RF Test Report

Project Number:	**5183320**	**Proposal:**	**SUW-202405006379**
Report Number:	**5183320EMC04**	**Revision Level:**	**6**

Client: **Trackonomy Systems, Inc.**
Equipment Under Test: **Multifunctional IoT Platform Sensor**
Model: **CGB-2002**
FCC ID: **2AXA8-CGB-2002**
IC ID: **27299-CGB2002**

Applicable Standards: **ANSI C63.10: 2013 (FCC Part 15 Subpart C, § 15.247)**
RSS-247, Issue 3, August 2023
RSS-GEN Issue 5

Report issued on: **10 June 2024**
Report revised on: **23 July 2024**
Test Result: **Compliant**

FOR THE SCOPE OF ACCREDITATION UNDER CERTIFICATE NUMBER: 3212.01
This report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the Federal Government.

Tested by: _____
Daniel Alvarez, RF/EMC Sr. Staff Engineer

Reviewed by: _____
Martin Taylor, EMC/RF Sr. Project Engineer

Table of Contents

1 Summary of Test Results

Test Description	Test Specification		Test Result
Duty Cycle	ANSI C63.10	ANSI C63.10	Reported
Bandwidth	15.247(a)(2)	RSS-247 S5.2 (a) RSS-GEN S6.7	Compliant
Output Power	15.247(b)(3)	RSS-247 S5.4 (d)	Compliant
Power Spectral Density	15.247(e)	RSS-247 S5.2 (b)	Compliant
Conducted Spurious Emissions / Band Edge	15.247(d)	RSS-247 S5.5	Compliant
Emissions in Restricted Frequency Bands	15.247(d) 15.205, 15.209	RSS-247 S5.5 RSS-GEN S8.9, S8.10	Compliant
Band Edge Emissions in Restricted Frequency Bands	15.205, 15.209	RSS-GEN S8.9, S8.10	Compliant
AC Powerline Conducted Emissions	15.207	RSS-GEN S8.8	N/A(2)
Antenna Requirement	15.203	RSS-GEN S6.8	Compliant (1)

(1) The device uses surface-mounted device (SMD) antenna which cannot be replaced by the end user.
(2) Product is DC powered. Mains testing does not apply.

1.1 *Modifications Required for Compliance*

None

2 General Information

2.1 *Client Information*

Company Name:	Trackonomy Systems, Inc.
Address:	214 Devcon Drive
City, State, Zip, Country:	San Jose, CA 95112, USA

2.2 *Test Laboratory*

Name:	SGS North America, Inc.
Address:	620 Old Peachtree Road NW, Suite 100
City, State, Zip, Country:	Suwanee, GA 30024, USA
Accrediting Body:	A2LA
Type of lab:	Testing Laboratory
Certificate Number:	3212.01
FCC Designation Number:	US1126
ISED Cab Identifier:	US0186

2.3 *General Information of EUT*

Manufacturer:	Trackonomy Systems, Inc.
Type of Product:	Multifunctional IoT Platform Sensor
Model Number (HVIN):	CGB-2002
Serial Number:	Sample 1 (Conducted Sample); Sample 2 (Radiated Sample)
Type / Frequency Range:	BLE / 2402 – 2480 MHz
Modulation / Data Rate(s):	GFSK / 2M PHY
Antenna:	Serica: SR4W035 SMD Antenna; +3.5 dBi*
Type / Frequency Range:	Lora / 2402 – 2480 MHz
Modulation / Data Rate(s):	CSS / 400, 800, 1600 kHz
Antenna:	Mixtus: A10194H SMD Antenna; +1.8 dBi*
Rated Voltage:	3 VDC
Test Voltage:	3 VDC
Sample Received Date:	05/15/2024
Dates of testing:	05/15/2024 – 07/22/2024

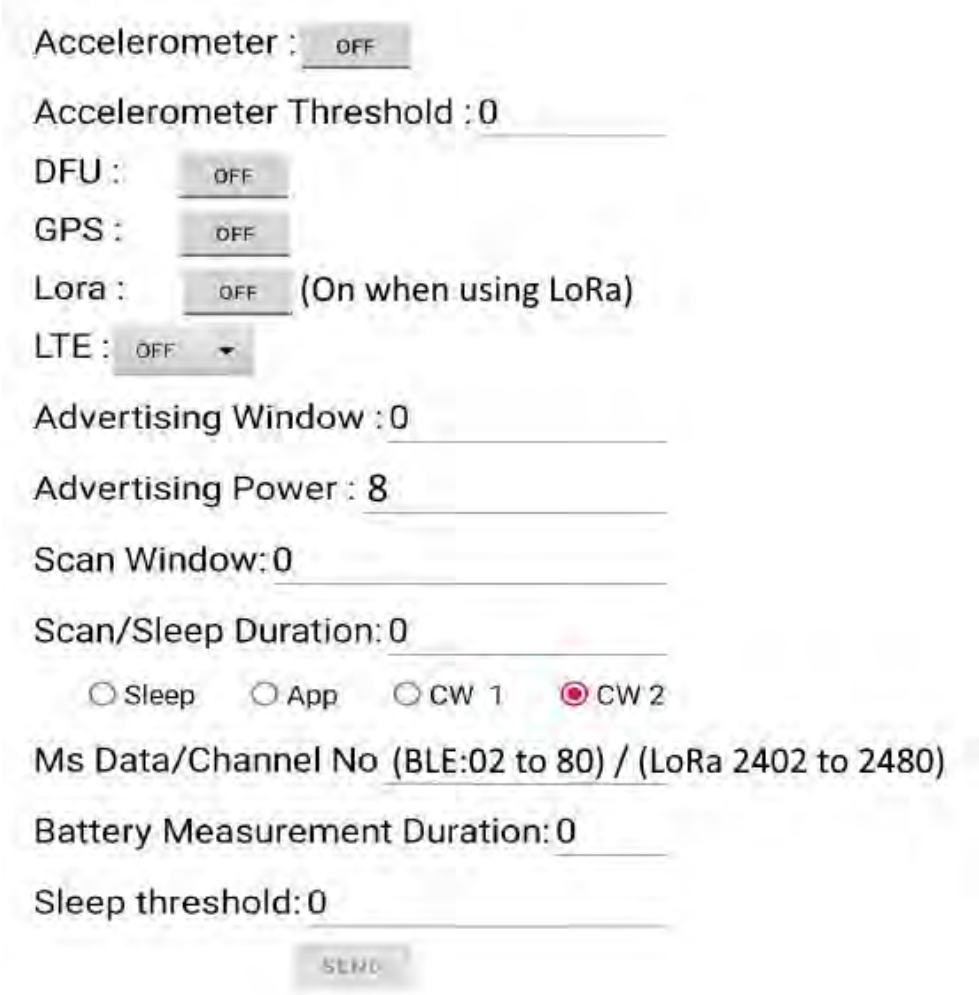
**Data was not measured; therefore, the lab is not responsible for accuracy. Data was obtained via customer, specification sheet, previous regulatory filing, or other means.*

2.4 *Product Description:*

The CGB-2002 is a multifunctional internet of all things platform sensor that allows the user to create a network of interconnected objects that enables the user to share information, including any possible distress signatures, from visibility and observation to process control, optimization, and autonomous workflows, through the use of platform fostered and AI-driven processes.

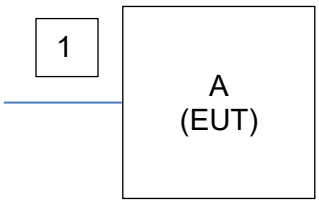
2.5 *Operating Modes and Conditions*

Firmware: V2
Software Settings: The EUT could be programmed to transmit through BLE or LORA communications. Each test section in the report specified the worst-case data rate utilized for each test.
Output: Was set to maximum output power. (Note: No input signal was needed or used during testing. The EUT used its wireless BLE connection to set the operating configurations for each test prior to testing.)
Test levels were set in accordance with the Device Test Procedure CGB-2002. Trackonomy software version 9.0.2 was used.

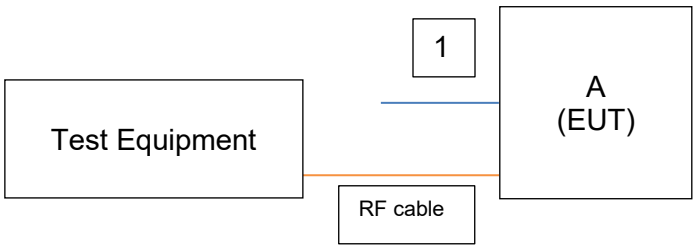


During emissions testing, the EUT was powered at its 3VDC test voltage and set to its test mode to exercise the transmitter during testing.

2.6 *EUT Connection Block Diagram – Radiated Measurements*



2.7 *EUT Connection Block Diagram – Conducted Measurements*



2.8 *System Configurations*

Device reference	Manufacturer	Description	Model Number	Serial Number
A	Trackonomy Systems, Inc.	Multifunctional IoT Platform Sensor (Conducted Sample)	CGB-2002	Sample 1
A	Trackonomy Systems, Inc.	Multifunctional IoT Platform Sensor (Radiated Sample)	CGB-2002	Sample 2

2.9 *Cable List*

Cable reference	Port Name	Start	End	Cable Length (m)	Ferrite installed?	Shielded?
1	DC Power Cable	EUT	External AC Adapter	<0.1	N	N

3 Duty Cycle

3.1 *Test Result*

Test Description	Reference Clause Number	Test Result
	ANSI C63.10	
Duty Cycle	11.6	Reported

3.2 *Test Method*

Duty cycle was measured according to the methods defined in ANSI C63.10 clause 11.6.

Limits

For devices operating under the provisions of FCC CFR47 Part 15.247, there is no requirement for duty cycle. However, the duty cycle can be used to derive a duty cycle correction factor (DCCF) that can be used when performing RSE measurements. Highest and lowest data rate for LoRa was reported.

3.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions:	15-May-2024	17-July-2024
Temperature:	23.46 °C	23.21 °C
Relative Humidity:	51.3 %	52.1 %
Atmospheric Pressure:	98.37 kPa	98.13 kPa

3.4 *Test Equipment*

Test End Date: 15-May-2024 Tester:SGM

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	20-Mar-2024	20-Mar-2025
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	3-Jan-2024	3-Jan-2025
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

Software Profile:
TSTPASS Version: 2.0 (2024.05.01_17.31.12)

Test End Date: 17-July-2024 Tester:SGM

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	20-Mar-2024	20-Mar-2025
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	3-Jan-2024	3-Jan-2025
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

Software Profile: No Software Used. Manual Measurements.

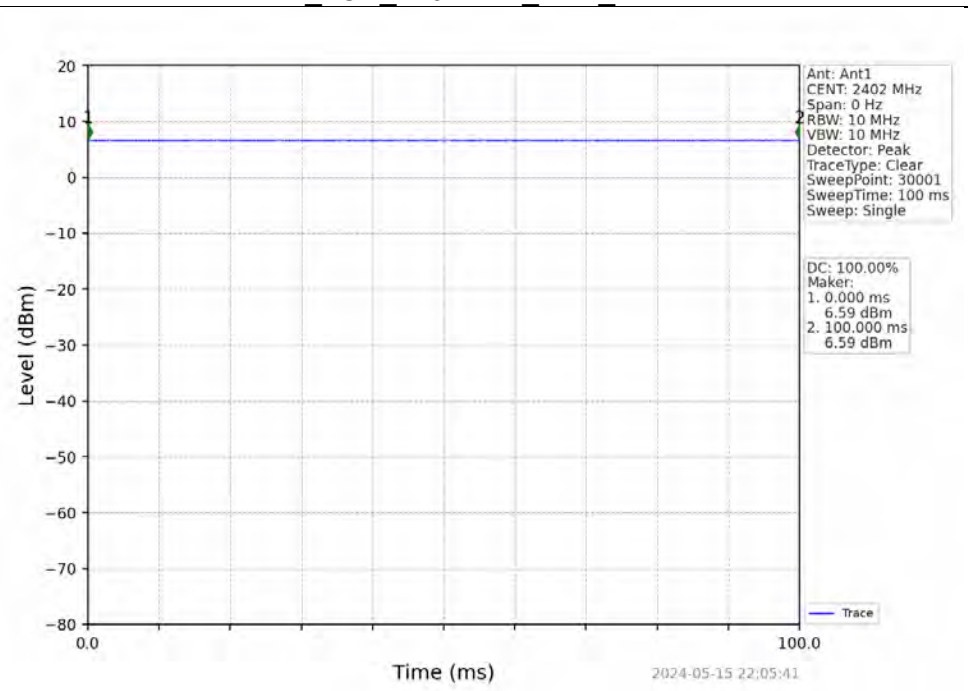
3.5 *Test Data*

Duty Cycle for BLE = 100 %
Duty Cycle for Lora = See Tables

BLE

Mode	TX Type	Frequency (MHz)	T_on (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	Max. DC Variation (%)
2M	SISO	2402	100.000	100.000	100.00	0.00	0.00
		2440	100.000	100.000	100.00	0.00	0.00
		2480	100.000	100.000	100.00	0.00	0.00

2M_LCH_2402MHz_Ant1_NTNV



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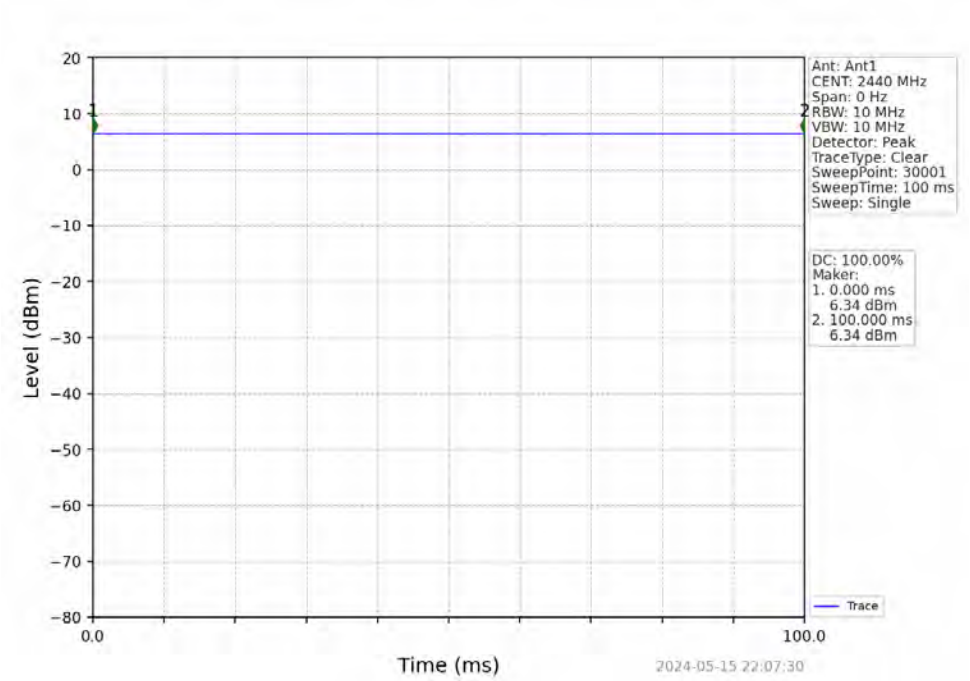
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Span: 0 Hz
RBW: 10 MHz
VBW: 10 MHz
Detector: Peak
TraceType: Clear
SweepPoint: 30001
SweepTime: 100 ms
Sweep: Single
DC: 100.00%
Maker:
1. 0.000 ms
6.34 dBm
2. 100.000 ms
6.34 dBm
Trace
Level (dBm)
Time (ms)
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100.0
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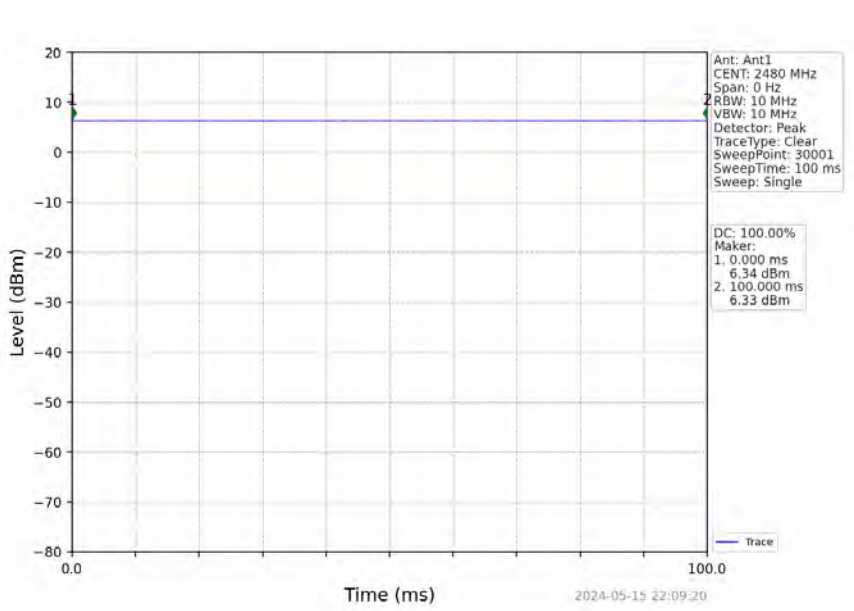
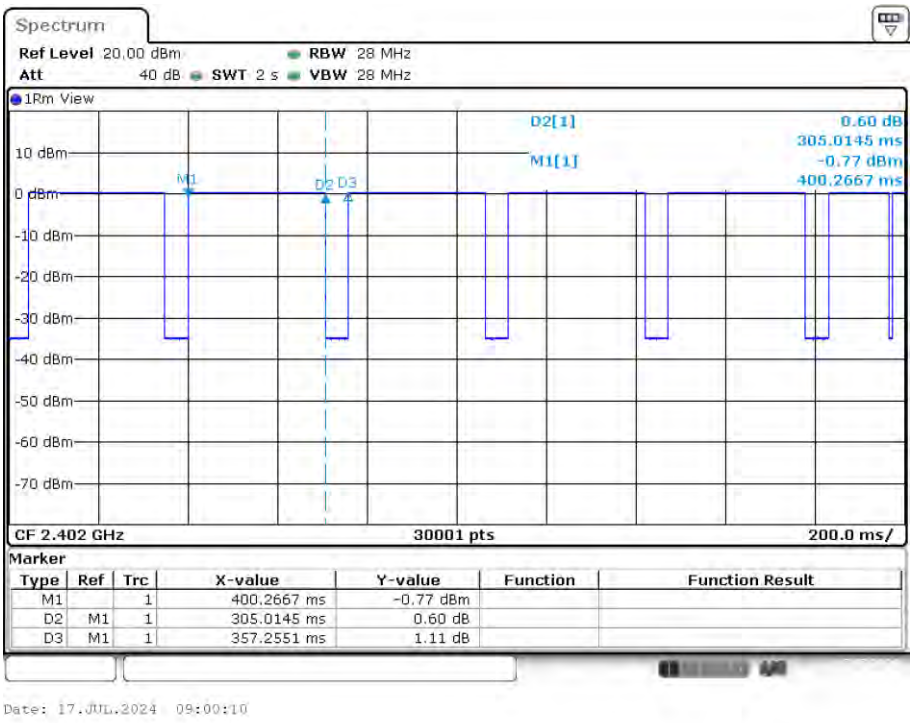
2M_HCH_2480MHz_Ant1_NTNV



LORA (400kHz BW):

Frequency (MHz)	Time On (ms)	Total (ms)	Duty Cycle (%)
2402	305.01	357.26	85.38
2440	304.41	357.15	85.23
2480	304.48	357.32	85.21

1_LCH_2402MHz_Ant1_NTNV



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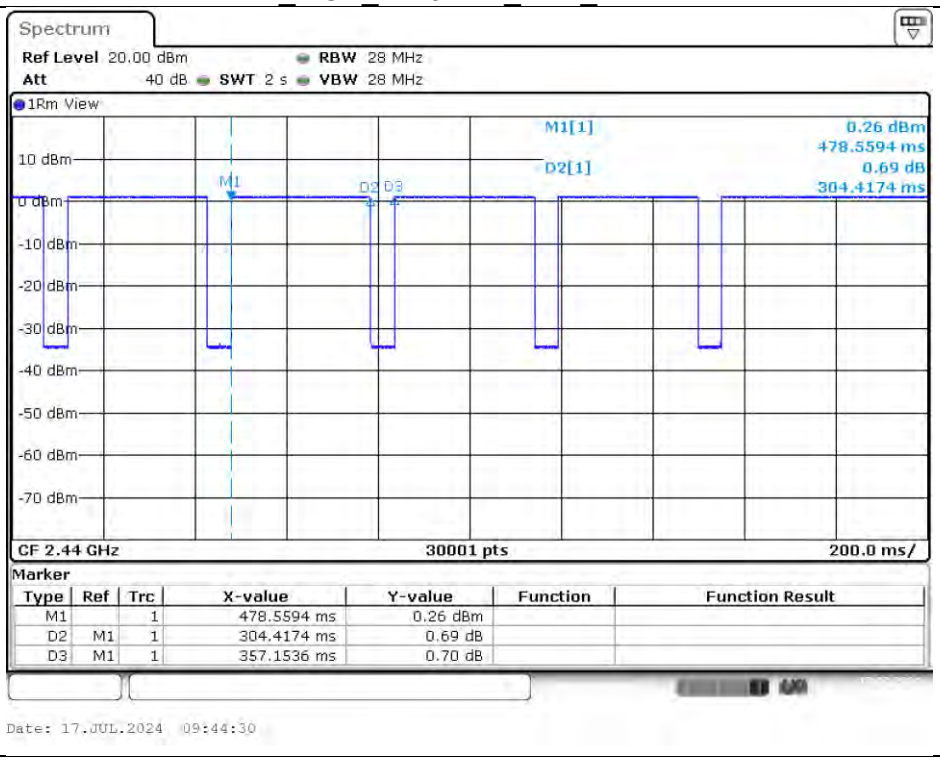
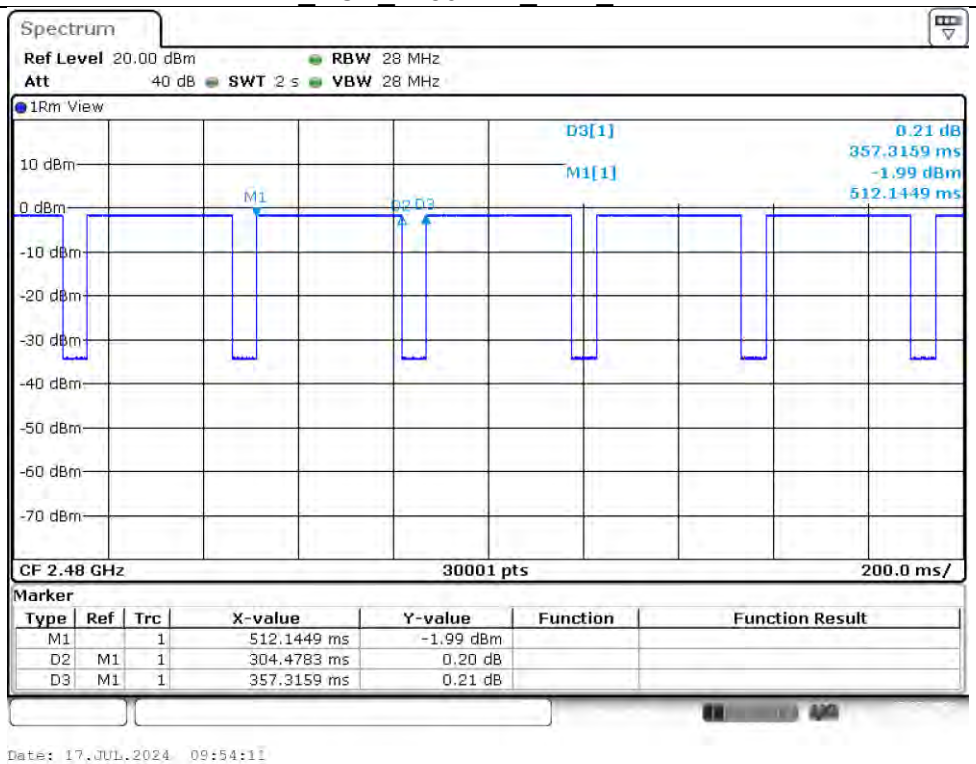


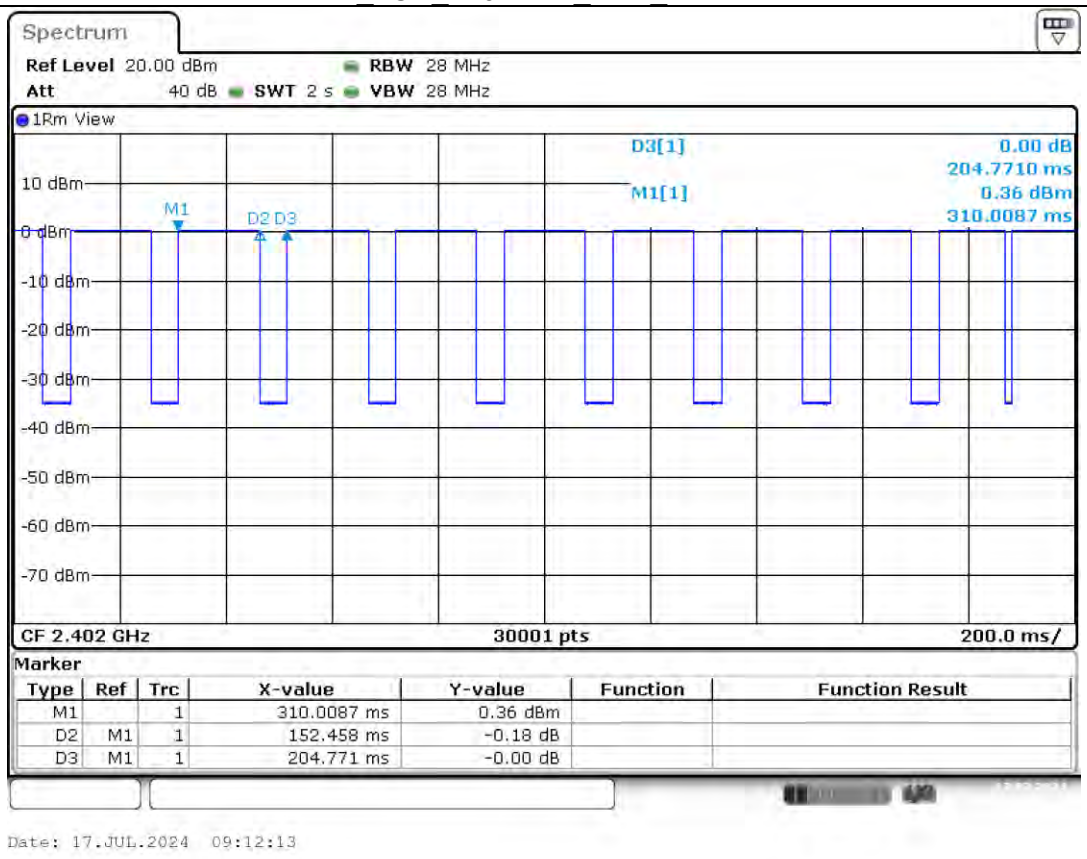
1_HCH_2480MHz_Ant1_NTNV



LORA (800kHz BW):

Frequency (MHz)	Time On (ms)	Total (ms)	Duty Cycle (%)
2402	152.46	204.77	74.45
2440	152.34	204.78	74.39
2480	152.41	204.80	74.42

1_LCH_2402MHz_Ant1_NTNV



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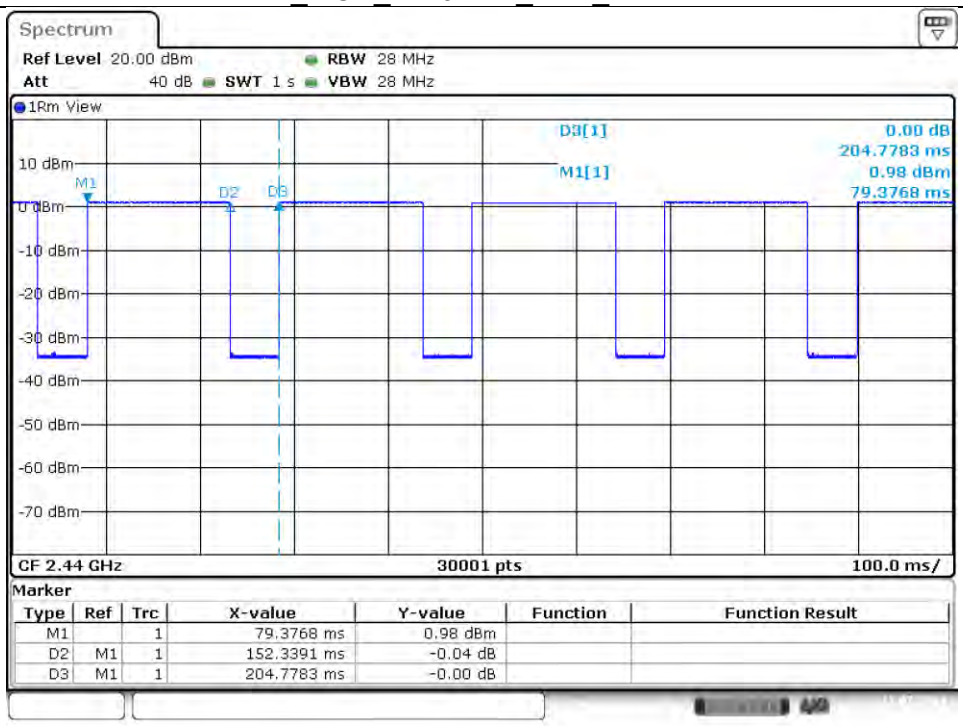
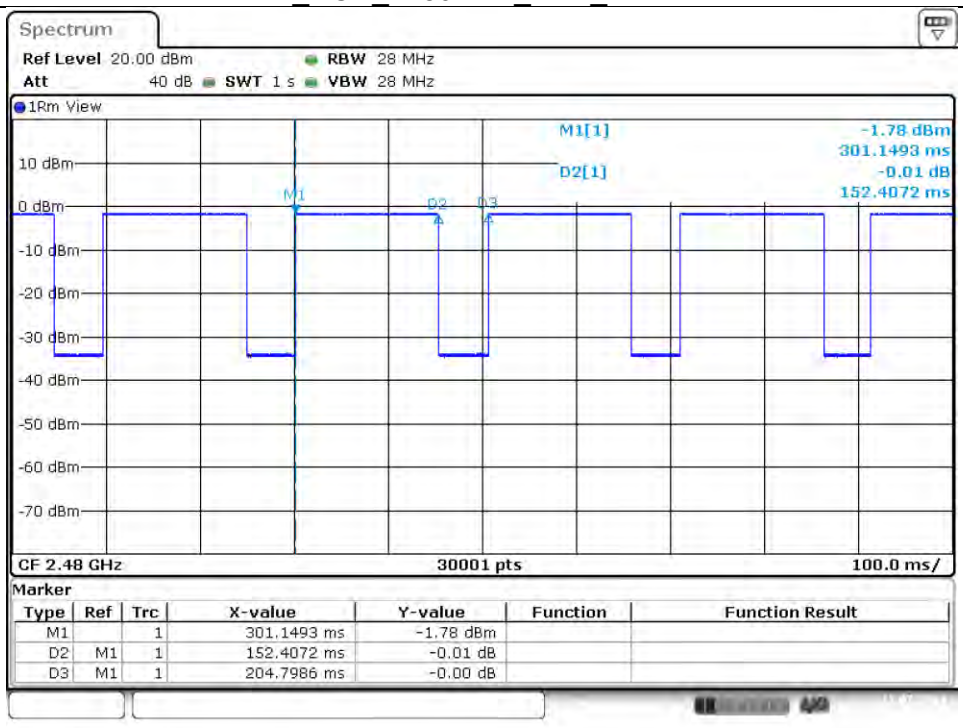


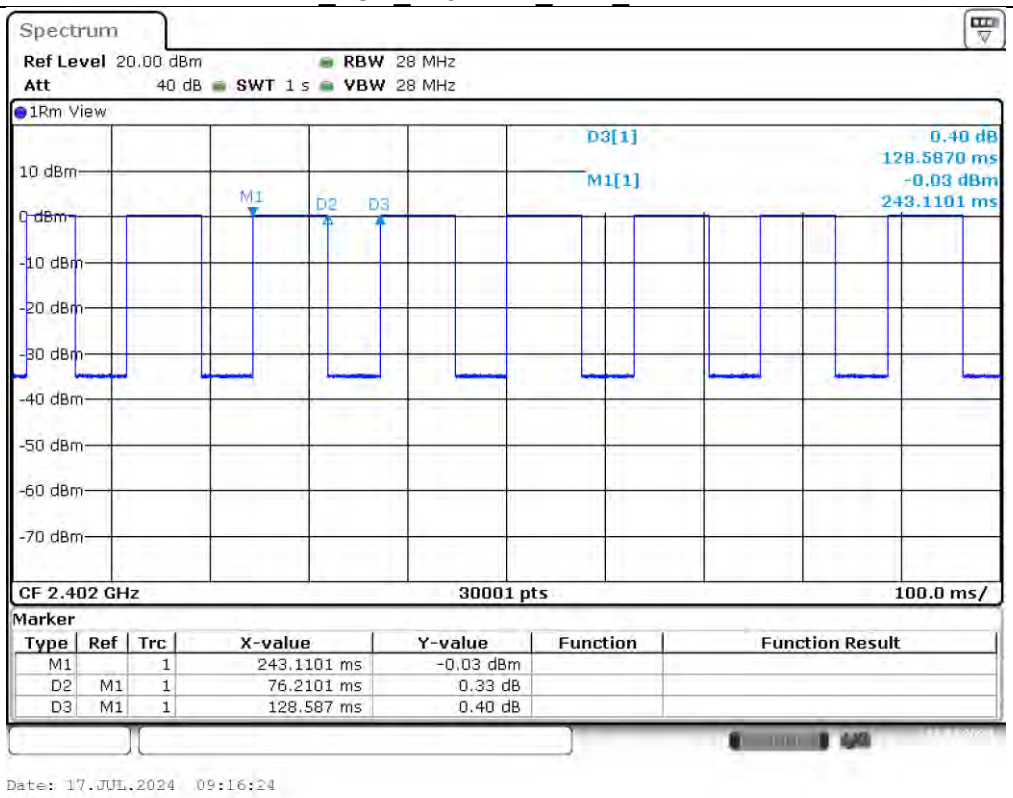
1_HCH_2480MHz_Ant1_NTNV



LORA (1600kHz BW):

Frequency (MHz)	Time On (ms)	Total (ms)	Duty Cycle (%)
2402	76.21	128.59	59.27
2440	76.26	128.47	59.36
2480	76.26	128.49	59.35

1_LCH_2402MHz_Ant1_NTNV



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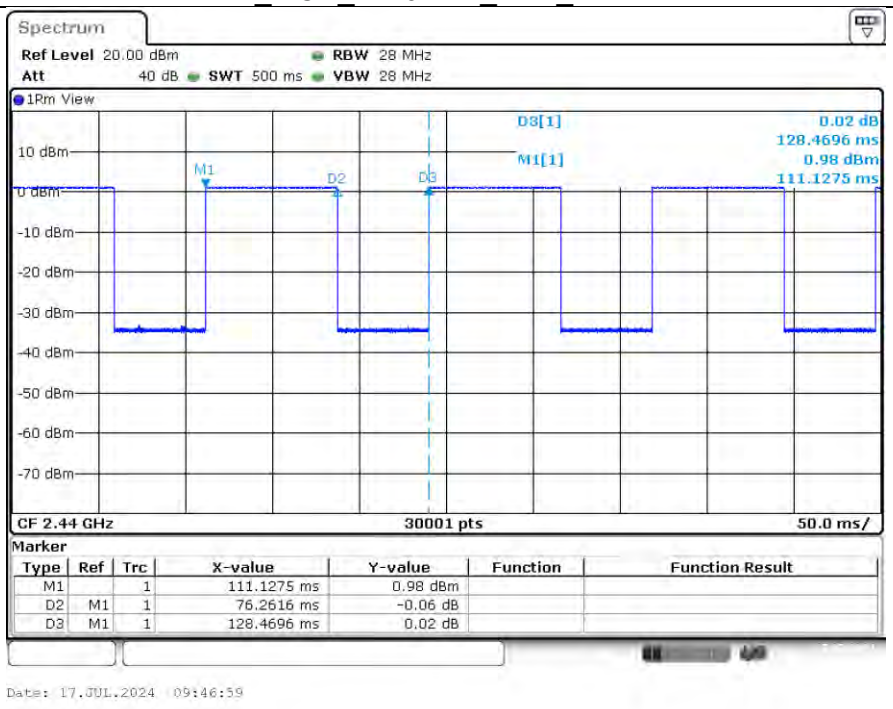
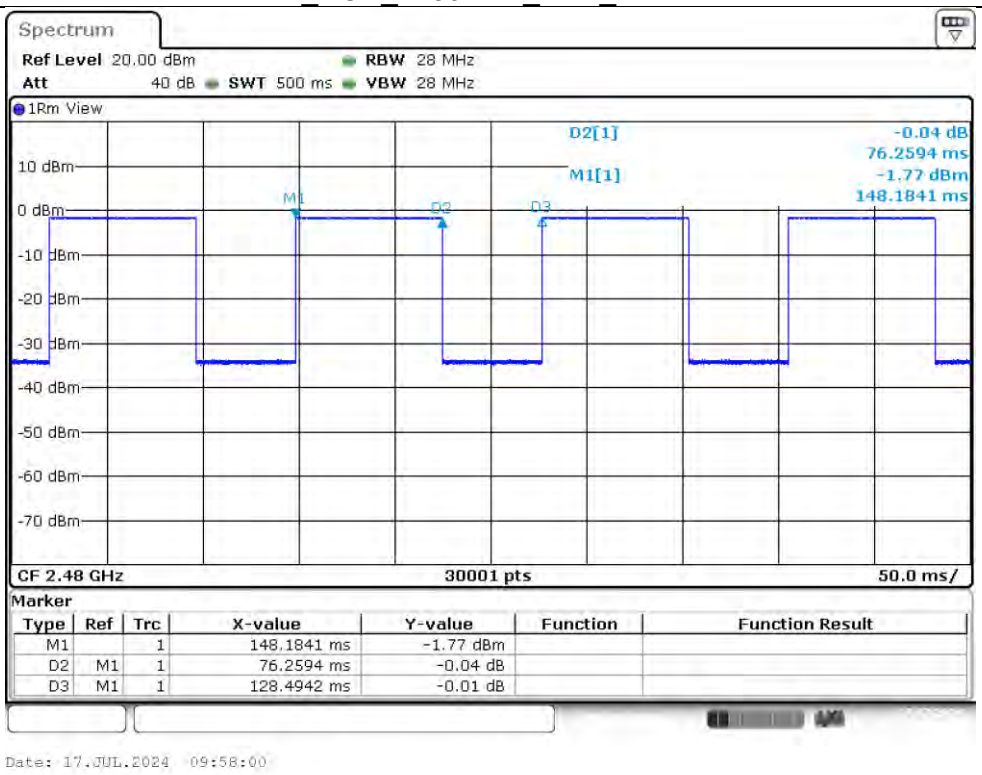


1_HCH_2480MHz_Ant1_NTNV



4 Bandwidth

4.1 *Test Result*

Test Description	Test Specification		Test Result
DTS Bandwidth (6dB)	15.247(a)(2)	RSS-247 S5.2 (a)	Compliant
Occupied Bandwidth (99%)	2.1049	RSS-GEN S6.7	Reported

4.2 *Test Methods*

The DTS 6dB bandwidth measurements were performed using the procedure from ANSI C63.10 clause 11.8.1, and the 99% occupied bandwidth measurements were performed using the procedure from ANSI C63.10 clause 6.9.3. These procedures are referenced in KDB 558074 D01 15.247 Meas Guidance v05r02.

The BLE 2M PHY data mode was used for this test. Lowest and Highest Bandwidths were reported for LoRa.

Limit
The minimum 6dB bandwidth shall be at least 500 kHz.

4.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	23.46 °C
Relative Humidity:	51.3 %
Atmospheric Pressure:	98.37 kPa

4.4 *Test Equipment*

Test End Date: 22-May-2024 Tester:SGM

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	20-Mar-2024	20-Mar-2025
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	3-Jan-2024	3-Jan-2025
TSTPASS SWITCHBOX	SB2	TSTPASS	23009	8-Apr-2024	8-Apr-2025
MULTIMETER	87V	FLUKE	23014	30-Aug-2023	30-Aug-2024
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

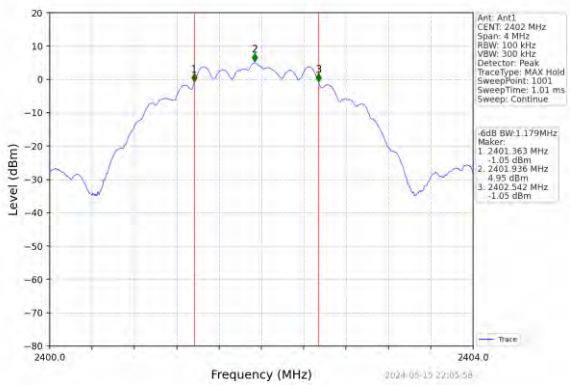
Software Profile:
TSTPASS Version: 2.0 (2024.05.01_17.31.12)

4.5 *Test Data – DTS Bandwidth (6dB) - BLE*

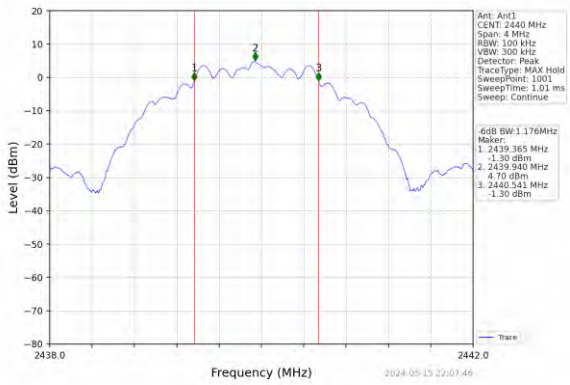
Mode	TX Type	Frequency (MHz)	ANT	6dB Bandwidth (MHz) Result	Verdict Limit
2M	SISO	2402	1	1.179	>=0.5
	SISO	2440	1	1.176	>=0.5
	SISO	2480	1	1.175	>=0.5

Representative Plot(s)

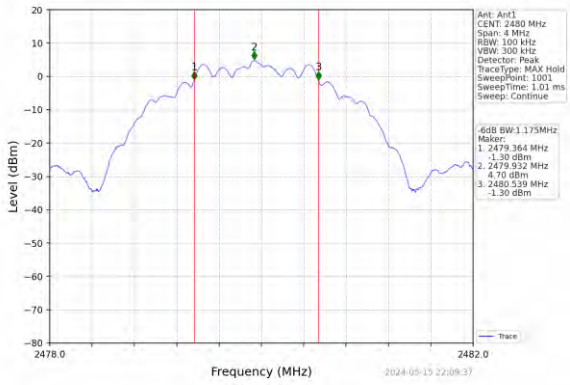
2M_LCH_2402MHz_Ant1_NTNV



2M_MCH_2440MHz_Ant1_NTNV



2M_HCH_2480MHz_Ant1_NTNV

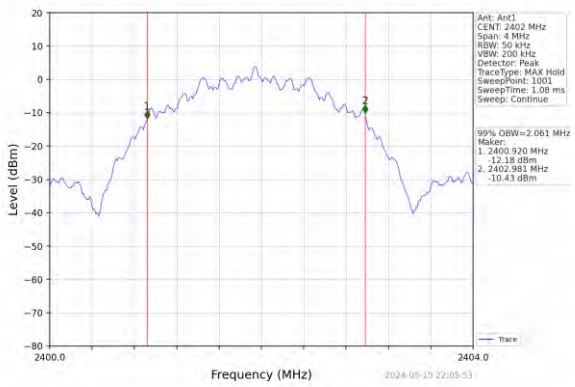


4.6 *Test Data – 99% Occupied Bandwidth - BLE*

Mode	TX Type	Frequency (MHz)	ANT	99% Occupied Bandwidth (MHz)	
				Result	
2M	SISO	2402	1	2.061	Reported
	SISO	2440	1	2.065	Reported
	SISO	2480	1	2.071	Reported

Representative Plot(s)

2M_LCH_2402MHz_Ant1_NTNV



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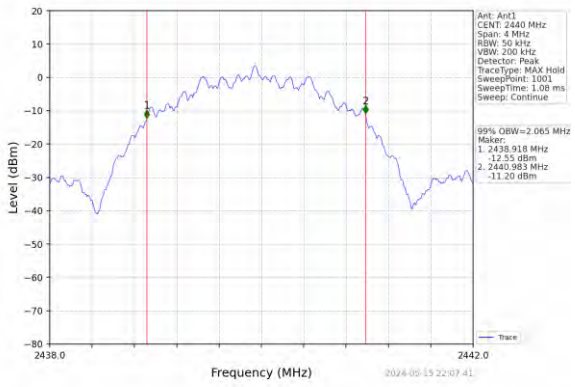
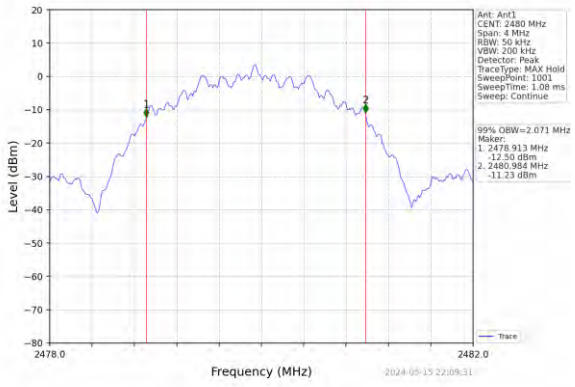


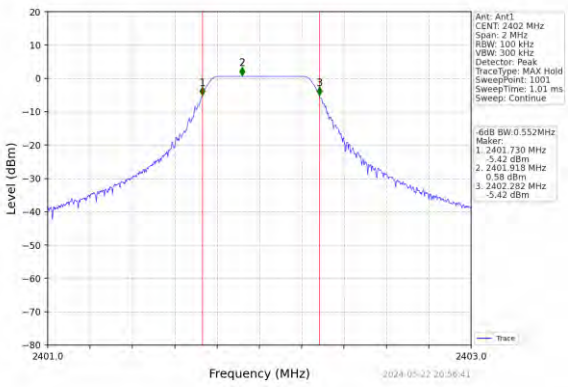
2M_HCH_2480MHz_Ant1_NTNV



4.7 *Test Data – DTS Bandwidth (6dB) – LoRa (400 kHz)*

Mode	TX Type	Frequency (MHz)	ANT	6dB Bandwidth (MHz)		Verdict
				Result	Limit	
1	SISO	2402	1	0.552	>=0.5	Pass
		2440	1	0.562	>=0.5	Pass
		2480	1	0.557	>=0.5	Pass

1_LCH_2402MHz_Ant1_NTNV



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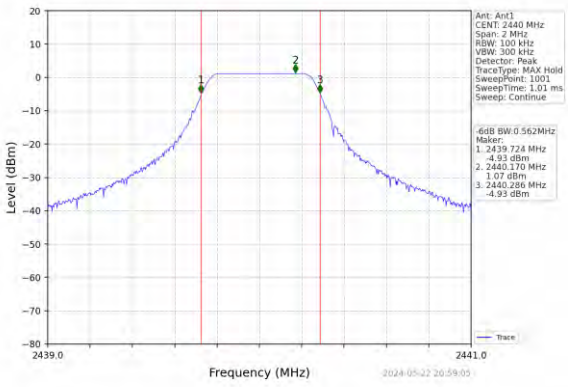
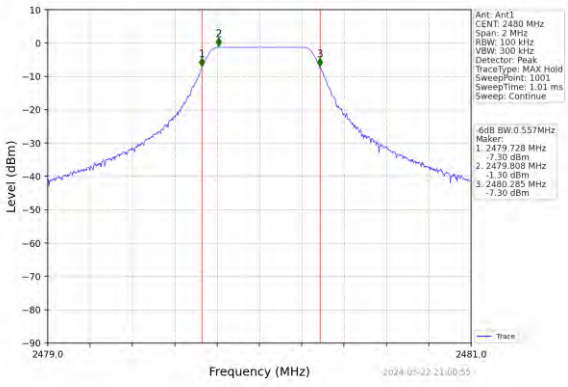


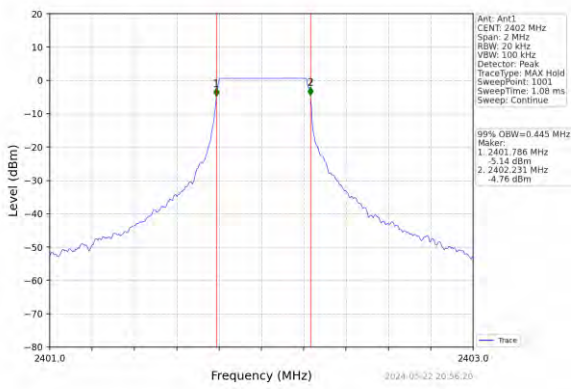
1_HCH_2480MHz_Ant1_NTNV



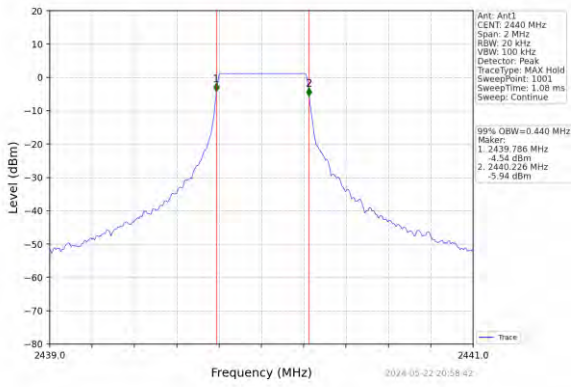
4.8 *Test Data – 99% Occupied Bandwidth – LoRa (400 kHz)*

Mode	TX Type	Frequency (MHz)	ANT	99% Occupied Bandwidth (MHz)		Verdict
				Result	Limit	
1	SISO	2402	1	0.445	/	Pass
		2440	1	0.440	/	Pass
		2480	1	0.441	/	Pass

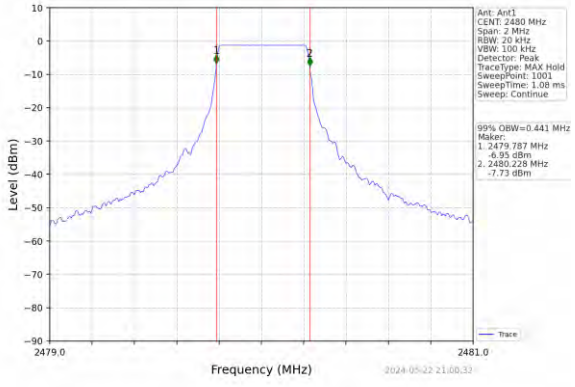
1_LCH_2402MHz_Ant1_NTNV



1_MCH_2440MHz_Ant1_NTNV



1_HCH_2480MHz_Ant1_NTNV

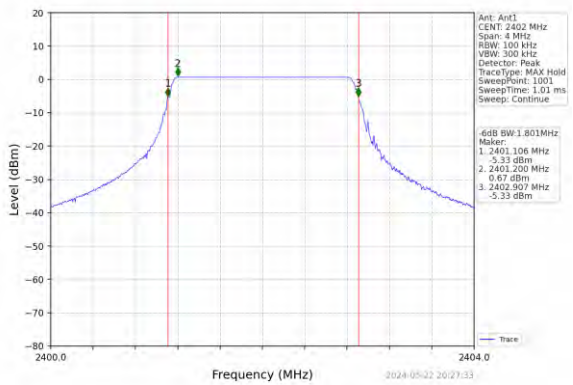


4.9 *Test Data – DTS Bandwidth (6dB) – LoRa (1600 kHz)*

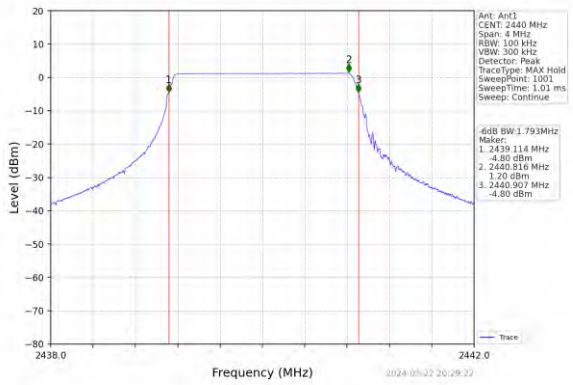
Mode	TX Type	Frequency (MHz)	ANT	6dB Bandwidth (MHz)		Verdict
				Result	Limit	
1	SISO	2402	1	1.801	>=0.5	Pass
		2440	1	1.793	>=0.5	Pass
		2480	1	1.795	>=0.5	Pass

Representative Plot(s)

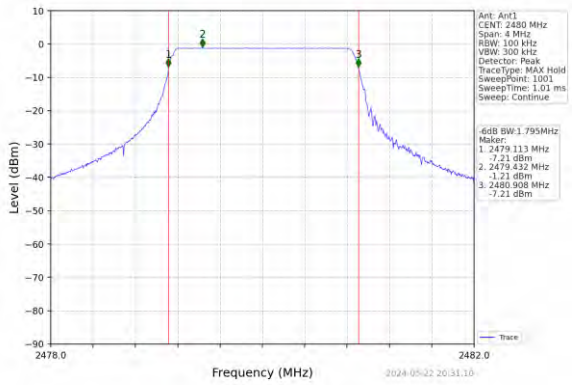
1_LCH_2402MHz_Ant1_NTNV



1_MCH_2440MHz_Ant1_NTNV



1_HCH_2480MHz_Ant1_NTNV

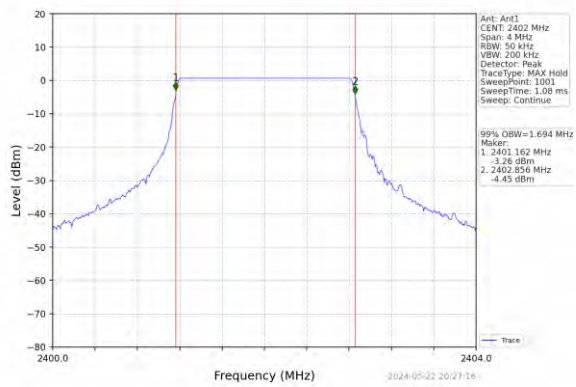


4.10 *Test Data – 99% Occupied Bandwidth – LoRa (1600 kHz)*

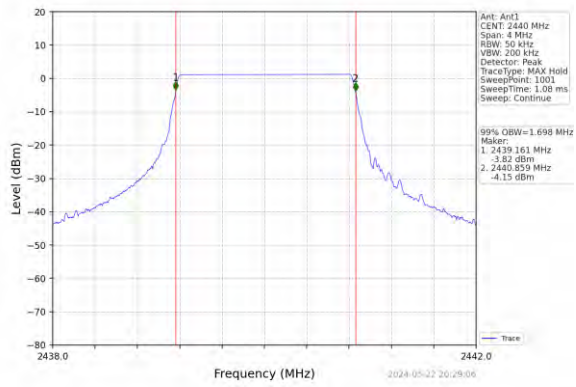
Mode	TX Type	Frequency (MHz)	ANT	99% Occupied Bandwidth (MHz)		Verdict
				Result	Limit	
1	SISO	2402	1	1.694	/	Pass
		2440	1	1.698	/	Pass
		2480	1	1.692	/	Pass

Representative Plots

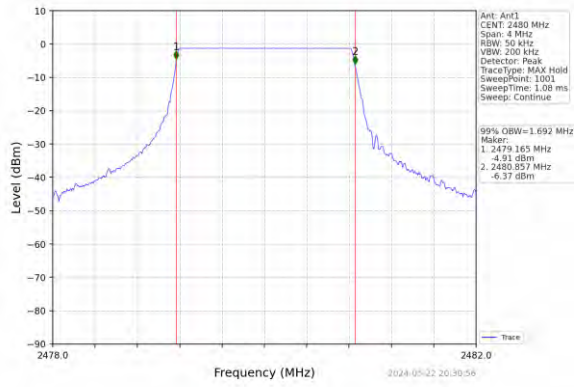
1_LCH_2402MHz_Ant1_NTNV



1_MCH_2440MHz_Ant1_NTNV



1_HCH_2480MHz_Ant1_NTNV



5 Output Power

5.1 *Test Result*

Test Description	Test Specification		Test Result
Fundamental Emission Output Power	15.247(b)(3)	RSS-247 S5.4 (d)	Compliant

5.2 *Test Method*

Fundamental maximum peak conducted output power measurements were performed using the method described in ANSI C63.10:2013 clause 11.9.1.1. This procedure is referenced in KDB 558074 D01 15.247 Meas Guidance v05r02.

The BLE 2M PHY data mode was used for this test. All data rates for LoRa were used for this test.

Limit

For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. For using antennas with greater than 6dBi of gain, the limit is reduced in dB by the amount the gain exceeds 6dBi (e.g. for a 7.4dBi antenna, the limit is reduced from 30dBm to 28.6dBm). Also, the e.i.r.p. shall not exceed 4 Watts (36 dBm) based on RSS-247 S5.4 (d).

5.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	23.46 °C
Relative Humidity:	51.3 %
Atmospheric Pressure:	98.37 kPa

5.4 *Test Equipment*

Test End Date: 22-May-2024 Tester:SGM

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	20-Mar-2024	20-Mar-2025
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	3-Jan-2024	3-Jan-2025
TSTPASS SWITCHBOX	SB2	TSTPASS	23009	8-Apr-2024	8-Apr-2025
MULTIMETER	87V	FLUKE	23014	30-Aug-2023	30-Aug-2024
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

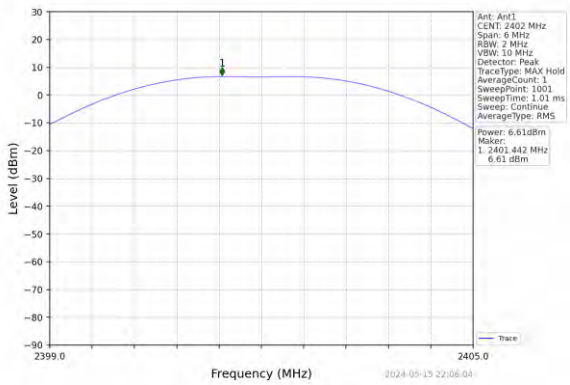
Software Profile:
TSTPASS Version: 2.0 (2024.05.01_17.31.12)

5.5 *Test Data - BLE*

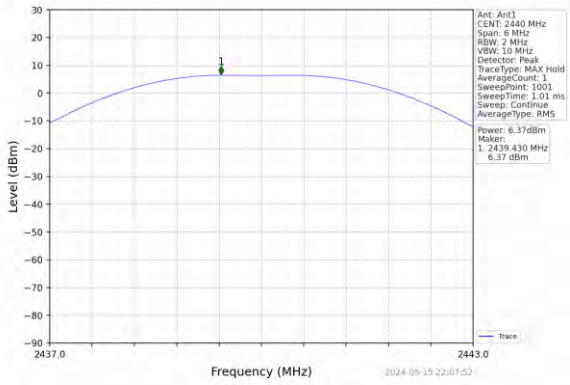
Mode	TX Type	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)		Verdict
			ANT1	Limit	
2M	SISO	2402	6.61	<=30	Pass
		2440	6.37	<=30	Pass
		2480	6.37	<=30	Pass
Note1: Antenna Gain: Ant1: 3.50dBi;					

Representative Plot(s)

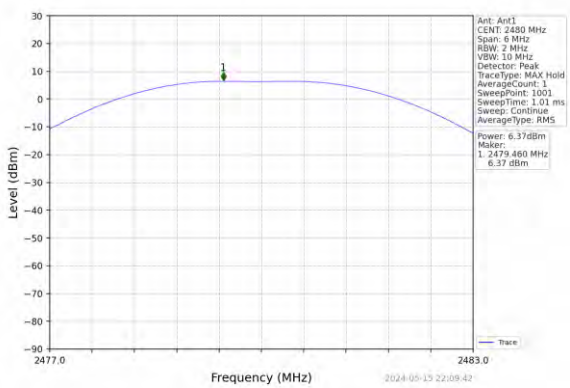
2M_LCH_2402MHz_Ant1_NTNV



2M_MCH_2440MHz_Ant1_NTNV



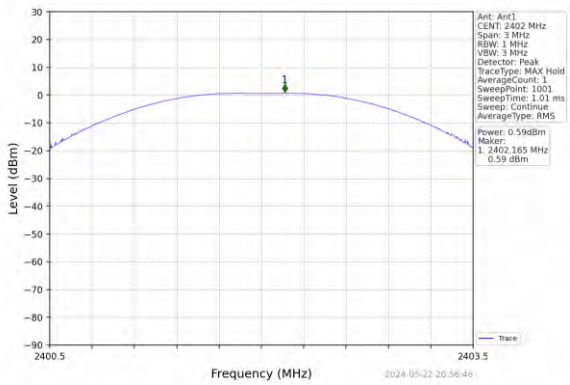
2M_HCH_2480MHz_Ant1_NTNV



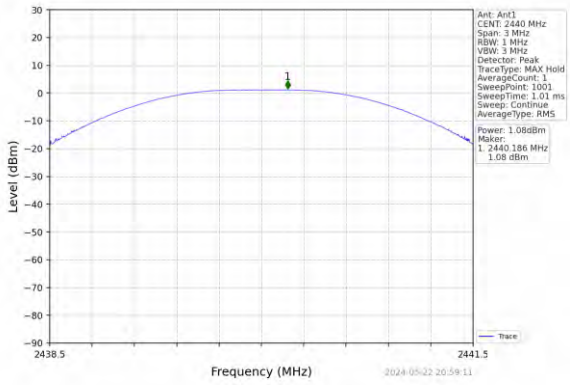
5.6 *Test Data – LoRa (400 kHz)*

Mode	TX Type	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)		Verdict
			ANT1	Limit	
1	SISO	2402	0.59	<=30	Pass
		2440	1.08	<=30	Pass
		2480	-0.73	<=30	Pass
Note1: Antenna Gain: Ant1: 1.80dBi;					

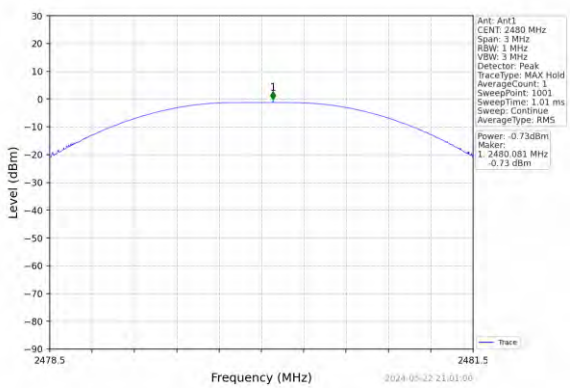
1_LCH_2402MHz_Ant1_NTNV



1_MCH_2440MHz_Ant1_NTNV



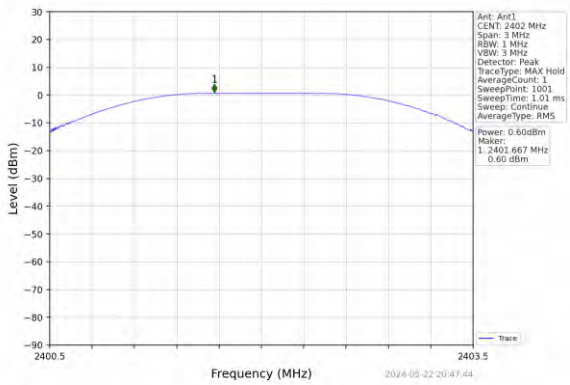
1_HCH_2480MHz_Ant1_NTNV



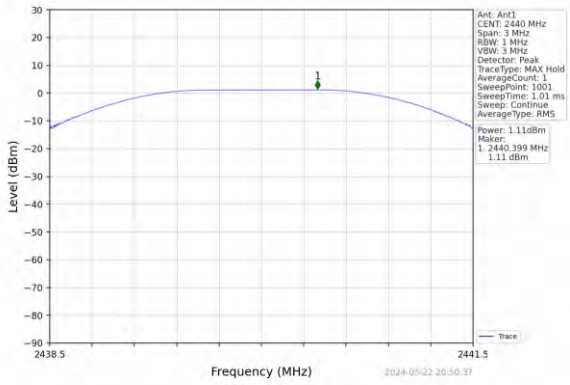
5.7 *Test Data – LoRa (800 kHz)*

Mode	TX Type	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)		Verdict
			ANT1	Limit	
1	SISO	2402	0.60	<=30	Pass
		2440	1.11	<=30	Pass
		2480	-0.90	<=30	Pass
Note1: Antenna Gain: Ant1: 1.80dBi;					

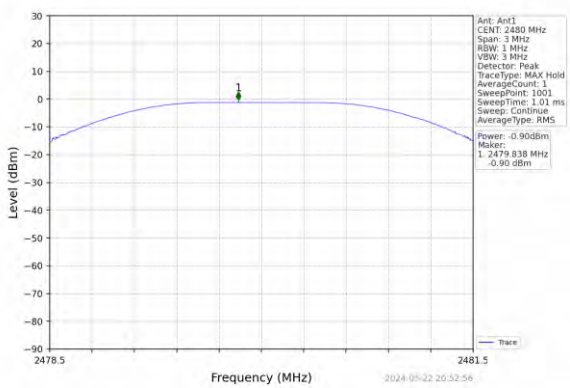
1_LCH_2402MHz_Ant1_NTNV



1_MCH_2440MHz_Ant1_NTNV



1_HCH_2480MHz_Ant1_NTNV

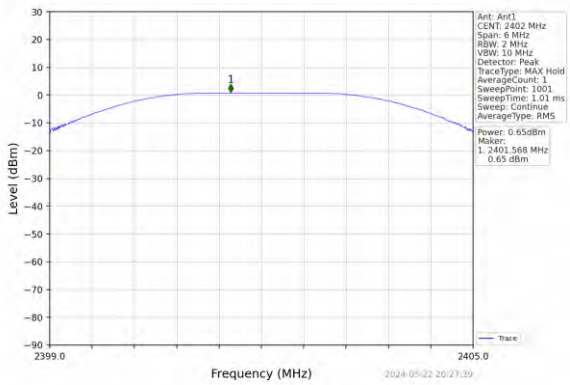


5.8 *Test Data – LoRa (1600 kHz)*

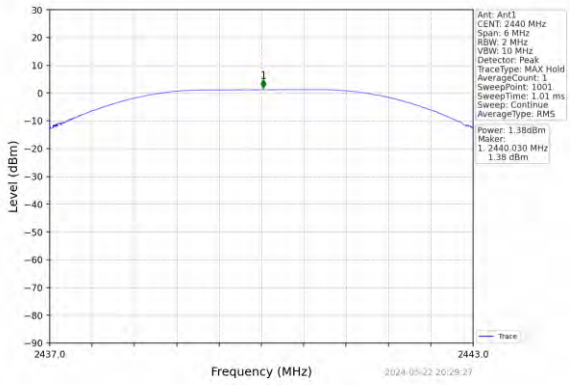
Mode	TX Type	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)		Verdict
			ANT1	Limit	
1	SISO	2402	0.65	<=30	Pass
		2440	1.38	<=30	Pass
		2480	-0.50	<=30	Pass
Note1: Antenna Gain: Ant1: 1.80dBi;					

Representative Plots

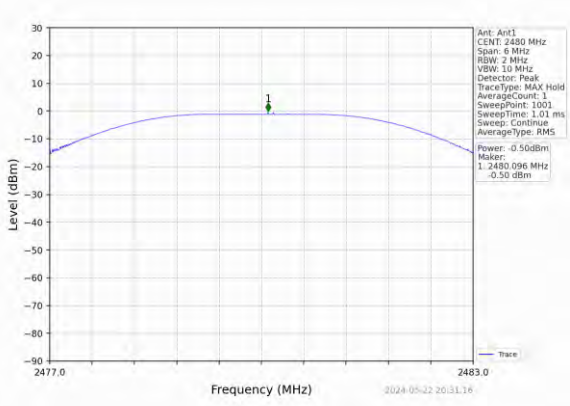
1_LCH_2402MHz_Ant1_NTNV



1_MCH_2440MHz_Ant1_NTNV



1_HCH_2480MHz_Ant1_NTNV



6 Power Spectral Density

6.1 *Test Result*

Test Description	Test Specification		Test Result
Power Spectral Density	15.247(e)	RSS-247 S5.2 (b)	Compliant

6.2 *Test Method*

Peak power spectral density measurements were performed using the procedures from ANSI C63.10: 2013 clause 11.10.2. These procedures are referenced in KDB 558074 D01 15.247 Meas Guidance v05r02.

The BLE 2M PHY data mode was used for this test. Lowest and Highest data rate for Lora was used for this test.

Limit
The maximum limit is 8 dBm / 3 kHz.

6.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	23.46 °C
Relative Humidity:	51.3 %
Atmospheric Pressure:	98.37 kPa

6.4 *Test Equipment*

Test End Date: 22-May-2024 Tester:SGM

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	20-Mar-2024	20-Mar-2025
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	3-Jan-2024	3-Jan-2025
TSTPASS SWITCHBOX	SB2	TSTPASS	23009	8-Apr-2024	8-Apr-2025
MULTIMETER	87V	FLUKE	23014	30-Aug-2023	30-Aug-2024
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

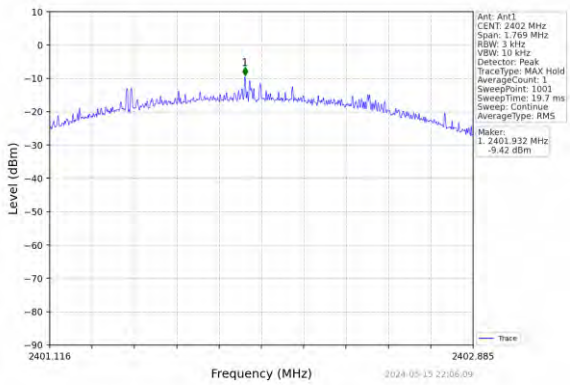
Software Profile:
TSTPASS Version: 2.0 (2024.05.01_17.31.12)

6.5 *Test Data - BLE*

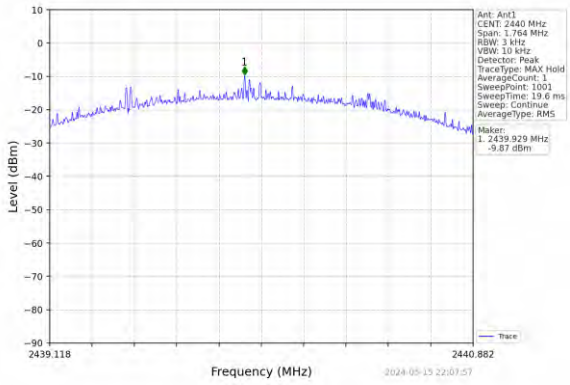
Mode	TX Type	Frequency (MHz)	Maximum PSD (dBm/3kHz)		Verdict
			ANT1	Limit	
2M	SISO	2402	-9.42	<=8	Pass
		2440	-9.87	<=8	Pass
		2480	-9.82	<=8	Pass
Note1: Antenna Gain: Ant1: 3.50dBi;					

Representative Plot(s)

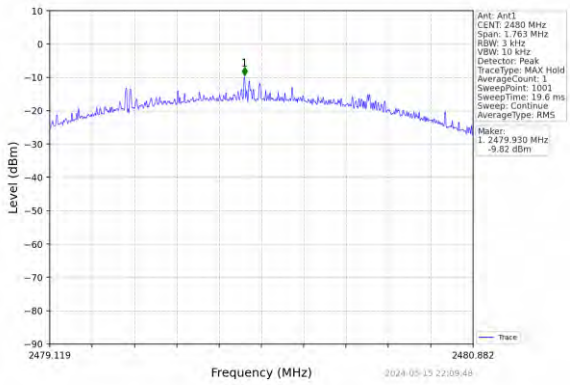
2M_LCH_2402MHz_Ant1_NTNV



2M_MCH_2440MHz_Ant1_NTNV



2M_HCH_2480MHz_Ant1_NTNV



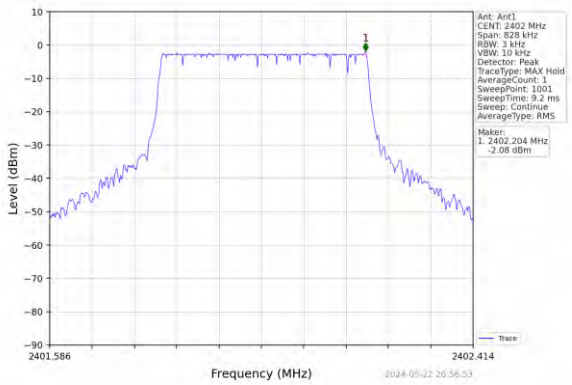
6.6 *Test Data – LoRa*

400 kHz data rate

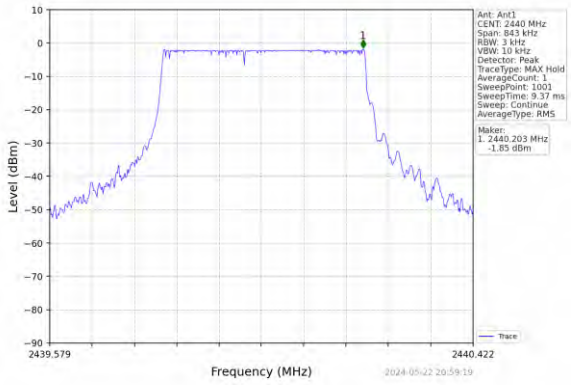
Mode	TX Type	Frequency (MHz)	Maximum PSD (dBm/3kHz)		Verdict
			ANT1	Limit	
1	SISO	2402	-2.08	<=8	Pass
		2440	-1.85	<=8	Pass
		2480	-3.91	<=8	Pass
Note1: Antenna Gain: Ant1: 1.80dBi;					

Representative Plots

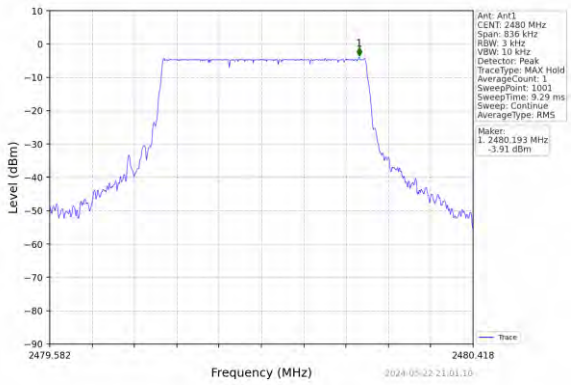
1_LCH_2402MHz_Ant1_NTNV



1_MCH_2440MHz_Ant1_NTNV



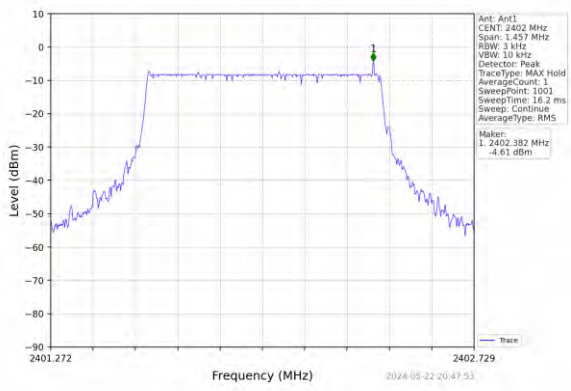
1_HCH_2480MHz_Ant1_NTNV



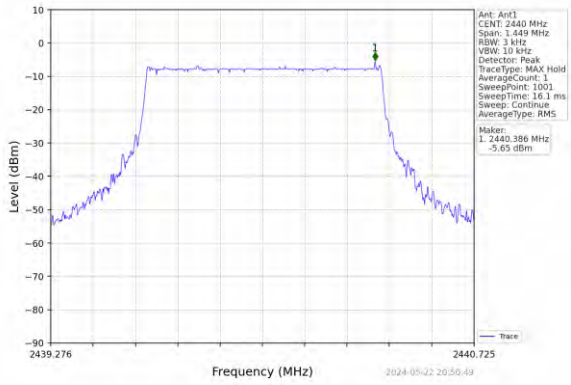
800 kHz data rate

Mode	TX Type	Frequency (MHz)	Maximum PSD (dBm/3kHz)		Verdict
			ANT1	Limit	
1	SISO	2402	-4.61	<=8	Pass
		2440	-5.65	<=8	Pass
		2480	-6.75	<=8	Pass
Note1: Antenna Gain: Ant1: 1.80dBi;					

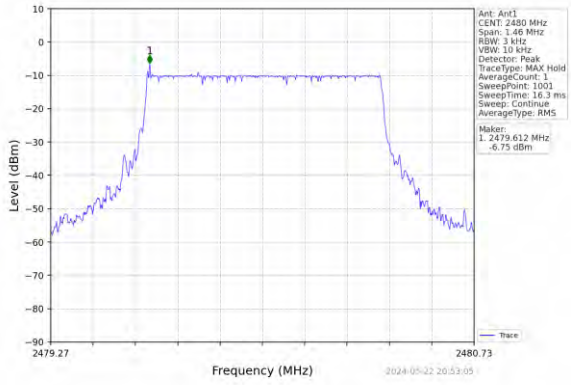
1_LCH_2402MHz_Ant1_NTNV



1_MCH_2440MHz_Ant1_NTNV



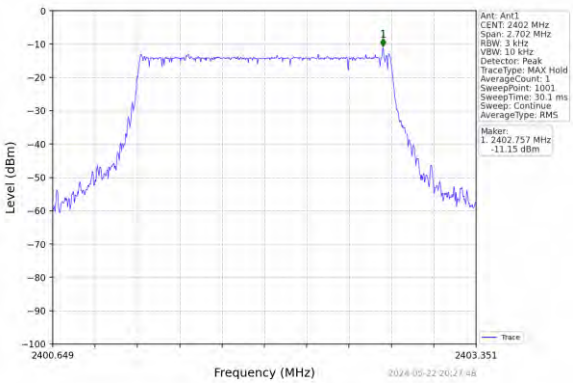
1_HCH_2480MHz_Ant1_NTNV



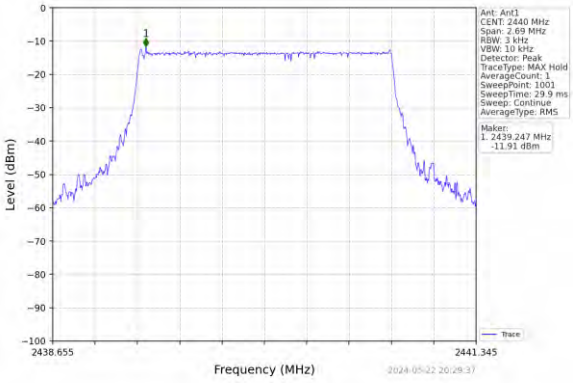
1600 kHz data rate

Mode	TX Type	Frequency (MHz)	Maximum PSD (dBm/3kHz)		Verdict
			ANT1	Limit	
1	SISO	2402	-11.15	<=8	Pass
		2440	-11.91	<=8	Pass
		2480	-12.66	<=8	Pass
Note1: Antenna Gain: Ant1: 1.80dBi;					

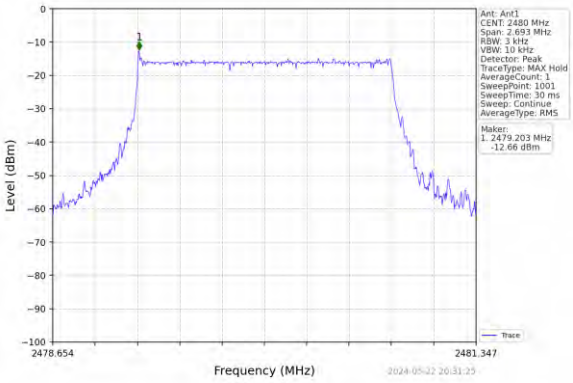
1_LCH_2402MHz_Ant1_NTNV



1_MCH_2440MHz_Ant1_NTNV



1_HCH_2480MHz_Ant1_NTNV



7 Band Edge in Non-restricted Frequency Bands

7.1 *Test Result*

Test Description	Test Specification		Test Result
Band Edge Emissions	15.247(d)	RSS-247 S5.5	Compliant

7.2 *Test Method*

Conducted band edge in non-restricted frequency bands were measured using the method defined in ANSI C63.10 clause 11.11. This procedure is referenced in KDB 558074 D01 15.247 Meas Guidance v05r02.

Limit

Because the maximum peak conducted output power was used to determine compliance with the output power limits, the limit in any 100 kHz band outside of the authorized band is 20 dB below the maximum in-band peak level.

The BLE 2M PHY data mode was used for this test. Lora 1.6 MHz data rate was used for this test.

7.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions:	24-May-2024	22-July-2024
Temperature:	23.46 °C	23.13 °C
Relative Humidity:	51.3 %	49.9 %
Atmospheric Pressure:	98.37 kPa	98.26 kPa

7.4 *Test Equipment*

Test End Date: 24-May-2024 / 22-July-2024 Tester:SGM

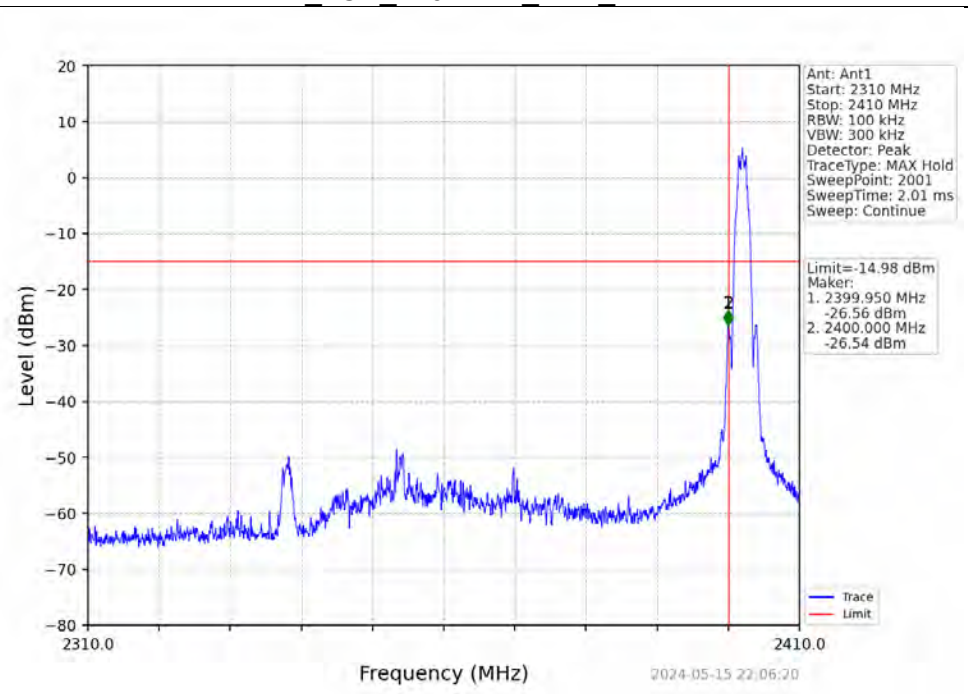
Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	20-Mar-2024	20-Mar-2025
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	3-Jan-2024	3-Jan-2025
TSTPASS SWITCHBOX	SB2	TSTPASS	23009	8-Apr-2024	8-Apr-2025
MULTIMETER	87V	FLUKE	23014	30-Aug-2023	30-Aug-2024
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

Software Profile:
TSTPASS Version: 2.0 (2024.05.01_17.31.12)

7.5 *Test Data – DTS Band Edge - BLE*

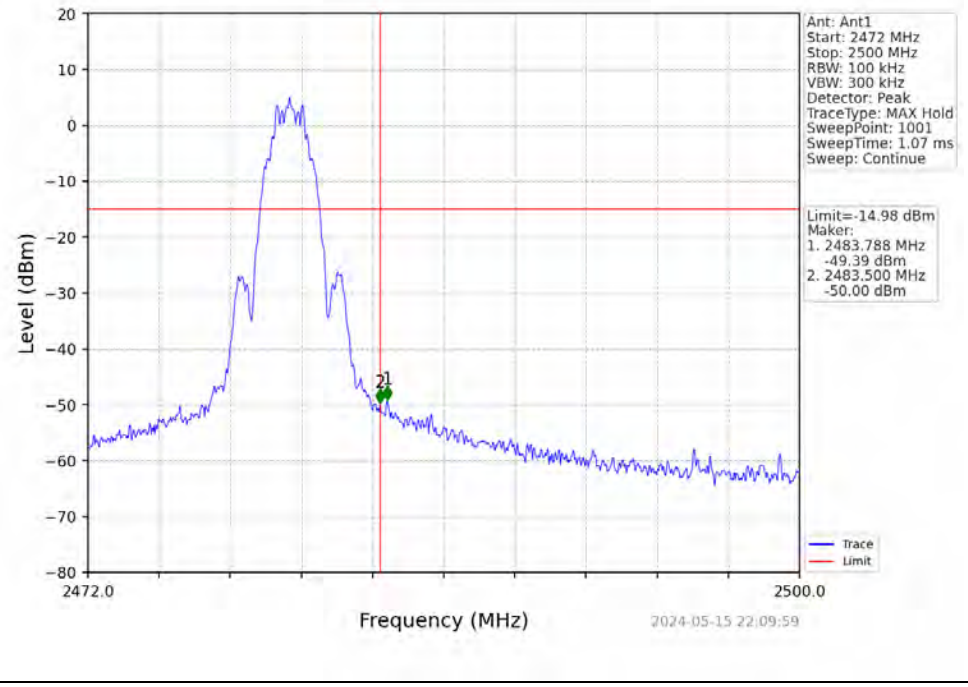
BLE - Lower band edge

2M_LCH_2402MHz_Ant1_NTNV



BLE - Upper band edge

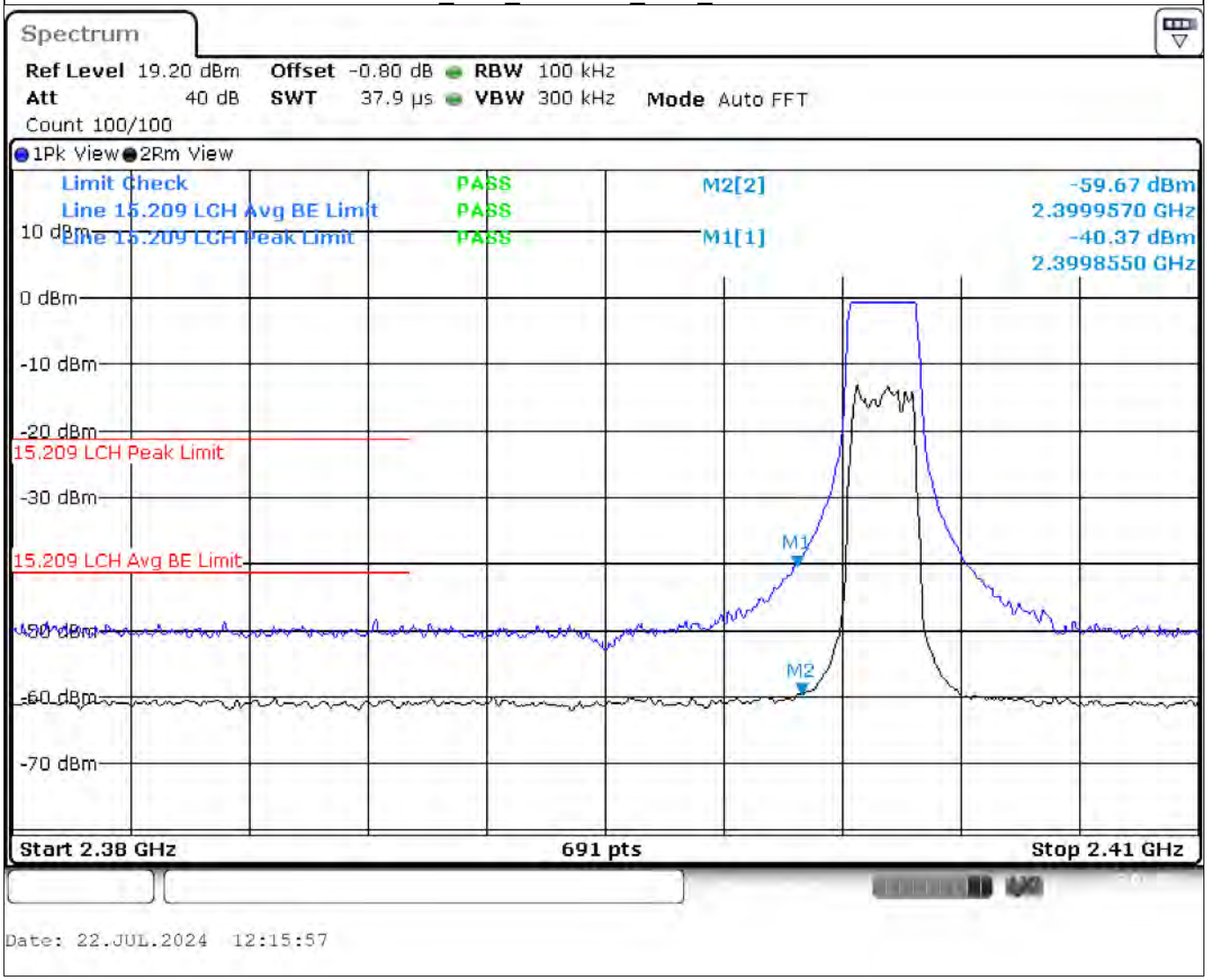
2M_HCH_2480MHz_Ant1_NTNV



7.6 *Test Data – DTS Band Edge - LoRa*

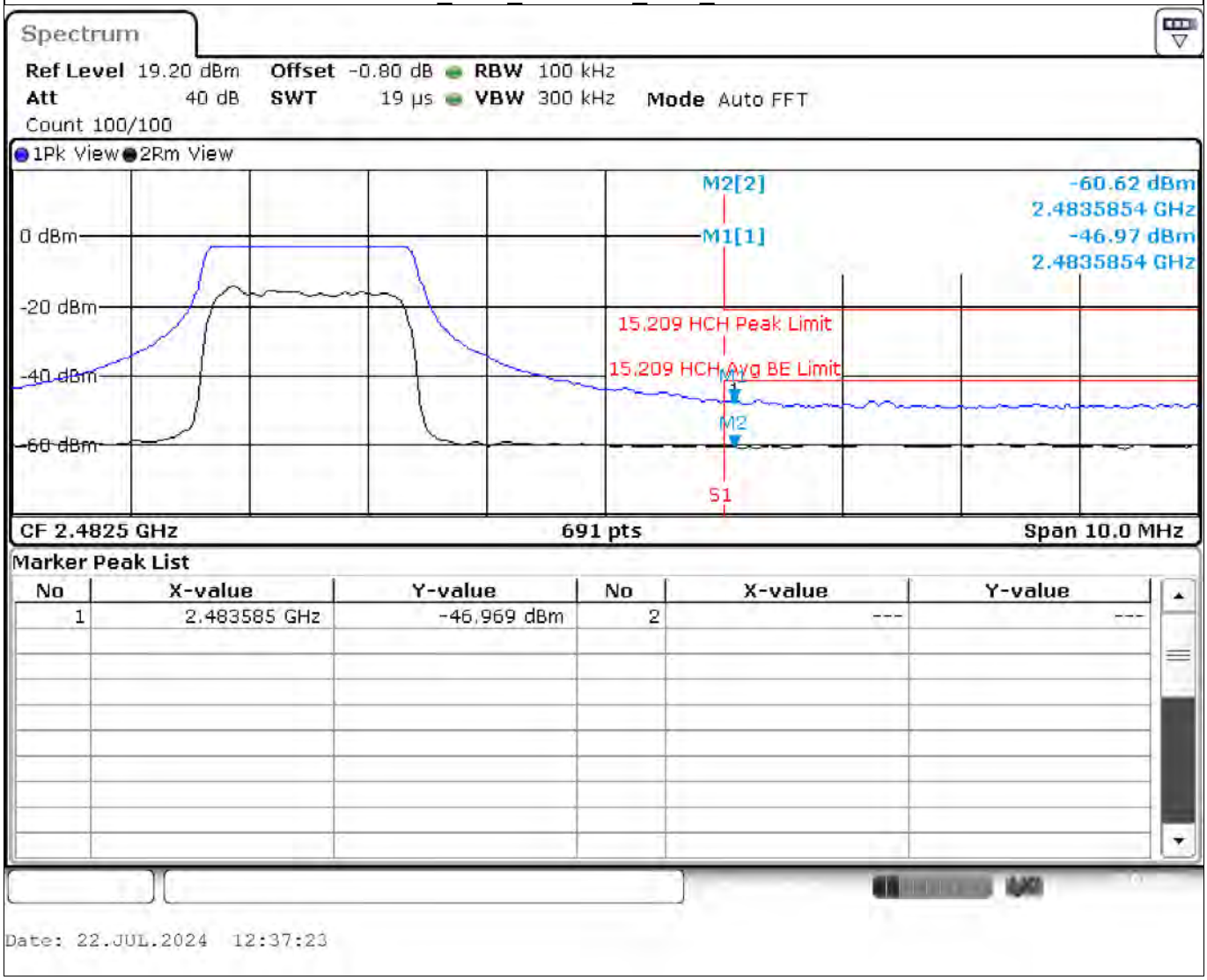
LoRa - Lower band edge

1_LCH_2402MHz_Ant1_NTNV



LoRa - Upper band edge

1_HCH_2480MHz_Ant1_NTNV



8 Emissions in Restricted Frequency Bands

8.1 *Test Result*

Test Description	Test Specification		Test Result
Emissions in Restricted Frequency Bands	15.247(d) 15.205, 15.209	RSS-247 S5.5 RSS-GEN S8.9, S8.10	Compliant

8.2 *Test Method*

Radiated emissions in restricted frequency bands were measured using methods defined in ANSI C63.10 clause 11.12. These procedures are referenced in KDB 558074 D01 15.247 Meas Guidance v05r02.

Lowest, middle and highest channels were investigated – the device was commanded to continuously transmit on channels 0, 19 and 39. Data rate with the highest spectral density measurement was used to perform testing.

The BLE 2M PHY data mode was used for this test. Lora 400 kHz data rate was used for this test.

Test distances for radiated tests:

9k to 30 MHz – Near field prescan to determine if there were any emissions
30 to 1000 MHz - The EUT to measurement antenna distance was 3 meters
1 to 18 GHz - The EUT to measurement antenna distance was 3 meters
18 to 26 GHz - The EUT to measurement antenna distance was 1 meter

Note: Radiated emission below 30MHz is measured in a 9m*6m*6m semi-anechoic chamber, the measurements correspond to those obtained at an open-field test site. There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

Limits within restricted bands of operation:

Frequency	Limits(1)		Peak Limits dBuV/m
	Microvolts/m	dBuV/m	
30 - 88 MHz	100	40 (2)	--
88 - 216 MHz	150	43.5 (2)	--
216 - 960 MHz	200	46 (2)	--
960 - 1000 MHz	500	54 (2)	--
1 - 40 GHz	500	54 (3)	74

(1) These limits are applicable to emissions outside of the intentional transmit frequency band.
(2) Quasi-peak limit
(3) Average limit

8.3 *Test Site*

3m Absorber Lined Shielded Enclosure (ALSE), Suwanee, GA
10m Absorber Lined Shielded Enclosure (ALSE), Suwanee, GA

Environmental Conditions	9kHz-1GHz	1-18GHz	18-26GHz
Temperature:	23.47 °C	23.32 °C	23.14 °C
Relative Humidity:	52.9 %	56.3 %	54.7 %
Atmospheric Pressure:	97.47 kPa	98.23 kPa	97.47 kPa

8.4 *Test Equipment*

9kHz-30MHz

Test End Date: 21-May-2024 Tester: ZH

Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
ANTENNA, LOOP, ACTIVE	ETS LINDGREN	6502	B085752	24-Mar-2024	24-Mar-2026
N to N RF Cable	ECHELON	EM-B810NM-276	24000	15-Jan-2024	15-Jan-2025
RF CABLE, NM TO NM.	TELEDYNE STORM MICROWAVE	90-195-157	21019	20-Mar-2024	20-Mar-2025
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW44	22027	3-Oct-2023	3-Oct-2024

30-1000MHz

Test End Date: 21-May-2024 Tester:ZH

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
ANTENNA, BILOG	JB6	SUNOL	B079689	16-May-2024	16-May-2026
N to N RF Cable	EM-B810NM-276	ECHELON	23007	31-Mar-2024	31-Mar-2025
N-FEMALE TO N-MALE RF CABLE	EM-B810NMNF-118	ECHELON	23010	17-Apr-2024	17-Apr-2025
RF CABLE NM TO NM, 0.01-18GHZ	90-195-118	TELEDYNE STORM MICROWAVE	20125	8-Aug-2023	8-Aug-2024
N to N RF Cable	90-076-020	TELEDYNE STORM MICROWAVE	22037	26-Dec-2023	26-Dec-2024
LOW NOISE AMPLIFIER	ZKL-2+	MINI-CIRCUITS	B079817	7-Aug-2023	7-Aug-2024
EMI TEST RECEIVER	ESW44	ROHDE & SCHWARZ	22032	15-Nov-2023	15-Nov-2024
MULTIMETER	87V	FLUKE	23014	30-Aug-2023	30-Aug-2024
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

1-18GHz

Test End Date: 23-May-2024 Tester: SGM

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
ANTENNA, DRG HORN (MEDIUM)	3117	ETS LINDGREN	B079699	29-Jul-2022	29-Jul-2024
N to N RF Cable	EM-B810NM-276	ECHELON	24000	15-Jan-2024	15-Jan-2025
RF CABLE	104PE	HUBER & SUHNER	B079793	7-Aug-2023	7-Aug-2024
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	15003	10-Oct-2023	10-Oct-2024
EMI TEST RECEIVER	ESW44	ROHDE & SCHWARZ	22027	3-Oct-2023	3-Oct-2024
MULTIMETER	87V	FLUKE	23014	30-Aug-2023	30-Aug-2024
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

18-26GHz

Test End Date: 24-May-2024 Tester:LM

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
ANTENNA, HORN (SMALL)	LB-180400-20-C-KF	A-INFO	15007	17-Apr-2024	17-Apr-2025
SMA to SMA RF Cable	NC12-K1K1-138	MEGAPHASE	22002	6-Feb-2024	6-Feb-2025
2.92MM MALE TO2.92MM MALE RF CABLE	HULL140A-29P-29P-60	HASCO COMPONENTS	18033	20-Mar-2024	20-Mar-2025
LOW NOISE AMPLIFIER	NSP1840-HG	MITEQ	B087572	10-Oct-2023	10-Oct-2024
EMI TEST RECEIVER	ESW44	ROHDE & SCHWARZ	22027	3-Oct-2023	3-Oct-2024
MULTIMETER	87V	FLUKE	23014	30-Aug-2023	30-Aug-2024
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

Software: “RSE 30-1000 MHz T7 220318” TILE 7! profile dated Mar 2022
“RSE 1-18GHz T7 220318” TILE 7! profile dated Mar 2022
“RSE 18-26 GHz T7 210212” TILE 7 profile dated Feb 2021

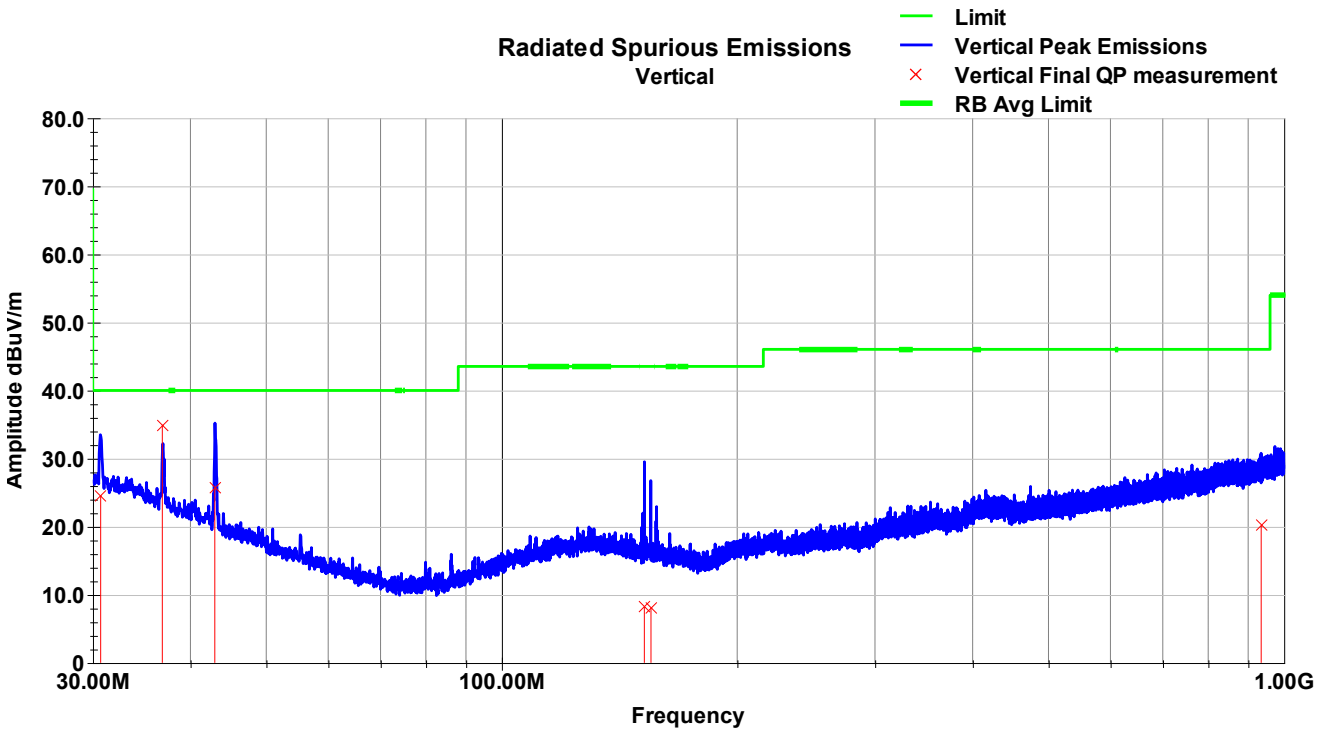
8.5 *Test Data*

No emissions were detected in the 9kHz to 30MHz frequency range.

8.5.1 30-1000 MHz BLE

There was no significant deviation based on axis or channel in the 30-1000MHz frequency range. Note: Observed emissions below 1 GHz were not related to the transmitter and are attributed to the unintentional emissions of the product which are not a part of this scope. No Spurious Emissions detected within 20 dB of the limit.

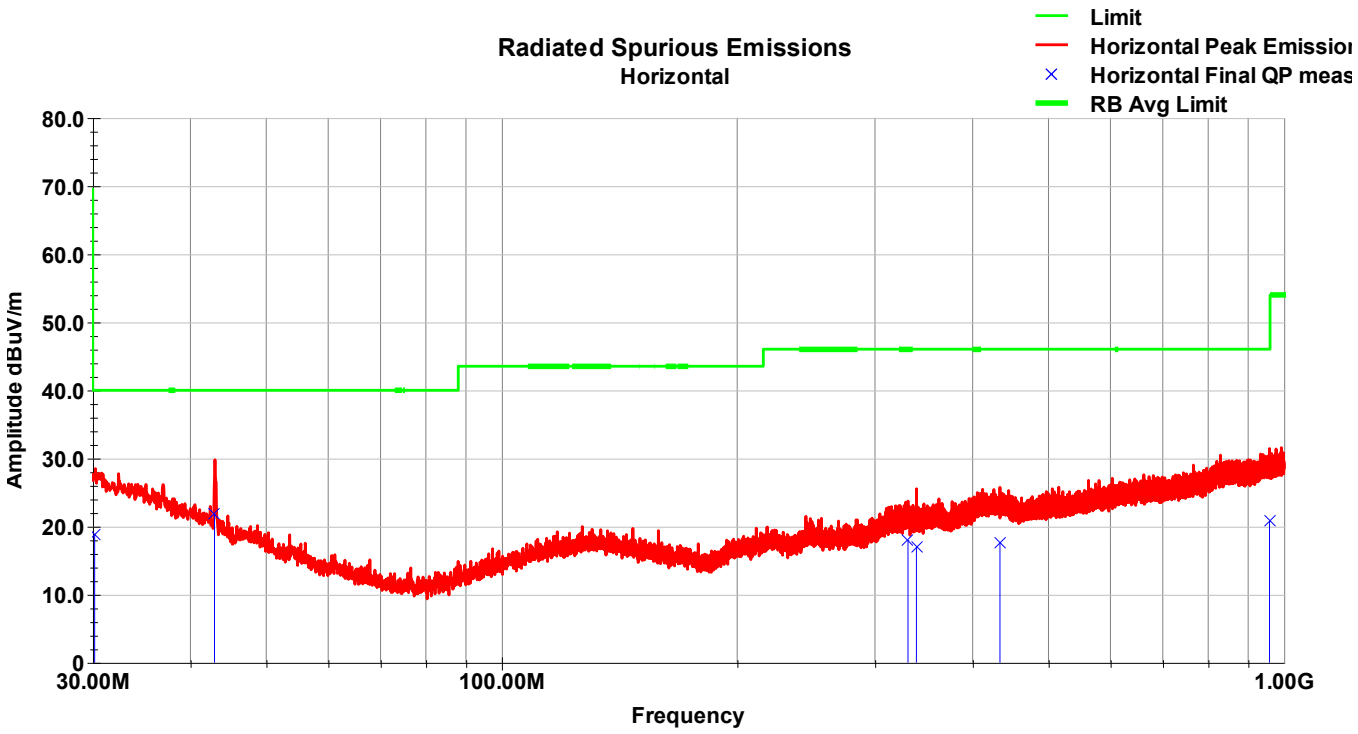
Vertical Polarity: Z-Axis Plot



Vertical Polarity: Z-Axis Test Data

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
30.71	28.4	V	333.0	100.0	27.9	0.3	32.0	24.6	40.0	-15.4
36.82	41.9	V	258.0	100.0	24.7	0.4	32.0	34.9	40.0	-5.1
42.98	35.7	V	336.0	116.0	21.6	0.4	32.0	25.7	40.0	-14.3
152.15	22.6	V	349.0	362.0	16.7	0.7	31.8	8.2	43.5	-35.3
155.16	22.8	V	35.0	157.0	16.4	0.8	31.8	8.1	43.5	-35.4
935.13	22.2	V	100.0	100.0	26.9	2.2	31.2	20.1	46.0	-25.9
QP Value = Raw QP + AF + Loss - Amp										
Margin = QP Value - Limit										

Horizontal Polarity: Z-Axis Plot



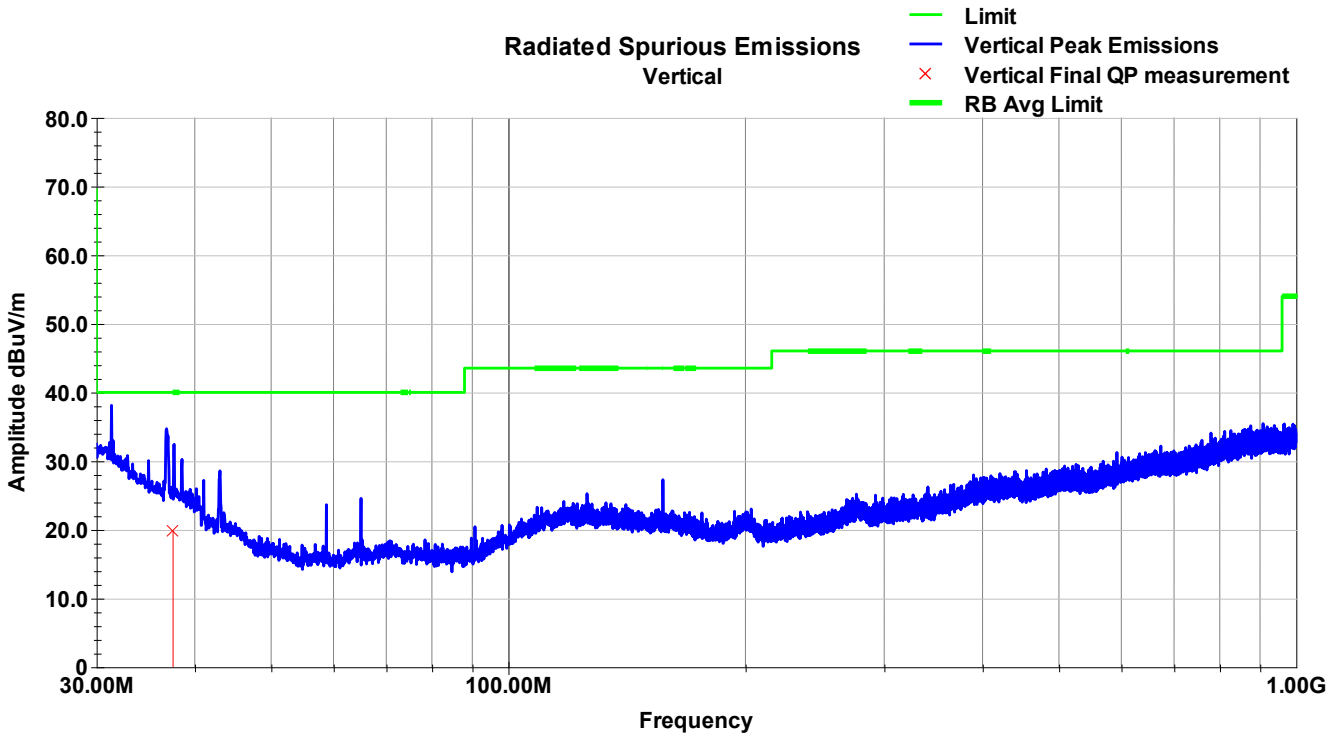
Horizontal Polarity: Z-Axis Test Data

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
30.17	22.3	H	349.0	119.0	28.2	0.3	32.0	18.8	40.0	-21.2
42.94	31.8	H	162.0	227.0	21.6	0.4	32.0	21.8	40.0	-18.2
330.67	28.7	H	140.0	100.0	19.3	1.5	31.5	18.0	46.0	-28.0
339.01	27.6	H	255.0	100.0	19.4	1.5	31.5	17.0	46.0	-29.0
433.39	25.7	H	166.0	100.0	21.5	1.9	31.5	17.7	46.0	-28.4
958.46	22.6	H	171.0	157.0	27.0	2.3	31.1	20.8	46.0	-25.2
QP Value = Raw QP + AF + Loss - Amp										
Margin = QP Value - Limit										

8.5.2 30-1000 MHz LoRa

There was no significant deviation based on axis or channel in the 30-1000MHz frequency range. Note: Observed emissions below 1 GHz were not related to the transmitter and are attributed to the unintentional emissions of the product which are not a part of this scope. No Spurious Emissions detected within 20 dB of the limit.

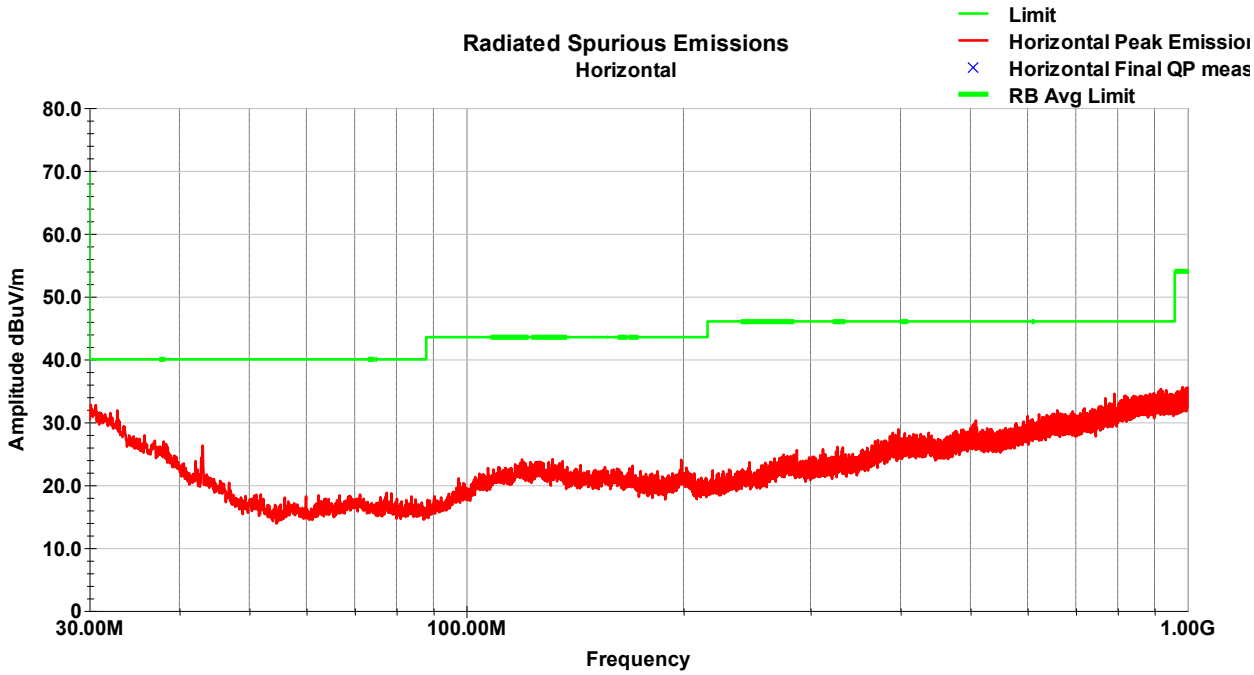
Vertical Polarity – Z-Axis – Test Plot



Vertical Polarity – Z-Axis – Test Data

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
37.54	30.1	V	309.0	113.0	20.3	0.4	31.0	19.8	40.0	-20.2
QP Value = Raw QP + AF + Loss - Amp										
Margin = QP Value - Limit										

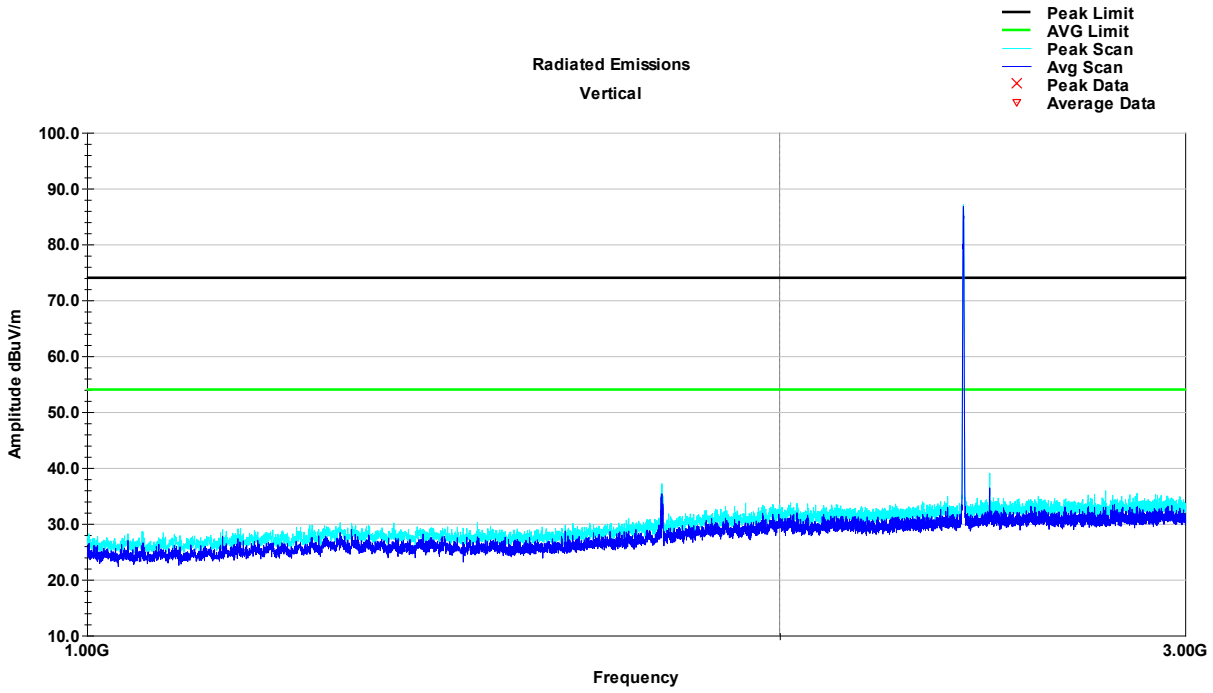
Horizontal Polarity – Z-Axis – Test Plot



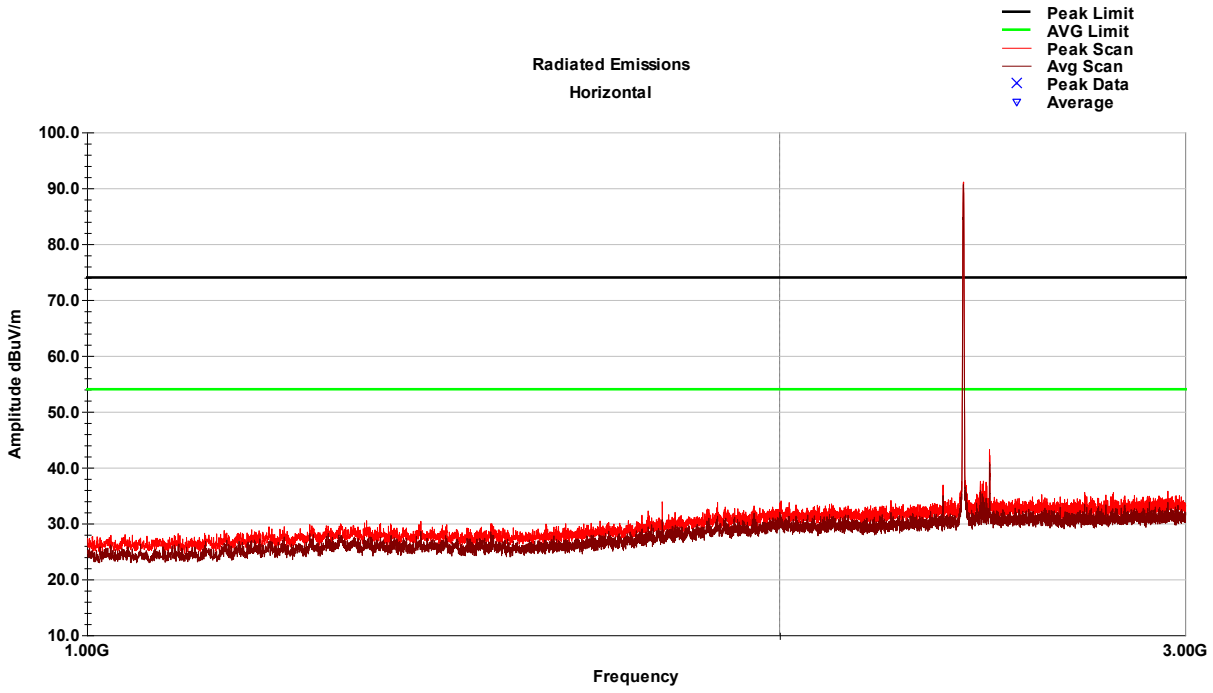
8.5.3 1-3 GHz BLE

There was no significant deviation based on axis. Z-Axis was worst case reported.

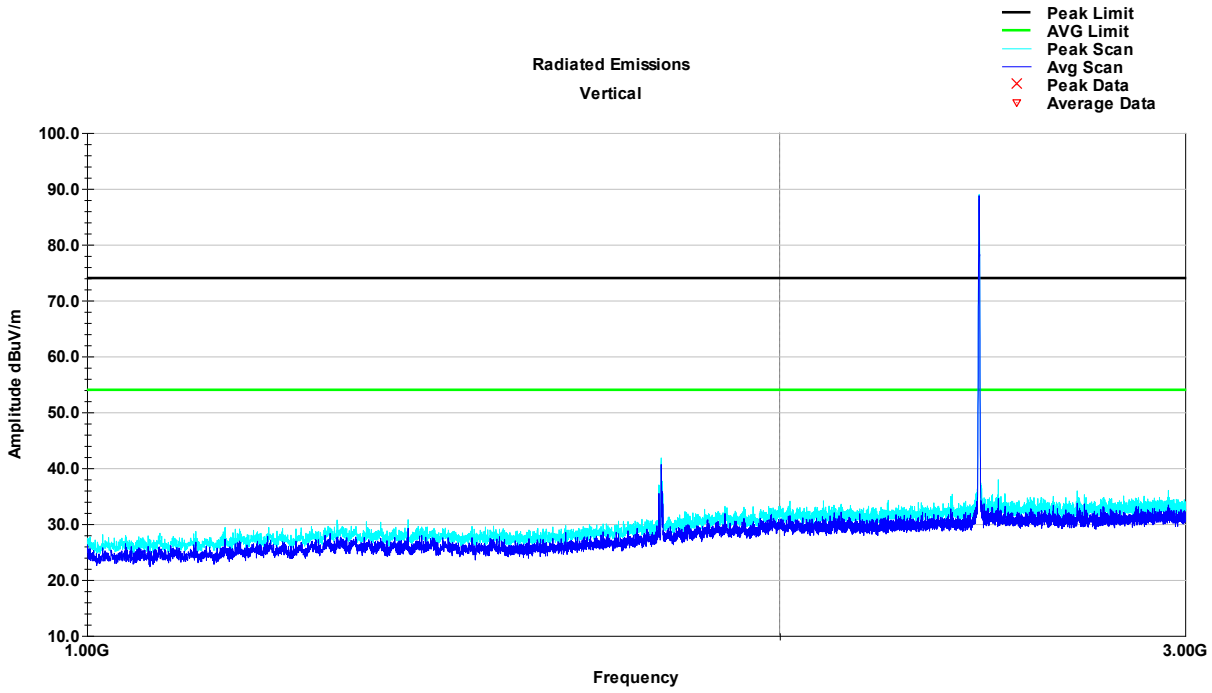
1-3GHz Vertical Low Channel



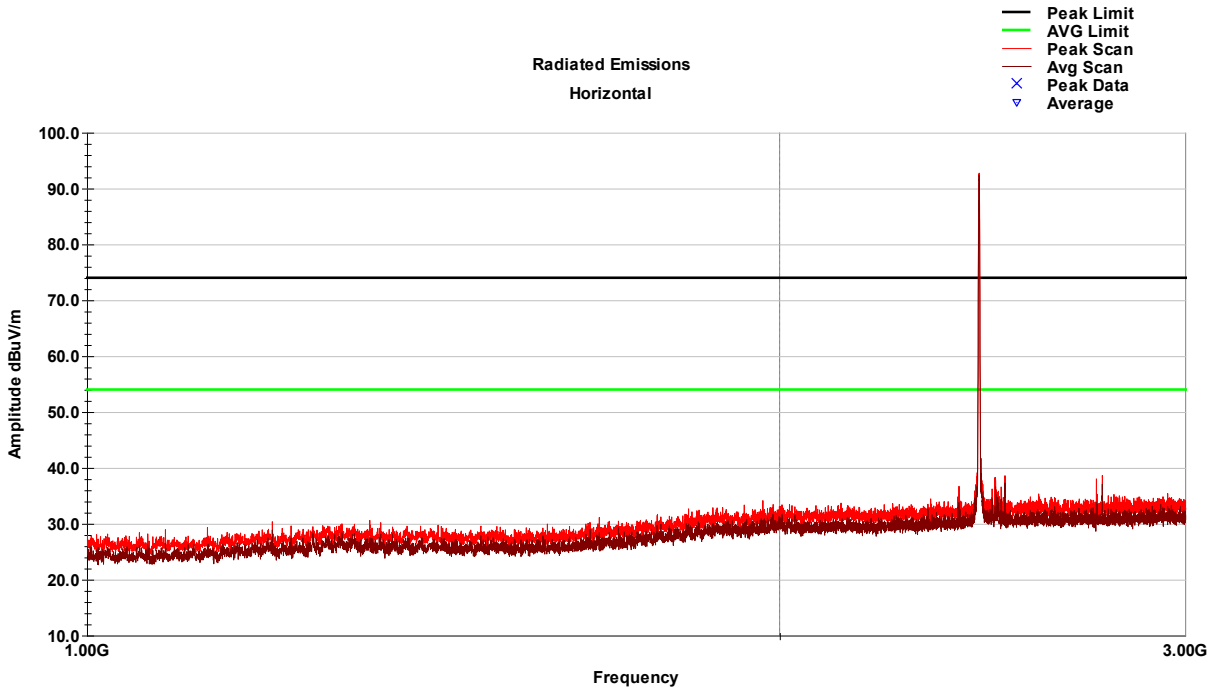
1-3 GHz Horizontal Low Channel



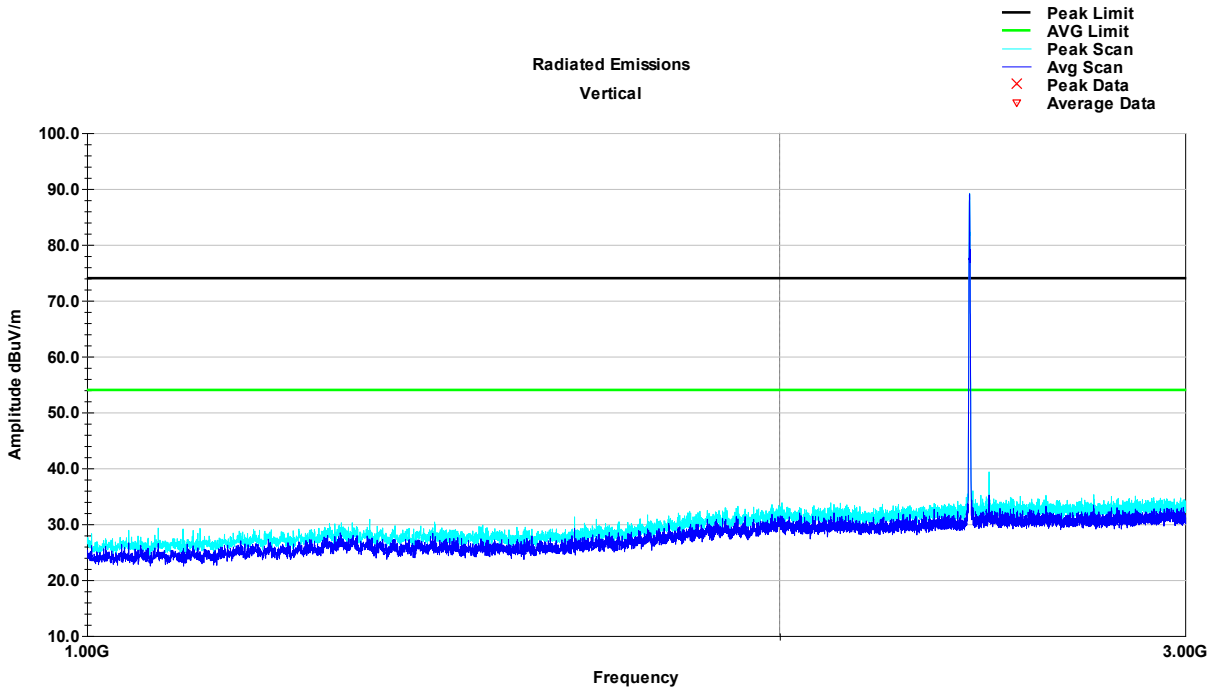
1-3GHz Vertical Mid Channel



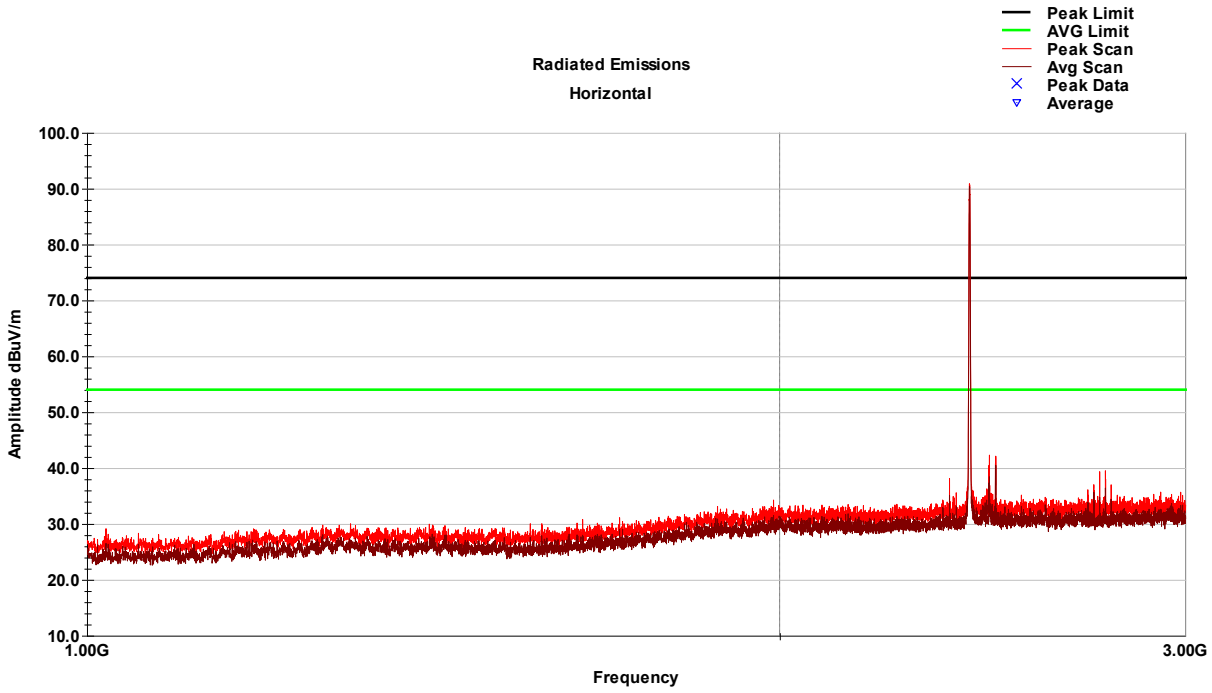
1-3 GHz Horizontal Mid Channel



1-3GHz Vertical High Channel



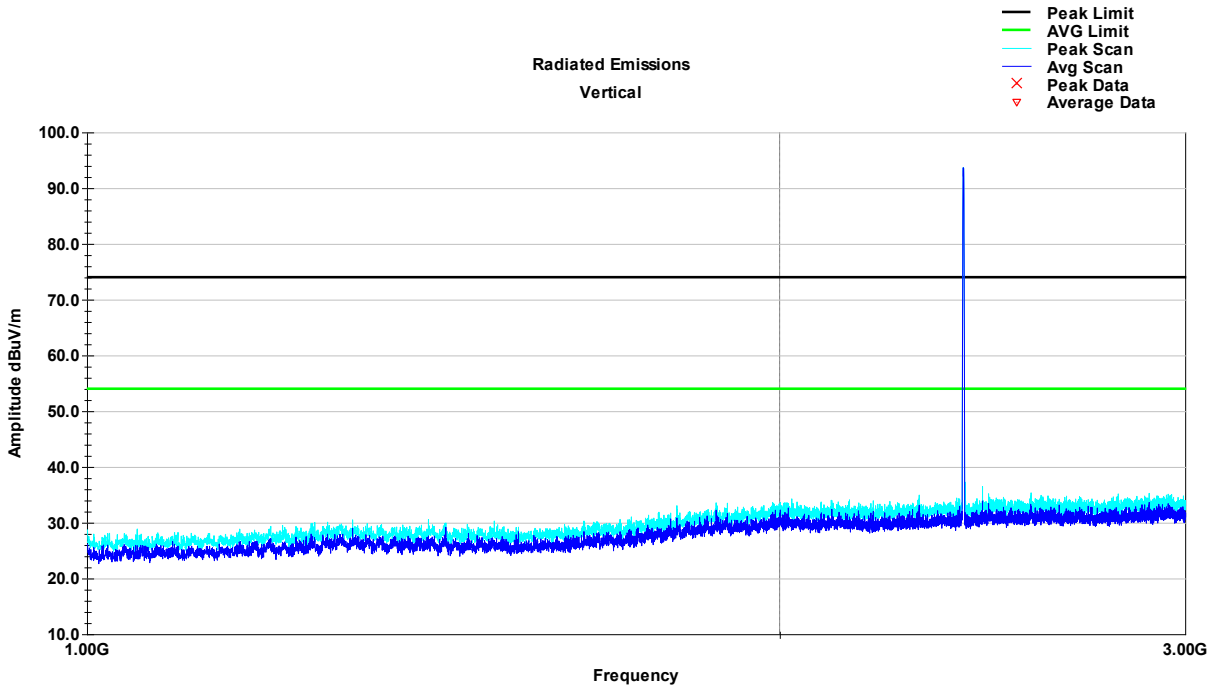
1-3 GHz Horizontal High Channel



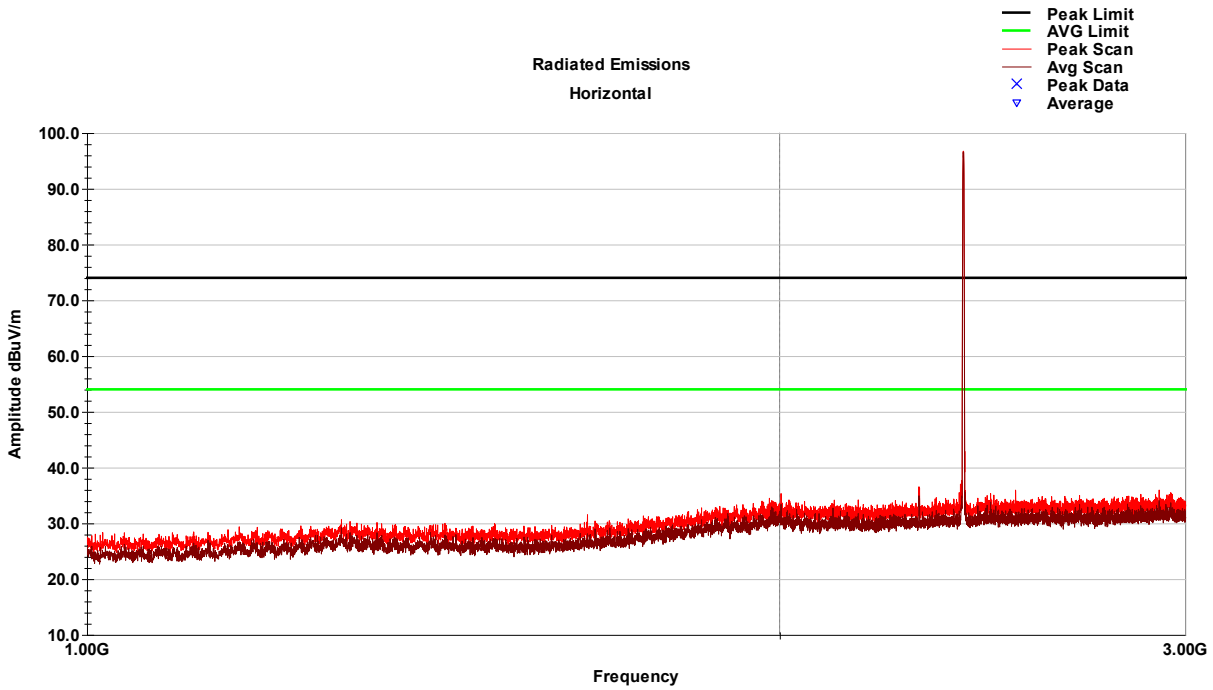
8.5.4 1-3 GHz Lora

There was no significant deviation based on axis. Z-Axis was worst case reported.

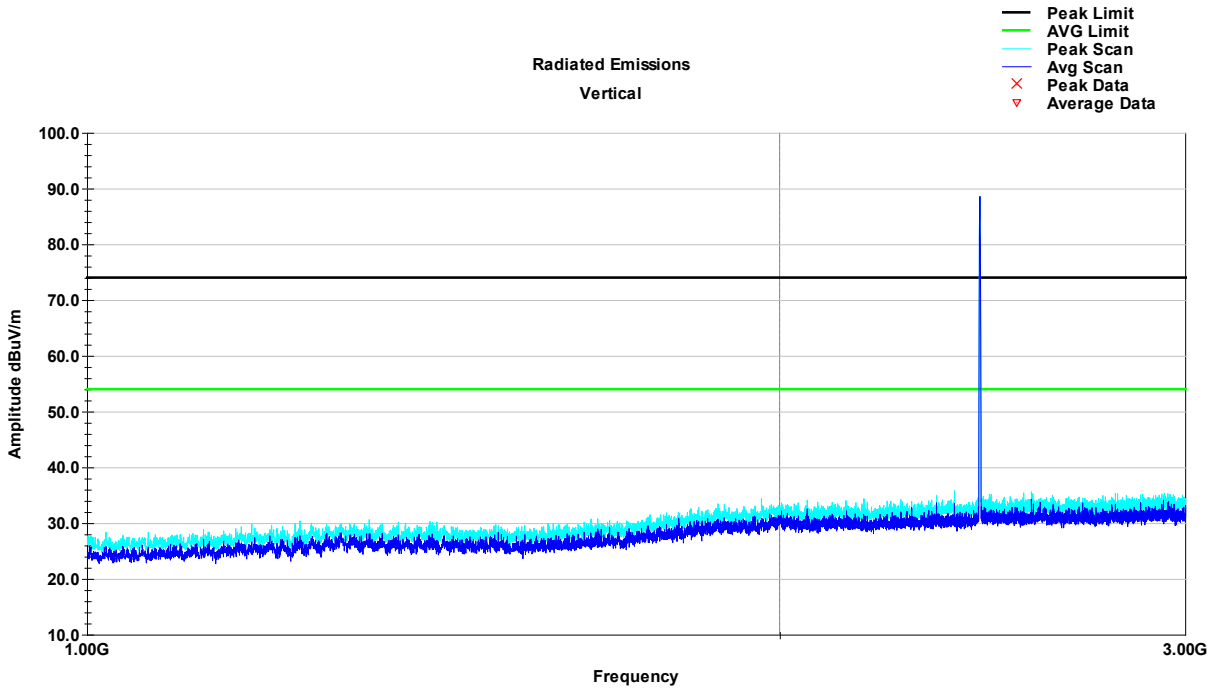
1-3GHz Vertical Low Channel



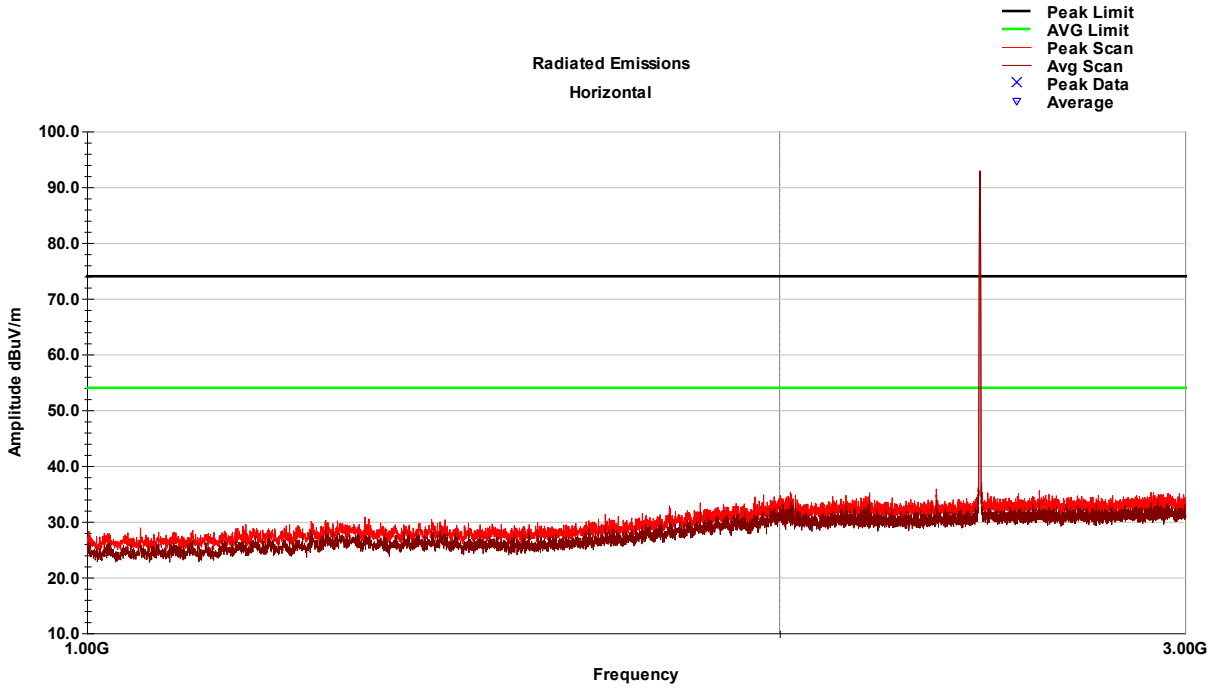
1-3 GHz Horizontal Low Channel



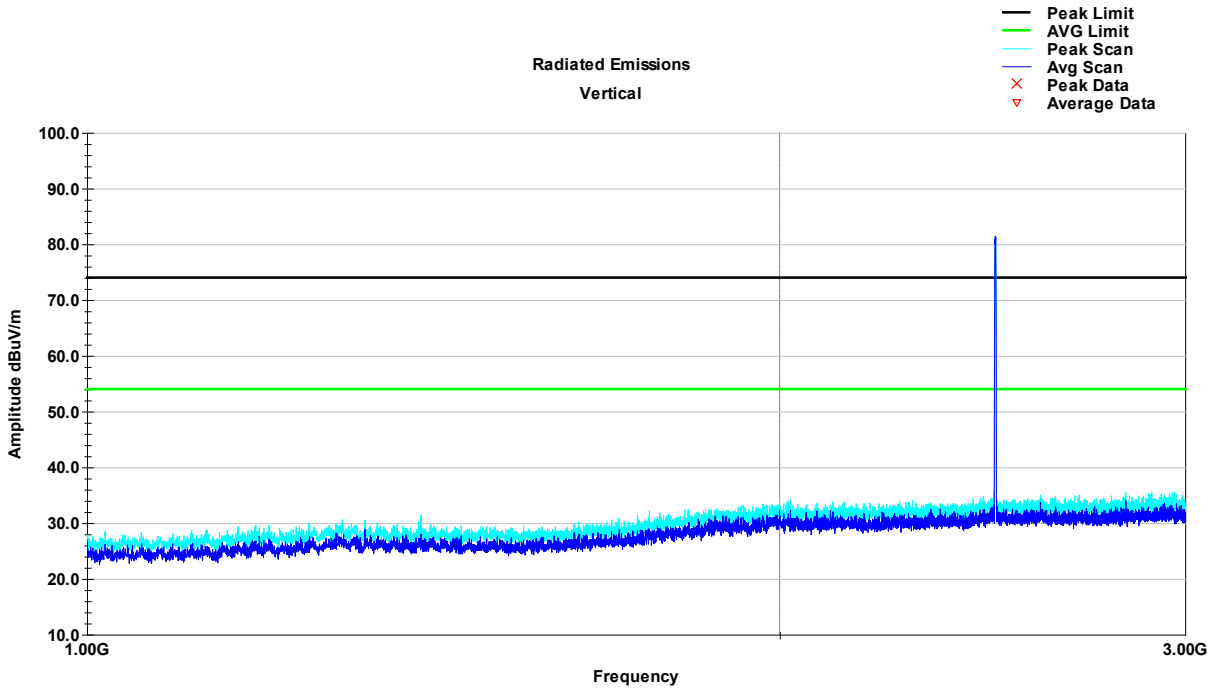
1-3GHz Vertical Mid Channel



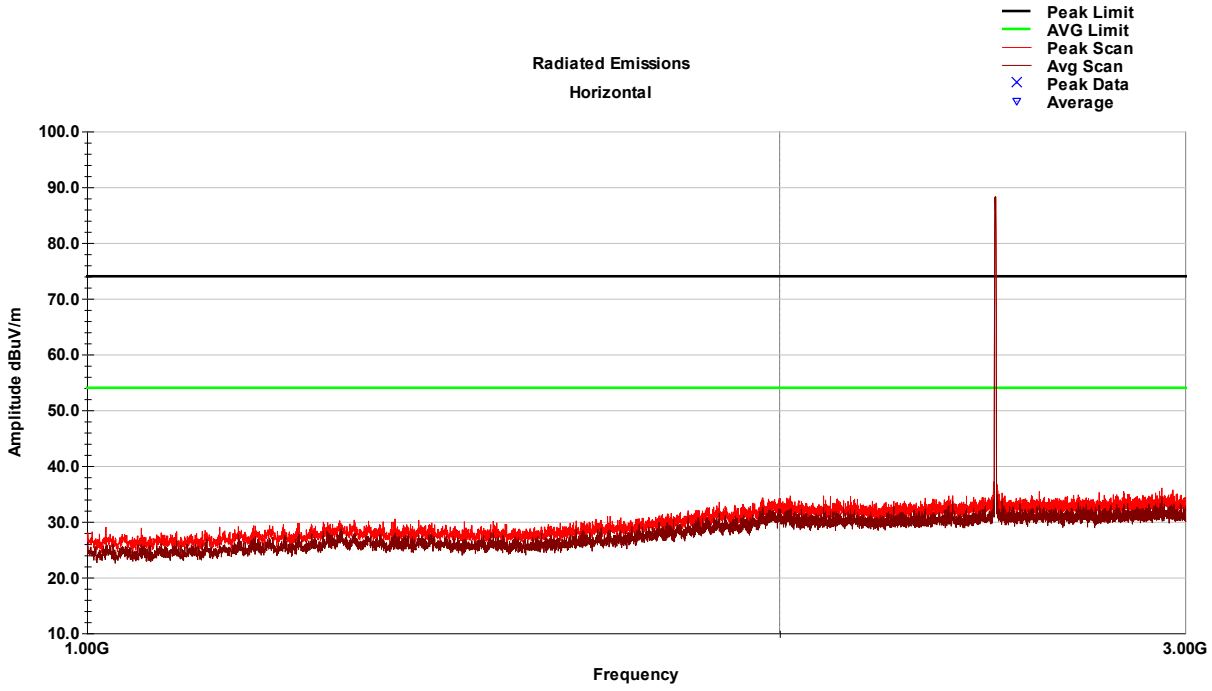
1-3 GHz Horizontal Mid Channel



1-3GHz Vertical High Channel



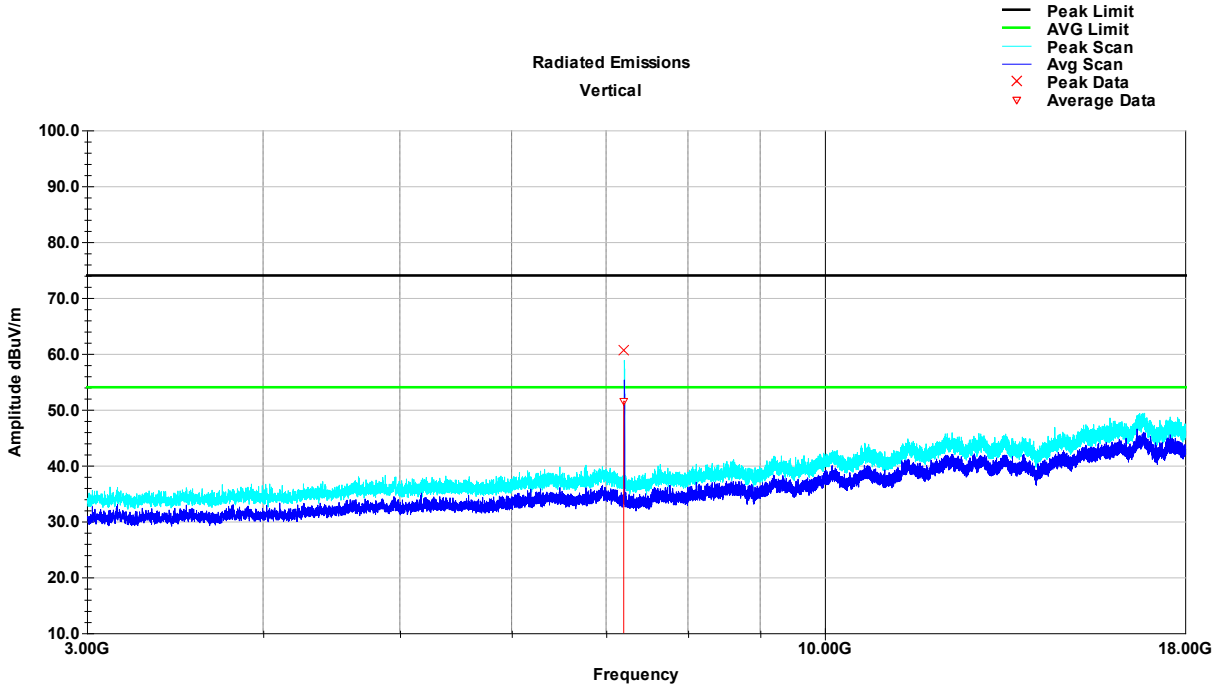
1-3 GHz Horizontal High Channel



8.5.5 3-18 GHz BLE

There was no significant deviation based on axis. Z-Axis was worst case reported.

3-18 GHz Vertical Low Channel - BLE



3-18 GHz Vertical Low Channel – Tabular Data - BLE

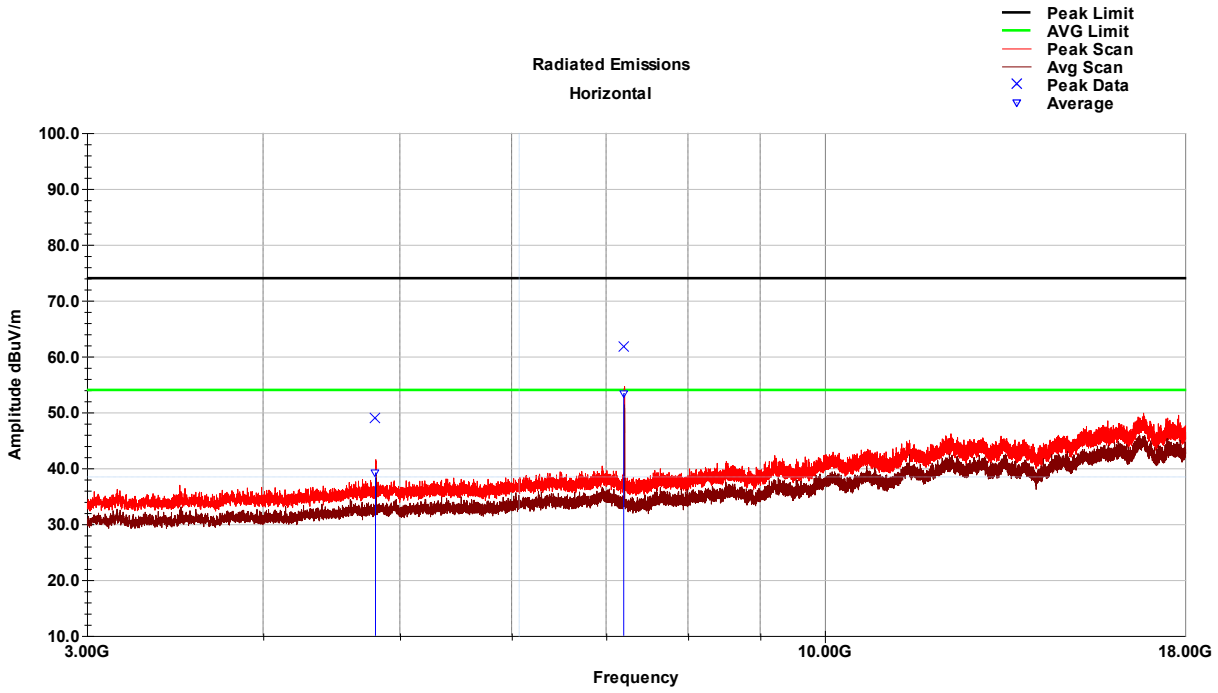
Peak

Frequency MHz	Raw Peak (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Peak Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
7204.30	63.0	V	4.0	100.0	35.9	3.6	41.9	60.5	74.0	-13.5
Peak Value = Raw Peak + AF + CL - Amp										
Margin = Peak Value - Limit										

Average

Frequency MHz	Raw Avg (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Avg Value dBuV/m	Limit (dBuV/m)	Margin (dB)
7204.30	54.0	V	4.0	100.0	35.9	3.6	41.9	51.6	54.0	-2.4
Avg Value = Raw Avg + AF + CL - Amp										
Margin = Avg Value - Limit										

3-18 GHz Horizontal Low Channel - BLE



3-18 GHz Horizontal Low Channel – Tabular Data - BLE

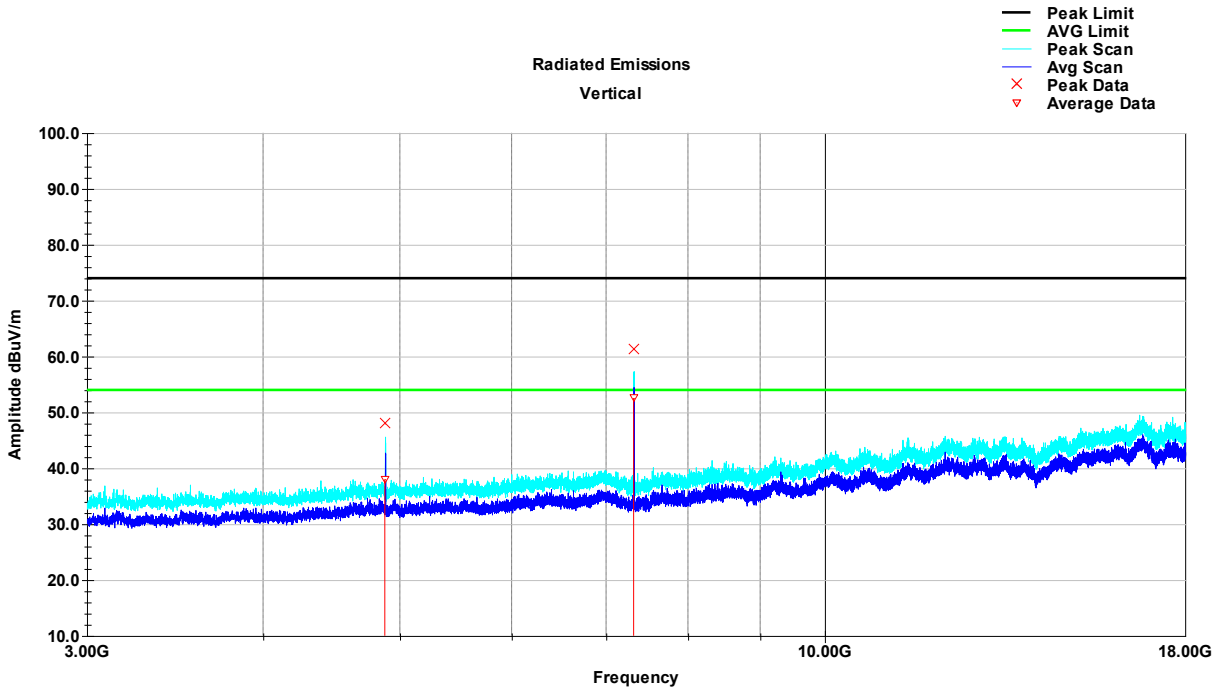
Peak

Frequency MHz	Raw Peak (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Peak Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4804.80	53.8	H	31.0	340.0	34.6	2.9	42.4	48.9	74.0	-25.1
7204.40	64.3	H	61.0	137.0	35.9	3.6	41.9	61.8	74.0	-12.2
Peak Value = Raw Peak + AF + CL - Amp										
Margin = Peak Value - Limit										

Average

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Avg Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4804.80	44.1	H	31.0	340.0	34.6	2.9	42.4	39.2	54.0	-14.8
7204.40	55.8	H	61.0	137.0	35.9	3.6	41.9	53.4	54.0	-0.6
Avg Value = Raw Avg + AF + CL - Amp										
Margin = Avg Value - Limit										

3-18GHz Vertical Mid Channel - BLE



3-18 GHz Vertical Mid Channel – Tabular Data - BLE

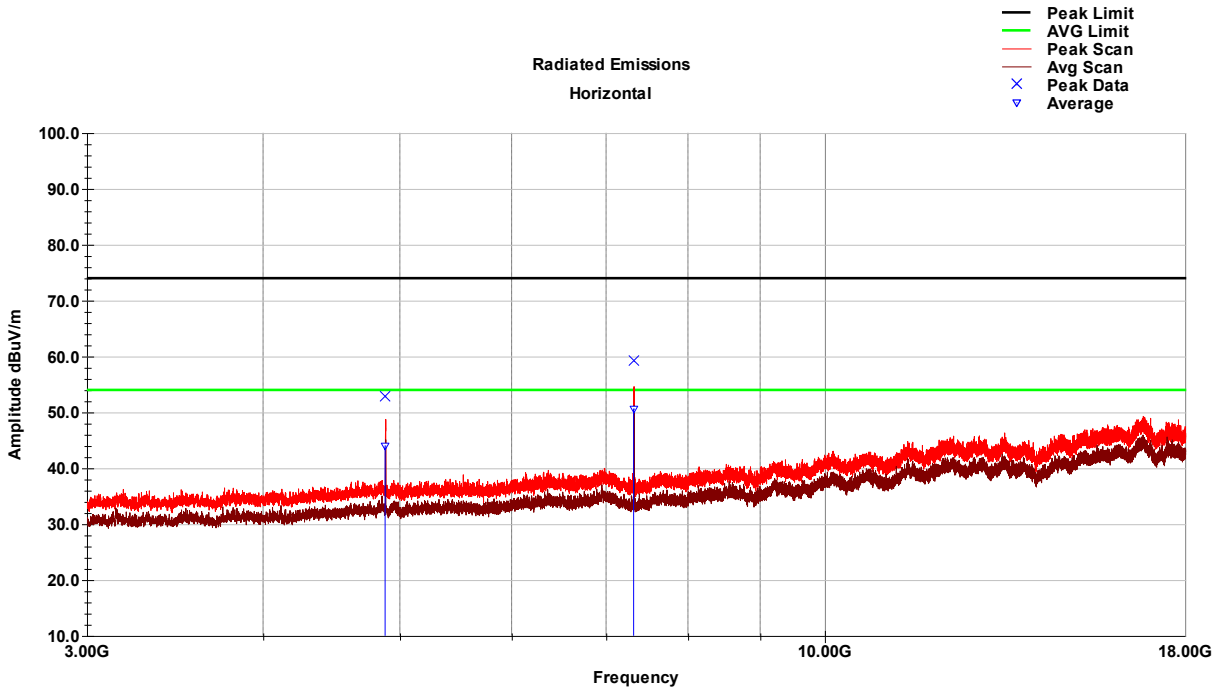
Peak

Frequency MHz	Raw Peak (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Peak Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4878.90	52.6	V	114.0	247.0	34.5	3.1	42.1	48.0	74.0	-26.0
7321.40	64.0	V	359.0	100.0	35.8	3.5	42.0	61.4	74.0	-12.6
Peak Value = Raw Peak + AF + CL - Amp										
Margin = Peak Value - Limit										

Average

Frequency MHz	Raw Avg (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Avg Value dBuV/m	Limit (dBuV/m)	Margin (dB)
4878.90	42.6	V	114.0	247.0	34.5	3.1	42.1	38.0	54.0	-16.0
7321.40	55.2	V	359.0	100.0	35.8	3.5	42.0	52.6	54.0	-1.4
Avg Value = Raw Avg + AF + CL - Amp										
Margin = Avg Value - Limit										

3-18GHz Horizontal Mid Channel - BLE



3-18 GHz Horizontal Mid Channel – Tabular Data - BLE

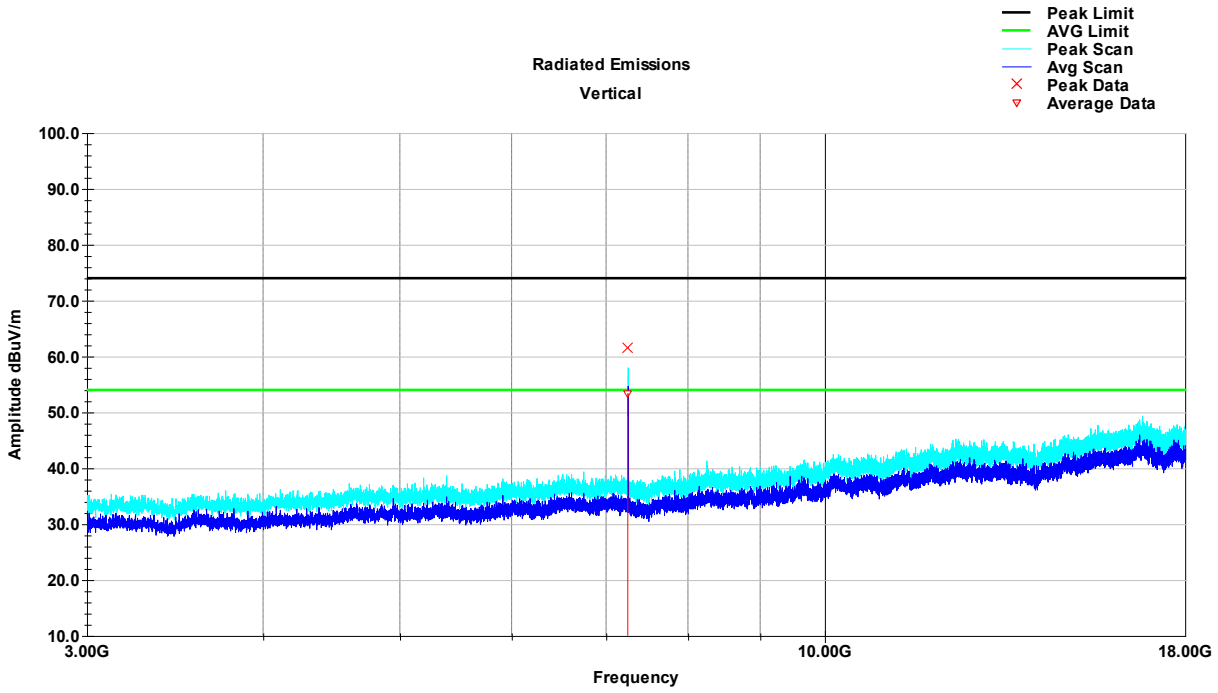
Peak

Frequency MHz	Raw Peak (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Peak Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4881.00	57.5	H	36.0	305.0	34.5	3.1	42.2	52.9	74.0	-21.1
7321.30	61.9	H	66.0	140.0	35.8	3.5	42.0	59.2	74.0	-14.8
Peak Value = Raw Peak + AF + CL - Amp										
Margin = Peak Value - Limit										

Average

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Avg Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4881.00	48.6	H	36.0	305.0	34.5	3.1	42.2	44.0	54.0	-10.0
7321.30	53.3	H	66.0	140.0	35.8	3.5	42.0	50.7	54.0	-3.3
Avg Value = Raw Avg + AF + CL - Amp										
Margin = Avg Value - Limit										

3-18 GHz Vertical High Channel



3-18 GHz Vertical High Channel – Tabular Data - BLE

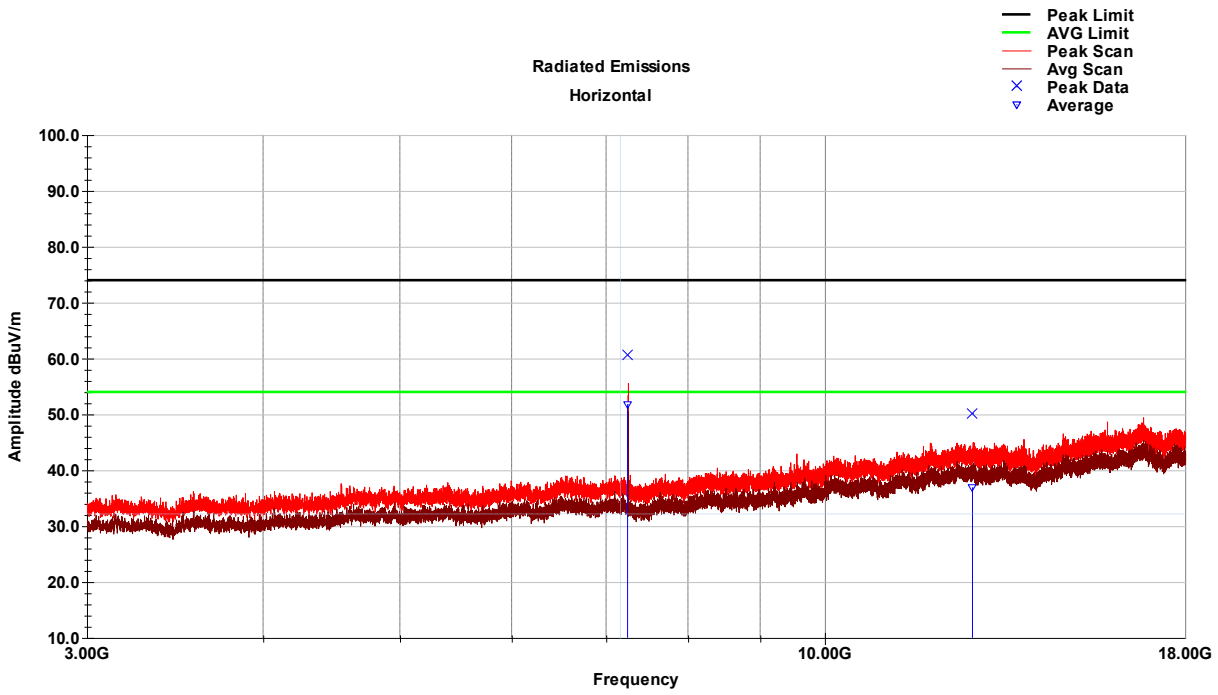
Peak

Frequency MHz	Raw Peak (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Peak Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
7252.30	64.7	V	7.0	128.1	35.8	3.4	42.3	61.6	74.0	-12.4
Peak Value = Raw Peak + AF + CL - Amp										
Margin = Peak Value - Limit										

Average

Frequency MHz	Raw Avg (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Avg Value dBuV/m	Limit (dBuV/m)	Margin (dB)
7252.30	56.4	V	7.0	128.0	35.8	3.4	42.3	53.4	54.0	-0.6
Avg Value = Raw Avg + AF + CL - Amp										
Margin = Avg Value - Limit										

3-18GHz Horizontal High Channel



3-18 GHz Horizontal High Channel – Tabular Data - BLE

Peak

Frequency MHz	Raw Peak (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Peak Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
7249.30	63.6	H	334.0	212.0	35.8	3.4	42.3	60.6	74.0	-13.4
Peak Value = Raw Peak + AF + CL - Amp										
Margin = Peak Value - Limit										

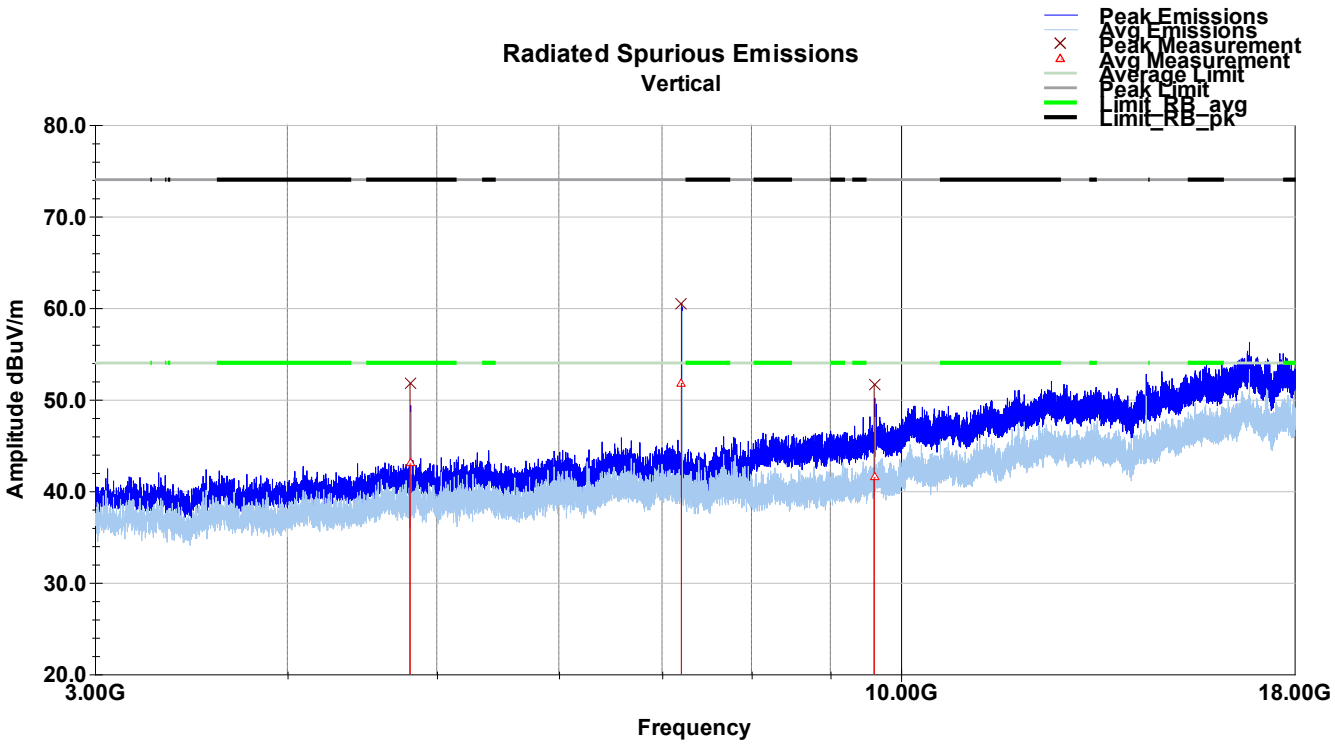
Average

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Avg Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
7249.30	54.8	H	334.0	212.0	35.8	3.4	42.3	51.8	54.0	-2.2
Avg Value = Raw Avg + AF + CL - Amp										
Margin = Avg Value - Limit										

8.5.6 3-18 GHz Lora

There was no significant deviation based on axis. X-Axis was worst case reported.

3-18 GHz Vertical Low Channel - Lora



3-18 GHz Vertical Low Channel – Lora Data

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
4804.52	56.6	V	84.0	112.0	34.6	2.9	42.4	51.8	74.0	-22.2
7205.58	63.0	V	325.0	100.0	35.9	3.6	41.9	60.5	74.0	-13.5
9608.66	53.3	V	101.0	149.0	36.6	4.1	42.3	51.7	74.0	-22.3

Final Pk = Raw Pk + AF + Loss - Amp

Margin = Final Pk - Limit

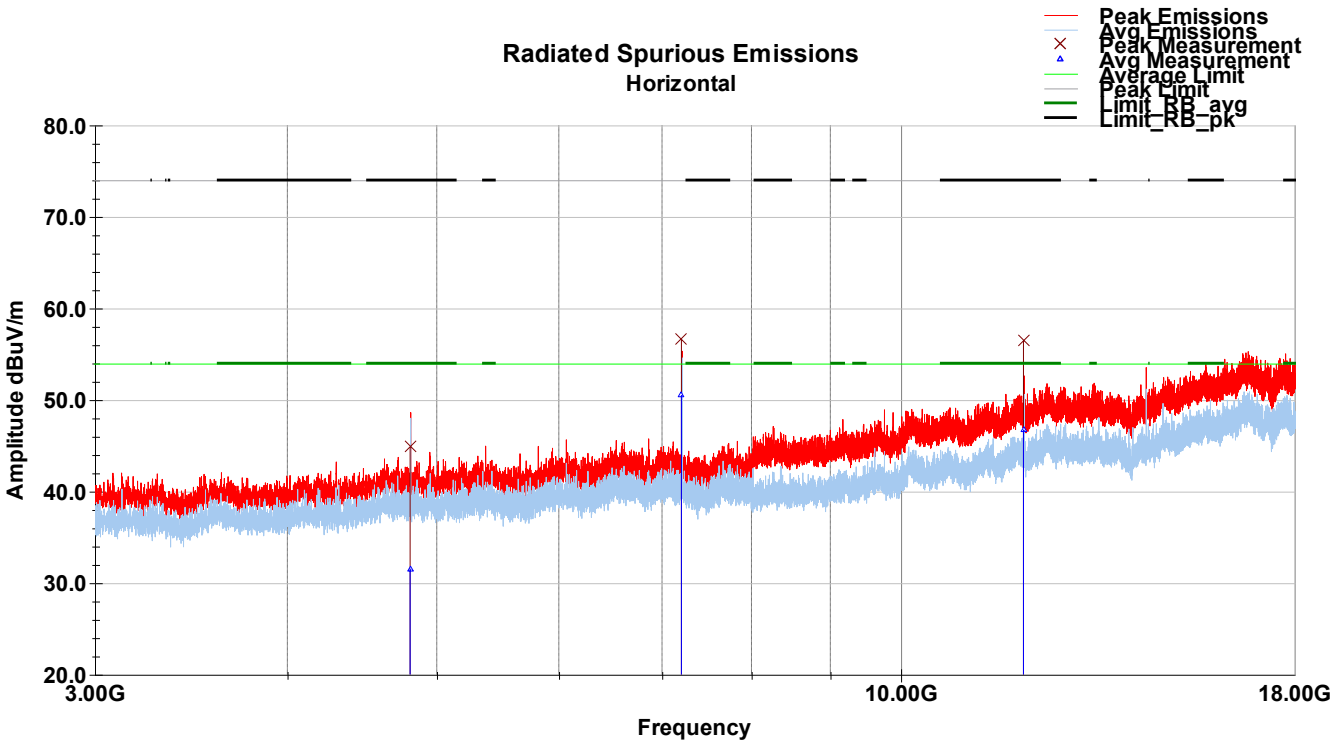
Average

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Avg dBuV/m	Limit (dBuV/m)	Margin (dB)
4804.52	47.9	V	84.0	112.0	34.6	2.9	42.4	43.0	54.0	-11.0
7205.58	54.3	V	325.0	100.0	35.9	3.6	41.9	51.8	54.0	-2.2
9608.66	43.1	V	101.0	149.0	36.6	4.1	42.3	41.5	54.0	-12.5

Final Avg = Raw Avg + AF + Loss - Amp

Margin = Final Avg - Limit

3-18 GHz Horizontal Low Channel - Lora



3-18 GHz Horizontal Low Channel – Lora Data

Peak

Frequency MHz	Raw Ave dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Ave Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4805.36	49.7	H	322.0	111.0	34.6	2.9	42.4	44.9	74.0	-29.1
7205.70	59.0	H	38.0	100.0	35.9	3.6	41.9	56.6	74.0	-17.4
12010.62	54.2	H	63.0	107.0	38.8	5.0	41.5	56.5	74.0	-17.5

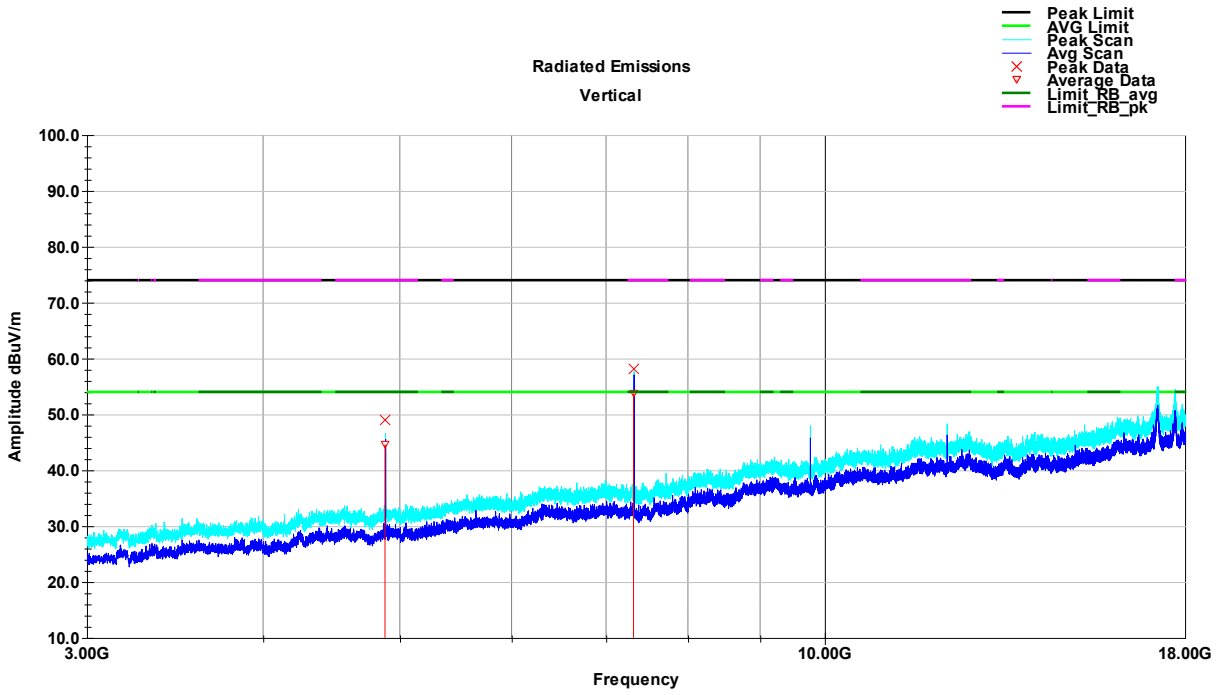
Final Pk = Raw Pk + AF + Loss - Amp
Margin = Final Pk - Limit

Average

Frequency MHz	Raw Ave dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Ave Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4805.36	36.4	H	322.0	111.0	34.6	2.9	42.4	31.6	54.0	-22.4
7205.70	53.0	H	38.0	100.0	35.9	3.6	41.9	50.5	54.0	-3.5
12010.62	44.4	H	63.0	107.0	38.8	5.0	41.5	46.7	54.0	-7.2

Final Avg = Raw Avg + AF + Loss - Amp
Margin = Final Avg - Limit

3-18 GHz Vertical Mid Channel - Lora



3-18GHz frequency range, Mid Channel Vertical Data

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
4880.20	47.1	V	91.0	178.0	34.1	3.1	35.2	49.0	74.0	-25.0
7320.00	54.7	V	191.0	109.0	35.5	3.5	35.5	58.1	74.0	-15.9

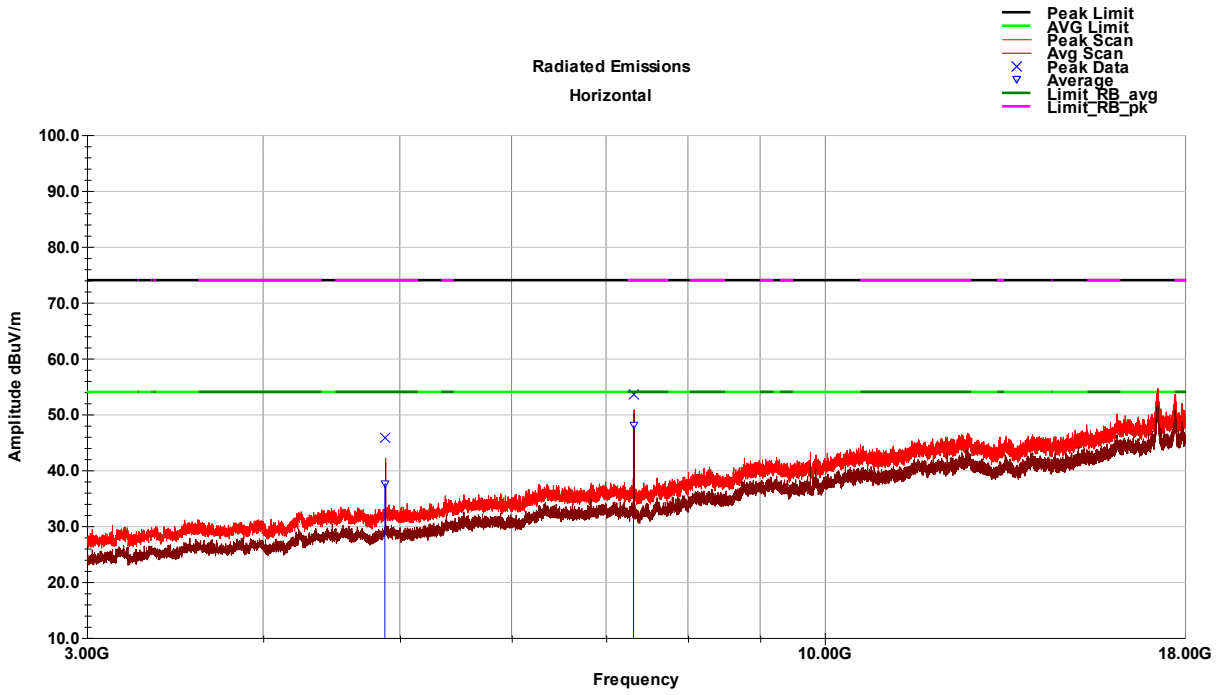
Final Pk = Raw Pk + AF + Loss - Amp
Margin = Final Pk - Limit

Average

Frequency MHz	Raw Ave dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Ave Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4880.20	42.7	V	91.0	178.0	34.1	3.1	35.2	44.6	54.0	-9.4
7320.00	50.2	V	191.0	109.0	35.5	3.5	35.5	53.7	54.0	-0.3

Final Avg = Raw Avg + AF + Loss - Amp
Margin = Final Avg - Limit

3-18 GHz Horizontal Mid Channel - Lora



3-18GHz frequency range, Mid Channel Horizontal Data

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
4879.60	43.9	H	72.0	117.0	34.1	3.1	35.2	45.8	74.0	-28.2
7319.90	50.2	H	146.0	117.0	35.5	3.5	35.5	53.6	74.0	-20.4

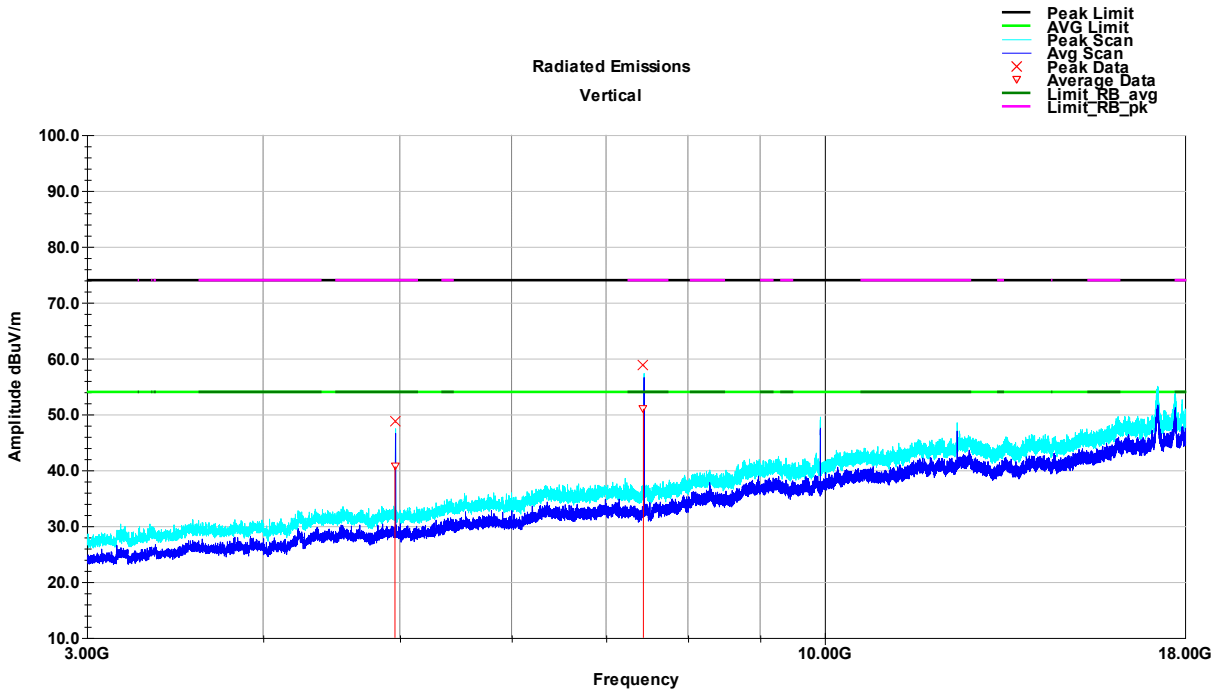
Final Pk = Raw Pk + AF + Loss - Amp
Margin = Final Pk - Limit

Average

Frequency MHz	Raw Ave dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Ave Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4879.60	35.7	H	72.0	117.0	34.1	3.1	35.2	37.6	54.0	-16.4
7319.90	44.5	H	146.0	117.0	35.5	3.5	35.5	48.0	54.0	-6.0

Final Avg = Raw Avg + AF + Loss - Amp
Margin = Final Avg - Limit

3-18 GHz Vertical High Channel - Lora



3-18GHz frequency range, High Channel Vertical Data

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
4960.50	38.6	V	61.0	178.0	34.0	3.2	35.2	40.6	74.0	-33.4
7439.50	47.6	V	360.0	120.0	35.5	3.4	35.5	51.0	74.0	-23.0

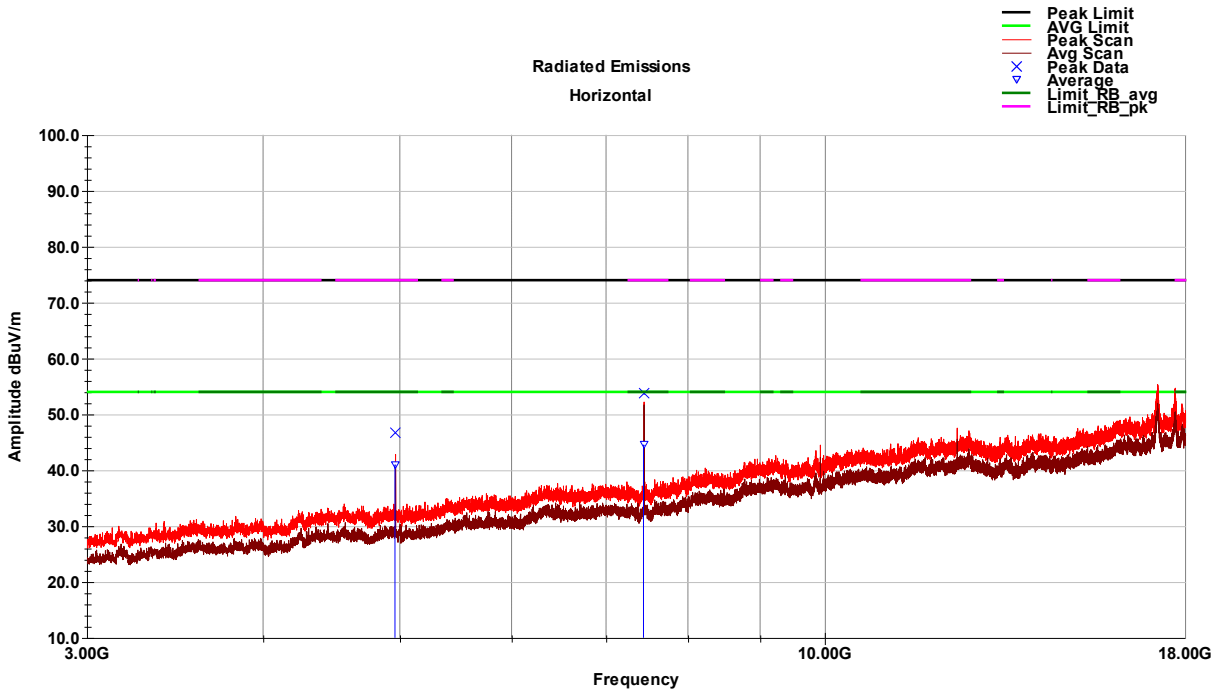
Final Pk = Raw Pk + AF + Loss - Amp
Margin = Final Pk - Limit

Average

Frequency MHz	Raw Ave dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Ave Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4960.50	38.6	V	61.0	178.0	34.0	3.2	35.2	40.6	54.0	-13.4
7439.50	47.6	V	360.0	120.0	35.5	3.4	35.5	51.0	54.0	-3.0

Ave Value = Level + AF + CL - Amp
Margin = Ave Value - Limit

3-18 GHz Horizontal High Channel - Lora



3-18GHz frequency range, High Channel Horizontal Data

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
4960.20	38.9	H	73.0	100.0	34.0	3.2	35.2	41.0	74.0	-28.2
7440.60	41.1	H	343.0	108.0	35.5	3.4	35.5	44.6	74.0	-20.4

Final Pk = Raw Pk + AF + Loss - Amp
Margin = Final Pk - Limit

Average

Frequency MHz	Raw Ave dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	CL (dB)	Amp (dB)	Ave Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4960.20	38.9	H	73.0	100.0	34.0	3.2	35.2	41.0	54.0	-13.0
7440.60	41.1	H	343.0	108.0	35.5	3.4	35.5	44.6	54.0	-9.4

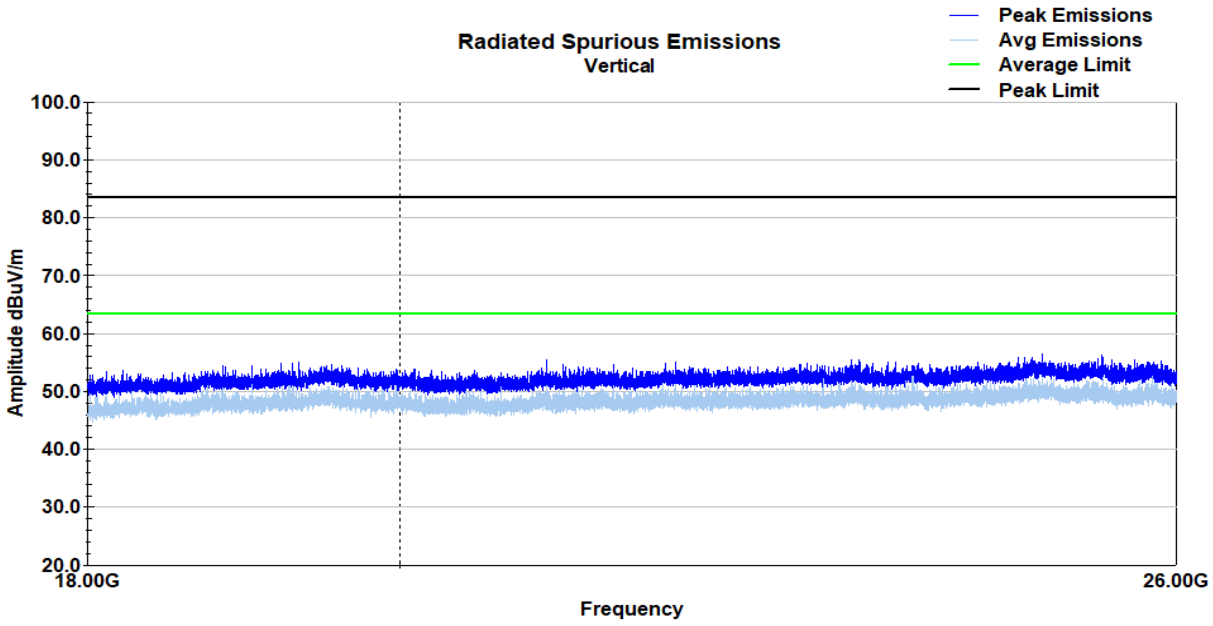
Final Avg = Raw Avg + AF + Loss - Amp
Margin = Final Avg - Limit

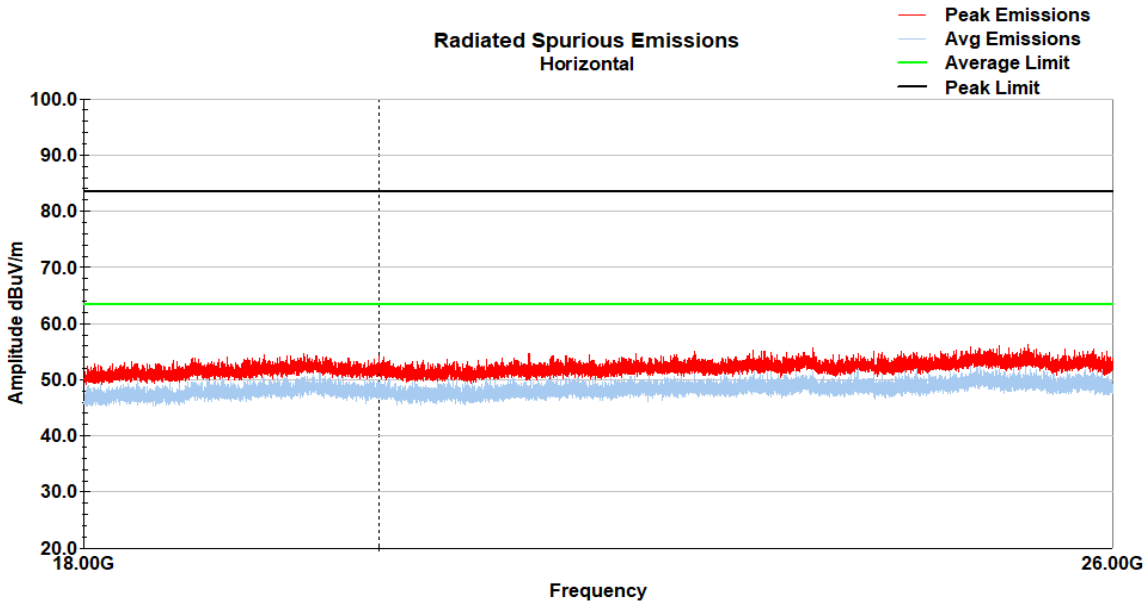
8.5.7 18-26 GHz BLE

BLE

No significant deviation based on axis or channel. Z-Axis/Mid Channel was worst case reported.

18-26GHz frequency range. 1m Antenna Distance



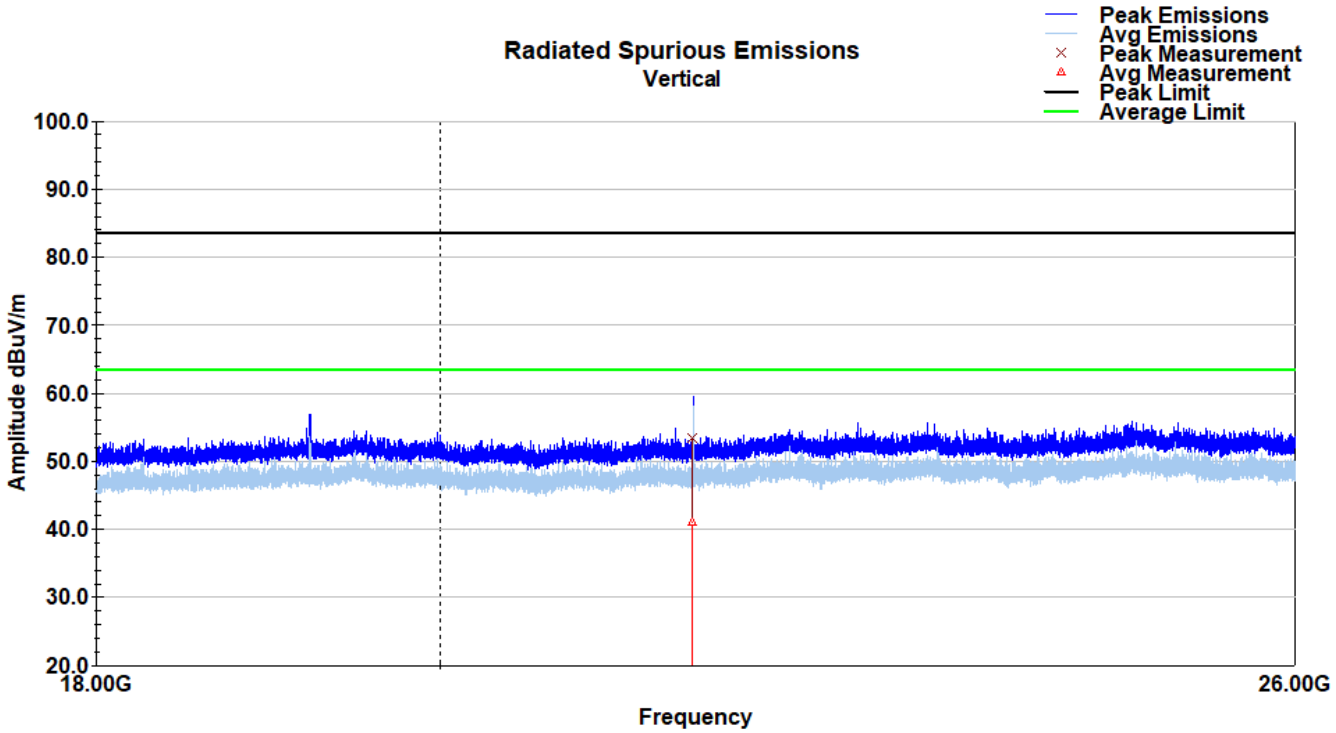


8.5.8 18-26 GHz Lora

Lora

There was no significant deviation based on axis or channel. Z-Axis was worst case reported.

18-26GHz frequency range, Low Channel Vertical Plot, 1m Antenna Distance



18-26GHz frequency range, Low Channel Vertical Data

Peak

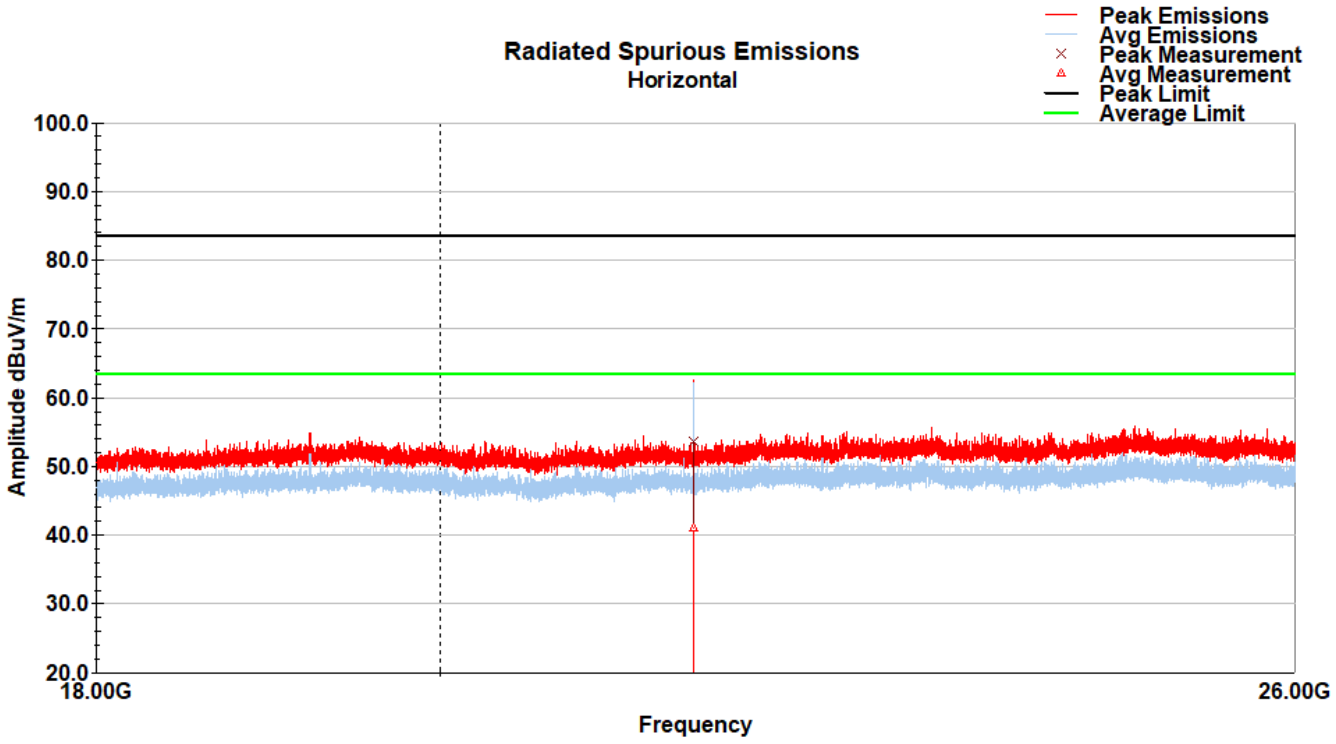
Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
21607.16	55.9	V	293.0	249.0	38.6	10.0	51.1	53.4	83.5	-30.1
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Avg

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Avg dBuV/m	Limit (dBuV/m)	Margin (dB)
21607.16	43.6	V	293.0	249.0	38.6	10.0	51.1	41.1	63.5	-22.4
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

Lora

18-26GHz frequency range, Low Channel Horizontal Plot, 1m Antenna Distance



18-26GHz frequency range, Low Channel Horizontal Data

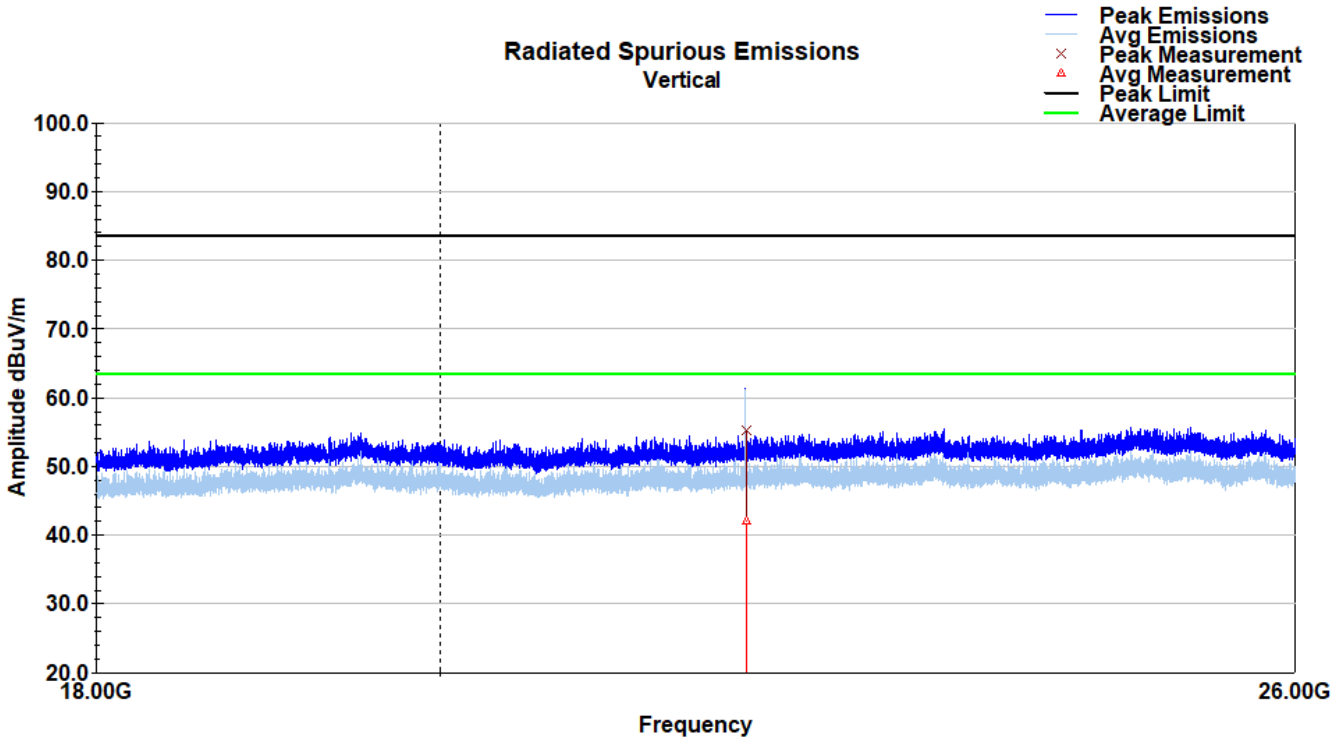
Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
21614.48	56.1	H	222.0	189.0	38.6	10.0	51.1	53.6	83.5	-30.0
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Avg

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Avg Value dBuV/m	Limit (dBuV/m)	Margin (dB)
21614.48	43.6	H	222.0	189.0	38.6	10.0	51.1	41.1	63.5	-22.4
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

Lora
18-26GHz frequency range, Mid Channel Vertical Plot, 1m Antenna Distance



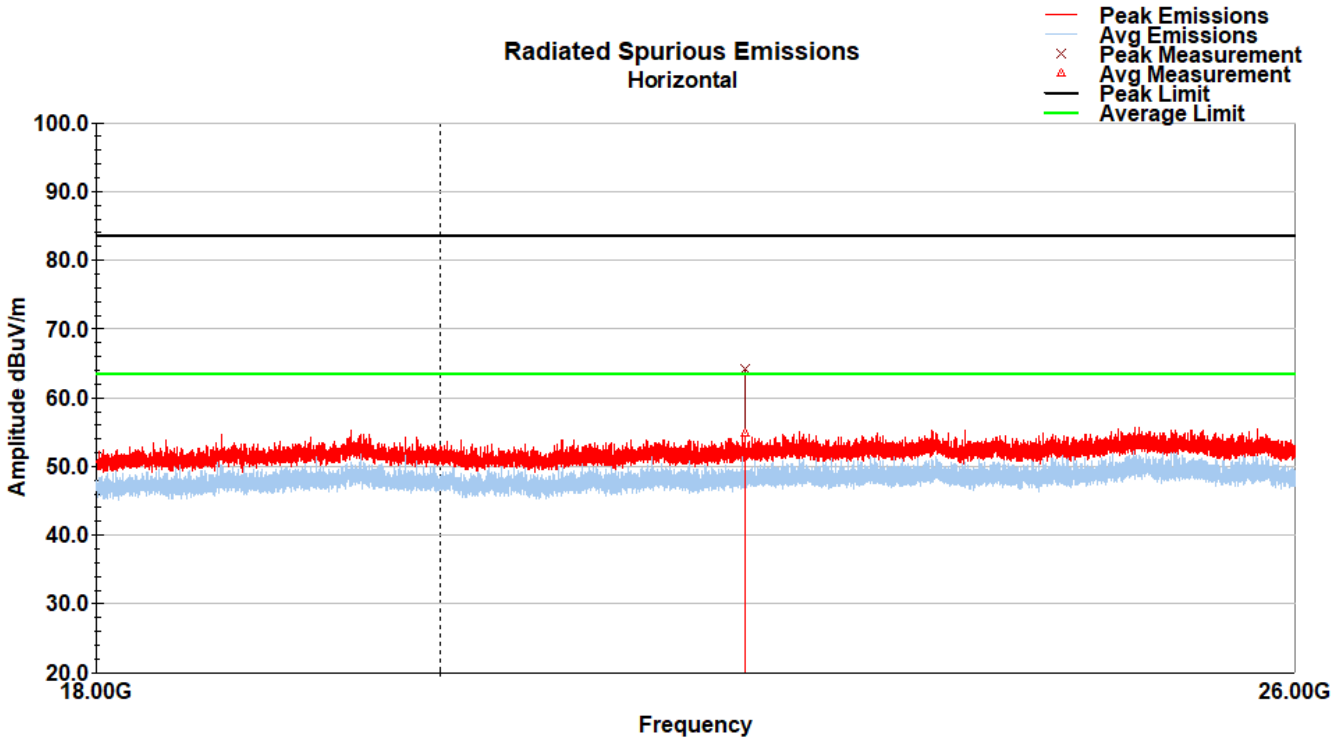
18-26GHz frequency range, Mid Channel Vertical Data
Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
21968.60	57.4	V	71.0	167.0	38.7	10.1	50.9	55.2	83.5	-28.3
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Avg

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Avg dBuV/m	Limit (dBuV/m)	Margin (dB)
21968.60	44.2	V	71.0	167.0	38.7	10.1	50.9	42.1	63.5	-21.5
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

Lora
18-26GHz frequency range, Mid Channel Horizontal Plot, 1m Antenna Distance



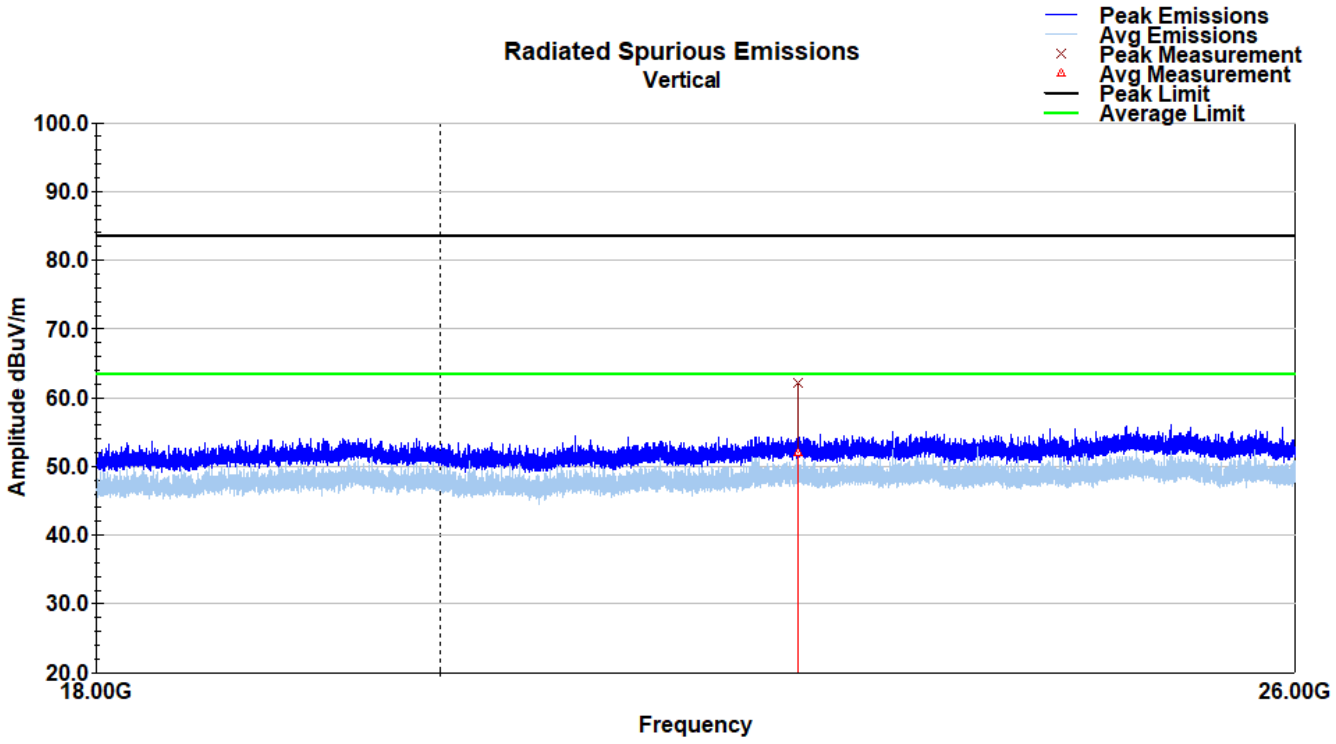
18-26GHz frequency range, Mid Channel Horizontal Data
Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
21960.88	66.4	H	233.0	168.0	38.7	10.1	51.0	64.2	83.5	-19.3
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Avg

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Avg Value dBuV/m	Limit (dBuV/m)	Margin (dB)
21960.88	57.0	H	233.0	168.0	38.7	10.1	51.0	54.8	63.5	-8.7
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

Lora
18-26GHz frequency range, High Channel Vertical Plot, 1m Antenna Distance



18-26GHz frequency range, High Channel Vertical Data
Peak

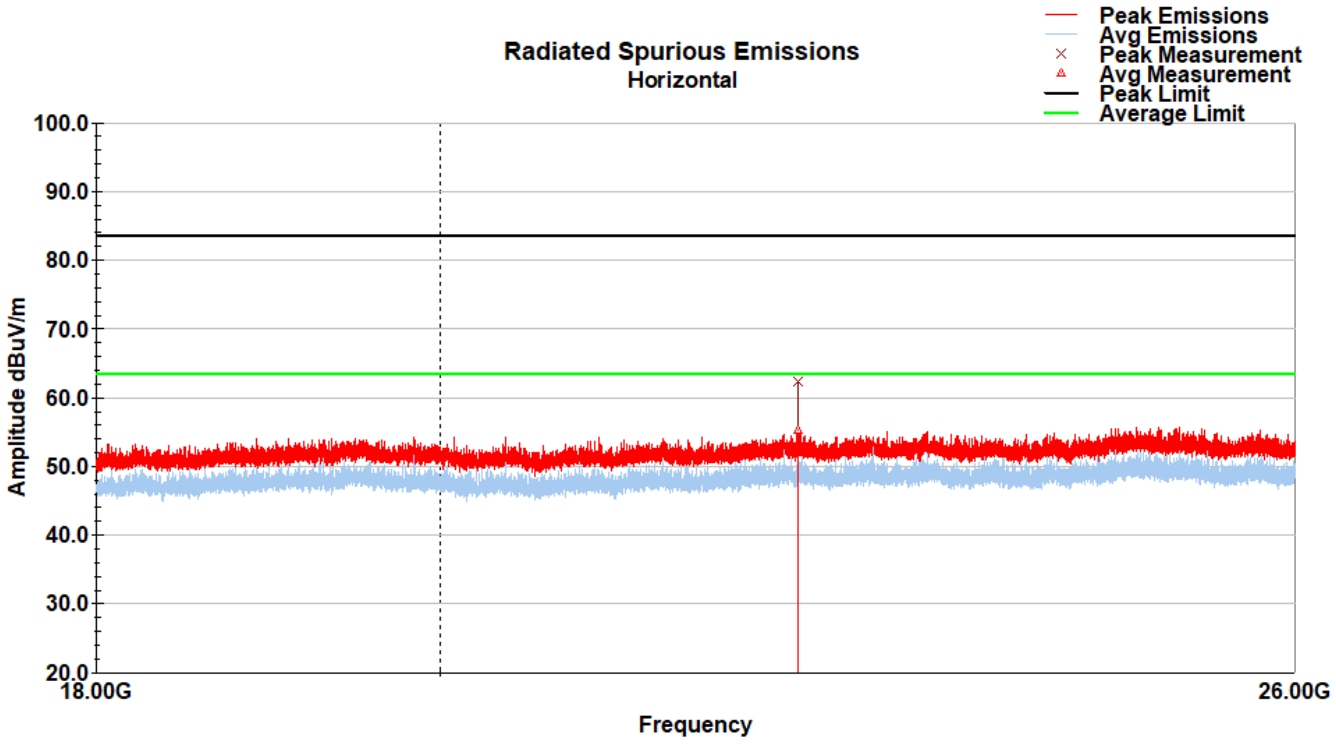
Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
22321.00	64.4	V	180.0	165.0	38.7	10.3	51.2	62.2	83.5	-21.4
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Avg

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Avg dBuV/m	Limit (dBuV/m)	Margin (dB)
22321.00	54.3	V	180.0	165.0	38.7	10.3	51.2	52.0	63.5	-11.5
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

Lora

18-26GHz frequency range, High Channel Horizontal Plot, 1m Antenna Distance



18-26GHz frequency range, High Channel Horizontal Data

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
22319.92	64.5	H	232.0	169.0	38.7	10.3	51.2	62.3	83.5	-21.3
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Avg

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Avg Value dBuV/m	Limit (dBuV/m)	Margin (dB)
22319.92	57.6	H	232.0	169.0	38.7	10.3	51.2	55.3	63.5	-8.2
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

9 Band Edge Emissions in Restricted Frequency Bands

9.1 *Test Result*

Test Description	Test Specification		Test Result
Band Edge Emissions in Restricted Frequency Bands	15.205, 15.209	RSS-GEN S8.9, 8.10	Compliant

9.2 *Test Method*

Field strength measurements were performed at the restricted band edges of 2390MHz and 2483.5MHz. Measurements were made using the conducted methods defined in ANSI C63.10: 2013 clause 11.12.2. The measurements were converted to a radiated field strength equivalent using the equations defined in that section. Both peak and average measurements were performed at the antenna port. These procedures are referenced in KDB 558074 D01 15.247 Meas Guidance v05r02.

A conversion factor of 95.2 dB (3m EIRP distance factor) needs to be applied to the peak and average conducted measurements and limits to represent field strength measurements in dBµV/m @ 3m.

(Ave Limit: -41.2dBm + 95.2dB = 54 dBuV)
(Peak Limit: -21.2 dBm + 95.2dB = 74 dBuV)
Ave Measurements + 95.2 dB = dBuV reading
Peak Measurements + 95.2 dB = dBuV reading

The BLE 2M PHY data mode was used for this test. Lora 1.6 MHz data rate was used for this test.

9.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions:	24-May-2024	18-July-2024
Temperature:	23.28 °C	23.46 °C
Relative Humidity:	50.9 %	51.3 %
Atmospheric Pressure:	98.16 kPa	98.37 kPa

9.4 *Test Equipment*

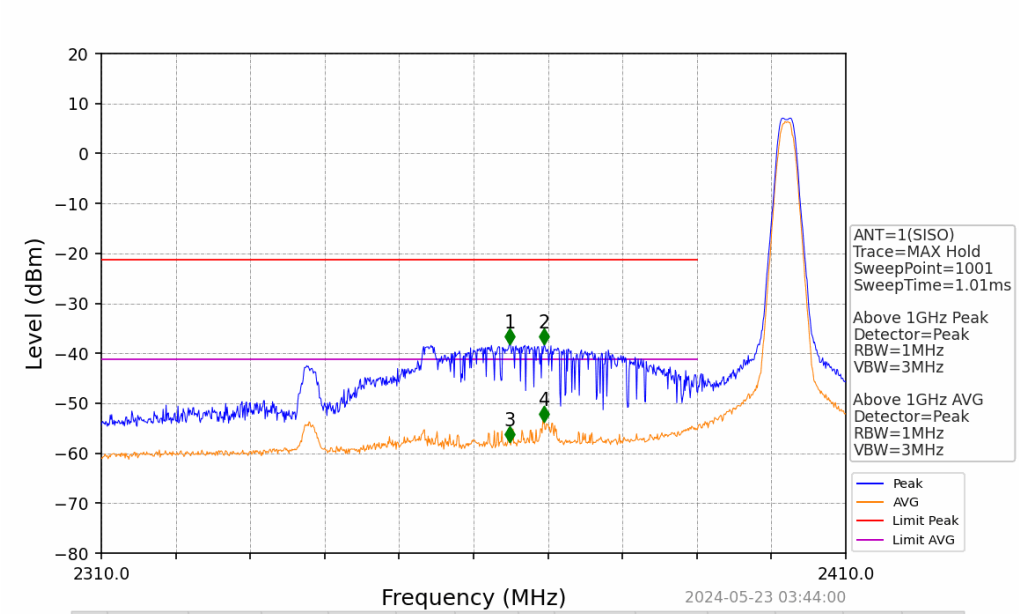
Test End Date: 24-May-2024 /18-July-2024 Tester:SGM

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	20-Mar-2024	20-Mar-2025
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	3-Jan-2024	3-Jan-2025
TSTPASS SWITCHBOX	SB2	TSTPASS	23009	8-Apr-2024	8-Apr-2025
MULTIMETER	87V	FLUKE	23014	30-Aug-2023	30-Aug-2024
DC POWER SUPPLY, PROGRAMMABLE	DP711	RIGOL	18027	CNR	CNR

Software Profile:
TSTPASS Version: 2.0 (2024.05.01_17.31.12)

9.5 *Test Data*

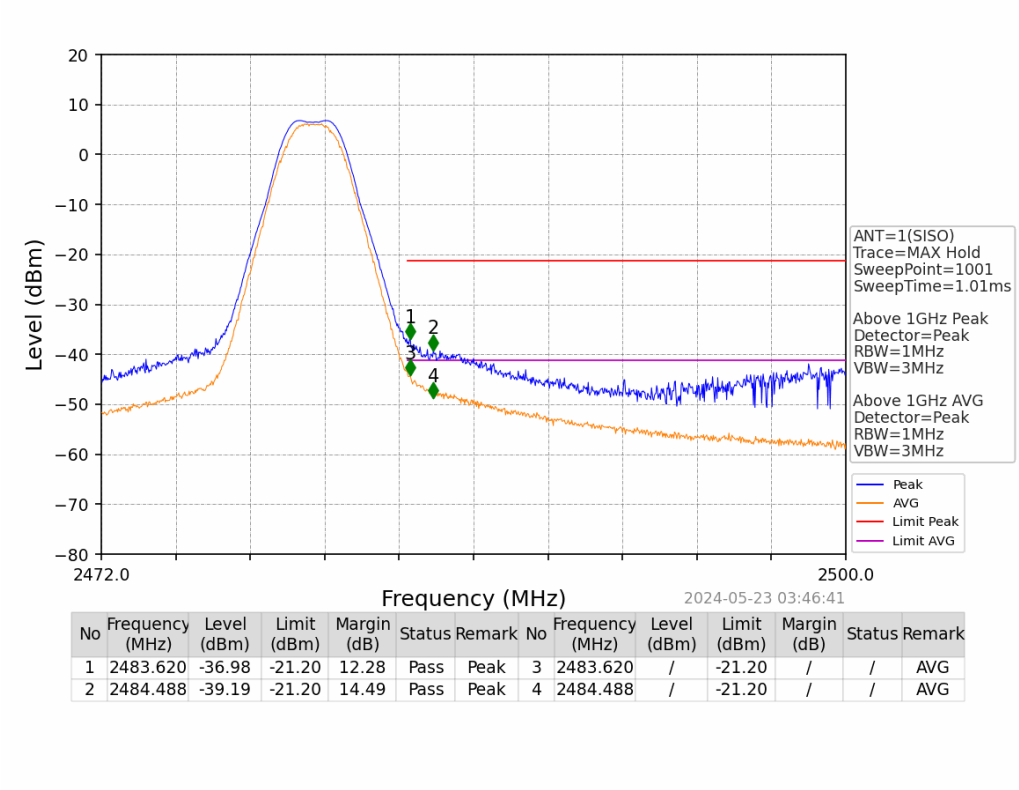
BLE – Low Channel – Plot



No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark	No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark
1	2364.900	-38.20	-21.20	13.49	Pass	Peak	3	2364.900	/	-21.20	/	/	AVG
2	2369.500	-38.27	-21.20	13.57	Pass	Peak	4	2369.500	/	-21.20	/	/	AVG

Frequency (MHz)	Peak Reading (dBm)	Conversion factor	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
2364.9	-38.2	95.2	57	74	-17	Peak
2369.5	-38.27	95.2	56.93	74	-17.07	Peak
2364.9	-58	95.2	37.2	54	-16.8	AVG
2369.5	-55	95.2	40.2	54	-13.8	AVG

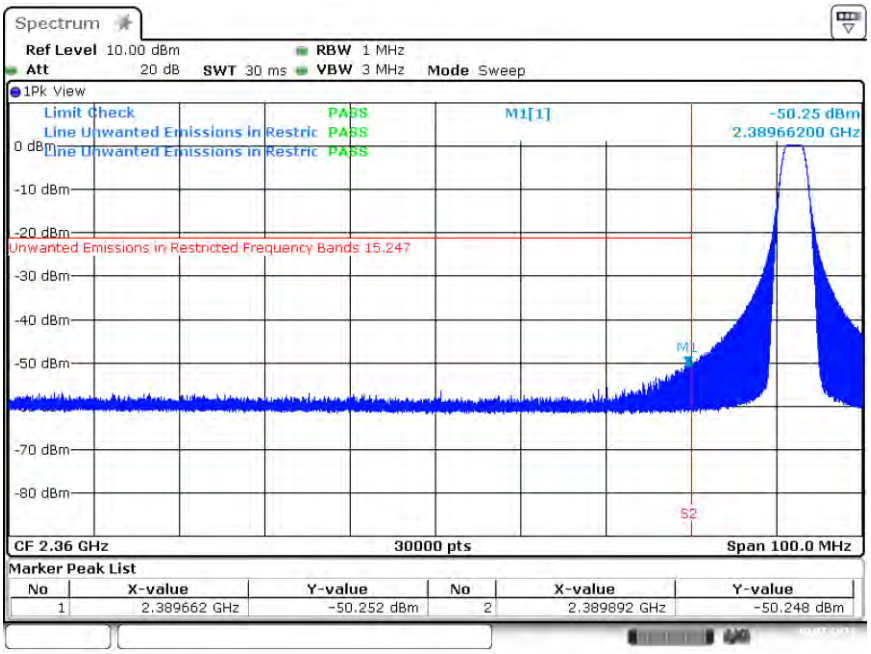
BLE – High Channel – Plot



No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark	No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark
1	2483.620	-36.98	-21.20	12.28	Pass	Peak	3	2483.620	/	-21.20	/	/	AVG
2	2484.488	-39.19	-21.20	14.49	Pass	Peak	4	2484.488	/	-21.20	/	/	AVG

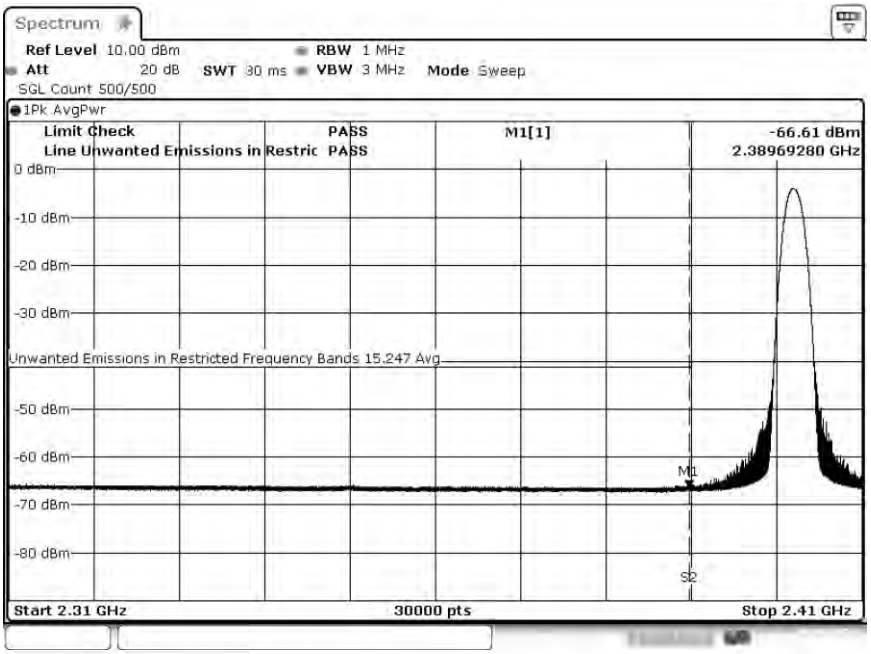
Frequency (MHz)	Peak Reading (dBm)	Conversion factor	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
2483.62	-36.98	95.2	58.22	74	-15.78	Peak
2484.488	-39.19	95.2	56.01	74	-17.99	Peak
2483.62	-42	95.2	53.2	54	-0.8	AVG
2484.488	-48	95.2	47.2	54	-6.8	AVG

LoRa – Low Channel – Plot Peak



Date: 18.JUL.2024 09:56:12

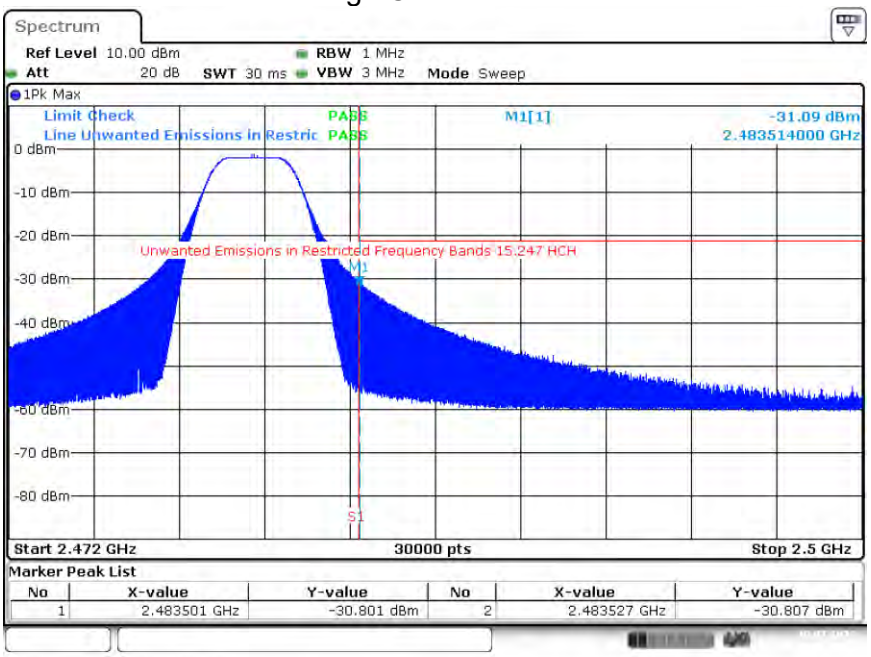
LoRa – Low Channel – Plot Peak



Date: 18.JUL.2024 13:44:35

Frequency (MHz)	Reading (dBm)	Conversion factor	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
2389.6	-50.25	95.2	44.95	74	-29.05	Peak
2389.6	-66.61	95.2	28.59	54	-25.41	Ave

LoRa – High Channel – Plot Peak



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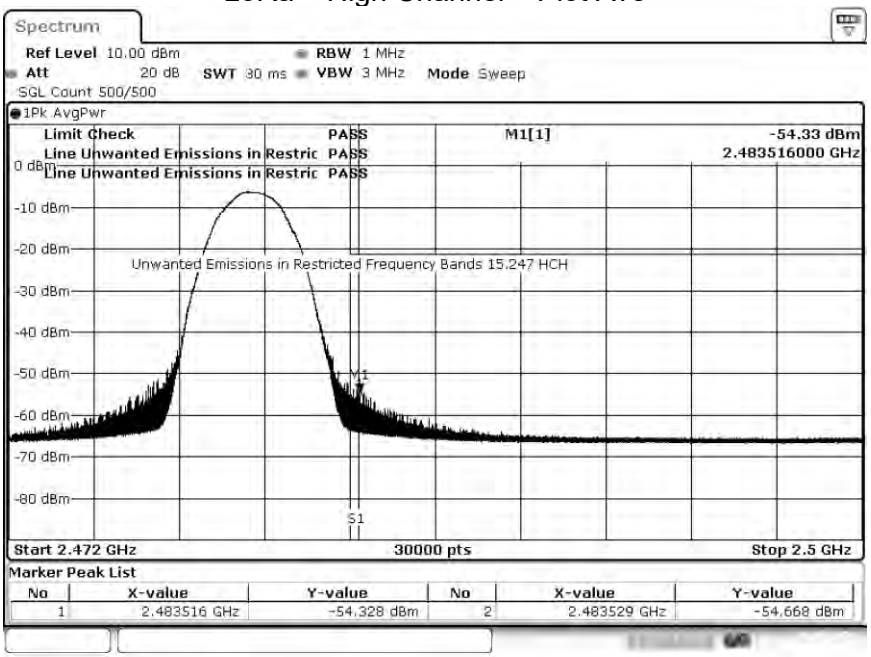
LoRa – High Channel – Plot Ave



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Frequency (MHz)	Reading (dBm)	Conversion factor	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
2483.501	-30.80	95.2	64.4	74	-9.6	Peak
2483.516	-54.33	95.2	40.87	54	-13.13	Ave

10 Measurement Uncertainty

The measurement uncertainty figures are be calculated in accordance with TR 100 028-1 [2] and correspond to an expansion factor (coverage factor) k = 2 (which provide confidence levels of 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

	Expanded Uncertainty for Normal k factor equal to 2	
Parameter	Required	Laboratory Actual
Radio Frequency	±1 x 10-5	±9.8 x 10-8
total RF power, conducted	±1.5 dB	±1.2 dB
RF power density, conducted	±3 dB	±0.7 dB
spurious emissions, conducted	±3 dB	±2.1 dB
all emissions, radiated	±6 dB	±4.8 dB
temperature	±1°C	±0.5°C
humidity	±5 %	±3.5%
DC and low frequency voltages	±3 %	±0.4%

11 Revision History

Revision Level	Description of changes	Revision Date
Draft	Draft Release	30 May 2024
0	Initial Release	10 June 2024
1	Duty Cycle information added. Updated sections 2.4, 2.5, 4.2. Passive equipment added to equipment list. Additional updates.	08 July 2024
2	Sections 2 & 3 updated.	17 July 2024
3	Section 1 updated antenna type from chip antenna to SMD. Updated section 7 and 9 LoRa plots.	18 July 2024
4	Updated Section 1. Updated Section 7. Updated section 8.	22 July 2024
5	Updated section 7	23 July 2024
6	Updated section 2	23 July 2024