

RF Test Report

Project Number: 4643713

Proposal Number: 05192020NG-1

Report Number: 4643713EMC03

Revision Level: 0

Client: Mueller Systems, LLC.

Equipment Under Test: Wireless Sensor Board

Model: Smart Hydrant Sensor

FCC ID: 2AXKR-SH-SEN-V1

Applicable Standards: ANSI C63.10: 2013 (FCC Part 15 Subpart C, § 15.247)

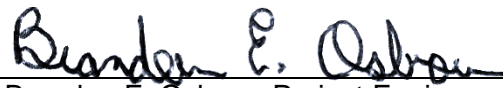
RSS-247, Issue 2

RSS-GEN Issue 5


Report issued on: 17 Aug 2020

Test Result: Compliant

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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.

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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
Peak 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
Field Strength of Spurious Radiation	15.247(d), 15.209	RSS-247 S5.5	Compliant
Emissions in Restricted Frequency Bands	15.205, 15.209	RSS-GEN S8.9, S8.10	Compliant
Antenna Requirement	15.203	RSS-GEN S6.8	Compliant
AC Powerline Conducted Emissions	15.107, 15.207	RSS-GEN S8.8	N/A ¹

Note¹: EUT only operated on a battery pack.

1.1 Modifications Required for Compliance

None

2 General Information

2.1 Client Information

Name: Mueller Systems, LLC.
Address: 1200 Abernathy Rd NE, Suite 1200
City, State, Zip, Country: Atlanta, GA 30328, 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

2.3 General Information of EUT

Product Marketing Name (PMN): Smart Hydrant Sensor
Model Number (HVIN): Smart Hydrant Sensor
Firmware Version ID (FVIN): V 2.6
Serial Number: SHS00000035

Frequency Range: 2402 – 2480 MHz
Data Modes: Bluetooth Low Energy – GFSK (1Mbps, 2Mbps)
Antenna type/gain: External Dipole in Potted material / 3.7dBi (max)

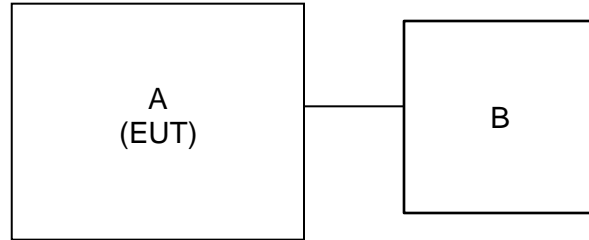
Rated Voltage: 3.5 VDC
Test Voltage: 3.5 VDC

Sample Received Date: June 30 2020
Dates of testing: Aug 11-17 2020

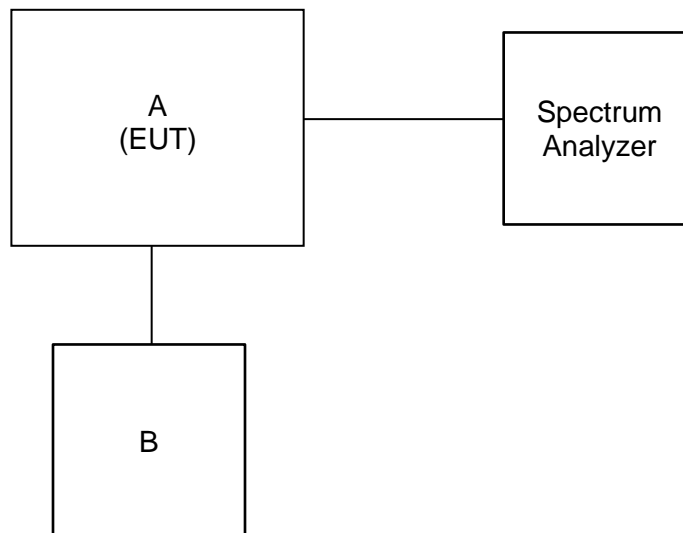
2.4 Operating Modes and Conditions

The EUT was programmed by the manufacturer to transmit on low, mid and high channels. The worst-case for radiated spurious emissions was 1Mbps data rate and 2Mbps for band edge requirements.

2.5 EUT Connection Block Diagram – Radiated Measurements



2.6 EUT Connection Block Diagram – Conducted Measurements



2.7 System Configurations

Device reference	Manufacturer	Description	Model Number	Serial Number
A	Mueller Systems, LLC.	BLE Sensor Board	Smart Hydrant Sensor	SHS00000035
B	Cynergy ³ Components	Pressure Gauge	IMP-S-333-S2002-001-000	580017

3 Intentional Radiator Antenna Requirement

3.1 Result

Test Description	Test Specification	Test Result
Antenna Requirement	47 CFR Part 15, Subpart C 15.203	Compliant

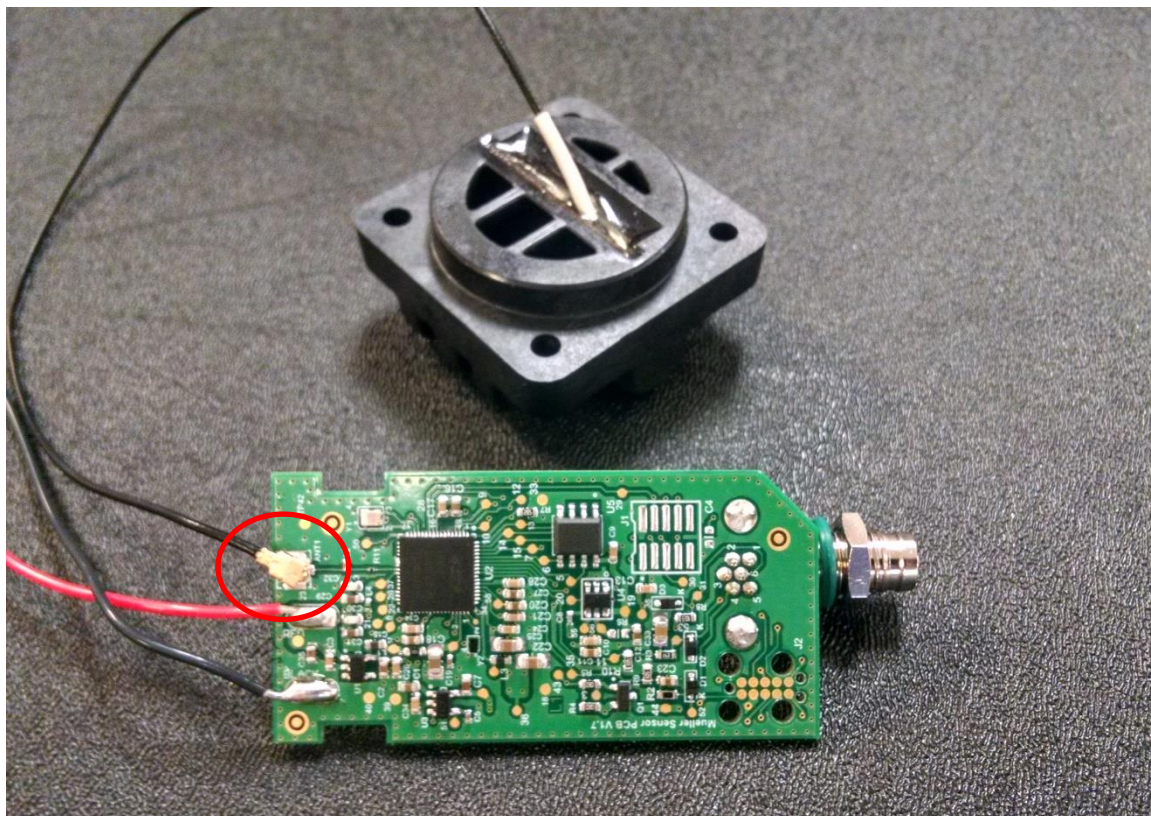
3.2 Requirement

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit permanently attached antenna or of so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

3.3 Conclusion

The dipole antenna on this device connects to PCB with a U.FL coax. This type connection is acceptable per 15.203 requirement.

3.4 Antenna Photograph



4 Bandwidth

4.1 Test Result

Test Description	Test Specification		Test Result
6 dB bandwidth	15.247(a)(2)	RSS-247 S5.2 (a) RSS-GEN S6.6	Compliant

4.2 Test Method

The procedures from ANSI C63.10: 2013 clause 11.8 and 558074 D01 DTS Meas Guidance v04 were used to determine the 6 dB bandwidth.

4.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.2 °C

Relative Humidity: 54.3 %

Atmospheric Pressure: 99.3 kPa

4.4 Test Equipment

Test End Date: 11-Aug-2020

Tester: JP

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	27-Dec-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-020	TELEDYNE STORM MICROWAVE	20106	6-Mar-2021

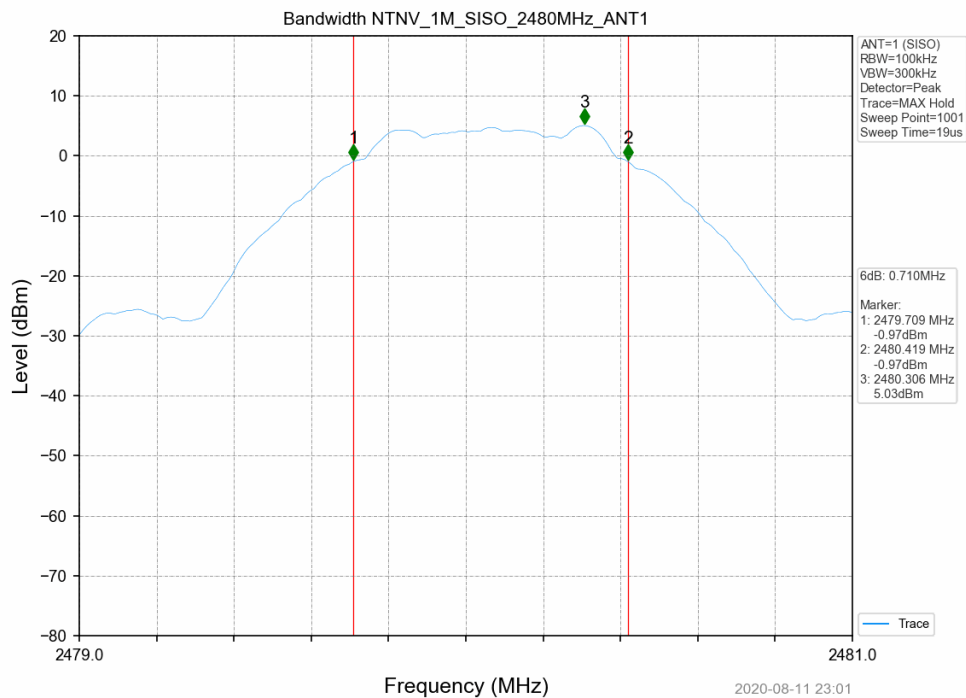
Note: The equipment calibration period is 1 year, except for the FSV30 which is on a 2 year cycle.

4.5 Test Data

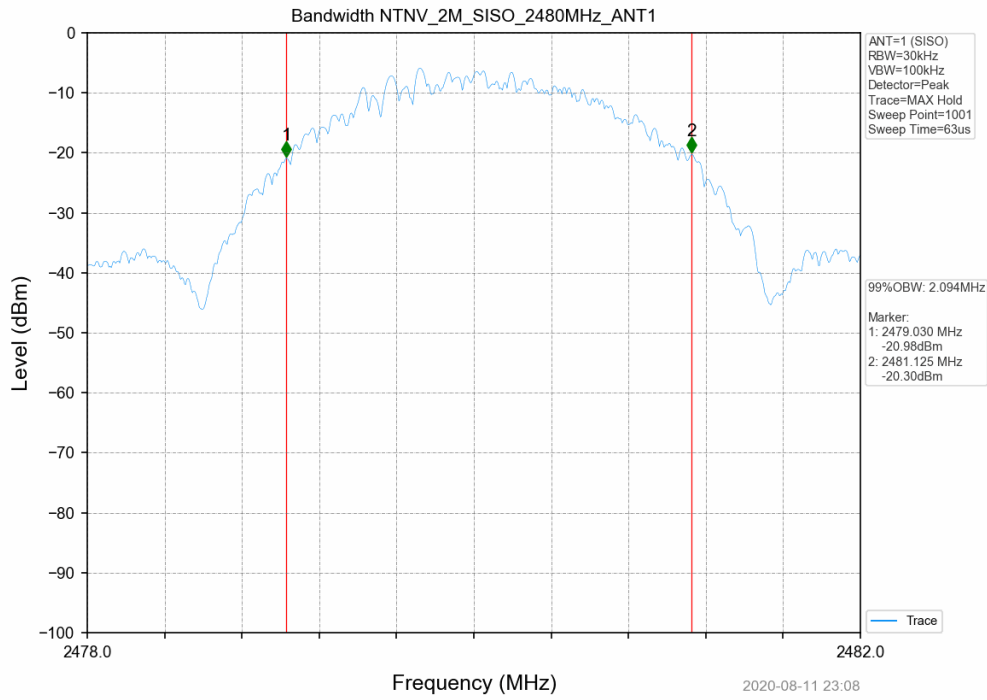
Test Mode	Frequency (MHz)	TX Type	ANT No.	6dB Bandwidth		Verdict
				Test Result (MHz)	Limits (MHz)	
1M	2402	SISO	1	0.715	≥0.5	PASS
	2440	SISO	1	0.713	≥0.5	PASS
	2480	SISO	1	0.710	≥0.5	PASS
2M	2402	SISO	1	1.373	≥0.5	PASS
	2440	SISO	1	1.367	≥0.5	PASS
	2480	SISO	1	1.372	≥0.5	PASS

Test Mode	Frequency (MHz)	TX Type	ANT No.	99% Occupied Bandwidth	Verdict
				Test Result (MHz)	
1M	2402	SISO	1	1.040	Reported
	2440	SISO	1	1.039	Reported
	2480	SISO	1	1.039	Reported
2M	2402	SISO	1	2.086	Reported
	2440	SISO	1	2.102	Reported
	2480	SISO	1	2.094	Reported

Sample Plot – 6dB Bandwidth



Sample Plot – 99% OBW



5 Peak Output Power

5.1 Test Result

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

5.2 Test Method

Fundamental peak power measurements were recorded using the procedures from ANSI C63.10: 2013 clause 11.9.1.1 and KDB 558074 D01 Measurement Guidance v04.

Limit

(3) 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)

5.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.2 °C

Relative Humidity: 54.3 %

Atmospheric Pressure: 99.3 kPa

5.4 Test Equipment

Test End Date: 11-Aug-2020

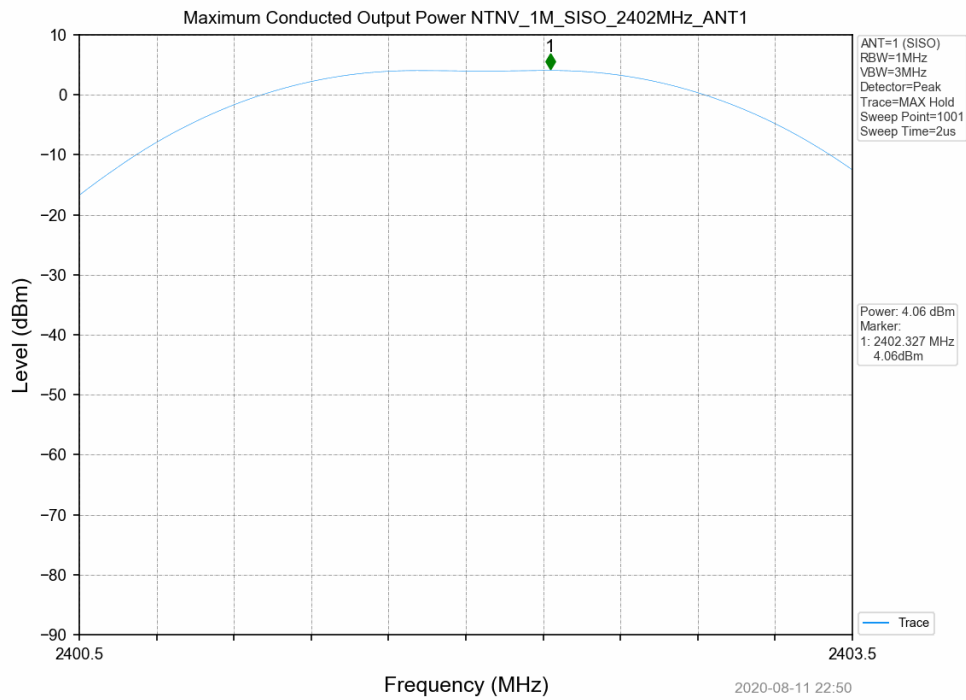
Tester: JP

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	27-Dec-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-020	TELEDYNE STORM MICROWAVE	20106	6-Mar-2021

5.5 Test Data

Test Mode	Frequency (MHz)	Tx Type	Measured Peak Output Power (dBm)	Limits (dBm)	Verdict
1M	2402	SISO	4.06	30	PASS
	2440	SISO	3.18	30	PASS
	2480	SISO	1.91	30	PASS
2M	2402	SISO	4.06	30	PASS
	2440	SISO	3.18	30	PASS
	2480	SISO	1.85	30	PASS

Sample Plot



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

Power spectral density measurements were recorded using the procedures from ANSI C63.10: 2013 clause 11.10.2 (method PKPSD) and KDB 558074 D01 Measurement Guidance v04.

Limit

The limit is 8 dBm.

6.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.2 °C
 Relative Humidity: 54.3 %
 Atmospheric Pressure: 99.3 kPa

6.4 Test Equipment

Test End Date: 11-Aug-2020

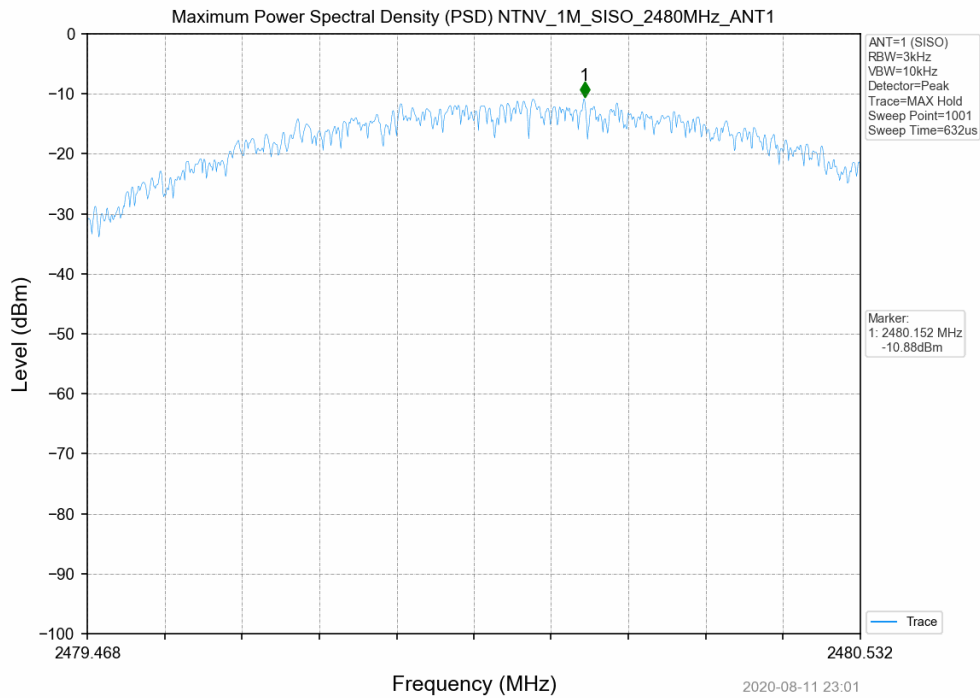
Tester: JP

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	27-Dec-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-020	TELEDYNE STORM MICROWAVE	20106	6-Mar-2021

6.5 Test Data

Test Mode	Frequency (MHz)	Tx Type	Maximum Power Spectral Density (dBm/3KHz)	Limits (dBm/3kHz)	Verdict
1M	2402	SISO	-12.64	≤8	PASS
	2440	SISO	-13.52	≤8	PASS
	2480	SISO	-10.88	≤8	PASS
2M	2402	SISO	-16.37	≤8	PASS
	2440	SISO	-17.17	≤8	PASS
	2480	SISO	-18.55	≤8	PASS

Sample Plot



7 Conducted Spurious Emissions / Band Edge

7.1 Test Result

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

7.2 Test Method

Spurious emissions in non-restricted frequency bands were recorded using the methods defined in ANSI C63.10: 2013 clause 11.11 and KDB 558074 D01 Measurement Guidance v04.

Lowest, middle, and highest channels were investigated.

Because the maximum conducted peak 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.

7.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.2 °C
 Relative Humidity: 54.3 %
 Atmospheric Pressure: 99.3 kPa

7.4 Test Equipment

Test End Date: 11-Aug-2020

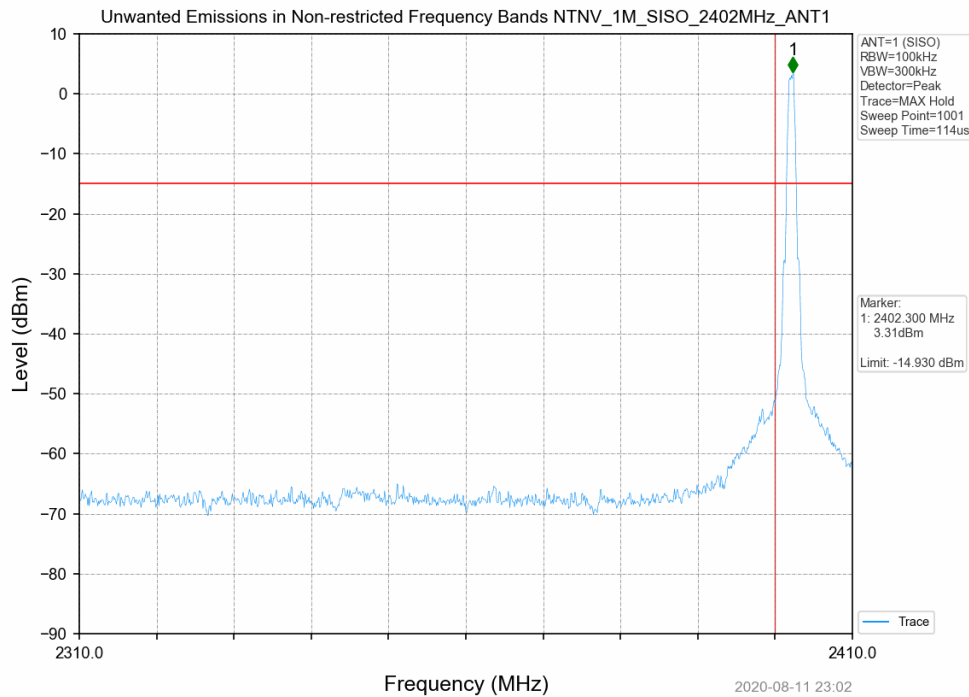
Tester: JP

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	27-Dec-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-020	TELEDYNE STORM MICROWAVE	20106	6-Mar-2021

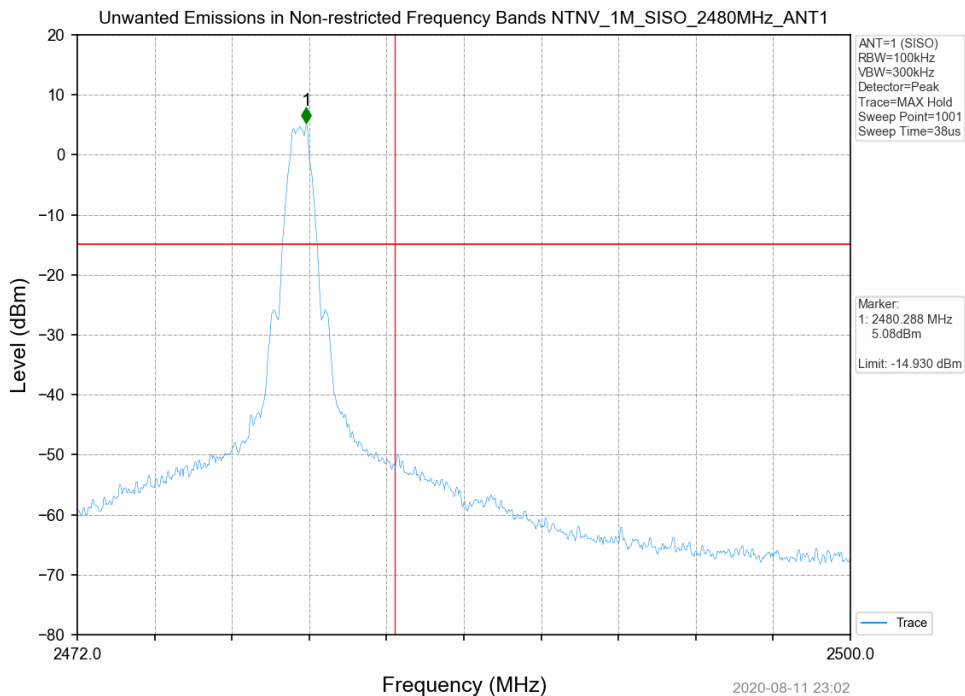
7.5 Test Data – DTS Band Edge / Conducted Spurious Emissions

Test Mode	Frequency (MHz)	TX Type	ANT No.	Spurious Conducted Emission (dBm)	Limits (dBm)	Verdict
1M	2402	SISO	1	Refer to test graph	-14.93	PASS
	2440	SISO	1	Refer to test graph	-14.93	PASS
	2480	SISO	1	Refer to test graph	-14.93	PASS
2M	2402	SISO	1	Refer to test graph	-18.98	PASS
	2440	SISO	1	Refer to test graph	-18.98	PASS
	2480	SISO	1	Refer to test graph	-18.98	PASS

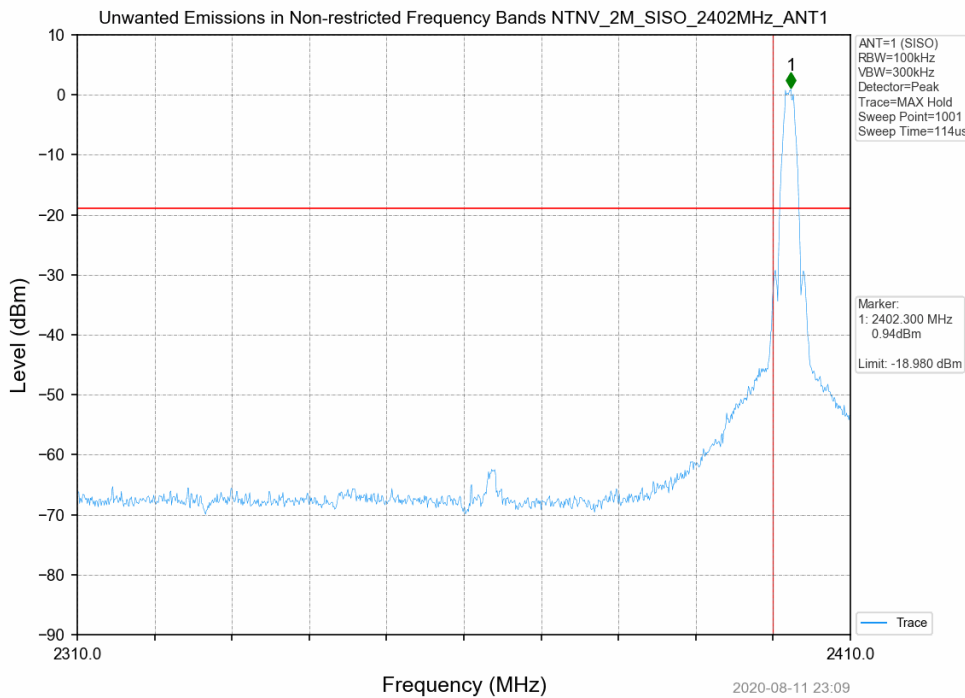
Low Channel @ 1MHz Modulation



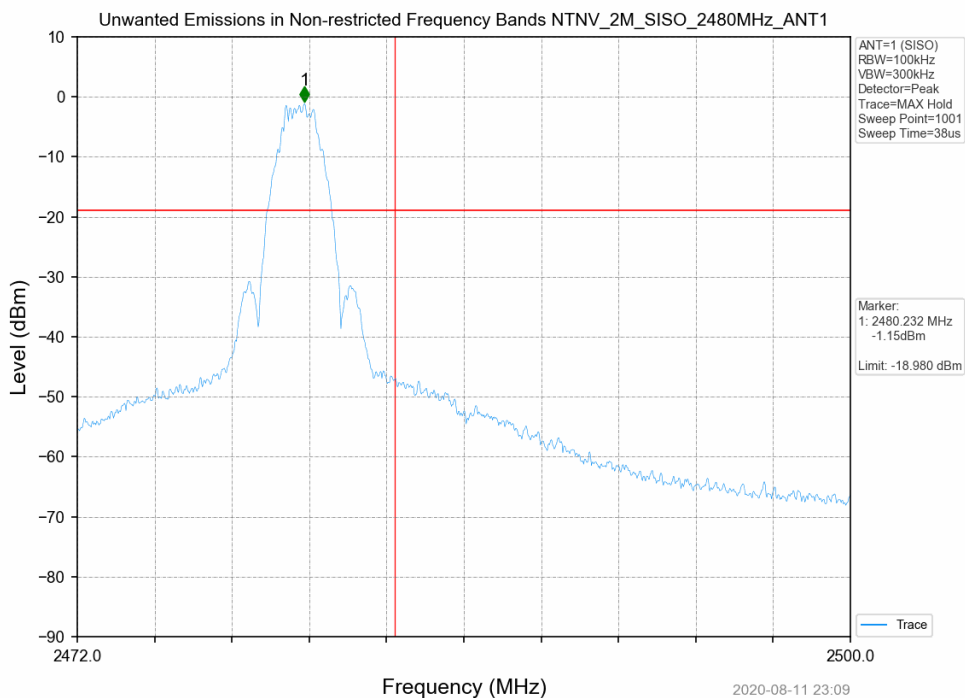
High Channel @ 1MHz Modulation



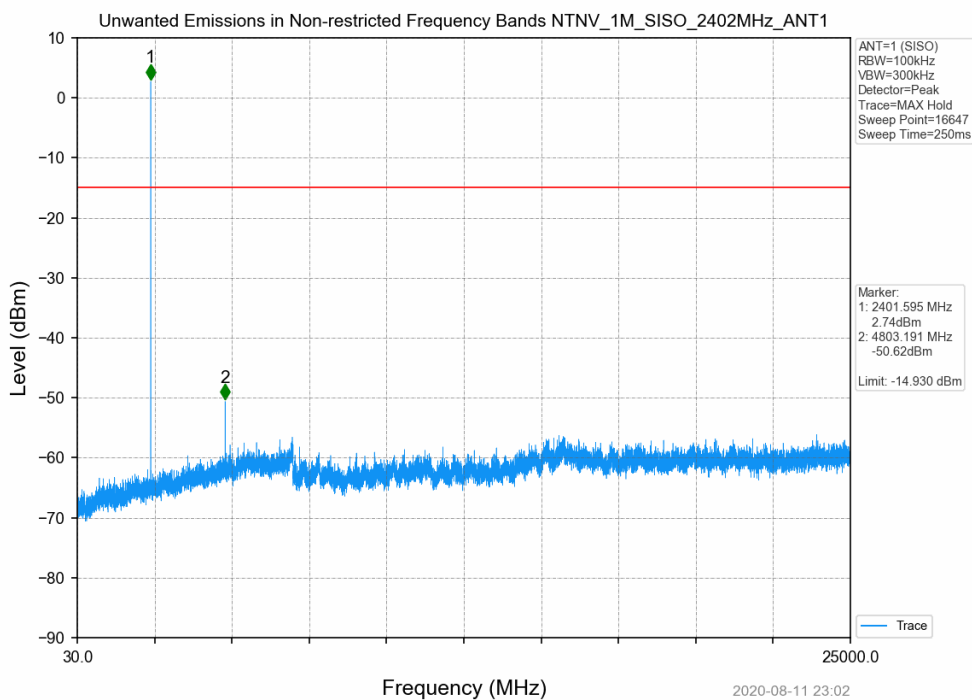
Low Channel @ 2MHz Modulation



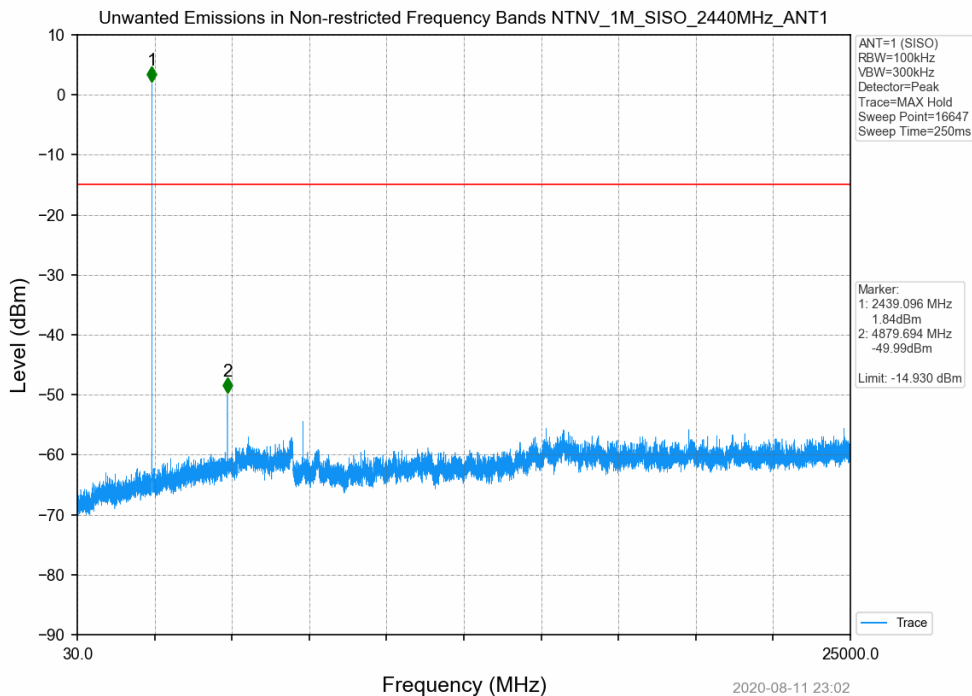
High Channel @ 2MHz Modulation



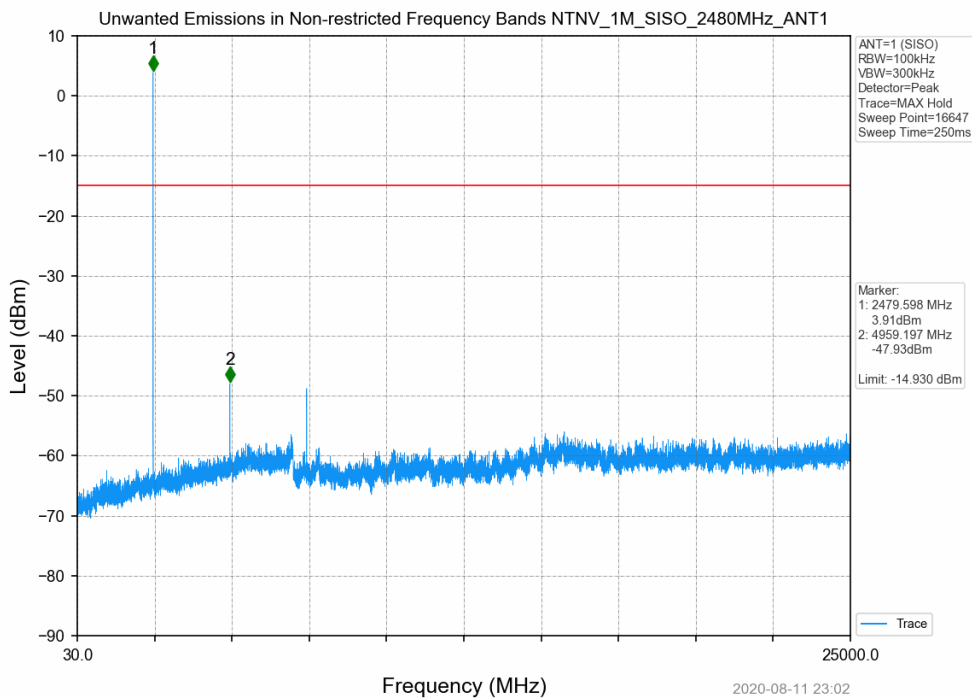
Low Channel @ 1MHz Modulation



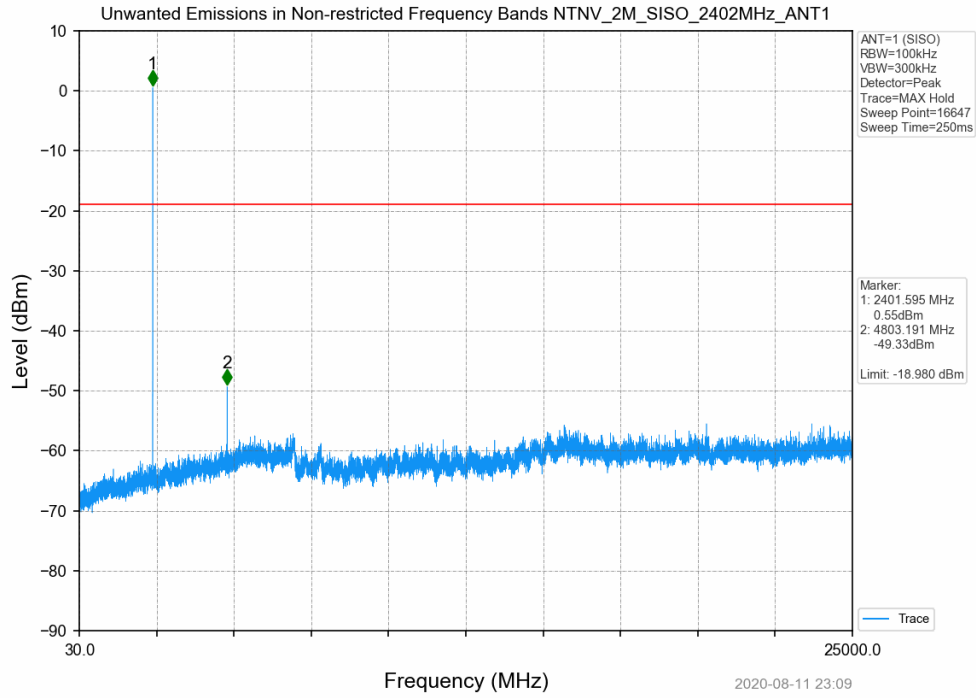
Mid Channel @ 1Mhz Modulation



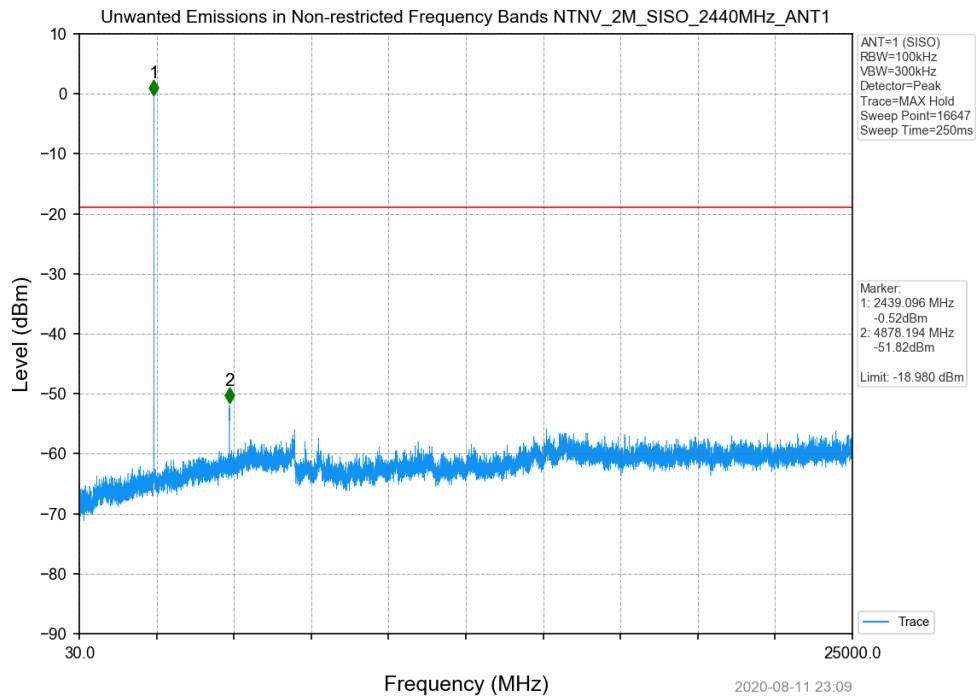
High Channel @ 1Mhz Modulation



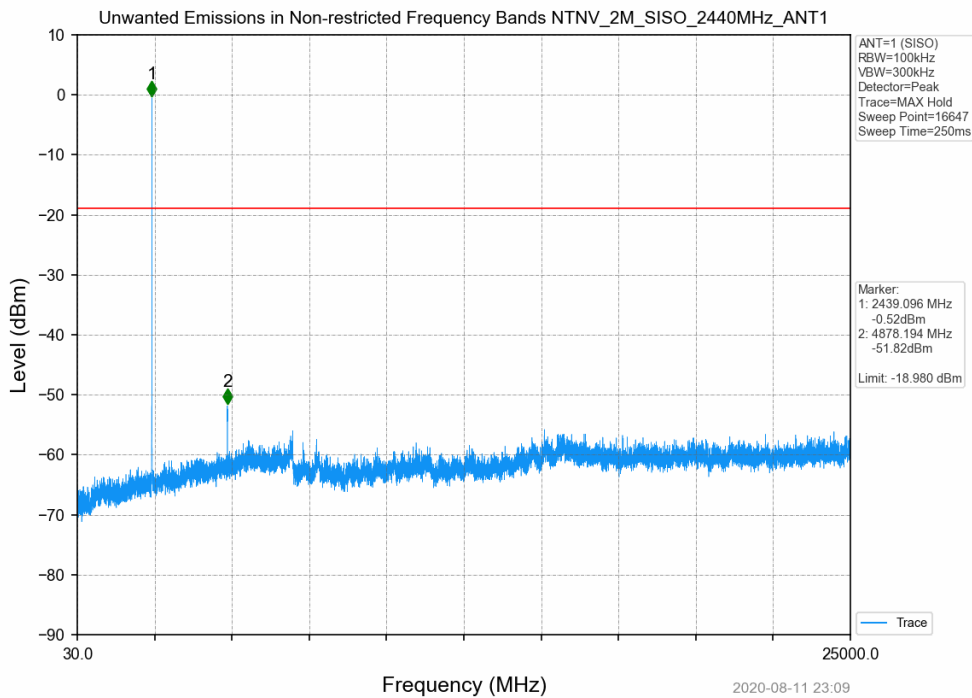
Low Channel @ 2MHz Modulation



Mid Channel @ 2MHz Modulation



High Channel @ 2Mhz Modulation



8 Field Strength of Spurious Radiation

8.1 Test Result

Test Description	Test Specification		Test Result
Radiated Spurious Emissions	15.247(d) and 15.209	RSS-247 S5.5	Compliant

8.2 Test Method

The measurement methods defined in ANSI C63.10: 2013 were used.

Lowest, middle, and highest channels were investigated – the device was commanded to continuously transmit on channels low, middle, and high channels. Worst-case

Test distance:

- 9k to 30 MHz – The EUT to measurement loop antenna distance was 3 meters
- 30 to 1000 MHz - The EUT to measurement bilog antenna distance was 3 meters
- 1 to 18 GHz - The EUT to measurement horn antenna distance was 3 meters
- 18 to 26 GHz - The EUT to measurement horn 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

8.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

- Temperature: 22.8 °C
- Relative Humidity: 60.1 %
- Atmospheric Pressure: 98.2 kPa

8.4 Test Equipment

9kHz-30MHz

Test End Date: 11-Aug-2020

Tester: ZH

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
EMI TEST RECEIVER	ESU8	ROHDE & SCHWARZ	B085759	7-May-2021
RF Cable Nm to Nm, 0.01-18GHz	90-195-276	TELEDYNE STORM MICROWAVE	20113	2-Mar-2021
RF CABLE	SF106	HUBER & SUHNER	B079712	5-Sep-2020
RF Cable Nm to Nm, 0.01-18GHz	90-195-118	TELEDYNE STORM MICROWAVE	20125	2-Mar-2021
ANTENNA, LOOP, ACTIVE	6502	ETS Lindgren	B085752	15-Aug-2020

Note: The equipment calibration period is 1 year.

30MHz- 1GHz

Test End Date: 11-Aug-2020

Tester: PV

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
ANTENNA, BILOG	JB6	SUNOL	B079690	11-Dec-2020
RF Cable Nm to Nm, 0.01-18GHz	90-195-276	TELEDYNE STORM MICROWAVE	20113	2-Mar-2021
RF CABLE	SF106	HUBER & SUHNER	B079713	7-Sep-2020
RF Cable Nm to Nm, 0.01-18GHz	90-195-118	TELEDYNE STORM MICROWAVE	20126	2-Mar-2021
LOW NOISE AMPLIFIER	ZKL-2+	Mini-Circuits	B079817	4-Oct-2020
RF CABLE	104PE	HUBER & SUHNER	B079793	5-Sep-2020
EMI TEST RECEIVER	ESU8	ROHDE & SCHWARZ	B085759	7-May-2021

Note: The equipment calibration period is 1 year.

Above 1GHz

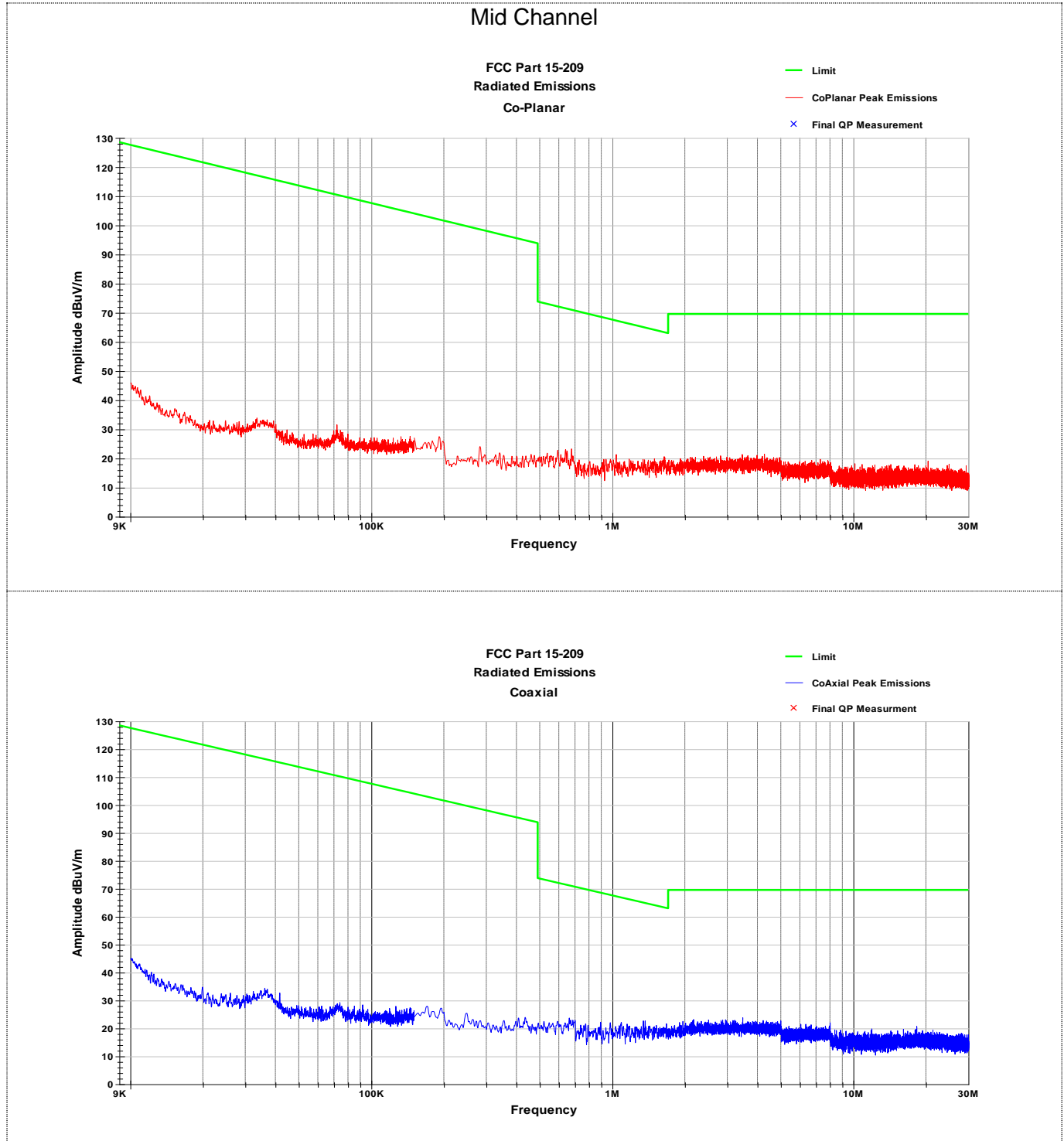
Test End Date: 12-Aug-2020

Tester: BEO

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	6-Apr-2021
RF Cable Nm to Nm, 0.01-18GHz	90-195-276	TELEDYNE STORM MICROWAVE	20113	2-Mar-2021
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	B094463	3-Dec-2020
RF CABLE	104PE	HUBER & SUHNER	B079793	5-Sep-2020
ANTENNA, DRG HORN (MEDIUM)	3117	ETS Lindgren	B079699	15-Jul-2022
ANTENNA, HORN (SMALL)	LB-180400-20-C-KF	A-INFO	15007	6-Apr-2022
LOW NOISE AMPLIFIER	NSP1840-HG	MITEQ	B087572	7-Oct-2020
RF Cable SMA to SMA, 0.01-40GHz	084-0505-138	TELEDYNE STORM MICROWAVE	20110	6-Mar-2021
RF Cable SMA to SMA, 0.01-40GHz	084-0505-020	TELEDYNE STORM MICROWAVE	20105	6-Mar-2021

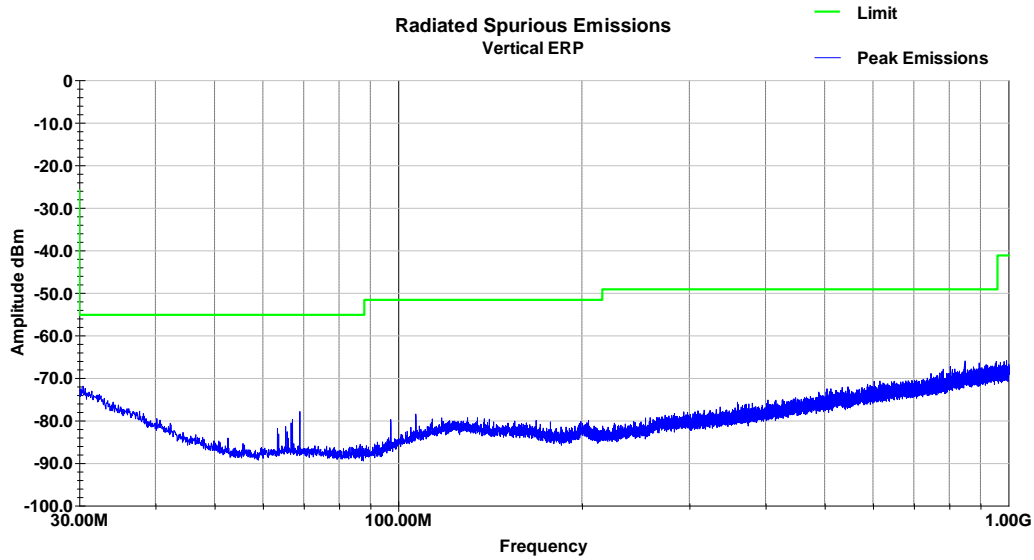
8.5 Test Data

9kHz-30MHz - (Low, Mid and High Channels were similar results)

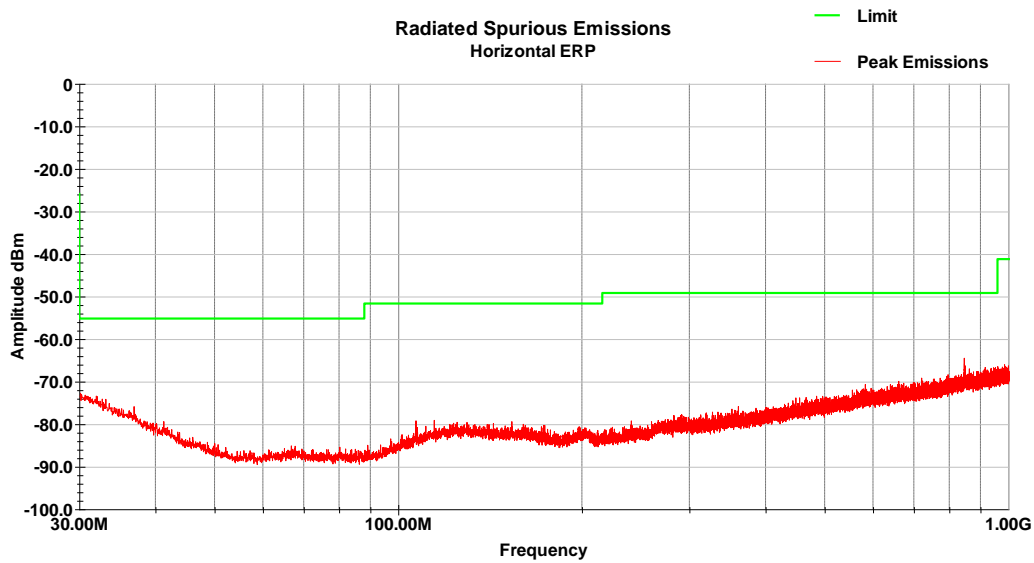


30-1000 MHz (Y-Axis highest emissions)

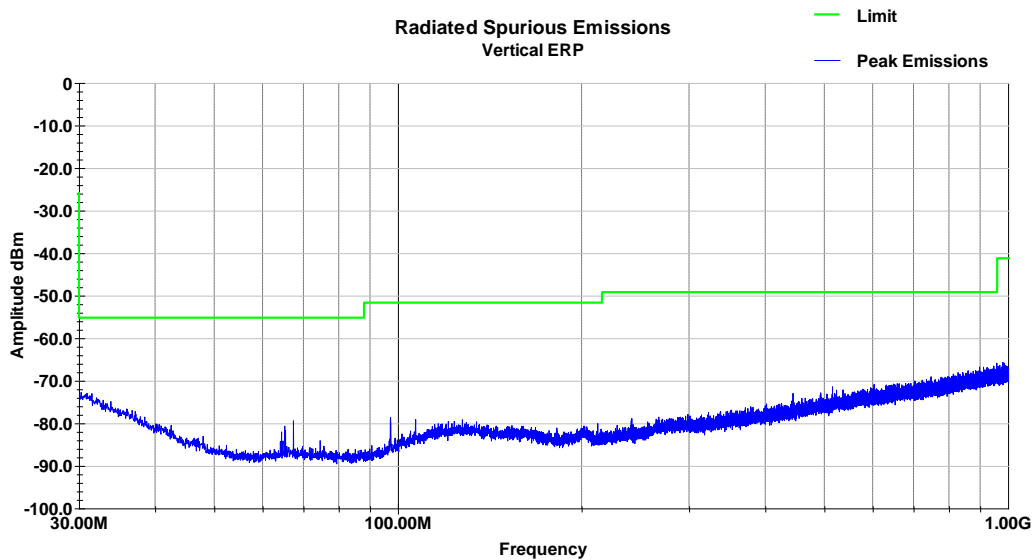
Low Channel Vertical



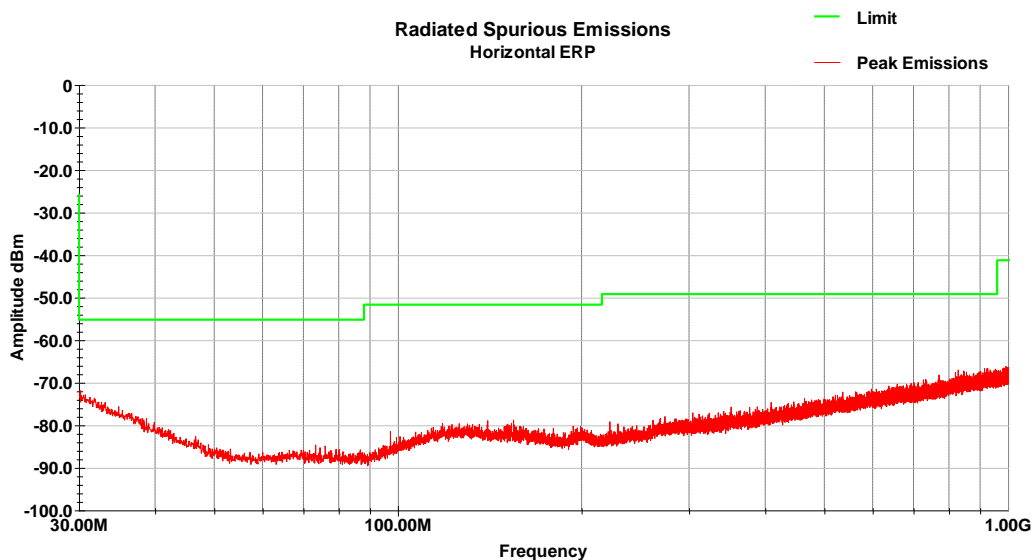
Low Channel Horizontal



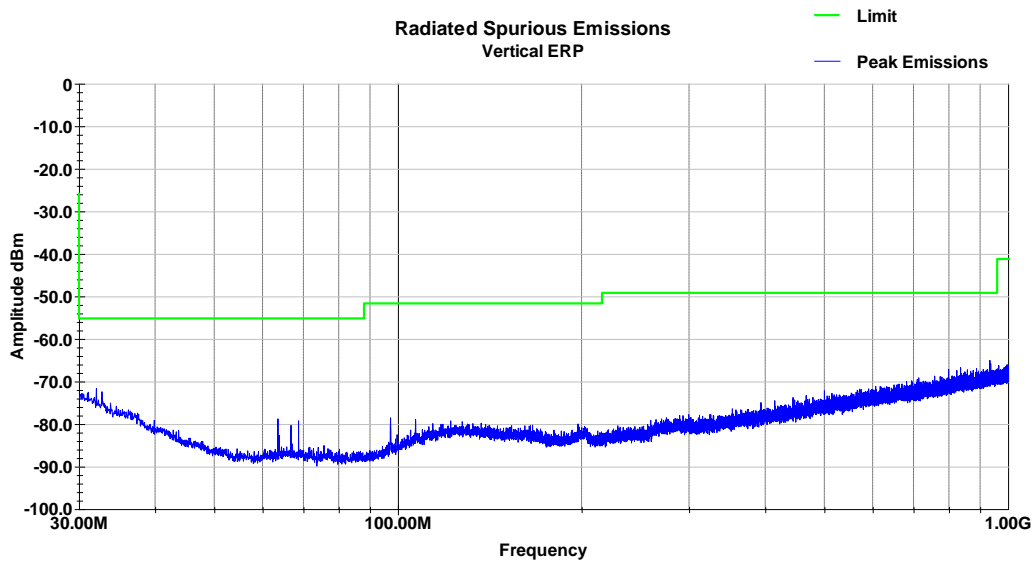
Mid Channel Vertical



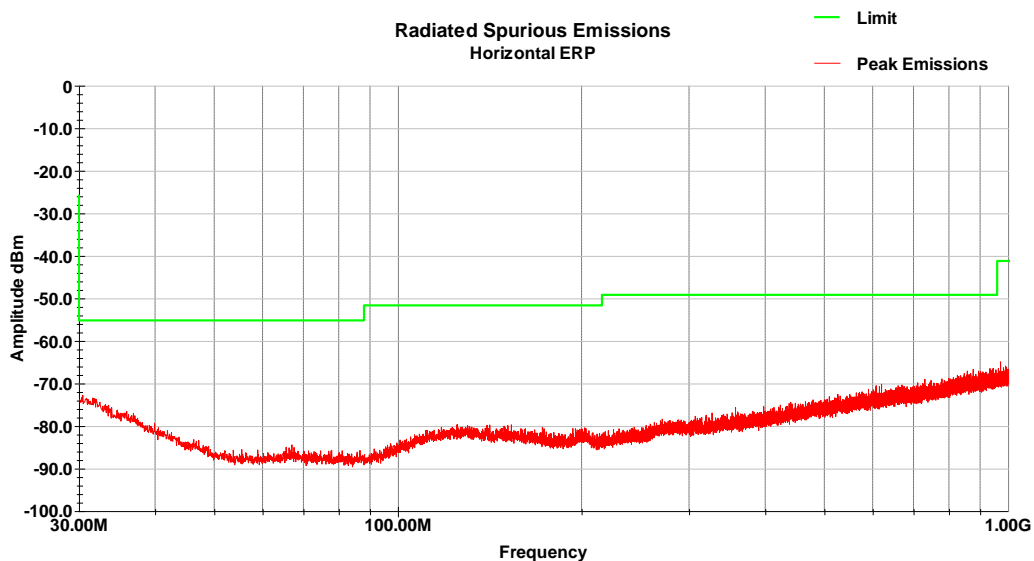
Mid Channel Horizontal



High Channel Vertical

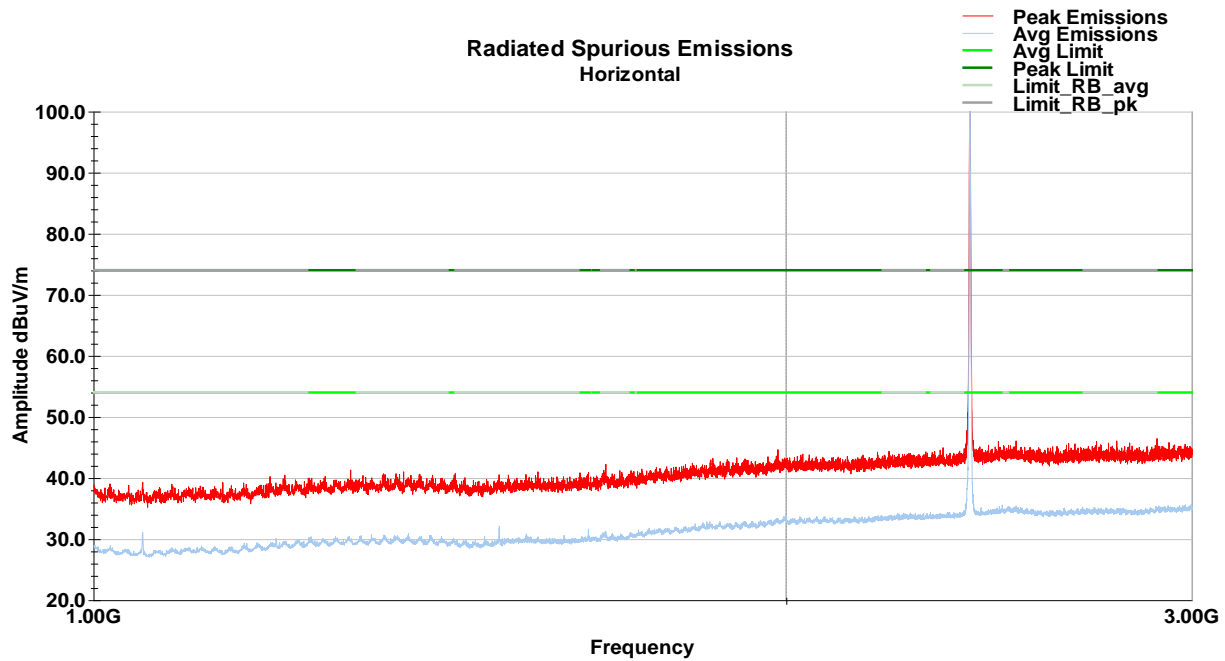
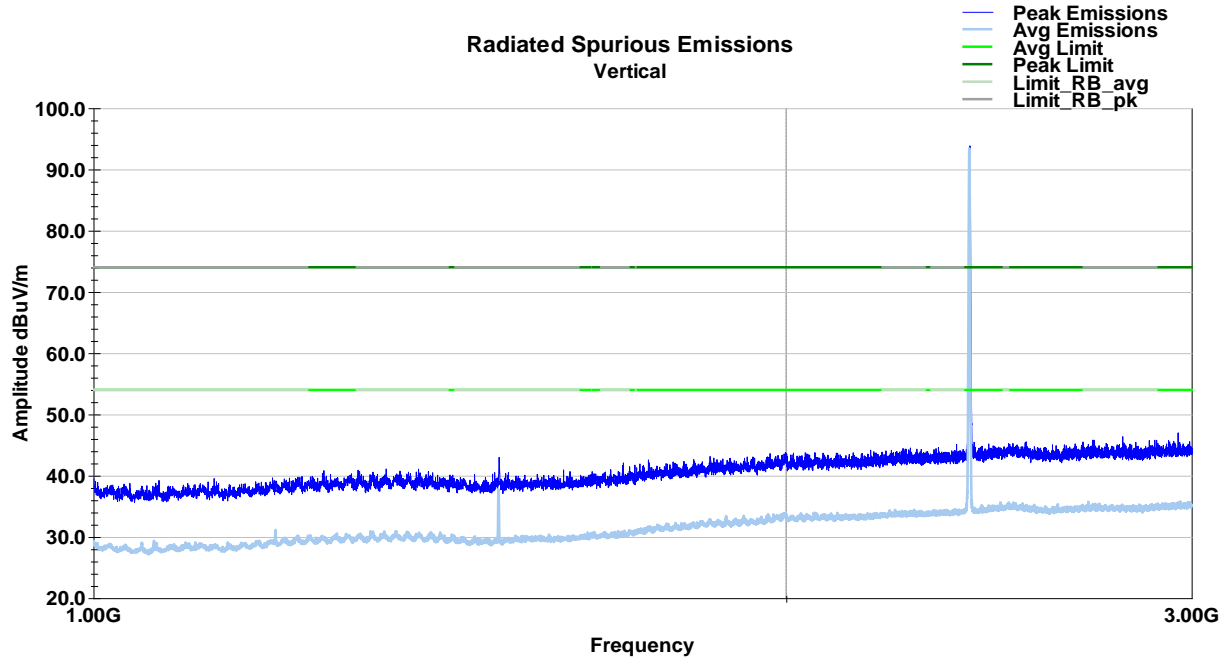


High Channel Horizontal

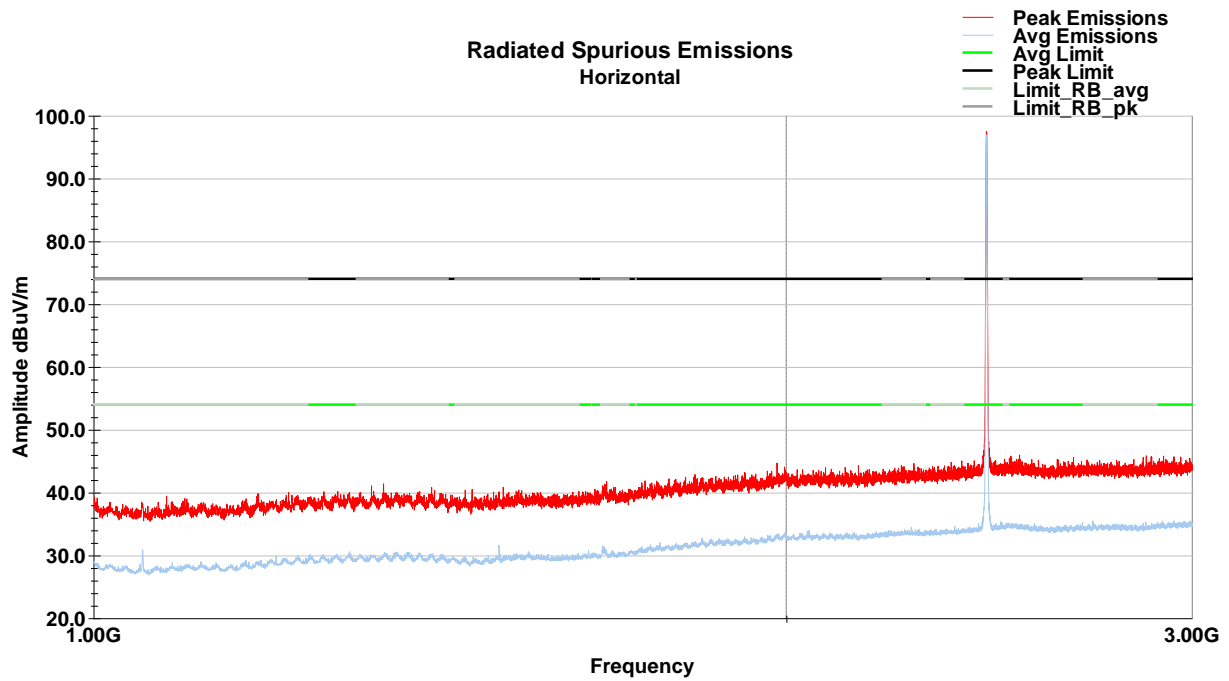
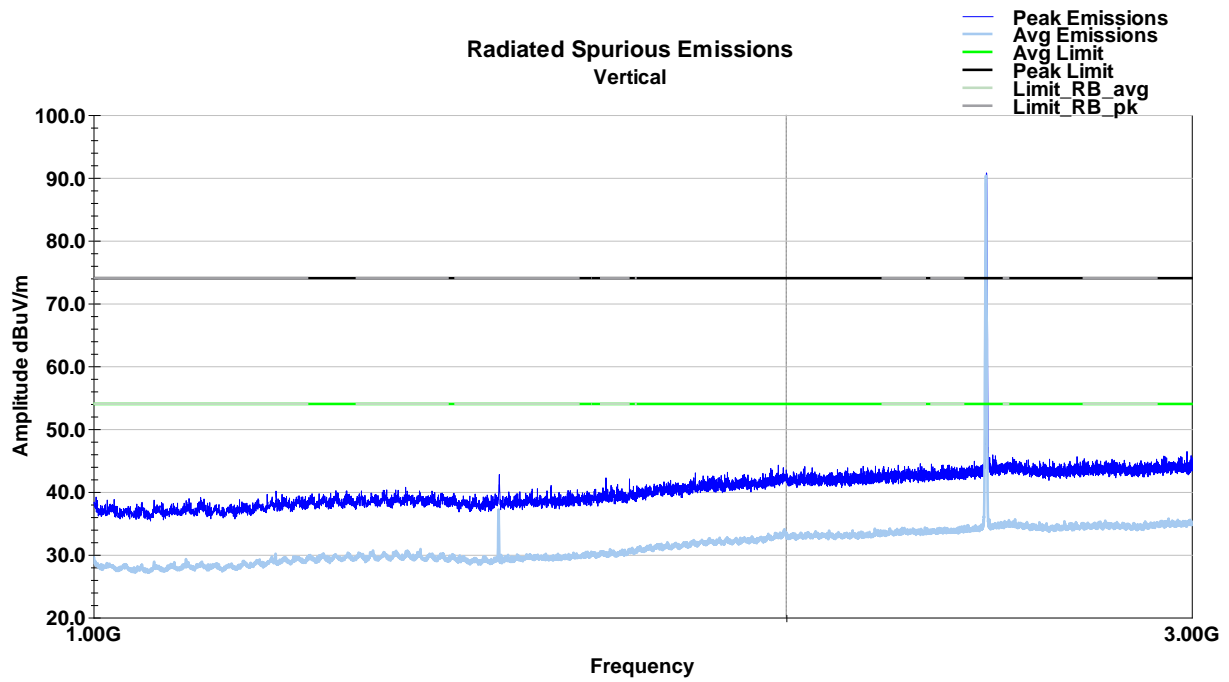


8.5.1 1-3 GHz (Y-Axis highest emissions)

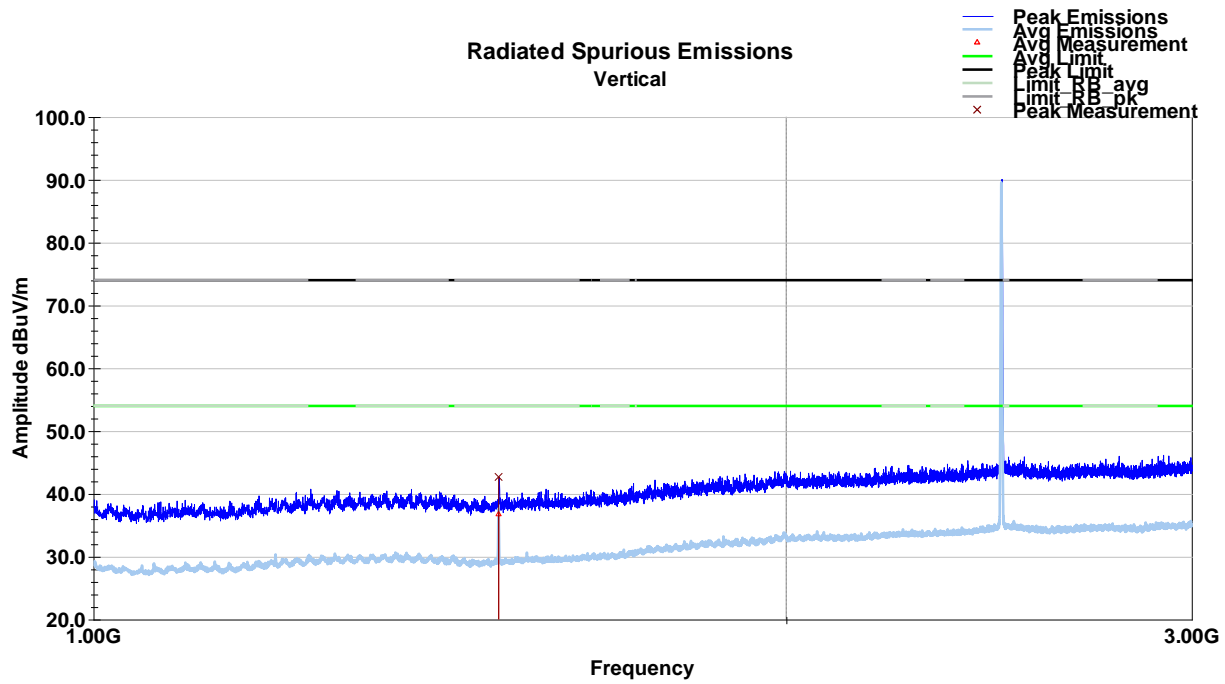
Low Channel



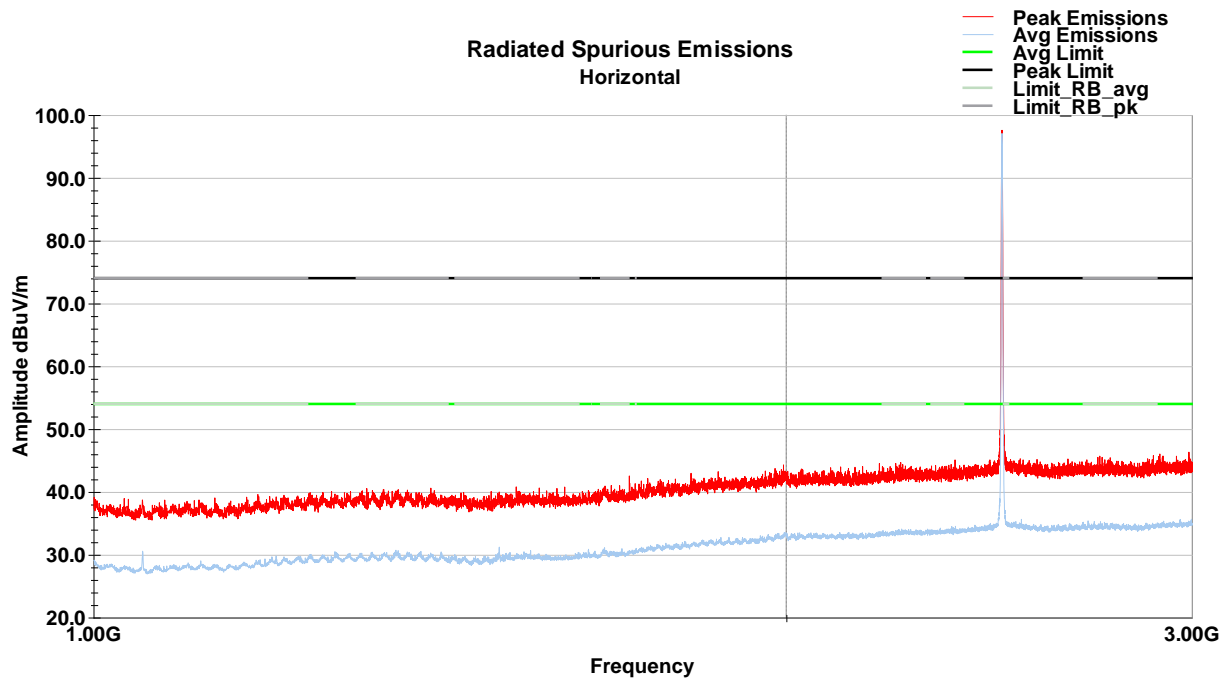
Mid Channel



High Channel



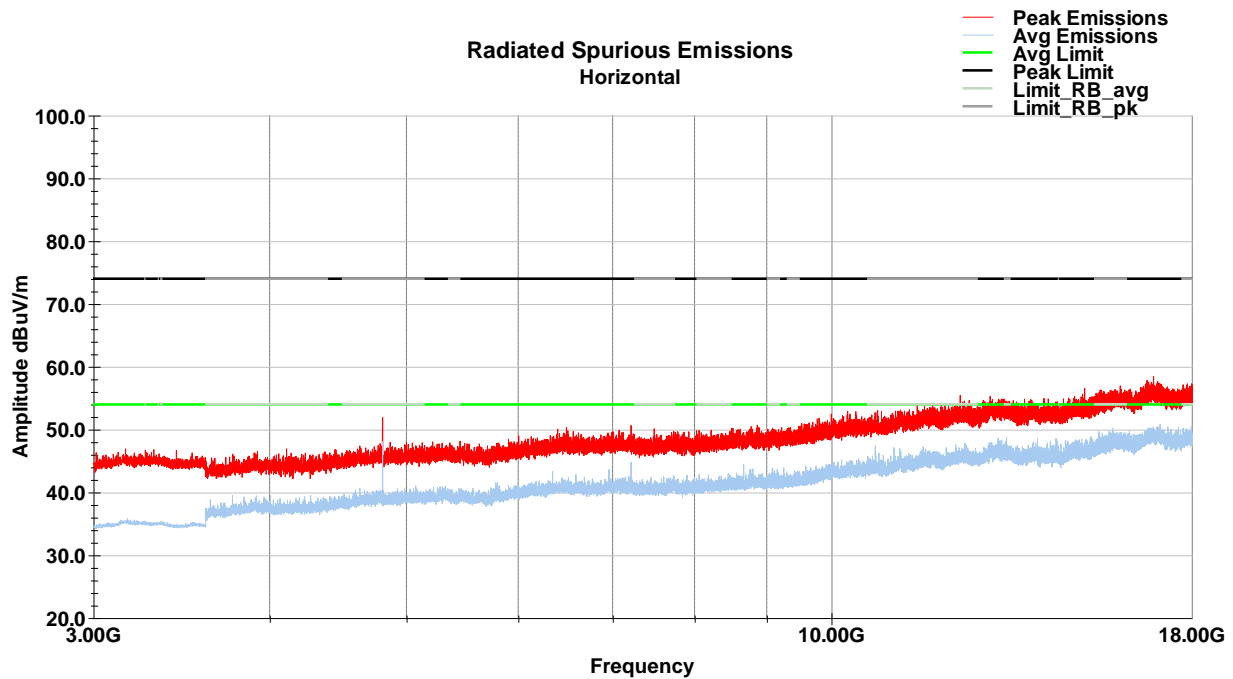
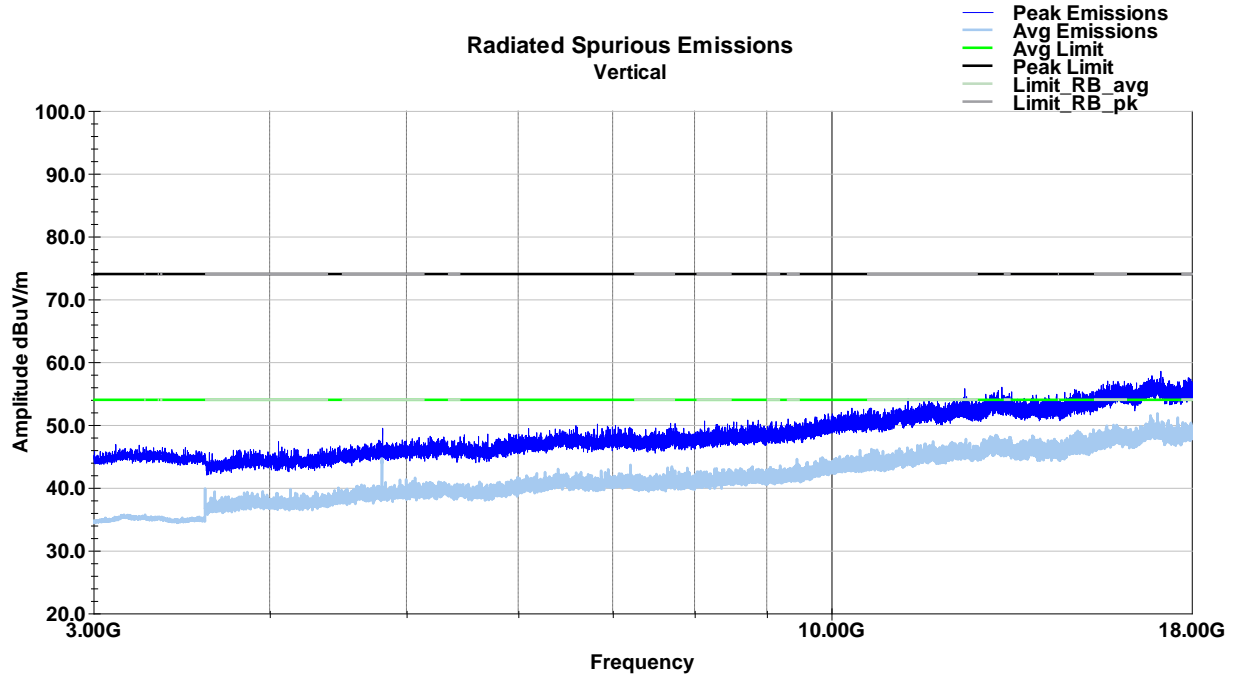
Frequency MHz	Raw Avg dBm	Polarity V/H	Azimuth degrees	Height cm	AF dB/m	Loss dB	Amp dB	Avg Value dBm	Limit dBm	Margin dB
1500.04	-52.9	V	211.0	175.0	27.7	2.0	35.0	-58.3	-41.2	-17.1
QP Value = Level + AF + CL - Amp										
Margin = QP Value - Limit										



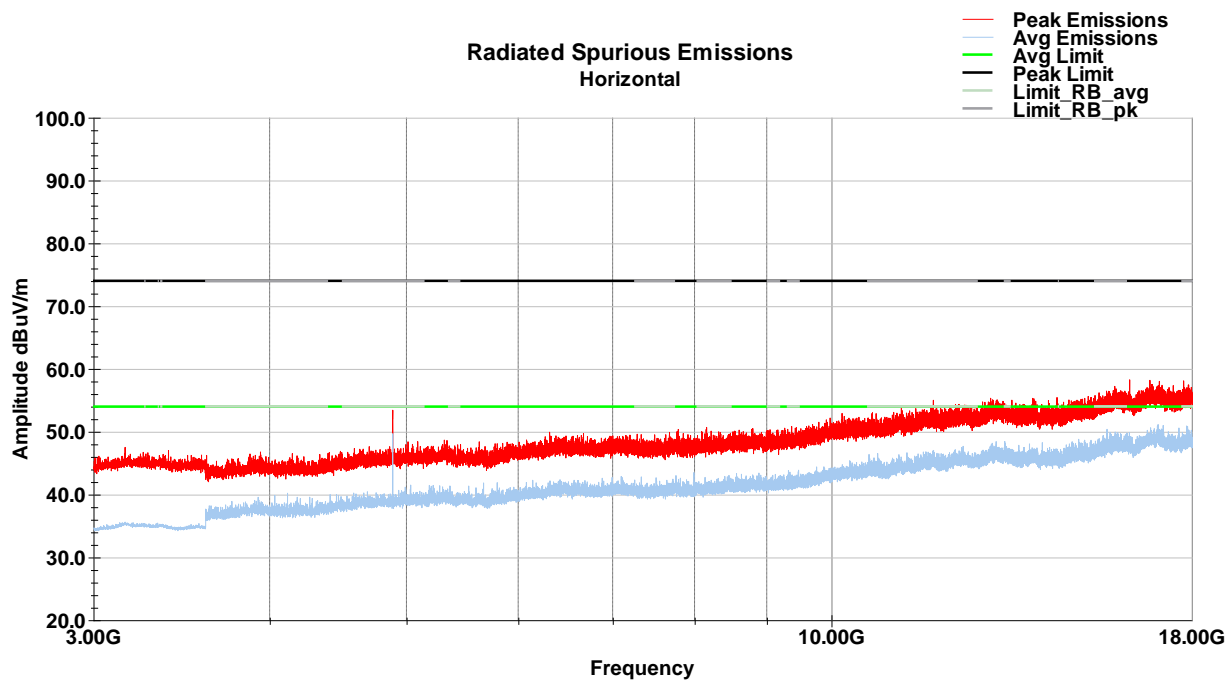
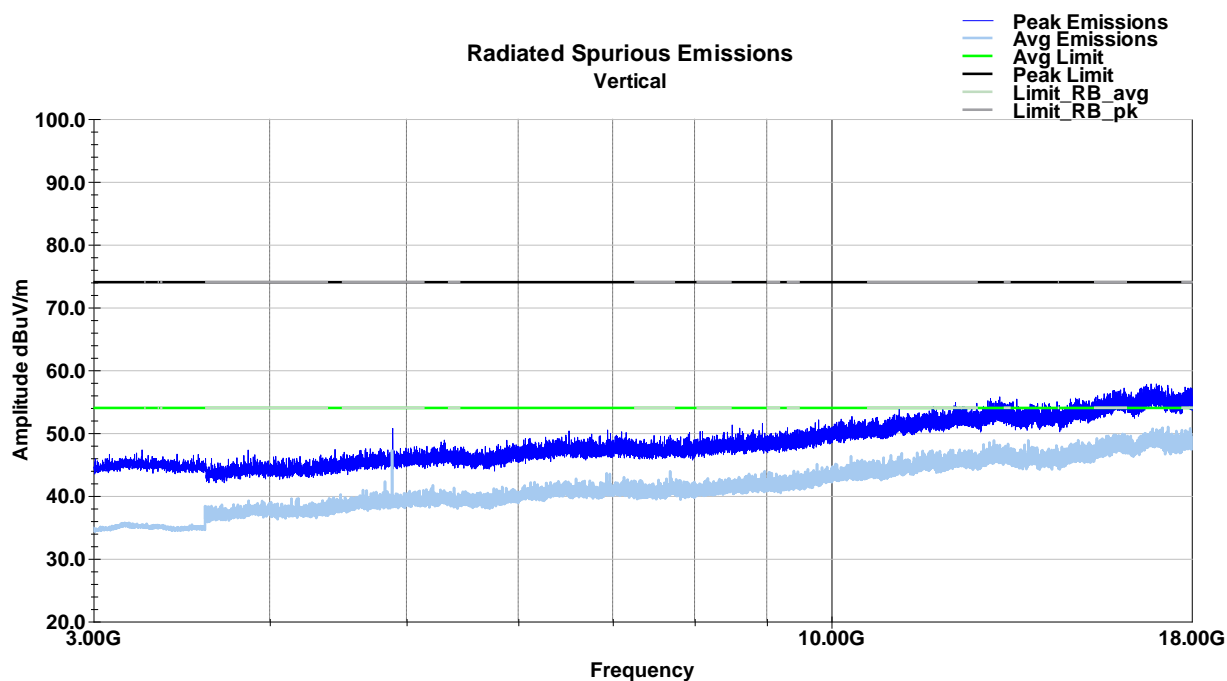
No peak emissions within 10dB of the limit

8.5.2 3-18 GHz (X-axis Highest Emission)

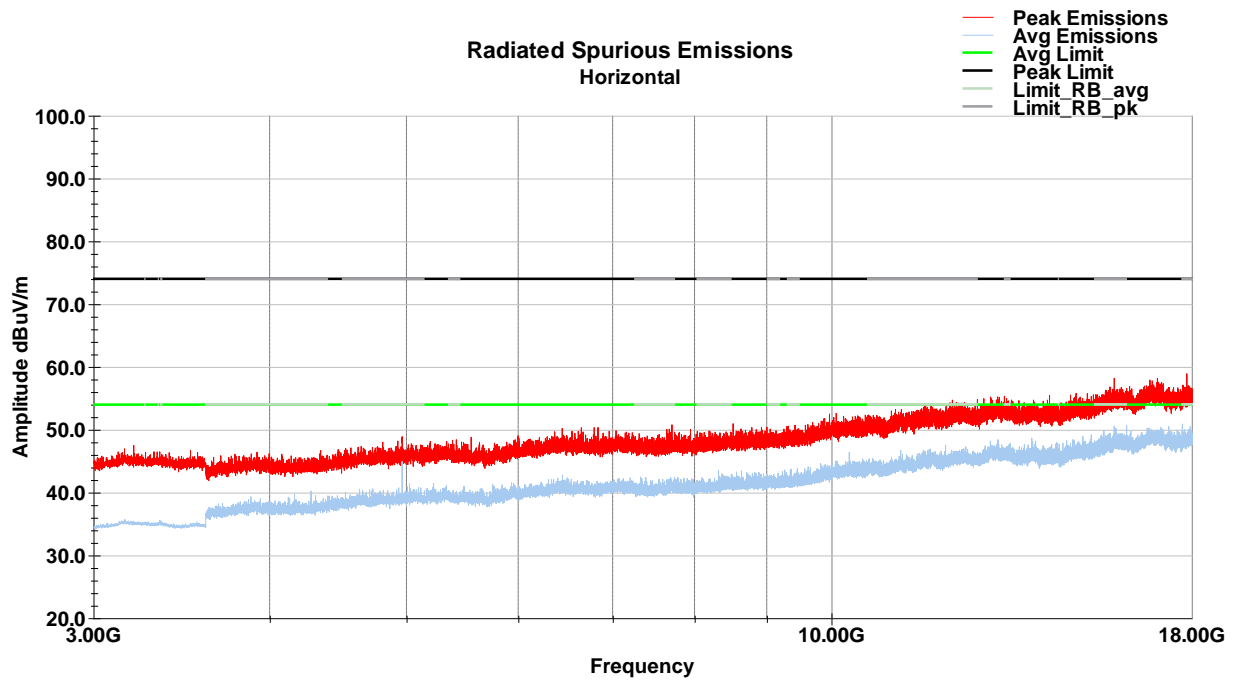
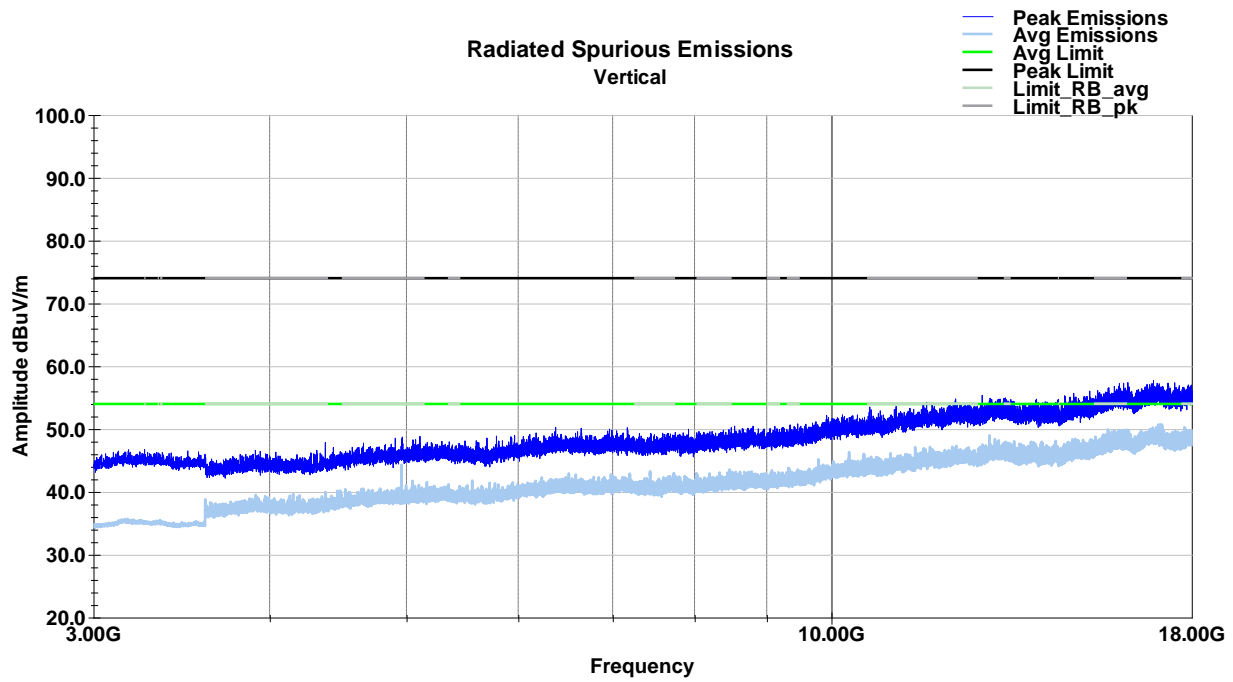
Low Channel



Mid Channel



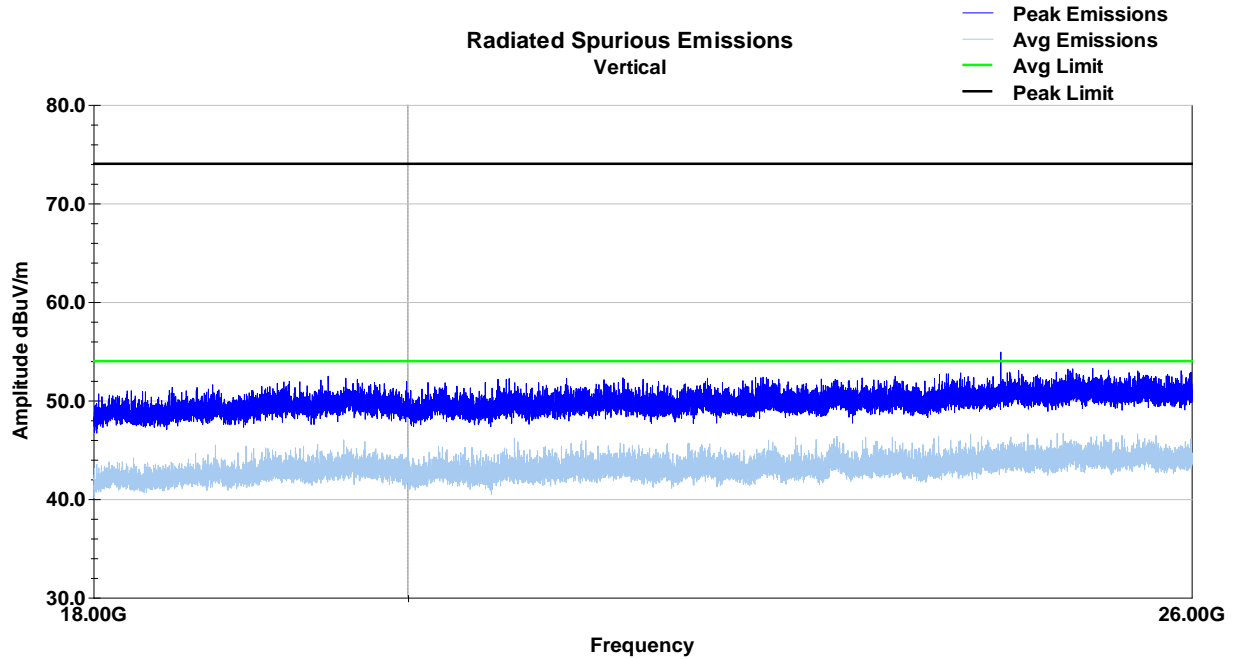
High Channel



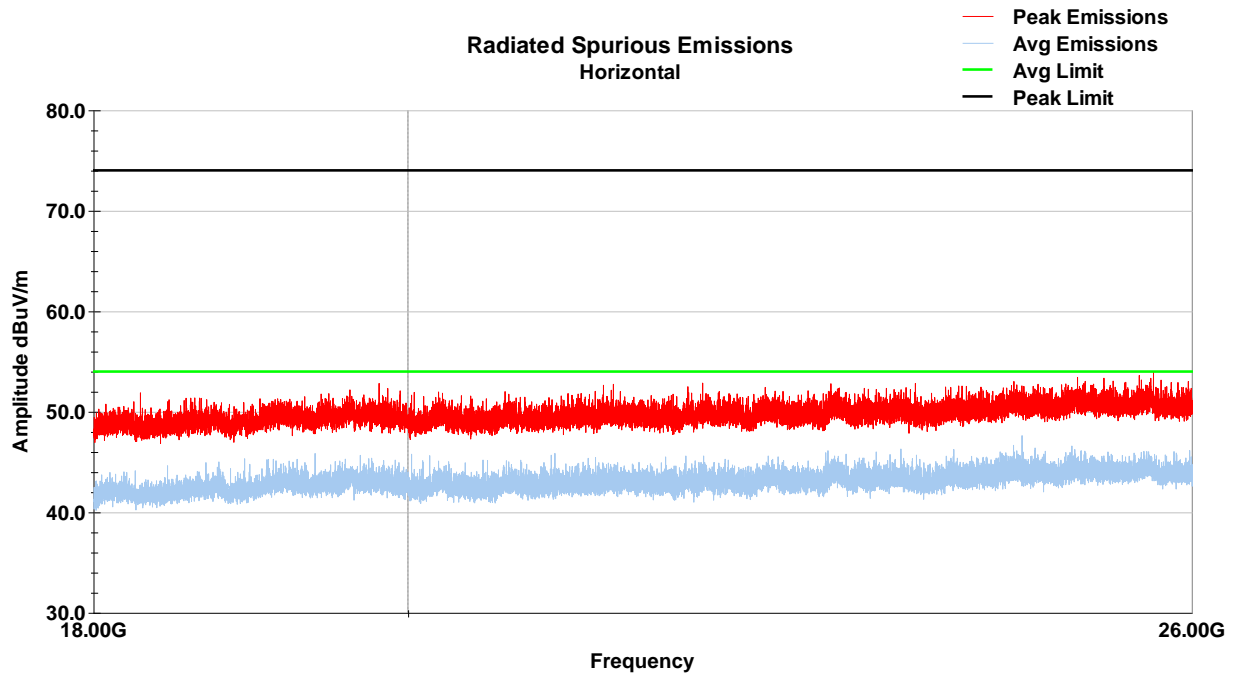
8.5.3 **18-26 GHz (Y-axis Highest Emission)**

Low, Mid and High Channels were very similar results

Mid Channel



No emissions within 10dB of the limits



No emissions within 10dB of the limit

9 Radiated Emissions at Band Edge / Restricted Band

9.1 Test Result

Test Description	Test Specification		Test Result
Restricted Band Emissions	15.205 / 15.209	RSS-GEN S8.9 / 8.10	Compliant

9.2 Test Method

Peak and average field strength measurements were performed at the restricted band edges of 2390MHz and 2483.5MHz. Measurements were made using the radiated methods defined in FCC KDB publication 558074 D01 DTS Meas Guidance v05r02 and ANSI C63.10.

9.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 24.2 °C
 Relative Humidity: 56.4 %
 Atmospheric Pressure: 98.18 kPa

9.4 Test Equipment

Test End Date: 21-Aug-2020

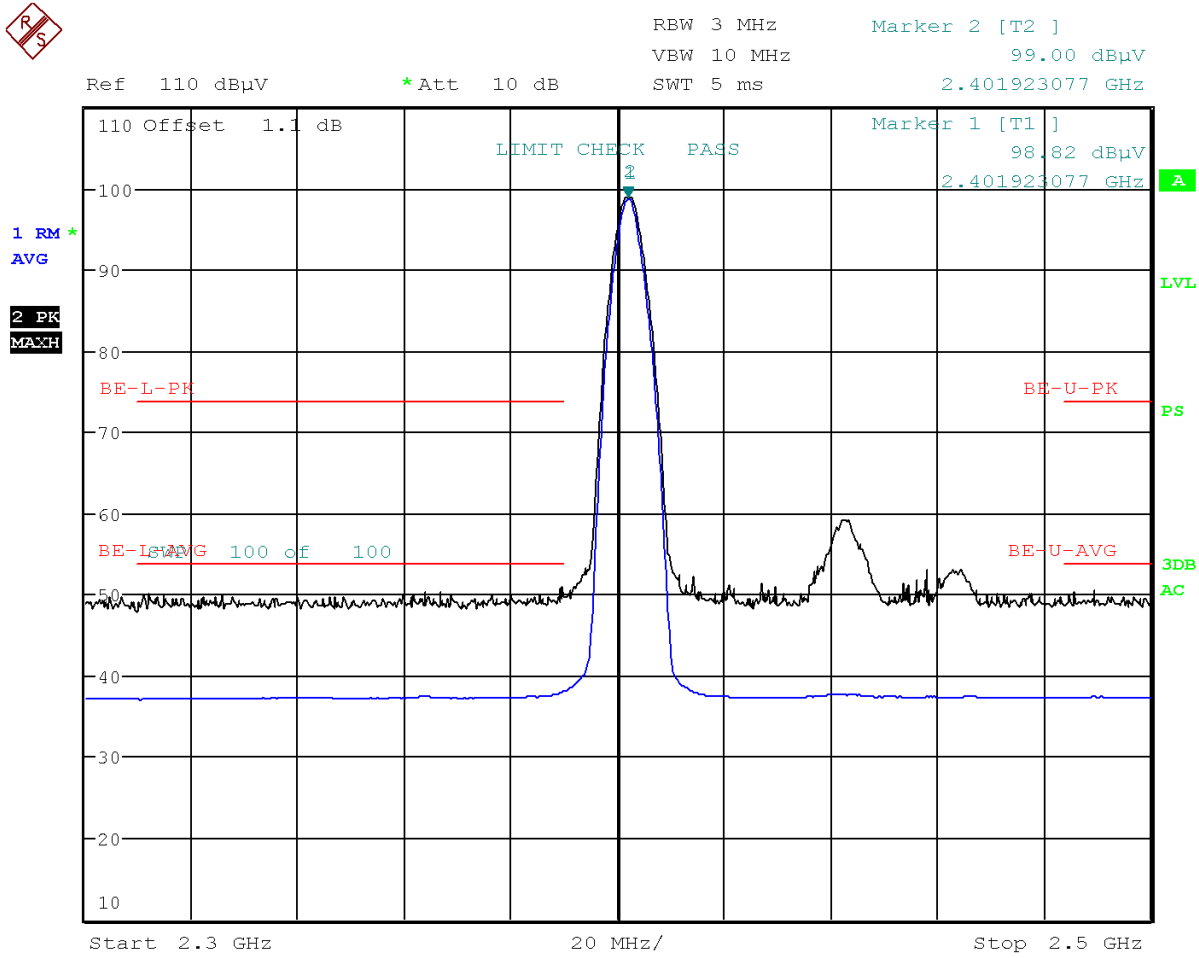
Tester: BEO

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
ANTENNA, DRG HORN (MEDIUM)	3117	ETS Lindgren	B079699	15-Jul-2022
RF Cable Nm to Nm, 0.01-18GHz	90-195-354	TELEDYNE STORM MICROWAVE	20120	2-Mar-2021
RF Cable Nm to Nf, 0.01-18GHz	90-213-118	TELEDYNE STORM MICROWAVE	20117	2-Mar-2021
RF Cable Nm to Nm, 0.01-18GHz	90-195-118	TELEDYNE STORM MICROWAVE	20126	2-Mar-2021
RF CABLE	104PE	HUBER & SUHNER	B079793	5-Sep-2020
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	B094463	3-Dec-2020
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	6-Apr-2021

Note: The equipment calibration period is 1 year.

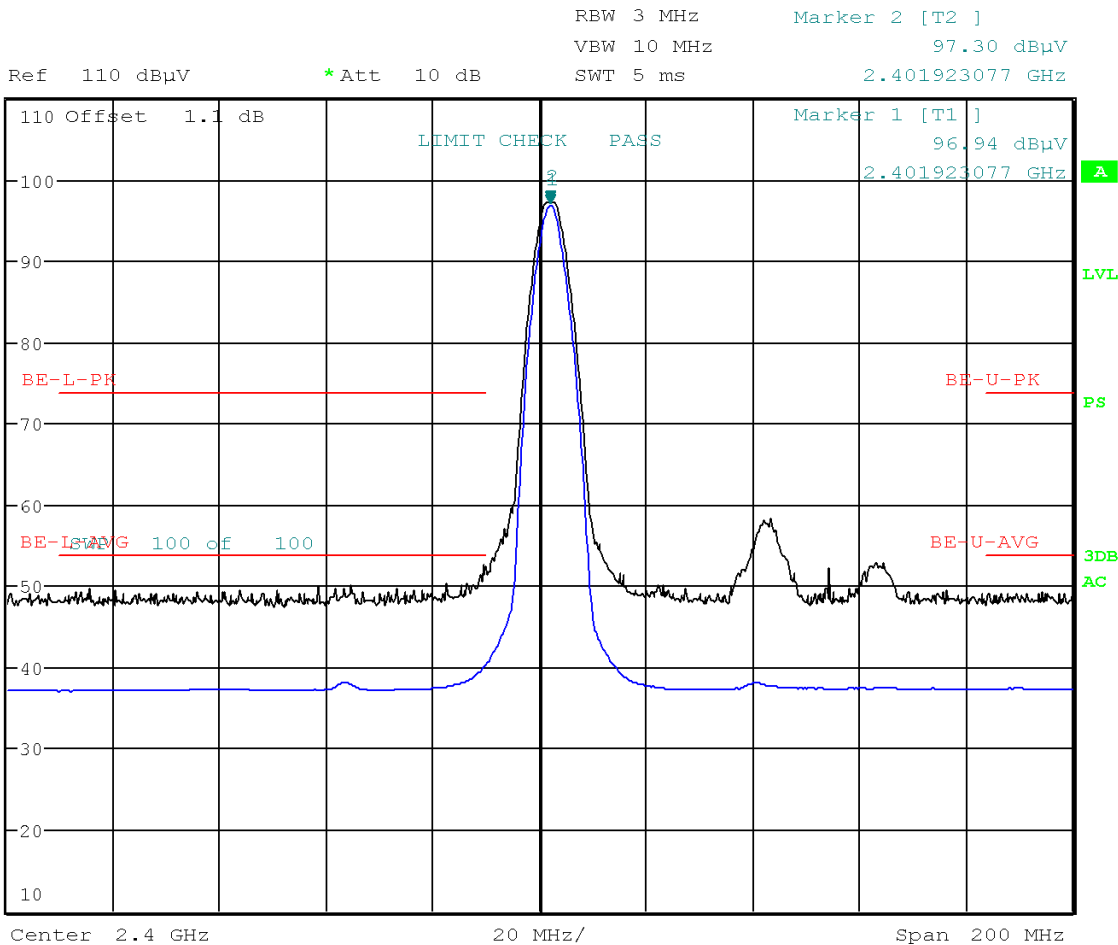
9.5 Test Data – Restricted Band Edge

Low Channel @ 1MHz Modulation



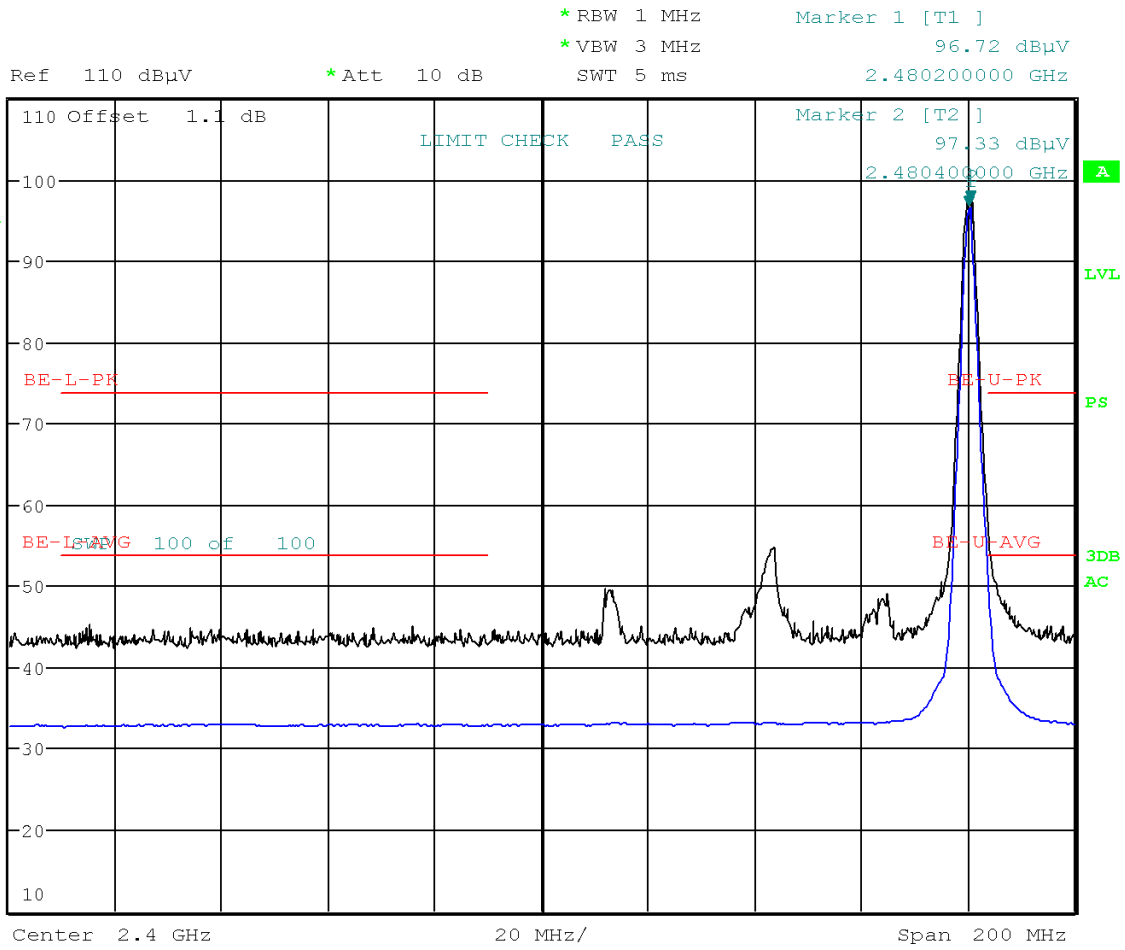
Date: 21.AUG.2020 17:37:40

Low Channel @ 2MHz Modulation



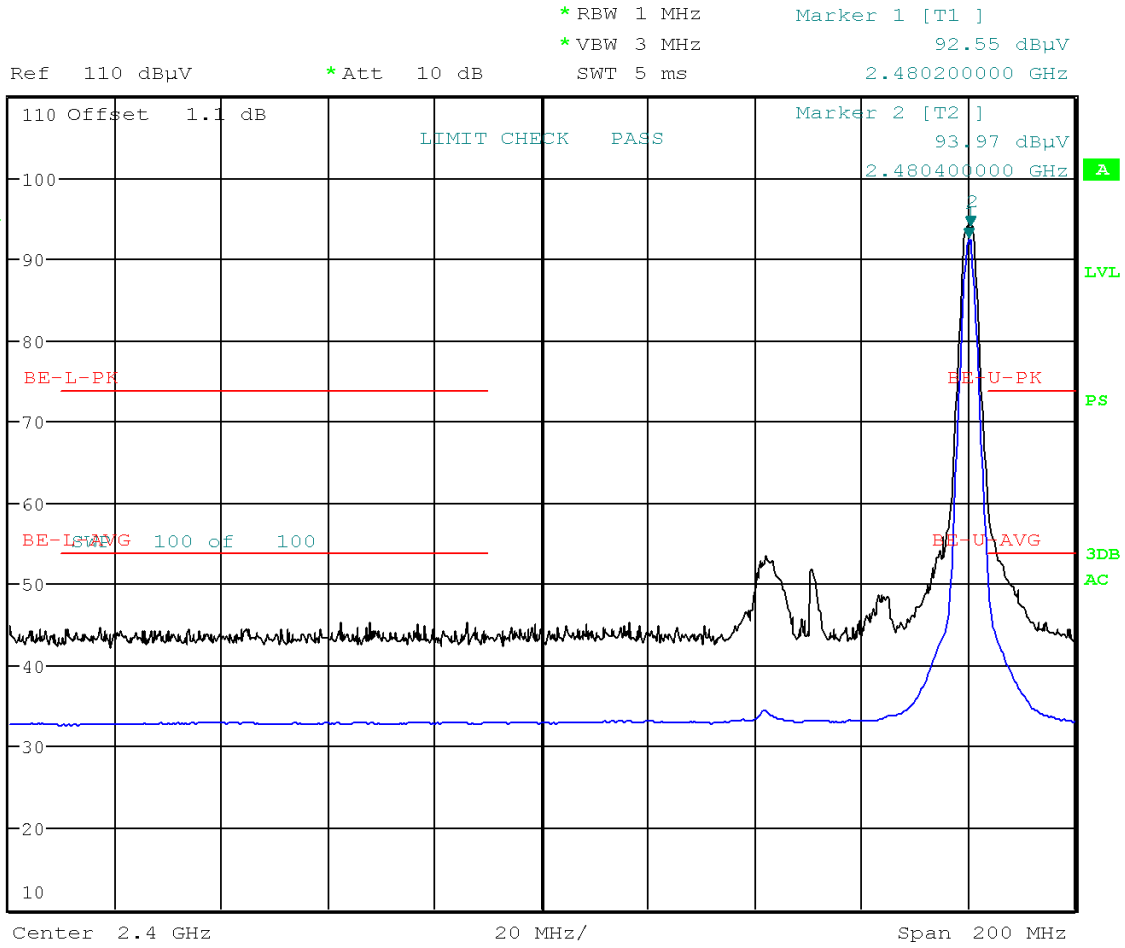
Date: 21.AUG.2020 17:43:11

High Channel @ 1 MHz Modulation



Date: 21.AUG.2020 17:52:08

High Channel @ 2MHz Modulation



Date: 21.AUG.2020 17:57:24

10 Revision History

Revision Level	Description of changes	Revision Date
0	Initial release	27 AUG 2020