RF Test Report

Project Number:	**4681230**	**Proposal Number:**	**11079**
Report Number:	**4681230EMC08**	**Revision Level:**	**1**
Client:	**ZEROKEY Inc.**		

Equipment Under Test:	**50V Ultrasonic Transducer**
Model Name:	**Relay Node**
Model Numbers:	**AGISRL10 and ZKISRL10**
FCC ID:	**2AX6LISRL10**
IC:	**26679-ISRL10**

Applicable Standards:	**FCC Part 15 Subpart C, § 15.247**
	RSS-247, Issue 2, February 2017
	RSS-GEN, Issue 5, February 2021, Amendment 2
	ANSI C63.10:2013

Report issued on:	**28 June 2021**
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.

Prepared by: Martin Taylor, Project Engineer

Reviewed by: Jeremy Pickens, RF Lab Manager

Remarks: This report details the results of the testing carried out on one sample; the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

Table of Contents

1 Summary of Test Results

Test Description	Test Specification		Test Result
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 (1)
Antenna Requirement	15.203	RSS-GEN S6.8	Compliant (2)

(1) The device does not connect to the AC Mains.
(2) The device uses two internal antennas which cannot be replaced by the end user.

1.1 *Modifications Required for Compliance*

None.

2 General Information

2.1 *Client Information*

Name:	ZEROKEY Inc.
Address:	3120 12 Street NE
City, State, Zip, Country:	Calgary, Alberta T2E 8T3 Canada

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
CAB ID:	US0186

2.3 *General Information of EUT*

Equipment Under Test:	50V Ultrasonic Transducer
Model Name:	Relay Node
Model Numbers:	AGISRL10 and ZKISRL10
Sample ID:	SUWES2012000108HZ
FCC ID:	2AX6LISRL10
IC ID:	26679-ISRL10
Frequency Range:	2402 – 2480 MHz (two BLE radios)
Data Modes:	Bluetooth Low Energy (GFSK 1Mbps & 2Mbps) Nordic Enhanced ShockBurst Protocol (GFSK 2Mbps)
Antenna:	Surface Mount Stamped Metal Antenna (4.9 dBi max gain) Internal Flexible PCB Antenna (3.2 dBi max gain)
Rated Voltage:	3.6 Vdc Lithium Thionyl Chloride Battery
Test Voltage:	3.6 Vdc Lithium Thionyl Chloride Battery
Sample Received Date:	02 February 2021
Dates of testing:	17 February to 30 April 2021

2.4 *Operating Modes and Conditions*

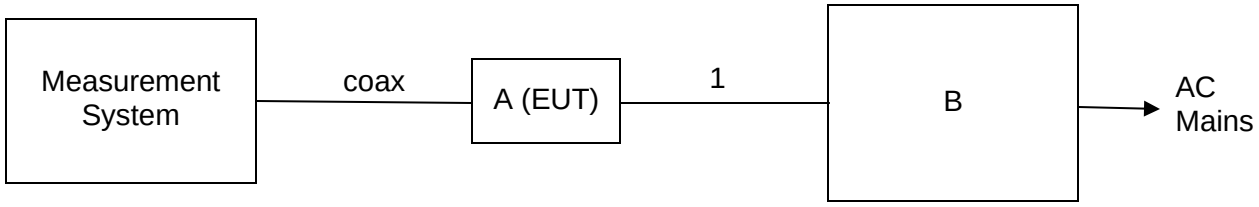
The EUT was running test mode firmware FCC Certification Version 1.0 that allowed control of the two Bluetooth LE radios from Nordic Semiconductor. This firmware was based on Nordic SDK v15.2.0. This software allowed the following:

1) selecting low, middle and high BLE channels;
2) selecting the modulation scheme as used in normal operation, but with 100% duty cycle;
3) setting the power level. [The maximum nominal power level of +8dBm was used for all tests.]

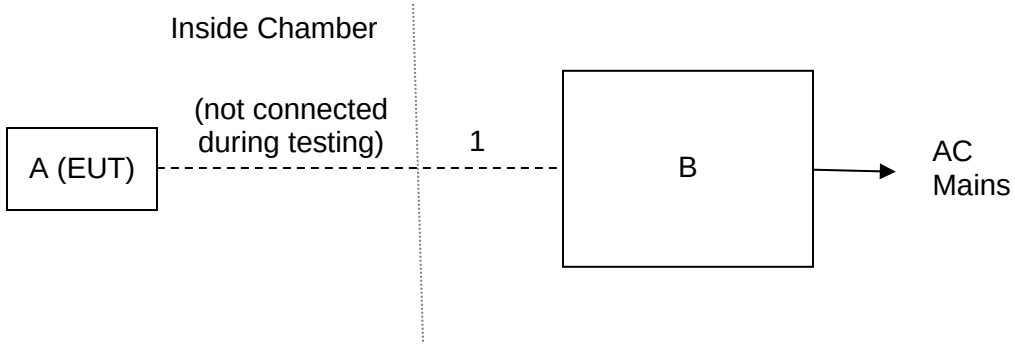
The following 3 data modes were tested and the worst-case results for each radio & test were reported.

- Enhanced ShockBurst 2Mbps: Used for normal operation
- BLE 1Mbps: Used only for over-the-air firmware updates
- BLE 2Mbps: Used only for over-the-air firmware updates

2.5 *EUT Connection Block Diagram – Conducted Measurements*



2.6 *EUT Connection Block Diagram – Radiated Measurements*



2.7 *System Configurations*

Device Reference	Manufacturer	Description	Model Number	Serial Number
A	ZEROKEY Inc.	50V Ultrasonic Transducer (EUT)	AGISRL10 ZKISRL10	Not labeled
B	Lenovo	Laptop Computer	T500	L3-ABV0N 08/12

2.8 *Cable List*

Cable reference	Port Name	Start	End	Cable Length (m)	Ferrite installed?	Shielded?
1	USB-Micro	EUT	Laptop Computer	1.0	N	N

3 Bandwidth

3.1 *Test Result*

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

3.2 *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 1Mbps data mode was used for these tests since it produced the narrowest bandwidth.

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

3.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	24.2 °C
Relative Humidity:	34.8 %
Atmospheric Pressure:	97.8 kPa

3.4 *Test Equipment*

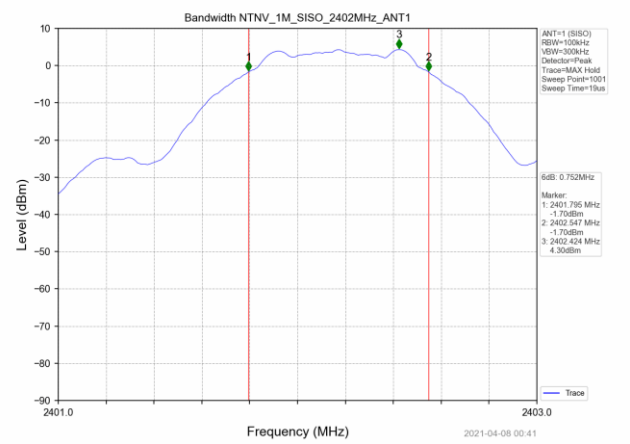
Test End Date: 7-Apr-2021 Tester: MT

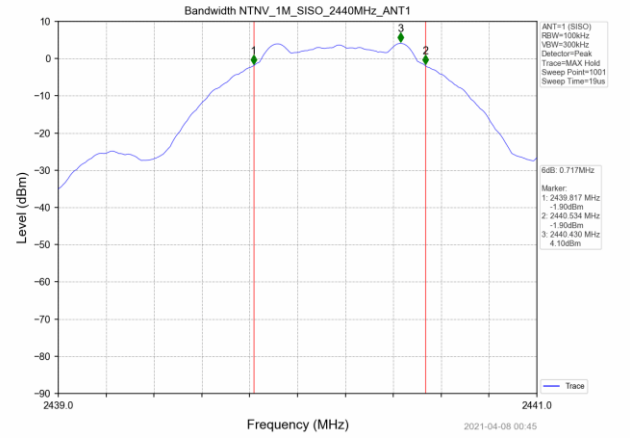
Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	27-Dec-2019	27-Dec-2021
ATTENUATOR, 10DB	BW-S10W2	Mini-Circuits	15032	28-Sep-2020	28-Sep-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-059	TELEDYNE STORM MICROWAVE	20108	16-Mar-2021	16-Mar-2022

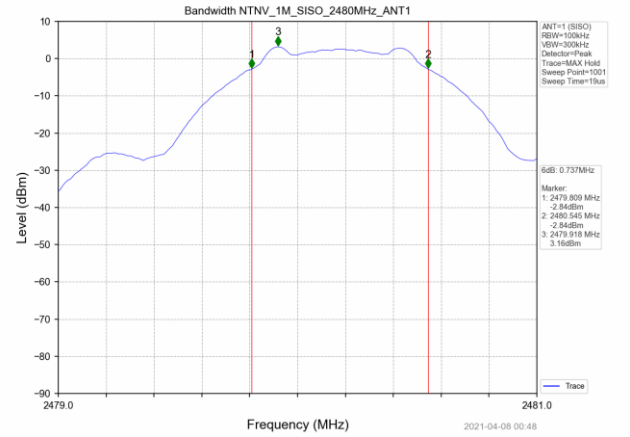
Note: The equipment calibration period is 1 year except for the FSV which is on a 2-year cycle.

3.5 *Test Data – Anchor Radio – DTS Bandwidth (6dB)*

Test Mode	Channel	Frequency (MHz)	6dB Bandwidth		Verdict
			Test Result (MHz)	Limits (MHz)	
BLE 1Mbps	0	2402	0.752	≥0.5	Pass
	19	2440	0.717	≥0.5	Pass
	39	2480	0.737	≥0.5	Pass

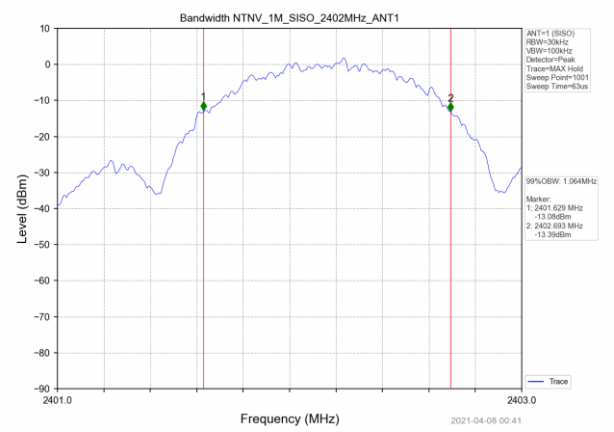


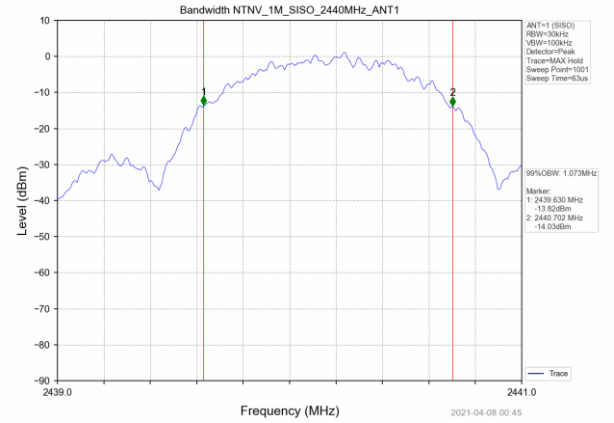


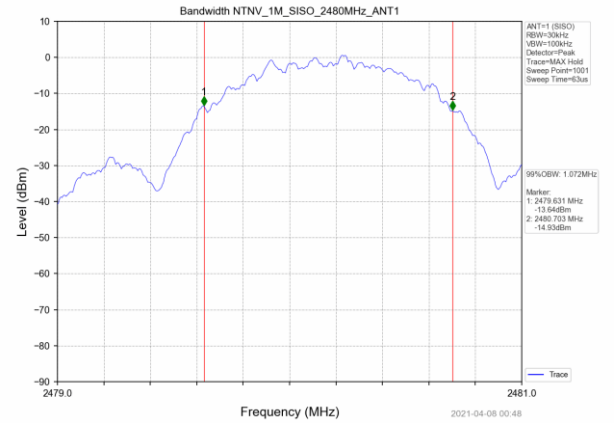


3.6 *Test Data – Anchor Radio – 99% Occupied Bandwidth*

Test Mode	Channel	Frequency (MHz)	99% Occupied Bandwidth Test Result (MHz)	Verdict
BLE 1Mbps	0	2402	1.064	Reported
	19	2440	1.073	Reported
	39	2480	1.072	Reported

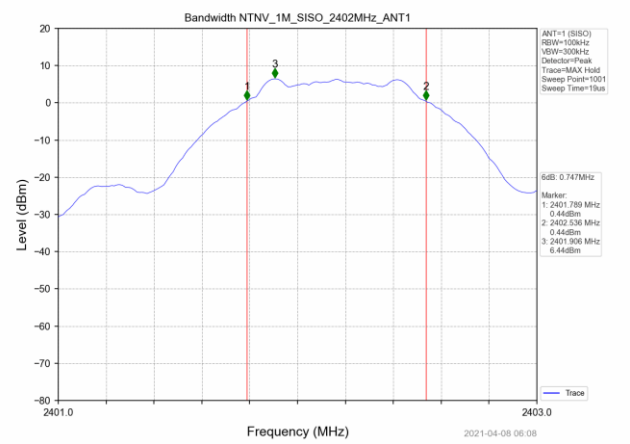


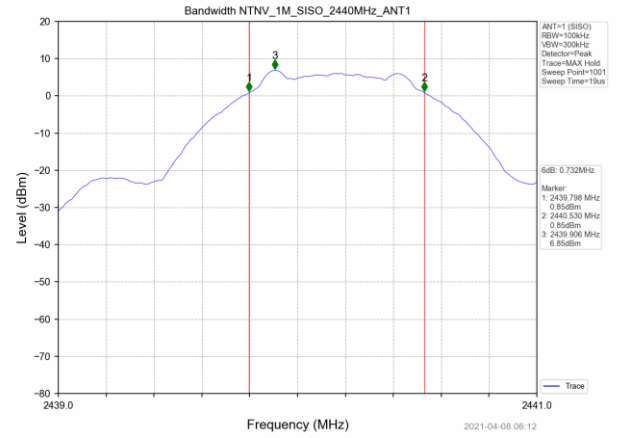


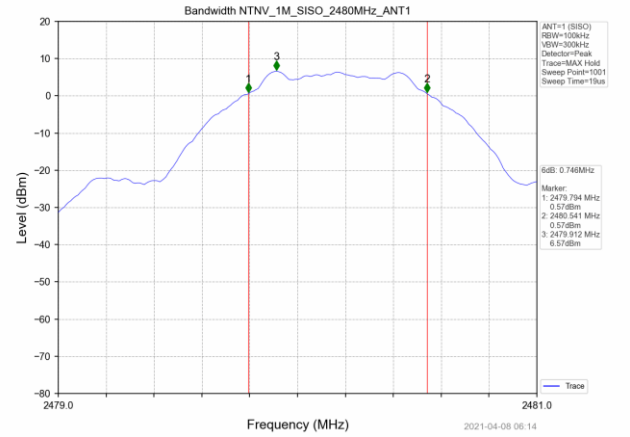


3.7 *Test Data – Relay Radio – DTS Bandwidth (6dB)*

Test Mode	Channel	Frequency (MHz)	6dB Bandwidth		Verdict
			Test Result (MHz)	Limits (MHz)	
BLE 1Mbps	0	2402	0.747	≥0.5	Pass
	19	2440	0.732	≥0.5	Pass
	39	2480	0.746	≥0.5	Pass

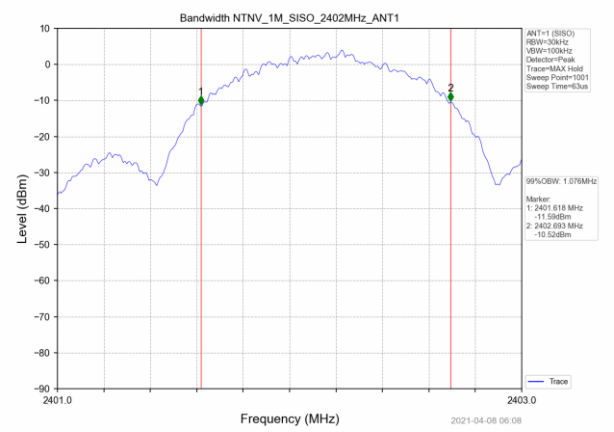


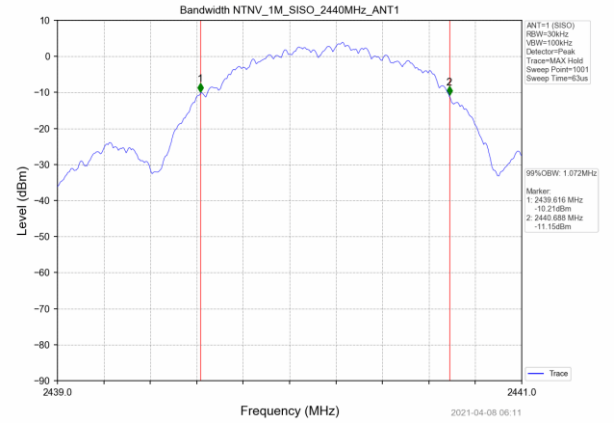


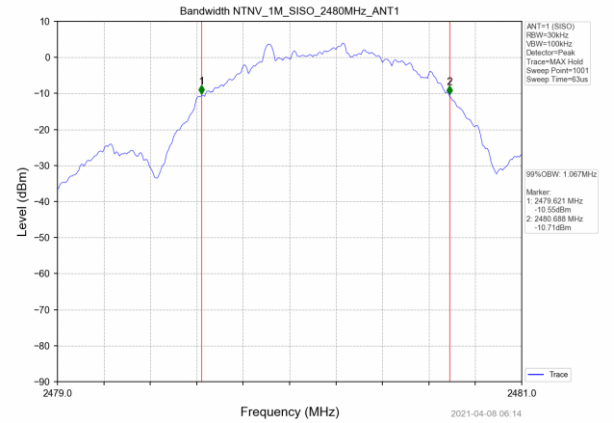


3.8 *Test Data – Relay Radio – 99% Occupied Bandwidth*

Test Mode	Channel	Frequency (MHz)	99% Occupied Bandwidth Test Result (MHz)	Verdict
BLE 1Mbps	0	2402	1.076	Reported
	19	2440	1.072	Reported
	39	2480	1.067	Reported







4 Output Power

4.1 *Test Result*

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

4.2 *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 ShockBurst 2Mbps data mode was used for this test since it produced the highest power.

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).

4.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	24.2 °C
Relative Humidity:	34.8 %
Atmospheric Pressure:	97.8 kPa

4.4 *Test Equipment*

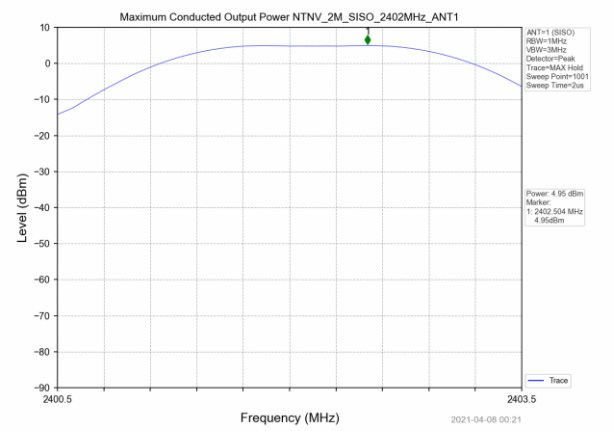
Test End Date: 7-Apr-2021 Tester: MT

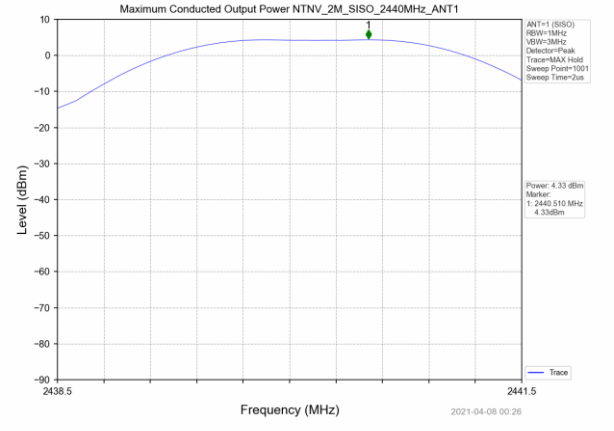
Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	27-Dec-2019	27-Dec-2021
ATTENUATOR, 10DB	BW-S10W2	Mini-Circuits	15032	28-Sep-2020	28-Sep-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-059	TELEDYNE STORM MICROWAVE	20108	16-Mar-2021	16-Mar-2022

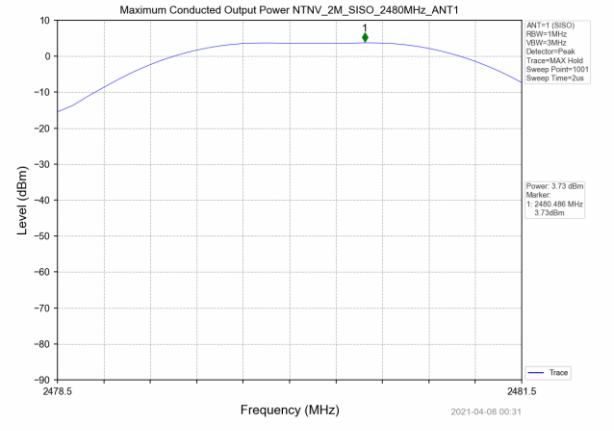
Note: The equipment calibration period is 1 year except for the FSV which is on a 2-year cycle.

4.5 *Test Data – Anchor Radio*

Channel	Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Peak EIRP (dBm)	Limit Max (dBm)	Verdict
0	2402	4.95	30	9.85	36	Pass
19	2440	4.33	30	9.23	36	Pass
39	2480	3.73	30	8.63	36	Pass

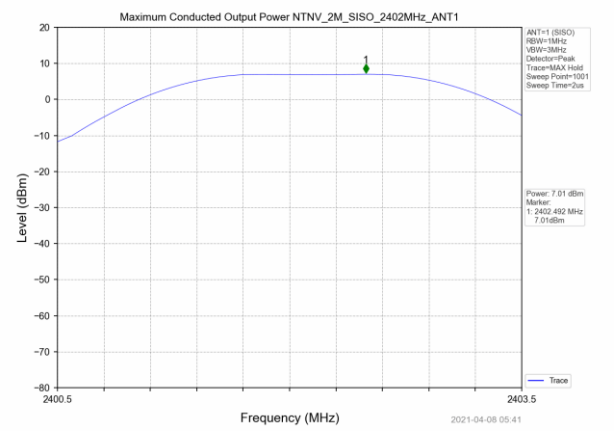


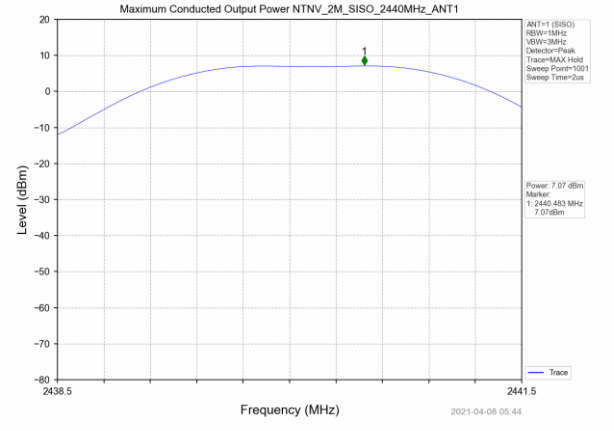


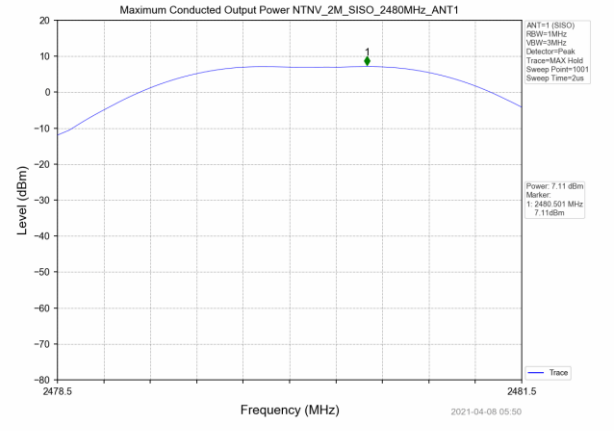


4.6 *Test Data – Relay Radio*

Channel	Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Peak EIRP (dBm)	Limit Max (dBm)	Verdict
0	2402	7.01	30	10.21	36	Pass
19	2440	7.07	30	10.27	36	Pass
39	2480	7.11	30	10.31	36	Pass







5 Power Spectral Density

5.1 *Test Result*

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

5.2 *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 1Mbps data mode was used for this test since it produced the highest Peak PSD.

Limit
The maximum limit is 8 dBm / 3 kHz.

5.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	24.2 °C
Relative Humidity:	34.8 %
Atmospheric Pressure:	97.8 kPa

5.4 *Test Equipment*

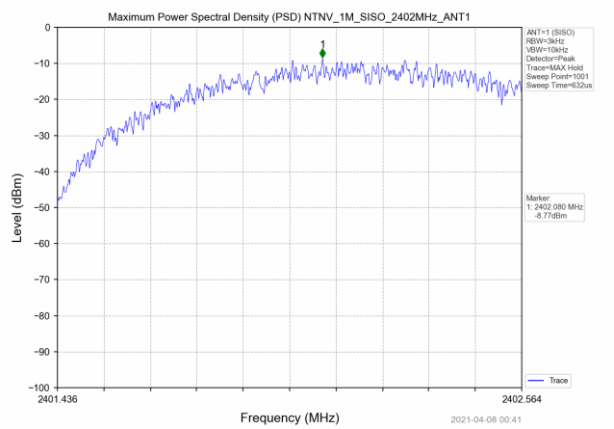
Test End Date: 7-Apr-2021 Tester: MT

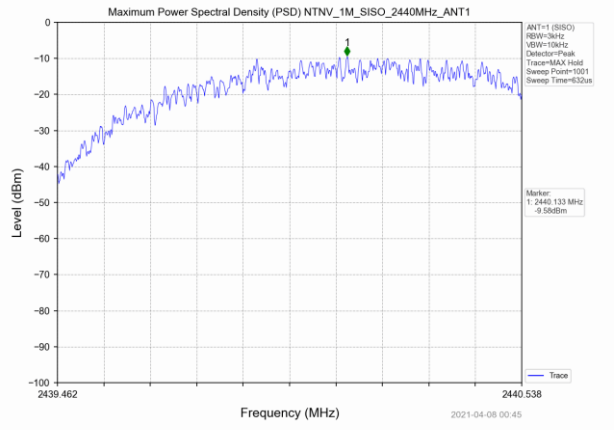
Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	27-Dec-2019	27-Dec-2021
ATTENUATOR, 10DB	BW-S10W2	Mini-Circuits	15032	28-Sep-2020	28-Sep-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-059	TELEDYNE STORM MICROWAVE	20108	16-Mar-2021	16-Mar-2022

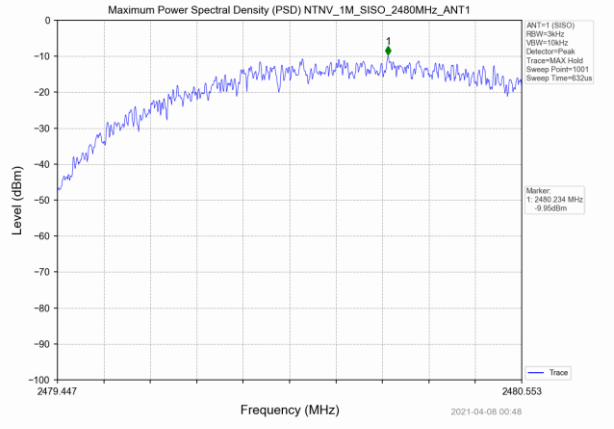
Note: The equipment calibration period is 1 year except for the FSV which is on a 2-year cycle.

5.5 *Test Data – Anchor Radio*

Channel	Frequency (MHz)	Peak PSD (dBm/3kHz)	Limit Max (dBm/3kHz)	Verdict
0	2402	-8.77	8	Pass
19	2440	-9.58	8	Pass
39	2480	-9.95	8	Pass

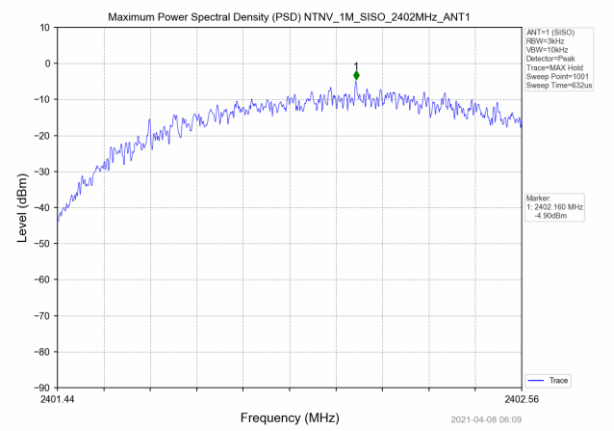


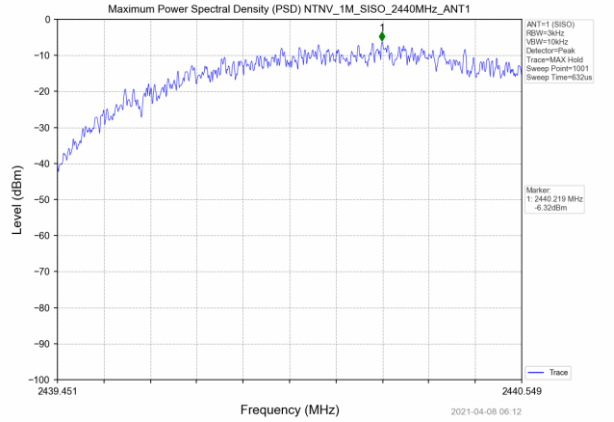


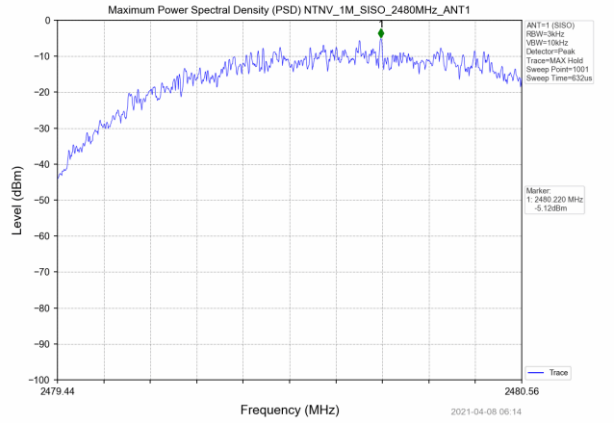


5.6 *Test Data – Relay Radio*

Channel	Frequency (MHz)	Peak PSD (dBm/3kHz)	Limit Max (dBm/3kHz)	Verdict
0	2402	-4.90	8	Pass
19	2440	-6.32	8	Pass
39	2480	-5.12	8	Pass







6 Conducted Spurious Emissions / Band Edge

6.1 *Test Result*

Test Description	Test Specification		Anchor Radio	Relay Radio
Conducted Spurious and Band Edge Emissions	15.247(d)	RSS-247 S5.5	Compliant	Compliant

6.2 *Test Method*

Conducted band edge and spurious band emissions 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.

The BLE 2Mbps data mode was used for these tests since it produced emissions closest to the band edges.

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.

6.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	24.2 °C
Relative Humidity:	34.8 %
Atmospheric Pressure:	97.8 kPa

6.4 *Test Equipment*

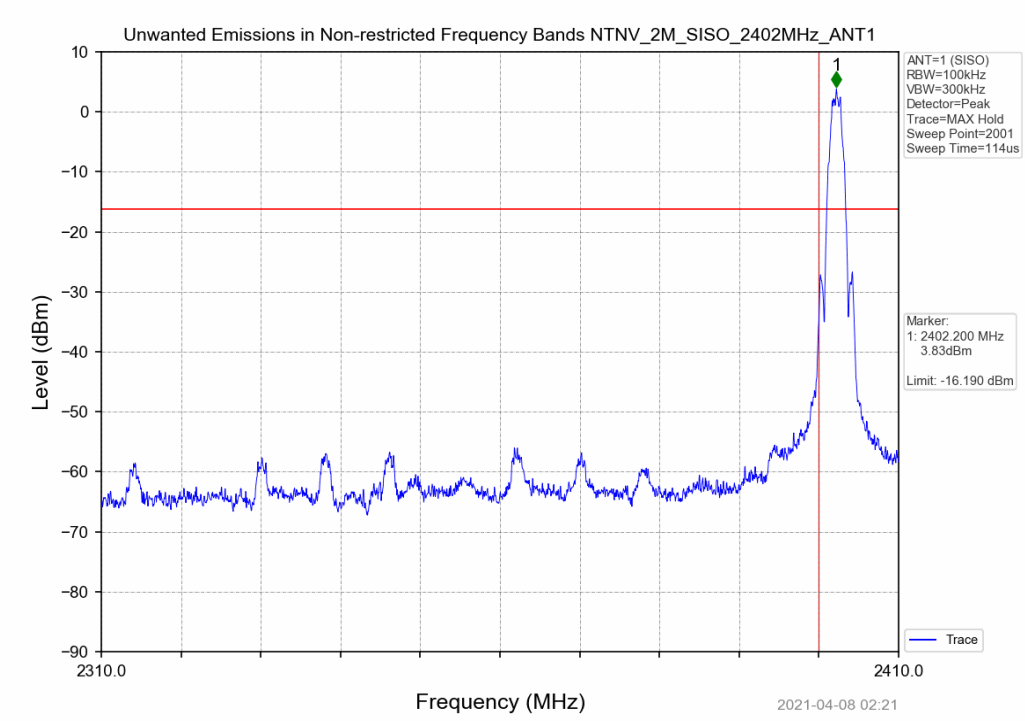
Test End Date: 7-Apr-2021 Tester: MT

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	27-Dec-2019	27-Dec-2021
ATTENUATOR, 10DB	BW-S10W2	Mini-Circuits	15032	28-Sep-2020	28-Sep-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-059	TELEDYNE STORM MICROWAVE	20108	16-Mar-2021	16-Mar-2022

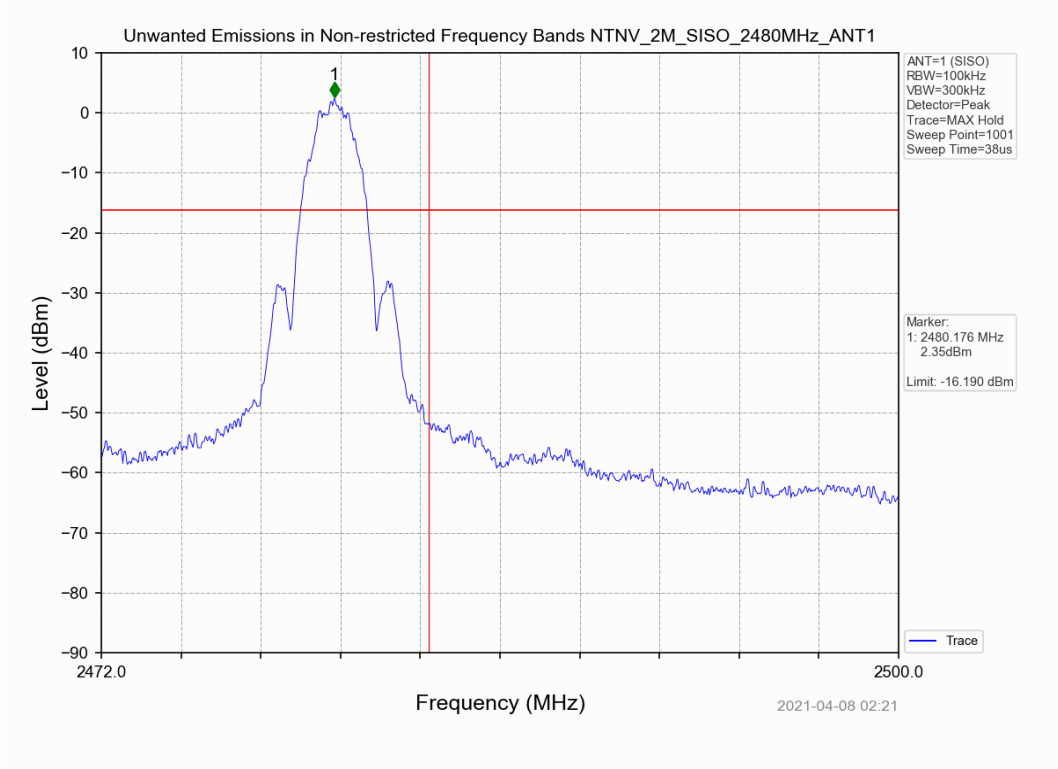
Note: The equipment calibration period is 1 year except for the FSV which is on a 2-year cycle.

6.5 *Test Data – Anchor Radio – DTS Band Edge*

BLE - Lower band edge

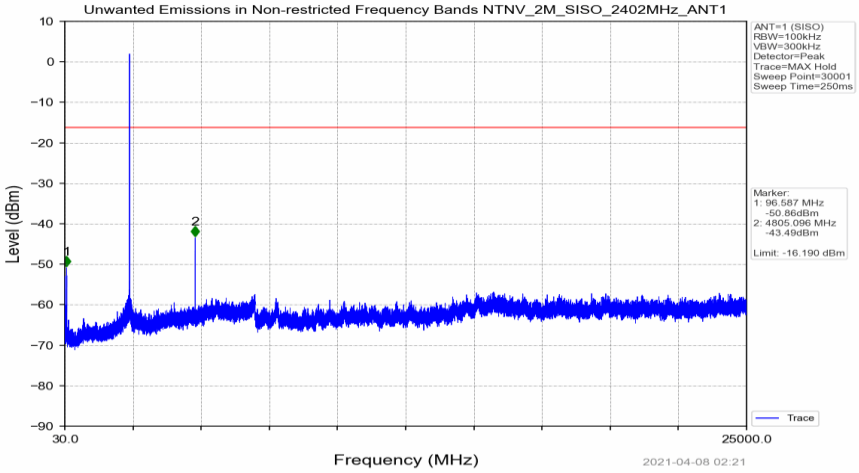


BLE - Upper band edge

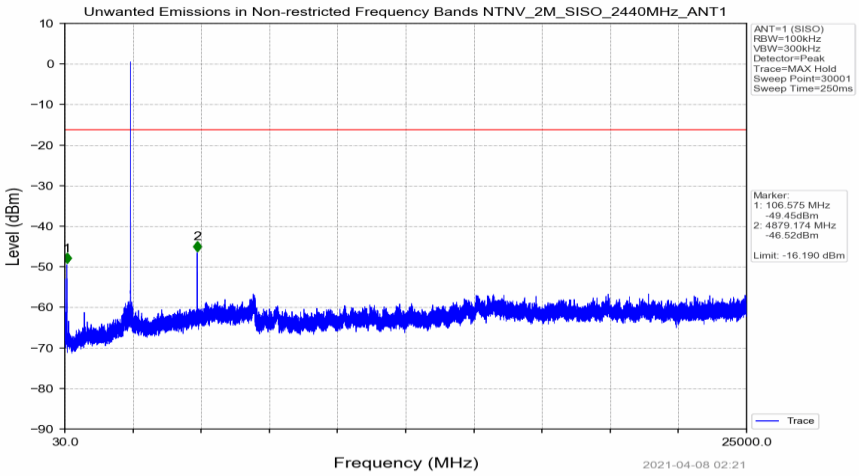


6.6 *Test Data – Anchor Radio – DTS Conducted Spurious Emissions*

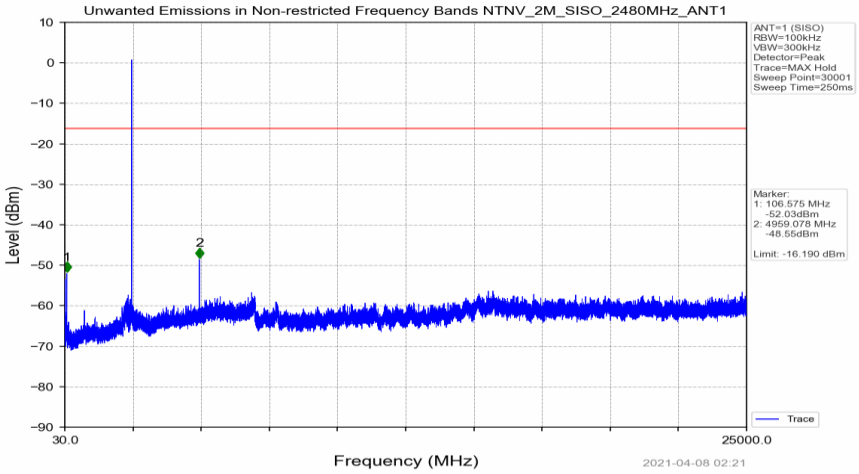
Conducted Spurs – BLE Channel 0



Conducted Spurs – BLE Channel 19

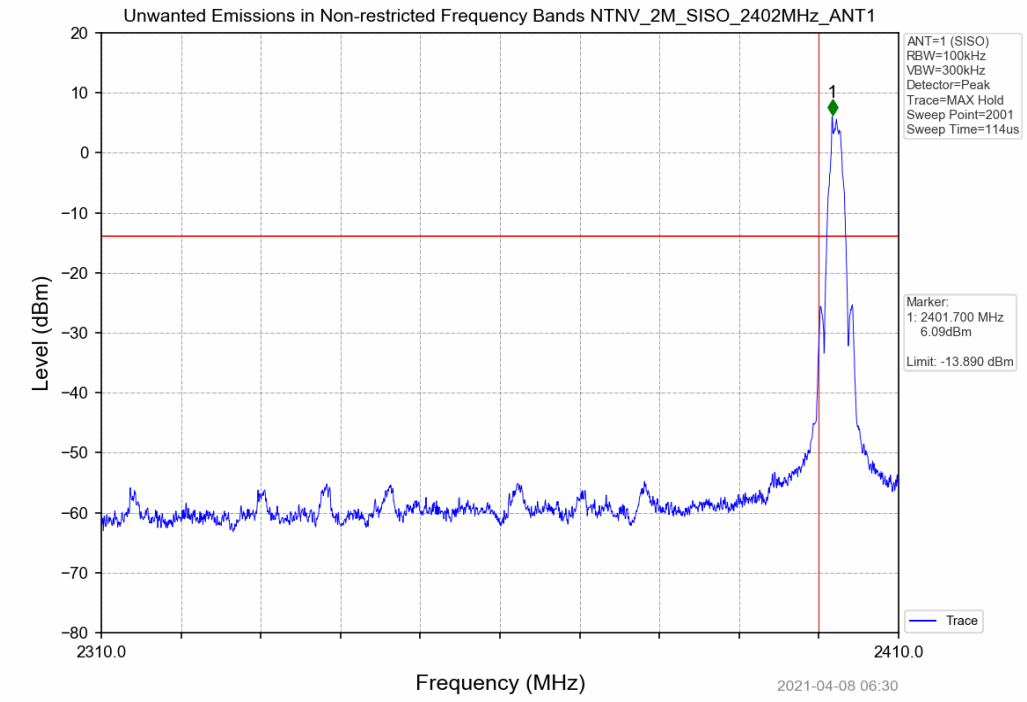


Conducted Spurs – BLE Channel 39

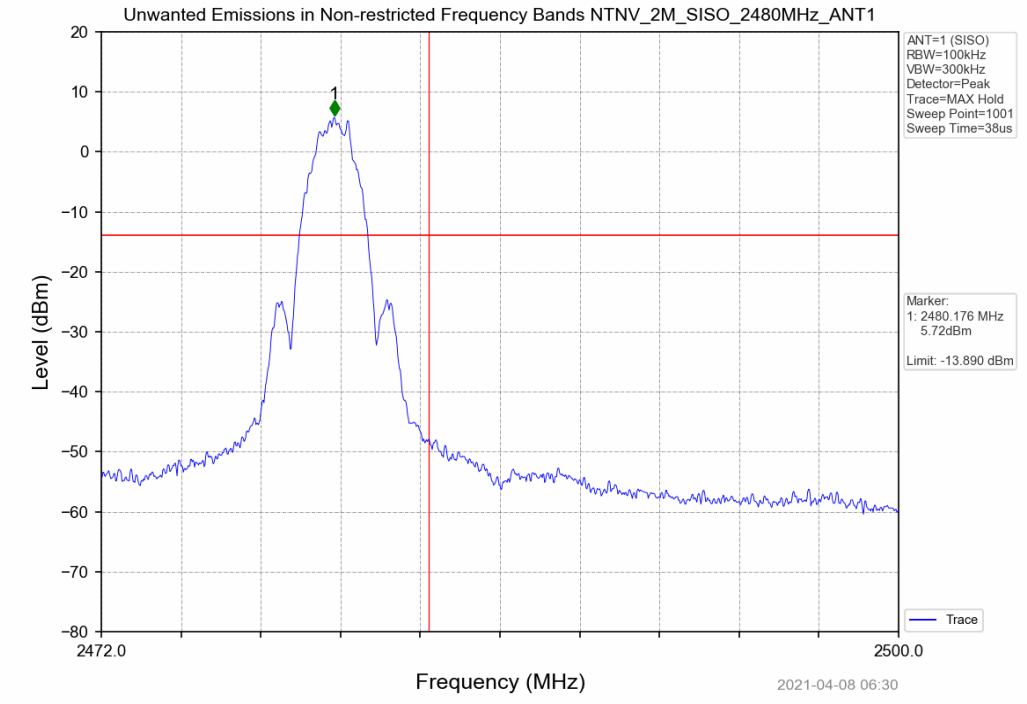


6.7 *Test Data – Relay Radio – DTS Band Edge*

BLE - Lower band edge

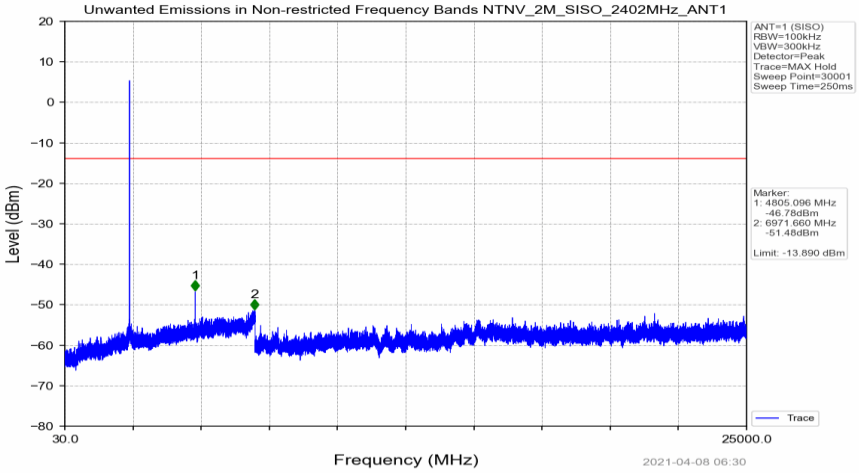


BLE - Upper band edge

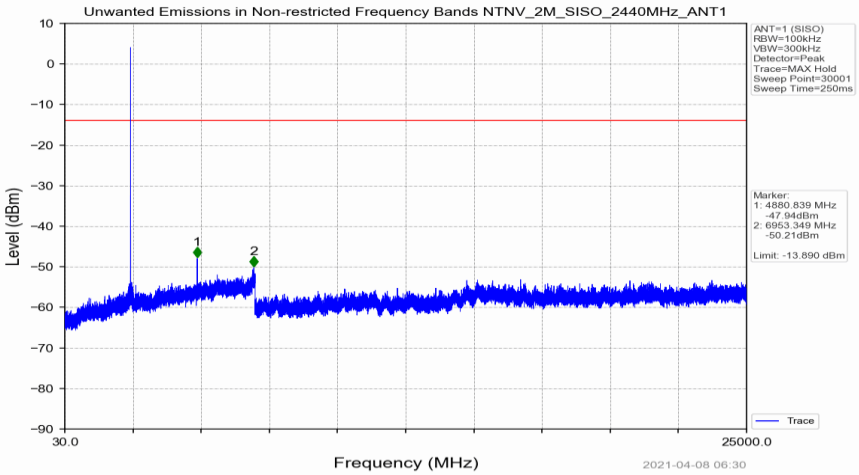


6.8 *Test Data – Relay Radio – DTS Conducted Spurious Emissions*

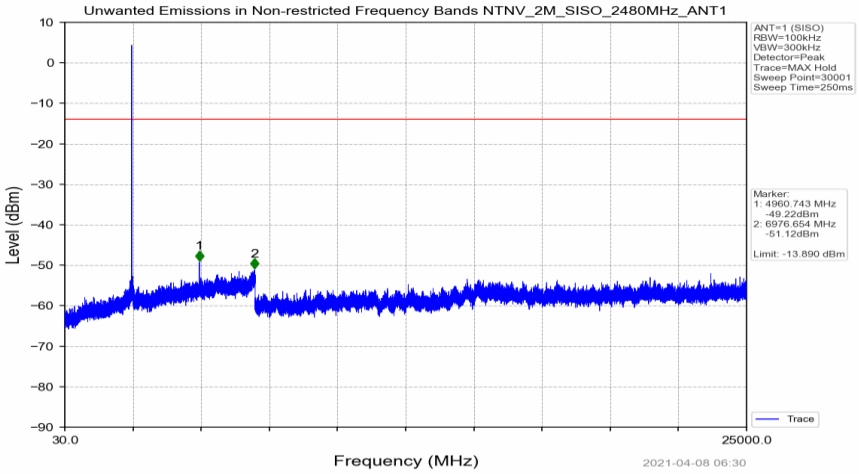
Conducted Spurs – BLE Channel 0



Conducted Spurs – BLE Channel 19



Conducted Spurs – BLE Channel 39



7 Emissions in Restricted Frequency Bands

7.1 *Test Result*

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

7.2 *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.

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 3 meters

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

7.3 *Test Site*

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

Environmental Conditions	30-1000MHz	1-18GHz	18-26GHz
Temperature:	23.8 °C	23.5 – 24.6 °C	23.8 °C
Relative Humidity:	22.7 %	19.4 – 25.7 %	22.7 %
Atmospheric Pressure:	98.0 kPa	97.5 – 97.7 kPa	98.0 kPa

7.4 *Test Equipment*

30-1000MHz

Test End Date: 19-Feb-2021 Tester: PL

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
ANTENNA, BILOG	JB6	SUNOL	B079689	5-Nov-2020	5-Nov-2022
RF Cable Nm to Nm, 0.01-18GHz	90-195-354	TELEDYNE STORM MICROWAVE	20120	2-Mar-2020	2-Mar-2021
RF Cable Nm to Nf, 0.01-18GHz	90-213-118	TELEDYNE STORM MICROWAVE	20117	2-Mar-2020	2-Mar-2021
RF Cable Nm to Nm, 0.01-18GHz	90-195-157	TELEDYNE STORM MICROWAVE	20122	2-Mar-2020	2-Mar-2021
RF CABLE	SUCOFLEX 100	Huber & Suhner	B108523	3-Sep-2020	3-Sep-2021
LOW NOISE AMPLIFIER	ZKL-2+	Mini-Circuits	B079817	28-Sep-2020	28-Sep-2021
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	6-Apr-2020	6-Apr-2021

1-18GHz

Test End Date: 17-Feb-2021 Tester: LM

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
ANTENNA, DRG HORN (MEDIUM)	3117	ETS Lindgren	B079699	15-Jul-2020	15-Jul-2022
RF Cable Nm to Nm, 0.01-18GHz	90-195-354	TELEDYNE STORM MICROWAVE	20120	2-Mar-2020	2-Mar-2021
RF CABLE	SUCOFLEX 100	Huber & Suhner	B108523	3-Sep-2020	3-Sep-2021
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	B094463	24-Nov-2020	24-Nov-2021
EMI TEST RECEIVER	ESU8	ROHDE & SCHWARZ	B085759	7-May-2020	7-May-2021
FILTER, HIGH PASS, >2800MHz	HPM50111	MICRO-TRONICS	B085747	8-Sep-2020	8-Sep-2021

1-3GHz Retest

Test End Date: 30-Apr-2021 Tester: LM

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
ANTENNA, DRG HORN (MEDIUM)	3117	ETS Lindgren	B079699	15-Jul-2020	15-Jul-2022
RF CABLE, Nm to Nm.	90-195-276	TELEDYNE STORM MICROWAVE	21020	26-Mar-2021	26-Mar-2022
RF CABLE	SUCOFLEX 100	Huber & Suhner	B108523	3-Sep-2020	3-Sep-2021
ATTENUATOR, 10DB	BW-N10W20+	Mini-Circuits	17023	3-Sep-2020	3-Sep-2021
5dB Attenuator NM to NF	BW-N5W5+	Mini-Circuits	19007	6-Apr-2020	22-Mar-2022
4dB Attenuator NM to NF	BW-N4W5+	Mini-Circuits	19004	6-Apr-2020	22-Mar-2022
ATTENUATOR, 3DB	11582A	HEWLETT PACKARD	B079664-3	8-Sep-2020	8-Sep-2021
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	15003	28-Oct-2020	28-Oct-2021
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	6-Apr-2020	6-May-2021

18-26GHz

Test End Date: 19-Feb-2021 Tester: PL

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
ANTENNA, HORN (SMALL)	LB-180400-20-C-KF	A-INFO	15007	6-Apr-2020	6-Apr-2022
LOW NOISE AMPLIFIER	NSP1840-HG	MITEQ	B087572	3-Nov-2020	3-Nov-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-138	TELEDYNE STORM MICROWAVE	20112	6-Mar-2020	6-Mar-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-020	TELEDYNE STORM MICROWAVE	20105	6-Mar-2020	6-Mar-2021
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	6-Apr-2020	6-Apr-2021

Note: The equipment calibration periods can be determined from the cal dates and cal due dates above.

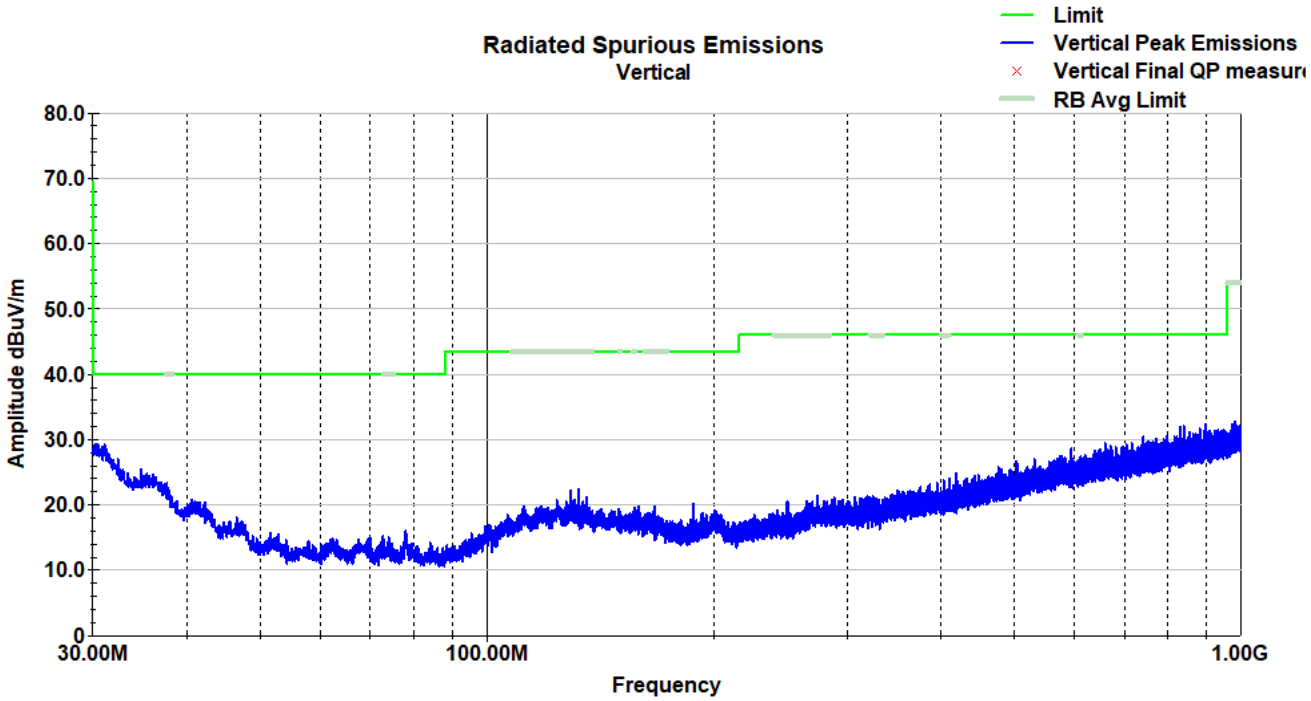
Software: “RSE 30-1000 MHz T7 201007” TILE 7! profile dated Oct 2020
“RSE 1-18 GHz T7 201007” TILE 7! profile dated Oct 2020
“RSE 18-40 GHz T7 190722” TILE 7! profile dated Jul 2019

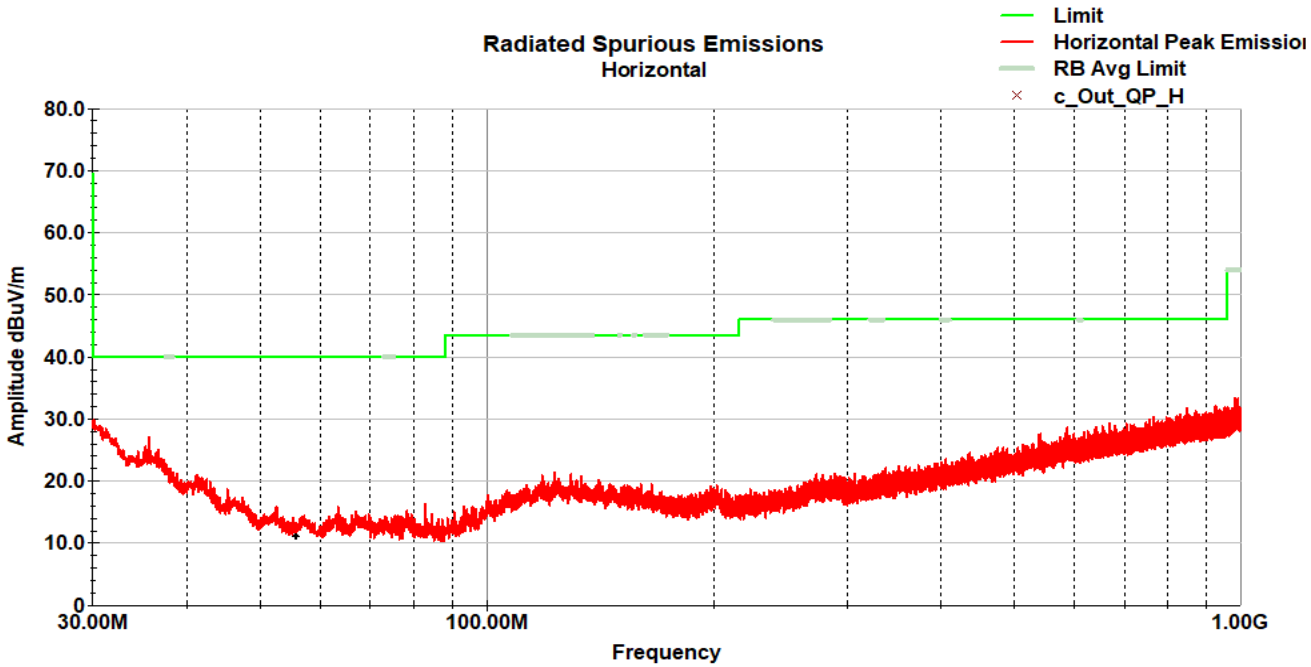
7.5 *Test Data*

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

7.5.1 30-1000 MHz

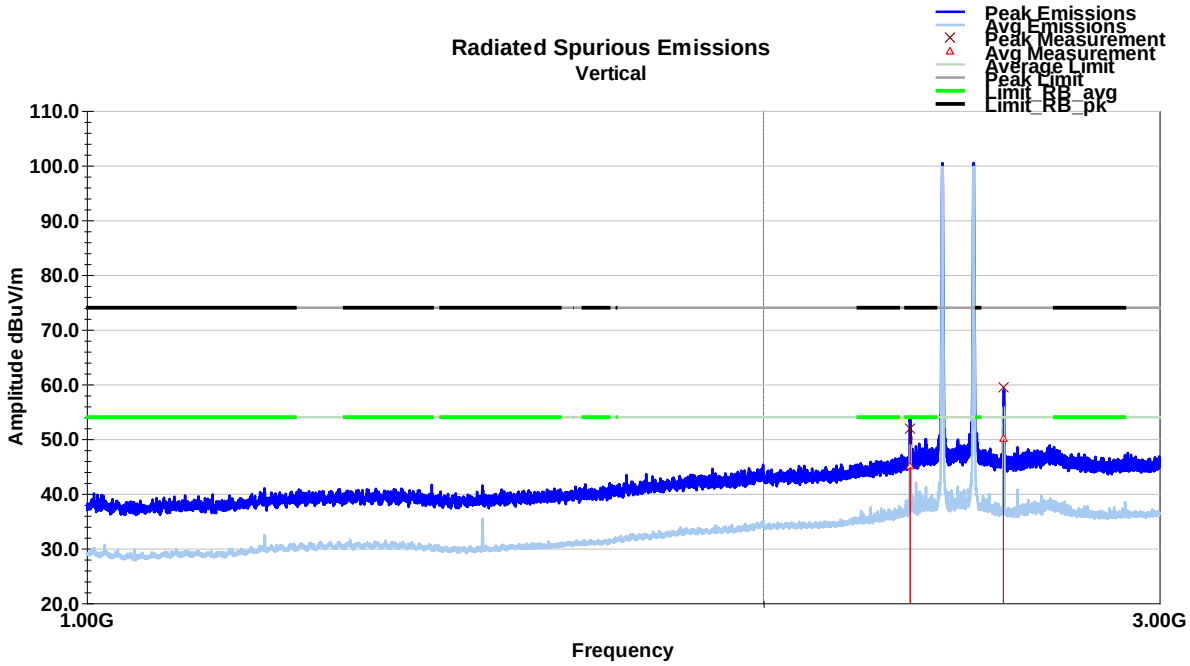
There was no deviation based on radio, axis or channel in the 30-1000 MHz spectrum.





7.5.2 1-3 GHz

1-3 GHz Vertical – Anchor Low Channel & Relay High Channel



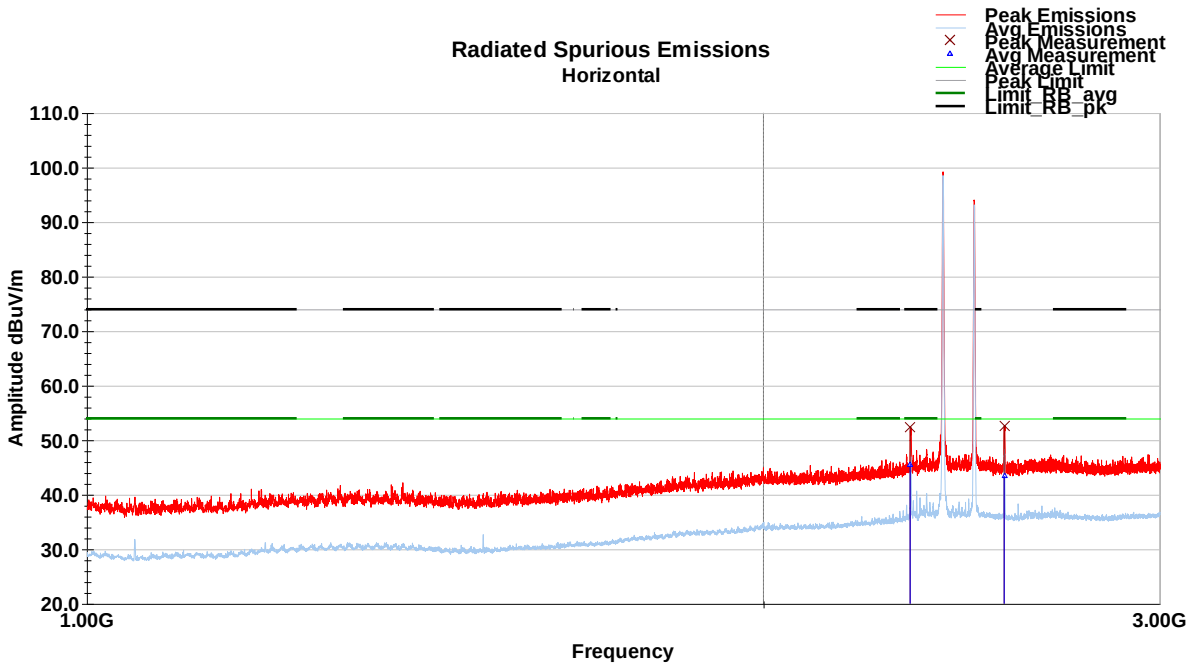
Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
2324.24	51.616	V	219	234	31.8	3.1	34.5	52	74	-22
2557.08	58.574	V	99	246	32.2	3.2	34.5	59.5	74	-14.5
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Final Avg	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
2324.24	44.589	V	219	234	31.8	3.1	34.5	44.934	54	-9
2557.08	49.147	V	99	246	32.2	3.2	34.5	50.051	54	-3.9
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

1-3 GHz Horizontal – Anchor Low Channel & Relay High Channel



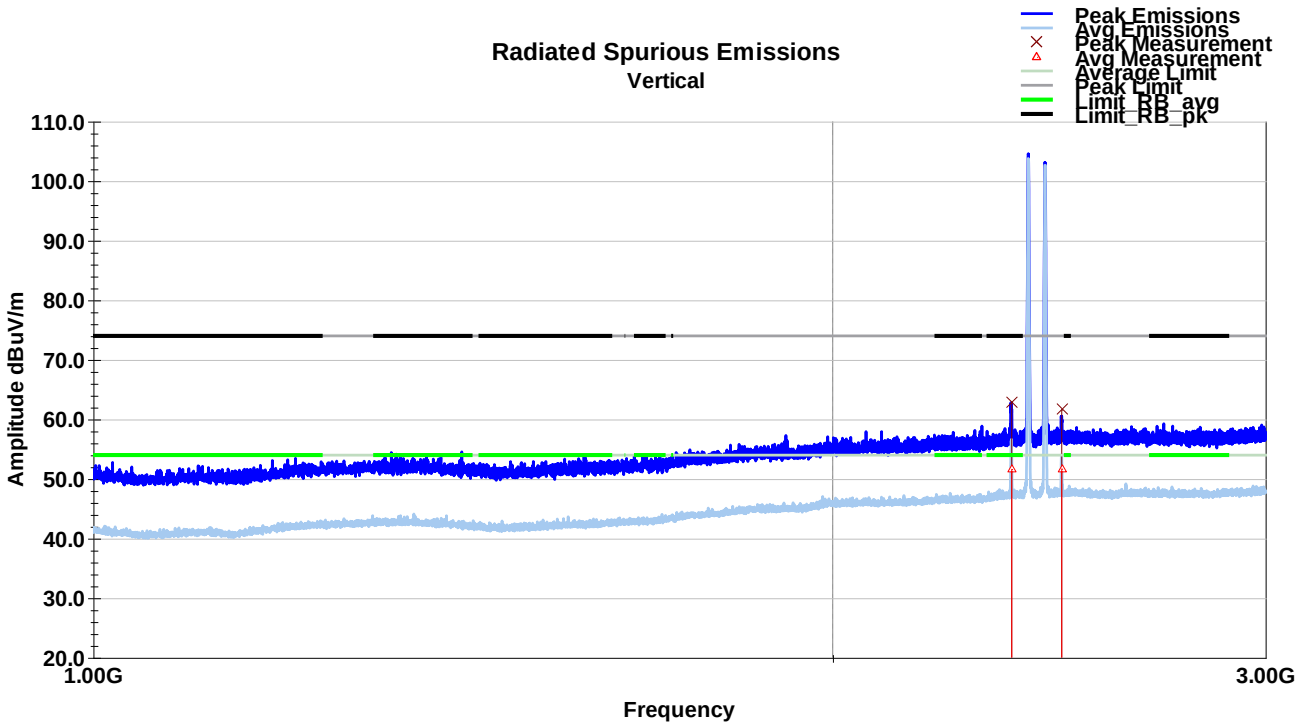
Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
2324	52.096	H	280	180	31.8	3.1	34.5	52.441	74	-21.6
2559.12	51.776	H	282	246	32.2	3.2	34.5	52.671	74	-21.3
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Avg Value	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
2324	45.225	H	280	180	31.8	3.1	34.5	45.57	54	-8.4
2559.12	42.474	H	282	246	32.2	3.2	34.5	43.37	54	-10.6
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

1-3 GHz Vertical – Anchor Mid Channel & Relay Low Channel



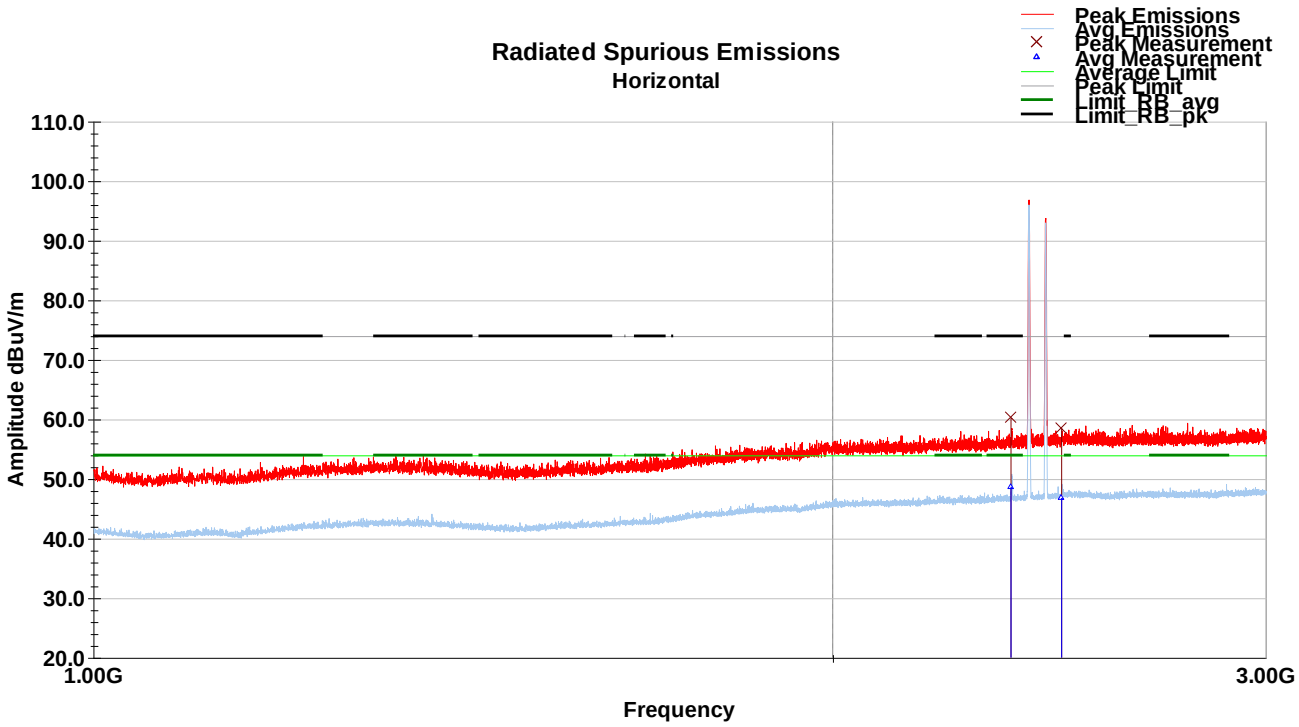
Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
2365.24	55.583	V	1	162	31.9	17.8	42.3	62.9	74	-11.1
2478.64	53.691	V	357	142	32.4	17.8	42.2	61.7	74	-12.3
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Final Avg	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
2365.24	44.333	V	1	162	31.9	17.8	42.3	51.682	54	-2.3
2478.64	43.764	V	357	142	32.4	17.8	42.2	51.727	54	-2.3
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

1-3 GHz Horizontal – Anchor Mid Channel & Relay Low Channel



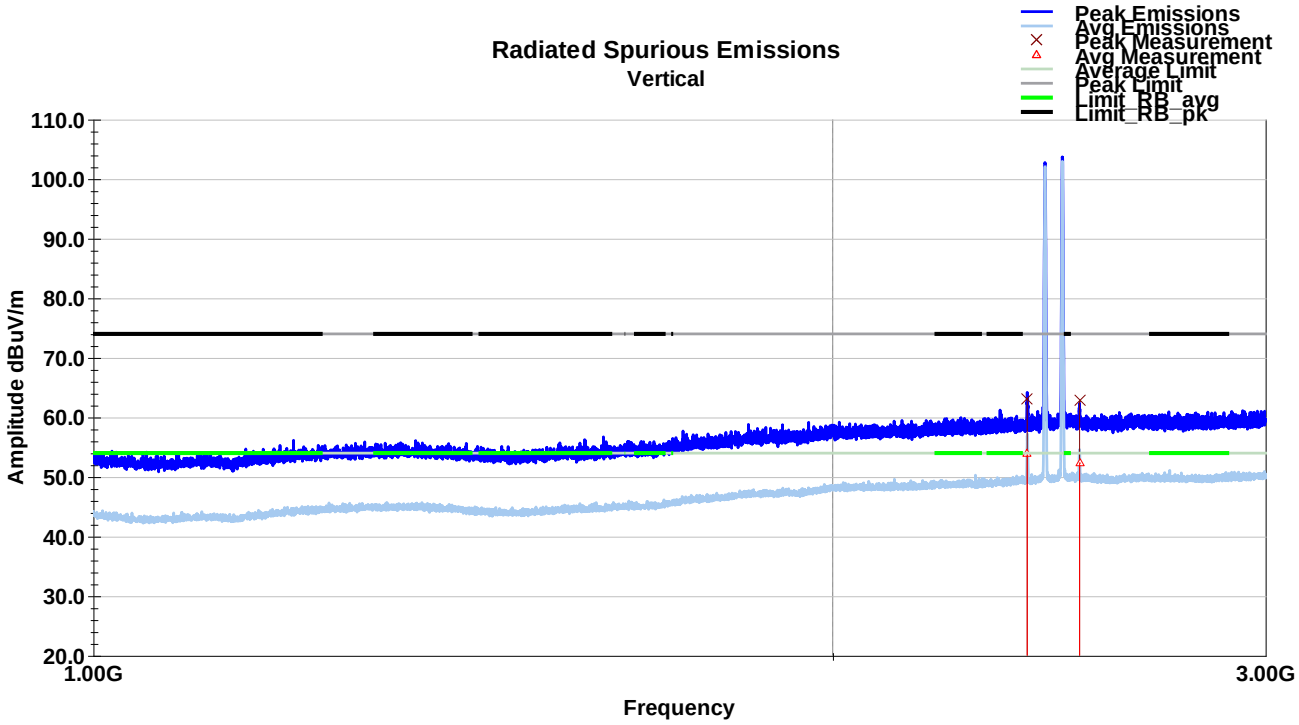
Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
2363.72	52.905	H	209	175	31.9	17.8	42.3	60.248	74	-13.8
2478.44	50.463	H	193	250	32.4	17.8	42.2	58.424	74	-15.6
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Avg Value	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
2363.72	41.323	H	209	175	31.9	17.8	42.3	48.666	54	-5.3
2478.44	38.816	H	193	250	32.4	17.8	42.2	46.777	54	-7.2
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

1-3 GHz Vertical – Anchor High Channel & Relay Mid Channel



Peak Data

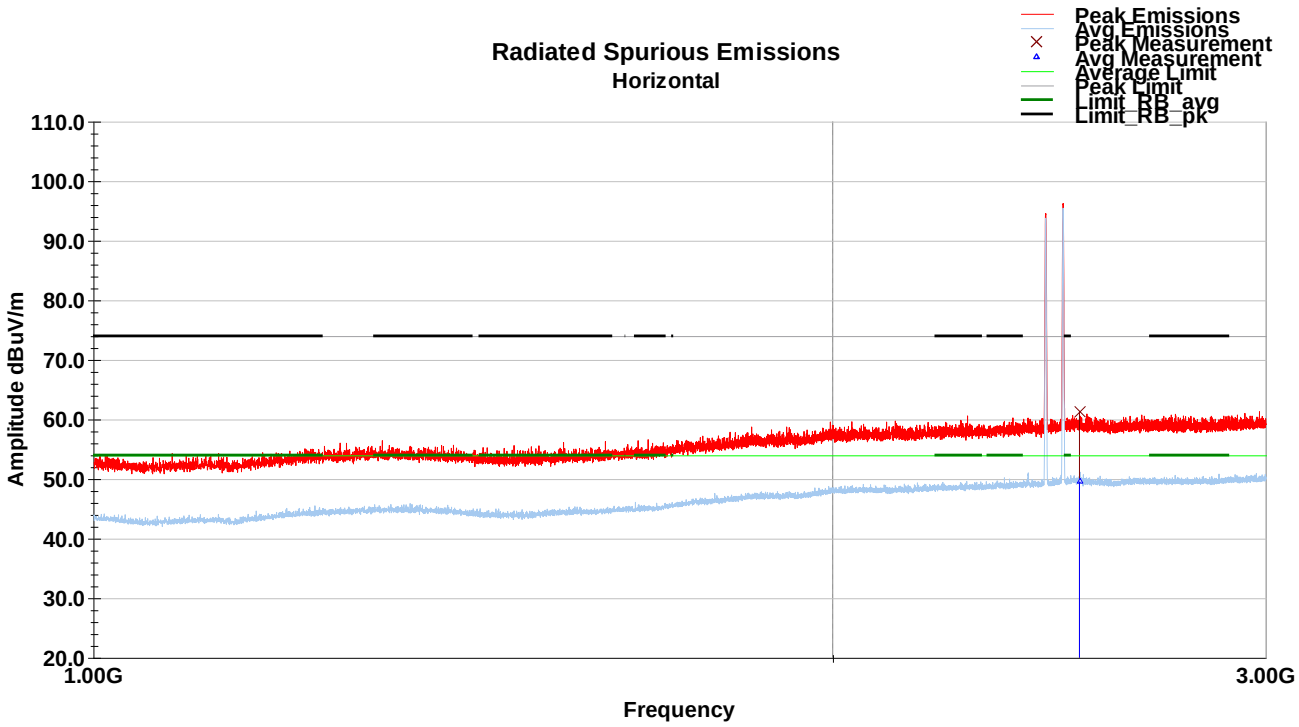
Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
2399.8	53.5	V	135	200	31.9	20	42.2	63.2	74	-10.8
2520.4	52.493	V	349	174	32.4	20.1	42.2	62.8	74	-11.2
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Final Avg	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
2399.8	44.365	V	135	200	31.9	20	42.2	54.07	54	0.1
2520.4	42.148	V	349	174	32.4	20.1	42.2	52.422	54	-1.6
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

2399.8 MHz does not fall within a restricted band and so is not required to meet the FCC 15.209 limits.

1-3 GHz Horizontal – Anchor High Channel & Relay Mid Channel



Peak Data

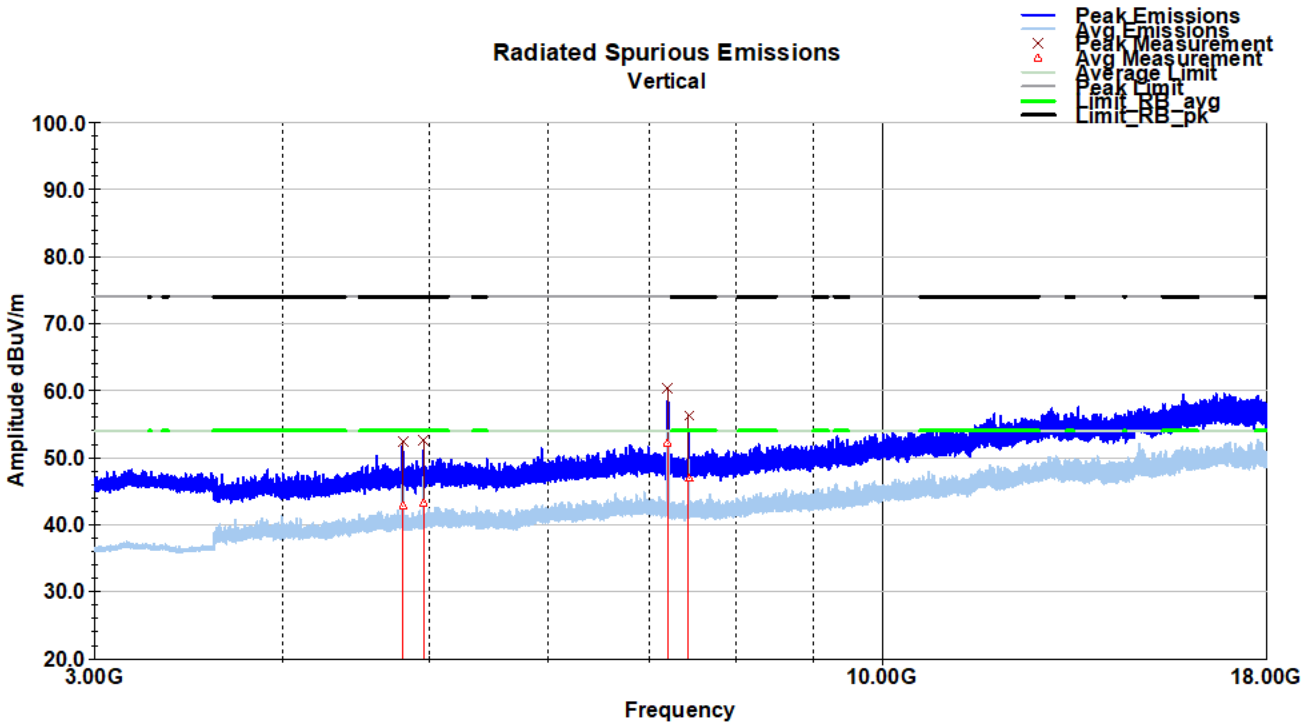
Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
2520.16	51.059	H	212	250	32.4	20.1	42.2	61.334	74	-12.7
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Avg Value	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
2520.16	39.276	H	212	250	32.4	20.1	42.2	49.552	54	-4.4
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

7.5.3 3-18 GHz

3-18 GHz Vertical – Anchor Low Channel & Relay High Channel



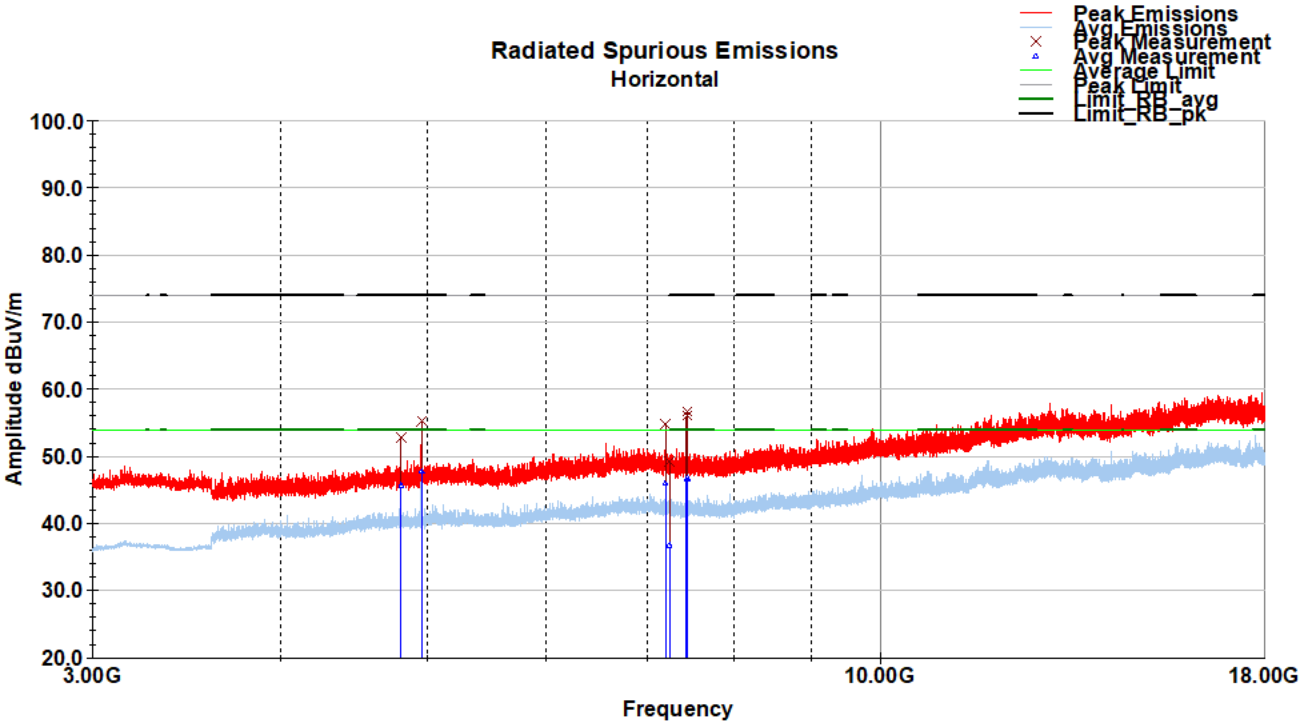
Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
4803.68	47.719	V	141	209	34.6	4.7	34.6	52.4	74	-21.6
4959.68	48.062	V	272	183	34.5	4.8	34.6	52.7	74	-21.3
7207.6	54.029	V	224	138	35.7	5.7	35	60.4	74	-13.6
7439.38	49.993	V	42	100	35.7	5.7	35.1	56.3	74	-17.7
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Final Avg	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
4803.68	38.15	V	141	209	34.6	4.7	34.6	42.82	54	-11.2
4959.68	38.764	V	272	183	34.5	4.8	34.6	43.359	54	-10.6
7207.6	45.788	V	224	138	35.7	5.7	35	52.163	54	-1.8
7439.38	40.532	V	42	100	35.7	5.7	35.1	46.845	54	-7.1
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

3-18 GHz Horizontal – Anchor Low Channel & Relay High Channel



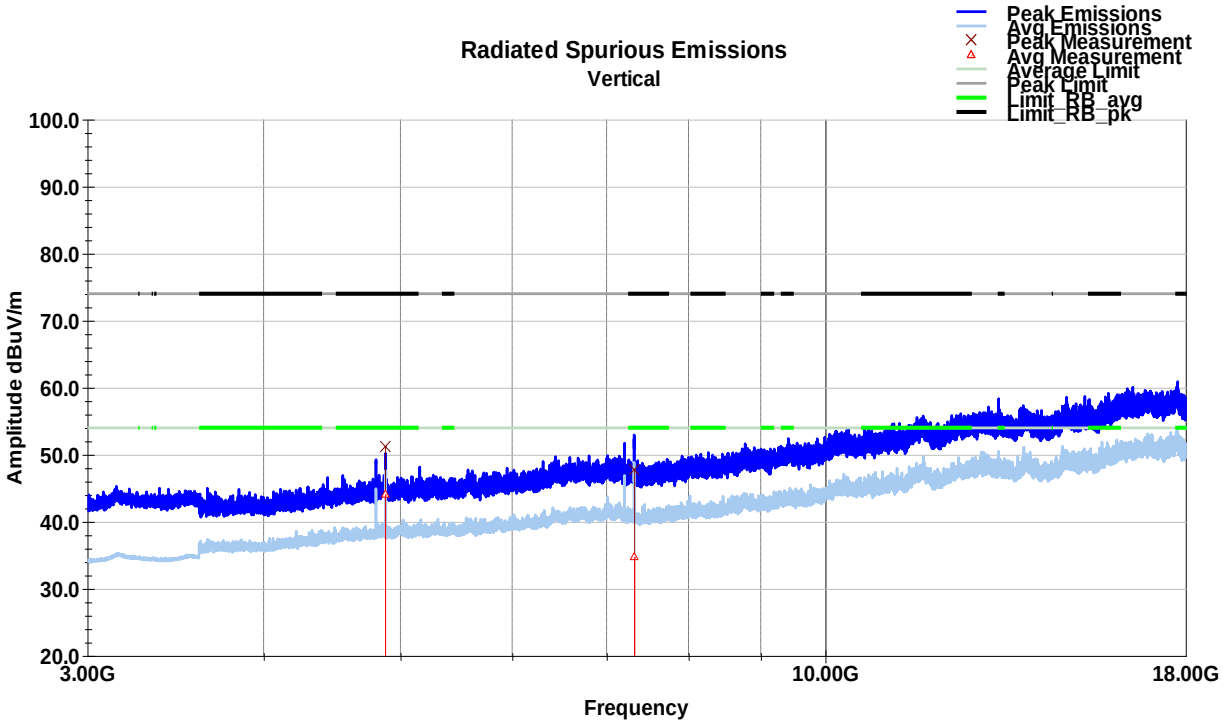
Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
4804.22	48.154	H	86	193	34.6	4.7	34.6	52.824	74	-21.2
4960.88	50.649	H	288	238	34.5	4.8	34.6	55.244	74	-18.8
7206.04	48.383	H	119	199	35.7	5.7	35	54.756	74	-19.2
7253.16	42.782	H	96	232	35.7	5.7	35	49.196	74	-24.8
7439.88	49.741	H	219	175	35.7	5.7	35.1	56.054	74	-17.9
7441.58	50.275	H	217	186	35.7	5.7	35.1	56.59	74	-17.4
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Avg Value	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
4804.22	41.022	H	86	193	34.6	4.7	34.6	45.692	54	-8.3
4960.88	43.117	H	288	238	34.5	4.8	34.6	47.712	54	-6.3
7206.04	39.566	H	119	199	35.7	5.7	35	45.939	54	-8
7253.16	30.321	H	96	232	35.7	5.7	35	36.735	54	-17.2
7439.88	40.23	H	219	175	35.7	5.7	35.1	46.543	54	-7.4
7441.58	40.49	H	217	186	35.7	5.7	35.1	46.804	54	-7.2
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

3-18 GHz Vertical – Anchor Mid Channel & Relay Low Channel



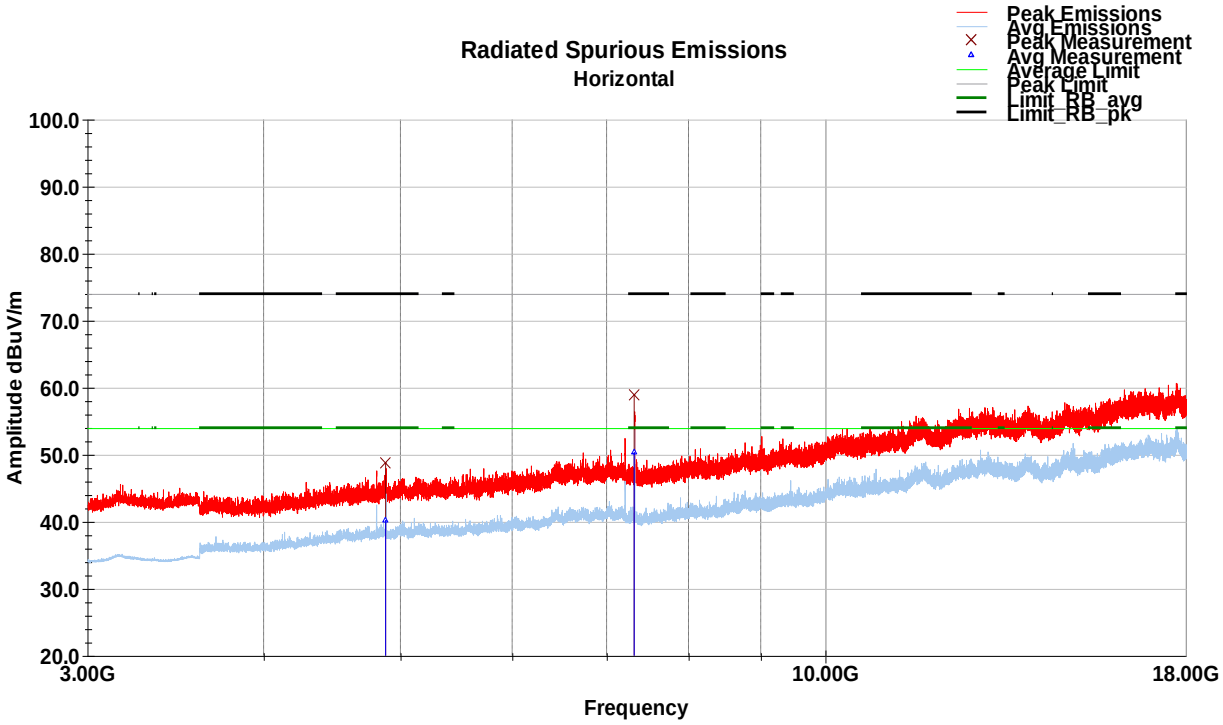
Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
4879.84	46.429	V	358	244	34.5	4.9	34.6	51.3	74	-22.7
7327.24	41.111	V	320	175	35.7	6.1	35.1	47.8	74	-26.2
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Final Avg	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
4879.84	39.212	V	358	244	34.5	4.9	34.6	44.065	54	-9.9
7327.24	27.998	V	320	175	35.7	6.1	35.1	34.729	54	-19.3
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

3-18 GHz Horizontal – Anchor Mid Channel & Relay Low Channel



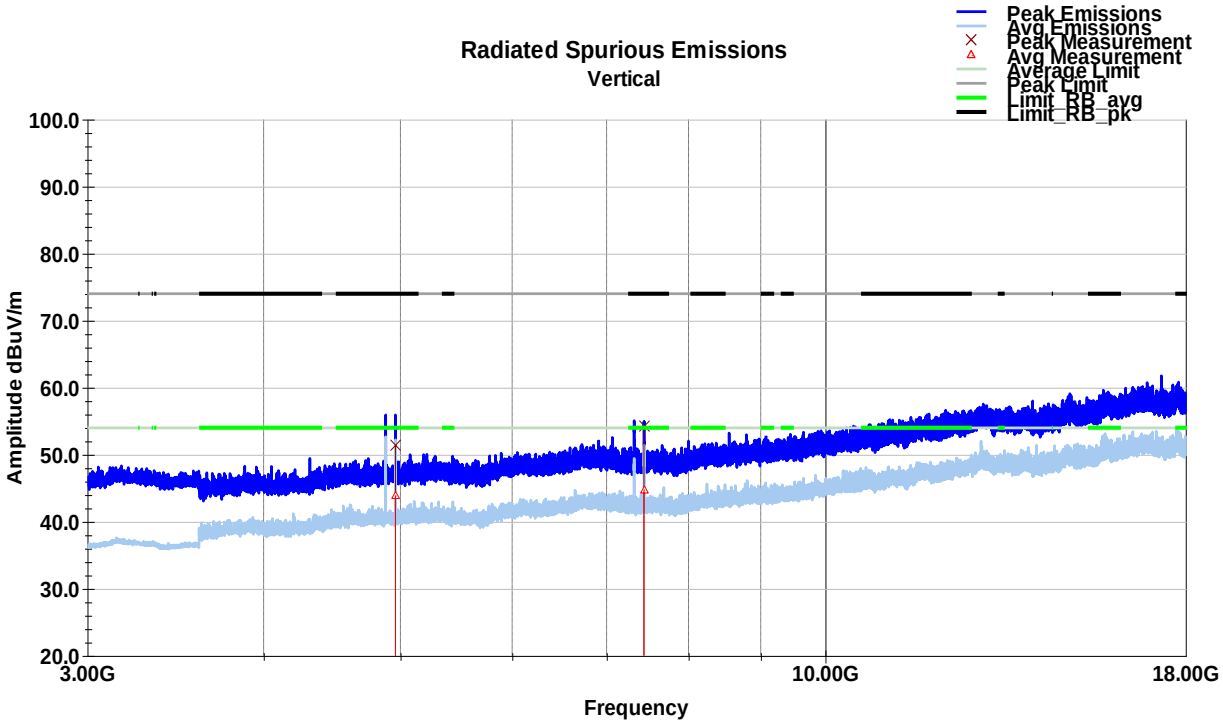
Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
4880.88	43.995	H	267	249	34.5	4.9	34.6	48.845	74	-25.2
7321.48	52.251	H	325	209	35.7	6.1	35.1	58.977	74	-15
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Avg Value	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
4880.88	35.387	H	267	249	34.5	4.9	34.6	40.237	54	-13.7
7321.48	43.658	H	325	209	35.7	6.1	35.1	50.384	54	-3.6
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

3-18 GHz Vertical – Anchor High Channel & Relay Mid Channel



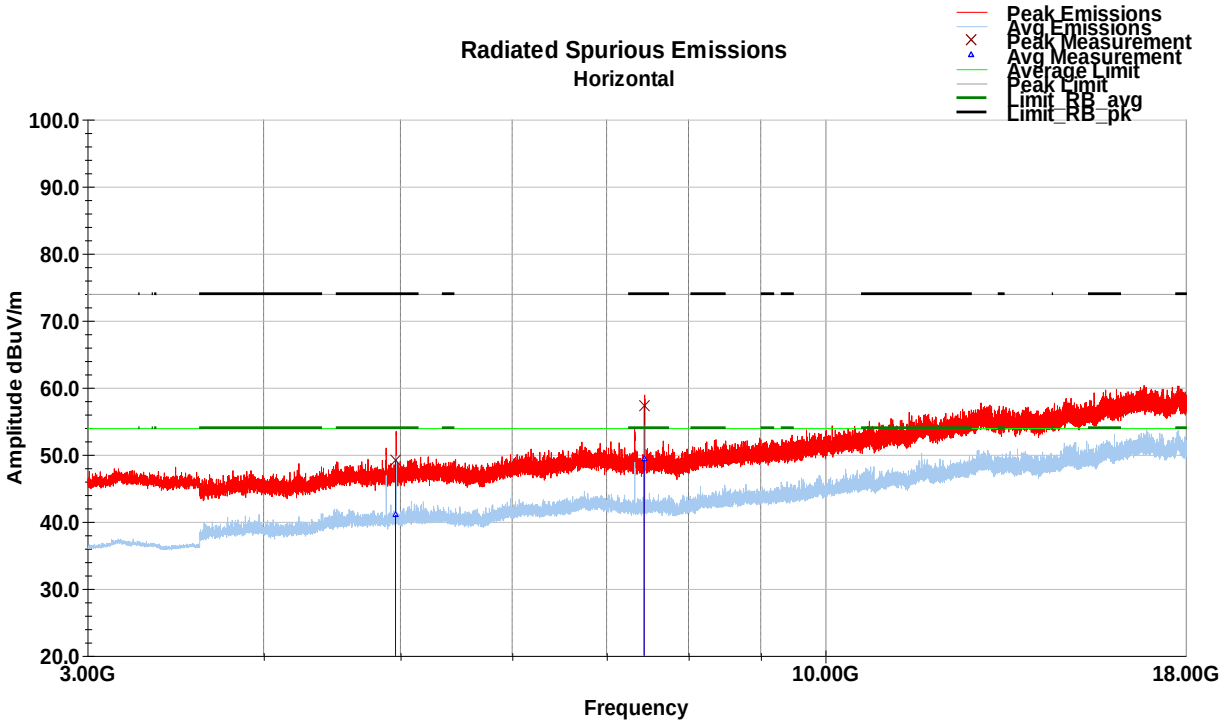
Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
4959.8	46.529	V	176	246	34.5	5	34.6	51.4	74	-22.6
7439.56	47.681	V	159	190	35.7	6.1	35.1	54.3	74	-19.7
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Final Avg	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
4959.8	39.08	V	176	246	34.5	5	34.6	43.913	54	-10.1
7439.56	38.137	V	159	190	35.7	6.1	35.1	44.8	54	-9.2
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

3-18 GHz Horizontal – Anchor High Channel & Relay Mid Channel



Peak Data

Frequency	Raw Pk	Polarity	Azimuth	Height	AF	Loss	Amp	Final Pk	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	dBuV/m	dB
4959.92	44.308	H	49	137	34.5	5	34.6	49.141	74	-24.9
7441.36	50.542	H	142	161	35.7	6.1	35.1	57.207	74	-16.8
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

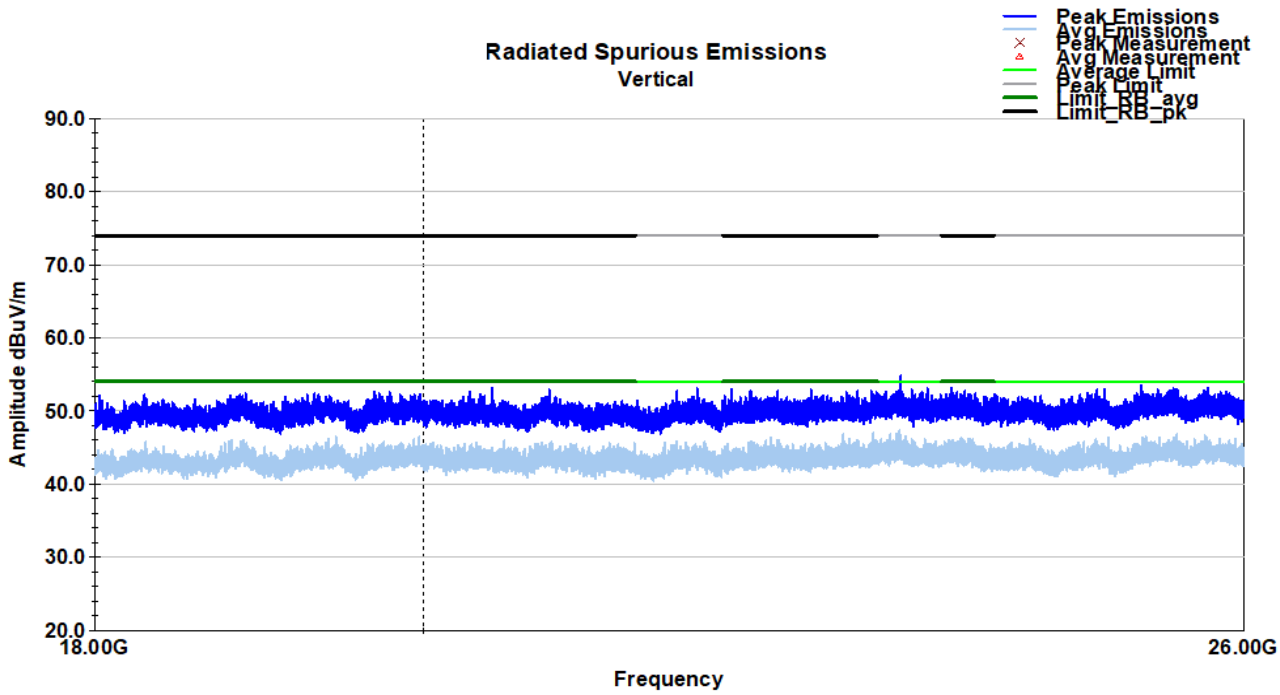
Average Data

Frequency	Raw Avg	Polarity	Azimuth	Height	AF	Loss	Amp	Avg Value	Limit	Margin
MHz	dBuV	(V/H)	(degrees)	(cm)	(dB/m)	(dB)	(dB)	dBuV/m	(dBuV/m)	(dB)
4959.92	36.178	H	49	137	34.5	5	34.6	41.011	54	-13
7441.36	42.788	H	142	161	35.7	6.1	35.1	49.452	54	-4.5
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										

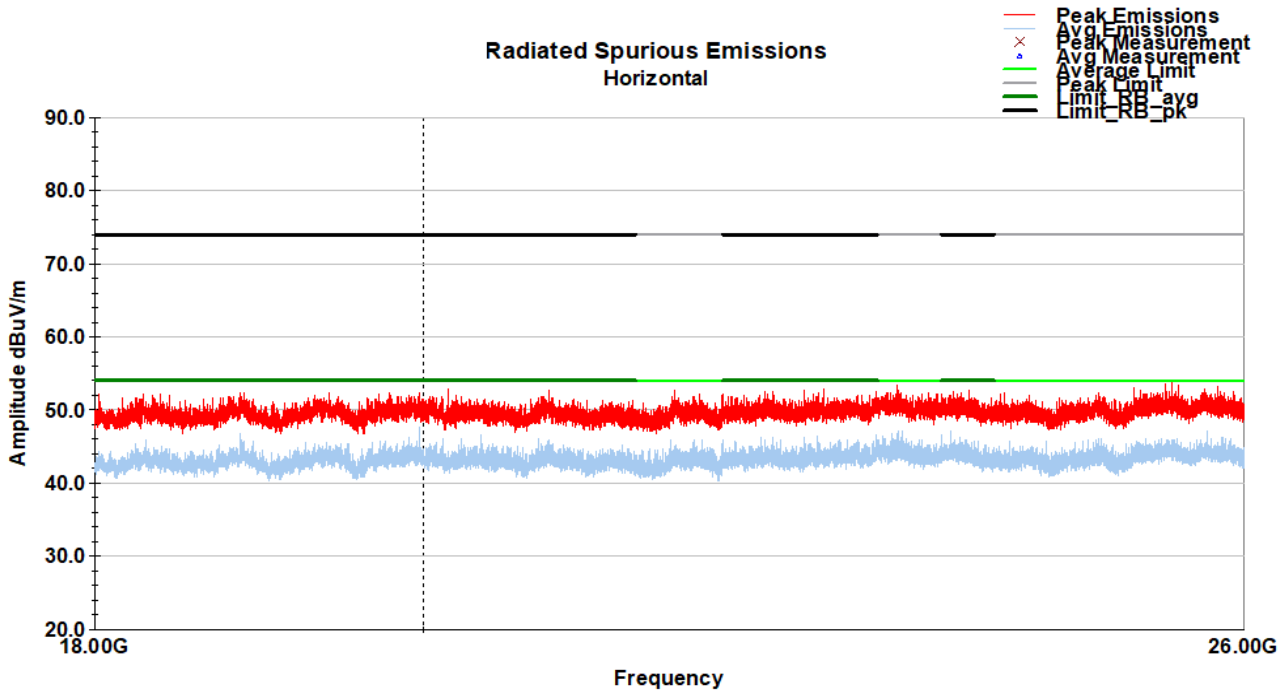
7.5.4 18-26 GHz

There was no deviation based on radio, axis or channel in the 18-26 GHz spectrum.

18-26 GHz Vertical



18-26 GHz Horizontal



8 Band Edge Emissions in Restricted Frequency Bands

8.1 *Test Result*

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

8.2 *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 reference level offset was applied to the spectrum analyzer so that conducted measurements represent field strength measurements in dBµV/m.

The BLE 2Mbps data mode was used for these tests since it produced emissions closest to the band edges.

8.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	24.2 °C
Relative Humidity:	34.8 %
Atmospheric Pressure:	97.8 kPa

8.4 *Test Equipment*

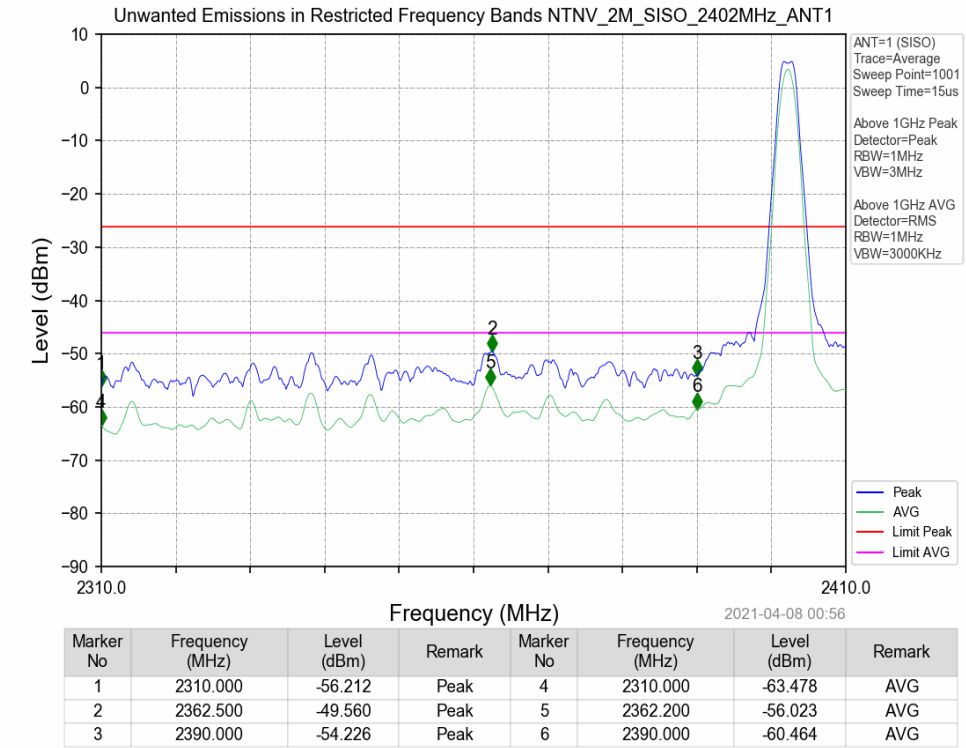
Test End Date: 7-Apr-2021 Tester: MT

Equipment	Model	Manufacturer	Asset Number	Cal Date	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	27-Dec-2019	27-Dec-2021
ATTENUATOR, 10DB	BW-S10W2	Mini-Circuits	15032	28-Sep-2020	28-Sep-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-059	TELEDYNE STORM MICROWAVE	20108	16-Mar-2021	16-Mar-2022

Note: The equipment calibration period is 1 year except for the FSV which is on a 2-year cycle.

8.5 *Test Data – Anchor Radio*

BLE – Low Channel – Plot

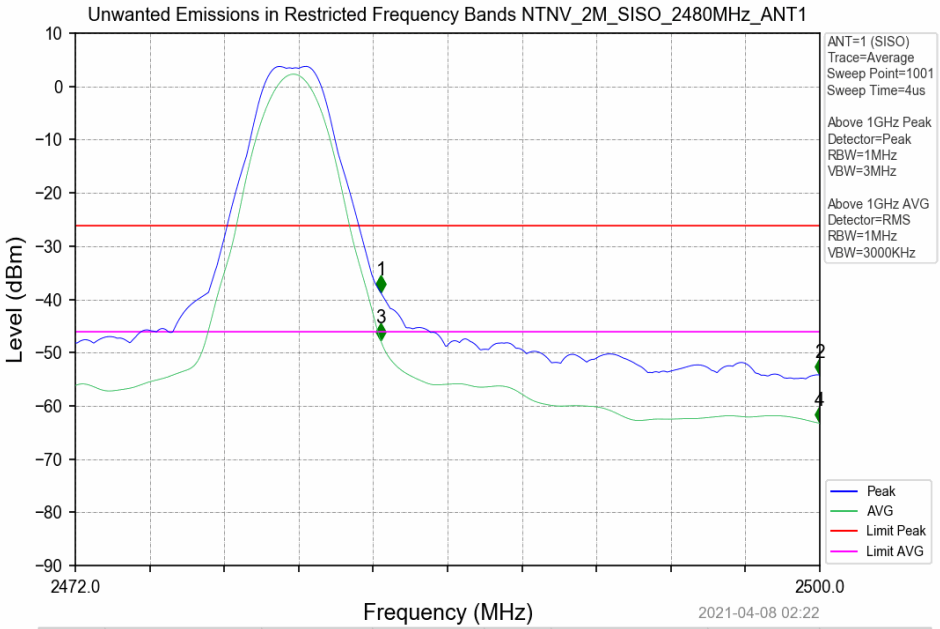


Marker No	Frequency (MHz)	Level (dBm)	Remark	Marker No	Frequency (MHz)	Level (dBm)	Remark
1	2310.000	-56.212	Peak	4	2310.000	-63.478	AVG
2	2362.500	-49.560	Peak	5	2362.200	-56.023	AVG
3	2390.000	-54.226	Peak	6	2390.000	-60.464	AVG

BLE – Low Channel – Data

Frequency (MHz)	Reading Level (dBm)	Antenna Gain (dBi)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
2310.000	-63.48	4.90	36.62	54	-17.38	AVG
	-56.21	4.90	43.89	74	-30.11	Peak
2362.200	-56.02	4.90	44.08	54	-9.92	AVG
2362.500	-49.56	4.90	50.54	74	-23.46	Peak
2390.000	-60.46	4.90	39.64	54	-14.36	AVG
	-54.23	4.90	45.87	74	-28.13	Peak

BLE – High Channel – Plot



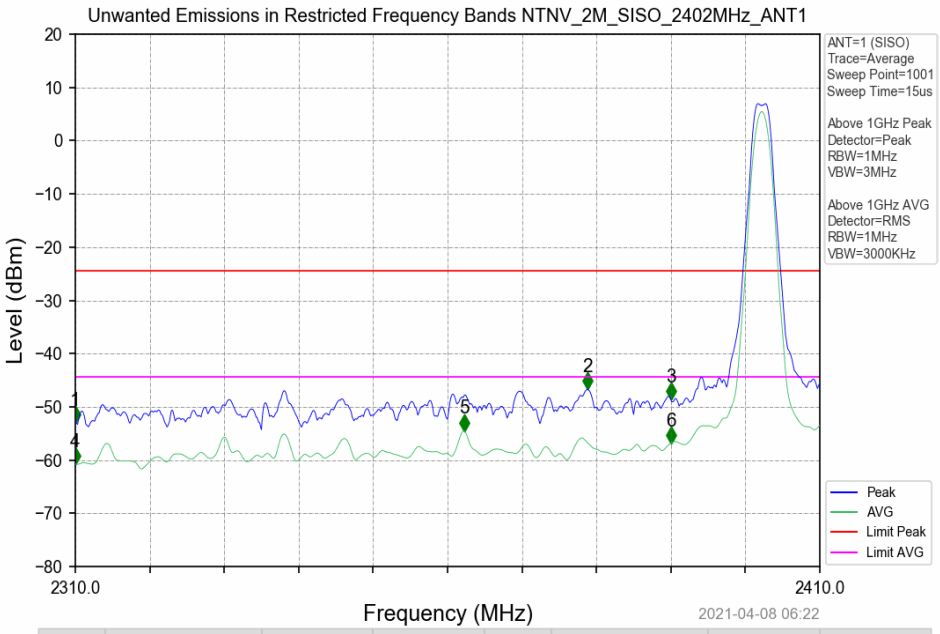
Marker No	Frequency (MHz)	Level (dBm)	Remark	Marker No	Frequency (MHz)	Level (dBm)	Remark
1	2483.500	-38.694	Peak	3	2483.500	-47.653	AVG
2	2500.000	-54.205	Peak	4	2500.000	-63.271	AVG

BLE – High Channel – Data

Frequency (MHz)	Reading Level (dBm)	Antenna Gain (dBi)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
2483.500	-47.65	4.90	52.45	54	-1.55	AVG
	-38.69	4.90	61.41	74	-12.59	Peak
2500.000	-63.27	4.90	36.83	54	-17.17	AVG
	-54.20	4.90	45.90	74	-28.11	Peak

8.6 *Test Data – Relay Radio*

BLE – Low Channel – Plot

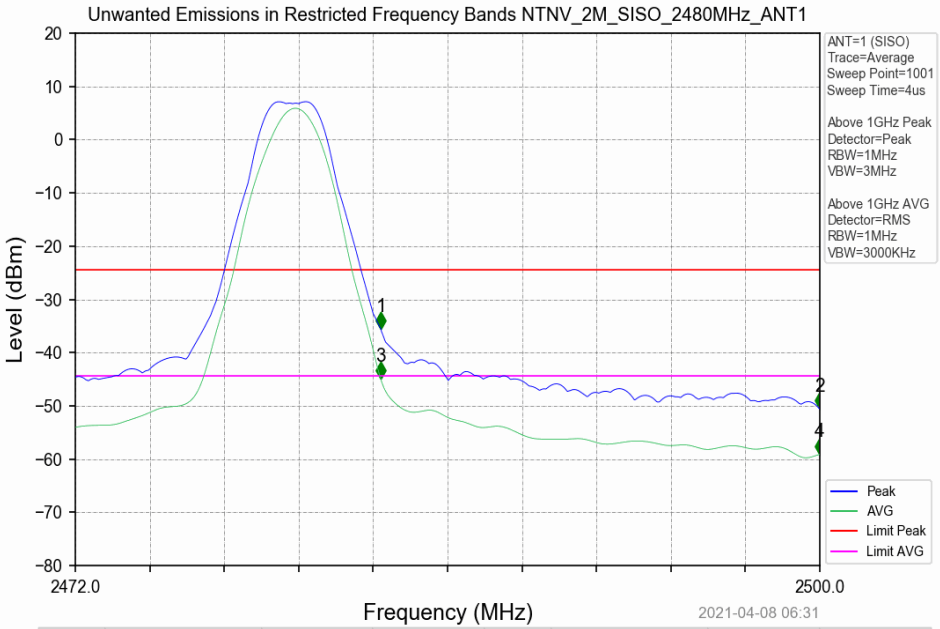


Marker No	Frequency (MHz)	Level (dBm)	Remark	Marker No	Frequency (MHz)	Level (dBm)	Remark
1	2310.000	-52.999	Peak	4	2310.000	-60.741	AVG
2	2378.800	-46.736	Peak	5	2362.200	-54.522	AVG
3	2390.000	-48.659	Peak	6	2390.000	-56.841	AVG

BLE – Low Channel – Data

Frequency (MHz)	Reading Level (dBm)	Antenna Gain (dBi)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
2310.000	-60.74	3.20	37.66	54	-16.34	AVG
	-53.00	3.20	45.40	74	-28.60	Peak
2362.200	-54.52	3.20	43.88	54	-10.12	AVG
2378.800	-46.74	3.20	51.66	74	-22.34	Peak
2390.000	-56.84	3.20	41.56	54	-12.44	AVG
	-48.66	3.20	49.74	74	-24.26	Peak

BLE – High Channel – Plot



Marker No	Frequency (MHz)	Level (dBm)	Remark	Marker No	Frequency (MHz)	Level (dBm)	Remark
1	2483.500	-35.600	Peak	3	2483.500	-44.880	AVG
2	2500.000	-50.518	Peak	4	2500.000	-59.123	AVG

BLE – High Channel – Data

Frequency (MHz)	Reading Level (dBm)	Antenna Gain (dBi)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
2483.500	-44.88	3.20	53.52	54	-0.48	AVG
	-35.60	3.20	62.80	74	-11.20	Peak
2500.000	-59.12	3.20	39.28	54	-14.72	AVG
	-50.52	3.20	47.88	74	-26.12	Peak

9 Measurement Uncertainty

The measurement uncertainty figures are calculated in accordance with TR 100 028-1 [2] and correspond to an expansion factor (coverage factor) k = 2 (which provides confidence levels of 95.45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

Parameter	Expanded Uncertainty for Normal k factor equal to 2	
	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%
Conducted disturbance at mains port using AMN	± 3.4 dB	± 2.5 dB

10 Revision History

Revision Level	Description of changes	Revision Date
Draft	--	04 May 2021
0	Initial release	04 June 2021
1	- Added the SGS North America CAB ID in section 2.2 - Added details of the test mode firmware in section 2.4	28 June 2021