

Test Report

Product	ultraBeacon Single-Zone
Name and address of the applicant	Sonitor Technologies AS Drammensveien 288 0283 Oslo, Norway
Name and address of the manufacturer	Sonitor Technologies AS Drammensveien 288 0283 Oslo, Norway
Model	INF-C361 / INF-C371
Rating	2400-2480 MHz transceiver 6V DC or 6V Battery powered
Trademark	
Additional information	FCC ID information – see page 4
Tested according to	FCC Part 15.247 Frequency Hopping Transmitters / Digital Transmission Systems Industry Canada RSS-247, Issue 3 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
Order number	PRJ0036884
Tested in period	2024.01.02 – 2024-07-19
Issue date	2024-08-02
Name and address of the testing laboratory	<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="text-align: center;">  Nemko Scandinavia AS Instituttveien 6 2007 Kjeller, Norway www.nemko.com </div> <div style="text-align: center;"> CAB Number: FCC: NO0001 ISED: NO0470 ISED No: 2040D-1 </div> <div style="text-align: center;">   </div> </div> <p style="text-align: center; color: red;">An accredited technical test executed under the Norwegian accreditation scheme</p>
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  Prepared by [Jan G Eriksen] </div> <div style="text-align: center;">  Approved by [Frode Sveinsen] </div> </div>	
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Revision history

Revision	Date	Comment	Sign
A	2024-04-25	First edition	JGER
B	2024-08-02	New radiated spurious emissions measurements above 1 GHz at low, mid, and high frequencies - for RF-modulation schemes BLE 1Mbps, BLE 2Mbps, and Snobee. Editorials	JGER

GENERAL REMARKS

This report applies only to the sample(s) tested. It is the manufacturer's responsibility to ensure the additional production units of this product are manufactured with identical electrical and mechanical components. The manufacturer is solely responsible for any modifications to the product that could result in non-compliance with the relevant regulations.

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Opinions expressed within this report regarding general assessments and qualifications for PASS or FAIL to the standards limits and requirements, are not part of the current accreditation. Neither are opinions expressed regarding model variants covered by the testing of this report.

CALIBRATION

All instruments used in the tests given in this test report are calibrated and traceable to national or international standards. Between calibrations all test set-ups are controlled and verified on a regular basis by periodic checks to ensure, with 95% confidence, that the instruments remain within the calibrated levels.

MEASUREMENT UNCERTAINTY

Measurement uncertainties are calculated or considered for all instruments and instrument set-ups used during these tests. Uncertainty figures are found in a separate clause in this report.

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1 INFORMATION

1.1 Test Item

Name	ultraBeacon Single-Zone
Model/version	INF-C361 / INF-C371
FCC ID	2AD7T21123102501
ISED ID	20330-21123102501
Serial number	01000034
Hardware identity and/or version	/
Software identity and/or version	/
Frequency Range	BLE: 2402 – 2480 MHz Snobee: 2405 – 2480 MHz
Number of Channels	BLE: 40 Snobee: 16
Operating Modes	Bluetooth Low Energy <input checked="" type="checkbox"/> 1 MBps <input checked="" type="checkbox"/> 2 MBps Snobee <input checked="" type="checkbox"/> 250 kbps
Type of Modulation	BLE: GFSK Snobee: O-QPSK
Conducted Output Power	Nominal value set during tests: 8 dBm
Antenna Connector	None
Number of Antennas	1
Diversity or Smart Antennas	No
Power Supply	6 V DC input and/or 6 V DC batteries (the device was tested with 6 V DC input and batteries installed)
Desktop Charger	NA

Description of Test Item

The Sonitor ultraBeacon™ Single-Zone products are used with Sonitor's Open Integration RTLS Platform. The units can be powered by batteries, Power over Ethernet (PoE) or DC.

The units transmit ultrasound messages, or ultrasound and BLE messages, to enhance the positioning accuracy and update rate of Sonitor tags and mobile phones containing Sonitor SDK-based apps. For remote management and coordinated operation with other devices, the units use Snobee or BLE communication.

1.2 Normal test condition

Temperature:	20 - 24 °C
Relative humidity:	20 - 50 %
Normal test voltage:	6 V DC and 6.0 V batteries

The values are the limits registered during the test period.

1.3 Test Engineer(s)

Jan G Eriksen

1.4 Antenna Requirement

Does the EUT have detachable antenna(s)?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO
If detachable, is the antenna connector(s) non-standard?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
The tested equipment has only integral antennas. Conducted tests were performed with a temporary antenna connector.		

Requirement: FCC 15.203, 15.204

1.5 EUT Operating Modes

Description of operating modes	Radiated Emissions and Power Line Conducted Emissions were performed with the EUT set to transmit at the channel with the highest output power as worst-case scenario.
Additional information	<p>The device was measured in horizontal and vertical orientations – and the measurement antenna was in vertical and horizontal polarization.</p> <p>The levels given in the report are the maximum level for any specific test.</p> <p>In the results below the transmitted channel is given either with the frequency in MHz or as "Low", "Mid", or "High", which means 2402, 2440, or 2480 MHz for BLE and 2405, 2440, or 2480 MHz for Snobee.</p>

1.6 Comments

All measurements were done with the EUT powered from fully charged batteries and with 6 V DC connected.

It was also checked that conducted power on TX channels did not vary depending on type of power applied, and that voltage variations between 85% and 115% did not have any influence on the measurements.

All ports were populated during spurious emission measurements.

2 TEST REPORT SUMMARY

2.1 General

The tests were conducted on a sample of the equipment for demonstrating compliance with one or more of the following standards.

Standard	Description
FCC CFR 47 Part 15.247	Operation within the bands 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz
ISED RSS-247, Issue 3	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
ISED RSS-GEN Issue 5	General Requirements for Compliance of Radio Apparatus

The following standards and documents were used for one or more measurements:

Standard	Description
ANSI C63.4-2014	Unintentional Radiators
ANSI C63.10-2013	Intentional Radiators
FCC KDB 558074 D01	15.247 Measurement Guidance for DTS and Frequency Hopping Systems
FCC KDB 412172 D01	Determining ERP and EIRP

All measurements are traceable to national standards.

A description of the test facility is on file with FCC and ISED Canada.

<input checked="" type="checkbox"/> New Submission	<input checked="" type="checkbox"/> Production Unit
<input type="checkbox"/> Class II Permissive Change	<input type="checkbox"/> Pre-production Unit
DTS Equipment Class	<input type="checkbox"/> Family Listing

2.2 Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 3, RSS-GEN Issue 5 reference	ANSI C63.10-2013 Reference	Result
Supply Voltage Variations	15.31(e)	6.11 (RSS-GEN)	5.13	Pass
Antenna Requirement	15.203	6.8 (RSS-GEN)	5.8	Pass
Power Line Conducted Emission	15.107(a) 15.207(a)	7.2 / 8.8 (RSS-GEN)	6.2	Pass
Occupied Bandwidth (99% BW)	N/A	6.7 (RSS-GEN)	6.9.3	N/A
DTS Bandwidth	15.247(a)(2)	5.2 (1) (RSS-247)	11.8 Option 2	Pass
Peak Power Output	15.247(b)	5.4 (RSS-247)	11.9.1.1	Pass
Power Spectral Density	15.247(d)	5.2 (2) (RSS-247)	11.10.2 PKPSD (DTS)	Pass
Spurious Emissions (Antenna Conducted)	15.247(c)	5.5 (RSS-247)	6.7 11.11 (DTS)	Pass
Spurious Emissions (Radiated)	15.247(c) 15.109(a) 15.209(a)	3.3 (RSS-247) 7.3 (RSS-GEN) 8.9 (RSS-GEN)	6.3, 6.5, 6.6, 6.10 11.12, 11.13 (DTS)	Pass

Also see comments in clause 1.6 above.

3 TEST RESULTS

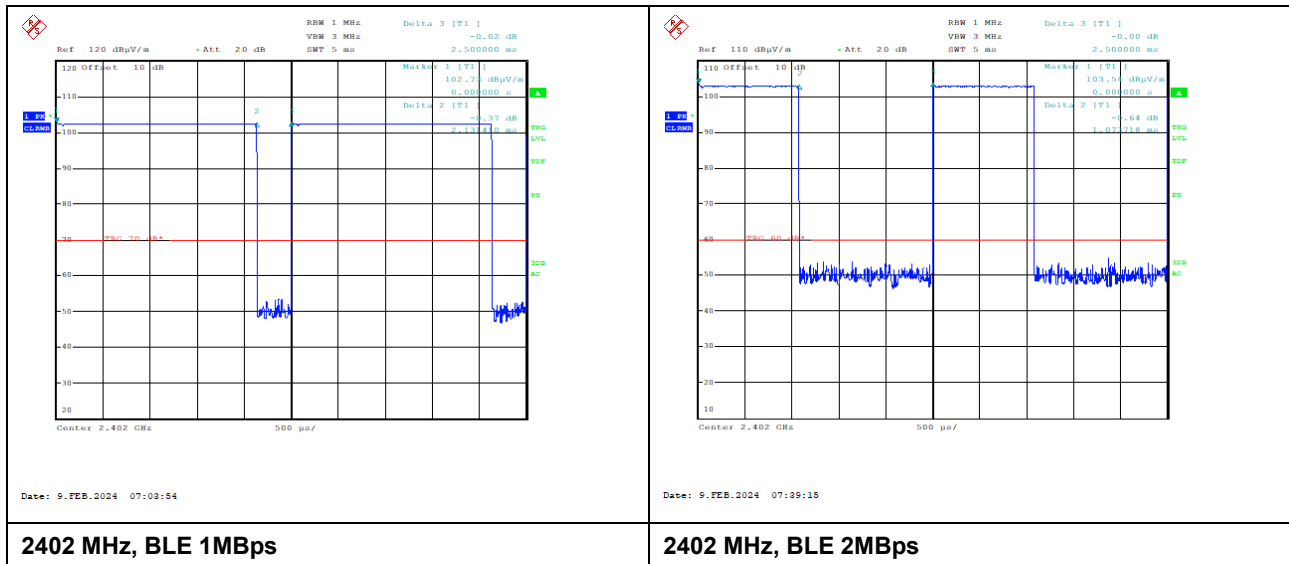
3.1 Duty Cycle (DC) measurement and calculations

The following Duty Cycle times are measured (calculated). BLE has a DC below 100% while Snobee has a DC of 100%.

Measured Duty Cycle		BLE 1MBps	BLE 2MBps	Snobee
Pulse lenght	(ms)	2.1314	1.0737	Not measured
Pulse period	(ms)	2.5000	2.5000	Not measured
DUTY cycle	(%)	85.26	42.95	100
DUTY cycle correction factor to be used in average calculations	(dB)	0.7	3.7	0

Note: The Duty cycle times are identical at all three channels

Measurement Data:



3.2 Power Line Conducted Emissions

FCC Part 15.207

ISED RSS-GEN Issue 5, Clause 7.2 / 8.8

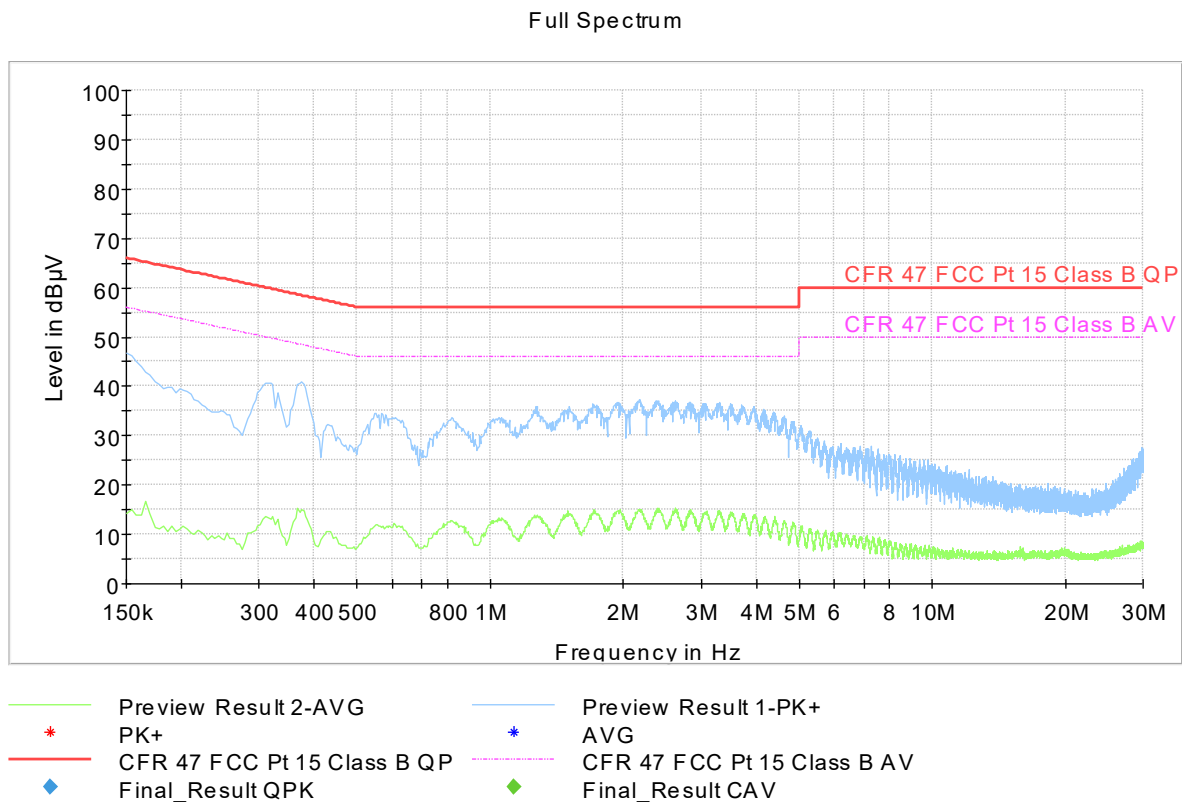
Measurement procedure: ANSI C63.4-2014 using 50 μ H/50 ohms LISN

Test Results: Complies

Measurement Data: See attached plots

Measurement Software: R&S EMC32 Conducted Emissions

Highest measured value (L1 and N):



It should be noted that the Peak (blue) and Average (green) lines above are the highest (worst case) levels for measurements on both N and L1 lines.

Measured Data

No QP-peak measurements performed because peak/avg levels are below respective limit with a high margin.

3.3 Occupied Bandwidth (99% BW)

ISED Canada RSS-GEN Issue 5, Clause 6.7

Measurement procedure: ANSI C63.10-2013 Clause 6.9.2

Test Results: Complies

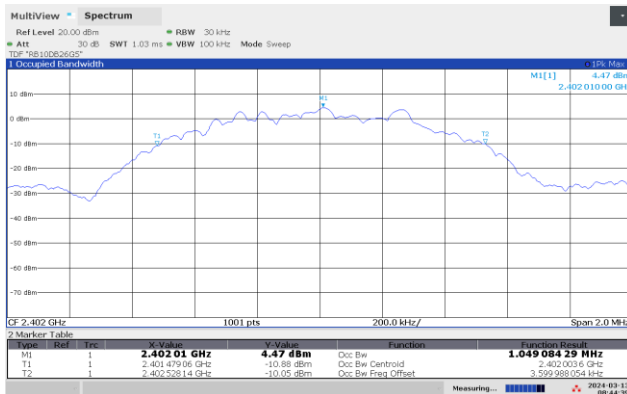
Measurement Data:

Carrier Frequency, Data Rate	Occupied Bandwidth (99% BW)		
	kHz		
	Low	Mid	High
BLE 1Mb	1049.1	1053.7	1052.3
BLE 2Mb	2066.1	2072.1	2074.4
Snobee 250 kbps	2256.9	2263.3	2266.5

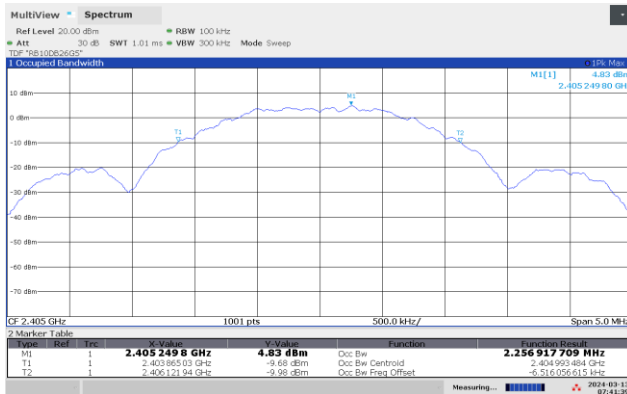
See attached plots

Requirements:

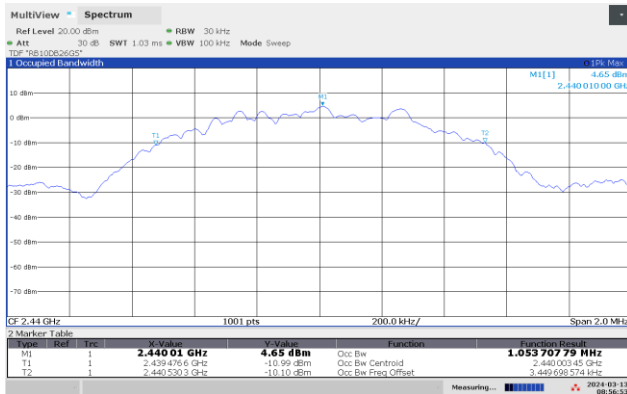
No requirement for 99% BW, reported for information only.



Low channel 99% Occupied BW, BLE 1Mb



Low channel 99% Occupied BW, Snobee



Mid channel 99% Occupied BW, BLE 1Mb



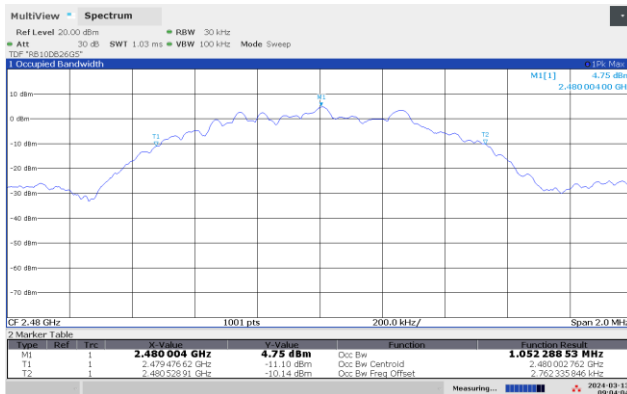
Mid channel 99% Occupied BW, Snobee



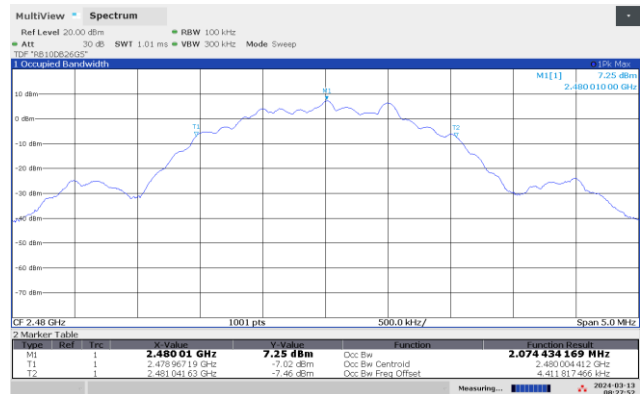
Low channel 99% Occupied BW, BLE 2Mb



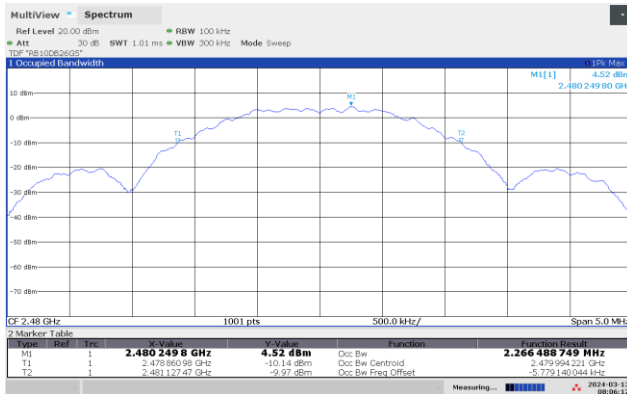
Mid channel 99% Occupied BW, BLE 2Mb



High channel 99% Occupied BW, BLE 1Mb



High channel 99% Occupied BW, BLE 2Mb



High channel 99% Occupied BW, Snobee

3.4 DTS Bandwidth

FCC Part 15.247 (a)(2)

ISED Canada RSS-247 Issue 3, Clause 5.2 (a)

Measurement procedure: ANSI C63.10-2013 Clause 11.8

Test Results: Complies

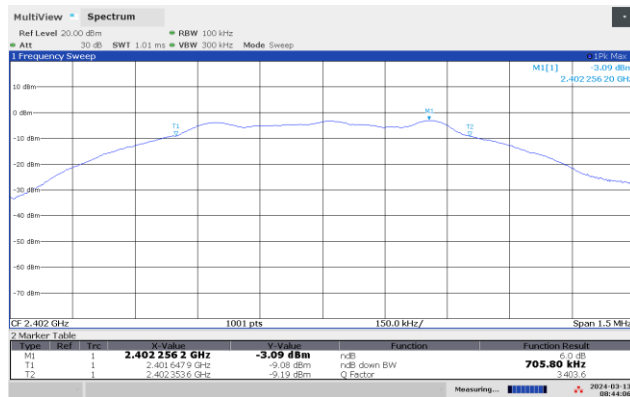
Measurement Data:

Modulation type and bitrate	Measured DTS Bandwidth (kHz)		
	Low	Mid	High
BLE: GFSK 1 Mbps	706	715	713
BLE: GFSK 2 Mbps	1170	1170	1170
Snoobee: O-QPSK 250 kbps	1550	1550	1560

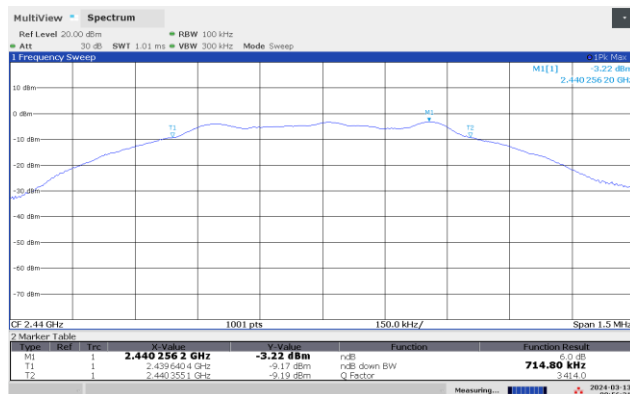
Power supply variation within 85 % to 115% of nominal value has no influence on measured value.

Frequency Band	Requirement for systems using Digital Modulation
902-928 MHz	The minimum 6 dB bandwidth shall be at least 500 kHz.
2400-2483.5 MHz	
5725-5850 MHz	

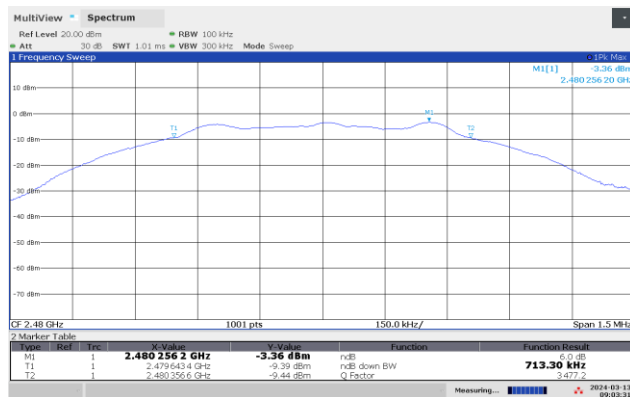
BLE DTS BW



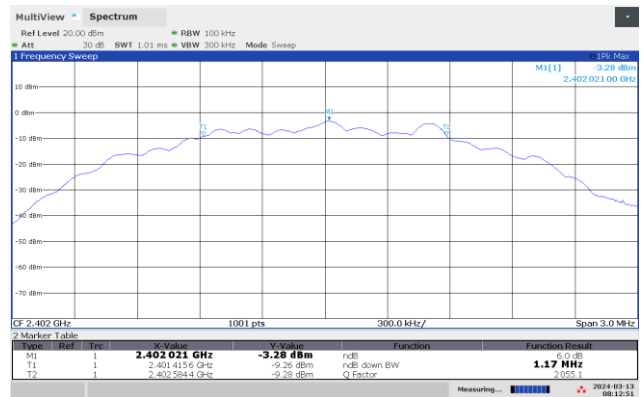
DTS BW, 2402 MHz, BLE 1M



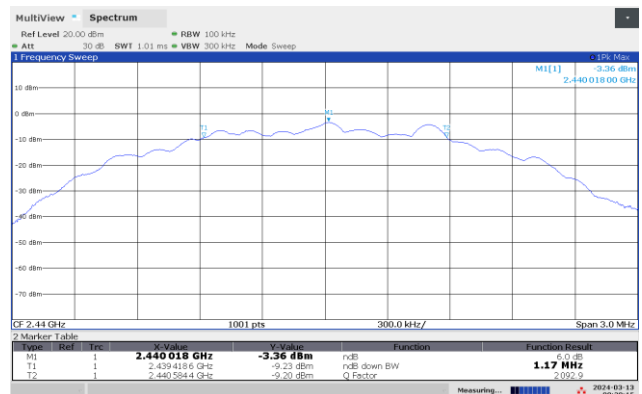
DTS BW, 2440 MHz, BLE 1M



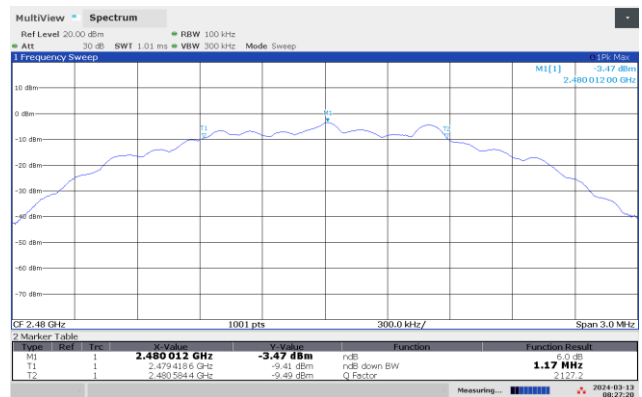
DTS BW, 2480 MHz, BLE 1M



DTS BW, 2402 MHz, BLE 2M

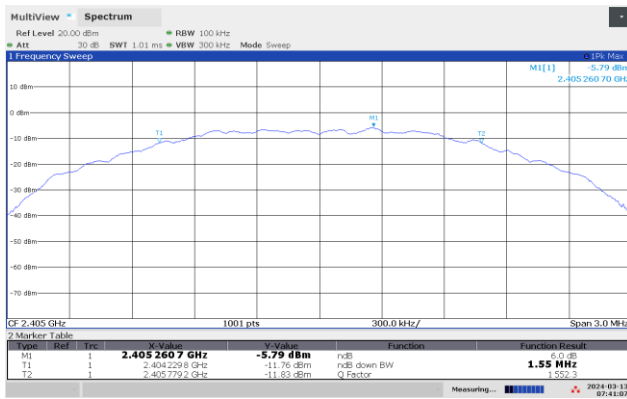


DTS BW, 2440 MHz, BLE 2M

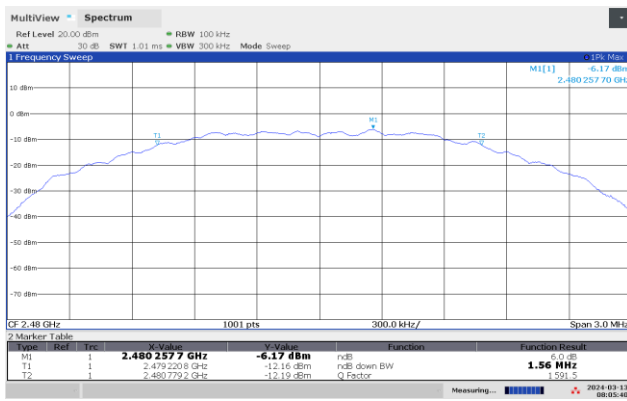


DTS BW, 2480 MHz, BLE 2M

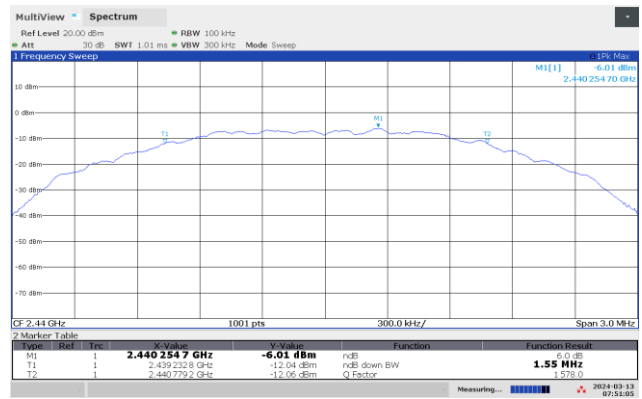
SNOBEE DTS BW



DTS BW, 2405 MHz, Snobee



DTS BW, 2480 MHz, Snobee



DTS BW, 2440 MHz, Snobee

3.5 Peak Power Output

FCC Part 15.247 (b)

ISED Canada RSS-247 Issue 3, Clause 5.4

Measurement procedure: ANSI C63.10-2013 Clause 11.9.1.2

Test Results: Complies

Measurement Data:

TX Chan (Low / Mid / High)	Peak Conducted Power, dBm			Peak EIRP, dBuV/m			Peak EIRP, dBm calculated			Antenna gain dBi		
	BLE 1Mb	BLE 2Mb	Snobee	BLE 1Mb	BLE 2Mb	Snobee	BLE 1Mb	BLE 2Mb	Snobee	BLE 1Mb	BLE 2Mb	Snobee
Low	7.7	7.7	7.7	105.9	106.1	105.3	10.7	10.9	10.1	3.0	3.2	2.4
Mid	7.6	7.6	7.5	105.2	104.9	105.3	10.0	9.7	10.1	2.4	2.1	2.6
High	7.4	7.4	7.4	105.5	105.4	107.0	10.3	10.2	11.8	2.9	2.8	4.4

Output Power reported is Maximum Peak Power.

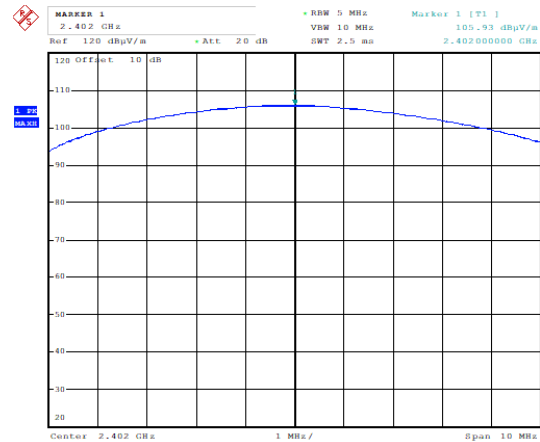
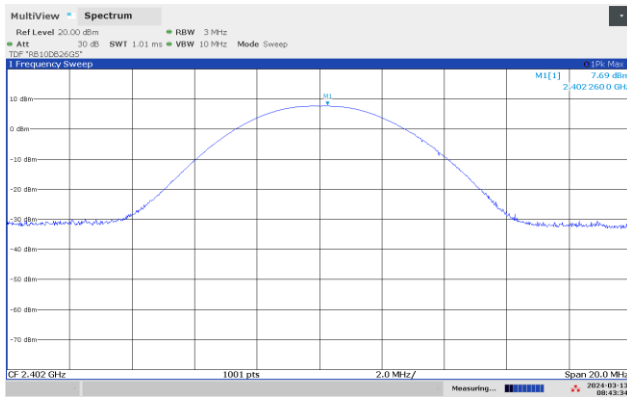
The Integrated Band Power Method was used to measure Output Power.

Radiated Power was calculated from measured Field Strength using the method described in ANSI C63.10-2013 Annex G.

Antenna Gain is less than 6 dBi.

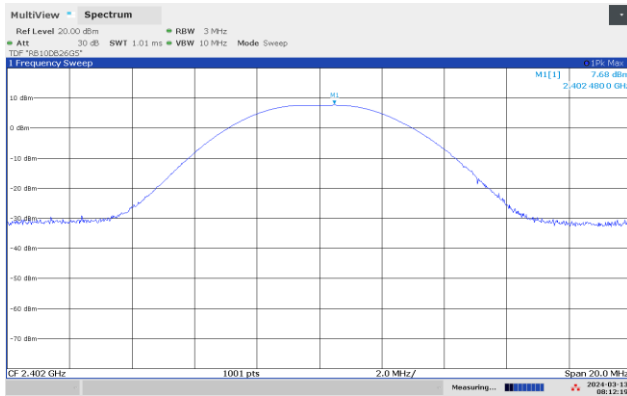
See attached plots.

Requirements for Digital Modulation systems
For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.
As an alternative to a peak power measurement, compliance with the 1 Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the <i>maximum conducted output power</i> is the highest total transmit power occurring in any mode.
Maximum allowed Antenna Gain
If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

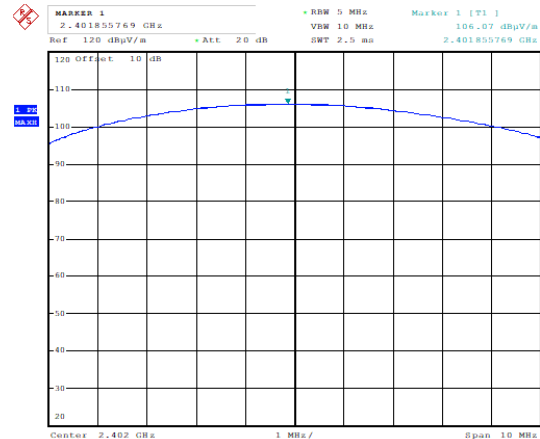


Date: 29.JUN.2024 10:16:52

BLE 1Mb, Peak Power, 2402 MHz

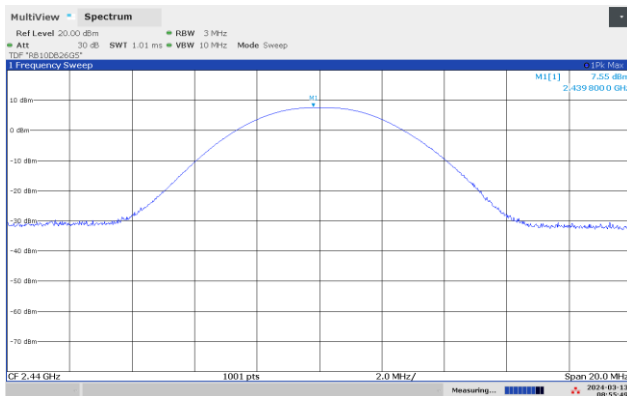


BLE 1Mb, Peak Field Strength, 2402 MHz

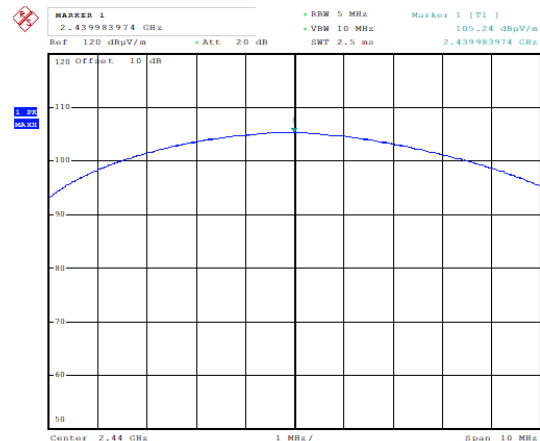


Date: 29.JUN.2024 10:23:26

BLE 2Mb, Peak Power, 2402 MHz



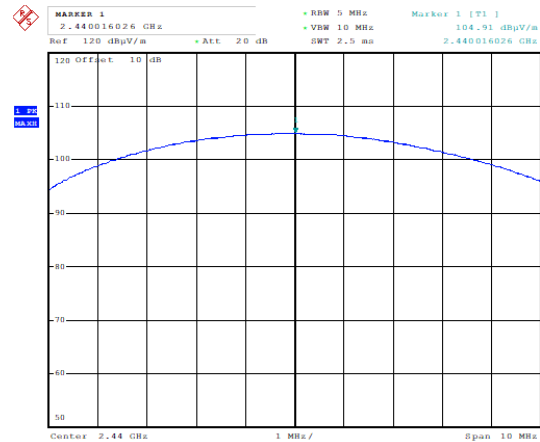
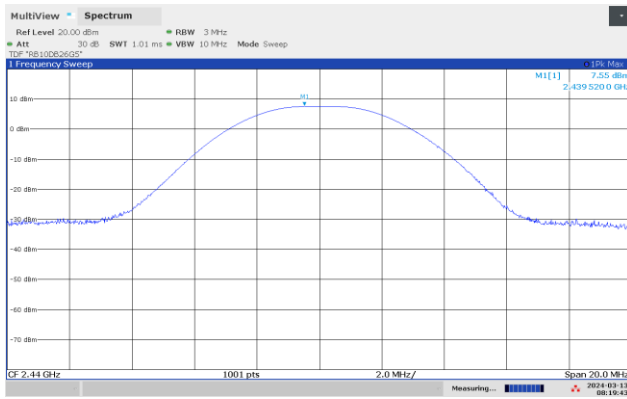
BLE 2Mb, Peak Field Strength, 2402 MHz



Date: 29.JUN.2024 09:42:31

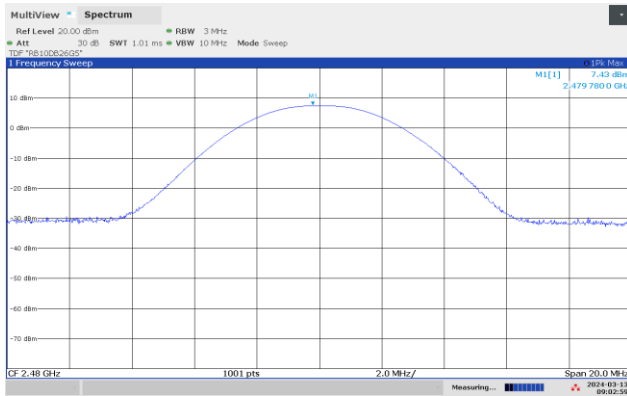
BLE 1Mb, Peak Power, 2440 MHz

BLE 1Mb, Peak Field Strength, 2440 MHz

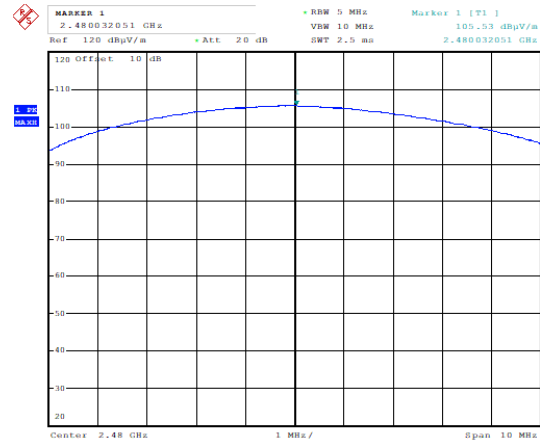


Date: 29.JUN.2024 09:49:49

BLE 2Mb, Peak Power, 2440 MHz

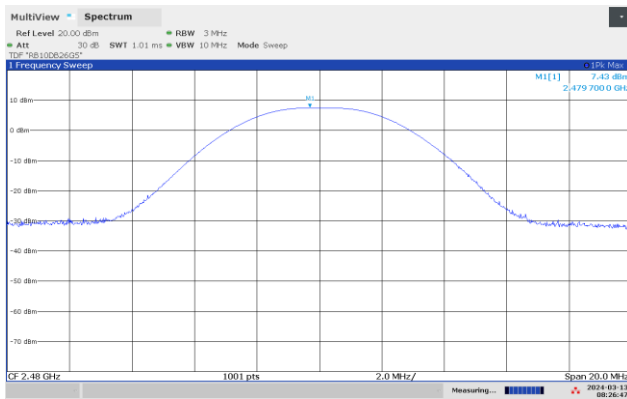


BLE 2Mb, Peak Field Strength, 2440 MHz

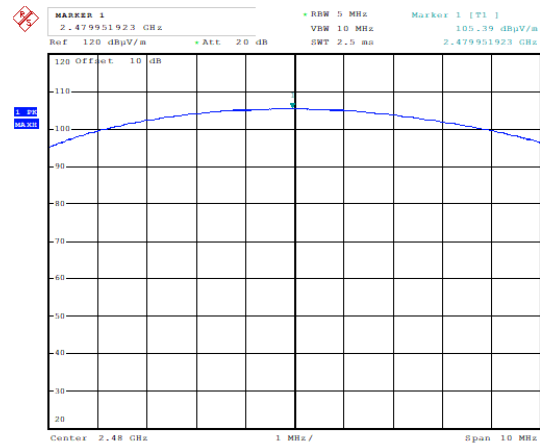


Date: 29.JUN.2024 09:10:11

BLE 1Mb, Peak Power, 2480 MHz



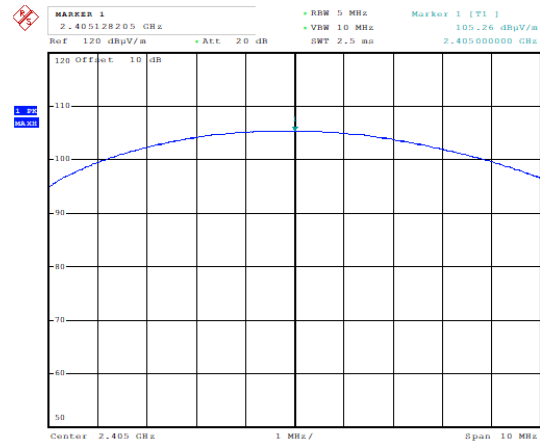
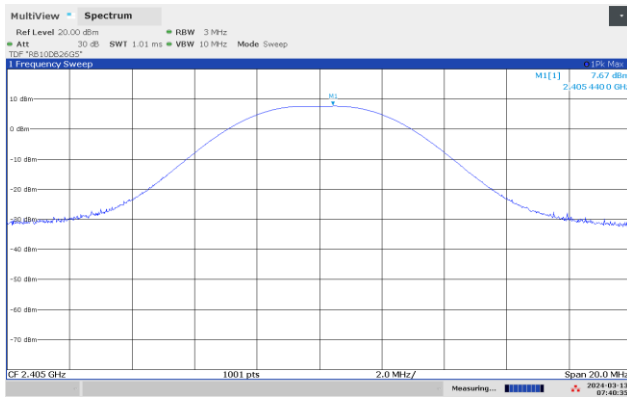
BLE 1Mb, Peak Field Strength, 2480 MHz



Date: 29.JUN.2024 08:59:40

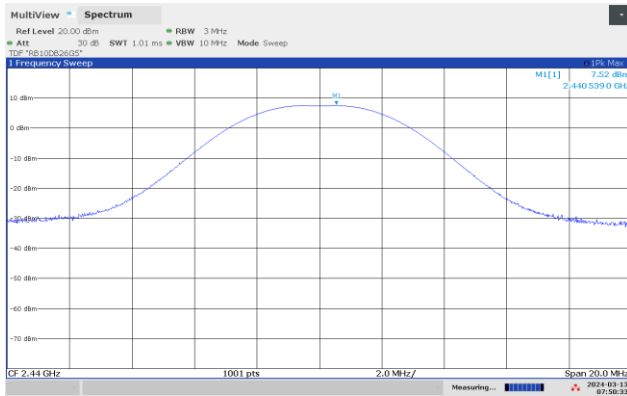
BLE 2Mb, Peak Power, 2480 MHz

BLE 2Mb, Peak Field Strength, 2480 MHz

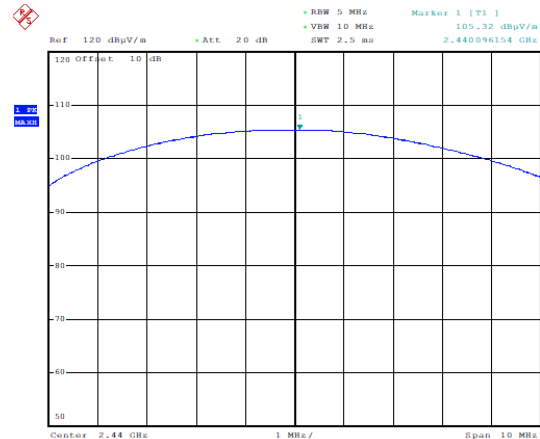


Date: 29.JUN.2024 10:01:22

Snobee, Peak EIRP, 2405 MHz

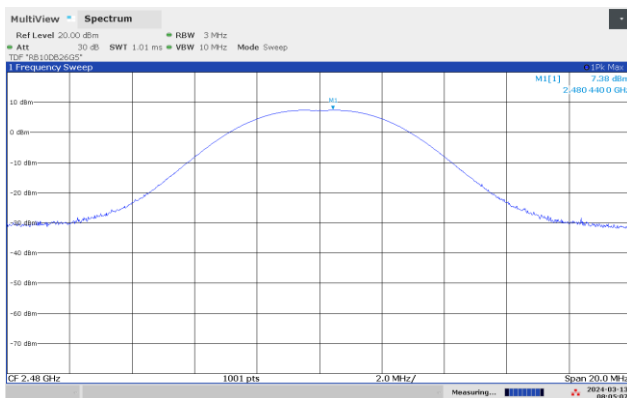


Snobee, Peak Field Strength, 2405 MHz

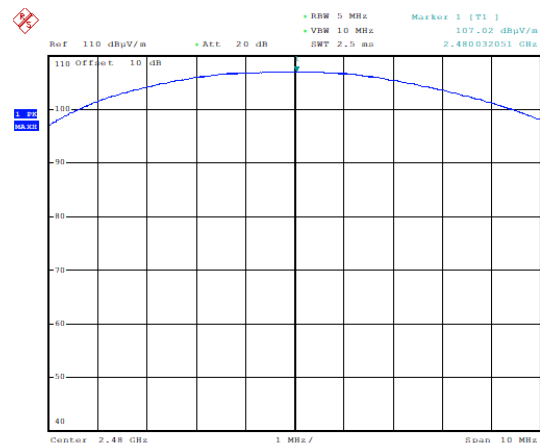


Date: 29.JUN.2024 09:22:25

Snobee, Peak EIRP, 2440 MHz



Snobee, Peak Field Strength, 2440 MHz



Date: 29.JUN.2024 08:10:57

Snobee, Peak EIRP, 2480 MHz

Snobee, Peak Field Strength, 2480 MHz

3.6 Conducted Emissions at Antenna Connector

FCC Part 15.247 (d)

ISED Canada RSS-247 Issue 3, Clause 5.5

Measurement procedure: ANSI C63.10-2013 Clause 11.11

Test Results: Complies

Measurement Data:

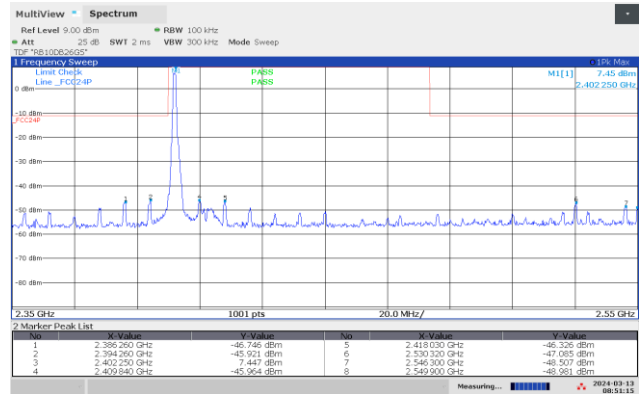
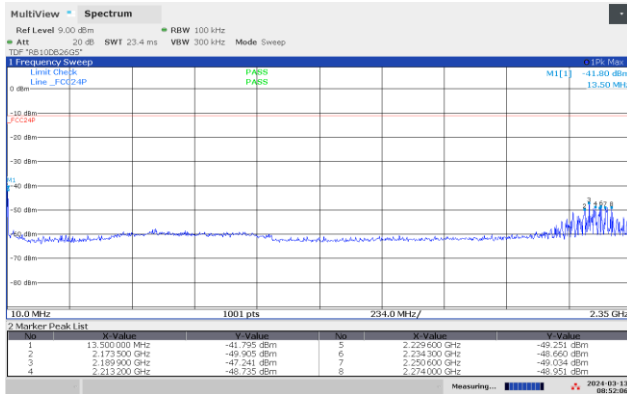
Carrier Channel	Inband level (dBm)			Spurious Level (dBm)			Margin (dB)			Verdict
Low / Mid / High	BLE 1MB	BLE 2MB	Snobee	BLE 1MB	BLE 2MB	Snobee	BLE 1MB	BLE 2MB	Snobee	
Low	7.5	7.3	4.6	-35.8	-36.5	-37.6	23.3	23.8	22.2	Pass
Mid	7.3	7.3	4.5	-31.9	-33.0	-36.3	19.2	20.3	20.8	Pass
High	7.3	7.2	3.8	-29.6	-30.3	-33.8	16.9	17.5	17.6	Pass

Measured with Peak Detector

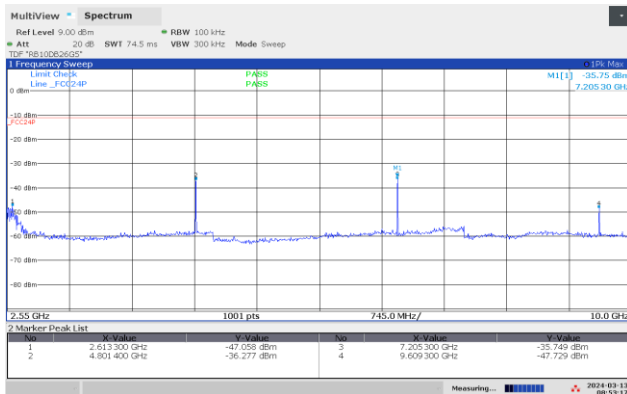
RF conducted power 10 MHz to 26 GHz: see attached plots. In the plots below the shown limit line is at -20 dBc relative to the highest measured TX carrier level at the frequency in question. From the plots it can be seen that all carrier levels are at more than 7 dBm for BLE and more than 3 dBm for Snobee.

Requirements for all systems	
Peak measurement	RMS averaging (alternative measurement)
20 dB or more below carrier measured in 100 kHz bandwidth	30 dB or more below carrier measured in 100 kHz bandwidth
<p>In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.</p> <p>Attenuation below the general limits specified in § 15.209(a) is not required.</p>	

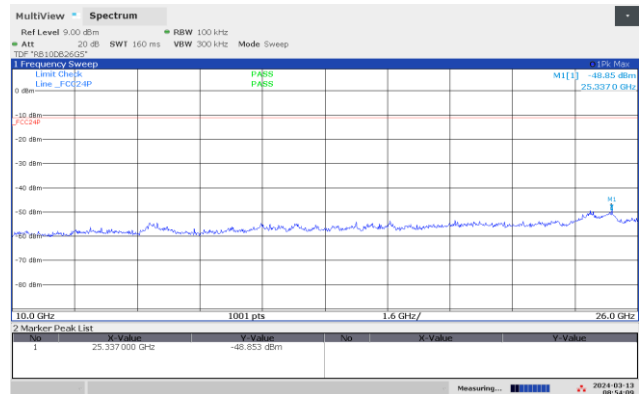
BLE 1Mb



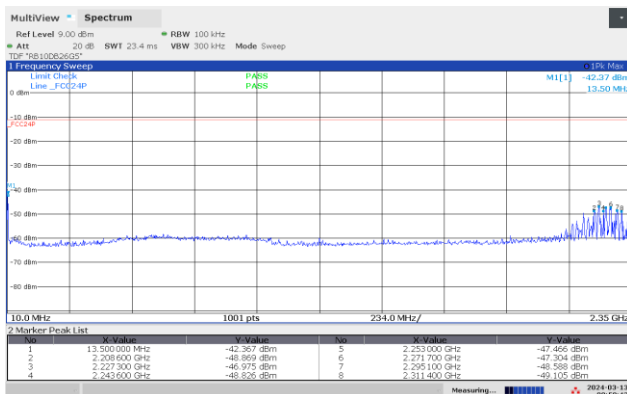
Conducted Emissions BLE 2402 MHz, 1Mb, 10-2350 MHz



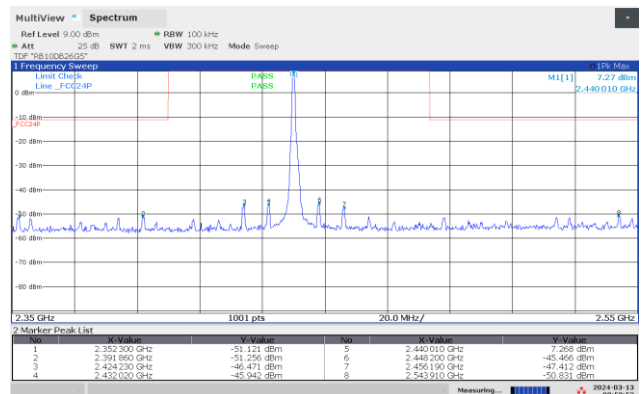
Conducted Emissions BLE 2402 MHz, 1Mb, 2350-2550 MHz



Conducted Emissions BLE 2402 MHz, 1Mb, 2550-10000 MHz



Conducted Emissions BLE 2402 MHz, 1Mb, 10000-26000 MHz

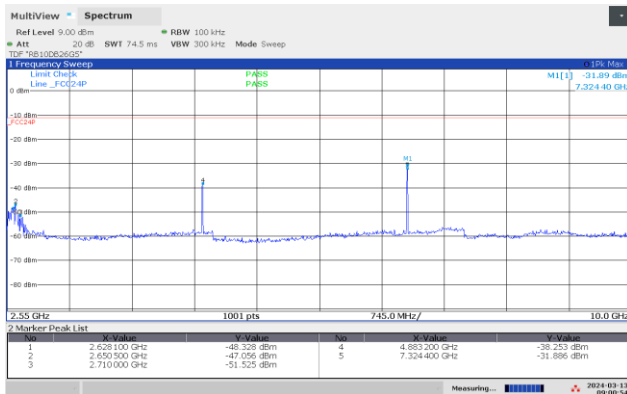


Conducted Emissions BLE 2440 MHz, 1Mb, 10-2350 MHz

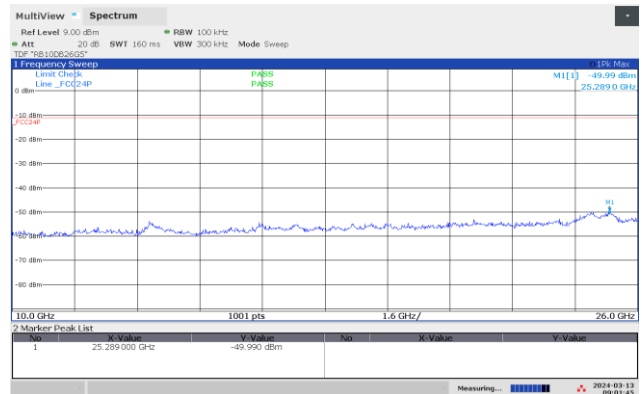


Conducted Emissions BLE 2440 MHz, 1Mb, 2350-2550 MHz

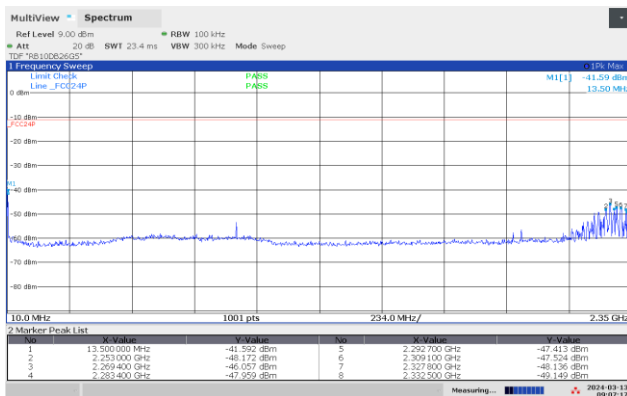




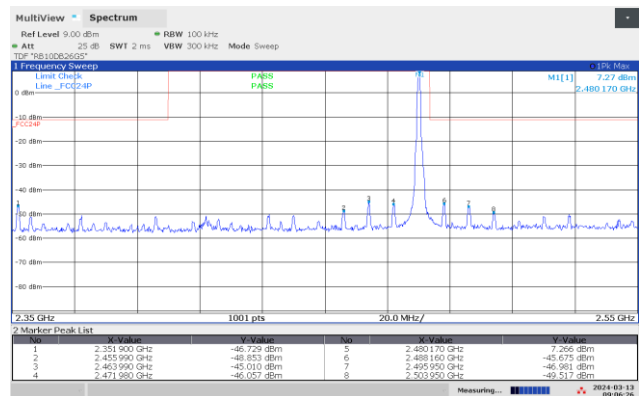
Conducted Emissions BLE 2440 MHz, 1Mb, 2550-10000 MHz



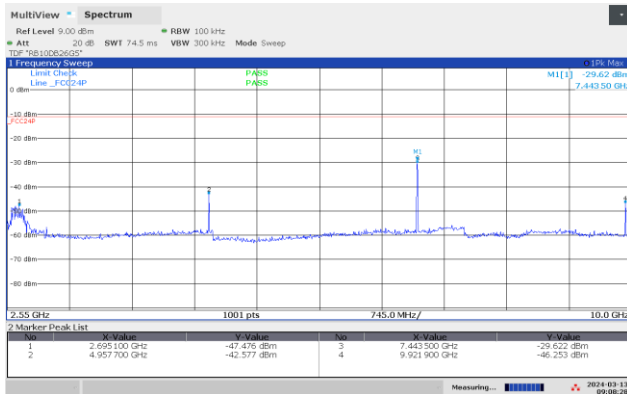
Conducted Emissions BLE 2440 MHz, 1Mb, 10000-26000 MHz



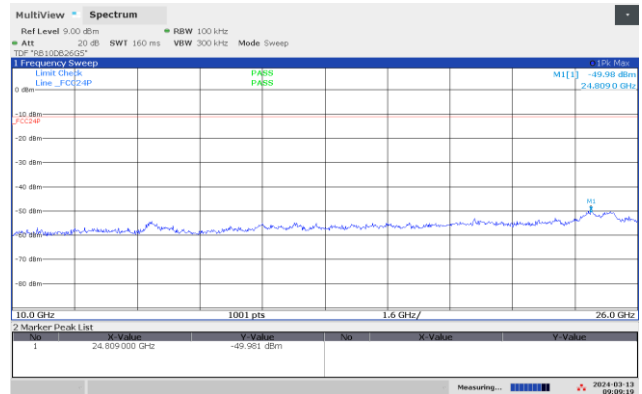
Conducted Emissions BLE 2480 MHz, 1Mb, 10-2350 MHz



Conducted Emissions BLE 2480 MHz, 1Mb, 2350-2550 MHz

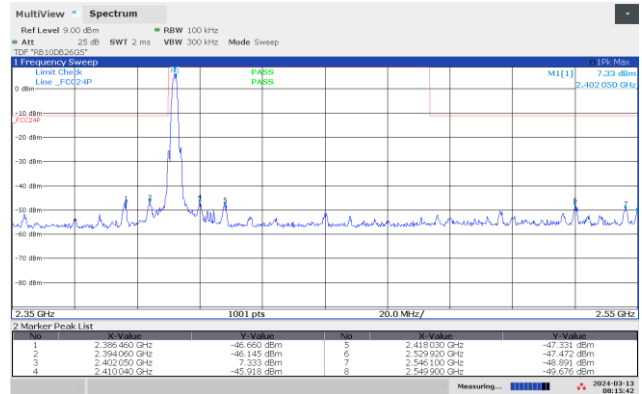
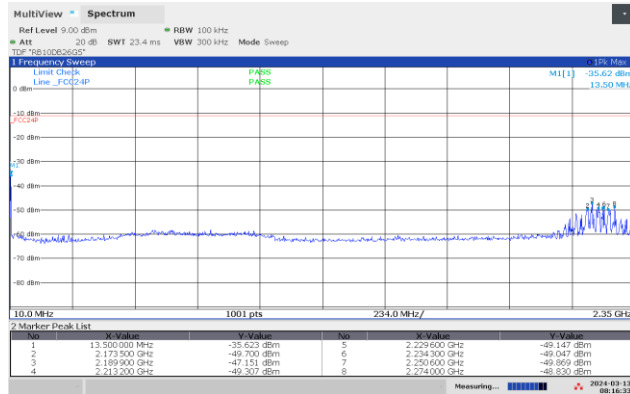


Conducted Emissions BLE 2480 MHz, 1Mb, 2550-10000 MHz

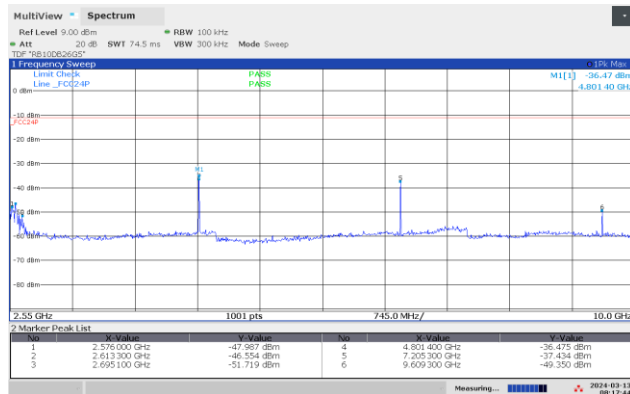


Conducted Emissions BLE 2480 MHz, 1Mb, 10000-26000 MHz

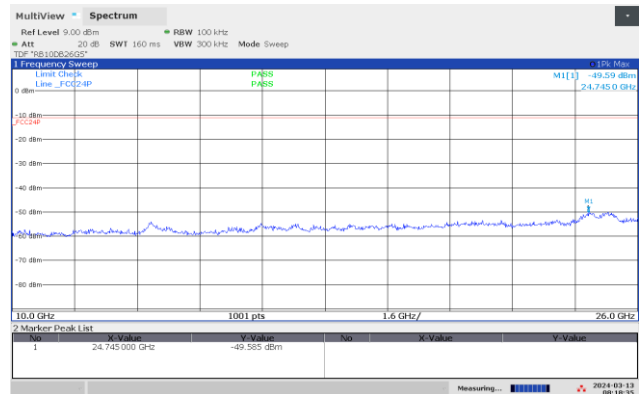
BLE 2Mb



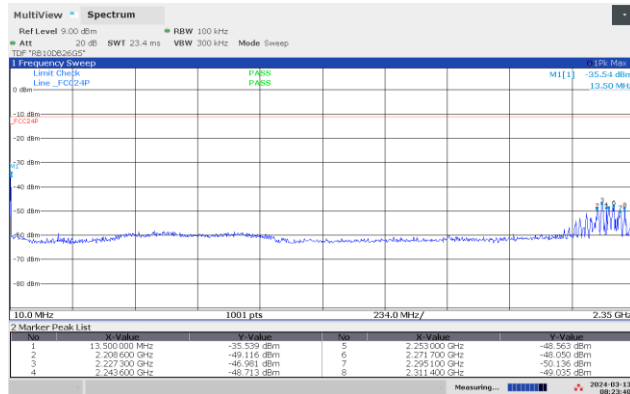
Conducted Emissions BLE 2402 MHz, 2Mb, 10-2350 MHz



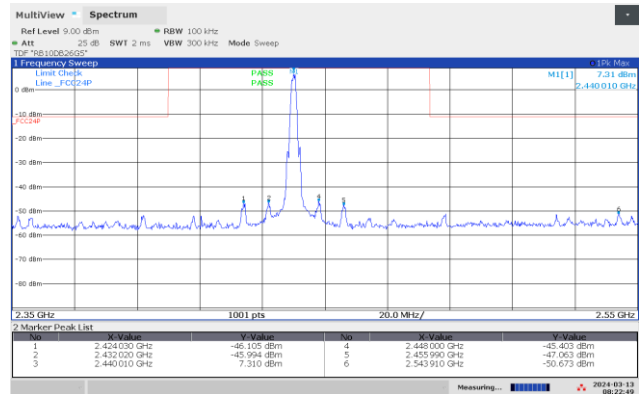
Conducted Emissions BLE 2402 MHz, 2Mb, 2350-2550 MHz



Conducted Emissions BLE 2402 MHz, 2Mb, 2550-10000 MHz

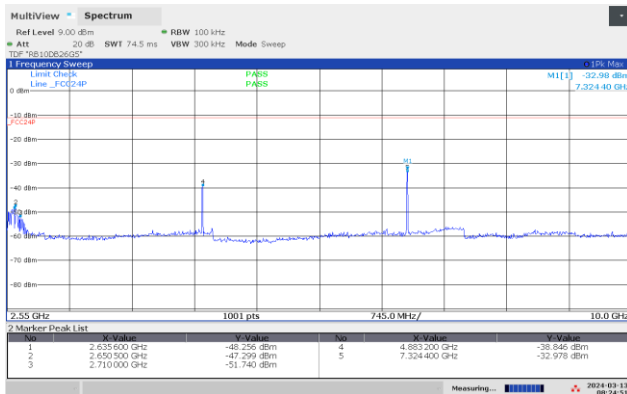


Conducted Emissions BLE 2402 MHz, 2Mb, 10000-26000 MHz

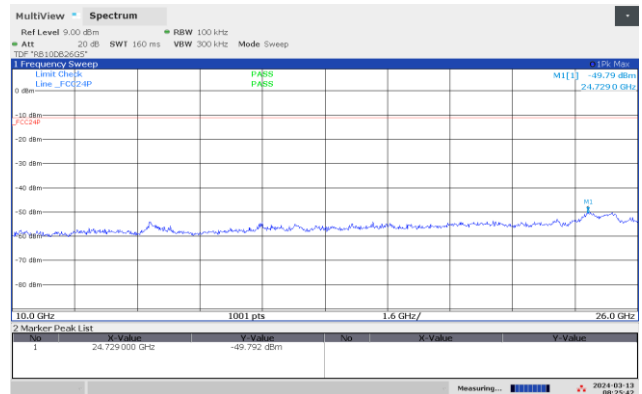


Conducted Emissions BLE 2440 MHz, 2Mb, 10-2350 MHz

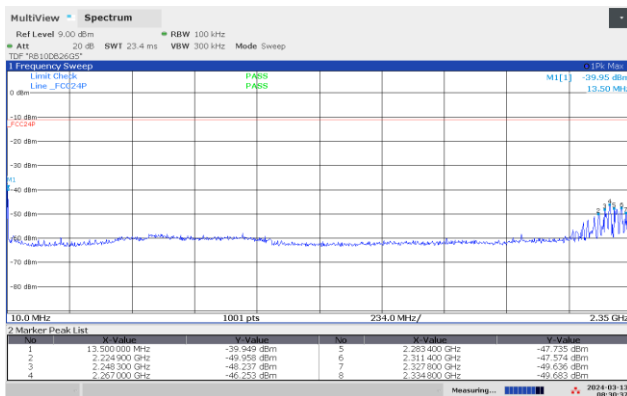
Conducted Emissions BLE 2440 MHz, 2Mb, 2350-2550 MHz



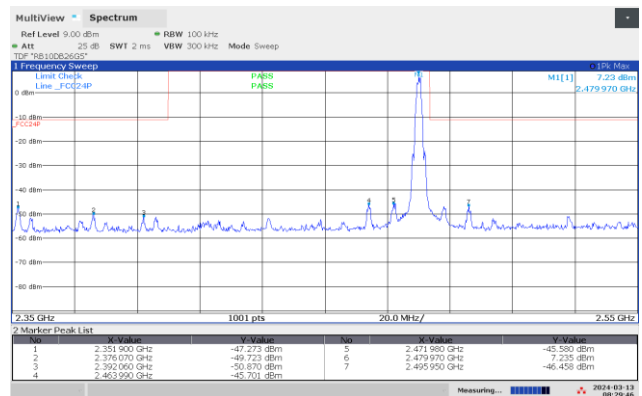
Conducted Emissions BLE 2440 MHz, 2Mb, 2550-10000 MHz



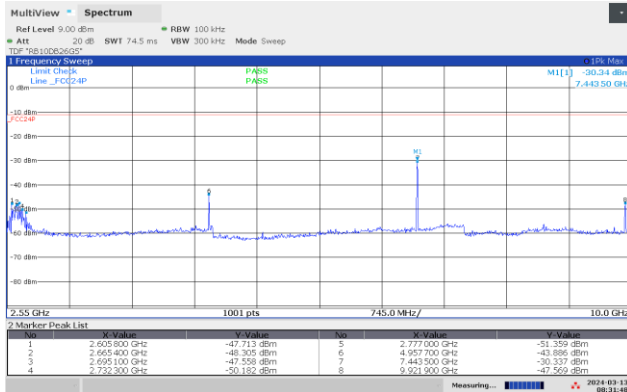
Conducted Emissions BLE 2440 MHz, 2Mb, 10000-26000 MHz



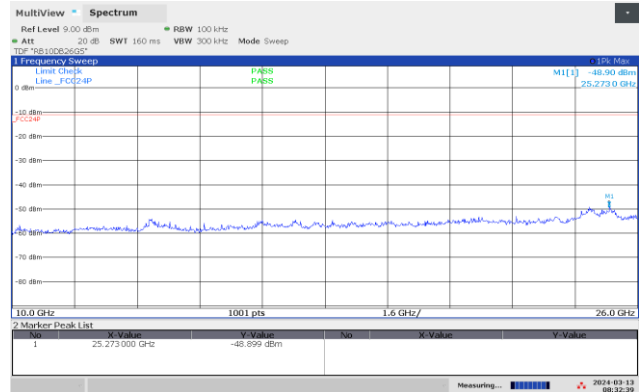
Conducted Emissions BLE 2480 MHz, 2Mb, 10-2350 MHz



Conducted Emissions BLE 2480 MHz, 2Mb, 2350-2550 MHz

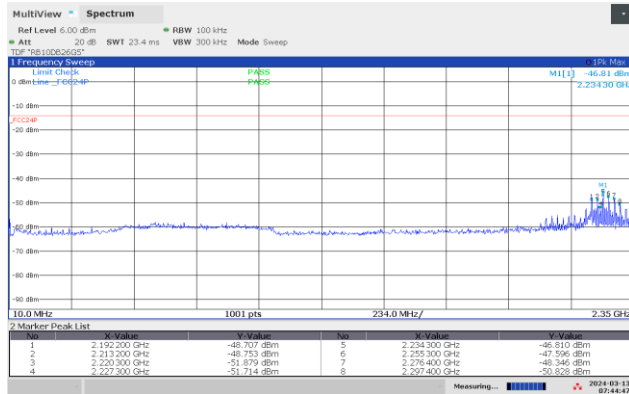


Conducted Emissions BLE 2480 MHz, 2Mb, 2550-10000 MHz

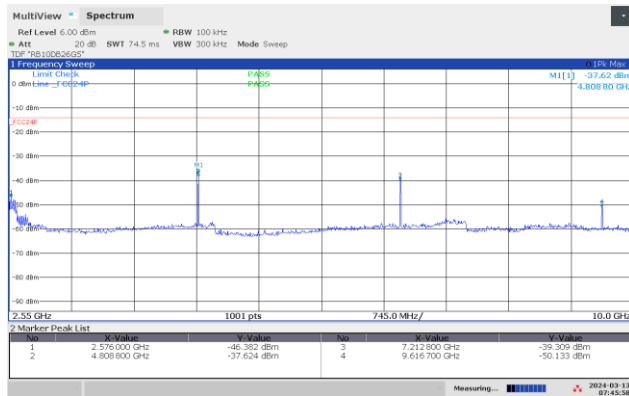


Conducted Emissions BLE 2480 MHz, 2Mb, 10000-26000 MHz

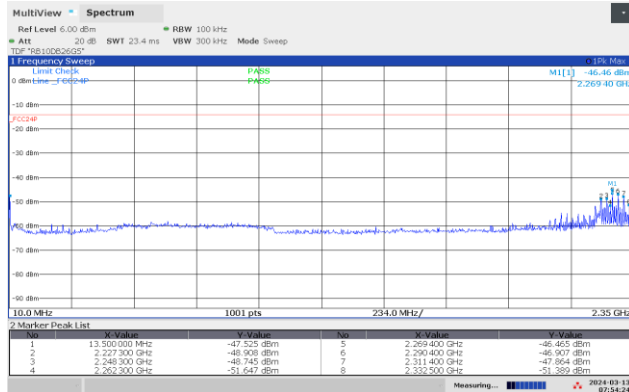
Snobee:



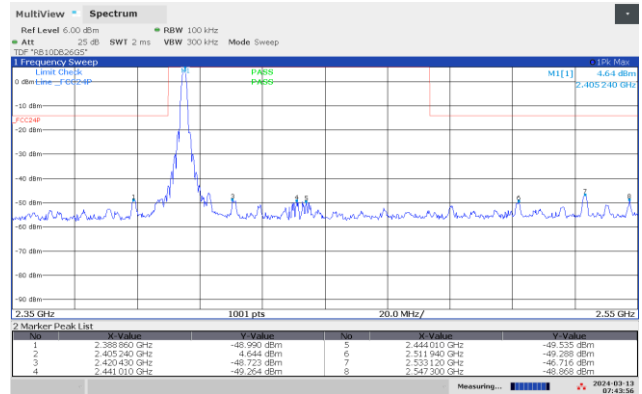
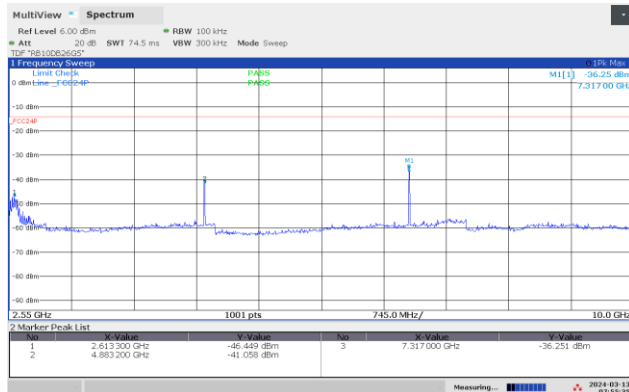
Conducted Emissions Snobee 2405 MHz, 10-2350 MHz



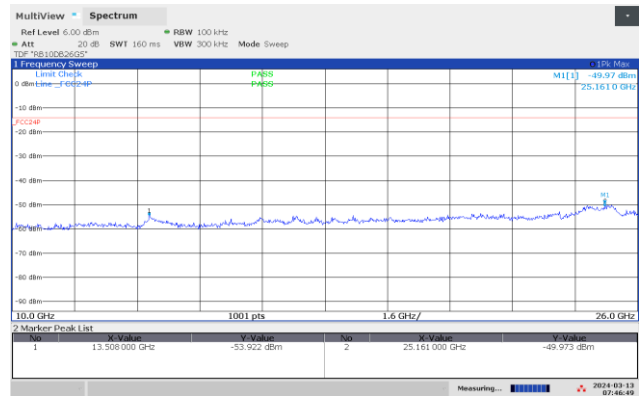
Conducted Emissions Snobee 2405 MHz, 2550-10000 MHz



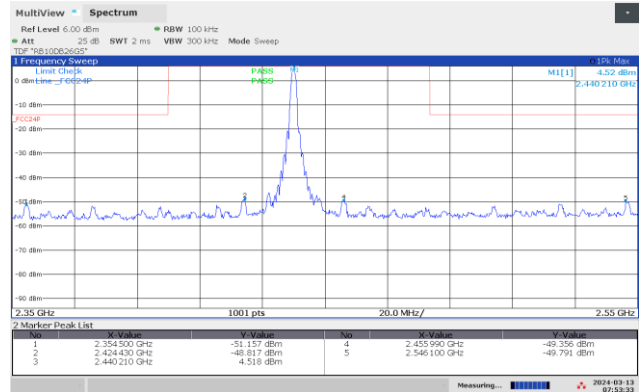
Conducted Emissions Snobee 2440 MHz, 10-2350 MHz



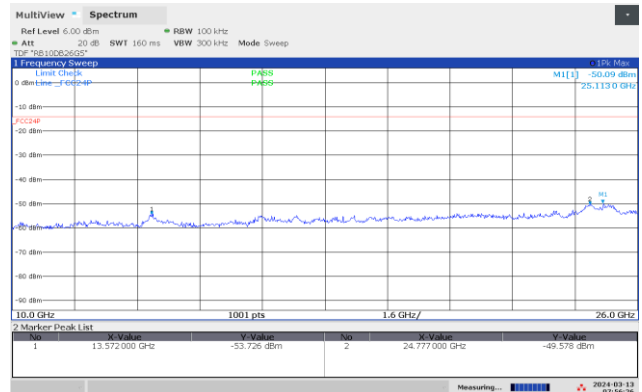
Conducted Emissions Snobee 2405 MHz, 2350-2550 MHz



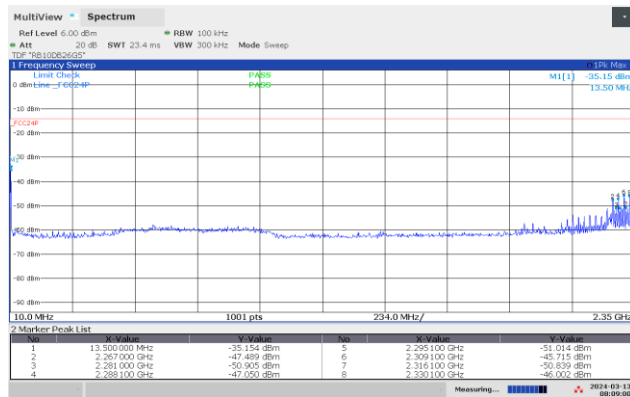
Conducted Emissions Snobee 2405 MHz, 10000-26000 MHz



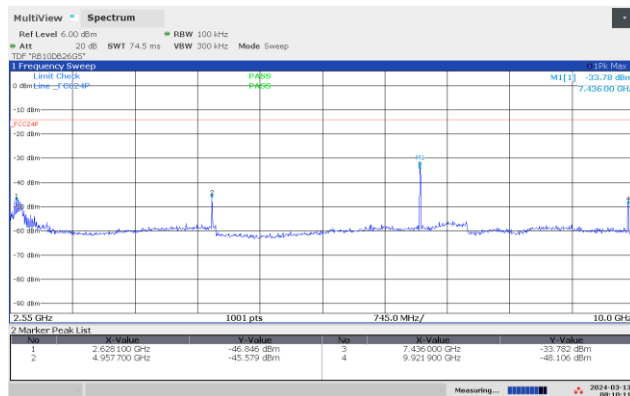
Conducted Emissions Snobee 2440 MHz, 2350-2550 MHz



Conducted Emissions Snobee 2440 MHz, , 2550-10000 MHz

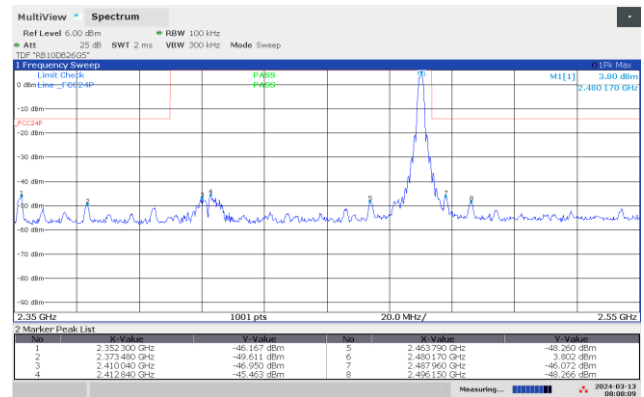


Conducted Emissions Snobee 2480 MHz, 10-2350 MHz

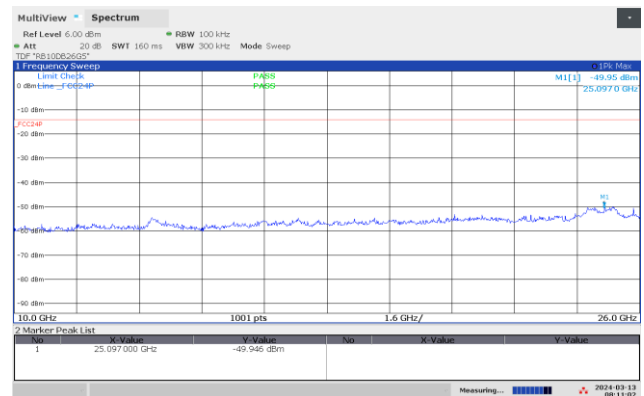


Conducted Emissions Snobee 2480 MHz, 2550-10000 MHz

Conducted Emissions Snobee 2440 MHz, 10000-26000 MHz



Conducted Emissions Snobee 2480 MHz, , 2350-2550 MHz



Conducted Emissions Snobee 2480 MHz, 10000-26000 MHz

3.7 Restricted Bands of operation

Restricted Bands of operation for FCC and ISSED are defined in FCC Part 15.205 and ISSED RSS-GEN, Issue 5 clause 8.10.

Generally, no fundamentals are allowed in the restricted bands and all emissions must comply with the limits in FCC 15.209 or RSS-GEN, Issue 5, clause 8.9.

FCC (MHz)	ISED (MHz)	FCC (GHz)	ISED (GHz)
0.090-0.110		0.96-1.24 1.3-1.427	0.96-1.427
0.495-0.505		1.435-1.6265	
2.1735-2.1905		1.6455-1.6465	
	3.020-3.026	1.660-1.710	
4.125-4.128		1.7188-1.7222	
4.17725-4.17775		2.2-2.3	
4.20725-4.20775		2.31-2.39	
	5.677-5.683	2.4835-2.5	
6.215-6.218		2.69-2.9	2.655-2.9
6.26775-6.26825		3.26-3.267	
6.31175-6.31225		3.332-3.339	
8.291-8.294		3.3458-3.358	
8.362-8.366		3.6-4.4	3.5-4.4
8.37625-8.38675		4.5-5.15	
8.41425-8.41475		5.35-5.46	
12.29-12.293		7.25-7.75	
12.51975-12.52025		8.025-8.5	
12.57675-12.57725		9.0-9.2	
13.36-13.41		9.3-9.5	
16.42-16.423		10.6-12.7	
16.69475-16.69525		13.25-13.4	
16.80425-16.80475		14.47-14.5	
25.5-25.67		15.35-16.2	
37.5-38.25		17.7-21.4	
73-74.6		22.01-23.12	
74.8-75.2		23.6-24.0	
108-121.94 123-138	108-138	31.2-31.8	
149.9-150.05		36.43-36.5	
156.52475-156.52525		Above 38.6	
156.7-156.9			
162.0125-167.17			
167.72-173.2			
240-285			
322-335.4			
399.9-410			
608-614			

Frequencies in **Bold** text are specific for FCC or ISSED, all other frequencies are common.

3.8 Radiated Emissions, Band Edge

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3 / 8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

Peak Detector					
Modulation and Bitrate	Measured field strength (dBμV/m)		Limit dB	Margin dB	
	2390 MHz	2483.5 MHz		2390 MHz	2483.5 MHz
GFSK, 1Mb	58.0	59.2	74	16.0	14.8
GFSK, 2Mb	57.7	61.3	74	16.3	12.7
Snobee, 1Mb	58.5	64.3	74	15.5	9.7

Average Detector					
Modulation and Bitrate	Measured field strength (dBμV/m)		Limit dB	Margin dB	
	2390 MHz	2483.5 MHz		2390 MHz	2483.5 MHz
GFSK, 1Mb	50.1	51.1	54	3.9	2.9
GFSK, 2Mb	50.7	51.8	54	3.3	2.2
Snobee, 1Mb	28.5	36.1	54	25.5	17.9

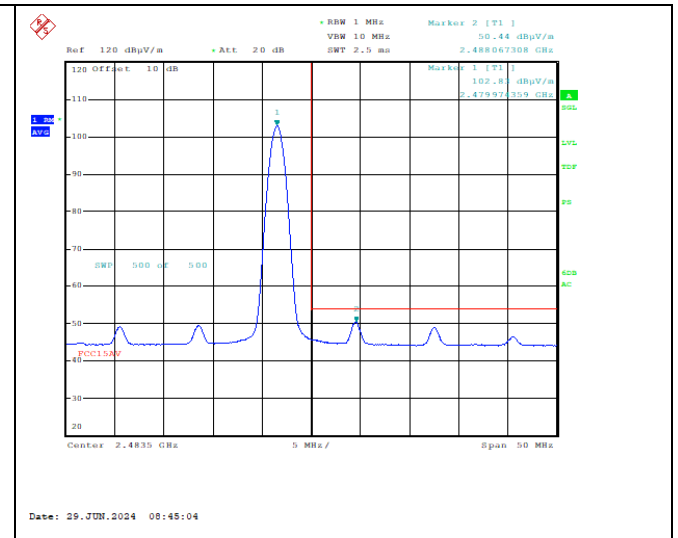
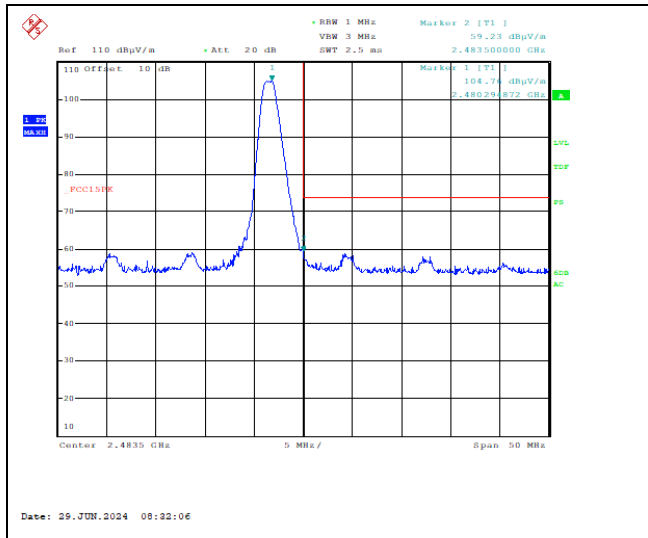
Average Detector measurements for BLE were performed with the method SA-2. The measurements for BLE 1Mb and BLE 2Mb had duty cycle less than 98%, duty cycle correction for BLE 1Mb is +0.7 dB (DC=85%) and for BLE 2Mb 3.7 dB (DC=43%).

For Snobee the method SA-1 was used since the duty cycle in test mode was 100%.

The manufacturer states that the maximum time of transmission for Snobee during a period of 100 ms is 4% for Snobee – see “*ultraBeacon Single-Zone Operational description V01.pdf*”.

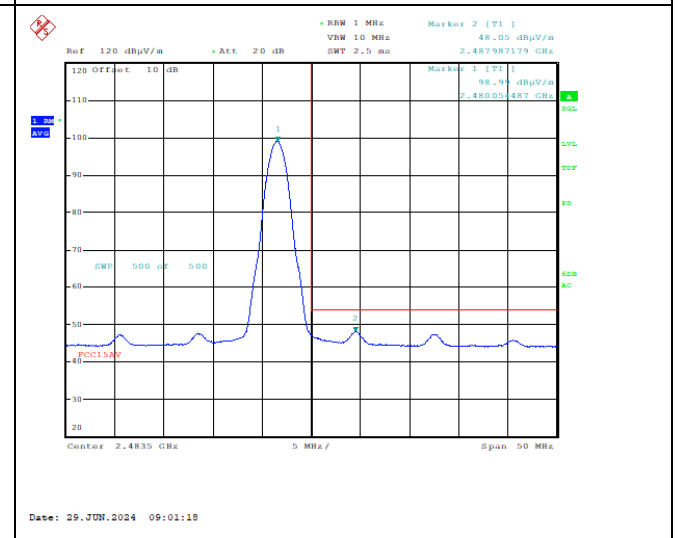
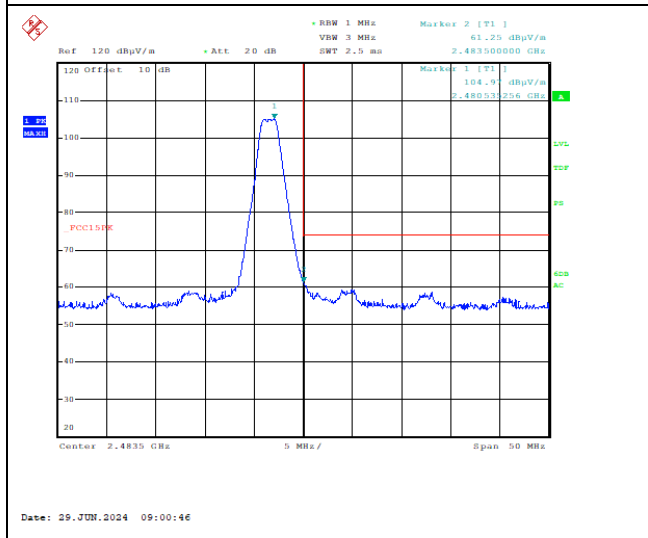
Duty Cycle Correction for Snobee is $-20 \times \log(0.04) = 28.0$ dB => Maximum allowed correction is 20 dB

See attached plots.



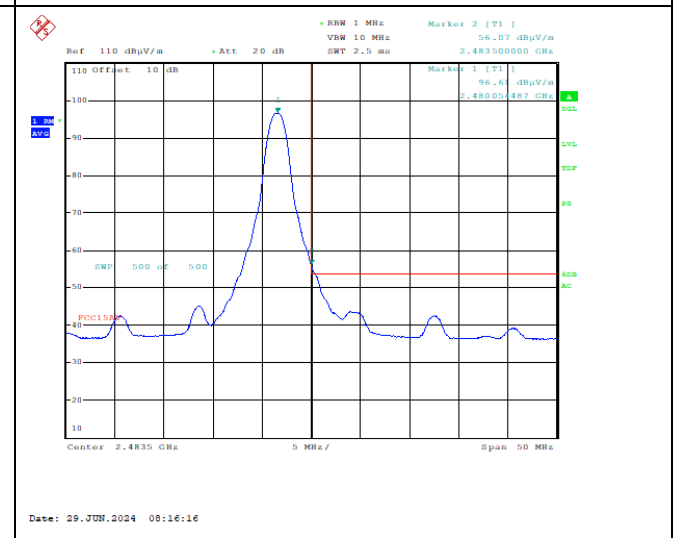
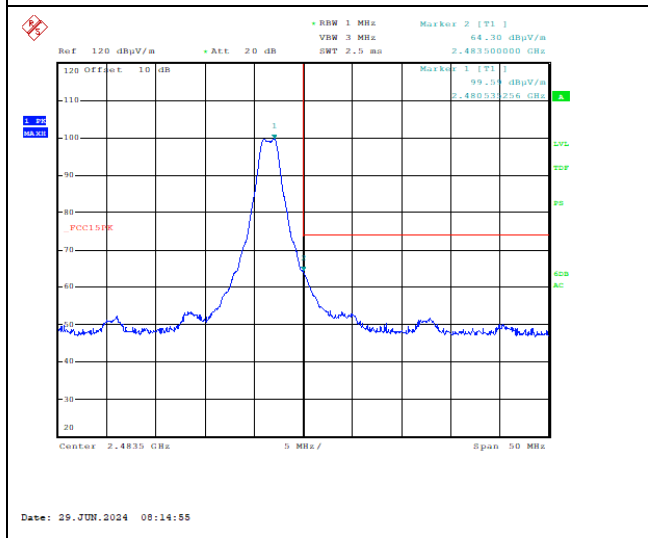
Upper Band Edge, 2480 MHz, BLE 1Mb, Peak

Upper Band Edge, 2480 MHz, 1Mb, Average



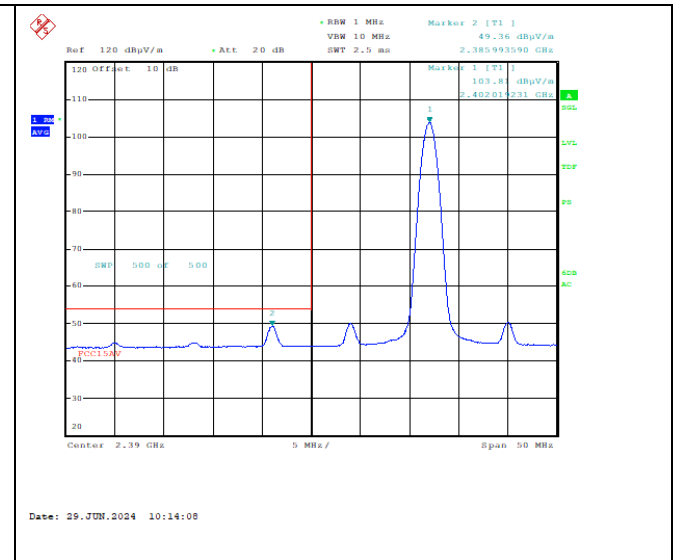
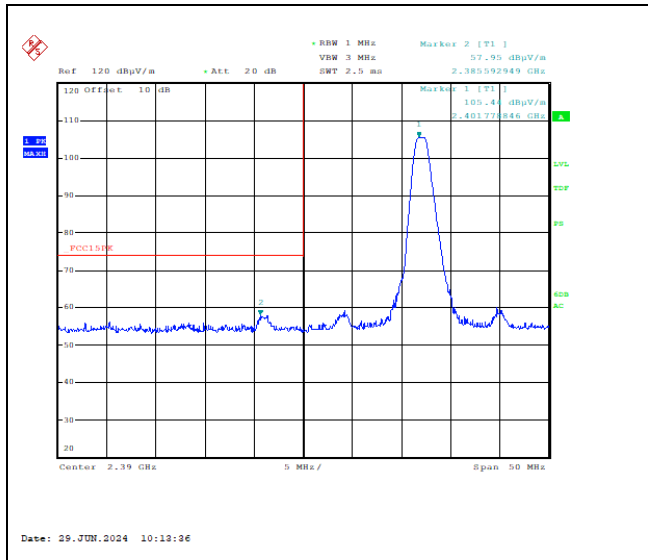
Upper Band Edge, 2480 MHz, BLE 2Mb, Peak

Upper Band Edge, 2480 MHz, 2Mb, Average



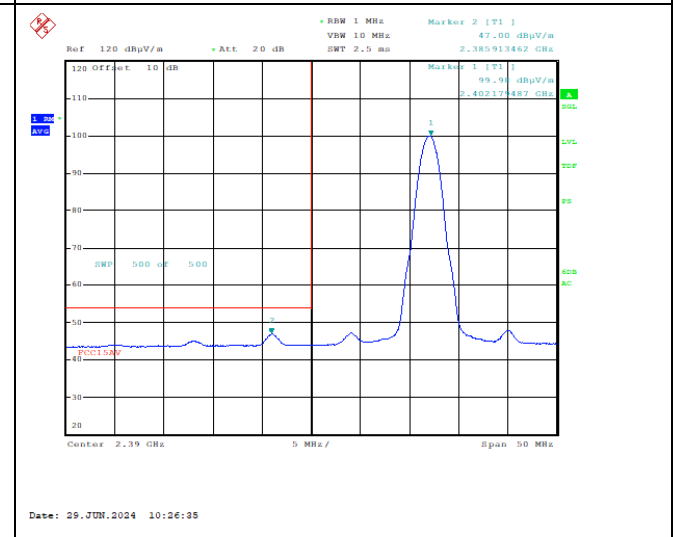
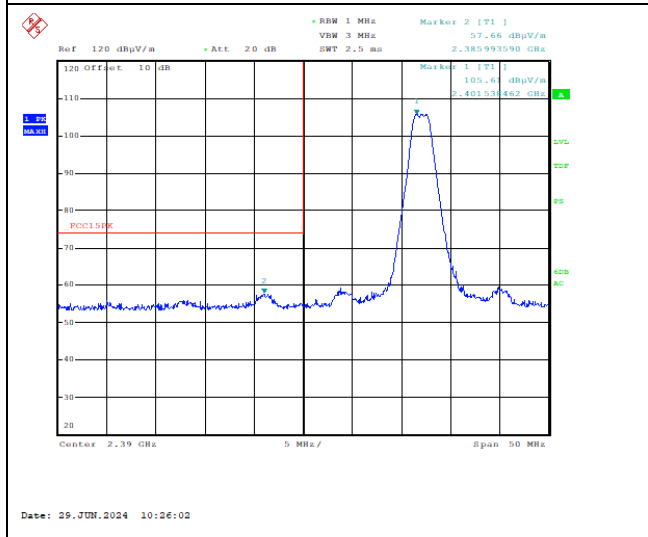
Upper Band Edge, 2480 MHz, Snobee, Peak

Upper Band Edge, 2480 MHz, Snobee, Average



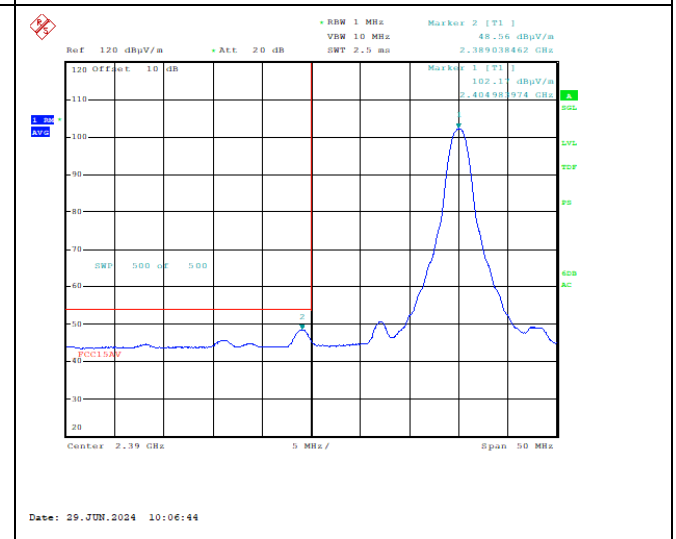
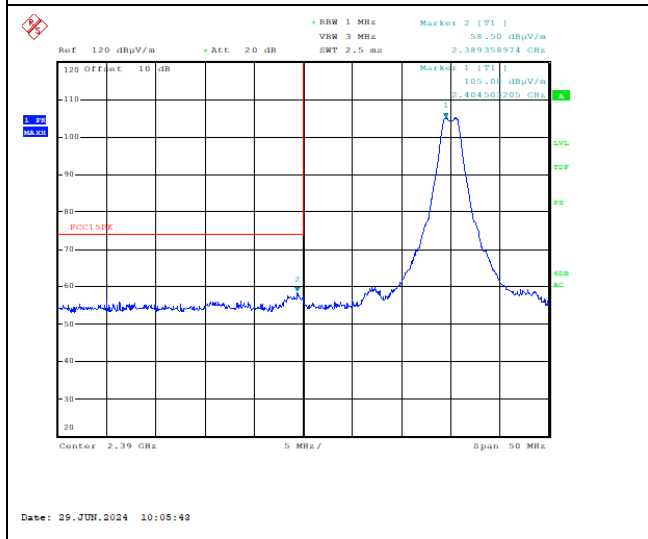
Lower Band Edge, 2402 MHz, BLE 1Mb, Peak

Lower Band Edge, 2402 MHz, BLE 1Mb, Average



Lower Band Edge, 2402 MHz, BLE 2Mb, Peak

Lower Band Edge, 2402 MHz, BLE 2Mb, Average



Lower Band Edge, 2405 MHz, Snobee, Peak

Lower Band Edge, 2405 MHz, Snobee, Average

3.9 Radiated Emissions, 30 – 1000 MHz.

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3/8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

Detector: Quasi-Peak

Measuring distance 3 m

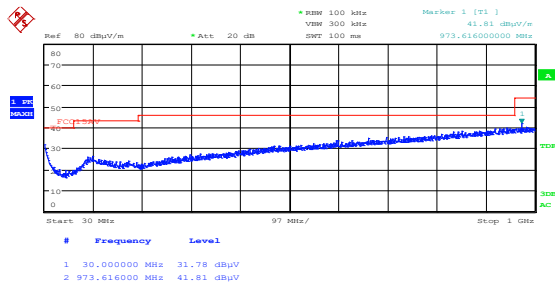
Tested in test mode with EUT transmitting on ch19

Measured Frequency (MHz)	Carrier Frequency (MHz)	Modulation	Measured Emission (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
30 – 88	All	All	< 33	40.0	> 7
88 – 216	All	All	< 30	43.5	> 13.5
216 – 960	All	All	< 43	46.0	> 3
960 – 1000	All	All	< 45	54.0	> 11

See attached plots

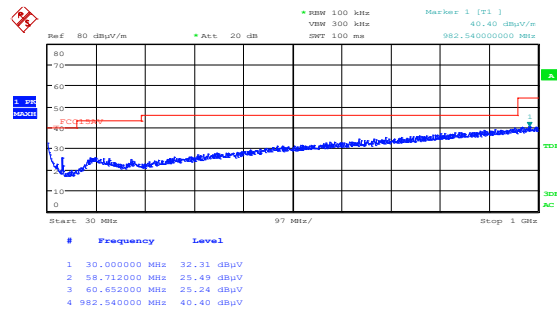
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10	
Frequency	Radiated emission limit @3 meters	
30 – 88 MHz	100 μ V/m	40.0 dB μ V/m
88 – 216 MHz	150 μ V/m	43.5 dB μ V/m
216 – 960 MHz	200 μ V/m	46.0 dB μ V/m
960 – 1000 MHz	500 μ V/m	54.0 dB μ V/m
	Limits above are with Quasi Peak Detector	



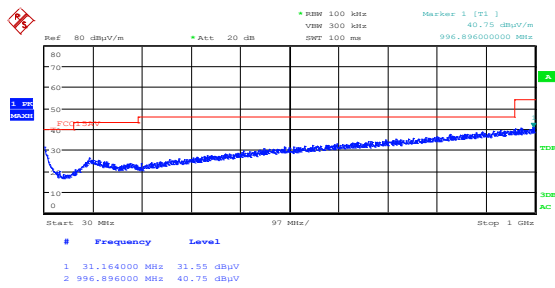
Date: 26.FEB.2024 11:16:52

Radiated Emissions 30 - 1000 MHz, BLE 2402, 1Mb, HP



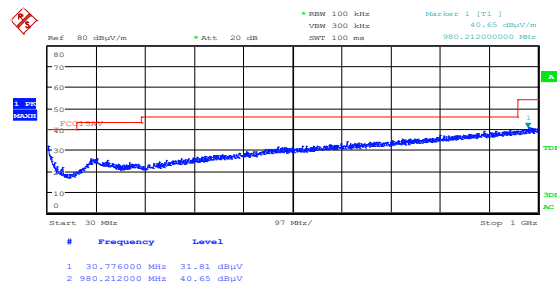
Date: 26.FEB.2024 11:14:56

Radiated Emissions 30 - 1000 MHz, BLE 2402, 1Mb, VP



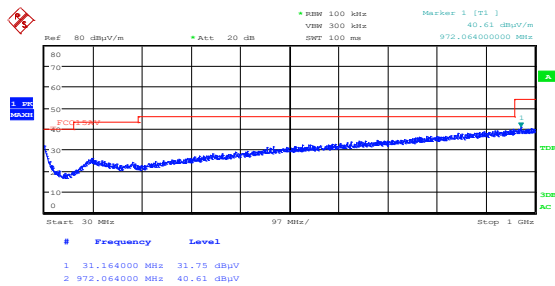
Date: 26.FEB.2024 12:32:12

Radiated Emissions 30 - 1000 MHz, BLE 2402, 2Mb, HP



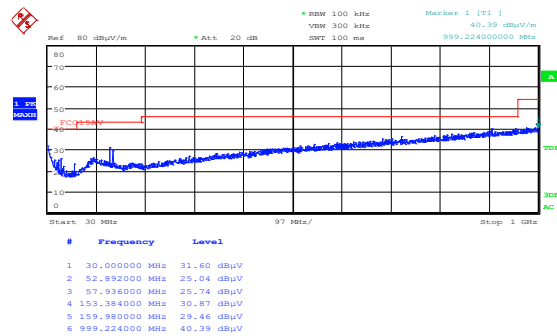
Date: 26.FEB.2024 12:30:16

Radiated Emissions 30 - 1000 MHz, BLE 2402, 2Mb, VP



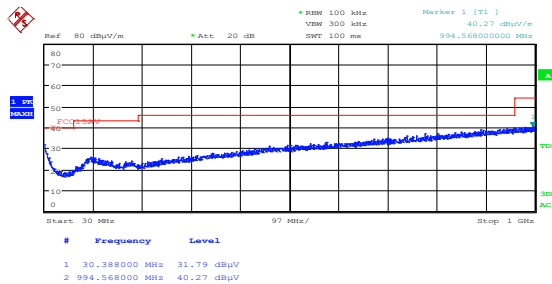
Date: 27.FEB.2024 07:05:46

Radiated Emissions 30 - 1000 MHz, Snobee 2405, HP



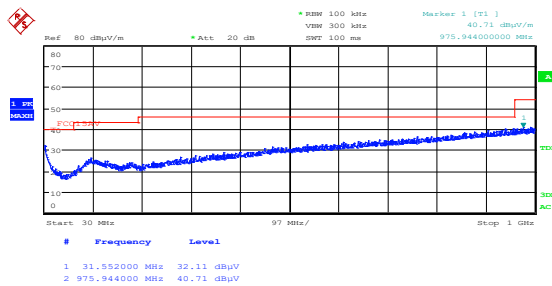
Date: 26.FEB.2024 14:31:03

Radiated Emissions 30 - 1000 MHz, Snobee 2405, VP



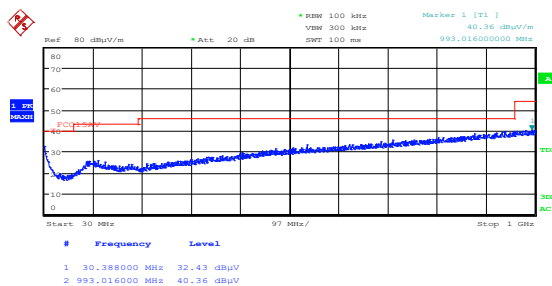
Date: 26.FEB.2024 12:05:25

Radiated Emissions 30 - 1000 MHz, BLE 2440, 1Mb, HP



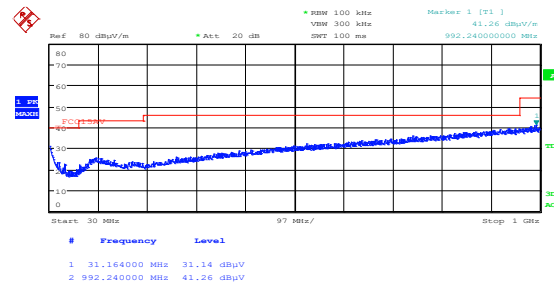
Date: 26.FEB.2024 13:47:23

Radiated Emissions 30 - 1000 MHz, BLE 2440, 2Mb, HP



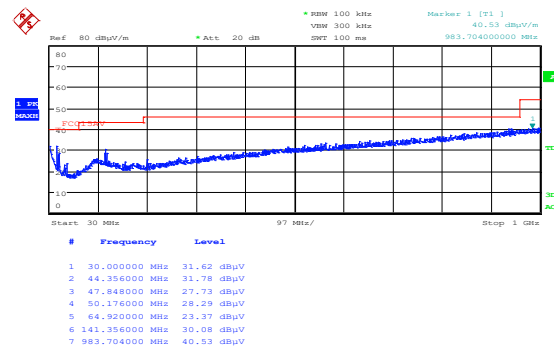
Date: 27.FEB.2024 07:17:08

Radiated Emissions 30 - 1000 MHz, Snobee 2440, HP



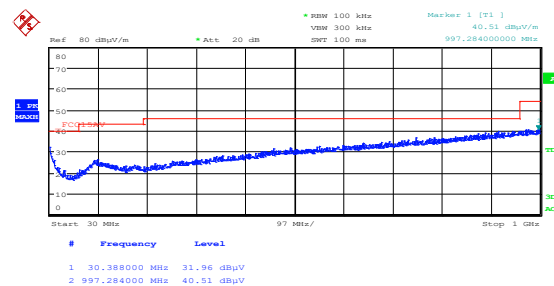
Date: 26.FEB.2024 12:03:30

Radiated Emissions 30 - 1000 MHz, BLE 2440, 1Mb, VP



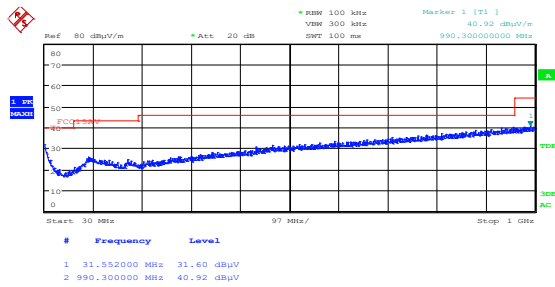
Date: 26.FEB.2024 13:45:27

Radiated Emissions 30 - 1000 MHz, BLE 2440, 2Mb, VP



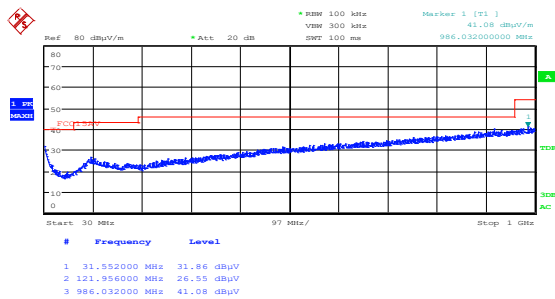
Date: 27.FEB.2024 07:15:13

Radiated Emissions 30 - 1000 MHz, Snobee 2440, VP



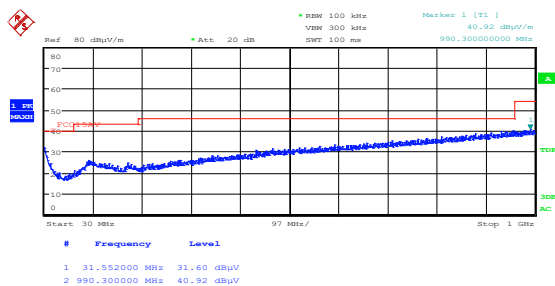
Date: 27.FEB.2024 07:39:35

Radiated Emissions 30 - 1000 MHz, BLE 2480, 1Mb, HP



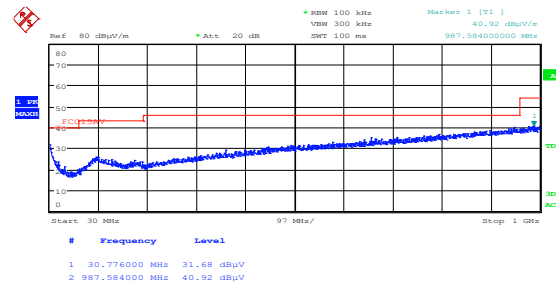
Date: 26.FEB.2024 13:53:31

Radiated Emissions 30 - 1000 MHz, BLE 2480, 2Mb, HP



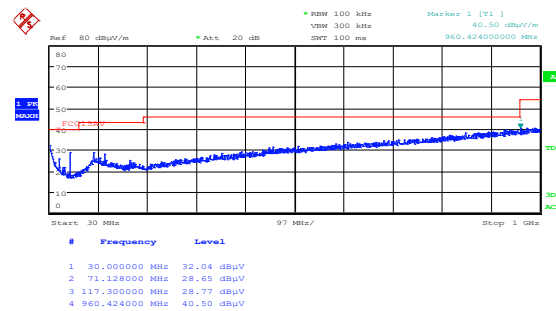
Date: 27.FEB.2024 07:39:35

Radiated Emissions 30 - 1000 MHz, Snobee 2480, HP



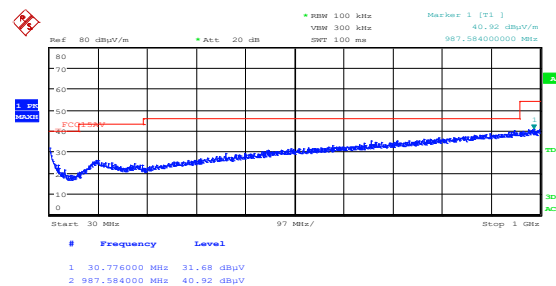
Date: 27.FEB.2024 07:37:39

Radiated Emissions 30 - 1000 MHz, BLE 2480, 1Mb, VP



Date: 26.FEB.2024 13:51:36

Radiated Emissions 30 - 1000 MHz, BLE 2480, 2Mb, VP



Date: 27.FEB.2024 07:37:39

Radiated Emissions 30 - 1000 MHz, Snobee 2480, VP

3.10 Radiated Emissions, 1 – 26 GHz

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3/8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

Measuring distance: 3m (1 – 18 GHz)

A pre-scan was performed above 18 GHz and only very low spurious emissions were detected – see plots below.

Carrier Frequency (MHz) Low / Mid / high	Measured Frequency (GHz)	Mode	Measured Emissions (dBμV/m)		Limit (dBμV/m)		Margin (dB)	
			Peak	Average	Pk	Av	Pk	Av
Mid	3 rd harm	BLE1Mb	56.8	36.8	74	54	17.2	17.2
Mid	3 rd harm	BLE2Mb	55.9	35.9	74	54	18.1	18.1
Mid	3 rd harm	Snobee	55.8	35.8	74	54	18.2	18.2
High	3 rd harm	BLE1Mb	54.5	34.5	74	54	19.5	19.5
High	3 rd harm	BLE2Mb	55.8	35.8	74	54	18.2	18.2
High	3 rd harm	Snobee	55.0	35.0	74	54	19.0	19.0
Low	8 th harm	BLE1Mb	40.8	/	74	54	33.2	/
Low	8 th harm	BLE2Mb	41.2	/	74	54	32.8	/
Low	8 th harm	Snobee	42.8	/	74	54	31.2	/
Mid	8 th harm	BLE1Mb	39.8	/	74	54	34.2	/
Mid	8 th harm	BLE2Mb	40.8	/	74	54	33.2	/
Mid	8 th harm	Snobee	42.8	/	74	54	31.2	/
High	8 th harm	BLE1Mb	36.5	/	74	54	37.5	/
High	8 th harm	BLE2Mb	37.4	/	74	54	36.6	/
High	8 th harm	Snobee	39.0	/	74	54	35.0	/
High	9 th harm	BLE1Mb	42.7	/	74	54	31.3	/
High	9 th harm	BLE2Mb	41.7	/	74	54	32.3	/
High	9 th harm	Snobee	43.2	/	74	54	30.8	/

A Band Reject Filter for 2400-2483.5 was used for spurious measurements from 1 GHz to 18 GHz. The filter has a passband down to DC and up to 18 GHz.

Antenna factor, amplifier gain and cable loss are included in spectrum analyzer "Transducer factor".

The manufacturer states that the device will have a maximum transmission time during 100 ms of 5 ms for BLE and 4 ms for Snobee, this gives a duty cycle correction of 20 dB for both BLE and Snobee.

Average value is not reported when Peak Value is below the Average Limit.

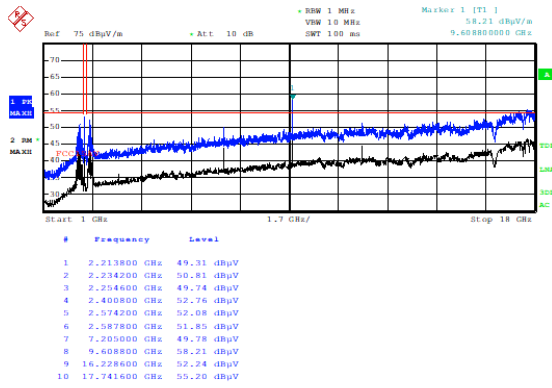
DC Correction = -20* log(Duty Cycle) (Maximum 20 dB)

See plots.

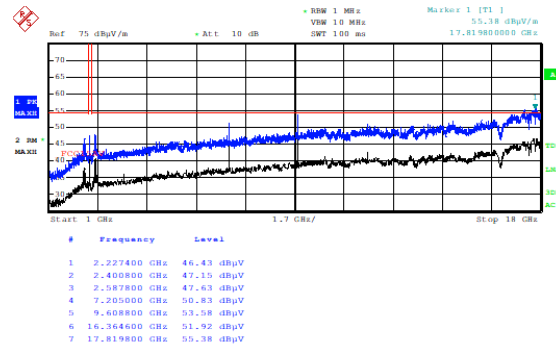
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency	Average Detector	Peak Detector
1 – 26 GHz	54.0 dBμV/m	74.0 dBμV/m

BLE 1Mbps

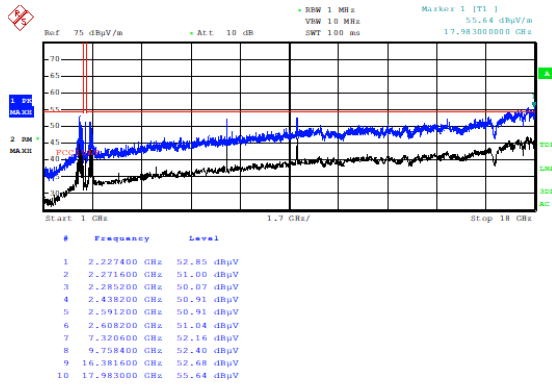


Date: 29.JUN.2024 15:36:42



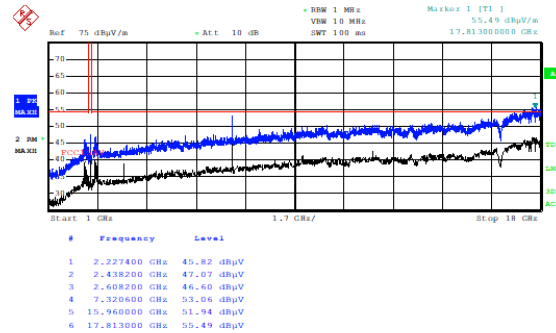
Date: 29.JUN.2024 15:34:45

Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 1M, 2402 MHz, HP



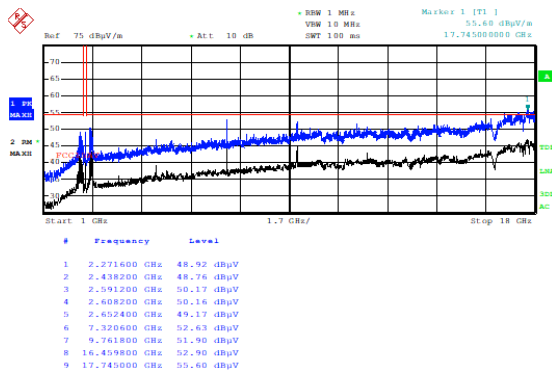
Date: 29.JUN.2024 13:21:51

Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 1M, 2402 MHz, VP



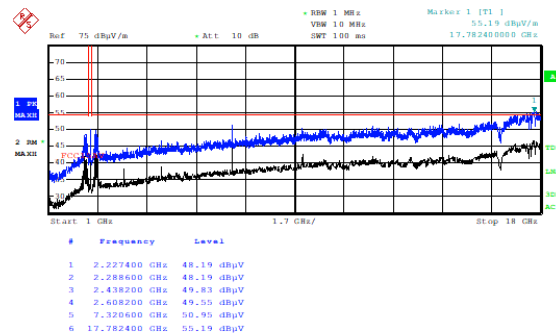
Date: 29.JUN.2024 13:19:52

Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 1M, 2440 MHz, HP



Date: 29.JUN.2024 13:27:11

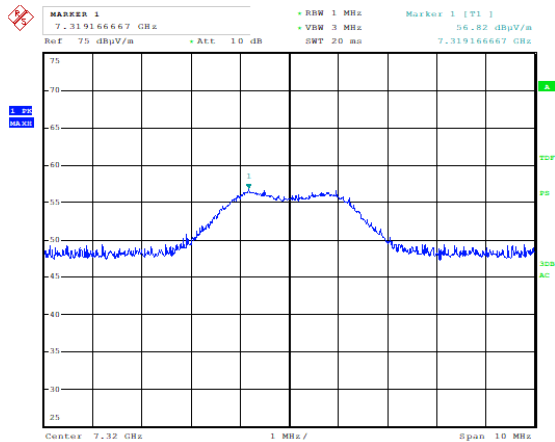
Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 1M, 2440 MHz, VP



Date: 29.JUN.2024 13:25:13

Radiated Emissions 1 - 18 GHz, EUT Vert, BLE 1M, 2440 MHz, HP

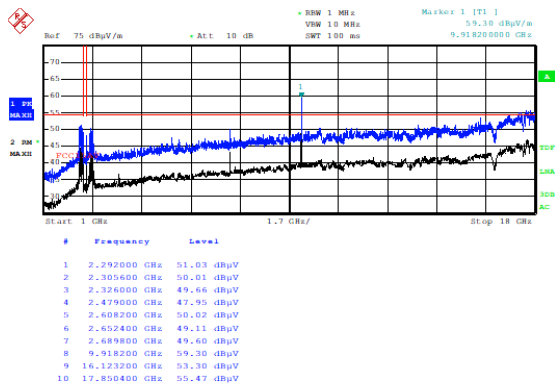
Radiated Emissions 1 - 18 GHz, EUT Vert, BLE 1M, 2440 MHz, VP



Vertical orientation of the device and horizontal polarization of measurement antenna gives the highest spurious level.

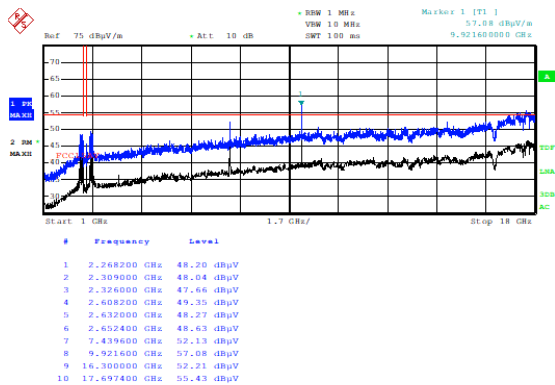
Date: 29.JUN.2024 13:00:16

Radiated Emissions 7320 MHz, EUT Vert, BLE 1M, 2440 MHz, HP



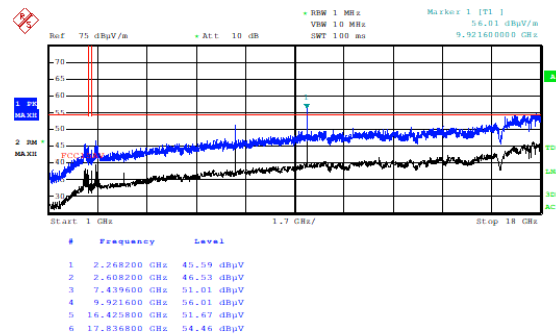
Date: 29.JUN.2024 15:10:24

Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 1M, 2480 MHz, HP



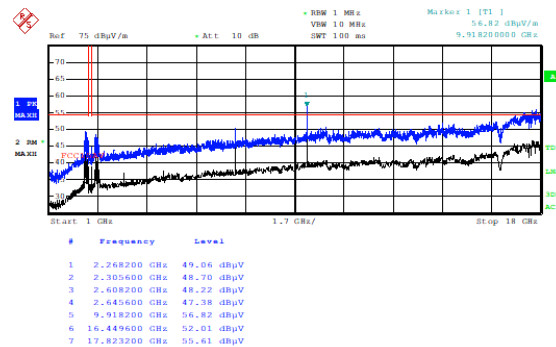
Date: 29.JUN.2024 15:16:53

Radiated Emissions 1 - 18 GHz, EUT Vert, BLE 1M, 2480 MHz, HP



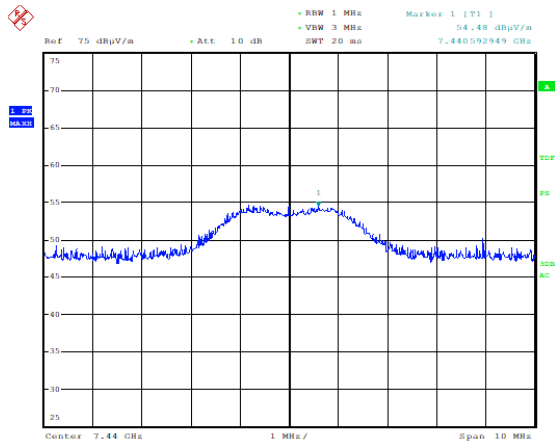
Date: 29.JUN.2024 15:08:26

Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 1M, 2480 MHz, VP



Date: 29.JUN.2024 15:14:56

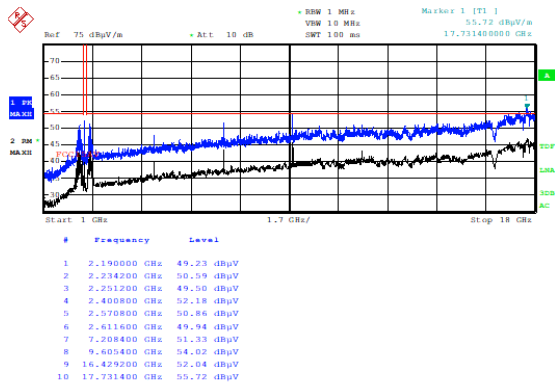
Radiated Emissions 1 - 18 GHz, EUT Vert, BLE 1M, 2480 MHz, VP



Date: 29.JUN.2024 14:45:49

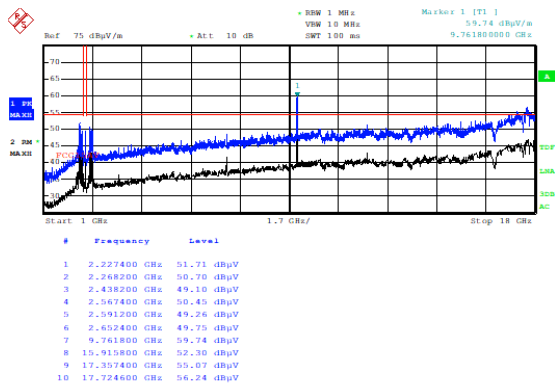
Radiated Emissions 7440 MHz, EUT Vert, BLE 1M, 2480 MHz, HP

BLE 2Mbps



Date: 29.JUN.2024 15:52:20

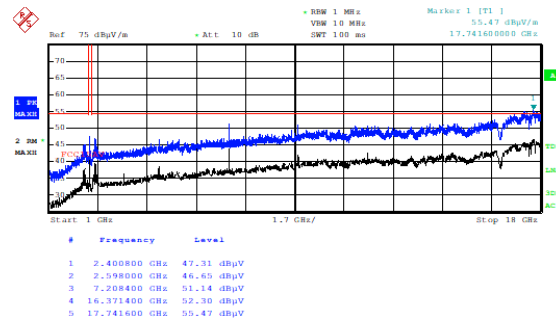
Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 2M, 2402 MHz, HP



Date: 29.JUN.2024 13:16:07

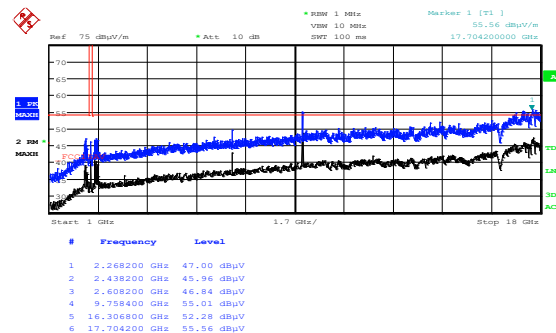
Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 2M, 2440 MHz, HP

Vertical orientation of the device and horizontal polarization of measurement antenna gives the highest spurious level.



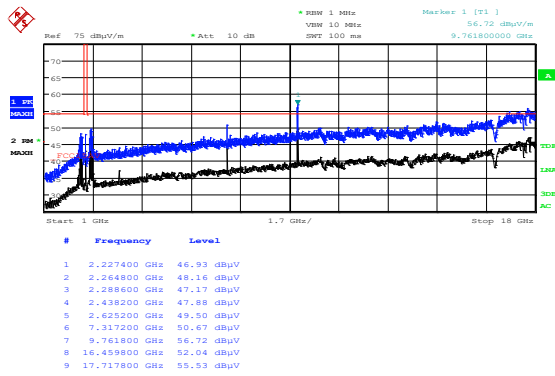
Date: 29.JUN.2024 15:50:22

Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 2M, 2402 MHz, VP



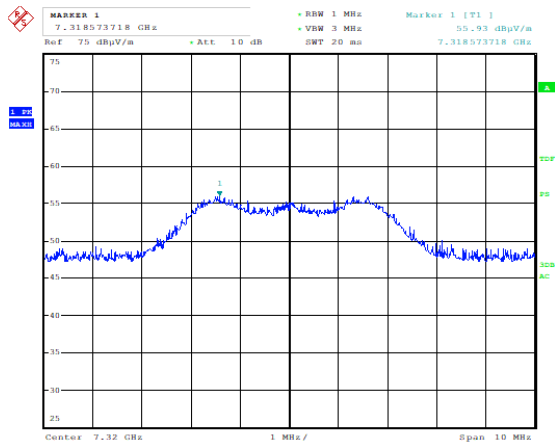
Date: 29.JUN.2024 13:14:09

Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 2M, 2440 MHz, VP



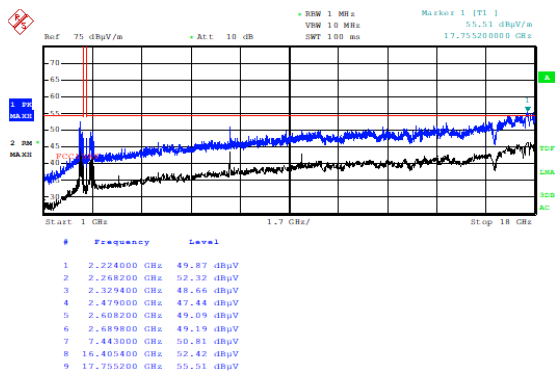
Date: 29.JUN.2024 13:11:04

Radiated Emissions 1 - 18 GHz, EUT Vert, BLE 2M, 2440 MHz, HP



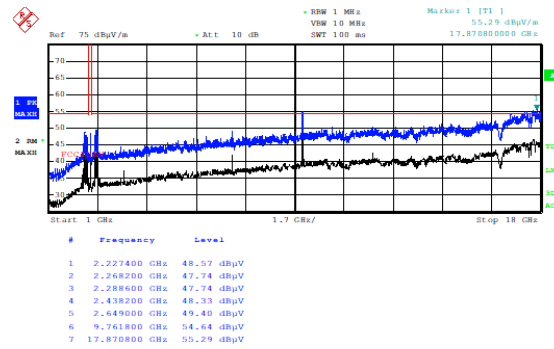
Date: 29.JUN.2024 13:05:05

Radiated Emissions 7320 MHz, EUT Vert, BLE 2M, 2440 MHz, HP



Date: 29.JUN.2024 14:54:25

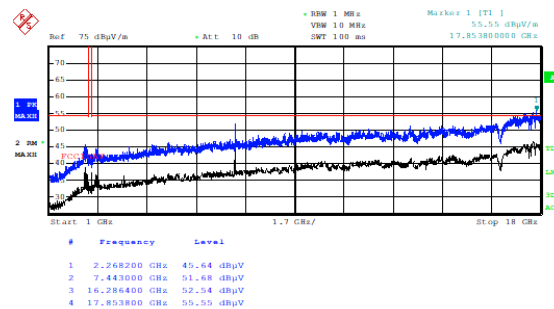
Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 2M, 2480 MHz, HP



Date: 29.JUN.2024 13:09:07

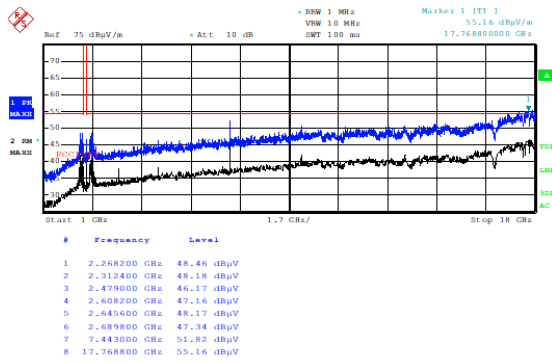
Radiated Emissions 1 - 18 GHz, EUT Vert, BLE 2M, 2440 MHz, VP

Vertical orientation of the device and horizontal polarization of measurement antenna gives the highest spurious level.



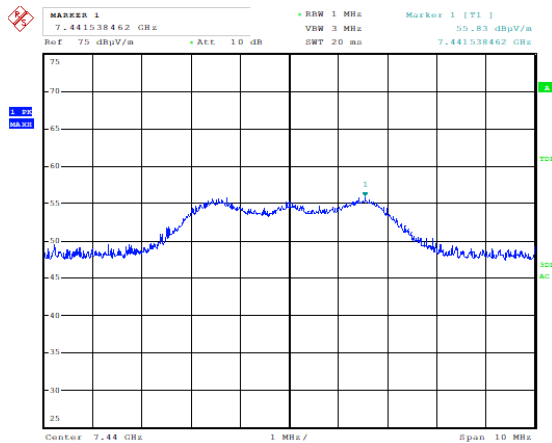
Date: 29.JUN.2024 14:52:27

Radiated Emissions 1 - 18 GHz, EUT Flat, BLE 2M, 2480 MHz, VP



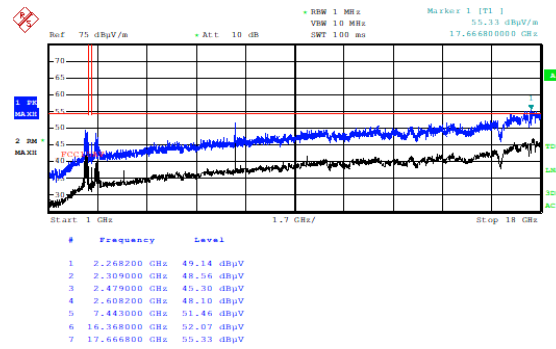
Date: 29.JUN.2024 14:59:28

Radiated Emissions 1 - 18 GHz, EUT Vert, BLE 2M, 2480 MHz, HP



Date: 29.JUN.2024 15:02:42

Radiated Emissions 7440 MHz, EUT Vert, BLE 2M, 2480 MHz, HP

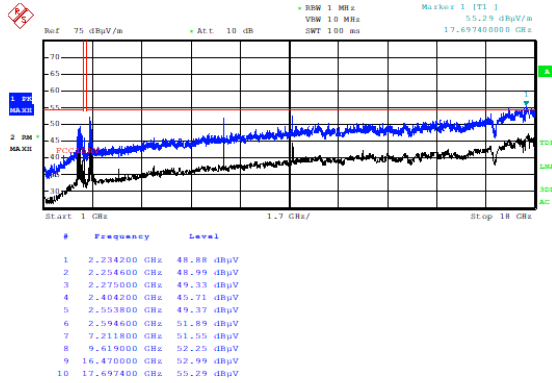


Date: 29.JUN.2024 14:57:29

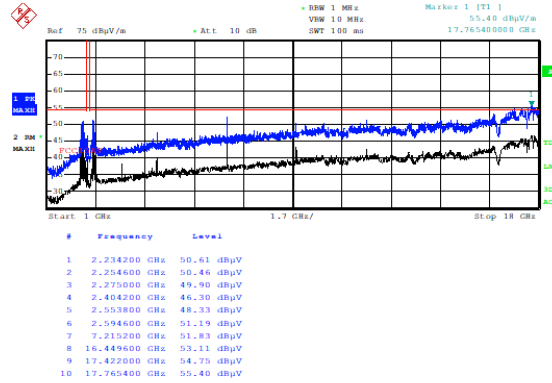
Radiated Emissions 1 - 18 GHz, EUT Vert, BLE 2M, 2480 MHz, VP

Vertical orientation of the device and horizontal polarization of measurement antenna gives the highest spurious level.

Snoobee

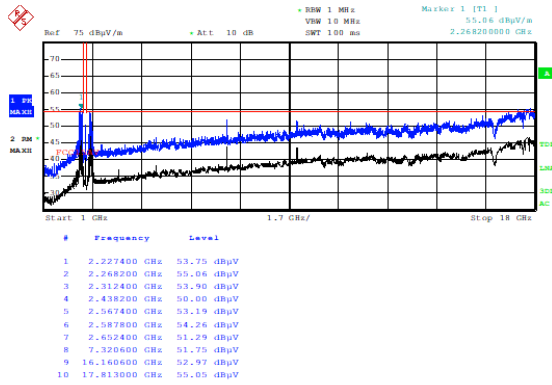


Date: 29.JUN.2024 15:30:09



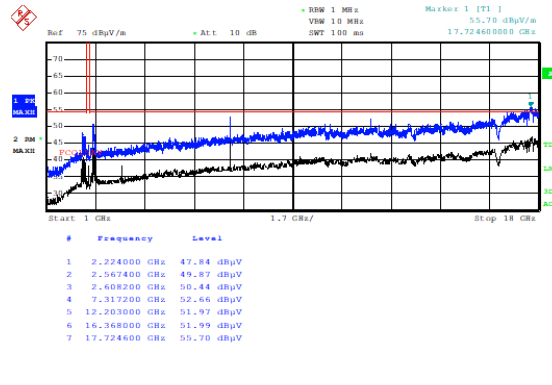
Date: 29.JUN.2024 15:28:11

Radiated Emissions 1 - 18 GHz, EUT Flat, Snoobee, 2405 MHz, HP



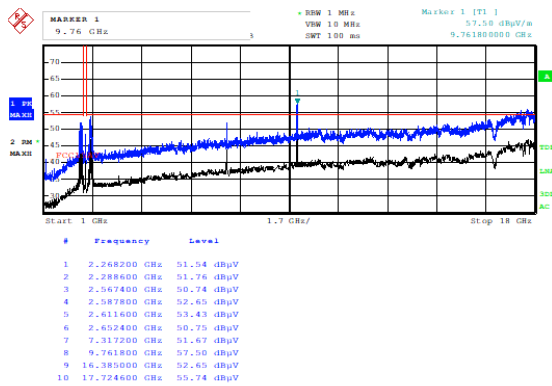
Date: 29.JUN.2024 12:10:08

Radiated Emissions 1 - 18 GHz, EUT Flat, Snoobee, 2405 MHz, VP



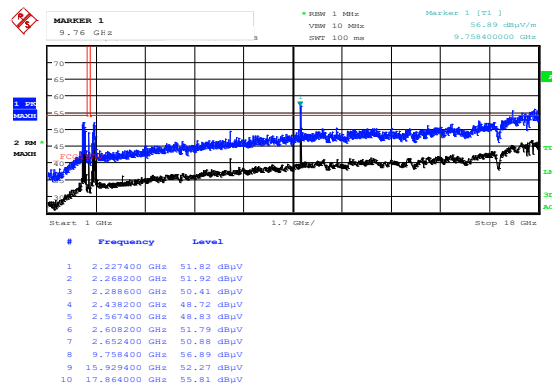
Date: 29.JUN.2024 12:08:11

Radiated Emissions 1 - 18 GHz, EUT Flat, Snoobee, 2440 MHz, HP



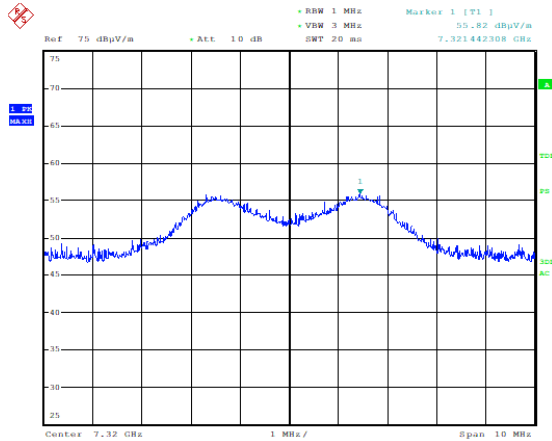
Date: 29.JUN.2024 12:42:43

Radiated Emissions 1 - 18 GHz, EUT Flat, Snoobee, 2440 MHz, VP



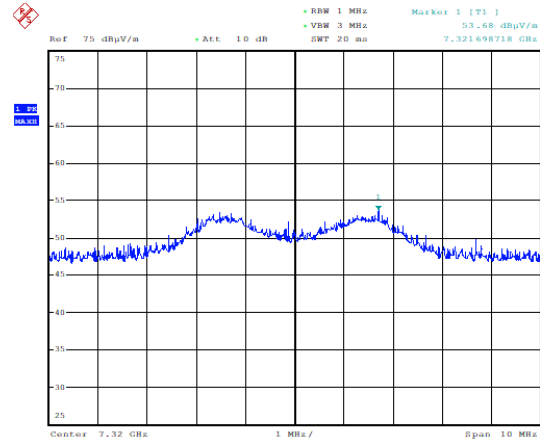
Date: 29.JUN.2024 12:40:45

Radiated Emissions 1 - 18 GHz, EUT Vert, Snobee, 2440 MHz, HP



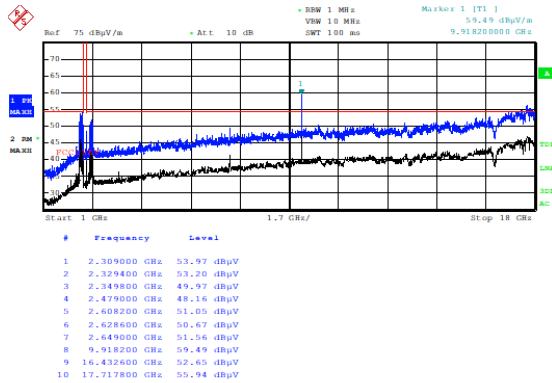
Date: 29.JUN.2024 12:50:49

Radiated Emissions 1 - 18 GHz, EUT Vert, Snobee, 2440 MHz, VP



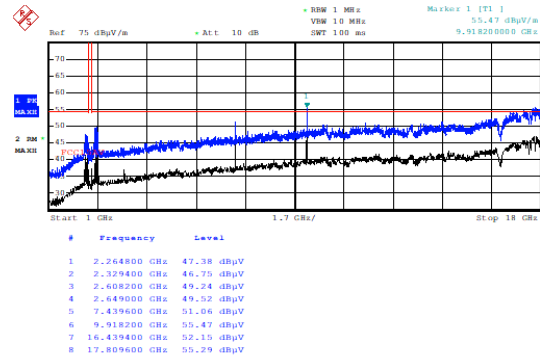
Date: 29.JUN.2024 12:52:38

Radiated Emissions 7320 MHz, EUT Vert, Snobee, 2440 MHz, HP



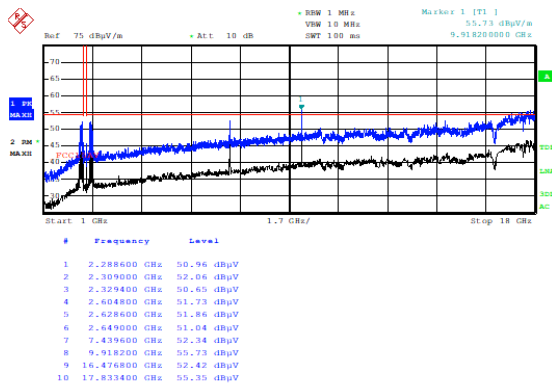
Date: 29.JUN.2024 13:24:04

Radiated Emissions 7320 MHz, EUT Vert, Snobee, 2440 MHz, VP



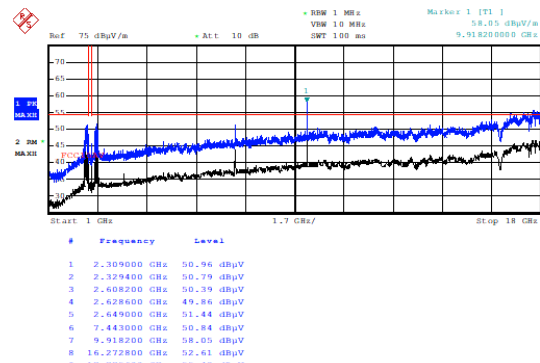
Date: 29.JUN.2024 13:32:06

Radiated Emissions 1 - 18 GHz, EUT Flat, Snobee, 2480 MHz, HP



Date: 29.JUN.2024 13:40:15

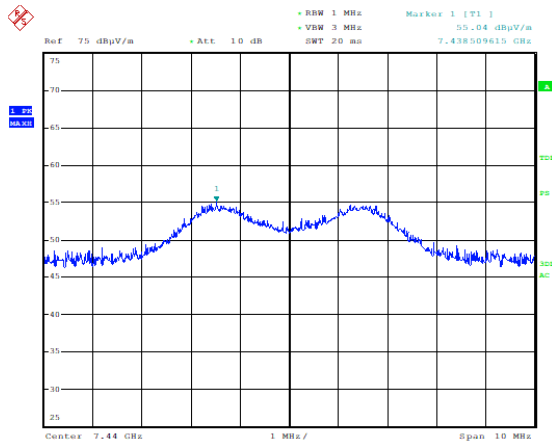
Radiated Emissions 1 - 18 GHz, EUT Flat, Snobee, 2480 MHz, VP



Date: 29.JUN.2024 13:38:18

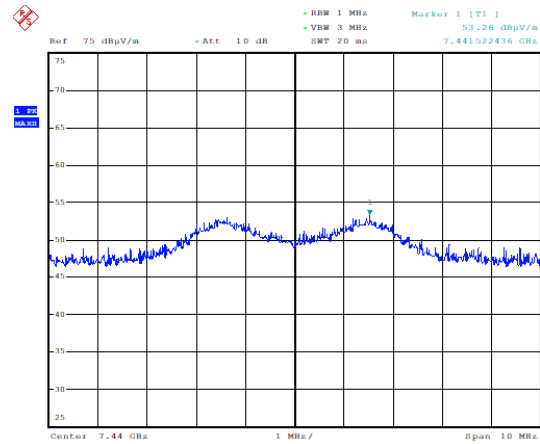
Radiated Emissions 1 - 18 GHz, EUT Vert, Snobee, 2480 MHz, HP

Radiated Emissions 1 - 18 GHz, EUT Vert, Snobee, 2480 MHz, VP



Date: 29.JUN.2024 14:17:36

Radiated Emissions 7440 MHz, EUT Vert, Snobee, 2480 MHz, HP



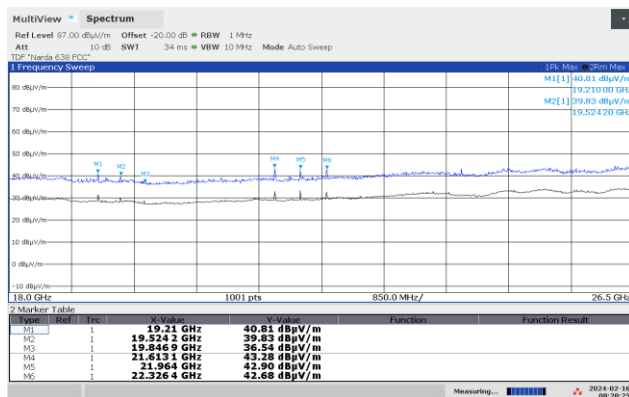
Date: 29.JUN.2024 14:15:30

Radiated Emissions 7440 MHz, EUT Vert, Snobee, 2480 MHz, VP

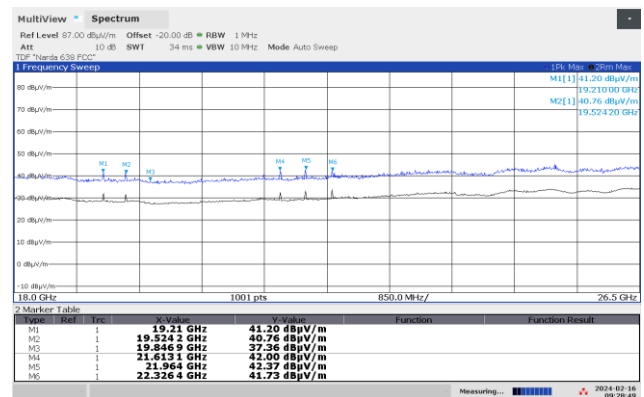
Below: Prescan 18-26 GHz at 5-10 cm distance.

The Offset of the analyzer is set to -20 dB - corresponding to a measurement distance of 30 cm.

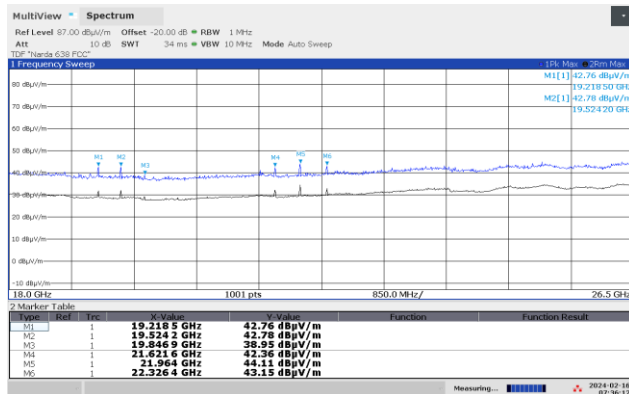
In order to see the spurious signals on the plots the actual measurement distance was decreased to 5-10 cms which corresponds to an additional offset of 9.5 dB.



Radiated Emissions 18 - 26 GHz, BLE 1Mb, 2402, 2440, 2480 MHz



Radiated Emissions 18 - 26 GHz, BLE 2Mb, 2402, 2440, 2480 MHz



Radiated Emissions 18 - 26 GHz, Snobee, 2405, 2440, 2480 MHz.

3.11 Power Spectral Density (PSD)

FCC part 15.247(d)

ISED Canada RSS-247 Issue 3, Clause 5.2 (2)

Measurement procedure: ANSI C63.10-2013 Clause 11.10

Test Results: Complies

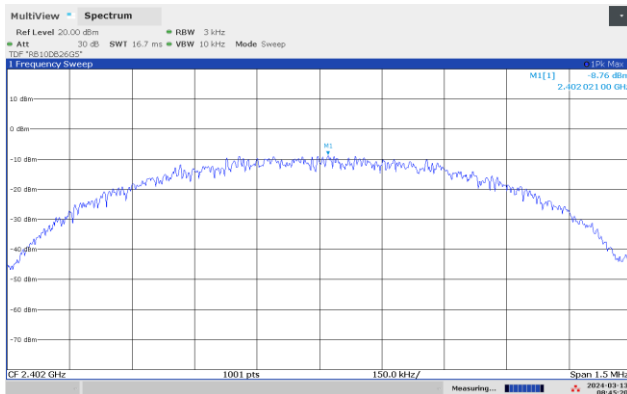
Measurement Data:

The measurement procedure PKPSD described in ANSI C63.10-2013 was used.

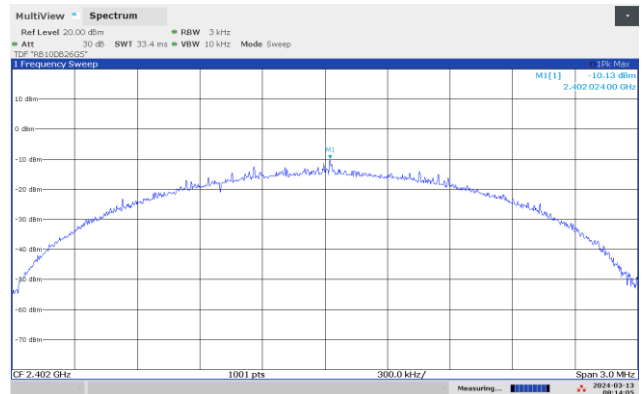
Modulation Type and Bitrate	Measured Power Spectral Density (dBm/3kHz)		
	Low	Mid	High
BLE 1Mb	-8.8	-8.9	-9.0
BLE 2Mb	-10.1	-10.1	-10.2
Snobee	-5.8	-5.6	-6.4

The measured values are with 3kHz RBW.

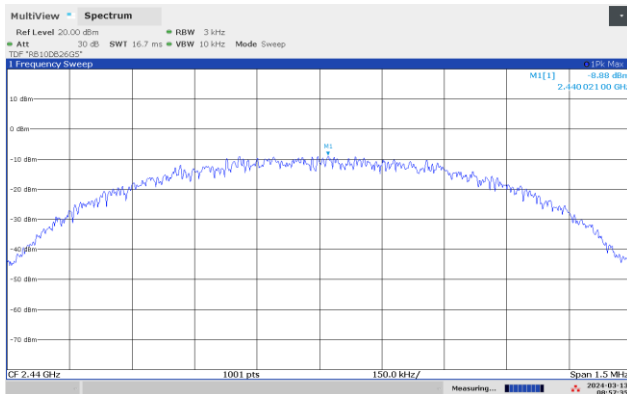
Requirement for systems using Digital Modulation
The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.
No requirements for Frequency Hopping Systems.



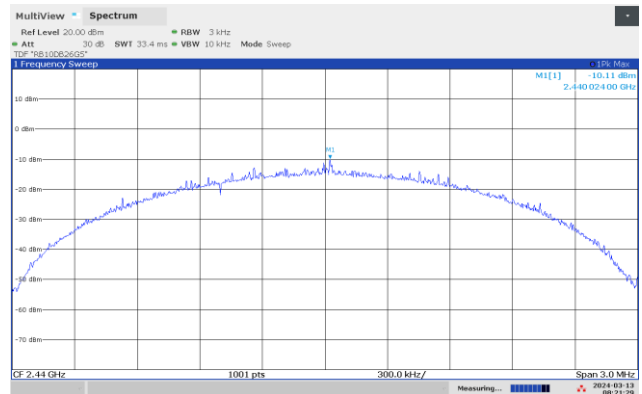
PSD, 2402 MHz, BLE 1Mb



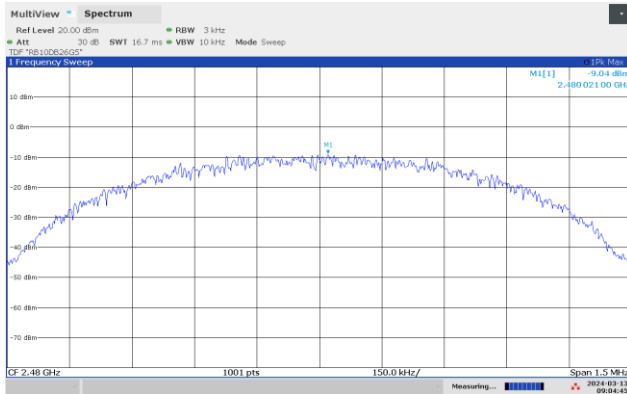
PSD, 2402 MHz, BLE 2Mb



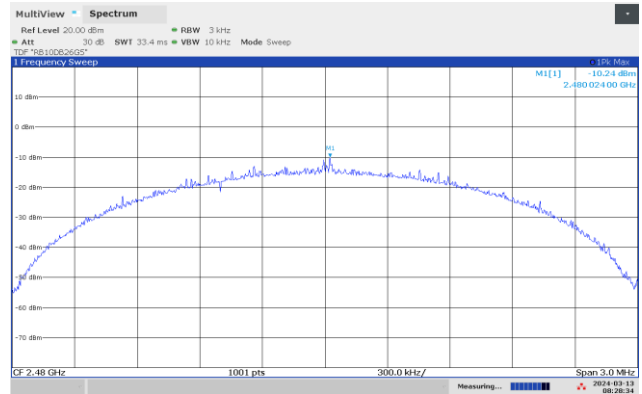
PSD, 2440 MHz, BLE 1Mb



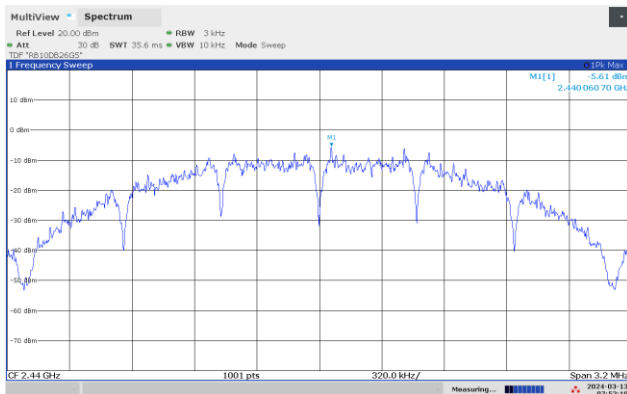
PSD, 2440 MHz, BLE 2Mb



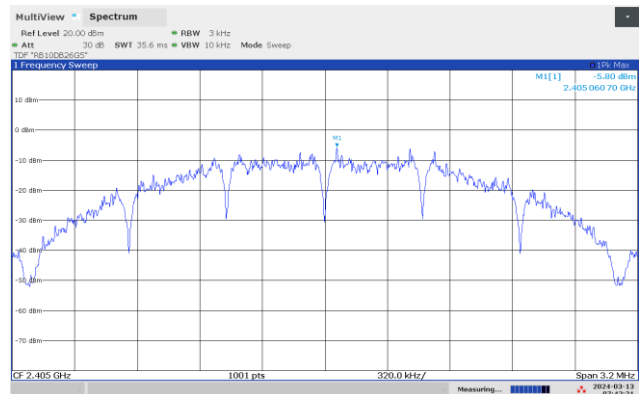
PSD, 2480 MHz, BLE 1Mb



PSD, 2480 MHz, BLE 2Mb



PSD, 2405 MHz, Snobee



PSD, 2440 MHz, Snobee



4 Measurement Uncertainty

Measurement Uncertainty Values		
Test Item		Uncertainty
Output Power		±0.5 dB
Power Spectral Density		±0.5 dB
Out of Band Emissions, Conducted	< 3.6 GHz	±0.6 dB
	> 3.6 GHz	±0.9 dB
Spurious Emissions, Radiated	< 1 GHz	±2.5 dB
	> 1 GHz	±2.2 dB
Emission Bandwidth		±4 %
Power Line Conducted Emissions		+2.9 / -4.1 dB
Spectrum Mask Measurements	Frequency	±5 %
	Amplitude	±1.0 dB
Frequency Error		±0.6 ppm
Temperature Uncertainty		±1 °C

All uncertainty values are expanded standard uncertainty to give a confidence level of 95%, based on coverage factor k=2

5 LIST OF TEST EQUIPMENT

To facilitate inclusion on each page of the test equipment used for related tests, each item of test equipment and ancillaries are identified (numbered) by the testhouse.

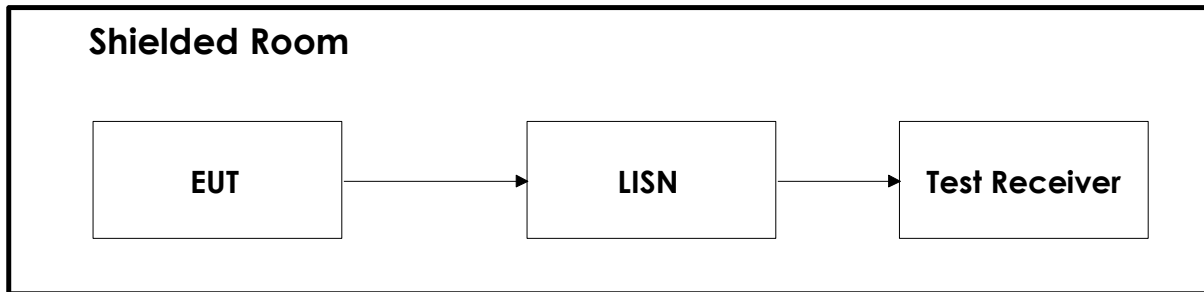
No.	Model number	Description	Manufacturer	Ref. no.	Cal. date	Cal. Due
1	FSW43	Spectrum Analyzer	Rohde & Schwarz	LR 1690	2024-01	2026-01
2	ESU40	Measuring Receiver	Rohde & Schwarz	LR 1639	2024-02	2025-02
3	6810.17B	Attenuator	Suhner	LR 1669	2023-03	2025-03
4	NO324415	Band Reject Filter	Microwave Circuits	LR 1760	COU	
5	JB3	Bilog Antenna	SunAR	N 4525	2023-04	2026-04
6	317	Preamplifier	Sonoma Inst.	LR 1687	2023-09	2024-09
7	3117-PA	Horn Antenna +PreAmp	EMCO	LR 1717	2023-08	2024-08
8	8449A	Pre-amplifier	Hewlett Packard	LR 1322	2023-09	2024-09
9	638	Antenna Horn	Narda	LR 1480	N/A	
10	Model 87V	Multimeter	Fluke	LR 1599	2023-04	2025-04
11	ST18/SMA/N/36	RF Cable	Suhner	LR 1627	COU	
12						
14						
15	The following was used for powering during conducted emissions test					
16	FW7600/05	AC/DC converter 5V	FWHK	/		

The software listed below has been used for one or more tests.

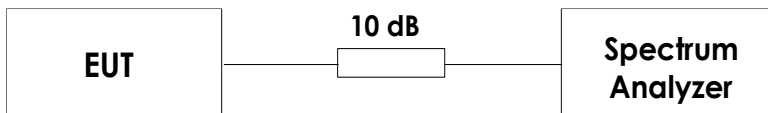
No.	Manufacturer	Name	Version	Comment
1	Rohde & Schwarz	EMC32	10.60	EMC test software
2	Nemko AS	RSPlot	1.0.8	Screenshots from R&S Spectrum Analyzers

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission

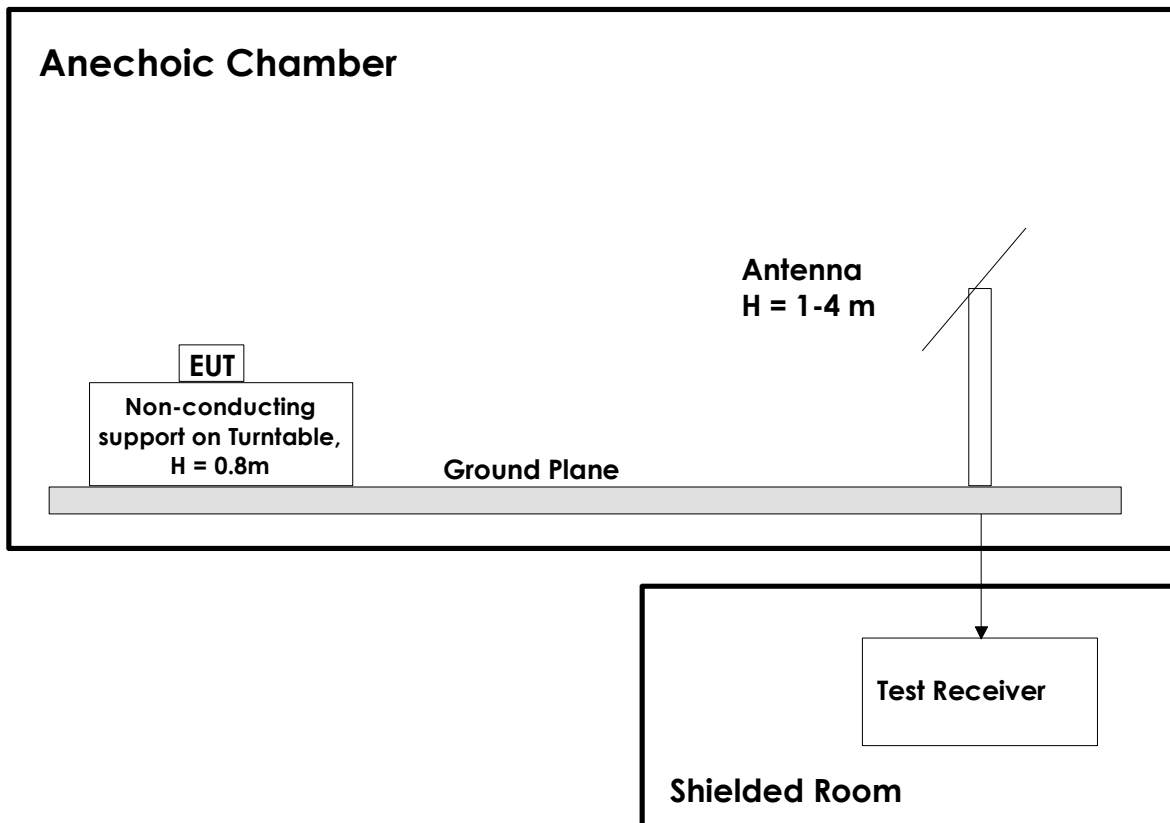


6.2 Conducted Tests



This test set-up is used for all Conducted tests.
For Frequency Stability test the EUT was placed in a climatic chamber.

6.3 Test Site Radiated Emission



This test setup is used for all radiated emissions tests. For frequencies below 30 MHz the measuring distance is 10m, for all other frequencies it is 3m or 1m. Emissions above 1 GHz are measured with a Spectrum Analyzer and Horn Antenna. For measurements above 18 GHz the test receiver is moved inside the anechoic chamber and located next to the antenna to minimize the cable loss. All measurements at 1GHz and above were performed with turntable height 1.5m and with the ground plane covered by absorbers. A pre-amplifier is used for all measurements above 30 MHz, and High-Pass or Band-Pass filter is used for all harmonics.