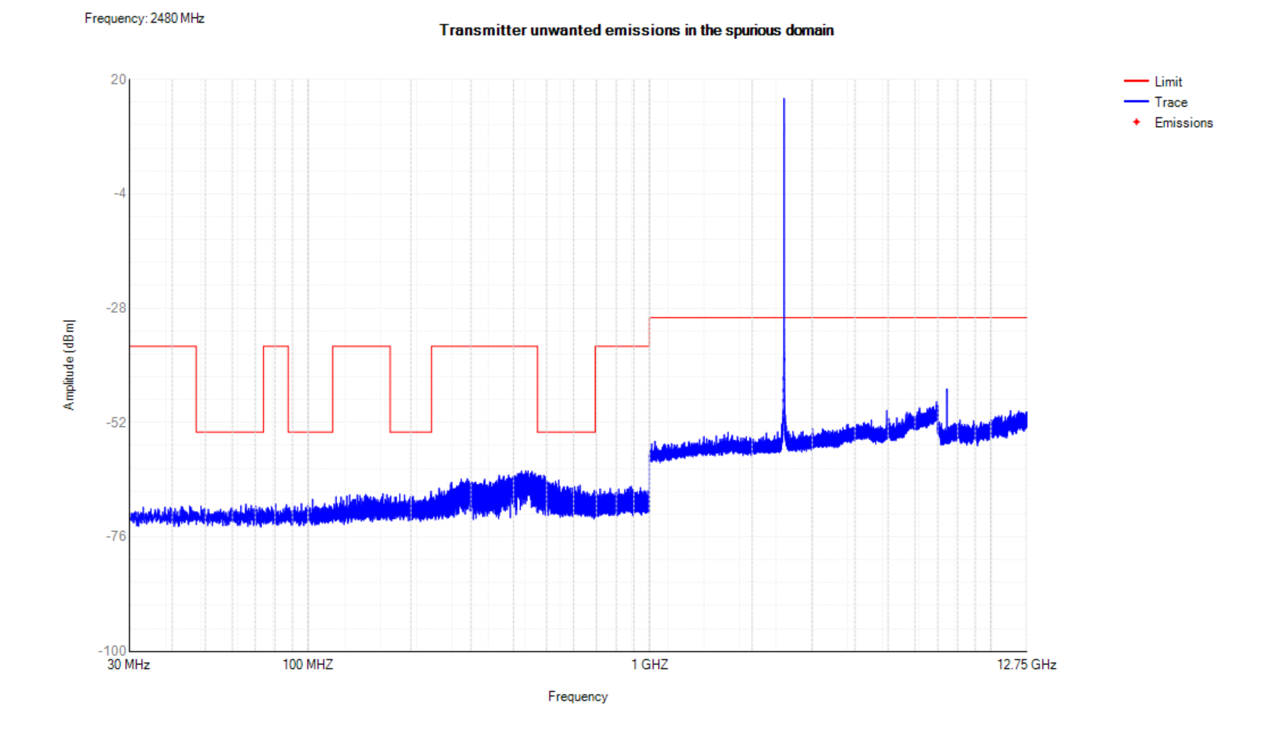
Tx. Spurious NVNT BLE 1M 2402MHz Ant1



Tx. Spurious NVNT BLE 1M 2440MHz Ant1

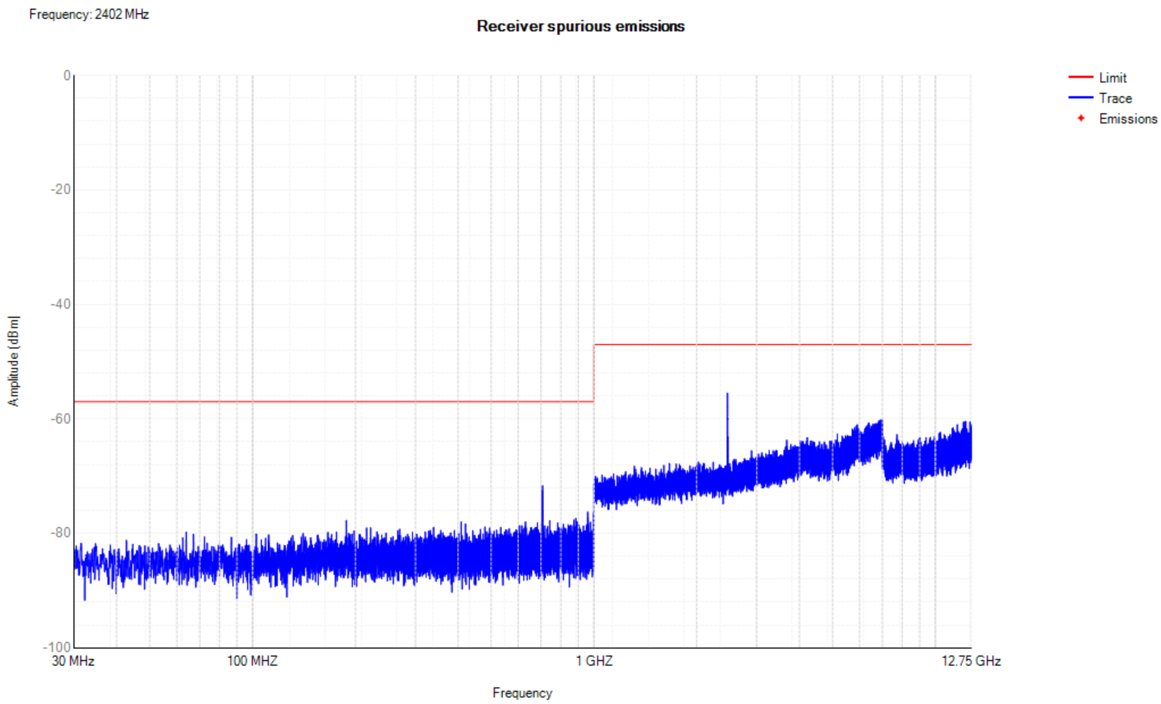
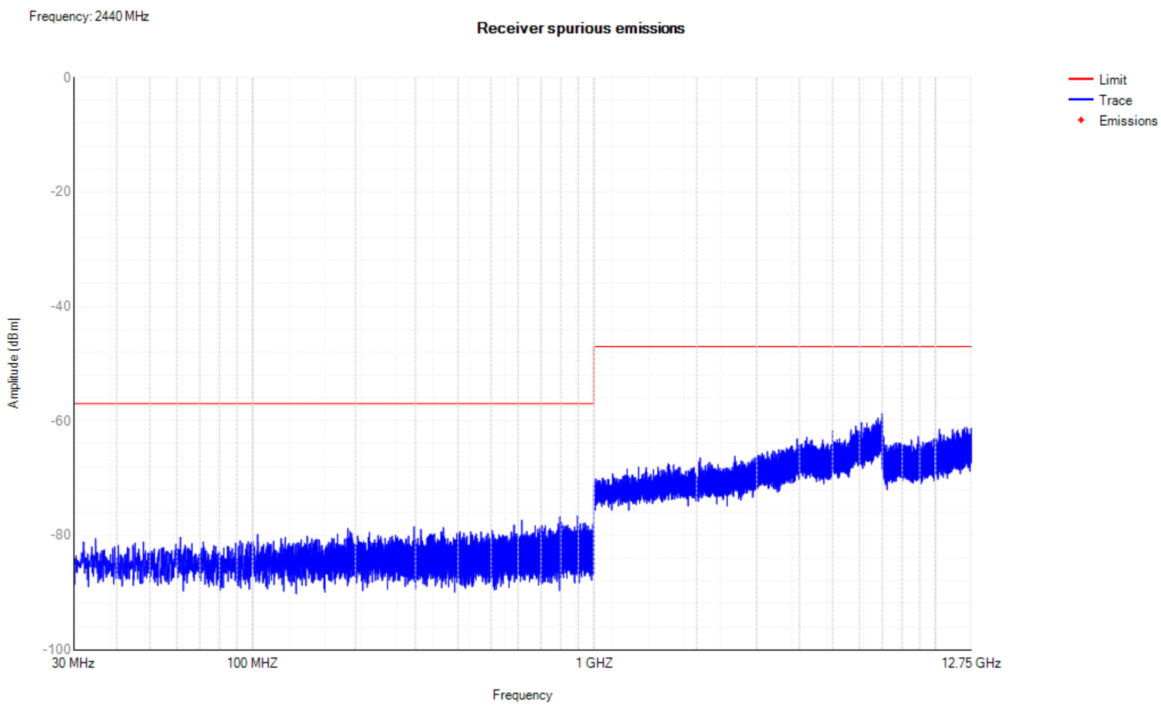


Tx. Spurious NVNT BLE 1M 2480MHz Ant1

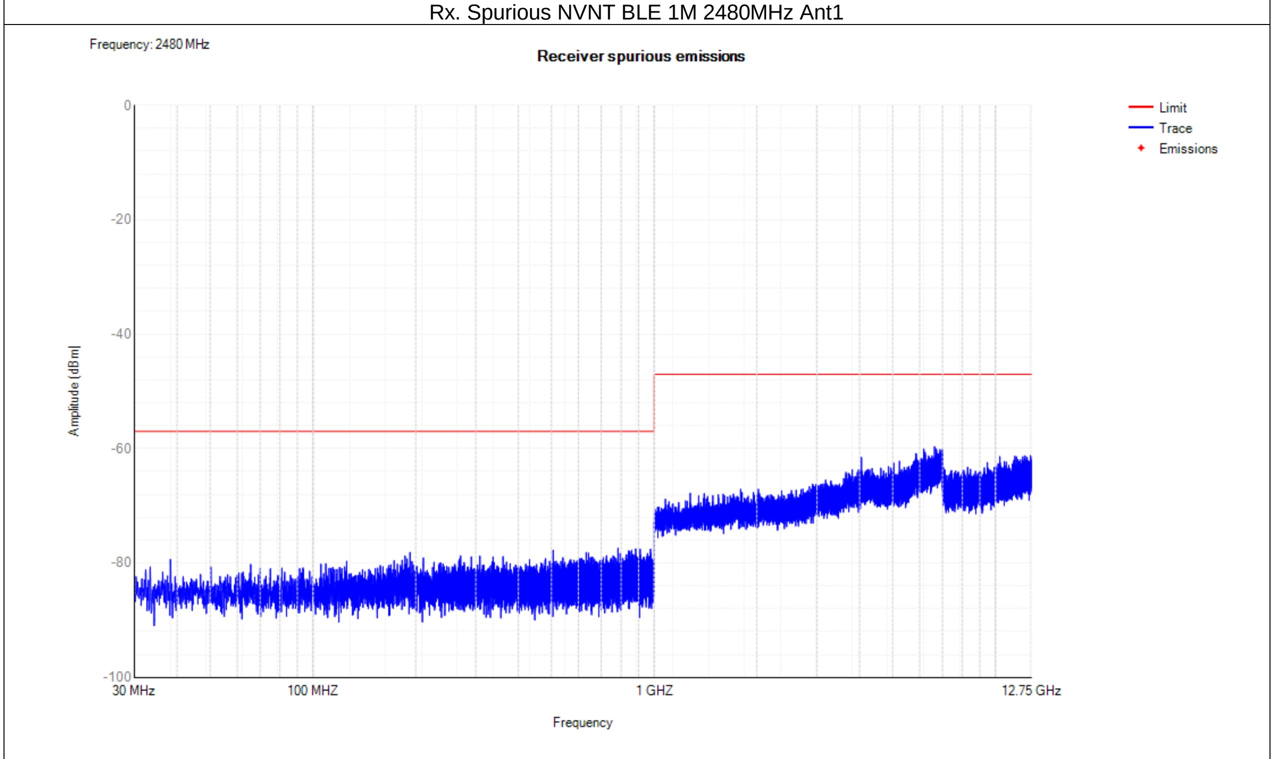


Receiver spurious emissions

Condition	Mode	Frequency (MHz)	Antenna	Range (MHz)	Spur Freq (MHz)	Peak (dBm)	RMS (dBm)	Limit (dBm)	Verdict
NVNT	BLE 1M	2402	Ant1	30 -1000	707.15	-71.68	NA	-57	Pass
NVNT	BLE 1M	2402	Ant1	1000 -12750	2460.5	-55.49	NA	-47	Pass
NVNT	BLE 1M	2440	Ant1	30 -1000	896.65	-76.58	NA	-57	Pass
NVNT	BLE 1M	2440	Ant1	1000 -12750	6982	-58.77	NA	-47	Pass
NVNT	BLE 1M	2480	Ant1	30 -1000	783.45	-77.41	NA	-57	Pass
NVNT	BLE 1M	2480	Ant1	1000 -12750	6630	-59.65	NA	-47	Pass

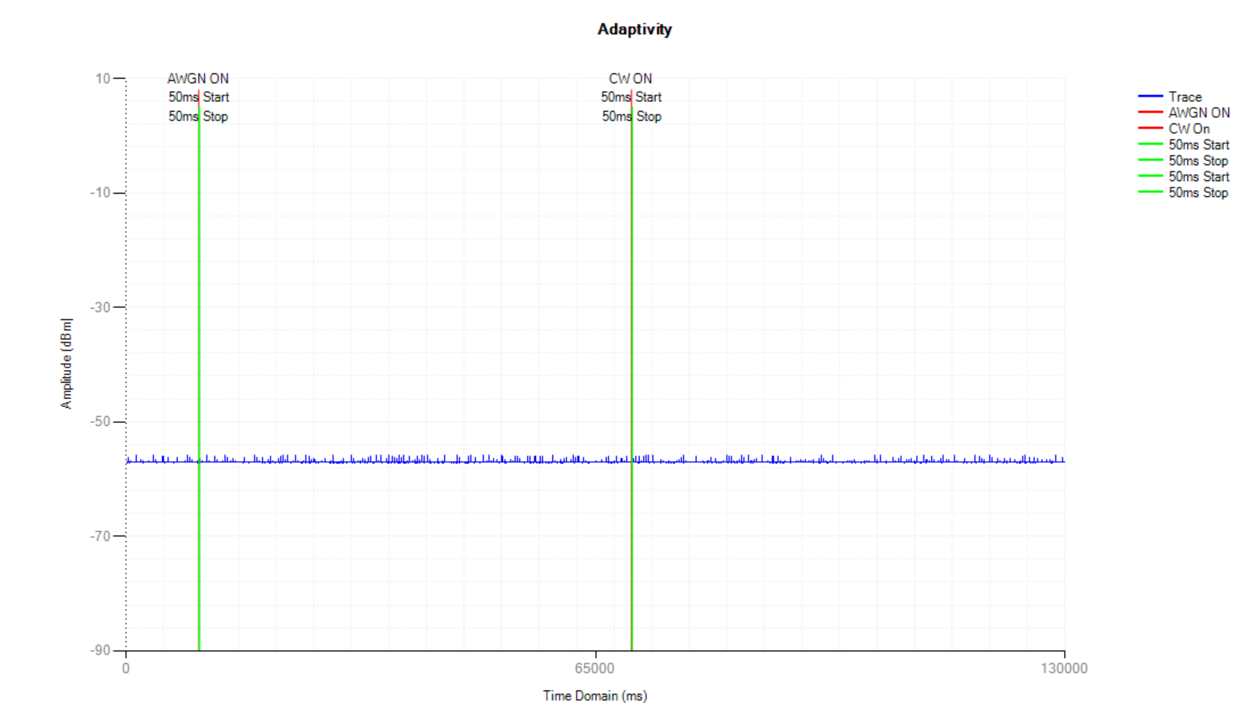
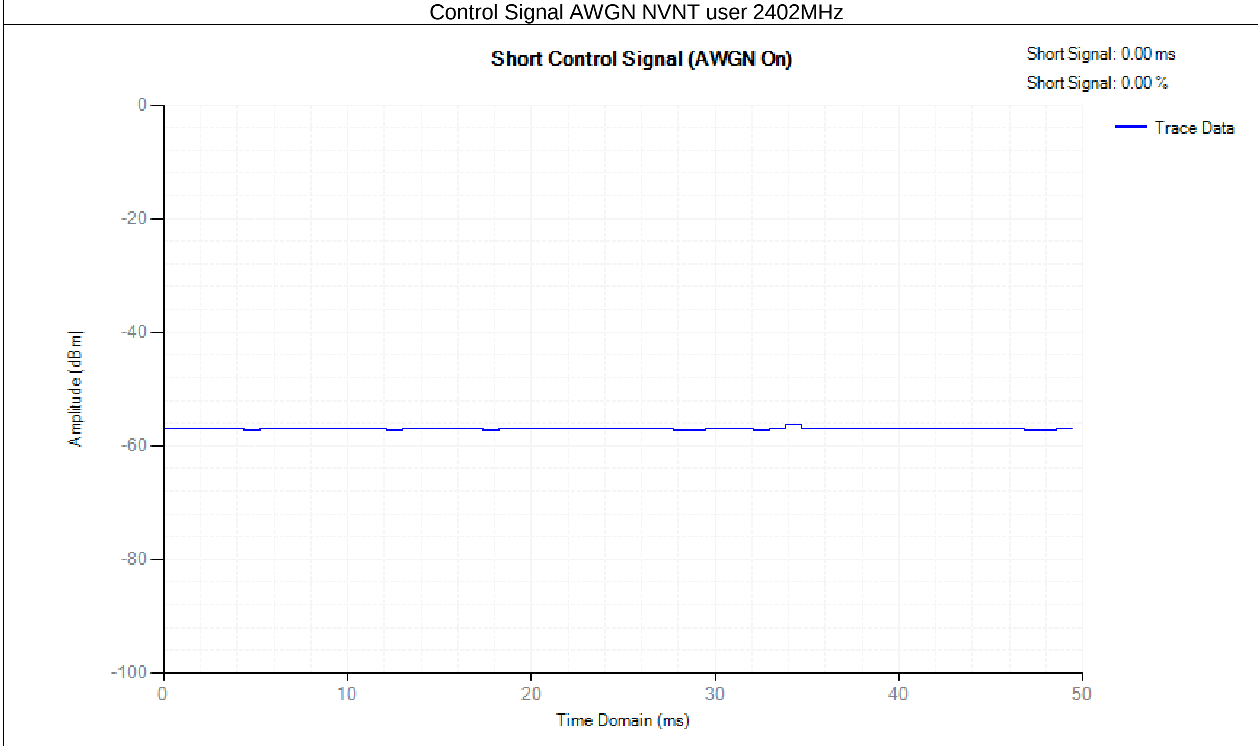
Test Graphs
Rx. Spurious NVNT BLE 1M 2402MHz Ant1

Rx. Spurious NVNT BLE 1M 2440MHz Ant1


Rx. Spurious NVNT BLE 1M 2480MHz Ant1

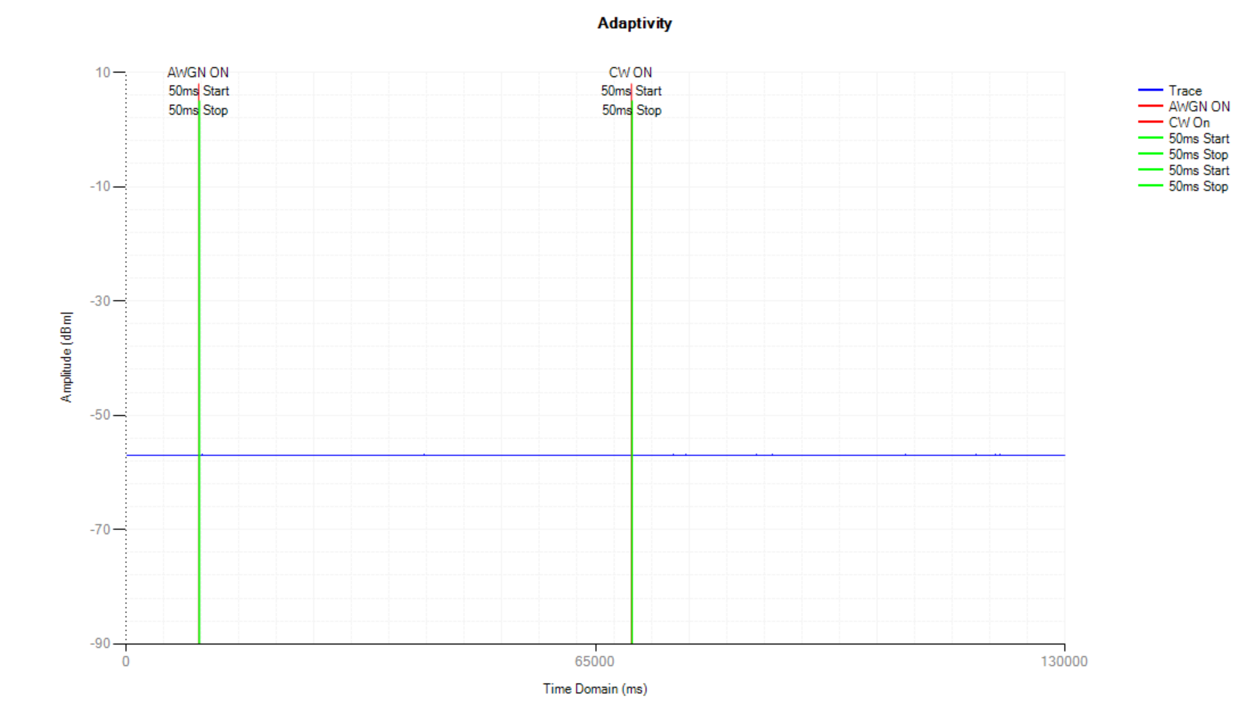


Adaptivity

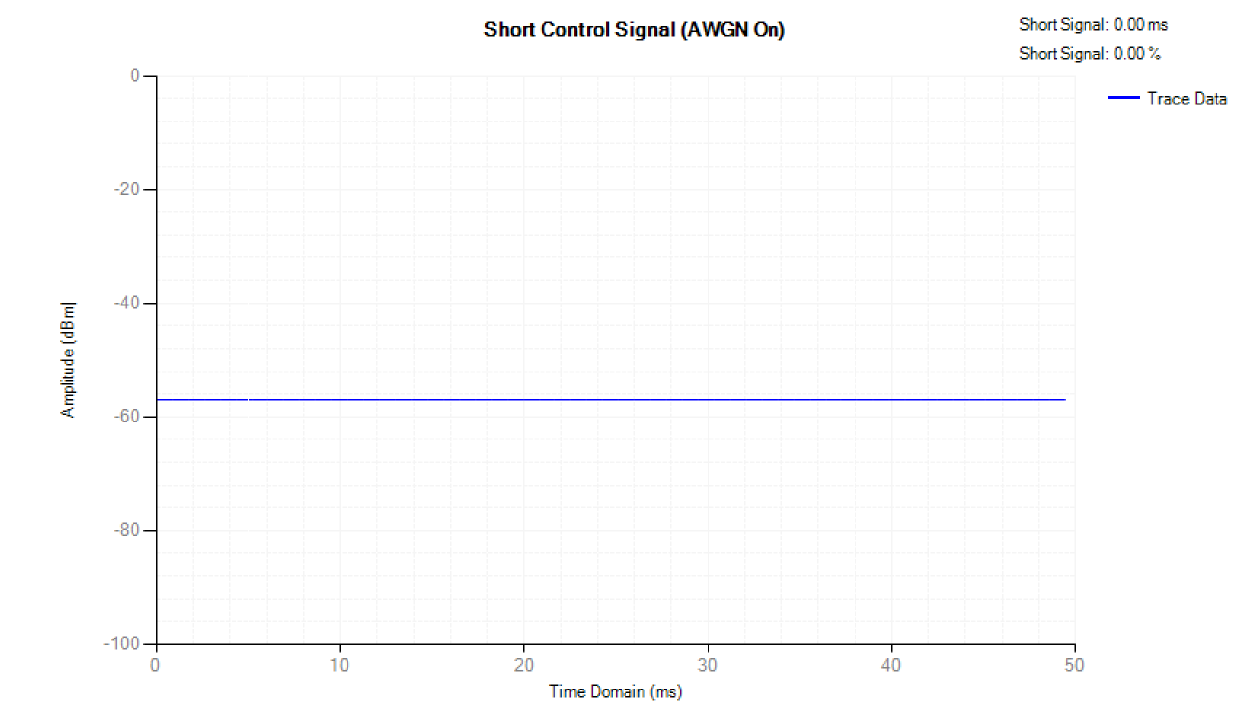
Condition	Mode	Frequency (MHz)	Antenna	AWGN Level (dBm)	CW Level (dBm)	AWGN Short Control(%)	CW Short Control(%)	Limit (%)	Verdict
NVNT	BLE	2402	Ant1	-60	-35	0	0	<=10	Pass
NVNT	BLE	2480	Ant1	-60	-35	0	0	<=10	Pass

Test Graphs
Adaptivity NVNT user 2402MHz

Control Signal AWGN NVNT user 2402MHz


Adaptivity NVNT user 2480MHz



Control Signal AWGN NVNT user 2480MHz



Receiver Blocking

Condition	Mode	Frequency (MHz)	Wanted Power (dBm)	Blocking Frequency (MHz)	Blocking Power (dBm)	PER (%)	Limit (%)	Verdict
NVNT	BLE	2402	-69	2380	-34	1.2	10	Pass
NVNT	BLE	2480	-69	2504	-34	1.1	10	Pass

APPENDIX: PHOTOGRAPHS OF THE EUT

Please refer to the test report: E01A23050809E00201.

END OF REPORT